

# On the connection of Atlantic inflow variability and the overflows via the Arctic Ocean loop

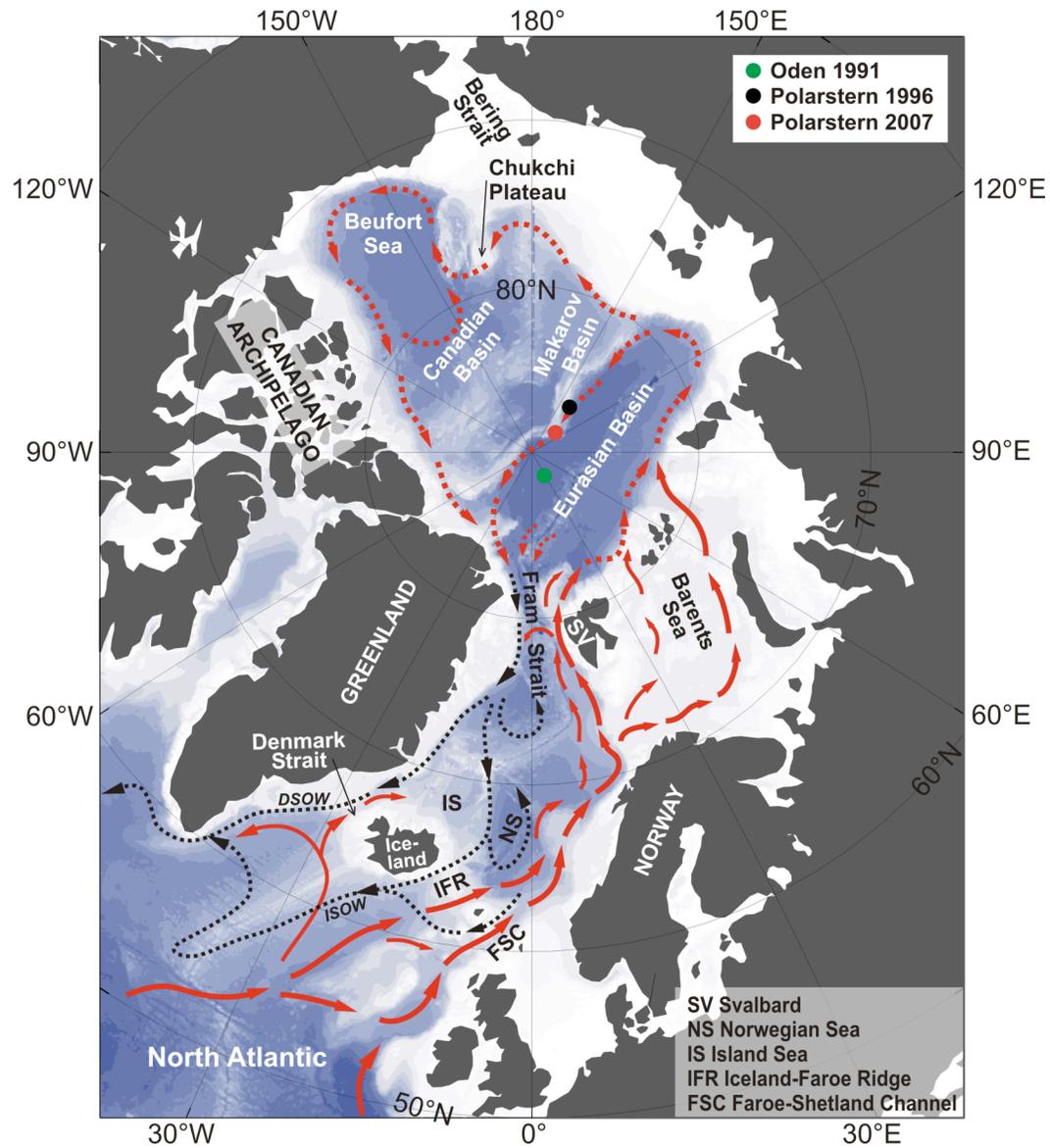
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S. Heyen<sup>1</sup>, B. Rudels<sup>3</sup>, U. Schauer<sup>1</sup>**

