Observed and Simulated Variability of the North Atlantic Sub-Polar Gyre

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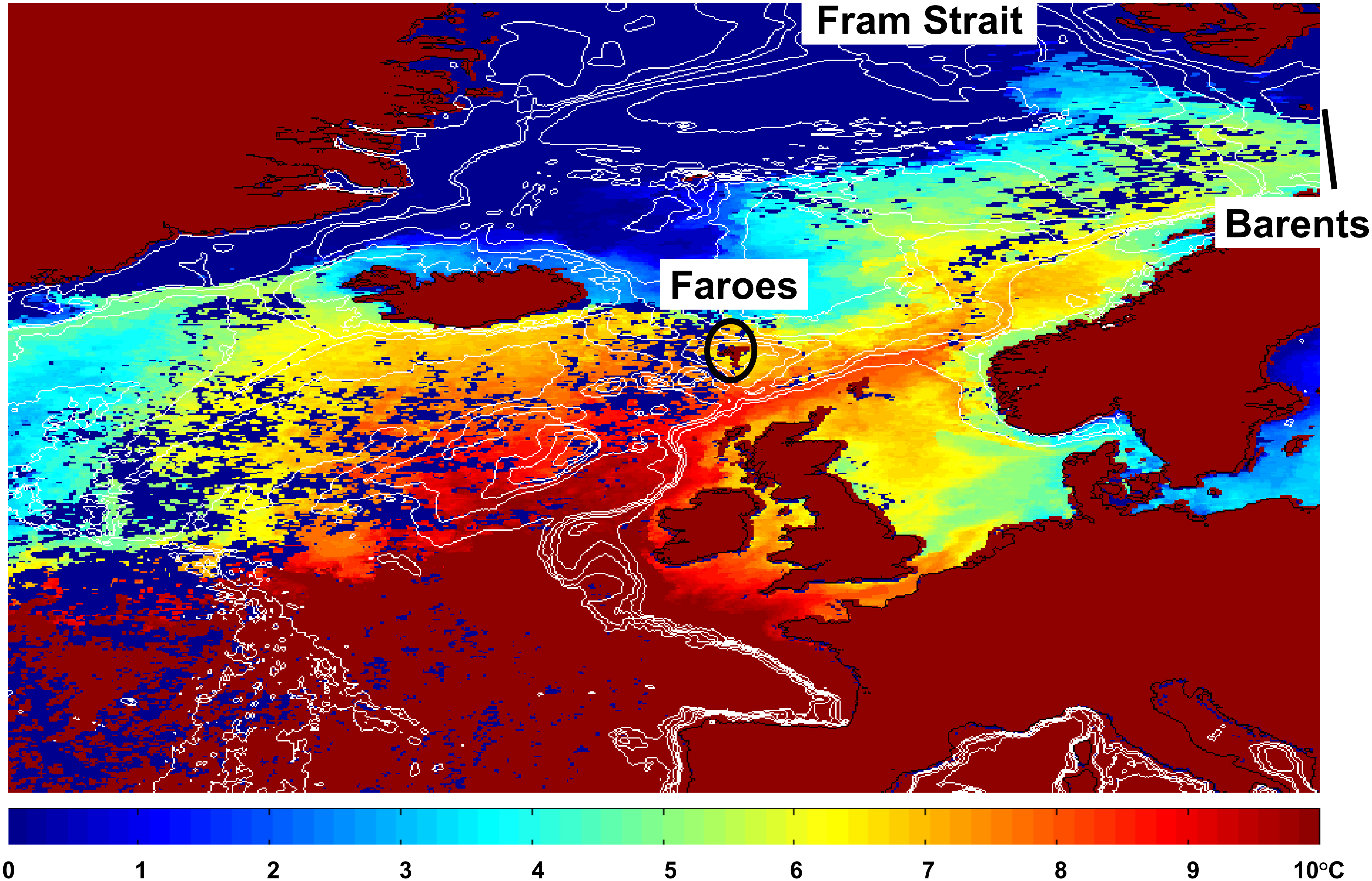
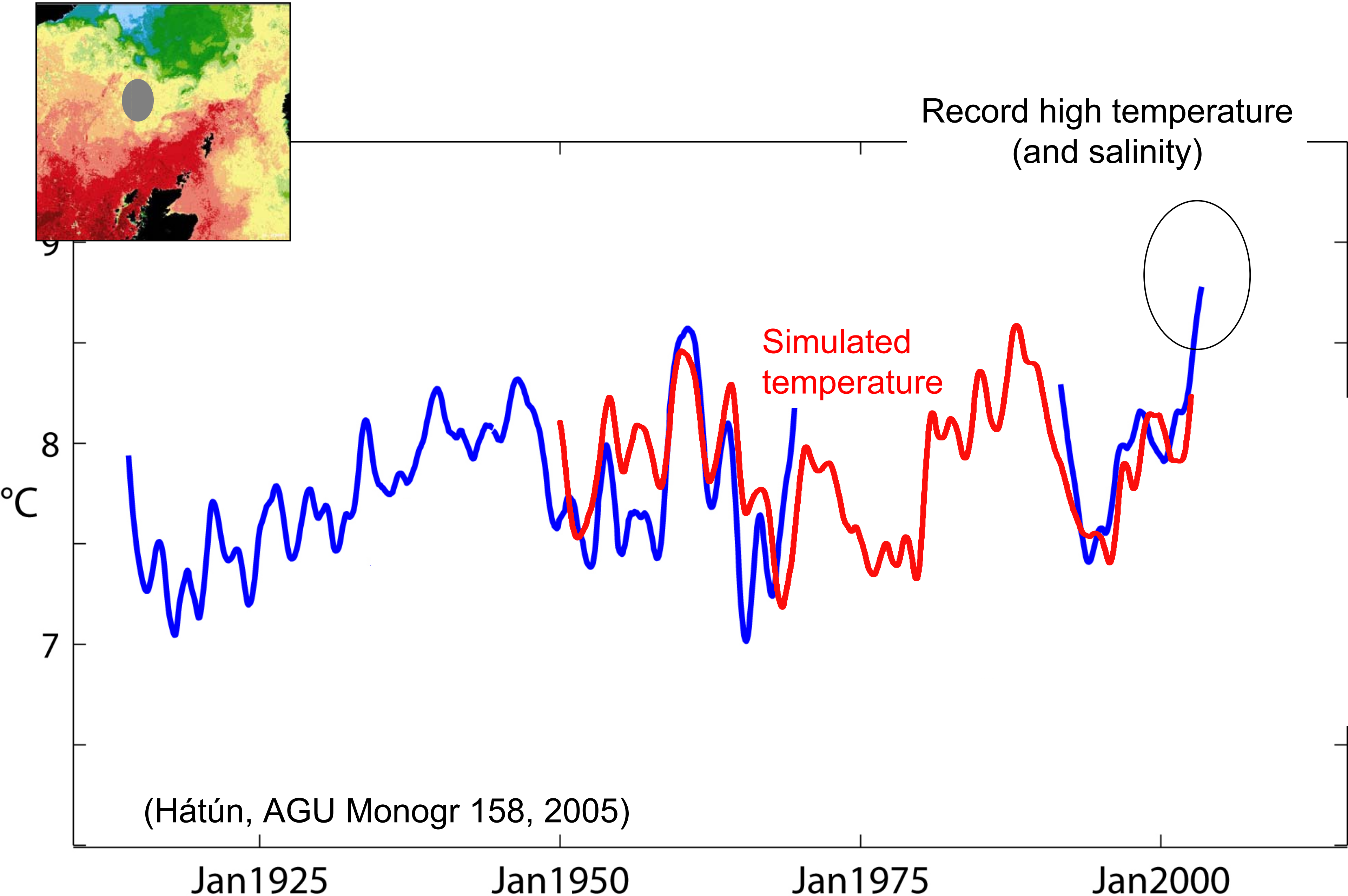
Observed hydrography, N Atl/Nordic Seas

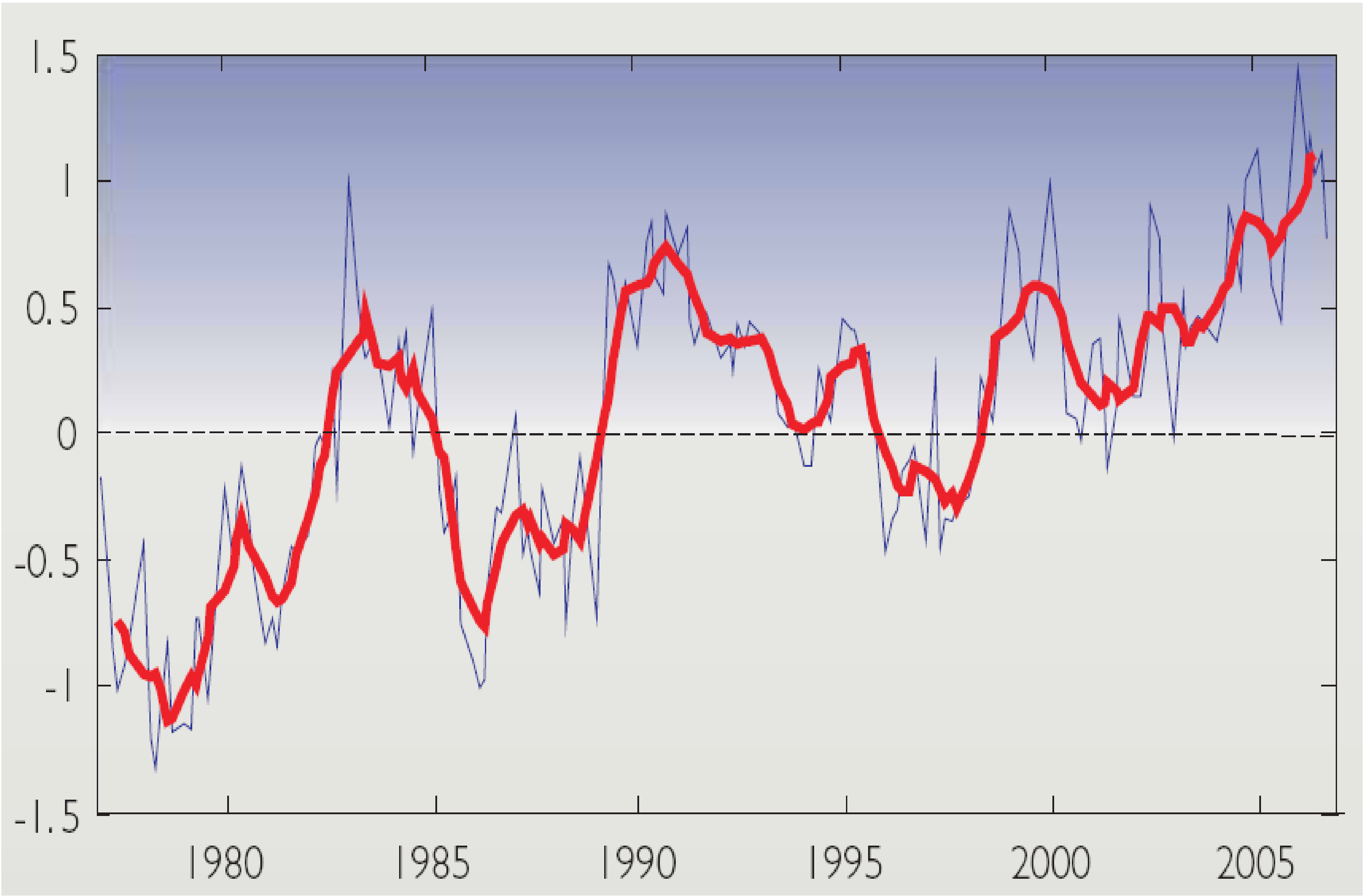
(NB: post 95-changes!)



