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Listen to the ocean

The impact of ocean biogeochemistry on physics and its consequences for modelling shelf seas

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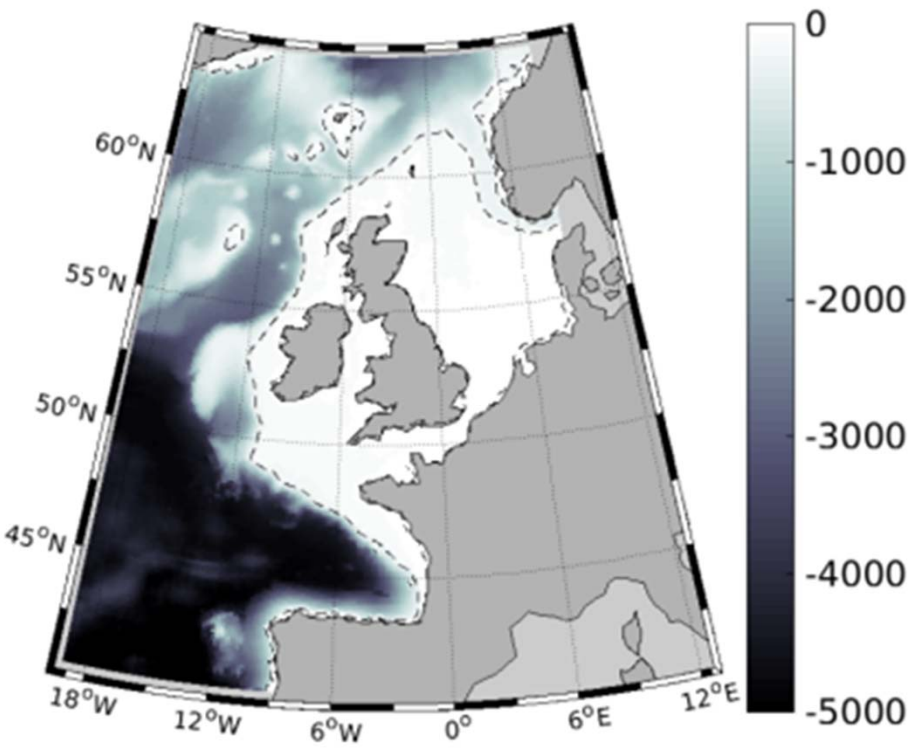
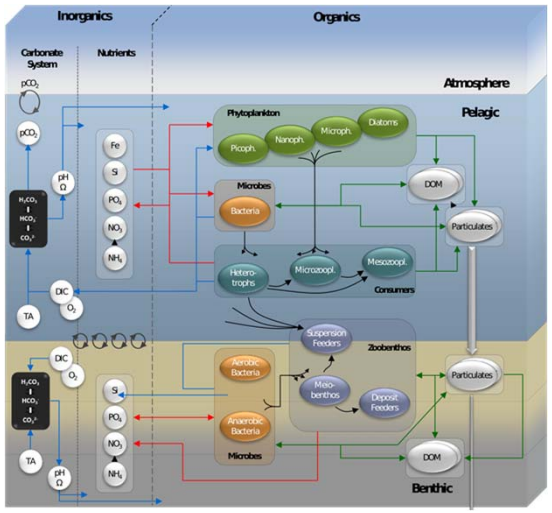
Key questions:

1. What is the size of the bgc impact on physics?
2. How sensitive are the simulated heat fluxes to the schemes modelling the attenuation of light by the bgc substances?
3. Does the ``best'' representation of light attenuation improve the skill of the physical-bgc model?
4. What is its impact on the UK Met Office system on the NWES?

