Novel Seasonal Latitude-Belt Simulation from 60 N to 60 S with 3 km Resolution

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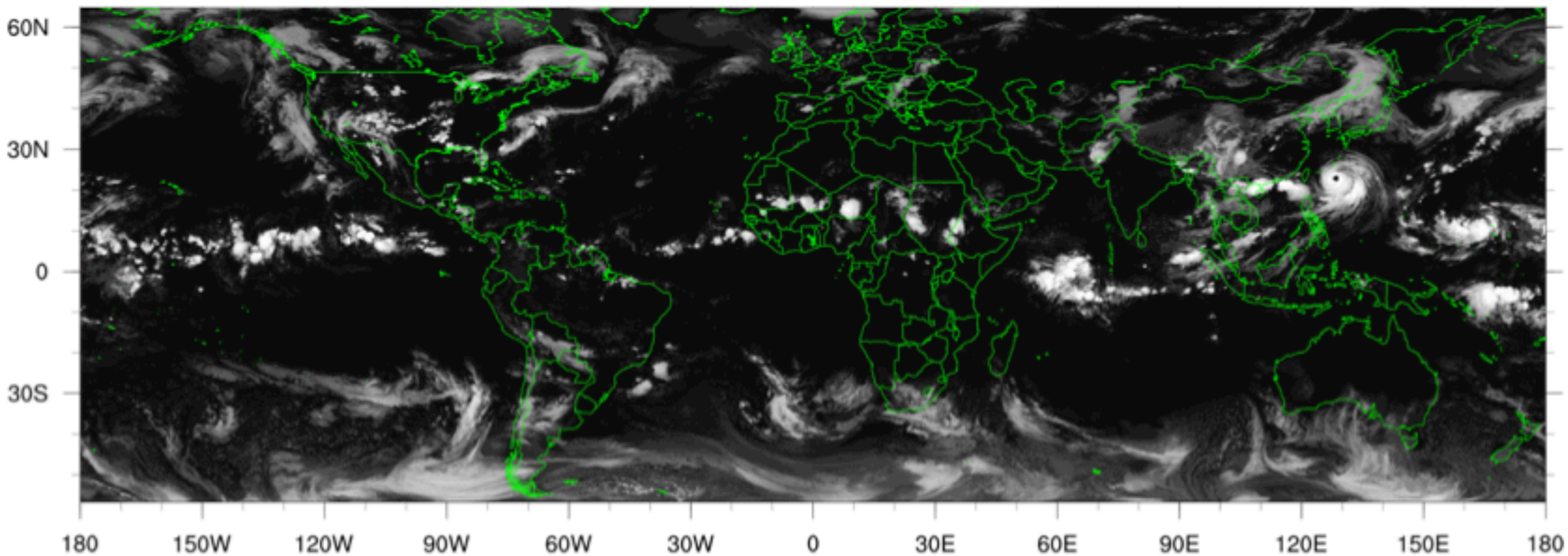
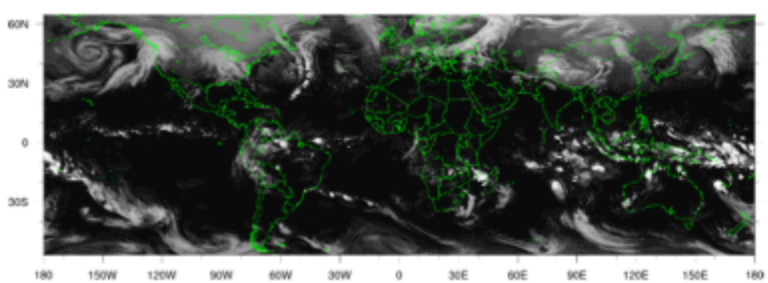
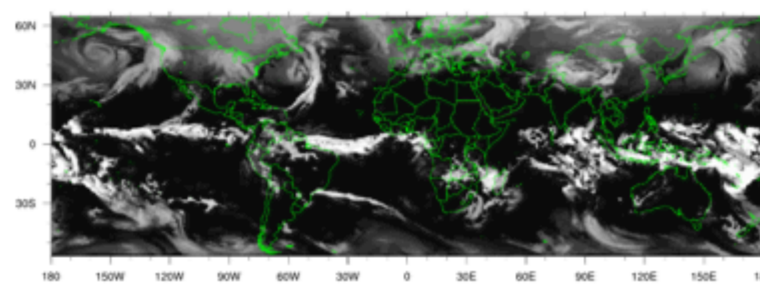


