Abstract nr. 1
Abstract code
Insight into the ice storm evolution and its forecasting challenges

Author - Sinjur, Iztok, Slovenian Forestry Institute, Ljubljana, Slovenia (Presenting author)
Co-author(s) - Ogris, Nikica , Slovenian Forestry Institute , Ljubljana , Slovenia
Co-author(s) - Vertačnik, Gregor , Slovenian Environment Agency , Ljubljana , Slovenia
Co-author(s) - Dolinar, Mojca , Slovenian Environment Agency , Ljubljana , Slovenia
Co-author(s) - Gustinčič, Martin , Weather and Climate Research Society , Petkovec , Slovenia
Co-author(s) - Pristov, Neva , Slovenian Environment Agency , Ljubljana , Slovenia
Co-author(s) - Kobler, Andrej , Slovenian Forestry Institute , Ljubljana , Slovenia
Topic Weather forecasting for mountainous regions
Keywords Ice storm; glaze ice; forecast; forest; Slovenia

The occurrence of glaze ice and consequently the amount of damage are strongly influenced by air temperature and precipitation amount. Due to cold air current in the lower levels of the atmosphere and warmer and moister air current above the area of Dinaric mountain range experiences ice storms quite frequently. The ice storm that hit Slovenia in 2014 was not exceptional only by its duration and the extent but also by the amount of damage in forests and on infrastructure. Significant spatial and temporal variability of glaze ice formation and damages occurred with a great impact of wind direction and precipitation amount on glaze ice formation respectively. For this case study, an extensive data from 153 meteorological stations of various networks was used. Based on hourly spatial distribution of temperature and precipitation the extend and intensity of glaze ice was determined. Furthermore, the ice storm was used for evaluation and calibration of computer model for forecasting probability and diameter of glaze ice in forests based on nowcasting/forecasting system INCA. It has computational grid of 1 km × 1 km and uses amount of freezing precipitation, wind speed and air temperature for forecasts with one-hour time step up to 12 hours into the future. The model for glaze ice hazard assessment is an empirical model based on index derived from glaze ice diameter, bedrock and tree species indexes and slope inclination. Model explains observed high spatial variability of damage on 1-10 kilometer spatial scale on one side and highlights potential sources of biases on the other side. Based on ice storm data, the model has been calibrated, improved and upgraded with data from meteorological model ALADIN-SI, which enables forecasting the diameter of glaze ice 72 hours ahead in spatial resolution 4.4 km × 4.4 km.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 2
Abstract code

Role of the orography in the generation of a tornadic supercell in the Mediterranean

Author - Miglietta, Mario Marcello, ISAC-CNR, Lecce, Italy (Presenting author)
Co-author(s) - Jordi, Mazon , Department of Physics. Universitat Politecnica de Catalunya – BarcelonaTech , Barcelona , Spain
Co-author(s) - Richard, Rotunno , NCAR , Boulder , USA
Topic Weather forecasting for mountainous regions
Keywords

On 28 November 2012, a multi-vortex EF3 tornado occurred in southeastern Italy causing one casualty and estimated damage of 60 M€. At approximately 1050 LT (0950 UTC), this tornado, which initially formed in association with an apparent supercell thunderstorm over the Ionian Sea, moved inland. The environment where the tornadic supercell developed was characterized by large vertical wind shear in the lowest 1 km of the atmosphere and moderate conditional instability. The WRF-model numerical simulations show that it is possible to produce the track, change in intensity, and evolution of a simulated supercell thunderstorm similar to the actual one that spawned the tornado in Taranto, southern Italy. The genesis of the simulated supercell is due to a combination of mesoscale-meteorological features: warm low-level air advected toward the Ionian Sea, combined with a mid-level cooling due to an approaching trough, increased the potential instability; the intense vertical shear favored the possibility of supercell development; boundary layer rolls over the Ionian Sea moved in phase with the cells produced by the orography of Calabria to supply moisture and heat to convection. An unusual feature of the present case of tornadogenesis is the central role of the orography, which was verified in a sensitivity experiment where the orography of Calabria was reduced by 80%. The upper-level vertical-vorticity couplets generated in the lee of the orography are evidence of updrafts in vertical wind shear for the cells triggered by the orography, which are essential for supercell dynamics.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 3
Abstract code

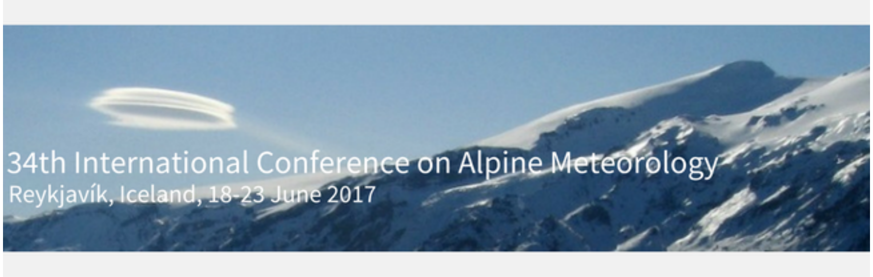
The Enhancement of Lake-Effect Precipitation over the Tug Hill Plateau during the Ontario Winter Lake-effect Systems (OWLeS) Field Program

Author - Steenburgh, Jim, University of Utah, Salt Lake City, USA (Presenting author)
Co-author(s) - Campbell, Leah , University of Utah , Salt Lake City , USA
Co-author(s) - Veals, Peter , University of Utah , Salt Lake City , USA
Co-author(s) - Minder, Justin , University at Albany, SUNY , Albany , USA
Co-author(s) - Minder, Ted , University at Albany, SUNY , Albany , USA
Co-author(s) - Geerts, Bart , University of Wyoming , Laramie , USA
Co-author(s) - Bergmaier, Phil , University of Wyoming , Laramie , USA
Topic Orographic precipitation
Keywords

Improved understanding of the influence of orography on lake-effect storms is crucial for weather forecasting in many lake-effect regions. During December 2013 and January 2014, the U.S. National Science Foundation sponsored Ontario Winter Lake-effect Storms (OWLeS) field program examined lake-effect storms in the vicinity of Lake Ontario, including their enhancement over the Tug Hill Plateau (hereafter Tug Hill), which rises 500 m above lake level and experiences some of the most intense snowstorms in the world. This presentation provides an overview of key OWLeS-derived findings related to the enhancement of lake-effect precipitation over Tug Hill. In contrast to contemporary conceptual models of lake effect interacting with downstream orography, which typically emphasize an invigoration of lake-effect convection (i.e., deepening and strengthening) over downstream terrain features, profiling radar observations from OWLeS indicate an overall decrease in echo depth, decrease in turbulence, and increase in the frequency and uniformity of radar echoes over Tug Hill, consistent with a convective-to-stratiform transition. Significant variations in precipitation enhancement with lake-effect mode have also been identified. For example, strongly organized long-lake-axis parallel bands produce the highest precipitation rates but the smallest increase in precipitation from lowland to upland locations. In contrast, non-banded lake-effect periods exhibit smaller precipitation rates, but much larger increases in precipitation from lowland to upland locations. Although precipitation rates are weaker, these non-banded periods are more frequent and appear to be primarily responsible for the climatological precipitation maximum produced over Tug Hill. Implications of these findings for operational forecasting and our understanding of lake-effect and orographic precipitation will be discussed.

Presentation Preference Oral
Audio/Visual Equipment
Awards

Additional information



Abstract nr. 4
Abstract code
Boundary-layer profiling with ceilometers in complex terrain

Author - Piringer, Martin, ZAMG, Vienna, Austria (Presenting author)
Co-author(s) - Baumann-Stanzer, Kathrin , ZAMG , Vienna , Austria
Co-author(s) - Lotteraner, Christoph , ZAMG , Vienna , Austria
Topic Boundary layers and turbulence in complex terrain
Keywords ceilometer, mixing height, Sahara dust event

Introduction
Since several years, ZAMG operates ceilometers to determine the mixing height (MH) from the analysis of aerosol backscatter (Lotteraner and Piringer, 2016) and stability classes from the cloud base heights and the cloud amount a ceilometer provides (Rau and Piringer, 2017). This manuscript gives first an overview of the measurement principles and shows the locations of the Austrian research ceilometers. This is followed by examples of the ABL structure detected by a ceilometer, both for an “ideal” and a “disturbed” day. Some peculiarities on MH determination in Alpine valleys and in special situations will also be discussed, followed by a few concluding remarks.
Material and method
ZAMG operates now a small network of Vaisala CL51 ceilometers (Baumann-Stanzer et al., 2017). Three of them are situated in Alpine valleys at the base of mountain tops with air pollution monitoring stations. The purpose of the ceilometers is to help investigate whether an air pollution episode at these mountain tops is primarily caused by advection or mixing from polluted valley floors. The most prominent mountain is Hoher Sonnblick (3106 m) with his well-known mountain observatory.
The ceilometer CL51 employs a diode laser lidar (Light Detection and Ranging) technology, with which short, powerful laser (Light Amplification by Stimulated Emission of Radiation) pulses with a wavelength of 910 ± 10 nm (infrared light) are sent out vertically. The laser source of the ceilometer CL51 is an eye-safe indium gallium arsenide diode. The single lens optics of the ceilometer enables detection in a measurement range above approximately 50 m above ground level, where a sufficient overlap of emitted and backscattered laser signals is given (Wagner and Schäfer 2015), up to 15 km.
The reflection of light, backscatter caused by clouds, precipitation, haze, fog, mist and virga, is measured as the laser pulses traverse the sky. The time delay between the launch of a laser pulse and the detection of the backscatter signal indicates the cloud-base height. The ceilometer CL51 is able to detect three cloud layers simultaneously. The backscatter profile is further used to detect up to three aerosol-layer heights by applying the so-called gradient method with a post-processing software (BL-VIEW), which contains an automated mixing-height detection algorithm described in Emeis et al. (2007). An improved algorithm to determine the mixing height from ceilometer aerosol

layer heights is described in Lotteraner and Piringer (2016). Its basic assumptions are to take the first aerosol layer height above ground as the mixing height. Aerosol layer heights above 500 m above ground are not considered as mixing heights between sunset and sunrise, thus avoiding to detect the night-time residual layer as the mixing height. If the near-ground wind speed is below 3 ms^{-1}, even a lower limit of 250 m above ground is applied. If at night no near-ground aerosol layer heights are found over a period of at least six hours, no mixing height is determined. In this way, daily time courses of the mixing height are obtained. The mixing height time series is then averaged and smoothed for a consistent course over time. Data gaps over 6 hours are not filled up.

Examples of the ABL structure

The post-processing software BL-VIEW provides, on a daily basis, colour plots of the backscatter intensity. Light blue to yellow colour in the plot indicates the intensity of the aerosol backscatter signal (in units of 10^{-9} m^{-1} sr^{-1}). Black dots or lines indicate aerosol-layer heights, white-rimmed dots or lines indicate cloud heights determined by Vaisala`s software BL-VIEW. Red colour in the plot denotes precipitation and clouds. A bold yellow line indicates the mixing-height time series for the particular day calculated by the method mentioned in the last section.

In the presentation, two days of back-scatter profiles will be shown. The first shows the typical evolution of the convective boundary layer on a clear sky day on which the successful determination of the mixing height from back-scatter profiles observed by a ceilometer at Vienna is demonstrated. During daytime, the mixing layer rises due to convection and reaches its maximum in the middle of the afternoon. At night, enough low-level data points are available in this example to construct a continuous time series of the mixing height.

The second example demonstrates how the method to determine mixing-height performs on a day with a complex structure of aerosol-layer heights and with precipitation. This day was characterized by an overcast sky in the morning, broken clouds during daytime, and intermittent rain in the evening. Between sunrise and sunset, the mixing-height course followed more or less the aerosol-layer height course, but in a smoothed form. In spite of several gaps in aerosol-layer height data and rain for several hours in the evening, a continuous mixing-height time series with 100% availability of mixing-height data could be calculated on this day by applying the method described in the former section.

Peculiarities on MH determination

Alpine valleys and basins are prone to low wind speeds, especially at night, and are often characterized by clear air. Both are not favourable for the build-up of ground-level aerosol layers. Therefore, very often no mixing heights can be determined at night at these sites. Then the ceilometer mixing height time series will be interrupted, especially when the data gap exceeds 6 hours. Examples for this behaviour will be given.

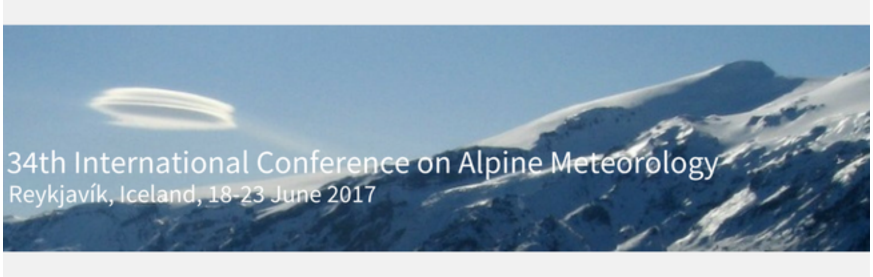
Ceilometers turn out as good tools to detect volcanic ash clouds or Saharan dust events. At the begin of April 2016, a Saharan dust cloud reached Central Europe, leading to enhanced PM10 concentrations and reduced visibility. The evolution of the atmospheric boundary layer (ABL) at the Eastern Alpine ridge is observed by a network of ceilometers. These data are especially valuable to distinguish whether PM10 concentrations are mainly influenced by long-range transport or by advection of aerosols from the ABL. Implications for MH determination on the peak day of the event will be shown.

Conclusions

Ceilometers are ground-based remote sensing devices important for the detection of the vertical aerosol distribution and cloud base heights. Based on this information, mixing heights and atmospheric stability can be determined. This presentation focused on the mixing height in complex terrain and analyzed the potential of ceilometers to detect a Saharan dust event over

Central Europe. For the latter, the advantages of a ceilometer network could clearly be shown.
Acknowledgement
The investigations concerning the interpretation of ceilometer backscatter profiles and especially the mixing height estimation are significantly stimulated by the EU COST Action ES 1303(TOPROF), dealing with ground-based remote sensing systems and the integration of their data into NWP models.
References
Baumann-Stanzer , K., C. Flandorfer , A. Klee , Ch. Lotteraner[a], M. Ortner , J. Vergeiner, M. Piringer, 2017: PM10 exceedances due to a prolonged Saharan dust episode over the Eastern Alps. Atmospheric Environment, submitted.
Emeis S, Jahn C, Münkel C, Münsterer C, Schäfer K, 2007: Multiple atmospheric layering and mixing-layer height in the Inn valley observed by remote sensing. Meteorol Z 16:415-424.
Lotteraner, Ch., M. Piringer, 2016: Mixing-Height Time Series from Operational Ceilometer Aerosol-Layer Heights. Boundary-Layer Meteorology 161, 265-287.
Rau, G., M. Piringer, 2017: Dispersion categories from visual observations compared to those derived from ceilometer and satellite cloud cover information. Meteorolgische Zeitschrift, submitted.
Wagner P, Schäfer K, 2015. Influence of mixing layer height on air pollutant concentrations in an urban street canyon. Urban Clim. http://dx.doi.org/10.1016/j.uclim.2015.11.001

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

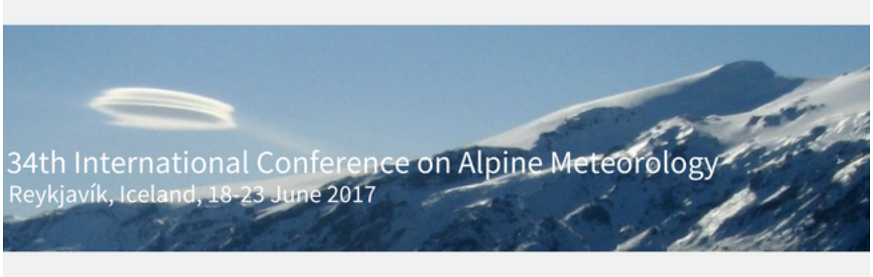


Abstract nr. 5
Abstract code
Validation of Global Ensemble Precipitation Forecasts and the Implications of Statistical Downscaling over the Western U.S.

Author - Steenburgh, Jim, University of Utah, Salt Lake City, USA (Presenting author)
Co-author(s) - Lewis, Wyndam , University of Utah , Salt Lake City , USA
Co-author(s) - Alcott, Trevor , NOAA/Earth Systems Research Laboratory , Boulder, CO , United States of America
Co-author(s) - Rutz, Jonathan , National Weather Service Western Region Headquarters , Salt Lake City, UT , USA
Topic Weather forecasting for mountainous regions
Keywords Orographic precipitation; weather forecasting

Contemporary operational medium-range ensemble modeling systems produce quantitative precipitation forecasts (QPFs) that provide guidance for weather forecasters, yet lack sufficient resolution to adequately resolve orographic influences on precipitation. In this study, we verify cool-season (October–March) Global Ensemble Forecast System (GEFS) QPFs using daily (24-h) Snow Telemetry (SNOTEL) observations over the western U.S., which tend to be located at upper elevations where the orographic enhancement of precipitation is pronounced. Results indicate widespread dry biases, which reflect the infrequent production of larger 24-h precipitation events (22.9 mm in Pacific Ranges and 10.2 mm in the Interior Ranges) compared to observed. Performance metrics, such as equitable threat score (ETS), hit rate, and false alarm ratio, generally worsen from the coast toward the interior. Probabilistic QPFs exhibit low reliability, and the ensemble spread captures only ~30% of upper-quartile events at Day 5. In an effort to improve QPFs without exacerbating computing demands, we explore statistical downscaling based on high-resolution climatological precipitation analyses from the Parameter-elevation Relationships on Independent Slopes Model (PRISM), an approach frequently used by operational forecasters. Such downscaling improves model biases, ETSs, and hit rates. However, 47% of downscaled QPFs for upper-quartile events are false alarms at Day 1, and the ensemble spread captures only 56% of the upper-quartile events at Day 5. These results should help forecasters and hydrologists understand the capabilities and limitations of GEFS forecasts and statistical downscaling over the western U.S. and other regions of complex terrain.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



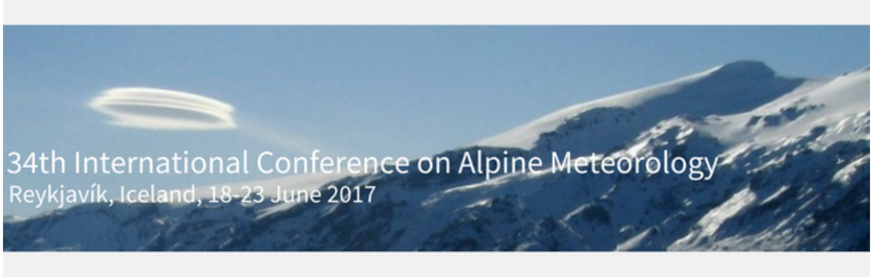
Abstract nr. 6
Abstract code

Validation and Intercomparison of Quantitative Precipitation Forecasts from the NCAR Cloud-Permitting Ensemble and Operational Models over the Western U.S.

Author - Steenburgh, Jim, University of Utah, Salt Lake City, USA (Presenting author)
Co-author(s) - Gowan, Tom , University of Utah , Salt Lake City , USA
Co-author(s) - Schwartz, Craig , National Center for Atmospheric Research , Boulder, CO , USA
Topic Weather forecasting for mountainous regions
Keywords Orographic precipitation; weather forecasting

High-resolution ensemble modeling systems are required to capture the large spatial variability and quantify the inherent uncertainty of precipitation forecasts in areas of complex terrain, however, such systems remain largely untested at cloud-permitting grid spacings (i.e., 4-km or less) over the western U.S. In this study, we assess the capabilities of quantitative precipitation forecasts (QPF) produced by the National Center for Atmospheric Research (NCAR) high-resolution (3-km horizontal grid spacing), 10-member ensemble forecast system using observations collected by Snow Telemetry (SNOTEL) stations at mountain locations across the western U.S. Emphasis is placed on identifying the capabilities of the control member (and hence individual members) in capturing the characteristics of precipitation events at these locations, as well as the reliability and resolution of probabilistic forecasts derived from the ensemble. Through intercomparison with forecasts produced by operational models run by the National Centers for Environmental Prediction (NCEP) and the Earth System Research Laboratory (ESRL), we highlight the usefulness and potential of a cloud-permitting ensemble over the western U.S.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 7
Abstract code
The environment of orographic wave clouds in the lee of the Colorado Front Range (and Oklahoma)

Author - Bluestein, Howard, University of Oklahoma, Norman, OK, United States of America (Presenting author)
Co-author(s) - Lee, Simon , University of Oklahoma , Norman, OK , United States of America
Co-author(s) - Pope, Kiernan , University of Oklahoma , Norman, OK , United States of America
Co-author(s) - Holliday, Matthew , University of Oklahoma , Norman, OK , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords wave clouds; mountain waves

A selection of several thousand photographs of orographic wave clouds taken in the lee of the Colorado Front Range (and elsewhere) from 1984 – 2016 were subjectively grouped into a number of categories based on their physical appearance. The purpose of our study is to (1) describe the different categories and (2) identify the upstream, environmental conditions associated with each category. The ultimate goals are to be able to predict what type of wave clouds will form based on numerical model forecasts of the synoptic environment and to infer properties of the atmosphere based solely on cloud observations.
Rawinsonde and North American Regional Reanalysis (NARR) data were used to characterize the upstream environment in Colorado. The former were used to characterize the far environment crudely, but with high vertical resolution; the latter were used to characterize the near environment (within 50 km or less), but with lower vertical resolution. The data are analyzed in the context of the properties of lee waves. Our results are interpreted with some caution because some of the wave cloud forms observed lasted only for relatively short periods of time, sometimes as briefly as an hour or less. Also, some of the wave clouds were rather isolated. The results of our study will be presented.
Finally, there is a small sample of wave clouds that appeared in other locations such as Norman, OK, where there are no nearby mountains. Some attention will be given to the synoptic environment of these clouds and a hypothesis for what may have triggered them will be offered.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 8
Abstract code
Radar kinematic information as surrogate for isentropes in stratiform orographic storms

Author - Geerts, Bart, University of Wyoming, Laramie, United States of America (Presenting author)
Co-author(s) - Christian, Jordan , University of Wyoming , Laramie , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords vertical-plane Doppler radar observations

This paper will illustrate that dual-Doppler-derived horizontal vorticity in stratiform (laminar) flow is structured in persistent, thin striations. The reason this has not been documented before is that scanning ground-based radars have rather poor and range-dependent vertical resolution. Here we use data from an airborne radar with a fine and constant vertical resolution. Geerts et al. (2017, in Mon. Wea. Rev.) have shown that Doppler-radar-derived vorticity (a kinematic conserved variable) may serve as a suitable proxy for thermodynamic conserved variables such as equivalent potential temperature in stratiform precipitation. Here we apply this observational technique to describe wave patterns over complex terrain, and we use it to validate numerically simulated flow over complex terrain.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

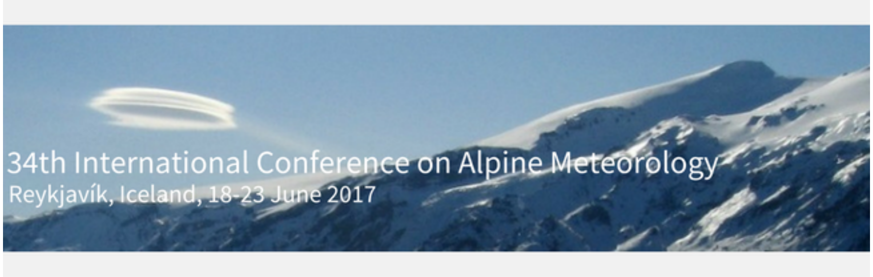
Abstract nr. 9
Abstract code

Earthquake-triggered avalanches along Central Apennines (Italy) in January 18th, 2017.

Author - Fazzini, Massimiliano, University of Camerino, Camerino, Italy (Presenting author)
Co-author(s) - Bisci, Carlo , University of Camerino , Camerino , Italy
Co-author(s) - Cardillo, Antonio , Regione Molise , Campobasso , Italy
Co-author(s) - Perucci, Roberto , Carabinieri - Forestali , Visso , Italy
Co-author(s) - Aringoli, Domenico , University of Camerino , Camerino , Italy
Co-author(s) - Farabollini, Piero , University of Camerino , Camerino , Italy
Co-author(s) - Materazzi, Marco , University of Camerino , Camerino , Italy
Co-author(s) - Pambianchi, Gilberto , University of Camerino , Camerino , Italy
Topic Other
Keywords Earthwuake, Avalanches, Snowfall, Apennines

The strong and long-lasting seismic sequence that has affected central Italy from the end of August 2016, besides widespread severe damages to building and infrastructures, also triggered of many mass movements of different typology and dimension. Namely, in January 18th four shocks (Mw ranging between 5.0 and 5.5, epicenters in the Laga Mts., depth from 9 to 11 Km) occurred between 10:25 and 14:33 (UTC+1) resulted in the activation of some snow avalanches, one of which also caused a casualty in Ortolano di Campotosto (AQ). The above earthquakes strongly shaked a complex mountain range, extending itself for nearly 200 km (from the Sibillini Mts. to the Matese Mts.). Since heavy snowfalls were almost uninterrupted all along the Adriatic side of Central Apennines from the morning of January 16th up to the afternoon of January 19th, the area was covered by a rather thick blanket of snow (thickness approximatively ranging between 150 and 320 cm at an elevation of 1500 m). In this paper, the spatial distribution of the above avalanches, whose co-seismicity has been confirmed by several testimonies, have been analyzed and compared with local morphologies, seismic events, meteorological features and known data on snow cover and stratigraphy.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 10
Abstract code
Mountain wave turbulence in the presence of directional wind shear over the Rocky Mountains

Author - Guarino, University of Reading, Reading, United Kingdom (Presenting author)
Co-author(s) - Teixeira , University of Reading , Reading , United Kingdom
Co-author(s) - Ambaum , University of Reading , Reading , United Kingdom
Co-author(s) - Keller , National Center for Atmospheric Research , Boulder Colorado , United States of America
Co-author(s) - Sharman , National Center for Atmospheric Research , Boulder Colorado , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords CAT; mountain waves; directional shear; PIREPs

Mountain wave turbulence occurring in the presence of directional wind shear over the Rocky Mountains in Colorado is investigated here. Pilot Reports (PIREPs) of turbulence were used to select cases in which moderate or severe turbulence encounters were reported in combination with significant directional wind shear in the upstream sounding from Grand Junction, CO (GJT). For a selected case, semi-idealized numerical simulations were performed using the WRF-ARW atmospheric model initialized with a single sounding, using the GJT atmospheric sounding, and the real orography profile. In order to isolate the role of directional shear in causing wave breaking, sensitivity tests were performed to exclude the variation of the atmospheric stability with height, the speed shear, and the mountain amplitude as dominant wave breaking mechanisms. Significant downwind transport of unstable air was detected in the flow cross-sections, resulting in mountain-wave-induced turbulence occurring at large distances from the first wave breaking point (and from the orography that originates the waves). The existence of an “asymptotic wake”, as predicted by Shutts (1998) for directional shear flows, was hypothesized to be the mechanism responsible for this downwind transport. Directional-shear-induced critical levels were further studied using spectral analysis of the magnitude of the horizontal velocity perturbation field. In these 2D power spectra, a rotation of the most energetic wave-modes with the background wind, as well as perpendicularity between the background wind vector and the wave-number vector of those modes at critical levels, can be found. Such behavior is explained by the mechanism leading to wave breaking in directional shear flows.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 11
Abstract code

The community foehn classification experiment

Author - Mayr, Georg, ACINN University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Plavcan, David , ACINN University of Innsbruck , Innsbruck , Austria
Topic Downslope windstorms, mountain waves and rotors
Keywords foehn; classification; climatology

"Is this foehn?", was the question posed to human experts and to algorithms. The answer matters for studies of the phenomenon itself but also for studies in a wide array of fields from air pollution to admission rates to hospital emergency rooms. Two different types of human experts provided answers; scientists studying foehn and orographic flows and Masters´ students of atmospheric science. Each group had about 20 - 30 participants. Time series of meteorological variables at five different foehn locations and a crest-station in Switzerland covering twelve 48-hour periods together with topographical maps and wind roses formed the common data set. The classification experiment allows to answer questions how well classifications from different experts and between the two types of experts agree, whether their classifications are repeatable, and whether they are distinguishable from two operational objective classification algorithms.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 12
Abstract code
The effects of directional wind shear on CAT generation by orographic gravity-wave breaking

Author - Guarino, University of Reading, Reading, United Kingdom (Presenting author)
Co-author(s) - Teixeira , University of Reading , Reading , United Kingdom
Co-author(s) - Ambaum , University of Reading , Reading , United Kingdom
Topic Downslope windstorms, mountain waves and rotors
Keywords mountain wave breaking; directional shear

Mountain wave breaking, and the mechanisms by which turbulence may be triggered by directional wind shear, are investigated using numerical simulations of idealized, nearly hydrostatic, atmospheric flows over an axisymmetric isolated mountain. These simulations, which use the WRF-ARW model, differ in degree of flow nonlinearity and shear intensity. The aim is to diagnose the conditions for mountain wave breaking in terms of the orography elevation and wind shear, quantified by the dimensionless mountain height and the Richardson number of the background flow, respectively. The simulation results have been used to produce a regime diagram describing the wave breaking behaviour in Richardson number–dimensionless mountain height parameter space. By selecting flow overturning occurrence as a discriminating factor, it was possible to split the regime diagram into sub-regions with and without wave breaking. When mountain waves break, the associated convective instability leads to turbulence generation (which is one of the known forms of clear air turbulence (CAT)). Thus, regions within the simulation domain where wave breaking and the development of CAT are expected have been identified. The extent of these regions increases with terrain elevation and background wind shear intensity. Analysis of the model output, supported by theoretical arguments, suggests the existence of a link between wave breaking and the relative orientations of the incoming wind vector and the horizontal velocity perturbation vector. More specifically, in a wave breaking event, due to the effect of critical levels, the background wind vector and the wavenumber vector of the dominant mountain waves are perpendicular. It is shown that, at least for the wind profile employed in the present study, this corresponds to a situation where the background wind vector and the velocity perturbation vector are also approximately perpendicular.

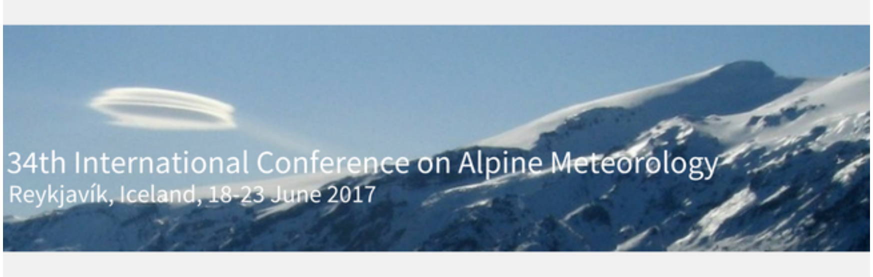
Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 13
Abstract code
Daily and sub-daily extreme rainfall over the Swiss Alps: a climatology

Author - Panziera, Luca, University of Bern and MeteoSwiss, Bern, Switzerland (Presenting author)
Co-author(s) - Gabella, Marco , MeteoSwiss , Locarno Monti , Switzerland
Co-author(s) - Germann, Urs , MeteoSwiss , Locarno Monti , Switzerland
Co-author(s) - Martius, Olivia , Department of Geography, University of Bern , Bern , Switzerland
Topic Other
Keywords extremes, radar, climatology

This study presents a radar-based climatology of daily and sub-daily rainfall over the Swiss Alps and the surrounding regions, thus focusing on extreme events which are likely to cause not only big inundations, but also flash floods, debris flow and landslides.
MeteoSwiss radar rainfall estimates, rain gauge measurements and a merging of the two sources of data (CombiPrecip) for the period 2005-2016 are employed in this study. Despite the relatively short length of the weather radar archives, in fact, their high spatial resolution reveals features of local precipitation extremes that cannot be resolved by standard rain gauge networks.
Precipitation is integrated over temporal periods ranging from 1 hour to 24 hours at each radar pixel of the radar domain (108000 km^2). Simple statistical analyses reveal huge differences in the spatial distribution of extremes between the Alps, the Pre-Alps, and the nearby flat regions; moreover, the spatial patterns of the heavy rainfall strongly depend on the length of the temporal integration.
An extreme rainfall analysis is also performed, in order to derive the return levels for precipitation measured over different temporal scales for each pixel of the radar domain.
A deep comparison between radar and rain gauge extreme rainfall statistics is also included in the study.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 14
Abstract code
Terrain-trapped airflows and orographic rainfall along the coast of northern California: Horizontal and vertical structures of kinematics and precipitation

Author - Valenzuela, Raul, University of Colorado, Boulder, Colorado, United States of America
Co-author(s) - Kingsmill, David , University of Colorado , Boulder, Colorado , United States of America (Presenting author)
Topic Orographic precipitation
Keywords

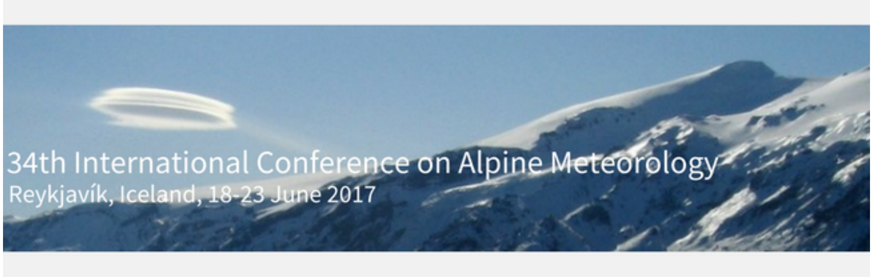
Land-falling extratropical cyclones are responsible for the majority of precipitation that falls in the western United States. The spatial distribution of precipitation from these storms is strongly influenced by the regions' complex terrain. A narrow channel of concentrated horizontal water vapor flux in the lowest 3-4 km MSL is often present immediately ahead of the cold fronts associated with extratropical cyclones. Upon impacting the terrain, these statically-neutral atmospheric rivers (ARs) can facilitate moist orographic uplift that leads to enhanced precipitation. While this relatively simple conceptual model can explain a significant fraction of orographic precipitation that falls in the region, it does not take into account the fact that mountains can produce their own mesoscale circulations that modify the spatial distribution of precipitation. One example is the presence of a terrain-trapped airflow (TTA), which is defined as a relatively narrow air mass flowing in close proximity and approximately parallel to the windward slope of a mountain barrier. TTA impacts on orographic precipitation have been studied extensively in association with several large-scale mountain ranges such as the European Alps, the Southern Alps of New Zealand, the Rocky Mountains of Colorado and the Sierra Nevada of California. In contrast, TTA impacts on orographic precipitation occurring in association with relatively small-scale mountains (altitudes below ~1 km MSL) has received much less attention. It is notable that orographic precipitation over small-scale mountains has the potential to produce rapid runoff and flooding due to the prevalence of precipitation in the form of rain (rather than snow) and the relative scarcity of flood control infrastructure. This is a particularly relevant issue along the coastal mountains of northern California, where unobstructed ARs can directly interact with the coastal terrain (~0.5 km MSL and oriented northwest to southeast) to produce intense rainfall that leads to significant economic impacts.
This study employs observations collected along the California coast north of San Francisco as part of the Hydrometeorology Testbed experiments operated by the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory (ESRL). The main observing system is a scanning X-band Doppler radar located on the coast at Fort Ross (FRS, 10 m MSL), which supplied reflectivity and radial velocity data in the horizontal and vertical throughout the evolution of seven land-falling storms. This information allows the detailed documentation of three-dimensional kinematic and precipitation structures associated with the

impact of TTAs on orographic precipitation. Another important instrument is a 915-MHz wind-profiling radar located on the coast at Bodega Bay (BBY, 15 m MSL) that supplies hourly, high-resolution (~100 m) vertical profiles of horizontal wind up to ~4 km MSL. These data are used to identify TTA conditions based on the mean wind direction in the lowest 500 m MSL; values less than 150° lasting two or more consecutive hours are associated with TTA conditions while values not meeting those thresholds are associated with NO-TTA conditions. Supporting information is provided by and surface meteorology and rain gauge observations at FRS, BBY and in the adjacent coastal mountains at Cazadero (CZD, 478 m MSL).

The seven-storm composite analysis of TTA conditions with data from the scanning Doppler radar reveals an average kinematic structure characterized by a significant horizontal gradient of wind direction with southeasterly winds along the coast transitioning to south-southwesterly at a range of ~50 km from the coast. In the vertical, mean TTA kinematic structure indicates a low-level jet (LLJ) of ~20 m s^{-1} surmounting a weaker airflow of ~10 m s^{-1} corresponding to the TTA. The LLJ center is displaced upward by the TTA from ~0.5 km MSL (offshore) to ~1.0 km MSL (at the coast). Mean precipitation structures in the horizontal and vertical show an enhanced precipitation zone offshore and oriented roughly parallel to the coastline. The center of this zone is located ~15 km offshore and extended upward from the surface to ~0.5 km MSL.

In contrast, seven-storm composite analysis of NO-TTA conditions indicates an average kinematic structure characterized by southerly winds and only a small amount of directional shear in the horizontal. Precipitation enhancement during NO-TTA conditions is restricted to a zone within ~10 km from the coast and extends upward to ~1.0 km MSL. LLJ structures are not readily apparent in either the horizontal or vertical. This does not mean that LLJ structures are nonexistent during NO-TTA conditions. Rather, it indicates that LLJ structures are smoothed out by the averaging process due to their relatively short duration compared to the relatively large NO-TTA data sample.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 15
Abstract code $DA

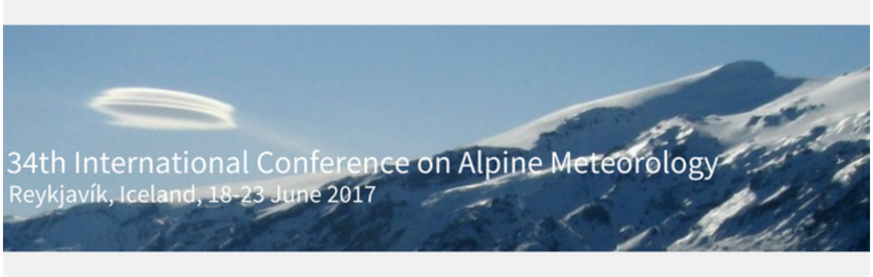
Terrain-trapped airflows and orographic rainfall along the coast of northern California: Long-term kinematic and precipitation characteristics

Author - Valenzuela, Raul, University of Colorado, Boulder, Colorado, United States of America
Co-author(s) - Kingsmill, David , University of Colorado , Boulder, Colorado , United States of America (Presenting author)
Topic Orographic precipitation
Keywords

Land-falling extratropical cyclones are responsible for the majority of precipitation that falls in the western United States. The spatial distribution of precipitation from these storms is strongly influenced by the regions’ complex terrain. A narrow channel of concentrated horizontal water vapor flux in the lowest 3-4 km MSL is often present immediately ahead of the cold fronts associated with extratropical cyclones. Upon impacting the terrain, these statically-neutral atmospheric rivers (ARs) can facilitate moist orographic uplift that leads to enhanced precipitation. While this relatively simple conceptual model can explain a significant fraction of orographic precipitation that falls in the region, it does not take into account the fact that mountains can produce their own mesoscale circulations that modify the spatial distribution of precipitation. One example is the presence of a terrain-trapped airflow (TTA), which is defined as a relatively narrow air mass flowing in close proximity and approximately parallel to the windward slope of a mountain barrier. TTA impacts on orographic precipitation have been studied extensively in association with several large-scale mountain ranges such as the European Alps, the Southern Alps of New Zealand, the Rocky Mountains of Colorado and the Sierra Nevada of California. In contrast, TTA impacts on orographic precipitation occurring in association with relatively small-scale mountains (altitudes below ~1 km MSL) has received much less attention. It is notable that orographic precipitation over small-scale mountains has the potential to produce rapid runoff and flooding due to the prevalence of precipitation in the form of rain (rather than snow) and the relative scarcity of flood control infrastructure. This is a particularly relevant issue along the coastal mountains of northern California, where unobstructed ARs can directly interact with the coastal terrain (~0.5 km MSL and oriented northwest to southeast) to produce intense rainfall that leads to significant economic impacts.
This study employs observations collected along the California coast north of San Francisco as part of the California Land-Falling Jets (CALJET), Pacific Land-Falling Jets (PACJET) and Hydrometeorology Testbed experiments operated by the National Oceanic and Atmospheric Administration’s (NOAA) Earth System Research Laboratory (ESRL). One of the main instruments is a 915-MHz wind-profiling radar located on the coast at Bodega Bay (BBY, 15 m MSL) that provided hourly, high-resolution (~100 m) vertical profiles of horizontal wind up to ~4 km MSL over 13 winter seasons. Supporting information is provided by surface meteorology and rain gauge

observations at BBY and in the adjacent coastal mountains at Cazadero (CZD, 478 m MSL). These data allow documentation of the long-term kinematic and precipitation characteristics of TTAs in this area.
Mean wind direction in the lowest 500 m MSL ($WDIR_{500}$) less than 140° is used as the initial criterion to identify TTA conditions based on the average orientation and altitude of topography near BBY and CZD. Employing this threshold reveals a distinct easterly jet structure of zonal-component winds at ~250 m MSL and enhanced meridional-component winds, especially above 500-m MSL. TTA-regime duration varies seasonally between 1.9 h and 3.2 h, with an average duration of 2.5 h. The mountain-to-coast ratio (i.e., CZD/BBY) of rainfall during TTA conditions is 1.4, which is significantly lower than the ratio of 3.2 observed when TTA conditions are not present. A more detailed analysis of the relationship between $WDIR_{500}$ and orographic rainfall reveals that a threshold of 150° more precisely divides the two regimes of orographic enhancement. Additionally, a TTA-duration threshold of at least 2 h filters out insignificant events.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

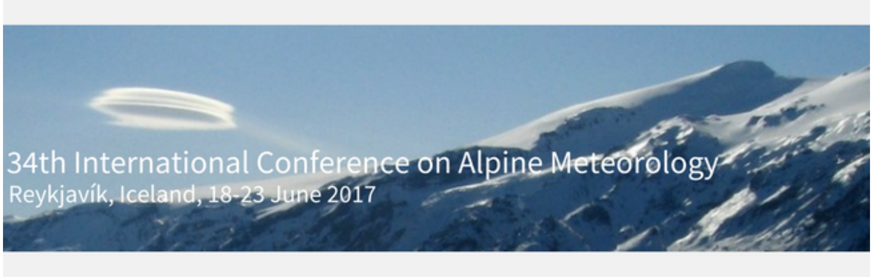


Abstract nr. 16
Abstract code
Trailing Mountain Waves

Author - Doyle, James, Naval Research Laboratory, Monterey, CA, USA (Presenting author)
Topic Results from major field campaigns
Keywords mountain waves; DEEPWAVE

Trailing waves are spectacular long wave beams frequently observed in the stratosphere over mid- to high latitude topography. Two trailing wave events documented over New Zealand during the DEEPWAVE experiment are examined using numerical simulations and theoretical analysis to better understand the trailing wave characteristics and formation mechanisms. The DEEP propagating gravity WAVE program (DEEPWAVE) is a comprehensive, airborne and ground-based measurement and modeling program centered on New Zealand and focused on gravity wave dynamics and impacts from the troposphere through the mesosphere and lower thermosphere. This program employed the NSF/NCAR GV (NGV) research aircraft from a base in New Zealand in a 6-week field measurement campaign in June-July 2014. During the field phase, the NGV was equipped with new Rayleigh and sodium resonance lidars and an advanced mesospheric temperature mapper (AMTM), a microwave temperature profiler (MTP), as well as dropwindsondes and a full suite of flight level instruments providing measurements spanning altitudes from immediately above the NGV flight altitude (~13 km) to ~100 km.
We utilized numerical simulations using the nonhydrostatic COAMPS and AIRS satellite observations to explore the dynamics of trailing waves. We find that trailing waves over New Zealand are orographically generated, and the formation of trailing waves is regulated by several aspects including the interaction between terrain and mountaintop winds, critical level absorption, wave reflection, and refraction. Among them, the interaction between topography and low-level winds determines the perturbation energy distribution over scales and directions near the wave source and it follows that trailing waves are sensitive to terrain features and low-level winds. Terrain induced perturbations are filtered by critical level absorptions associated with directional wind shear and when the wave intrinsic frequency approaches the Coriolis coefficient. The former plays a role in limiting the wave beam orientation, and the latter sets an upper limit for the permissible wavelength for trailing waves. Once entering into the stratosphere, the orographic waves are subject to refraction associated with the meridional shear of the stratospheric westerlies, which tends to refract waves toward stronger winds. This effect stretches out the wave fronts pointing toward stronger winds, resulted in elongated trailing wave beams, and in the meantime, shortens the wave fronts pointing toward weaker winds. We further explore the dynamics of trailing waves using idealized simulations initialized with a zonally balanced stratospheric jet. The idealized results confirm the importance of horizontal wind shear for the refraction of the waves. Furthermore, the zonal momentum flux minimum is shown to bend or refract into the jet in the stratosphere as a consequence of the wind shear.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

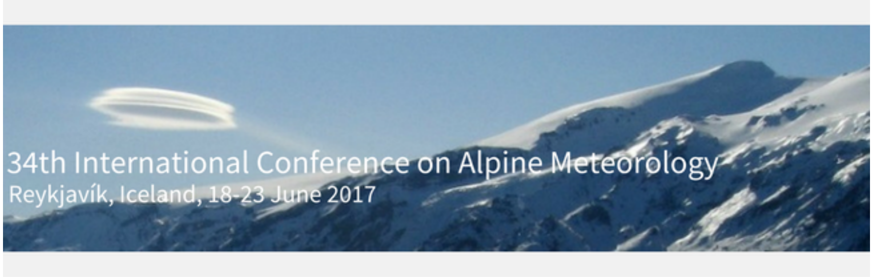


Abstract nr. 17
Abstract code
Air pressure disturbances that cause meteotsunamis

Author - Tudor, Martina, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Šepić, Jadranka , Institute for Oceanography and Fisheries , Split , Croatia
Co-author(s) - Vilibić, Ivica , Institute for Oceanography and Fisheries , Split , Croatia
Co-author(s) - Mihanović, Hrvoje , Institute for Oceanography and Fisheries , Split , Croatia
Co-author(s) - Janeković, Ivica , The University of Western Australia , Crawley , Australia
Topic Weather forecasting for mountainous regions
Keywords atmospheric waves; meteotsunami; NWP;

Meteorological tsunamis are long-ocean waves generated by intense small-scale air pressure disturbances.The waves can be several metres high and cause substantial damage to coastal towns. The main objective of the MESSI project (Meteotsunamis, destructive long ocean waves in the tsunami frequency band: from observations and simulations towards a warning system") is to build a reliable prototype of a meteotsunami warning system.
When an air pressure disturbance of several hPa in amplitude propagates above the sea surface at the speed of long ocean waves (sqrt(g*H) where g is gravity acceleration and H is ocean depth) the long ocean wave amplifies due to Proudman resonance. Therefore, the model should predict the intensity, speed and direction a fast and intensive pressure disturbance. Atmospheric numerical weather prediction models represent one of the main components of any meteotsunami warning system. The non-hydrostatic 2km resolution ALADIN-ALARO forecast is running operationally in Meteorological and Hydrological Service of Croatia since July 2011. The suite predicts propagating small-scale pressure disturbances capable to excite meteotsunamis. However, the comparison of forecast pressure evolution to the measured data shows that the intensity of the observed pressure disturbances is simulated fairly by the model, but at a slightly different position and time, and propagate with slightly different speed and direction. Meteotsunamis are known to be highly sensitive to these parameters. Here we analyse the model disturbance's position, shape, variability in space and time, as well as speed and direction and track it to its origin. The sea surface temperature (SST) used in the model forecast arrives from the global model that is used for lateral boundary conditions. It has been shown that model SST can be quite far from real values over the Adriatic, especially over the coastal areas, such as in the WAC and Kvarner bay. The use of more realistic SST, from OSTIA and MUR analyses and the ROMS ocean model influences the intensity and propagation of the pressure disturbance. Recently, it has been shown that the physiography fields used by the model are of too low resolution and contain errors in the Adriatic area. More realistic physiography of the terrain surrounding the Adriatic sea affects the triggering of the disturbance. Finally, we examine the role of resolved/parametrized deep and shallow convection and turbulence scheme.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



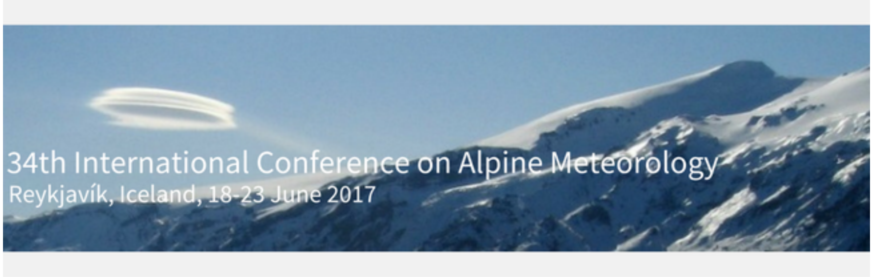
Abstract nr. 18
Abstract code
Multi-sensor precipitation estimation in the Alps: challenges and opportunities

Author - GABELLA, MARCO, MeteoSwiss, Locarno, Switzerland (Presenting author)
Co-author(s) - Speirs, Peter , EPFL , Lausanne , Switzerland
Co-author(s) - Panziera, Luca , University of Bern , Bern , Switzerland
Co-author(s) - Sideris, Ioannis , MeteoSwiss , Locarno , Switzerland
Co-author(s) - Hamann, Ulrich , MeteoSwiss , Locarno , Switzerland
Co-author(s) - Berne, Alexis , EPFL , Lausanne , Switzerland
Co-author(s) - Germann, Urs , MeteoSwiss , Locarno , Switzerland
Co-author(s) - Calpini, Bertrand , MeteoSwiss , Payerne , Switzerland
Topic Other
Keywords Precipitation, dual-pol radar, spaceborne radar

To measure precipitation in a mountainous region is like pitching a tent in a snowstorm: the practical use is obvious and valuable, but problems are abundant. Better knowledge of precipitation fields in the Alpine environment is needed both in weather Nowcasting and climate research: more accurate precipitation measurements, especially in complex-orography catchments, are essential to develop reliable warnings.
In this contribution we will see the complex problem of quantitative precipitation estimation in the Alpine region from four different points of view: 1) a modern network of automatic telemetered rain gages (GAGE); 2) a recently upgraded dual-polarization Doppler ground-based weather radar network (RADAR); 3) a real-time integration of GAGE and RADAR using a co-kriging-with-external-drift technique (CombiPrecip); 4) spaceborne observations acquired by the dual-wavelength precipitation radar onboard the Global Precipitation Measuring (GPM) satellite. Obviously there are large differences in sampling modes, which we have tried to minimize by integrating synchronous observations during the first two years of the GPM mission. The data comprises more than 250 “wet” overpasses over Switzerland since the launch of GPM in February 2014.
By comparing the GPM radar estimates with the other three MeteoSwiss products, we find similar performance in terms of bias. That is, GPM suffers from similar underestimation when compared with GAUGE, RADAR and CombiPrecip. For instance, the underestimation amounts to about -0.4 dB over the Swiss plateau and -1.3 dB in the Alps provided that both GPM and RADAR are able to measure precipitation below the melting layer. Consequently, GPM is not suitable to precisely assess which is the best product in terms of average precipitation over the Alps. However, GPM can be used to evaluate the dispersion of the error around the mean, which is the geographical distribution of the error inside the Country. Using 215 rain-gauge sites, the result is clear both in terms of correlation and scatter, which is a robust, weighted measure of the dispersion of the multiplicative error around the mean. The best agreement is between GPM and CombiPrecip.