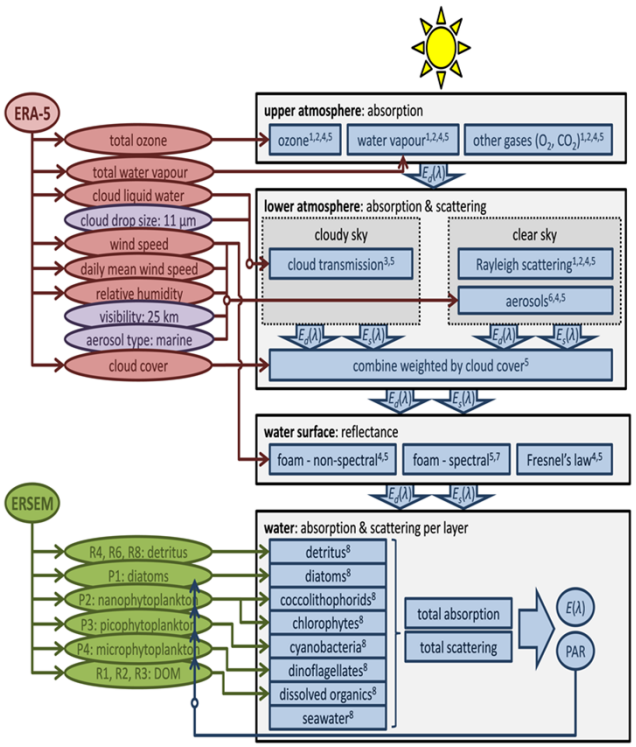


Model: NEMO – FABM – ERSEM + NEMOVAR DA

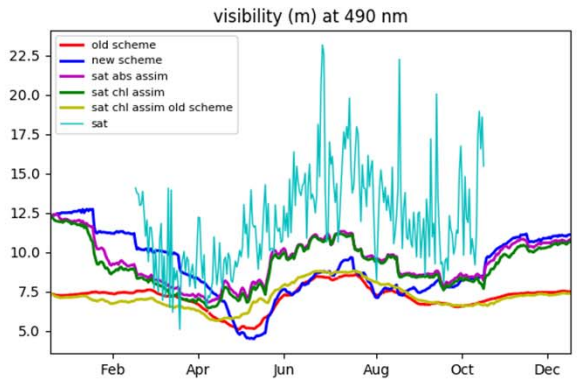


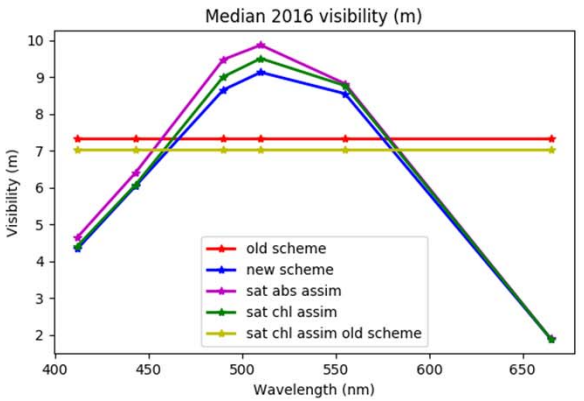
The current light scheme calculates attenuation for 2 bands: the visible band (400-700nm) is attenuated based on satellite Kd for 490nm, the rest is attenuated by the clear sea water.

Recent development: *Implementation of bio-optical module (based on OASIM model, Gregg & Casey, 2009) into ERSEM (Skakala et al, 2020).*