<sup>1</sup>Alfred Wegener Institute for Polar and Marine Research

<sup>2</sup>O.A.Sys – Ocean Atmosphere Systems

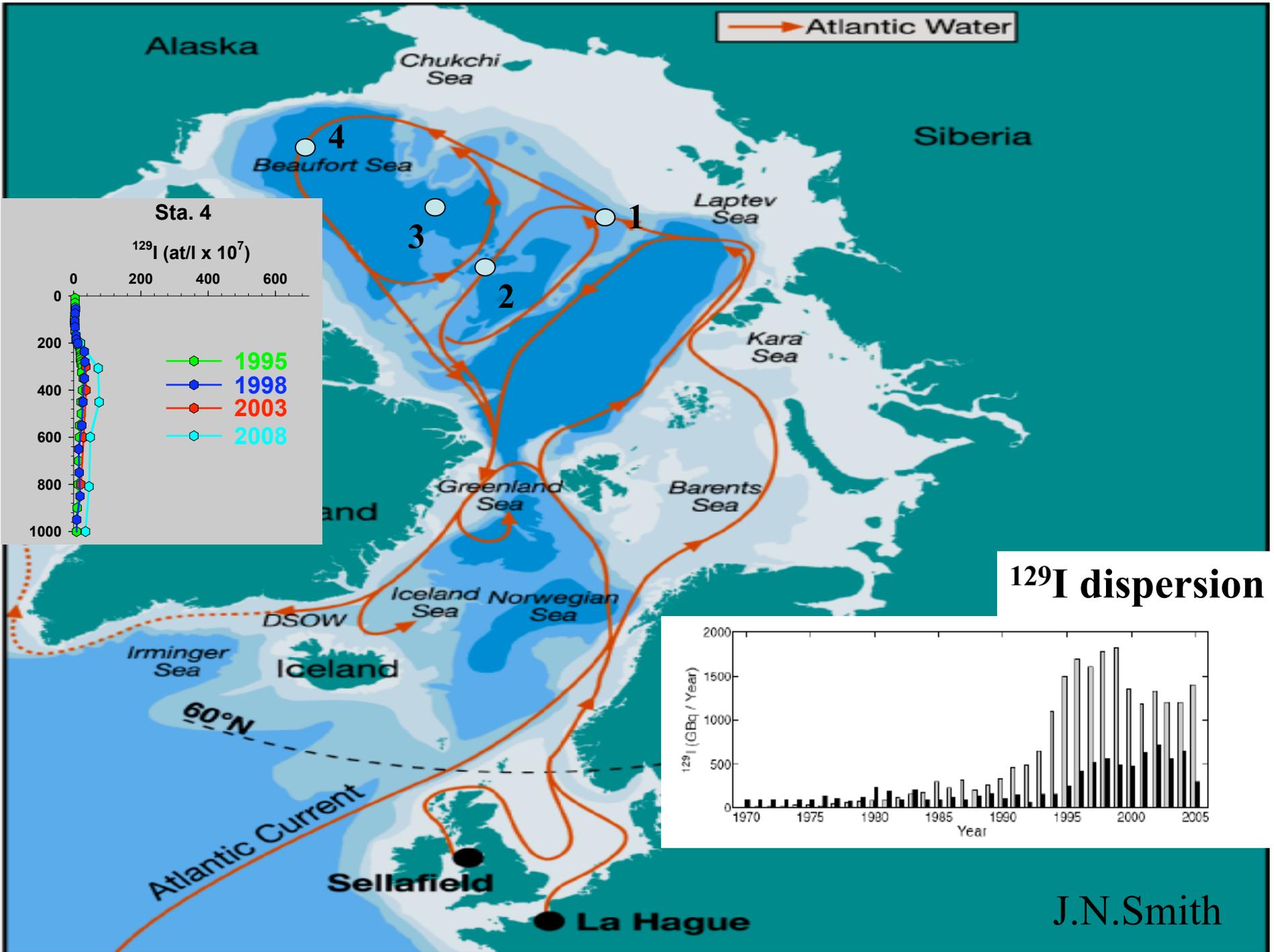
<sup>3</sup>Finish Institute for Marine Research





AW flow in the Arctic Ocean

based on Rudels et al (1994)

