Project: 1406 Project title: **RESM4CORDEX (Regional Earth System Model simulations for CORDEX)** Principal investigator: **Ha Hagemann** Report period: **2023-11-01 to 2024-10-31**

Project RESM4CORDEX applied for **200 TB** disk storage for the time period of 2023-11-01 to 2024-10-31 to evaluate the RESM **hindcast simulations** within the CLM-Community, and **170 TB** was granted. The CLM-Community, a global network of scientists, develops and implements regional climate models, including COSMO-CLM (also known as CCLM) and ICON-CLM. The CLM-Community will provide simulations with CCLM and ICON-CLM for EURO-CORDEX in the next years. Beside those atmosphere-only simulations, the CLM-Community also plans to provide simulations of regional Earth system models (RESMs) in which CCLM and ICON-CLM are the atmospheric model components. In this case, CCLM/ICON-CLM can be coupled to the regional ocean model NEMO (which can be run over the North Sea, the Baltic Sea, the North Atlantic, and the Mediterranean Sea); the hydrological discharge model HD (over the European domain); and the Community Land Model CLM (over the EURO-CORDEX domain) (see Table 1).

RESM	Components	Coupling domain
GCOAST-AHOI1-1	CCLM6.0+NEMO3.6+HD5.2	GCOAST (North Sea, Baltic Sea, North Atlantic)
GCOAST-AHOIB1-1	CCLM6.0+NEMO3.6+HD5.2+ECOSMO	GCOAST (North Sea, Baltic Sea, North Atlantic)
GCOAST-AHOI2-0	ICON-CLM (icon266)+NEMO3.6+HD5.1	GCOAST (North Sea, Baltic Sea, North Atlantic)
GCOAST-AHOI2-1	ICON-CLM (icon-2024.07)+NEMO3.6+HD5.2	GCOAST (North Sea, Baltic Sea, North Atlantic)
ROAM-NBS	ICON-CLM (icon-2024.07)+NEMO4.2	GCOAST (North Sea, Baltic Sea, North Atlantic)
IOW-ESM	CCLM5.0+MOM5	Baltic Sea
GUF-ESM	CCLM5.0+NEMO-MED3.6	Mediterranean Sea
TMSP1	CCLM5.0+CLM3.5+ ParFlow3.12	EURO-CORDEX

Table 1: List of CLM-Community RESMs over the EURO-CORDEX domain

The RESMs shall be used to conduct hindcast simulations (forced by the atmospheric ERA5 reanalysis data and the ocean boundary ORAS5 reanalysis data) as well as to downscale several CMIP6 historical and scenarios simulations. For the time period of 2023-11-01 to 2024-10-31, we requested disk storage for the RESM **hindcast simulations** at the resolution of about 12-13 km in the atmospheric and land surface models over the EURO-CORDEX domain, and about 3.5 km in the ocean model over the above mentioned seas. Simulations of those RESMs were planned to be conducted separately by different CLM-Community institution members (i.e. Hereon, DWD, IOW, FZJ, GUF) using their **own** project computing resources, either on Levante or other super computing centers (e.g. JSC). The post-processed (daily) output data of the model components should be stored within this project RESM4CORDEX account to be commonly evaluated for the RESM performance.

We aimed to start the long-term hindcast simulations with the RESMs for the period of 1959-2018 (FZJ from 1979-2018) at the beginning of 2024. However, it was not guaranteed, that all the simulations that are included in the estimate will come in 2024. The upgrade process of component model versions as well as a single evaluation process of each RESM before conducting the long-term hindcast may affect the realisation of these simulations in real time.

Til October 2024, some hindcast simulations have been completed, namely those from the coupled models Hereon GCOAST-AHOI1-1 (i.e. CCLM6.0+NEMO3.6+HD5.2 for the North Sea and the Baltic Sea, so-called the GCOAST domain), the GUF-ESM (i.e. CCLM5.0+NEMO3.6 for the Mediterranean Sea) and FZJ TSMP1 (i.e. CCLM5.0+CLM3.5+ParFlow3.12). They are currently being validated separately by these centres and will be subject to the joint evaluation when the other model results are available. The available simulations are recently completed, and some of them couldn't be ported to the RESM4CORDEX project repository for the joint evaluation this year. The model bias tuning process and the implementation of transient aerosols in the COSMO-CLM took a longer time than expected, which are two main reasons for the late arrival of the hindcast simulations. The GCOAST-AHOI1-1 simulation was

conducted with the transient aerosols from the CMIP6 MRI-ESM2-0 data as requested by the EURO-CORDEX protocol. However, the GUF-ESM and TMSP1 simulations are still with the aerosol climatology data, therefore, should be re-run to fulfil the EURO-CORDEX protocol requirement. In addition, the lack of storage space allocated to the individual projects involved and the significant problems with the Stronglink system for archiving data on Levante (DKRZ) also prevent us from conducting the simulations in time.

In addition, some hindcast simulations could not be performed in time as planned due to the upgrade of the ICON model version (in the case of ROAM-NBS, i.e. ICON-CLM+NEMO4.2) and the model bias tuning process (in the case of IOW-ESM, i.e. CCLM5.0+MOM5). The 10-year tuning simulation of the coupled model GCOAST-AHOI2-0 (i.e. ICON-CLM+NEMO3.6+HD5.1) was completed and evaluated by Hereon (Ho-Hagemann et al, 2024) but with an older version of ICON-CLM (ICON266). The coupled model ROAM-NBS with the optimal settings for the new ICON version (ICON.2024-07) has been set up and tuned by DWD for the best configuration but has not yet been used to run the hindcast simulation.

Moreover, after the hindcast and the historical simulations of the GCOAST-AHOI1-1 have been completed recently, we found out that the coupled model has a salinity drift problem which needs to be investigated with several sensitivity long-term test simulations for at least 30 years each. Then the hindcast simulation will be re-conducted to contribute to the joint evaluation of the EURO-CORDEX community.

Besides the simulations of GCOAST-AHOI1-1, several spin-up simulations and the hindcast simulation of the new coupled model GCOAST-AHOIB1-1 have been conducted in 2024 and stored at the RESM4CORDEX project repository. The salinity drift problem will be also investigated for this coupled model.