Using the ECMWF OpenIFS model and state-of-the-art training techniques in meteorological education

Gabriella Szépszó[1,2], Victoria Sinclair[3], Glenn Carver[1]

[1] European Centre for Medium-Range Weather Forecasts
[2] Hungarian Meteorological Service
[3] University of Helsinki

ECMWF

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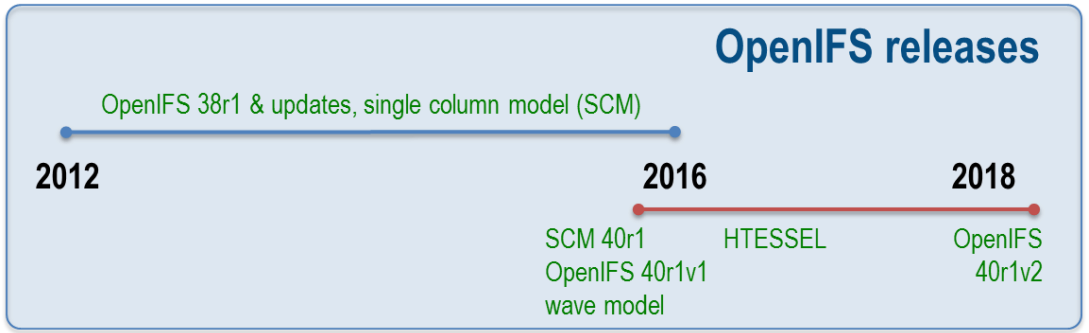
EMS Annual Meeting

Outline

1. Introduction
2. OpenIFS in teaching
3. New training technologies
4. Outlook

OpenIFS project & model since 2011

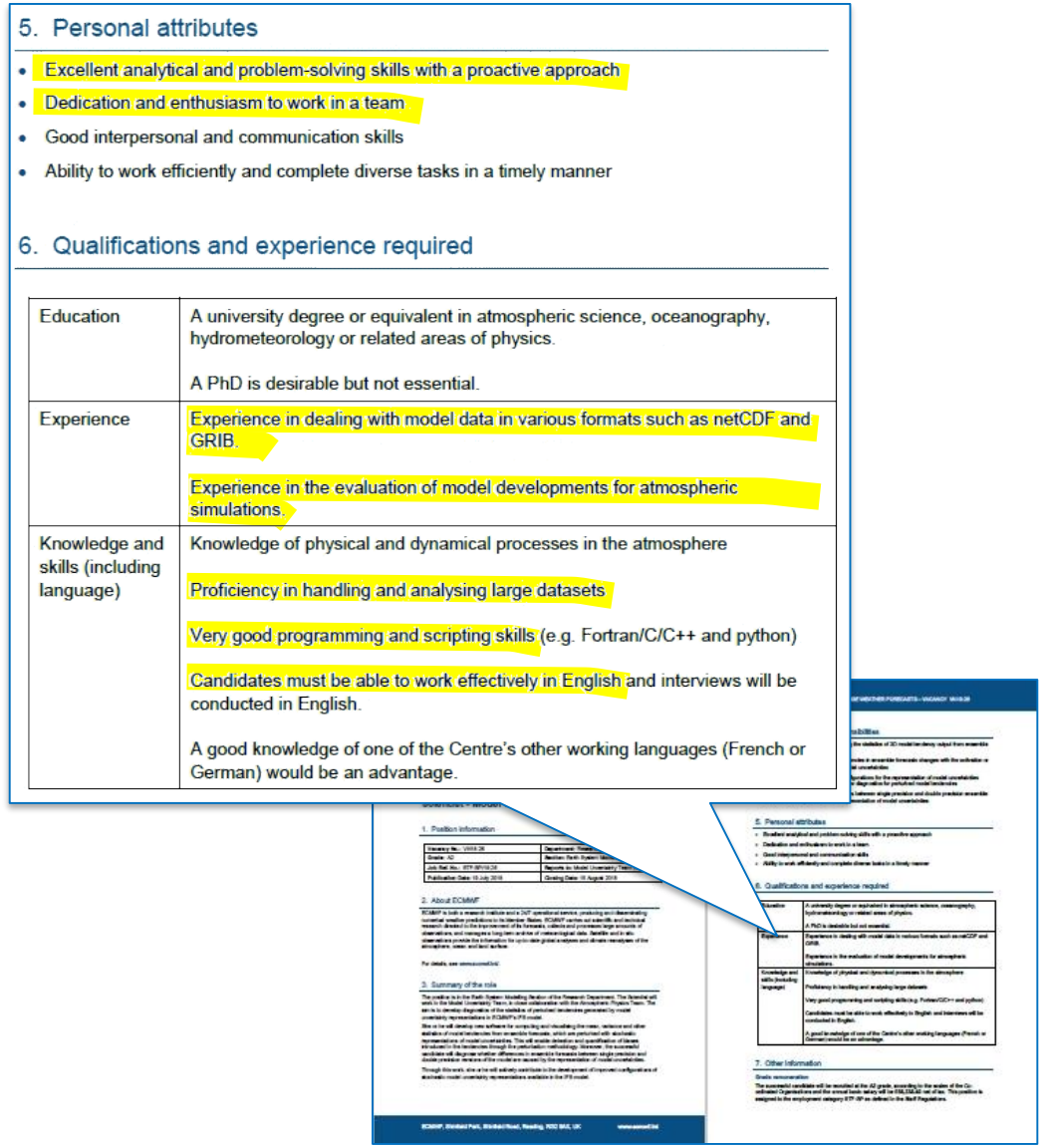
- Easy-to-use and supported version of the ECMWF operational global IFS (Integrated Forecasting System) model to **academic & research institutions**
- Objectives:
  - Increase scientific **research** using IFS
  - Increase collaborations with ECMWF on topics of interest
  - Support numerical weather prediction (NWP) **training** & provide IFS specific training
- Requires an OpenIFS **license** from ECMWF
- Differences from the operational model:
  - **No data assimilation** → only forecasts
  - No coupling to ocean & sea ice model