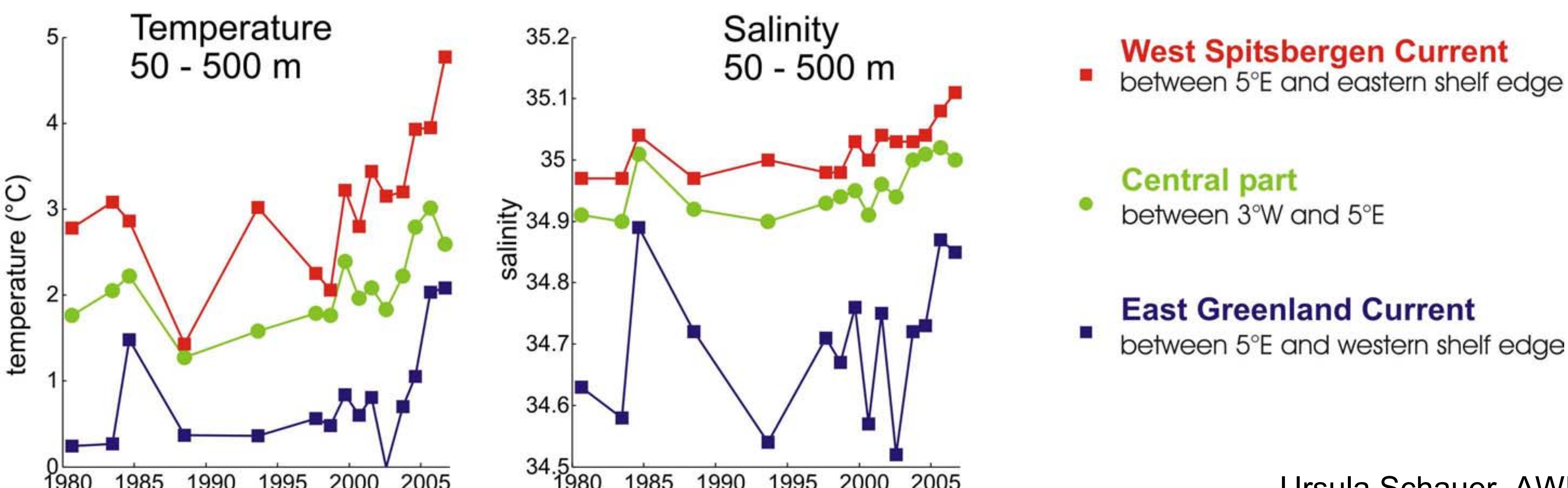
SST variability (Atl inflow), Faroe Islands



Temperature anomaly (ºC), 50-200 m Barents Sea



Ingvaldsen, Loeng and Ådlandsvik, 2007



Ursula Schauer, AWI

Influence of the Atlantic Subpolar Gyre on the Thermohaline Circulation

Hjálmar Hátún,[1,2]* Anne Britt Sandø,[3,4] Helge Drange,[3,4,5,6] Bogi Hansen,[1] Heðinn Valdimarsson[7]

During the past decade, record-high salinities have been observed in the Atlantic Inflow to the Nordic Seas and the Arctic Ocean, which feeds the North Atlantic thermohaline circulation (THC). This may counteract the observed long-term increase in freshwater supply to the area and tend to stabilize the North Atlantic THC. Here we show that the salinity of the Atlantic Inflow is tightly linked to the dynamics of the North Atlantic subpolar gyre circulation. Therefore, when assessing the future of the North Atlantic THC, it is essential that the dynamics of the subpolar gyre and its influence on the salinity are taken into account.

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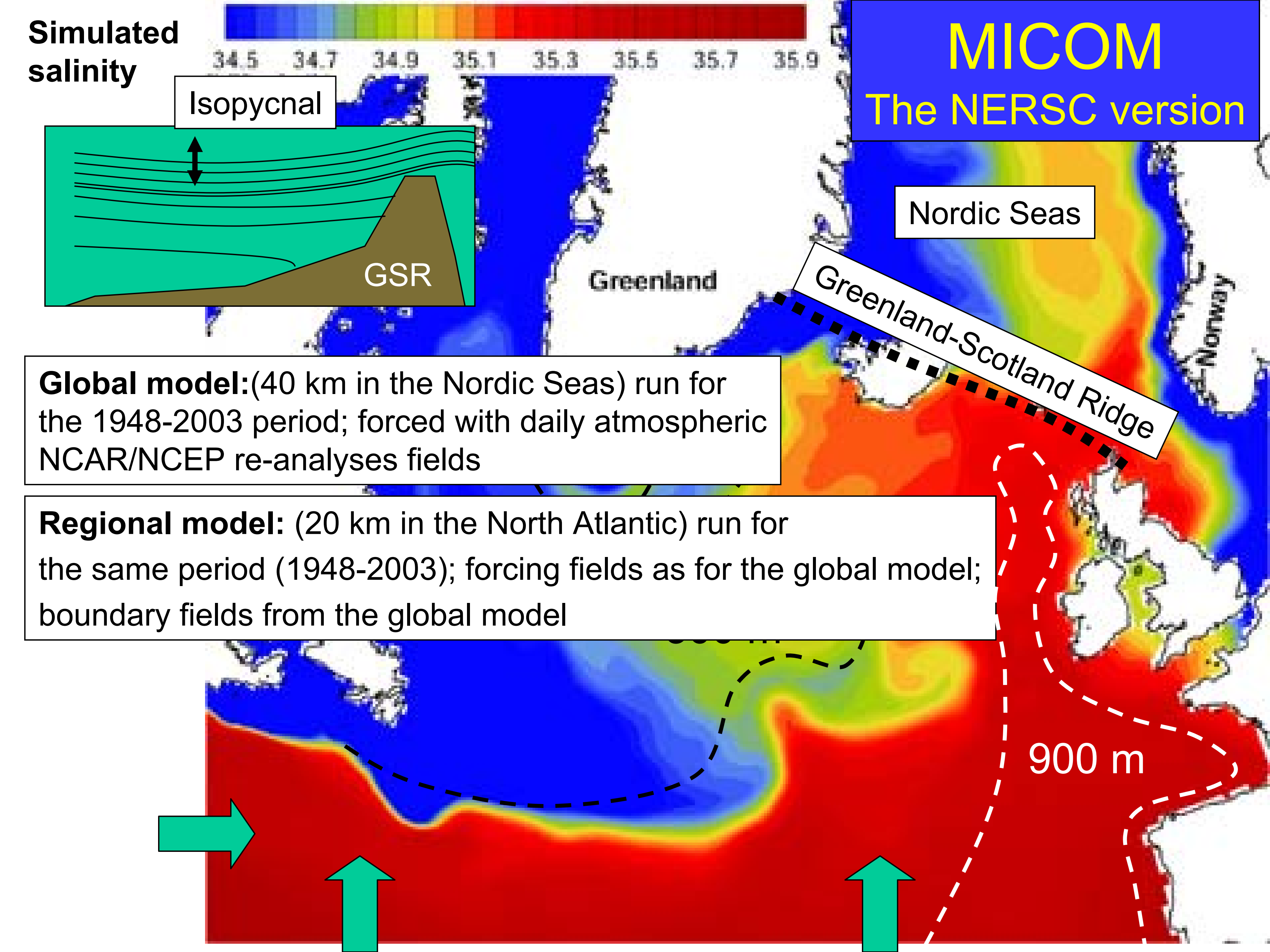
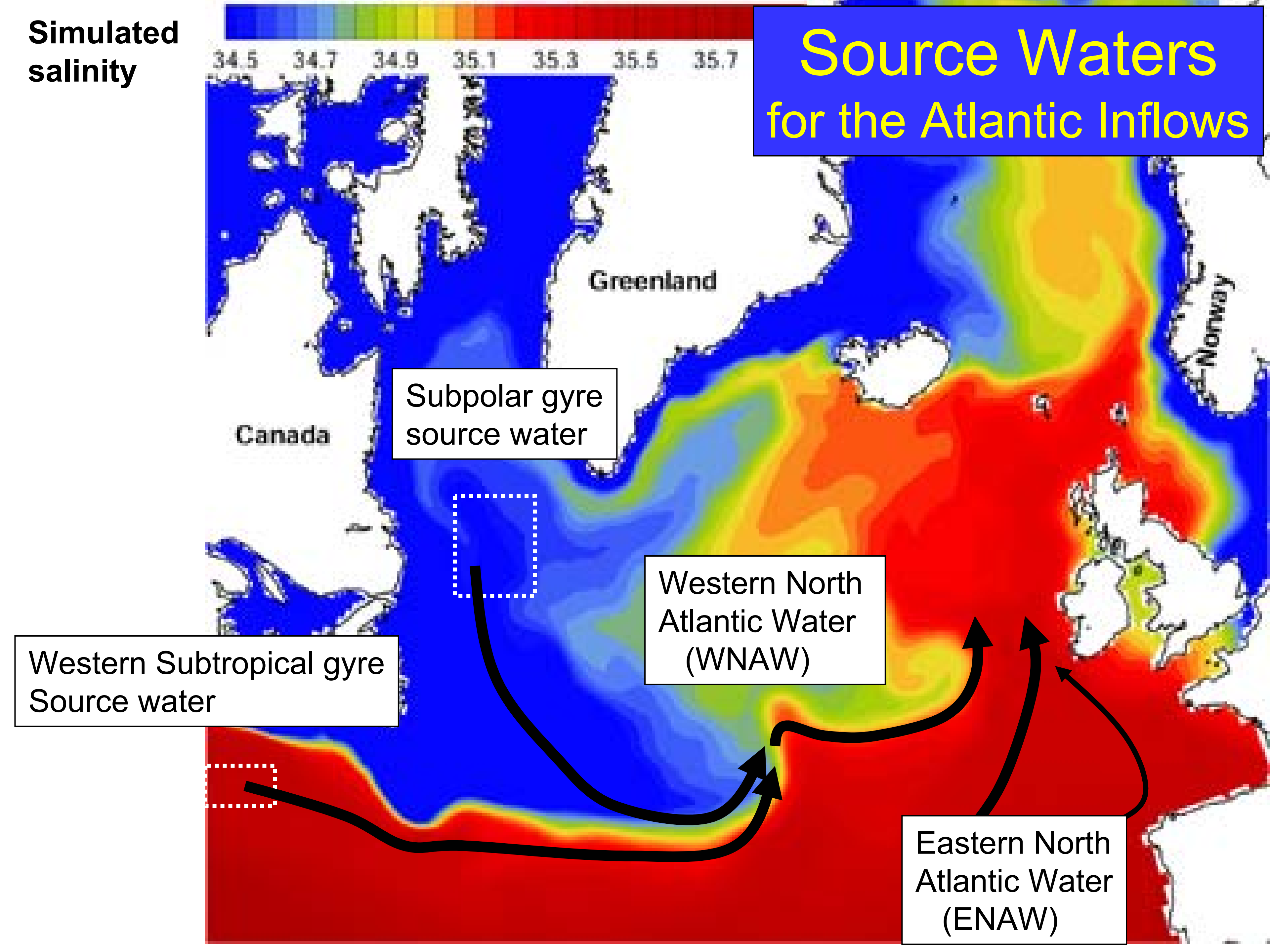
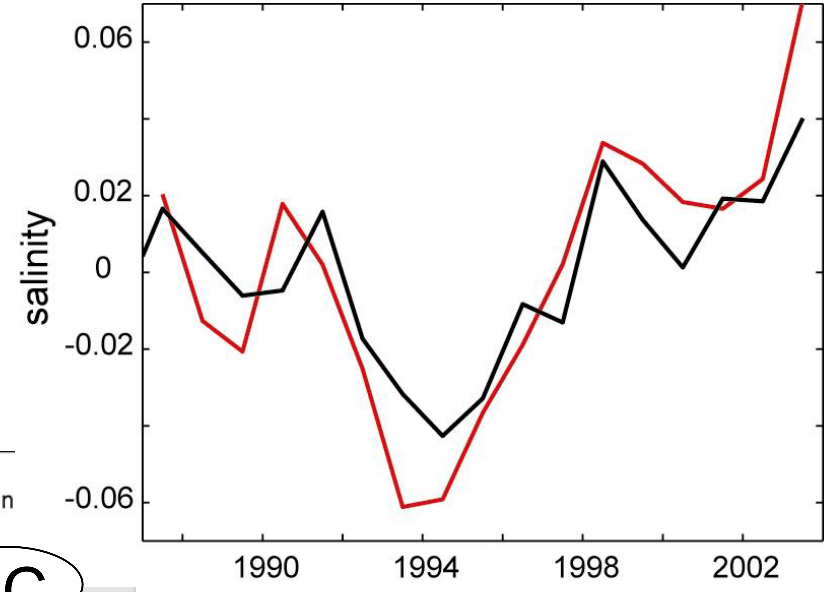
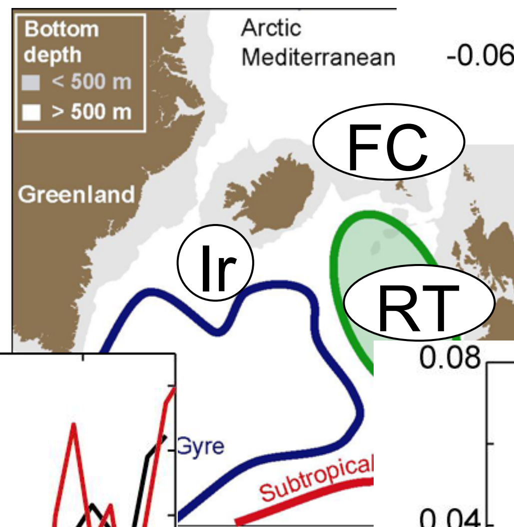

