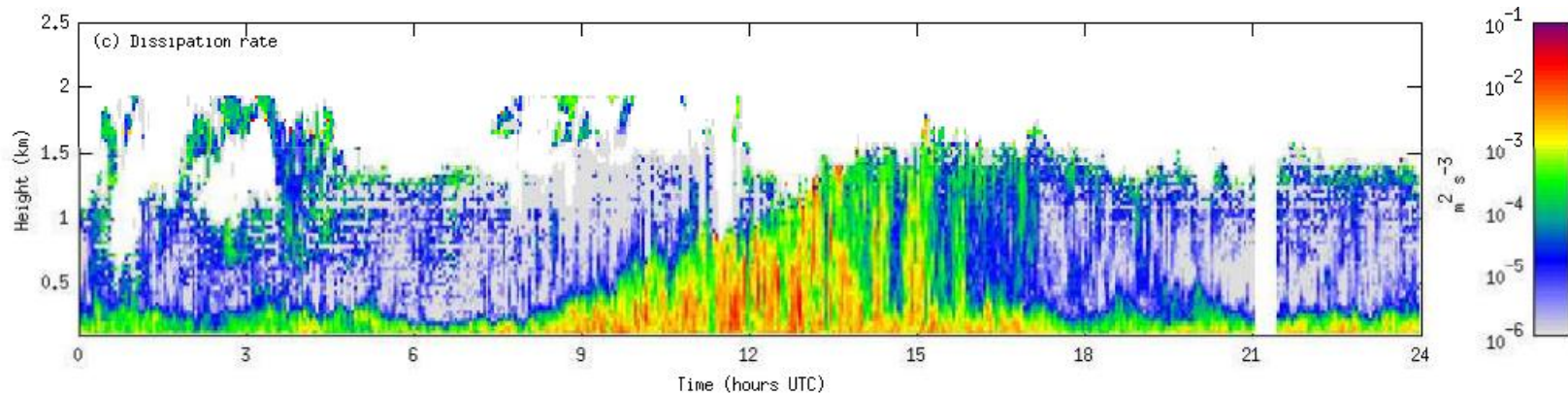




Forecasting applications from ground-based active remote sensing

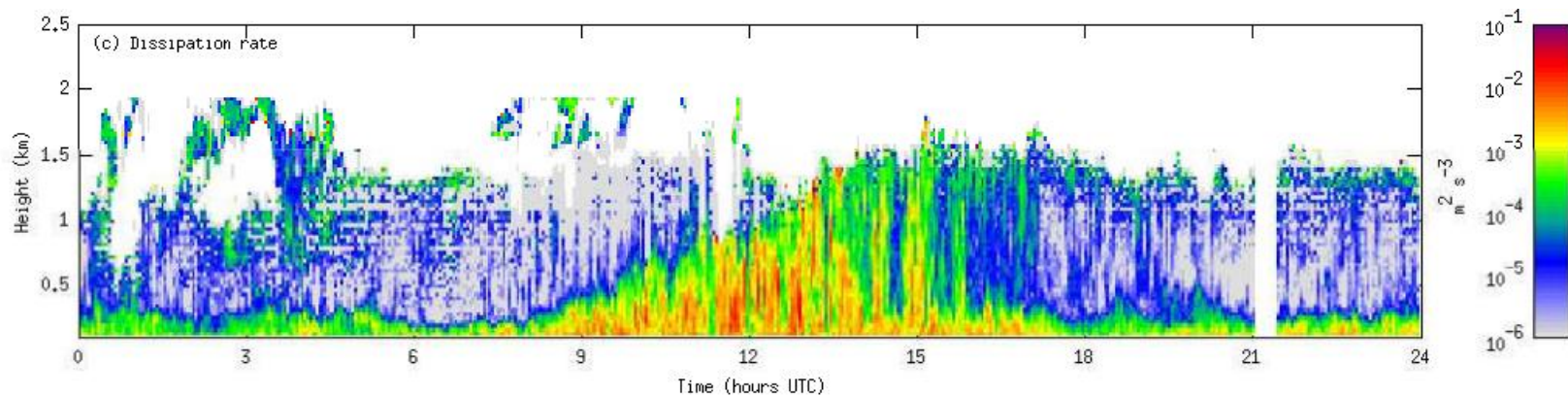


Ewan O'Connor

FMI (Finnish Meteorological Institute), Helsinki, Finland



Vertical profiling of Clouds, Aerosol, Winds and Turbulence



Ewan O'Connor

FMI (Finnish Meteorological Institute), Helsinki, Finland

Profiling instruments



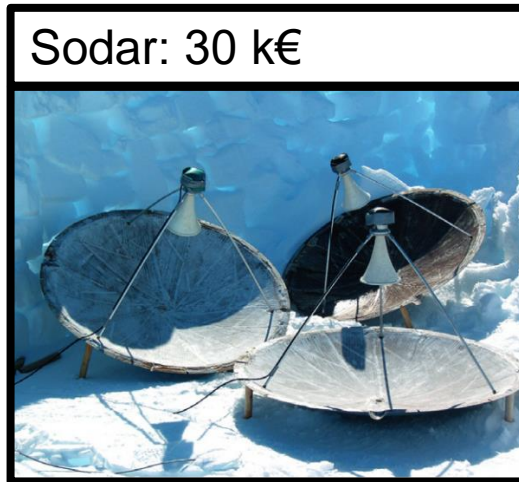
Cloud radar: 240-600 k€



Doppler lidar: 200-300 k€



Multi- λ lidar: > 200 k€



Sodar: 30 k€

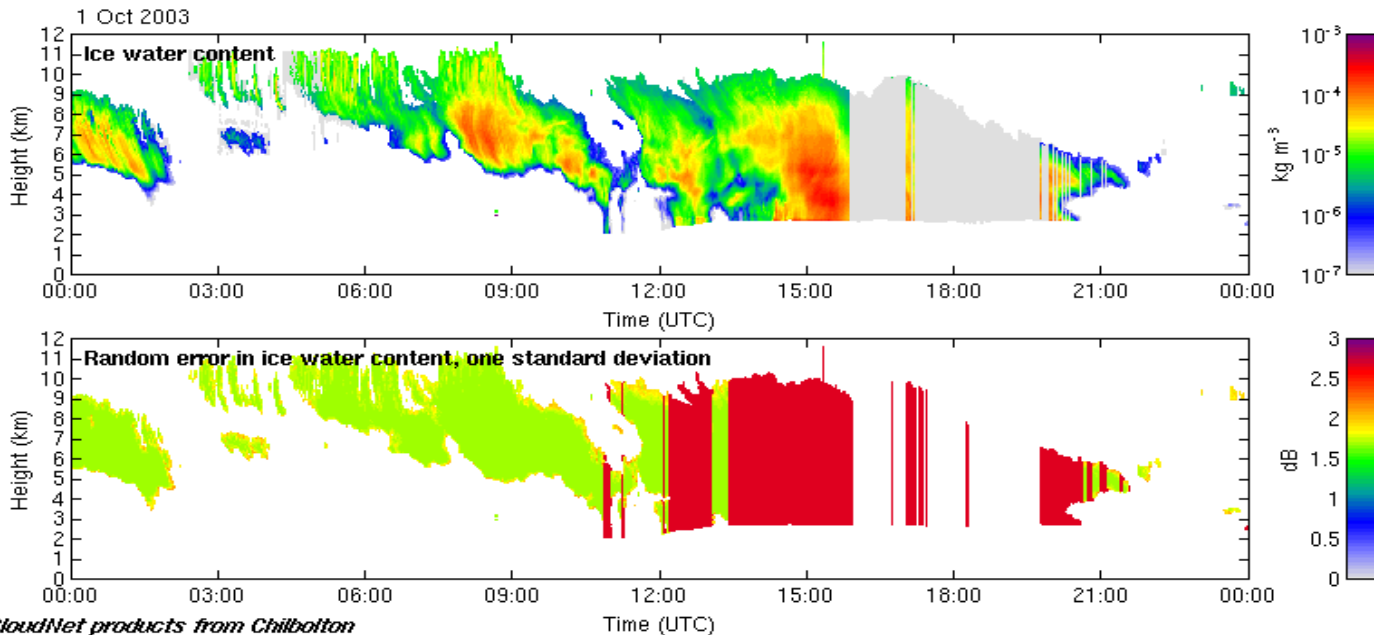


Ceilometer: <30 k€



Vertically-pointing (can scan)

- Usually combine with lidar and microwave radiometer



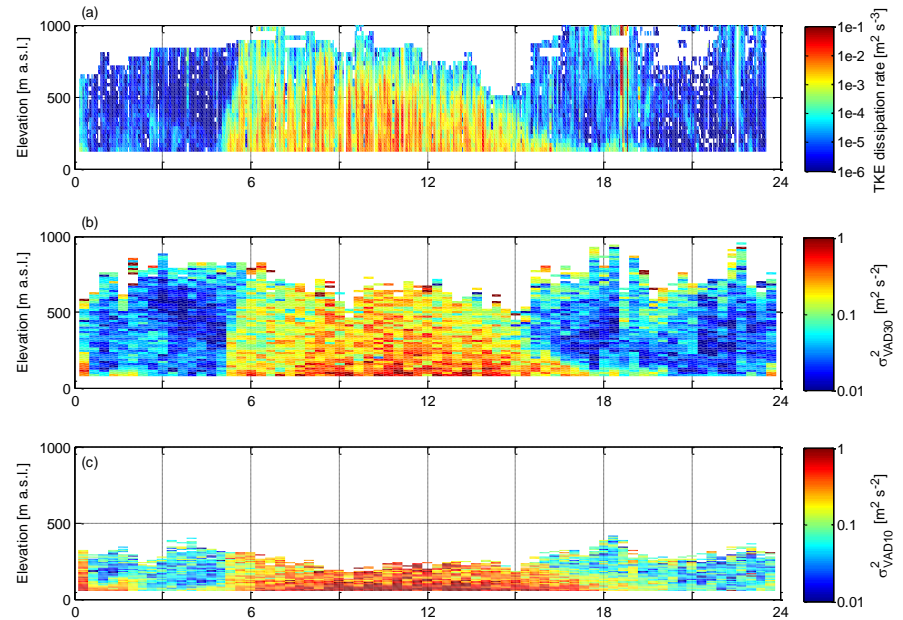
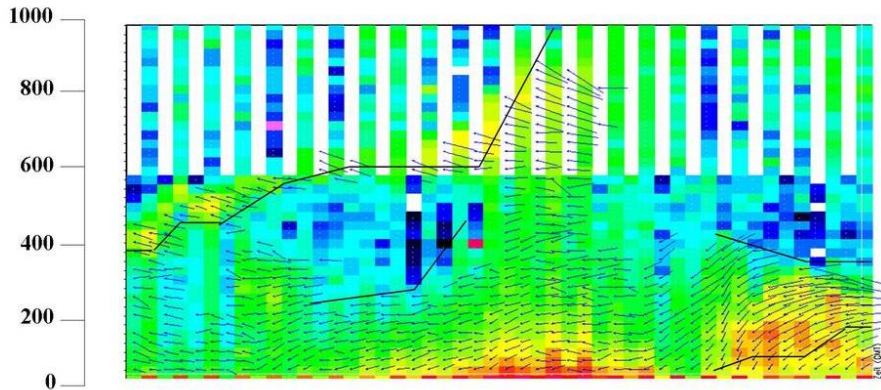
Note larger error above melting-layer due to uncertain attenuation

IWC not reported if rain at ground

Liquid, ice, precipitation microphysical properties
Turbulent properties



Provide winds and turbulent parameters in the boundary layer





FMI has 7 Doppler lidars
5 in an operational network
2 for campaigns

Products also include:

Wind shear

Low level jets

Mixing level height

BL classification

Wind gusts





Wind shear

Different Winds





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FINNISH METEOROLOGICAL INSTITUTE

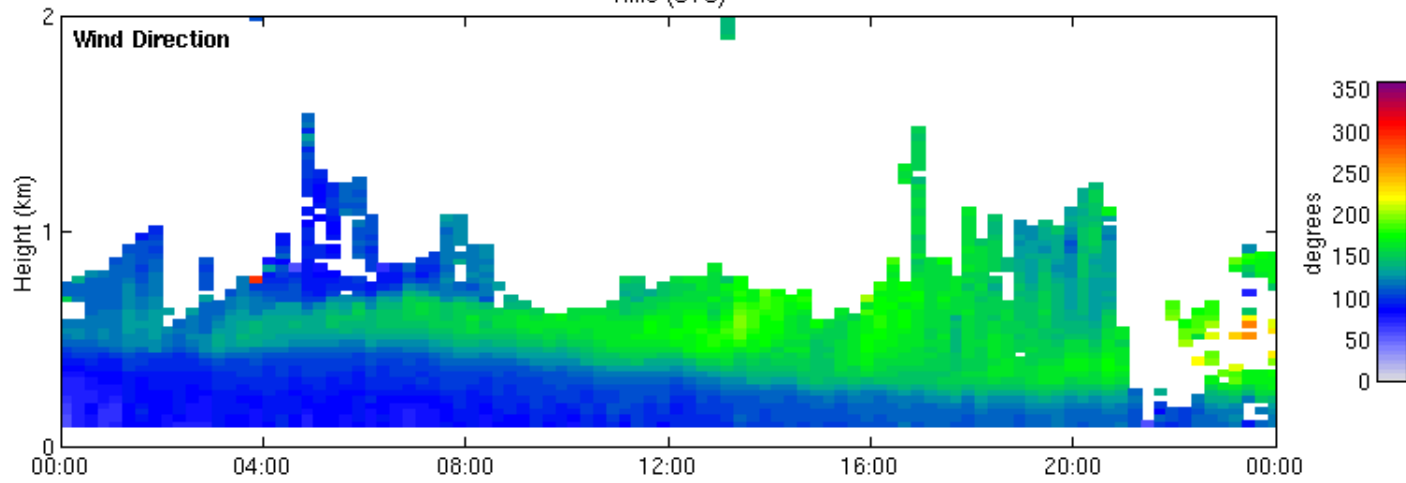
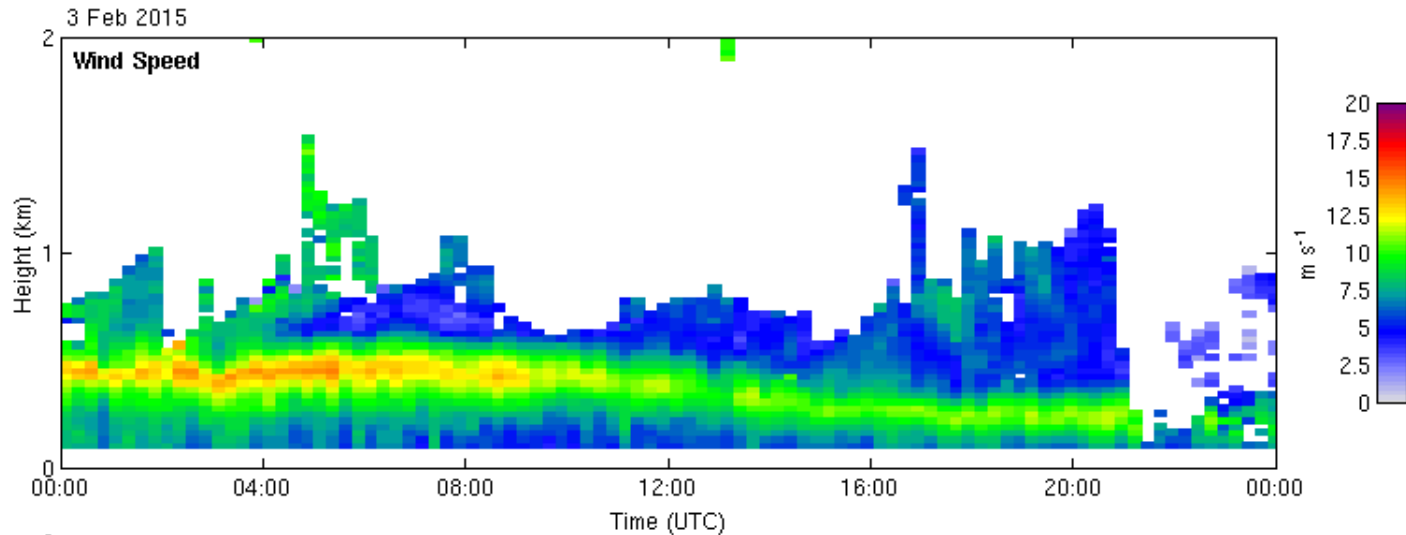


