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: Runoff, precipitation, evaporation, melting, freezing and inflows through Bering Strait, Fram Strait and Barents Sea Opening are all marked with a separate passive tracer.
The model is run for 63 years (1948-2011) using NCEP reanalysis data and s monthly river runoff climatology as forcing. For more details on the model see (Mårtensson etal, 2012).

Main conclusions:

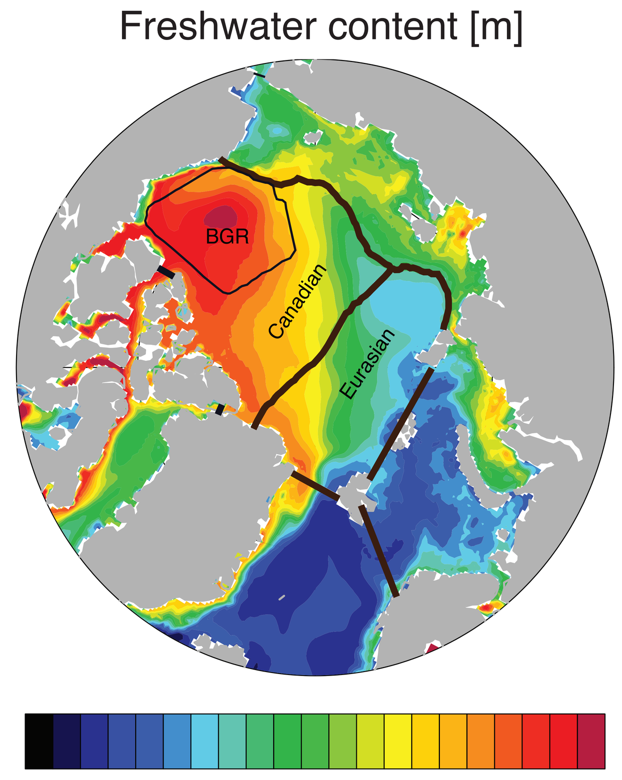
The dominant FW balance is between Eurasian runoff and net sea-ice melt. However regional differences exist in the central Arctic Ocean, especially in the halocline where PW and meltwater are also important FW sources.

The halocline is ventilated both by shelf/basin exchange and by interior mixing processes and the two components are of equal magnitude with a total renewal rate of 0.9 Sv.

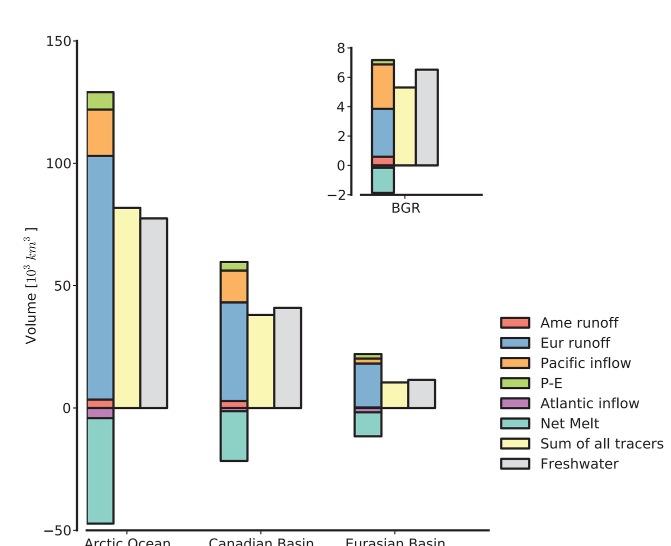
What FW source can we find where?

A balance between Eurasian runoff 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 predominate to runoff in the Beaufort Gyre Region (BGR).

Freshwater content [m]



