Atlantic Water movement in the Arctic -the state of the AOMIP analysis and an update on AOMIP relevant results with NAOSIM

M. Karcher[1,2], F. Kauker[1,2], R. Gerdes[1]

[1]Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[2]O.A.Sys. – Ocean Atmosphere Systems GbR, Hamburg, Germany

9th AOMIP Workshop
McGill University, Montreal

June 6-7, 2005

AOMIP coordinated analysis 1948 to 2002

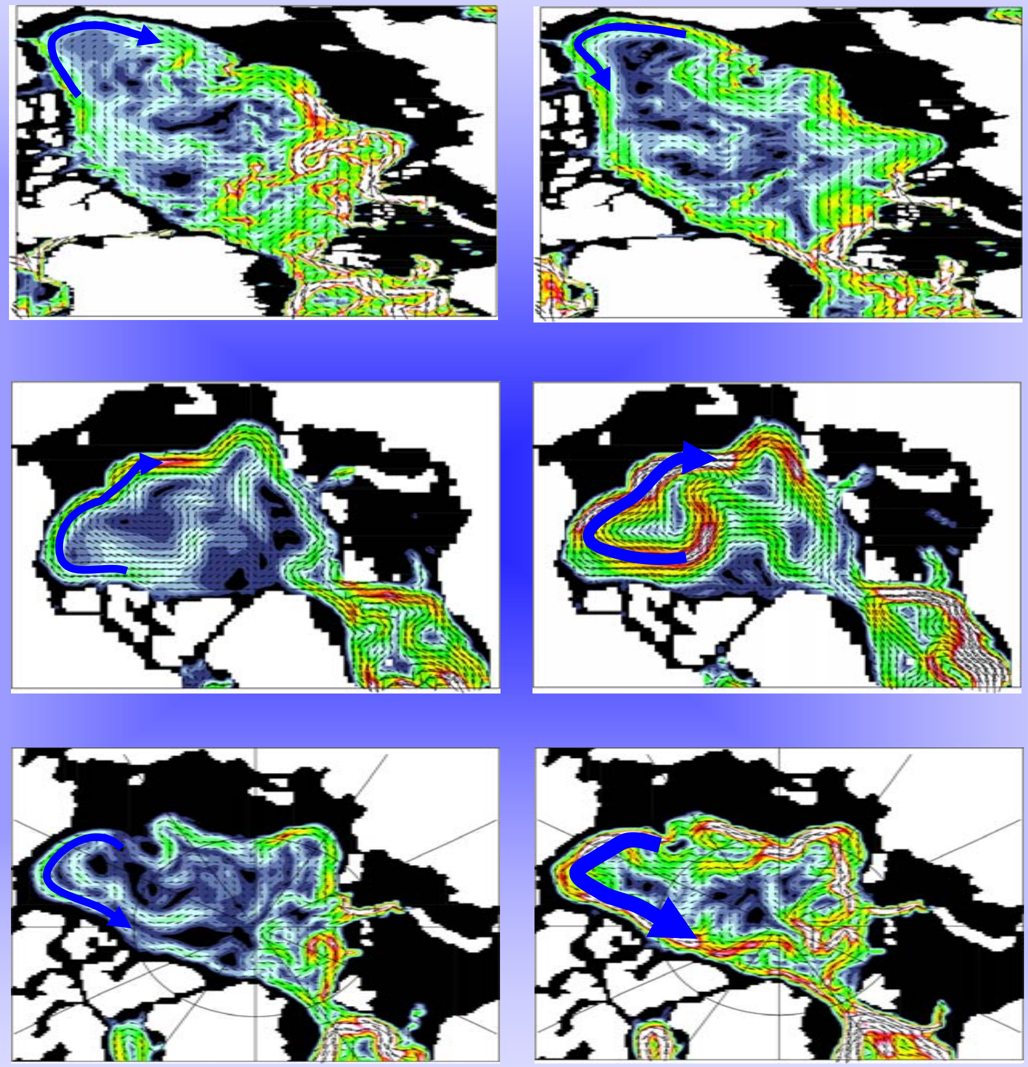
AW circulation (depth about 300m) in

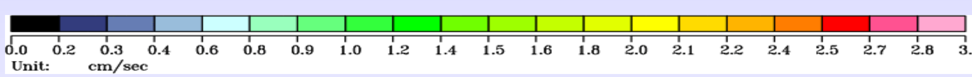
1955 1975

LANL — Hunke

UW — Zhang

AWI





AOMIP
Arctic Ocean Model Intercomparison Project

Conclusions I:

It turns out that this behaviour of the AW is governed by a fragile balance between the wind driven barotropic mode (anticyclonic) and the baroclinic mode (cyclonic).

- **all 3 models start anticyclonic in 1948**
- **LANL turns cyclonic in the 1970s: caused by a very warm and saline pulse of Atlantic Water entering through Fram Strait.**
- **UW circulates anticyclonic - hypothesis: open boundary conditions in the Nordic Seas and also the use of a non-monotonous advection scheme for tracers are responsible for that behaviour.**
- **AWI turns persistemtly cyclonic in the 1950s**
- **even a very strong BG can not suppress a fully developed AW circulation (AWI 100y Reconstruction in 1910s)**
- **AWI forced with OMIP-climatology shows persistent anticyclonic CB: strange Barents Sea watermasses?**

AWI noFCT experiments

FCT for tracer advection is replaced by centered-differences in two experiments:

- **noFCT I:**

  Centered-differences from the start of the AOMIP period (1948)

- **noFCT II:**

  FCT replaced by centered-differences in AOMIP run in 1975 (when cyclonic AW is fully developed in the AOMIP run)

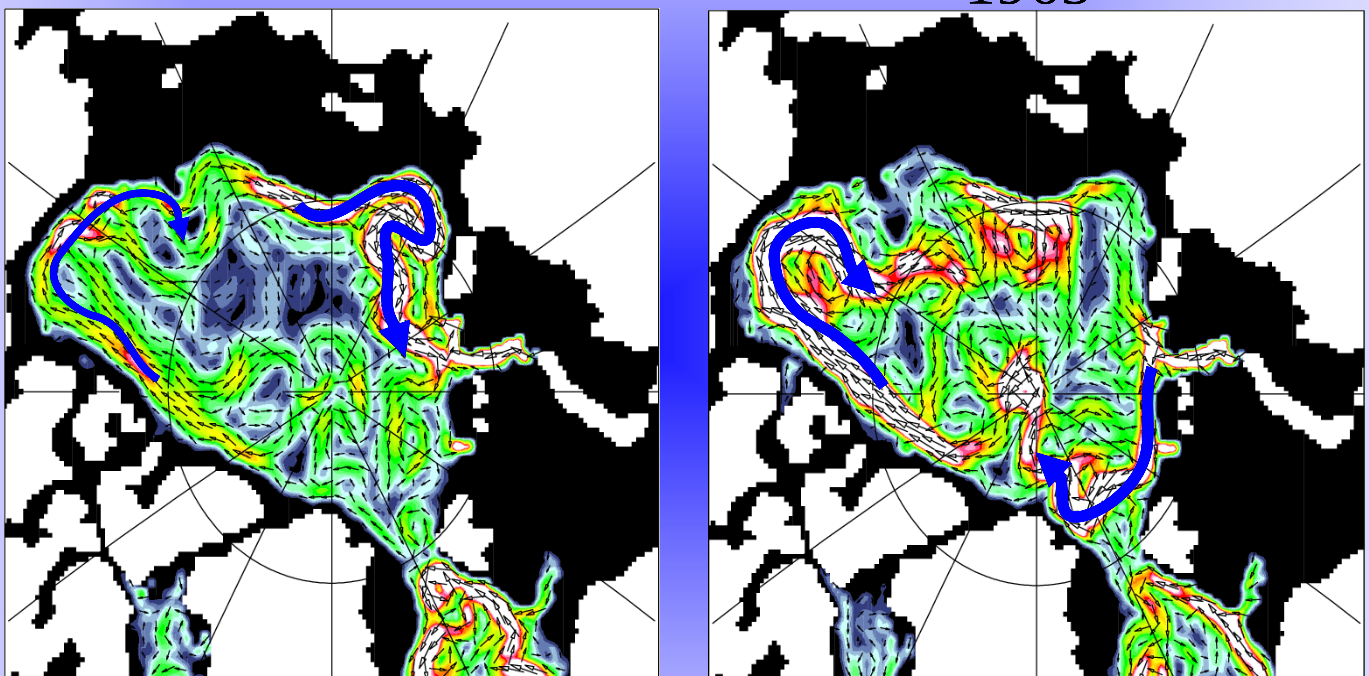
AOMIP
Arctic Ocean Model Intercomparison Project

AWI noFCT experiment I

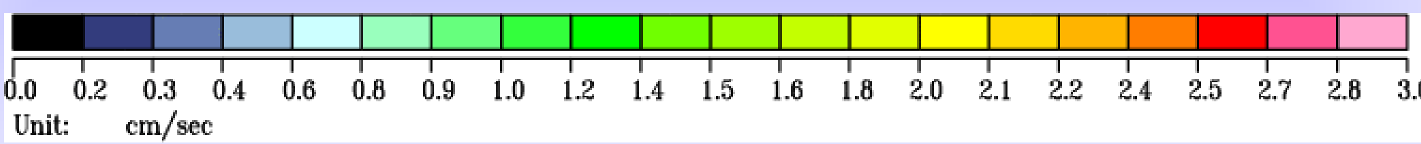
AW circulation (300m)

Centered-differences from 1948 on

1955 | 1965



AW circulates anticyclonically, similar to (old) UW model.