- More than 60 licenced institutes (not only from member states) use OpenIFS for research & **education**

OpenIFS in meteorological education

- Aims: meteorological & computing training, work-relevant skills, bridge the gap between the studying & research using a **complex, state-of-the-art NWP model**
- Various approaches:
  - Case study with a “meteorological story” (Météo-France École Nationale de la Météorologie – ENM, universities of Gent, Oxford etc.)
  - Case studies with different model settings (Hungarian Met Service, universities of Helsinki, Reading, Stockholm etc.)
  - Vertical processes & “what if” questions (universities of Innsbruck, Perugia etc.)
- Further applied tools: single column model, Metview macro system, web tutorials, virtual machine, cloud technology



5. Personal attributes

- Excellent analytical and problem-solving skills with a proactive approach
- Dedication and enthusiasm to work in a team
- Good interpersonal and communication skills
- Ability to work efficiently and complete diverse tasks in a timely manner

6. Qualifications and experience required

Education	A university degree or equivalent in atmospheric science, oceanography, hydrometeorology or related areas of physics. A PhD is desirable but not essential.
Experience	Experience in dealing with model data in various formats such as netCDF and GRIB. Experience in the evaluation of model developments for atmospheric simulations.
Knowledge and skills (including language)	Knowledge of physical and dynamical processes in the atmosphere Proficiency in handling and analysing large datasets Very good programming and scripting skills (e.g. Fortran/C/C++ and python) Candidates must be able to work effectively in English and interviews will be conducted in English. A good knowledge of one of the Centre's other working languages (French or German) would be an advantage.

