Project Report

Project: 1315

Project title: CoastalFutures

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Several groups at Hereon are involved in the modeling activities within the framework of the CoastalFutures project. The following is the report for 2023/2024, organized according to the work packages (WPs) of CoastalFutures. A list of publications within the CoastalFutures project is provided at the end of the report.

WP2 and WP5:

WP2: Framework for integrated E2E Coastal Modelling

WP5: It is related to sectoral stressors and protection concepts

1. Coastal Ocean and Morphology

The main part of our resource share was used to further develop the SCHISM-ECOSMO model, incorporating a carbonate module, variable stoichiometry for organic matter, and several methods of ocean alkalinity enhancement (OAE) as climate mitigation measures. These extensions required comprehensive test simulations, leading to the detection and elimination of bugs in the model code.

We investigated the influence of barotropic and internal tides on shelf CO2 uptake, finding that tidal mixing increases biological primary production but unexpectedly decreases net CO2 uptake (Kossack et al., 2024). Variable stoichiometry improved seasonality of air-sea CO2 exchange, reducing annual biases against observations (Demir et al., in prep). Sensitivity experiments showed that alkalinity inputs near the North Sea coast are more efficient in drawing down atmospheric CO2 than widespread distribution along ship tracks (Liu et al., 2025).

Additionally, ICON-Coast simulations (with CLICCS A5) examined the impact of permafrost organic matter on Arctic Ocean carbon dynamics and carbonate saturation, revealing that increased coastal erosion leads to enhanced ocean acidification, causing harmful carbonate undersaturation states more frequently and severely (Mathis et al., in prep). ICON-O was coupled with the ECOSMO biogeochemical model using the FABM framework, with numerous experiments performed to adapt ECOSMO to the global model domain.

2. Marine ecosystem modelling E2E coastal Modelling

We conducted 35 runs for OSMOSE, with 5 replicates for each offshore wind farm scenario (including 7 control scenarios). Each run represents a 20-year simulation. Additionally, we performed a NEMO-ECOSMO run covering the 1993-2017 time period.

3. Smelt Life Cycle

In 2024, we primarily focused on developing the model using small-scale simulations (with few particles and shorter periods) and 1D simulations. We have taken the first steps towards successful 3D simulations and have included new forcing parameters into the model system.

WP3: Ecosystem impacts from offshore wind energy development

Offshore wind farms in regional climate

Experiments using the COSMO-CLM atmospheric model have been conducted both with and without wind farm parameterization, utilizing resolutions of approximately 5 km. This resolution range has been identified as optimal for effectively capturing wind farm dynamics within the atmospheric model. The study includes five technical scenarios, each consisting of 10 years (2008–2017) of wind farm installations, along with one scenario without wind farm simulations.

WP6: Climate scenarios and multiple stressors

1. Climate simulation using regional atmosphere ocean coupled system

We have conducted part of the planned simulations with the GCOAST-AHOI1-1, GCOAST-AHOI2-0 and GCOAST-AHOIB1-1 (formally named as COSMO-NEMO-HD) setups as listed in the following:
GCOAST-AHOI1-1: hindcast simulation for 64 years (1959-2022); historical simulation for 56 years (1959-2014) and scenario simulation for 66 years (2015-2080, still running until 2100). GCOAST-AHOI2-0: evaluation simulation for 11 years (2008-2018). GCOAST-AHOIB1-1: hindcast simulation for 12 years (1959-1970, still running until 2022).
Besides, we also ran some sensitivity tests of the coupled models to find the best configuration for the considered domain.

Two issues had severely impacted to conducting of our planned simulations:

- Due to the lack of storage granted for CoastalFutures, we had to temporally store our output at other projects' disk space. We need more storage at /work/bg1315 to store output data to evaluate the simulations. The shortage of storage prevented us to complete the planned simulations for the project.
- The continuous problems with archiving system (i.e. Stronglink) severely affected our simulations. That impeded the retrieving of forcing data as well as the archiving of produced data. Due to the latter, we also ran into storage problems as produced data could not be archived, disk space ran full, and model runs subsequently crashed due to no space to write the output data. In addition, we also had technical coupling problems with the GCOAST-AHOIB1-1 coupled system. In summary, we couldn't run the long-term simulations as planned and store the data at /arch/bg1315. Hence, the archive was underused by us, but from this year on, we really need the storage at /arch/bg1315.

2. Regional ocean simulations

In 2024, setups for the simulations above have been developed. This task comprised extensive validations and calibrations of the model systems. Simulations have been initiated with a focus on hindcasts covering the last ~30 years. Currently, a suite of reference configurations is compiled to be used for future simulations.