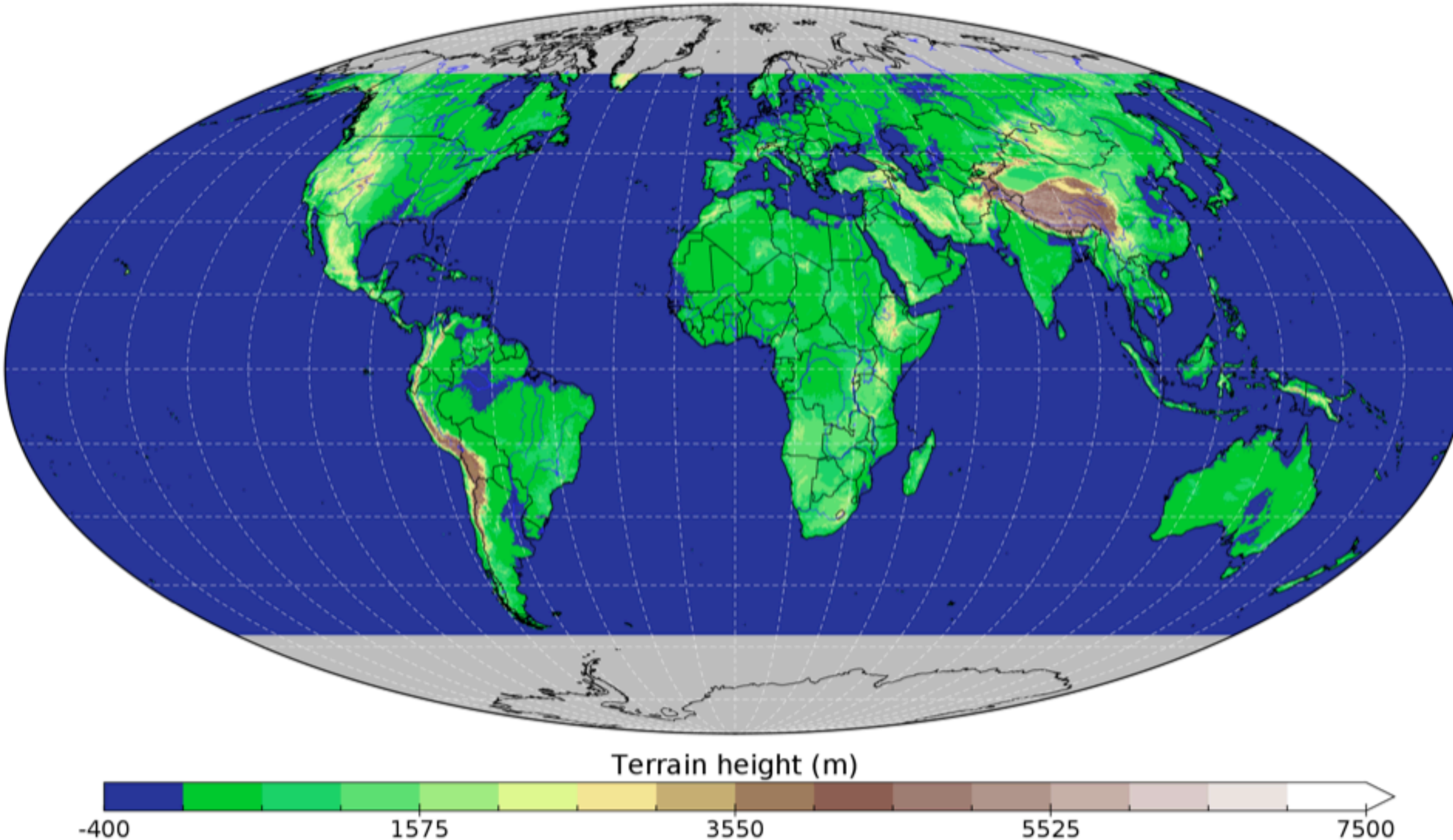
Motivation

- Recent results demonstrate the importance of seasonal forecasting for food security and disaster management (Tucker et al, 2018, Clim. Services).
- Latitude-belt simulations are not affected by meridional boundary conditions (Schwitalla et al, 2017, GMD).
- For optimizing the simulation of land-atmosphere (L-A) feedback, a sophisticated land surface model (LSM) like NOAH-MP is required.
- Convection and temperature extremes are better represented on the convection permitting scale (Warrach-Sagi et al, 2013, J. Clim).
- The current generation of HPC system enables large scale, high-resolution simulations for a duration of several months.





Model configuration



Technical aspects

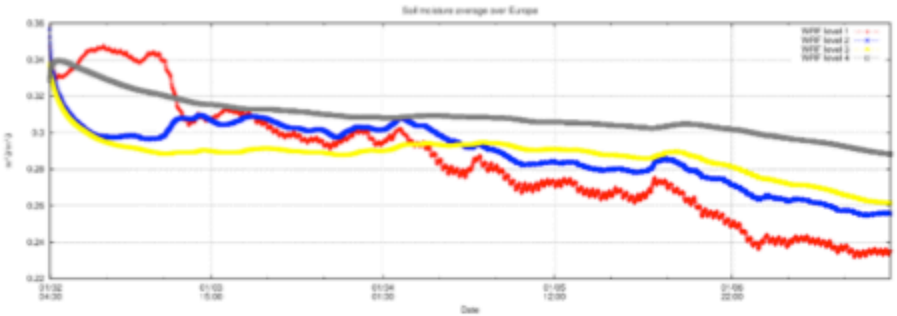
- 4096 nodes of Cray XC40@HLRS (98304 cores in total)
- 6 hourly output for data on pressure levels
- 30 min output for most interesting surface fields
- Daily restart files with 1150 Gbytes file size
- Time spend on I/O is about 1.5 days
- Move from NetCDF-CDF2 standard to CDF5 standard required (details see Schwitalla et al., 2017*)*
- In case no SST data are available during initialization and as lower boundary conditions, we implemented adjustments to prevent unrealistic open and frozen water body temperatures

