Report on Project: **1040**

Project title: **ESiWACE: Scalability of Earth System Models**

Principal investigator: **Joachim Biercamp**

Report period: **2021-11-01 to 2022-10-31**

ICON Simulations

In 2022, we performed two 30-years coupled ICON simulations with a global spatial resolution of 10km (R2B08) and a high temporal resolution output. Due to its high resolution, the simulation is eddy-rich and permits deep convection. These simulations are in the today's forefront of science due to its long simulated time at such a high global resolution. For ICON, one of ESiWACE flag-ship codes, they only became possible by the high simulation throughput of 1 SYPD. The output serves many scientists, e.g. within the nextGEMS project, as it is unique with its comparatively long duration at the high resolution. This output also serves as an input base for developing a high-resolution ML-based climate emulator by NVIDIA.

Additionally, together with nextGEMS we worked on pushing the resolution in the coupled model, leading up to nextGEMS performing the first days of coupled 1.25 km resolution simulations.

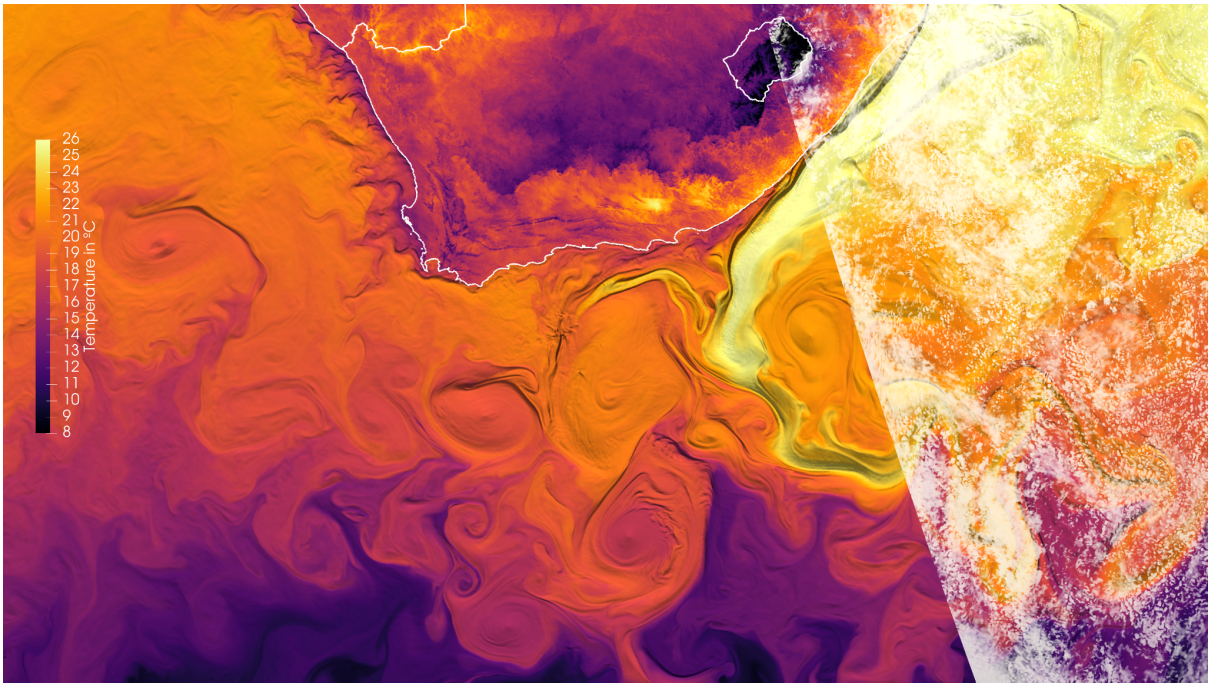

Figure 1: A first glimpse of the 1.25 km coupled ICON-ESM simulation of nextGEMS. Focus is the Agulhas stream forming rings when passing the coast of the southern tip of Africa. Over land, the near surface temperature is shown, over the ocean the sea-surface temperature and as structure the flow speed of the surface waters is overlaid. On the right side of the figure, the simulated cloud field is shown in white shading.

Data provision for DYAMOND

The initiative *DYAMOND* (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains) sets up a framework for the intercomparison of global storm-resolving models, i.e. an emerging class of atmospheric circulation models. Through their explicit resolution of the major modes of atmospheric heat transport, they endeavour to represent the most important scales of the full three-dimensional fluid dynamics of the atmospheric circulation. DYAMOND is coordinated by the Max Planck Institute for Meteorology (MPI-M) and the German Climate Computing Center (DKRZ) and supported by the Centre of Excellence in Simulation of Weather and Climate in Europe (*ESiWACE*[1]). It consists of two experiment phases: *DYAMOND Summer*, closed in 2018 and *DYAMOND Winter*, starting in 2019.

During the last reporting period we archived all the so far contributed DYAMOND Winter datasets to DKRZs tape archive. The change of the archive system substantially slowed down that process as we had to change from our previous archival tool *packems*[2] to the StrongLink command line interface *slk*, which had its problems in its first months. Also our developed processes[3] searching and retrieving archived data files have been slowed down or even disabled by this system change by at least 6 months.

