NUMERICAL MODELLING EDUCATION AT THE UNIVERSITY OF HELSINKI

VICTORIA SINCLAIR & HEIKKI JÄRVINEN

Thanks to Glenn Carver, Filip Váňa & Gabi Szépszó (ECMWF)

UNIVERSITY OF HELSINKI

Motivation: almost all meteorological jobs now require the use of a numerical model, or model output, or analyzing large amounts of data

Aims: teach students work-relative skills, increase employability, engage students, bridge the gap between studying and research

UNIVERSITY OF HELSINKI

Approach

- Teach students to use a complex, state-of-the-art numerical weather prediction model
- Since 2015, OpenIFS has been used in a masters level course (NumLab) at the University of Helsinki.

UNIVERSITY OF HELSINKI

OpenIFS

- **IFS:** Integrated Forecast System
- Used operationally at ECMWF for weather forecasts, seasonal prediction and reanalysis

UNIVERSITY OF HELSINKI

OpenIFS

- **IFS:** Integrated Forecast System
- Used operationally at ECMWF for weather forecasts, seasonal prediction and reanalysis

- **OpenIFS**: a version of the IFS available to universities and research institutions under license (no cost)
- Exactly the same dynamics and physical parameterizations
- No data assimilation, ocean model or sea-ice model (yet)

UNIVERSITY OF HELSINKI

OpenIFS

- **IFS:** Integrated Forecast System
- Used operationally at ECMWF for weather forecasts, seasonal prediction and reanalysis

- **OpenIFS**: a version of the IFS available to universities and research institutions under license (no cost)
- Exactly the same dynamics and physical parameterizations
- No data assimilation, ocean model or sea-ice model (yet)

- Supported by a small team at ECMWF
- User workshop every 2nd year

UNIVERSITY OF HELSINKI

- Will soon become the atmospheric component of EC-Earth

Laboratory course in numerical meteorology (NumLab)

- Has been taught since the 1970s at UHel
- Previously a different model was used each time
  - Very time-consuming to prepare
- Since 2015, the model has been OpenIFS each year

UNIVERSITY OF HELSINKI

Laboratory course in numerical meteorology (NumLab)

- Has been taught since the 1970s at UHel
- Previously a different model was used each time
  - Very time-consuming to prepare
- Since 2015, the model has been OpenIFS each year

- Different topic / focus each year
  - 2015: Lothar extra-tropical cyclone
  - 2016: Different deep convective parameterizations
  - 2017: forecast busts
  - 2018: sensitivity studies and Kiira storm in Helsinki

UNIVERSITY OF HELSINKI

Laboratory course in numerical meteorology (NumLab)

5 ECTS course: 12 two-hourly meetings, one per week
M.Sc and Ph.D students

UNIVERSITY OF HELSINKI

Laboratory course in numerical meteorology (NumLab)

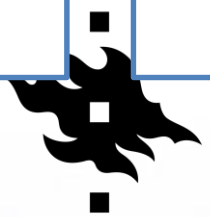
5 ECTS course: 12 two-hourly meetings, one per week
M.Sc and Ph.D students

Weeks 1-6: students work individually

- Learn to compile and run OpenIFS on HPC system
- Learn to post-process and plot model output

Weeks 7 – 12: students work in groups

- Perform a small research project
- Design and conduct different numerical experiments



UNIVERSITY OF HELSINKI

Laboratory course in numerical meteorology (NumLab)

5 ECTS course: 12 two-hourly meetings, one per week
M.Sc and Ph.D students

Weeks 1-6: students work individually

- Learn to compile and run OpenIFS on HPC system
- Learn to post-process and plot model output

Weeks 7 – 12: students work in groups

- Perform a small research project
- Design and conduct different numerical experiments

End of the course: students present results in a public seminar

UNIVERSITY OF HELSINKI

What do students learn?

- How to run a complex atmospheric model
- Run to perform sensitivity experiments (change the source code in a version controlled manner)

UNIVERSITY OF HELSINKI

What do students learn?

- How to run a complex atmospheric model
- Run to perform sensitivity experiments (change the source code in a version controlled manner)

- How to use a high performance computing system
- General Linux skills (e.g. command line, scripting)
- Data analysis skills
- Dealing with large amounts of data (writing efficient code)

UNIVERSITY OF HELSINKI

What do students learn?

- How to run a complex atmospheric model
- Run to perform sensitivity experiments (change the source code in a version controlled manner)

Both meteorological and computing training

- How to use a high performance computing system
- General Linux skills (e.g. command line, scripting)
- Data analysis skills
- Dealing with large amounts of data (writing efficient code)

UNIVERSITY OF HELSINKI

Example of one group research project from NumLab 2018

UNIVERSITY OF HELSINKI

Research questions

- Does surface wind decrease when friction is increased?
- Does the surface wind turn towards the lower pressure when friction is increased, leading to increased convergence?
- Is the change in OpenIFS linear?

