Latest developments at ECMWF

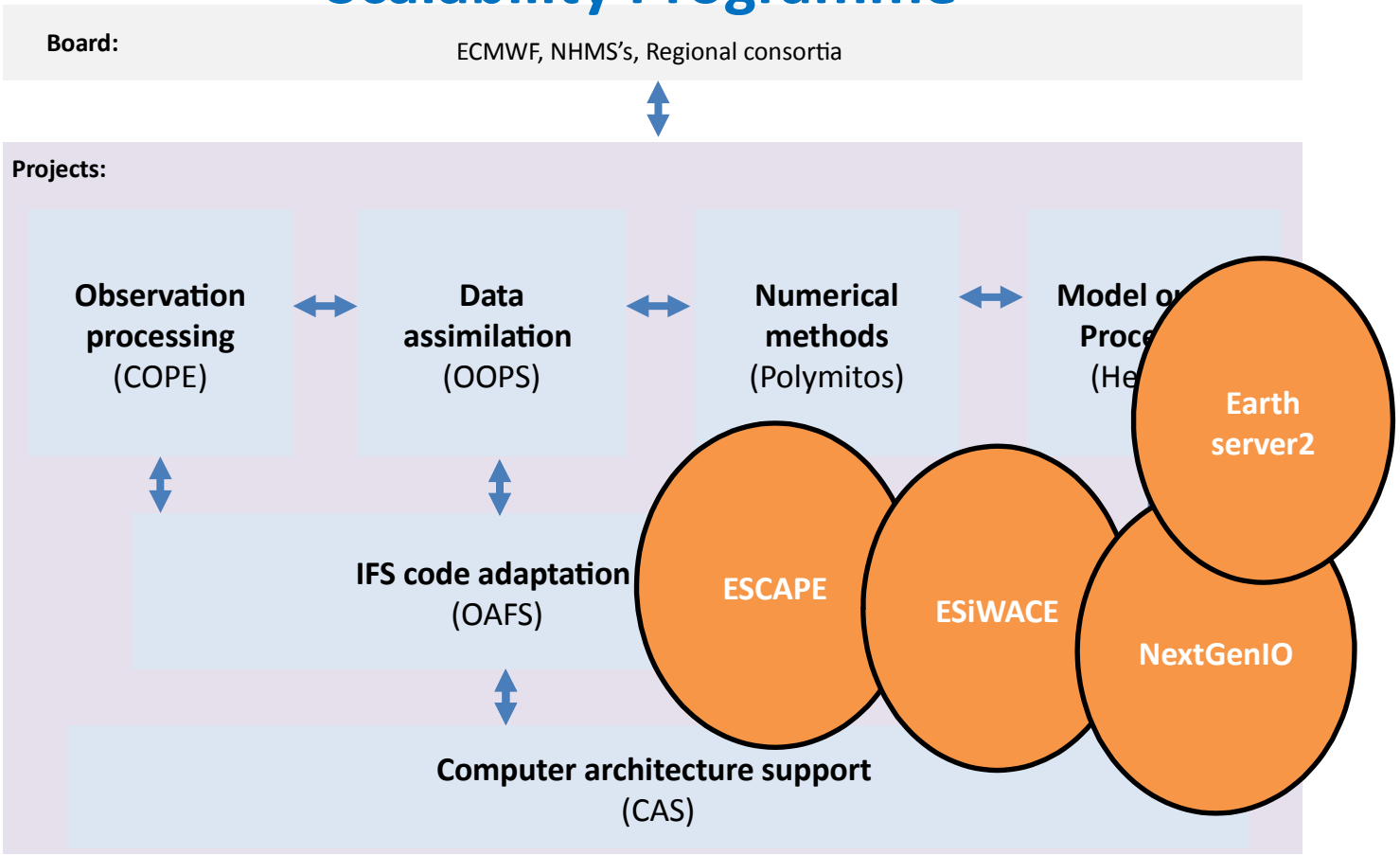
Scalability

and

IFS cycle 41r2

Scalability Programme

Peter Bauer



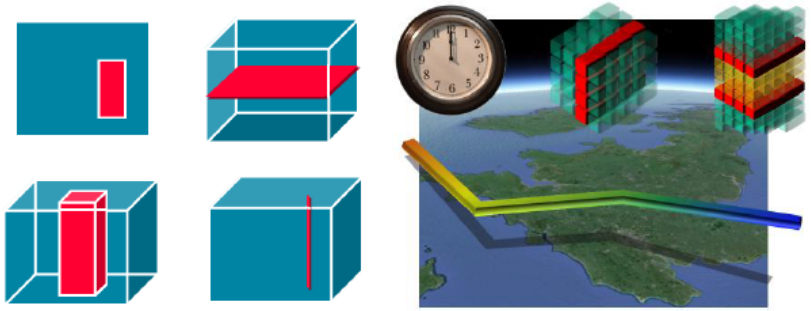
+ bilateral collaboration with IBM and INTEL

Model output processing

EarthServer-2*, Agile Analytics on Big Data Cubes:

- navigation, extraction, aggregation, and recombining of any-size space/time data cubes;
- easy to install & maintain value-adding services extending the existing portfolio of data and compute centres;
- based on open standards, in particular: the OGC Big Data standards and the forthcoming ISO SQL/MDA ("Multi- Dimensional Arrays") standard.

The project will advance the existing, world-leading rasdaman Array Database technology wrt query functionality, inter-federation data processing with automatic data and query distribution, tape archive integration, and 3D/4D visualization based on NASA's virtual globe technology.



