Project 1460

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

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Report period: 2024-11-01 to 2025-10-31

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 aim to couple the ocean model NEMO version 5.0 to the atmospheric model OpenIFS version 48r1 using the coupler OASIS3-MCT5 and XIOS3 for the model output management. This is a new configuration, that has not yet been run in the latest code versions. We closely collaborate with international experts in coupled simulations on the development: Dr. Joakim Kjellsson from SMHI, Norkoeping, Sweden, and the group of Prof. Wonsun Park at IBS, Busan, Southkorea.

In the report period, we unfortunately could not yet setup the planned configuration successfully. When applying for the computational resources for the DKRZ project WHIRLS for the year 2025, we expected that a predecessor of the above described setup could quickly be set up at DKRZ, as this predecessor setup consisting of NEMO4.2.2 and OpenIFS43r3 using the same coupler and XIOS2 has been run on a different high performance computing system already. Furthermore, we had experience with coupled simulations on DKRZ but with ECHAM, a different atmospheric model. After solving several initialization problems in the first months of the project, we could run the predecessor version of the coupled configuration with OpenIFS. Thereby, a horizontal resolution of 0.5 degree that covers the ORCA grid and 46 vertical levels in the ocean and a truncation number of 95 (about 100 km grid-spacing) and 91 vertical levels in the atmosphere has been used. However, the low vertical resolution and also the extend of the ORCA grid fall way behind the goals of the current project. This is why we subsequently tried to switch to an advanced set up that is (as ocean-only) developed on a different HPC system (NHR). This advanced coupled setup uses for the ocean 75 vertical levels and the extended ORCA grid (eORCA), which covers the full Antarctic shelf which is important for the representation of the meridional overturning in the Southern Ocean. For unknown reasons, the advanced setup continuously crashed without meaningful error messages and could not be brought to run on DKRZ despite focused and continuous work on the set up.

In the ERC-Synergy grant project WHIRLS an extensive model development is conducted in the field of ocean-only modeling. A snapshot of the surface speed of one of the ocean-only simulations is shown in Figure 1. A clean comparison of simulations with these ocean-only models to parallel simulations with the here developed coupled models requires also the use of the same ocean model version. Apart from this systematic comparison, the use of the recent NEMO version 5.0 comes along with several advantages including a very efficient time-stepping. The switch from NEMO 4.2.2 to NEMO 5.0 was smooth and not associated with any problems on the ocean-only model side. Moreover, the switch from XIOS2 to XIOS3 was similarly smooth. Based on this experience we joined forces with our international colleagues and compiled the desired set-up from scratch including NEMO5.0, OpenIFS48r1, and XIOS3. A compiler switch from INTEL to GNU was executed as previous experience indicated a performance gain with GNU. Unfortunately, the compiled setup still stalled with cryptic error messages. However, step by step we could make progresses and could finalize the models initialization successfully. Now, the model starts to run but quickly crashes within the first time-steps in a routine of the atmospheric model. Our group is currently in contact with the support of the OpenIFS developers to find a

respective solution. The solution is however not straight-forward, as the error message is also new to the OpenIFS support. Additionally, we submitted an ESiWACE3 project (esiwace.eu) in which we aim to set-up the target configuration in a containerized form which then will hopefully run soon on DKRZ. Our group collaborates with national and international experts with huge effort to overcome the technical problems with the setup. Additionally, we are exploring fall-back alternatives including a combination of NEMO5, OpenIFS 43r3, and XIOS2.

Despite the ongoing technical problems, we used current the period to fine-tune our scientific strategy in exchange with our international colleagues and modified the proposal for computational power at DKRZ for 2026 accordingly. Given that we are able to solve the technical problems in the remaining time of this project period, we aim at a more modest and conservative requirement before then applying for the double-nested configuration in one of the upcoming project periods.

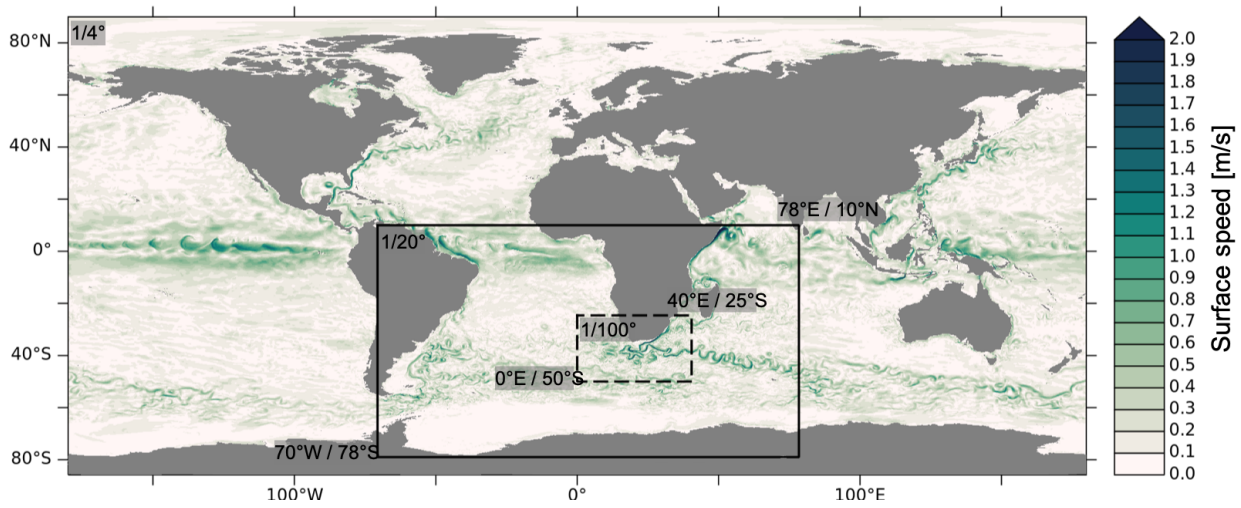

Figure 1: ***eINALT100 in ocean-only mode*** *A snapshot of the surface speed in m* s^{-1} *in our double-nested configuration eINALT100, which consists of a global 1/4° grid with a 1/20° grid-refinement in the South Atlantic, the adjacent Southern Ocean and the Western Indian Ocean in which a secondary 1/100° grid-refinement is embedded for the Agulhas region.*