Simulated salinity
34.5
34.7
34.9
35.1
35.3
35.5
35.7
35.9
MICOM
The NERSC version
Isopycnal
GSR
Greenland
Nordic Seas
Greenland-Scotland Ridge
Norway
Global model:(40 km in the Nordic Seas) run for the 1948-2003 period; forced with daily atmospheric NCAR/NCEP re-analyses fields
Regional model: (20 km in the North Atlantic) run for the same period (1948-2003); forcing fields as for the global model; boundary fields from the global model
900 m

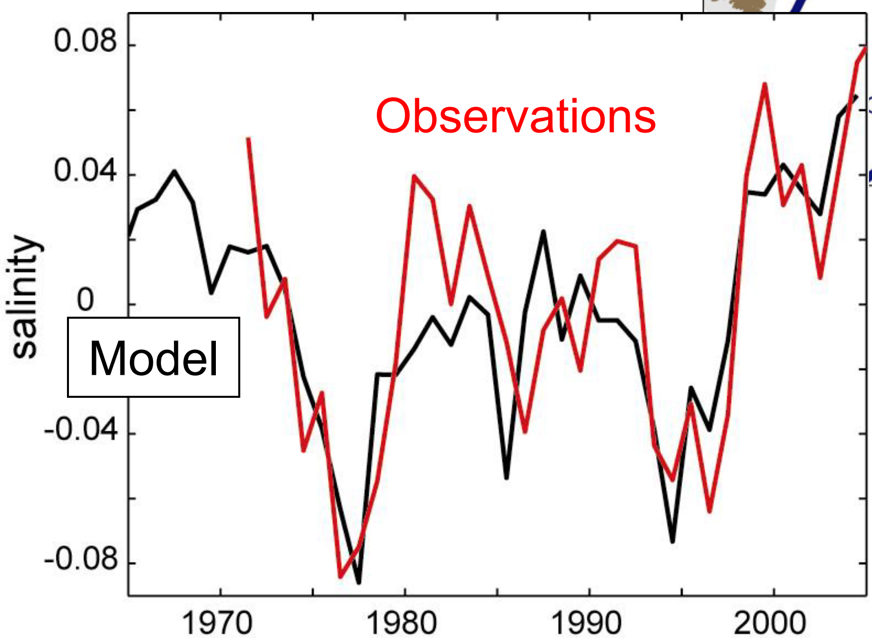
Source Waters for the Atlantic Inflows

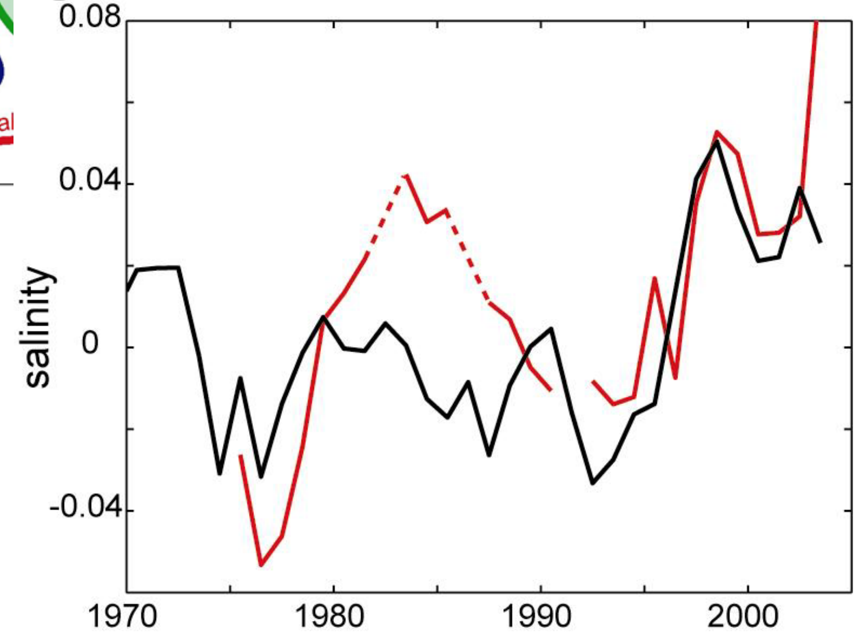


Observed and simulated Inflow salinities





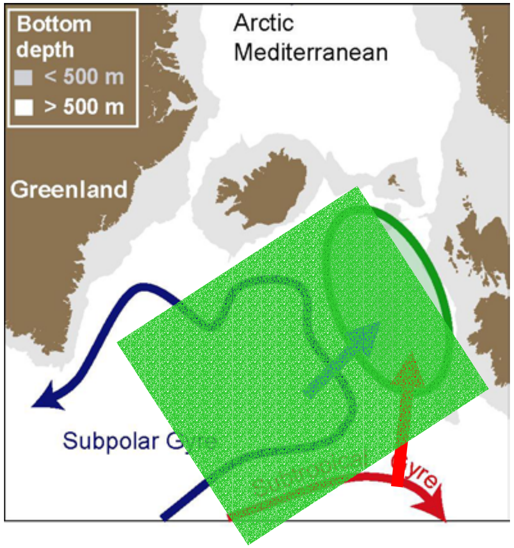




Possible mechanisms causing the Inflow salinity variability

4) Evaporation minus Precipitation (E-P)

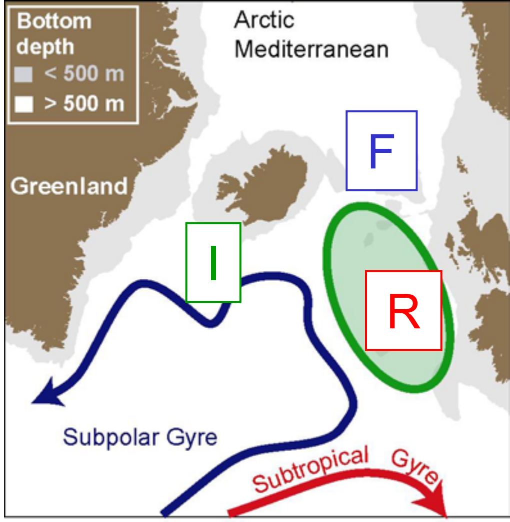
3) Salinity variability in the Subpolar gyre (SPG)



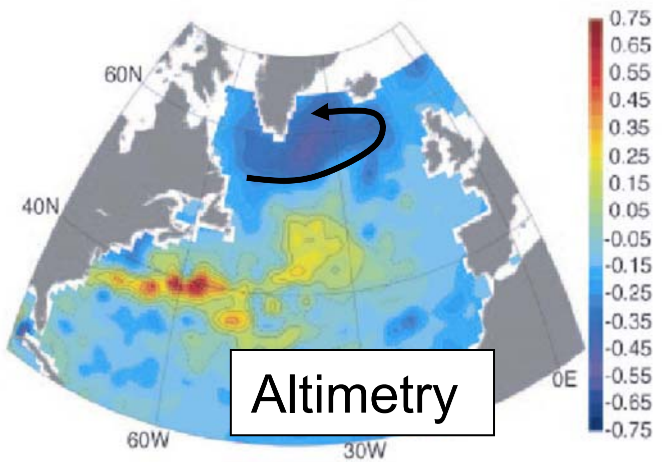
1) Relative contribution from the two gyres (Dynamics)