Status:

- Project kicked off 1st May 2015
- 1PB reanalysis dataset test case

→ http://www.earthserver.eu/

* Funded by EC H2020 framework, e-Infrastuctures, Managing, preserving and computing with big research data
Partners: **Jacobs U Bremen**, rasdaman, Plymouth Marine Lab, ECMWF, MEEO S.R.L., CITE S.A., NASA & NCI (unfunded)

Numerical methods – Code Adaptation - Architecture

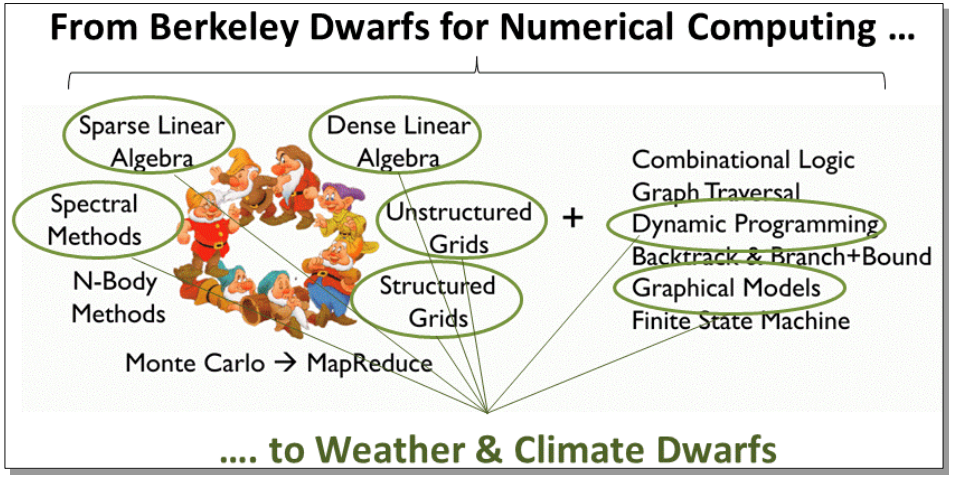
ESCAPE*, Energy efficient SCalable Algorithms for weather Prediction at Exascale:

- Next generation IFS numerical building blocks and compute intensive algorithms
- Compute/energy efficiency diagnostics
- New approaches and implementation on novel architectures
- Testing in operational configurations

Status:

- Project kicked off 1-2 October 2015
- 6 deliverables submitted 1 December 2015
- 1st webinar on dwarfs and interaction on codes held early December
- 1st dwarf available on interactive platform
- Recruitment completed

→ http://www.hpc-escape.eu



*Funded by EC H2020 framework, Future and Emerging Technologies – High-Performance Computing
Partners: **ECMWF**, Météo-France, RMI, DMI, Meteo Swiss, DWD, U Loughborough, PSNC, ICHEC, Bull, NVIDIA, Optalysys

Numerical methods - Model output processing - Architecture

NextGenIO*, Next Generation I/O:

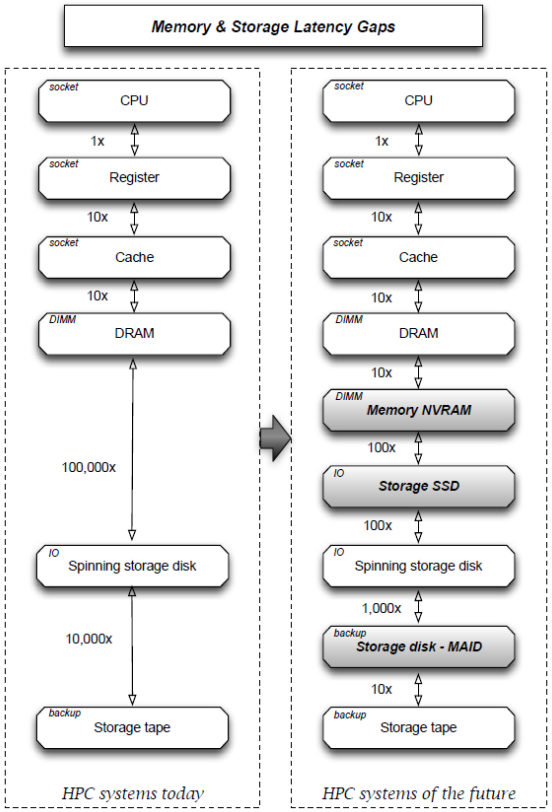
- Define exascale I/O requirements across demanding applications
- Define hardware architectures
- Define data architecture
- Develop I/O workload simulators
- Develop support tools for NVRAM
- Develop necessary systemware
- Develop prototype hardware

Status:

- Project kicked off 5-6 October 2015
- Informal meeting on definition/scope of I/O workload simulators
- Recruitment completed

→ http://www.nextgenio.eu/

*Funded by EC H2020 framework, Future and Emerging Technologies – High-Performance Computing
Partners: **U Edinburgh**, Intel, Fujitsu, BSC, TU Dresden, Allinea, ECMWF, Arctur

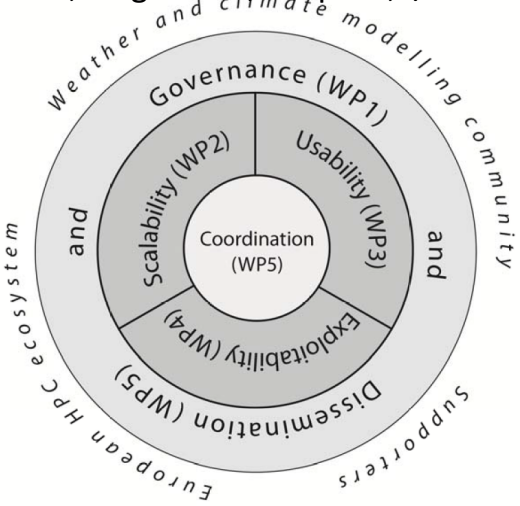


Numerical methods – Code Adaptation – Model output processing - Architecture

ESiWACE*, Excellence in Simulation of Weather And Climate in Europe:

