Seasonal cycle of the Fram Strait freshwater export: A model perspective

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Introduction

The freshwater (FW) export variability from the Arctic Ocean is a topic of great interest, as the Arctic FW has the potential to affect the deep water formation in the North Atlantic. Due to the ice conditions in the passages between the Arctic Ocean and the North Atlantic, observations of the liquid freshwater (FW) export from the Arctic Ocean are very limited. To understand the seasonal variability of the liquid FW export, we analyze a model simulation from the Community Climate System Model (CCSM), Version 3, which includes passive tracers that track the movement of FW from different sources in the Arctic.

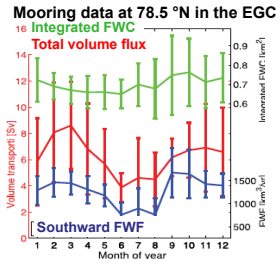
Objective

How does the Fram Strait liquid FW export vary seasonally and what causes this variability? This is important to correctly interpret geochemical tracer observations obtained during different seasons

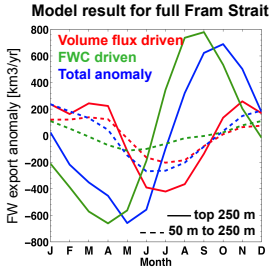
Model

- The CCSM3 is a fully coupled global climate model, which includes models for the atmosphere, the ocean, the sea-ice, and the land surface.
- Its atmospheric component has a spectral truncation of T85 (about 1.4°). The ocean model has a 1° rotated orthogonal grid, in which the North Pole is displaced to Greenland, and 40 vertical levels.
- To differentiate FW from different sources (meteoric FW (sum of runoff and precipitation), Pacific FW inflow, Atlantic FW inflow, sea ice melt and formation), passive tracers have been added to the ocean model (Jahn et al., 2010)
- The simulation analyzed here is a 140 year long 1990 equilibrium simulation, initialized from the end of a 400 year long 1990 equilibrium simulation. Results are shown for the 100 year period after the tracer concentrations have reached steady-state.

Seasonal cycle: Observations versus Model

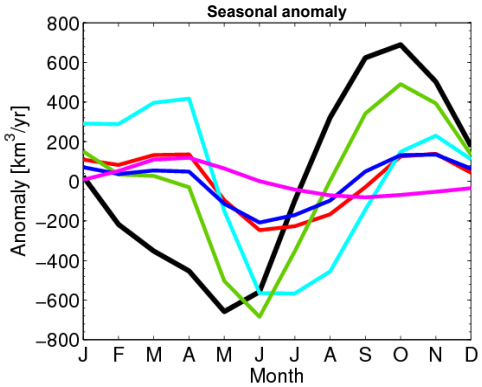


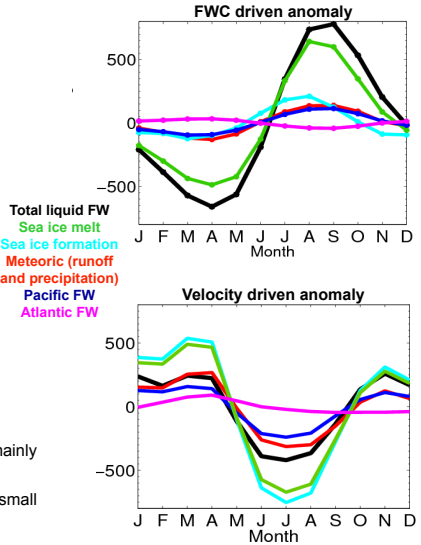
De Steur et al., 2009, ©AGU



- The simulated seasonal cycle of the Fram Strait liquid FW export is mainly driven by FW content (FWC) anomalies
- The mooring data shows that the Fram Strait liquid FW export is driven by volume flux changes
- As most (~90%) of the seasonal cycle of the FWC in Fram Strait occurs in the top 50m in the model, the mooring data misses most of these changes in FWC, as no measurements near the surface are available

What is driving seasonal cycle of FW export?





- The seasonal cycle of the liquid Fram Strait FW export is mainly driven by upstream sea-ice melt.
- Pacific FW, Atlantic FW, and meteoric FW have a small seasonal cycle that is mainly driven by velocity changes

Conclusions

- The seasonal cycle of the Fram Strait liquid FW export is dominated by changes in the FW content, not velocity changes. Most of this signal (>90%) is contained in the top 50m, which explains why the mooring data from Fram Strait (de Steur et al. 2009) misses most of the seasonal FW content signal.
- The seasonal cycle of the FW content is mainly due to changes in the concentration of sea-ice melt water.
- The Pacific FW and meteoric FW export have a small seasonal cycle, which is dominated by velocity changes.

➡ **Measurements from different seasons can be used to analyze the interannual variability of the concentration of Pacific FW and meteoric FW in Fram Strait, but to determine the interannual variability of the concentration of sea-ice melt water, its seasonal cycle needs to be considered**

References

- Jahn, A., L.B Tremblay, R. Newton, M.M. Holland, and L.A. Mysak (2010), A tracer study of the Arctic Ocean's liquid freshwater export variability, J. Geophys. Res. – Oceans, in press, doi:10.1029/2009JC005873.
- De Steur, L., E. Hansen, R. Gerdes, M. Karcher, E. Fahrbach, and J. Holfort (2009), Freshwater fluxes in the East Greenland Current: A decade of observations, *Geophys. Res. Lett.*, *36*, L23611, doi:10.1029/2009GL041278.

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