On-line diagnostic tools for high resolution modelling

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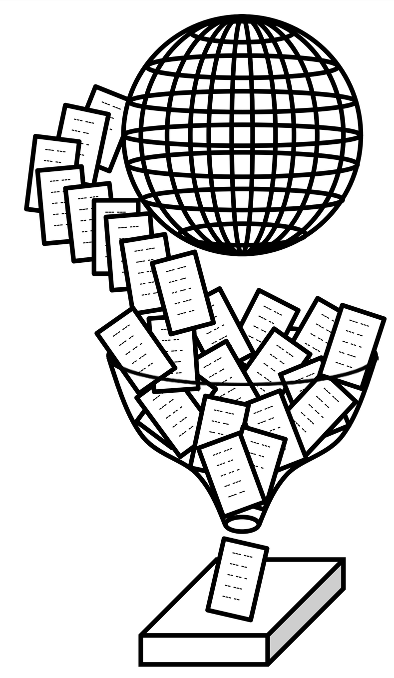
High resolution simulations on modern multi-core high performance computing (HPC) systems

Problems:
- large amount of output data
- limited I/O bandwidth of the system
- challenge to the user: how to store / handle / process / archive large datasets

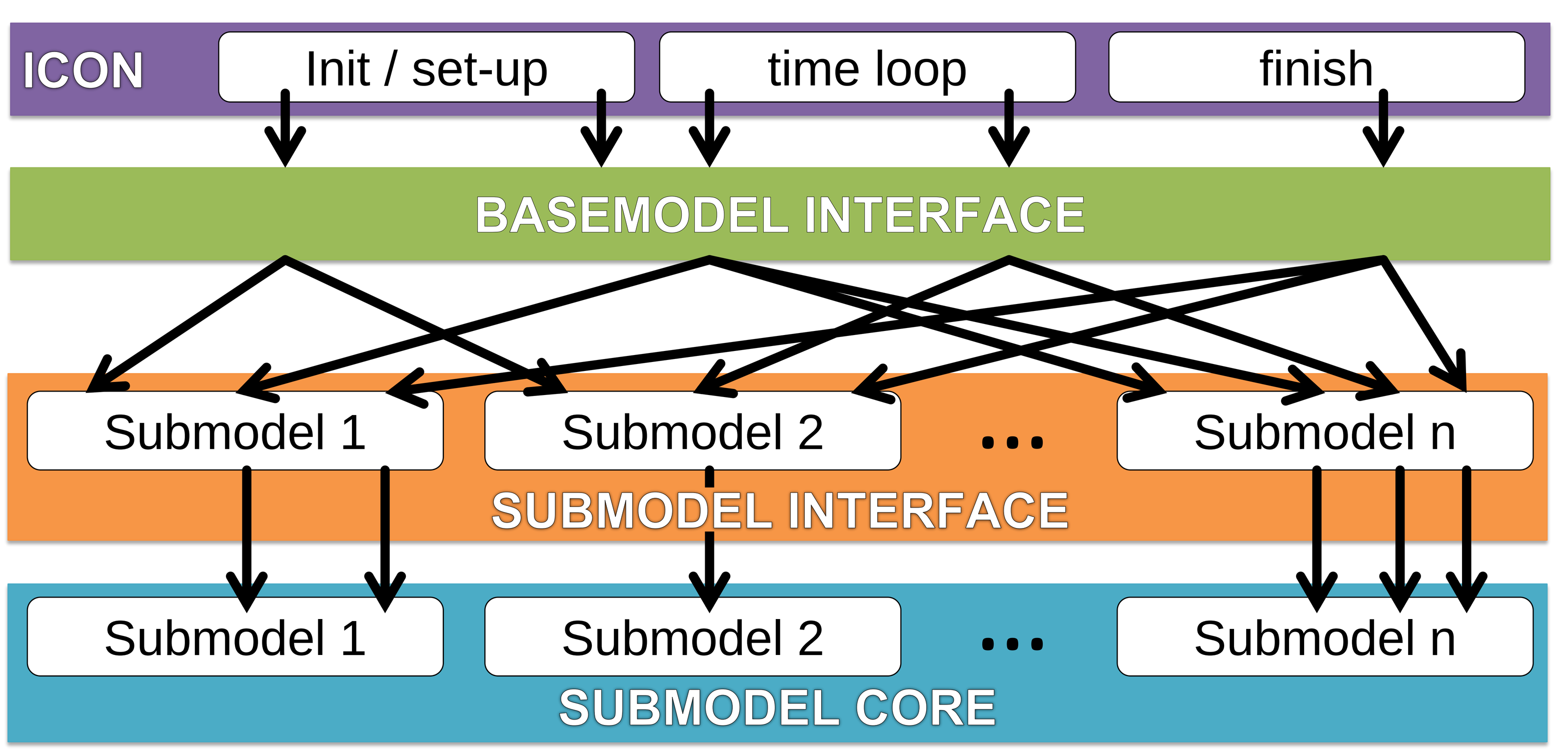
Solution:
- reducing the amount of output data
  - ➪ on-line data aggregation
  - ➪ executing "post-processing tools" on-line (during model simulation)

