Connecting AMOC variability and biological cycling in two Earth System Models

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1. Motivating Questions

Large interannual variations seen in biological cycling in various parts of North Atlantic, occurring on similar time scales as SST variations (AMO Index)

Do interannual changes in the AMOC drive changes in primary productivity big enough to explain such large variations?

Are such changes robust across physical models?

Is there any predictability of such changes?

Example: haddock associated with warm bottom temperatures (Stein, 2007)

2. Model description-common elements

Two Earth System Models with identical
-Atmosphere
-Land
-Sea ice
-Ocean biogeochemical cycling

Schematic of nutrient flows in biogeochemical model. Key pieces of model to understand.
-Phytoplankton
-Dissolved components
-Nutrient flow
-Sinking particles
-Remineralization/disolution

ESM2M: Level-coordinate B-grid ocean
-Resolves transition layer below mixed layer.
-Does not do a good job representing overflows, narrow straits, fine variations in MLD

ESM2G: Isopycnal coordinate C-grid ocean
-Strengths and weaknesses inverse of level coordinate model.

3. Model description-differences

Different ocean models

ESM2M: Level-coordinate B-grid ocean

ESM2G: Isopycnal coordinate C-grid ocean

4. Biogeochemical variability

Interannual coefficient of variation of diatom (large phytoplankton) biomass.

But still little variation in annual mean in —

ESM2G (colors) or ESM2M (contours)

5. Ecosystem variability in sync with AMOC

Ln(High AMOC conditions/Low AMOC Conditions) for diatom biomass (colors), nitrate (contours)

Observations: nitrate drawn down over summer.

ESM2G qualitatively similar.

ESM2M retains nitrogen.

6. West Greenland variability in ESM2G

Biomass tracks Winter MLD

High biomass associated with low salinity stratification.

Variability consistent with Great Salinity Anomaly impacts on temperatures, fisheries. Some questions about whether amplitude of variability in ESM2G is realistic.

7. Labrador Coast variability in ESM2G

Because ESM2G is more (realistically) nitrate-limited, it shows more response to changes in nitrate supply.

Sevenfold variation in biomass with fourfold variation in nitrate

8. Conclusions

One of GFDL’s ESMs is capable of generating large variability in ecosystems in response to changes in AMOC.

Salinity anomalies lead the AMOC and may provide predictability…

But response are far from robust across models. Need to get both physics and factors limiting biology right.