Global simulations of the atmosphere with 1.45 km grid-spacing with the Integrated Forecast System

Peter Düben[1], Nils Wedi[1], Sami Saarinen[2], Christian Zeman[1]

European Centre for Medium-Range Weather Forecasts[1] and Eidgenössische Technische Hochschule Zürich[2]; Contact: peter.dueben@ecmwf.int

1. Outline:

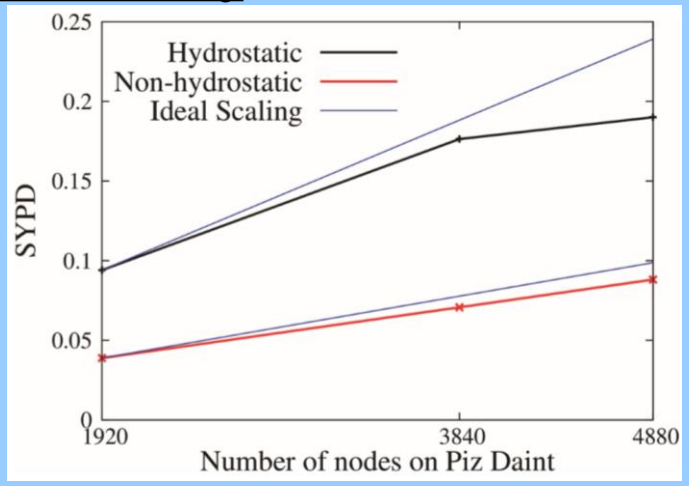
We show results for simulations with the Integrated Forecast System (IFS) of the European Centre for Medium-Range Weather Forecasts (ECMWF) at cloud-resolving resolution that allow to switch off the parametrisation of deep convection. We investigate the impact of hydrostatic vs. non-hydrostatic equations and the size of the time step on model fidelity and analyse scalability.

IFS can in principle handle very long time steps due to the semi-implicit semi-Lagrangian time stepping scheme. The model can run in both hydrostatic and non-hydrostatic mode.

These results have been published in:

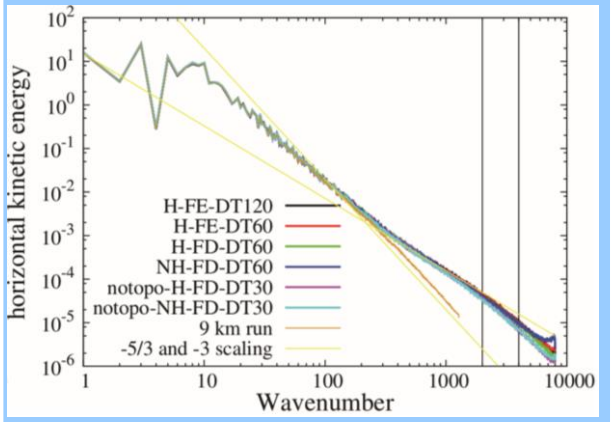
Dueben, P. D., N. Wedi, S. Saarinen, and C. Zeman, 2020: Global simulations of the atmosphere at 1.45 km grid-spacing with the Integrated Forecasting System. J. Meteor. Soc. Japan, 98

3. Cost and scaling:

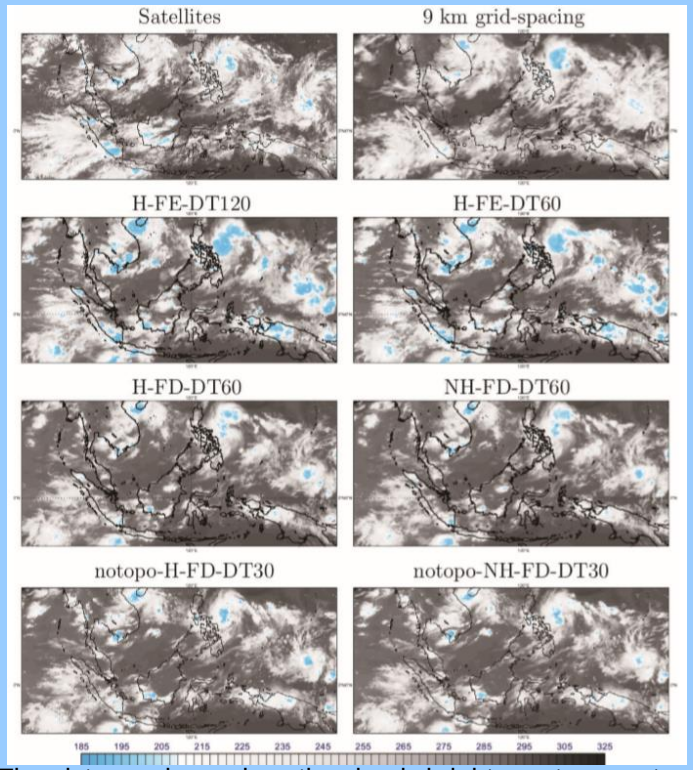


Scaling results on the Piz Daint supercomputer. Non-hydrostatic simulations are much more expensive when compared to hydrostatic simulations since they require additional transforms between spectral and gridpoint space.

5. Global energy spectra at 500 hPa:



4. Realism:



The pictures above show the cloudy brightness temperature [K] over Indonesia for 31st October 2016, 12 UTC.

2. Six model runs with 1.45 km grid-spacing (all in single precision):

Run Identifier	Hydrostatic?	Topography	Vertical levels	Vertical disc.	Timestep and number of PC iterations
H-FE-DT120	Yes	Yes	137	Finite element	120 s/0 PC
H-FE-DT60	Yes	Yes	137	Finite element	60 s/0 PC
H-FD-DT60	Yes	Yes	62	Finite difference	60 s/3 PC
NH-FD-DT60	No	Yes	62	Finite difference	60 s/3 PC
notopo-H-FD-DT30	Yes	No	62	Finite difference	30 s/2 PC
notopo-NH-FD-DT30	No	No	62	Finite difference	30 s/2 PC

6. Take-home-message:

The IFS model scales well at very high resolution and allows global simulations with an average grid-spacing of 1.45 km.

Spectral models continue to be competitive in efficiency and model quality compared against grid-point models towards global storm-resolving simulations.

Simulations at an average grid-spacing of 1.45 km show a clear improvement of realism for tropical convection and rain-fall pattern when compared to simulations with parametrised deep convection.

Differences between simulations with hydrostatic and non-hydrostatic equations or with different timesteps are visible but we do not see sufficient improvements to justify the significant computational cost of non-hydrostatic simulations with short timesteps yet.

The presenter gratefully acknowledges the funding from a Royal Society University Research Fellowship and the ESiWACE project. The ESiWACE2 project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 800 987.