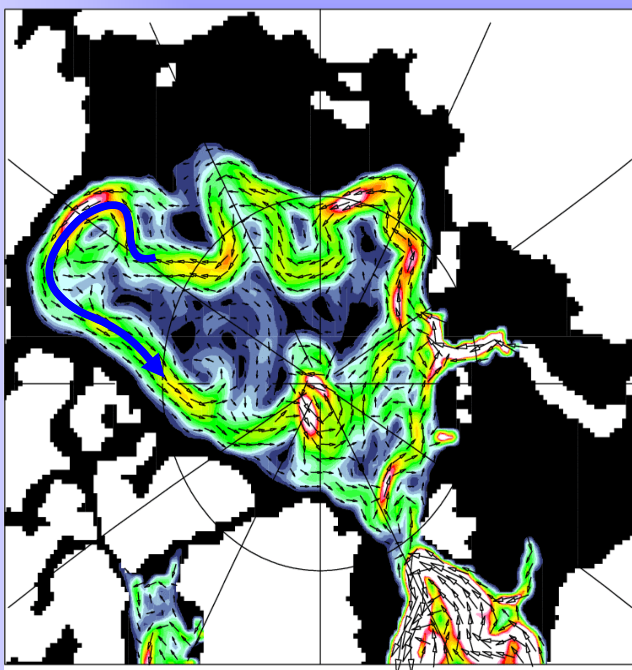
AWI noFCT experiment II

AW circulation (300m)

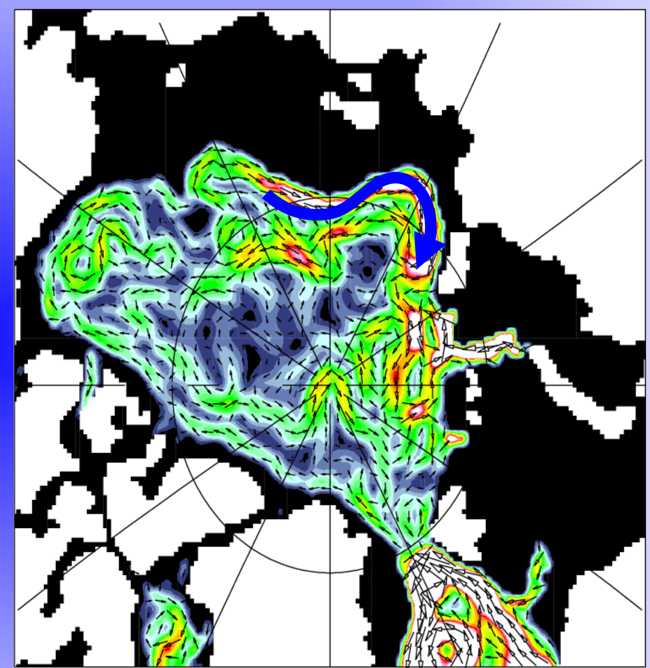
Switch to centered-differences after 1975 – start from strong cyclonic AW circulation

AOMIP
Arctic Ocean Model Intercomparison Project

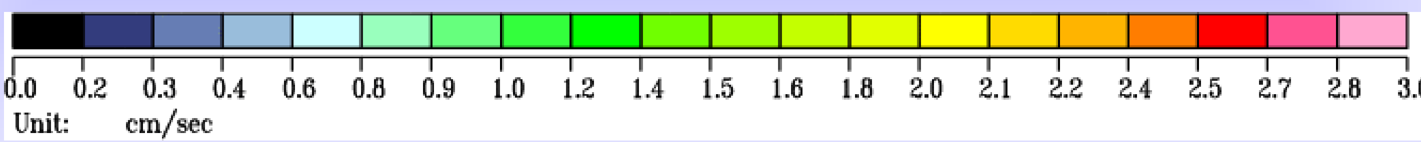
1976



1981



Breakdown and reversal of the cyclonic AW circulation in 1981.

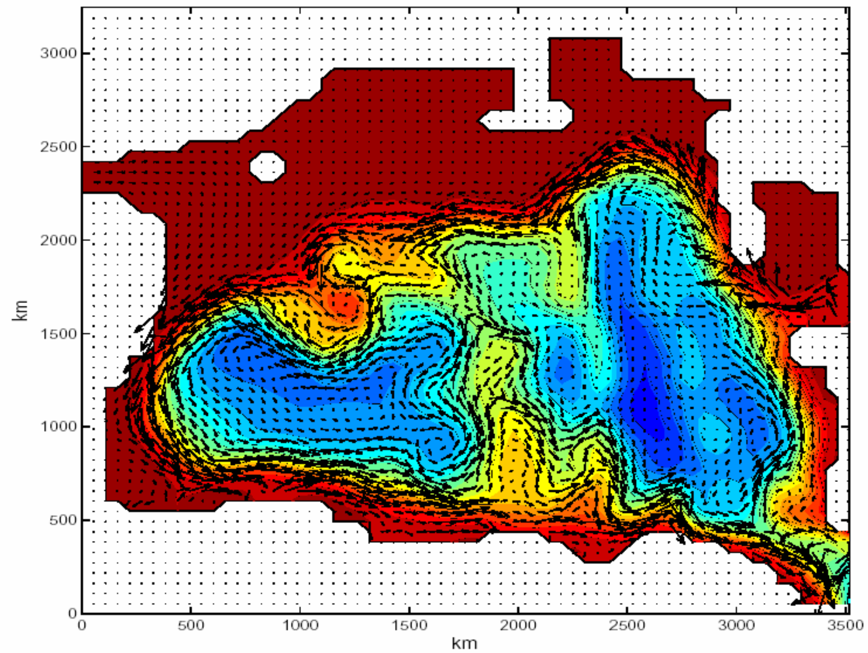


Conclusions II: noFCT experiments

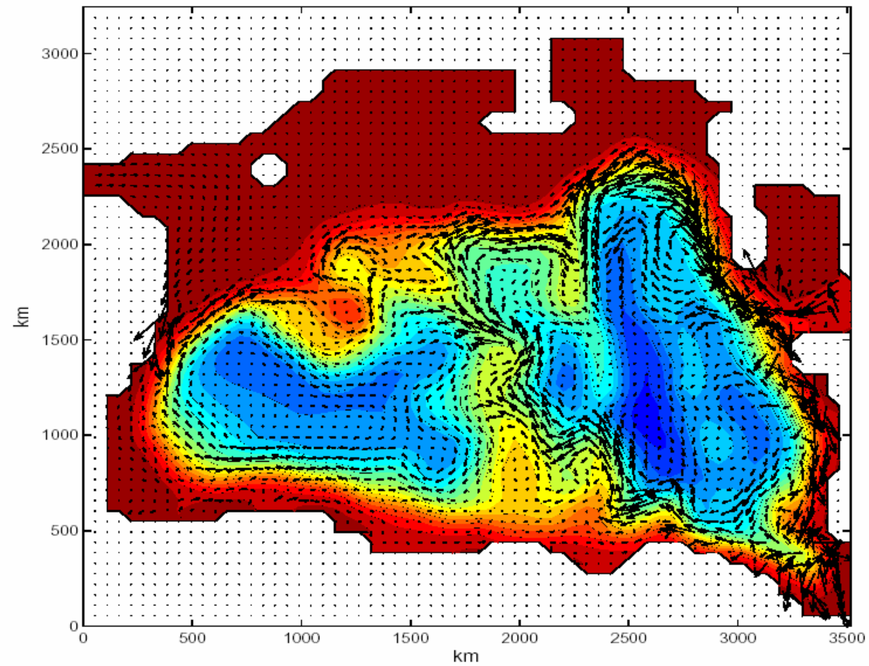
• the use of a non-monotonous scheme for tracer advection leads to a loss of cyclonic AW flow: diffusion/less consevation of water mass properties, probably BG dominates

Sense of rotation depending on net lateral PV flux

Transport velocities



Standard run



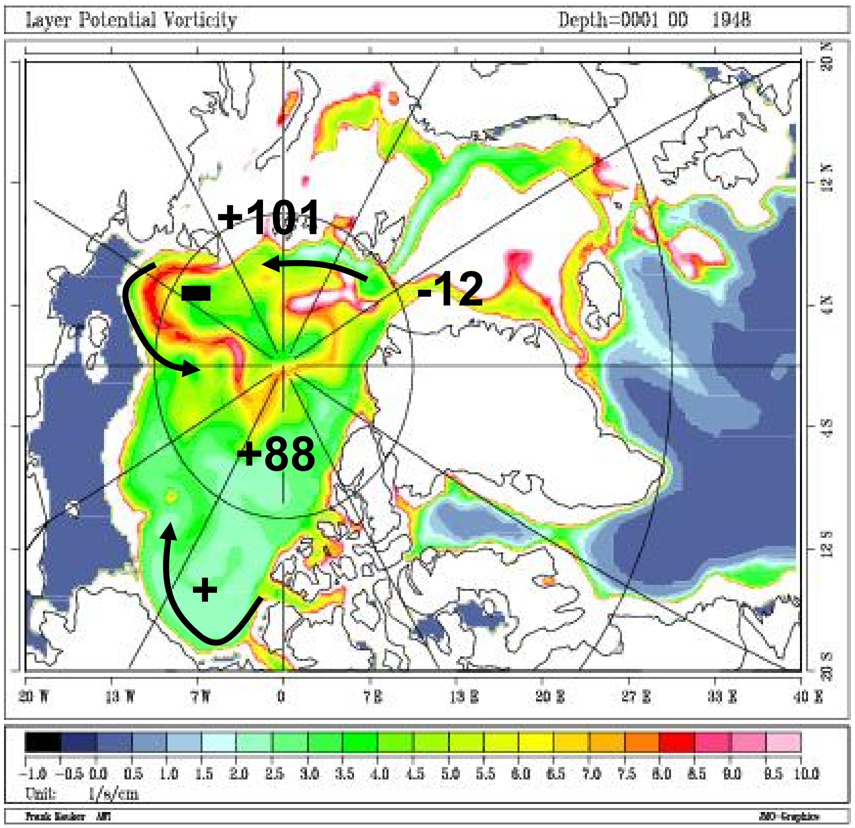
PV flux out > PV flux in

[Yang, 2005]