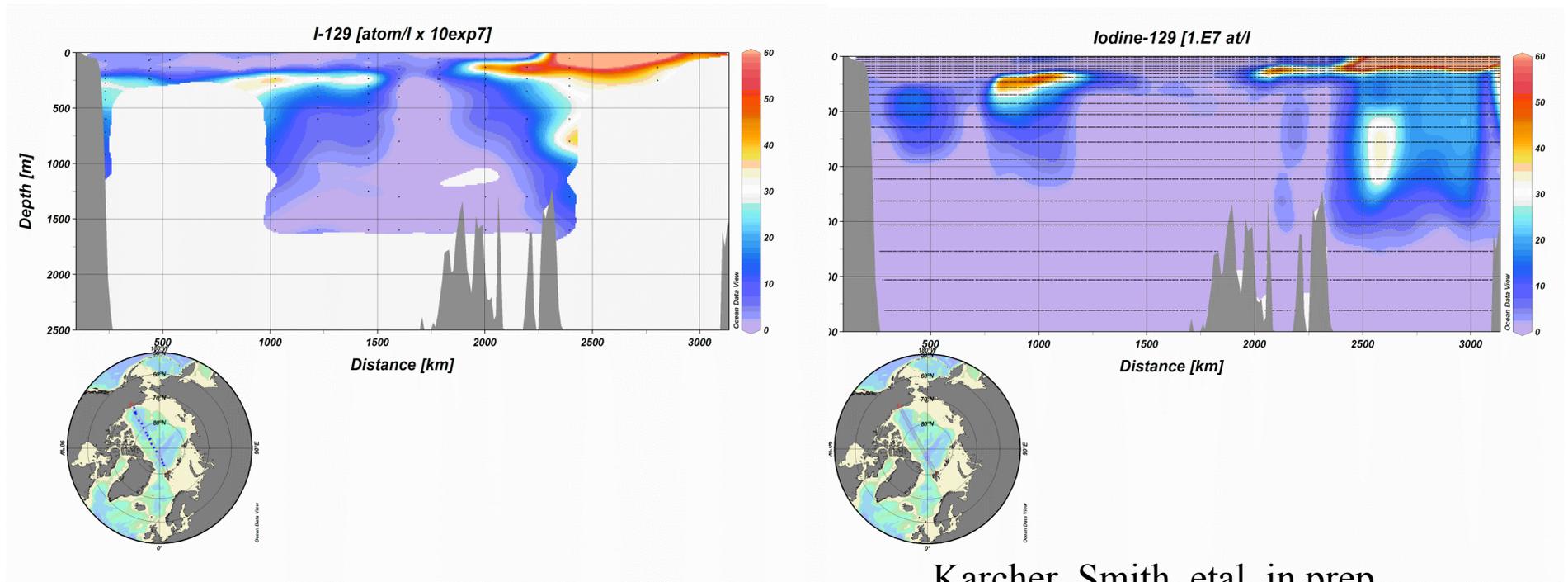


# $^{129}\text{I}$ Iodine Concentrations USS Pogy section 1996

indications for shortcuts...

Observed (J.N. Smith)