Hypotheses

Less friction

- Stronger surface winds
- Wind more geostrophic near the surface, slightly less convergence

More friction

- Weaker surface winds
- Wind turns towards lower pressure, leading to more convergence and Ekman pumping

From NumLab (2018)
Kerttu Kouki, Viive Kallio and Vilma Kangasaho

UNIVERSITY OF HELSINKI

Model runs

- Time range 10 August 2017 00 UTC - 13 August 2017 00 UTC (72 hours)
- Time step 30 min
- Output every 2 hours
- Resolution T255 L91
- Reference run
- Seven modified runs
  - Surface transfer coefficient for momentum multiplied by 0.0, 0.5, 0.8, 1.2, 1.5, 2.0 and 5.0

From NumLab (2018)
Kerttu Kouki, Viive Kallio and Vilma Kangasaho

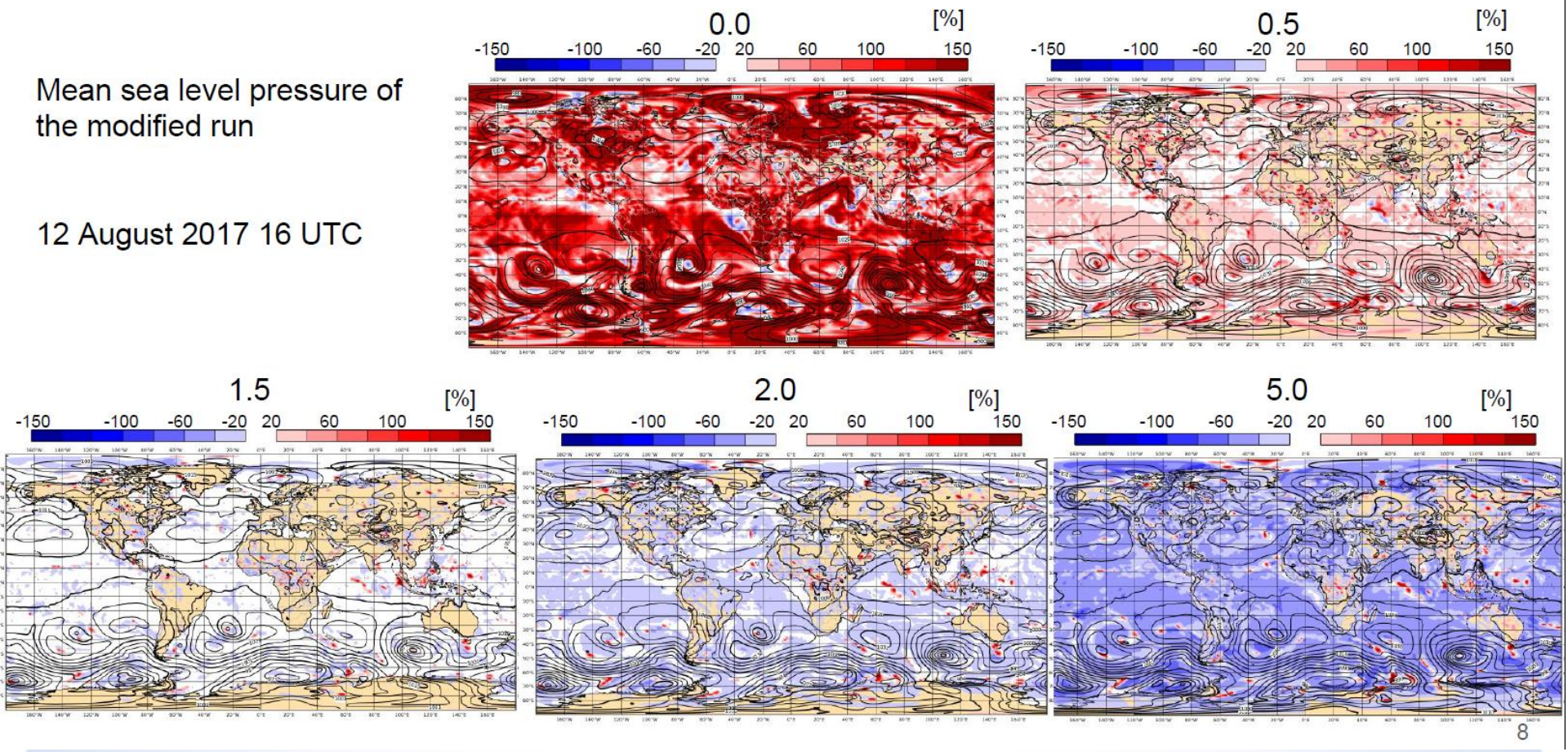
UNIVERSITY OF HELSINKI

Relative change of 10 m wind

$$\frac{\text{modified - reference}}{\text{reference}} \cdot 100\ \%$$

Mean sea level pressure of the modified run