Validity for 3d GCMs?
……Interpretation of AOMIP GCMs

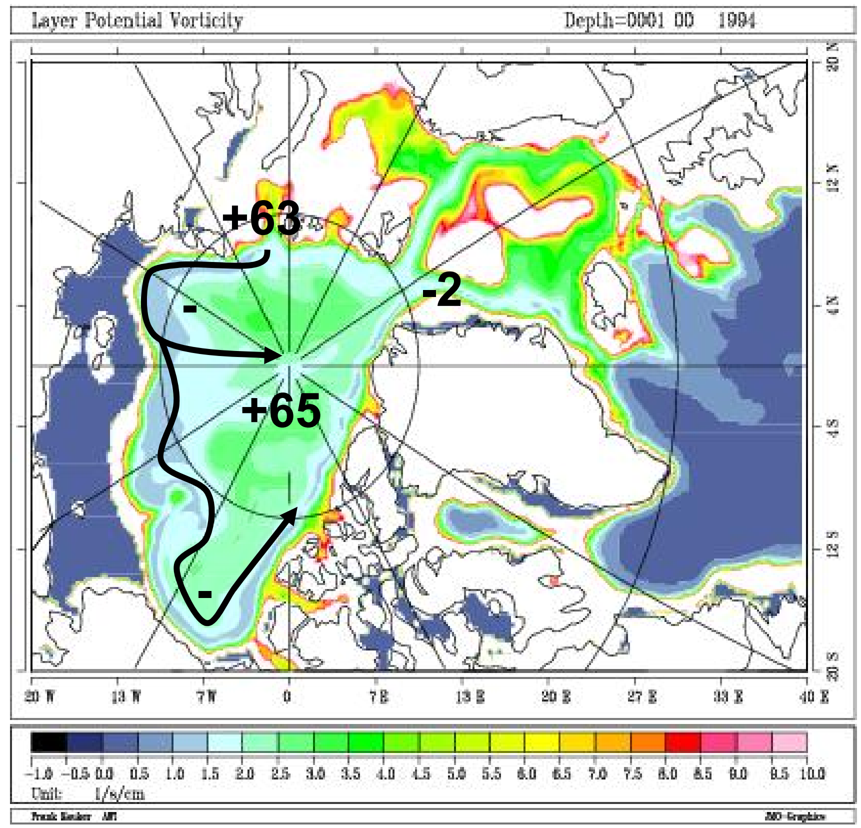
AW Potential Vorticity on σ =(27.7-28.1) [10^{-2} m^2/s^2]

NCEP run initial condition = year 50 of OMIP forcing



Both basins rotate differently: EB cyclonic, CB anticyclonic

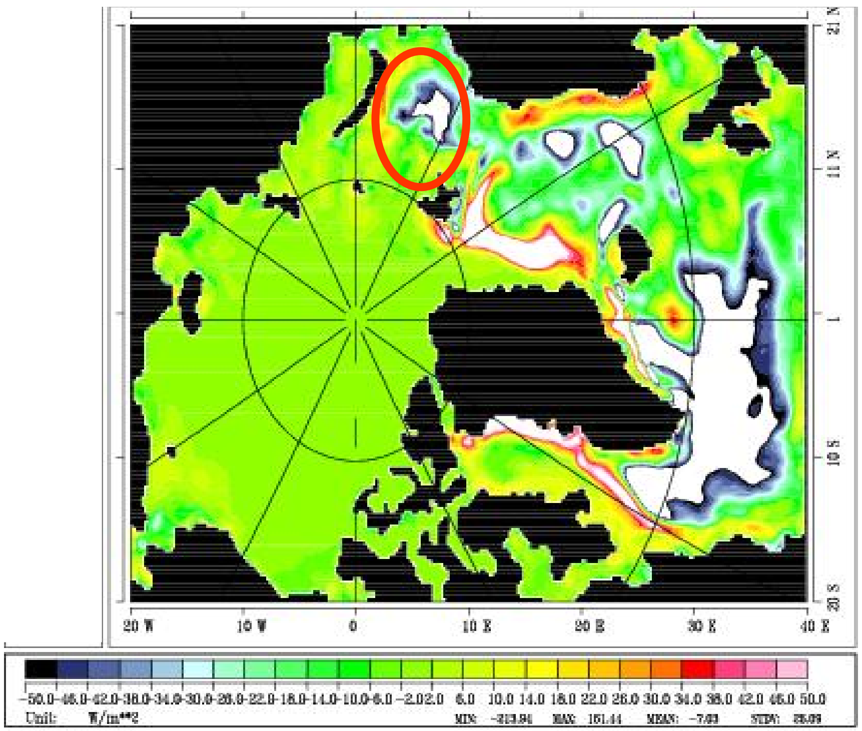
NCEP forcing Year 1994



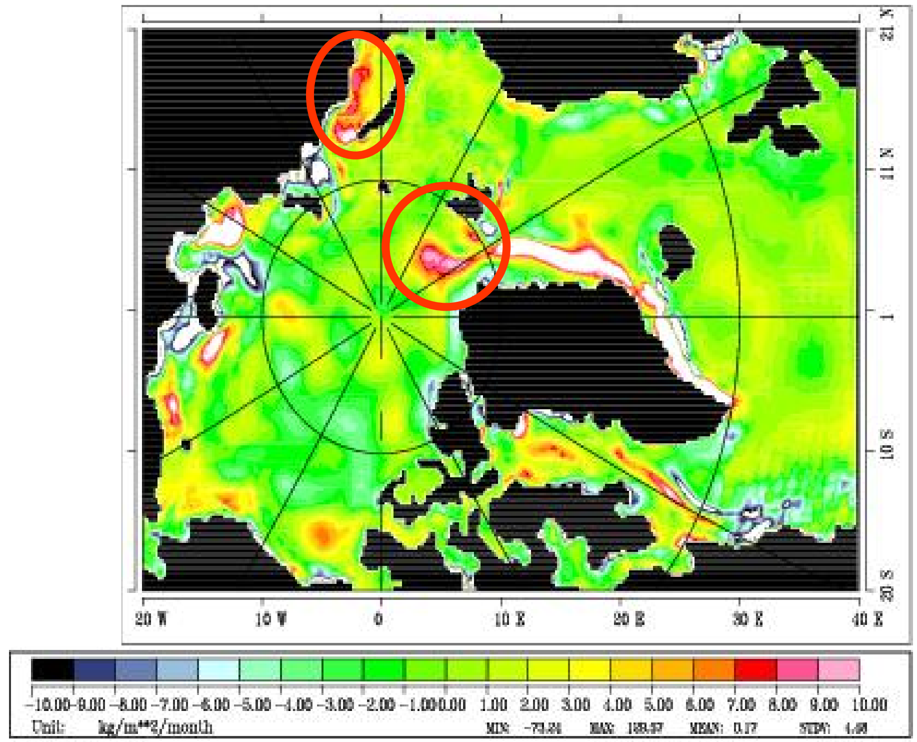
A band of low PV is associated with the cyclonic boundary current