Second comes RADAR, whereas larger disagreement was found for GPM versus GAGE.
In short, comparison with GPM confirms that for precipitation mapping in the Alpine region the best result is obtained by combining ground-based radar and rain-gauge measurements.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 19
Abstract code

Sea surface temperature and forecast precipitation on the surrounding mountains

Author - Tudor, Martina, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Stanešić, Antonio , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Ivatek-Šahdan, Stjepan , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Janeković, Ivica , The University of Western Australia , Crawley , Australia
Co-author(s) - Odak Plenković, Iris , Meteorological and Hydrological Service , Zagreb , Croatia
Topic Weather forecasting for mountainous regions
Keywords mountain precipitation; model forecast; SST;

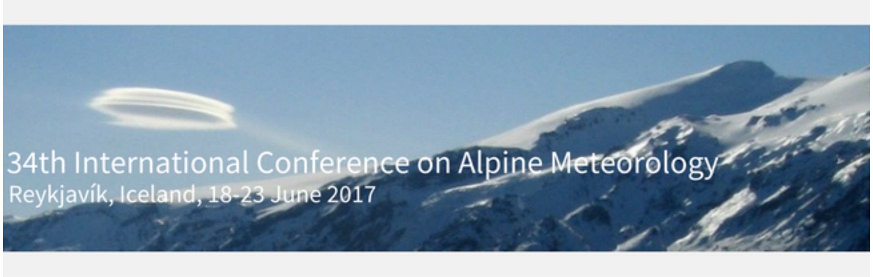
Sea surface temperature (SST) influences the model forecast. For example it is important for modelling of land/sea breeze and influences the intensity of precipitation downstream. The operational forecast in Meteorological and hydrological service of Croatia is performed using ALADIN System. The sea surface is treated in a way that keeps the initial SST field unchanged during the model forecast (72 hours). But SST does change from one analysis (model run) to the next one. There are two sets of SST fields and associated two sets of lateral boundary conditions provided in the coupling files from operational forecasts of IFS and ARPEGE, from ECMWF and Meteo-France respectively. In this study we compared the SST from the global models to the values measured in situ on a number of stations in Croatia and Italy. The comparison reveals errors that can reach 10K over the Adriatic. Such errors are expected to have substantial impact on the forecast precipitation on the surrounding mountains.

The ARPEGE operational SST analysis combines AVHRR satellite data and in situ measurements in the operational oceanographic model Mercator. The SST from IFS forecast is derived from the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) analysis. SST from the Regional Ocean Modelling System (ROMS) was used over the Adriatic Sea with OSTIA analysis over the rest of the Mediterranean.

The impact of SST on the intensity and location of intensive rainfall is investigated by using alternative SST fields in the initial conditions, first from ARPEGE and IFS. In the first set of experiments, SST effects on forecast precipitation are analysed by modifying the SST field in the initial file by shifting the SST field uniformly. For each model forecast, the SST field obtained from ARPEGE is modified by increasing or decreasing SST values by 2K and 5K and finally decreasing by 10K for all sea points in the model domain. The results show increase in precipitation with warmer SST that is expected due to increase in evaporation from the warmer sea surface. But the surrounding mountains can receive less rainfall when SST is warmer. Warmer sea triggers more convection above the sea surface. Therefore, surrounding mountains do not necessarily receive more moisture.

In the further set of experiments, SST in the model was replaced using OSTIA and MUR analyses as well as ROMS model output. In one experiment we also nudged the SST field towards the measurements in order to test if precipitation forecast can be improved when SST is based on measurements.
The errors in the SST fields from the global models over Adriatic can exceed 10K. In reality, Kvarner Bay and Velebit Channel are often much colder than the rest of the Adriatic. In winter, western Adriatic current (WAC) is much colder too. The sea surface is too warm in the model and, consequently, the evaporation is much stronger yielding excess precipitation on the Velebit mountain. Turbulent fluxes of heat are also too strong above the sea surface. Colder SST in the Velebit Channel reduces the precipitation on the mountain.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 20
Abstract code
Cooling by melting snowfall in Alpine valleys: could its predictability get improved in the near future?

Author - Zängl, Günther, Deutscher Wetterdienst, Offenbach, Germany (Presenting author)
Co-author(s) - Schneider, Sten , Goethe University Frankfurt , Frankfurt , Germany
Co-author(s) - Schmidli, Juerg , Hans-Ertel-Zentrum für Wetterforschung , Frankfurt , Germany
Topic Weather forecasting for mountainous regions
Keywords High-resolution modelling;orographic precipitation

In cases of sustained heavy precipitation over the Alps, it occasionally happens even in early or late summer that the snow line descends down into some inner-Alpine valleys, despite the large-scale freezing level lying thousand metres or more above the valley floor level. A precondition for this phenomenon is that the airmass, from which the latent heat of melting is withdrawn, gets decoupled from the large-scale ascending flow generating the precipitation. The flow evolution related to this decoupling can be characterized as a bifurcation process: once the valley airmass starts to get decoupled and develops increasingly stable stratification within the melting layer, mixing with the ambient airflow is reduced and the decoupling and cooling get reinforced. On the other hand, nothing may happen in other valleys where the initial melting layer does not lie far enough below the local crest line for the decoupling process to be initiated. The bifurcational behaviour of this cooling phenomenon makes its prediction very challenging, even though experienced forecasters know in principle which valleys are susceptible to it. Likewise, correctly reproducing this process in a numerical model is very challenging because the model needs a dynamical core that allows resolving steep mountains with very little orography smoothing, and the model dynamics must not induce spurious circulations over steep slopes. Moreover, the model needs to get the mesoscale wind and precipitation fields approximately right. In this study, we investigated five striking cases of cooling by melting using DWD's new global and regional weather prediction model ICON, three (two) of which occurred in the northern (southern) Alps. We used ICON's multi-step nesting capability to scale down from a global mesh size of 20 km to 625 m over the Alps. Although we simply started from global analysis data without performing additional mesoscale data assimilation, four out of the five cases were predicted very well, whereas cooling was underestimated in part of the observed region in the fifth case. Using a coarser resolution (1.25 km instead of 625 m) somewhat degrades the forecast quality in agreement with expectation, but the forecast still would have been useful in the majority of cases. This makes us very optimistic that a skillful model prediction of cooling by melting in Alpine valleys will be achievable quite soon with the upcoming generation of high-resolution NWP models.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information

Abstract nr. 21
Abstract code

Influence of surface roughness on downslope windstorms and mountain waves

Author - Tudor, Martina, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Ivatek-Šahdan, Stjepan , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Stanešić, Antonio , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Hrastinski, Mario , Meteorological and Hydrological Service , Zagreb , Croatia
Topic Downslope windstorms, mountain waves and rotors
Keywords surf. roughness; downslope windstorm; mountainwave

Surface friction affects the flow over the mountains and reduces the amplitude of the mountain waves, the effect is stronger for lower mountains. Surface friction depends on the surface roughness. The surface roughness is a parameter field that depends on unresolved terrain features, type of surface, vegetation cover etc.
Here we analyse the effect of surface friction in a framework of the ALADIN System, particularly the version used for operational forecast at 2 km horizontal grid spacing with ALARO physics package and non-hydrostatic dynamics. The problem is analysed using real terrain and real meteorological conditions. Surface friction is controlled via the surface roughness field. In order to assess the relative importance of the surface friction to the turbulence scheme, experiments with two alternative turbulence schemes were performed: I) a pTKE scheme and II) more advanced TOUCANS, which includes additional prognostic equation for total turbulence energy, as well as the anisotropy effects among other.
The quality of the fields describing the terrain height, surface roughness etc. depends on the quality and resolution of the input data. These fields described above were extracted from a rather old database of quite a low resolution, hence an interpolation procedure created rather non-physical fields. These fields were used in the operational forecast in the absence of better ones. Many recent developments in the model were implemented and tuned using the physiography fields from this old database.
Here we show how the implementation of new roughness length data impacts the model forecast, particularly the formation of mountain waves and associated windstorms and validate the results for 10 m wind. The old roughness length was too smooth for the Dinaric Alps region and had unnatural pattern over the Alps. The roughness length computed initially from the new database in high resolution had much higher values over the Dinaric Alps, but lower maximum values over the domain. Alternative ways of computing the roughness length due to unresolved topography were tested and applied to 2 km horizontal grid spacing non-hydrostatic forecast using the ALADIN System and two different turbulence schemes. Results show that introducing new roughness length field has larger impact on the model forecast than more sophisticated turbulence scheme.

The impact of modified roughness length was tested by running 31 consecutive forecasts at 2 km horizontal grid spacing starting from 00 UTC 1st of March 2016. The forecast using low roughness length (from the old database) occasionally produced excessive wind speed for location Knin in a valley downstream of mountain during bura. Simultaneously, wind speed was underpredicted for another location (Lokvine) which is in the lee of a mountain about 50 km westward from Knin. The experiments have shown that this windstorm develop due to too smooth mountains (which is unrealistic). The introduction of roughness length from the new database made the terrain rougher in general. Using this more realistic and larger surface roughness, the windstorm did not develop over Knin, but it did over Lokvine, which corresponds to the measurements better. Conclusion: more realistic surface roughness allowed for model dynamics to develop local features at appropriate place and time and produce correct forecast.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 22
Abstract code

Characteristics of Easterly-Induced Snowfall in the Yeongdong region of Korea

Author - Kim, Byung-Gon, Gangneung-Wonju National University, Gangneung, Korea (Rep) (Presenting author)
Co-author(s) - Koh, Dae-Hong , Gangneung-Wonju National University , Gangneung , Korea (Rep)
Co-author(s) - Park, Juncheul , Gangneung-Wonju National University , Gangneung , Korea (Rep)
Co-author(s) - Eun, Seung-Hee , Gangneung-Wonju National University , Gangneung , Korea (Rep)
Co-author(s) - Choi, Byeong-Cheol , National Institute of Meteorological Research , Gangneung , Korea (Rep)

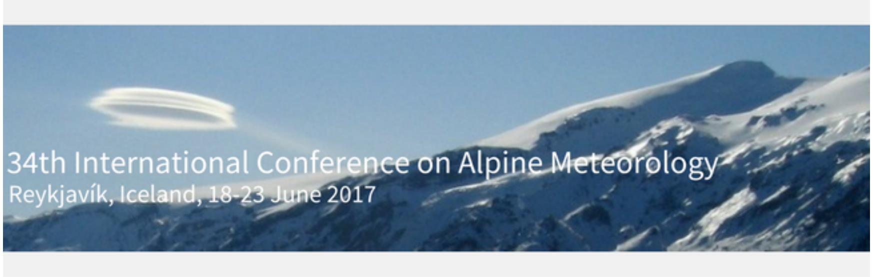
Topic Orographic precipitation
Keywords snowfall; easterly; dendrite

In general, Yeongdong in Korea has heavy snowfall in late winter because of high Taeback Mountains and an adjacent East Sea to the east. The synoptic setting for the heavy snowfall in winter are the Siberian High extended to East Sea and further northern Japan along with the Low system passing by the southern Korean peninsula, which eventually results in the northeasterly or easterly flows in the Yeongdong region. The basic mechanism to initiate snowfall around Yeongdong seems to be similar to that of lake-effect snowstorms around Great Lakes in Canada, and the United States, and also western Japan across the East Sea. Interestingly, snowfall appeared to begin in case of an air-sea temperature difference exceeding over 15.

We also attempted to investigate temporal variations of water vapor, liquid water and snowfall using ground-based Global Navigation Satellite System measurements, Microwave radiometer, and radiosonde systems. The results show that low-level clouds exist below 2~3km thickness with cloud base less than 1km, where northeasterly and northerly winds are consistent. The analysis has been made along with the classification of 3 dominant synoptic patterns such as Low Crossing, Low Passing, and Stagnation types. The snowfall intensity of the largely easterly-induced Stagnation type is highest in spite of lower available water vapor. Late-winter snowfall is likely to have mixed precipitation, such as relatively heavier melting snow. In general, easterly-induced snowfall consists of mainly various kinds of dendrite habits along with frequently rimed particles through both an i-phone and a digital camera. Interestingly the clouds are confined with distinctive shear in wind direction below 2 ~ 2.5 km below the stronger inversion in equivalent potential temperature.

Presentation Preference Oral
Audio/Visual Equipment

Awards
Additional information



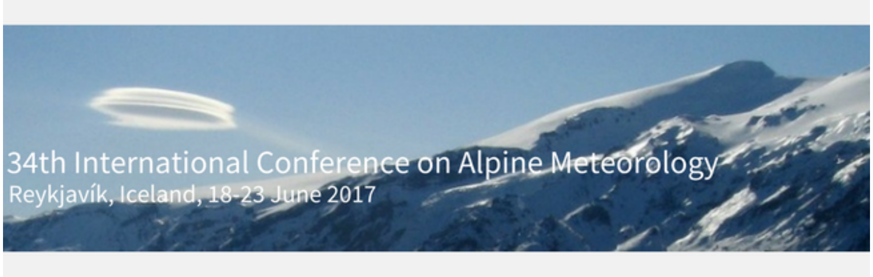
Abstract nr. 23
Abstract code

Study on characteristics of snow crystal from the two-layer cloud structure in Yeongdong region of Korean Peninsula

Author - Kim, Yoo-Jun, National Institute of Meteorological Sciences, Gangneung, Korea (Rep) (Presenting author)
Co-author(s) - Choi, Byoung-Choel , National Institute of Meteorological Sciences , Gangneung , Korea (Rep)
Co-author(s) - Shim, Jae-Kwan , National Institute of Meteorological Sciences , Gangneung , Korea (Rep)
Co-author(s) - Kim, Byung-Gon , Gangneung-Wonju National University , Gangneung , Korea (Rep)
Topic Orographic precipitation
Keywords

The Yeongdong region of Korean Peninsula is vulnerable to natural disasters that are mostly caused by high-impact weather events. Because of their complicated geographical characteristics and lake effect, heavy snowfall episodes have frequently occurred in winter season. Snow crystals play an important role in cloud physics because they affect the scattering of light and fall speed of solid precipitation, which is an essential element for improvement of numerical model. Riming process and seeder-feeder processes contribute significantly to the snowfall formation in mountainous regions, but "seeder-feeder" processes are mainly focused on the summer heavy rainfall rather than winter snow so far.
In this study, the high-resolution dataset of upper-air observations and photographs of snow crystals in the campaign of Experiment on Snow Storms At Yeongdong (ESSAY) were used to apply a new approach for the characterization of snow crystal involved in winter seeder-feeder mechanisms over the Yeongdong region. We also attempt to simulate the snowfall of two-layer cloud structure that occurred on 29-30 January, 2016 using a high-resolution cloud resolving model, namely Cloud Resolving Storm Simulator (CReSS).
The previous studies showed that the snow crystals in the ESSAY campaign were mainly dendrite, consisting of about 70% of the entire habits. This study demonstrated that the rimed habits were frequently captured specifically when two-layerd clouds were observed under conditions of the strong wind shear and inversion in equivalent potential temperature about 2~3 km altitude, such as a case of 29-30 January 2016. Rimed particles, however, tended to change to dendrite form as 850 hPa temperature decreased with time. The CReSS simulation well captured the variations of snow crystal habits as well as two-layer cloud structure. The strong vertical air motion in the low-level cloud represented in the CReSS model appears to play a critical role in producing graupel-like habits.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 24
Abstract code
Observation plans of ICE-POP2018 and the preliminary results

Author - Choi, Byoung-Choel, National Institute of Meteorological Sciences, Gangneung, Korea (Rep) (Presenting author)
Co-author(s) - Jeon, Gye-Hak , National Institute of Meteorological Sciences , Gangneung , Korea (Rep)
Co-author(s) - Kim, Yoo-Jun , National Institute of Meteorological Sciences , Gangneung , Korea (Rep)
Co-author(s) - Joo, Sang-Won , Numerical Modeling Center , Seoul , Korea (Rep)
Topic Results from major field campaigns
Keywords

The 23rd Winter Olympic and the 13th Paralympic Games will be held in PyeongChang, Korea on February-March, 2018. The Games provide great opportunities for the meteorologists to understand mountain meteorology over complex terrain areas like PyeongChang. Therefore, KMA (Korea Meteorological Administration) and NIMS (National Institute of Meteorological Sciences) have been working on the International Collaborative Experiments for PyeongChang Olympic and Paralympic 2018 (ICE-POP2018) project, and the preliminary results from ICE-POP2018 will be used to improve the accuracy of nowcasting and very-short-range forecast systems around the mountainous region.
The HIWRC (High Impact Weather Research Center) is practically in charge of the observation part in the ICE-POP2018. In order to characterize lake-effect snowstorm and orographic enhancement on the evolution of snow clouds over the PyeongChang area, intensive observation campaign has been designed and will be carried out during winter from 2016 to 2018. Beside synoptic observations, radars, wind profilers, multi-purpose aircraft, observing ship, and mobile observation vehicles (MOVE) will be intensively used in this campaign. The data from MOVE could be especially provided specifically in areas of limited mountainous sites.
During the 29-30 January 2016, accumulated snowfall amount at the mountain site (Daegwallyeong) reached 5.5 cm, and the inversion in equivalent potential temperature and strong wind shear about 2~3 km altitude were observed from the upper-air soundings of MOVE. However, snow flurries were observed at the lowland site (Bokwang) of the western direction with the different vertical structure, which means that snow depends on the small scales flows, stability, and phase change in a low level. Analysis of the data collected by MOVE observing platforms combined with other remote sensing measurements will provide new insights into the mechanisms contributing to a unique perspective on snowfall over PyeongChang area.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information

Abstract nr. 25
Abstract code
Limited-area ensemble forecasts during Sochi-2014 Winter Olympics: multi-model vs single-model approach

Author - Montani, Andrea, Arpae, Bologna, Italy (Presenting author)
Co-author(s) - Marsigli, Chiara , Arpae , Bologna , Italy
Co-author(s) - Paccagnella, Tiziana , Arpae , Bologna , Italy
Topic Weather forecasting for mountainous regions
Keywords predictability, ensemble forecasting; olympics

In the framework of 2014 Winter Olympic Games, held in Sochi (Russia), the FROST (Forecast and Research: the Olympic Sochi Testbed) research project developed a number of initiatives. In the field of limited-area ensemble forecasting, six different forecast systems were implemented and deployed so as to assist the local meteorologists in the probabilistic prediction of high-impact weather events with a great spatio-temporal detail. The weather prediction systems were based on both European models (COSMO, HIRLAM, Aladin) as well as the Nonhydrostatic Multiscale Model by NCEP. Several forecast products by the different systems were displayed on FROST web site in real time and are now available on the project archive. In this work, the added value of the multi-model with respect to the single-model approach is assessed by investigating the performance of the different ensemble systems over a case study basis as well as over the full Olympic season, from 15 January to 15 March 2014. The skill of the different systems, either running in convection-parameterised or convection-permitting mode, is mainly studied in terms of probabilistic prediction of precipitation for forecast ranges up to day 3. The relative benefits of higher resolution and/or larger ensemble size are quantified over the verification period as well as for the individual case studies.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 26
Abstract code
Broad spectrum mountain waves

Author - Smith, Ron, Yale University, New Haven, United States of America
Co-author(s) - Kruse, Christopher , Yale University , New Haven , United States of America (Presenting author)
Topic Downslope windstorms, mountain waves and rotors
Keywords

Recent airborne mountain wave measurements over New Zealand in the lower stratosphere during the DEEPWAVE campaign allow improved spectral analysis of velocity (i.e. u, v, w), pressure and temperature fluctuations. The surprising aspects of these data are the breadth of the power spectra and their different spectral shapes.
Using idealized complex terrain as a guide, the spectra are divided into the long-wave “volume mode” arising from airflow over the whole massif and the short-wave “roughness mode” arising from flow into and out of valleys. The roughness mode is evident in the aircraft data as an intense band of w-power from wavelength . The shorter part of this band falls near the non-hydrostatic buoyancy cut-off ( ). It penetrates easily into the lower stratosphere but carries little u-power or momentum flux. The longer part of this roughness mode carries most of the wave momentum flux. The volume mode for New Zealand, in the range , is detected using the u-power, p-power and T-power spectra. Typically, the volume mode carries a third or less of the total wave momentum flux but it dominates the u-power and thus may control the wave breakdown aloft. Spectra from numerical simulations agree with theory and aircraft data.
Based on the DEEPWAVE results, we discuss how broad gravity wave spectra pose challenges for observing and parameterizing waves. Observations that measure T-power or u-power are biased with respect to momentum flux. Regarding parametrization, the volume mode controls the wave breakdown while the roughness mode carries most of the momentum flux; casting doubt on the concept of saturation momentum flux.

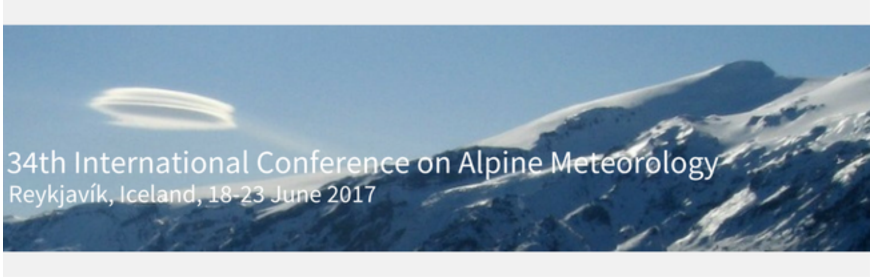
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 27
Abstract code
Numerical Study of Physical Processes Controlling Summer Precipitation over the Western Ghats Region

Author - Zhang, Gang, Yale University, New Haven, United States of America
Co-author(s) - Smith, Ronald , Yale University , New Haven , United States of America
(Presenting author)
Topic Orographic precipitation
Keywords orographic precipitation; numerical modeling

Summer precipitation over the Western Ghats and its adjacent Arabian Sea is an important component in the Indian monsoon. To advance our understanding of the physical processes controlling the regional precipitation, we conduct a series of high resolution convection-permitting simulations using the Weather Research and Forecasting (WRF) model. Convection simulated in the WRF model agrees with TRMM and MODIS satellite estimates. Sensitivity simulations are conducted, by altering topography, latent heating, and sea surface temperature (SST), to quantify the effects of different physical forcing factors.
It is helpful to put India west coast rainfall systems into three categories with different causes and characteristics: (1) Offshore rainfall is controlled by incoming convective available potential energy (CAPE) in the monsoon westerlies and the SST of the Arabian Sea. It is not triggered by the Western Ghats. When present, it steals CAPE and reduces coastal rainfall. Strong (weak) offshore rainfall is associated with high (low) SSTs in the Arabian Sea, suggested by both observation and sensitivity simulations. (2) Coastal rainfall is forced by both the coastline and the Western Ghats topography. The Western Ghats enhances convection-induced rainfall over the mountains and produces a drier rain shadow to the east. Convection is the biggest overall rain producer. (3) Orographic stratiform rain dominates the precipitation on the crest of the Western Ghats.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 28
Abstract code

Mountain wave attenuation and momentum deposition in sheared environments

Author - Kruse, Christopher, Yale University, New Haven, United States of America (Presenting author)
Co-author(s) - Ronald, Smith , Yale University , New Haven , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords wave breaking, gravity wave drag

Recently, mountain wave (MW) attenuation above the Southern Alps of New Zealand has been investigated during the entire DEEPWAVE period. Within this period, MWs were often strongly attenuated in a negative shear region in the lower stratosphere, where wind reduction causes mountain waves to steepen, attenuate, and deposit negative momentum. Occasionally, MWs propagated to altitudes greater than z = 35 km when lower-stratospheric negative ambient wind shear was minimized and positive ambient wind shear dominated.

The objective of this investigation is to study differences in MW breakdown or attenuation in no-shear, positive-shear, and negative-shear environments. MW attenuation is simulated using the non-linear WRF model in a 2-D idealized configuration. Compact single-mode and dual-mode 500 m high cosine terrains are used to launch waves in the sheared profiles. A unique aspect of this work is that the domains are horizontally periodic. While this is an unrealistic idealization, this boundary condition allows intuitive wave-mean flow interaction. The ambient wind speed reduction is the time integrated gravity wave drag.

In no-shear environments, MW attenuation/momentum deposition has multiple maxima in the vertical. In negative shear cases, attenuation is confined to the layer with negative shear and attenuation is smoother with height. The largest decelerations are seen in the positive shear cases, where wave steepening due to decreasing density is countered somewhat by increasing ambient wind. In simulations with a large-scale “volume” mode and a small-scale “roughness” mode, momentum deposition profiles are qualitatively similar to those with only the volume mode, suggesting the volume mode u’ modulates the environment of the smaller-scale roughness mode and controls where this mode attenuates. Conventional gravity wave saturation equations are not able to produce the WRF-computed ambient wind reductions.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 29
Abstract code

Comparison of resolved and parameterized orographic gravity waves over New Zealand, the Andes, and the Himalayas

Author - Kruse, Christopher, Yale University, New Haven, United States of America (Presenting author)
Co-author(s) - Ronald, Smith , Yale University , New Haven , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords gwd parameterization, New Zealand, Andes, Himalaya

A deep, 6-km resolution realistic WRF simulation has recently been completed over New Zealand for three months containing the DEEPWAVE period. This simulation was extensively validated against research aircraft, radiosonde, and satellite observations. WRF-resolved gravity wave drag (GWD) was quantified and compared with that parameterized in the MERRA and MERRA-2 reanalysis datasets. The MERRA parameterized GWD was 3-6 times less than that in WRF below z = 30 km. This underrepresentation was reduced in MERRA-2. Additional three month long WRF simulations were completed over the entire Andes and Himalaya mountain ranges in order to further evaluate the parameterized GWD in MERRA and MERRA-2 and to provide context for the New Zealand results.
In the mid-troposphere, the Patagonian Andes produced the largest amplitude mountain waves. In the negative shear region above the sub-tropical jet, GWD is peaked over all mountain ranges. The largest GWD at this level was found over the Himalayas. In the mid- to upper-stratosphere, the largest amplitude mountain waves were found over the Patagonian Andes. Below z = 25 km, parameterized GWD was underrepresented in both MERRA and MERRA-2 over all mountain ranges. Above z = 25 km over the Andes and New Zealand, GWD was overrepresented in MERRA-2 by about an order of magnitude.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 30
Abstract code

Coherent structures in the alpine atmospheric surface layer coupled with blowing snow response

Author - Aksamit, Nikolas, University of Saskatchewan, Canmore, Canada (Presenting author)
Co-author(s) - Pomeroy, John , University of Saskatchewan , Saskatoon , Canada
Topic Cryosphere and mountain hydrology
Keywords PTV, blowing snow, turbulence

Wind transport of snow is a turbulence driven phenomenon impacting mountain hydrology, glaciology, and avalanche safety. Furthermore, blowing snow behaves as a wind momentum sink, especially in the dense near-surface region where snow is in saltation. In two-way coupled atmosphere-blowing snow models, this transfer of kinetic energy from the wind to snow particles is typically accounted for as an increased roughness length in a log-linear wind model. When steady state, equilibrium transport models do not apply, however, understanding the timescales of particle response to turbulent gusts becomes increasingly important to know what turbulence statistics accurately characterize snow transport. Small variations in transport can translate to large variability in blowing snow deposition. Currently, there is limited understanding of the timescales relevant in the two-way coupling of wind and snow in complex terrain and in the presence of high turbulence intensity. Through laser illuminated high-speed videography, snow particle tracking velocimetry, and ultrasonic anemometry in an alpine setting, surface layer structures were observed and coupled with intermittent blowing snow events. This has allowed better understanding of the nonlinear relationships between time-dependent turbulence statistics of high and low frequency motions and subsequent snow transport.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 31
Abstract code

Comparison and optimization of radar based hail detection algorithms in Slovenia

Author - Skok, Gregor, Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia, Ljubljana, Slovenia (Presenting author)
Co-author(s) - Gregor, Stržinar , Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia , Ljubljana , Slovenia
Topic Orographic precipitation
Keywords

In this study we evaluated four commonly used radar based hail detection algorithms over Slovenia. The algorithms were verified against ground observations of hail in the period between May-August 2002-2010. The algorithms were optimized by determining optimal values of algorithm parameters. The best performance indexes were given by Waldvogel and SHI methods, followed by VIL and maximum radar reflectivity methods. In the end, using the optimal parameter values, a hail frequency climatology map for the whole Slovenia was produced. The analysis showed that within the Republic of Slovenia there is a considerable variability of hail occurrence. The hail frequency ranges from 0.2 to 1.8 with an average value of 0.9 hail days per year.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 32
Abstract code

Objective climate classification of Slovenia

Author - Skok, Gregor, Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia, Ljubljana, Slovenia (Presenting author)
Co-author(s) - Kozjek, Katja , Slovenian Environment Agency , Ljubljana , Slovenia
Co-author(s) - Dolinar, Mojca , Slovenian Environment Agency , Ljubljana , Slovenia
Topic Other
Keywords

In the study the climate regions of Slovenia were determined. The regionalization was based on the gridded climate data for the reference period 1981–2010. The climatic regionalization was performed predominately objectively with a combination of two statistical methods; the factor analysis which was followed by k-means clustering. With the use of factor analysis the initial number of 31 climate variables was reduced to 4 variables or factors, which comprised the input for the cluster analysis where Slovenia was divided into 6 climate regions: Submediterranean climate region, Wet climate of hilly region, Moderate climate of hilly region, Subcontinental climate region, Subalpine climate region and Alpine climate region. Compared to previous climatic regionalization studies for Slovenia, the presented study uses a higher degree of objectivity in the determination of the extent and borders between climate regions. The current study was based purely on climate data, while in the previous studies, the borders were defined more subjectively, based on the authors' expertise of local climate.

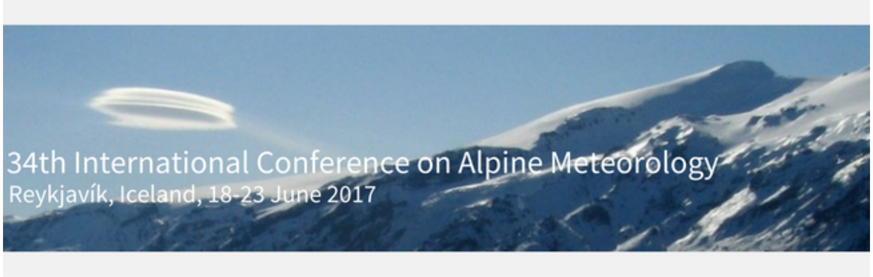
Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 33
Abstract code
Forecast verification of precipitation and wind in complex terrain

Author - Skok, Gregor, Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia, Ljubljana, Slovenia (Presenting author)
Co-author(s) - Roberts, Nigel , MetOffice@Reading , Reading , United Kingdom
Co-author(s) - Veronika, Hladnik , Slovenian Environment Agency , Ljubljana , Slovenia
Topic Weather forecasting for mountainous regions
Keywords

Verification of forecasted precipitation and wind fields over complex terrain presents a special challenge. This was recognized and addressed by the ongoing MesoVICT project. In recent years, new verification methods have been developed and one of these is the Fractions Skill Score (FSS). Firstly, we show how the FSS can be used to provide meaningful information about the displacement between precipitation in one field compared to another. Secondly, the FSS, as originally defined, can analyze only scalar variables and here an attempt has been made to extend the score so as to analyze wind vector fields in a meaningful way. The new score was calculated and analyzed for real cases in the greater Alpine region as well as idealized setups.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



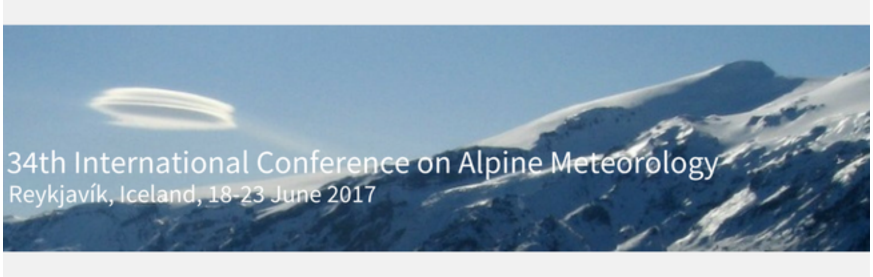
Abstract nr. 34
Abstract code

Nocturnal cooling in a very shallow cold air pool

Author - Skok, Gregor, Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia, Ljubljana, Slovenia (Presenting author)
Co-author(s) - Rakovec, Jože , Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia , Ljubljana , Slovenia
Co-author(s) - Žagar, Nedjeljka , Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia , Ljubljana , Slovenia
Co-author(s) - Žabkar, Rahela , Slovenian Environment Agency , Ljubljana , Slovenia
Topic Boundary layers and turbulence in complex terrain
Keywords

Cold air pools (CAPs) may develop during nights in very shallow depressions. The depth of the stagnant air within a CAP influences the process of the cooling of nocturnal air and the resulting minimum temperature. A seven-month long field experiment was performed during winter 2013/2014 in an orchard near Krško, Slovenia, located inside a very shallow basin only a few meters deep and approximately 500 m wide. Two locations at different elevations inside the basin were selected for measurement. The results showed that the nights (in terms of cooling) can be classified into three main categories; nights with overcast skies and weak cooling, windy nights with clear sky and strong cooling but with no difference in temperatures between locations inside the basin, and calm nights with even stronger cooling and significant temperature differences between locations inside the basin. On calm nights with clear skies, the difference at two measuring sites inside the basin can be up to 5 °C but the presence of even weak winds can cause sufficient turbulent mixing to negate any difference in temperature. To better understand the cooling process on calm, clear nights, we developed a simple 1-D thermodynamic conceptual model focusing on a very shallow CAP. The model has 5-layers (including two air layers representing air inside the CAP), and an analytical solution was obtained for the equilibrium temperatures. Sensitivity analysis of the model was performed. As expected, a larger soil heat conductivity or higher temperature in the ground increases the morning minimum temperatures. An increase in temperature of the atmosphere also increases the simulated minimum temperatures, while the temperature difference between the higher and lower locations remains almost the same. An increase in atmosphere humidity also increases the modelled equilibrium temperatures, while an increase of the humidity of the air inside the CAP results in lower equilibrium temperatures. The humidity of the air within the CAP and that of the free atmosphere strongly influence the differences in equilibrium temperatures at higher and lower locations. The more humid the air, the stronger the cooling at the lower location compared to the higher location.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 35
Abstract code
Carpathian mountain forest vegetation and its responses to extreme climate stressors

Author - ZORAN, MARIA, National Institute of R&D for Optoelectronics, Magurele Bucharest, Romania (Presenting author)
Co-author(s) - SAVASTRU, DAN , National Institute of R&D for Optoelectronics , Magurele Bucharest , Romania
Co-author(s) - DIDA, ADRIAN , University of Brasov , Brasov , Romania
Topic Other
Keywords Climate change ; Extreme events ; Mountain forests

The altitude and the shape of the Carpathian mountain chain in Romania are responsible of significant climate disturbances in the zonal climate and in the general atmospheric circulation. Have been reported variations of the thermal vertical lapse according to the aspect, slope and land cover, which can be reflected in the local conditions and in the other meteorological variables, such as relative humidity, wind speed, and snow cover. Due to anthropogenic and climatic changes, Carpathian Mountains areas in Romania are experiencing environmental degradation. Mountain forests represent unique areas for the detection of climatic change and the assessment of climate-related impacts. Forest systems are all sensitive to climatic factors and extreme events and are likely to have different vulnerability thresholds according to the species, the amplitude, and the rate of climatic stressors.
As a result of global climate change, there is a growing evidence that some of the most severe weather events could become more frequent in Romania over the next 50 to 100 years. In the case of Carpathian mountain forests, winter storms and heat waves are considered key climate risks, particularly in prealpine and alpine areas. Effects of climate extremes on forests can have both short-term and long-term implications for standing biomass, tree health and species composition. The preservation and enhancement of mountain forest vegetation cover in natural, semi-natural forestry ecosystems is an essential factor in sustaining environmental health and averting natural hazards
This paper aims to (i) describe observed trends and scenarios for summer heat waves, windstorms and heavy precipitation, based on results from simulations with global circulation models, regional climate models, and other downscaling procedures, and (ii) discuss potential impacts on mountain forest systems in Romania. In montane forests, the more frequent occurrence of dry years may accelerate the replacement of sensitive tree species and reduce carbon stocks, and the projected slight increase in the frequency of extreme storms by the end of the century could increase the risk of windthrow. Some possible measures to maintain goods and services of forest ecosystems are mentioned, but it is suggested that more frequent extremes may have more severe consequences than progressive changes in means. In order to effectively decrease the risk for social and economic impacts, long-term adaptive strategies in silviculture,

investments for prevention, and new insurance concepts seem necessary.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 36
Abstract code
Cloud formation in the lee of isloated mountains: Dependence on wind speed and wind shear

Author - Wirth, Volkmar, Johannes Gutenberg University Mainz, Mainz, Germany (Presenting author)
Co-author(s) - Schappert, Sebastian , Deutscher Wetterdienst , Offenbach , Germany
Co-author(s) - Bubel, Pascal , Johannes Gutenberg University Mainz , Mainz , Germany
Topic Boundary layers and turbulence in complex terrain
Keywords Isolated mountain; banner cloud; lee vortex

Sometimes clouds are observed in the lee of isolated steep mountains. These so-called banner clouds arise primarily due to an asymmetry of the vertical displacement of air parcels in the neighborhood of the mountain. Previous research has shown that weakly stratified flow past an isolated obstacle with large aspect ratio produces a plume of large uplift in the lee of the obstacle. The leeside uplift of air is associated with a bow-shaped vortex immediately behind the obstacle. The current contribution investigates the dependence of the flow on the strength and vertical shear of the oncoming flow. This is done with the help of large-eddy simulations of flow past an idealized mountain. The simulations indicate that the flow depends only weakly on the strength of the wind. This result is consistent with measurements taken some 10 years ago at Mount Zugspitze. On the other hand, the flow geometry and, in particular, the shape of the leeside vortex depend very sensitively on the vertical shear of the incoming flow.
Simple arguments are given in order to understand this strong sensitivity. In addition, the simulations are used in order to explore the potential to detect such sensitivities using current wind lidar techniques.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 37
Abstract code
Climate changes impacts on mountain vegetation land cover from time-series satellite imagery

Author - ZORAN, MARIA, National Institute of R&D for Optoelectronics, Magurele Bucharest, Romania
Co-author(s) - SAVASTRU, DAN , National Institute of R&D for Optoelectronics , Magurele Bucharest , Romania
Co-author(s) - Savastru, Roxana , National Institute of R&D for Optoelectronics , Magurele Bucharest , Romania (Presenting author)
Topic Other
Keywords climate mountain; satellite imagery; Romania

This paper addresses a number of issues related to current and future climatic change and its impacts on mountain vegetation land cover, focusing on the Carpathian region in Romania. Mountains are important sources of water, energy, minerals, forest and agricultural products and areas of recreation. They are storehouses of biological diversity, home to endangered species and an essential part of the global ecosystem. Due to global warming and climate changes Carpathian zones in Romania are experiencing environmental degradation. However, climate change effects like increased precipitation, moth attacks, freezing and thawing events during winter and long-transported air pollution (e.g. nitrogen) as well as heat wave event during summer period may also have reinforced the changes in biomass. Use of vegetation indicators derived from remotely sensed imagery, give us the possibility to forecast shifts in the future distribution of mountain vegetation due to climate changes. Remotely sensed metrics representing cumulative greenness, seasonality, and minimum cover have successfully been linked to species distributions over broad spatial scales. Climatic variables from regional weather stations and NOAA AVHRR satellite data for the 2000-2016 period together with Normalized Difference Vegetation Index (NDVI) and leaf area index (LAI) time- series MODIS Terra/Aqua satellite data revealed some consistent changes. So, mountain vegetation had a nonlinear response to changing climate, this response of vegetation to climatic factors was varying in different seasons and also related to different land cover vegetation characteristics and climatic conditions. Anyway, mountain ecosystem functions regulated the relationships between vegetation and climate.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 38
Abstract code
The causes of foehn warming in the lee of mountains

Author - Renfrew, Ian, University of East Anglia, Norwich, United Kingdom (Presenting author)
Co-author(s) - Elvidge, Andrew , University of East Anglia , Norwich , United Kingdom
Topic History of mountain meteorology
Keywords foehn

The foehn effect is well known as the warming, drying and cloud clearance experienced on the leeside of mountain ranges during ‘flow over’ conditions. Foehn flows were first described more than a century ago, when two mechanisms for this warming effect were postulated. An isentropic drawdown mechanism where potentially warmer air from aloft is brought down adiabatically; and a latent heating and precipitation mechanism, where air cools less on ascent – due to condensation and latent heat release – than on its dry descent on the leeside. Here, for the first time, the direct quantitative contribution of these and other foehn warming mechanisms are shown. The results suggest a new paradigm is required after it is demonstrated that a third mechanism, mechanical mixing of the foehn flow by turbulence, is significant. In fact depending on the flow dynamics any of the three warming mechanisms can dominate. A novel Lagrangian heat-budget model, back trajectories, high resolution numerical model output and aircraft observations are all employed. The study focuses on a unique natural laboratory – one that allows unambiguous quantification of the leeside warming – the Antarctic Peninsula and Larsen C Ice Shelf. The demonstration that three foehn warming mechanisms are important has ramifications for weather forecasting in mountainous areas and associated hazards such as ice shelf melt and wildfires.