Tool:
- an easy-to-use, generalised, standardised interface for on-line (diagnostic) tools



The interface

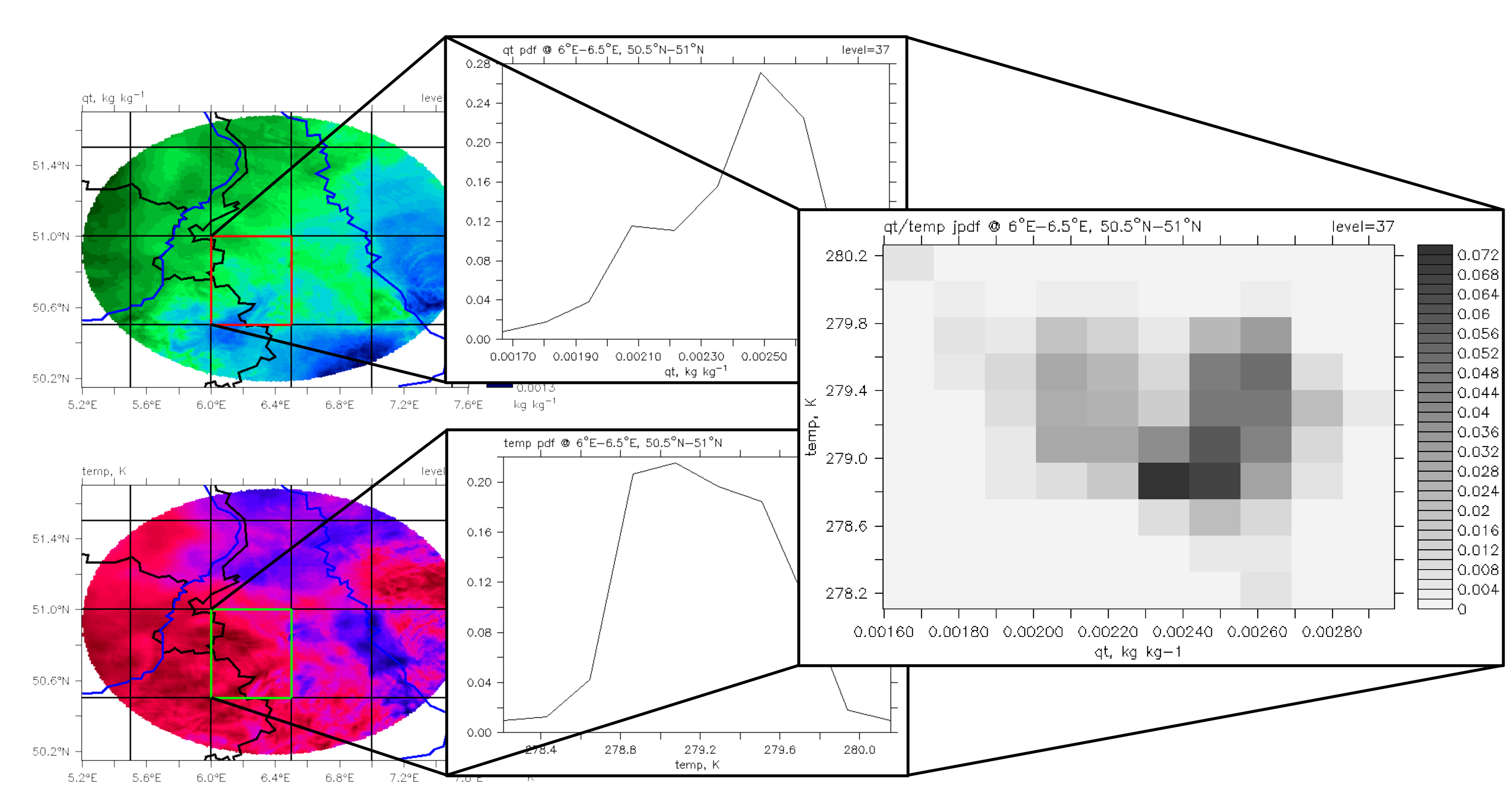
During HD(CP)², we implemented an interface for on-line diagnostic tools based on the Modular Earth Submodel System (MESSy; Jöckel et al., 2010) into the ICOsahedral Non-hydrostatic (ICON) modelling framework (Zängl et al., 2015).