Join weather and climate communities to provide support, training, services

- fostering community models, tools and software (NEMO, EC-Earth, diagnostics, couplers, I/O servers, ESM workflow, Cylc)
- towards enhanced code performance (e.g. MPI/OpenMP, I/O, single-precision)
- towards exascale (e.g. concurrency, knowledge compression)



Status:

- Project kicked off 1 December 2015
- 1st HPC workshop being prepared (April, Toulouse)
- Recruitment completed

→ https://www.esiwace.eu/

*Funded by EC H2020 framework, e-Infrastuctures, Centres of Excellence for Computing Applications
Partners: **DKRZ**, ECMWF, CNRS-IPSL, MPG, CERFACS, BSC, STFC, Met Office, U Reading, SMHI, ICHEC, CMCC, DWD, Seagate, Bull, Allinea

Scalability programme

- Well on track
- Major progress has been made in setting up projects
- First promising results

Higher resolution model

IFS cycle 41r2

Its contents & evaluation

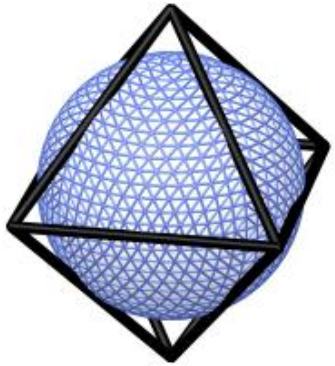
Erik Andersson,Thomas Haiden, Richard Forbes, Paul Dando, Linus Magnusson, Martin Janousek, Fernando Prates, Ervin Zsoter…

Contents of IFS cycle 41r2 - 1

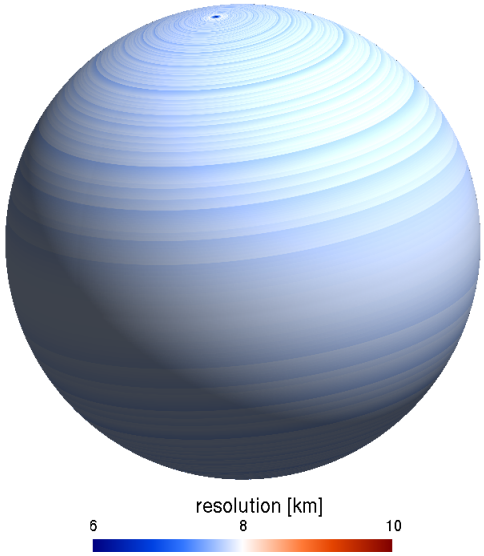
- The horizontal resolution is increased by changing from linear (TL) to cubic (TC) spectral truncation and introducing an octahedral reduced Gaussian grid.

- The realism of the kinetic energy spectrum is significantly improved with more energy in the smaller scales

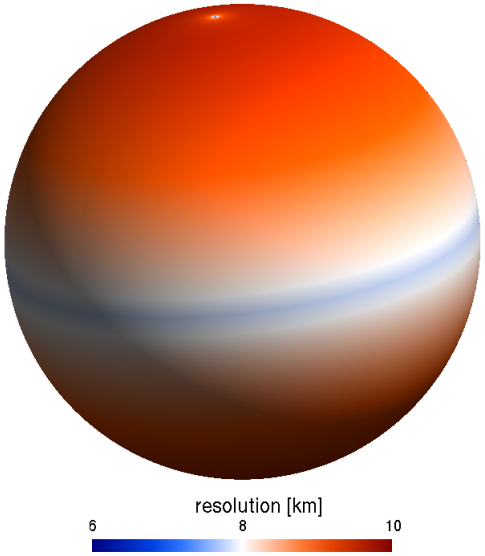
Upcoming resolution upgrade (8 March 2016)



- High resolution forecast (HRES): twice per day
  9 km 137-level, to 10 days ahead
- Ensemble forecast (ENS): twice per day
  51 members, 18 km 91-level, **to 15 days ahead**
- Monthly ENS extension: twice a week (Mon/Thursdays)
  51 members, 36 km 62 levels, to 46 days ahead