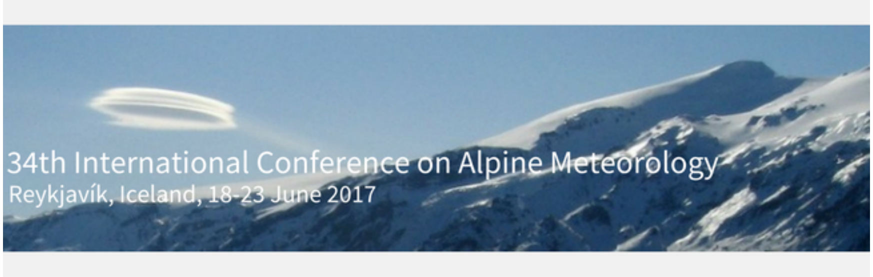
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 39
Abstract code
Meteorological controls on local and regional volcanic ash dispersal

Author - Renfrew, Ian, University of East Anglia, Norwich, United Kingdom (Presenting author)
Co-author(s) - Poulidis, Alex , Kyoto University , Kyoto , Japan
Co-author(s) - Phillips, Jerry , University of Bristol , Bristol , United Kingdom
Co-author(s) - Barclay, Jenni , University of East Anglia , Norwich , United Kingdom
Co-author(s) - Jenkins, Susannah , University of Bristol , Bristol , United Kingdom
Co-author(s) - Robertson, Richie , University of the West Indies , Port of Spain , Trinidad and Tobago
Co-author(s) - Pyle, David , University of Oxford , Oxford , United Kingdom
Topic Other
Keywords

Volcanic ash has the capacity to impact human health, livestock, crops and infrastructure; in addition to disrupting international air traffic. For recent major eruptions, information on the plume and ash distribution has typically been combined with relatively coarse-resolution meteorological model output to provide simulations of regional ash dispersal, with reasonable success on the scale of hundreds of kilometres. Here, we will present results from a dynamic meteorology-ash-dispersion model configured with sufficient resolution to represent local topographically-forced flows and initialised with realistic atmospheric and ash-distribution structures. We focus on an archetypal volcanic setting, Soufriere, St. Vincent, and draw on the exceptional historical record of the 1902 and 1979 eruptions to compare with our simulations. We find that the evolution and characteristics of ash deposition on St Vincent and nearby islands can be accurately simulated when the wind shear associated with the Trade Wind inversion and topographically-forced flows are represented. Sensitivity tests demonstrate that the wind shear has a primary role in local ash dispersal, with topographic flows an important secondary role, for ash fall on both St Vincent and Barbados. Consequently we propose a new explanation for secondary ash deposition maxima, a common observation in volcanic eruptions, namely a result of interactions between mesoscale meteorology and the ash plume.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



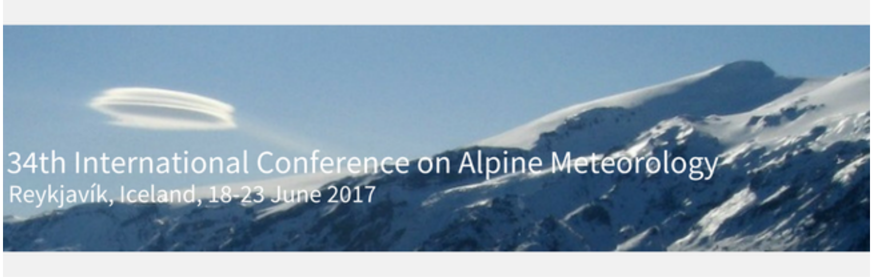
Abstract nr. 40
Abstract code
Winter and high-altitude dust size distributions with the balloon-borne Light Optical Aerosol Counter (LOAC)

Author - Dagsson Waldhauserova, Pavla, University of Iceland and Agricultural University of Iceland, Reykjavik, Iceland (Presenting author)
Co-author(s) - Olafsson, Haraldur , University of Iceland , Reykjavik , Iceland
Co-author(s) - Renard, Jean-Baptiste , LPC2E-CNRS / Université d’Orléans , Orléans , France
Co-author(s) - Vignelles, Damien , LPC2E-CNRS / Université d’Orléans , Orléans , France
Co-author(s) - Verdier, Nicolas , CNES , Toulouse , France
Co-author(s) - Arnalds, Olafur , Agricultural University of Iceland , Reykjavik , Iceland
Topic Results from major field campaigns
Keywords aerosol, high latitudes altitudes, air pollution

Iceland has the largest area of volcaniclastic sandy desert on Earth where dust is originating from volcanic, but also glaciogenic sediments. Total Icelandic desert areas cover 44,000 km^2 which makes Iceland the largest Arctic as well as European desert. The mean frequency of days with dust suspension was to 135 dust days annually in 1949-2011. The annual dust deposition was calculated as 31 - 40.1 million tons yr^{-1} affecting the area of > 500,000 km^2. About 50% of the suspended PM10 are submicron particles. Icelandic dust is of volcanic origin; it is very dark in colour and contains sharp-tipped shards with bubbles. Such properties allow even large particles to be easily transported long distances as revealed on the satellite MODIS images with dust plumes traveling over 1000 km at times. There is a need to understand better the vertical distribution of such aerosols as well as their residence time in the atmosphere, especially during occasions such as polar vortex.
Four LOAC flights were performed under meteorological balloons during the Iceland Polar Vortex 2016 campaign in January 9-13 2016 when stratospheric polar vortex occurred above Iceland. LOAC is an optical aerosol counter that uses a new optical design to retrieve the size concentrations in 19 size classes between 0.2 and 100 µm, and to provide an estimate of the main nature of aerosols. Vertical profile of aerosol size distribution showed the presence of volcanic dust particles up to altitudes of 8 km for two of the flights (9-10 January). The MODIS satellite images confirmed a dust plume present above the southern coast from the deposits of September 2015 glacial outburst flood (jökulhlaup) while the rest of the country was covered by snow. These deposits had been actively suspended in November and December 2015. The ground PM10 mass concentration measurements in Reykjavik showed elevated PM measurements over 100 µg m^{-3}, confirming the particle presence 250 km far from the source.
The number concentration exceeded 200 particles cm-3 at altitude of 1 km and 60 particles cm-3 at altitude of 5 km, which is at least 5 times higher than during background conditions. The particles were <3 µm in size at >1 km altitude while largest particles, up to 20 mm, were detected

close to the ground. Such high number concentrations in several km height were captured by LOAC only during Saharan dust plume with larger particles (around 5 µm). Our results show that fine volcanic glacially reworked dust can reach high altitudes relatively close to the dust source and reside in terms of days under the stratospheric polar vortex conditions. The remaining question is the further transport of these high altitude particles outside Iceland.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 41
Abstract code

Impact of Icelandic volcanic dust on cryosphere

Author - Dagsson Waldhauserova, Pavla, University of Iceland and Agricultural University of Iceland, Reykjavik, Iceland (Presenting author)
Co-author(s) - Meinander, Outi , Finnish Meteorological Institute , Helsinki , Finland
Co-author(s) - Gritsevich, Maria , Finnish Geospatial Institute , Helsinki , Finland
Co-author(s) - Peltoniemi, Jouni , Finnish Geospatial Institute , Helsinki , Finland
Co-author(s) - Arnalds, Olafur , Agricultural University of Iceland , Reykjavik , Iceland
Co-author(s) - Olafsson, Haraldur , University of Iceland , Reykjavik , Iceland
Topic Cryosphere and mountain hydrology
Keywords light absorbing impurities, glaciers

Iceland is extremely active dust region and with over 44,000 km^2 counts as the largest Arctic and European desert. Frequent dust events, up to 135 dust days annually, transport dust particles far distances towards the Arctic and Europe. Satellite MODIS pictures have revealed dust plumes exceeding 1,000 km. The annual dust deposition was calculated as 40.1 million tons yr^{-1}, which places Iceland among the most active dust sources on Earth. About 5.5 - 13.8 million tons is deposited annually over the oceans around Iceland covering wide areas of 370,000 km^2.
Despite the location of Iceland in the high-latitude cold region, half of the annual dust events in the southern part of Iceland took place at sub-zero temperatures or in winter, when dust may be mixed with snow. We observed a “Snow-Dust Storm” in March 2013 when dust was transported over 250 km and consequently was deposited on snow in Reykjavik. The snow was nearly black with several mm volcanic dust layer close to the dust source, while a clumping mechanism was found in thin layer of impurities in Reykjavik. This has been the first observation of such mechanism in natural conditions.
Icelandic dust consists of fine reactive volcanic materials. It is dark in color and it contains sharp-tipped shards, often with bubbles. About 75-80 % of the material is a volcanic glass. However, extreme dust storms in Iceland transport also large proportion of organic material or diatoms. We conducted several experiments during winter campaigns investigating changes in albedo, bidirectional reflectance factor and other snow properties monitored on the clean snow and areas affected by the dust deposition through the following melting period. These experiments also included black carbon (BC) observations revealing that volcanic dust has similar effects on snow albedo as BC. Icelandic volcanic dust tends to act as a positive climate forcing agent, both directly and indirectly, which is different than concluded for crustal dust in the 2013 IPCC report. This suggests that the Icelandic dust may be a contributor to the Arctic warming.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information

Abstract nr. 42
Abstract code
Extreme temperatures in the cold air pool of the central Apennines (Italy): comparison with those of the Veneto Pre-Alps during winter 2016-17

Author - Fazzini, Massimiliano, University of Camerino, Camerino, Italy (Presenting author)
Co-author(s) - Cardillo, Antonio , Regione Molise - Civil protection service , Campobasso , Italy
Co-author(s) - Di Fiore, Thomas , Associazione meteorologica Caput Frigoris , L'Aquila , Italy
Co-author(s) - Lucentini, Luca , Associazione meteorologica Caput Frigoris , L'Aquila , Italy
Co-author(s) - Scozzzafava, Marco , Associazione meteorologica Caput Frigoris , L'Aquila , Italy
Topic Other
Keywords Cold air pool, apennine, snowmaking, pre-alps

Despite Mediterranean latitude, the Italian peninsula shows geomorphological situations that determine the presence of cold air pool, where are observed extreme and mean minimum temperatures comparable to those of the cold poles of the pre-alps and even of Central Europe. In the Central Apennines and in particular in the Abruzzo and Molise region- at latitudes N between 41°30 'and 42°15', plateau tectonic - karst are present, at altitudes between 1200 and 1500 meters (less than 500 meters in the case of the Boiano valley) which, in recent years, are densely monitored by official and amateur meteorological monitoring networks, that still adhere perfectly to the WMO standard. The coldest areas are found in the "Pezza", “Campo Felice” and "Cinquemiglia” plateau on Abrusses Apennine and in the Campitello Matese and Boiano plateau in the Molise Apennine. It is almost completely disabled areas but which are wery popular for the practice of winter sports, being situated a short distance from cities such as Rome and Naples. In the presence of specific synoptic situations, characterized by advection of continental polar air - especially if amplified by an extended snowmaking - is possible to reach several times, during every winter, absolute minimum values lower than -25 ° C and exceptionally lower than -35 ° C - with an absolute minimum of -37.4 ° C at Piani di Pezza, the morning of February 15, 2012. Already during a polar pulse that has reached Central Italy in August 2016, they were observed repeated night frost; meteo - climatic the analysis performed on data from several monitoring stations for winter 2016-17 and comparison with the thermal values recorded in the highlands karst of the Venetian Pre-Alps confirmed the peculiarities at the local scale of these Apennine sites.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 43
Abstract code

An adiabatic Foehn effect

Author - Damiens, Florentin, Ecole Normale Superieure, Paris, France (Presenting author)
Co-author(s) - Lott, François , Ecole Normale Superieure , Paris , France
Co-author(s) - Millet, Christophe , CEA , Arpajon , France
Co-author(s) - Plougonven, Riwal , Ecole Polytechnique , Palaiseau , France
Topic Downslope windstorms, mountain waves and rotors
Keywords Foehn; Downslope windstorms; Mountain waves;

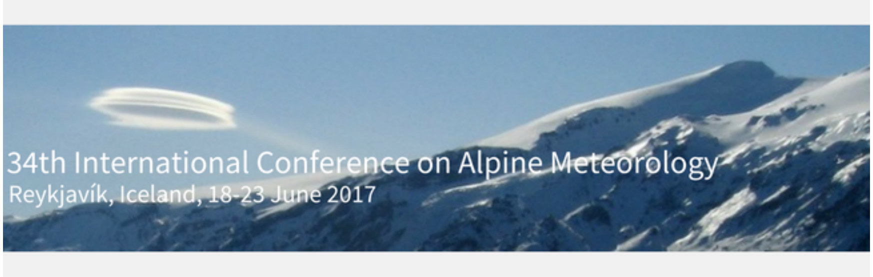
Mountain waves produced by incident winds that are null at the surface are evaluated with models of increasing complexity. All models confirm that downslope windstorms and Foehn (i) can be a direct consequence of the presence of a critical level located just below the surface, (ii) are stronger when the surface flow is more stable (e.g. when the surface Richardson number J increases) and (iii) are not necessarily produced by upper level wave breaking or internal reflections, as often suggest popular theories.

The first model used in this study is a theoretical model which combines linear gravity wave dynamics with a nonlinear boundary condition (Lott, 2016). In this model the wave breaking does not feedback onto the dynamics by construction. Partial linear waves reflections can also be minimized by using smooth profiles of the incident wind and uniform stratification $N2$, and even suppressed in the case of constant wind shears Uz. The second model used in this study is WRF, and we show that it predicts mountain wave-field that can be reproduced by the theoretical model, providing that we specify adequate boundary layer depth in the theory.

The dependence of the onset of downslope windstorms onto the parameter Jrather than on a dimensionless mountain height is also explained. In the presence of shear, the local vertical gravity wave wavelength at the mountain top Hscales like UzH/N. It is smaller than the mountain height when $Uz/N<1$ (e.g. when $J=N2/Uz2>1$).

Lott, F., 2016: A New Theory for Downslope Windstorms and Trapped Mountain Waves.*J. Atmos. Sci.,*73, 3585–3597, doi: 10.1175/JAS-D-15-0342.1.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 44
Abstract code
Characteristics of the spectral gap in a valley convective boundary layer

Author - Babic, Nevio, University of Virginia, Charlottesville, United States of America (Presenting author)
Co-author(s) - Vecenaj, Zeljko , Faculty of Science, University of Zagreb , Zagreb , Croatia
Co-author(s) - De Wekker, Stephan , University of Virginia , Charlottesville , United States of America
Topic Boundary layers and turbulence in complex terrain
Keywords CBL, spectral gap, upslope flow

The notion of decomposing time series of winds and scalars into a mean and a fluctuating component, historically known as Reynolds decomposition, is essential for the determination of the turbulent fluxes in the atmospheric boundary layer. Proper estimates of these fluxes are crucial for a number of applications, including calculating the annual budget of the net ecosystem exchange or the development of new turbulence closure parameterizations for numerical weather prediction. Assuming that the turbulent, microscale motions of interest are separated from macroscale motions by a spectral gap, one can readily apply Reynolds decomposition. Several studies have reported a range of scales that fall into such a spectral gap, especially for flat terrain. However, spatial and temporal information of the spectral gap scales are still lacking, especially over complex terrain. Micro- and mesoscale flows in complex terrain, such as valley and slope flows, may degrade the presence of a spectral gap and/or shift it to scales that are different than those over flat terrain. Thus, more information is needed about the variability of gap scales over complex terrain.
The main dataset we analyze is comprised of measurements obtained during the Terrain-Induced Rotor Experiment, conducted in the spring 2006 in Owens Valley, CA. Specifically, we analyze time series of winds obtained on 16 weather stations spread out across the valley, as well as sonic anemometer measurements of winds and temperature at two locations. To these we apply two methods to determine the climatology of gap scales, including the fast Fourier transform and multiresolution flux decomposition. We also focus on several phenomena typical for complex terrain, such as rotors and upslope flows, with the goal of determining if and how gap scales react to their occurence.
Our results indicate that the typical range of gap scales is between 17 and 29 min, with substantial cross-valley variability and along-valley homogeneity. At the high-frequency end of the spectral gap, rotors and the deepening of the convective boundary layer are found to be the main gap scale drivers. This work has also gained insight into the low-frequency end of the gap, where the valley-slope flow system was found to be the dominant phenomenon. Here, the dominant mode of upslope flow variability, ranging from 80 to 200 min, was both observed and modelled using a simple periodicity model.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 45
Abstract code
Isotope Fractionation and Orographic Precipitation over New Zealand

Author - Smith, Ron, Yale University, New Haven, United States of America (Presenting author)
Co-author(s) - Nugent, Alison , Univ. Hawaii , Honolulu , United States of America
Co-author(s) - Kruse, Christopher , Yale University , New Haven , United States of America
Co-author(s) - Watson, Campbell , IBM , Yorktown Heights , United States of America
Co-author(s) - Garreaud, Rene , Univ. Chile , Santiago , Chile
Co-author(s) - Revell, Mike , NIWA , Wellingtoin , New Zealand
Topic Orographic precipitation
Keywords

The Southern Alps of New Zealand is one of the best defined and best studied regions for orographic enhancement of mid-latitude cyclone precipitation. Due to the frequent occurrence of moist NWly airstreams, the west coast “Westland” receives nearly ten times the annual precipitation of the eastern “Canterbury Plains” . The SALPEX program in the 1990’s advanced our understanding and the DEEPWAVE project in 2014 added some aircraft, radar and sounding data. High resolution convection-permitting models WRF and NZCSM are now run in forecast and research mode over NZ.

In this study, an unconventional “isotope” approach is used. Stream water samples from four transects across the Southern Alps were analyzed for deuterium and 18-O ratios giving estimates of the Drying Ratio from DR=30 to 50%. This rather large DR value will be compared with other lines of evidence such as rain gauges and convection-permitting mesoscale models. Several issues will be examined to explain any discrepancy. First, the weighting of heavy rain events in the isotope signal is included. Second, a linear model is used to estimate the cloud time delay between ascent and precipitation. Third, the role of convection and the seeder-feeder process will be analysed.

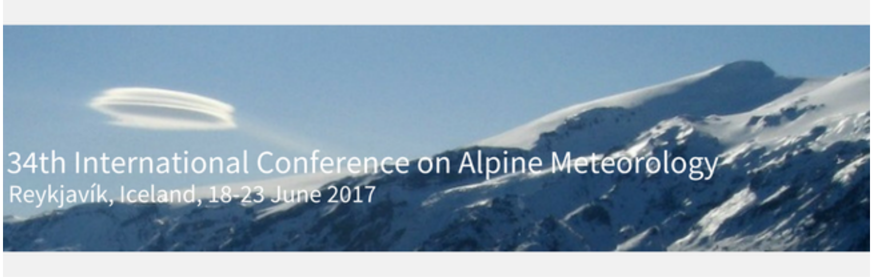
Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 46
Abstract code
Gravity waves generated at small Rossby number by large amplitude topography

Author - Muraki, David, Simon Fraser University, Burnaby, BC, Canada (Presenting author)
Co-author(s) - Klemp, J , National Center for Atmospheric Research , Boulder, CO , USA
Topic Downslope windstorms, mountain waves and rotors
Keywords

Our theoretical understanding for the nonlinear aspects of topographic waves owes much to the 1953 theory of Long, but does not include the effects of Coriolis rotation. A rotating analog of Long's theory is presented that illustrates the effects of nonlinearity, beyond the familiar 1948 linear results of Queney, to near-overturning flows. These steady 2D solutions give insight into how short waves are introduced into small Rossby number, geostrophic flow by large-scale topography. This work is in collaboration with J. Klemp at the National Center for Atmospheric Research (NCAR-MMM).

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 48
Abstract code

Intense snowfalls of January 2017 along the central-southern Apennines (Italy), in comparisons with the 2015, 2012 and 205 events.

Author - Bisci, Carlo, University of Camerino, Camerino, Italy
Co-author(s) - Fazzini, Massimiliano , University of Camerino , Camerino , Italy (Presenting author)
Co-author(s) - Romeo, Vincenzo , Forestal Guards of Carabinieri , Roma , Italy
Co-author(s) - Cardillo, Antonio , Molise Regional Govenment , Campobasso , Italy
Topic Other
Keywords Central Italy; exceptional snowlalls; avalanches

During the first two decades of 2017, along the central-southern Apennines (Italy) very intense end abundant snowfalls took place, confirming once more the trend toward extreme meteorological phenomena of the Mediterranean basin.
After a mild and almost dry beginning of winter, starting from January 4th the Azores anticyclone expands itself with the main axis toward northern Europe. Contemporaneously, a dynamic depression centered on Poland started to expand and deepen; intensively attracting polar air currents that start to take a cyclonic curvature. In the meanwhile, however, the polar vortex progressively became bilobed, creating ideal conditions for its freezing air to flow more than once in the Mediterranean area.
As a consequence, in Italy extremely cold nuclei affected twice both the Adriatic and Jonian regions: first between January 5th and 11th and a second time between January 16th and 20th. During the former advection, pressure maxima at the ground level were observed over the Scandinavian peninsula while the depression followed a retrograde motion to reach southern Italy. The subsequent advection assumed polar continental characteristics: weather become unstable, with snowfalls that in January 6th and 7th affected coastal areas too, from the Marche to the Lucania Regions, and temperatures marking the lowest record of the last thirty years. Snowfalls were particularly abundant on the Molise and Apulia reliefs: up to one meter in the Murge highlands, were they were really exceptional.
After a temporary expansion to the East of the Azores high pressure, starting from the 14th Arctic high pressure started again to deepen toward the Mediterranean somehow responding to the rise of the above said anticyclone toward Scandinavia. “Intermediate” polar air, slightly less cold but more humid of that of a few days before, reaches the central Mediterranean, where a depression is generated over the northern Tyrrhenian Sea. This resulted in very intense precipitations lasting from the morning of January 16th to the whole 20th. The above snowfalls were particularly intense in the hilly and mountain areas between central Marche and southern Abruzzi, where locally they exceeded the exceptional ones recorded in 2015 and 2012. They also contributed to the activation of many snow avalanches, among which that of Rigopiano resulting in 29 casualties.

Using the data provided by the Meteomont service managed by the Forestal Guards of the Carabinieri and by local meteorological services it was possible to evaluate with a fair approximation the outcome of the above meteorological phenomena and to compare them with those referring to the most intense snowfalls of the last decade in the same area.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 49
Abstract code
The impact of upstream flow on the boundary layer in a valley – observations and high-resolution simulations

Author - Adler, Bianca, Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen, Germany (Presenting author)
Co-author(s) - Kalthoff, Norbert , Karlsruhe Institute of Technology (KIT) , Eggenstein-Leopoldshafen , Germany
Co-author(s) - Bischoff-Gauß, Inge , Karlsruhe Institute of Technology (KIT) , Eggenstein-Leopoldshafen , Germany
Topic Downslope windstorms, mountain waves and rotors
Keywords

Comprehensive measurements on the mountainous island of Corsica were used to investigate how the mountain atmospheric boundary layer (mountain ABL) in a valley downstream of the main mountain ridge was influenced by the upstream flow. The data used were mainly collected during the Hydrological cycle in the Mediterranean Experiment (HyMeX) in 2012 and were based on various in situ, remote sensing and aircraft measurements. Two days in autumn 2012 were analysed in detail.
On these days the mountain ABL evolution was a result of convection and thermally-driven circulations as well as terrain-induced dynamically-driven flows. The observations indicate that during periods when dynamically-driven flows were dominant, warm and dry air from aloft with a large-scale westerly wind component was transported downwards into the valley. On one day, these flows controlled the mountain ABL characteristics for several hours, while on the other day their impact was observed for about 1 h only. To help explaining the observed phenomena, Consortium for small scale modelling (COSMO) simulations with 500 m grid-spacing were performed. Observations and simulations show that the spatio-temporal structure of such a mountain ABL over complex terrain, which was affected by various interacting flows on multiple scales, differs a lot from that of the classical ABL over homogeneous, flat terrain.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

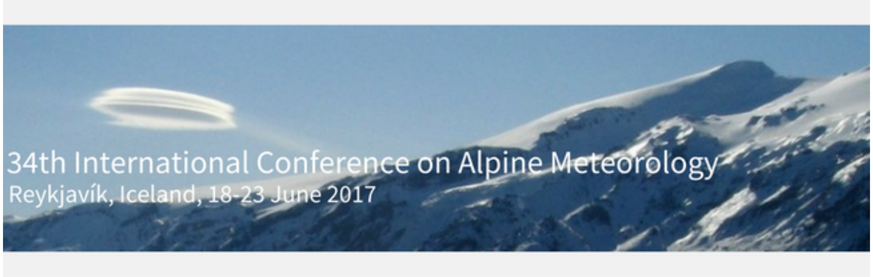
Abstract nr. 50
Abstract code

Exchange processes in the boundary layer over a mountainous island – observations and high-resolution simulations

Author - Kalthoff, Norbert, Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen, Germany (Presenting author)
Co-author(s) - Adler, Bianca , Karlsruhe Institute of Technology (KIT) , Eggenstein-Leopoldshafen , Germany
Co-author(s) - Bischoff-Gauß, Inge , Karlsruhe Institute of Technology (KIT) , Eggenstein-Leopoldshafen , Germany
Topic Boundary layers and turbulence in complex terrain
Keywords

Comprehensive in situ and remote sensing measurements were performed on the mountainous island of Corsica during the HYdrological cycle in Mediterranean EXperiment (HyMeX) field campaign in late summer and autumn 2012 to investigate the evolution of the mountain atmospheric boundary layer (mountain ABL) in a valley under fair weather conditions.
The observations show that convection, thermally-driven circulations and topographic and advective venting determine the diurnal cycle of temperature, humidity and wind over complex terrain in the mountain ABL. The mountain ABL was found to be deeper than an ABL over homogeneous flat terrain under equal surface forcing. The observations also indicate that combined transport processes on different scales result in vertical exchange processes in a valley which extend those found in a surface-based, buoyancy-driven convection layer over flat terrain.
High-resolution (100 m grid spacing) simulations with the Consortium for small scale modelling (COSMO) were conducted (i) to investigate whether the model was able to reproduce the observed ABL characteristics and (ii) to verify the hypothesized underlying processes deduced from the observations. Both, observations and simulations will be presented.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 51
Abstract code

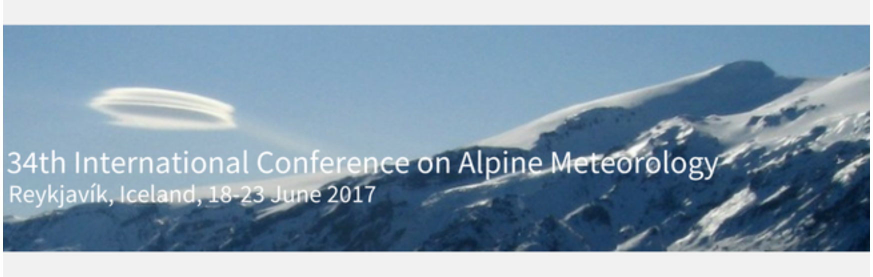
Measurements and probabilistic forecasting of ice formation on wind turbines at a hilltop site in Germany

Author - Serafin, University of Vienna, Department of Meteorology and Geophysics, Vienna, Austria (Presenting author)
Co-author(s) - Strauss, Lukas , University of Vienna, Department of Meteorology and Geophysics , Vienna , Austria
Co-author(s) - Dorninger, Manfred , University of Vienna, Department of Meteorology and Geophysics , Vienna , Austria
Co-author(s) - Beck, Alexander , Zentralanstalt für Meteorologie und Geodynamik (ZAMG) , Vienna , Austria
Co-author(s) - Wittmann, Christoph , Zentralanstalt für Meteorologie und Geodynamik (ZAMG) , Vienna , Austria
Co-author(s) - Bourgeois, Saskia , Meteotest , Bern , Switzerland
Co-author(s) - Cattin, René , Meteotest , Bern , Switzerland
Co-author(s) - Burchhart, Thomas , VERBUND Hydro Power , Vienna , Austria
Co-author(s) - Fink, Martin , VERBUND Hydro Power , Vienna , Austria
Topic Weather forecasting for mountainous regions
Keywords

The formation of ice on wind turbines is a major limiting factor for the operation of wind farms during winter time. Icing alters the aerodynamic behaviour of turbine blades, reduces the energy yield and may cause dangerous ice shedding. It can lead to unplanned downtimes, implying increased balancing costs and severe economic losses to power companies. Forecasts of wind power production loss caused by icing can be obtained from a chain of physical models, consisting of a global and a limited-area numerical weather prediction model, an icing model and a production loss model. Each element of the model chain is affected by significant uncertainty, which can be quantified using a probabilistic forecasting approach. Forecast skill can be evalated using targeted observations. In this contribution, we present preliminary results from the recently launched project ICE CONTROL, an Austrian research initiative on the measurement, probabilistic forecasting, and forecast verification of ice formation on wind turbine blades. ICE CONTROL includes an experimental field phase with measurement campaigns in a wind park in Rhineland-Palatinate, Germany, in the winters 2016/17 and 2017/18. The wind park is located on top of a hill range (Hunsrück) with a prominence of about 300 m over the surroundings. The instrumentation deployed during the campaigns consists of a conventional icing detector on the turbine hub and newly devised ice sensors on the turbine blades, as well as sensors for wind, temperature, humidity, visibility, and precipitation type and spectra. In addition, three cameras document the icing conditions on the instruments and on the blades. Different aspects of icing forecast

uncertainty are considered. The uncertainty related to the initial conditions of the weather prediction is evaluated using the existing global ensemble prediction system of the European Centre for Medium-Range Weather Forecasts. Furthermore, observation system experiments are conducted with the AROME model and its 3D-Var data assimilation to investigate the impact of additional observations (such as Mode-S aircraft data, SCADA data and MSG cloud mask initialization) on the icing forecast. The uncertainty related to limited-area model formulation is estimated from a multi-physics and perturbed-physics ensemble based on the Weather Research and Forecasting model. Uncertainties in the icing model and in its adaptation to the rotating turbine blade are also addressed.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 52
Abstract code

Mountain wave events and associated rotors over the Pyrenees during The Cerdanya-2017 field experiment: observations and model simulations

Author - Udina, University of Barcelona, Barcelona, Spain (Presenting author)
Co-author(s) - Soler , University of Barcelona , Barcelona , Spain
Co-author(s) - Bech , University of Barcelona , Barcelona , Spain
Co-author(s) - Miró , Servei Meteorològic de Catalunya , Barcelona , Spain
Co-author(s) - Mercader , Servei Meteorològic de Catalunya , Barcelona , Spain
Co-author(s) - Bravo , Servei Meteorològic de Catalunya , Barcelona , Spain
Co-author(s) - Paci , CNRM, UMR3589 METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Dumas , CNRM, UMR3589 METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Sabatier , CNRM, UMR3589 METEO-FRANCE & CNRS , Toulouse , France
Topic Downslope windstorms, mountain waves and rotors
Keywords Cerdanya valley; mountain waves; rotors; numerical

Mountain waves are topographically generated gravity waves or buoyancy oscillations produced when a stably stratified flow crosses an obstacle, such as a mountain range. They transport momentum and energy farther downstream and/or up in the vertical and several turbulent phenomena may be developed in the lee side of the topographic barrier.
In this study we analyze episodes of gravity waves (GWs) generated at the lee side of the Pyrenees when northern flows cross this mountain barrier, that is oriented from west to east. We use datasets provided by several instrumentation deployed during The Cerdanya-2017 field experiment: an Ultra High Frequency wind profiler, radiosoundings, a radiometer, a lidar, a windrass, an eddy covariance station, a ceilometer and several automatic weather stations, among others. Using the WRF model, numerical simulations are run in order to understand the mesoscale dynamics of the episodes and to validate the model, comparing the results against measurements. We explore the structure and evolution of these GWs, their wavelength and amplitude, and their associated valley circulations, with the possible formation of a low-level rotor. Simulations of previous similar events have shown that the rotor generated by the model is intermittent and brief, and it interacts with other flows coming from multiple directions. We will compare the new field measurements and model simulations with these results.

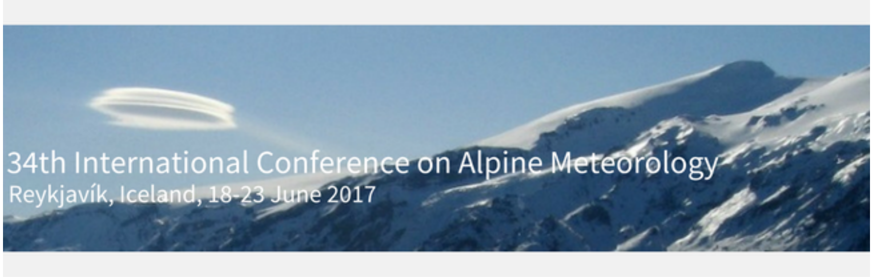
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 53
Abstract code
A simple model for the amplitude of lee waves on the boundary-layer inversion

Author - Sachsperger, MeteoServe Wetterdienst GmbH, Vienna, Austria
Co-author(s) - Serafin , University of Vienna, Department of Meteorology and Geophysics , Vienna , Austria (Presenting author)
Co-author(s) - Grubišic , Earth Observing Laboratory, National Center for Atmospheric Research , Boulder Co , USA
Co-author(s) - Stiperski , Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck , Innsbruck , Austria
Co-author(s) - Paci , CNRM, METEO-FRANCE and CNRS (UMR 3589) , Toulouse , France
Topic Downslope windstorms, mountain waves and rotors
Keywords

An analytical model for the amplitude of lee waves on the boundary-layer inversion in two-dimensional flow is presented. Previous linear lee wave models, in which the amplitude depends on the power spectrum of topography, can be inaccurate if the wave amplitude is large. Our model incorporates nonlinear effects by assuming that lee waves originate at a region of transition between super- and subcritical flow (internal jump) downstream of topography. Energy flux convergence at this location is compensated by the radiation of laminar lee waves. The available energy is estimated using a hydraulic jump model and the resulting wave amplitude is determined from linear theory. According to the new model, the amplitude of lee waves depends essentially on their wavelength and on the inversion height difference across the jump. Amplitude estimates from the model generally agree very well with two-dimensional numerical simulations. The conditions under which the wave amplitude exceeds the limits of linear theory are explained. The regime transition from lee waves (linear behaviour) to hydraulic jumps (nonlinear behaviour) is described by combining the Froude number and the non-dimensional mountain and inversion heights in a single nonlinearity parameter. A comparison between model predictions and the results of experiments in a stratified water tank is also presented.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 54
Abstract code

Downslope windstorms, mountain waves, orographic precipitation and associated processes analysis during 10-17 January 2017 in The Cerdanya-2017 field experiment

Author - Udina, University of Barcelona, Barcelona, Spain (Presenting author)
Co-author(s) - Trapero , Andorran Research Institut (IEA-CENMA) , Sant Julià De Lòria , Andorra
Co-author(s) - Soler , University of Barcelona , Barcelona , Spain
Co-author(s) - Bech , University of Barcelona , Barcelona , Spain
Co-author(s) - Miró , Servei Meteorològic de Catalunya , Barcelona , Spain
Co-author(s) - Paci , CNRM, UMR3589 METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Ferreres , Universitat Politècnica de Catalunya , Manresa , Spain
Topic Results from major field campaigns
Keywords Cerdanya valley; mountain waves; downslope windsto

In the framework of the GWOP’17 (Gravity Waves and Orographic Precipitation) project, we use measurements from The Cerdanya-2017 field campaign to analyze episodes of mountain waves, orographic precipitation and their associated processes over the Pyrenees. The Pyrenees is a west to east oriented mountain range located along the border between France and Spain. In its oriental part, between Occitaine and Catalunya, The Cerdanya valley sits around 1000 m above sea level (a.s.l.) with surrounding peaks that reach above 2900 m a.s.l. The instrumentation deployed during The Cerdanya-2017 field experiment includes: an Ultra High Frequency wind profiler located at the foot of a lee slope and several instruments located at the center of the valley: a radiometer, a lidar, a windrass, a microwave rain radar, a disdrometer, an eddy covariance station and a ceilometer, among others. Some radiosoundings were launched during intensive observation periods and several automatic weather stations were deployed along the valley.
In this study we will present the preliminary results obtained during a selected severe weather period from 10th to 17th January 2017, mainly dominated by northern strong winds and some precipitation events, and we have analyzed the data from the observational network. In the 8-day analyzed period we identify different episodes including: downslope windstorms and possible hydraulic jumps, mountain wave generation with associated rotors near the surface, and heavy precipitation events with large amounts of snow accumulation. In addition, we explore the interaction and connection between these phenomena.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 55
Abstract code

LANFEX: Understanding fog behaviour in a region of small hills.

Author - Price, Jeremy, Met Office, Shortstown, United Kingdom (Presenting author)
Co-author(s) - Lane, Sian , Met Office , Shortstown , United Kingdom
Co-author(s) - Boutle, Ian , Met Office , Exeter , United Kingdom
Topic Boundary layers and turbulence in complex terrain
Keywords Fog; cold pools; field campaign

The LANFEX (Local And Non-local Fog EXperiment) campaign is an attempt to improve our understanding of radiation fog formation through a combined field and numerical study. The field trial was deployed in the UK for 18 months using an extensive range of surface based equipment, including some novel measurements (e.g. dew measurement and thermal imaging). In a region of hills we instrumented flux towers in four adjacent valleys to observe the evolution of similar, but crucially different meteorological conditions at the different sites, and correlated these with the formation and evolution of fog which formed within the valley cold pools. The results presented show certain locations are more prone to fog, as expected, but that the overriding condition for in situ fog formation within the cold pool is that turbulence must remain be below a certain threshold. The presence of orography does not appear to affect the value of this threshold. Once fog formed locally it was sometimes seen to advect within the valley systems, and at some sites the occurrence of fog was due to advection as much as insitu development.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 56
Abstract code
High resolution modelling of fog formation in complex terrain

Author - Boutle, Ian, Met Office, Exeter, United Kingdom
Co-author(s) - Price, Jeremy , Met Office , Exeter , United Kingdom (Presenting author)
Topic Boundary layers and turbulence in complex terrain
Keywords

We present results from high-resolution simulations with the Met Office Unified Model (UM) of fog evolution in the complex valley systems of Shropshire, measured as part of the Local and Non-Local Fog Experiment (LANFEX). Simulations at a range of horizontal resolutions, down to 100m, are presented to show how the fog evolution is closely tied to terrain induced flows (such as valley cooling), and the extent to which the UM is able to simulate this. It is shown that whilst horizontal resolution is clearly important in the representation of flows in narrow valleys, vertical resolution is equally important in the simulation of the near-surface drainage flows and cooling which leads to fog formation. We also show how model parametrizations, such as that of subgrid turbulence, can have large affects on the evolution of fog and its location within the valley system.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 57
Abstract code

Introduction to ice-pop 2018(international collaborative experiments for pyeongchang olympic and paralympic games 2018)

Author - Ahn, KwangDeuk, Korea Meteorological Administration, Seoul, Korea (Rep) (Presenting author)
Co-author(s) - Sangwon, Joo , Korea Meteorological Administration , Seoul , Korea (Rep)
Co-author(s) - Dong kyou, Lee , Korea Meteorological Administration , Seoul , Korea (Rep)
Topic Other
Keywords fields campaign

The 23rd Olympic Winter and the 13th Paralympic Winter Games will be held in Pyeong-Chang, Korea, February 9-25 / March 9-18, 2018. It is a great opportunity to improve our understanding of local scale and severe weather over mountainous terrain and the capability of high-resolution (convective scale) numerical weather prediction at the time of winter games. KMA (Korea Meteorological Administration) and NMC (Numerical Modelling Center) have a responsibility to provide weather information for the management of games and the safety of the public and launch the ICE-POP 2018(International Collaborative Experiments for Pyeonchang Olympic and Paralympic games 2018) for RDP/FDP in 2015. Goals of PC-2018 FDP/RDP is to demonstration of a nowcasting and very short-range forecasting system to support the winter Olympic Games and to improve our understanding on severe weather (orographic precipitation and snow, visibility, rapid wind change and gusts, snow falls caused by mountain and coastal effect) over mountainous terrain. In this presentation, the current progress of the ICE-POP will be presented including the intensive observation experiments held from January to February 2017, and support of test event games. The preliminary results of first observation group meeting in ICE-POP 2018 and observation network for international intensive observation experiment will be introduced.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 58
Abstract code

Spatial variations in the diurnal cycle of turbulent fluxes in an east-west oriented valley

Author - Lehner, Manuela, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Rotach, Mathias W. , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Sfyri, Eleni , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Stiperski, Ivana , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Obleitner, Friedrich , University of Innsbruck , Innsbruck , Austria
Topic Boundary layers and turbulence in complex terrain
Keywords

Diurnal cycles of turbulent heat and moisture fluxes, as well as of standard meteorological variables, such as temperature and humidity, are strongly influenced by local net radiation under synoptically undisturbed conditions. In complex Alpine topography, they will thus be strongly dependent on the specific location of a given site within the valley and its exposure towards the sun. Additionally, indirect effects such as timing and strength of thermally driven flows will have an influence on those daily cycles.
As part of the i-Box project, which was designed to study the turbulence structure in complex terrain, long-term field measurements are being made at six sites within the approximately east-west oriented Inn Valley, Austria. The measurement sites are located within an approximately 6.5-km long section of the approximately 2-3-km wide valley. One of the sites is located at the almost flat valley floor, one site at a mountain top approximately 1500 m above the valley floor, two sites on the south-facing sidewall, and two sites on the north-facing sidewall.
In this presentation, we will compare the diurnal cycles of turbulent heat, moisture, and momentum fluxes at the six valley sites together with local radiation observations to determine spatial variations in the timing and magnitude of the turbulent fluxes within the valley during synoptically undisturbed conditions. Two of the measurement sites are equipped with sonic anemometers at different levels, which are used to investigate vertical variations and constancy throughout the diurnal cycle.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 59
Abstract code

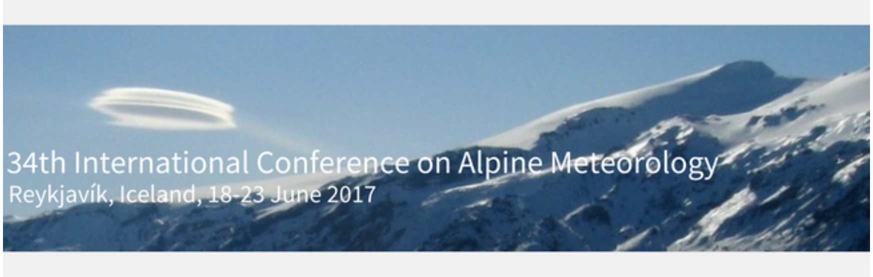
Temperature and wind speed oscillations at Arizona's Meteor Crater

Author - Lehner, Manuela, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Whiteman, C. David , University of Utah , Salt Lake City , USA
Co-author(s) - Hoch, Sebastian W. , University of Utah , Salt Lake City , USA
Topic Boundary layers and turbulence in complex terrain
Keywords

The Meteor Crater basin in northern Arizona is almost circular with a diameter of approximately 1.2 km, a depth of about 170 m, and a crater rim that extends approximately 30-50 m above the surrounding terrain. The crater is located on a large plain that slopes slightly upward toward the southwest so that a southwesterly katabatic flow develops over the plain during quiescent, clear-sky nights, which interacts with the crater basin and its rim. The Second Meteor Crater Experiment (METCRAX II) field campaign took place at the Meteor Crater in October 2013 to study these interactions of the nocturnal katabatic flow with the crater topography.

The typical nocturnal vertical temperature structure in the Meteor Crater is influenced by cold air draining over the southwest crater rim into the basin as a result of the southwesterly katabatic flow over the surrounding plain. The temperature profile consists of a strong and shallow surface-based inversion and a near-isothermal layer that extends almost to the top of the crater. Periodic oscillations in the nocturnal surface temperature and wind fields have been observed within the crater-floor inversion during several nights, with a typical periodicity of about 15--20 min. The phase shift between these oscillations over the southwest sidewall and the opposite northeast sidewall indicates a sloshing of the crater-floor inversion, induced by the cold air draining down the southwest crater sidewall. Oscillations with a similar periodicity have also been observed in the upstream katabatic flow coming over the crater rim. In this presentation, we will look at the origin of these oscillations in the katabatic flow and whether they influence the sloshing frequency of the crater-floor inversion.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 60
Abstract code

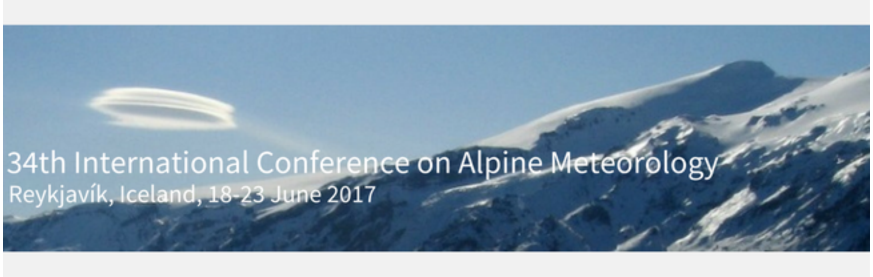
Periodic wind systems in the Dead Sea valley – first comprehensive measurements of their characteristics and evolution

Author - Metzger, Jutta, Karlsruhe Institute of Technology, Karlsruhe, Germany (Presenting author)
Co-author(s) - Corsmeier, Ulrich , Karlsruhe Institute of Technology , Karlsruhe , Germany
Topic Results from major field campaigns
Keywords

The Dead Sea is located at the lowest point of the Jordan Rift valley and its water level is currently at -429 m above mean sea level (amsl). To the West the Judean Mountains (up to 1000 m amsl) and to the East the Moab Mountains (up to 1300 m amsl) confine the north-south oriented valley. Previous studies showed that the valley's atmosphere is often governed by periodic wind systems. However, their analysis was based on ground measurements only and could therefore not resolve the three-dimensional structure and evolution of these wind systems.
Therefore, a field campaign with the mobile observatory KITcube was conducted to study the three dimensional structure of these atmospheric processes in 2014. The combination of several in-situ (e.g. energy balance stations, radiosondes) and remote sensing (e.g. lidar, microwave radiometer, radar) instruments allows temporally and spatially high-resolution measurements in an atmospheric volume of about 10x10x10 km^3.
Based on near surface measurements and lidar data, we identified three typical diurnal wind systems, their evolution, as well as the impact of regional scale conditions on the valley's atmosphere. The three diurnal wind systems are (i) nocturnal northerly along-valley flows, (ii) the Dead Sea lake breeze during the day, and (iii) downslope windstorm-type flows (DWFs) in the evening, with wind velocities of over 10 m s^{-1}. The results show that these DWFs occur at nearly 70 % of the days in summer. They are triggered by temperature differences between the air masses at the crest and the valley, caused by prolonged warming of the air in the valley compared to the air masses upstream. Additionally, cooler maritime air masses are frequently advected upstream by the Mediterranean Sea Breeze supporting the development. They can be further classified according to their duration, height, penetration distance into the valley, and wind velocitiy, into three groups. We conclude that in the morning, afternoon, and night, wind conditions in the valley are mainly decoupled from the regional scale, but that in the evening the upstream processes determine the atmospheric conditions in the valley.

Presentation Preference Oral
Audio/Visual Equipment
Awards

Additional information



Abstract nr. 61
Abstract code

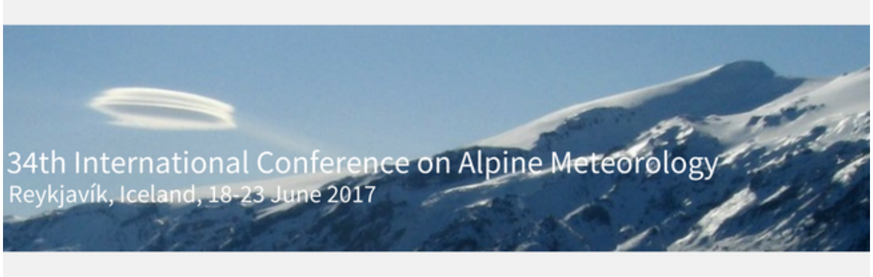
Hydrometeorological reconstruction of snow-influenced streamflow series in France since 1871

Author - Vidal, Jean-Philippe, Irstea, Villeurbanne, France (Presenting author)
Co-author(s) - Caillouet, Laurie , Irstea , Villeurbanne , France
Co-author(s) - Sauquet, Eric , Irstea , Villeurbanne , France
Co-author(s) - Graff, Benjamin , Compagnie Nationale du Rhône (CNR) , Lyon , France
Co-author(s) - Gouttevin, Isabelle , Irstea , Villeurbanne , France
Co-author(s) - Thirel, Guillaume , Irstea , Antony , France
Co-author(s) - Devers, Alexandre , Irstea , Villeurbanne , France
Topic Cryosphere and mountain hydrology
Keywords

The length of streamflow records is generally limited to the last 50 years, and therefore prevents studying the long-term evolution of streamflow regimes. In order to overcome this limit, this work takes advantage of a 140-year ensemble hydrometeorological dataset over France based on: (i) a 8 km daily ensemble precipitation and temperature downscaling of the global Twentieth Century Reanalysis over France (Caillouet *et al.*, 2016a), and (ii) a continuous hydrological modelling that uses these meteorological reconstructions as forcings (Caillouet *et al.*, 2016b). The resulting dataset, called *SCOPE Hydro*, provides an ensemble of 25 equally plausible daily streamflow – and hydrological state variable – time series for a reference network of more than 600 stations in France over the 1871-2012 period.
A subset of 184 catchments located in French mountain ranges (Alps, Pyrenees, Massif Central, Jura and Vosges) is specifically targeted here. This work aims at studying the long-term evolution of streamflow in mountainous catchments where the regime is largely influenced by snow accumulation and snowmelt processes. Results show a high interannual variability of the seasonal snowpack and the associated snowmelt, in terms of both intensity and timing. Spatial patterns also emerge across the different mountain ranges for specific years. This variability is modulated by a relatively large multidecadal variability highlighting periods with a large (1910s) or small (1950s) snowmelt component of streamflow. Results also highlight the reduced snowmelt component in the post-1980 period compared to the 150-year average. The *SCOPE Hydro* dataset thus allows putting into a historical perspective observations from the last few decades that show a declining trend in snowpack and an advanced snowmelt season.
References
Caillouet, L., Vidal, J.-P., Sauquet, E. & Graff, B. (2016a) Probabilistic precipitation and temperature downscaling of the Twentieth Century Reanalysis over France. *Climate of the Past*, 12(3), 635-662. doi: 10.5194/cp-12-635-2016
Caillouet, L., Vidal, J.-P., Sauquet, E., Devers, A. & Graff, B. (2016b) Ensemble reconstruction of spatio-temporal extreme low-flow events in France since 1871. *Hydrology and Earth System*

Sciences Discussions, in review. doi: 10.5194/hess-2016-405

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 62
Abstract code

Long-range transport to summits north, south and at the Eastern Alpine divide – an outstanding Sahara dust event

Author - Baumann-Stanzer, Kathrin, ZAMG, Vienna, Austria (Presenting author)
Co-author(s) - Flandorfer, Claudia , ZAMG , Vienna , Austria
Co-author(s) - Lotteraner, Christoph , ZAMG , Vienna , Austria
Co-author(s) - Piringer, Martin , ZAMG , Vienna , Austria
Co-author(s) - Greilinger, Marion , ZAMG , Vienna , Austria
Co-author(s) - Kasper-Giebl, Anneliese , Technical University of Vienna , Vienna , Austria
Co-author(s) - Schauer, Gerhard , ZAMG , Vienna , Austria
Topic Results from major field campaigns
Keywords mountain stations; flow modelling

Introduction
Long range transport of mineral dust e.g. from the Sahara desert or of volcanic ash, plumes of forest fires or transport of anthropogenic pollution to the Alpine ridge may influence the Alpine ecological system (e.g. via changes of the radiation budget or the nutrient input) and is relevant in the context of air quality. Background stations at remote sites are an essential part of air quality networks to differentiate between the impact of local or regional emissions and long-range transport and to quantify contributions of the latter. Aerosols, especially light absorbing particles, furthermore may influence the snow albedo after being deposited on the snow cover via wet or dry deposition. Finally, aerosols plumes of sufficient density may have a significant impact on direct radiative forcing in the atmosphere.
In an ongoing study, air pollution measurements are operated at three meteorological mountain stations in Austria to investigate the impact of long-range transport to the Eastern Alpine divide as well as to the Alpine Forelands north and south with special focus on outstanding Sahara dust events.
Monitoring network
Atmospheric trace gases, particulate matter and meteorological parameters are continuously observed at the Sonnblick Observatory (3109 m asl). Due to the remote position of this site in high Alpine environment these data allow the monitoring of the background pollution level in the Alpine boundary layer unaffected from local sources as well as in free tropospheric air masses. Manned meteorological stations are operated about 105 km north of Sonnblick, at top of the mountain Feuerkogel (1618 m asl) and about 40 km south of Sonnblick, at top of the mountain Dobratsch (2117m asl). These stations were additionally equipped with monitoring instrumentation for gaseous atmospheric constituents (SO_2, NO_2, ozone) and particle matter (PM10 and PM2.5). This line of mountain top observations across the Eastern Alps is accomplished by ceilometer observations of the aerosol structure within and above near-by valleys. These remote sensing

measurements support the distinction between boundary layer air and free tropospheric air contributing to the pollution observations at the mountain tops.