Plume observations - Kuopio





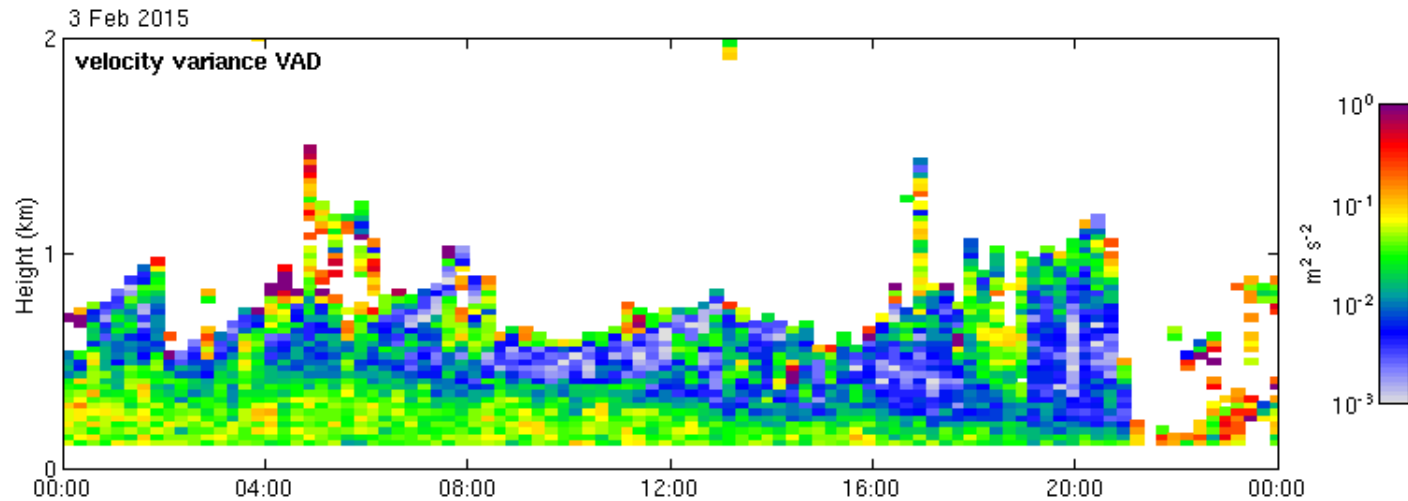
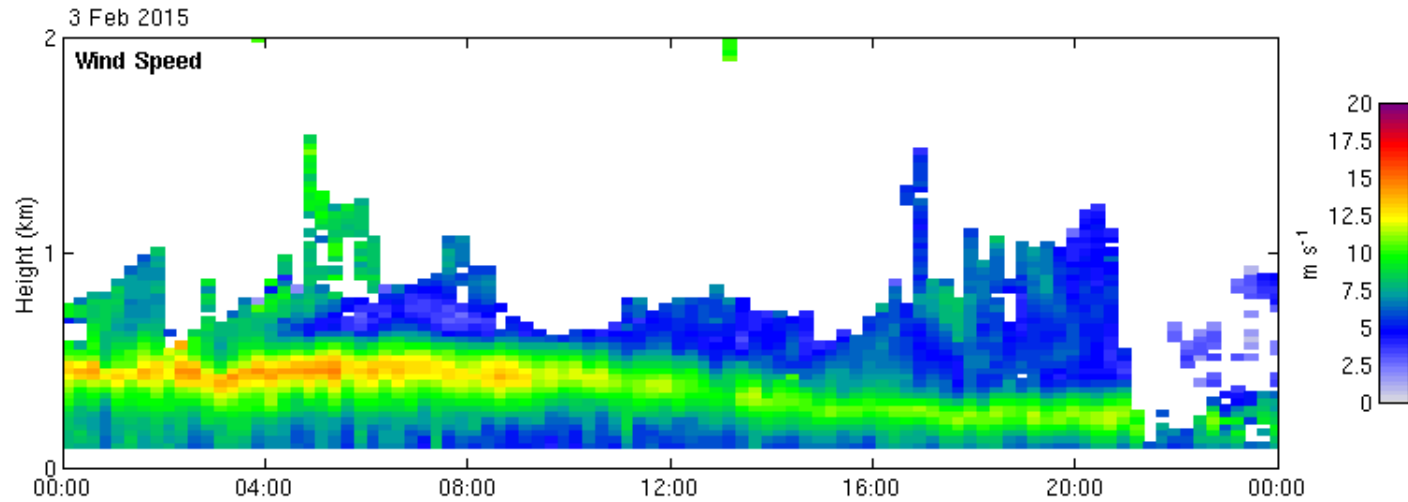
Wind shear and LLJ



Pyhäjoki 1.5 micron Doppler Lidar



Wind shear and LLJ





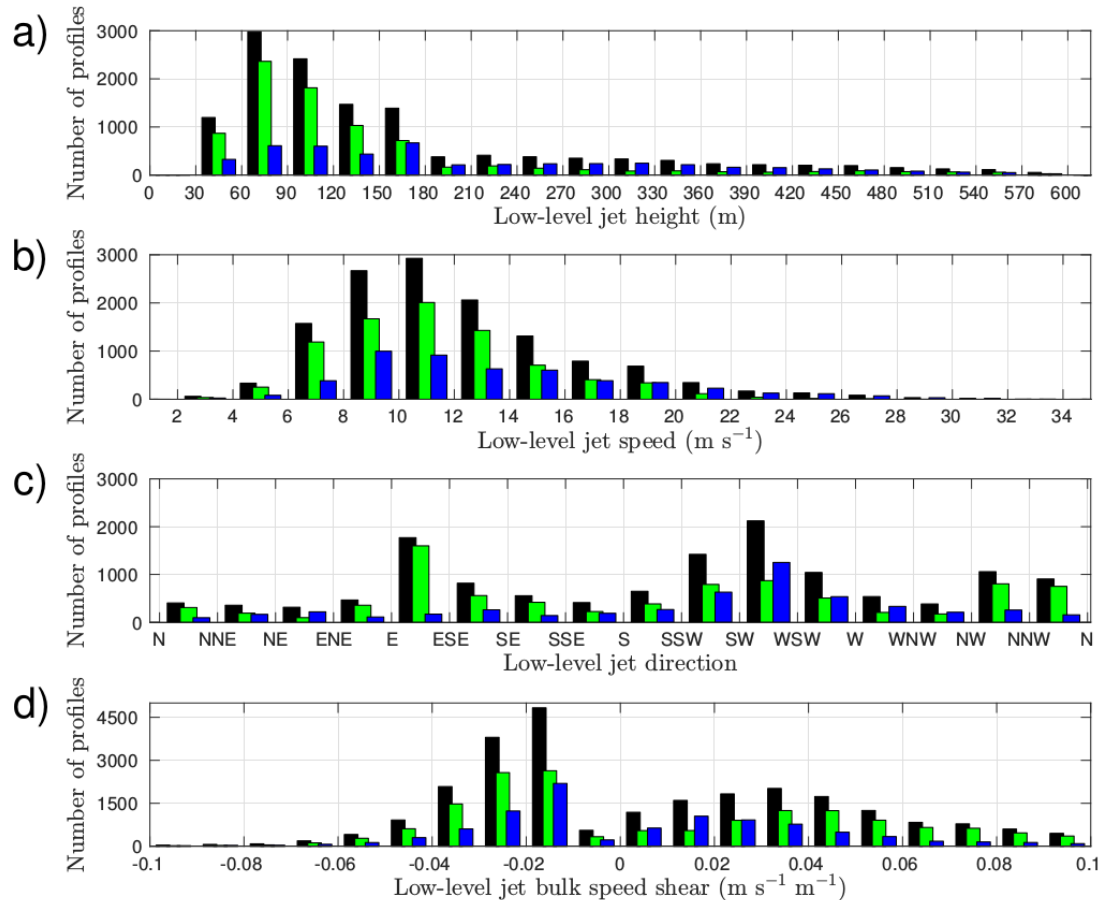
LLJ Climatologies

- **Methodology**

- Height
- Speed
- Direction
- Shear

- **Climatology**

- Diurnal
- Seasonal

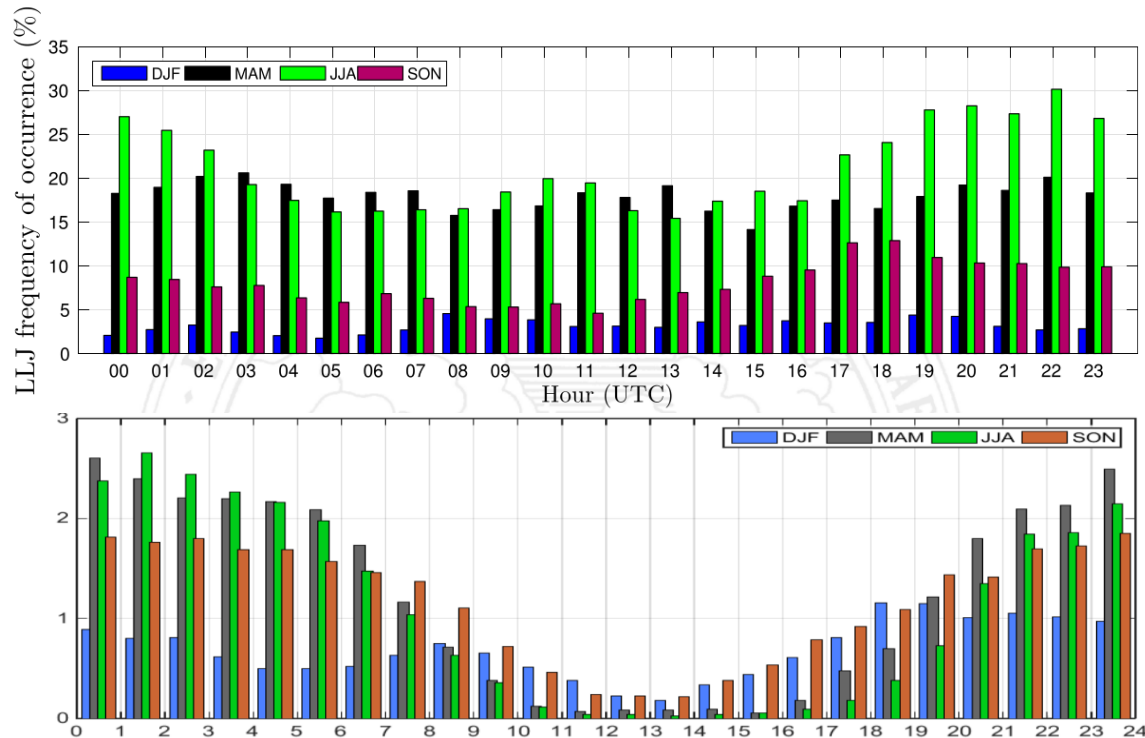


Tuononen, M., et al., “Low-level jets over Utö, Finland, based on Doppler lidar observations”, J. Appl. Meteorol. Climatology, 2017.



LLJ Climatologies

- **Implemented routinely**
 - Different surface, weather regime
- **Island**
 - Utö, Finland
- **Continental**
 - Juelich
- **Coastal**
 - Mace Head,
- **Boreal Forest**
 - Hyytiälä

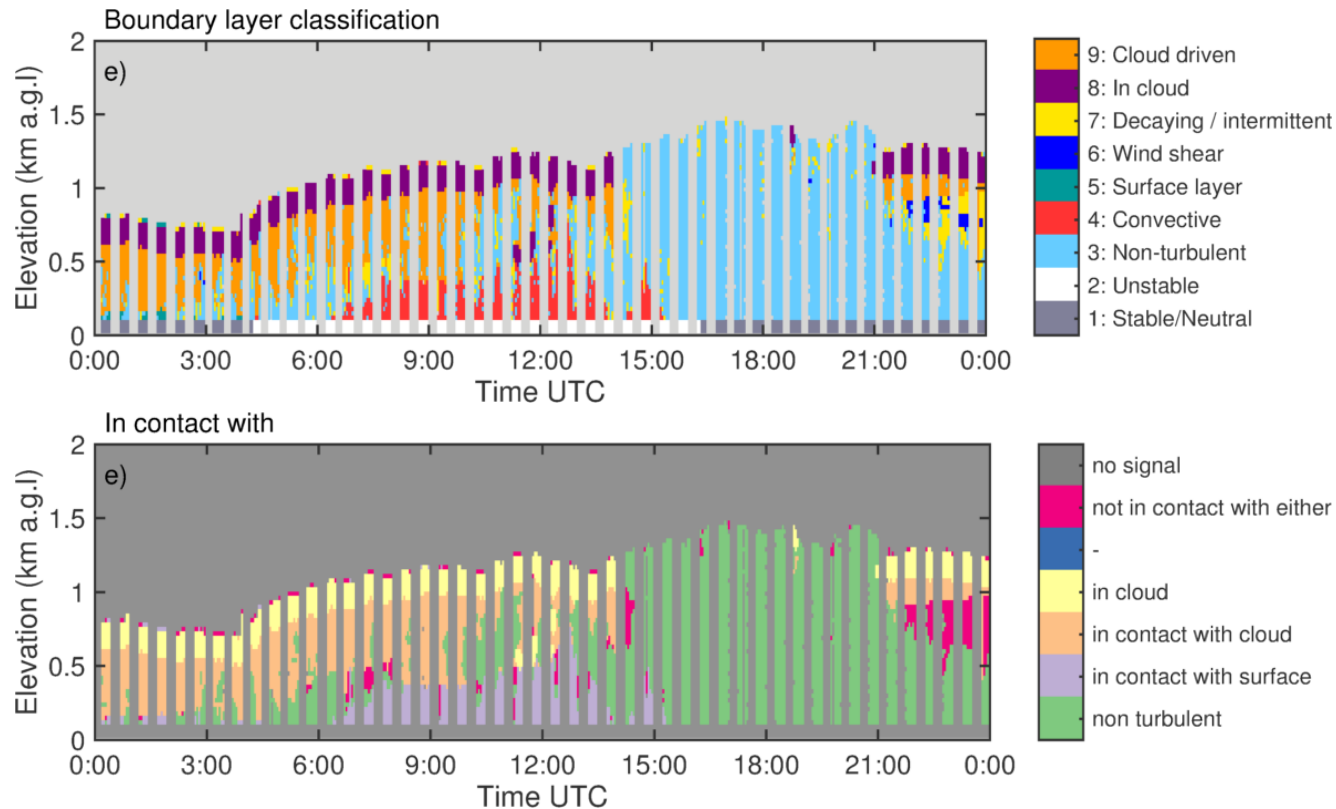




Boundary layer classification

Fields: Turbulent source, and in-contact-with

Includes: LLJ, cloudy boundary-layers





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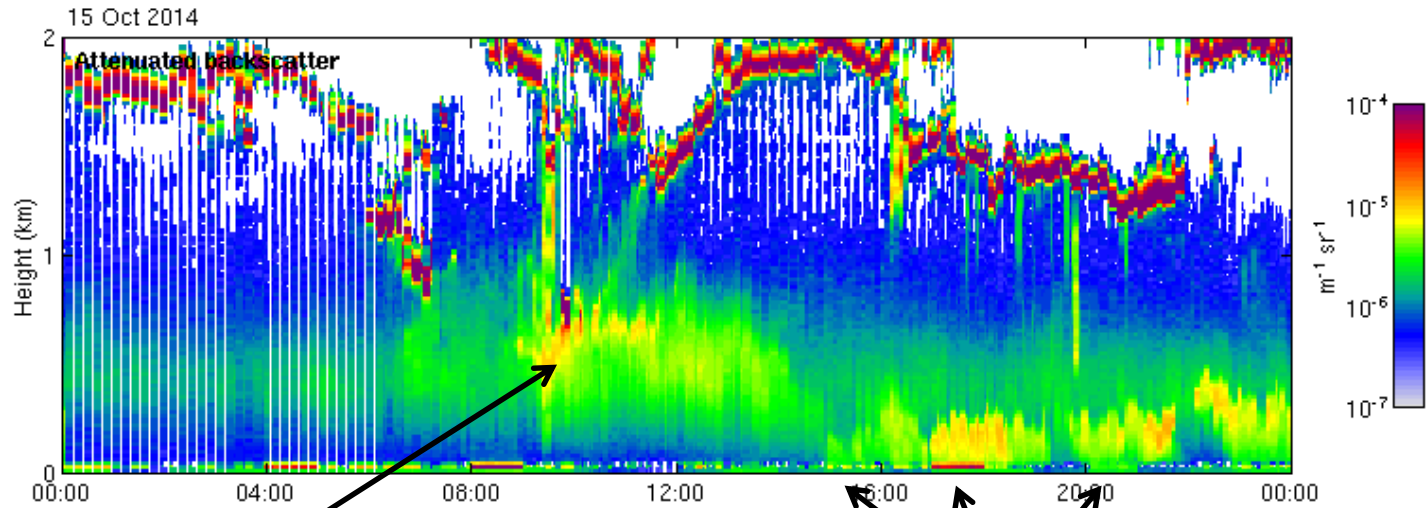
Re-suspended ash/dust