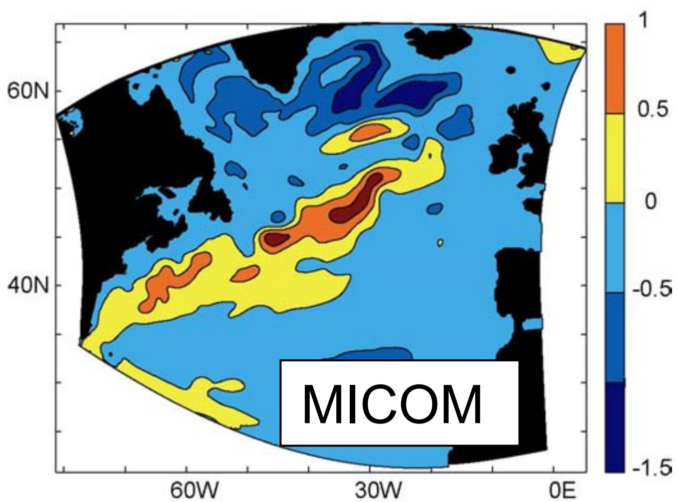
2) Salinity variability in the subtropical gyre (STG)

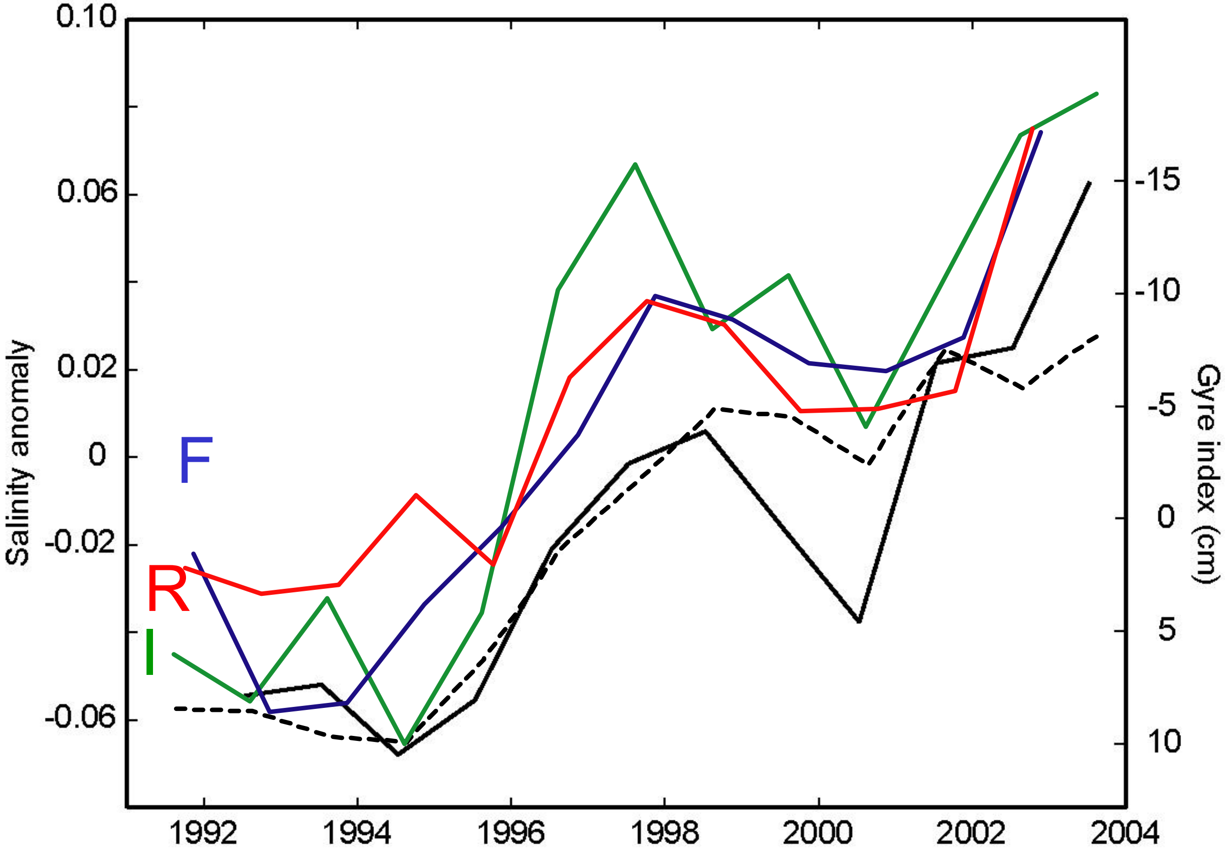
Dynamical SPG influence



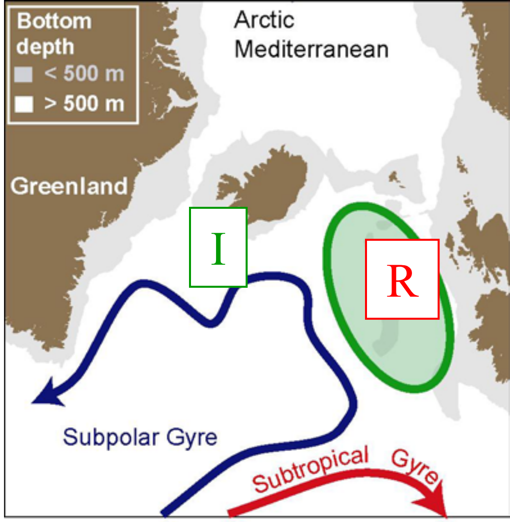
SSH EOF (Häkkinen and Rhines, Science, 2004)

