Project 1460

WHIRLS - The impacts of ocean fine-scale whirls on climate and ecosystems

Arne Biastoch, René Schubert, Franziska U. Schwarzkopf, Sebastian Wahl, and Markus M. Scheinert

Principal Investigator: Prof Dr. Arne Biastoch

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In the DKRZ project WHIRLS, we are developing a series of global high-resolution coupled ocean-atmosphere models that are part of the model development within the ERC-Synergy grant project WHIRLS. We developed a new configuration using the ocean model NEMO version 5.0 which is coupled by the coupler OASIS3-MCT5 to the atmospheric model OpenIFS version 48r1.1 in close collaboration with the international experts Dr. Joakim Kjellsson from SMHI, Norkoeping, Sweden, and the Prof. Wonsun Park at IBS, Busan, South Korea.

In the report period, we could set-up the planned configuration. In autumn 2025, we made progress by identifying that parts of the previous problems were related to the use of XIOS3. Switching back to XIOS2 enabled us to continue with the model development. In late 2025, as part of the collaboration with Dr. Joakim Kjellson in the framework of the successful ESiWACE3 project (esiwace.eu), we could identify the main bug in the atmospheric model code that had further hindered the development in the last year. In spring and summer 2026, we synchronized the configuration development with the ocean-only configurations that are developed in WHIRLS. This is a very important step, as our scientific focus lies on the impact of air-sea interactions on the ocean. A clean comparison of ocean-only and parallel coupled simulations require a similar ocean model component in both configurations. We use eORCA025.Z120 for the ocean grid, which is a version of the widely used quarter degree global ocean grid that has been extended to the Antarctic continent. In the vertical, the grid is associated with 120 vertical z-star levels with increasing vertical extents of 1 m at the surface to 100 m at depth. eORCA025.Z120 is used now in both our ocean-only and coupled configurations. Additionally, after extensive code work, we could set-up a parallel coupled configuration with a 1/20 degree grid-refinement for the South Atlantic, the Western Indian Ocean, and the adjacent Southern Ocean. The respective ocean grid is called eINALT20.Z120 and is also used in the ocean-only runs. A snapshot of simulated sea-surface temperature after a first month of the simulation highlights the resolution of fine-scale ocean features in the domain of the high-resolution grid (Figure 1).

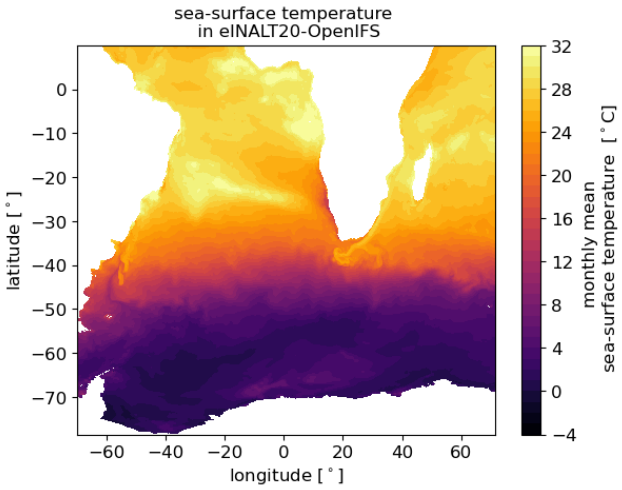


Figure 1: ***A snapshot of sea-surface temperature in eINALT20-OpenIFS*** *The sea-surface temperature after the first month run with eINALT20-OpenIFS in the 1/20 degree domain. It highights the resolution of fine-scale ocean features.*