Re-suspended ash/dust – NCAS DL at Hatun (Iceland)

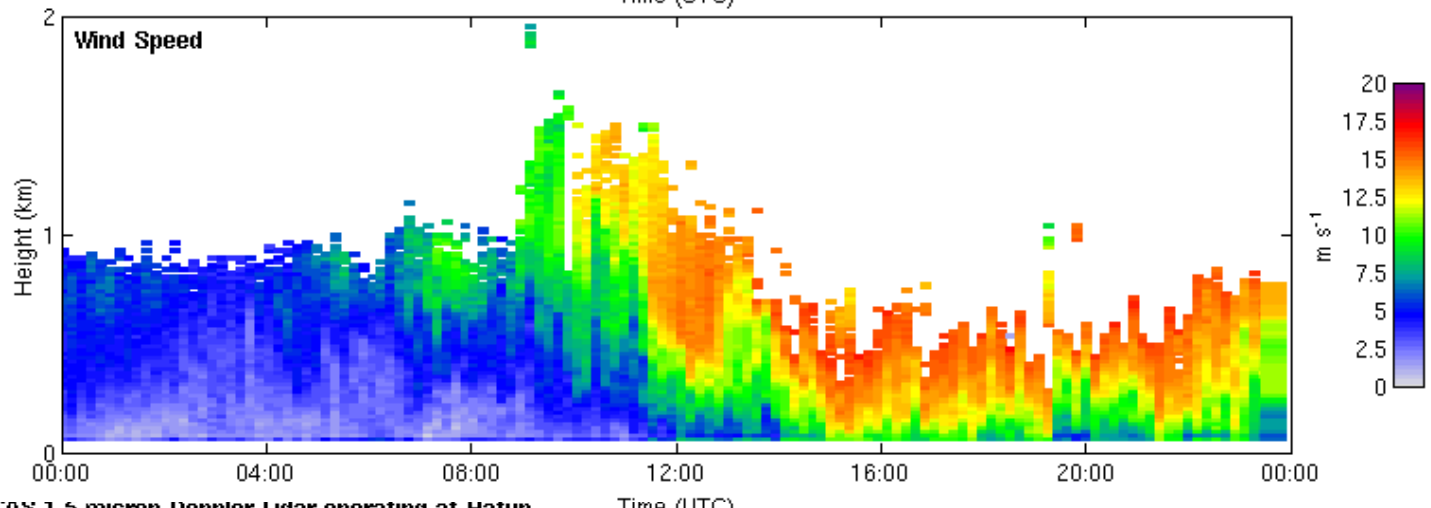
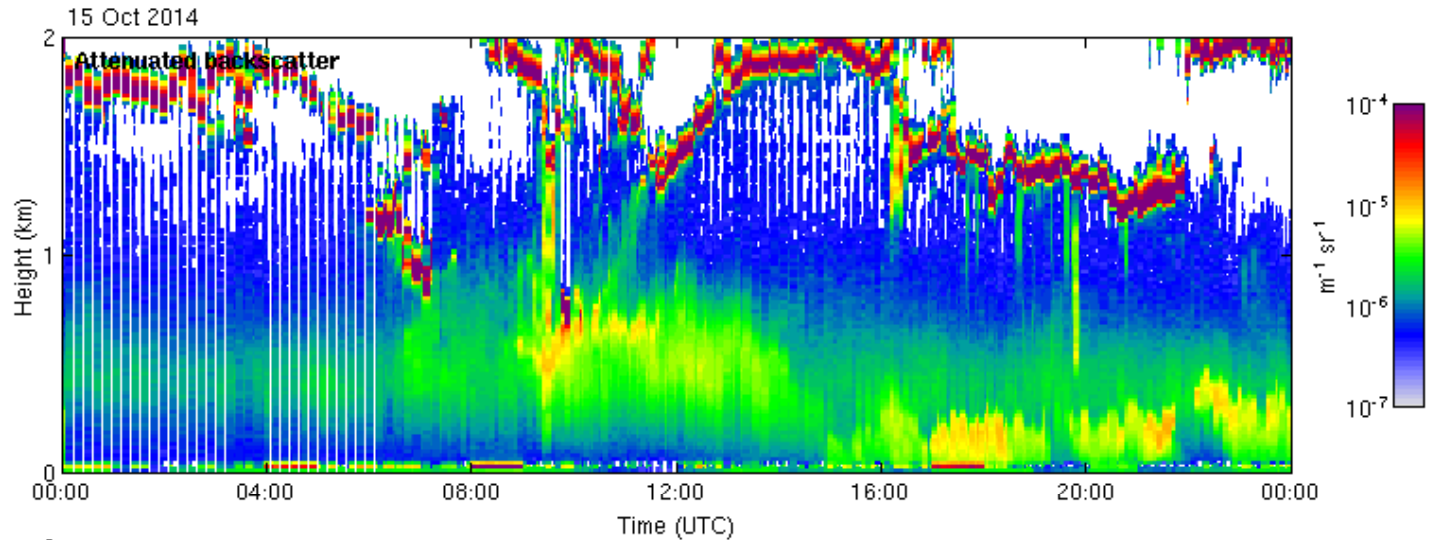


Elevated dust

Local dust being lofted




Re-suspended ash/dust – NCAS DL at Hatun (Iceland)

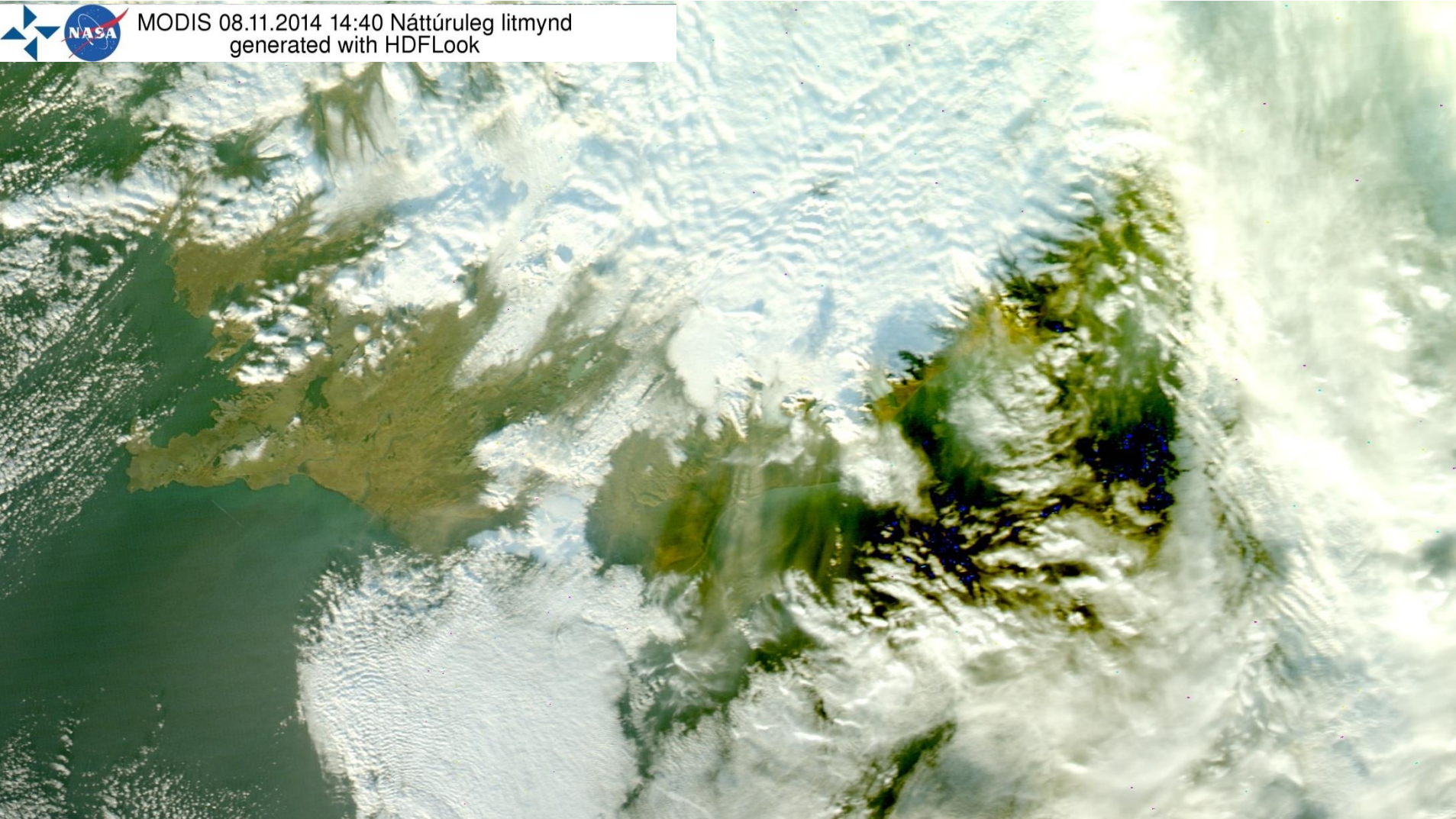




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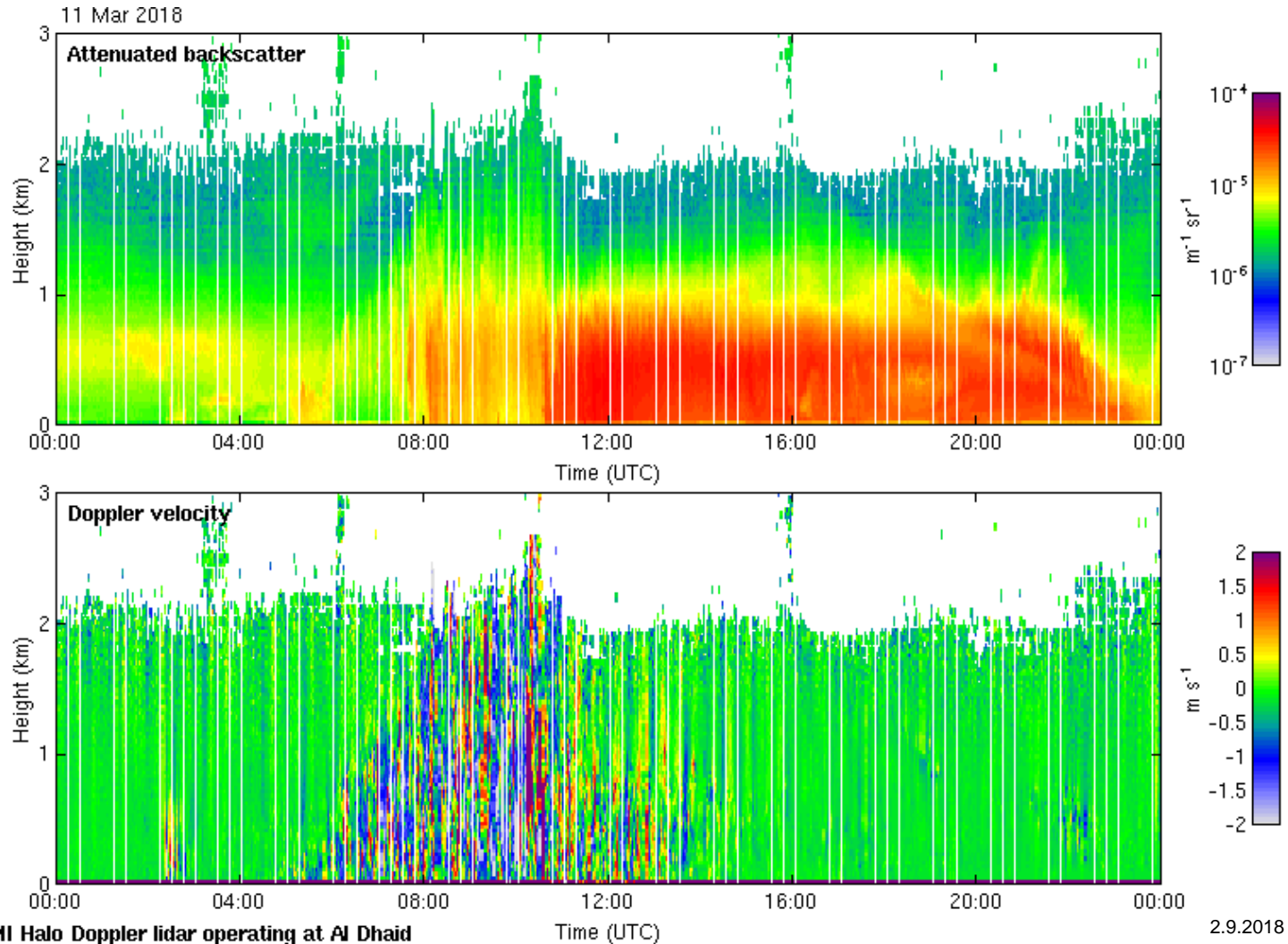
Re-suspended ash/dust

 MODIS 08.11.2014 14:40 Náttúruleg litmynd
generated with HDFLook



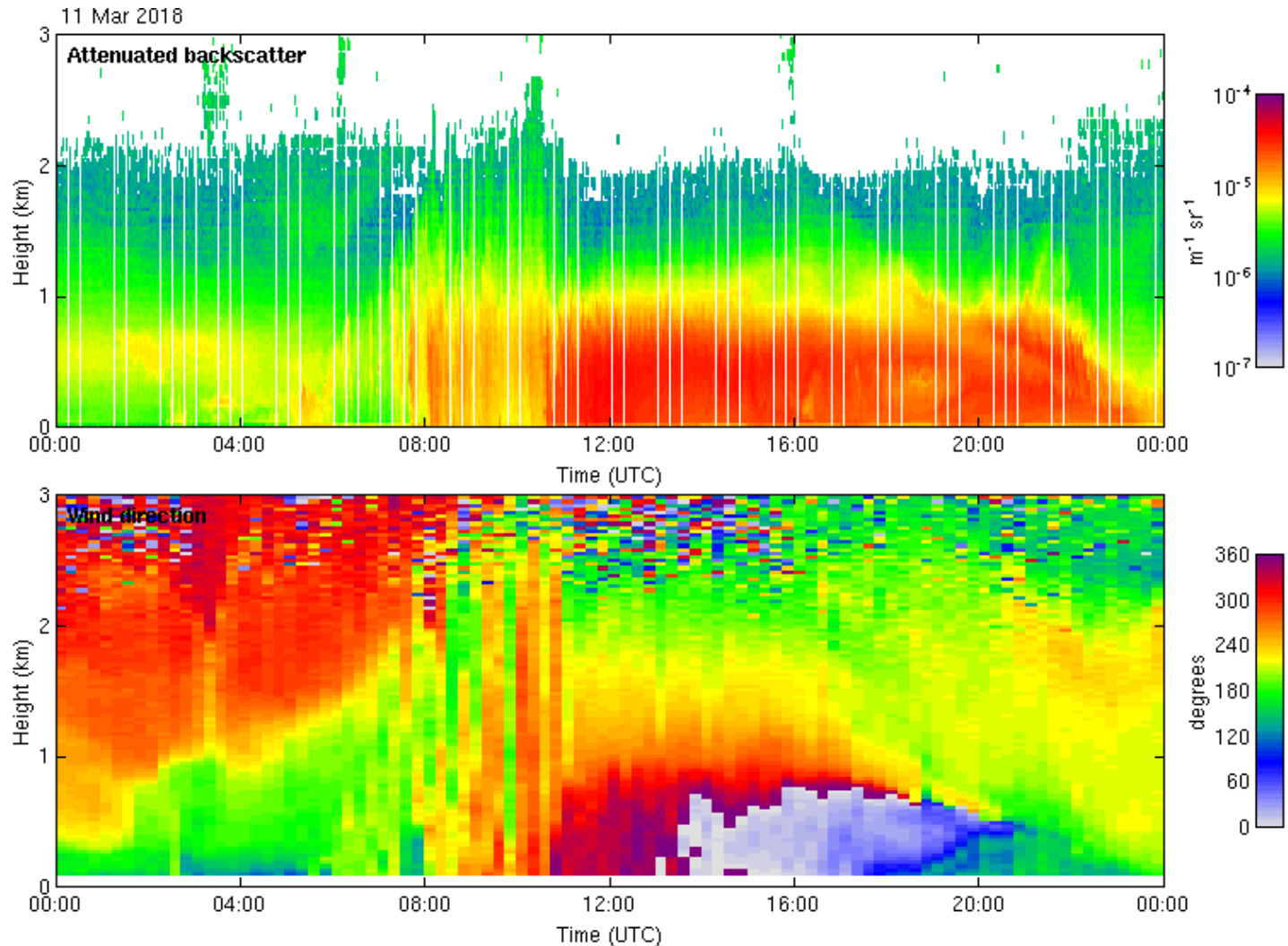


Re-suspended dust – Al Dhaid (UAE)