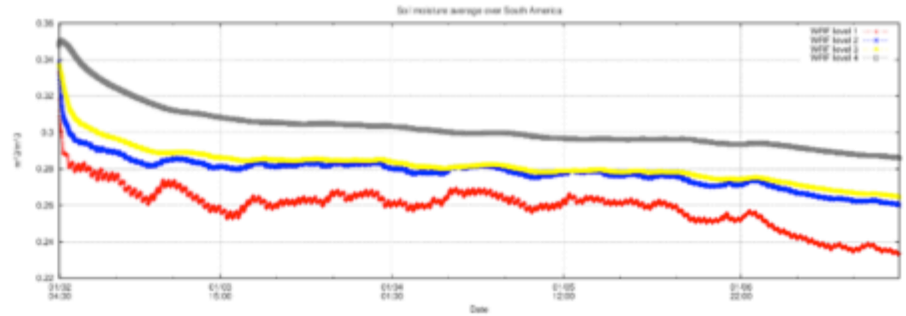
WRF scaling behavior

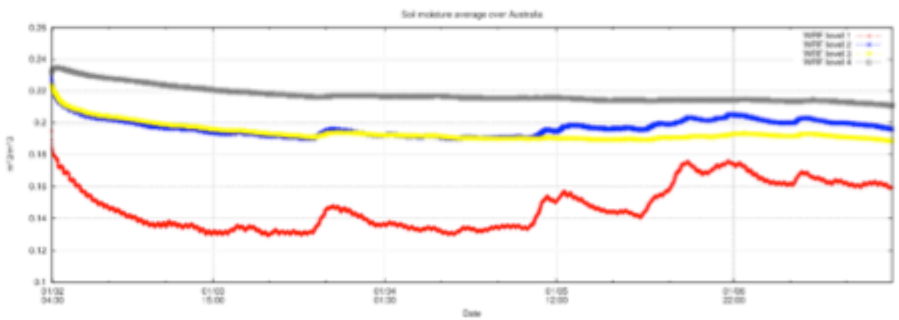
# Nodes	# Threads	# MPI tasks	Elapsed time (s)	Speedup	Theoretical speedup
4096	4	24576	0.21	11	11.1
4096	6	16384	0.22	10.5	11.1
700	6	2800	1.25	1.84	1.89
600	1	14400	1.6	1.44	1.62
380	2	4560	2.1	1.1	1.03
370	1	8888	2.3	-	-

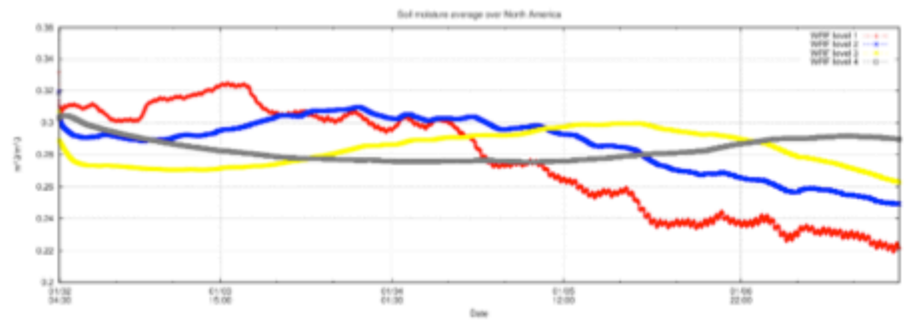
However: I/O rates drop down to a few GB/s as soon as you are using more >> 5000 MPI tasks ☹