- MESSy 4-layer structure
- easy-to-use, generalised, standardised
- disentangles code developments
- backward compatible
- separated (#IFDEF…)
- available in the developer SVN
- documentation to be submitted to GMD(D)

Diagnostic tool: GRid AGGregation (GRAGG)

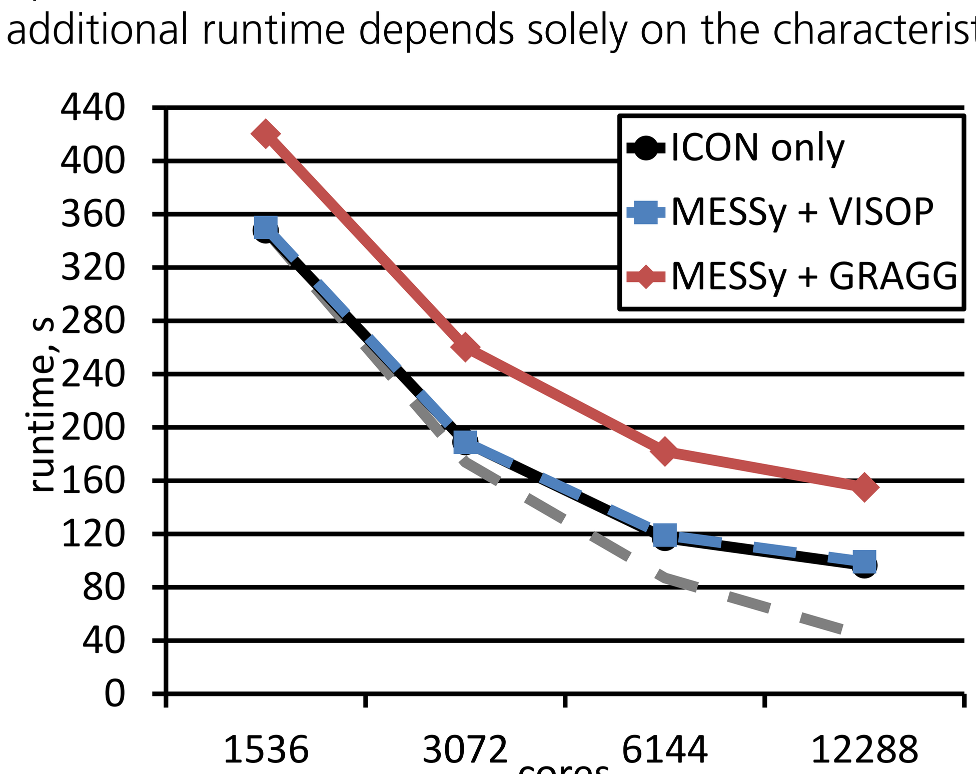
As prototype application, an advanced diagnostic tool for aggregation of high resolution data on a user defined regular coarse grid was implemented. It can be used for the calculation of joint-PDFs. Because of the distributed nature of the data in the model system, the tool requires additional MPI communication.