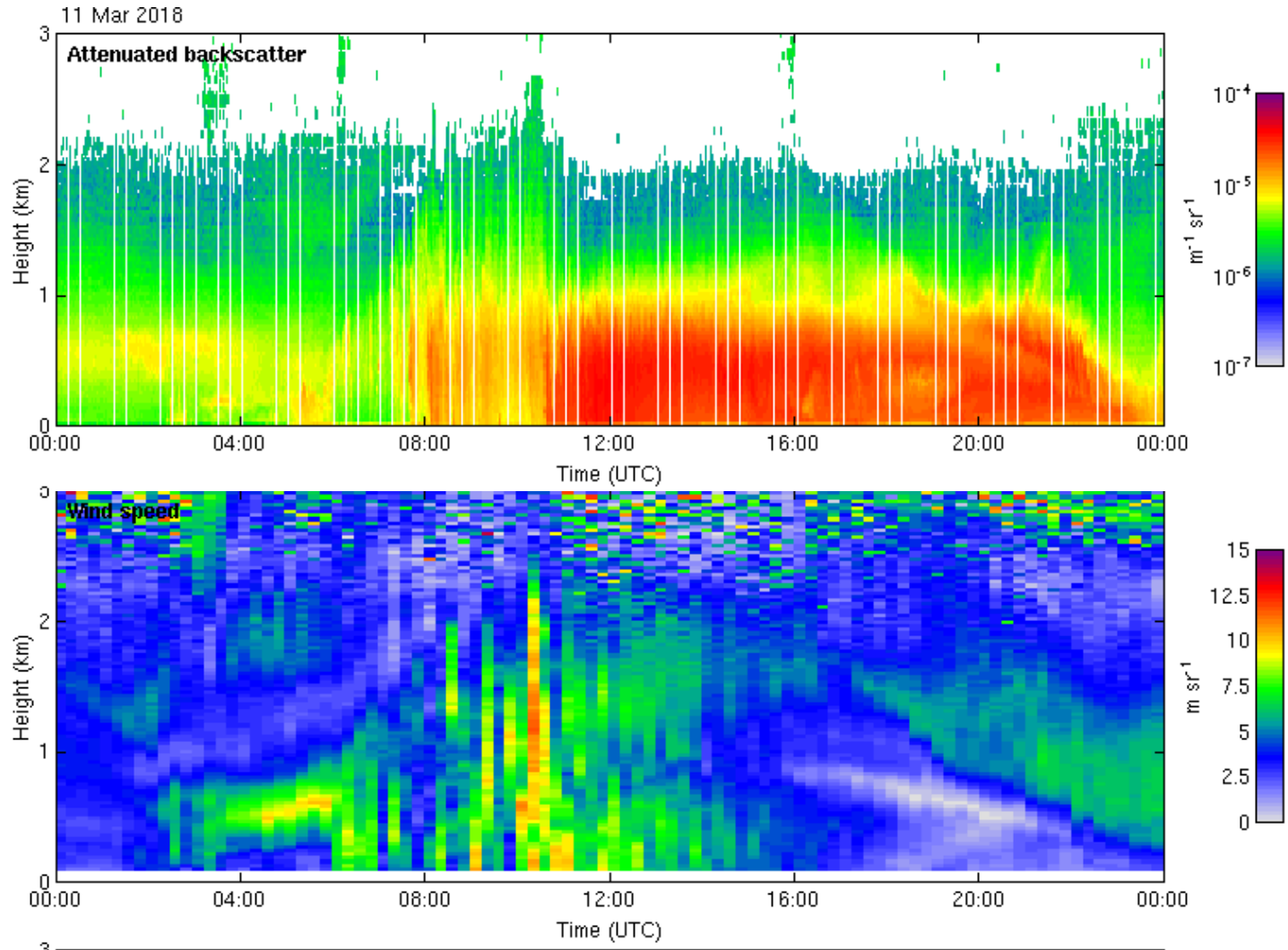


Re-suspended dust – Al Dhaid (UAE)



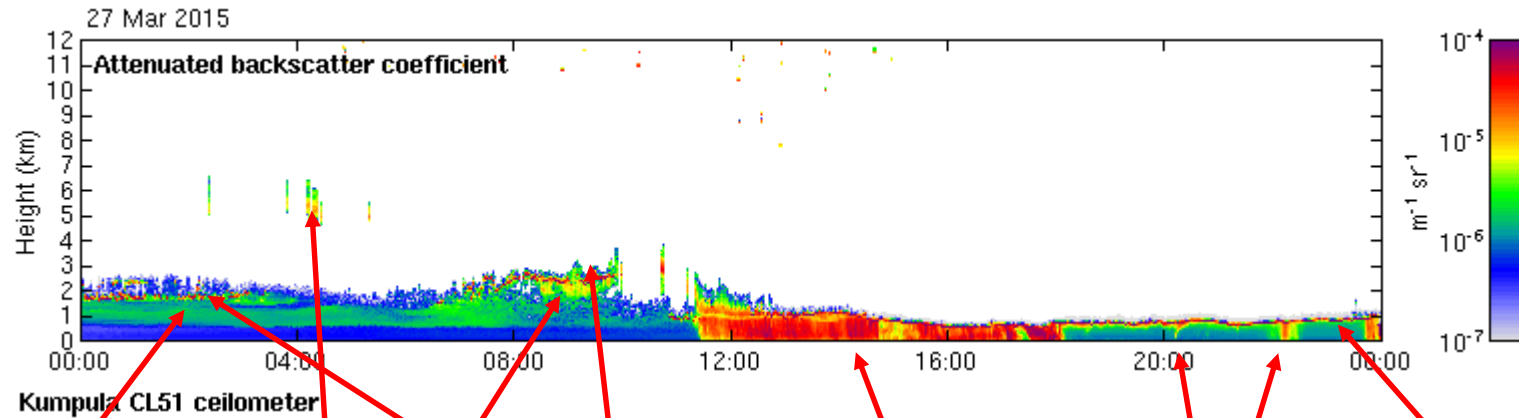


Re-suspended dust – Al Dhaid (UAE)





Originally designed to measure cloud base
Can do so much more!