Soil moisture spin-up



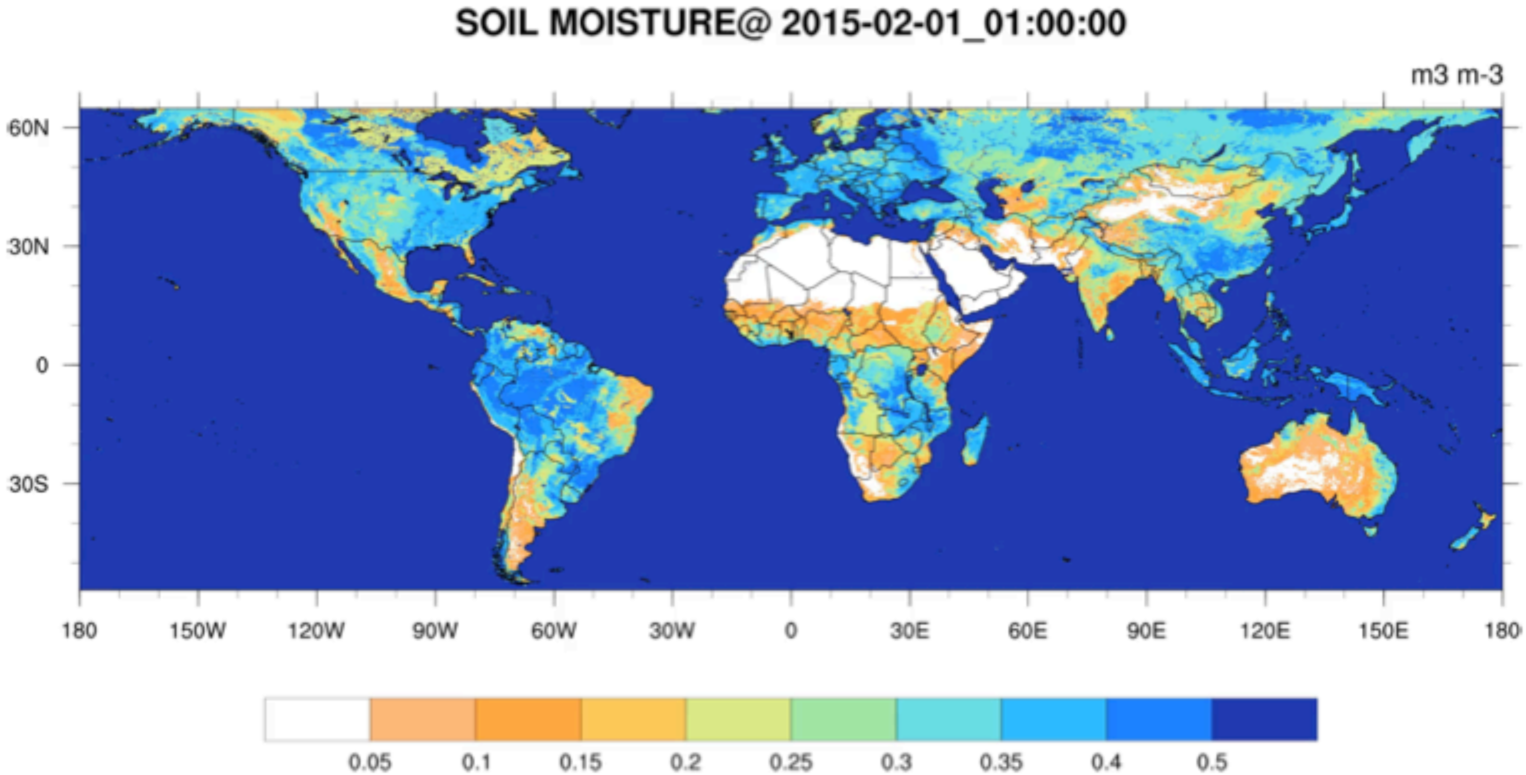




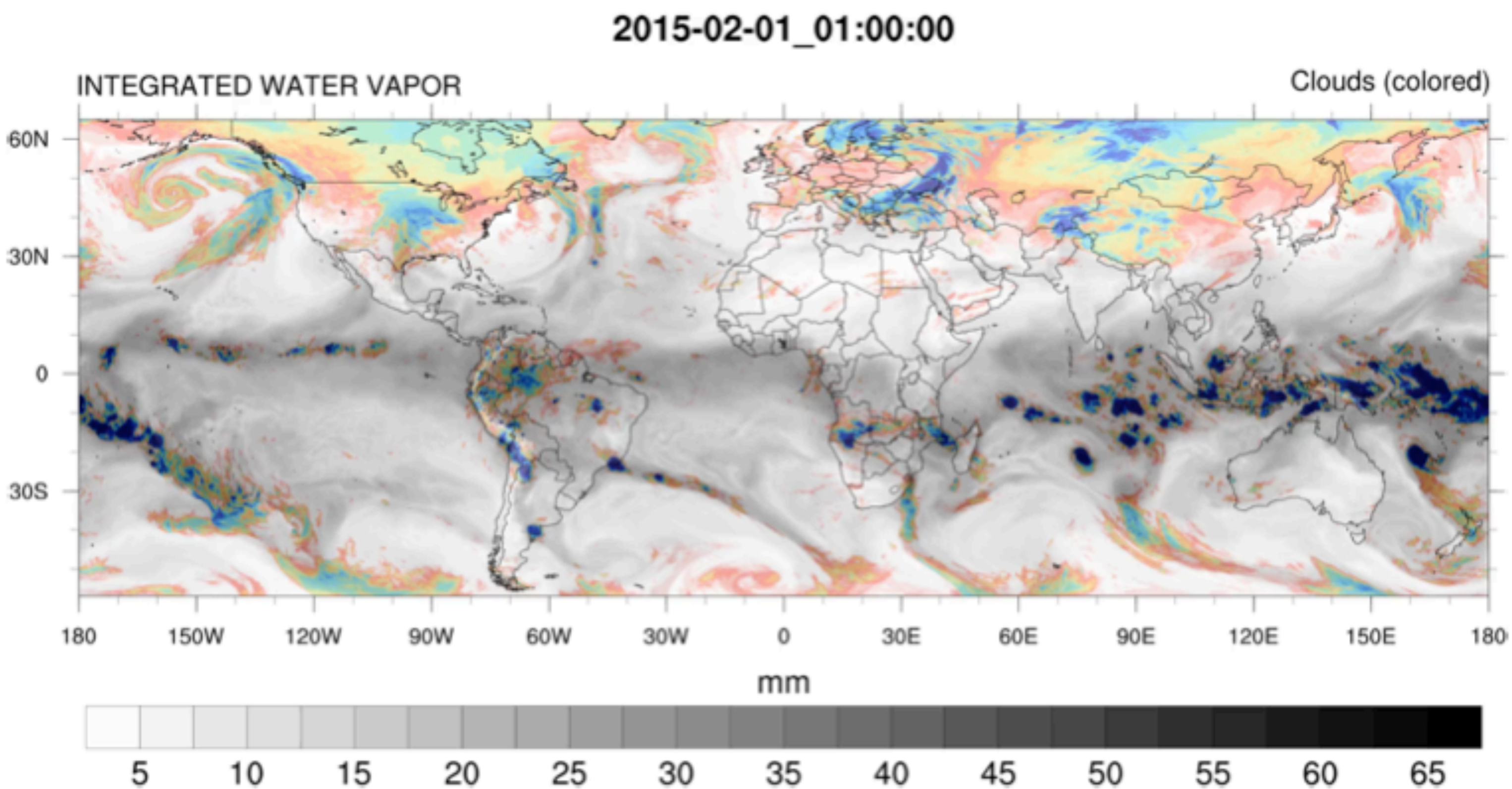


- Soil moisture spin-up ~ 4 weeks (region dependent)
- Global high-resolution observations?