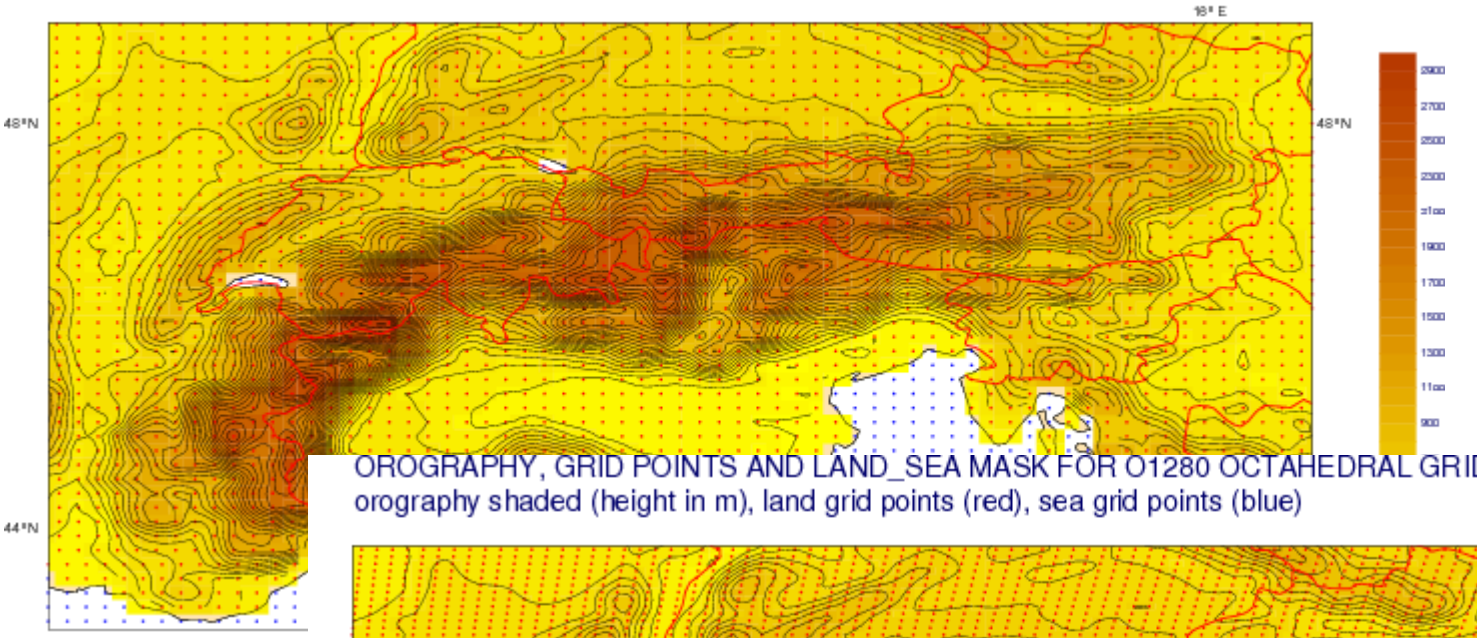


Comparing the global variations in resolution between current (Gaussian-reduced) and new (octahedral) grids at ~9km.

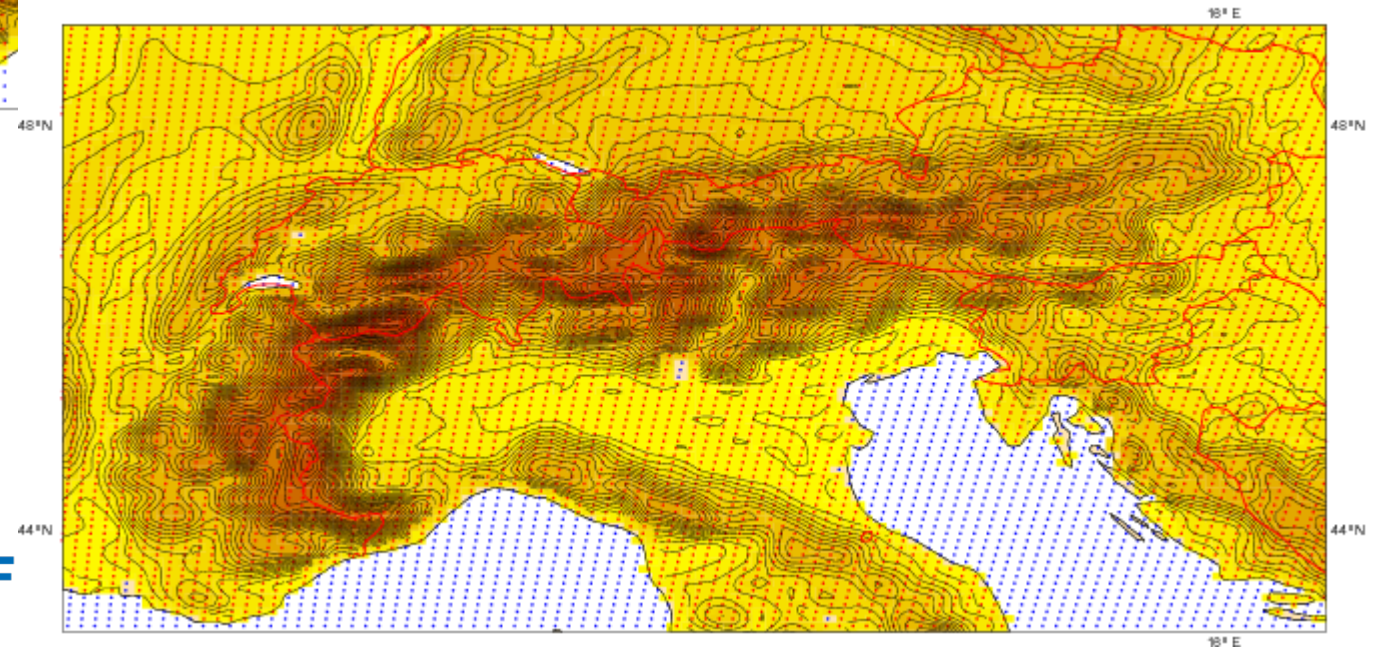


Improved representation of the Alps

OROGRAPHY, GRID POINTS AND LAND_SEA MASK FOR N640 ORIGINAL GRID
orography shaded (height in m), land grid points (red), sea grid points (blue)



OROGRAPHY, GRID POINTS AND LAND_SEA MASK FOR O1280 OCTAHEDRAL GRID
orography shaded (height in m), land grid points (red), sea grid points (blue)