Difference in mean surface fluxes
OMIP - NCEP

Heatflux

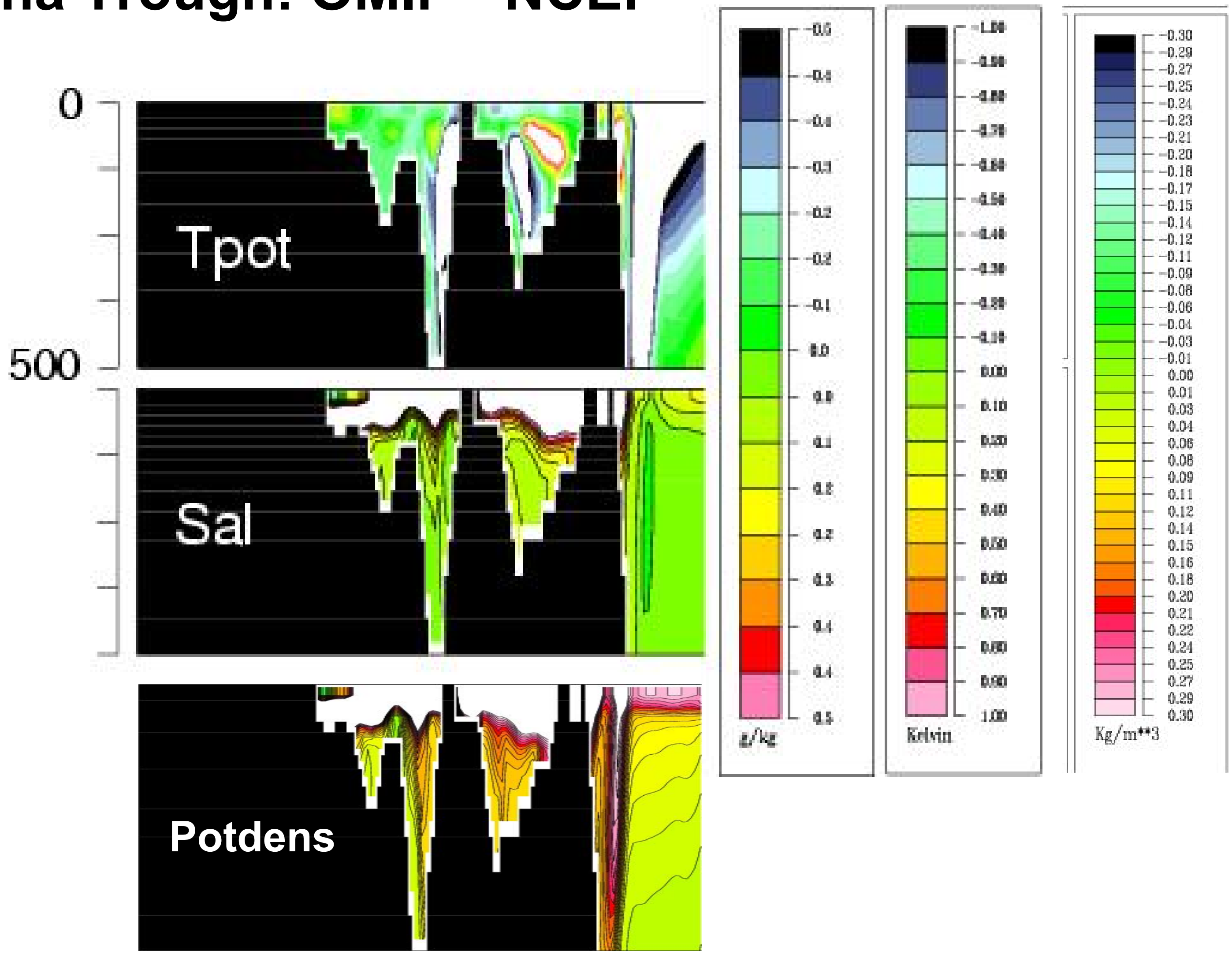


Saltflux



AOMIP
Arctic Ocean Model Intercomparison Project

St.Anna Trough: OMIP - NCEP

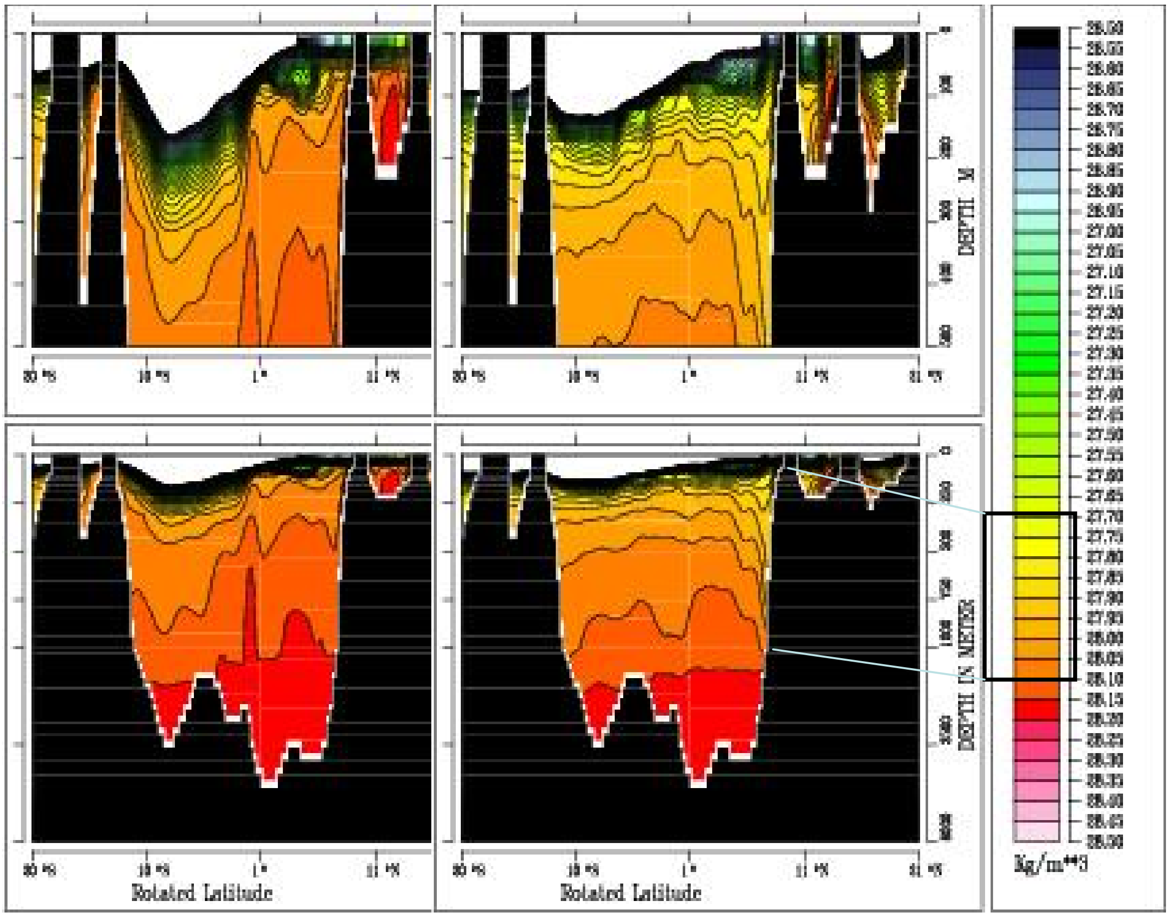


High density outflow in case of OMIP forcing

New exp: cool only in Barents (start from IC or full flow)

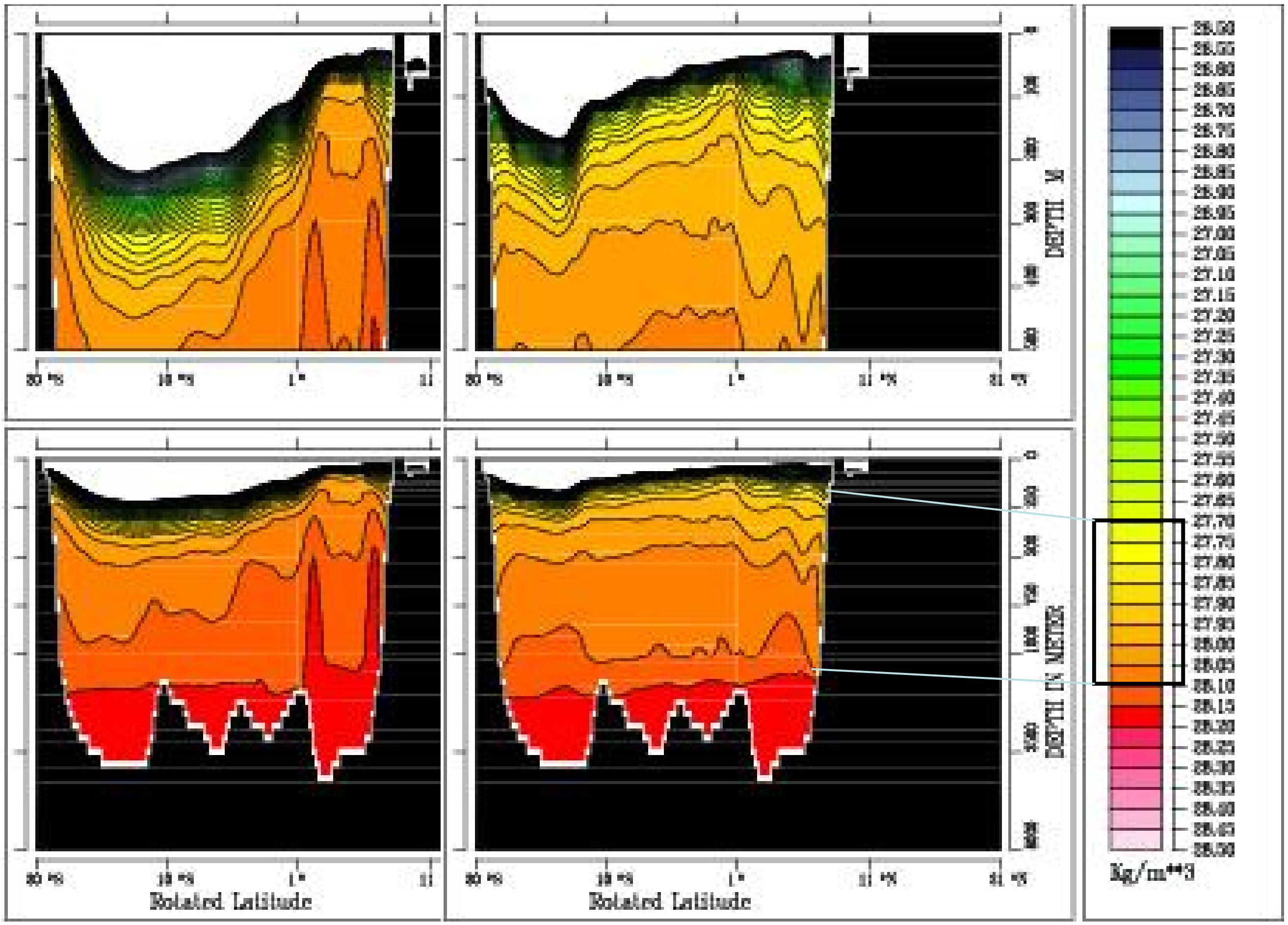
Potential density section before St.Anna Trough