Soil moisture spin-up

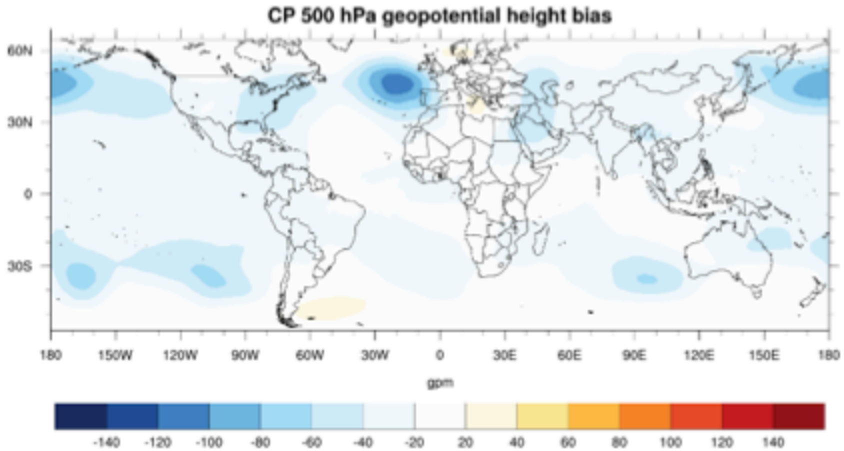


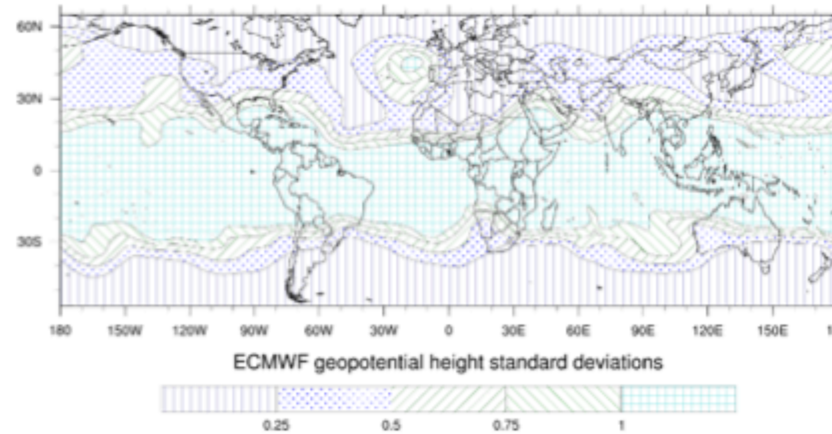
Cloud development

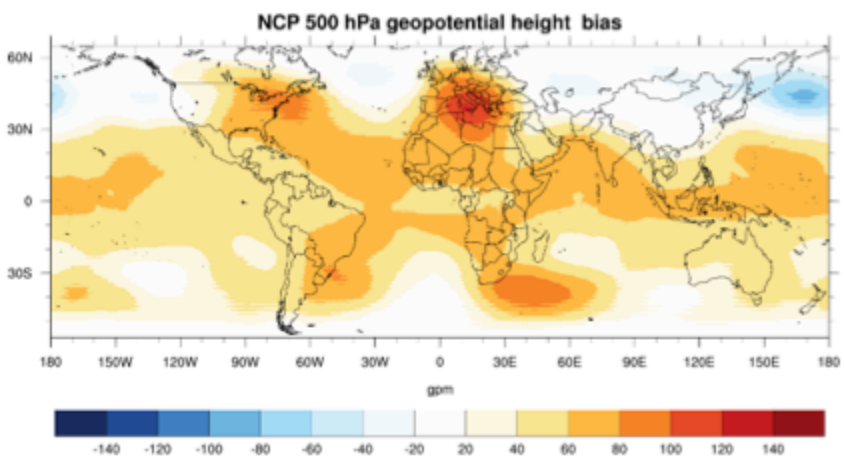


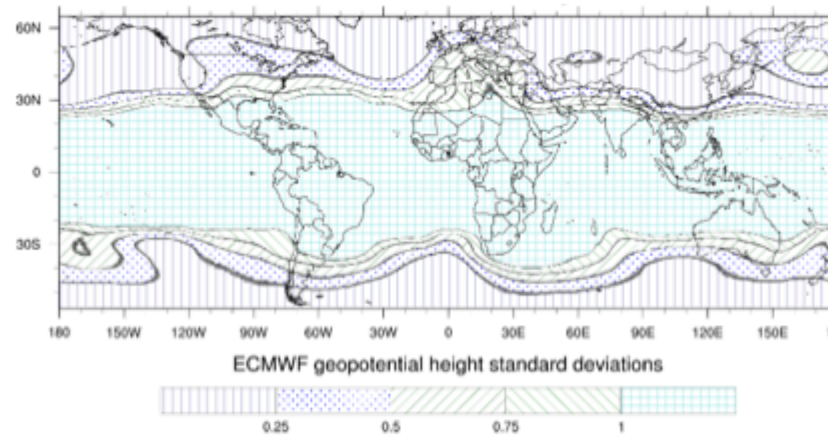
Large scale pattern