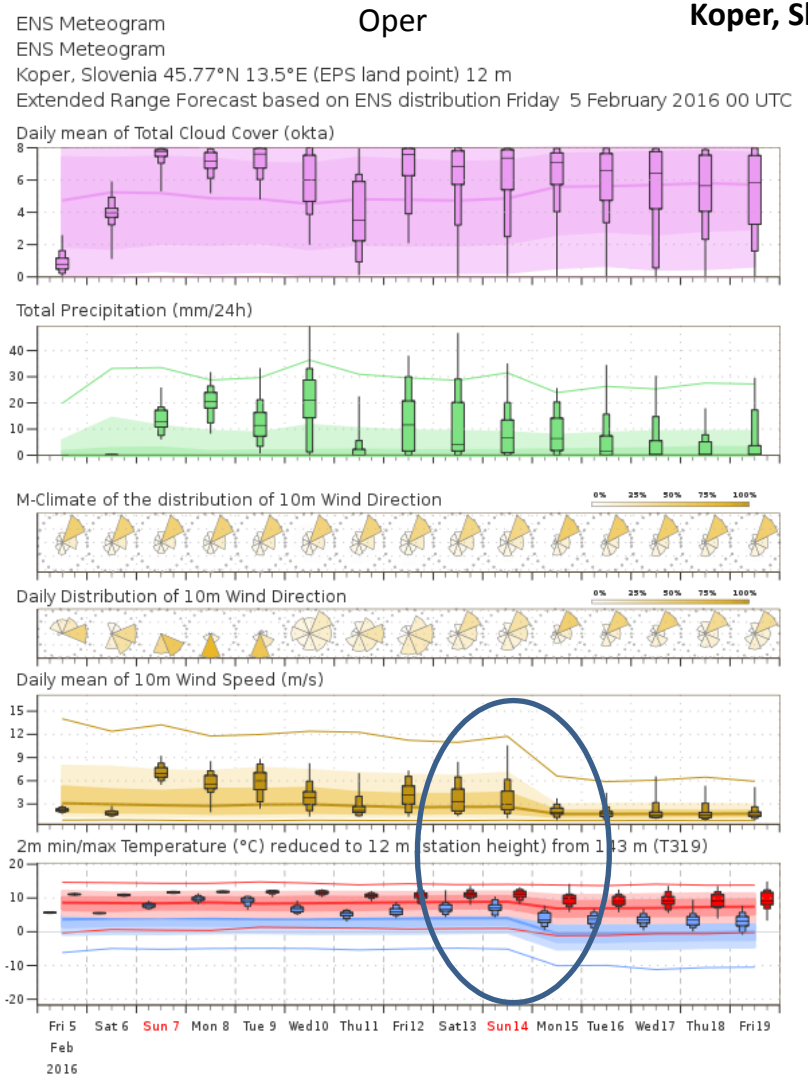
ECMWF

Higher resolution ENS up to 15 days

Improvement on the 15-day EPSgrams – **NO JUMP at DAY10**

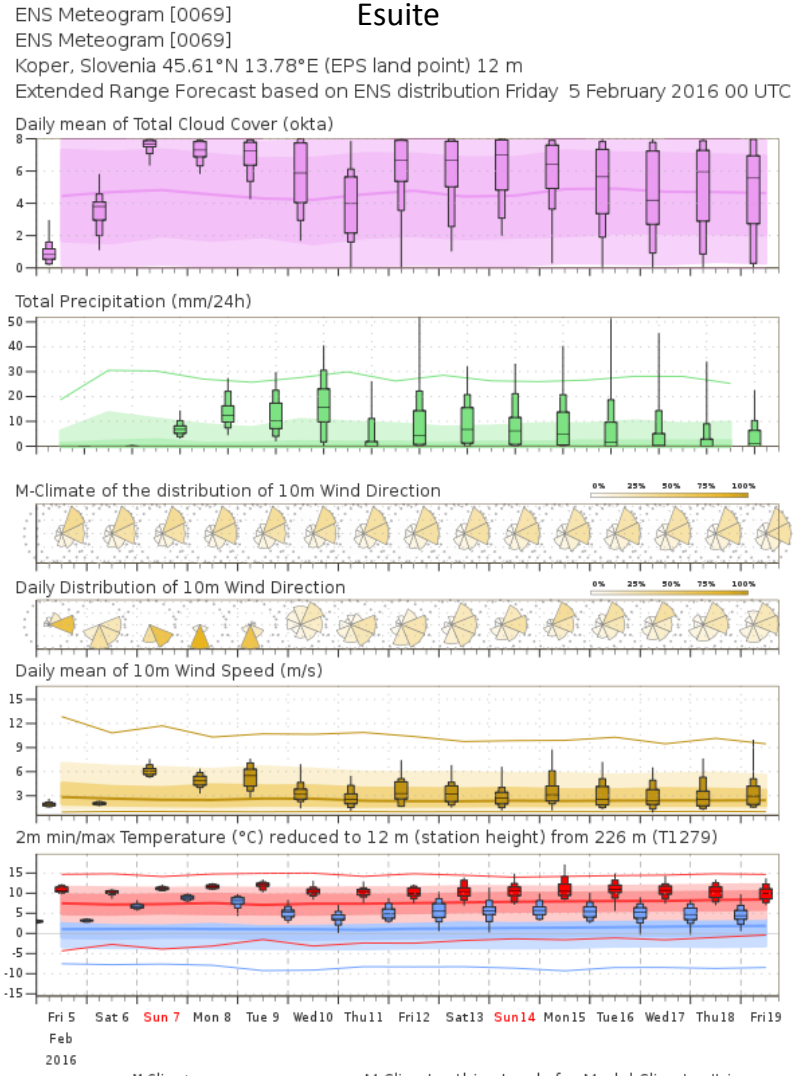
Koper, Slovenia

Oper



M-Climate: this stands for Model Climate. It is a function of lead time, date (+/-15days), and model version. It is derived by rerunning a 11 member ensemble over the last 20 years twice a week (1980 realisations). M-Climate is always from the same model version as the displayed ENS data.

