Arctic Ocean change in the 1990s: impact on riverwater pathways and freshwater export

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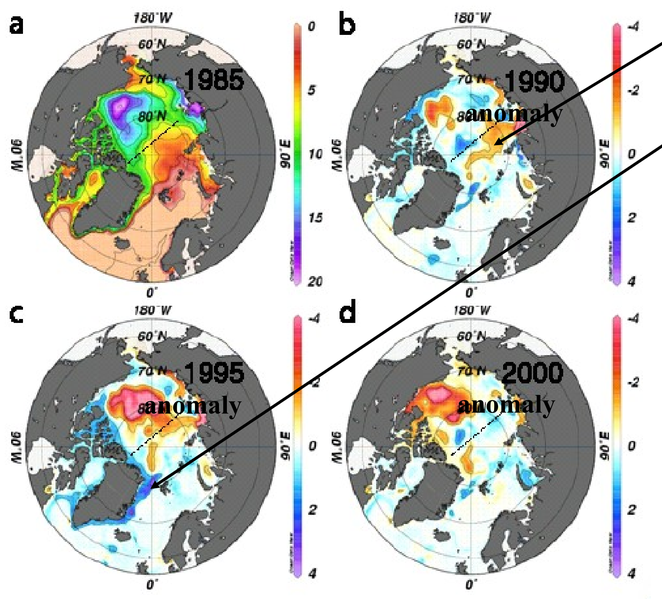
The dynamics of Arctic Ocean freshwater storage and release are investigated with the coupled ice-ocean model NAOSIM, driven with atmospheric reanalysis data from NCEP. The Great Salinity Anomaly (GSA) of the 1970s was triggered by an increased ice export. In contrast, a large freshwater outflow in the 1990s had ice and liquid components. It was preceeded by a re-structuring of the Arctic Ocean hydrography as a consequence of the record high state of the AO (NAO) between 1989 and 1995. After return to moderate vales of the AO index in recent years, the stratification has partially recovered. In contrast to the usual pattern, the river runoff, a key player in the freshwater freshwater dynamics of the Arctic, has been diverted to the eastern Siberian Seas for several years. This is reflected e.g. in δ^{18} O runoff tracer distribution simuated with the model. The simulated freshwater dynamics as analysed from salinity and δ^{18} O tracer are consistent with observations.

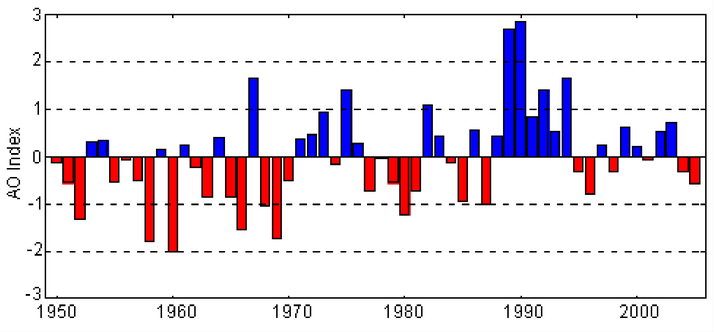
Upper 250m freshwater content shifts (rel. 34.8)



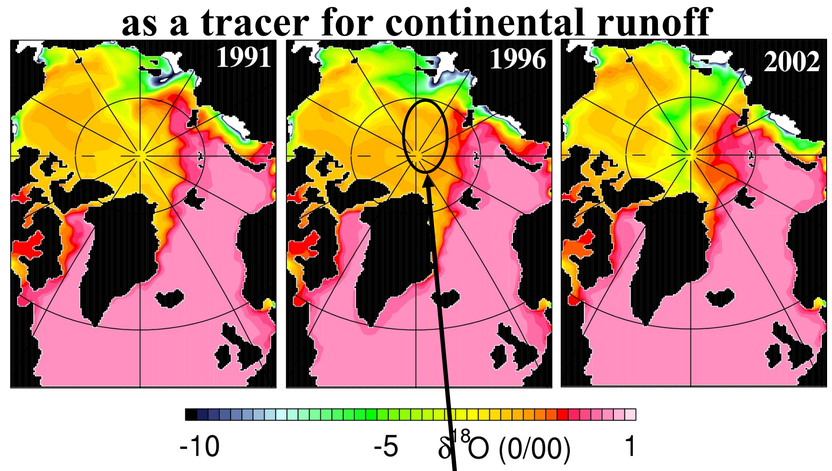
(Karcher, Gerdes, Kauker, Köberle und Yashayev, GRL 05)