Expressed in ECMWF standard deviations



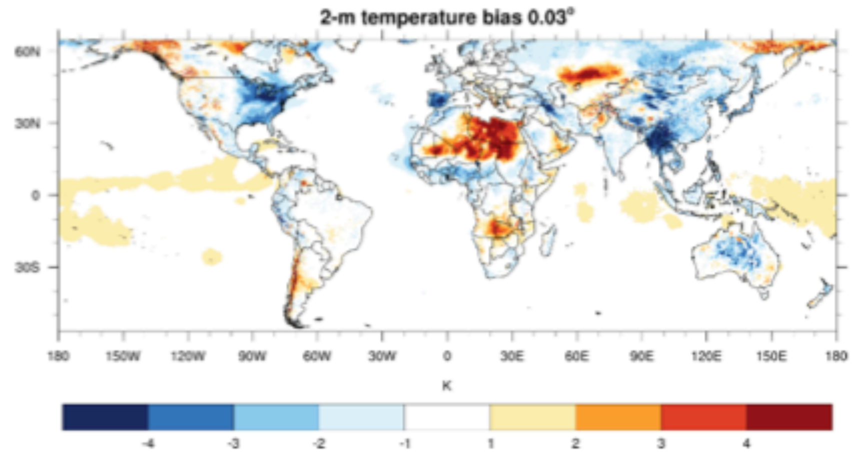




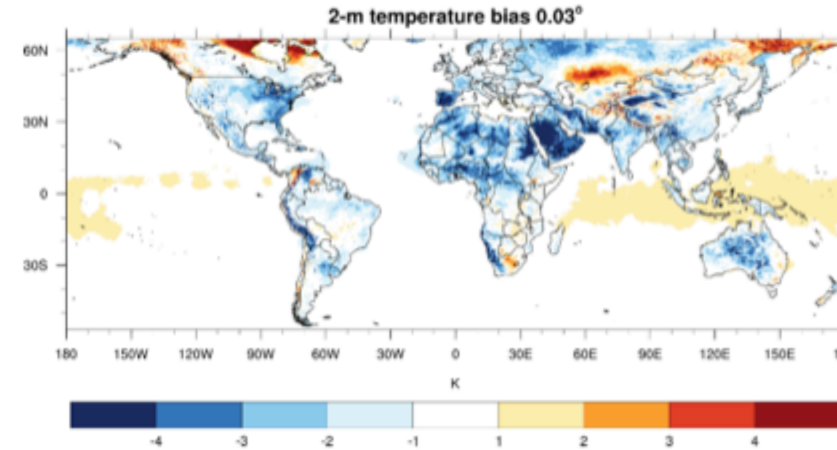


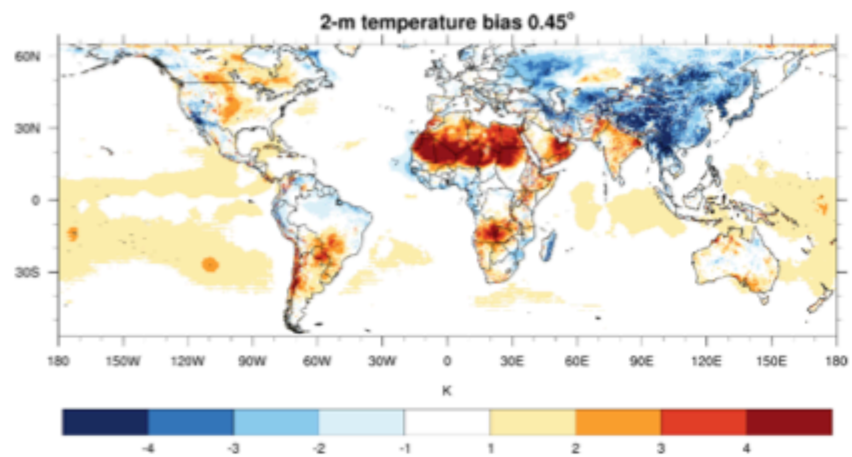
2-m temperature biases

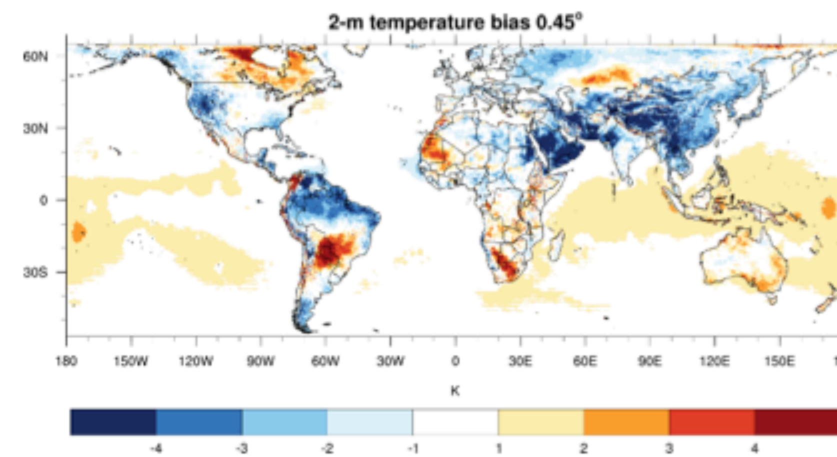