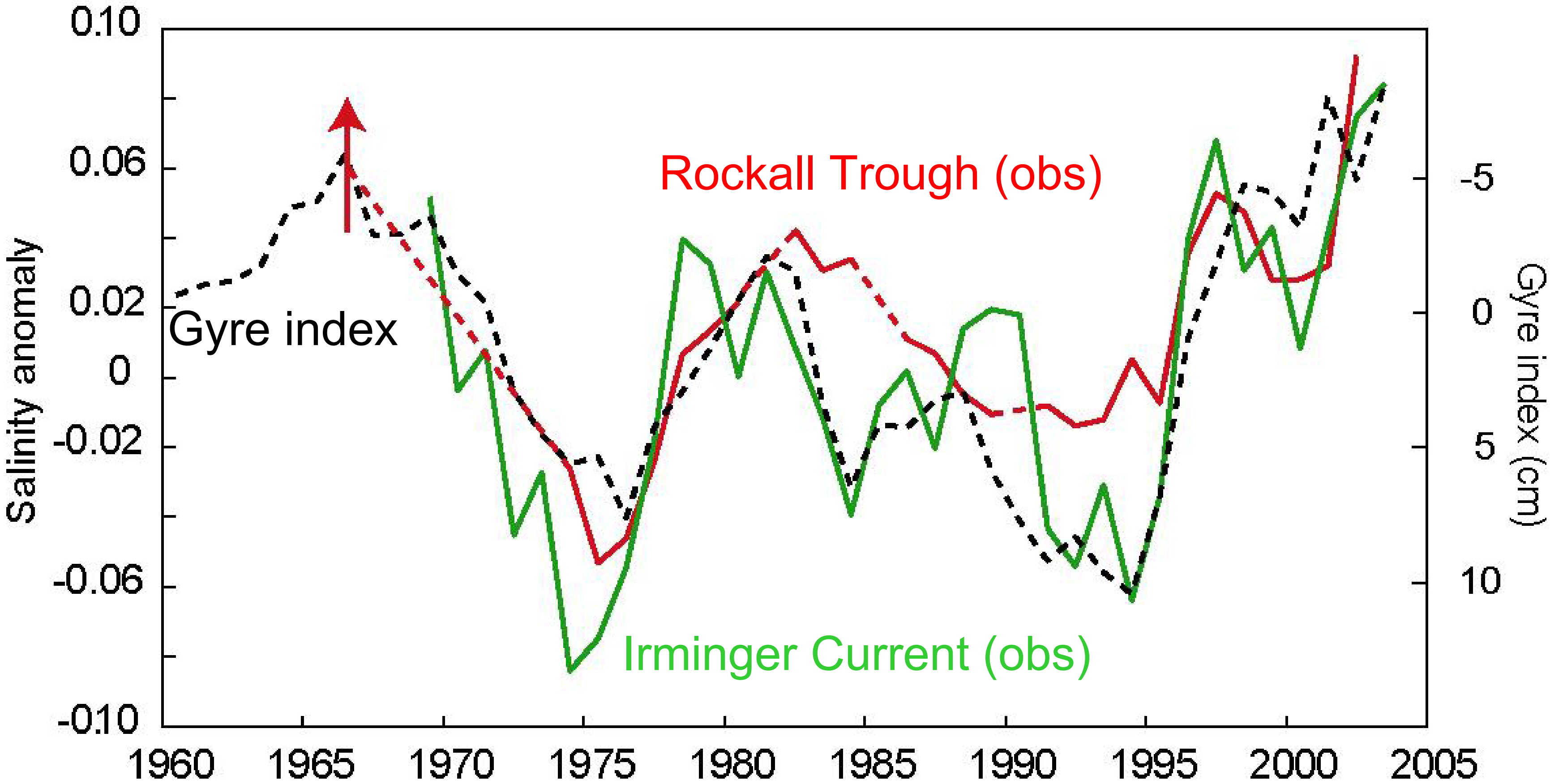




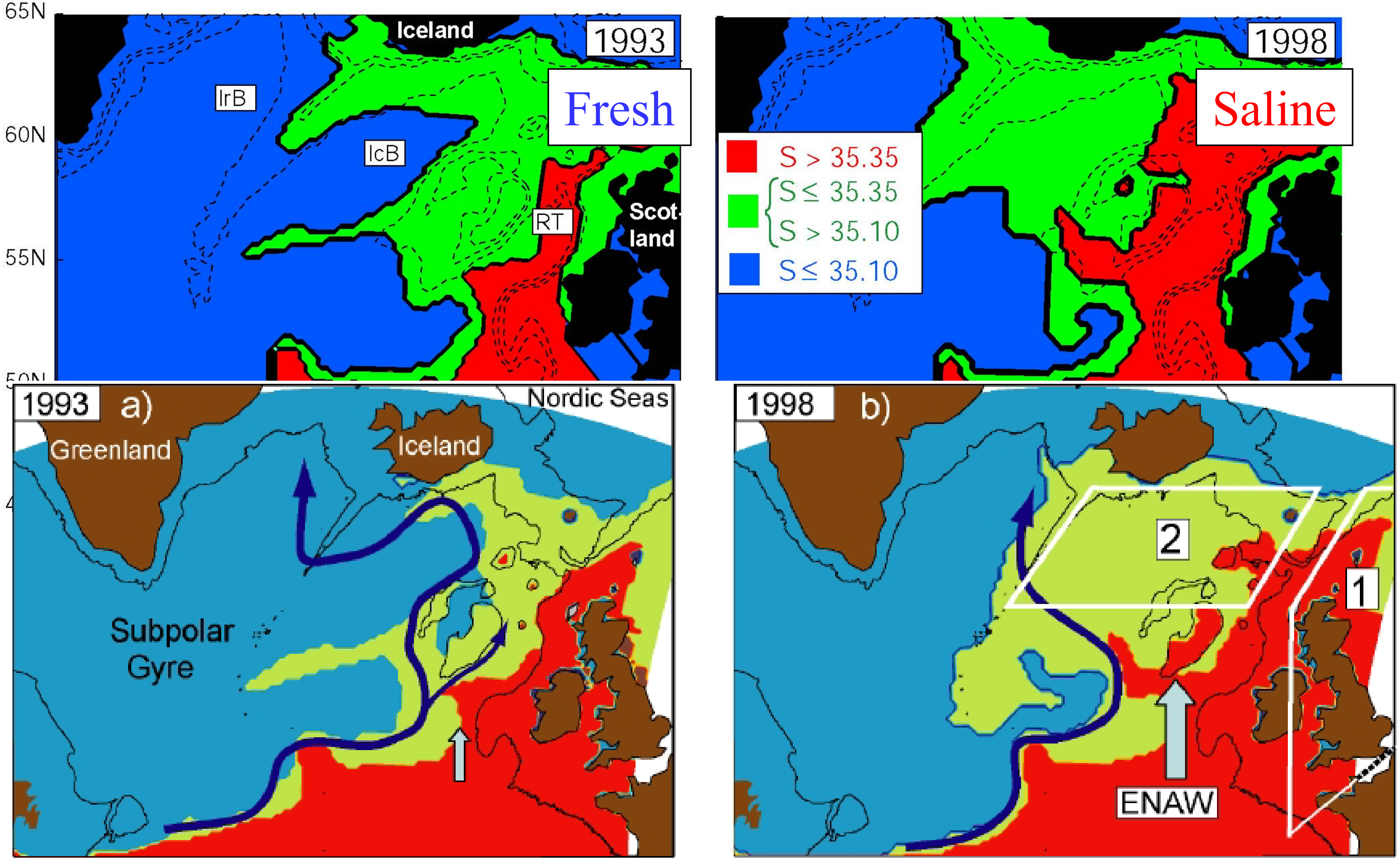


A longer term perspective



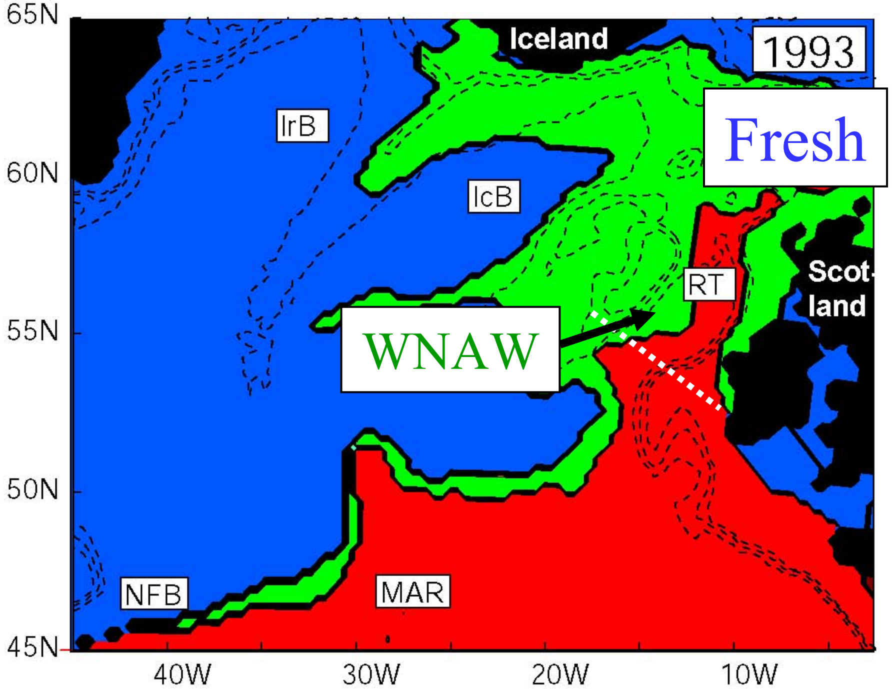


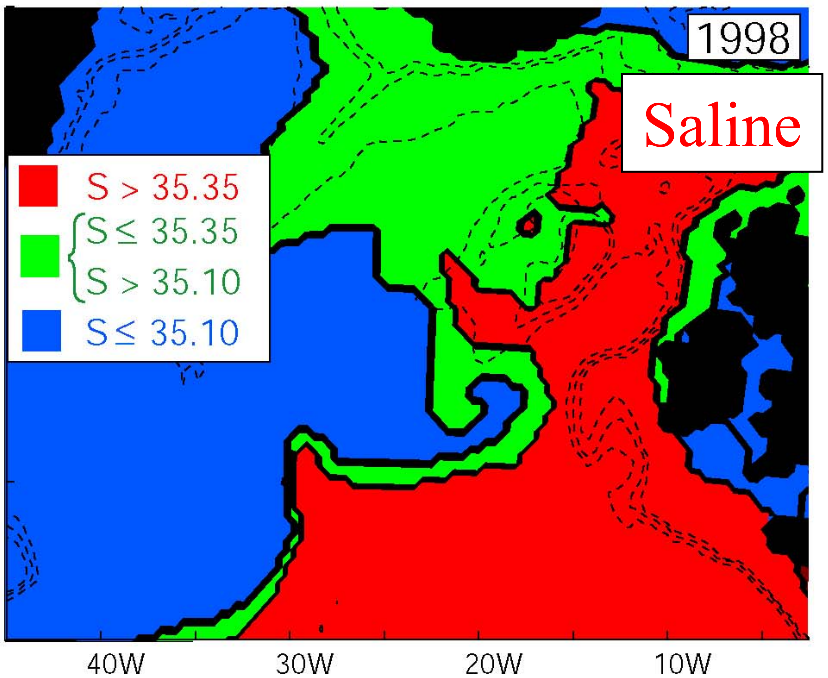
Relative contribution from the two gyres

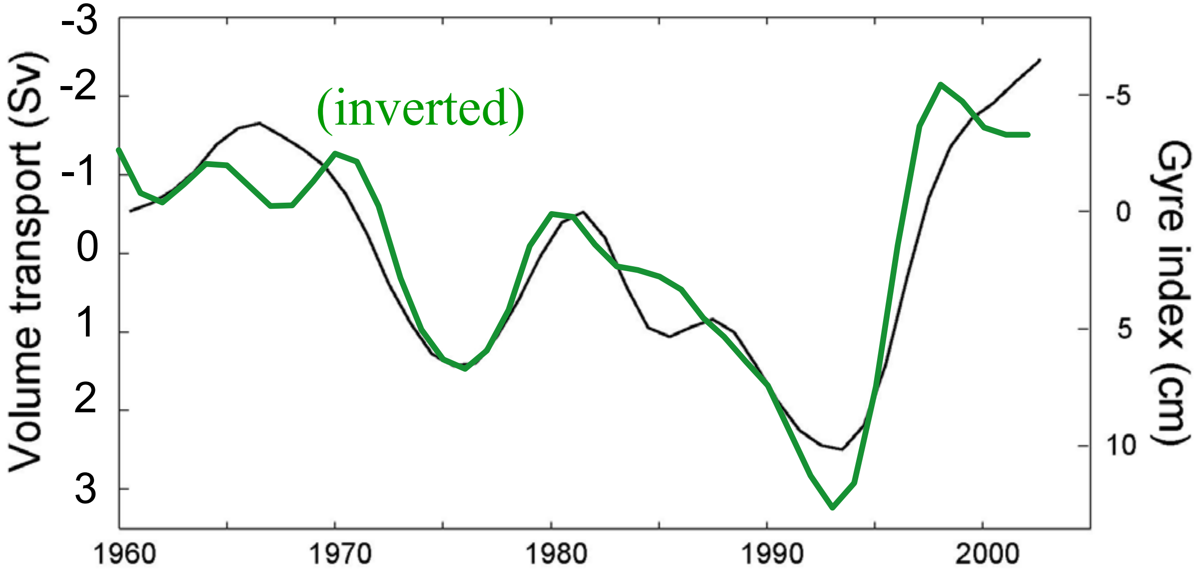


Simulated temperature (σ < 27.38)

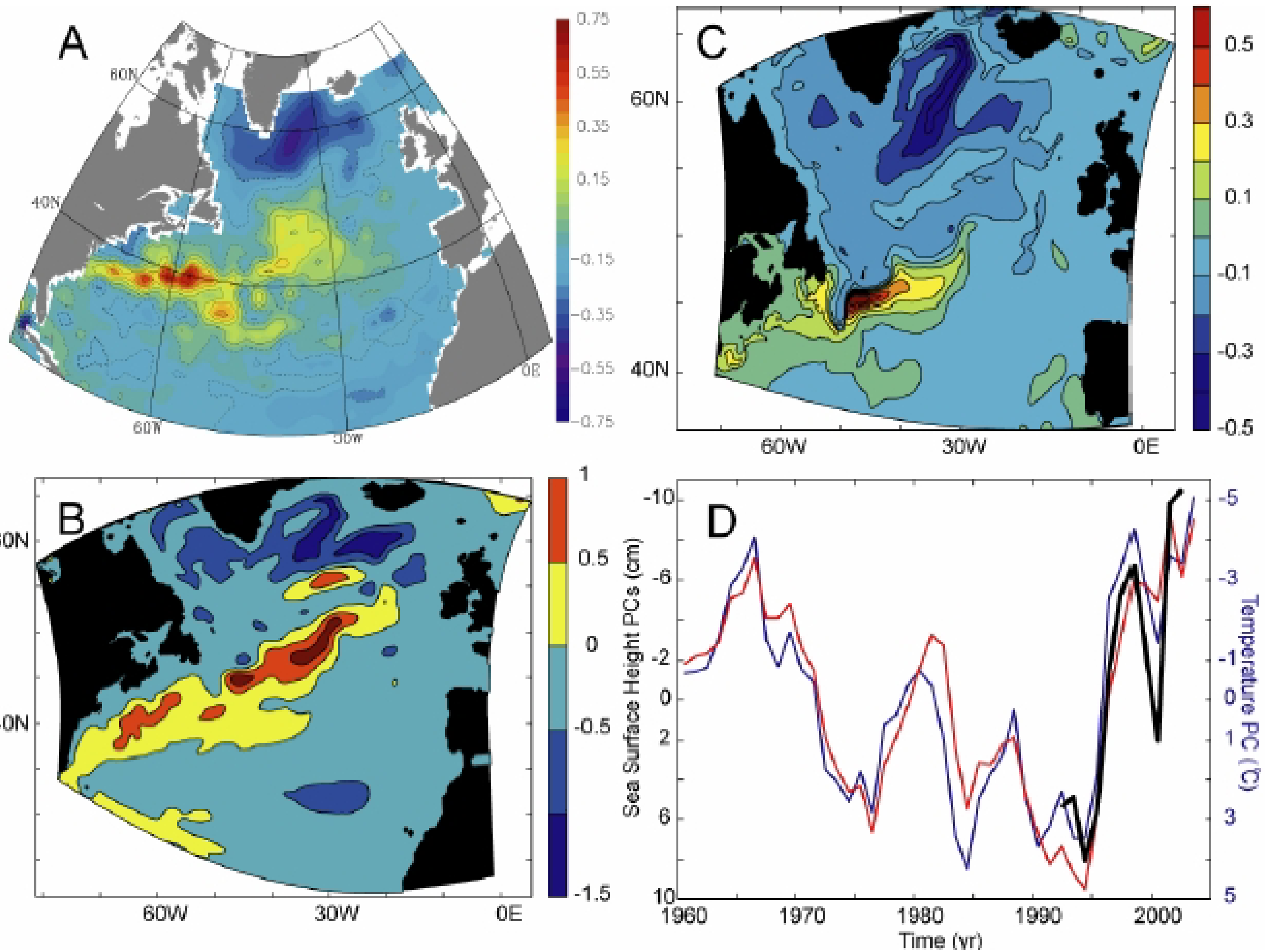
Relative contribution from the two gyres