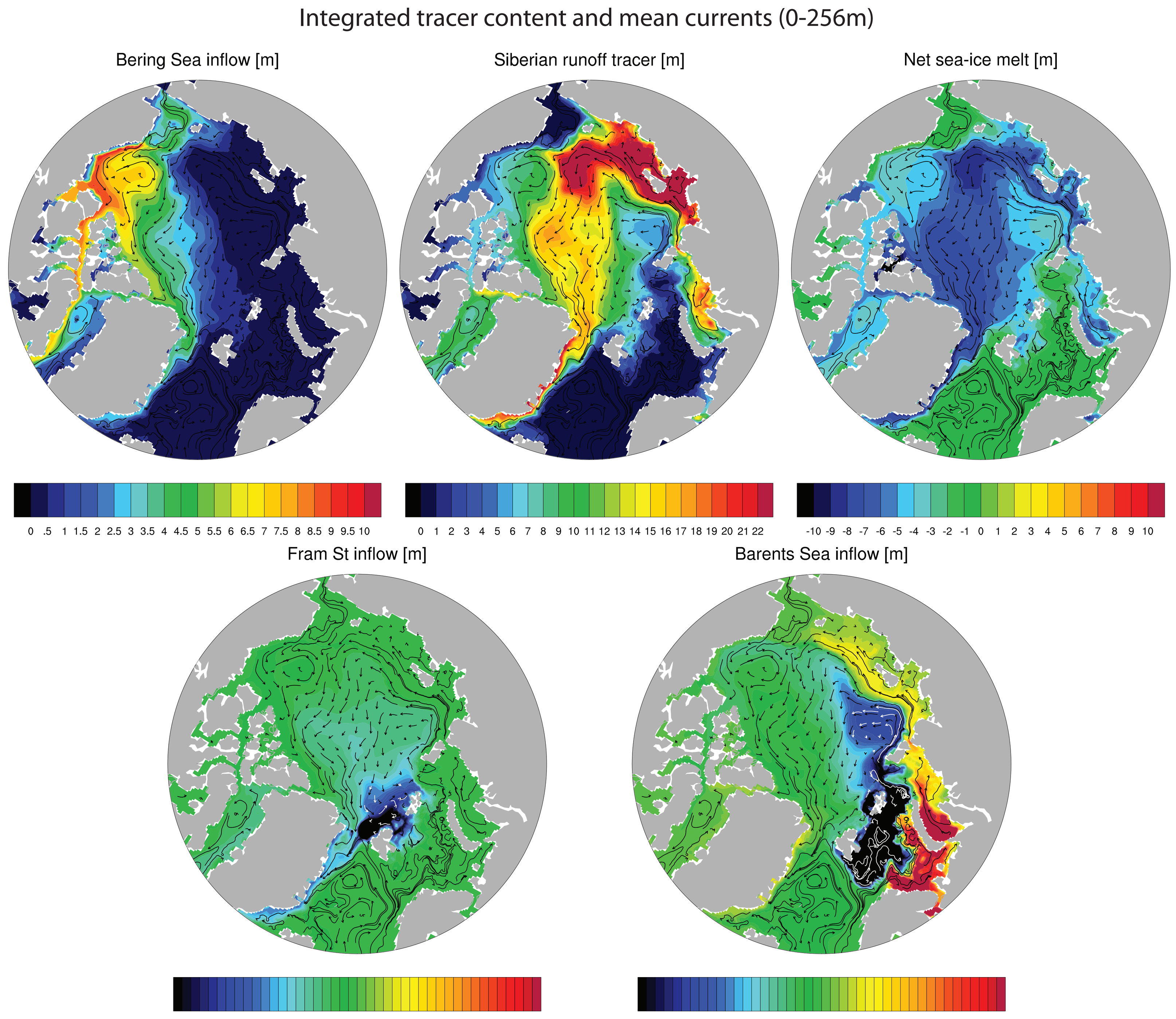
Tracer/FW volume [10^3 km^3]



From source regions to the interior?