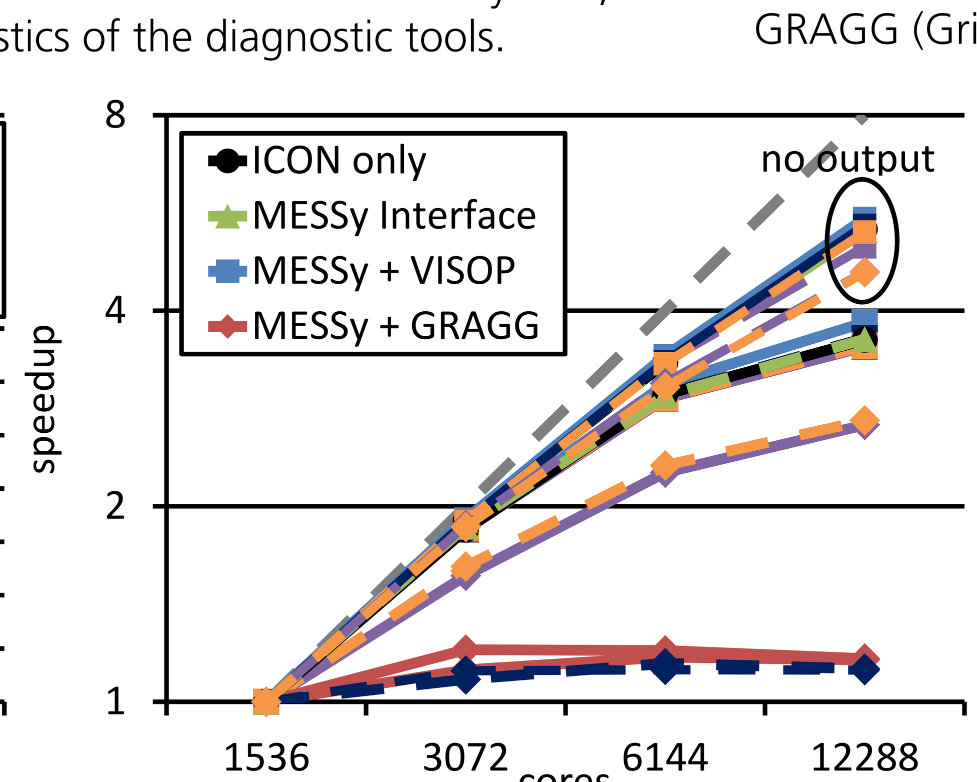
Performance

We conducted several performance tests of the model system on HLRE3 (Mistral, DKRZ) with and without the interface, different diagnostic tools and several optimisations. The interface itself introduces no overhead to the model system, additional runtime depends solely on the characteristics of the diagnostic tools.

