Modelling the grey zone with the MPAS model using a scale-aware convection parameterization

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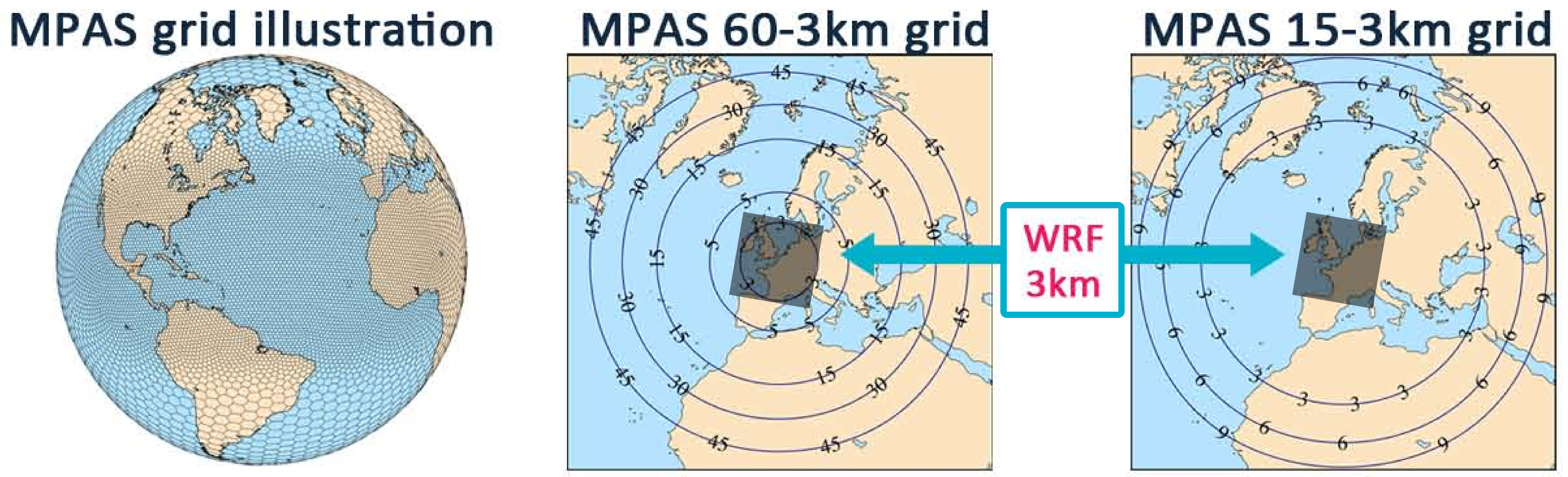
Introduction

Regional models that employ nested domains encounter problems with the interpolation from their initial conditions to the domain grid and from the resolution transition between domains. The novel Model for Prediction Across Scales (MPAS) uses an irregular grid to avoid these issues. We compared MPAS to WRF over Europe in 3 cases, with 3 grids, 2 initialization times, and with ECMWF and NCEP CFSR2 initial conditions.