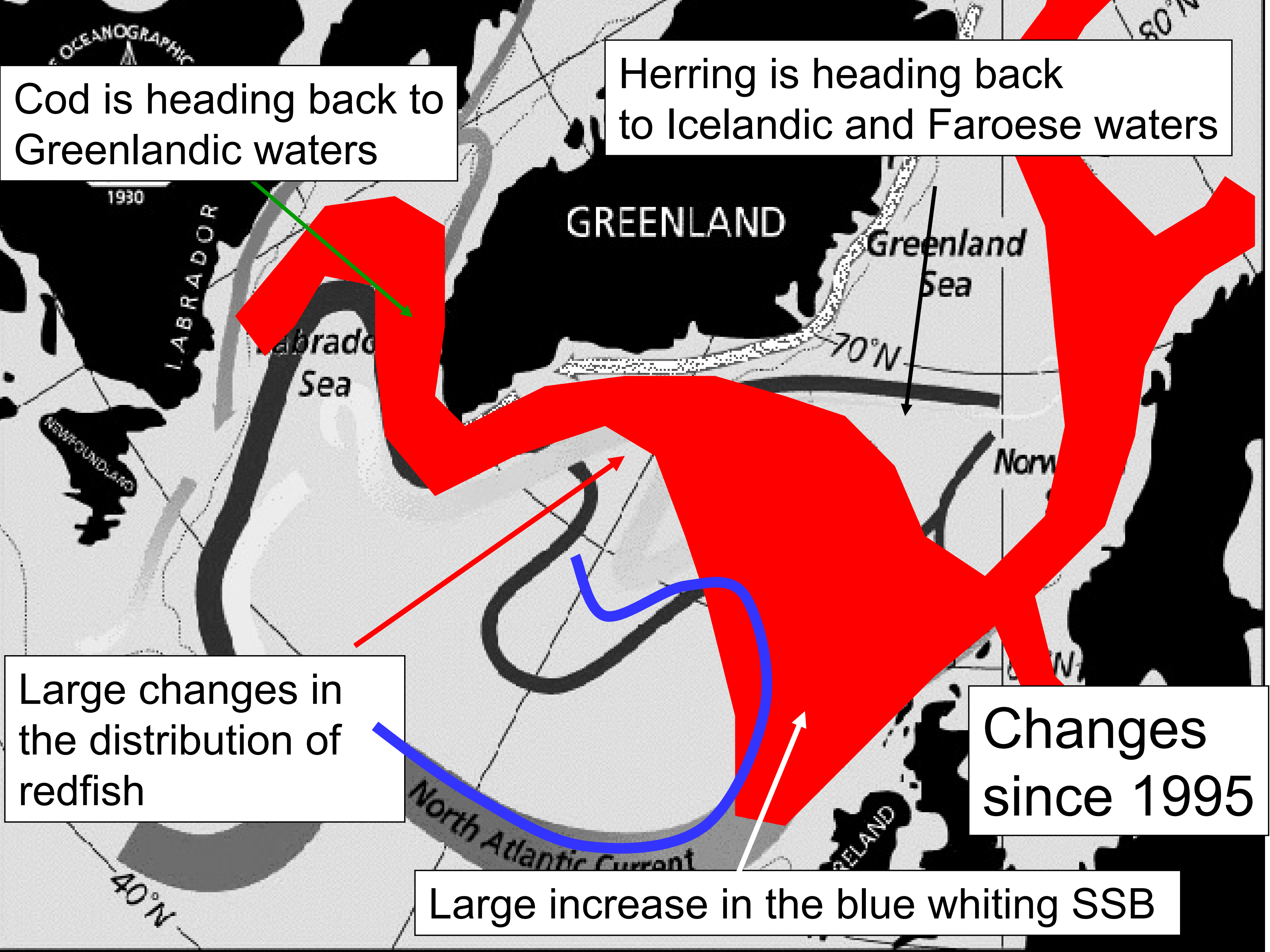






Relationship valid for temperature also!

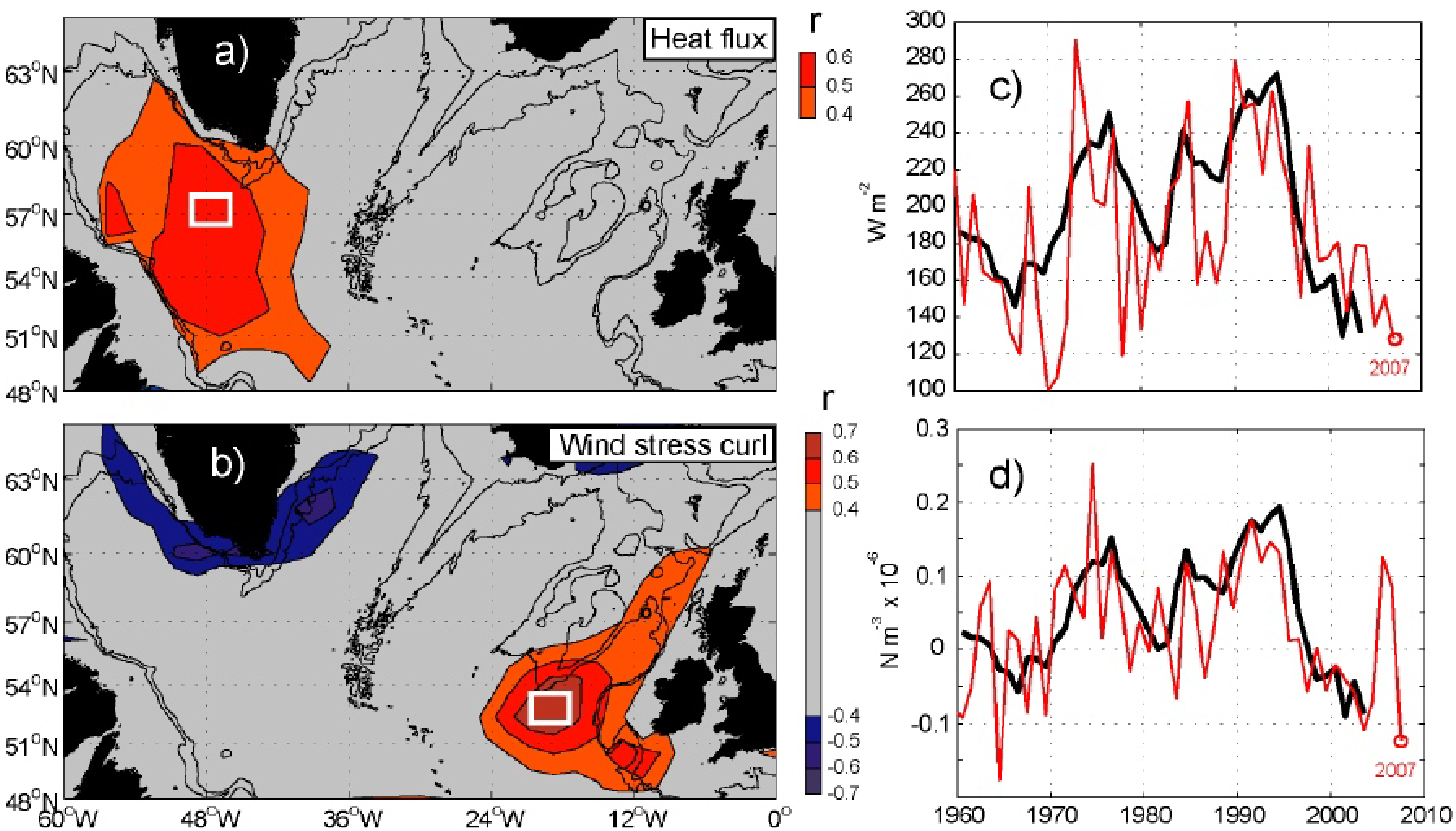




Cod is heading back to Greenlandic waters
Herring is heading back to Icelandic and Faroese waters
Large changes in the distribution of redfish
Changes since 1995
Large increase in the blue whiting SSB
1930
LABRADOR
GREENLAND
Greenland Sea
70°N
NEWFOUNDLAND
North Atlantic Current
40°N

