TORUS-AWI
Decadal climate predictions using the TORUS model system with regional refinement of the Arctic

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Abstract

The project, for which we apply for computer ressources at DKRZ, consists in the part of the Alfred Wegener Institue for Polar and Marine Research of the project TORUS: **TO**wards **R**egionally foc**U**sed modelling of decadal climate prediction**S**. TORUS has been funded within the BMBF Research Programme on Decadal Climate Prediction (MiKlip) and will contribute to its Module B: Processes and Modelling.

The proposed research of the modelling groups at AWI focuses on the following technical and scientific key question: *How will decadal prediction benefit from an improvement in simulating the Arctic key region with a coupled global atmosphere-ocean-sea ice system based on unstructured grids with strong regional adaptation in the ocean-sea ice subsystem?* Therefore we will implement a global setup with the finite-element ocean-sea ice model FESOM and the atmospheric model ECHAM. The use of FESOM with its unstructured grid allows a strong regional refinement of Arctic key regions. The project aims on studying the influence of an improved regional modelling of the Arctic on the simulation of decadal variability and predictability. The global TORUS model system will contribute to the MIKLIP system particularly by performing sensitivity studies with respect to the influence of a different ocean model formulation and to the influence of regionally refined resolution of the Arctic aiming at a better understanding of key mechanisms of decadal variability and predictability.

More precisely, TORUS-AWI aims at achieving the following specific objectives:
(A) Providing a model system with an alternative formulation of the ocean dynamics which allows regionally focused modelling of the Arctic key region. To avoid the numerical, physical and technical problems of model nesting or open boundaries, we will implement a global setup with the unstructured grid, finite-element ocean-sea ice model FESOM and the atmospheric model ECHAM.
(B) Assessing the effects of enhanced resolution. Sensitivity studies on the influence of regionally enhanced resolution over the Arctic ocean on the model climate and its simulation of decadal variability and predictability will be performed within TORUS-AW.
(C) Investigating mechanisms of decadal variability. TORUS-AWI will study in particular dynamical processes in the Arctic key region which are fundamental for generating large-scale atmospheric and oceanic variability patterns and hence decadal variability and predictability.

A prerequisite to answer these scientific objectives posed in TORUS-AWI is the existence of a reliable and validated technical tool. In the project, two well tested models are

employed, which use different numerical concepts. In particular, the latest version of the atmospheric model component ECHAM will be coupled to the finite element sea ice-ocean model FESOM via the community coupler OASIS4, which has been extended by an interface for unstructured grids at AWI-SC. Within TORUS-AWI tuning, validation and further optimization of the coupled system will be necessary. We expect extensive technical research in the field of load balancing for the parallel ocean model (patchy and solver dependent distribution of connected nodes), and for the validation on the up- and down-scaling of vertical fluxes between the atmosphere and the ocean covered by sea-ice.

The steps on the way to achieve the above mentioned scientific objectives during the whole period of TORUS (2011-2015) are: tuning, validation and further optimization of the coupled system (mainly during the actual application period from 1st January to 31st December 2012), performance of control runs, studies concerning the influence of regionally focused modelling on decadal variability, studies on the decadal hindcast skill and decadal forecasts of the TORUS model system. During all these steps, a large amount of computer ressources will be required due to the following reasons:
(1) The finite element method used for FESOM provides vast freedom with respect to the discretisation of the model domain. On the other hand the numerical burden is usually much higher than in finite difference models with regular grids.
(2) The regional focused modelling will refine the northern North-Atlantic and the Arctic ocean locally in critical regions up to $9km$.
(3) For providing decadal hindcast skill and decadal forecasts of the TORUS model system, ensemble runs according to the MIKLIP strategy will be ncessary.