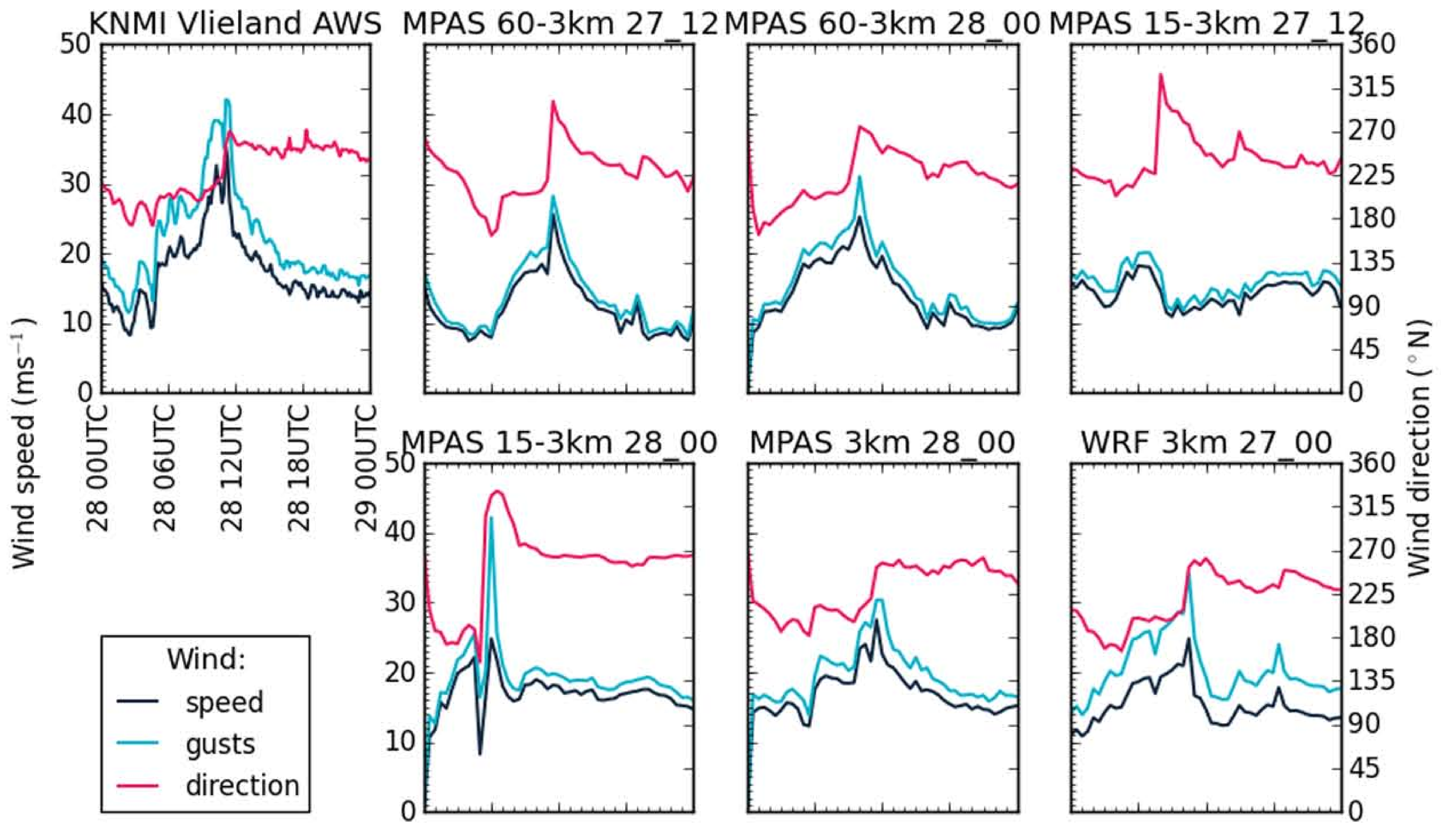
Model grids

Compare WRF (v3.6.1) for operational weather forecasting (3km resolution, 374.5k grid columns, 39 levels, 0.125° initial conditions) to three MPAS (v4.0 with modifications) grids (55 levels, 0.250° initial conditions):