Esuite



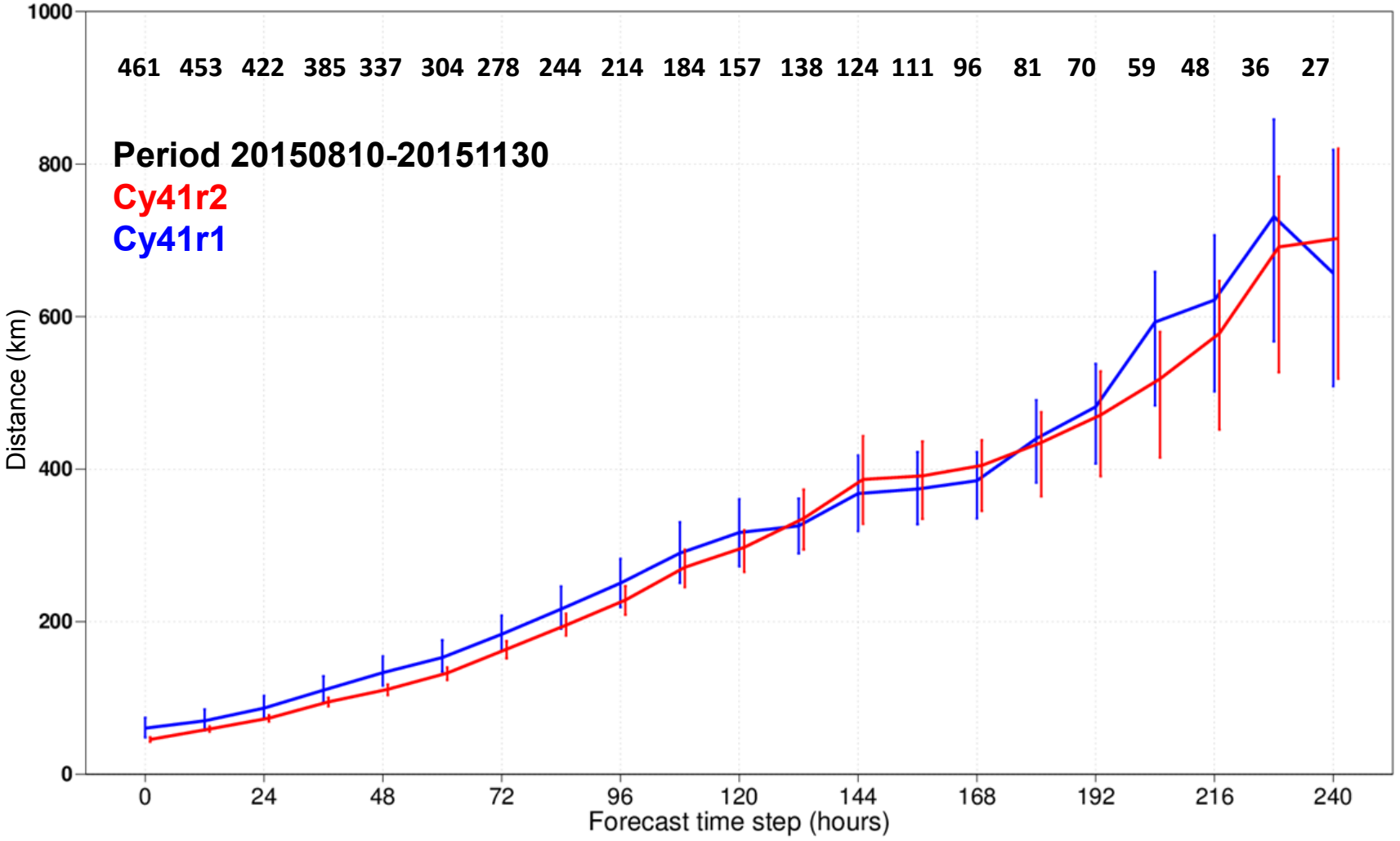
M-Climate: this stands for Model Climate. It is a function of lead time, date (+/-15days), and model version. It is derived by rerunning a 11 member ensemble over the last 20 years twice a week (1980 realisations). M-Climate is always from the same model version as the displayed ENS data.

Contents of IFS cycle 41r2 -2

- Significant revision to the specification of statistics used in the HRES data assimilation due to the increased resolution of the EDA and the introduction of scale-dependence of the hybrid B (climatological and EDA), thereby relying more on the EDA "errors of the day" for the smaller scales.

- Improvements in the use and coverage of assimilated satellite data due to changes in observation selection and error representation (for GPS radio occultation data, all-sky microwave, AMSU-A, IASI and AMVs) and improved observation operators for radiance data from microwave sounders.

Tropical cyclone position error



Contents of IFS cycle 41r2 -3

- The stability of the semi-Lagrangian scheme near strong wind gradients is improved, reducing noise downstream of significant orography and in tropical cyclones.

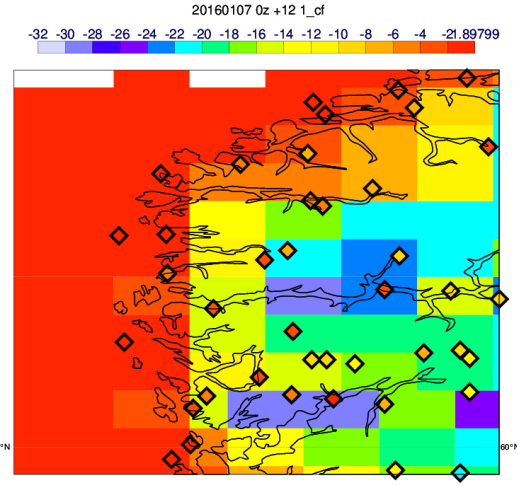
- The radiative heating/cooling at the surface is improved by introducing approximate updates on the full resolution grid at every timestep. This leads to a reduction in 2-metre temperature errors, particularly near coastlines.