OMIP y50 NCEP 1994



Potential density section behind St.Anna Trough

OMIP y50 | **NCEP 1994**

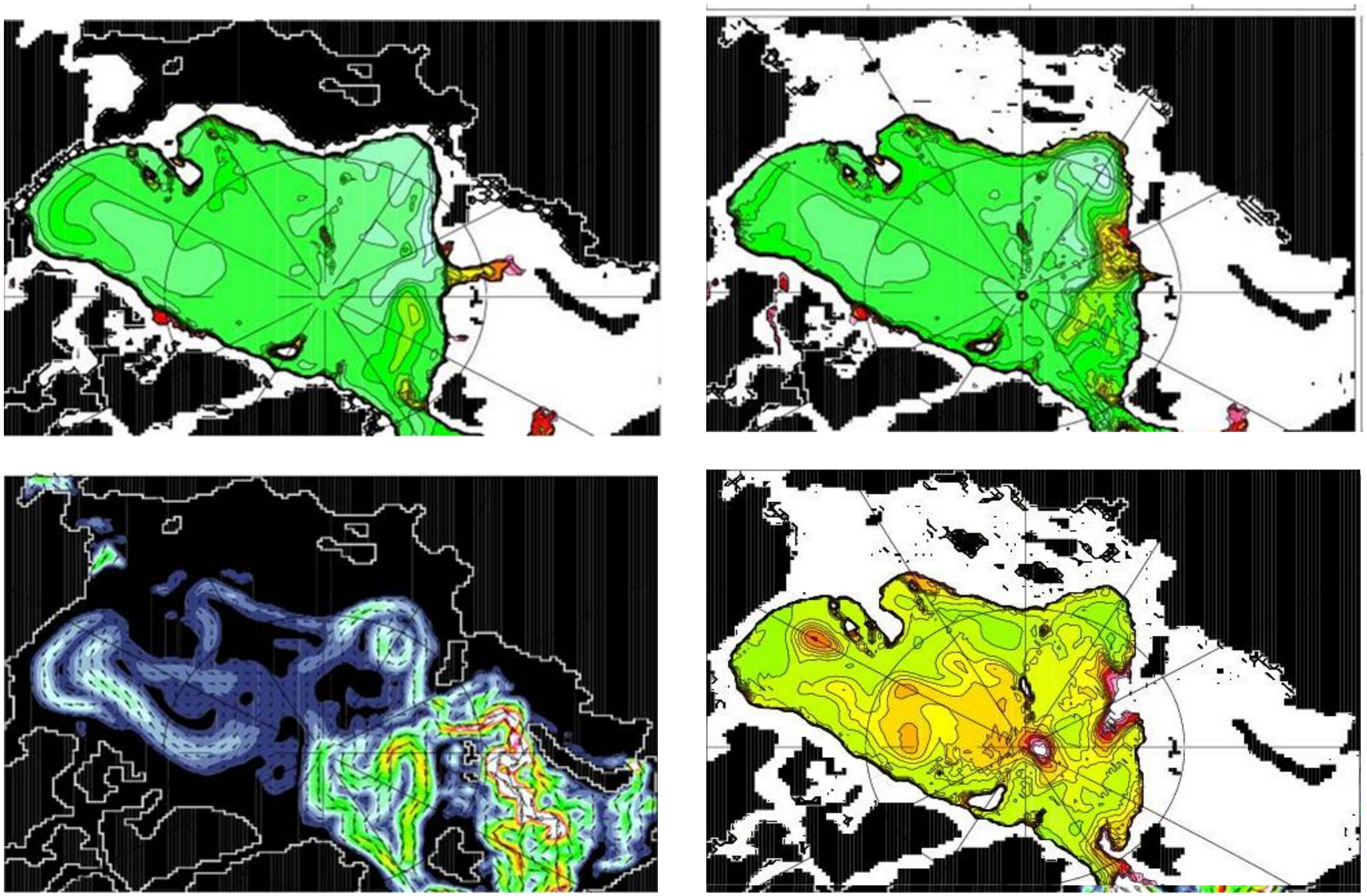


High density outflow in case of OMIP forcing

New exp: cool only in Barents (start from IC or full flow)

AOMIP 1952 (y5)

AOMIP noFCT EXP I 1952 (y5)



AOMIP noFCT EXP II (y5)

AOMIP
Arctic Ocean Model Intercomparison Project

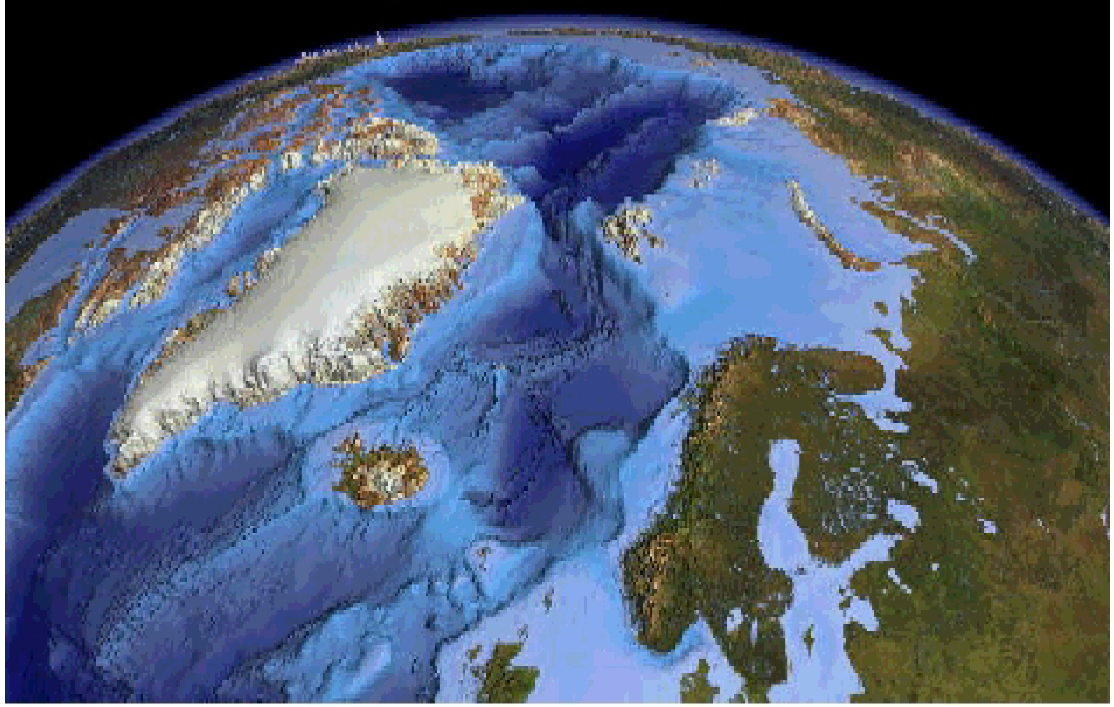
Conclusions III: PV analysis

- Counterrotating OMIP flow despite higher net PV input: no determination of flow direction by PV lateral fluxes
- Role of lower boundaries of AW!
- Role of BG likely (BG/halocline upper boundary of AW!)
- noFCT experiments show no conservation of PV (prevents lateral flux interpretation)

- NEW EXPERIMENTS:
  - Barents Sea cooling exp. based on NCEP or restored AOMIP
  - More complex PV-model exps. (multi-layer, adaptation processes) based on Yangs work
- FURTHER MODEL INTERCOMPARISON: detailed PV source/sink analysis?!

AOMIP
Arctic Ocean Model Intercomparison Project

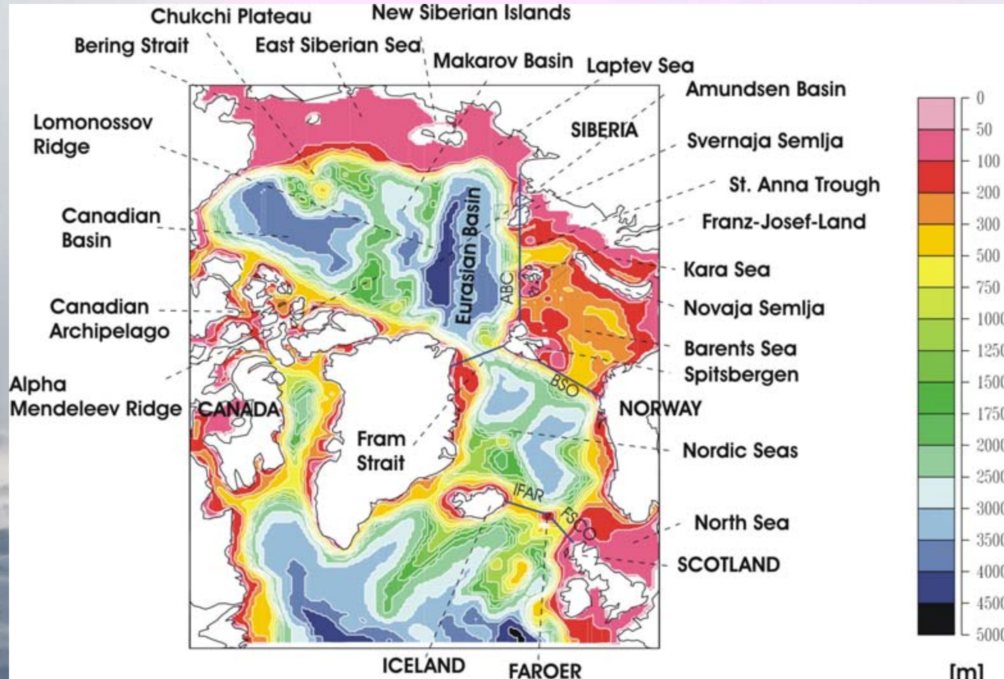
New AOMIP relevant results with NAOSIM



- A mid 1990s freshwater export event
- A recent warming of AW

AOMIP
Arctic Ocean Model Intercomparison Project

NAOSIM model setup

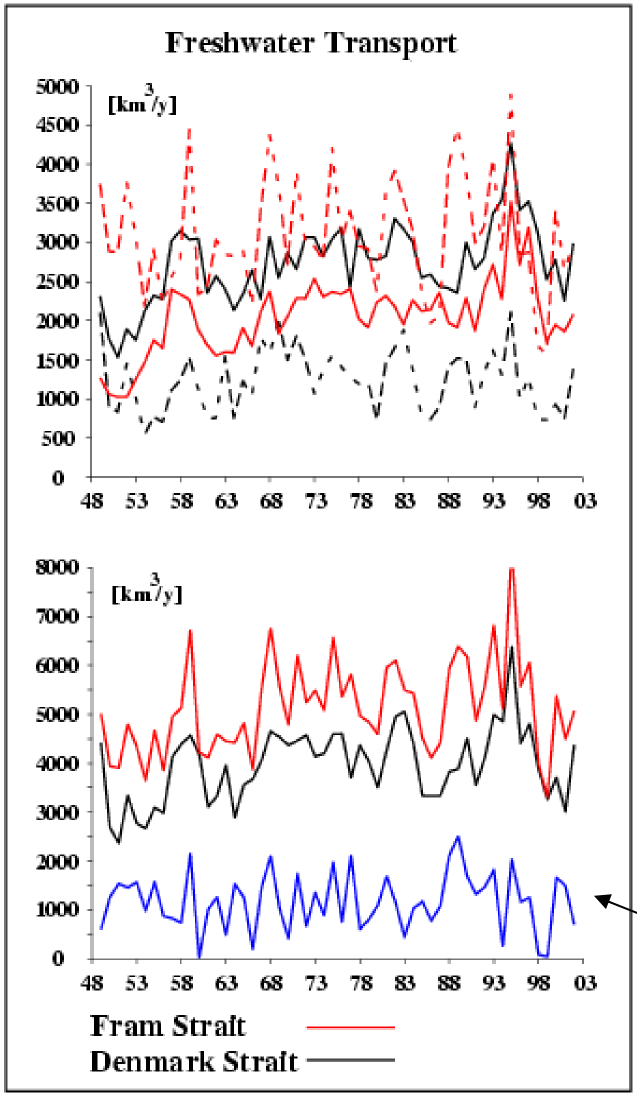


NAOSIM Group:
Fieg
Gerdes
Karcher
Kauker
Köberle

- **Atmospheric forcing: NCEP 1948-2004**

A fresh flush from the Arctic –
on the sources of a large freshwater export event in the 1990s