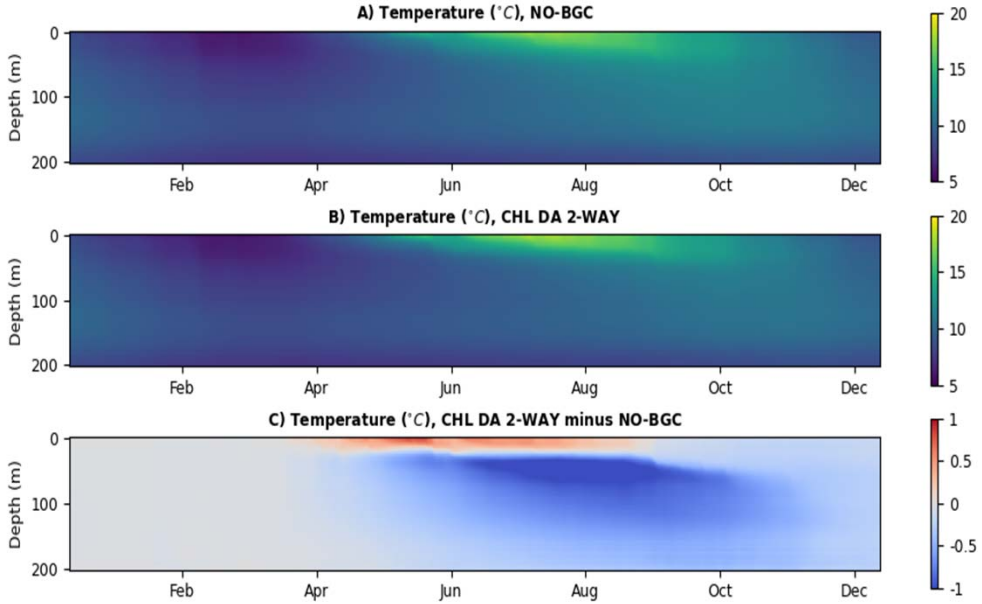
- resolves wavelengths in 33 wavebands,
- splits irradiance into diffuse and direct part,
- attenuation is calculated based on clear sea water, simulated PFT chlorophyll and Ady tracer, which is a passive tracer forced by a wavelenth-extrapolated satellite product for POC, CDOM and sediment.

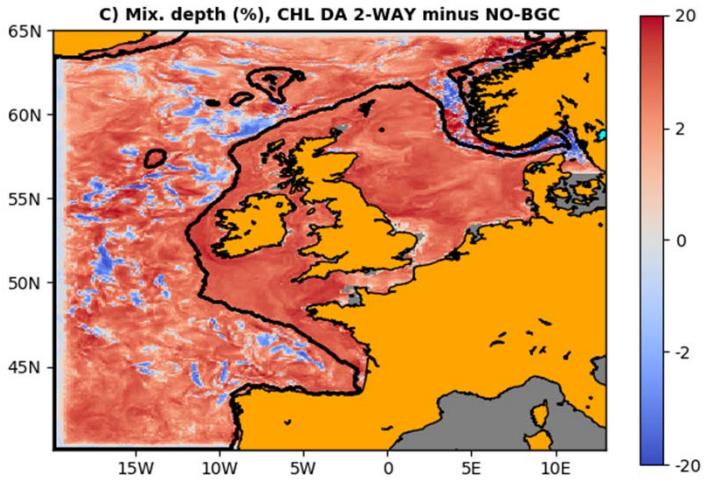




Q1: What is the size of the impact of biogeochemistry on the heating in the ocean?

- *compare the simulation using the bio-optical module with OC chlorophyll DA (the best estimate) with a simulation where irradiance was attenuated only with a clear sea water*





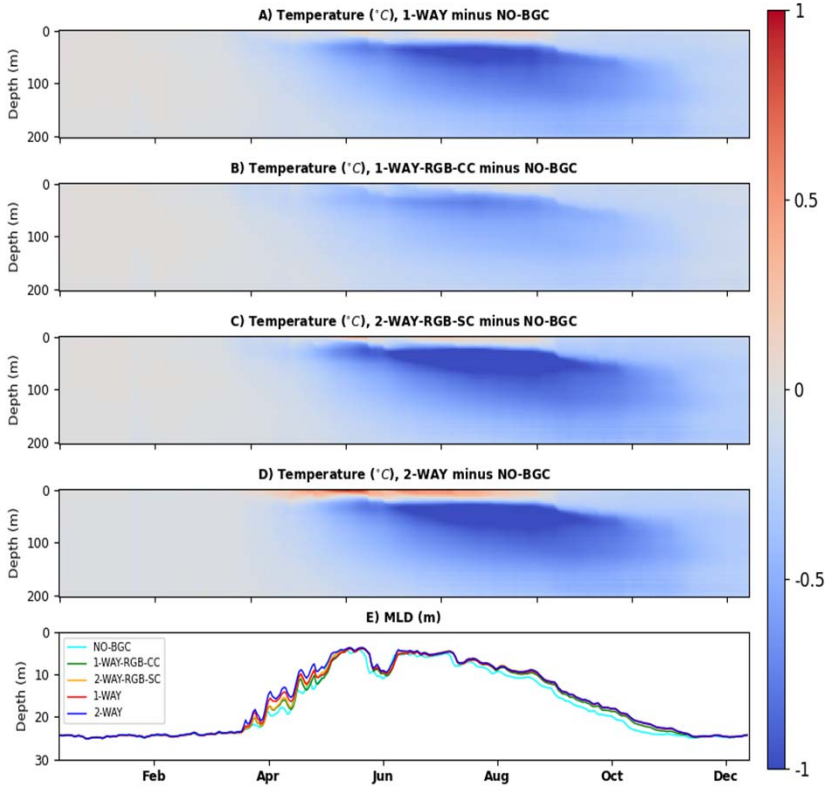
Conclusion: it matters!!

Increase of temperature up to 1°C in the uppermost layer and decrease of temperature by a similar margin beneath the layer up to 200m depth.

Q2: What is the sensitivity of temperature to the different light schemes used in the current and previous literature?

These are:

- the current operational scheme: 2 bands, driven by 490nm sat Kd
- RGB+invisible bands, attenuated by constant chlorophyll = 0.05 mg/m^3: open ocean set-up
- RGB+invisible bands, attenuated by the simulated total chlorophyll
- bio-optical module, 33 bands, direct/diffuse, attenuation by many components

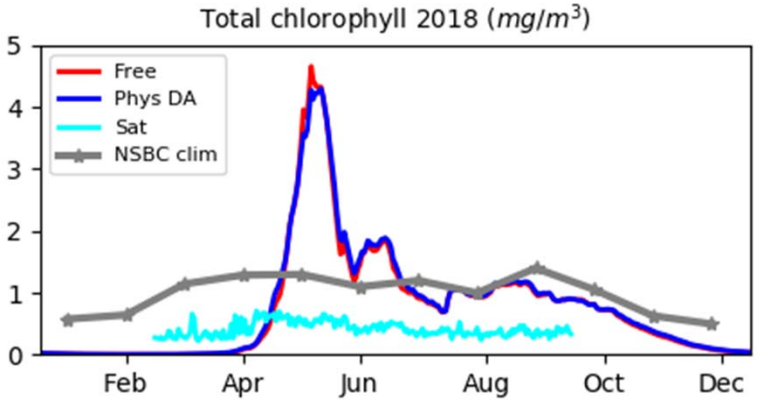


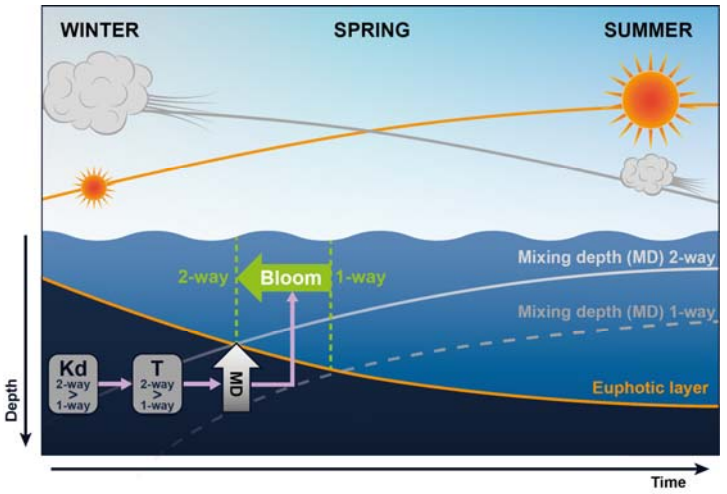
Conclusion:

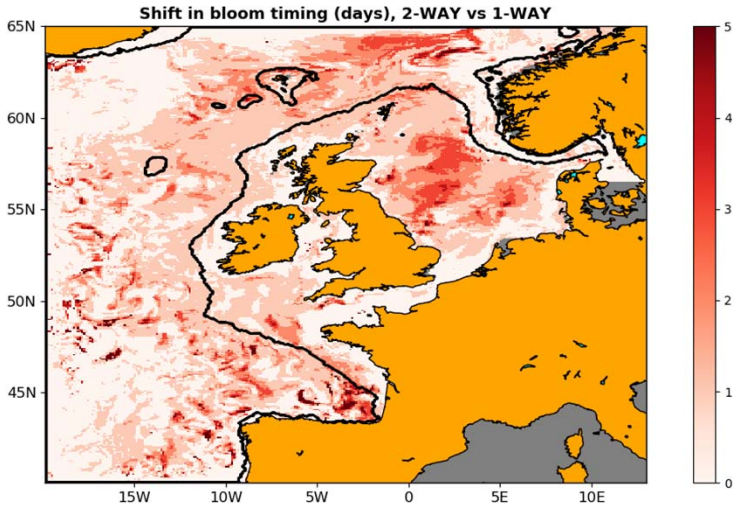
The heating is quite sensitive to the light scheme used in the model, so it is worth investing energy in getting it approx. right!

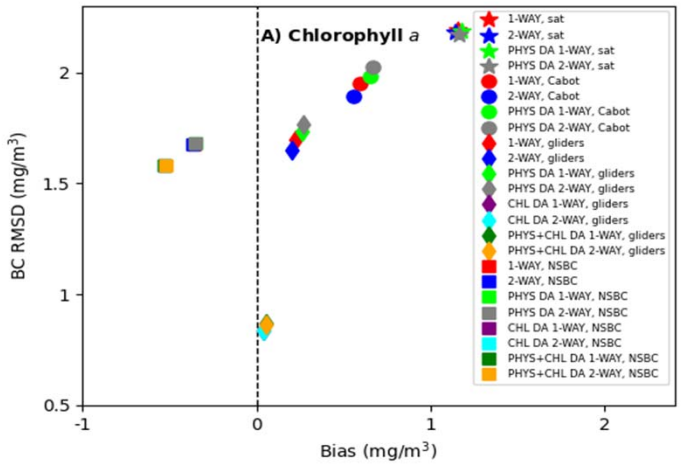
Q3: How does the two-way coupled model impact the physical-biogeochemical model skill?

An issue with phytoplankton phenology: model sees late and intense Spring blooms… Since seasonal blooms play a key role on the shelf, the failure to capture bloom correctly has a knock-on effect on the biogeochemical model skill…









Conclusions:

- the attenuation of light by the organic matter and sediment has a major impact on temperature and vertical mixing on the NWES and needs to be represented by our models

- physical model is quite sensitive to the scheme representing the attenuation of light by bgc constituents and thus it is important to resolve the spectra, substances and optically active tracers well

- the ERSEM model has an issue with a late and intense phyto bloom, which fails to be corrected by the improved simulated irradiance. There was a hope that improvement can be carried by the better estimate of heat fluxes based on the bio-optical module. This indeed happened, but the improvement in bloom timing was relatively minor compared to the bloom delay.

- the two-way coupled model carries a modest improvement in the ERSEM model skill within the UK Met Office operational system for the NWES. It also seems to improve T & S, although this is not always consistent. Within the phys & bgc DA the improvement is marginal, although it is quite possible that it can become more significant in forecasts (not tested yet).