Elevated aerosol

Ice

Supercooled liquid

Rain

Drizzle

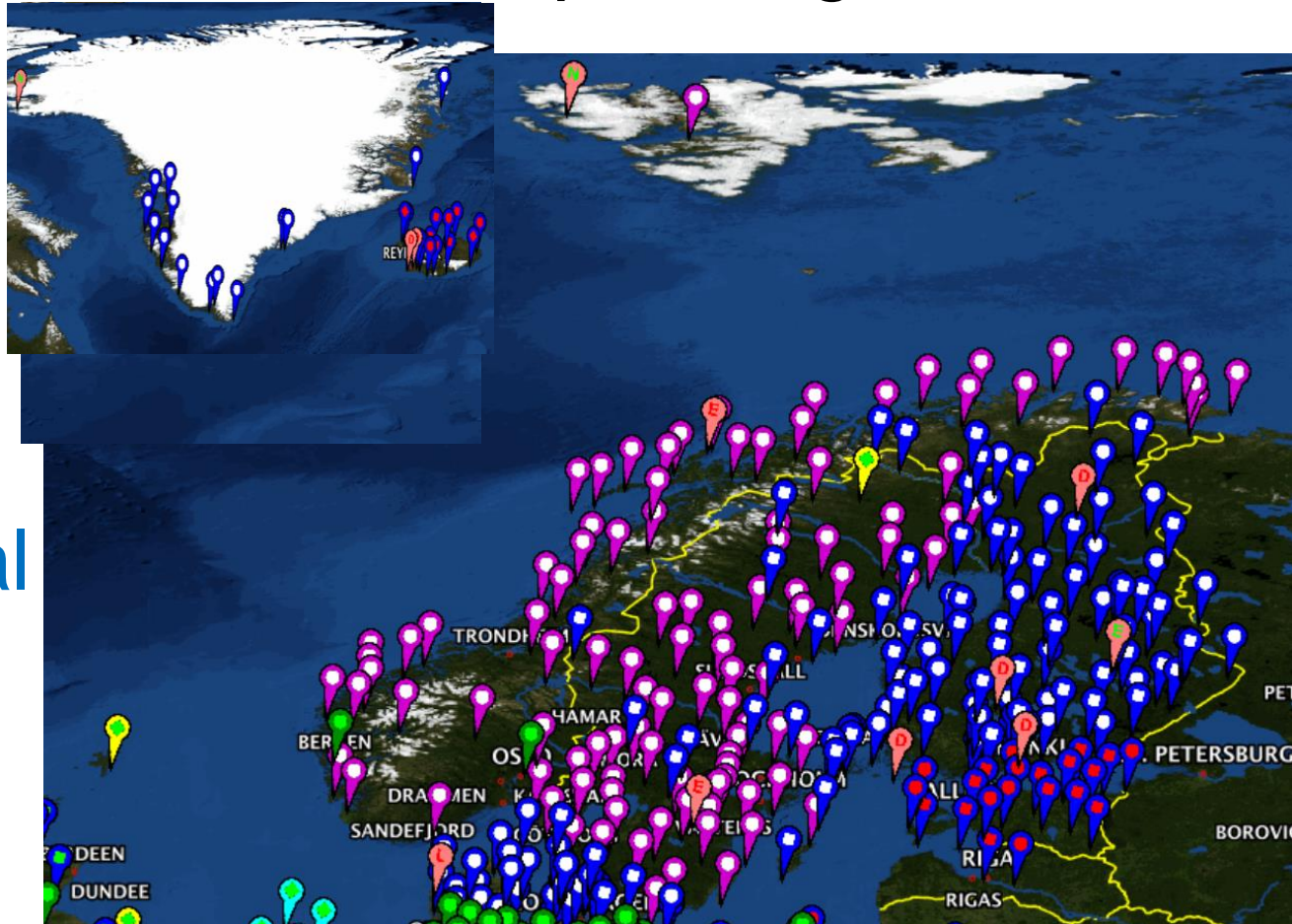
Liquid layer



Nordic network – ~ 20 providing profiles
~ 200 operating

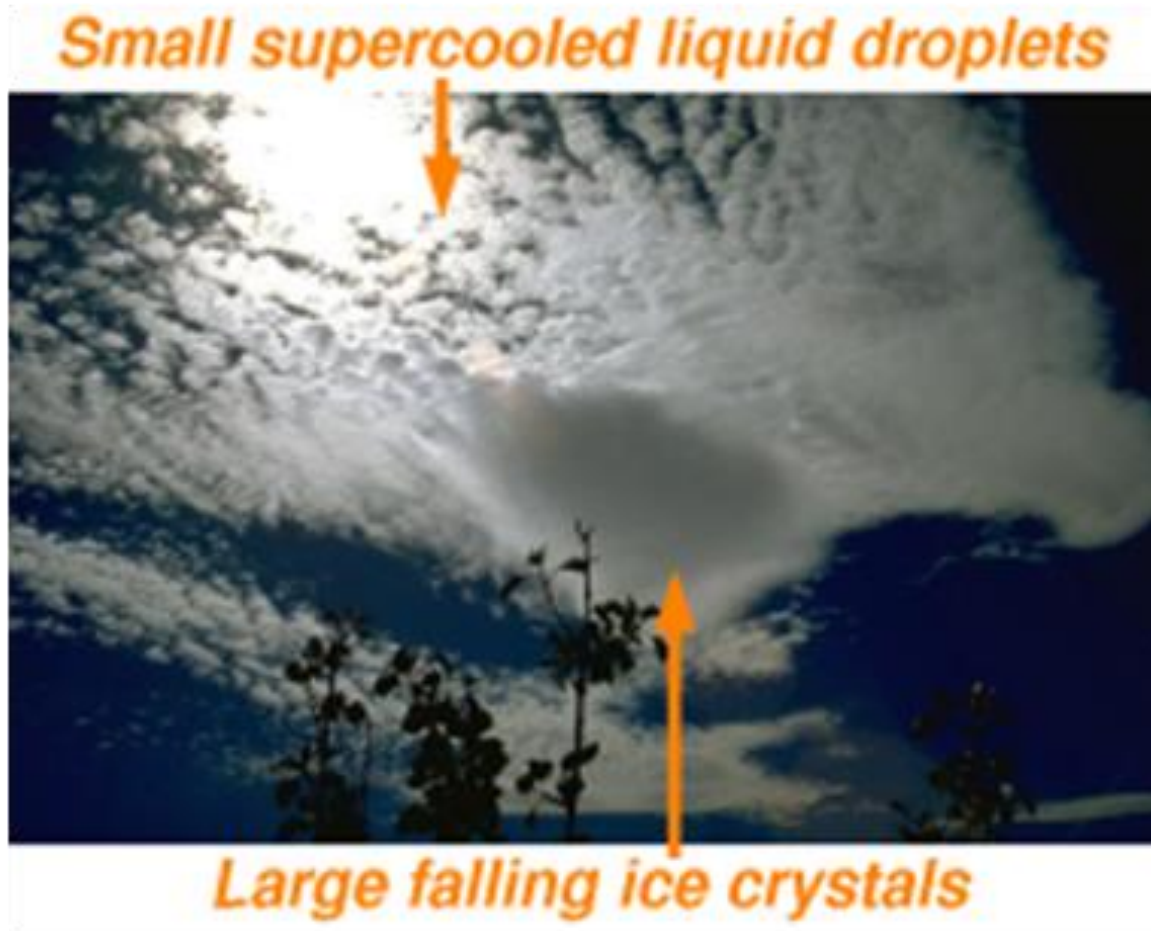
Cloud base
Cloud phase
Precipitation

Icing potential



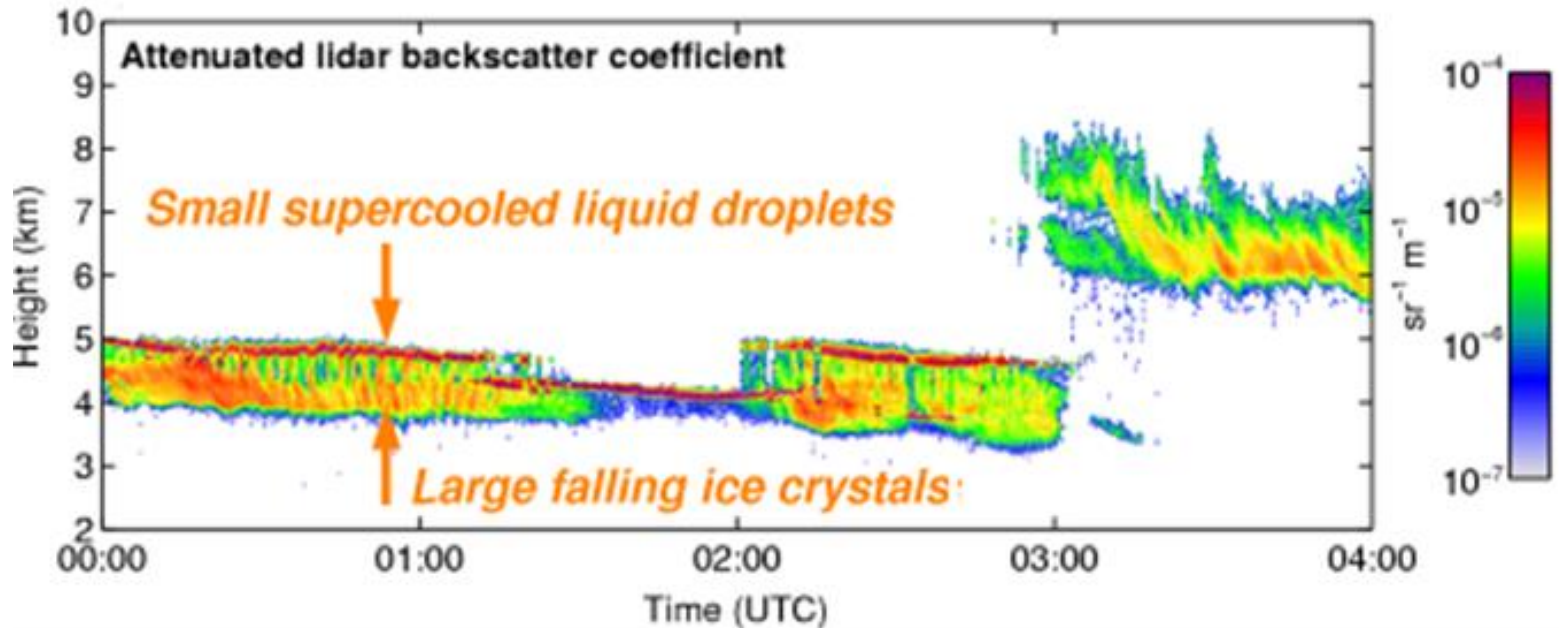


Mixed-phase clouds



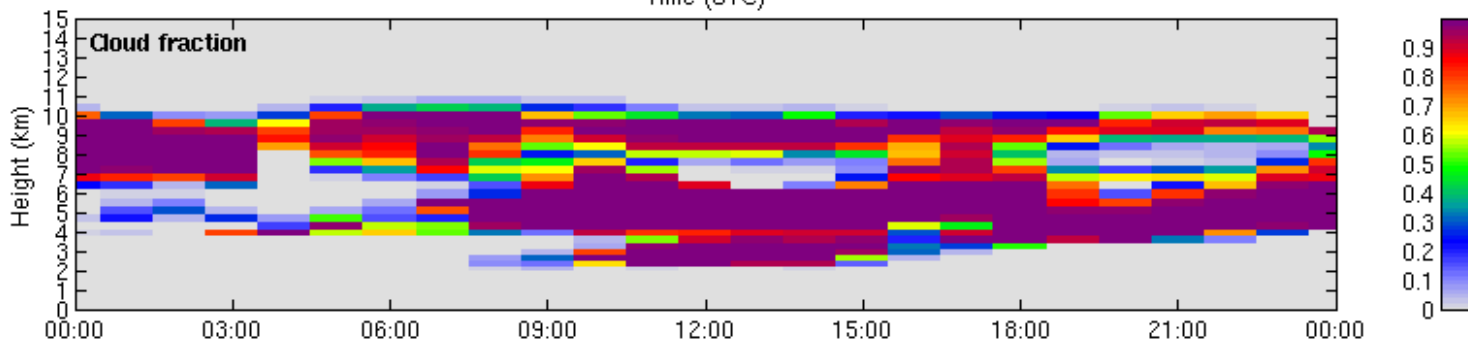
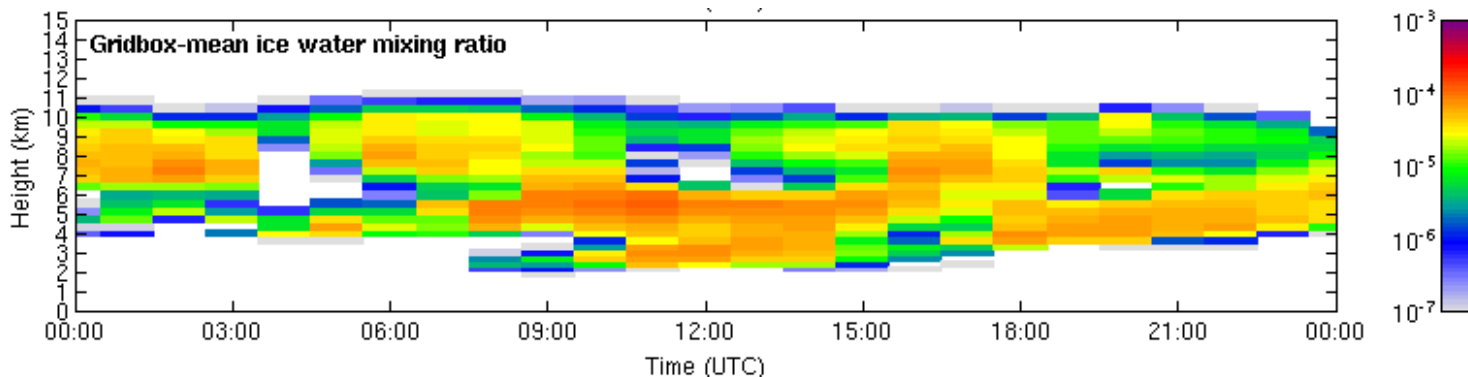
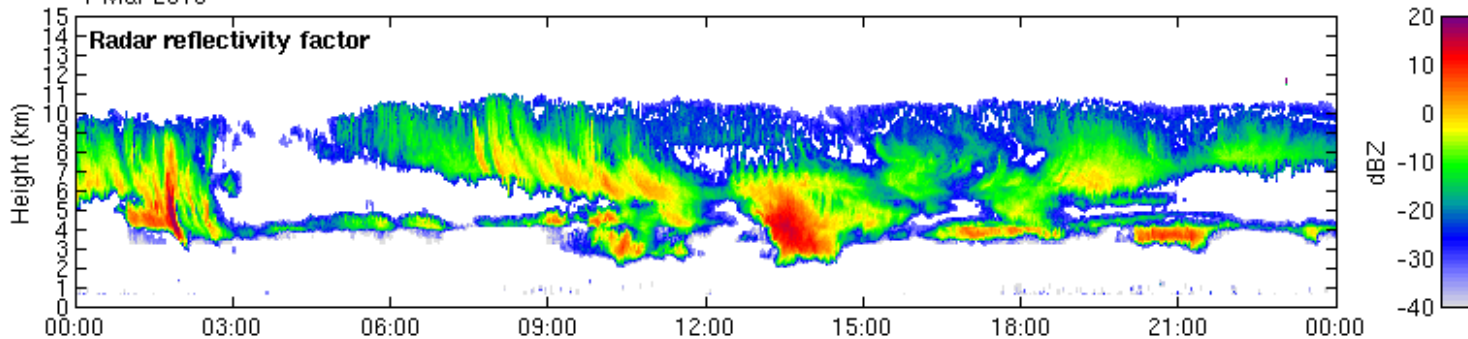


Mixed-phase clouds





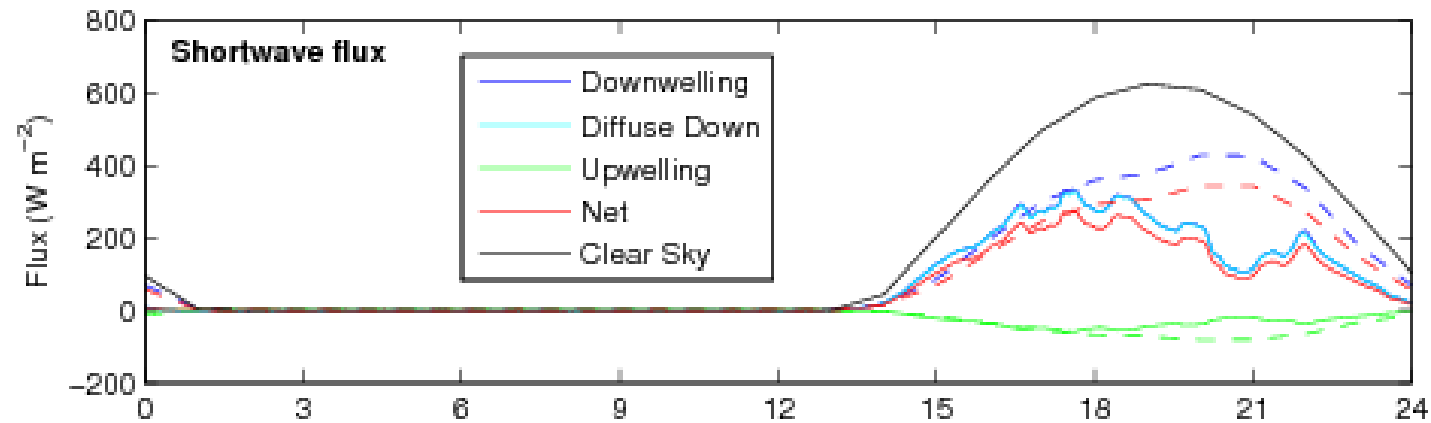
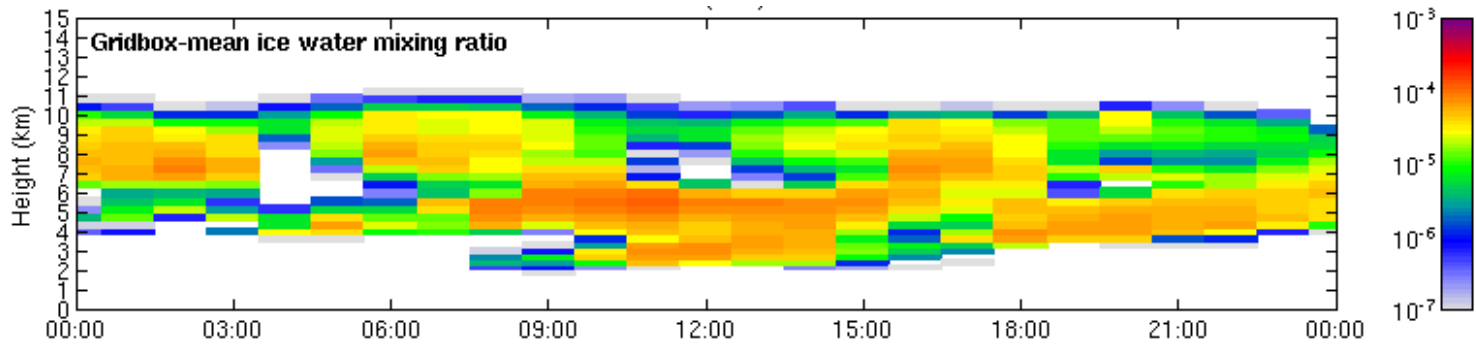
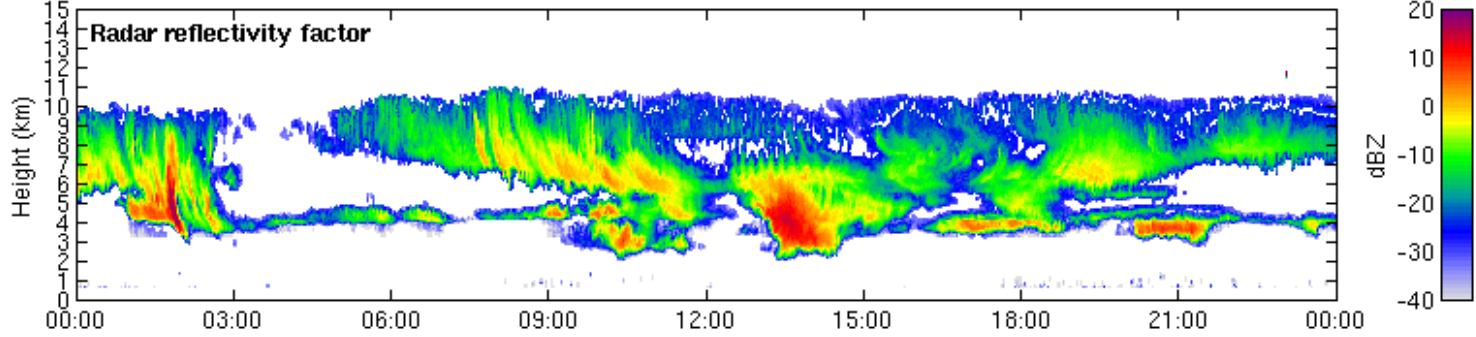
1 Mar 2010



ECMWF forecast model

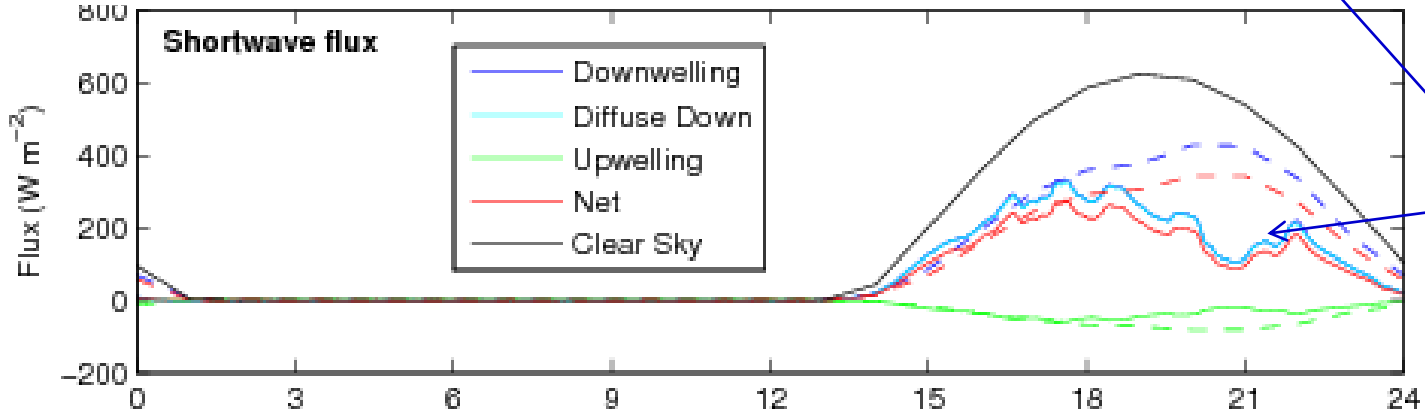
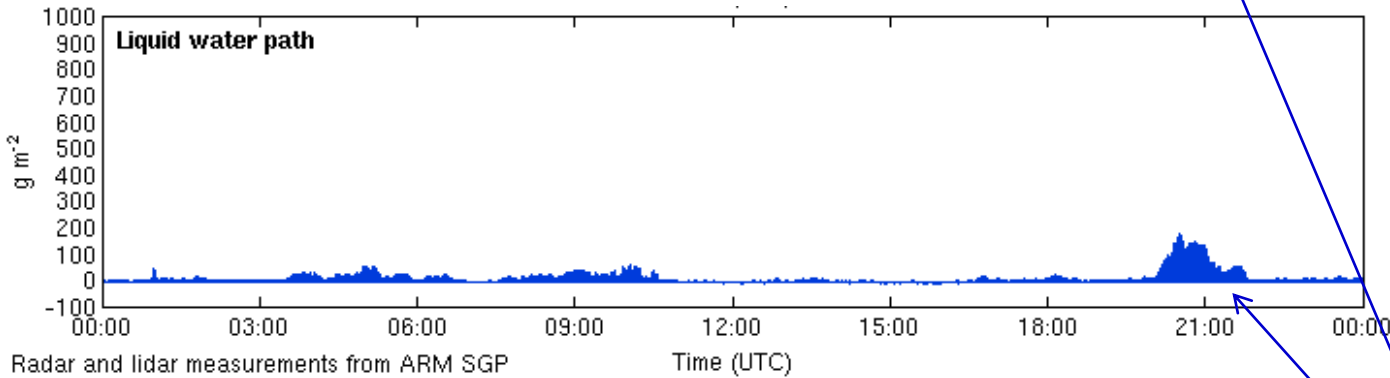
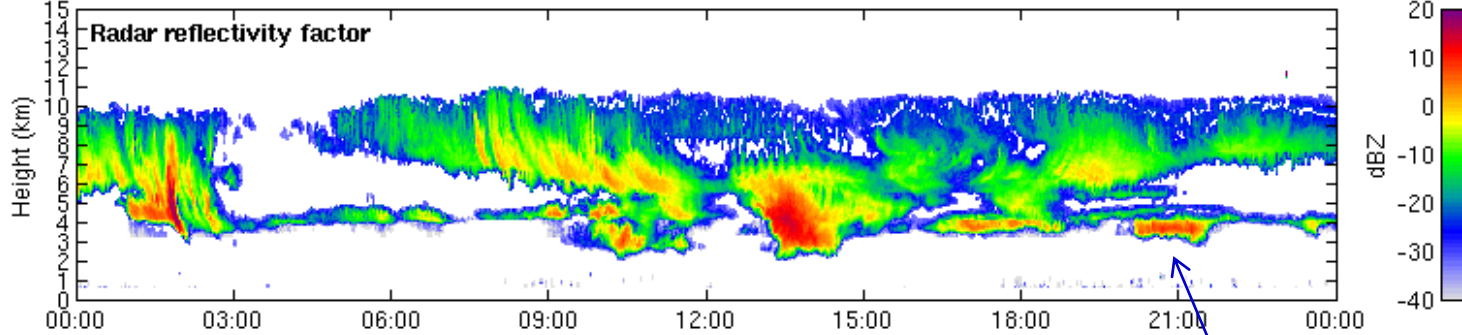


