Research foci in coastal and open ocean settings: Knowledge gaps and future needs

Physical Circulation and Climate

A) What are the critical dynamical processes and feedbacks driving variability and change in the coupled Atmosphere-Ocean-Cryosphere in the Arctic-North Atlantic system?

B) How will a changing Arctic cryosphere influence ocean-atmosphere-ice interactions, BGC processes and ecosystem structure?

Framework of Processes

(Focus on Arctic and subpolar N Atlantic physics)

1. Lateral Exchanges
2. Vertical Processes
3. Deep Circulation
4. Shelf-Basin Interactions
5. FW processes
6. Sea Ice
7. Regional Sea Level Distributions
8. High Priority Model Issues

1. Lateral Exchanges

- Refine existing measurements of large scale Arctic-Atlantic ocean fluxes to balance the time-varying budgets of mass, heat and salt, in particular:
  - Flows through CAA passageways
  - Deep water flows across sills
- What are the dynamics and magnitudes of lateral exchanges between boundary currents and the basin interior?
- What is the role of mixed-layer eddies (MLEs) in restratification of the high latitude upper ocean?

2. Vertical Processes: mixing, convection, stratification

- How will changes in northern atmospheric circulation patterns affect ocean dynamics and physical / biogeochemical property distributions?
- What is the sensitivity of convection and carbon sequestration to changing FW forcing in the Arctic-Subarctic basins?
- How large were past changes and variability of the AMOC and how did they affect transports, productivity, biogeochemistry and climate?

3. Deep circulation

- How will the poleward extent of AMOC evolve in the future?
- What are the pathways linking the deep Arctic basins and the Nordic Seas, and how stable have these been in the past?
- Improve characterizations of entrainment processes south of the Nordic Seas overflow sills.
- Better quantify the pathways and transports for spreading of the deep waters in the North Atlantic.

4. Shelf – Basin Interactions

- What is the importance of seasonally ice-covered shelf/basin exchanges to distributions of properties (e.g. FW, carbon, nutrients)?

- What are the dominant timescales governing these processes?

5. Freshwater Processes

- How does an accelerating hydrologic cycle affect the Arctic FW budget?
- How does a warming Arctic affect the partitioning between solid and liquid FW fluxes in the atmosphere and ocean?
- What are the relative contributions of FW exports through Fram Strait and the CAA and how do they influence dense water formation in the AMOC?
- How does the ocean affect land ice, and how does ice mass attrition affect ocean circulation?

6. Sea Ice

- How does thinning and loss of sea ice affect air- sea fluxes?
- What are the feedbacks between sea ice loss and atmospheric circulation?
- How will changing ice exports affect the downstream basins?
- How does increasing open water fetch alter the dynamics of the marginal ice zone?
- How does the changing geography of marginal ice zones influence primary production and export?

7. Regional Sea Level Distributions

- What are the relative roles of decadal (internal) and secular changes to SL variability (e.g. in the Beaufort Gyre)?
- What is the partitioning of steric changes, mass input and ocean dynamics in SL variability (e.g. a weakening Gulf Stream) ?
- What is the SL imprint of mass loss from the Greenland Ice Sheet?
- How do changes of high latitude storm tracks affect storm surges?

8. High Priority Model Issues

Many Arctic physical processes and feedbacks are poorly represented in state-of-the-art ESMs, including:

- Sea ice thickness, deformation and export, fast ice, snow cover, melt ponds and surface albedo, permafrost
- Oceanic eddies, tides, surface/bottom mixed layers
- Atmospheric modes of circulation, clouds, aerosols, fronts
- Interactions and coupling between: GIS/ocean, fjord-shelf-basin, wave-ice, and air-sea-ice systems