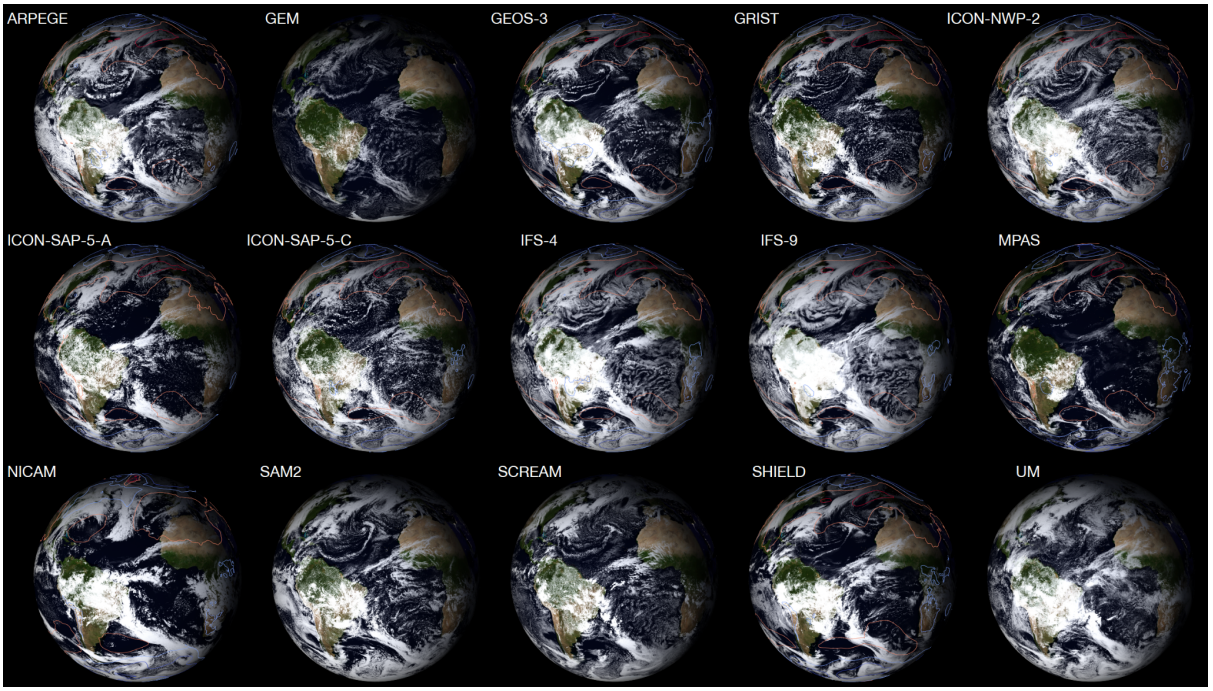

Figure 2: An overview of DYAMOND Winter models and their modelled cloud fields. Where available, sea level pressure is overlaid. Not all models were already available at the time of making this figure.

With archiving the 900 TB of contributed DYAMOND Winter data we were able to reduce our disk space consumption at Levante and made disk storage available for new incoming data sets. These were the runs

[1] https://www.esiwace.eu/
[2] https://code.mpimet.mpg.de/projects/esmenv/wiki/Packems
[3] To reduce the Levante disk space, unused data files are deleted on a regular basis. To access data files which are not on Levante disk storage but in the archive, users need to make a request so that the ESiWACE team retrieves the data, thereby making it accessible to all DYAMOND users.

- 5km GRIST simulation provided by the Chinese Academy of Meteorological Sciences (CAMS), China[4]
- 3.5 NICAM simulation provided by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan[5]
- 3km SCREAM simulation provided by the Lawrence Livermore National Laboratory (LLNL), USA[6].

To ease multi-model comparisons, we are standardising all contributed DYAMOND Winter simulation data sets. In this process, we assign common variable names based on the CMIP6-standard and rearrange the data into files with one file per variable and day. We see this granularity as the ideal for providing data on user-request, and allowing for efficient analysis. For a simplified multi-model comparisons with semantic data access we provide an intake-esm catalogue.
In 2022 we could standardise 8 additional data sets. A list of all variable names and standardised data sets available can be found in our overview of the processed variables[7].

Together with the *nextGEMS*[8] project we essentially improved documentation of all DYAMOND simulation data sets, processing tutorials and analysing hints at https://easy.gems.dkrz.de.
In the context of the H2020 projects ESiWACE and nextGEMS, easy.gems has been set-up as a user-driven site for documenting high-resolution climate simulation output and its increasingly challenging analysis. While the original use case was the Winter phase of DYAMOND, it is aimed at going beyond individual projects and at documenting all simulation gems hosted at DKRZ. It provides descriptive text explaining the models and model output, tutorials in form of basic scripts or code snippets with explanations to teach newcomers to work efficiently with the model output, and sample scripts showing more sophisticated analyses highlighting interesting things that can be done or looked at with Storm-Resolving Earth System Model simulations. To make easy.gems accessible to the ESM community and to best exploit newly developed workflow patterns, this page is set up as a public website.

The scientific value of DYAMOND can be seen by its publication list[9], including a special edition (2019-2021) in the Journal of the Meteorological Society of Japan (JMSJ). For DYAMOND Winter simulations, a call for papers for a second special edition by JMSJ has been published in August 2022[10]. Also the size of data accessed during the last 3 months (June-August 2022): 155 TB DYAMOND Summer data and 600 TB of standardised DYAMOND Winter data, shows a well used data collection.

[4] https://easy.gems.dkrz.de/DYAMOND/Winter/Models/description/grist.html
[5] https://easy.gems.dkrz.de/DYAMOND/Winter/Models/description/nicam.html
[6] https://easy.gems.dkrz.de/DYAMOND/Winter/Models/description/scream.html
[7] https://easy.gems.dkrz.de/_static/DYAMOND/WINTER/variable_table.html
[8] https://nextgems-h2020.eu/
[9] https://www.esiwace.eu/services/dyamond-initiative/dyamond-related-publications
[10] http://jmsj.metsoc.jp/special_issues_editions/JMSJ2022-23_HPC.html