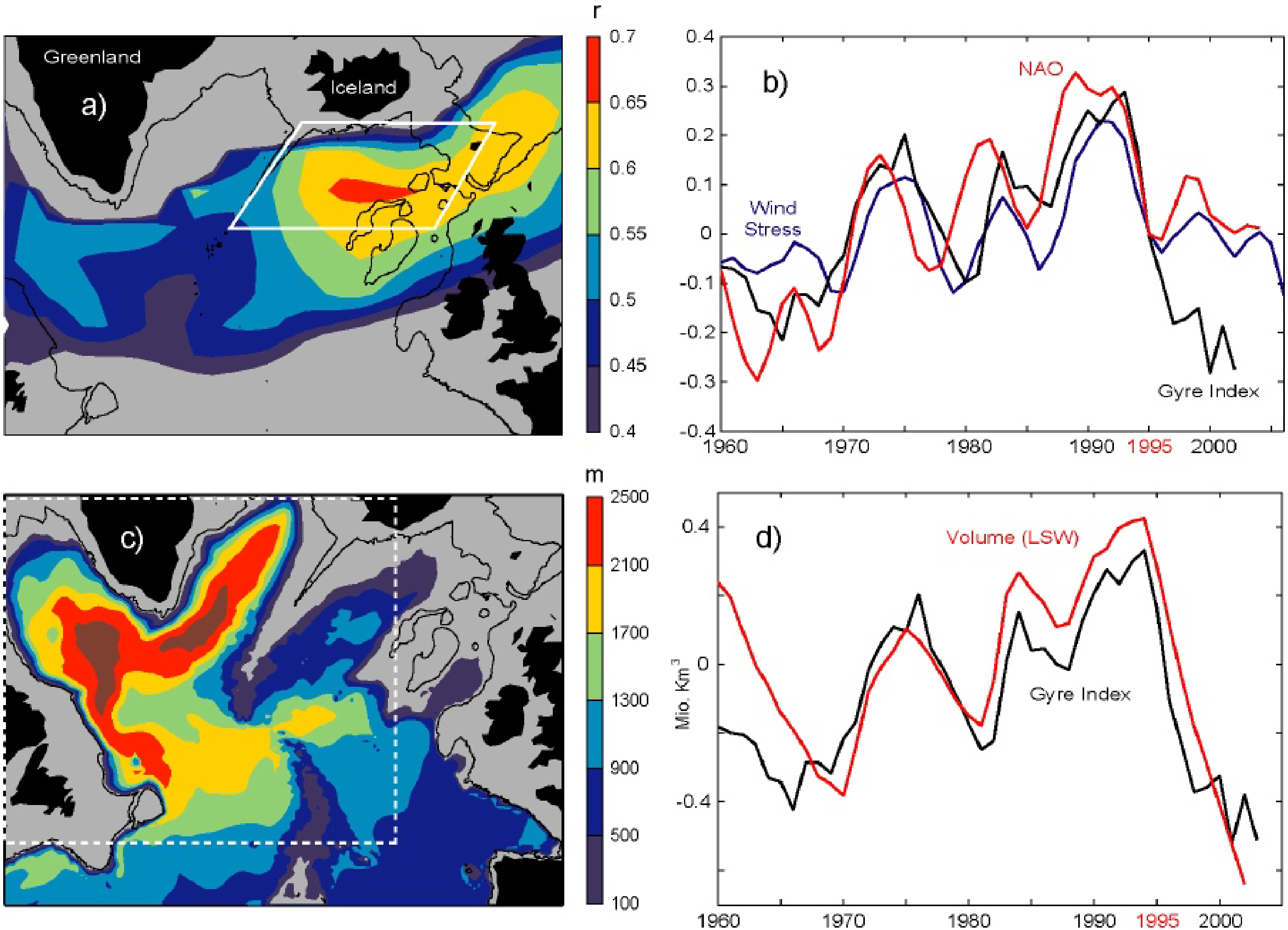

JOTUN Arctic
DEVOLD
Bergans
Lincoln Sea
Wandel Sea
Peary Land
Greenland Sea
Qaanaaq (Thule)
Pituffik (Thule Air Base)
Nordgrønland
Nordøstgrønland National Park
Greenland
(Denmark)
Baffin Bay
Upernavik
Vestgrønland
Østgrønland
Jameson Land
Disko
Uummannaq (Umanak)
Ilulissat (Jakobshavn)
Aasiaat (Egedesminde)
Qasigiannguit (Christianshåb)
Gunnbjørn Fjeld
3700
Sisimiut (Holsteinsborg)
Kangerlussuaq (SøndreStrømfjord)
Maniitsoq (Sukkertoppen)
Davis Strait
Tasiilaq (Angmassalik)
Denmark Strait
ICELAND
Nuuk (Godthåb)
ATLANTIC OCEAN
Paamiut (Frederikshåb)
Ivittuut (Ivigtut)
Narsarsuaq
Qaqortoq (Julianehåb)
Uummannarsuaq (Kap Farvel)
400 km

Foring mechanisms



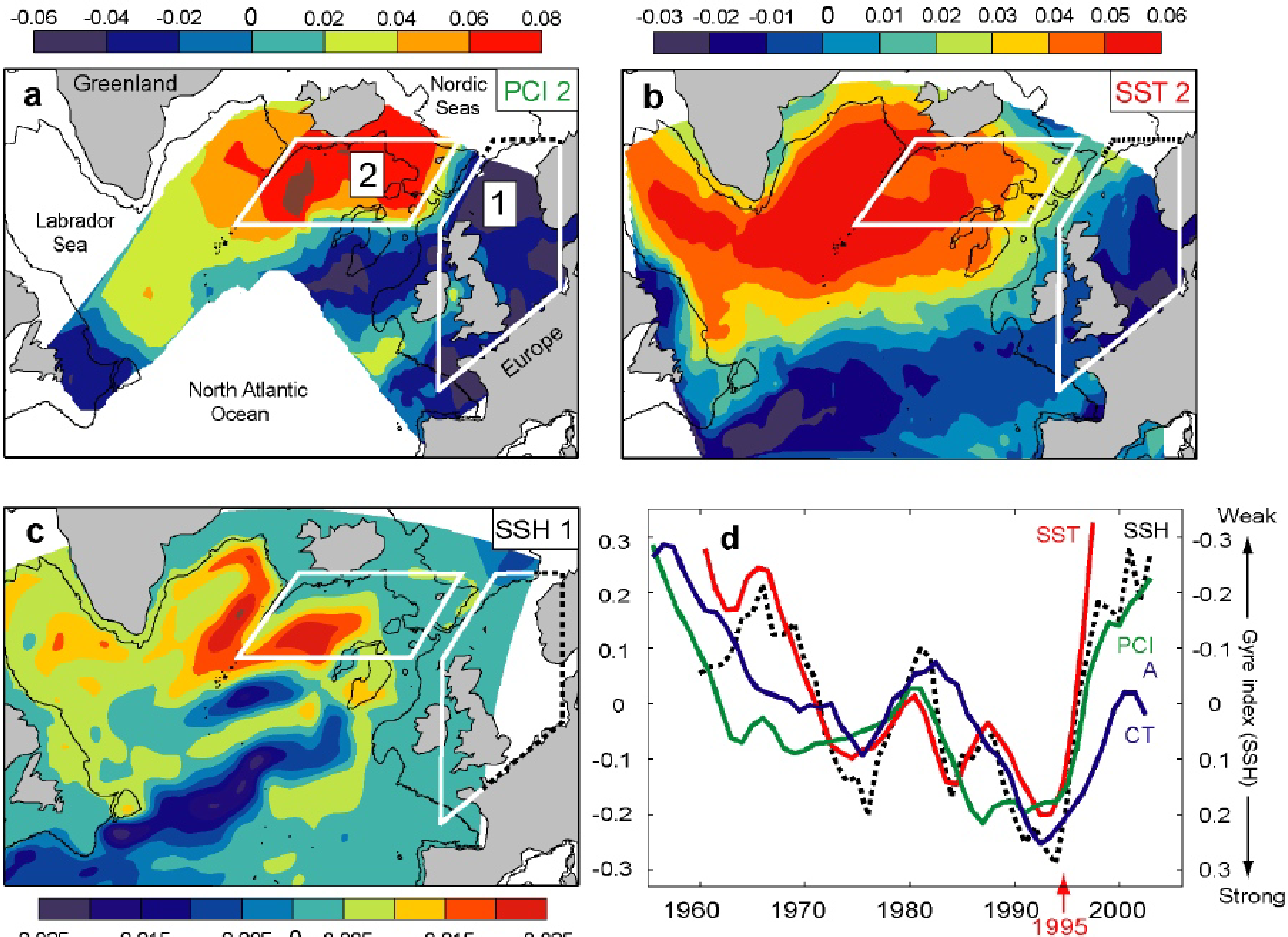
Hatun et al., 2007

Foring mechanisms



Hatun et al., 2007

Influence on phyto and zooplankton



Hatun et al., 2007

Summary

1) On decadal/multi-decadal time scales, the salinity of the Atlantic inflow to the Arctic Mediterranean is controlled by the intensity of the SPG circulation

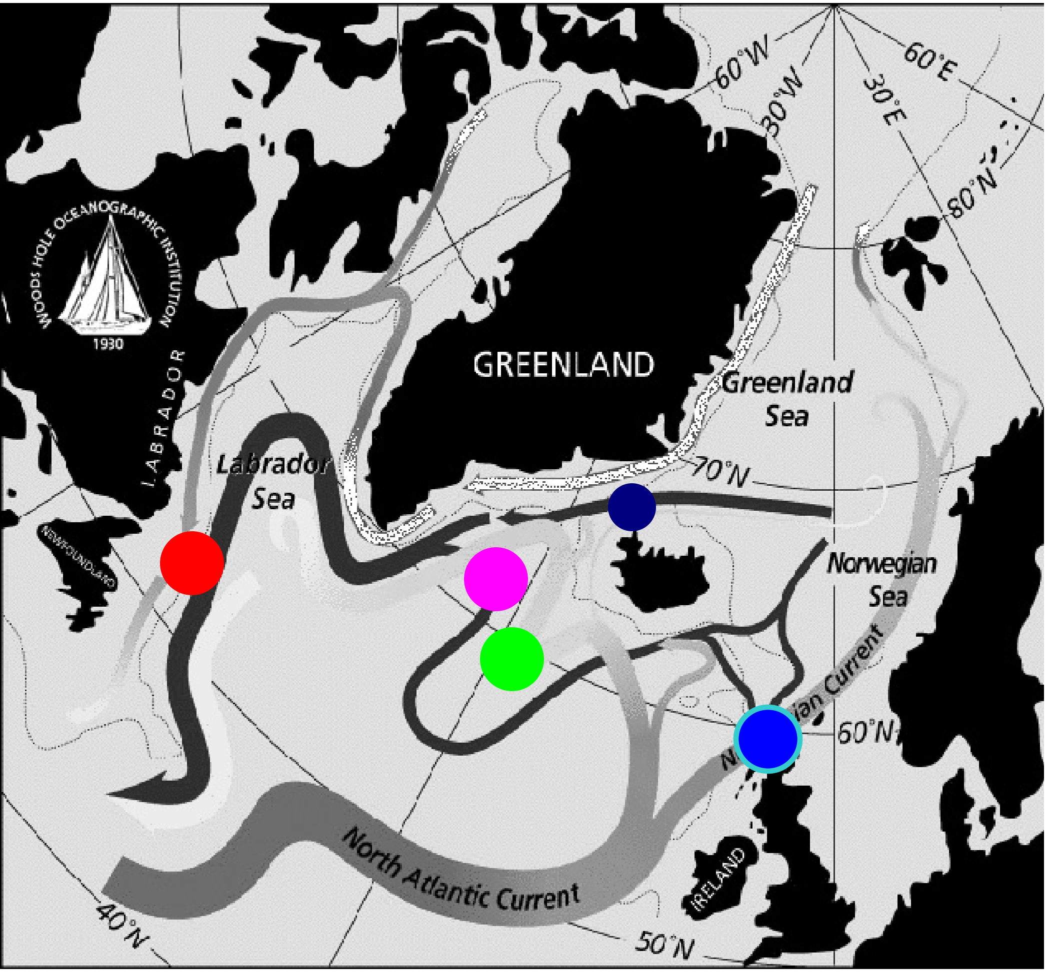
2) The strength of the SPG is governed by the local (winter) buoyancy forcing in west and wind stress forcing in east