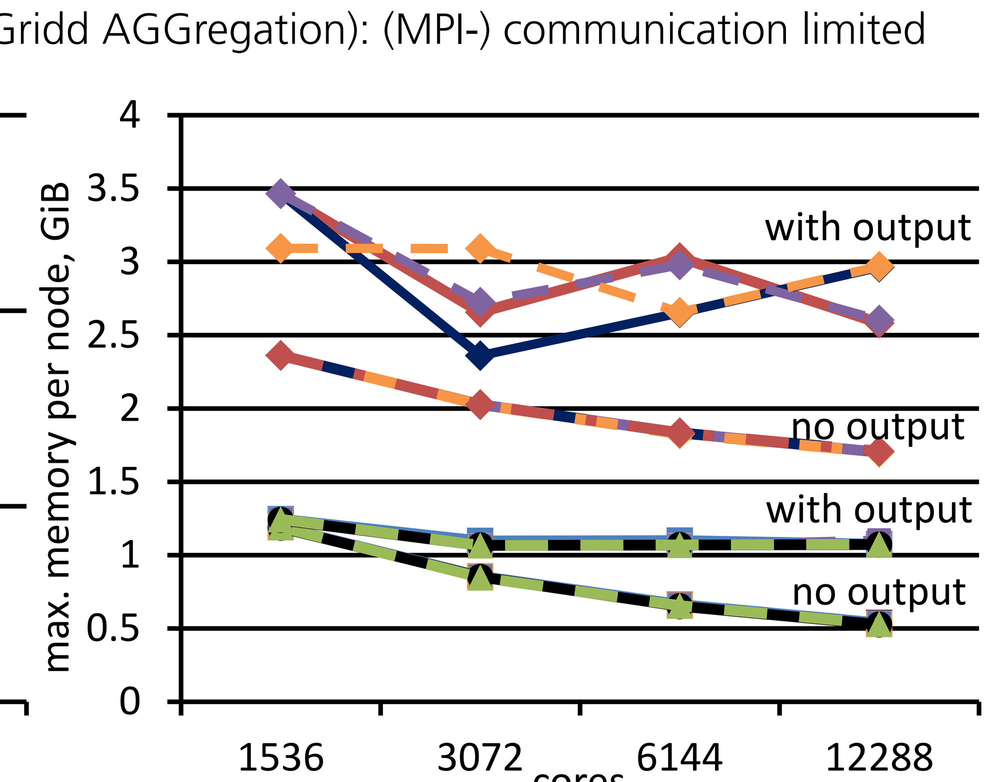
VISOP (Visual Satellite Operator; Scheck et al., subm.): computation limited
GRAGG (Gridd AGGregation): (MPI-) communication limited



Runtime for ICON and the testcases with VISOP and GRAGG. Calls to the diagnostic tools were reduced to the output time-step, calculation loops were parallelised with OpenMP, serial NetCDF output was activated.



Speedup for all testcases. Bad scaling is achieved for GRAGG, without reduced calling frequency (red, dark-blue) because of the large contribution to MPI communictation.



Maximum memory consumption per node for all testcases. The memory consumption is higher for the testcases with output. Simulations with GRAGG have higher memory demands compared to the other simulations.

Test simulation
3 nested grids
1 420 592 hor. grid cells
50 levels
10 s time-step
1h simulation
15 min. output

Jöckel, P., Kerkweg, A., Pozzer, A., Sander, R., Tost, H., Riede, H., Baumgaertner, A. J. G., Gromov, S., and Kern, B.: Development cycle 2 of the Modular Earth Submodel System (MESSy2), Geosci. Model Dev., 3, 717–752, doi:10.5194/gmd-3-717-2010, 2010.

Scheck, L., Frerebeau, P., Buras, R., and Mayer, B.: A fast radiative transfer method for the simulation of visible satellite imagery, J. Quant. Spectrosc. Ra., submitted.

Zängl, G., Reinert, D., Rípodas, P., and Baldauf, M.: The ICON (ICOsahedral Non-hydrostatic) modelling framework of DWD and MPI-M: Description of the non-hydrostatic dynamical core, Q. J. Roy. Meteor. Soc., 141, 563–579, doi:10.1002/qj.2378, 2015.

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Applications and Outlook

Implemented: VISOP (Scheck et al., subm.), GRAGG

In development: LAMETTA (on-line trajectory tool, see N. Goersch's poster), COSP (J. Quaas)

Outlook: Improvements of interface's I/O, diagnostic's memory footprint, combination of feature identification and trajectories (with A. Kuhn, for HD(CP)² Phase II)

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