12 UTC



18 UTC

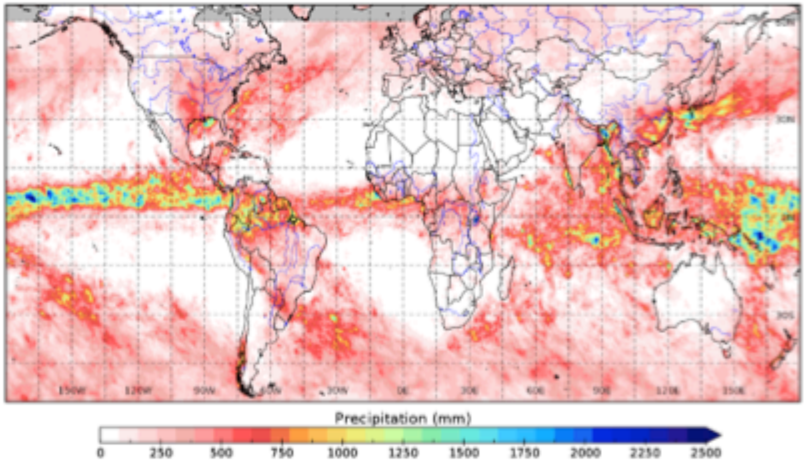




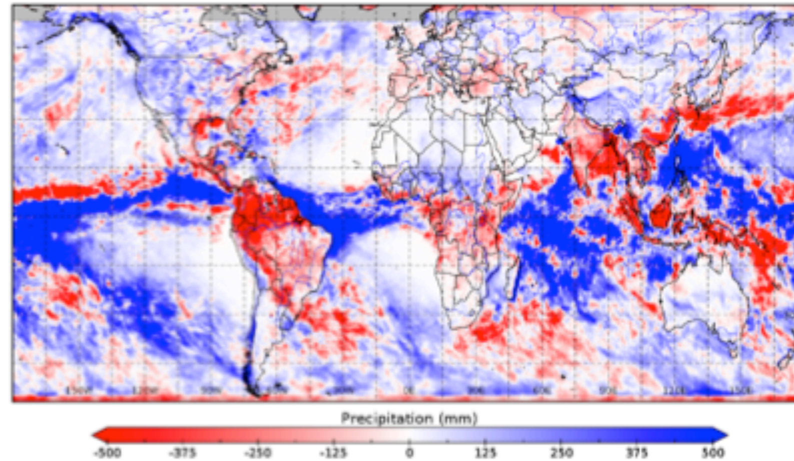


Precipitation

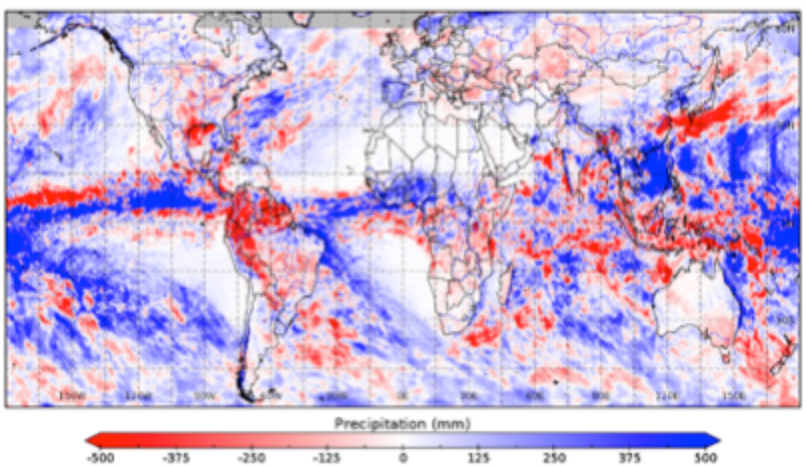
Observed precipitation April-May-June 2015