Left: Anomaly of the upper 250 m freshwater content relative to 1985. The loss of freshwater in the Eurasian Basin and the Transpolar Drift in the early to mid 90s is evident, as is the maximum freshwater in the outflow areas

Annually-averaged Arctic Oscillation Index (AO) (www.cpc.ncep.noaa.gov)



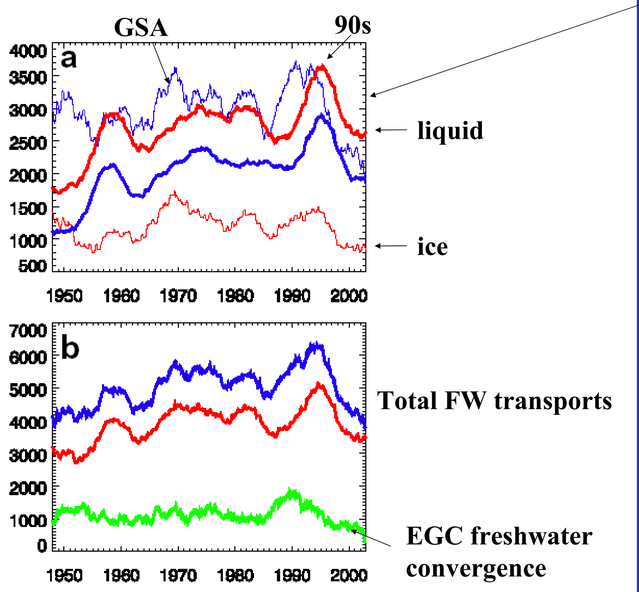
Simulated surface concentration of δ^{18} O as a tracer for continental runoff



Runoff signature in Transpolar Drift disappeared in 90s

Above: The shift of riverwater to the Eastern Siberian Sea occurs with a few years time lag to the extremely high AO, as is depicted by the δ^{18} O runoff tracer. In the late 90s/early 2000s the Transpolar Drift and the fresh Eurasian Basin have reestablished.

FW-Transport through Fram and Denmark straits

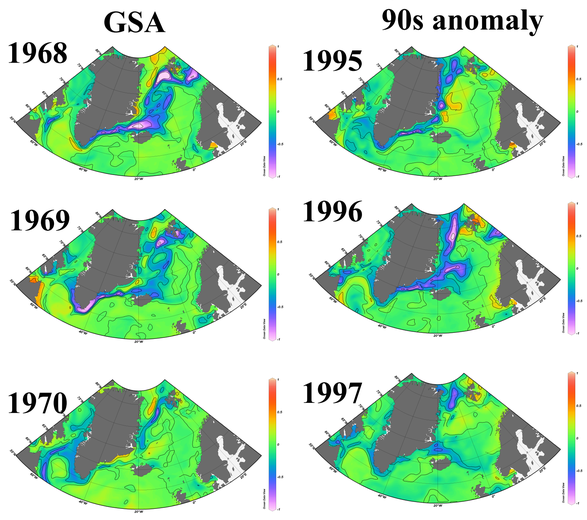


(Karcher, Gerdes, Kauker, Köberle und Yashayev, GRL 2005)

Left: While the ice export in Fram Strait (thin blue) reacts instantaneously on the AO changes, the hydrography (see above left and right) and the liquid freshwater outflow (thick blue) react with a time lag of several years. Due to convergence of freshwater transports between Fram Strait and Denmark Strait a net input of freshwater due to the 90s event took place in the Nordic Sea.