Modeling

WRF-Chem (Grell, 2005) is the Weather Research and Forecasting (WRF) model coupled with chemistry. The model simulates the emission, transport, mixing, and chemical transformation of trace gases and aerosols simultaneously with the meteorology. The model is used for the investigation of regional-scale air quality, field program analysis, and interactions between clouds and chemistry. In the current study, the meteorological fields are based on ECMWF forecasts run twice daily for 72 hours. The horizontal resolution is 12 km for the area of Europe.

The sensitivity of a receptor (e.g. the average PM10 concentration at the grid cell representing the observatory at Hoher Sonnblick) to a source (in this case the dust emissions from the Saharan desert, a volume source acting during a specified time interval) can be described by the source – receptor relationship (Seibert and Frank, 2004). The calculations are done with the Lagrangian particle model FLEXPART (Stohl et al., 2002) in the backward-running, receptor-oriented mode considering the atmosphere up to 2000 m. In this mode, the particle trajectories are integrated backward in time, using a negative time step. The results are so-called source-receptor sensitivity (SRS) fields which describe both the origin and the concentration of PM10 at the receptor.

Results

The largest dust source region in the world is North Africa. About 10% of the desert dust which is entrained into the free atmosphere is transported towards the Mediterranean Sea and Europe depending on the prevailing large-scale pressure fields and flow patterns (Schepanski et al., 2016). Sahara dust fall on the Alpine ridge is documented by the observations at mountain stations several times of the year (Collaud et al.,2004; De Angelis and Gaudichet, 1991; Sodemann et al., 2006).

At the begin of April 2016, a Saharan dust cloud reached the Eastern Alps, leading to enhanced PM10 concentrations and reduced visibility over several consecutive days. Exemplary results from this outstanding Sahara dust event will be shown in this presentation. Particle matter concentrations significantly increased at the Austrian mountain stations. Webcam pictures reveal large differences in visibility before and during the dust episode in a very impressive way. From visible inspection only one cannot solely determine whether the poor visibility is due to the Saharan dust cloud or to fog. Therefore, ceilometer profiles close to the mountains are considered, as this remote sensing technique discerns cloud droplets from other aerosols.

The respective pronounced Sahara dust event is successfully forecasted with the model WRF-Chem. The dust emissions in the Algerian Sahara desert due to stormy winds and the transport across the Mediterranean Sea to Central Europe are well reproduced in the model simulations. The modelled PM10 concentrations are furthermore in good agreement with the increased values measured at the Austrian air quality stations. Finally, the results of the FLEXPART backward model runs integrated over days as well as loops render insight in the most dominant source regions in a demonstrative way. The temporal evolution of the flow patterns north and south of the Alpine ridge, the boundary layer structure and the corresponding transport phenomena are revealed by the synopsis of the available data and material and discussed in detail.

This case study demonstrates that the combination of the meteorological and air quality monitoring network and modelling and analysis tools renders the optimum basis for the interpretation of exceptional air pollution events as for example caused by long-range transport of Sahara dust to the Alps. This application is of particular relevance as these events can be classified as “natural events” in the official reporting of air quality measurements to the European Union and do not add to the number of PM10 daily mean threshold exceedances.

Acknowledgement

The federal authorities of Austria are thanked for the air quality measurement data from the operational network as well from the mountain stations Dobratsch and Feuerkogel. Stefan Oitzl and Gerhard Heimburger are especially acknowledged for supporting this study. The PM10 measurements at Sonnblick are conducted by the Environment Agency Austria. This study has been funded by the Austrian ministry of Science and Research in the course of a development grant to ZAMG for the year 2016. The investigations concerning the interpretation of ceilometer backscatter profiles and especially the mixing height estimation are significantly stimulated by the EU COST Action ES 1303(TOPROF), dealing with ground-based remote sensing systems and the integration of their data into NWP models.

References

Collaud Coen, M., Weingartner, E., Schaub, D., Hueglin, C., Corrigan, C., Henning, S., Schwikowski, M., and Baltensperger, U. (2004). Saharan Dust Events at the Jungfraujoch: Detection by Wavelength Dependence of the Single Scattering Albedo and First Climatology. Analysis. Atmos. Chem. Phys. 4: 2465–2480. http://www.atmos-chem-phys.net/4/2465/2004/acp-4-2465-2004.pdf

De Angelis, M., Gaudichet, A., 1991. Saharan dust deposition over Mont Blanc (French Alps) during the last 30 years. Tellus (1991), 43B, 61-75. http://www.tellusb.net/index.php/tellusb/article/viewFile/15246/17076

Grell, G.A., Peckham, S.E., Schmitz, R., McKeen, S.A., Frost, G., Skamarock, W.C., Eder, B., 2005. Fully coupled on-line chemistry within the WRF model. Atmos. Environ. 39, 6957-6975.

Schepanski, K., Mallet M., Heinold B., Ulrich, M., 2016. North African dust transport toward the western Mediterranean basin: atmospheric controls on dust source activation and transport pathways during June–July 2013. Atmos. Chem. Phys., 16, 14147–14168. www.atmos-chem-phys.net/16/14147/2016/ doi:10.5194/acp-16-14147-2016

Seibert, P. and Frank, A., 2004. Source-receptor matrix calculation with a Lagrangian particle dispersion model in backward mode. Atmos. Chem. Phys., 4, 51-63, doi:10.5194/acp-4-51-2004 http://www.atmos-chem-phys.net/4/51/2004/.

Sodemann, H., Palmer, A. S., Schwierz, C., Schwikowski, M., Wernli, H., 2006. The transport history of two Saharan dust events archived in an Alpine ice core. Atmos. Chem. Phys., 6, 667–688, 2006 www.atmos-chem-phys.net/6/667/2006/

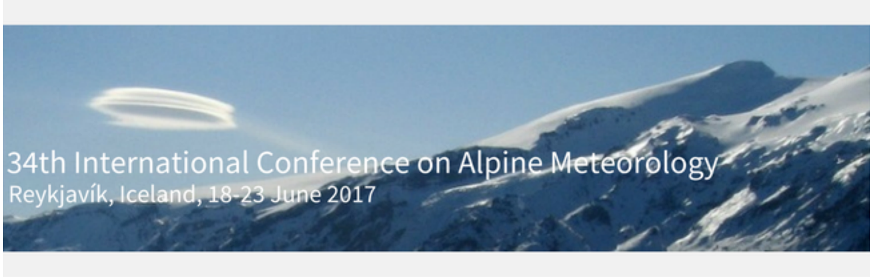
Stohl, A., Eckhardt, S., Forster, C., James, P., Spichtinger, N., Seibert, P., 2002. A replacement for simple back trajectory calculations in the interpretation of atmospheric trace substance measurements. Atmospheric Environment, Volume 36, Issue 29, p. 4635-4648. doi: 10.1016/S1352-2310(02)00416-8

Presentation Preference Oral

Audio/Visual Equipment

Awards

Additional information



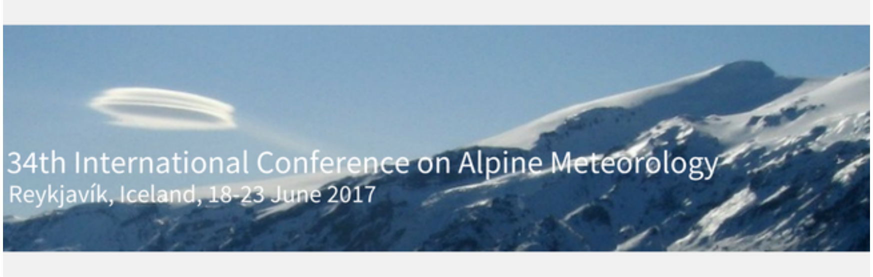
Abstract nr. 63
Abstract code
Environmental Research and Monitoring at Sonnblick Observatory

Author - Baumann-Stanzer, Kathrin, ZAMG, Vienna, Austria (Presenting author)
Co-author(s) - Ludewig, Elke , ZAMG , Salzburg , Austria
Co-author(s) - Kasper-Giebl, Anneliese , Technical University of Vienna , Vienna , Austria
Topic Other
Keywords high Alpine mountain observatory

Introduction
The Sonnblick Observatory was founded in 1886 by the Austrian climatologist Julius Hann at the summit of Hoher Sonnblick (3106 m asl). Among a larger number of mountain observatories established that time, Sonnblick is the only station located in a high alpine environment which survived without any breaks until today. Besides of the long time-series of meteorological measurements, miscellaneous other research disciplines identified the great experimental potential of this site: experiments on cosmic rays, glaciological studies and the investigaton of climatological trends, atmospheric chemistry and climate impacts in the Alpine environment. Today, the Sonnblick Observatory is part of the Global Atmosphere Watch Program (GAW) of the World Meteorological Organization.
The Observatory serves as a research platform for many national and international science institutions and universities focusing on research and monitoring in areas of atmospheric physics, chemistry, glaciology and biological studies. Due to its unique exposed location, the high altitude observatory is an important measurement location within several monitoring networks, such as the early nuclear radiation warning system and the air pollution monitoring network.
The research program "ENVISON" (Environmental Research and Monitoriung SONnblick) summarizes the research focus in the field of Atmosphere, Biosphere and Cryoshpere. An overview of ongoing monitoring activities and research projects is given in this presentation.
Monitoring activities and research projects
The environmental monitoring and related research projects grew significantly since the late 1990s and show the internationally outstanding position of Sonnblick in the fields of climatology, atmospheric research and glaciology, which is reflected in the increasing number of publications: The long climate time-series from 1886 until now allow the investigation of climate change in the Alpine region from the pre-industrial level to the period of significant anthropogenic impact. The position of the atmospheric monitoring platform at 3100m at the summit of Sonnblick is unaffected by any local pollution sources around.
Highly interlinked monitoring and research programmes investigating the atmosphere, the hydrosphere, the lithosphere and the biosphere, take advantage of the easy access to all environments – thus enabling to study not only temporal trends but also exchange and cycling processes in the environment. Onsite technical staff enables permanently supervised

measurements or sampling campaigns.
ENVISON covers three main research fields:
Climate change including its natural and anthropogenic driving forces and of climate impact on various spheres of the nature in the Alps as the region with most significant changes observed based on the advantage of using long term data series
Anthropogenic impact on concentration levels of trace species (gases, aerosols) as well as on processes and biogeochemical cycles in the background environment (with special focus on the atmosphere, the cryosphere and the biosphere)
Outstanding events (e.g. dust falls, volcanic activity, long range transport, active layer thickness, extreme glacier melt) and understanding of their impact on the environment
The Sonnblick Observatory is participating in involved in various international programs and networks:
WMO-GAW (Global Atmosphere Watch www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html)
GAW-DACH (GAW-cooperation Germany, Austria, Switzerland)
NDACC (Network for the Detection of Atmospheric Climate Change www.ndsc.ncep.noaa.gov)
WGMS (World Glacier Monitoring Service www.wgms.ch)
GTN-P (Global Terrestrial Network for Permafrost www.gtnp.org)
Copernicus (Monitoring atmospheric composition and climate www.gmes-atmosphere.eu)
BSRN (Baseline Surface Radiation Network www.gewex.org/bsrn.html)
WMO GCW (Global Cryospheric Watch www.globalcryospherewatch.org)
LTER (European Long-Term Ecosystem Research Network www.lter-europe.net)
INTERACT (International Network for Terrestrial Research and Monitoring in the Arctic and adjacent forests and alpine regions www.eu-interact.org)
MONET (Monitoring Network of persistent organic compounds www.recetox.muni.cz)
The Sonnblick Observatory holds strategic partnerships to MRI (Mountain Research Initiative), VAO (Virtuelles Alpenobservatorium) and Nationalpark Hohe Tauern.
Acknowledgements
ENVISON-2 is not a funding program by itself. It is based on a synergy of running and already funded monitoring programs and research projects as well as, considering future activities and research foci of Austrian funding agencies. The authors acknowledge the contributions of all members of the Sonnblick Advisory Councel and the substantial support of the Sonnblick Association.
The majority of measurements of the ENVISON monitoring are funded by the national GAW-DACH MoU, which is funded by the BMLFUW, the BMWFW, the province of Salzburg, the province of Carinthia and the Austrian Environmental Agency. The cryospheric monitoring is performed with funding from BMLFUW including the projects GCW-G and PERSON-GCW. The operation of Sonnblick Observatory is a sovereign function of ZAMG. A PhD project within the framework of the FWF DK GIScience (University Salzburg) is carried out during ENIVISON-2. The Austrian Academy of Sciences (ÖAW) is supporting ENVISON for permafrost monitoring.
References
Sonnblick Beirat, 2016: ENVIronmental Research and Monitoring SONnblick -Program 2016-2020, Zentralanstalt für Meteorologie und Geodynamik (ZAMG) , Vienna, August 2016, pp 17.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



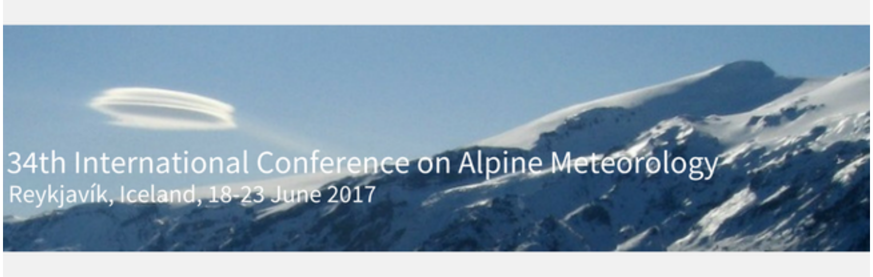
Abstract nr. 64
Abstract code

Analysis of precipitation forecast over the alpine area by an ensemble prediction system

Author - Salerno, Raffaele, Epson Meteo Centre, Milan, Italy (Presenting author)
Topic Weather forecasting for mountainous regions
Keywords Ensemble; Precipitation; Mesoscale; Convection

A regional ensemble prediction system based on the WRF-ARW model was applied in an area centred over Northern Italy. Initial perturbations were produced by a modified version of the Ensemble Transform Kalman filter, which was able to allow covariance localization whilst maintaining computational efficiency and removing spurious long-range correlation. Different physical schemes were also used at the same time in the WRF model for each simulation. A model climatology was built based on three years of runs to determine the model's biases. The horizontal resolution at the regional scale was 18 km, with 42 vertical levels and 20 ensemble members. To identify the effects of resolutions over the precipitation locations and intensity and the capability of predict the mesoscale circulation, simulations were made for several selected cases at 12, 5.5 and 3 km, without modifying the number of vertical levels and members. The cases were selected on the basis of different types of weather situations, especially looking at convective situations, which model initialization times were selected on the basis of the initiation of the observed convection. Simulations were compared to the observations based on measures derived from weather stations, satellite data and radars. The results generally showed that precipitations are generally over-estimated in the alpine area, while in the Po Valley model's estimation is much closer to the observed values. For convective systems, results suggest that resolutions of 5.5 km is fair enough to reproduce much of the mesoscale structure, at least in the squall-line-type convective systems; at 3-km simulations a better definition of mesoscale structure is achieved, even if the location and intensity of convective rain events are not always well reproduced. The mesoscale circulation becomes stronger at 12 and 18 km than that produced in the 3-km simulations. This result for coarse-resolution simulations is mostly due to the strengthening of convection at later times in the region of relatively cold and stable air. This circulation is also the result from an over-prediction of the vertical mass transport produced by the convection at the forefront of the system, probably due to the inadequacy of coarse-resolution simulations (12 and 18 km) of properly representing non-hydrostatic effects.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 65
Abstract code

Dual-pol radar based hydrometeor classification: analysis of orographic precipitation mechanisms

Author - Besic, Nikola, EPFL, Lausanne, Switzerland (Presenting author)
Co-author(s) - Panziera, Luca , University of Bern , Bern , Switzerland
Co-author(s) - Figueras i Ventura, Jordi , MeteoSwiss , Locarno-Monti , Switzerland
Co-author(s) - Gabella, Marco , MeteoSwiss , Locarno-Monti , Switzerland
Co-author(s) - Germann, Urs , MeteoSwiss , Locarno-Monti , Switzerland
Co-author(s) - Romppainen-Martius, Olivia , University of Bern , Bern , Switzerland
Co-author(s) - Berne, Alexis , EPFL , Lausanne , Switzerland
Topic Orographic precipitation
Keywords

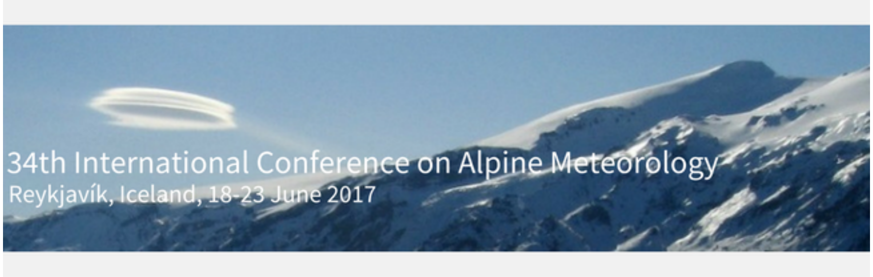
In assigning a hydrometeor label to every radar sampling volume, the new MeteoSwiss semi-supervised hydrometeor classification algorithm [1] exploits the complementary information provided primarily by dual-pol radar moments: radar reflectivity (Z_H), differential reflectivity (Z_{DR}), specific differential phase (K_{dp}) and correlation coefficient (ρ_{hv}). By doing so, it distinguishes between nine different hydrometeor types: crystals, aggregates, light rain, rain, rimed ice particles, wet snow, vertically aligned ice particles, ice hail/high density graupel and melting hail.
The presentation introduces the hydrometeor classification algorithm and shows its application to the study of selected 21 orographic heavy rainfall events in the Lago Maggiore area on the southern Alps, located in the vicinity of the Monte Lema MeteoSwiss operational radar. Spanning over six years (2011-2016), these events caused the discharge peaks of the river Maggia, ranging from 300 to 2300 m^3/s, and are therefore associated to the flooding of the local settlements [2]. Estimated spatial probability density functions (PDFs) of occurrences of different hydrometeor classes in the vertical cross sections above the valley of interest are shown. On one side, by estimating them over the entire event, we obtain a unique signature for every rainfall case. On the other side, by estimating PDFs at hourly scale, we can track their evolution during the event, providing us with an original insight into the microphysical and dynamical processes of the orographic rainfall. Associating the observed hydrometeor tendencies to the local topography is of great help in further understanding the orographic precipitation mechanisms.
[1] Besic, N., et al.: Hydrometeor classification through statistical clustering of polarimetric radar measurements: a semi-supervised approach, Atmos. Meas. Tech., 9, 4425-4445, 2016.
[2] Panziera, L., et al.: Mesoscale organization and structure of orographic precipitation producing flash floods in the Lago Maggiore region. Q.J.R. Meteorol. Soc., 141, 224–248, 2015.

Presentation Preference Oral
Audio/Visual Equipment

Awards

Additional information

REYKJAVÍK
Conferences Events Incentives



Abstract nr. 66
Abstract code

Wintertime circulation in the Chamonix-Mont-Blanc valley from scanning wind lidar measurements (Passy-2015 field experiment) and numerical simulations

Author - Sabatier, Tiphaine, Meteo-France & CNRS, Toulouse, France (Presenting author)
Co-author(s) - Paci, Alexandre , Meteo-France & CNRS , Toulouse , France
Co-author(s) - Largeron, Yann , Meteo-France & CNRS , Toulouse , France
Co-author(s) - Lac, Christine , Meteo-France & CNRS , Toulouse , France
Co-author(s) - Dabas, Alain , Meteo-France & CNRS , Toulouse , France
Co-author(s) - Canut, Guylaine , Meteo-France & CNRS , Toulouse , France
Co-author(s) - Martinet, Pauline , Meteo-France & CNRS , Toulouse , France
Co-author(s) - Donier, Jean-Marie , Meteo-France & CNRS , Toulouse , France
Topic Boundary layers and turbulence in complex terrain
Keywords Scanning wind lidar; Cold pool, NWP model

Wintertime anticyclonic conditions lead to the formation of persistent stable boundary layers which may induce air pollution episodes in urban or industrialized areas. This phenomenon can be particularly severe in mountainous regions as in the Arve river valley (French Northern Alps) around the city of Passy (France, Haute-Savoie), 20 km down valley past Chamonix-Mont-Blanc. This area is actually one of the worst place in France regarding air quality since the concentration of fine particles and Benzo(a)pyrene (a carcinogenic organic compound) regularly exceeding the EU legal admissible level during winter.
Besides air quality measurements, a good knowledge of the atmospheric boundary layer dynamics and processes at the valley scale under these persistent stable conditions is crucial in order to improve our understanding on how it drives pollutant dispersion. These issues motivated the Passy-2015 field experiment which took place during the winter 2014-2015. A relatively large set-up of instruments was deployed over several sites in the valley.
The present study focuses on scanning wind lidar measurements during two intensive observation periods (6-14 February and 17-20 February 2015). The scanning strategy was established in order to get vertical and horizontal transects with a frequency of 10 to 30 min. Large aerosol concentrations are usually observed in the area under persistent stable conditions, so the lidar range was regularly over 6 km. This allows to cover most of the region of interest. Circulation patterns in the valley and its surrounding (slope winds, adjacent valleys) retrieved from the lidar measurements will be discussed with a particular focus on diurnal cycle and fine horizontal and vertical scales. Then, high-resolution Meso-NH numerical simulations will be evaluated and studied to provide a better understanding of the circulation origins.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information

REYKJAVÍK
Conferences Events Incentives

Abstract nr. 67
Abstract code
Photogrammetric analysis of rotor clouds observed during T-REX

Author - Romatschke, Ulrike, NCAR, Boulder, USA (Presenting author)
Co-author(s) - Grubišić, Vanda , NCAR , Boulder , USA
Co-author(s) - Zehnder, Joseph A , Southwest Weather Consulting , Tempe , USA
Topic Downslope windstorms, mountain waves and rotors
Keywords

Stereo photogrammetric analysis is a little utilized but highly valuable tool for studying smaller, highly ephemeral clouds. In this study, we make use of stereo digital photographs that were collected during the Terrain-induced Rotor Experiment (T-REX) but little used thus far. The data set consists of matched stereo pairs of photographic images obtained at high temporal (on the order of seconds) and spatial resolution (limited by the pixel size of the cameras). Using computer vision techniques we have been able to develop algorithms for camera calibration, automatic feature matching, and ultimately reconstruction of 3D cloud scenes.
Applying these techniques to images from different T-REX IOPs we can capture the motion of clouds in several distinct mountain wave scenarios ranging from short lived lee wave clouds on an otherwise clear sky day to rotor clouds formed in an extreme turbulence environment with strong winds and high cloud coverage. Tracking the clouds in 3D space and time allows us to quantify phenomena such as growth, and vertical and horizontal movement of clouds, turbulent motion at the upstream edge of rotor clouds, the structure of the lifting condensation level, extreme wind shear, and the life cycle of clouds in lee waves. When placed into context with the existing literature that originated from the T-REX field campaign our results complement and expand our understanding of the complex dynamics observed in a variety of different lee wave settings.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 68
Abstract code

CLIM'PY: Characterization of the evolution of climate and provision of information for adaptation in the Pyrenees

Author - Trapero, Andorran Research Institute (IEA-CENMA), Sant Julià De Lòria, Andorra (Presenting author)
Topic Other
Keywords Homogenization of climate series; daily quality co

The cross-frontier CLIM´PY project aims to investigate the Pyrenees's climate evolution under the context of global change. The main objective is to analyse present and future trends in temperature, precipitation and snow cover in the Pyrenees. This goal will be achieved by considering different priority actions: i) the database generation of daily quality-controlled and homogenized series; ii) developing climate indices for present and future evaluation of climate extremes in this area; iii) performing a detailed analysis of the snow cover distribution (i.e., spatio-temporal variability, trends, and local differences), using satellite imagery and in-situ measurements, and complemented with a snowpack modeling. Finally, iv) we will apply downscaling methodologies for the computation of regionalised climate change projections, using models (EUROCORDEX, CMIP5 and HARMONIE) and empirical algorithms, under different future climate change scenarios over the Pyrenees, which will be crucial to explore future temperature, precipitation and snowpack trends.
CLIM´PY (EFA 081/15) is funded by the European Regional Development Fund (FEDER) through the Interreg Program V-A Spain-France-Andorra (POCTEFA 2014-2020). It gives continuity to the climate action of the OPCC-EFA235/11 project, and relies on the cooperation established between the main research centers on both sides of the Pyrenees. At the same time, it fits the need to offer a long-term, updatable initiative that will enable the possibility to perform a valuable assessment of future climate projections. The results will contribute to the development of the strategy and plan of the Pyrenees Climate Change Observatory (OPCC). In addition, they will provide knowledge that allows to evaluate the impacts on water resources, ecosystems, biodiversity, tourism, energy, among others, and implement both regional policies and adaptation strategies to climate change.

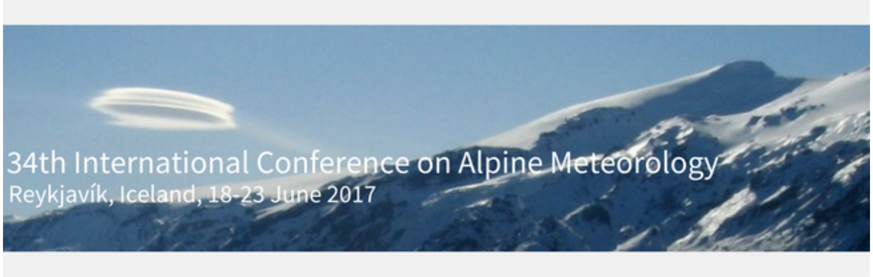
Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 69
Abstract code
MODIS snow cover data for calibration and evaluation of hydrological models in French mountainous regions

Author - Garavaglia, Federico, EDF - DTG, Grenoble, France (Presenting author)
Co-author(s) - Le Lay, Matthieu , EDF - DTG , Grenoble , France
Co-author(s) - Gottardi, Fréderic , EDF - DTG , Grenoble , France
Topic Cryosphere and mountain hydrology
Keywords MODIS | snow cover | conceptual hydrologic model |

The objective of this study is to assess the potential of snow cover data from MODIS satellite sensor for calibration and evaluating conceptual lumped and semi-distributed hydrological models. Primary, this investigation assesses the impact of model structure on flow simulation and snow modelling using two versions of a conceptual hydrological model called MORDOR: (i) a lumped and (ii) a semi-distributed structures. As a rule model intercomparison experiments are widely used to investigate and improve hydrological model performances. However, a study based only on runoff simulation is not sufficient to discriminate different model structures. The first objective of this study is to investigate in an evaluation mode, the impact of spatial discretization (lumped vs. semi-distributed approaches) on flow and snow simulation. The evaluation framework, founded on a multi-criteria split sample strategy, is enriched by a direct comparison of snow cover simulated by hydrological models and MODIS data. The results show that the semi-distributed approach provides better validation performances for snow cover area, snow water equivalent and runoff simulation, especially for nival catchments. The second goal of this work is to evaluate the use of MODIS snow cover data for calibrating the semi-distributed structure of MORDOR. We consider two different techniques: (i) calibration to runoff alone and (ii) calibration to both runoff and MODIS snow cover. The results indicate that the use of MODIS snow cover data improves the snow model performance without a noticeable degradation on flow simulation. This outcome is especially true for mid-mountain catchments where the streamflow data are not sufficient for calibrating parameters of snow model. The analysis is performed for an extensive dataset composed of 50 catchments located in French mountainous regions.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 70
Abstract code

Real time bias correction of very high resolution weather forecasting models for nowcasting in complex terrain

Author - Buzzi, Matteo, MeteoSwiss, Locarno, Switzerland (Presenting author)
Co-author(s) - Liniger, A. Mark , MeteoSwiss , Zürich , Switzerland
Co-author(s) - Gaia, Marco , MeteoSwiss , Locarno , Switzerland
Co-author(s) - Frei, Christoph , MeteoSwiss , Zürich , Switzerland
Co-author(s) - Sassi, Marco , MeteoSwiss , Locarno , Switzerland
Topic Weather forecasting for mountainous regions
Keywords Nowcasting temperature; Nowcasting Humidity

In recent years, various operational weather centers increased the resolution of their numerical weather prediction models (NWP) reaching now convection-permitting scales in the order of 1-2km. Specifically, MeteoSwiss is operating now COSMO-1 at 1.1 km horizontal resolution over the Alpine arch. The model is able to resolve complex alpine terrain and associated processes such as radiation, convective cells and topographic driven wind systems. Nevertheless, the local temperature and humidity biases even at analysis time can be substantial. For example, temperature and humidity values show significant biases in foehn cases due to non-perfect timing of foehn breakthroughs and non-accurate prediction of inversions erosions. Other difficult situations are very strong inversions and some convective situations.

MeteoSwiss uses the INCA system (Haiden et. al, 2011) for the bias real time correction of the NWP forecast during the nowcasting window (0-6h). INCA derives a temperature and humidity analysis through a real-time bias correction of the NWP model data in a two-step approach. In a first step, the fields of the NWP model are interpolated to the high-resolution INCA grid of 1km horizontal grid spacing. In a second step, differences between these high-resolution fields and station observations are interpolated in space using an inverse-distance-squared weighting in the horizontal.

The INCA system has originally been developed to deal with NWP models having horizontal resolutions in the order of 10km. The new generation of NWP models reduce the differences between the NWP and INCA topography. Therefore, we suggest a more direct interpolation approach in order to better maintain the height of temperature inversions and to take into account the better NWP performance also on small scales. Additionally, the observed typical thermal differences between nearby valleys, such as confinement of valley-scale cold-pool layers and channeling of warm foehn air, suggest that an approach considering the obstruction of air mass exchange by topographic barriers would be more suitable to avoid erroneous corrections of the NWP model. For these reasons, we propose to use non-Euclidean distances that weight the vertical distance across mountains based on the vertical layering of the temperature, such as introduced by Frei (2013) for gridding daily mean temperatures.

We will present the newly implemented two-step INCA correction algorithm. Validation results are analyzed both for temperature and humidity fields, for different seasons and several selected case-studies with challenging temperature distributions. In general, the results show an improvement to the previous approach.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

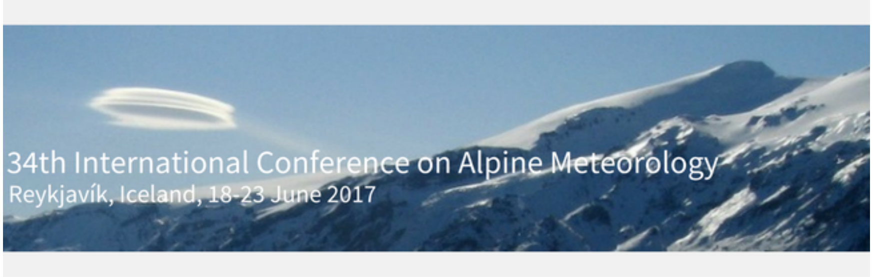
Abstract nr. 71
Abstract code

Dynamical downscaling overcomes deficiencies in gridded precipitation products in the Sierra Nevada, California

Author - Hughes, Mimi, Univ of Colorado at Boulder and NOAA, Boulder, United States of America (Presenting author)
Co-author(s) - Lundquist, Jessica , University of Washington , Seattle , United States of America
Co-author(s) - Henn, Brian , Scripps Institution of Oceanography , San Diego, CA , United States of America
Topic Cryosphere and mountain hydrology
Keywords precipitation, WRF, convection-permitting

Uncertainties in gridded and regional climate estimates of precipitation are large at high elevations where observations are sparse and spatial variability is substantial. We explore these uncertainties for water year 2008 across California's Sierra Nevada in 10 datasets: six regional climate downscalings generated using the Weather, Research, and Forecast (WRF) model at convection-permitting resolution with differing lateral boundary conditions and microphysical parameterizations, and four gauge-based, interpolation-gridded precipitation datasets. Precipitation from these 10 datasets is evaluated against 95 snow pillows and a precipitation dataset inferred from stream gauges using a Bayesian inference method. During water year 2008, the gridded datasets tend to underestimate frozen precipitation on the windward slope of the Sierra Nevada, particularly in the vicinity of Yosemite National Park. The WRF simulations with single-moment microphysics tend to overestimate precipitation throughout much of the region, whereas the WRF simulations with double-moment microphysics tend to better agree with both the snow pillows and inferred precipitation estimates, although they somewhat overestimate the windward/leeside precipitation contrast in the northern Sierra Nevada. WRF simulations, in particular those with single-moment microphysics, better distinguish spatial patterns of wet-versus-dry pillows and watersheds over the water year than the gridded estimates. Our results suggest treating gauge-based datasets as 'truth' may give a misleading representation of model accuracy, since these gauge-based datasets often have issues of their own.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

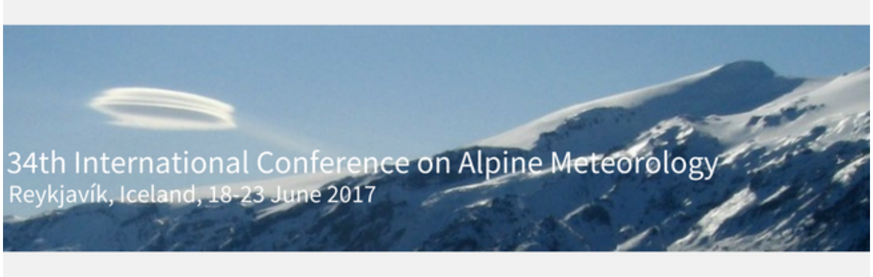


Abstract nr. 73
Abstract code
The Influence of Mountain-Forced Waves on the Atmospheric Kinetic Energy Spectrum

Author - Menchaca, Max, University of Washington, Seattle, United States of America (Presenting author)
Co-author(s) - Durran, Dale , University of Washington , Seattle , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords Midlatitude Cyclone; Energy Spectra; Gravity Waves

The observed kinetic energy spectrum of the atmosphere exhibits a k^-3 wavenumber dependence at large scales that transitions to a k^-5/3 dependence in the mesoscale. The synoptic slope appears well explained by 2D turbulence theory, but there is no clear consensus on the processes that generate mesoscale k^-5/3 slope. Previous studies have suggested possibilities including an inertial cascade from a localized large- or small-scale source, or direct mesoscale forcing via gravity waves or convection.
Here we show that mountain waves can make a substantial contribution to the k^-5/3 portion of atmospheric kinetic energy spectrum. A prototypical midlatitude low pressure system is generated in an idealized basic state favorable for unstable growth after seeding with a finite-amplitude PV anomaly. A mountain is placed well downstream of the initial anomaly. The cold front impinges on the terrain, and a full lifecycle of mountain wave generation, propagation, and decay is simulated. In comparison to a no-mountain simulation, these orographic waves produce a distinct shallowing of the KE spectrum towards a k^-5/3 slope. In simulations with higher ridges, this k^-5/3 slope is evident over a wider range of scales.
The spectral energy budget is calculated using Fourier transforms analogous to the methods used in Peng et al. (2014). Terrain-forced gravity waves propagating from the troposphere into the stratosphere inject energy directly into the mesoscale; this mechanism is much weaker in the absence of a mountain. These results are in accordance with the growing literature suggesting that gravity waves provide a pathway through which the k^-5/3 spectral slope can be directly forced on the mesoscale, and that inertial cascade arguments are not necessary for its production.
Peng J., L. Zhang, Y. Luo, and C. Xiong, 2014: Mesoscale Energy Spectra of the Mei-Yu Front System. Part II: Moist Available Potential Energy Spectra. *J. Atmos. Sci.*, **71**, 1410–1424.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 74
Abstract code

How essential are 3D shear effects for the representation of the turbulence kinetic energy (TKE) structure in an Alpine valley?

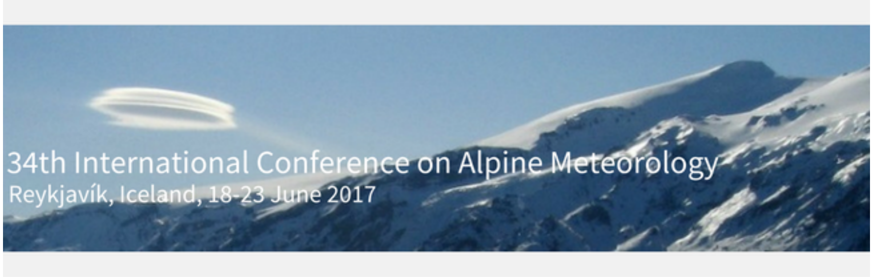
Author - Goger, Brigitta, University of Innsbruck, 6020, Austria (Presenting author)
Co-author(s) - Rotach, Mathias W. , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Gohm, Alexander , University of Innsbruck , 6020 , Austria
Co-author(s) - Fuhrer, Oliver , Federal Office for Meteorology and Climatology, Meteo Swiss , Zürich , Switzerland
Co-author(s) - Stiperski, Ivana , University of Innsbruck , 6020 , Austria
Co-author(s) - Holtslag, Albert A. M. , Wageningen University , Wageningen , Netherlands
Topic Boundary layers and turbulence in complex terrain
Keywords model evaluation; turbulence parameterization;

The correct simulation of the boundary layer structure in complex terrain is still a challenge for numerical weather prediction (NWP) models. This is often related to the models' turbulence parameterizations, which were initially developed for horizontal homogeneous and flat terrain and consider vertical exchange only.
In our study, we evaluate the 1D and 3D turbulence parameterizations of the NWP model COSMO on a horizontal grid size of 1 km. Our location of interest is the Inn Valley, Austria, and the main focus of the model evaluation is the representation of turbulence kinetic energy (TKE) and its contributing budget terms. This is possible with the so-called Innsbruck-Box (i-Box) measurement sites, which consist of turbulence flux towers at various representative locations in the Inn Valley (valley floor, south- and north-facing slopes). We have chosen cloud-free days and nights, in which boundary layer processes dominate and a thermally-induced valley wind circulation is present. We test both the model's standard 1D turbulence parameterization and a hybrid turbulence parameterization, which also considers horizontal contributions to shear production of TKE.
During shear-dominated up-valley wind phases and during night-time conditions, when a stable boundary layer is present, we find an underestimation of TKE by the model with the 1D turbulence parameterization. The hybrid turbulence parameterization brings a much better agreement with the observations of TKE in these situations. On the slopes in particular, the TKE structure is more realistic, together with a better-simulated (3D) shear production term.
This leads to the conclusion that 3D effects are crucial for the correct simulation of turbulence structure in complex terrain.

Presentation Preference Oral
Audio/Visual Equipment

Awards

Additional information

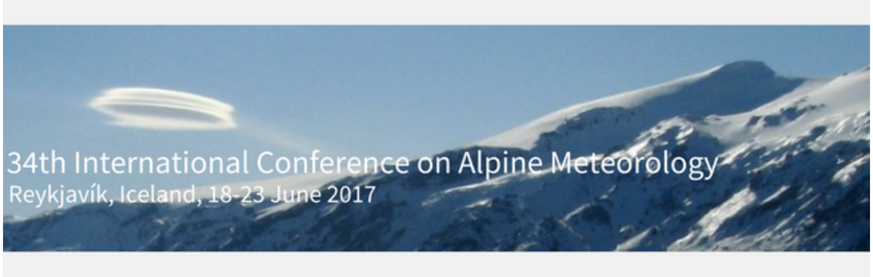


Abstract nr. 75
Abstract code
US Army Research Lab's Meteorological Sensor Array

Author - Pattantyus, Andre, Army Research Laboratory, White Sands Missile Range, United States of America (Presenting author)
Co-author(s) - Smith, Jeffrey , Army Research Laboratory , White Sands Missile Range , United States of America
Co-author(s) - Hocut, Christopher , Army Research Laboratory , White Sands Missile Range , United States of America
Co-author(s) - MacCall, Benjamin , Army Research Laboratory , White Sands Missile Range , United States of America
Topic Other
Keywords Instrumentation; mesoscale; microscale

US Army Research Laboratory’s (ARL) Atmospheric Science Center is developing a reliable, sustained, and world-class high resolution observational Meteorological Sensor Array (MSA) as an atmospheric science community asset for basic research on the dynamics of boundary layer processes in mountainous complex terrain. The array will address a community need for high resolution observational data for developing and verification and validation of high resolution meso-gamma and micro-scale forecast models, exploring new flow physics processes, integrating observations and state-of-the-art assessment tools, and sensor development.
When complete, the MSA will be a complex of 108 towers outfitted with state-of-the-science meteorological and ground sensing instrumentation at grid resolutions below 1km. The proposed location includes a continuous domain of 45 km x 25 km, that encompasses a valley (USDA’s Jornada Experimental Range (JER) near Las Cruces, New Mexico) at an elevation of 1300 m and the San Andres Mountains (White Sands Missile Range (WSMR), New Mexico) which peak at an elevation of 2500 m. This configuration provides the unique opportunity to examine diverse climatological complex terrain meteorological phenomena due to the varying seasonal background meteorological conditions and continual operation. The scientific objectives including collaboration interests, available instrumentation assets, and ARL’s new Atmospheric Science Center, which provides unique opportunities for scientific collaboration, will be discussed.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 76
Abstract code

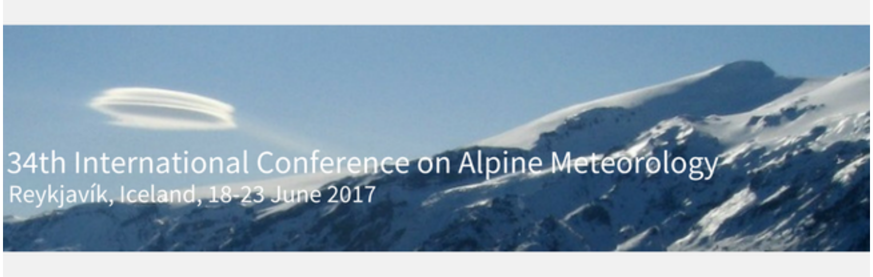
Penetration and interruption of Alpine foehn (PIANO): preliminary high-resolution numerical simulations

Author - Umek, Lukas, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Gohm, Alexander , University of Innsbruck , Innsbruck , Austria
Topic Downslope windstorms, mountain waves and rotors
Keywords complex terrain; numerical modeling; WRF; foehn;

In the framework of previous field campaigns, such as the Mesoscale Alpine Programme, a broad understanding of the well-developed phase of foehn in the Alpine region has been gained. However, the initial and final stage of foehn received far less scientific attention. These transient phases during the penetration of the foehn flow down to the valley bottom or the breakdown of foehn feature complex turbulent interactions between the foehn and cooler valley air. The research project “Penetration and interruption of Alpine foehn (PIANO)” aims at increasing the understanding of the governing processes during these periods based on high-resolution numerical simulations as well as observations collected during an upcoming field experiment in the Inn Valley (Austria). An overview over the project and the field campaign in fall 2017 will be given in a separate presentation, whereas this contribution will focus on aspects of numerical modeling. Very-high-resolution numerical simulations of selected foehn events in the Alpine region around Innsbruck, Austria, are conducted with the Weather Research and Forecasting (WRF) model. The application and performance of the WRF model at the transition between very-high-resolution mesoscale simulations and large-eddy simulations (LES) will be evaluated based on a verification against routine observations. Results of the numerical simulations will also support the planning of the PIANO field campaign in fall 2017 and help to determine appropriate locations for the installation of various measurement systems (including Doppler wind lidars and scintillometers) as well as appropriate flight patterns for airborne in-situ measurements. A nesting approach will be presented that allows to capture all relevant mesoscale and microscale processes. The highly complex and steep terrain in the target area influences several atmospheric phenomena at various scales, e.g., rotor or cold pool formation. Hence, strategies to incorporate a realistic topography in the numerical model while ensuring numerical stability will be explored and presented. Moreover, the representation of turbulent processes within the model and the turbulent inflow at nested domain boundaries pose another challenge and will be investigated. At the conference we will present preliminary modeling results and an appropriate model setup which will be used to conduct numerical simulations of foehn events during the PIANO field campaign.

Presentation Preference Oral
Audio/Visual Equipment

Awards
Additional information



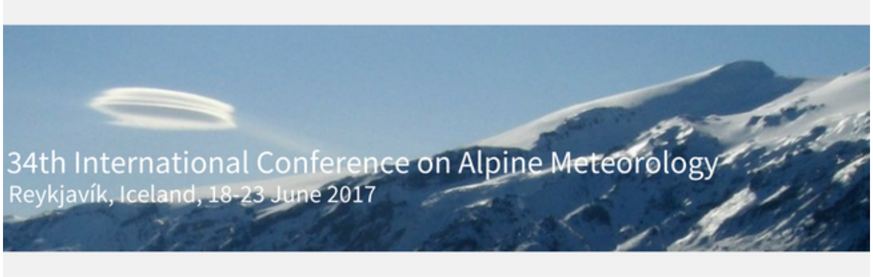
Abstract nr. 77
Abstract code
Parameterizing surface wind speed in complex topography for coarse-scale models

Author - Helbig, Nora, WSL Institute for Snow and Avalanche Research SLF, Davos Dorf, Switzerland (Presenting author)
Co-author(s) - Mott, Rebecca , WSL Institute for Snow and Avalanche Research SLF , Davos Dorf , Switzerland
Co-author(s) - Van Herwijnen, Alec , WSL Institute for Snow and Avalanche Research SLF , Davos Dorf , Switzerland
Co-author(s) - Winstral, Adam , WSL Institute for Snow and Avalanche Research SLF , Davos Dorf , Switzerland
Co-author(s) - Jonas, Tobias , WSL Institute for Snow and Avalanche Research SLF , Davos Dorf , Switzerland
Topic Cryosphere and mountain hydrology
Keywords

Surface wind fields are altered over complex topography giving rise to sheltering or speed-up. Accurate wind speed estimates are important for various models in complex terrain, such as spatial snow melt predictions, since wind is an important component of the surface energy balance. The impact of unresolved topography on wind speed in coarse-scale models is usually accounted for by using subgrid parameterizions, based on a variety of terrain parameters. These parameterizations were generally validated on a limited number of measurements in specific geographical areas.
We therefore systematically investigated which terrain parameters most affect near-surface wind speed over complex topography. Wind fields under neutral conditions were simulated using the Advanced Regional Prediction System (ARPS) on Gaussian random fields as model topographies to cover a wide range of terrain characteristics. Coarse-scale mean wind speed, i.e., a spatial average over the large grid cell accounting for influence of unresolved topography, correlated best with sky view factor. We therefore parameterized coarse-scale wind speed using a previously suggested subgrid parameterization for sky view factor and results compared well with domain-averaged ARPS wind speed. To derive local wind speed, we further scaled the subgrid parameterized wind speed using local, fine-scale topographic parameters which correlated best with fine-scale ARPS wind speed. Comparing downscaled numerical weather prediction wind speed with measurements from a large number of stations throughout Switzerland resulted in overall improved correlations and distribution statistics.