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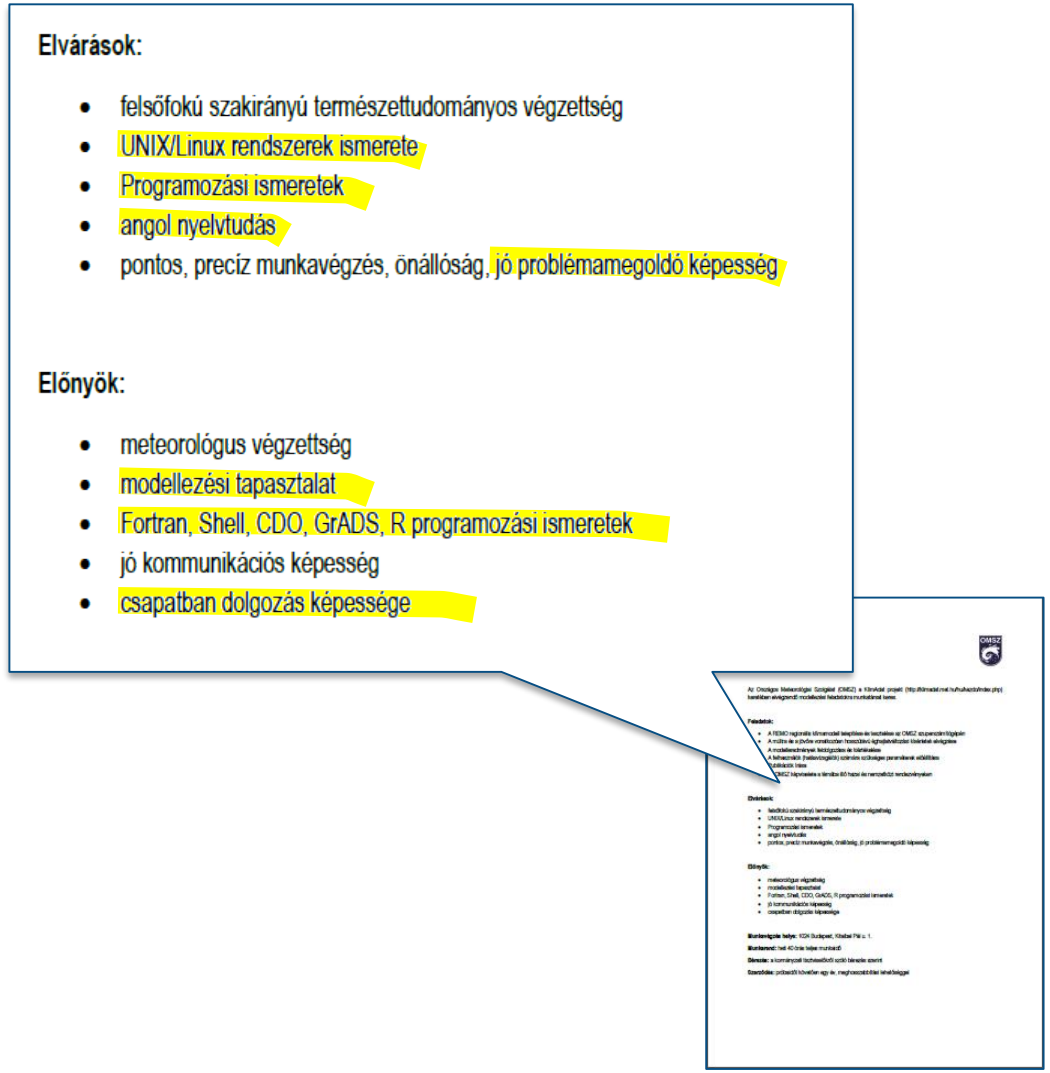


OpenIFS @ University of Helsinki

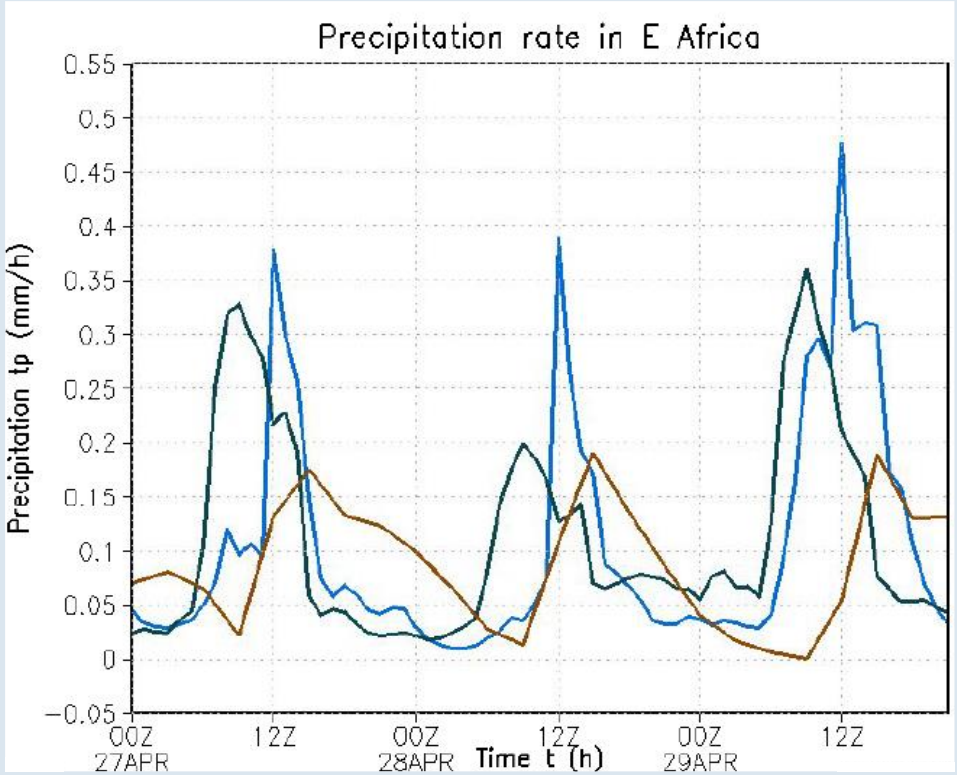
- 5 ECTS laboratory (NumLab) course for MSc and PhD students
- Different models since 1970s – OpenIFS since 2015 (also in research)
- NumLab content:
  - 2-hour meetings in 12 weeks
  - Weeks 1–6: students **individually** compile and run OpenIFS, learn to post-process and plot output
  - Weeks 7–12: **group** projects based around a common theme
  - End of the course: students present results in a seminar
  - English working language
- Students learn to work in Linux environment and on high performance computing system with a complex model, analyse large amount of data and work in English