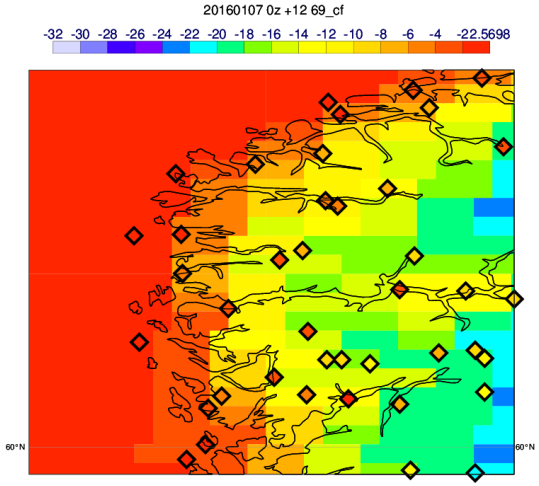
- Additionally there are changes to the triggering of deep convection, non-orographic wave drag and improvements to the linear physics in the data assimilation (for gravity wave drag, vertical diffusion and the surface exchange).

O-suite

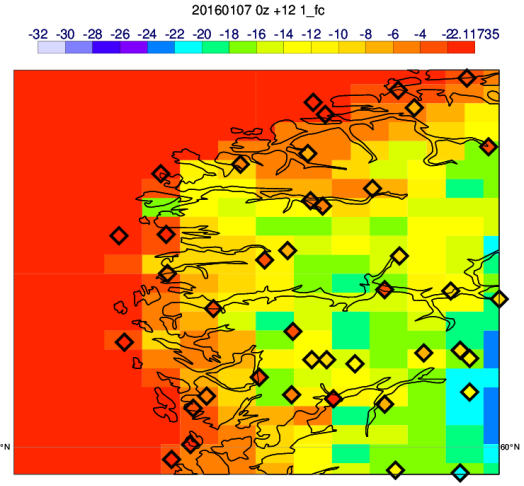
E-suite

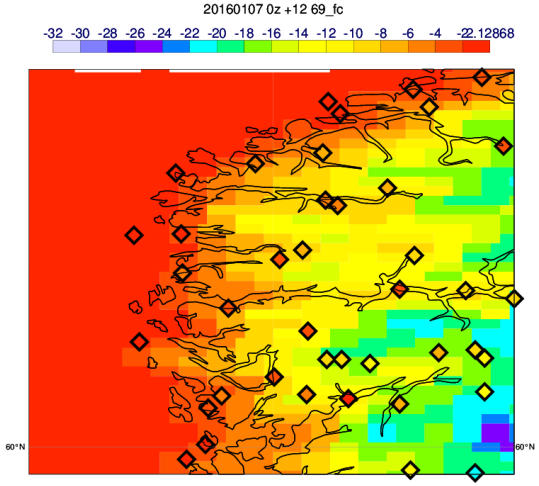
ENS control forecast





HRES

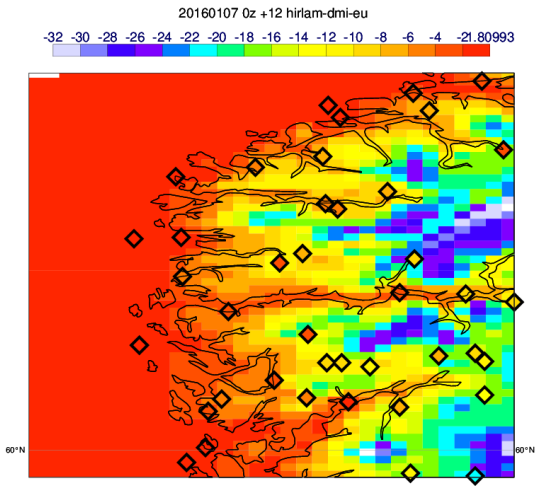




2-metre temperature western Norway
12-hour forecast from 7 January 00UTC

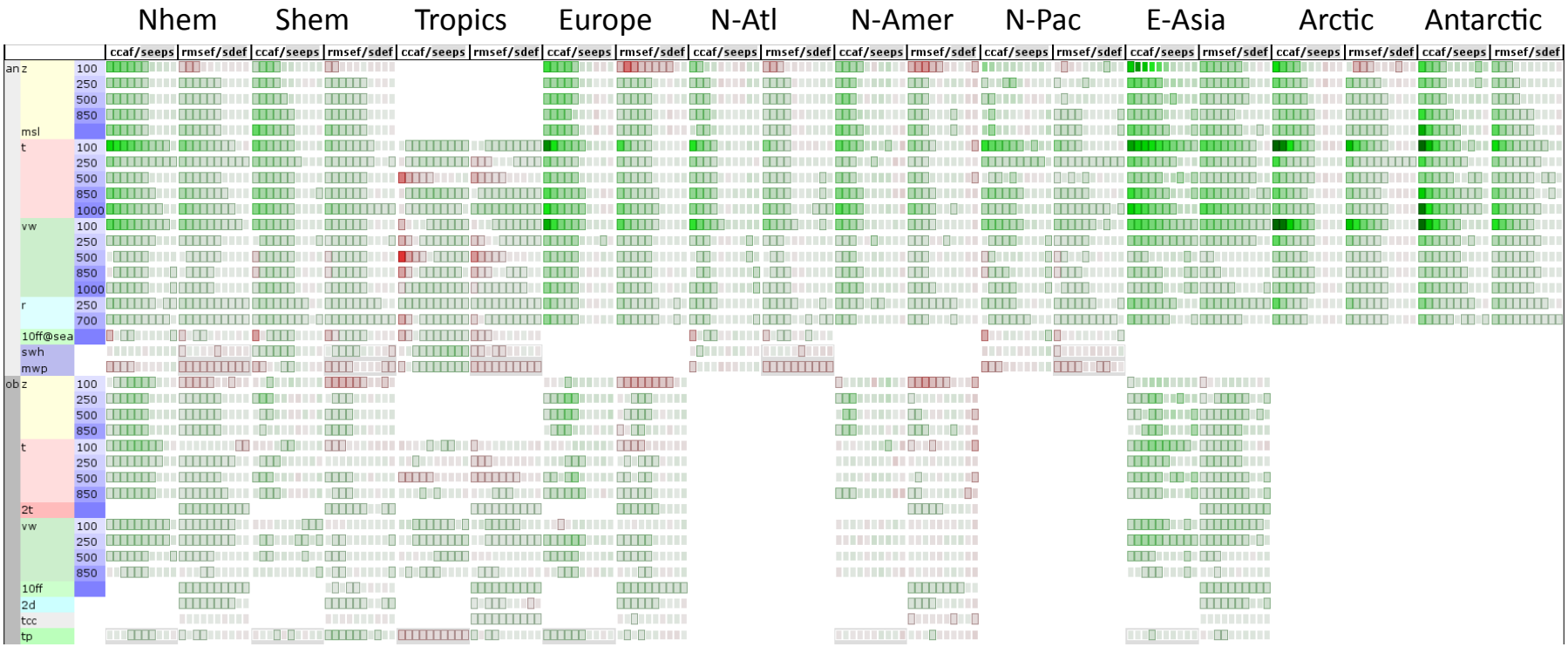
Synop observations in symbols

DMI contribution to TIGGE-LAM



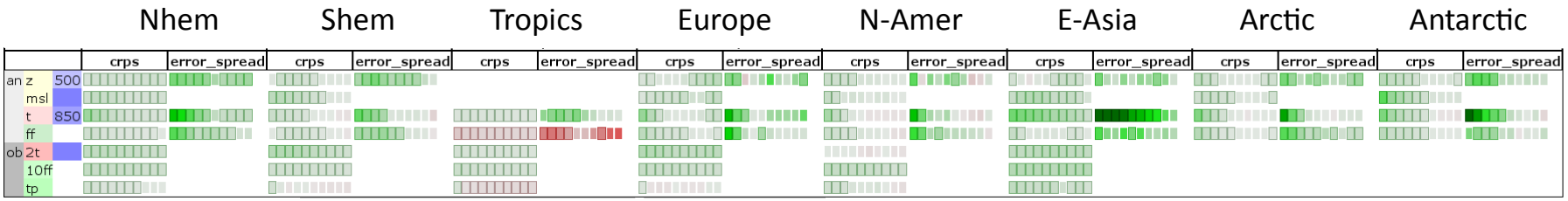