1 Mar 2010





1 Mar 2010



Significant liquid layer

Applications: ECMWF cloud scheme

SEPTEMBER 2014

FORBES AND AHLGRIMM

3441

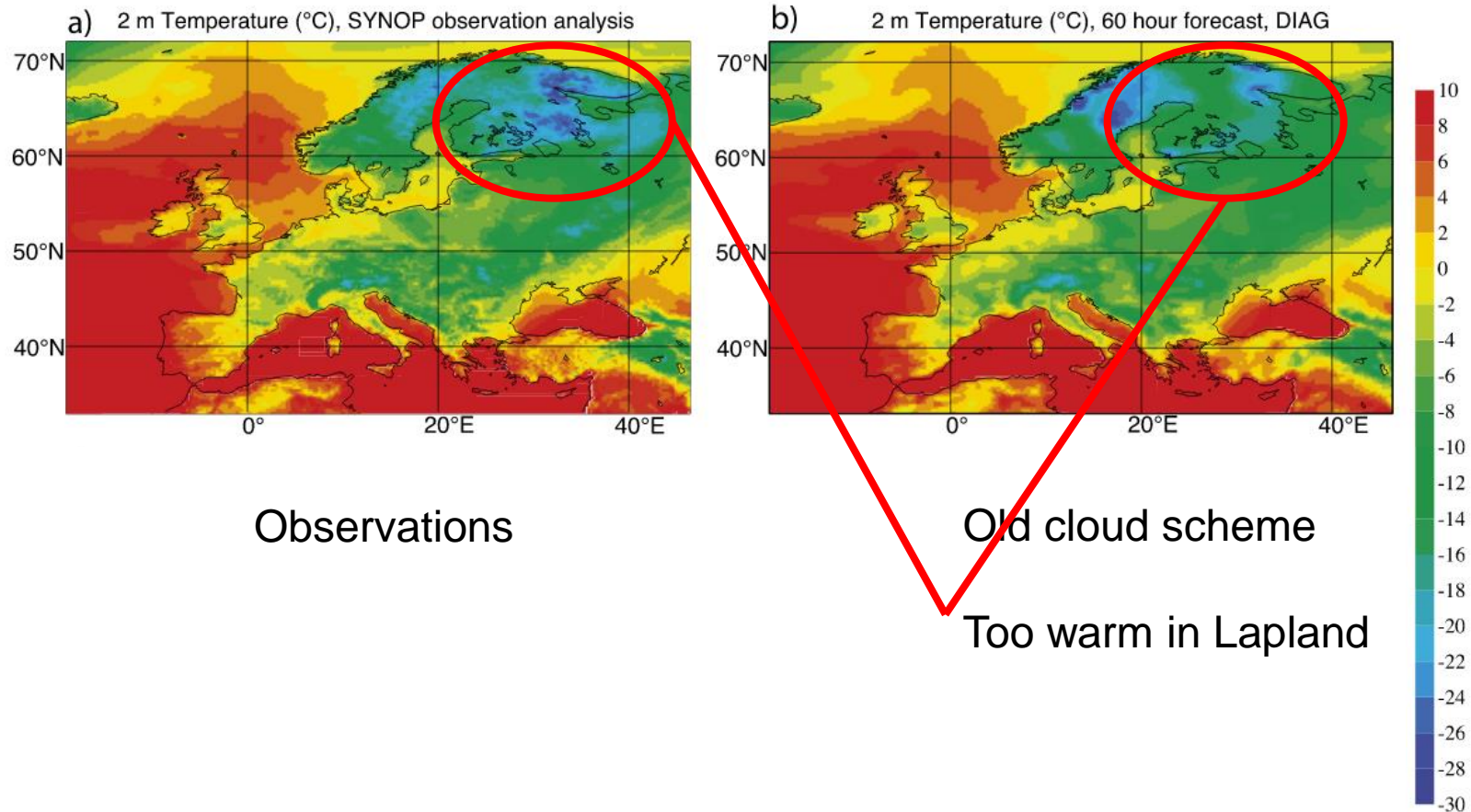


FIG. 10. 2-m temperature (°C) over northern Europe at 0000 UTC 4 Jan 2011 for (a) SYNOP observation analysis, and 60-h forecasts for (b) DIAG simulation, (c) PROG simulation, and (d) PROG+ simulation.

Applications: ECMWF cloud scheme

SEPTEMBER 2014

FORBES AND AHLGRIMM

3441

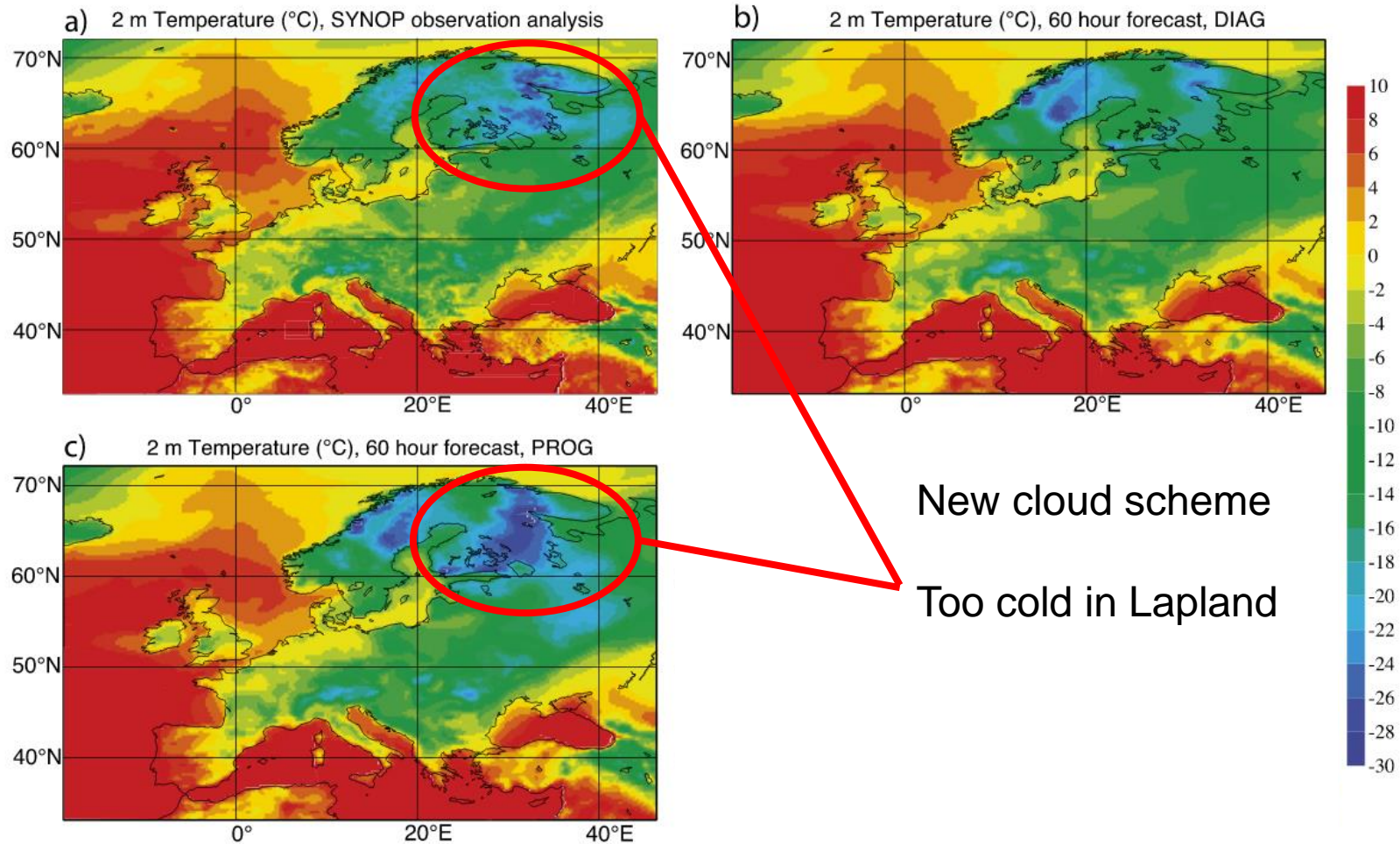
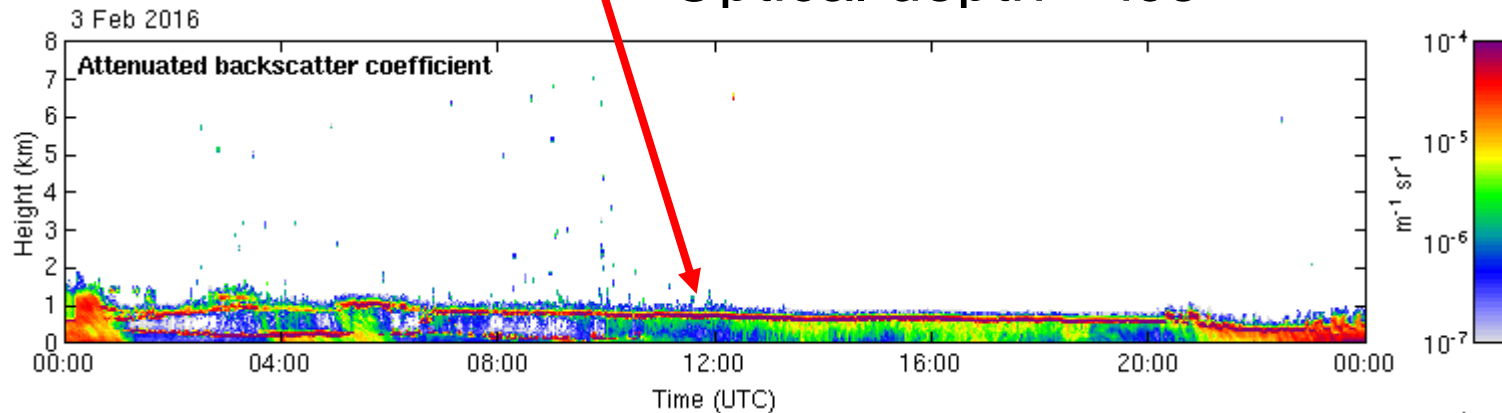


FIG. 10. 2-m temperature ($^{\circ}\text{C}$) over northern Europe at 0000 UTC 4 Jan 2011 for (a) SYNOP observation analysis, and 60-h forecasts for (b) DIAG simulation, (c) PROG simulation, and (d) PROG+ simulation.

Applications: ECMWF cloud scheme

Ceilometer data: supercooled liquid layers

Optical depth > ice



Model forecast

Old scheme -

too much supercooled liquid distributed in a thick layer

Prognostic scheme -

ice-only layers

New prognostic scheme - 'realistic' supercooled layers

Applications: ECMWF cloud scheme

SEPTEMBER 2014

FORBES AND AHLGRIMM

3441

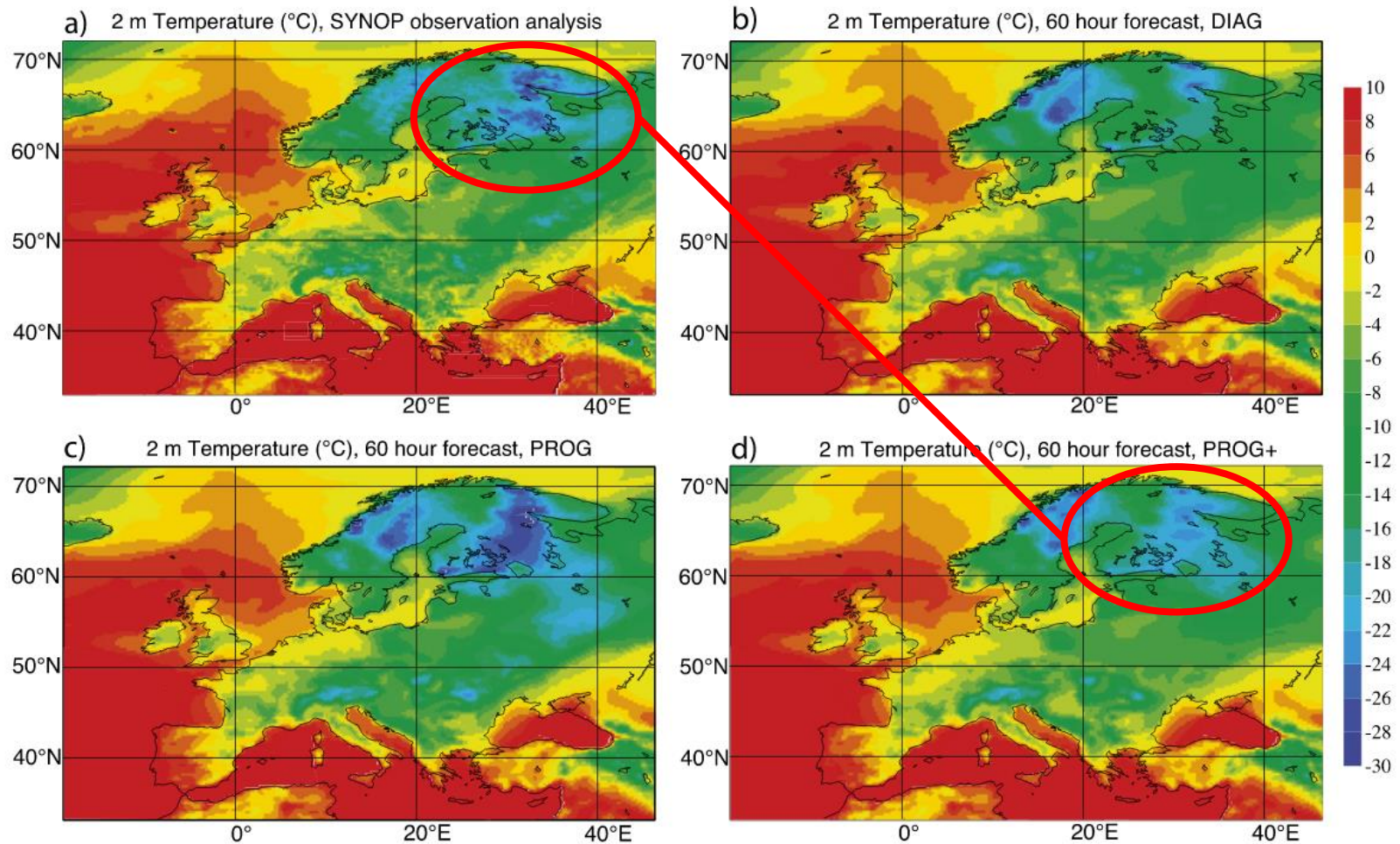
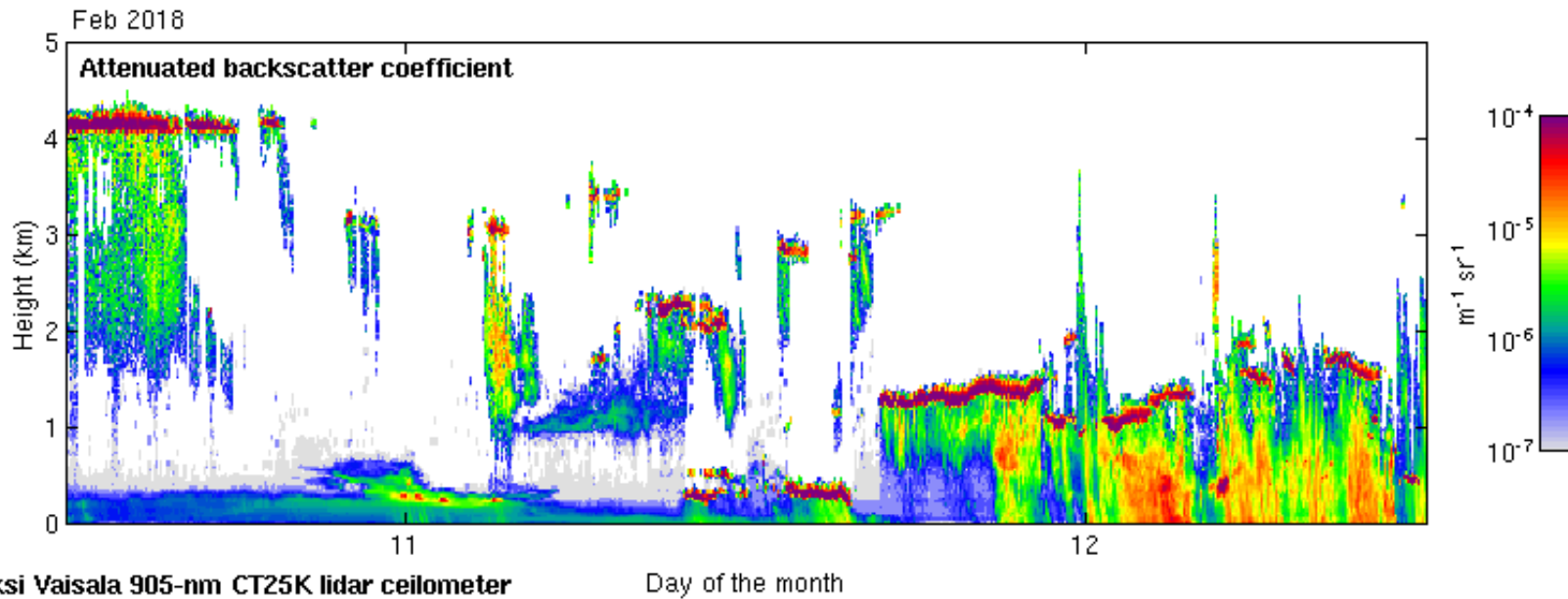


FIG. 10. 2-m temperature (°C) over northern Europe at 0000 UTC 4 Jan 2011 for (a) SYNOP observation analysis, and 60-h forecasts for (b) DIAG simulation, (c) PROG simulation, and (d) PROG+ simulation.

