Notes first working group meeting

discussion 21 November 2025, 10-12 am, online
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Participants

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Introduction OBGC working group

Judith Hauck presented our meeting notes on the prior in-person OBGC workshop and its goal towards a sustainable community-oriented way to develop and maintain the natESM model. We are looking for open development and shared development goals. Judith then presented the working group proposal, also available on the natESM website (https://www.nat-esm.de/how-to-participate/working-groups/natesm_wgogbc_proposal.pdf). The working group objectives were presented and opened for discussion, as was the meeting agenda. There were no objections.

natESM support opportunities

Niki Gruber asked for opportunities available from natESM in terms of work contributed. It was confirmed that

- we can have multiple sprints in a row within natESM
- natESM RSE can do the technical work of implementing a (even new) modular framework

OBGC working group task 1: survey of models

A brainstorming discussion revealed several ideas on the categories (eventually Excel sheet columns) should be assessed for the survey of existing models. We identified the following questions to shape these categories

1. General:
    a. What is the model purpose?
    b. What are noteworthy technical features?
    c. What are noteworthy process/scientific features?
    d. Would you like to highlight a particular feature (e.g., something that everyone needs or is well transferable or otherwise not community-available)
2. Biological and Ecological complexity euphotic zone
    a. What nutrients are represented
    b. what phytoplankton types, in which currencies (C, N)
    c. what zooplankton types
    d. fixed or variable stoichiometry in what compartment?
    e. resolution of dissolved organic matter (semilabile …)
    f. Is oxygen represented?
    g. what is the complexity of calcium carbonate precipitation and dissolution?
    h. are carbonate chemistry / CO2 gas exchange represented

    i. which greenhouse gases are represented (CO2, N2O, CH4)
    j. are aerosols precursors represented (DMS, TEP)
    k. complexity of nitrogen cycle. (de-)nitrificaton, fixation
    l. Parameterisation of phytoplankton growth, nutrient assimilation, chlorophyll synthesis
    m. Is plankton vertical migration considered?
3. Biological complexity aphotic zone
    a. How is particle sinking implemented
    b. How is ballasting represented
    c. What is the complexity of remineralization
    d. What about chemical silicate and carbonate dissolution
4. Lateral coupling
    a. which BGC inputs does the model use (river, atmospheric, ..)
    b. are sediment processes represented, and how (benthic BGC, resuspension, benthic ecology)
5. Is the code accessible to the community, restricted or open?
6. What is the granularity/modularity of the code
7. Which physical hosts can be/have been coupled
8. What is the coupling interface
9. Give references to model
10. What are the HPC requirements, where has it been run
11. How is the model evaluated/calibrated, data sets and metrics
12. Do you have a wish for further natESM support?
13. Do you have a wish for further community support, e.g. additional processes

Discussion of Objectives

Iris earlier coined the constellation "OBGC box with modular components". We have to clarify what is inside such a box, and how the different components are technically linked.

- Niki: CMIP focussed or seamlessly bridging temporal and spatial scales?
- Olaf: needs to be configurable, across spectrum of uses; simple for long timescales, complex for process studies, all code under one roof
- Christoph: having one model to do it all with lots of switches is not good, this would be an overhead, which would make it slow and terrible to use.
- Carsten: purposes food provisioning, carbon storage,
- Carsten: don't exclude process-based modeler community by focussing too much on CMIP
- Judith: scattered model families might make technical development more difficult
- Niki: do not develop everything at once. define key integration areas, focus on them until done, then the next one.

Outcome: we need one code system and this needs to be modular and flexible. This does not mean that every possible combination of modules may work sensibly out of the box. Need to have a limited number of configurations that meets the needs of engaged modelling groups. We should be able to cover different scales and metrics, this is especially difficult for BGC.

What are the core components?

- Niki: Guiding principle: model needs to address at minimum (i) the (physical and) biological carbon pump, and (ii) input for studies addressing food provision (NPP, phytoplankton and zooplankton biomass)

- Andreas: start with a simplest possible model (Bacastow/Maier-Reimer)?. Any add-on has to demonstrate improvement relative to some defined metric as more complex models are more expensive. Metrics to be discussed, could be mean fields, but also assess sensitivities to change (suggested: seasonal cycle, paleo). → different configurations. simplest configuration ideally modularized in such a way that more tracers and processes can be added.

Possible configurations:

1) **targeting climate studies** (CMIP-type), paleo, integration over long temporal scales. Essentially OCMIP2-type from the 1990s.

   Should contain: Biological carbon pump and export production (could be DIC, alkalinity, photons, nutrients, phytoplankton, zooplankton?, detritus particles. Start with one each, scalable matrices. CaCO3 cycle may be represented)

   Semi-labile DOM (mimicking OCMIP set-up, contributes to C-export, fixed stoichiometry)

   Sinking: Martin-type curve (implicit), Greenhouse gas emissions (CO2, N2O, CH4), simple parameterizations for CH4 and N2O

2) **intermediate complexity biogeochemical model**, more targeting ecosystem questions (lower trophic levels) as input for food provision studies, possibly also more of interest for regional / high-resolution studies.

   Should contain: variable stoichiometry, (incl for DOM), more complexity of lower trophic levels, multiple phyto- and zooplankton groups (size distribution), zooplankton vertical migration, at least three nutrients (N/P, Fe, Si)

   Modular/optional: more complex N cycle; aerosol precursors; trace metals, explicit higher trophic levels, sedimentary fluxes

3) **Coastal set-up**. targeting global and regional coasts, additional benthic BG; resuspension; more refined coupling/representation in the host of tides, collapsing vertical resolution, dryfalling. Ocean colour feedback on heat transfer.

   Modular/optional: pathogens. Feedback, tidal flat/marsh processes?

Open to switch from NPZD- or NPZD-type model to other 'cores' if evidence arises that such other cores perform better with regard to defined metrics. Quite possible, it is not about resolution of compartments or species but only about the resolution of changed BGC fluxed by the ecosystem.

We should have a look at the MARBL framework at NCAR, which is more an NPZD-type model in a modular framework (for technical implementation).

Open questions:

- mixotrophy was mentioned, what to do with it?
- isotopes were mentioned, could be added as modules. → in which configuration?

Performance

- co-advection of tracers to "reduce" number of transported tracers (e.g., as implemented by HAMOCC)

→ efficient handling of large number of tracers, both for MPI communication and advection in the physical model. This is very relevant, though maybe probably more for the physical model interface.

Final remarks

- technical exploration not yet addressed. Challenge to bring knowledge on technical requirements and scientific needs together and identify the best way forward. Interactions between RSEs and scientists needed.
- Niki: think about non-fortran. This is being discussed in the ICON community.

Next steps

- set-up survey
- → circulate both by **Dec, 5th**
- input to survey by **January, 10th**
- analyze survey and map models to proposed configurations
- online meeting to present and discuss survey results → early **February (Doodle, tentative 9-13, 16, 20)**
- Short presentation at natESM workshop February 24/25
- Carsten/Judith draft scientific concept/roadmap
- community workshop to discuss concept/roadmap and technical options → **March (Doodle, tentative 16-20)**
- draft sprint proposal (scientific concept/roadmap + proposed technical solution)
- online meeting to discuss sprint proposal → **April**