FW-Transport through Fram and Denmark straits



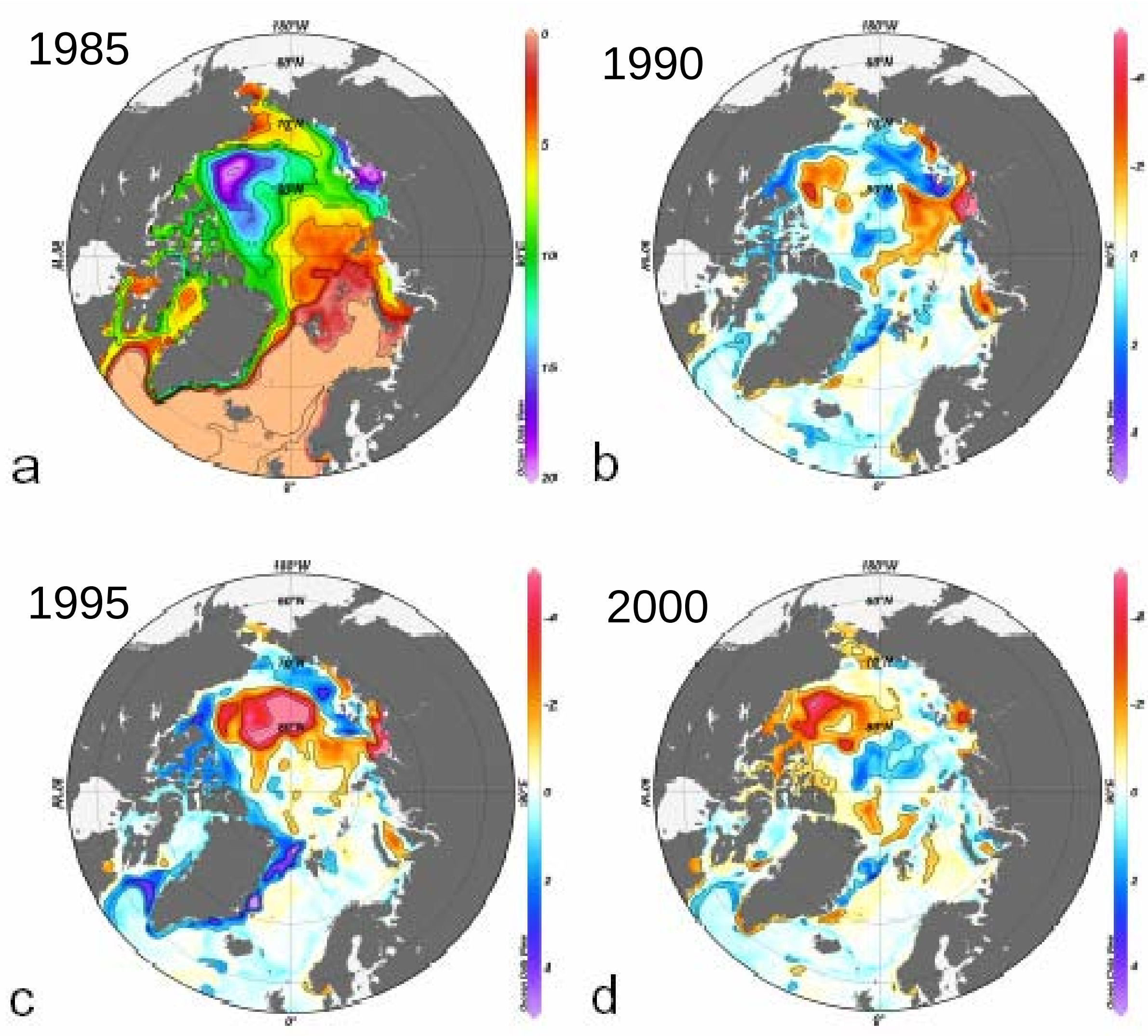
EGC freshwater convergence

NAOSIM

(Karcher, Gerdes, Kauker, Köberle und Yashayev, subm. 2005)

A fresh flush from the Arctic –
on the sources of a large freshwater export event in the 1990s

Top 250m FW
Content and anomalies



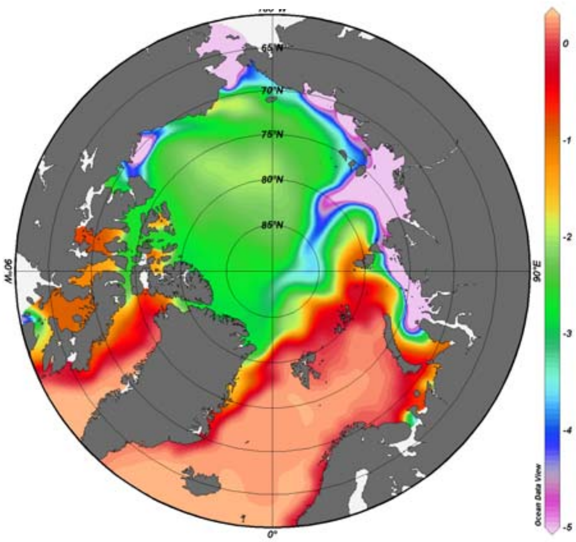
NAOSIM

AWI

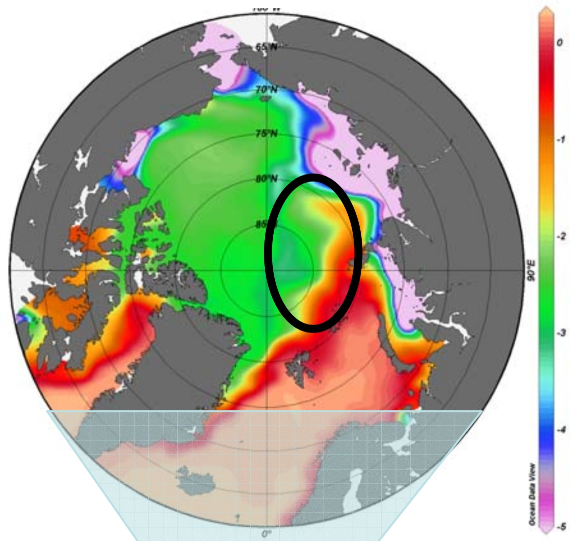
(Karcher, Gerdes, Kauker, Köberle und Yashayev, subm. 2005)