NAOSIM

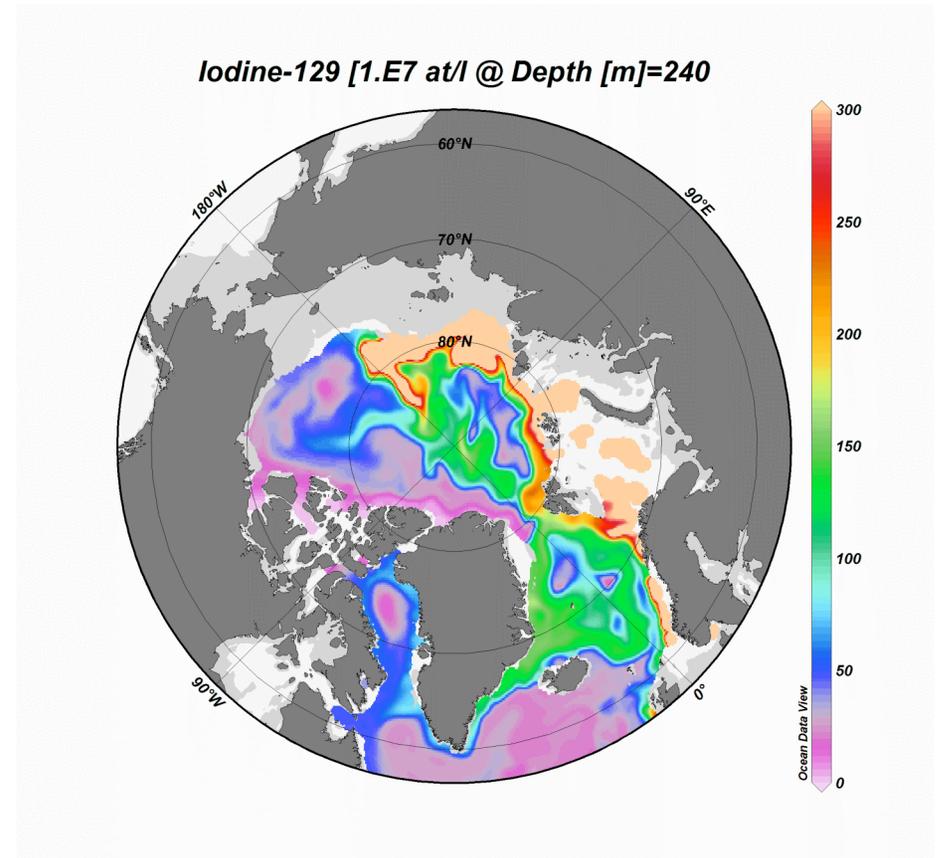
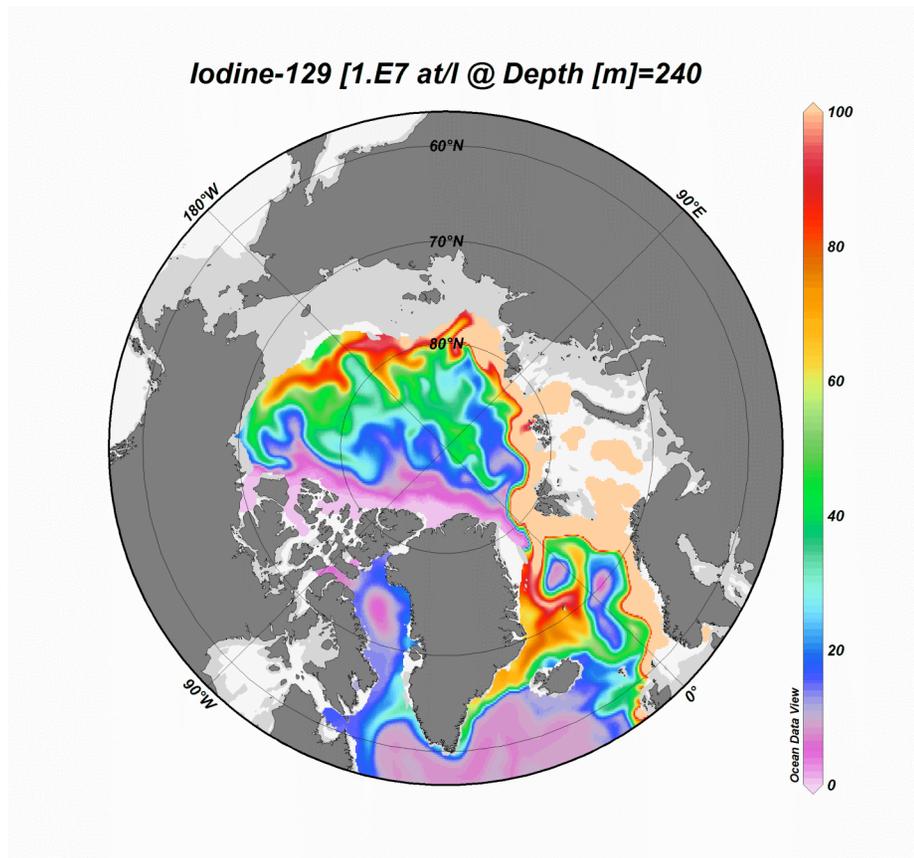