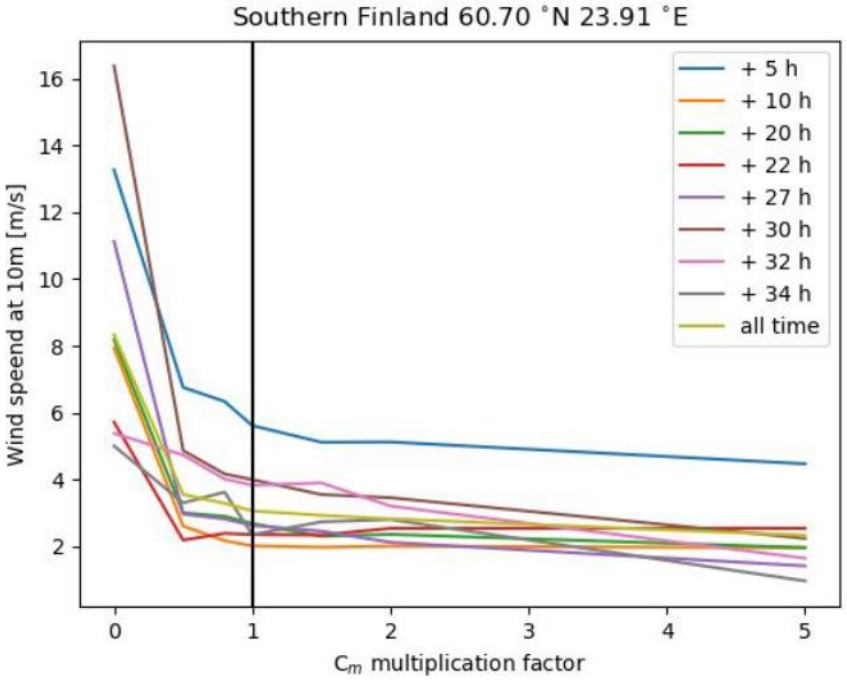
12 August 2017 16 UTC

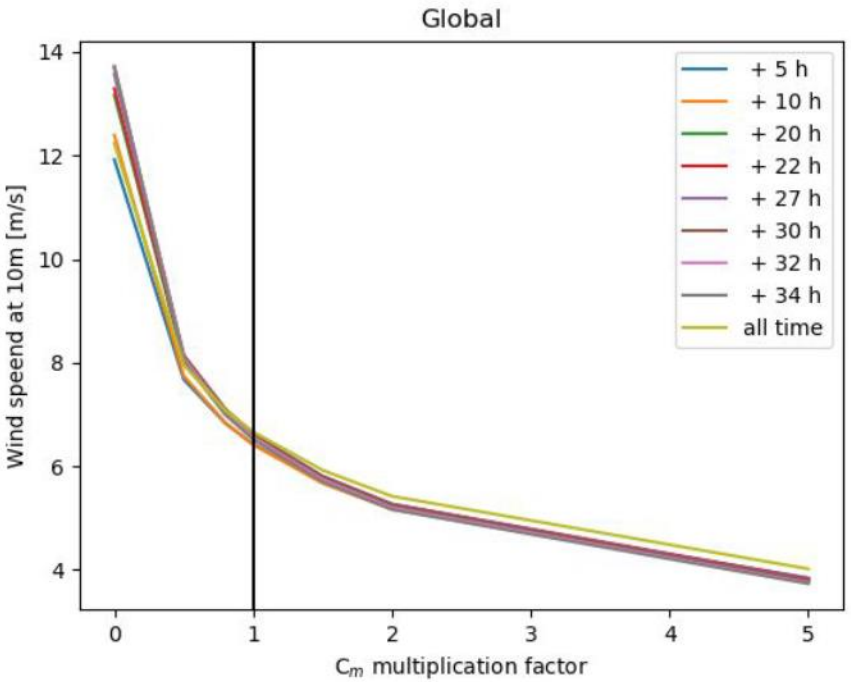


From NumLab (2018)
Kerttu Kouki, Viive Kallio and Vilma Kangasaho

UNIVERSITY OF HELSINKI

Non-linearity of the model





Hypothesis: response is non-linear

From NumLab (2018)
Kerttu Kouki, Viive Kallio and Vilma Kangasaho

UNIVERSITY OF HELSINKI

victoria.sinclair@helsinki.fi

Conclusions

- About 50 students have taken the course so far
- Generally positive feedback
- Steep learning curve for some students to start with
- Becoming easier for teachers – can re-use material from the first part of the course each year

- Benefit to research
  - OpenIFS is a major research tool in UHel
  - new PhD students are well equipped to start research

- Future plans
  - 2019: sudden stratospheric warming of 2018
  - Potentially expand to allow remote groups from other Nordic countries