Simulated surface concentration of δ^{18} O

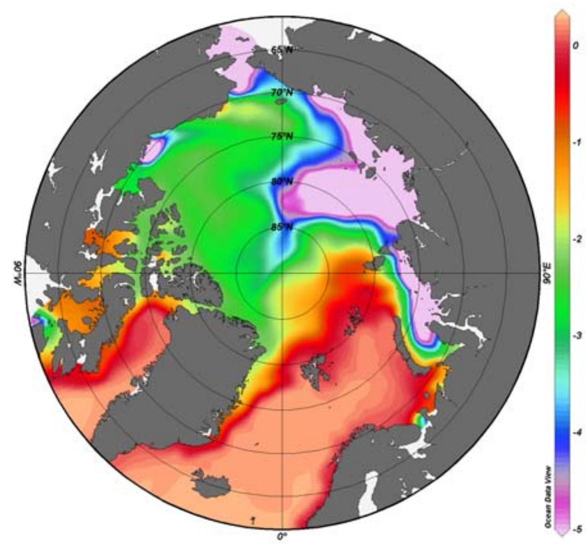
1983-88

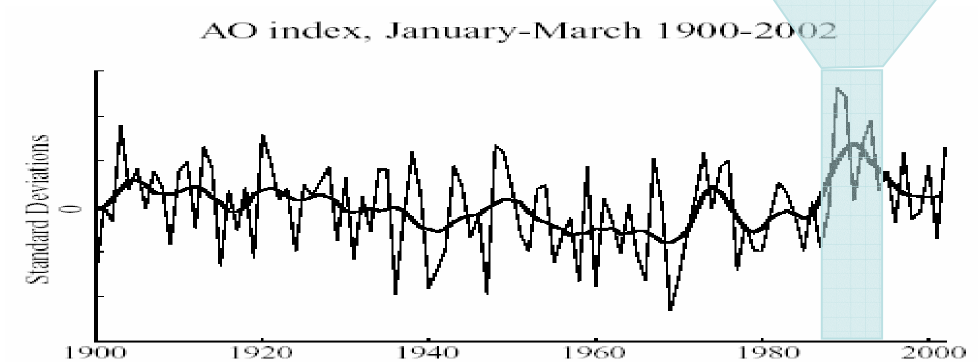


1989-94



1995-2002

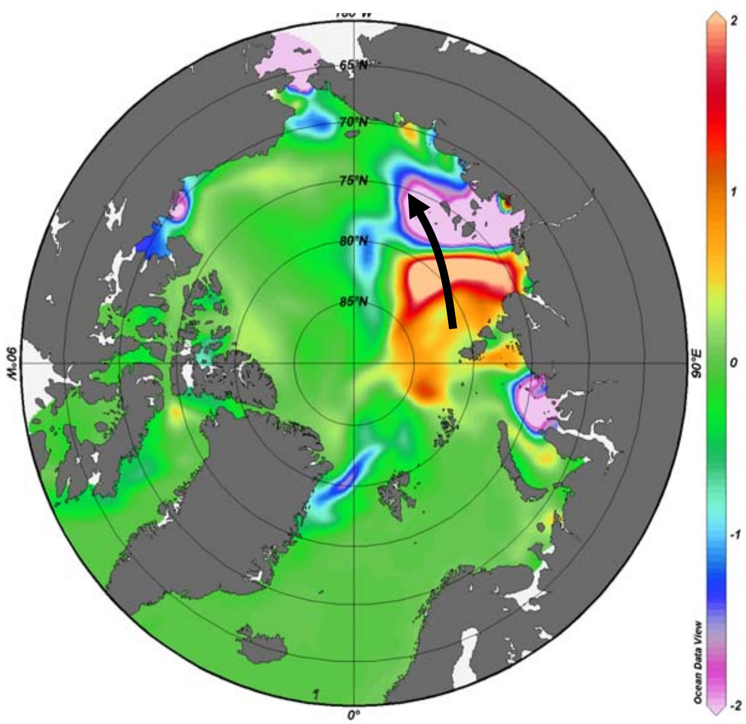




Surface concentration of δ^{18} O

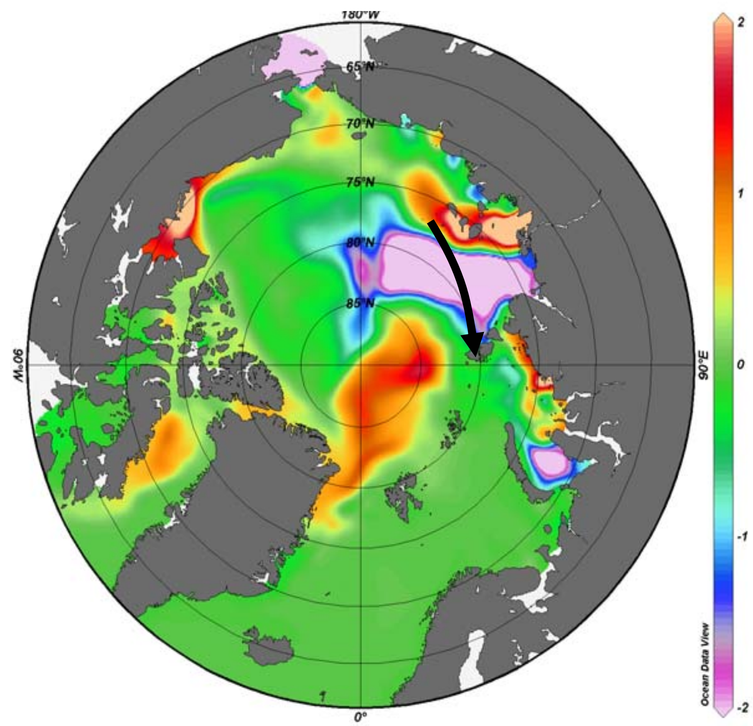
Changes

1989-94 minus 1983-88



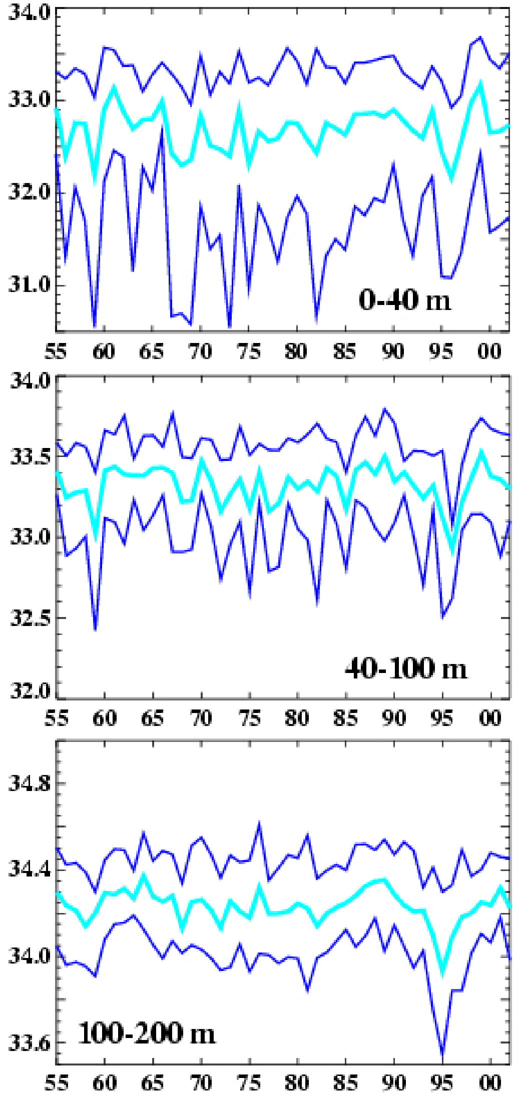
Freshwater retreat…

1995-2002 minus 1989-94

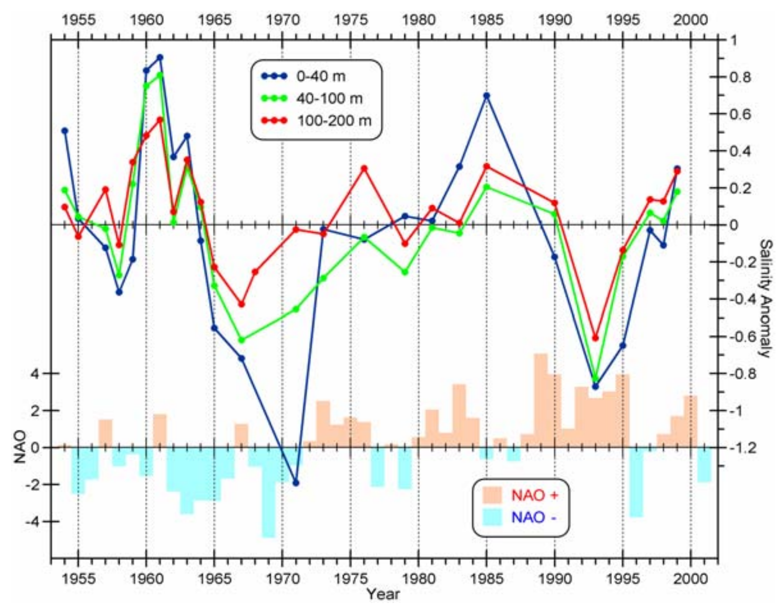


…restructuring

A fresh flush from the Arctic –
on the sources of a large freshwater export event in the 1990s



Simulated EGC-Salinity



Observed EGC-Salinity

NAOSIM

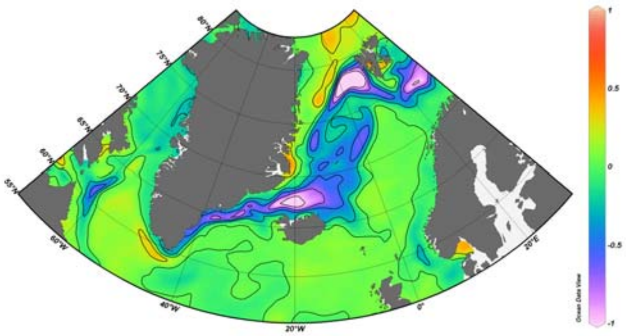
AWI

(Karcher, Gerdes, Kauker, Köberle und Yashayev, subm. 2005)

