Tracing sources and sinks of freshwater in the Arctic Ocean

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Why?
The haline stratification is a key feature of the Arctic Ocean. Its composition has already been studied using geochemical tracer observations and with models (passive tracers). However, observations are sparse in time and space and previous modeling studies have not included all major freshwater (FW) components. Here we do a more complete study by including all the major sources and sinks of FW in a model to answer the questions: How do the different sources and sinks spread from source regions to the interior? What is the composition of the halocline and how is it ventilated?

What has been done?
Using a regional ice/ocean model (RCO) the main source/sinks of FW: Runo and net sea-ice melt dominates the overall composition of the upper 250 m of FW. However, regional differences exist in the central Arctic Ocean, especially in the halocline where PW and meltwater are also important FW sources. The halocline is ventilated both by shelf/basin exchange and by interior mixing processes. Differences exist in the central Arctic Ocean, especially in the halocline where PW and meltwater are also important FW sources.

Main conclusions:
The dominant FW balance is between Eurasian runo and net sea-ice melt. However, regional differences exist in the central Arctic Ocean, especially in the halocline where PW and meltwater are also important FW sources.

What FW source can we find where?
A balance between Eurasian runo and net sea-ice melt dominates the overall composition of the upper 250 m of FW. However, a distinct difference between the central basins exists where PW becomes equally predominant to runo in the Beaufort Gyre Region (BGR).

From source regions to the interior?
Eurasian runo follows the coast and enters the central basins from Laptev and East Siberian Sea. The residence time is 17-21 years. PW mainly follows the coast, some ends up in the Beaufort Gyre and the residence time is 11 years. There are two distinct inflow branches of Atlantic water in the upper 250 meters.

What is in the halocline and where?
The most prominent FW sources in the halocline layer (S=31-34) are PW, runo and sea-ice melt while the dominating sink is brine-enriched water from sea-ice formation. West to east differences are found with meltwater begin more dominant in Hansen, runo and PW in Makarov and Canada basins.

Freshwater content [m] & Tracer/FW volume [10^3 km^3]

Water-mass transformation in salinity coordinates
The exchange rates between the central parts and shelf seas and the Nordic Sea are studied in a Walin framework (Walin, 1977) by transforming the flow to salinity coordinates. Where the volume budget is

\[ \frac{dV(S, t)}{dt} = M(S, t) + G(S, t) + E(S, t) \]

Here M, G and E are the net cumulative fluxes across a control, isohaline- and atmosphere/ocean surface into a volume V with S=S'. Control surfaces are defined so that the Central Arctic Ocean is separated from the shelves and Nordic Seas. Generally, there is a net inflow at low and high salinities and outflow in an intermediate range, with the exception of S=30-31.5.

Renewal of the halocline?
From the cumulative fluxes we can calculate the transport in a range ΔS by taking \(\int M(S, t) dS\). Here we do it for surface (0-31), halocline (31-34) and Atlantic (34-35) salinity ranges to estimate the halocline renewal rates.

Integrated tracer content and mean currents (0-256m)

References:

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This text is a summary of the research presented in the paper by Pemberton et al. It outlines the study's objectives, methods, and findings regarding the tracing of freshwater sources and sinks in the Arctic Ocean, with a focus on the Beaufort Gyre Region (BGR). The research uses a regional ice/ocean model to analyze the composition and distribution of freshwater, with a particular emphasis on the halocline layer (S=31-34). The study highlights the dominant freshwater balances and the impact of various sources and sinks on the Arctic Ocean's freshwater content.

The freshwater sources include Eurasian runoff and net sea-ice melt, which are significant in the central Arctic Ocean, especially in the halocline. The halocline is ventilated by both shelf/basin exchange and interior mixing processes, with differences existing in the central Arctic Ocean. The study presents main conclusions indicating the significance of these freshwater balances and their implications for the Arctic Ocean's freshwater distribution.

The freshwater content and tracer volume are shown in graphical representations, providing a visual summary of the model's output. The water-mass transformation in salinity coordinates is discussed, with emphasis on the volume budget equation and the calculation of transport in salinity ranges to estimate the halocline renewal rates. The halocline renewal is calculated for different salinity ranges, including surface (0-31), halocline (31-34), and Atlantic (34-35) salinity ranges.

The references cited in the text include contributions from Mårtensson et al. (2012) and Walin (1977), providing a theoretical framework for the description of estuaries and the simulation of Arctic sea-ice variability, respectively.