Presentation Preference Oral
Audio/Visual Equipment

Awards
Additional information



Abstract nr. 78
Abstract code
The spatial variability of the temperature structure in a major east-west oriented valley in the Alps

Author - Markl, Zentralanstalt für Meteorologie und Geophysik, Salzburg, Austria
Co-author(s) - Laiti , University of Trento , Trento , Italy
Co-author(s) - Rotach , University of Innsbruck , Innsbruck , Austria (Presenting author)
Topic Boundary layers and turbulence in complex terrain
Keywords

The thermal and dynamical structure of the valley atmosphere in the Inn Valley in Austria is investigated by means of airborne, as well as ground-based meteorological data. Therefore the observations of an instrumented airplane were used that conducted three measurement flights in summer 2013. The collected data of potential temperature and water vapour mixing ratio were interpolated to a regularly-spaced three-dimensional grid. For the interpolation the method of Residual Kriging (RK) was applied, which was found to be a better performing interpolation technique compared to Natural Neighbour interpolation. A time-correction was conducted that filters out the temporal trend of potential temperature (diurnal cycle of temperature) so as to ensure that interpolated temperatures from different flight legs do not reflect the different times of those legs. The amplitude of the temperature change was determined using a ground-based station (i-Box) in the centre of the observed area in combination with an estimate of the vertical decay of the daily cycle of temperature as assessed from profiler data.
With the aid of cross-sections through the interpolated volume and vertical profiles at specific locations the temperature characteristics of the valley atmosphere were investigated. The along-valley variability of vertical temperature profiles in the valley-centre (approx. east-west) was found to be much smaller (quasi-uniform) than that in cross-valley direction (approx. north-south). Despite the predominantly thermal forcing of the valley flow (small synoptic pressure gradients, strong irradiance), the mixed layer did not grow higher than some 500 m and was topped by a deep stable layer (still below crest height in the morning and exceeding crest height in the afternoon). A second elevated well-mixed layer (around crest height in the morning and above in the afternoon) was found to be strikingly similar to results from idealized simulations with relatively deep (narrow) valley geometry.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 79

Abstract code

Using a cosmic ray sensor and weather radar composites to estimate the snow water equivalent on a Swiss glacier

Author - Gugerli, Rebecca, University of Fribourg, Fribourg, Switzerland (Presenting author)

Co-author(s) - Salzmann, Nadine , University of Fribourg , Fribourg , Switzerland

Topic Cryosphere and mountain hydrology

Keywords

Precipitation estimates in high-mountain regions are essential for environmental studies in many research fields (glaciology, meteorology, hydrology, climate risk and adaptation). Although precipitation data exist for the Swiss Alps, accuracy is limited by data sparsity and measurement challenges in high-mountain regions. We propose a novel approach to estimate the snow water equivalent (SWE) on glaciers and to spatially integrate these measurements.

Reliable and continuous measurements of SWE are indispensable for inferring temporal snow-accumulation dynamics. Therefore, we investigate the application of a cosmic ray sensor to directly measure SWE continuously on the Glacier de la Plaine Morte in Switzerland. The sensor is located on the surface of the glacial ice below the snowpack and counts low-energy neutrons at an hourly interval. The neutron count is negatively correlated to SWE. Initial results show good agreement with independent measurements of SWE using conventional surveys in snow pits.

We use operational weather radar composites compiled by MeteoSwiss to spatially integrate our SWE measurements. These weather radar composites show precipitation estimates over Switzerland at a horizontal grid resolution of one kilometre and a temporal grid resolution of one hour. This grid resolution is sufficient to directly compare precipitation estimates with SWE measurements from the field site. In addition, several grid cells in the weather radar composites cover the glacier area, and, therefore, we can evaluate the spatial variability in precipitation measured by the weather radars. Snow height data collected on the glacier allows us to verify the spatial variability of snow-accumulation data.

In summary, we present precipitation data derived by combining in-situ continuous SWE measurements with operational weather radar composites. This will complement existing precipitation data and improve their representation in high mountain regions.

Presentation Preference Oral

Audio/Visual Equipment

Awards

Additional information

Abstract nr. 80

Abstract code

Investigation and evaluation of atmospheric processes in orographic terrain applying the WRF model with very high resolution: examples from selected cases

Author - Bauer, Hans-Stefan, University of Hohenheim, Stuttgart, Germany (Presenting author)
Co-author(s) - Muppa, Shravan Kumar , University of Hohenheim , Stuttgart , Germany
Co-author(s) - Wulfmeyer, Volker , University of Hohenheim , Stuttgart , Germany
Co-author(s) - Behrendt, Andreas , University of Hohenheim , Stuttgart , Germany
Co-author(s) - Spaeth, Florian , University of Hohenheim , Stuttgart , Germany

Topic Boundary layers and turbulence in complex terrain
Keywords

Numerical models have long been used as tools to better understand atmospheric processes and their evolution. In recent years, simulations with finer and finer resolution have been applied for this purpose.

To serve process understanding and model evaluation, we apply the WRF model in a chain of simulations from the mesoscale down to a resolution of 100 m. In the fine scale domain, WRF is applied in Large-Eddy simulation (LES) mode with switched-off turbulence scheme. Advantage of WRF, as compared to “traditional” LES models, are the possibility to set up the system for real atmospheric cases, namely with realistic lower boundaries and meteorological forcing. Furthermore, a consistent set of physical parameterization is applied through the whole chain of simulations. Starting from the ECMWF analysis, we operate WRF with four nests from 2.7 km down to 100 m.

The evolution of the convective boundary layer on a sunny spring day and the life cycle of supercell that developed over southwestern Germany on 30 June 2012 are selected as examples to present the capabilities of the system.

The results are very promising and demonstrate that WRF can be applied at such high resolutions for detailed process studies.

Presentation Preference Oral

Audio/Visual Equipment

Awards

Additional information

Abstract nr. 81
Abstract code

Origin of the lee-side hydraulic jump

Author - Rotunno, Richard, National Center for Atmospheric Research, Boulder, United States of America (Presenting author)
Co-author(s) - Bryan, George , National Center for Atmospheric Research , Boulder , United States of America
Topic Downslope windstorms, mountain waves and rotors
Keywords

Laboratory observations of the hydraulic jump indicate it is composed of statistically stationary (and dissipative) turbulent motion in an overturning wave. From the point of view of the shallow-water equations, the hydraulic jump is a discontinuous increase in the height and decrease of the velocity of the fluid layer; at steady state, kinetic energy is dissipated at the jump. Questions concerning the physical origin of the hydraulic jump are necessarily outside the boundaries of any steady-state description. To provide an understanding of the origin of the hydraulic jump in the atmospherically relevant case in which a hydraulic jump forms on the lee side of an obstacle, three-dimensional numerical solutions of the exact fluid equations are carried out along with numerical solutions to the shallow water equations for the same physical initial-value problem. The simulations are carried out in a regime where a stationary lee-side hydraulic jump is expected from steady-state shallow-water theory. Starting from a constant-height layer flowing over an obstacle at constant speed, it is demonstrated that the solutions to the shallow water equations form a lee-side discontinuity owing to the collision of the upstream-moving characteristics launched from the lee side of the obstacle. The solution to the exact fluid equations indicates the lee-side hydraulic jump forms as a steepening, and then overturning, of the originally horizontal density interface; subsequent to this overturning, the fluid interface becomes statically unstable and eventually transitions to turbulence. Analysis of the initial-value problem in these solutions shows that the tendency to form either the lee-side height/velocity discontinuity in the shallow water equations, or the overturning density interface in the exact fluid equations, is a feature of the inviscid, nonturbulent fluid dynamics. Dissipative processes, which are associated with the lee-side jump and/or overturning wave at steady state, are properly understood as a consequence of the inviscid fluid dynamics that initiates and maintains the locally unstable conditions.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 82
Abstract code
Influence of horizontal grid spacing in mountainous terrain on simulated planetary boundary layer depths in large-scale transport models

Author - Duine, Gert-Jan, University of Virginia, Charlottesville, USA (Presenting author)
Co-author(s) - De Wekker, Stephan FJ , University of Virginia , Charlottesville , USA
Topic Boundary layers and turbulence in complex terrain
Keywords terrain smoothing; WRF; PBL depth and height

The difficulty of modeling atmospheric transport and mixing processes introduces significant uncertainties in the atmospheric fluxes estimated with carbon transport models. An important diagnostic for vertical transport and mixing is the planetary boundary layer (PBL) depth, the height above the surface up to which surface fluxes of heat, moisture, momentum, and trace gases such as CO2 are transported and mixed on a diurnal time scale. CO2-concentrations at the surface are inversely related to the PBL depth. PBL depths are known to vary considerably in mountainous areas. Atmospheric transport models used for CO2-flux estimations are typically run on coarse grid spacing (i.e. around 100 km horizontal grid spacing) and therefore miss terrain information needed for an accurate PBL depth calculation and so a correct CO2-budget estimation. We relate subgrid terrain parameters to differences in PBL depths between a ‘coarse’ (10 km horizontal grid spacing) and a ‘fine’ (3.3 km) grid domain. We focus on an area which consists of a mixture of flat and mountainous terrain, and investigate for a period of two consecutive years. PBL depths are larger in the coarse than in the fine grid domain. Most significant differences are found for areas with unresolved ridges and attain more than 200 m in summer, or a relative difference of about 10%, and are attributed to terrain smoothing and the resulting lack of physical and dynamical processes in the coarse grid domain. The PBL depth differences can only be partly removed after correcting for the fine grid terrain elevation in the coarse domain, or the use of PBL height. The choice of the parameter for evaluation of a coarse model depends greatly on whether the PBL follows the terrain elevation or not. On a longer term, the understanding of these differences would lead to an improved simulation and understanding of the location and quantification of North American and global carbon sources and sinks.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 83
Abstract code

What causes weak orographic rain shadows? Insights from case studies in the cascades and idealized simulations.

Author - Durran, Dale, University of Washington, Seattle, USA (Presenting author)
Co-author(s) - Siler, Nicholas , Scripps Institution of Oceanography , La Jolla , USA
Topic Orographic precipitation
Keywords rain shadow, orographic precipitation

Recent studies have shown that weak rain shadows in the Cascade Mountains are associated with passing warm fronts, but the specific mechanisms responsible for this connection have eluded consensus. One theory maintains that weak rain shadows are the result of enhanced precipitation over eastern slopes caused by easterly upslope flow; the other suggests that condensation is produced primarily over the western slopes, with enhanced east-slope precipitation occurring in dynamical regimes that minimize descent and evaporation east of the crest. Here these mechanisms are investigated through numerical simulations involving both real and idealized topography. Consistent with the second theory, storms with weak rain shadows are found to exhibit much weaker mountain waves in the lee of the Cascades than storms with strong rain shadows, with correspondingly weaker lee-side evaporation. The muted wave activity during weak-rain-shadow storms is found to be caused by cold, zonally-stagnant air at low levels in the lee, which precedes the warm front, and remains in place as the progression of the front is impeded by the mountains. As the front brings warmer air aloft, the static stability of the zonally-stagnant layer increases, making it more resistant to erosion by the overlying flow. This in turn allows the weak rain shadow to persist long after the front has passed. If the mid-latitude storm tracks shift poleward in a warmer climate, our results suggest there could be an increase in the strength of the rain shadow in mountainous regions astride the current storm tracks.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 84
Abstract code

Meteorological observations in a valley during the 21 August 2017 solar eclipse

Author - Palomaki, Ross, University of Virginia, Charlottesville, United States of America (Presenting author)
Co-author(s) - De Wekker, Stephan , University of Virginia , Charlottesville , United States of America
Topic Boundary layers and turbulence in complex terrain
Keywords

On 21 August 2017, a total solar eclipse will occur over the continental United States for the first time since 1979. This presents a rare opportunity for atmospheric scientists to collect atmospheric measurements in a quasi-laboratory setting, as the timing of the eclipse is known with accuracy to fractions of a second. Meteorological data have been collected over flat terrain during past eclipse events, but a comprehensive dataset from a mountainous site does not exist.
This project will focus on the convective boundary layer (CBL) in a valley in the Great Smoky Mountains, which fall within the path of totality for the 2017 eclipse. We are particularly interested in observing the evolution of the vertical structure of the valley atmosphere, as well as the response time of slope and valley winds to radiative forcing changes during the eclipse event. Eclipse totality occurs at approximately 15:00 local time at the study site, which allows time for slope and valley flows to fully develop prior to the eclipse.
This presentation will discuss some initial modeling results of an idealized valley with a focus on the daytime evolution of the CBL during a simulated eclipse event. Additionally, a description of the field campaign plans will be presented, with details on instrumentation, site selection, and meteorological variables of focus.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 86
Abstract code

Trapped lee waves at an inversion in flow over axisymmetric hills: theory and laboratory measurements of the drag

Author - Teixeira, University of Reading, Reading, United Kingdom (Presenting author)
Co-author(s) - Paci , Meteo France , Toulouse , France
Co-author(s) - Belleudy , Meteo France , Toulouse , France
Topic Downslope windstorms, mountain waves and rotors
Keywords

The drag produced by 3D lee waves trapped at an inversion in flow over an axisymmetric hill is calculated using linear non-hydrostatic theory. These waves may propagate in the atmosphere at the capping inversion existing at the top of the boundary layer, and are responsible for near-surface wave drag that may be mistaken for turbulent form drag. This drag receives contributions from a continuous range of wavenumbers excited by the orography, in contrast to 2D flow (where all possible trapped wave modes are discrete), since the waves may vary their angle of incidence to satisfy their dispersion relationship. Hence (contrary to 2D linear flow), the drag is non-zero for both subcritical and supercritical flow, and its maximum is attained for a Froude number slightly lower than 1. This drag maximum is less pronounced than in the hydrostatic limit, due to wave dispersion. The drag calculated from the theory agrees well with that obtained from measurements performed in laboratory flume experiments using axisymmetric obstacles of different heights, especially for the lowest obstacle. Agreement is best when the effects of both a rigid lid bounding the upper fluid layer and dissipative effects (modelled as a Rayleigh damping) are taken into account. The theory performs somewhat worse for the highest hill considered in the experiments, as this amounts to stronger nonlinearity of the flow. But even then the theory remains qualitatively correct, being much more accurate than 3D hydrostatic or 2D non-hydrostatic calculations. This supports the idea that 3D and nonhydrostatic effects are of decisive importance in the drag behaviour shown by the measurements. The waves associated with this drag behaviour are predominantly transverse waves for relatively small Froude numbers, form a dispersive "Kelvin ship wake" in the vicinity of the Froude number where the drag is a maximum, and are predominantly divergent waves for larger Froude numbers. The density interface defining the inversion has a maximum depression directly in the lee of the hill, by an amount that is significantly correlated with the drag magnitude. This is not surprising, since the flow region beneath that depression is characterized by a pressure deficit that is the ultimate cause for the drag force exerted on the hill in the flow under consideration.

Presentation Preference Oral
Audio/Visual Equipment

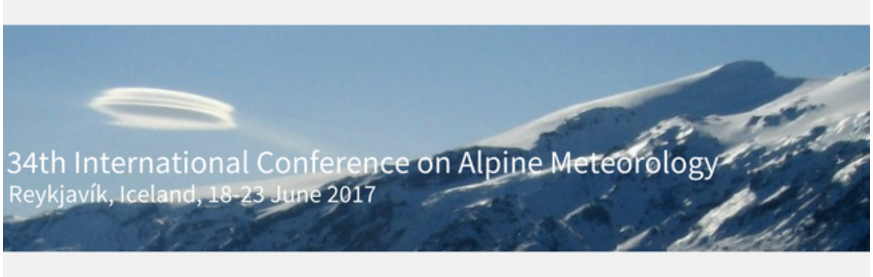
Awards

Additional information

cp

REYKJAVÍK

Conferences Events Incentives

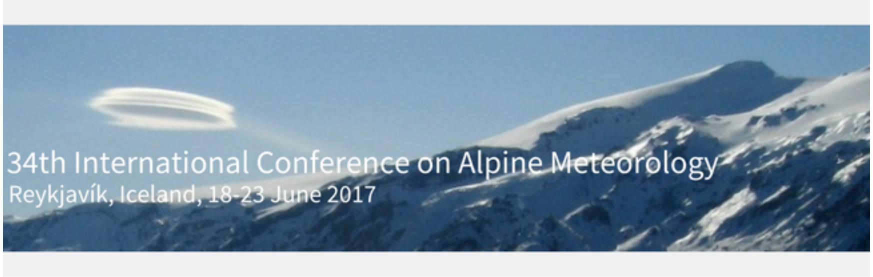


Abstract nr. 87
Abstract code
The importance of boundary layer friction in the representation of lee rotor onset using linear theory

Author - Teixeira, University of Reading, Reading, United Kingdom (Presenting author)
Topic Downslope windstorms, mountain waves and rotors
Keywords

Linear theory is used to predict the occurrence of flow stagnation associated with the onset of rotors beneath trapped lee waves in flow over 2D mountains, for an atmosphere that is neutral near the ground, has stable stratification aloft, and a sharp temperature inversion dividing the two layers. An inviscid two-layer mountain-wave model developed previously coupled with a bulk boundary-layer model shows some skill in detecting flow stagnation as a function of key input parameters, including the Froude number and the height of the inversion, when compared to numerical simulation data and laboratory experiments performed by previous authors. Flow stagnation crucially depends on the effect of the boundary layer, with the inviscid version of the model severely overestimating the critical dimensionless mountain height for which stagnation occurs. A simplified model including only the effects of mean flow deceleration and velocity perturbation amplification inside the boundary layer predicts flow stagnation much more accurately than the inviscid model in cases where conditions are considerably non-hydrostatic, since the waves seem to be directly excited by the mountains. However, when the flow is more hydrostatic, only a full model including the modified boundary condition imposed on the inviscid flow by the boundary layer predicts flow stagnation adequately in parameter space. This corroborates the idea put forward by previous authors that in such cases the trapped lee waves are not forced directly by the orography, but rather indirectly by nonlinear processes, an effect that is captured to some extent by the full model. Neglecting this effect underestimates the trapped lee wave amplitude in the most hydrostatic conditions, especially when the Fourier transform of the orography has zeros, since this corresponds to weak direct wave forcing. Despite its fairly good performance, in the full model the flow stagnation condition fails to discriminate between rotors and hydraulic jumps. This is explained by differences in the flow perturbations produced at stagnation between the full model and numerical simulations, which are especially pronounced for the most hydrostatic flows, where the waves are generated indirectly. This suggests that the model may not produce flow stagnation for the correct reasons in those cases.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 88
Abstract code

Accuracy of high-resolution gridded precipitation and temperature datasets in the Alps: evaluation by hydrological modelling in the Adige catchment (Italy)

Author - Laiti, Lavinia, University of Trento, Trento, Italy
Co-author(s) - Mallucci, Stefano , University of Trento , Trento , Italy
Co-author(s) - Piccolroaz, Sebastiano , University of Utrecht , Utrecht , Netherlands
Co-author(s) - Bellin, Alberto , University of Trento , Trento , Italy
Co-author(s) - Zardi, Dino , University of Trento , Trento , Italy (Presenting author)
Co-author(s) - Fiori, Aldo , University Roma Tre , Rome , Italy
Co-author(s) - Nikulin, Grigory , Swedish Meteorological and Hydrological Institute , Norrköping , Sweden
Co-author(s) - Majone, Bruno , University of Trento , Trento , Italy
Topic Cryosphere and mountain hydrology
Keywords

A good accuracy of gridded climate datasets is of crucial importance to climate studies, for the analysis of past and present climate, as well as for the validation, bias correction and/or statistical downscaling of climate models. Achieving accurate estimates for climate variables is especially challenging in the Alpine region, where spatio-temporal variability is exacerbated by complex topography and peculiar weather phenomena, and surface observations are rather scarce. This work aims to (1) assess the uncertainty of different high-resolution precipitation and temperature gridded products available over the Alps and (2) indirectly evaluate their accuracy by means of hydrological modelling. The HYPERstream model *(Piccolroaz et al. 2016)* is calibrated and run for the Alpine catchment of the river Adige (Italy), according to daily meteorological inputs from five datasets, namely E-OBS *(Haylock et al. 2008)*, MSWEP *(Beck et al. 2016)*, MESAN *(Landelius et al. 2016)*, APGD *(Isotta et al. 2014)* and ADIGE (a regional dataset), for the period 1989-2008. The datasets with the highest observational density, APGD and ADIGE, show similar spatio-temporal patterns of precipitation and provide high modeling efficiencies and small biases in simulated streamflow, at both catchment and sub-catchment scales. On the other hand, despite showing reasonable (albeit non optimal) results at the large catchment scale (thanks to counterbalancing effects), at smaller scales E-OBS, MESAN and MSWEP are found to be not accurate enough. Thanks to the use of hydrological modelling as an indirect and integrated evaluation tool, the different climate datasets are thus ranked according to their accuracy. In addition, their suitability for possible hydrological applications in impact studies is also determined.
[References: Beck et al. (2016), MSWEP: 3-hourly 0.25° global gridded precipitation (1979–2015) by merging gauge, satellite and reanalysis data, Hydrol. Earth Syst. Sci., Discuss., 21, 589-615, doi:10.5194/hess-21-589-2017. Haylock et al. (2008), A European daily high-resolution gridded dataset of surface temperature and precipitation, J. Geophys. Res., 113, D20119,

doi:10.1029/2008JD10201. Isotta et al. (2014), The climate of daily precipitation in the Alps: development and analysis of a high-resolution grid dataset from pan-Alpine rain-gauge data, Int. J. Climatol., 34, 1657–1675, doi:10.1002/joc.3794. Landelius et al. (2016), A high-resolution regional reanalysis for Europe. Part 2: 2D analysis of surface temperature, precipitation and wind, Q.J.R. Meteorol. Soc., 142, 2132–2142, doi:10.1002/qj.2813. Piccolroaz et al. (2016), HYPERstream: a multi-scale framework for streamflow routing in large-scale hydrological model, Hydrol. Earth Syst. Sci., 20, 2047–2061, doi:10.5194/hess-20-2047-2016.]

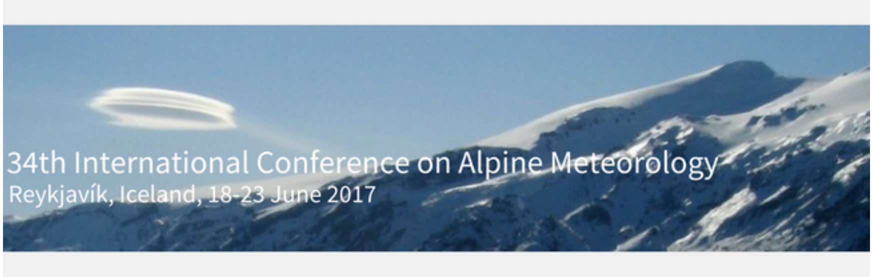
Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 89
Abstract code
Penetration and interruption of Alpine foehn (PIANO): Description of upcoming field experiment

Author - Gohm, Alexander, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Umek, Lukas , University of Innsbruck , Innsbruck , Austria
Topic Downslope windstorms, mountain waves and rotors
Keywords foehn, field experiment

Alpine foehn is one of the world's most intensively studied downslope windstorm. However, previous research has primarily focused on the well-developed stage rather than the complex initial and final stage of foehn. Hence, the mechanisms of foehn penetration into valleys and of foehn breakdown as well as the associated interaction of foehn with cooler air in the valley are still poorly understood. Potential processes responsible for the breakthrough and breakdown of foehn are, e.g., (I) large-scale air mass advection, (II) cold-air pool displacement and outflow, (III) turbulent mixing at the top of the cold pool, (IV) daytime heating and (V) nocturnal cooling of the boundary layer. Some of the previous studies disagree on which are the dominant processes. Furthermore, it is not clear to which extent todays high-resolution NWP models are able to represent these processes and, therefore, to predict the time of onset and decay of foehn.
In the framework of the recently started research project “Penetration and interruption of Alpine foehn (PIANO)” we aim at answering some of these open questions. In this conference contribution we will present the motivation and goals of the project. Furthermore, we will give an overview of the associated field experiment that will take place in fall 2017 in the Inn Valley (Austria). More specifically, the target area is the city of Innsbruck. The most important observing systems are three to four Doppler wind lidars (Halo Photonics Streamline) as well as the research aircraft DLR Cessna Grand Caravan. In order to support the planning of the field campaign, high-resolution numerical simulations have been conducted with the WRF model. First modeling results will be presented in an separate contribution.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 90
Abstract code
Integral length scales in atmospheric surface boundary layers

Author - Večenaj, Željko, University of Zagreb, Faculty of Science, Zagreb, Croatia (Presenting author)
Co-author(s) - Belušić, Danijel , Swedish Meteorological and Hydrological Institute , Norrköping , Sweden
Co-author(s) - Grisogono, Branko , University of Zagreb, Faculty of Science , Zagreb , Croatia
Topic Boundary layers and turbulence in complex terrain
Keywords

In many NWP and climate models with prognostic turbulence kinetic energy (TKE) equation, one can find that the TKE dissipation rate is parameterized via suitable ratio of TKE and some kind of a length scale. This length scale is often referred to as the integral length scale, l, and, in this case, a constant of proportionality, C, is introduced in the parameterization equation (PE). Estimation of C from real datasets will therefore be sensitive to the choice of l, and this can lead to inconsistencies in parameterization of ε in NWP and climate models. Regarding l, one can find a variety of different formulations in the literature. Most frequently used are integral scales derived from autocorrelation functions (so called 1/*e* and zero crossing scales) and scales at which a normalized Fourier spectra achieve their maximum values. Therefore, it appears that there is no consensus in the scientific community on the unique definition of l.
This work was initiated with the goal to estimate l and, after that, C for bora flows. For the analysis of bora flows, we used data obtained in the town of Senj settled at the north-eastern Adriatic coast (44.99°N, 14.90°E, 2 m above MSL). In the period from March 2004 to June 2006, WindMaster ultrasonic anemometer (Gill Instruments) mounted 13 m above the ground (at the very coast in Senj) recorded 294 bora events with cumulative duration of almost 7000 h. Possessing such a large dataset gives us an opportunity to estimate l, as well as C, and test the PE for bora's surface layer flows. Prior to this analysis, we used certain reference data to test different formulations of l mentioned above and choose the one that is most suitable for bora flows. These reference data include well known CASES99 dataset (which is considered as the reference data for a flat, homogeneous terrain) and T-REX dataset (which is considered as the reference data for a complex, mountainous terrain). Our results suggest that 1/e scale performs best as the integral scale for bora flows.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 91
Abstract code
Observational and numerical analysis of pulsations and turbulence in a bora downslope windstorm event

Author - Horvath, Kristian, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Vecenaj, Zeljko , Faculty of Science University of Zagreb , Zagreb , Croatia
Co-author(s) - Grisogono, Branko , Faculty of Science University of Zagreb , Zagreb , Croatia
Co-author(s) - Kosovic, Branko , National Center for Atmospheric Research , Boulder, CO , United States of America
Co-author(s) - Hrastinski, Mario , Meteorological and Hydrological Service , Zagreb , Croatia
Topic Downslope windstorms, mountain waves and rotors
Keywords bora; multiscale modelling, pulsations, TKE

Turbulent downslope windstorm events are frequent phenomena over complex terrain of the eastern Adriatic coast. While severe northern-Adriatic downslope windstorms are since long in the focus of interest, strong bora winds in the hinterland of middle Adriatic coast are much less studied, yet frequent and equally severe phenomena. The predictability of these events is considerably lower than for its northern counterpart due to the inflow complexity induced by the upwind chain of secondary orographic steep mountain sub-ranges and deep valleys. The aims of this work are first to study sub-mesoscale pulsations embedded in the bora flow and second, to study sources and sinks of bora turbulence through the analysis of the turbulence kinetic energy (TKE) budget.
The analyzed event was a strong late-winter anticyclonic bora (28 Apr 2010) in the very complex terrain, characterized by three-dimensional flow, shallow bora layer, a pronounced directional vertical wind shear and interaction with valley circulations in deep valleys. Observational analysis, performed with the use of ultrasonic anemometers at Pometeno brdo hill at 10, 22 and 40 m AGL, suggested that two distinct regimes of pulsations exist: i) Regime A – pulsations observed predominantly during the night and morning hours with periods of 3 – 8 minutes and ii) Regime B – pulsations observed predominantly during the afternoon with periods of 8-11 minutes.
Numerical analysis of the event used the WRF model with realistic initial and boundary conditions and multiple nested computational domains in two configurations. The first used a mesoscale model setup at a grid spacing reaching 333 m in the highest resolution domain and a Mellor-Yamada type of the Planetary Boundary Layer (PBL) scheme while the second used a multiscale setup at a grid spacing as fine as 37 m using explicit simulation of large turbulent eddies. The strongest simulated wind speed pulsations were of comparable periods as in the observations and originated beneath the primary mountain gravity wave. These pulsations propagated farther away from the point of origin during the daytime convective PBL than those during the statically stable nighttime conditions. The analysis of sensitivity simulations suggested that pulsations originate

beneath the primary mountain wave due to Kelvin-Helmholtz instability. Additionally, during daytime they are also found in the upstream flow. While mechanical production and dissipation of TKE are the dominant terms of the TKE budget, other terms such as turbulent transport and advection play an important role for the TKE budget. Finally, main differences in the bora subtle structure over the middle and northern Adriatic coastal areas, the latter pertaining to more known bora cases, are pointed out, as well as main differences between results in mesoscale and multiscale simulations.

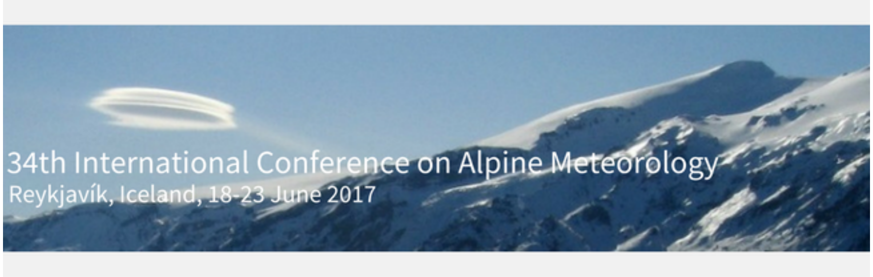
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 92
Abstract code
Forcing snow cover models with meteorological data to derive snow instability for avalanche forecasting

Author - Richter, Bettina, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland (Presenting author)
Co-author(s) - Schweizer, Jürg , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Rotach, Mathias W. , Institute of Atmospheric and Cryospheric Sciences , Innsbruck , Austria
Co-author(s) - Van Herwijnen, Alec , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Topic Cryosphere and mountain hydrology
Keywords avalanche forecasting; snow cover modeling;

In mountain regions in winter, snow avalanches are relatively frequent and widespread. To warn the public, avalanche forecasts are issued in many regions on a daily basis. The forecasting process is data-driven, but mainly experience-based. For example, snow instability is assessed by linking present snow stratigraphy with future weather. While information on snow stratigraphy plays a key role, obtaining such data is difficult and time consuming. The ability to forecast avalanches, i.e. predicting snow instability, is limited by current experience-based forecasting practices and the poor resolution in space and time of snow stratigraphy data that can only be overcome with numerical modeling. In this study, we therefore investigated the ability of the snow cover model SNOWPACK driven with meteorological data from automatic weather stations (AWS) to evaluate snow instability. Throughout two winter seasons we collected data on snow instability at two field sites above Davos, Switzerland. Both sites are equipped with an AWS and stability was assessed by evaluating the critical crack length from modeled snow properties and compared to results of in-situ propagation saw tests. Overall, the modeled temporal evolution of the critical crack length compared quite well with field measurements, although the increase in stability with time was overestimated by up to 40%. The discrepancy was explained by an overestimation of the density of the critical weak layer in the snow cover simulation. Using density derived from daily in-situ snow micro-penetrometer measurements improved the stability estimates to an error of 15%. This study shows that it is feasible to predict the critical crack length from snow cover simulations solely driven with meteorological data. Operational use of spatially distributed snow instability data derived from a numerical weather prediction model for numerical avalanche forecasting requires to further investigate influences of input uncertainties on modeled snow density and subsequently modeled snow instability.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



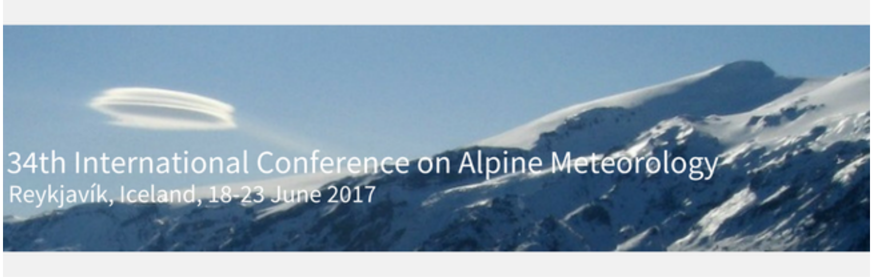
Abstract nr. 93
Abstract code

Convective plumes in a daytime valley atmosphere: Structure, scaling and flux contributions

Author - Babic, Nevio, University of Virginia, Charlottesville, United States of America (Presenting author)
Co-author(s) - De Wekker, Stephan , University of Virginia , Charlottesville , United States of America
Topic Boundary layers and turbulence in complex terrain
Keywords coherent structures, CBL, wavelet

Near-surface turbulent flow in the convective boundary layer (CBL) is usually characterized by a high degree of stochasticity, resulting in the need for a statistically oriented approach to describe its attributes. Even so, this turbulent flow oftentimes organizes itself in deterministically more describable formations. The most common example of these formations are coherent structures, defined as an organized three-dimensional region of turbulent flow in which some property (e.g. temperature) is highly correlated with itself at a time scale larger than the smallest scale of the flow. Daytime near-surface coherent structures (convective plumes) have received considerable attention over flat terrain and across the forest-canopy interface. On the other hand, convective plumes over complex terrain (e.g. a valley) have received very little attention. It is unknown to what degree convective plumes are influenced by flows in complex terrain. Interactions between coherent structure and complex terrain flows may cause substantial deviations in the flux contributions from those observed over flat terrain. Here we present preliminary results, with the aim to elucidate the structure of complex terrain convective plumes (frequency of occurence, mean duration) and their scaling properties.
The main dataset we analyze is comprised of high-frequency turbulence measurements obtained during the Terrain-Induced Rotor Experiment, conducted in the spring 2006 in Owens Valley, CA. Specifically, we analyze sonic temperature time series obtained on three 34-m towers. Each tower was equipped with 6 levels of sonic anemometers. Convective plumes are most easily discernible in the sonic temperature time series, with well defined ramp-like signatures. To determine their properties and contributions to vertical fluxes, we employ three methods: quadrant analysis, multiresolution flux decomposition and the wavelet covariance technique. To determine the scaling variables necessary for generalizing the parameterization relationships, we use: the inertial dissipation method to estimate viscous dissipation; detection of the peak in the velocity spectra for the determination of the CBL depth; and the Theodorsen ejection-amplifier (TEAL) scaling framework. The TEAL scaling, Monin-Obukhov scaling, free-convection scaling and mixed-layer scaling are compared and initial conclusions are drawn pertaining to the possibility of scaling convective plume properties and flux contributions in complex terrain.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 94
Abstract code

Glacio-hydrological modelling on few alpine catchments: from recent past simulation to scenarios of future evolution.

Author - LE LAY, Matthieu, EDF, Grenoble, France (Presenting author)
Co-author(s) - Gottardi, Frédéric , EDF , Grenoble , France
Co-author(s) - Brenot, Agnès , EDF , Grenoble , France
Co-author(s) - Gailhard, Joël , EDF , Grenoble , France
Co-author(s) - Garavaglia, Federico , EDF , Grenoble , France
Topic Cryosphere and mountain hydrology
Keywords glacier hydrology;modelling

On many alpine catchments, understanding the effect of glacier recession on streamflow response is crucial for modelling past hydrology and for predicting water resources in the next decades. This study aims to evaluate a glacio-hydrological model on both observed streamflow and glacier mass balance, on two partially glacierized catchments: the Upper Rhone in Switzerland (Rhone at Porte de Scex, 5237 km²) and the Arve in France (Arve at Arthaz, 1650 km²). In glacier hydrology, first challenge is the water balance closure, given that total annual runoff is affected by glacier mass balance. An empirical method derived from the Budyko approach is used to estimate a realistic rainfall input, consistent with an interannual glacier melt proxy. We then evaluate the performance of the MORDOR semi-distributed glacio-hydrological model to simulate river discharges, snow cover and glacier mass balance on long-term periods. Within this conceptual model, glacier melt is modelled by a classical temperature-index method and glacier area may be considered constant or variable. Model calibration and evaluation are performed on the two catchments of interest, considering not only runoff simulation, but also snow and glacier simulations. On evaluation periods, we show a very strong agreement between model and observations. The model simulates daily, seasonal and annual streamflows very consistently. In the same time snow cover dynamic and proxy mass balance (Aletsch and Argentiere glaciers) are precisely reproduced over several decades. Pluvial, nival and glacier contributions to the hydrological response are well identified. In the last part of this study, we model future streamflow response for these catchments, considering several CMIP5 climate projections and contrasted glacier evolution scenarios.

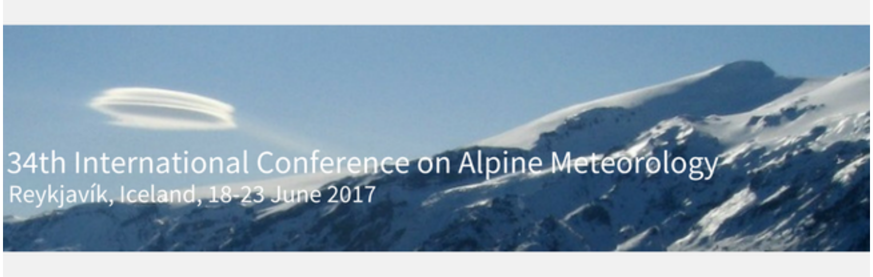
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 95
Abstract code
Wind speed analog-based predictions in complex topography

Author - Odak Plenkovic, Iris, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Delle Monache, Luca , Research Applications Laboratory, NCAR , Boulder , USA
Co-author(s) - Horvath, Kristian , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Hrastinski, Mario , Meteorological and Hydrological Service , Zagreb , Croatia
Topic Weather forecasting for mountainous regions
Keywords Analog-ensemble forecast; the ALADIN model;

Post-processing techniques improve weather prediction by combining dynamical and statistical information. Research on statistical post-processing is predominantly focused on the average case, while rare or extreme weather events, which are of high socio-economic impact, remain a substantial challenge. In order to improve predictions of rare and extreme weather events, the focus in this work is on a group of stations in coastal complex terrain prone to high wind speeds (e.g. bora wind). The analog-based predictions generated by Aire Limitée Adaptation dynamique Développement InterNational model (ALADIN) are tested at several climatologically and topographically different regions of Croatia for point-based wind speed predictions at 10 m AGL (Above Ground Level). The verification procedure is formulated and used to assess and improve the performance of analog-based wind speed predictions.
This study shows that deterministic analog-based predictions, compared to model used to generate them, improve the correlation between predictions and measurements while reducing bias and root-mean-square error. This is especially the case in the coastal complex terrain. Analog ensemble mean forecasts (AN) exhibit the highest correlation, while applying Kalman filter to the AN removes bias almost completely. Distribution of analog-based deterministic predictions of high wind speeds is more similar to the distribution of observations than the distribution of raw model or Kalman filter approach predictions, particularly for the small ensemble size. Furthermore, predictions of high wind speeds are improved by using additional predictors.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 96
Abstract code

GWOP’17: Gravity Waves, Orographic Precipitation and related processes in The Cerdanya-2017 field experiment

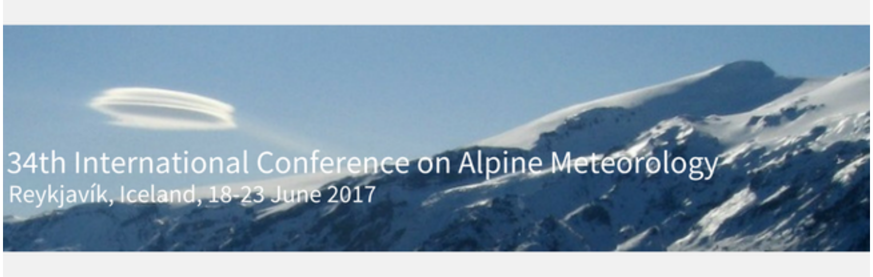
Author - Trapero, Andorran Research Institute (IEA-CENMA), Sant Julià De Lòria, Andorra (Presenting author)
Co-author(s) - J. , University of Barcelona (UB) , Barcelona , Spain
Co-author(s) - M.R. , University of Barcelona (UB) , Barcelona , Spain
Co-author(s) - M. , University of Barcelona (UB) , Barcelona , Spain
Co-author(s) - A. , Météo-France (MF) , Toulouse , France
Co-author(s) - A. , CENMA-IEA , Sant Julià De Lòria , Andorra
Co-author(s) - J. , Servei Meteorològic Catalunya (SMC) , Barcelona , Spain
Co-author(s) - J.R. , Servei Meteorològic Catalunya (SMC) , Barcelona , Spain
Co-author(s) - A. , Universitat Politècnica de Catalunya (UPC) , Barcelona , Spain
Co-author(s) - S. , Agencia Estatal de Meteorología (AEMET) , Madrid , Spain
Co-author(s) - A. , University of Barcelona (UB) , Barcelona , Spain
Topic Results from major field campaigns
Keywords Pyrenees; Cerdanya valley; mountain waves; orograp

The Pyrenees massif plays an important role in the atmospheric circulation usually triggering extreme meteorological phenomena. In the framework of the cross-frontier subproject GWOP’17 a field campaign has been devoted to Gravity Waves and Orographic Precipitation from December 2016 to April 2017. The 5 month field campaign took place over the Cerdanya Valley (Eastern Pyrenees) and was complemented with an intensive observation period from 10 January to 3 February 2017. The ground-based and remote sensing observing strategy was devised to characterize the gravity waves and associated phenomena as well as the description of the processes leading to orographically induced precipitation effects, including both enhancement and rain-shadow effects.

The main goals of GWOP'17 are to improve the knowledge of: 1) lee mountain waves and associated processes as rotors and subrotors and boundary layer separation, 2) the dynamics and microphysics of the precipitation processes influenced by orographic effects, with emphasis on heavy precipitation events, and 3) the interaction of gravity waves with cloud structures and its influence on precipitation processes in the Pyrenees.

An overview of the field campaign and a database of the selected case studies for process understanding and fine scale numerical modeling are presented in this work. Examples of observations recorded during selected events will be included, covering wind-profiler, microwave-radiometer, micro-rain radar and disdrometer datasets and preliminary results comparing field-campaign behavior with previous climatological observations.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 97
Abstract code

Comparison of different configurations of the TOUCANS system of turbulence parametrizations

Author - Hrastinski, Mario, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Horvath, Kristian , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Tudor, Martina , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Kovačić, Tomislav , Meteorological and Hydrological Service , Zagreb , Croatia
Co-author(s) - Odak Plenković, Iris , Meteorological and Hydrological Service , Zagreb , Croatia
Topic Boundary layers and turbulence in complex terrain
Keywords turbulence; TOUCANS; TKE; TTE; mixing length

Third Order moments Unified Condensation Accounting and N-dependent Solver – TOUCANS is a compact 2.5 level parametrization of turbulence, which integrates several ideas into its framework: non existence of critical Richardson number (Ri_{cr}), anisotropy of turbulence, prognostic treatment of Turbulent Kinetic Energy (TKE) and Total Turbulent Energy (TTE), inclusion of moisture influence on turbulence, as well as the possibility of prognostic treatment of mixing length and 3D turbulence parametrization. TOUCANS is based on the framework of four free parameters which influence the basic properties of the scheme and three functional dependencies which define the shape of stability functions. By adjusting the scheme parameters and modifying the stability component in functional dependencies, TOUCANS is able to emulate more advanced turbulence parametrizations like Quas-Normal Scale Elimination (QNSE) and Energy- and Flux-Budget (EFB). On the other hand, TOUCANS is able to go step backwards, i.e. it can emulate its long term predecessor – diagnostic Louis scheme.
In this work we use the emulation property of the TOUCANS system and compare the performance of turbulence parametrizations mentioned above, focusing on the TKE and covariances, along with the terms of the TKE budget equation. For this purpose we run the non-hydrostatic regional NWP ALADIN-HR 2 km horizontal grid spacing model with 37 vertical levels during the episode of bora downslope windstorm. Furthermore, we compare the performance of the currently operational Geleyn-Cedilnik mixing length formulation against TKE-based formulations, e.g. Bougeault-Lacarrere and Deardorff. Model outputs are verified against the three level (10, 22 and 40 m AGL) 3D 5 Hz ultrasonic tower measurements at the top of Pometeno Brdo (≈ 600 ASL) in the hinterland of Split, Croatia. Additionally, the results are compared to the WRF-LES simulations.
The observational and model analysis suggests dominant contribution of mechanic production and TKE dissipation terms of the TKE budget, but large portion of TKE also originates from the non-local turbulence. We discuss the applicability of the simplified 1D TKE budget equation to this bora case, as well as the impact of different configurations of the TOUCANS system to the TKE forecast, with an emphasis on the link between the TKE and mixing length.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

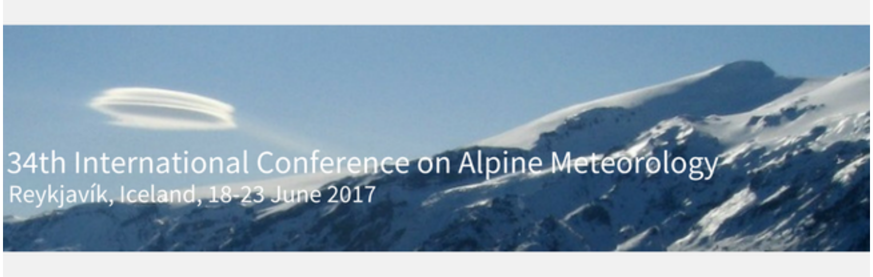
Abstract nr. 98
Abstract code
On forecasting snow surface temperature in complex alpine terrain

Author - Bellaire, Sascha, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland (Presenting author)
Co-author(s) - Sauter, Tobias , Institute of Geography, University of Erlangen-Nuremberg , Erlangen-Nuremberg , Germany
Co-author(s) - Rotach, Mathias W. , Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck , Innsbruck , Austria
Topic Weather forecasting for mountainous regions
Keywords numerical weather prediction, snow cover, energy b

Numerical weather prediction (NWP) is the core business of any operational weather service. The horizontal and vertical resolution of numerical weather prediction models strongly increased during the last decades. However, numerical weather prediction in complex terrain is still challenging, because the underlying physics in the majority of subgrid-scale parameterizations have been developed for flat or idealized terrain. Weather prediction in alpine countries – such as Austria or Switzerland – is not only challenged by complex topography, furthermore, for a good part of the year the ground is snow covered influencing boundary layer processes such as turbulence and radiation. Currently, most NWP models predict the formation and evolution of the seasonal mountain snow cover in a simplified way, i.e. often by means of a single layer model. For this study we validated the performance of the currently implemented snow cover scheme of the COSMO model (Consortium for Small-scale Modelling) in terms of the snow surface temperature, a key parameter for the evolution of the snow cover as well as the near-surface air temperature. In a case study snow surface temperature measured at an automated weather station over a 48-hour period was compared to the corresponding COSMO run at 2 km horizontal resolution. Snow surface temperature was found to be overestimated especially during the night. This corresponds to the performance of COSMO when 'climatologically' evaluating 2 m temperature at 120 sites in the Swiss Alps over a year. By implementing a multi-layer snow module, which minimizes the energy balance equation with regard to snow surface temperature and then iteratively solves the heat equation the daily cycle of the snow surface temperature can be predicted accurately. This procedure shows promising potential not only for an accurately modeled snow surface temperature – hence an improved snow cover evolution – it has also the potential to improve the NWP performance in predicting the near surface air temperature during snow covered periods.