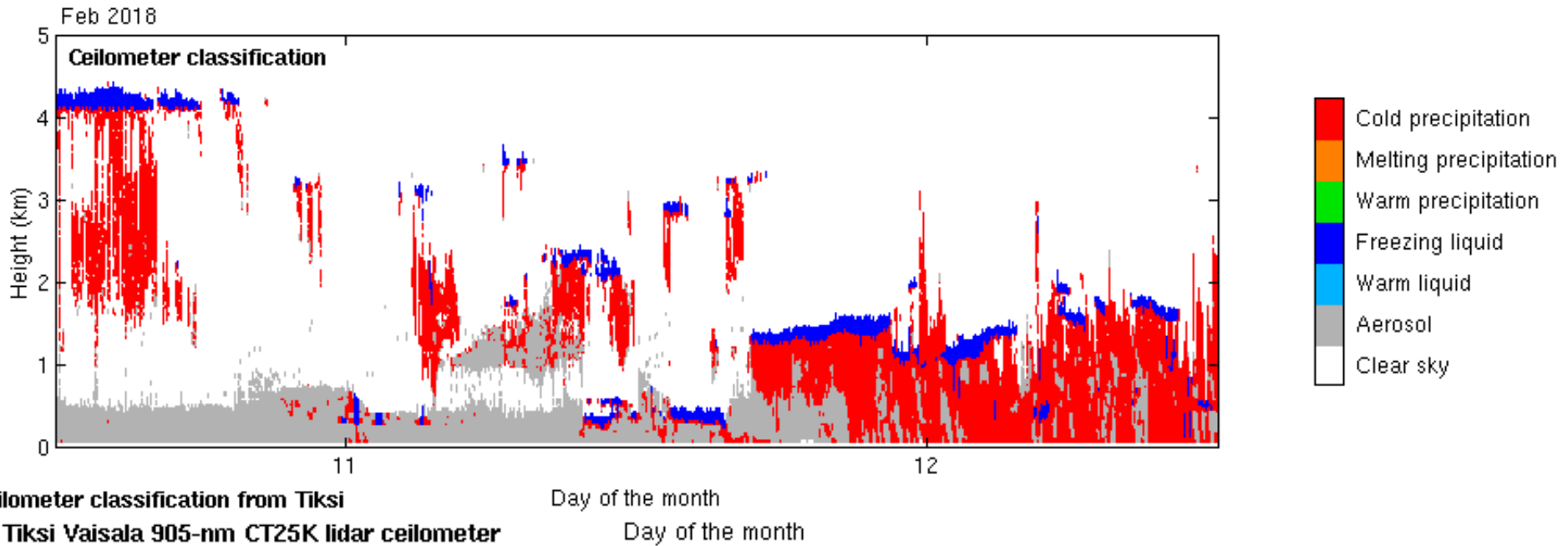


Ceilometer classification



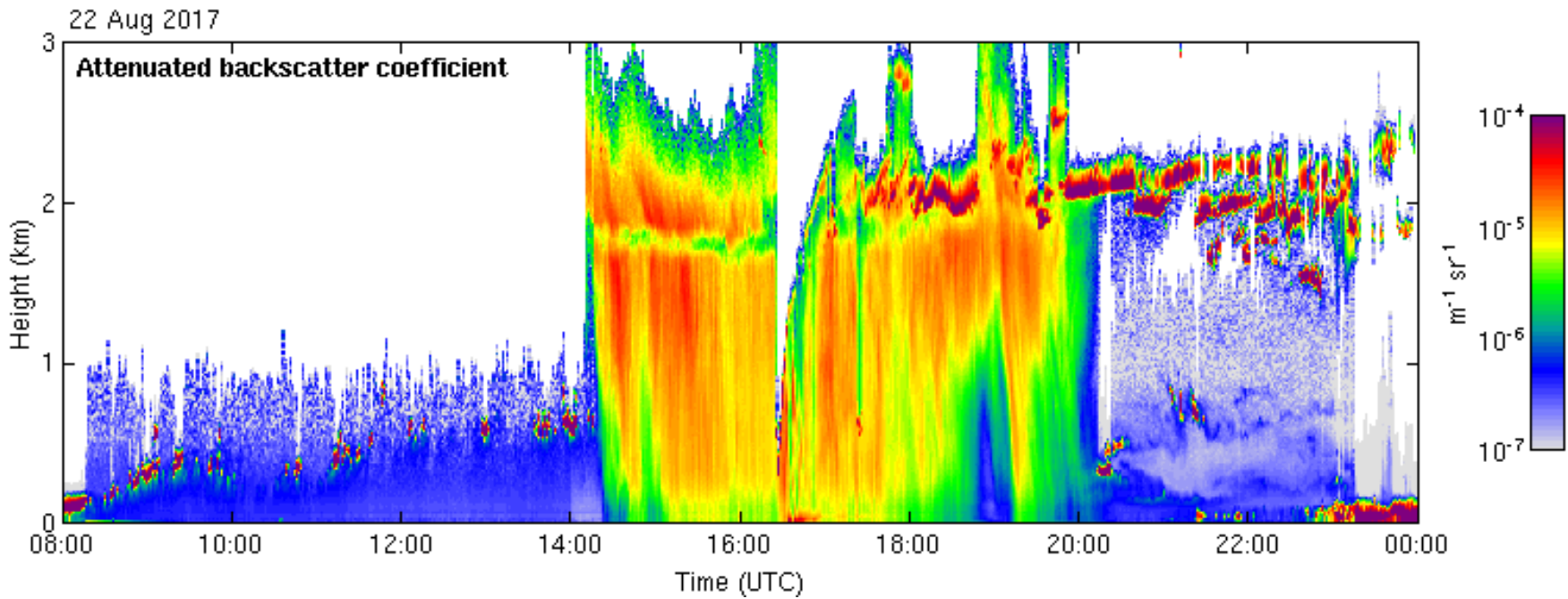


Ceilometer classification





Melting layer detection



Metno ceilometer network – aerosol profiling

Metno operates two CHM15k ceilometers

Oslo (2013)

Urban station

1615 running days

Flesland (2014)

Urban station influenced by sea salts

1240 running days



Real-time aerosol retrievals:
V-Profiles

Evaluate chemistry transport
Models (e.g. CAMS)

<http://aerocom.met.no/vprofiles>

Real-time

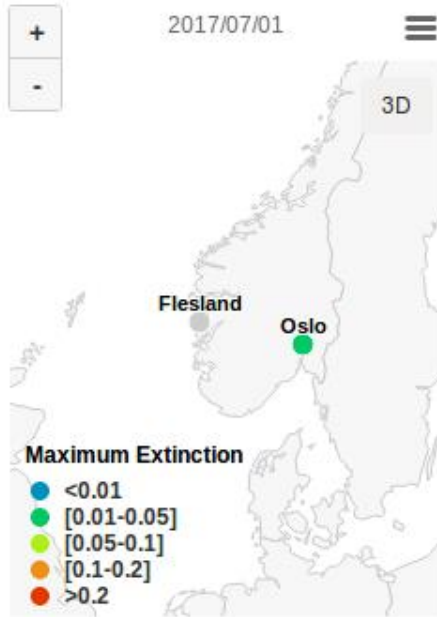
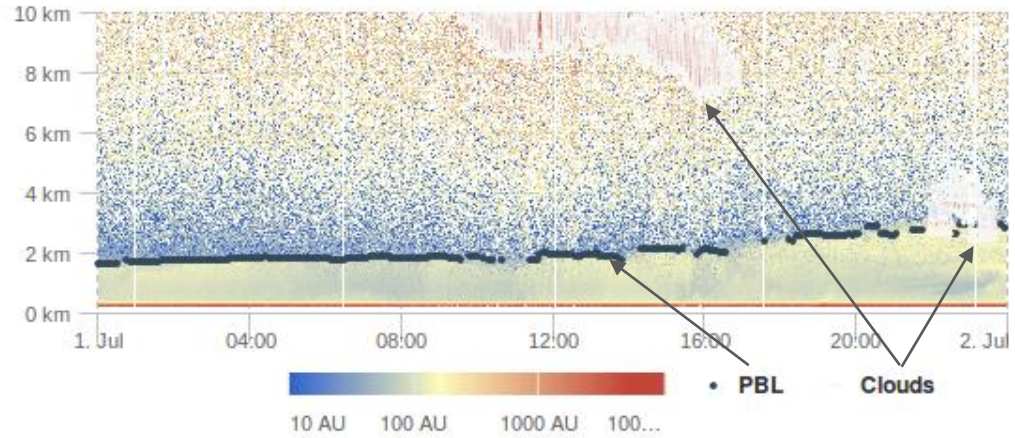


