Collaborative Research Centre (CRC) “TRR 181” sub-project S2: Improved Parameterizations and Numerics in Climate Models

At present, climate models feature energetic inconsistencies. This leads to biases in the models and limits their ability to predict climate-relevant processes and mechanisms which ultimately affect climate projections. To resolve these shortcomings, the modelling community urgently needs to address model inconsistencies of numerical and mathematical nature by deepening the physical understanding of energy transfers between the three main dynamical regimes in the atmosphere and the ocean, i.e. small-scale turbulence, gravity waves and geostrophically balanced motion. This CRC assembles expertise in observational and theoretical physical oceanography and meteorology, numerical modelling, and mathematics to improve climate model such as those contributing to the Coupled Model Intercomparison Project and IPCC.

The subproject S2 contributes to synthesize research work promoted in the CRC and to implement the new and consistent parameterizations and numerical algorithms into the two national climate models: ICON-a/ICON-o and OpenIFS/FESOM2. The two models developed in Germany are currently cutting-edge in model development and are based on the concept of unstructured grids.

As part of the German national climate model development strategy, it is envisioned to push the cooperative development of both models, which is strongly supported by this CRC. Together with subproject S1, where metrics for model performance and energy consistency are developed, S2 will provide an assessment of the effects of improved energetically consistent methods in applications of the coupled ocean and atmosphere models. Three main areas are the focus of S2: ocean parameterizations, atmosphere parameterizations, and numerics.

We will implement extended versions of the gravity wave effect closure IDEMIX in the ocean models FESOM and ICON-o, and we will implement a framework of energy-based parameterizations for submesoscale ocean turbulence. For the atmosphere, we will implement two similar, but complementary gravity wave parameterizations (IDEMIX-a and MS-GWaM) into ICON-a. For the numerics, we will continue the implementation of a generalized vertical coordinate framework (ALE) in FESOM and ICON-o, and continue the work on higher-order advection schemes. The implementation of the new energy-based closures in the atmosphere and ocean models represents an important step towards our goal of energetically consistent coupled climate models.

In contrast to several other subprojects in the CRC (which often work on individual processes and parameterizations and can therefore use local computing facilities) S2 will need extensive computational resources to explore and evaluate the values of improved numerics and parameterizations in the very climate models used to simulate present and future climate and on the very HPC machine these models are run for production. Given the limited amount of computational resources of the partner institutions and the added value for the community, we therefore apply for computational resource from the Community Share.