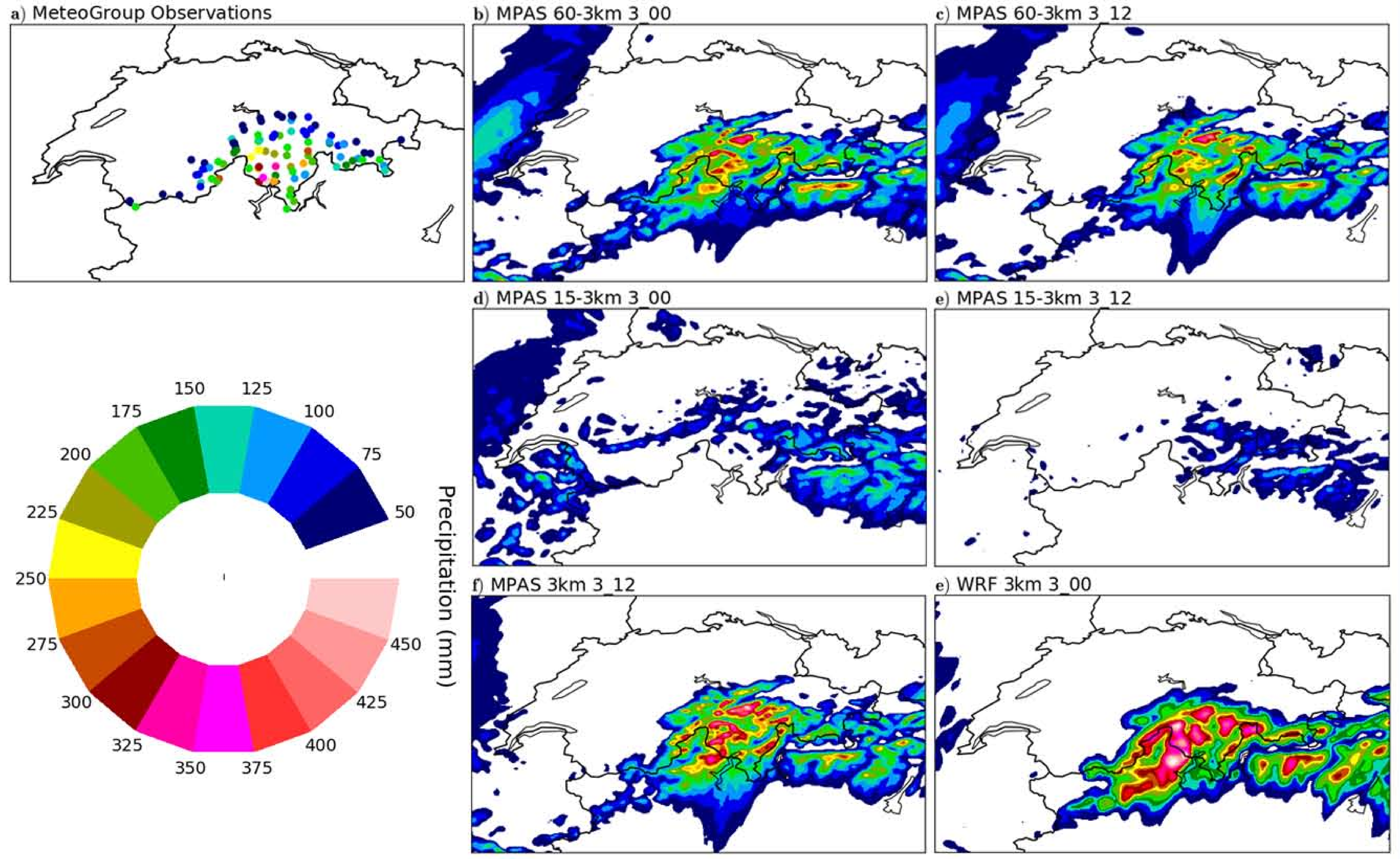
- 60-3km variable resolution (835.5k grid columns)
- 15-3km variable resolution (6.5M grid columns)
- Global 3km resolution (65.5M grid columns)