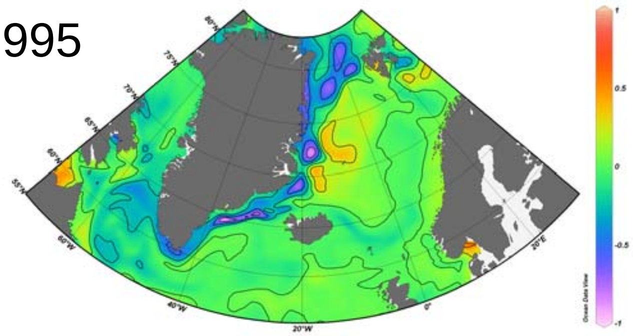
SSS anomaly

NAOSIM

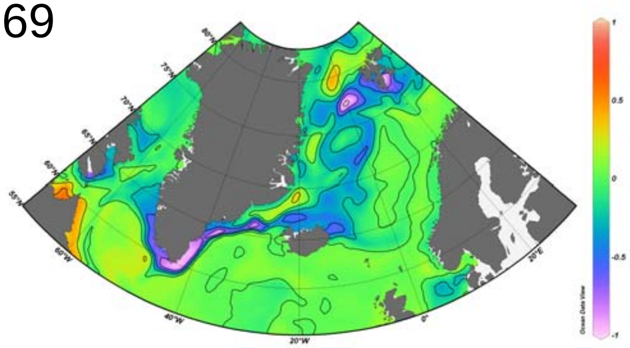
1968



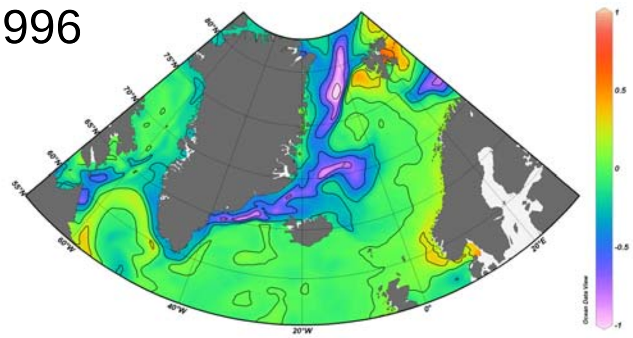
1995



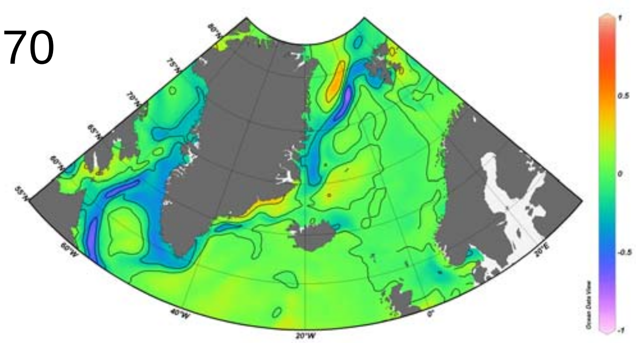
1969



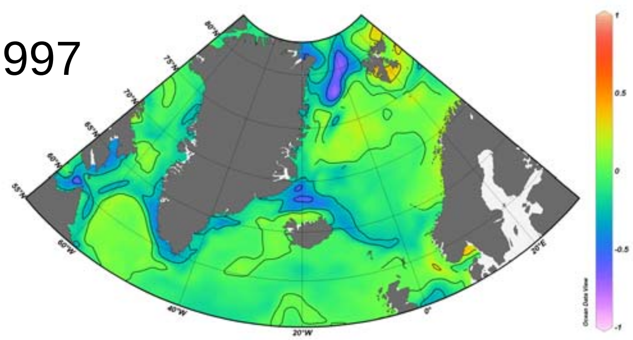
1996



1970



1997

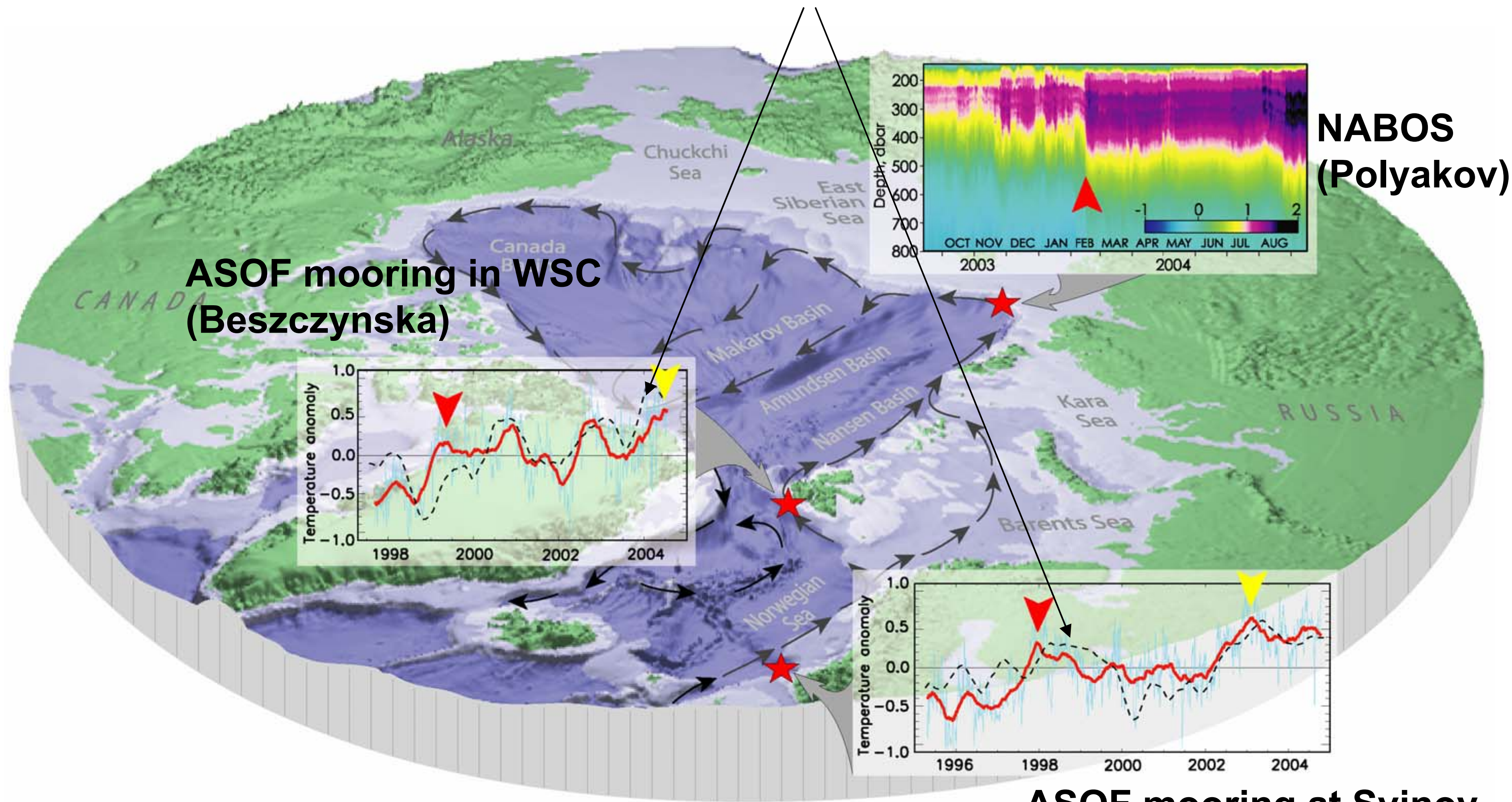


GSA

90s anomaly

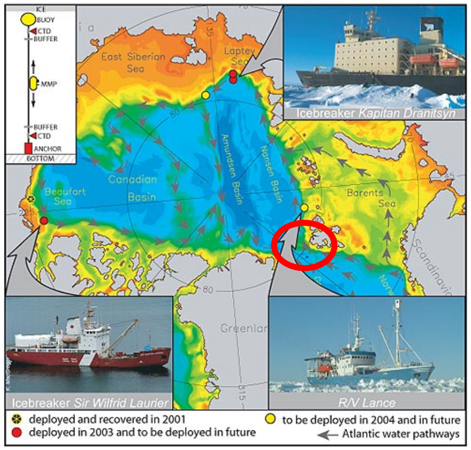
Recent warm events entering the Atlantic Layer of the Arctic Ocean
Observations and model results (NAOSIM)

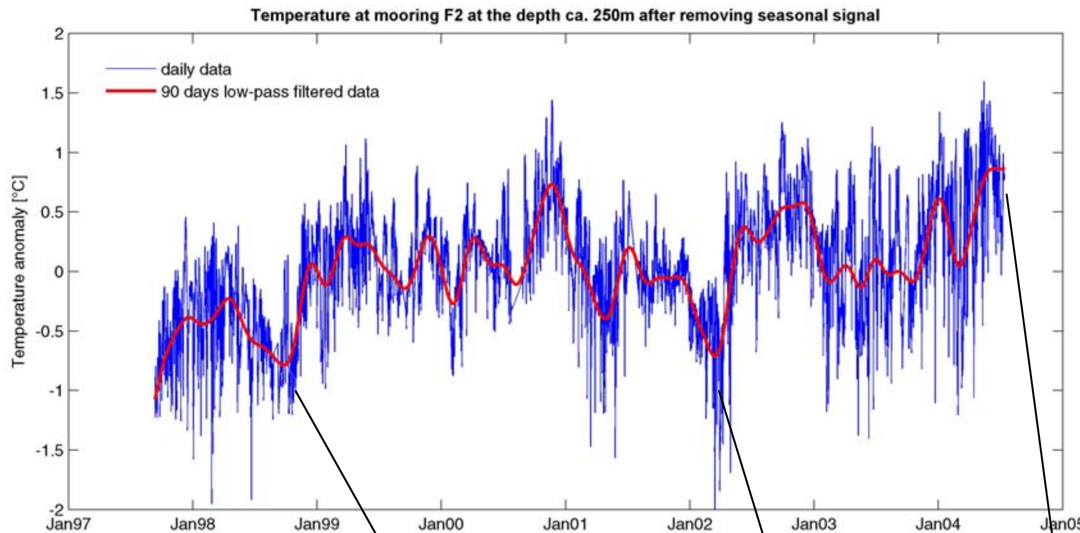
NAOSIM



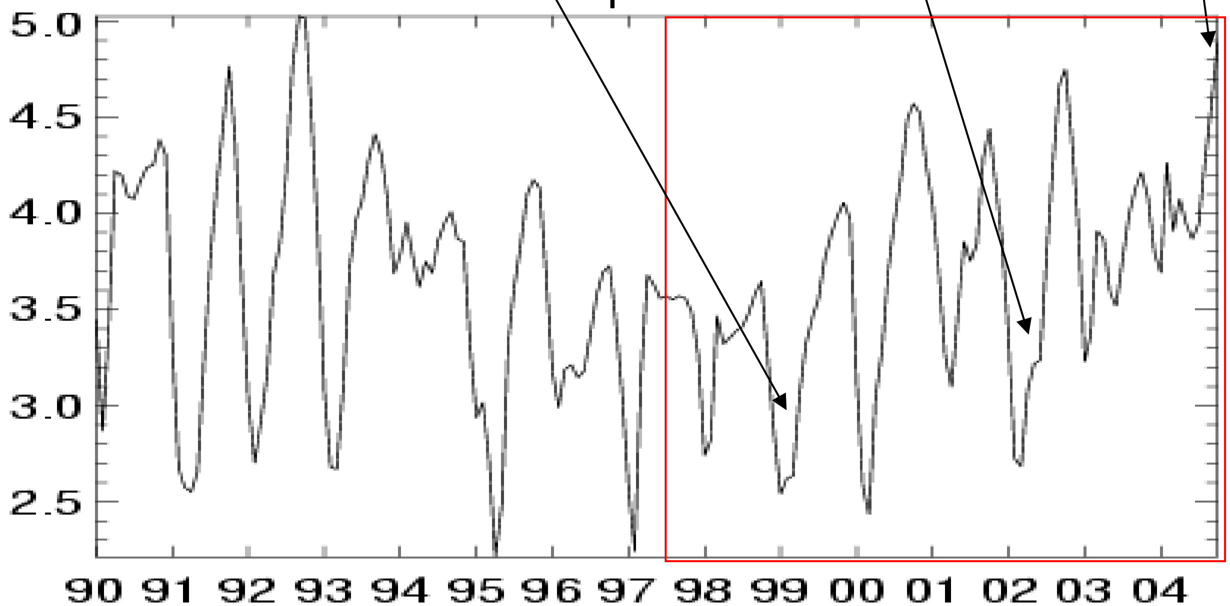
Polyakov et al. (submitted)
Ivanov et al. (Poster at EGU)

ASOF-N WSC 250m temperature (Beszczynska et al)





NAOSIM WSC temperature320-380 m



NAOSIM