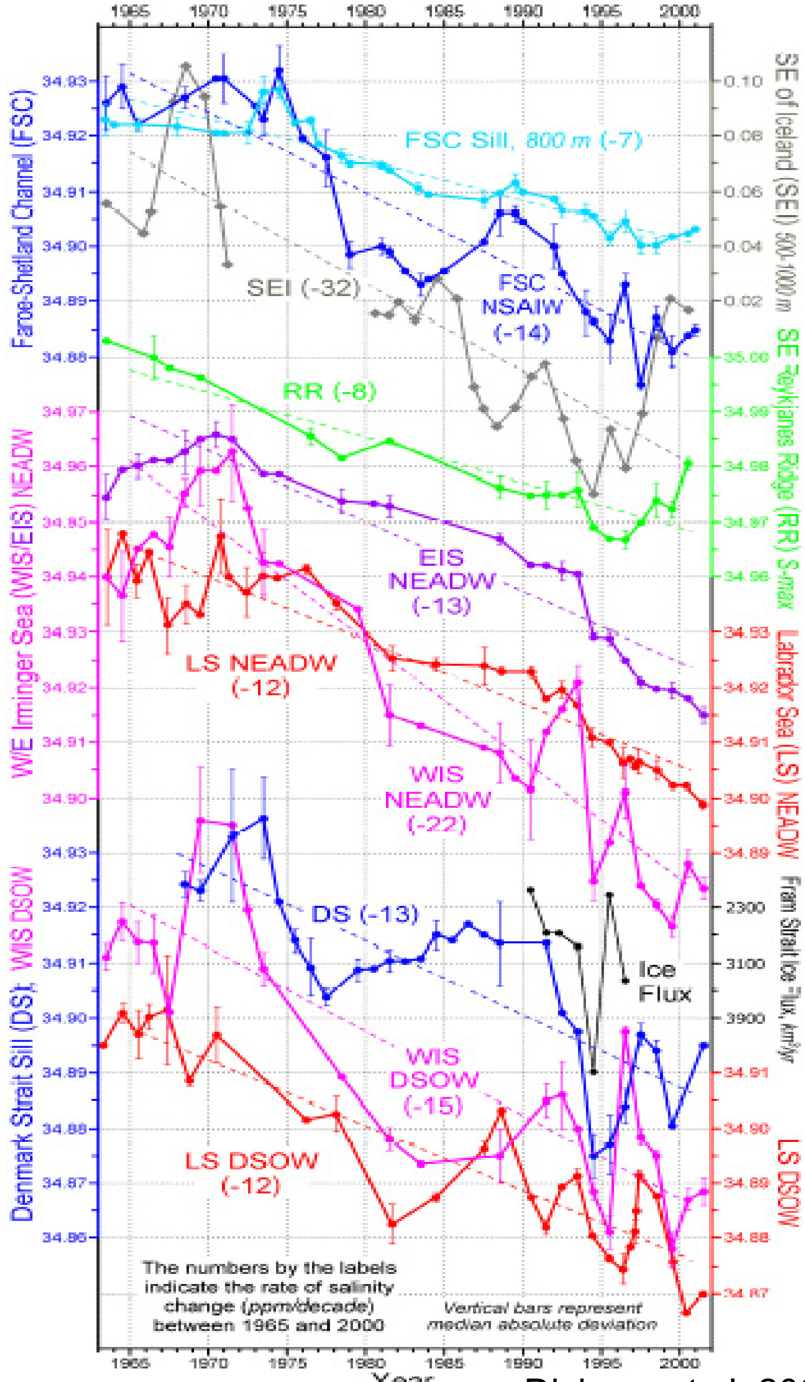
3) Feedback loop: Strong and expanded SPG - reduced T and S of inflow waters - reduced N Atl salinity - reduced formation of dense waters in the SPG - Weak and contracted SPG - strong inflow - etc.

4) For the period 1960-1995, both NAO and the gyre index were good proxies for the hydrography and biology in the N Atl/Nordic Seas. Post 1995, the gyre index, <u>but not NAO</u>, describes the evolution of hydrography and biology in the region

Reduced sub-surface salinity

1963 to 2002

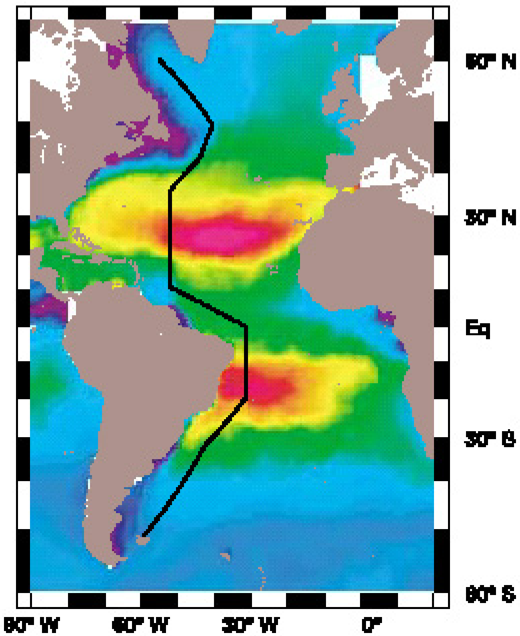




Dickson et al. 2002

Observed change in salinity

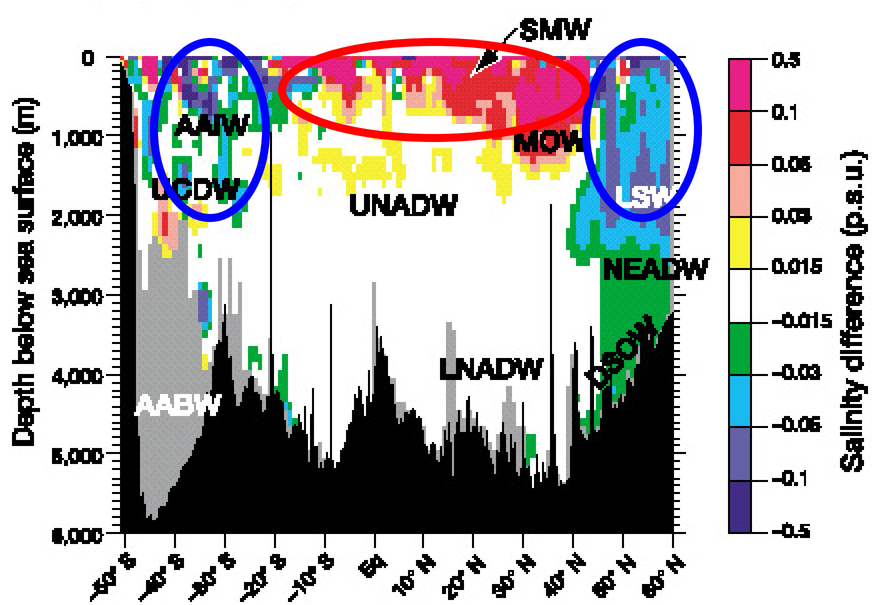
1985-99 minus 1955-69



Fresher

More saline

Curry et al. 2003

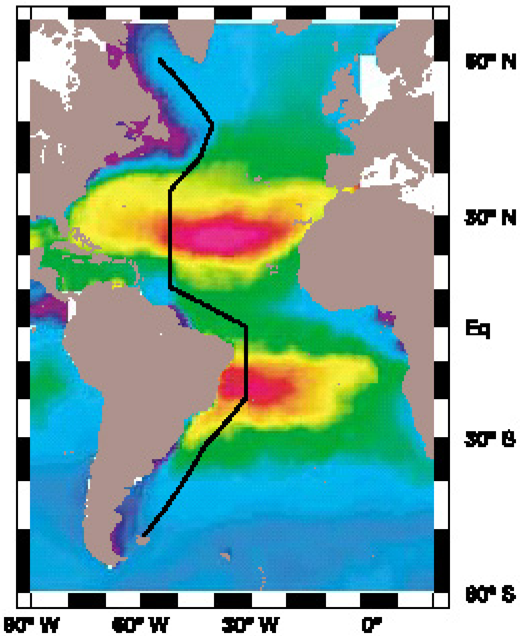


Observed change in salinity

1985-99 minus 1955-69

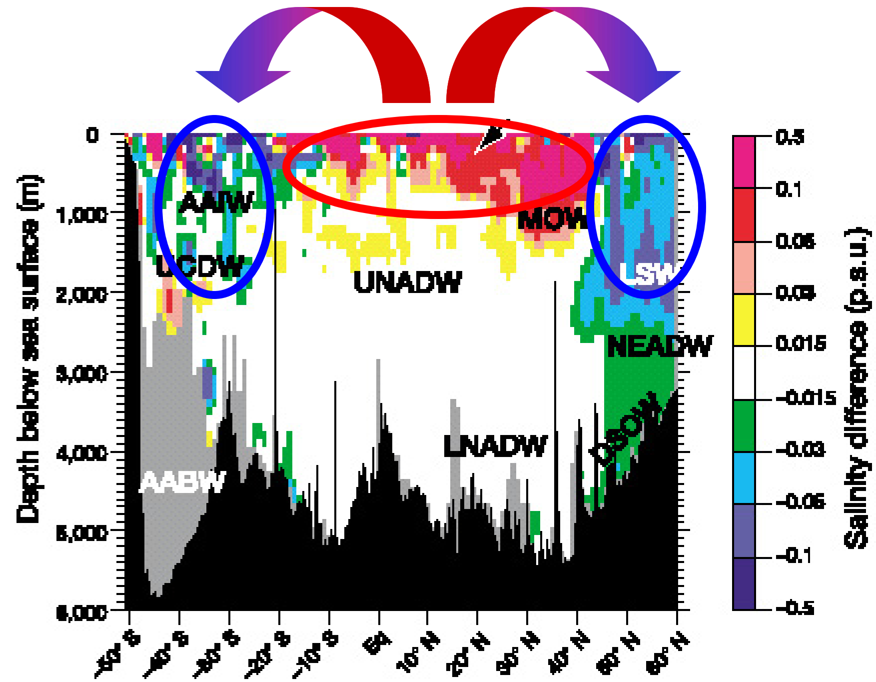
Reason: Enhanced evaporation at low latitudes followed by/plus

- enhanced precip at high latitudes
- melting of Arctic sea ice
- increased runoff to the Arctic Ocean
- melting of glaciers and Greenland



Fresher

More saline



Curry et al. 2003