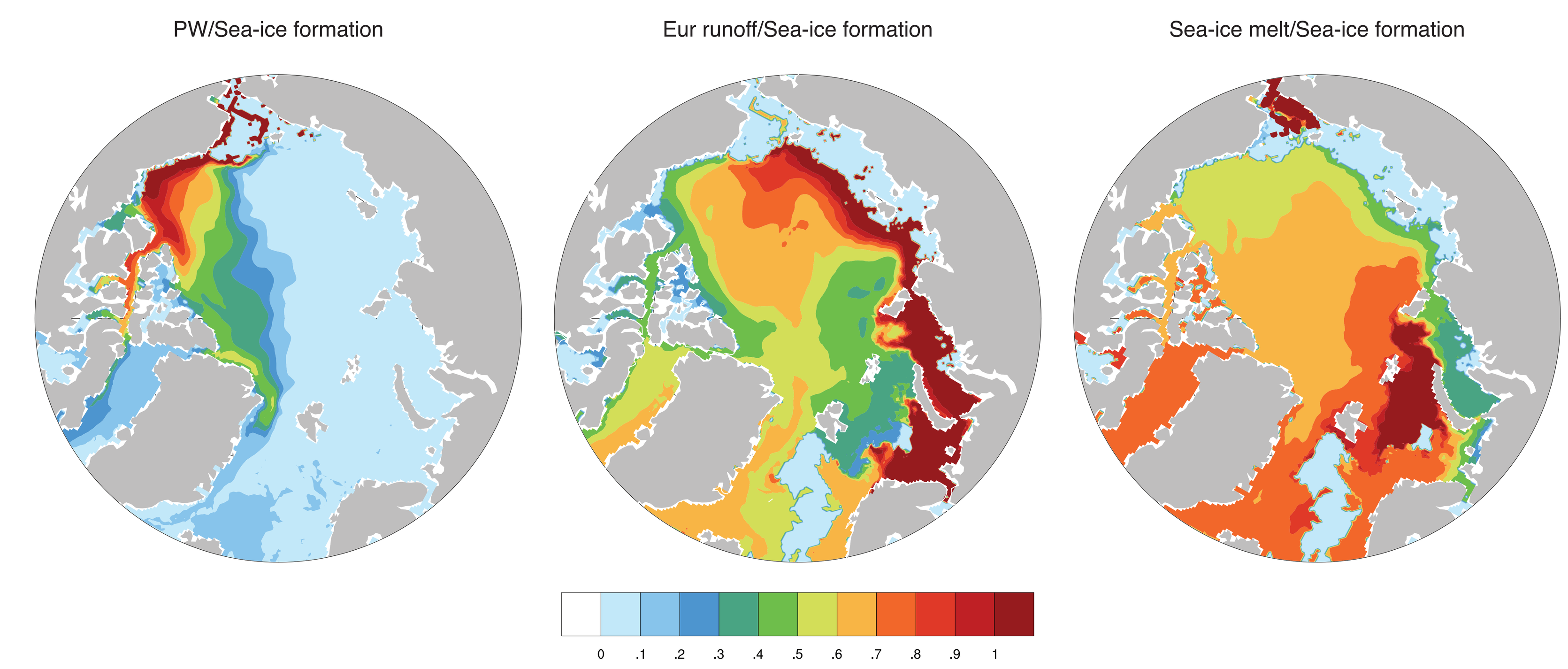
Eurasian runoff follows the coast and enters the central basins from Laptev and East Siberian Sea. The residence time is 17-21 years. PW mainly follows the coast, some ends up in the Beaufort Gyre and the residence time is 11 years. There are two distinct inflow branches of Atlantic water in the upper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

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



What is in the halocline and where?

The most prominent FW sources in the halocline layer (S=31-34) are PW, runoff 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 Nansen, runoff and PW in Makarov and Canada basins.



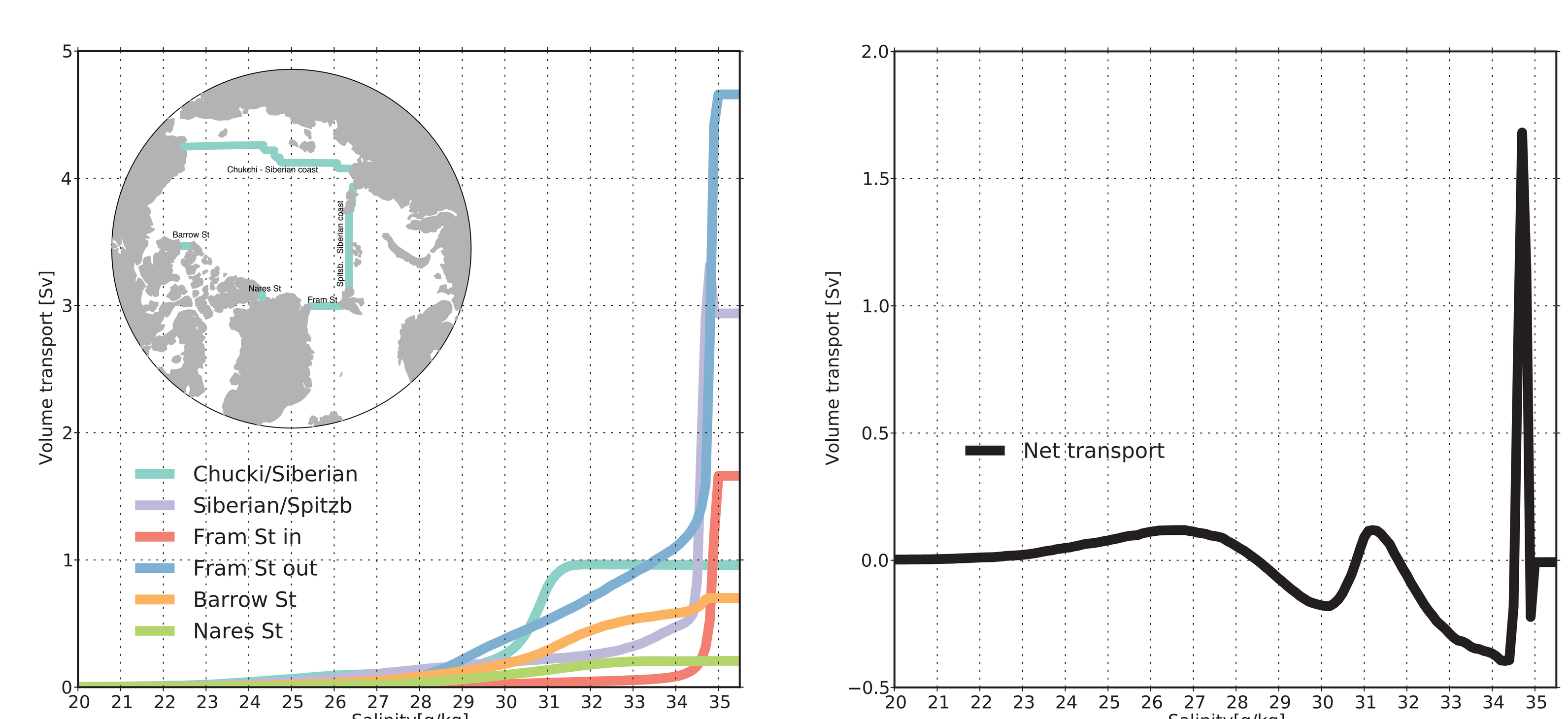
Water-mass transformation in salinity coordinates