Presentation Preference Oral
Audio/Visual Equipment
Awards

Additional information



Abstract nr. 99
Abstract code

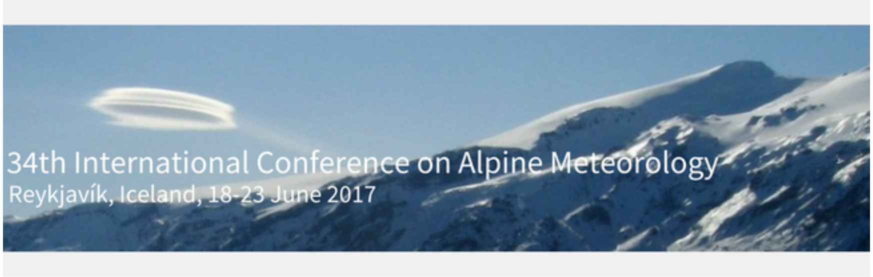
Measured and modeled snow cover properties across the Greenland Ice Sheet

Author - Bellaire, Sascha, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland (Presenting author)
Co-author(s) - Proksch, Martin , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Schneebeli, Martin , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Niwano, Masashi , Meteorological Research Institute, Japan Meteorological Agency , Tsukuba , Japan
Co-author(s) - Steffen, Konrad , Swiss Federal Institute for Forest, Snow and Landscape Research WSL , Birmensdorf , Switzerland
Topic Cryosphere and mountain hydrology
Keywords

The Greenland ice sheet (GrIS) is known to contribute to sea level rise in a warming climate. The snow cover on the ice sheet, which is the direct link between a potentially warmer atmosphere and the ice itself, is, however, poorly investigated and little is known about the microstructure and especially about the spatial and temporal variability of the snow cover, except from indirect evidence from remote sensing. During a field campaign in 2015 spatially distributed snow observations of the GrIS were gathered. This data set consists of high-resolution snow profiles located at stations of the Greenland Climate Network (GC-Net). Resistance profiles were measured with the SnowMicroPen (SMP) and used to estimate the density of the upper snow cover. In addition, snow samples from the upper snow cover were analyzed with regard to the specific surface area (SSA) using the IceCube. This data set of high-resolution snow microstructure measurements represents the first detailed dataset of observations since the 1950's. The snow cover model SNOWPACK was forced with reanalysis data from the model NHM-SMAP. The measured mean density of the upper snow cover was in good agreement with the simulations using constant densities for new snow deposition depending on the geographical location on the GrIS. However, the observed stratigraphy in terms of density and SSA could not be reproduced suggesting the need of a better understanding of the processes relevant in the formation of the snow stratigraphy and their model implementation. Furthermore, homogenous climatological conditions across the Greenland Ice Sheet might indicate that local post-depositional processes are more relevant for the formation and evolution of the snow stratigraphy than the meteorological conditions during precipitation events.

Presentation Preference Poster

Audio/Visual Equipment
Awards
Additional information



Abstract nr. 100
Abstract code
The thermally driven wind system of the Adige Valley in the Alps

Author - Giovannini, Lorenzo, University of Trento, Trento, Italy (Presenting author)
Co-author(s) - Laiti, Lavinia , University of Trento , Trento , Italy
Co-author(s) - Serafin, Stefano , University of Vienna, Department of Meteorology and Geophysics , Vienna , Austria
Co-author(s) - Zardi, Dino , University of Trento , Trento , Italy
Topic Boundary layers and turbulence in complex terrain
Keywords valley winds; pressure gradients

The Adige Valley is one of the main corridors connecting the Po Plain with the inner Alps. A series of permanent weather stations and one wind profiler provide a regular monitoring of air temperature, atmospheric pressure, global solar radiation, wind speed and direction over the 140-km valley length and in the adjacent plain. Data covering the period 2012-2014 are analysed, objectively selecting days in which favorable weather conditions allowed a full development of valley winds. The typical alternating pattern of diurnal upvalley winds –peaking in the afternoon– and nocturnal down-valley winds –weaker but persisting throughout the night– is clearly observed. This daily wind cycle is associated with a corresponding cycle of the horizontal pressure gradient, as shown by the daily oscillation of the surface-level pressure at the valley stations. In particular, the wind intensity depends linearly on the along-valley pressure gradient, supporting the concept of a quasi-steady balance between pressure gradient and surface friction. In accord with previous investigations, the amplitude of the surface pressure cycle increases in the up-valley direction, displaying the smallest and the largest values respectively over the Po Plain and in the uppermost valley, and causing the reversal of the horizontal pressure gradient twice a day. On the other hand, no appreciable differences in the amplitude of the near-surface temperature daily cycle are observed between the valley and the plain or between different sections of the valley. The combined analysis of temperature and pressure perturbations suggests that the increasingly larger surface level pressure perturbations in the upvalley direction are caused by the increased depth of the atmospheric layer subject to heating and cooling. Finally, the typical behaviour of valley winds is found to be locally altered by irregularities in the geometry of the valley, which presents narrower and wider sections. In particular, anomalous pressure gradients and a local modification of the typical cycle of down- and up-valley winds are observed in the vicinity of a large basin, where the valley widens significantly. Also the presence of major urban areas, which affect the temperature of the lowest atmospheric layers, is found to alter the development of down-valley winds, inducing local wind convergence over cities during nighttime.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information

Abstract nr. 101
Abstract code

Air quality management along the Brenner corridor in the Italian Alps: the BrennerLEC project

Author - Giovannini, Lorenzo, University of Trento, Trento, Italy (Presenting author)
Co-author(s) - Antonacci, Gianluca , CISMA s.r.l. , Bolzano , Italy
Co-author(s) - Cavaliere, Roberto , IDM Südtirol / Alto Adige , Bolzano , Italy
Co-author(s) - De Biasi, Ilaria , Autostrada del Brennero Spa , Trento , Italy
Co-author(s) - Guariento, Massimo , Environmental Protection Agency of the Province of Bolzano , Bolzano , Italy
Co-author(s) - Pretto, Laura , Environmental Protection Agency of the Province of Trento , Trento , Italy
Co-author(s) - Ragazzi, Marco , University of Trento , Trento , Italy
Co-author(s) - Schiavon, Marco , University of Trento , Trento , Italy
Co-author(s) - Zardi, Dino , University of Trento , Trento , Italy
Topic Boundary layers and turbulence in complex terrain
Keywords Air quality, weather and air quality forecasts

“BrennerLEC” (Brenner Lower Emissions Corridor) is an European LIFE project aiming at testing and applying an advanced “environmental traffic management” system on the Italian A22 highway, in order to reduce pollutants, and in particular NOx emissions. The A22 highway is one of the main North-South transit route crossing the Alps and connecting Austria to the Po Plain through the Brenner Pass and the Adige Valley. In the region road traffic is responsible for about 60% of all NOx emissions, one third of which being generated by highway traffic. Air pollutant emissions generated by road traffic are the main cause of the exceedances of the annual NO_2 average law limits registered in the past years: this situation is particularly critical since conditions of poor air quality mainly refer to locations where the majority of the inhabitants live.
A dense network of meteorological, including sonic anemometers, and air quality sensors is going to be implemented for the project, aiming at fully characterising air quality conditions along the highway and traffic-induced turbulence. The air quality network will be composed not only of conventional sensors but also of innovative and low-cost instruments for monitoring NOx. During the project the performance of this kind of sensors under true ambient conditions will be continuously monitored, by comparing their measurements against the conventional stations, providing the basis for enhanced understanding of the accuracy of these instruments in changing environmental conditions. In fact, evaluation of the performance of innovative instruments is still limited and mainly based on laboratory experiments. Another innovative aspect connected to environmental monitoring is the measurement of black carbon (BC), which will be performed using aethalometers working at different wavelengths, in order to discriminate between BC emitted from traffic and from biomass burning.
Moreover, during the project an advanced modelling chain, composed of integrated

meteorological, air quality and traffic models, will be developed to support the extensive testing and application of temporary reduction of speed limits connected to critical air quality situations. Meteorological forecasts will be performed using the Weather Research and Forecasting (WRF) model, down to a resolution of 1 km. Operational meteorological forecasts will take advantage of data assimilated by a dense network of surface stations, both installed specifically for the project and operated by the local meteorological offices, including a thermal profiler and a wind profiler. Air quality forecasts, performed using the CALPUFF and AUSTAL2000 dispersion models, will provide the decision support tool for the application of reduced speed limits on the highway, in order to maximize the benefits of the policies implemented limiting negative impacts for the highway users, by putting in action measures only when necessary and anticipating environmental issues.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 102
Abstract code

Use of a sub-grid orographic rain enhancement scheme in the MetUM

Author - Smith, Samantha, Met Office, EX1 3PB, United Kingdom (Presenting author)
Co-author(s) - Field, Paul , Met Office , Exeter , United Kingdom
Co-author(s) - Vosper, Simon , Met Office , Exeter , United Kingdom
Topic Orographic precipitation
Keywords Seeder feeder

At low resolution, numerical models are unable to produce enough orographic rain due to their poor representation of surface height variations (Smith et al 2015). Therefore a subgrid parameterisation scheme has been designed to represent seeder feeder rain enhancement produced by unresolved hills (Smith et al 2016). An estimate of the extra orographic water produced by ascent over unresolved hills is used by the microphysics scheme to enhance the rain accretion rate. In Smith et al, the scheme was tested using the idealised Kinematic Driver (KiD) model and it was shown to perform well in the warm, moist low-level flow typically encountered during orographic rain enhancement over the UK. The scheme is now being coded into the Met Office Unified model (MetUM) and some initial results will be described.

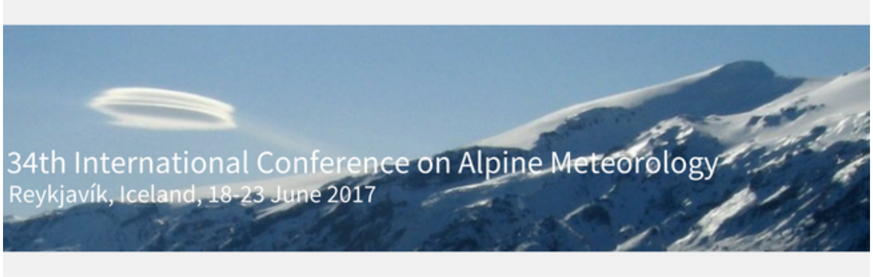
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 103
Abstract code
Greenhouse gas budgets and convective boundary layer heights in mountainous terrain

Author - Duine, Gert-Jan, University of Virginia, Charlottesville, USA (Presenting author)
Co-author(s) - De Wekker, Stephan FJ , University of Virginia , Charlottesville , USA
Topic Boundary layers and turbulence in complex terrain
Keywords budget method; horizontal grid spacing

The rise of greenhouse gases, like carbon dioxide (CO2), has led to an increasing interest in CO2 budget estimations from both science and policy perspectives. Studies have indicated that half or more of the US gross primary production of CO2 is from mountainous regions. Currently, regional-to-continental scale CO2 budgets are estimated using coarse global models that have horizontal grid spacings on the order of 50-100 km. A correct simulation of planetary boundary layer is crucial for the accurate estimation of CO2 budgets. Duine and De Wekker (2017) showed that as a consequence of terrain smoothing, convective boundary layer (CBL) depths are overestimated in coarse grid domains and physical and dynamical processes that are important for the transport and mixing of CO2 are poorly simulated in mountainous terrain. This inevitably leads to errors in CO2 budget calculations. In this poster, we use simulations of the Weather Research & Forecasting (WRF)-Chem model to investigate the impact of horizontal grid spacing on trace gas budgets in mountainous terrain using the boundary-layer budget method. A better understanding of this impact and its representation in large scale models would lead to an improved simulation and understanding of the location and quantification of North American and global carbon sources and sinks.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

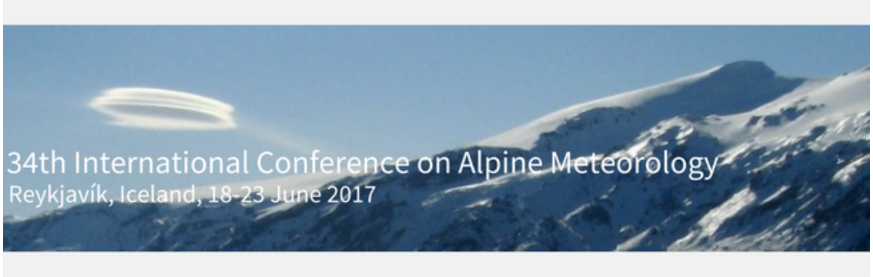


Abstract nr. 104
Abstract code
How do orographic and non-orographic gravity wave events during DEEPWAVE compare in measurements and ECMWF model data?

Author - Portele, Tanja Christina, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Weßling, Germany (Presenting author)
Co-author(s) - Dörnbrack, Andreas , Deutsches Zentrum für Luft- und Raumfahrt (DLR) , Weßling , Germany
Topic Results from major field campaigns
Keywords Orographic GW; non-orographic GW

The DEEP propagating gravity WAVE experiment (DEEPWAVE) took place in and around New Zealand during austral winter 2014. The design of the campaign allowed to measure gravity waves (GW) excited from various sources, and their propagation through the atmosphere up to their dissipation. Extensive surveys were conducted over land and sea. Within 26 missions, the NSF/NCAR Gulfstream V (GV) aircraft performed 2/5 of all flight legs over the Southern Alps of New Zealand and 3/5 over the Tasman Sea and the Southern Ocean. This allows to study both orographically induced and non-orographic gravity waves.
During the DEEPWAVE intensive observing period (IOP) 9, the main focus was on the observation of orographically induced GW over the Southern Alps. Cross-mountain legs were flown within four subsequent research flights by the GV and the DLR Falcon aircraft covering 2 days. During IOP 16, the GV research flight (RF) 25 was performed over the Southern Ocean. This flight was dedicated to the observation of GW without any orographic source. These GW are expected to be either related to a tropopause jet or to the stratospheric polar night jet.
Those two wave events are juxtaposed by means of available measurements (e.g. aircraft insitu, lidar, airglow imager, radiosondes, dropsondes) and the derived wave properties. GW scales and amplitudes, as well as their altitude range of occurrence and their temporal evolution are examined. Those are then compared to their representation in ECMWF IFS operational analyses and forecasts and further analysed using normal modes analysis. This allows to assess the differences between orographic and non-orographic wave representation in ECMWF and their conformity with the observations.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 105
Abstract code

Impact of along-valley orographic variations on the dispersion of passive tracers in a stable atmosphere: an idealized study.

Author - Quimbayo-Duarte, Julian, Université Grenoble Alpes, Grenoble, France (Presenting author)
Co-author(s) - Staquet, Chantal , Université Grenoble Alpes , Grenoble , France
Co-author(s) - Chemel, Charles , University of Hertfordshire , Hatfield , United Kingdom
Co-author(s) - Arduini, Gabriele , University of Hertfordshire , Hatfield , United Kingdom
Topic Boundary layers and turbulence in complex terrain
Keywords Valley-flows; Numerical modelling;Tracer transport

During wintertime, mountain valleys frequently experience very stable and dynamically-decoupled atmospheric conditions leading to air pollution episodes. Under such conditions, the valley-wind system (consisting of thermally-driven down-slope and down-valley flows) plays a key role in the ventilation of the valley atmosphere. High-resolution numerical simulations using the Weather Research and Forecasting model have been performed for two different configurations of three-dimensional valleys opening onto a plain. The first configuration corresponds to a single valley opening onto a plain (draining case). The second one consists in a system of two valleys sharing the same axis, one valley opening on a narrower valley which opens on the plain (pooling case); the former and latter valleys are referred to as the upstream and downstream valleys, respectively. The aim of this work is to investigate the response of the transport of pollutants, modelled as passive tracers, to orographic variations along the valley axis during night-time.

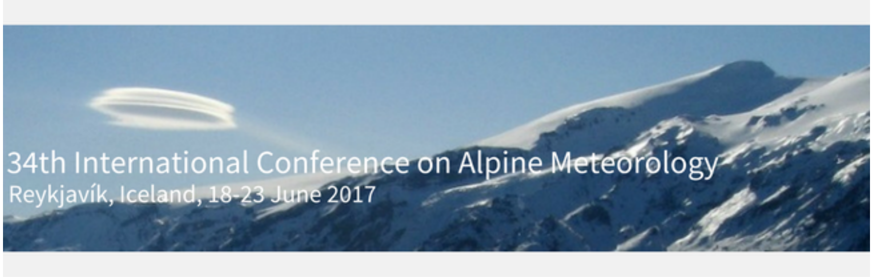
The difference in the thermal structure of the valley and the plain atmosphere generates a horizontal pressure gradient leading to the development of the down-valley flow. This flow is the major driver of pollutant dispersion within and out of the valley. Along-valley variations in the valley width produce diverse responses of pollutant transport, from a long-lasting stagnation in the pooling case to a full ventilation in the draining case. For the latter case however, results are very sensitive to the ambient stratification.

When considering the draining case, results show that both the down-slope and down-valley flows display temporal oscillations of similar frequency, which is set by that of the down-slope flow. Most importantly, these oscillations are imprinted on the tracer field (as is expected) with amplitude for some short time periods as high as 30% of the mean concentration value. Once the down-valley flow is fully developed, three independent layers can be identified along the vertical within the valley atmosphere regardless of the ambient stratification. The height of the first layer close to the ground is limited by the first jet maxima. Tracers released at ground level before sunset remain trapped within this first layer for the entire night. Regardless of the initial stratification of the atmosphere (from 1.5 K/km to 6 K/km), all layers appear to be completely independent of each other, leading to a mainly horizontal dispersion of the tracers released within each layer. For the

strongest stratification considered, the down-valley wind is strongly reduced, leading to very weak pollutant transport and, in practice, a quasi-stagnation of the tracers close to their emission source.

For the pooling case, preliminary results show that the impact of the narrower downstream valley on the pollutant concentration field in the upstream valley is major. Ventilation can indeed be completely suppressed during the first 4 hours after sunset due to the development of an up-valley wind in the downstream valley. Further results will be discussed at the conference.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



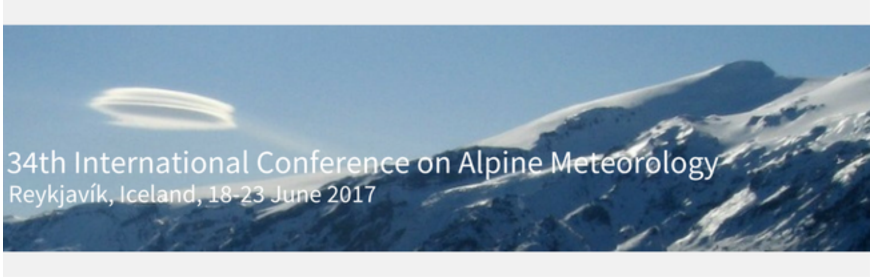
Abstract nr. 106
Abstract code

Large eddy simulation of snowfall preferential deposition over complex topography

Author - Comola, Francesco, Swiss Federal Institute of Technology, Lausanne, Switzerland (Presenting author)
Co-author(s) - Giometto, Marco G. , University of British Columbia , Vancouver , Canada
Co-author(s) - Parlange, Marc B. , University of British Columbia , Vancouver , Canada
Co-author(s) - Lehning, Michael , WSL Institute for Snow and Avalanche Research, SLF , Davos , Switzerland
Topic Boundary layers and turbulence in complex terrain
Keywords snow; turbulence; deposition; hill

Snowfall preferential deposition is a significant control on the spatial variability of snow depth in complex terrain. As such, it plays a key role in avalanche formation, hydrologic response, and water resource management in alpine regions. Here, we investigate the role of near-surface flow-particle interactions, as opposed to larger scale orographic processes, in driving preferential deposition at hillslope scale. We perform large eddy simulations (LES) of turbulent flows over Gaussian hills, accounting for the effect of the complex topography with an immersed boundary method (IBM). We compute the trajectories of falling snow in the turbulent flow with a Lagrangian stochastic model (LSM) driven by the LES fields. We first validate our modeling approach against wind tunnel experiments of dust deposition over ranges of hills. We then apply the model to simulate snowfall deposition over isolated hills and study the sensitivity of the deposition pattern to variations in the particle Stokes number and Froude number. The model results suggest that snow depth is generally smaller on the slopes than on the flat terrain. Snow deposition on the leeward slope, however, increases with decreasing the Stokes number, that is, when flow advection becomes relevant with respect to particle inertia. Flow advection, in fact, keeps particles aloft in the updrafts over the windward slope and enhances settling in the recirculation region. Conversely, snow deposition on the windward slope increases with increasing the Froude number, i.e., when particle inertia becomes relevant with respect to gravity. We finally show that the deposition pattern is also significantly affected by the steepness of the hill. Overall, our study singles out and indentifies the controls of advection, inertia, gravity, and hill steepness on preferential snow deposition. As such, it can provide solid guidelines for improved quantifications of snow depth spatial variability in alpine terrain under different wind conditions.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 107

Abstract code

The Cerdanya-2017 field experiment: an overview of the campaign and a few preliminary results

Author - Paci, Alexandre, METEO-FRANCE & CNRS, Toulouse, France (Presenting author)
Co-author(s) - Cuxart, Joan , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - Bech, Joan , University of Barcelona , Barcelona , Spain
Co-author(s) - Soler, Maria Rosa , University of Barcelona , Barcelona , Spain
Co-author(s) - Miró, Josep Ramon , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Aressy, Patrick , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Arús, Joan , AEMET , Madrid , Spain
Co-author(s) - Barrié, Joël , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Bouhours, Gilles , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Bravo, Manel , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Cayez, Grégoire , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Conangla, Laura , Universitat Politècnica de Catalunya , Manresa , Spain
Co-author(s) - Couzinier, Jacques , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Dabas, Alain , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Defoy, Stephan , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Donier, Jean-Marie , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Douffet, Thierry , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Dumas, Hélène , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Ferreres, Enriqueta , Universitat Politècnica de Catalunya , Manresa , Spain
Co-author(s) - Garrouste, Olivier , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Georgis, Jean-Francois , Laboratoire d'Aérologie , Toulouse , France
Co-author(s) - Girres, Sandrine , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - González, Sergio , AEMET , Madrid , Spain
Co-author(s) - Guillot, Rémi , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Jiménez, Maria Antònia , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - López, Alvaro , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - Martí, Belén , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - Martínez-Villagrasa, Daniel , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - Maurel, William , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Mercarder, Jordi , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Moliné, Gilles , Université Grenoble-Alpes , Grenoble , France
Co-author(s) - Moulin, Eric , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Pepin, Nick , University of Portsmouth , Portsmouth , United Kingdom
Co-author(s) - Picos, Rodrigo , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - Roberts, Greg , METEO-FRANCE & CNRS , Toulouse , France

Co-author(s) - Sabatier, Tiphaine , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Sairouni, Abdelmalik , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Simó, Gemma , University of Balearic Islands , Palma de Mallorca , Spain
Co-author(s) - Soula, Serge , Laboratoire d'Aérologie , Toulouse , France
Co-author(s) - Tabarelli, Davide , Universitá degli studi do Trento , Trento , Italy
Co-author(s) - Trapero, Laura , CENMA - IEA , Sant Julià de Lòria , Andorra
Co-author(s) - Udina, Mireia , University of Barcelona , Barcelona , Spain
Co-author(s) - Unger, Vinciane , METEO-FRANCE & CNRS , Toulouse , France
Co-author(s) - Veciana, Roger , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Wrenger, Burkhard , Hochschule Ostwestfalen-Lippe , Höxter , Germany
Co-author(s) - Zardi, Dino , Universitá degli studi do Trento , Trento , Italy
Topic Results from major field campaigns
Keywords cold pool; mountain waves;orographic precipitation

La Cerdanya is one of the largest valley of the Pyrenees mountain range, spreading across Spain and France (between Occitanie and Catalunya). It is about 10 km wide and 35 km long oriented ENE-WSW (whereas most valley in the Pyrenees are oriented N-S) with a relatively flat bottom at about 1000 m above sea level and mountain ridge around rising above 2900 m.
The field experiment Cerdanya-2017 took place in this valley from October 2016 to April 2017, focusing on three meteorological phenomena in mountainous terrain: cold pool, mountain waves and orographic precipitations.
The Cerdanya-2017 field experiment focuses in particular on the detailed inversion structure and the surface energy budget of cold pool, rotors and boundary layer separation in mountain waves situations, and orographic triggering and intensification of precipitations under stratiform and convective regimes.
An overview of the field experiment, the instruments and the meteorological situations observed will be presented first. Then some preliminary results regarding in particular fine scale circulation within the valley and numerical weather prediction model performance will be shown.
This research is a joint effort of several teams from the Euroregion Pyrenees-Mediterranean, these teams belong to the Universities of the Balearic Islands and of Barcelona, METEO-FRANCE & CNRS and the Meteorological Service of Catalonia.

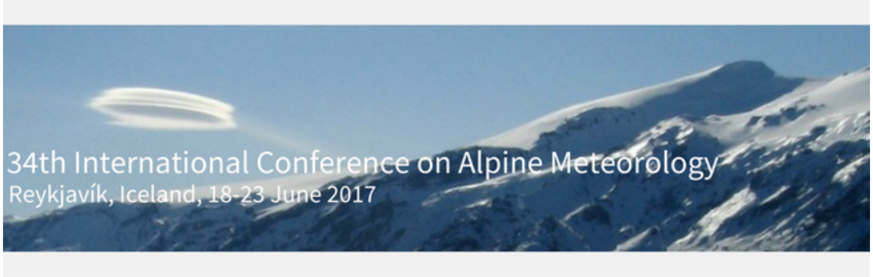
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 108
Abstract code
On forecasting wet-snow avalanche activity using simulated snow cover data

Author - Bellaire, Sascha, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland (Presenting author)
Co-author(s) - Van Herwijnen, Alec , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Bavay, Mathias , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Techel, Frank , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Mitterer, Christoph , Avalanche Warning Service Tyrol , Innsbruck , Austria
Co-author(s) - Schweizer, Jürg , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Topic Cryosphere and mountain hydrology
Keywords

Wet-snow avalanches are relatively poorly understood and difficult to forecast. By definition, liquid water is a prerequisite for wet-snow avalanche formation, thus assessing the liquid water content of the snow cover is of paramount importance for wet-snow avalanche forecasting. While evaluating wet-snow instability through field measurements is difficult, physically based snow cover models can be used to estimate the amount of liquid water within the snow cover using meteorological input. Recently, an index based on the liquid water content of the snow cover was suggested showing high potential to predict the onset of wet-snow avalanche activity. However, as the snow cover model was forced with data from automated weather stations (AWS) only a now-cast was possible. As snow cover conditions quickly change during snow melt, a forecast would be useful. For this study, we therefore force the snow cover model SNOWPACK with data from the high-resolution numerical weather prediction model COSMO and investigate whether forecasting regional patterns of the onset of wet-snow avalanche activity is feasible. To validate the index, we compared simulations performed at the location of numerous AWS in the Swiss Alps with wet-snow avalanche observations from the corresponding region. By forcing SNOWPACK with data from automated weather stations up to the actual day and then adding the forecasted input data to produce a forecast lead to results comparable to the simulations with station data only. While using this combined setup, the index was able to predict the onset of wet-snow avalanching with reasonable accuracy (up to 74%) for three winters between 2013 and 2016 and for two different climate regions in Switzerland. In addition, we will present preliminary results on the first operational winter season 2016-2017.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

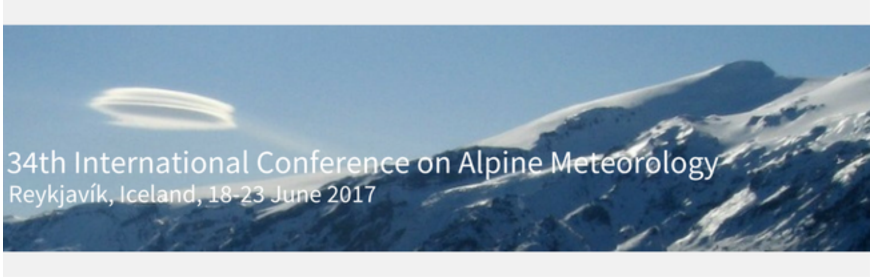


Abstract nr. 109
Abstract code
Investigating time scales in the meteorological forcing on snow avalanche activity

Author - Van Herwijnen, Alec, WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland (Presenting author)
Co-author(s) - Nebel, Konstantin , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Heck, Matthias , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Co-author(s) - Schweizer, Jürg , WSL Institute for Snow and Avalanche Research SLF , Davos , Switzerland
Topic Cryosphere and mountain hydrology
Keywords snow avalanches

Snow avalanches are a major natural hazard in snow covered mountainous areas and are considered a meteorologically induced hazard. Forecasting snow avalanches therefore requires a detailed understanding of the meteorological forcing on avalanche activity. Data on avalanche activity are generally obtained through visual observations, which are imprecise and impossible when visibility is limited. This leads to large uncertainties in the number and exact timing of avalanches, resulting in rather poor correlations between avalanche activity and meteorological parameters. We therefore used unique avalanche activity catalogues obtained through seismic monitoring to establish links between avalanche activity and local meteorological parameters. To identify characteristic time scales associated with the onset of avalanche activity and relaxation time scales associated with a return to stability we performed a de-trended cross-correlation analysis (DCCA). Our results suggest that typical time scales for wet-snow avalanches in spring are on the order of several hours to one day, while for dry-snow avalanches in winter time scales are on the order of a few days. Furthermore, a moving window DCCA showed that different meteorological drivers are related to increased avalanche activity throughout a season. While air temperature and incoming solar radiation are the dominant drivers in early spring, wind and precipitation correlated best with avalanche activity during winter and in late spring. Overall, our results show that accurate avalanche activity data can be used to improve our knowledge on avalanche formation processes and ultimately improve their forecasting using readily available meteorological data.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 110
Abstract code

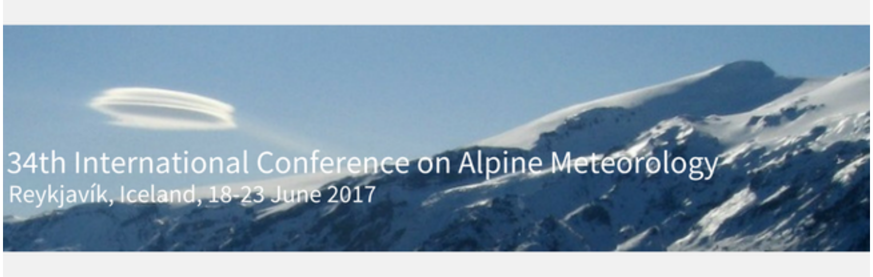
Interactions of a mesoscale katabatic flow with a small crater basin to produce cold and warm air intrusions, flow bifurcations and a hydraulic jump

Author - Whiteman, Dave, University of Utah, Salt Lake City, United States of America (Presenting author)
Co-author(s) - Lehner, Manuela , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Hoch, Sebastian , University of Utah , Salt Lake City , United States of America
Co-author(s) - Adler, Bianca , University of Karlsruhe , Karlsruhe , Germany
Co-author(s) - Kalthoff, Norbert , University of Karlsruhe , Karlsruhe , Germany
Co-author(s) - Vogt, Roland , University of Basel , Basel , Switzerland
Co-author(s) - Feigenwinter, Iris , University of Basel , Basel , Switzerland
Co-author(s) - Haiden, Thomas , ECMWF , Reading , United Kingdom
Co-author(s) - Rotunno, Rich , National Center for Atmospheric Research , Boulder , United States of America
Co-author(s) - Hills, Matthew , University of Utah , Salt Lake City , United States of America
Topic Results from major field campaigns
Keywords

Observations from the Second Meteor Crater Experiment (METCRAX II) on the night of 19-20 October 2013 are used to investigate the interactions between a regional scale katabatic flow and Arizona's Meteor Crater. The crater is a 1.2 km wide, 170-m-deep, near-circular basin with a rim that extends 30-50 m above the plain. On clear, quiescent nights a southwesterly katabatic flow lifts the stable boundary layer (SBL) on the 1° tilted plain over the crater rim to produce a continuous inflow of negatively buoyant air that runs down the crater's inner sidewall. As the SBL deepens and the katabatic flow strengthens, a flow bifurcation forms above the rim with the negatively buoyant lower portion running down the inner sidewall to produce a hydraulic jump and the neutrally buoyant upper portion carried quasi-horizontally over the basin. Unsteady short waves form in this overflow behind the rim. As the stable layer continues to deepen and a mesoscale downslope flow develops above the katabatic flow, a high-amplitude short wave develops in the lee of the rim bringing warm air from the elevated residual layer downward into the basin. Interactions between the continuous cold-air intrusion and the descending lee wave accelerate the flow down the slope to enhance the hydraulic jump, which then reaches vertically to merge with the rising air in the ascending portion of the lee wave. The strong winds penetrate to the basin floor, displacing and stirring the pre-existing, intensely stable, cold pool and creating warm air streaks.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information



Abstract nr. 111
Abstract code

Local and non-local controls on a persistent cold-air pool in the Arve River Valley

Author - Chemel, Charles, University of Hertfordshire, Hatfield, United Kingdom (Presenting author)
Co-author(s) - Arduini, Gabriele , University of Hertfordshire , Hatfield , United Kingdom
Co-author(s) - Staquet, Chantal , University Grenoble Alpes , Grenoble , France
Topic Boundary layers and turbulence in complex terrain
Keywords

The Weather Research and Forecasting numerical model is used to simulate the life cycle of a persistent cold-air pool (CAP) event that occurred between 9 and 14 February 2015 in the section of the Arve River Valley between Cluses and Servoz in the French Alps. This section of valley presents three major tributaries. During this period, an upper-level ridge from the Atlantic moved quickly over Europe, allowing a CAP to form and persist over time. Model outputs are in good agreement with observations collected during the PASSY-2015 field campaign, in particular the temporal evolution of the vertical structure of the CAP is well captured throughout the episode.
The impact of the moving upper-level ridge on the flows through the tributaries and thus on the thermal structure of the CAP and the dynamics within the valley section is quantified, by examining the heat and mass budgets of the valley volume. The real-case numerical results are contrasted with those from a semi-idealised numerical simulation initialised with a horizontally homogeneous atmosphere and the wind speed set to zero across the domain.
During the persistent stage of the CAP life cycle the flow from the tributary valleys controls by and large the nighttime valley-scale circulation. Indeed, the mass budget over the valley volume shows that mass fluxes through the tributaries account for 70 to 90% of the along-valley drainage out of the valley section when averaged over the course of the night. It can exceed 100% (resulting in a vertical transport of mass out of the valley) when the upper-level ridge passed over the area and a strong down-valley flow formed in one of the tributary valley. However, because of the strong stratification of the CAP the inflow from the tributaries detrain at the top of the CAP, thereby gradually eroding the CAP during nighttime and generating valley-scale standing waves (seiches) within the CAP. The thermal structure of the near-surface inversion layer is primarily locally controlled by the divergence of the radiative and turbulent fluxes and advection from thermally-driven flows. The seiches within the CAP associated with the non-local effects resulting from the flows from the tributaries modulate the thermally-driven flows and so the near-surface drainage of cold air out of the valley section.

Presentation Preference Oral
Audio/Visual Equipment

Awards

Additional information

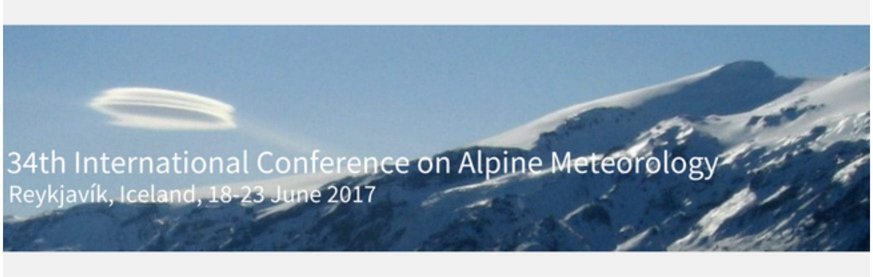
Abstract nr. 112
Abstract code
Lidar observations and high-resolution modelling of a wind jet at the exit of the Isarco Valley (Italy)

Author - Falocchi, Marco, University of Trento, Trento, Italy (Presenting author)
Co-author(s) - Giovannini, Lorenzo , University of Trento , Trento , Italy
Co-author(s) - Tomasi, Elena , University of Trento , Trento , Italy
Co-author(s) - Antonacci, Gianluca , CISMA s.r.l. , Bolzano , Italy
Co-author(s) - Pallaveri, Tommaso , University of Trento , Trento , Italy
Co-author(s) - Zardi, Dino , University of Trento , Trento , Italy
Topic Results from major field campaigns
Keywords valley exit jet

The Isarco Valley is one of the main tributary valleys that feed into the Bolzano basin, in theCentral Italian Alps. The wind field in this area is characterised by a very complex behaviour, due to the interaction between the local thermally-driven circulations, that daily develop in the different valleys joining the basin.
Recently it was observed that the nocturnal drainage flow at the exit of the Isarco Valley behaves like a low-level jet with peak intensities between 5 and 10 m s^{-1}. The topography of the valley is indeed suitable for the development of such a flow, since it is characterised by narrow cross sections up to its outlet in the Bolzano basin. A Doppler wind lidar (WindCube100S, Leosphere) was installed in the period January-March 2017 at the outlet of the Isarco Valley, in order to monitor the wind field at the exit of the valley. The experimental dataset is completed by a sodar and by a thermal profiler installed in the Bolzano basin and by several surface weather stations. Different scans with the lidar were carried out using different spatial resolutions, to capture the structure and the dynamics of the jet both in the Isarco Valley and in the Bolzano basin. A correlation of the shape of the jet with the influence of synoptic forcing and with the presence of thermal inversions was observed. In particular the presence (absence) of synoptic forcing determines the development of dynamically-driven (thermally-driven) jets. Ground-based and upper thermal inversions modify the vertical profile of the jet from a wall-jet-like profile to a free-jet-like one.
In this contribution results obtained from the experimental dataset are presented. Moreover observations are complemented by high-resolution numerical simulations performed with the WRF model, in order to get a complete three-dimensional picture of the development of the valley exit jet and to evaluate its spreading into the Bolzano basin.

Presentation Preference Oral
Audio/Visual Equipment
Awards

Additional information



Abstract nr. 113
Abstract code

On the relationship between atmospheric dynamics and PM10 concentration in the Arve Valley around Passy

Author - Staquet, Chantal, University Grenoble Alpes, Grenoble, France (Presenting author)
Co-author(s) - Quimbayo Duarte, Julian , LEGI, University Grenoble Alpes , Grenoble , France
Co-author(s) - Todzo, Stella , LEGI, University Grenoble Alpes , Grenoble , France
Co-author(s) - Peinke, Isabel , LEGI, University Grenoble Alpes , Grenoble , France
Co-author(s) - Arduini, Gabriele , CAIR, University of Hertfordshire , Hatfield , France
Co-author(s) - Chemel, Charles , CAIR, University of Hertfordshire , Hatfield , United Kingdom
Co-author(s) - Troude, Florence , Atmo Auvergne-Rhône-Alpes , Bron , France
Topic Boundary layers and turbulence in complex terrain
Keywords

During wintertime anticyclonic episodes the urbanized Arve valley in the French Alps displays a strong spatial heterogeneity in air pollution, which raises questions about the ventilation processes in this valley. The highest concentration levels are usually recorded in the city of Passy during these episodes, which motivates the present study. Our aim is to understand the role of valley geometry and of the tributary valleys in the ventilation processes and associated impacts on pollutant concentrations, considering that spatial and temporal variations in pollutant emissions are known. Field data are used for this purpose: the three velocity components recorded by a wind Lidar located at the valley floor in Passy and scanning from 40 m to about 500 m above ground level, the temperature recorded on a tethered balloon platform and in ground-based stations, and the ground-level PM10 concentration at a few routine monitoring sites managed by the local air quality agency. As an attempt to get a general view of the atmospheric dynamics in the valley during wintertime polluted episodes, three very polluted episodes are considered, in January 2015, February 2015 and December 2016. Realistic numerical modelling of the February episode (to be presented in a separate communication at this meeting) also helps in interpreting the field data. The February episode corresponds to an IOP of the PASSY-2015 field campaign (Paci et al 2016). The geography of the Arve valley in its most polluted part, around Passy, is already very specific. This section of the valley is indeed nearly closed at both ends, with a strong narrowing downstream and a pass leading to Chamonix upstream, 500 m above the valley floor. Two tributary valleys open onto this valley section on its south side.
Regardless of the episode considered, the analysis of the field data collected in Passy shows that the dominant wind close to the ground is down-valley for the most part of the day and displays oscillations about a very weak mean value, less than 1 m/s. Three factors account for this very weak wind: (i) the presence of the pass upstream, (ii) the very strong temperature gradient close to the ground (resulting in wind kinetic energy able to move the fluid upward by no more than 15 m) and, very likely, (iii) the narrowing of the valley downstream which strongly reduces the speed

of the along-valley wind (Arduini et al., submitted). The analysis of the vertical structure of the wind above the valley floor shows that the along-valley wind flowing from the part of the valley upstream, beyond the pass, detrains above that valley floor, therefore leaving the near-surface atmosphere unperturbed and promoting pollutant accumulation. Mixing processes may however occur at the detrainment level, which are currently investigated.
While the link between atmospheric dynamics and PM10 concentration in the most polluted section of the Arve valley seems to be broadly understood from this analysis, the relationship with the detailed sub-diurnal evolution of the PM10 concentration (Chemel et al 2016) remains to be clarified. This point is currently under investigation and will also be discussed at the conference.
References:
PACI A., C. STAQUET and 39 authors, 2016. The PASSY-2015 field campaign: atmospheric dynamics and air quality in the Arve valley. Pollution atmosphérique, N°231 - 232, APPA ed. (in French).
ARDUINI G., C. CHEMEL, C. STAQUET. Energetics of deep Alpine valleys in pooling and draining configurations. Journal of the Atmospheric Sciences (submitted).
CHEMEL C., G. ARDUINI, C. STAQUET, Y. LARGERON, D. LEGAIN, D. TZANOS, A. PACI 2016 Valley heat deficit as a bulk measure of wintertime particulate air pollution in the Arve River Valley. Atmospheric Environment, 128, 208-215.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 114

Abstract code

Predicting local winds in a deep Alpine valley under fair weather conditions

Author - Schmidli, Juerg, Goethe University, Frankfurt/Main, Germany (Presenting author)

Co-author(s) - Ghasemi, Abouzar , Goethe University , Frankfurt/Main , Germany

Topic Boundary layers and turbulence in complex terrain

Keywords

Under fair weather conditions, thermally driven local winds often dominate the wind climatology in mountain regions. In deep valleys, such as the Rhone valley in south-western Switzerland, their impact is seen in all seasons. In a previous study, we showed that the thermally driven along-valley winds during a one-month summer period (July 2006) are generally well represented in numerical simulations at 1.1 km resolution for most locations in the larger valleys in the Swiss Alps, provided that high-resolution land surface datasets are used for the simulations. In contrast, the skill at 2.2 km resolution was poor. The study nicely demonstrated the potential benefit of going to 1.1 km resolution for numerical weather prediction of local weather in Alpine regions. While their was a clear benefit of going to higher resolution for most locations, for one station in particular (Sion in the Rhone valley) little improvement in the mean diurnal evolution of the simulated along-valley winds was found. Despite this poor skill for the mean diurnal evolution, on some days the diurnal evolution is well represented by the model. In this study we take a closer look at the wind climatology in Sion and investigate the causes leading to good skill on some days and poor skill on other days.

Presentation Preference Poster

Audio/Visual Equipment

Awards

Additional information

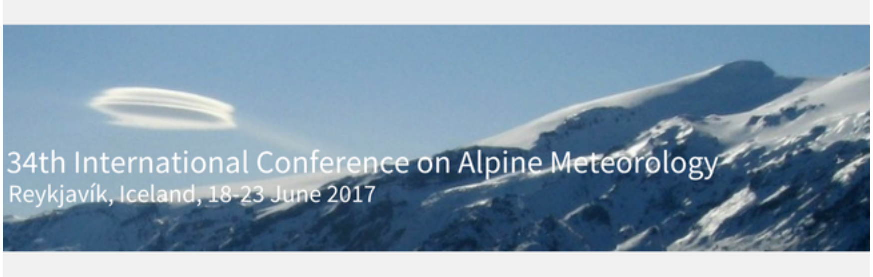
Abstract nr. 115
Abstract code

Precipitation on Dominica during Tropical Storm Erika (2015)

Author - Nugent, Alison, University of Hawaii at Manoa, Honolulu, USA (Presenting author)
Co-author(s) - Rios-Berrios, Rosimar , University at Albany, SUNY , Albany , USA
Topic Orographic precipitation
Keywords extreme precipitation, terrain-cyclone interaction

Tropical cyclones are generally characterized by strong rotating winds, and yet the associated rainfall can be even more destructive. Tropical Storm Erika (2015) is an example of such a cyclone whose heavy rainfall south of the storm center was responsible for significant loss of life and property. Erika was a weak tropical storm in a sheared environment that passed through the Lesser Antilles on August 27th of 2015. Rain gauges on the Commonwealth of Dominica measured half a meter of rainfall in about 5 hours. Understanding the factors leading to heavy rainfall on Dominica is important for future prediction of similar weak, sheared tropical storms passing near mountainous islands. In this study, we use multiple observation platforms to investigate the tropical storm structure and storm environment including aircraft radar, ground radar, rain gauges, and satellite. The goal is to understand the effect of Dominica's orography and other aspects that played a role in the heavy precipitation. Preliminary results show that interactions between the storm and Dominica’s orography were a primary factor in the resulting precipitation. Radar tracked winds show a mesovortex imbedded within the outer rainband which persisted for hours over the island even as the storm center continued to move westward. Our results highlight the multi-scale interactions that can contribute to heavy precipitation associated with tropical cyclone passage near mountainous islands.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 116
Abstract code

Experimental validation of a modelling chain simulating the dispersion of pollutants from the incinerator of Bolzano (Italy)

Author - Zardi, Dino, University of Trento, Trento, Italy (Presenting author)
Co-author(s) - Alessandrini, Stefano , National Center for Atmospheric Research , Boulder , United States of America
Co-author(s) - Antonacci, Gianluca , CISMA - Center of Engineering and Development of Models for the Environment , Bolzano , Italy
Co-author(s) - Bisignano, Andrea , University of Eastern Piedmont , Alessandria , Italy
Co-author(s) - Falocchi, Marco , University of Trento , Trento , Italy
Co-author(s) - Ferrero, Enrico , University of Eastern Piedmont , Alessandria , Italy
Co-author(s) - Giovannini, Lorenzo , University of Trento , Trento , Italy
Co-author(s) - Guariento, Massimo , Environmental Agency of the Province of Bolzano , Bolzano , Italy
Co-author(s) - Lodi, Marco , Mario Negri Institute for Pharmacological Research, , Milano , Italy
Co-author(s) - Mortarini, Luca , Institute of Atmospheric Sciences and Climate, National Research Council , Torino , Italy
Co-author(s) - Palmitano, Marco , Eco-center , Bolzano , Italy
Co-author(s) - Tirler, Werner , Eco-research , Bolzano , Italy
Co-author(s) - Tomasi, Elena , University of Trento , Trento , Italy
Co-author(s) - Verdi, Luca , Environmental Agency of the Province of Bolzano , Bolzano , Italy
Topic Boundary layers and turbulence in complex terrain
Keywords Pollutant dispersion; basin; tracer; WRF; CALPUF.