More information:
Victoria Sinclair
victoria.sinclair@helsinki.fi

NumLab @ University of Helsinki

- Different theme each year:
  - 2015: Lothar extra-tropical storm
  - **2016: deep convection**
  - 2017: forecast busts
  - 2018: Kiira storm in Helsinki
- Over 50 students have taken the course
- 2019 topic: sudden stratospheric warming of 2018
- Potential expansion with remote groups from other Nordic countries

Impact of convective parameterization closure, 2016



Later daily precipitation maximum in the **new scheme** in better agreement with **observations**

Bechtold et al., 2014: Representing Equilibrium & Nonequilibrium Convection in Large-Scale Models. *J. Atmos. Sci. 71,* 734–753

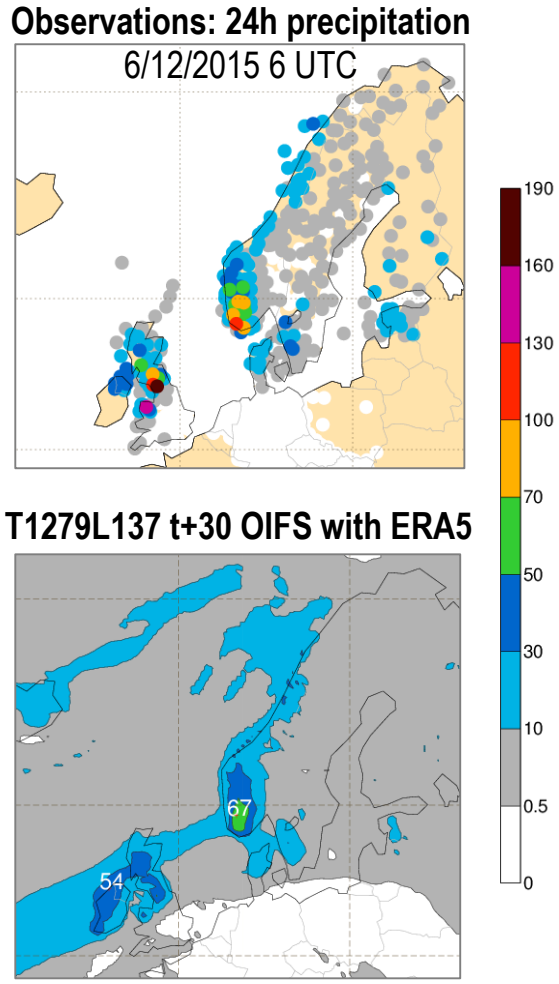
OpenIFS in teaching @ Hungarian Meteorological Service

- 2 semesters on teaching numerical weather prediction & practical modelling
- **Meteorologist & applied mathematician masters students** of Eötvös Loránd University, Budapest
- Practical session:
  - Several student groups
  - Articles and model simulations in chosen NWP topics
  - Using different models: Lorenz model, **OpenIFS**, SURFEX etc.
  - Supervision by NWP practitioners
  - Students' presentations and discussion
- 2018 practical session: testing the **new evaluation package of OpenIFS**