Cycle 41r2 – HRES scorecard

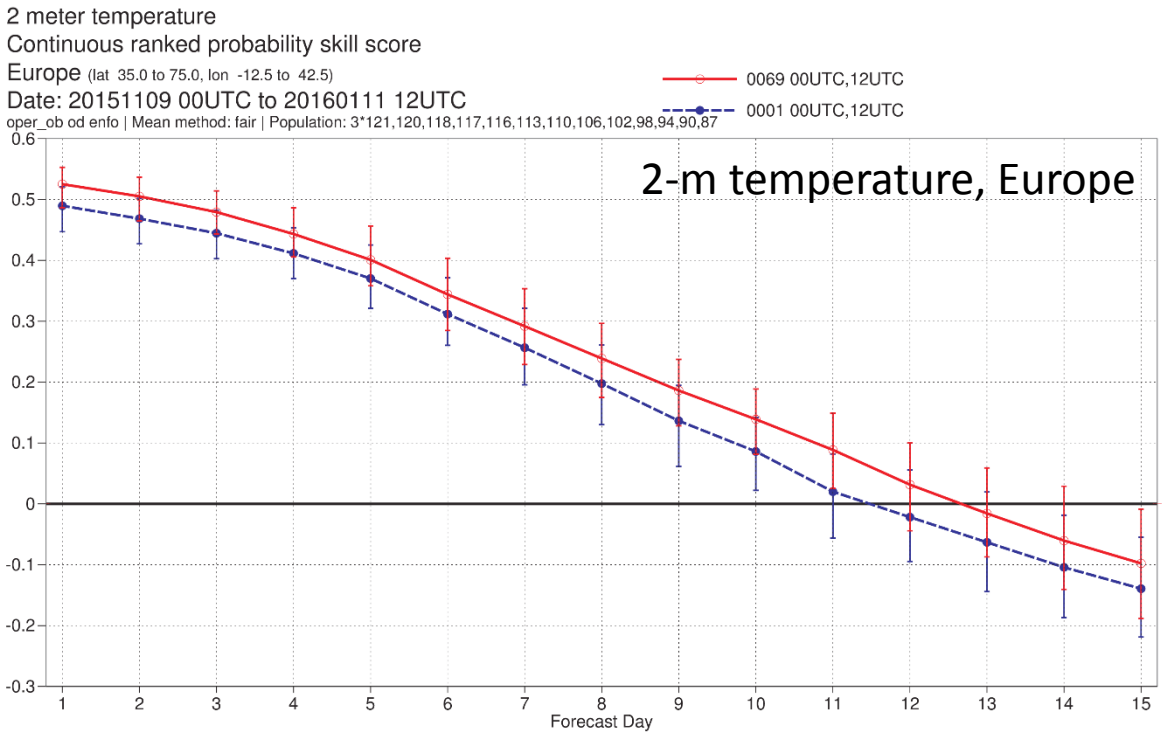
Evaluation period: 2015-08-09 to 2016-01-19 (164 days)



Cycle 41r2 – ENS scorecard

Evaluation period: 2015-11-09 to 2016-01-18 (71 days)





Summary

- Resolution upgrade will be a major achievement, providing forecasts at higher resolution (9 km) than any other global NWP centre

- Made possible through coordinated efforts in numerics, physics, data assimilation, HPC, evaluation, diagnostics, software development and scalability efficiency gains

- Significant progress in terms of forecast skill: upper-air, surface and TC-position performance improved