We performed a few decadal test runs with the eORCA025.Z120 configuration that showed reasonable first results in terms of the oceanic large-scale circulation and mesoscale variability, but also the top of the atmosphere radiation balance. We showed that using 137 instead of 91 levels in the atmosphere improved the top of the atmosphere radiation balance and the global mean two meter temperature (Fig. 2). The synchronization with the ocean-only model required several additional steps that lead to unexpected delays in the configuration development. Among others, the inverse barometer effect needed to be implemented into the coupled configuration, as well as the mass-weighted depth distribution of the run-off. In the ocean-only case, the amount of the prescribed runoff is known before the simulations and respective mass-weighted depth distribution masks can be computed before. In the coupled case, the run-off is computed internally and thus is not known before the simulation. Here, we will use the run-off of a 10 year test experiment to compute the mass-weighted depth distribution mask that we then use in the coupled simulations. A further step was the implementation of simulated tides. Finally, we modified the integration strategy to follow the HighResMIP protocol and to use CMIP7 atmospheric forcing. Respective modifications needed also time due to that respective settings were hard-coded in OpenIFS and could not simply be modified by namelist changes.

Given all the delays due to the listed issues regarding the configuration development, we unfortunately came only recently to the stage where we could finalize the configuration and start a first experiment with the target settings. We expect to perform the planned model experiments in the coming quarters. Until the end of the current year, we plan to complete the 50 year spin-up under 1950 forcing of eORCA025-OpenIFS.

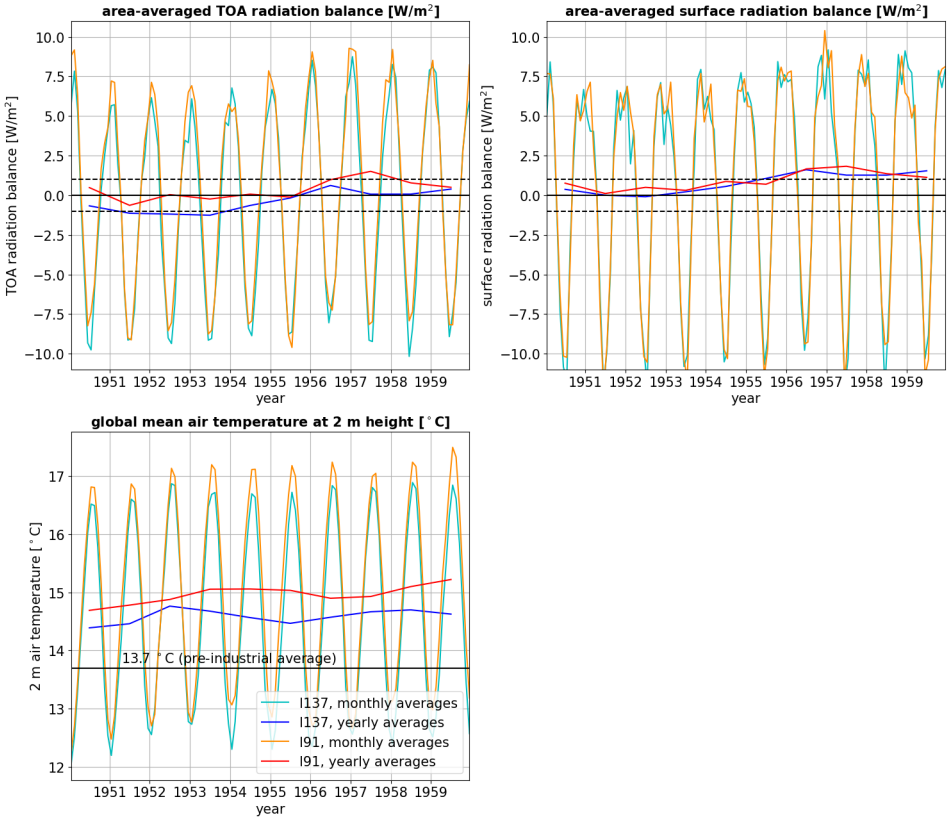


Figure 2: ***The impact of the vertical resolution in the atmosphere*** *Global mean top of the atmosphere (TOA) radiation balance (**a**), surface radiation balance (**b**), and two meter air-temperature (**c**) in two parallel test runs with eORCA025.Z120-OpenIFS319.L137 and eORCA025.Z120-OpenIFS319.L91.*