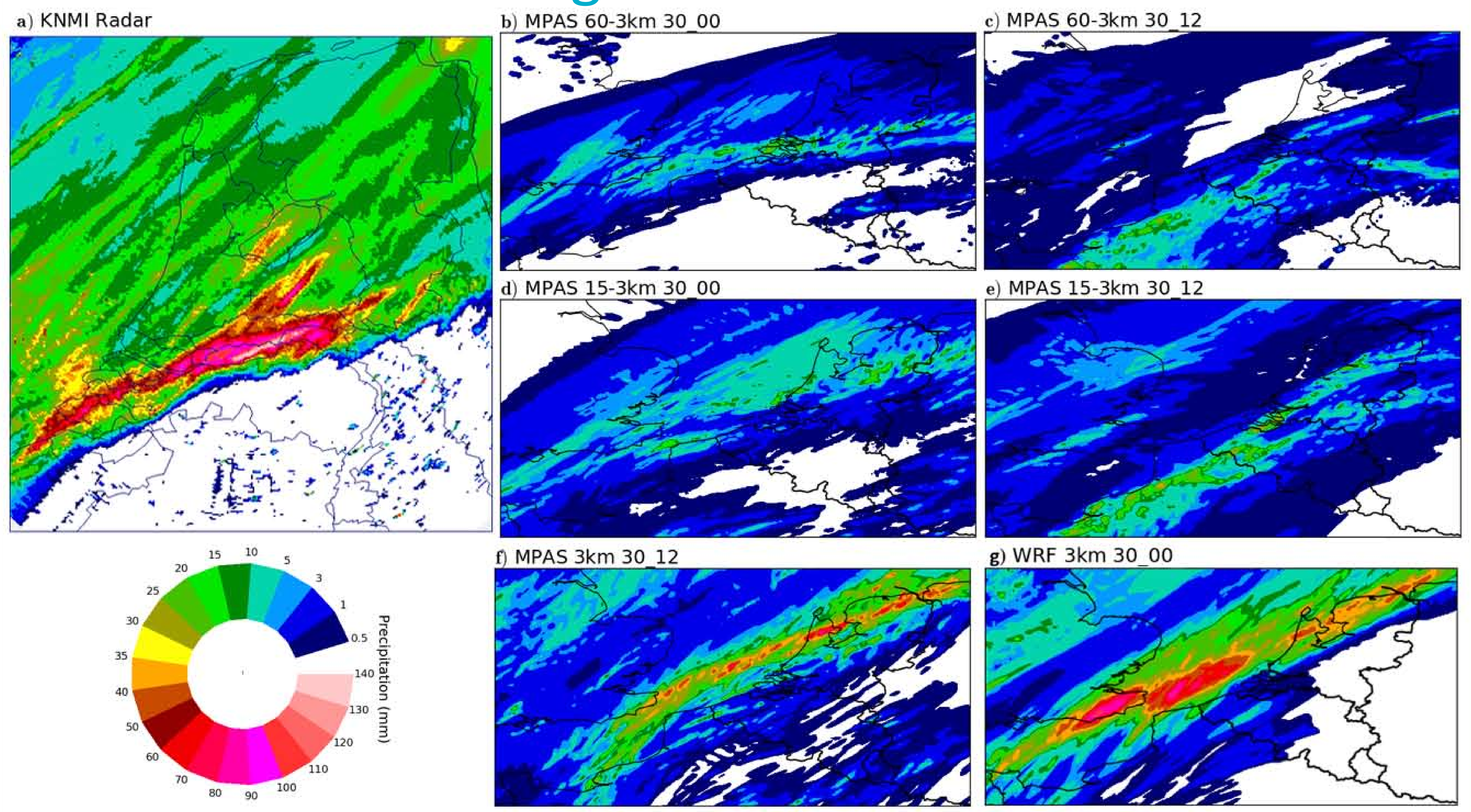
Gale case North Sea October 28th 2013



Föhn case Switzerland November 3-6 2014



Convection with hail case the Netherlands August 31st 2015



Acknowledgements

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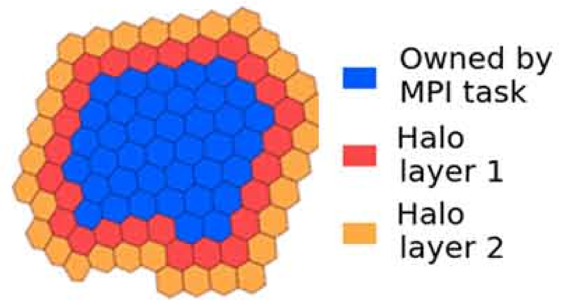
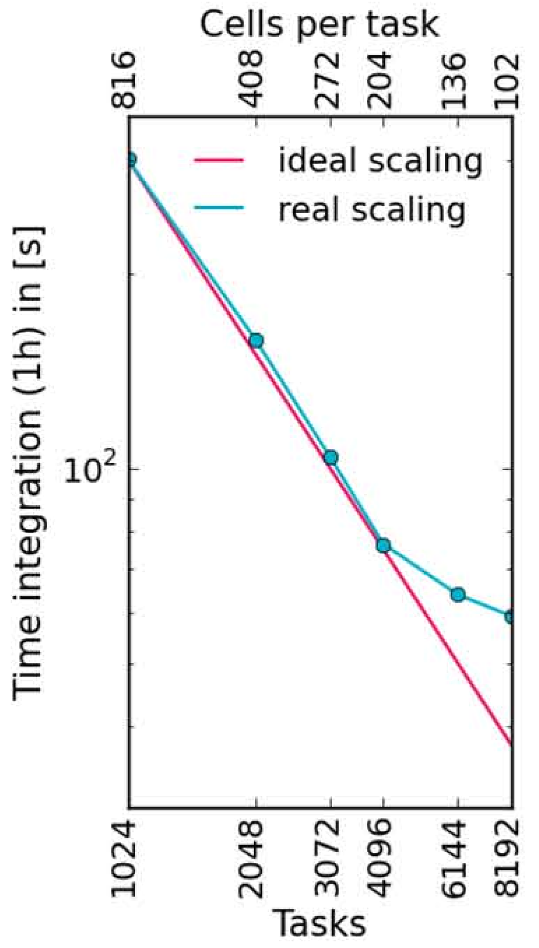
Computing performance

The time integration routine in MPAS (dynamics, physics, file I/O) offers excellent parallel scaling up to very large numbers of tasks for all grids employed in this study.

- Unstructured Voronoi grids in MPAS remove the issue of singularities at the poles and permit areas of variable resolution with smooth transitions in between across the globe (local filters, improved model stability).
- A suitable I/O library that scales up to several thousand tasks is required to maintain the scaling of the time integration for large grids (SIONlib in our study).
- Parallel performance of MPAS as a function of grid columns (cells) owned per MPI task is independent of the grid; on SuperMUC for less than 200 owned cells, the parallel performance breaks down.
- MPAS 60-3km grid (±2x WRF cells) requires at least 10x computational resources.
- Tuning of MPAS on hardware and grid, and optimisations in MPAS v5.0 improve its performance to close to that of WRF (not shown).





36h forecast scenario		Mesh	Nodes required	Task required	Core-hours forecast
Model integration time	36h	3km	3927	62,832	251,328
Time to solution	4h	15-3km	386	6176	24,704
Grid columns per task	1050	60-3km	50	800	3200
Cores per node (MPAS)	16	WRF 3km	N/A	70	280

Conclusions/future work

- WRF-3km is comparable to global MPAS-3km: a regional WRF is able to produce good quality operational forecasts (especially in extreme events).
- In two cases, MPAS 60-3km is promising as it shows comparable results to WRF/MPAS 3km.
- The erroneous results of the MPAS 15-3km runs needs further investigation (initial conditions, divergence damping parameter, ...).
- MPAS shows excellent scaling up to large numbers of tasks for all grids.
- The ability to design grids with multiple areas of refinement and different shapes opens up entirely new possibilities to generate forecasts for customers across the globe from one single model run.

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