More information:
Gabriella Szépszó
Gabriella.Szepszo@ecmwf.int

2018 practical session @ Hungarian Meteorological Service

- 4 x 6-hour meetings
- 2 sets of case studies for European severe weather events with different operational skills (Xaver 2013, Desmond 2015)
- Experiments on **impact of the horizontal resolutions, initial conditions, forecast length** on the forecast quality
- The meteorological evaluation package consists of:
  - **Initial conditions** & namelist to the experiments
  - ERA-Interim & ERA5 **reference data** to the evaluation
  - Detailed **guide** about post-processing & visualization of the results
  - Metview macros for **visualization**
  - **Output figures** as reference for comparison



OpenIFS Meteorological Evaluation: https://software.ecmwf.int/wiki/x/jxwXBQ

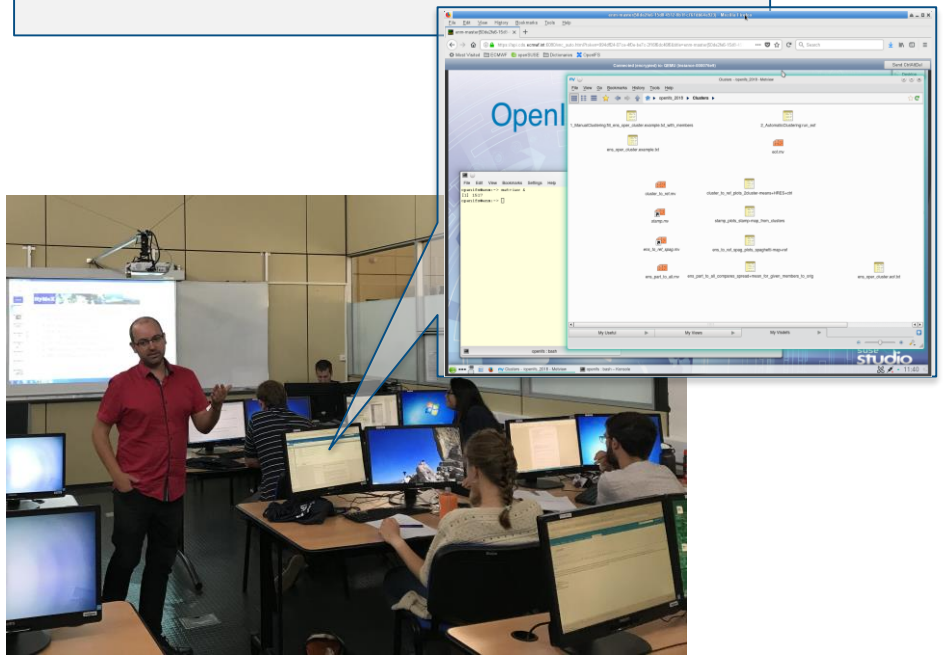
Szépszó & Carver, 2018: New forecast evaluation tool for OpenIFS. *ECMWF Newsletter 156,* 14–15

Training technologies: virtual machines & cloud server

- Pre-installed virtual machines (operating system, scripts, data on VMs) on cloud server of Copernicus Climate Data Store
- Applied in the **2018 ENM training**:
  - 3 days with ~15 students
  - Objective: **real forecaster case** (Nadine, 2012) **& support to decision making**
  - 8 virtual CPUs + 16Gb RAM per VM
  - Accessible via web browser
  - Exercises, tutorial and lectures
- Disadvantages:
  - Responsiveness (cf. locally installed VMs)
  - Saving outputs
  - Rely on cloud service allocations

Copernicus Climate Data Store

- Cloud-based tool to browse and combine raw data, build own applications, maps & graphs online in real time, and access information about the past, present & future climate (observations, historical climate data records, re-analyses, climate projections, seasonal forecasts)
- CDS toolbox: set of software enabling users to develop their own web-based applications



Outlook

- Next OpenIFS cycle will be **cy43r3** (it was operational until June):
  - New cubic octahedral grid
  - More effective radiation code
  - Lake model
- Weather & climate experiments using **OpenIFS@home** in collaboration with climate*prediction*.net
- OpenIFS plans in education:
  - Extension of **idealized configurations** (aquaplanet run, baroclinic wave)
  - **Container version** of OpenIFS (installation & running on the fly)
- **5th OpenIFS user meeting 2019** (University of Reading, UK): Atmospheric rivers and their impact on forecasts

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Thank you for your attention !