The simulation of dispersion processes in complex terrain is still a challenging task due to the inherent difficulties in accurately reproducing all the physical phenomena involved. This contribution presents results from a study aiming at characterising dispersion processes from the incinerator of Bolzano (262 m a.s.l., 106000 inhabitants, Central Italian Alps). The experiment included a modelling chain, simulating both meteorological processes and pollutants dispersion, and field campaigns, performed to validate the simulated emission-impact scenarios against ground measurements of a gas tracer released from the incinerator stuck.
Meteorological simulations were performed with the Weather Research and Forecasting (WRF) model using four nested domains down to a horizontal resolutionof 500 m. In the innermost domain observational nudging was used to assimilate meteorological data from 7 ground weather stations, a temperature profiler, a SODAR and a Doppler wind lidar. Then the CALMET model refined the meteorological field up to the resolution of 200 m, in order to improve its adherence to the complex terrain. Finally, the dispersion processes and the emission-impact areas of the tracer were simulated by the CALPUFF model, a non-steady-state lagrangian gaussian puff model, and

by the SPRAY model, which adopts a purely lagrangian stochastic particle scheme. Both models were fed with real time data of emission rates and temperature, measured at the incinerator.
Two 1h-long tracer emissions at constant release rate were performed in order to investigate the dispersion processes under two typical wintertime meteorological conditions. The first release was performed in the early morning, under stable atmosphere and Northerly winds, while the second release was performed in the early afternoon, under weakly unstable atmosphere and Southerly winds. During each release 14 teams collected air samples in the Bolzano basin for a total of 59 samples.Data from the different samples were analysed and used to calibrate and validate the modelling chain.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 118
Abstract code

The Cerdanya Cold Pool Experiment 2015 (CCP15): a field campaign study of the cold pool in the largest pyrenean valley

Author - Martinez-Villagrasa, Daniel, University of Balearic Islands, Palma, Spain (Presenting author)
Co-author(s) - Simó, Gemma , University of Balearic Islands , Palma , Spain
Co-author(s) - Conangla, Laura , Polytechnic University of Catalonia , Manresa , Spain
Co-author(s) - Tabarelli, Davide , University of Trento , Trento , Italy
Co-author(s) - Miró, Josep Ramon , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - López-Grifol, Álvaro , University of Balearic Islands , Palma , Spain
Co-author(s) - Wrenger, Burkhard , University of Applied Sciences Hochschule Ostwestfalen-Lippe , Ostwestfalen-Lippe , Germany
Co-author(s) - Jiménez, Maria Antònia , University of Balearic Islands , Palma , Spain
Co-author(s) - Picos, Rodrigo , University of Balearic Islands , Palma , Spain
Co-author(s) - Zardi, Dino , University of Trento , Trento , Italy
Co-author(s) - Cuxart, Joan , University of Balearic Islands , Palma , Spain
Topic Results from major field campaigns
Keywords

The Cerdanya Cold Pool Experiment 2015 (CCP15) consisted in a two-week long field campaign that took place in October 2015 in the Cerdanya valley, western Pyrenees. This valley, a graben 35 km long and 15 km wide, has a distinct ENE-WSW orientation that stands out among the rest of the pyrenean valleys, generally oriented in the N-S direction. Its topographical configuration, with a valley floor at 1000 m above sea level (asl) and surrounded by mountain ranges rising above 2900 m asl to the north and up to 2700 m asl to the south, is prone for the development of intense cold-air pooling at its bottom part, even under the presence of significant synoptic pressure gradients. This campaign was designed to study the structure and evolution of the cold-air pool at the bottom part of the valley, together with the slope and valley winds that generate under fair weather conditions. For this purpose, a boundary-layer temperature and wind profiler (Windrass, Scintec) and a fully equipped surface energy budget station operated by the Catalan Met Service (Meteocat) were installed near their operational station at the Das Aerodrome, a facility situated at the valley bottom where the minimal temperature values of Catalonia are recorded under good weather conditions. This instrumentation was supplemented by a 2-m height column of thermistors to analyse the lowest part of the surface thermal inversion. An additional surface weather station was installed at a secondary sub-basin of the Cerdanya valley located few kilometres downstream to evaluate the spatial thermal differences at the surface.
Five Intensive Observational Periods (IOPs) were selected during the field campaign for the continuous operation of a tethered balloon from evening to morning transitions, while a remotely-

controlled multicopter was involved at shorter time windows. Both devices provide in-situ data that complement the vertical profiles obtained by the remote sensing device. The selected IOPs represent a variety of cases that allow to study the cold-air pool formation and development of local winds under quiescent conditions, under the presence of a weak general wind channelized along the main valley axis or with increasing cloud cover.
This presentation will provide an overview of the field campaign and summarize the recent research results on the phenomena observed, which will be compared against the corresponding outputs from a high-resolution mesoscale simulation.
A preliminary analysis of these results lead to the design of a second field campaign that took place in January-February 2017 to study the cold-air pool and thermally-driven flows under snow conditions. An overview of this last campaign, which has been finished very recently, will be presented in another communication at this conference.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 119
Abstract code

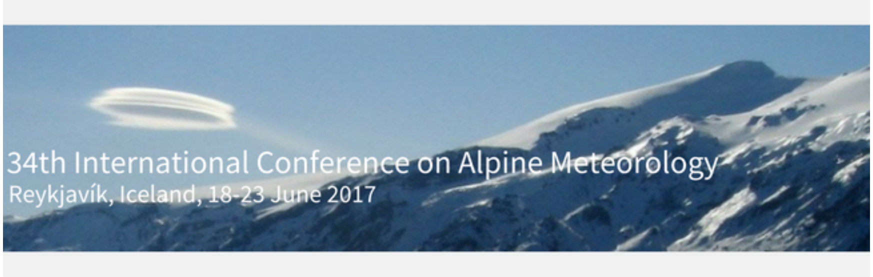
BOU: a low-cost tethered balloon sensing system for monitoring the lower atmospheric boundary-layer

Author - Martinez-Villagrasa, Daniel, University of Balearic Islands, Palma, Spain (Presenting author)
Co-author(s) - Martí, Belén , University of Balearic Islands , Palma , Spain
Co-author(s) - López-Grifol, Álvaro , University of Balearic Islands , Palma , Spain
Co-author(s) - Simó, Gemma , University of Balearic Islands , Palma , Spain
Co-author(s) - Wrenger, Burkhard , University of Applied Sciences Hochschule Ostwestfalen-Lippe , Ostwestfalen-Lippe , Germany
Co-author(s) - Dünnermann, Jens , University of Applied Sciences Hochschule Ostwestfalen-Lippe , Ostwestfalen-Lippe , Germany
Co-author(s) - Picos, Rodrigo , University of Balearic Islands , Palma , Spain
Co-author(s) - Cuxart, Joan , University of Balearic Islands , Palma , Spain
Topic Other
Keywords

The study of nocturnal thermal inversions and thermally-driven flows often requires the observation of vertical profiles of the main meteorological variables for the first 500 m. Typically, these needs are covered with the use of captive balloons but the commercial version of such instrumental platforms are scarce and expensive. Recent advancements in electronics allow for low-cost alternatives like the device that we present in this communication: BOU (tethered **B**alloon sonde **O**WL-**U**IB).
This system has been developed in the last years in a joined effort between the Universities of Applied Sciences of Ostwestfalen-Lippe (OWL) and of Balearic Islands (UIB). It has been configured to sample temperature, humidity, air pressure and wind speed at 1 second, although the system is easily reconfigurable, and more sensors can be added. The sonde is able to operate up to 1000 m and a polymer battery allow the device to work autonomously for more than 6 hours. This device has been successfully used in different campaigns, showing its potential for monitoring the lower atmospheric boundary layer (ABL) over complex terrain. In this poster, we will present details on the sensor package, data acquisition system and hardware aspects, as well as some data comparison against other devices like an unmanned aerial vehicle and a remote sensing device.

Presentation Preference Poster
Audio/Visual Equipment
Awards

Additional information



Abstract nr. 120
Abstract code

Evolution of the temperature profile during the life-cycle of a valley-confined cold-pool in the Pyrenees

Author - Cuxart, Joan, University of the Balearic Islands, Palma (Mallorca), Spain (Presenting author)
Co-author(s) - Conangla, Laura , Universitat Politècnica de Catalunya , Manresa , Spain
Co-author(s) - Martínez-Villagrasa, Daniel , University of the Balearic Islands , Palma (Mallorca) , Spain
Co-author(s) - Wrenger, Burkhard , Hochschule Ostwestfalen-Lippe , Höxter , Germany
Co-author(s) - Miró, J.R. , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Simó, Gemma , University of the Balearic Islands , Palma (Mallorca) , Spain
Co-author(s) - Jiménez, Maria Antonia , University of the Balearic Islands , Palma (Mallorca) , Spain
Topic Boundary layers and turbulence in complex terrain
Keywords cold pool; surface energy budget; thermal inversio

During the Cerdanya Cold Pool experiment in 2015 (CCP'15, see companion presentation by Martínez-Villagrasa et al for a complete description), a number of cases of cold-pool (CP) formation were observed with the enhanced instrumention available. The campaign took place in early October, still without snow, with large thermal diurnal cycles of about 20 ºC, reaching negative temperatures at night.

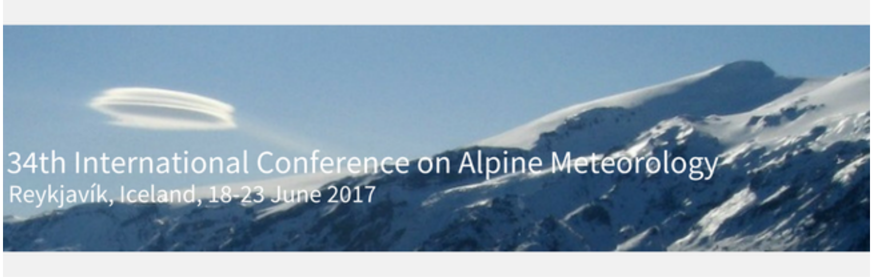
The vertical structure of the CP could be sampled with the following devices: i) a Scintec WindRass that provided wind, temperature and turbulence profiles between 40 and 400 m above ground level (agl), ii) a tethered ballon which was operated between the surface and an approximate height of 300 m agl and iii) a remotely-piloted multicopter that was flown up to 200 m. Close to the surface, iv) a standard meteorological weather station was supplemented with v) a complete surface energy station, which allowed to estimate all terms of the energy budget (latent and sensible heat flux, net radiation and ground flux) and vi) a column of thermistors between 2m and the surface.

There were five Intensive Operation Periods, each corresponding to one night, which captured CP with diverse evolutions, described in the companion talk of Martínez-Villagrasa et al. The most frequent case consisted in moderate valley winds before and after sunset of mesoscale origin, which calmed between 1 to 3 hours after dawn, leading to the late development of the cold pool. The second type of CP was in absence of the mesoscale winds, which allowed a soft evening transition with almost calm winds at sunset and establishment of down-slope and down-valley winds along the night, and the CP development starting around dawn.

In this presentation we focus on IOP3, belonging to the second type, taken as the campaign's Golden Case, since most of the observed dynamics seem to be generated locally in the main

Cerdanya valley, its slopes and its tributaries. The evolution of the temperature profile between late afternoon and next morning is described using the ensemble of available data and put in relation with the topographically generated circulations at the valley scale. The surface energy budget and the behaviour of the thermal profile below 2m allow to explore the interaction with the underlying surface.
Finally, the observed evolution is compared with the one provided by a high-resolution mesoscale simulation (horizontal grid of 400 m) of the same night, assessing the performance of the simulation and looking for the causes of the differences between model and observations.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 121
Abstract code
Influence of a valley exit jet on the experimental site of the BLLAST field campaign

Author - Martinez-Villagrasa, Daniel, University of Balearic Islands, Palma, Spain (Presenting author)
Co-author(s) - Jiménez, Maria Antònia , University of Balearic Islands , Palma , Spain
Co-author(s) - Cuxart, Joan , University of Balearic Islands , Palma , Spain
Topic Boundary layers and turbulence in complex terrain
Keywords

The Boundary Layer Late Afternoon and Sunset Transition (BLLAST) field campaign was an experiment conducted in June-July 2011 in Lannemezan, France, with the main objective to study the convective boundary-layer decay to a night-time stable boundary layer during the late afternoon and evening transition. The experimental site was located on an elevated plateau at the northern foothills of the Pyrenees, few km far from the mountain range and, therefore, particularly influenced by the mountain-plain wind circulation. During several Intensive Observation Periods (IOPs), a strong flow with a jet-like structure arrived to the experimental site from southern directions at night.
High-resolution mesoscale simulations performed for the IOPs free of rain and clouds show that this low-level jet has its origin on the exit jet generated at the Aure's valley. This is a 40-km long pyrenean valley located 10 km south of Lannemezan, with the main axis oriented in the N-S direction. It has a v-shape valley cross-section with a maximum distance between ridges of 10 km, a depth up to 900 m and with the highest peaks rising above 2500 m above sea level (asl). This topographical configuration generates a diurnal valley wind system that has been characterised for the different synoptic conditions developed during particular IOPs.
When background winds are weak, thermally-driven down-slope and down-valley winds organise inside the valley around sunset and feed the valley exit jet that generates two hours later over the plateau. When background winds aloft are moderate or strong, they are channelised down the Aure valley axis, producing a dynamically-driven exit jet. Both types are able to reach Lannemezan depending on the intensity and direction of the general wind over the plateau. The characteristics of the exit jet (intensity, maximum height) also depend on the general wind conditions and exit jet type. In this communication, we will show the most relevant results from the numerical outputs, which agree well with the observations in Lannemezan taken during the BLLAST field campaign.

Presentation Preference Oral
Audio/Visual Equipment
Awards

Additional information

Abstract nr. 123
Abstract code
Consistent implicit compressible/soundproof EULAG dynamical core for COSMO model - status and challenges

Author - Piotrowski, Zbigniew, Institute of Meteorology and Water Management, Warsaw, Poland (Presenting author)
Co-author(s) - Polkowski, Marcin , Institute of Meteorology and Water Management , Warsaw , Poland
Co-author(s) - Ryczkowski, Adam , Institute of Meteorology and Water Management , Warsaw , Poland
Topic Weather forecasting for mountainous regions
Keywords COSMO, EULAG

New EULAG dynamical core for the operational Consortium for Small-scale Modeling (COSMO) model is being developed at IMGW within the CELO priority project of COSMO. Recently, the COSMO-EULAG was extended to include consistent implicit compressible/soundproof formulation. Its parallel formulation is being reformulated towards the implementation on modern supercomputing architectures using GridTools Domain Specific Language. Further efforts concentrate on research on the realization of surface fluxes within the nonoscillatory forward-in-time numerics of EULAG. Within this presentation I will discuss the current status of COSMO-EULAG performance and on-going efforts conducted within ESCAPE H2020 at Poznan Supercomputing and Networking Center and PROPOZE project conducted at the Institute of Meteorology and Water Management.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

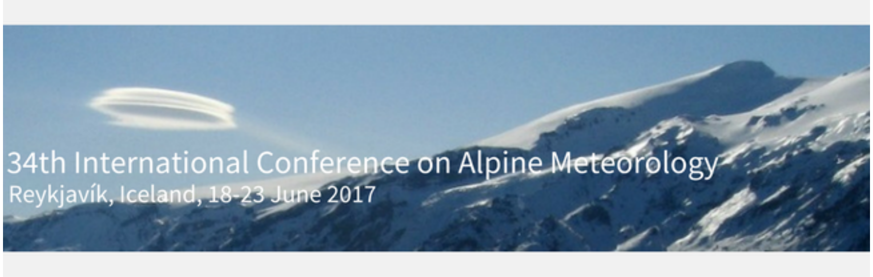
Abstract nr. 124
Abstract code

Mountain wave momentum fluxes in evolving large scale flows and complex terrain: perspectives from DEEPWAVE

Author - Metz, Johnathan, University of Washington, Seattle, United States of America (Presenting author)
Co-author(s) - Durran, Dale , University of Washington , Seattle , United States of America
Topic Results from major field campaigns
Keywords DEEPWAVE; mountain waves; momentum flux

While steady-state mountain waves have been studied in detail, non-steady-state mountain waves have not received as much attention due to the increased complexity inherent in their analysis. However, since non-steady-state gravity waves are also observed and are not commonly represented in current parameterizations, more study is necessary.
The DEEP Propagating Gravity WAVE Experiment (DEEPWAVE) was conducted over New Zealand in the austral winter of 2014. Case days with strong wave activity identified from the DEEPWAVE datasets were simulated with high-resolution Weather Research and Forecasting (WRF) model runs with 2 km grid spacing over New Zealand. Diagnostics derived from these simulations as well as observed data from the campaign were used to analyze these cases.
The presence of strongly accelerating mean flows in the DEEPWAVE dataset provide an opportunity to analyze the impacts of non-steady-state waves. Preliminary analyses demonstrate significant temporal variations in the fluxes. In addition, while momentum fluxes integrated only in one dimension (across the mountain) exhibit significant short-wavelength variations in both the horizontal and the vertical, momentum fluxes horizontally averaged over two dimensions in relatively long and narrow bands demonstrate more expected behavior, and are relatively constant with height. These results appear to indicate an influence from the topography normal to the cross-mountain flow, which, while often homogenous in idealized studies, is an important aspect of realistic topographies.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 125
Abstract code
Simulations of convective flash flood events in southern Switzerland

Author - Plunkett, Camden, Embry-Riddle Aeronautical University, Prescott, United States of America (Presenting author)
Co-author(s) - James, Curtis , Embry-Riddle Aeronautical University , Prescott , United States of America
Topic Orographic precipitation
Keywords

The Weather Research and Forecasting model (WRF) was used to perform high-resolution numerical simulations for nine convective events with high peak discharges and flash flooding of the Maggia River in the Lago Maggiore region of southern Switzerland. The dynamics and kinematics behind the observed convective echo training were studied in an attempt to obtain additional insight into the atmospheric conditions that produce these flash flood episodes.
Model verification was performed using radar-estimated rainfall totals (Panziera et al. 2015) and routine radiosonde observations from Milan, Italy. Seven of the nine simulations adequately depicted the location and amount of precipitation when compared to the observed elliptical precipitation totals.
Mean atmospheric characteristics were analyzed using temporal averaging of the WRF output fields during the periods of heaviest precipitation over the Maggia catchment for each event as determined by the model composite reflectivity. Confluence of low-level southerly and easterly jets was observed in the cavity of the Alps surrounding the Lago Maggiore region. Furthermore, model omega and mixing ratio fields indicated significant downsloping and drying of the flow on the northern lee slope of the Apennines which led to deflection of the flow and the formation of the easterly barrier jet. This barrier jet converged with the southerly LLJ from the Ligurian Sea. The flow pattern was enhanced by a lee cyclone in the Piedmont region of northwest Italy, and the amount of the convective triggering over the region was related to the intensity of the convergence of the low-level flow. The confluence of these flow features and resultant orographic lifting of conditionally unstable air in the southerly LLJ are likely the mechanisms for the frequent convective triggering leading to intense flash floods in the Lago Maggiore region.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 126
Abstract code

The influence of an isolated ridge on a mid-latitude cyclone and upper level jet.

Author - Durran, Dale, University of Washington, Seattle, USA (Presenting author)
Co-author(s) - Menchaca, Maximo , University of Washington , Seattle , USA
Topic Downslope windstorms, mountain waves and rotors
Keywords mountain waves; wave drag

Idealized studies of the influence of mountains on the atmosphere have primarily focused on the steady-state response to horizontally uniform flows encountering an obstacle. In this research, we extend previous studies of non-steady mountain waves to examine their generation, propagation, and influence on the mean flow when forced by a mid-latitude cyclone impinging on an isolated ridge. The cyclone is obtained by superimposing a localized finite-amplitude potential vorticity anomaly on a baroclinically unstable jet. An isolated ridge is placed in an initially quiescent region of the flow away from the initial PV anomaly. As maturing cyclone propagates towards the ridge, mountain waves are generated exhibiting strong time-dependent behavior. For a 2-km-high ridge, the pressure drag increases at 6 days and remains large for the remainder of the simulation. The low-level vertical momentum flux is significantly less than the pressure drag. This difference is balanced largely by ageostrophic forcing (equal to the sum of the pressure gradient and Coriolis terms in the momentum budget), and is related to the complex dynamics associated with blocking near the mountain. Extensive wave breaking is also present, and is predominately observed (1) at low levels in the lee of the terrain prior to frontal passage and (2) persistently in the stratosphere after frontal passage. This wave breaking causes significant removal of the cross-mountain momentum, and strong regions of deceleration are observed above the jet core. While gravity-wave breaking is not observed in the upper troposphere, localized patches of strong flow deceleration are also observed at this level. Despite the existence of several regions obvious flow deceleration, the total terrain-induced momentum changes, averaged horizontally over the full domain, are strongly influenced by the presence of small-amplitude perturbations distributed over a broad area.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 128
Abstract code
Winter precipitation efficiency of mountain ranges in the Colorado Rockies under climate change

Author - Grubisic, Vanda, NCAR, Boulder, CO, USA (Presenting author)
Co-author(s) - Eidhammer, Trude , NCAR , Boulder, CO , USA
Co-author(s) - Rasmussen, Roy , NCAR , Boulder, CO , USA
Co-author(s) - Ikeda, Kyoko , NCAR , Boulder, CO , USA
Topic Orographic precipitation
Keywords drying ratio; climate

Orographic precipitation depends on both the environmental conditions and the barrier shape. As a measure of precipitation efficiency of a mountain range we use the drying ratio (DR), defined as the ratio of precipitation to incoming water flux. In this study, we explore the winter precipitation efficiency of mountain ranges in the Colorado Rockies under the current and future warmer and moisture conditions. The sensitivity of the DR to the barrier shape, temperature, stability, and horizontal velocity of the incoming air mass is examined for a number of individual mountain ranges in the Colorado Rockies. This analysis is based on the results of the Colorado Headwaters Simulations, carried out with the Weather Research and Forecasting (WRF) model run at the 2 km grid spacing over the inter-mountain west region of the US for four different winter seasons. For studying future climate scenarios, a pseudo-global warming (PGW) technique was applied.
For given environmental conditions, we find the DR to be primarily dependent on the upwind slope for wider mountain ranges, and on the width of the barrier for narrower ranges. Temperature is found to exert an influence on the DR for all Colorado mountain ranges, with DR decreasing with increasing temperature, under both the current and future climate conditions. Finally, while the DR of the Colorado mountain ranges is found to be sensitive to temperature, the predicted decrease of DR is less than 0.5% per degree K of warming for all examined mountain ranges.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 129
Abstract code
Atmospheric rotors, downslope windstorms and severe turbulence in a deep long valley

Author - Grubisic, Vanda, NCAR, Boulder, CO, USA (Presenting author)
Co-author(s) - Strauss, Lukas , University of Vienna , Vienna , Austria
Co-author(s) - Serafin, Stefano , University of Vienna , Vienna , Austria
Topic Downslope windstorms, mountain waves and rotors
Keywords rotors, downslope windstorms; valley

Turbulent atmospheric rotors are frequently observed in Owens Valley, a deep long valley in the lee of the southern Sierra Nevada in California. This contribution presents a comprehensive analysis of strong mountain-wave activity cases from the 2006 Terrain-Induced Rotor Experiment (T-REX). The analysis reveals the rich variety of rotor-like turbulent flow structures that may form during periods of strong cross-mountain winds. Observations show that the elements of the classic rotor conceptual model are modulated and, at times, almost completely offset by dynamically- and thermally-driven processes in the valley.
A 5-yr climatology of westerly wind events in Owens Valley, derived from the semi-permanent 16-station mesoscale network managed by the Desert Research Institute (DRI), show that relatively strong westerly winds at the valley floor are most commonly observed in the afternoon hours in late spring and summer. However, intense and potentially damaging westerly wind storms can happen at any time of the day throughout the year. The temperature and humidity variations caused by westerly windstorms at the valley floor depend on the properties of the approaching air masses. In some cases, the windstorms lead to overall warming and drying of the valley atmosphere, similar to foehn or chinook intrusions.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 130
Abstract code
Improving orographic drag parametrization schemes: high-resolution simulations over the Rockies.

Author - Vosper, Simon, Met Office, Exeter, United Kingdom (Presenting author)
Topic Other
Keywords Gravity-wave drag

Despite the well-known important influence of mountain drag on the atmospheric circulation, the parametrization schemes used in weather and climate models to represent this drag are poorly constrained. Typically, these schemes are tuned to optimize large-scale aspects of the forecast, with little consideration for the realism of the processes which they represent. Furthermore the partitioning of the drag from different processes, such as gravity waves, flow blocking and turbulent form drag, tends to be tuned arbitrarily and varies widely between different models, leading to a large but often overlooked degree of uncertainty in weather and climate modelling. Ideally we would constrain the drag schemes in models with direct measurements, but these are very difficult to obtain in the atmosphere. An alternative way forward is to use high resolution model simulations, which are realistic enough that they can be regarded as "the truth". In this study we will use large-domain high-resolution model simulations of flow over Continental mountain ranges such as the Canadian Rockies to evaluate the drag parametrization schemes used in global models. The extent to which the schemes are able to reproduce the drag due to resolved processes in the high-resolution simulations will be investigated. By sampling different sub-regions of the model domain we will determine whether the optimal tuning of the drag schemes is universal, or is regionally specific. The extent to which the results are applicable to other mountain ranges will also be examined.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 131
Abstract code
Performance of a quality control system in complex terrain with open access data

Author - Eibl, Birgit, University of Vienna, Vienna, Austria (Presenting author)
Topic Weather forecasting for mountainous regions
Keywords

The very high spatio-temporal variation of meteorological data in a highly complex terrain makes it necessary to develop innovative methodologies for reasonable and sensible quality control of observational data.
Components of observational data can be assigned to phenomena of different meteorological scales. Different kinds of variations and errors characterize every measurement. To effectively extract the wanted information about the atmospheric condition a complex quality control system should be performed. Systematic and stochastic errors should be eliminated and an analysis of the atmospheric state allowing phenomena within different scales to remain in the data set.
The methodology and performance of the complex quality control whereas large scale and topographically induced mesoscale patterns are preserved while stochastic noise is simultaneously eliminated, is briefly presented. The aim of the quality control mechanism is to preserve physically explicable deterministic disturbances on the mesoscale and to remove stochastic noise of observational values.
The main focus on the presented poster lies on the applicability of the quality control scheme on real data obtained from different complex terrain areas. Results of testing the quality control within data sparse and dense areas under the usage of open source data will be discussed.
The quality controlled observational surface station data will be used for the Vienna Enhanced Resolution Analysis (VERA) Scheme which interpolates and downscales the irregularly distributed data to a regular grid with a horizontal resolution of 1 km or less. The resulting analysis fields are prognostic model independent and therefore highly recommended for model validation purpose.

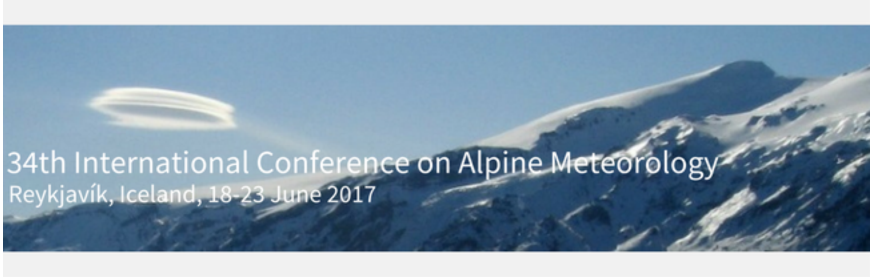
Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 132
Abstract code
Towards an operational method to forecast snow events at low altitude in Catalonia

Author - Álvarez Téllez, Manuel, Servei Meteorologic de Catalunya, Barcelona, Spain (Presenting author)
Co-author(s) - Soler, Xavier , Servei Meteorologic de Catalunya , Barcelona , Spain
Co-author(s) - Figuerola, Francesc , Servei Meteorologic de Catalunya , Barcelona , Spain
Co-author(s) - Aran, Montse , Servei Meteorologic de Catalunya , Barcelona , Spain
Co-author(s) - Gallego, Sergio , Servei Meteorologic de Catalunya , Barcelona , Spain
Topic Weather forecasting for mountainous regions
Keywords Snow, wetbulb temperature, forecast

Snow episodes at low altitude in Catalonia are one of the main problems to manage properly by civil protection authorities. Consequently, an accurate forecast is necessary to a suitable activation of the emergency plan.
Catalonia, located in the north-east of Iberian Peninsula, is limited by the Mediterranean Sea to the east and south and by the Pyrenees in the north. This geographical situation favours the interaction of cold air masses moving from north-west with warmer air masses from the sea. Moreover, the uncertainties of precipitation and snow level forecasted by meteorological models and the Catalan complex orography add some degrees of difficulty to the forecast.
In this work, there are presented the results of applying two different methods to estimate the snow level in Catalonia. The first one uses the wet bulb temperature with a threshold of 1.5 degrees (WBT1.5), and the second one is estimated by using the hourly precipitation rate and the wet bulb zero level (WBZL).
The results show that, when there is a quick change of the air mass, it is better to use WBT1.5. WBZL method shows a better accuracy when the precipitation rate is persistent. This last method seems to work better in complex orography but it is essential a precise precipitation forecast.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



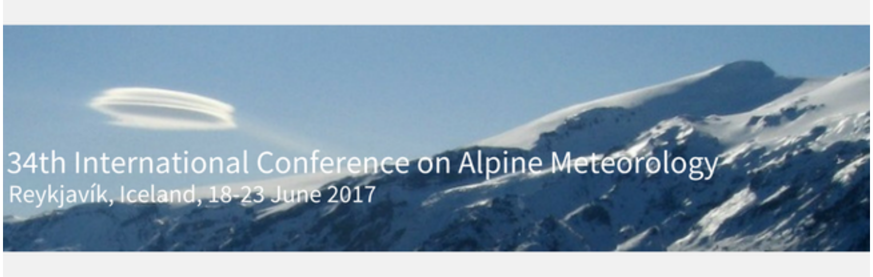
Abstract nr. 133
Abstract code

Identification of the annual 0°C and -1°C isotherms current elevation and recent altimetric trends in the Italian Eastern Alps

Author - Fazzini, Massimiliano, University of Camerino, Camerino, Italy (Presenting author)
Co-author(s) - Billi, Paolo , University of Ferrara , 44123 Ferrara , Italy
Co-author(s) - Trotta, Lorenzo , University of Ferrara , 44123 Ferrara , Italy
Topic Other
Keywords Isotherms, Alps, trend

IN THE LAST CENTURY, the temperatures recorded in the alpine domain increased on average twice that measured for the northern hemisphere and is estimated at about 2 °C. This signal is almost homogeneous throughout the Alpine region and has been particularly marked since 1980, with average annual rates of about 0.35 °C per decade. Evident effects are found in the very quick melting of glaciers, in temporal and spatial uneven snowmaking, in the modified thermodynamic genesis of precipitation and in an evident change in meteoric regimes, with consistent impacts and growing uncertainties on sustainable development of mountain areas. At high altitudes, the Italian alpine sectors have been particularly affected by global warming, to such an extent that the percentage of glacier retreat has increased to 89% and most of the glaciers of the Southern Alps will likely disappear during this century. Based on these evidences, this study aims to provide a quantification of the increase in temperature in the Tridentine Alps - which include the data of Trentino - Alto Adige, Veneto and Friuli. Thanks to the remarkable improvement of meteo-climatic monitoring at medium to high elevation , which occurred since the beginning of this century, it was possible to make a preliminary study of the thermal climate from January 2003 to December 2015 and to determine the variation of the elevation of the 0 ° C and -1 ° C. annual isotherms. Fifteen groups, consisting of 3 to 6 meteo climatic station, and located in the valley bottom, slope and peak,respectively, were thus identified so as to calculate the number of frost and ice days, the average vertical thermal gradients and extrapolate the elevation of the already mentioned temperature thresholds. The altitude of the stations considered varies between 640 and 3015 m asl for an average of 1556 m asl; the average annual temperature is 5.3°C, the minimum 0.9°C and the maximum 9.7°C. For the period of study, the increase is 0.22°C. The mean temperature gradient is about 0:46°C/100 m, while the number of days of frost and ice is 153 and 46, respectively. Finally, the average elevation of annual isotherms 0 ° C and -1 ° C are 2660 and 2867 m. The trends show a strong increase of the elevation, estimated at 41 and 44 myr^{-1}, respectively and often up to about 90 myr^{-1} in Venetian Dolomites. A slight opposite trend is observed in the high Fassa valley (north - eastern Trentino). Evidently, to confirm these preliminary results, would be advisable to extend this simple methodology to other sectors of the mountain chain, to understand even if it is a signal at the regional scale rather than whole Alpine domain.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 134
Abstract code

Water tank experiments on stratified flow over double mountain-shaped obstacles at high-Reynolds number

Author - Ivana, Stiperski, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Stefano, Serafin , University of Vienna , Vienna , Austria
Co-author(s) - Alexandre, Paci , METEO-FRANCE, CNRM, UMR 3589 , Toulouse , France
Co-author(s) - Veronika, Krieger , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Christoph, Knigge , Leibniz Universität Hannover, , Hannover , Germany
Co-author(s) - Hálfdán, Ágústsson , Kjeller Vindteknikk , Kjeller , Norway
Co-author(s) - Anne, Belleudy , METEO-FRANCE, CNRM, UMR 3589 , Toulouse , France
Co-author(s) - Radiance, Calmer , METEO-FRANCE, CNRM, UMR 3589 , Toulouse , France
Co-author(s) - Kristian, Horvath , Meteorological and Hydrological Service, , Zagreb , Croatia
Co-author(s) - Johannes, Sachsperger , University of Vienna , Vienna , Austria
Co-author(s) - Lukas, Strauss , University of Vienna , Vienna , Austria
Co-author(s) - Vanda, Grubišić , National Center for Atmospheric Research , Boulder , USA
Topic Downslope windstorms, mountain waves and rotors
Keywords

We present an overview of the HyIV-CNRS-SecORo laboratory experiments carried out in the CNRM large stratified water flume. The experiments were designed to systematically study the influence of double obstacles on stably stratified flow. The experimental setup consisted of a two-layer flow in the water tank, with a lower neutral and an upper stable layer separated by a sharp density discontinuity. A series of 395 experiments performed for a range of Froude numbers Fr extending from 0.17 to 1.4, and for non-dimensional inversion heights H/Zi from 0.3 to 1.3, in the stratified water tank successfully reproduced the range of phenomena expected to occur with this type of layering, such as trapped lee waves, rotors, hydraulic jumps, lee wave interference and flushing of the valley atmosphere.

Here we present the first results of the laboratory experiments with a special focus on lee wave interference and coupling between lee wave amplitude and rotor strength. We develop a regime diagram for flow over single and double obstacles and examine the parameter space where the secondary obstacle has the largest influence on the flow. Particle-image velocimetry (PIV) is used to obtain the velocity field. Obstacle height and ridge separation distance are shown to control lee wave interference. Results, however, differ partially from previous findings on the flow over double ridges reported in the literature due to presence of nonlinearities and possible differences in the boundary layer structure. The secondary obstacle also influences the transition between different flow regimes and makes trapped lee waves possible for higher Froude numbers than expected for an isolated obstacle.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 135
Abstract code
Scale interactions in katabatic flows

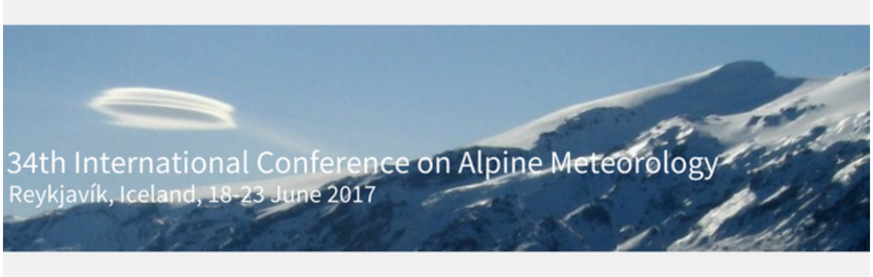
Author - Ivana, Stiperski, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Nikki, Vercauteren , Freie Universität Berlin , Berlin , Germany
Co-author(s) - Mathias W., Rotach , University of Innsbruck , Innsbruck , Austria
Co-author(s) - C. David, Whiteman , University of Utah , Salt Lake City , USA
Topic Boundary layers and turbulence in complex terrain
Keywords

Stable boundary layers pose a significant challenge to numerical weather prediction. The reasons are subgrid scale interactions (from mesoscale through sub-mesoscale to turbulence scale) that characterize stable boundary layers and are not only unrepresented in models, but also not well understood. This is particularly true for very stable boundary layers where turbulence is sporadic and submeso motions are one of its major triggering factors.

Over sloping surfaces stable boundary layers are characterized by katabatic flows. Due to strong near-surface wind shear katabatic flows are able to generate sustained turbulence even in very stable conditions. Still, strong stability associated with near surface cooling is conducive to gravity waves and other submeso motions that can propagate and interact with katabatic winds.

In this contribution we examine katabatic winds over slopes of different steepness from the Metcrax II campaign (1° slope) and i-Box project (slopes of 10° and 27°) and their interaction with motions on scales larger than the turbulent scales. For this purpose we employ a recently developed statistical approach that allows for a clustering of turbulence data into periods with different influence of the sub-mesoscale motions on the turbulent fluctuations. Multi-resolution flux decomposition is then used to examine the interacting scales of motion in each identified cluster, and examine the scale separation or lack of separation of turbulent and sub-mesoscale processes.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 136
Abstract code
Dependence of similarity theory on turbulence anisotropy

Author - Ivana, Stiperski, University of Innsbruck, Innsbruck, Austria
Co-author(s) - Marc, Calaf , University of Utah , Salt Lake City , USA (Presenting author)
Topic Boundary layers and turbulence in complex terrain
Keywords

Accurate numerical weather predictions are essential for many applications including: transportation, agriculture, wind energy, hydrology and military. For these applications, it is crucial that the region of the atmosphere closest to the land-surface (atmospheric surface layer, ASL) is well captured numerically. Within the ASL, land-atmosphere forcings are transmitted to the rest of the atmosphere via turbulent exchange of momentum and heat. The short time scale and limited spatial extent of the processes related to the turbulent exchanged make it impossible for traditional weather forecast models to completely capture them. The numerical weather prediction models therefore make use of similarity theories to compute surface fluxes of momentum, sensible and latent heat from the corresponding averaged quantities at a height (z). Strictly speaking, similarity relationships were originally developed for ensemble averages of statistically stationary and horizontally homogeneous surface layer flows. Still, the same similarity relationships are regularly applied in regions of heterogeneous and non-flat terrain. Furthermore, modern numerical methods rarely rely on the mean equations anymore but need more detailed information about the fluxes than simply a mean behavior, as boundary conditions. To be able to model real flows over heterogeneous and complex surfaces, theory and application must be reconciled under the principle of "*local*" homogeneity and statistical stationarity. Meaning, that over small enough regions, sampled long enough, what *a-priori* might resemble a heterogeneous surface, can ultimately be interpreted otherwise.
The validity of surface layer similarity relations have so far been evaluated in terms of required time averaging, the appropriate spatial/local averaging, stationarity and surface heterogeneity through several experimental field campaigns located in places ranging from quasi-perfect horizontal homogeneity to highly complex terrain and complex atmospheric conditions. From the results, procedures and rules-of-use have been developed to ensure appropriate use of similarity relationships.
Within this work we present an analysis of the range of validity of similarity relationships based on the anisotropy of the turbulence Reynolds stress tensor. Turbulence data from multiple field campaigns over flat and complex terrain are separated according to the different states of anisotropy (isotropic, two component axisymmetric and one component turbulence) and flux-variance relationships are tested. Results illustrate that different states of anisotropy correspond to different similarity relations, especially under stable stratification. Experimental data with isotropic turbulence match Monin-Obukhov similarity relationships well for all the datasets. On the other

hand, strongly anisotropic turbulence significantly deviates from the traditional scaling relations. We connect these limiting states of anisotropy with different governing parameters and identify conditions in which they occur. We believe that this new perspective to the land-atmosphere turbulent exchange processes might lead to improved parameterizations, as well as help advance numerical modeling of the land-atmosphere interface.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 137
Abstract code
Turbulence characteristics and scaling of katabatic flows on a shallow slope

Author - Ivana, Stiperski, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - C. David, Whiteman , University of Utah , Salt Lake City , USA
Co-author(s) - Manuela, Lehner , University of Innsbruck , Innsbruck , Austria
Co-author(s) - Albert A.M., Holtslag , University of Wageningen , Wageningen , Netherlands
Topic Results from major field campaigns
Keywords

On nights with weak synoptic forcing and clear or partly cloudy skies a deep katabatic flow develops on an extensive tilted 1° mesoscale plain outside Arizona's Meteor Crater. In its fully developed stage, near surface temperature deficit of 8-10 °C causes katabatic flow with a jet maximum height on the plain that ranges typically between 20-50 m AGL and jet maximum speeds exceeding 5 m/s. This katabatic flow was sampled on multiple nights using a variety of research instrumentation including a 50-m-tall, heavily instrumented turbulence tower as part of the Second Meteor Crater Experiment (METCRAX II) in October 2013. The tower was instrumented at 10 levels using 3-D sonic anemometers and aspirated temperature and humidity probes.
Here we examine the turbulence characteristics of these deep katabatic flows focusing in particular on the structure below the jet maximum. We examine the factors that cause the variability in the mean and turbulence structure on different nights as well as within the same night. Of these, Richardson number is shown to play a dominant role in determining the turbulence structure of the flow. In addition, we develop scaling based on the dominant length scale of turbulent eddies. The analyses are compared to work by previous investigators on shallower katabatic flows.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 138
Abstract code
Scaling the downslope flows in mountainous terrain

Author - Ivana, Stiperski, University of Innsbruck, Innsbruck, Austria (Presenting author)
Co-author(s) - Mathias W., Rotach , University of Innsbruck , Innsbruck , Austria
Topic Boundary layers and turbulence in complex terrain
Keywords

Orography presents a significant forcing to the atmosphere above and around it, spanning a wide range of scales, from large scale to turbulence. In mountainous terrain turbulence is by definition considered to be heterogeneous inhibiting efforts of developing a unified similarity theory for complex terrain. This heterogeneity of turbulence stems from local surface characteristics such as changes in slope angle and vegetation cover and inhomogeneity in the thermal forcing as well as different type of dynamic forcing: under low synoptic forcing thermally driven flows develop in mountain valleys and on the slopes whereas under strong synoptic forcing downslope windstorm-type flows can develop. The question remains whether these effects cause the flows in mountainous terrain to have different turbulence characteristics to those over flat terrain and how this influence is manifested.
In this contribution we present results from long-term turbulence measurements from the Inn Valley, Austria, as part of the i-Box project. We focus on the difference between the turbulence generated by thermally and dynamically driven winds at the valley floor and on the steep slope where towers with multiple levels allow the examination of the non-dimensional wind shear. We then compare the scaling to that over flat terrain. The results from stable stratification on the steep slope suggest scaling for both dynamically and thermally driven types of flow diverges from the flat terrain scaling. This divergence is, however, more pronounced for stronger stabilities, corresponding to shallow thermally driven flows. On the other hand, more neutrally stratified flows caused by strong dynamic forcing, although more horizontally inhomogeneous, correspond better to flat terrain scaling.

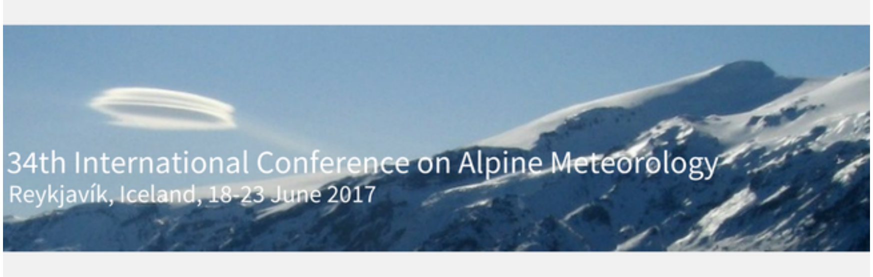
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 139
Abstract code
Föhn events across the Antarctic Peninsula and their connection to local and regional meteorology

Author - Kirchgaessner, Amélie, British Antarctic Survey, Cambridge, United Kingdom (Presenting author)
Co-author(s) - King, John , British Antarctic Survey , Cambridge , United Kingdom
Co-author(s) - Gadian, Alan , National Centre for Atmospheric Science , Leeds , United Kingdom
Topic Weather forecasting for mountainous regions
Keywords

One year of meteorological measurements with an Automatic Weather Station located on the lee side of the Antarctic Peninsula Mountain range have been analysed in detail with regard to the occurrence of Föhn conditions. These are of interest as they have potentially significant impact on the surface energy balance on the Larsen Ice Shelf. We report on the frequency and characteristics of these events and how their strength is determined by the mesoscale situation. Between January 2011 and March 2012 observations of pressure, temperature, humidity and wind speed and direction have been carried out at the AWS at Cole Peninsula. An algorithm combining regional scale model output of flow conditions with the in-situ measurements has been used to identify Föhn. The observations show Föhn occurring throughout the year, not only when circumpolar westerlies are at their strongest. Comparison with runs of the Weather Research and Forecast model WRF as run for the Antarctic Mesoscale Prediction System found that Föhn conditions and their strength are not satisfactorily captured by the model. As we have found a close correlation of Föhn events with air pressure measurements on the South Shetland Islands, which are a good indicator for the state of the Drake Passage Low, we investigate whether and how this relationship can be on one hand exploited to predict the occurrence and strength of Föhn events, and on the other hand be used to extend Föhn statistics in the region beyond the periods of in-situ measurements.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 140
Abstract code

Glacial morpho-climatic system analysis of the swedish lapland using remote sensing technology

Author - Duca, Marvin, University of Ferrara , Ferrara, Italy
Co-author(s) - Billi, Paolo , International Platform for Dryland Research and Education, Tottori University , Tottori , Japan
Co-author(s) - Fazzini, Massimiliano , University of Ferrara , Ferrara , Italy (Presenting author)
Co-author(s) - Pettersson, Rickard , University of Uppsala , Uppsala , Sweden
Co-author(s) - Vega Riquelme, Carmen , University of Uppsala , Uppsala , Sweden
Topic Other
Keywords glacier; GIS; geomorphology, Sweden

Average annual temperatures have risen globally over the past century, with the most rapid changes occurring at high elevations and latitudes. Glaciers are particularly sensitive to current climate change, resulting in glacial retreat. Swedish glaciers are mainly located in the Swedish Lapland, a sparsely populated area, which has not been thoroughly studied. Storglaciären, Mårmaglaciären, Riukojieknaglaciären, Tarfalaglaciären and Rabotglaciären are located in the Sarek and Kebnekaise areas, two mountain chains on the border with Norway and ~100 km north of the Arctic Circle.
The aim of this study includes the morpho-climatic analysis of the Swedish Lapland through the examination of 5 glaciers over the 1984-2010 period, and statistical analysis of the correlation between glacial area extent and their mass balance.
Remote Sensing Technology and GIS platform (ArcGIS and ENVI) were used for this study; Supervisor Classification was essential to distinguish the glacial surfaces and thereby calculate their areas.
We found that each glacier shows areal and volumetric regression, relative to the 1984-2010 period. This is mainly due to the significant increase in annual average temperatures recorded at the three analysed weather stations (≈+1.2°C).
The average loss of these glaciated areas is around 20%, with much higher values for the Tarfalaglaciären (~50%), which is the only continental and slope glacier type with purely Scandinavian characteristics. The absence of peaks surrounding the glacier determines the total exposure of its surface to solar radiation, and the lack of avalanche injections contributes to the definition of this substantial retreat. Surprisingly, most of the glaciers studied here have morphological characteristics of valley glaciers, and are thus similar to Alpine glaciers rather than Scandinavian and/or circus types. The other Scandinavian type glacier, the Riukojieknaglaciären, does not exhibit the same significant, negative trend of the Tarfalaglaciären but rather exhibits a more modest, negative trend similar to the other Alpine-type glaciers. This is likely due to higher snowfall, attributed to the Atlantic moisture from the west. We find a strong relationship between the glacial area and the mass balance trend, demonstrated by both high correlation and

determination coefficients, which are close to 1. The areal trend of the glaciers examined here shows increasing areal extent until the end of the 1990s and rapid decline over the last 10-15 years. Further aerial analyses of six glaciers, of which we do not have mass balance data, fully confirm the aforementioned trends. It is important to emphasize that the strong relationship between glacial area and mass balance refers only to the last 30 years, in the presence of strong global warming.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 141
Abstract code
INCA analysis and nowcasting as part of the international collaborative experiments for the PyeongChang Olympic and Paralymic Games 2018 (ICE-POP 2018)

Author - Bica, Benedikt, ZAMG, Vienna, Austria (Presenting author)
Co-author(s) - Khurshid Awan, Nauman , ZAMG , Vienna , Austria
Co-author(s) - Kemetmüller, Josef , ZAMG , Vienna , Austria
Co-author(s) - Kann, Alexander , ZAMG , Vienna , Austria
Co-author(s) - Wang, Yong , ZAMG , Vienna , Austria
Topic Weather forecasting for mountainous regions
Keywords INCA; ICE-POP; Pyeongchang; Analysis; Nowcasting

After SNOW-V10 (Vancouver 2010) and FROST (Sochi 2014), ICE-POP 2018 is the third major WMO/WWRP supported RDP/FDP project focusing on the observation and forecasting of winter weather at and around Olympic venues. The 23rd Olympic and the 13th Paralympic Winter Games will be held in PyeongChang, Korea in February and March 2018 and offer a unique opportunity to enhance, apply and verify NWP models and nowcasting systems in an extremely user-oriented environment and setting.
One of the goals of ICE-POP 2018 is thus, amongst others, to “advance seamless prediction from nowcasting to short-range forecasting for winter weathers over complex terrains based on intensive observation campaigns”. That is supported by an extremely dense observation network, featuring almost all kinds of in-situ and remotely sensed measurements.
The INCA Analysis and Nowcasting System is widely used and also plays an important role in the provision of very short range field- and point-forecasts over the Olympic area. INCA is coupled with and merged into to the Korean VDAPS model and currently provides analyses and forecasts up to +6h of lead time on a 1 km x 1 km regular grid covering the north-eastern part of the Korean peninsula. The time resolution and update frequency is currently set to 1 hour for temperature, relative humidity, snowfall line, zero degree line, wind and gusts and to 10 min for precipitation and precipitation type.
In accordance with the requirements defined in ICE-POP 2018, INCA has been set up in test mode for the PyeongChang Olympic area during the last winter season, and it is now being evaluated, enhanced and prepared for application in the upcoming Olympic winter season.
The presentation will give an introduction into ICE-POP 2018 and it will summarize the current status of the implementation of INCA for PyeongChang, including case studies and first evaluations.