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

$$\frac{\partial V(S,t)}{\partial t} = M(S,t) + G(S,t) + E(S,t)$$

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 shelfs 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.

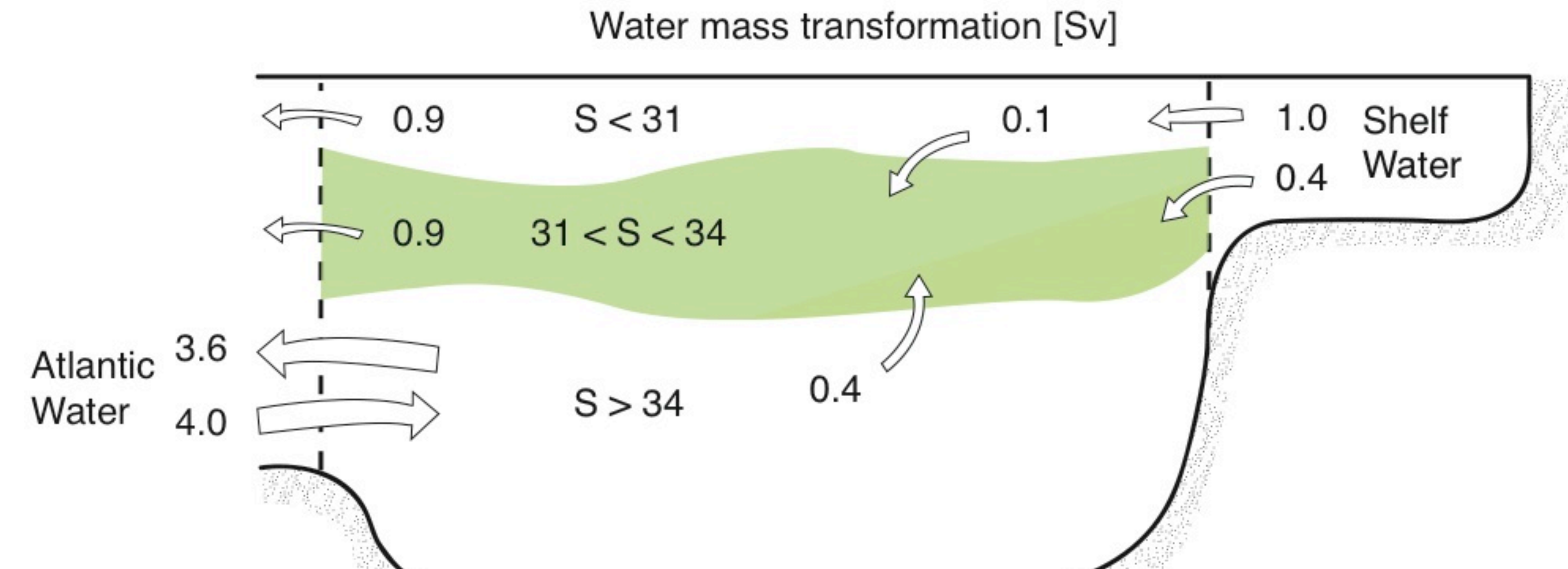
Exchange functions M(s)



Renewal of the halocline?

From the cumulative fluxes we can calculate the transport in a range ΔS by taking *(dM/dS)ΔS*. Here we do it for surface (0-31), halocline (31-34) and Atlantic (34-35) salinity ranges to estimate the halocline renewal rates.

Water mass transformation [Sv]



References:
Mårtensson, S. et al., 2012, Simulated long-term variability of ridged sea-ice in the Arctic Ocean using a coupled multi-category sea-ice ocean model. *Journal of Geophysical Research*.
Walin, G., 1977, A theoretical framework for the description of estuaries, *Tellus* 29.

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