RCS Inversion

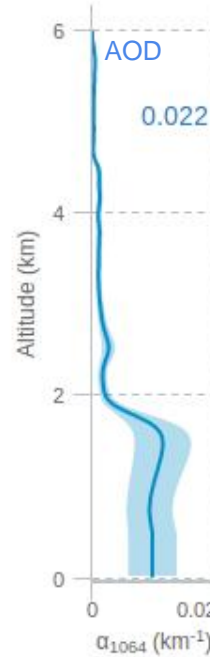
Oslo - 2017/07/01

Hi-Res

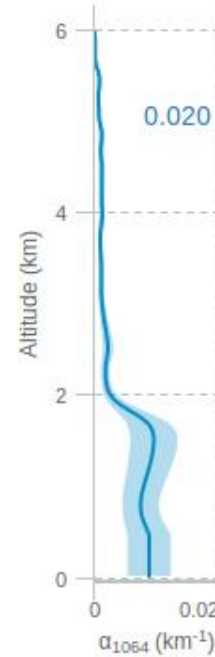
Range Corrected Signal



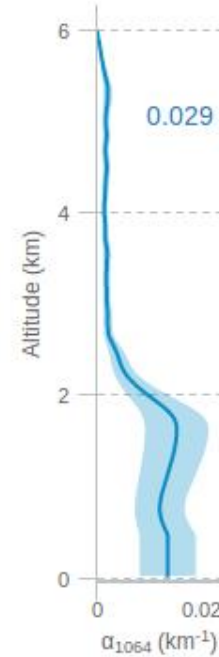
00-06h



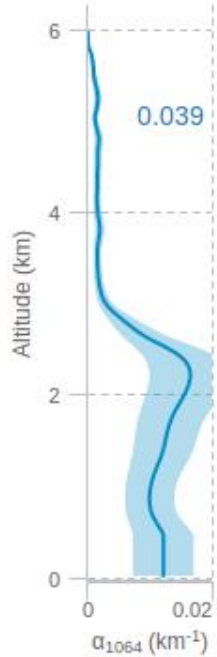
06-12h



12-18h

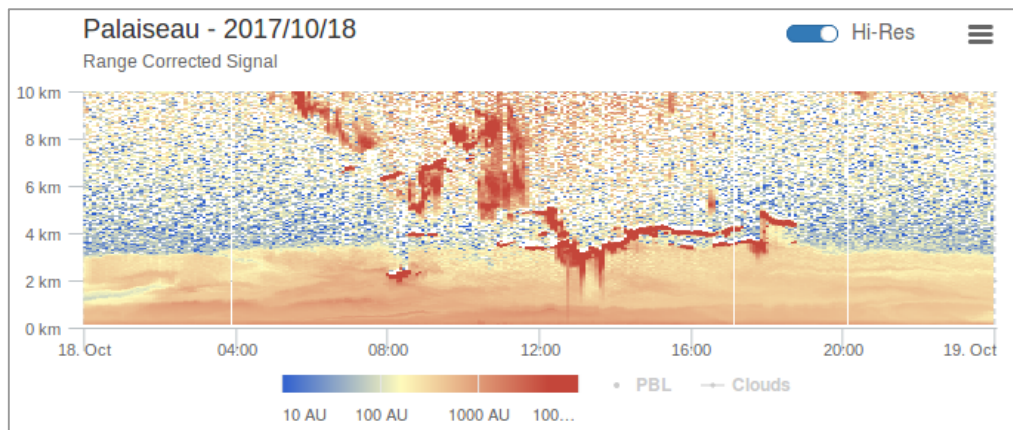


18-24h

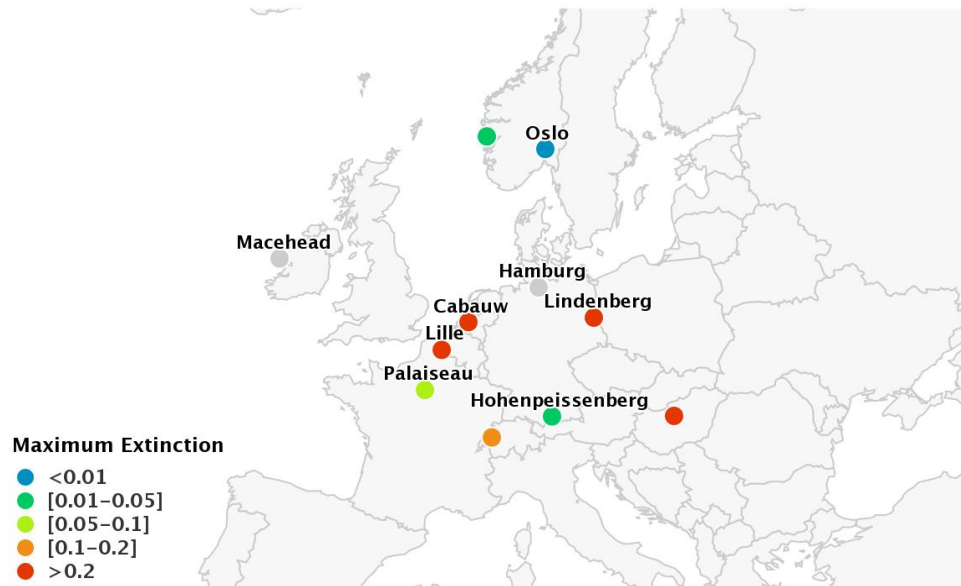


Aerosol event – Ophelia 2017 - E-PROFILE data

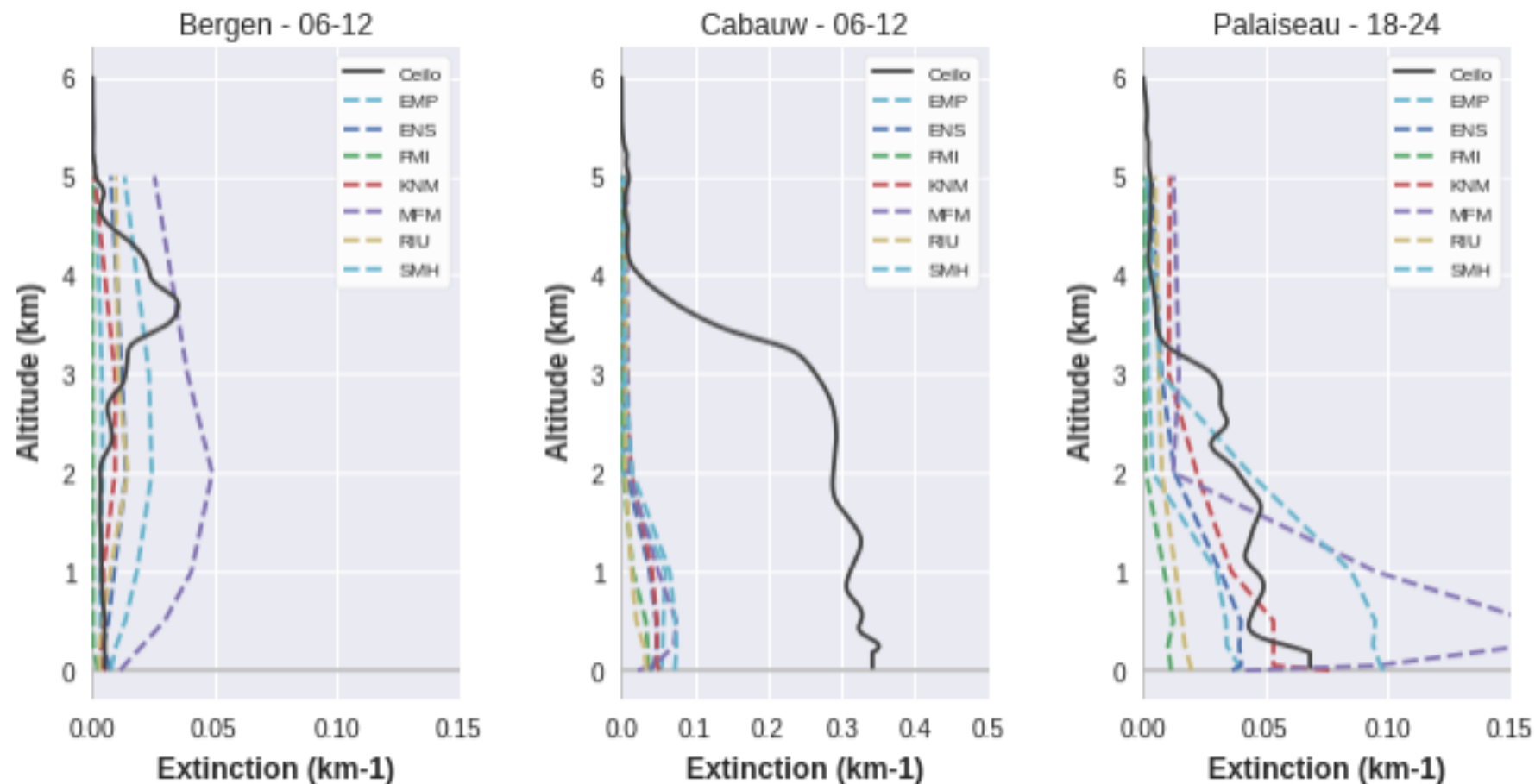
Saharan **desert dust** and **biomass burning** from large forest fires in Portugal.



2017/10/18



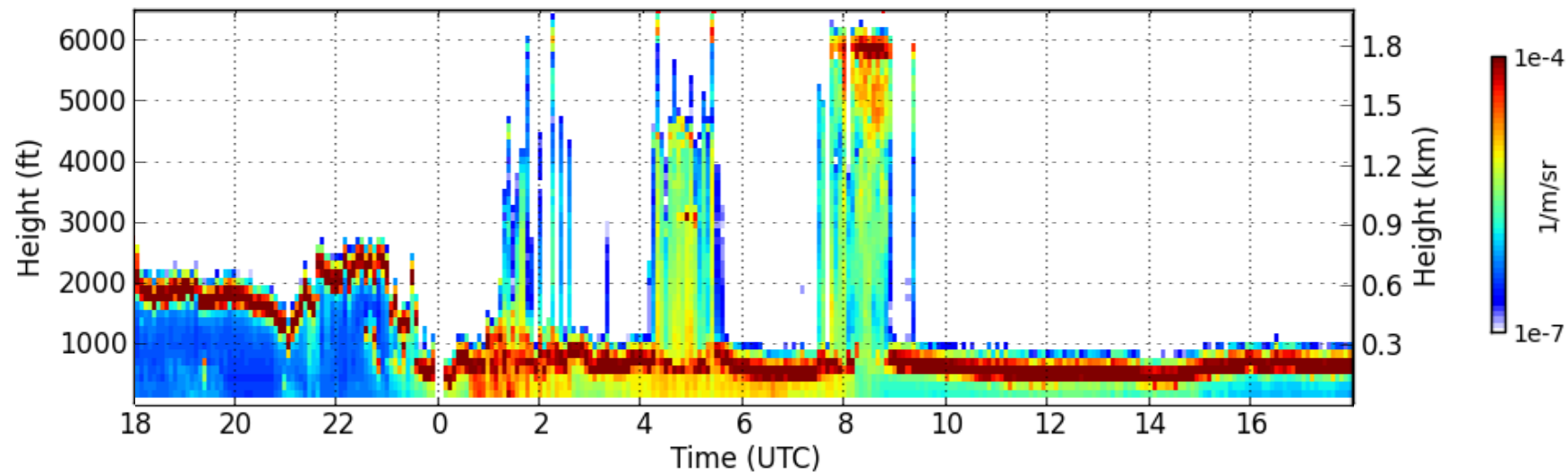
Aerosol event - E-PROFILE data – CAMS evaluation



Extinction profiles derived at 532 nm from Ceilometer retrievals (black line) and for the CAMS-50 models (dashed lines) during an aerosol episode on the 18th of October 2017.

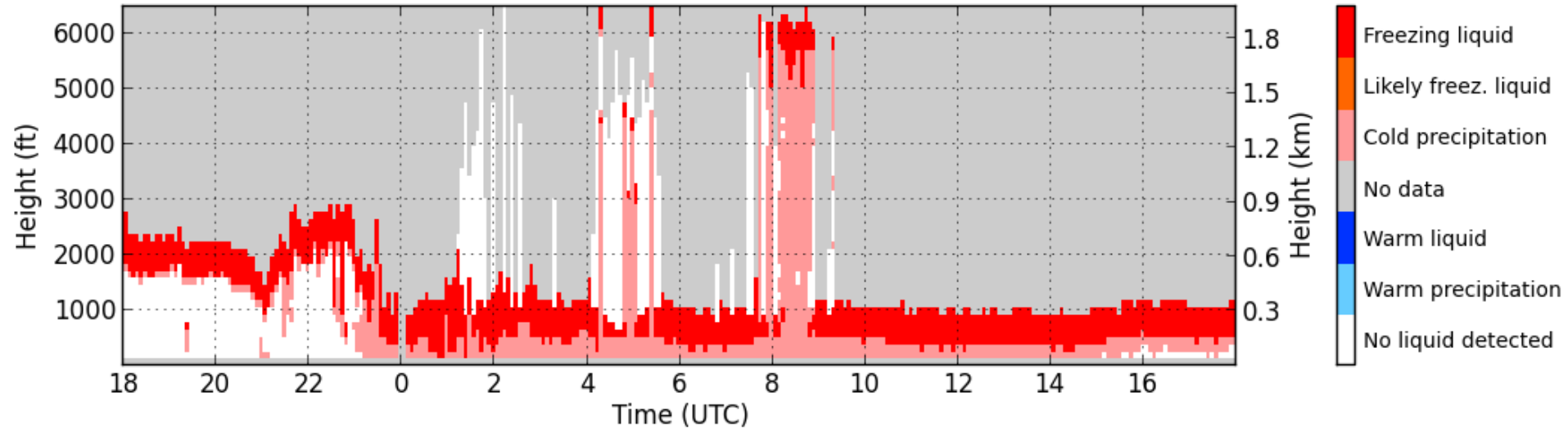


Supercooled liquid layers - icing



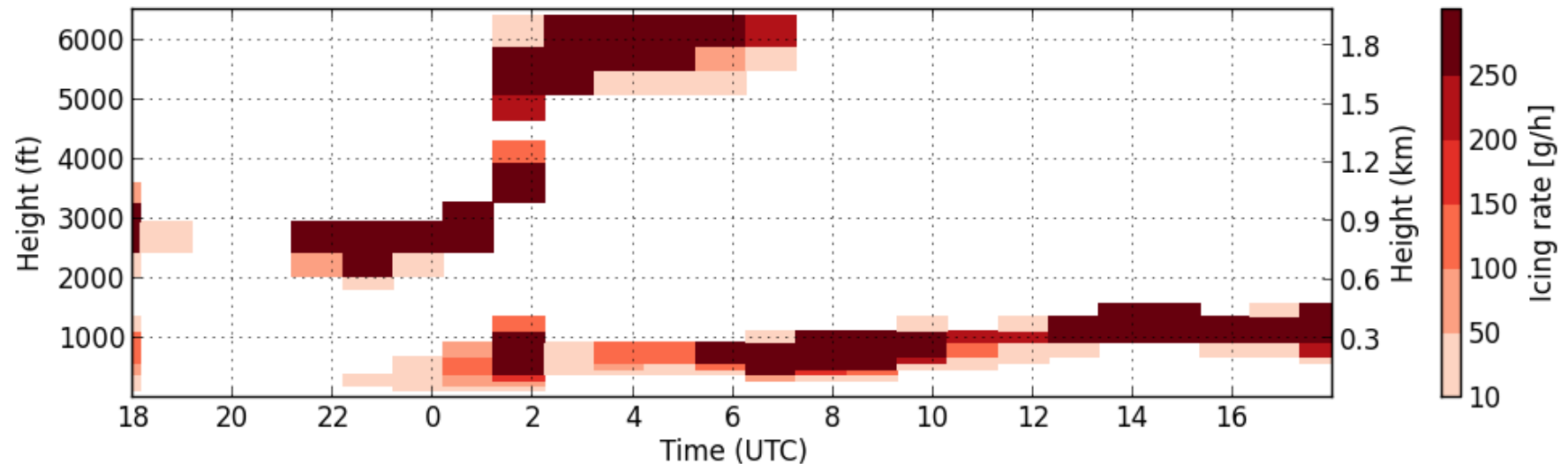
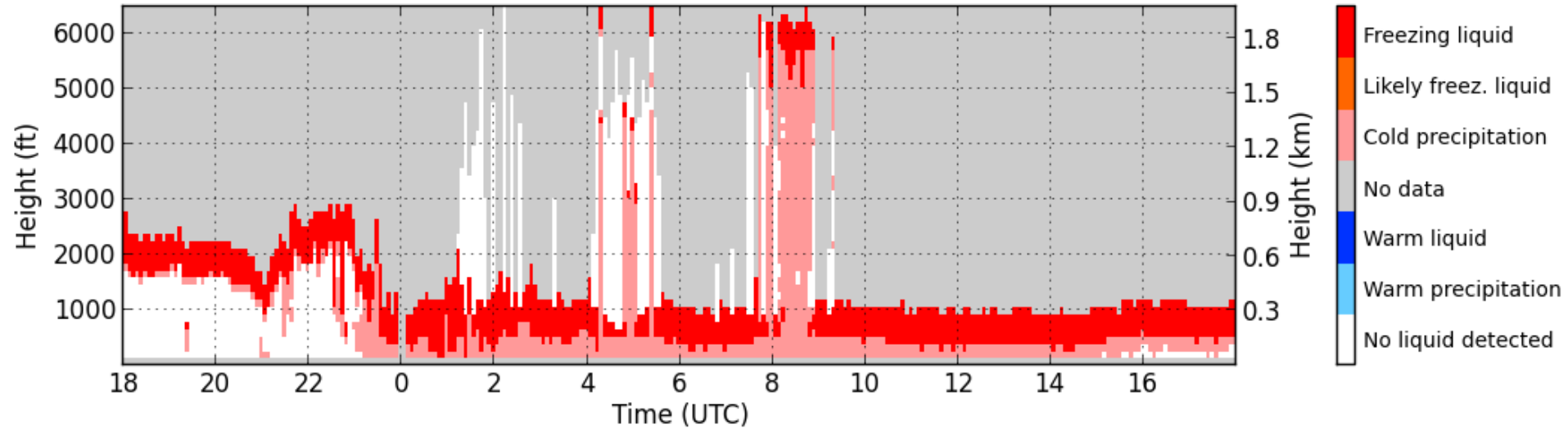


Supercooled liquid layers - icing



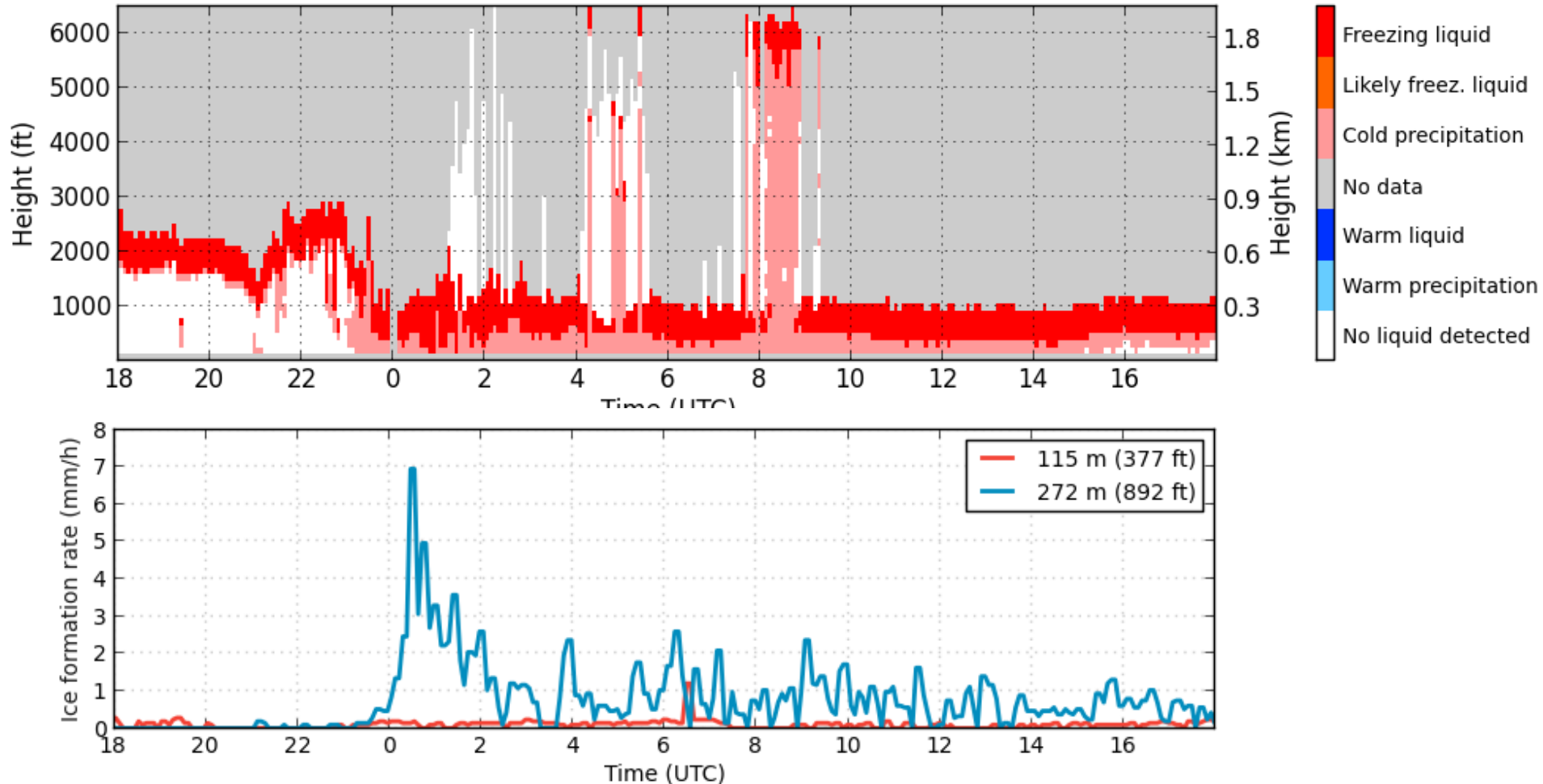


Supercooled liquid layers - icing





Supercooled liquid layers - icing





Ground-based active remote sensing provides

- High resolution profiling of
 - Clouds, Aerosol, Winds, Turbulence..
 - Especially in the boundary layer
- Suitable for
 - Process studies
 - Model assimilation and evaluation
 - Nowcasting and forecasting
- Most products can be made available in NRT