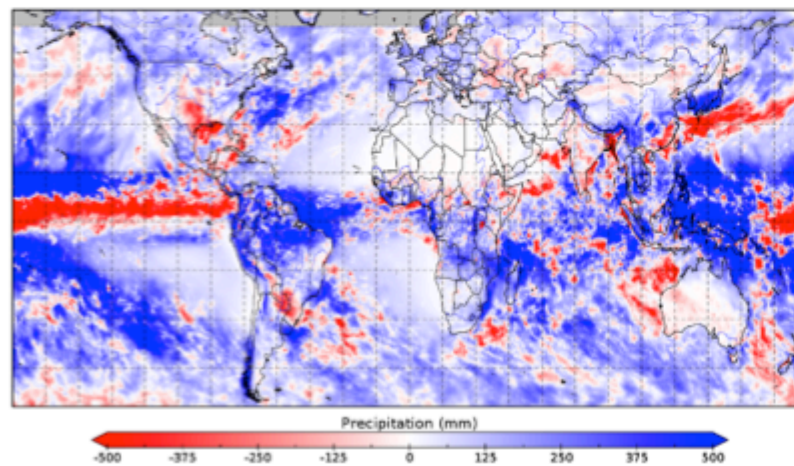
NCP-GPM precipitation



Precipitation difference GPM-CP

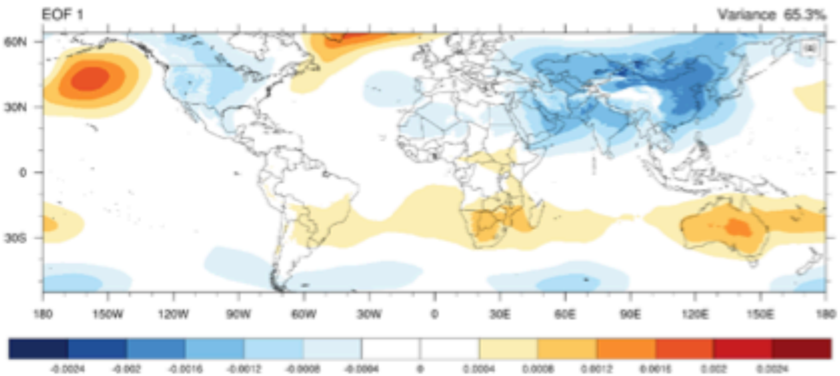


S4-GPM precipitation

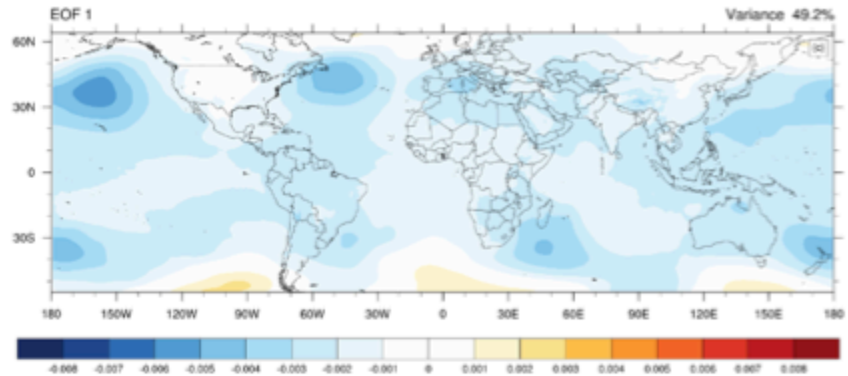


Teleconnection

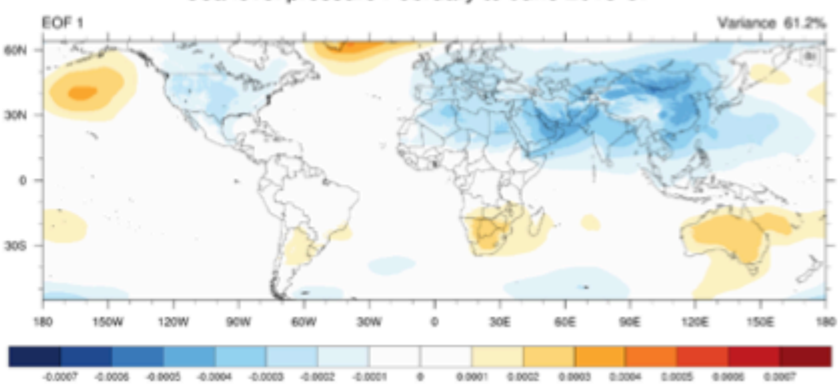
Sea level pressure February to June 2015 from ECMWF analysis



Sea level pressure February to June 2015 NCP



Sea level pressure February to June 2015 CP



- EOF analysis performed for monthly mean sea level pressure
- Similar patterns for EOF 1 in CP and ECMWF
- Underestimated variance by the NCP simulation

Summary

- First latitude-belt seasonal forecast on the CP scale with WRF
- Reasonable scaling of the WRF code up to 100000 cores
- Verification of such a high resolution is a challenging task
- More accurate representation of the large scale pattern on the CP scale
- More realistic precipitation distribution of the CP simulation
- CP resolution has the potential to improve representation of teleconnections
- Implication for next generation climate projections
- Need for ensembles
- Further optimization could reduce the necessary wall time to about 6 days for a single seasonal forecast

Thank you for your attention