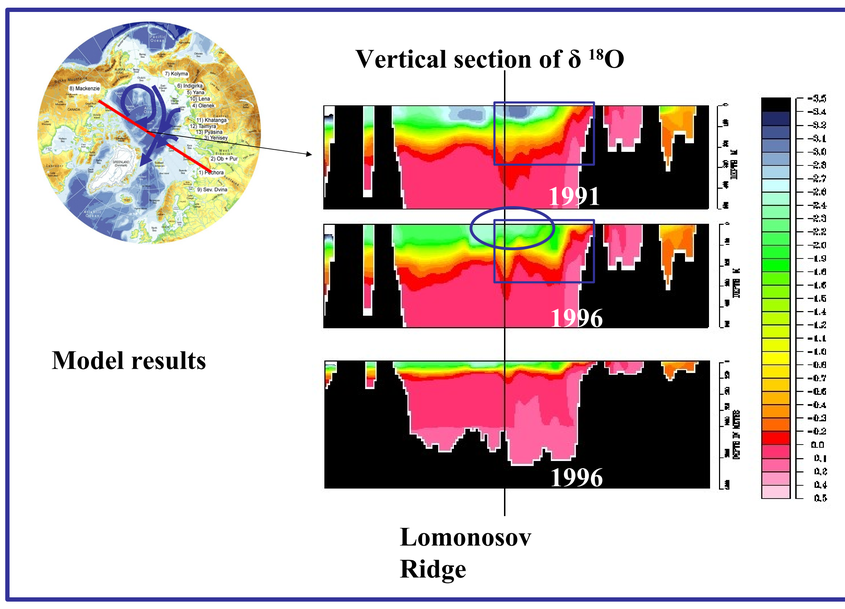
Below: For both extreme events, the GSA and the 90s anomaly, large surface salinity anomalies flush the Nordic Sea and the Labrador Sea.

SSS anomaly



Left: Low salinity outflow events during the GSA and the 90s anomaly are also found in observations from DenmarkStrait, confirming the model results. This is also true for the fact that the GSA had ist strongest expression at the surface and 90s anomaly was more evenly distributed in the water column. This reflects the different sources: high ice export (GSA) and large liquid export from the Arctic (90s anomaly)

Vertical section of δ^{18}O

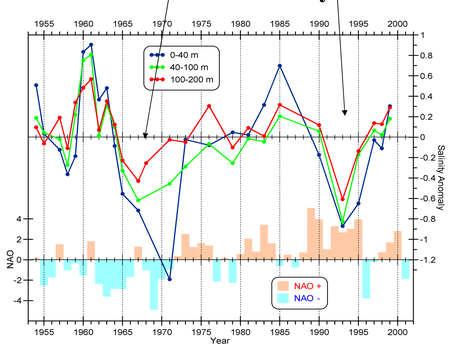


Above: A vertical section of simulated δ^{18} O in 1991 and 1996 reveal the deep reaching shift of runoff signature.

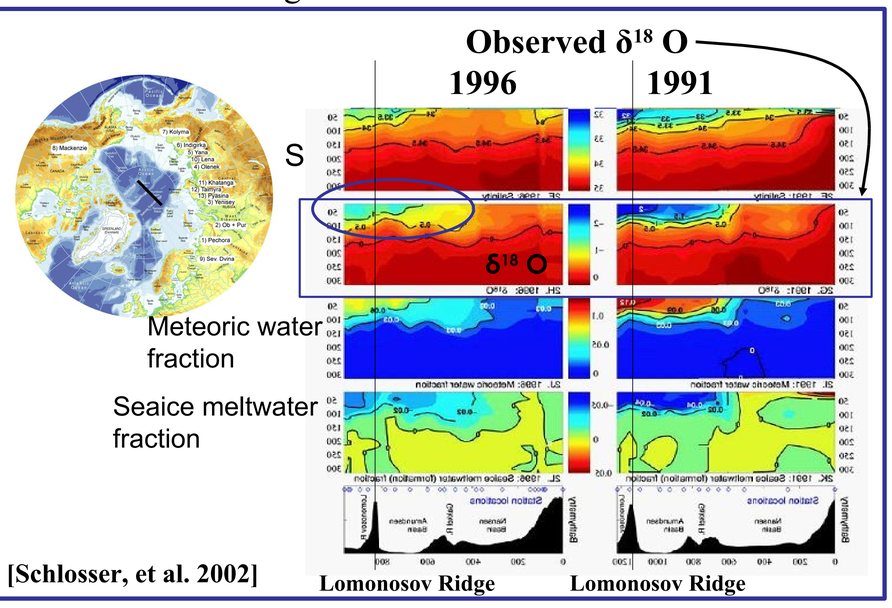
Below: Observations from the same section (reversed for same direction of view, blue square) show the missing freshwater being mainly a missing runoff signal in 1996, with some contribution of missing seaice meltwater.

Denmarkstrait low salinity releases: GSA and mid-90s

Observed EGC-Salinity



(Karcher, Gerdes, Kauker, Köberle und Yashayev, GRL 2005)



Our investigations highlight the potential of GCM investigations including realistic tracers, in close interaction with observational work.

Here we have gained insight into the internal dynamics of Arctic Ocean freshwater storage, pathways and release, an important component of the meridional overturning circulation.