SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2021
Project Title:	DECK Simulations with an alternative EC-Earth v4 prototype basedon OpenIFS-43r3 coupled to FESOM2
Computer Project Account:	de1a
Principal Investigator(s):	Streffing, Jan
Affiliation:	AWI
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	1. of January 2020
Expected end date:	31. of December 2020

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	35000	956.5	0	0
Data storage capacity	(Gbytes)	5.500	0	0	0

Summary of project objectives (10 lines max)

The project aims to provide a first benchmark for a new coupled system based on latest cycle of OpenIFS cy43 and the AWI developed unstructured grid finite volume ocean model FESOM2. Performing CMIP6 DECK simulations will enable further tuning and development of a comprehensive Earth System Model. The project also serves as a testbed during the development of the first prototypes of EC-Earth4, since the coupled model tested here is one of the possible AOGCM configurations of EC-Earth4

Summary of problems encountered (10 lines max)

The FESOM2 model had not previously been compiled and run on with a CRAY compiler environment. With it's stricter adherence to the FORTRAN90 standard, the CRAY compiler required a number of small improvements in the code. The surrounding framework, that is used to download, compile run and post-process the coupled model, the ESM-tools, were not set up for use with PBS and aprun. While the PBS integration proved simple aprun lead to continued problems. In order to run OpenIFS efficiently at high SYPD requires MPI/OMP hybrid parallelization. FESOM2 on the other hand scales to about one order of magnitude higher numbers of MPI threads and OpenIFS, and does not contain any OMP pragmas. The custom slurm heterogeneous job solution that was developed to allow one modell to run hybrid-parelellized, and the other MPI-only-parelellized was not portable to aprun. This would have resulted either in low SYPD or high SBU/simulated year.

Summary of plans for the continuation of the project (10 lines max)

The project was not continued at ECMWF, and the simulations were carried out on the ESM-partition of the juwels@fz-juelich.de hpc facility. This system is more familiar to the project members, resembles more closely the system on model was developed, and allowed for results to be obtained swiftly. The previously reserved ECMWF resources were relinquished in May 2020 to allow for alternative usage.

List of publications/reports from the project with complete references

AMOC variability and watermass transformations in AWI-CM climate model, Sidorenko et al. 2021 *under revision with Journal of Advances in Modeling Earth Systems*

Description of the AWI-CM3 coupled climate model and evaluation of DECK experiments, Streffing et al. i*n preparation for Geoscientific Model Development*

Summary of results

The work carried out at ECMWF resulted in several minor improvement of the coupled system and will enable an easier transition to other hpcs down the road. The problems encountered with scalability and heterogeneous paralellization on cca were ultimatly solved in 2021 when the system was adapted for use on another Cray/PBS/aprun maschine (aleph@iccp.kr).

The simulations originally planned for cca and ultimatly run on juwels lead to the detection of errors in the zero-layer thermodynamics handeling of heat fluxes from the atmosphere into the snow layer on top of sea ice. Furthermore improvements to the river routing and drainage arrival points were made. These process representation improvements in high lattitudes allowed for a global retuning of the AOGCM.

The resulting model shows substantial reduction of the of key surface field biases compared to the state of the model before the project was started. First studies using the simulation results are underway, while further research requiring new simulations will benefit from the improvements made.

Example of model improvement based on the performed simulations:
Reduction of 10 year mean SST bias after 50 year spinup with constant 1990 GHG forcing: