Assessing the performance of a sympagic included biogeochemical model coupled to a regional oceanographic model for the subArctic system, the Hudson Bay Complex

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Introduction and methods:

The Hudson Bay Complex (HBC) is a sub-Arctic system that experiences seasonal ice cover and high volumes of river runoff. Sea ice provides a niche that the ice associate (sympagic) ecosystem can take advantage of and contribute to the overall carbon draw down of the system.

Modelling studies are a tool to provide insight into environments that are hard to observe all year round. Biogeochemical models (BGCM) are particularly useful to understand what is happening at the base of the pelagic and sympagic ecosystems.

Can the biogeochemical models simulate the chlorophyll-a spatial and temporal patterns seen in observational data and what are the drivers of variability for ice algal growth?

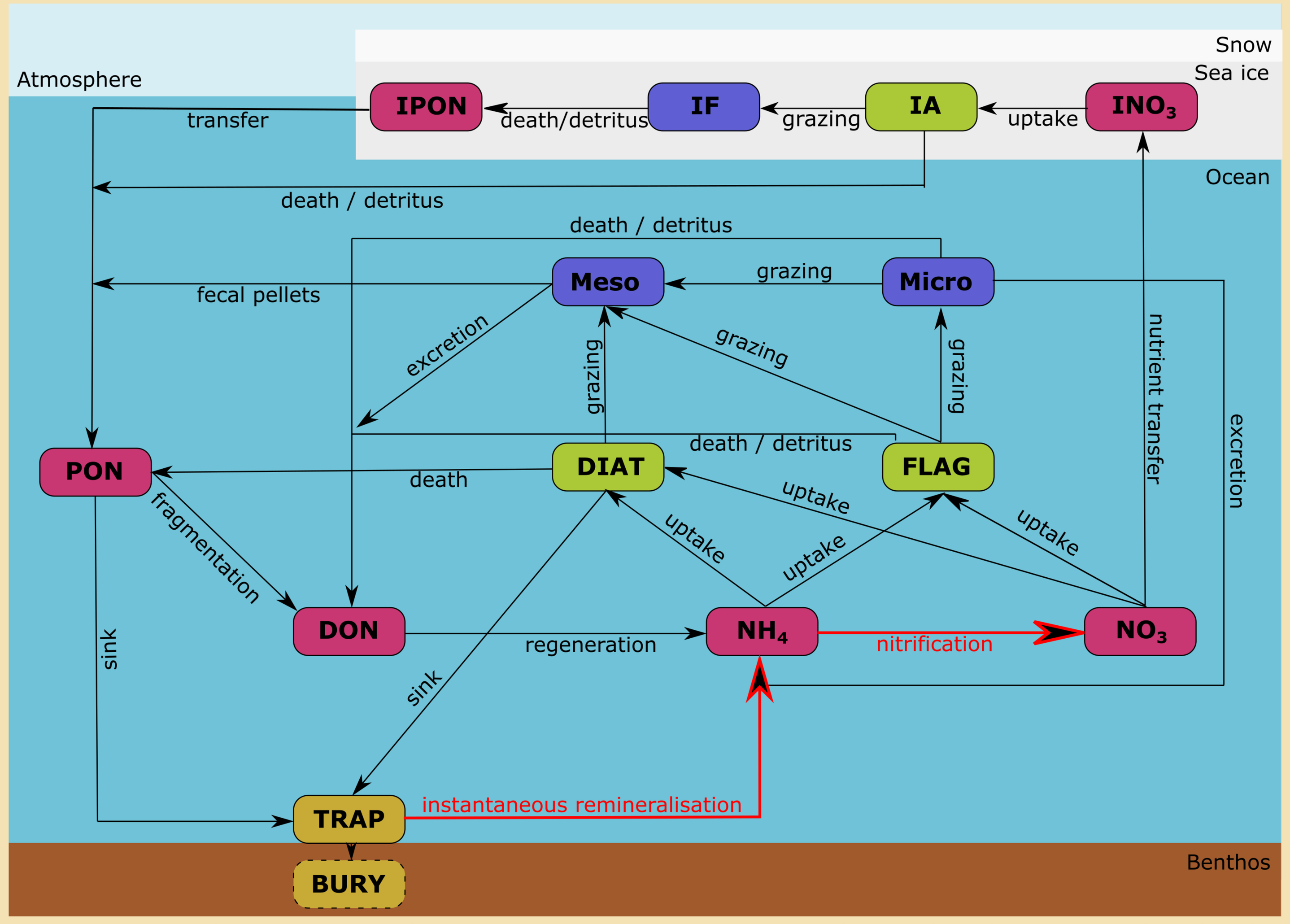

Figure 1: The BioGeochemical Ice Incorporated model (BiGCIIM) which includes pelagic and sympagic components.

Particulate Organic Nitrogen (PON), Dissolved Organic Nitrogen (DON), ammonium (NH_4), nitrate (NO_3), diatoms (DIAT), flagellates (FLAG), mesozooplankton (Meso), micorzooplankton (Micro), bottom sedimented material (TRAP), buried material (BURY), ice nitrate (INO_3), ice Particulate Organic Nitrogen (IPON), ice algae (IA), ice fauna (IF)

Model specifics:

- Canadian Meteorological Centre Global Deterministic Prediction System ReForecast (CGRF)- 2002 -2021
- Louvain-la-Neuve sea Ice Model version 2 (LIM2)
- Nucleus for European Modelling of the Ocean version 3.6 (NEMOv3.6) 1/4 resolution configuration
- Arctic HYdrological Predictions for the Environment (A-HYPE)
- BioGeoChemical Ice Incorporated Model (BiGCIIM)

Observational data for evaluation:

- MODIS-Aqua 4 km resolution Chlorophyll-a and SST 8-day average (2003-2021)
- AMSR2 6.25 km resolution sea-ice concentration (2018)
- CCGS Amundsen 2018 BaySys cruise

Model sensitivity and evaluation:

Investigation into the increase of total nitrogen content of the HBC.

Table 1: Sensitivity simulations testing different control mechanisms on the drift in total nitrogen content in BiGCIIM

Experiment Name	Ice Colonisation	Burial of sedimented material
Control	Full ice thickness	-
Ice only	restricted to 20 cm	-
Ice-burial	restricted to 20 cm	5%

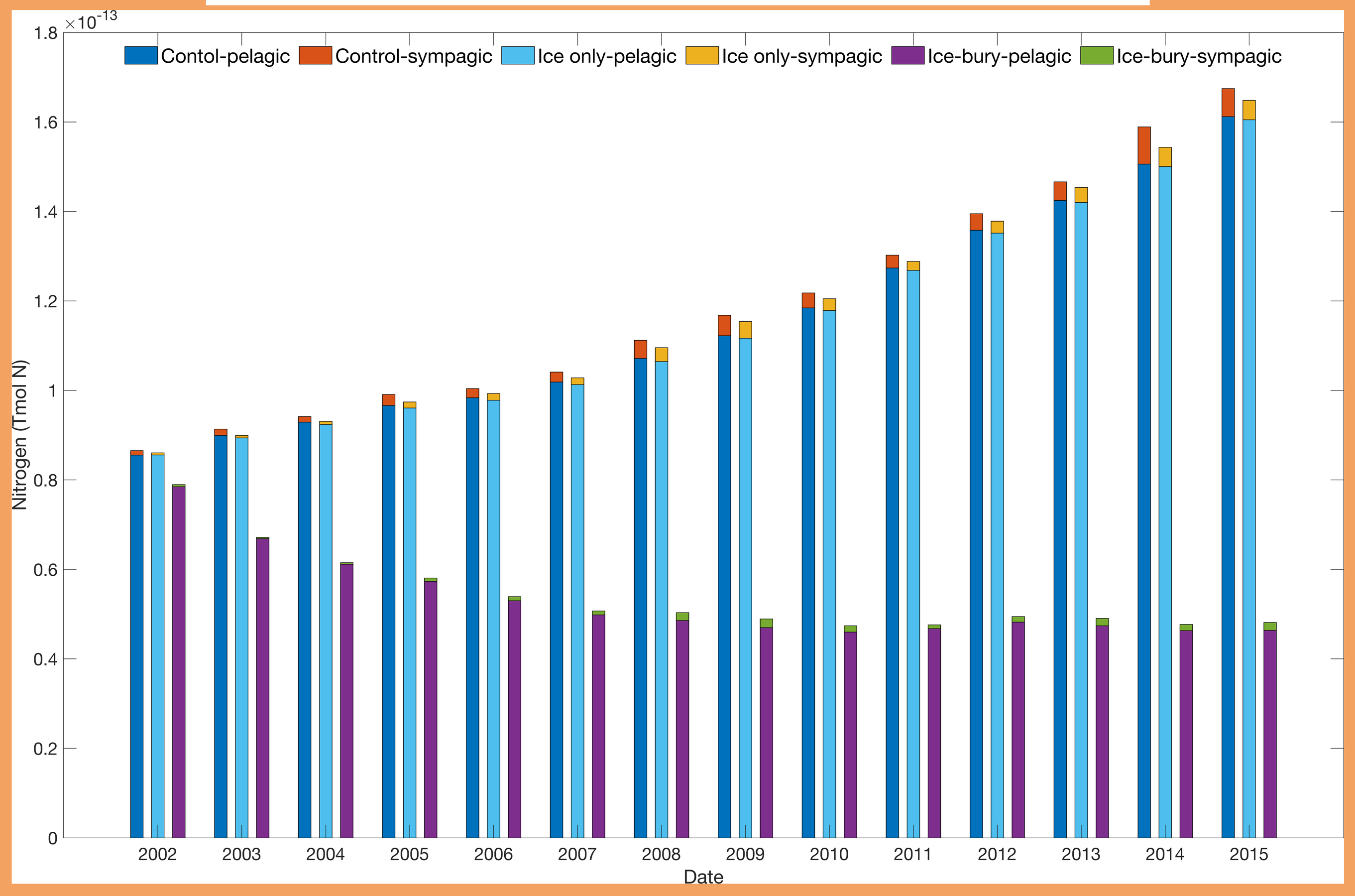

Figure 2: Bar plot illustrating the different sensitivity runs and their impact on total nitrogen content

- Burial controls the nitrogen drift the best, but removes too much matter.
- Reduced sea-ice colonisation decreases drift, but not sufficiently

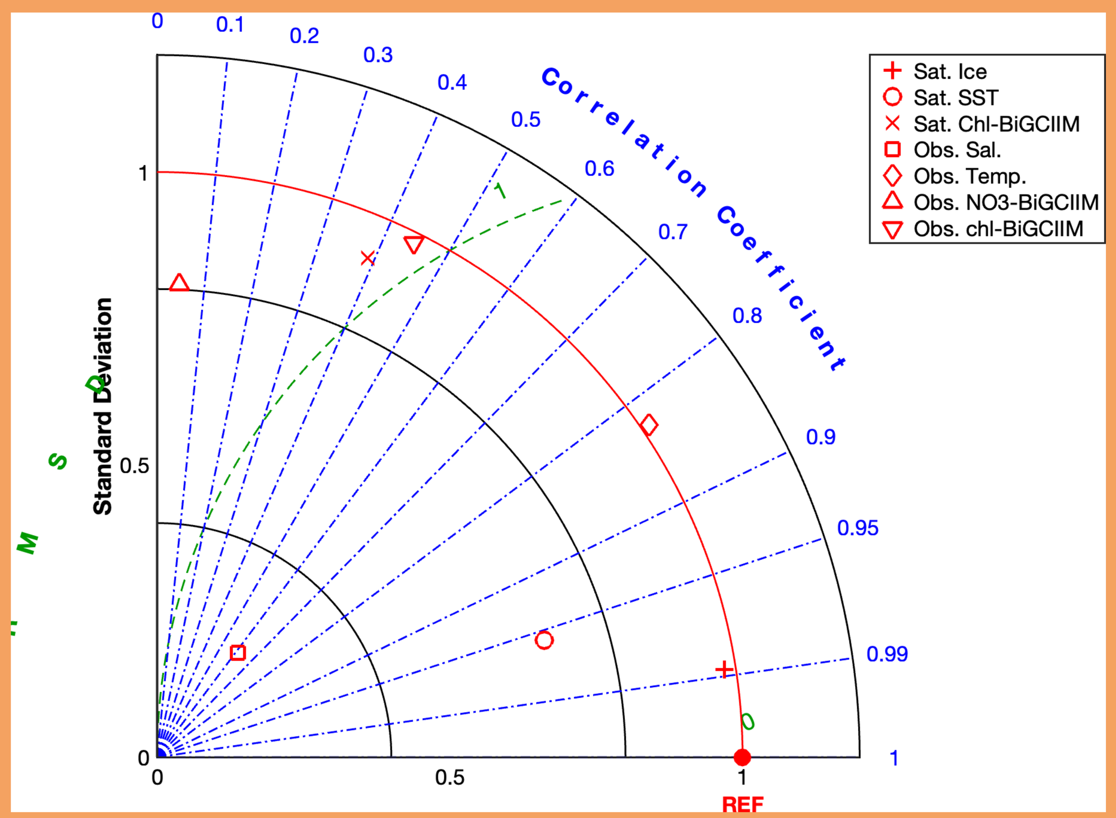

Figure 3: Taylor diagram comparing observed satellite and in situ measurments with model output.

- Comparison with satellite sea surface temperature (SST) and ice concentration show high correlations (>0.83).
- Comparison with chlorophyll-a satellite (0.45) and in situ (0.39) data does well.

Empirical Orthogonal Function (EOF) evaluation:

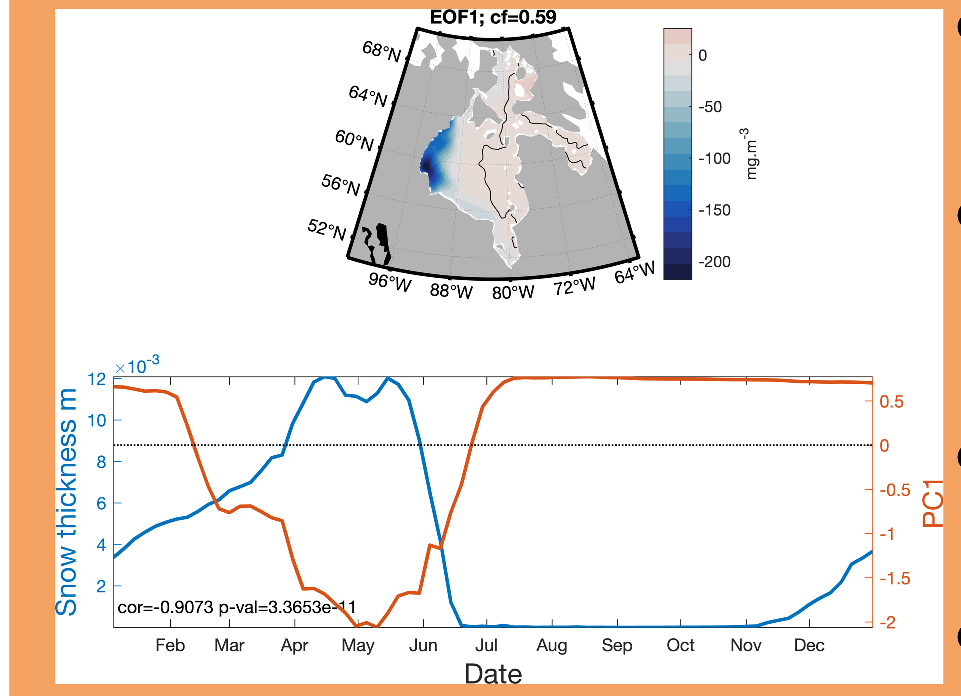

Figure 4: EOF 1 explaining 59% of the variability with the principal component (PC, orange) correlated to snow thickness (m, blue)

- There is a west to east spatial distribution in EOF1.
- Snow thickness negatively correlates with the first PC strongly (-0.91).
- Snow impacts light availability for growth.
- Ice algae (IA) growth can only start once snow thins allowing light through.

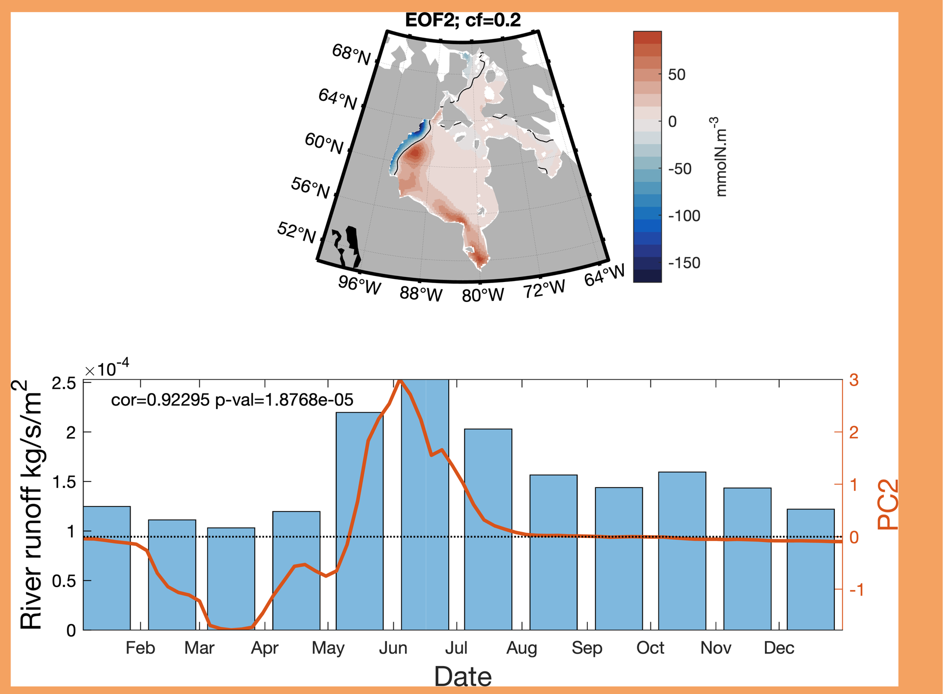

Figure 5: EOF 2 explaining 20% of the variability with the PC (orange) correlated to river runoff ($kg/s/m^2$, blue)

- There is a northwest to southeast spatial distribution in EOF2.
- River runoff correlates with the PC2 strongly (0.92).
- River runoff provides nutrients underice that can stimulate growth of ice algae.

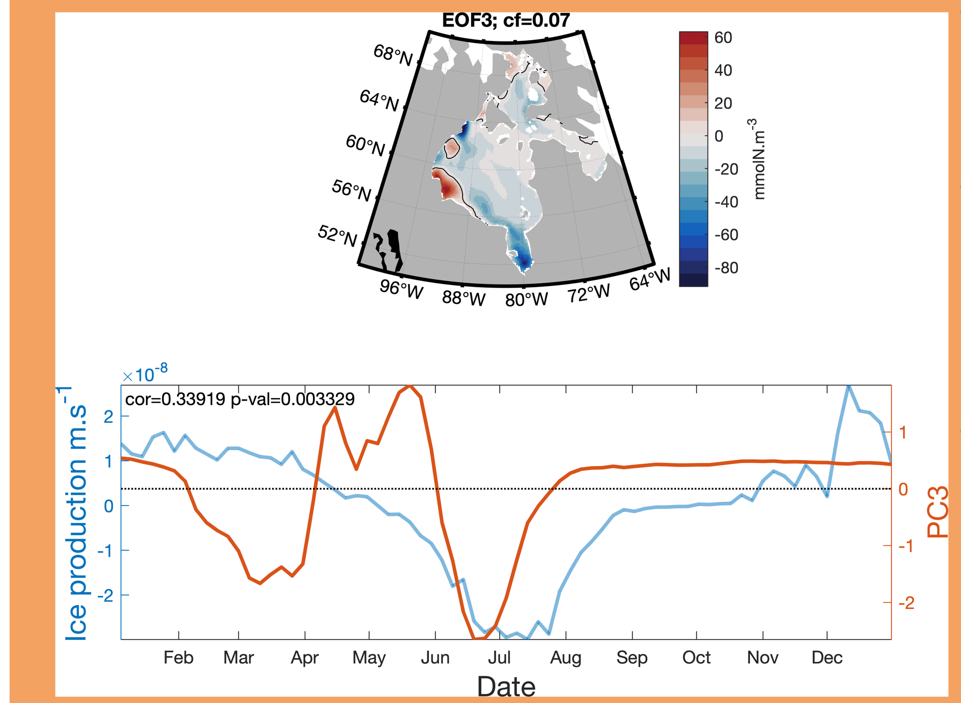

Figure 6: EOF 3 explaining 7% of the variability with the PC (orange) correlated to ice production (m/s, blue).

- EOF3 shows more spatial and temporal complexity.
- The correlation with the PC and ice production decreases (0.34).
- Drivers of the third EOF need to be assessed in a more spatially spacific region.
- However, as the ice melts it ice algae are flushed from the ice.

Conclusions:

- NEMOv3.6, LIM2 and BiGCIIM are able to simulate the important dynamics seen in satellite SST, sea-ice concentration and chlorophyll-a.
- Controls of the total nitrogen drift can be achieved through ice colonisation restriction and matter burial mechanisms.
- Snow thickness impacts the variablility if ice algae growth through light control on growth and river runoff through supply of nutrients.

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