Presentation Preference Oral
Audio/Visual Equipment

Awards

Additional information

Abstract nr. 142
Abstract code

Anelastic and compressible EULAG solvers for limited-area numerical Alpine weather prediction in the COSMO consortium

Author - Wojcik, Damian, Institute Of Meteorology and Water Management, Warszawa, Poland (Presenting author)
Co-author(s) - Rosa, Bogdan , Institute Of Meteorology and Water Management , Warszawa , Poland
Co-author(s) - Ziemiański, Michał Z. , Institute Of Meteorology and Water Management , Warszawa , Poland
Topic Weather forecasting for mountainous regions
Keywords convective-scale weather forecasting, Alpine flows

Research conducted at Polish Institute of Meteorology and Water Management – National Research Institute, in collaboration with Consortium for Small Scale Modeling (COSMO) have resulted in the development of a new prototype nonhydrostatic anelastic NWP model COSMO-EULAG (CE-A) [1]. The dynamical core of the CE-A model is based on the anelastic set of equations and numerics adopted from the EULAG [2] fluid solver. The model turned out to be capable to compute convection-permitting weather forecast in limited-area regional domains with steep orography and to provide competitive forecasts with respect to the equivalent COSMO model setup. Furthermore, it allowed to perform very high resolution simulations of realistic flows (up to 0.1km grid length) in small Alpine domains with slopes reaching 80 degree of inclination. More recently, the research framework was extended with a new compressible EULAG solver. The compressible solver was developed at ECMWF [3]. Preliminary results obtained with the new model (CE-C) are accurate and promising.
Continuous growth of high-performance resources is expected to allow employing sub-kilometer grid spacing for operational forecasting in the coming decade. Today one can already test model performance for single case studies performed with very fine computational grids. Both CE-A and CE-C models allow to carry out experiments for horizontal grid lengths ranging from 2.2 km to 0.1 km in the convective and stable weather regimes. Our tests have a form of case studies as well as verification comparisons. Results show that computational grid and orography refinement has a noticeable impact on the representation of the flow field and convective development. In particular, finer orography modifies flow field in boundary layer and is a source of increased gravity wave activity. It alters upslope wind patterns which in turn modify location of single clouds and the transition phase between shallow and deep convection. Finally, computational grid and orography refinement has a noticeable impact on the timing of convective precipitation in the model.
References
[1] M. J. Kurowski, D. K. Wójcik, M. Z. Ziemianski, B. Rosa, and Z. P. Piotrowski 2016 *Mon. Wea. Review* vol 144 p 1961-1982

[2] J. M. Prusa, P. K. Smolarkiewicz, and A. Wyszogrodzki 2008 *Computers and Fluids* vol 37 p 1193-1207
[3] P. K. Smolarkiewicz, C. Kühnlein, and N. Wedi 2014 *J. Comput. Phys.* vol 263 p 185-205

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 143
Abstract code

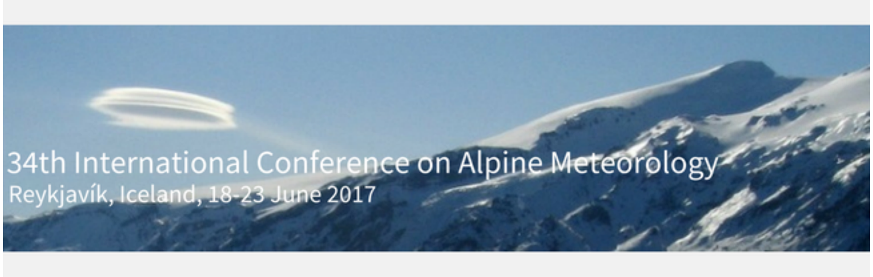
Orography as a source of predictability of deep convection

Author - Keil, Christian, LMU Munich, Munich, Germany (Presenting author)
Co-author(s) - Bachmann, Kevin , LMU Munich , Munich , Germany

Topic Other
Keywords ensemble, predictability, convection,orography

Predictability of convective weather depends on the interaction between synoptic forcing and local-scale flow characteristics influenced by surface inhomogeneities like orography. In this study the role of orography as a source of predictability is investigated using the idealized convective-scale ensemble data assimilation and forecasting system COSMO-KENDA. This integrated system offers the possibilty to introduce physical consistent uncertainties at different scales. The impact of small scale errors provided by assimilating radar data taken from a nature run on the intensity and position of deep convection during airmass convection is compared to a free forecast ensemble as reference, both with and without orography. First results suggest that the orography increases the predictability of precipitation in the free forecasts, whereas the efficient, ensemble based data assimilation of radar reflectivites and wind exerts a very strong constraint on the position of deep convection surmounting the influence of orography.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



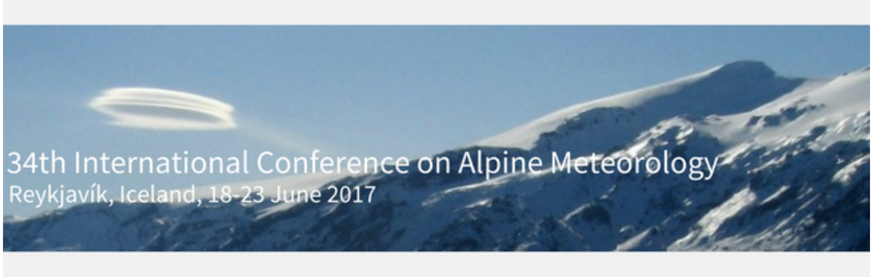
Abstract nr. 144
Abstract code

Strong Relationship Between Dry-Season Rainfall Over West Africa And Extratropical Disturbance.

Author - Ewanlen, Rufus, Federal University Oye-Ekiti, Oye-Ekiti, Nigeria (Presenting author)
Co-author(s) - Shaowen, Shou , Nanjing University of Information Science & Technology , Nanjing , China
Topic Other
Keywords ITD, Upper-level disturbance, Precipitation, Tropi

The recent concerns for food security over Africa related to several climatic factors, such as the strength of the flood and drought within the growing and harvesting seasons and the long-term rainfall variability have motivated the study of identifying the extratropical causes of “anomalous” dry-season precipitation for the region. The paper examines the role of upper level disturbance in the unusual rainfall over the tropical region of West Africa in the dry-season for the month of December, 2014. The rainfall is examined using the global precipitation climatology project (GPCP) merged satellite-gauge daily precipitation estimate and station rain-gauge measurements obtained from Nigeria Meteorological Agency. While the atmospheric circulation features are determined by using the National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP-NCAR) reanalysis dataset. Composites of NCEP/NCAR Reanalysis wind fields, pressure, temperature, humidity and moisture fluxes suggest that rainfall event that affected few countries (Nigeria, Ghana & Cote d’Ivoire) during the period is linked with an enhanced on-shore westerly low-level flow from the Gulf of Guinea into inland, northward displacement of Inter-Tropical Discontinuity (ITD), intensification of the weak dry-season Sahara heat-low and upper-cyclonic vortex which help the generating of convection over the region. The influence of synoptic systems was also evident in the rainfall analysis for December, 2014. During the periods of study, the observed low-level flow over West Africa is likely to be an important contributor to the observed dry-season heavy rainfall, regulated by extra-tropical synoptic scale disturbances. The results provide an important basis for further studies on several cases over the past decade years producing heavy rainfall exceeding some kind of climatological, statistically-based threshold.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 145
Abstract code

Numerical analysis of a ducted internal gravity-wave package causing an exceptional meteotsunami event in the Adriatic

Author - Horvath, Kristian, Meteorological and Hydrological Service, Zagreb, Croatia (Presenting author)
Co-author(s) - Telisman Prtenjak, Maja , Faculty of Science University of Zagreb , Zagreb , Croatia
Co-author(s) - Sepic, Jadranka , Institute of Oceanography and Fisheries , Split , Croatia
Topic Downslope windstorms, mountain waves and rotors
Keywords gravity waves, duct, Apennines, meteotsunami

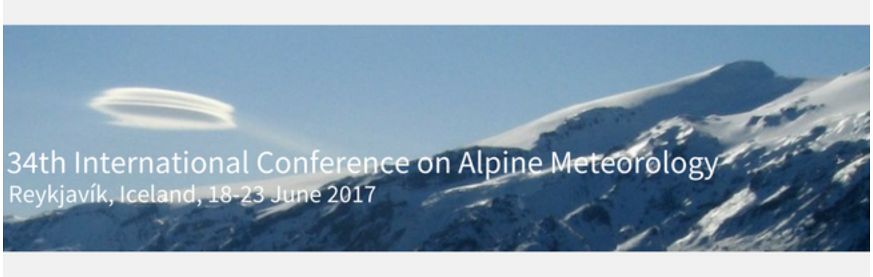
Meteotsunamis are long sea surface waves caused by propagating weakly dissipative atmospheric pressure perturbations formed by ducted internal atmospheric gravity waves and/or convection. Several high-amplitude meteotsunamis occurred in the northern Mediterranean countries during a major meteotsunami period from 23-27 June 2014. The largest sea level oscillations were recorded in Vela Luka Bay, Croatia, in the morning of 25 June 2014, where the amplitude of sea level oscillations reached 3 m. Sea level oscillations reaching 2 m were recorded also near Balearic Islands (Spain), Sicily (Italy), and Odessa (Ukraine). The extraordinary spatial dimension of this event shows that meteotsunamis can have a widespread influence that is comparable to other major tsunami-genic mechanisms.

The large-scale setting during the meteotsunami period was characterized by an incoming upper-level trough as well as the upper-level jet aloft and warm low-level advection from the African continent. The numerical analysis of the event was carried out using the Weather and Research Forecasting (WRF) mesoscale non-hydrostatic model. The model was configured with four telescoping domains reaching 0.5 km grid spacing over the Adriatic.

As inferred by comparison with the ECMWF reanalysis, the model represents well these environmental conditions during the meteotsunami period. The dynamically unstable mid-troposphere with Richardson number smaller than 0.25 capped the warm statically stable air in the lower troposphere. These environmental conditions were favorable for sustaining the internal gravity wave which induced on the Apennines mountain range, as lower layer was statically stable and of sufficient depth. The oscillating surface pressure perturbations at the sea level were also well represented in the simulation. Simulated pressure perturbations were sustained and reached amplitudes of several hPa at the mean sea level, which is of sufficient amplitude to cause a meteotsunami.

Finally, we also provide guidance on the model setup requirements necessary for inclusion of numerical weather prediction models in the operational applications of the meteotsunami warning system.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 146
Abstract code
Detection of gravity waves across the Snaefellsnes Peninsula: A case study

Author - Colfescu, Ioana, National Centre for Atmospheric Science, Leeds, United Kingdom (Presenting author)
Co-author(s) - Mobbs, Stephen , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Burton, Ralph , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Wellpott, Axel , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Olafsson, Haraldur , Icelandic Meteorological Office , Reykjavík , Iceland
Co-author(s) - Petersen, Guðrún Nína , Icelandic Meteorological Office , Reykjavík , Iceland
Co-author(s) - Gadian, Alan , National Centre for Atmospheric Science , Leeds , United Kingdom
Topic Downslope windstorms, mountain waves and rotors
Keywords Gravity waves, modelling, aircraft observations

On October 20th 2016 the FAAM BAE-146 aircraft conducted a flight to observe mountain waves over the Snæfellsnes peninsula, Iceland. The pattern of the vertical velocity suggests that the waves were generated by the air flow over the peninsula (waves parallel to the peninsula) as well as by Snæfellsnesjökull glacier at the tip of the peninsula. A horizontal wavelength of 12-15 km was observed. A series of nested simulations of this gravity wave event have been performed using the Weather Research & Forecasting (WRF) model initialised using GFS analyses. The studies have focused on the resolution required to accurately simulate the observed waves and to explore the role of cloud-microphysical processes on the wave generation. Simulations carried out at two horizontal resolutions (2 km and 400 m) have demonstrated that the wavelength and wave amplitude are well simulated at both resolutions but that details of the wave close to the mountains are sensitive to resolution. This sensitivity also affects the phase of the wave downstream of the mountains. In order to better understand how the physical processes close to the wave generation region affect the evolution of the wave, a series of model simulations have been undertaken with different cloud microphysics and boundary-layer schemes. We will compare each of these simulations with the aircraft data in order to better understand the influence of the detailed physical processes close to the wave generation region on the downstream wave structure.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 147
Abstract code

Wake formation in the lee of a small but high island: modelling and observations

Author - Ross, Andrew, University of Leeds, Leeds, United Kingdom (Presenting author)
Co-author(s) - Hughes, John , University of Leeds , Leeds , United Kingdom
Co-author(s) - Vosper, Simon , Met Office , Exeter , United Kingdom
Topic Downslope windstorms, mountain waves and rotors
Keywords

South Georgia in the Southern Ocean is a small (~30km long,) but high (~3km peak height) makes an ideal natural laboratory for studying wake formation and gravity wave generation. Here we combine high resolution (1.5km horizontal grid spacing) numerical modelling with ASCAT scatterometer winds and radiosonde observations from the SG-WEX field campaign to study the development and structure of the wake in the lee of the island. The high resolution simulations were conducted using the Met Office Unified Model for three month-long field campaigns as part of SG-WEX. Each ASCAT pass typically only covers part of the island and its wake, but using 6 years worth of ASCAT data (2010-2015) a climatology of wake structure was constructed as a function of wind direction, and upstream Froude number (calculated using the ERA-Interim reanalysis). To account for differences in wind speed the fractional wind speed difference relative to the background wind was calculated. This shows a clear wake structure in the lee of South Georgia. The wake structure varies depending on the wind direction relative to the orientation of the island. Surprisingly only a relatively weak dependence on Froude number is observed, with slightly weaker wakes for higher Froude number. This weak dependence is likely due to the fact that the height of the mountains almost always means the flow is in a low Froude number regime with flow blocking. The wake climatology in the high resolution numerical simulations shows a very similar pattern to the ASCAT observations suggesting the model is accurately capturing the flow processes leading to wake formation. The temperature structure of the wake is also studied using the model simulations. On average the wake can be up to a couple of degrees warmer than the surroundings, although the warming is slightly less for the higher Froude number cases.

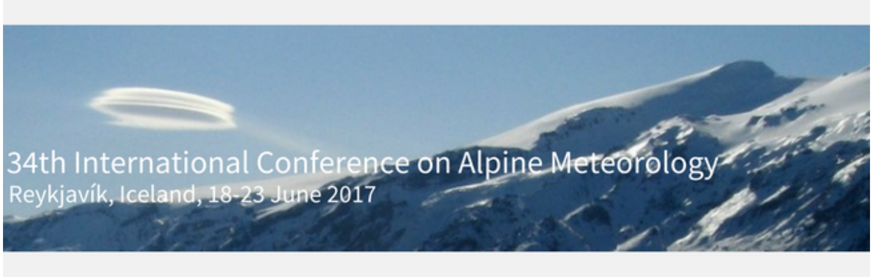
Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 148
Abstract code
Detection of gravity waves across the Snaefellsnes Peninsula: A case study

Author - Colfescu, Ioana, National Centre for Atmospheric Science, Leeds, United Kingdom (Presenting author)
Co-author(s) - Mobbs, Stephen , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Burton, Ralph , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Wellpott, Axel , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Olafsson, Haraldur , Icelandic Meteorological Office , Reykjavík , Iceland
Co-author(s) - Petersen, Guðrún Nína , Icelandic Meteorological Office , Reykjavík , Iceland
Co-author(s) - Gadian, Alan , National Centre for Atmospheric Science , Leeds , United Kingdom
Co-author(s) - Brooks, Barbara , National Centre for Atmospheric Science , Leeds , United Kingdom
Topic Downslope windstorms, mountain waves and rotors
Keywords Gravity waves, modelling, aircraft observations

On October 20th 2016 the FAAM BAE-146 aircraft conducted a flight to observe mountain waves over the Snæfellsnes peninsula, Iceland. The pattern of the vertical velocity suggests that the waves were generated by the air flow over the peninsula (waves parallel to the peninsula) as well as by Snæfellsnesjökull glacier at the tip of the peninsula. A horizontal wavelength of 12-15 km was observed. A series of nested simulations of this gravity wave event have been performed using the Weather Research & Forecasting (WRF) model initialised using GFS analyses. The studies have focused on the resolution required to accurately simulate the observed waves and to explore the role of cloud-microphysical processes on the wave generation. Simulations carried out at two horizontal resolutions (2 km and 400 m) have demonstrated that the wavelength and wave amplitude are well simulated at both resolutions but that details of the wave close to the mountains are sensitive to resolution. This sensitivity also affects the phase of the wave downstream of the mountains. In order to better understand how the physical processes close to the wave generation region affect the evolution of the wave, a series of model simulations have been undertaken with different cloud microphysics and boundary-layer schemes. We will compare each of these simulations with the aircraft data in order to better understand the influence of the detailed physical processes close to the wave generation region on the downstream wave structure.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 149
Abstract code
Sub-kilometer modelling in operational NWP for areas with complex orography

Author - Yang, Xiaohua, Danish Meteorological Institute, Copenhagen, Denmark (Presenting author)
Topic Weather forecasting for mountainous regions
Keywords sub-km operational NWP; complex orography;

In late 2016 Danish Meteorological Institute and Icelandic Meteorological Office launched jointly a mesoscale weather forecast model, IGA, for routine weather forecast of Iceland and South Greenland, with a grid resolution of 2.5 km. IGA is based on the forecast system HARMONIE-AROME (40h1.1) as released by the international research programme HIRLAM-C, based on joint model development with Meteo France, ALADIN and ECMWF. From verification, IGA has shown clear advantages over coarser resolution models in forecast and warning of hazards weather events frequently encountered in this regions, especially the high wind conditions often associated with complex landscape over Greenland and Iceland. On the other hand, operational experiences do reveal numerous situations where the IGA forecast for individual area deviates substantially from station measurement, often in form of over-prediction of storm conditions, sometimes a severe under-prediction. Preliminary examination indicates that, while the present IGA setup is able to simulate overall "large scale" flow condition rather satisfactorily, careful postprocessing is necessary to extract model information to describe weather condition for a geographic point. Moreover, the current IGA model at 2.5 km grid resolution appears insufficient, sometimes, to model the flow complex in areas with complicated orography and landscape. Several domain setup with HARMONI-AROME model and a 750-meter grid has been configured, centered around selected regions with small scale orography complex, such as Tasiilaq, Nuuk and Qaanaaq in Greenland, Westfjords pensinsula in Northwest of Iceland, and Vaga airport in Faor Island, to explore use of sub-km mesoscale NWP model for improved weather forecasting especially for hazards storm conditions. Preliminary results so far show an overall encouraging results, in which the sub-km model is seen to be able to simulate weather patterns with improved realism. Tests have also shown a satisfactory stability and reliability, hence operationally feasible in the near future. It is recognised that NWP model at sub-km involves numerous complex scientific challenges, such as those on data assimilation, nesting, model dynamics and physics, high resolution physiographic database, and postprocessing toward end forecast products. Hence, experiences to be reported here is only start of a long scientific endeavour.

Presentation Preference Oral
Audio/Visual Equipment
Awards

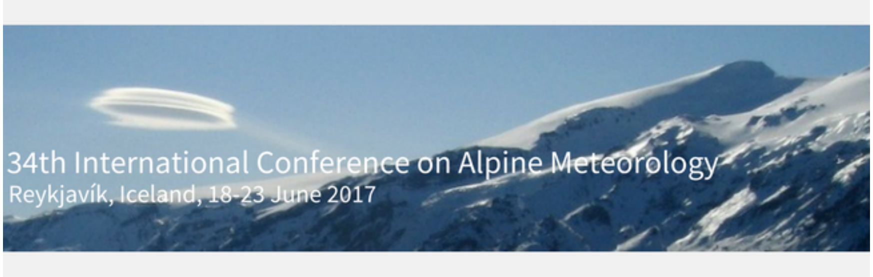
Additional information

Abstract nr. 150
Abstract code
An unexpected severe downslope wind event in Catalonia

Author - Argemí, Oriol, Meteorological Service of Catalonia, Barcelona, Spain (Presenting author)
Co-author(s) - Aran, M. , Meteorological Service of Catalonia , Barcelona , Spain
Co-author(s) - Miró, J.R. , Meteorological Service of Catalonia , Barcelona , Spain
Topic Downslope windstorms, mountain waves and rotors
Keywords downslope;catalonia;

Catalonia is a region located in the north-east of the Iberian Peninsula with a very complex terrain. In the north, it is limited by the Pyrenees, a natural border with France oriented from west to east. The Pre-Pyrenees is a parallel range of mountains located south side, with peaks above 2.500 m. As a result of the interaction between strong northerly airflows with the Pyrenees, severe lee-winds are frequently observed in the Pre-Pyrenees. On 9 December 2014, a northerly episode produced an extraordinary downslope windstorm that reached areas 100 km far from the Pyrenees, close to the Barcelona coast. The southern areas affected included lower orography. At the end of this episode, two deaths and unforeseen forest devastations were caused among others damages. In this study, different meteorological factors that played a crucial role in this event are analysed: the jet stream, its orientation and strength, the stability present in the atmosphere and the interaction of the mountain waves with successive mountain ranges (downslope of the Pre-Pyrenees). As a result of their confluence, the wind gusts observed on the leeward of the Pre-Pyrenees were up to 48 m/s (175 km/h) and exceed 33 m/s (120 km/h) in the affected area near the coast.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 151

Abstract code

The impact of resolution on the representation of wind field in the vicinity of large Greenlandic fjords

Author - Moore, Kent, University of Toronto, Toronto, Canada (Presenting author)

Co-author(s) - Marc, Debenedetti , University of Toronto , Toronto , Canada

Topic Downslope windstorms, mountain waves and rotors

Keywords Greenland, barrier winds, katabatic flow

Greenlandic fjords

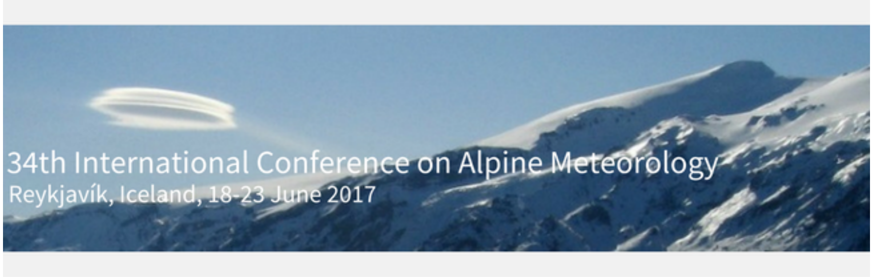
East Greenland is characterized by complex local topographic that gives rise to a number of low-level high wind speed weather systems that are the result of topographic flow distortion. These systems include barrier winds, downslope windstorms and katabatic flow. Global atmospheric reanalyses have proven to be important tools in furthering our understanding of these orographic winds and their role in the climate system. However, there is evidence that the mesoscale characteristics of these systems may be missed in these global products. For example, the 1935-36 British East Greenland Expedition (BEGE) noted a sharp gradient in the wind field along the Kangerdlugssuaq Fjord. Here we compare and contrast the representation of the wind field in the vicinity of the Kangerdlugssuaq and Kangertittivaq (Scoresby Sund) Fjords, two of the large fjords along the east coast of Greenland, in the 30km and 15 km versions of the Arctic System Reanalysis (ASR). We introduce a new diagnostic, the decorrelation length scale (DCLS), that is used to characterize the impact that model resolution has on spatial variability in the wind field. We show that the 15km version of the ASR is better able to represent this variability including the gradient in the wind field in the vicinity of the Kangerdlugssuaq Fjord that were identified by the BEGE. This gradient is shown to be the result with tendency for downslope windstorms to occur to east of the fjord, while katabatic flow is focused to its west. We also use the DCLS to show that the two weather stations in the vicinity of the fjords have wind climates that are not representative of the regional winds.

Presentation Preference Oral

Audio/Visual Equipment

Awards

Additional information



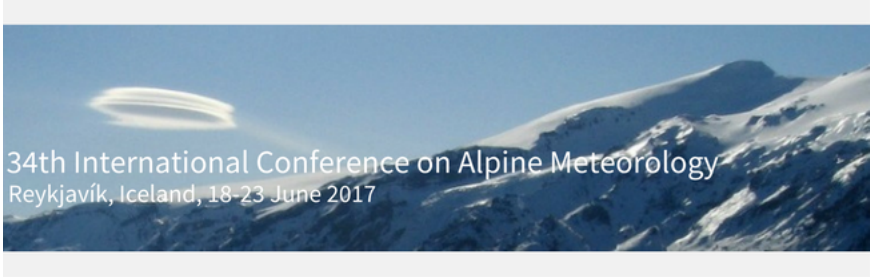
Abstract nr. 152
Abstract code

The impact of foehn winds on the Larsen C ice shelf, Antarctic Peninsula

Author - Turton, Jenny, British Antarctic Survey and University of Leeds, Cambridge, United Kingdom
Co-author(s) - Ross, Andrew , University of Leeds , Leeds , United Kingdom (Presenting author)
Co-author(s) - Kirchgaessner, Amelie , British Antarctic Survey , Cambridge , United Kingdom
Co-author(s) - King, John , British Antarctic Survey , Cambridge , United Kingdom
Co-author(s) - Kuipers Munneke, Peter , Utrecht University , Utrecht , Netherlands
Topic Cryosphere and mountain hydrology
Keywords Foehn; Larsen C ice shelf; surface energy balance

The Antarctic Peninsula (AP) is a narrow, elongated mountain range stretching ~1500km, and orientated roughly north-south. The AP acts as a physical barrier to the prevailing circumpolar westerly winds. Föhn winds frequently flow down the eastern slopes of the AP due to the interaction of the mountain range and the westerly airflow. The collapse of Larsen A and B ice shelves from the east coast of the AP in 1995 and 2002 (respectively) became a symbol for climate change in the Polar Regions. A proposed theory for the destabilisation of the eastern AP ice shelves is surface melting induced by föhn winds. The work presented here uses near-surface observations and simulations using the Weather Research and Forecasting (WRF) model to assess the impact of föhn winds on the surface of Larsen C ice shelf.
Observations from an automatic weather station on Larsen C ice shelf (67.02°S, 61.5°W) were ingested into a SEB model to estimate values of the energy balance components, prior to this study. Daily averaged values of all SEB components from 2009-2012 were provided for the project. Annual and seasonal analysis of these components has highlighted the impact of föhn winds on the ice shelf.
The increased downward shortwave radiation due to the cloud-clearing effect and the increased (positive) sensible heat flux during föhn winds lead to residual energy available for melt. When surface temperatures reach 0°C, this residual energy is used to melt the ice shelf surface. During austral spring (SON), föhn events cause earlier onset of the melt season, increase the number of melt days and increase the intensity of the surface melt. Surface melt is observed up to 100km from the foot of the AP. Surface melt from föhn events is greatest in years with multiple consecutive föhn events in late spring.
Numerical simulations accurately capture the number of melt days in a season but fail to capture the increased amount of surface melt during föhn events. Largely this is due to the low albedo value used in WRF, and the lack of a feedback effect once surface melting ensues. A presentation of the impacts of föhn winds on the Larsen C ice shelf and the representation of föhn-induced surface melt in numerical simulations is discussed.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 153
Abstract code

Mountain waves and cloud bands: case studies of 21 May 1937 and 1 February 2014 within a long research tradition

Author - Volkert, Hans, DLR, Oberpfaffenhofen, Germany (Presenting author)
Topic Downslope windstorms, mountain waves and rotors
Keywords Mountains waves; history of meteorology

Airflow across mountain ridges can induce in a stably stratified atmosphere vertically oscillating motions, which are termed *mountain waves*. Such wave patterns can be stationary over hours and can have considerable extension downstream. When the ambient humidity is suitable, the wave crests are often marked by elongated *cloud bands*. These basic mechanisms have been gradually discovered and described in the 1930s, especially by German glider pilots and scientists. In a pioneering study, Küttner (1939) collected photographic evidence for wave clouds at quite a number of mountain ranges. Furthermore, he used no less than 22 barogrammes from gliders taking part in a regional competition to map out the vertical velocity field in the lee of the modest size *Riesengebirge* ridge at the border between Czechia (northern part of the Czech Republic) and Silesia (today in the southern part of Poland).

The dynamics of mountains waves in two- and three-dimensional settings with various degrees of idealization became a core topic of (mesoscale) dynamical meteorology. At the turn of the century, the state of the art linking data from different observational platforms with three-dimensional episode-type simulations was documented for the Alpine case of 25 Sept. 1999 during MAP-SOP (Volkert et al., 2003).

In recent years detailed, multi-channel satellite observations with high spatial resolution (MODIS-instrument on the TERRA and AQUA satellites) as well as high temporal resolution (SEVIRI instrument on Meteosat second generation) make possible the detailed documentation of waves generated cloud systems and help to infer their (quasi-)stationarity. Image sequences from mountain based web-cameras provide the human perspective from the surface. During the exceptional case of 1 February 2014 stationary cloud structures of various wavelengths could be detected embedded in the transient frontal cloud system within a southerly airflow over an area extending from the Alps to the *Riesengebirge* some 400 km further to the north (cf. self-steerable satellite loop under www.pa.op.dlr.de/~HansVolkert/GraWaves).

The presentation (oral preferred; poster possible in an abbreviated fashion) contains highlights from a research tradition spanning a period of more than 75 years and links its findings with the development of observation technology and research interests.

<u>References:</u>

Küttner, J., 1939: Moazagotl und Föhnwelle (moazagotl cloud and foehn wave). *Beitr. Phys. fr. Atmos*. **25**, 79-114.

Volkert, H. et v alii, 2003: Gravity waves over the eastern Alps: A synopsis of the 25 October 1999 event (IOP 10) combining in situ and remote-sensing measurements with a high-resolution simulation. *Q. J. Roy. Meteorol. Soc.* **129**, 777-797.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 154
Abstract code

Processes leading to heavy precipitation over north-eastern Adriatic during the HyMeX SOP1

Author - Ivancan-Picek, Branka, Meteorological and Hydrological Service - DHMZ, Zagreb, Croatia (Presenting author)
Co-author(s) - Tudor, Martina , Meteorological and Hydrological Service - DHMZ , Zagreb , Croatia
Co-author(s) - Horvath, Kristian , Meteorological and Hydrological Service - DHMZ , Zagreb , Croatia
Co-author(s) - Stanesic, Antonio , Meteorological and Hydrological Service - DHMZ , Zagreb , Croatia
Co-author(s) - Ivatek-Sahdan, Stjepan , Meteorological and Hydrological Service - DHMZ , Zagreb , Croatia
Topic Results from major field campaigns
Keywords HyMeX, heavy precipitation, orography, convection

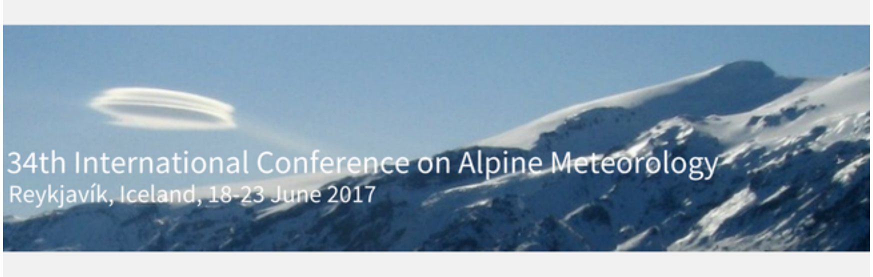
During SOP1, 16 IOPs were dedicated to heavy precipitation events (HPE) over the western Mediterranean and 8 of these events subsequently affected the eastern Adriatic Sea and Croatia. All of them produced localized heavy precipitation and often were properly forecast by the available operational model ALADIN but prediction of the amount, precise time and the location of maximum intensity was not always exactly represented. The total precipitation for the SOP1 was above the corresponding climatology for the Adriatic. Maximum of precipitation (more than 1.000 mm in 61 days at some locations) was recorded on the northern Adriatic (city of Rijeka) and its mountainous hinterland of Gorski Kotar.

Most the HPEs contain similar ingredients and synoptic setting but of different intensity: a deep upper level through, a cyclone strengthening over the Mediterranean (or developing over Gulf of Genoa, Lyon or Tyrhennian sea), a strong south-westerly low-level jet stream that advects the moist and warm air towards the orographic obstacles along eastern Adriatic coastline and destabilizes the atmosphere and the strong low level winds which pick up the moisture from the sea. As the sea provides a large source of moisture and heat, the steep slopes of the surrounding mountains in the vicinity of urbanized northern Adriatic coastal areas are the key factors in determining the moisture convergence and the rapid uplift of moist and unstable air responsible for triggering condensation and convective instability processes.

Overview of processes leading to heavy precipitation over north-eastern Adriatic during the HyMeX SOP1 will be presented, with special focus on the extraordinarily rare heavy precipitation event IOP2 (12 September 2012) that occurred in wider area of the city of Rijeka.

Presentation Preference Oral

Audio/Visual Equipment
Awards
Additional information



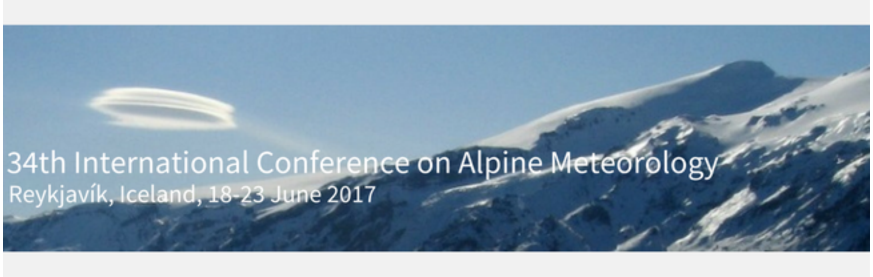
Abstract nr. 155
Abstract code

Impact of higher boundary temperatures on simulations of atmospheric ice accretion on structures during the 2015-2016 icing winter in West-Norway

Author - Ingvaldsen, Kristian, University of Oslo, Oslo, Norway (Presenting author)
Co-author(s) - Ágústsson, Hálfdán , Kjeller Vindteknikk , Kjeller , Norway
Co-author(s) - Nygaard, Bjørn Egil , Kjeller Vindteknikk , Kjeller , Norway
Co-author(s) - Koren Berntsen, Terje , University of Oslo , Oslo , Norway
Topic Other
Keywords Atmospheric icing;

Atmospheric icing has been studied for several decades now, not only due to the hazardeous consequences it can have to air traffic, but also due to the damage it can cause to human installations such as power lines, wind turbines and radio towers etc. Overhead structures that are built in mountaineous regions at mid and high latitudes are particulary vulnerable to the exposure of super-cooled water in clouds.. The aim of this study is to quantify the possible effects that increased, global temperatures may have on atmospheric icing conditions in the complex orography of western Norway.
Using the Weather Research and Forecasting (WRF) Model we did two simulations of the full 2015-16 winter season covering approximately 18 km^2 of the mountaineous regions of western Norway. The model was forced by ERA-Interim reanalysis data, and applied the Thompson microphysics scheme. The first simulation was used as a control run, where the calculated accumulated ice load on a so-called standard icing object, was compared to observations provided by state-of-the-art instruments. The second simulation was made using modified input data, where temperatures at the boundaries of the model domain were increased by 2°C while the relative humidty was kept the same, allowing higher specific humidity. The results showed significantly smaller accumulative ice loads in the warm run compared to the control. This was found to be mostly due to several episodes where the temperature was above freezing in the warm run and just below freezing in the control run, resulting in fewer icing events as well as more frequent melting episodes in the warm run . The differences seemed to increase with terrain height, and only sporadic events where the icing intensity was higher in the warm run was found. A part of the differences in frequency and intensity of atmospheric icing is explained by a spatial redistribution of high atmospheric water content in the warm run compared to the control run.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information



Abstract nr. 156
Abstract code

Building 'extreme' bridges in complex terrain – Observing and simulating the atmospheric conditions in Sulafjorden for the E39 project of the Norwegian Public Roads Administration

Author - Furevik, Birgitte, Norwegian Meteorological Institute, Bergen, Norway (Presenting author)
Co-author(s) - Ágústsson, Hálfdán , Kjeller Vindteknikk , Oslo , Norway
Co-author(s) - Harstveit, Knut , Kjeller Vindteknikk , Oslo , Norway
Co-author(s) - Byrkjedal, Øyvind , Kjeller Vindteknikk , Oslo , Norway
Topic Results from major field campaigns
Keywords

In 2014, the Norwegian Public Roads Administration (NPRA) started an evaluation of the environmental conditions i.e. wind, atmospheric turbulence, waves and currents, pertaining to the construction of a 'ferry-free' road connection between Kristiansand and Trondheim on the western coast of Norway. The Norwegian west coast is famous for its fjords, and the project includes crossing of 8 of the largest, with fjord widths between 2 and 7.5 km, depths up to 1300 m and typically surrounded by very steep mountains of up to 1200 m. This requires a detailed description of the wind, wave and ocean current climate at the proposed bridge locations, which will then be used as input to the design of the fjord crossings.
The project started with a downscaling of the state of atmosphere to a resolution of 500 m x 500 m for the last ten years at planned crossings. The simulations are done with the WRF-model forced by the global Interim analysis of the ECMWF and are continuously updated when new global analysis become available. The downscaled data is used in forcing high-resolution wave and ocean current models. At a later stage, the simulated atmospheric data will be corroborated by additional simulated data produced by a CFD-model run by the Norwegian Meteorological Institute. A measurement program started in 2014 in the fjords of Mid-Norway and a considerable increase in measurement effort was initiated in October 2016. The measurement program includes numerous tall meteorological masts equipped with sonic anemometers observing at 10 Hz at several elevations. The most recent masts are 100 m high while the initial masts have an elevation of 50 m. A number of wave buoys with 4 m masts for meteorological measurements are being installed and a campaign including concurrent observations from several scanning LIDARs will commence in the summer of 2017. All observational data will be put in the open domain.
The current analysis includes extreme wind maps for the fjord crossings, analysis of atmospheric turbulence and coherent structures in the flow. The observational data describes in detail the flow structure during numerous storm events in complex terrain. For example, the most recent measurements reveal vertical wind speeds (3 second average) in excess of +10 m/s, and -22 m/s as an extreme value, immediately downstream of a 500 m high mountain at the site of a proposed fjord crossing. The strong vertical winds occur in a rather wide wind sector (180 - 270°, background wind aloft), and a change on the order of 15° in background wind direction leads to

horizontal wind shift of 100° at lower levels. In light of the importance for the design of the fjord crossings, atmospheric structures and variability such as this must be mapped in detail, in particular their horizontal and vertical extent across the fjord.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 157
Abstract code
Heavy Precipitation and Flash Flood Events over Eastern Pyrenees

Author - RICHARD, EVELYNE, Laboratoire d'Aérologie, Toulouse, France (Presenting author)
Co-author(s) - TOUS NADAL, Maria , Laboratoire d'Aérologie , Toulouse , France
Topic Weather forecasting for mountainous regions
Keywords heavy precipitation

Southeastern France is prone to heavy precipitation and flash-flood events. These high-impact weather events usually occur ahead of a trough directing upper-level southern flow and providing large-scale ascent whereas at the surface the moist and warm marine inflow is strongly influenced by the coastal orography. This presentation is focused on the events which affect the eastern tip of the Pyrenees. First, the climatology of these events is examined using ERAI reanalyzes together with precipitation and discharges time series. Unlike the events which hit the Massif Central or the Southern Alps, the eastern Pyrenees events are mostly associated with a low-level cyclone (located in the vicinity of the Balearic Islands). According to the climatological trends deduced from ERAI, the associated cyclones, tend to become deeper and to progress westward. Then, the results of various hydro-meteorological simulations are analyzed. Three past severe episodes have been investigated with the Meso-NH atmospheric model (500 m resolution) coupled with the MARINE distributed hydrological model. It is shown that the Meso-NH precipitation forecasts remain skillful even for small size water sheds (~1500 km2).

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 158
Abstract code
Sensitivity of orographic precipitation to aerosols, a HyMeX case study.

Author - PINTY, Jean-Pierre, Laboratoire d'Aérologie, Toulouse, France (Presenting author)
Co-author(s) - RICHARD, Evelyne , Laboratoire d'Aérologie , Toulouse , France
Topic Results from major field campaigns
Keywords

During Fall 2012, the HyMeX experiment which took place in the South of France, collected a lot of microphysics and precipitation data over medium orography, here the Cevennes ridge of Massif-Central, facing warm and humid southeasterly flows from the Mediterranean (Gulf of Lion). The Cloud-Resolving Mesoscale model MesoNH was then used to simulate in detail many precipitating events. For that purpose, the 2-moment microphysics scheme LIMA of MesoNH was initialized with 3D aerosol analyses taken from the MACC-II database at ECMWF. The poster presents briefly the LIMA scheme and the way Cloud Condensation Nuclei (CCN) and Ice Forming Nuclei (IFN) are initialized. The case of several experiments is described for short but intense HyMeX events. Then interestingly, doubling and halving the aerosol concentrations, is leading to a visible displacement of the precipitation field with respect to the orientation of the low level flow to the orography. The significance of these results is commented and the role of the aerosol load is emphasized for high resolution rainfalls over orography.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 159
Abstract code

Precipitation impacts of atmospheric rivers on the west coast of southern South America

Author - Viale, Maximiliano, IANIGLA-CONICET , Mendoza, Argentina (Presenting author)
Co-author(s) - Valenzuela, Raúl , Universidad de Chile , Santiago , Chile
Co-author(s) - Garreaud, Rene D. , Universidad de Chile , Santiago , Chile
Topic Orographic precipitation
Keywords Atmospheric Rivers, Andes, Precipitation

Similar to other mountainous west coast around the world, the west coast of southern South America (SA) is strongly affected by heavy orographic precipitation events that result from the landfalling Atmospheric Rivers (AR). An AR is a narrow and long corridor of enhanced moisture transport over the oceans that often, but not always, develops just ahead of midlatitude cold fronts. When frontal systems develops an AR over southeastern Pacific ocean and it strikes the Andes mountains, orographic processes enhance precipitation over the upstream and the windward and immediate lee slopes sectors that occasionally produce floods, landslides, and at worst irrecoverable losses and fatalities. On the other hand, these heavy orographic precipitation events are a major contributor to water resources in the region, especially at the subtropical latitudes where the Andes are higher and melted snow irrigates the desert lands on both flanks of the range. Despite their importance, the SA region has a significant gap in the knowledge of AR phenomena and their impacts compared to North America and western Europa. In this study, we will discuss results from the quantification of how AR storms contribute to the annual total and extreme precipitation along the west coast of SA, between the southern tip of the continent and 30ºS, and across the Andes from the west coast (Chile) to the leeside (Argentina). The Integrated Water Vapor Transport (IVT), derived from Climate Forecast System Reanalysis (CFSR) data, is used for the AR identification over the period of 2001-2016; while daily and snow precipitation data networks of Chile and Argentina are used to quantify the impact of AR on precipitation over the region.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 160
Abstract code
Orographic effects of the subtropical and extratropical Andes on precipitating clouds

Author - Viale, Maximiliano, IANIGLA-CONICET , Mendoza, Argentina (Presenting author)
Co-author(s) - Zalazar, Gualberto , IADIZA-CONICET , Mendoza , Argentina
Co-author(s) - Bianchi, Emilio , INTA-CONICET , Bariloche , Argentina
Topic Orographic precipitation
Keywords Precipitation, Clouds, Andes, Orographic effects

The orographic effect of the Andes (35°S-50°S) on precipitating clouds from midlatitude frontal systems is investigated using surface and CloudSat satellite data. The Andes is a long mountain chain that extends in the north-south direction on the west coast of South America. Its crest descent from the subtropics to extratropics and its perpendicular disposition to the westerlies makes this barrier an excellent natural laboratory to investigate orographic effects on frontal precipitation systems. Seven transects of hourly rain gauges between 35°S and 45°S from the windward side (Chile) to the lee side (Argentina) were installed as part of a project initiated in 2016. Installed rain gauges were complemented with daily precipitation data managed by Argentinean and Chilean Weather and Water agencies, although these datasets do not sample well near the crest and in the immediate lee sectors of the Andes. Surface precipitation observations indicate orographic enhancement and suppression in annual total amount from the Pacific coast to the leeward slopes that varies with latitude. Hourly gauges and instantaneous satellite observations show that the cross-barrier increase and decrease in annual precipitation responds to increase and decrease in both the intensity and frequency of precipitation. In addition, CloudSat satellite data reveal cross-barrier variations in precipitating cloud properties that suggest orographic influences on the airflow dynamics and microphysical processes that will be discussed in the presentation.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 161
Abstract code

Recent Tendencies in the Regime of the Snow Cover Seasonal Maxima in the Mountain Regions of Bulgaria - Preliminary Results

Author - Nikolov, Dimitar, National Institute of Meteorology and Hydrology, Sofia, Bulgaria (Presenting author)
Co-author(s) - Cvetan, Dimitrov , National Institute of Meteorology and Hydrology , Sofia , Bulgaria
Topic Cryosphere and mountain hydrology
Keywords

This study represents the preliminary results of an ongoing research of the snow cover characteristics in the mountainous regions of Bulgaria. The period of investigation spans over more than 50 years (1962-2016) and covers regions with altitudes form 900 up to 2400 m a.s.l. The following characteristics of the seasonal maximums of the snow cover have been investigated: time change and assessment of the trend of their values and date of appearance. Some remarkable differences in both characteristics for different altitudes have been observed.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 162
Abstract code

History of the mountain meteorology in Bulgaria

Author - Nikolov, Dimitar, National Institute of Meteorology and Hydrology, Sofia, Bulgaria
(Presenting author)
Topic History of mountain meteorology
Keywords

This study describes briefly the history of the Bulgarian mountainous meteorological stations, the main research carried out there and the perspectives for their future development. There are 5 alpine meteorological stations in the network of the Bulgarian Institute of Meteorology and Hydrology with altitudes from 1700 up to 2900 m a.s.l. The oldest one – peak Mussala was built in 1932 and is the highest meteorological station on the Balkan Peninsula.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 163
Abstract code
Precipitation scavenging effects on Mt. Washington cloud chemistry

Author - Bailey, Adriana, Dartmouth College, Hanover, USA (Presenting author)
Co-author(s) - Murray, Georgia , Appalachian Mountain Club , Pinkham Notch , USA
Topic Orographic precipitation
Keywords cloud chemistry; water isotopes

With cloud deposition the largest source of atmospheric pollutants to many fragile alpine environments, understanding the processes that control mountain cloud-water chemistry is critical. Using 20 years of summer cloud and rainwater samples collected near the summit of Mt. Washington, New Hampshire, US, this study evaluates how condensation and precipitation during atmospheric transport influence pollutant concentrations in air masses arriving from different geographic sectors. To characterize the condensation history of air masses arriving at Mt. Washington, the analysis leverages the fact that isotopically heavy water molecules condense more readily than their lighter counterparts. The more condensate removed as precipitation, the “lighter” the remaining cloud water becomes. Thus, the water isotope ratios of the samples serve as proxies for the amount of rainout that occurs “upstream” of the mountain. HYSPLIT back trajectories suggest the majority of Mt. Washington samples are associated with air masses arriving from locations to the west and southwest of New Hampshire, from regions such as the Great Lakes, the industrial Ohio River Valley, and the Boston-Washington, DC urban corridor. Concentrations of pollutants like sulfate, nitrate, and ammonium are highest for these geographic sectors. Despite the fact that water isotope ratios vary strongly with latitude, regression models suggest condensation and precipitation during air mass transport explain a third of the variance in Mt. Washington cloud chemistry. The dependence of pollution on “upstream” rainout becomes even more apparent when samples are binned by geographic origin, providing compelling evidence that precipitation scavenging effectively removes pollutants from air masses en route to mountain environments.

Presentation Preference Oral
Audio/Visual Equipment
Awards
Additional information

Abstract nr. 164
Abstract code
Orographic influence of Greenland on two cyclones

Author - Thorsteinsson, Sigurdur, Icelandic Met. Office, Reykjavik, Island (Presenting author)
Topic Results from major field campaigns
Keywords

The orographic infuence will be described.

Presentation Preference Poster
Audio/Visual Equipment
Awards
Additional information