Karcher, Smith, et al, in prep

# $^{129}\text{I}$ Iodine Concentrations NAOSIM

2000

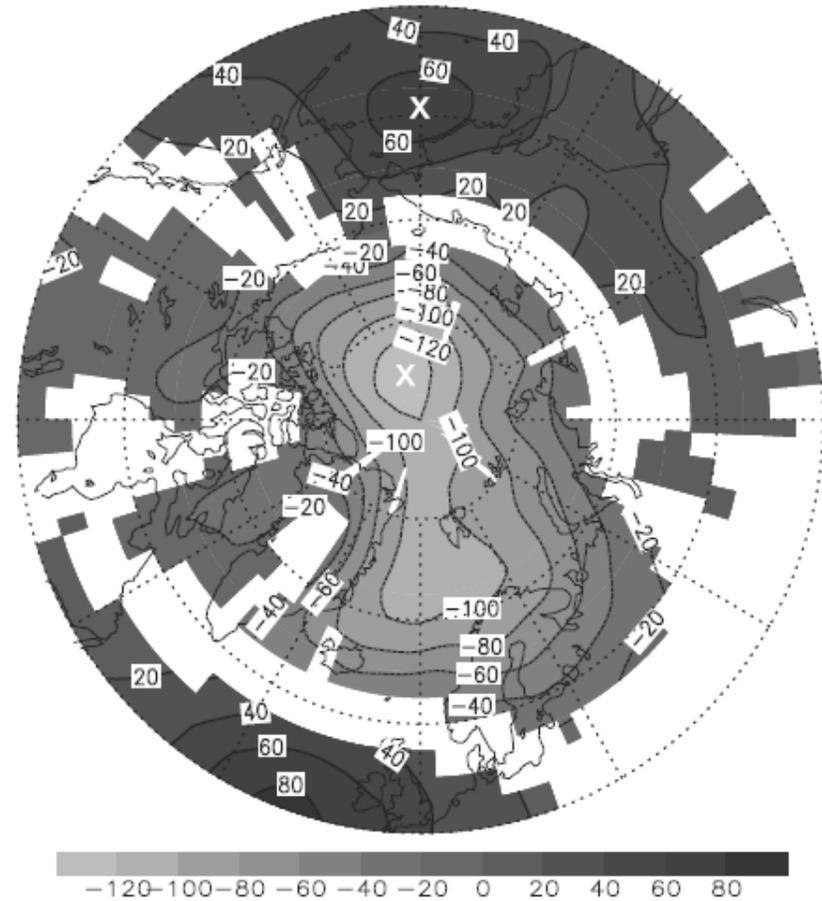
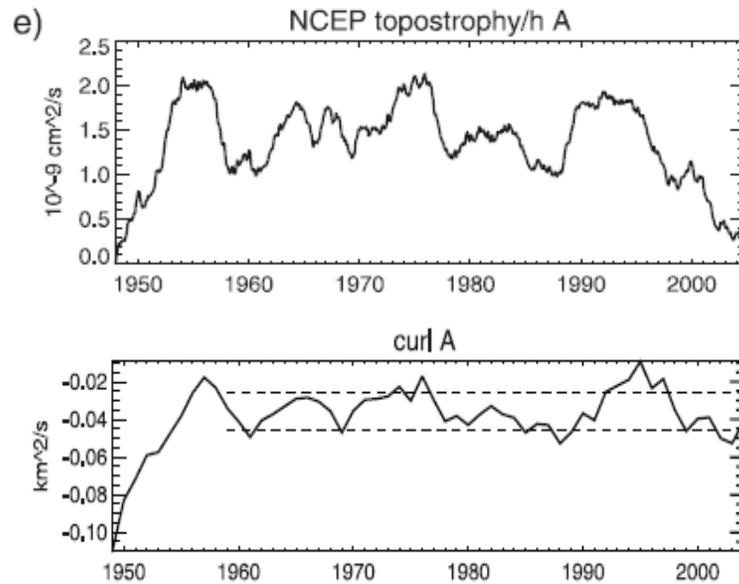
2008



Karcher, Smith, et al, in prep

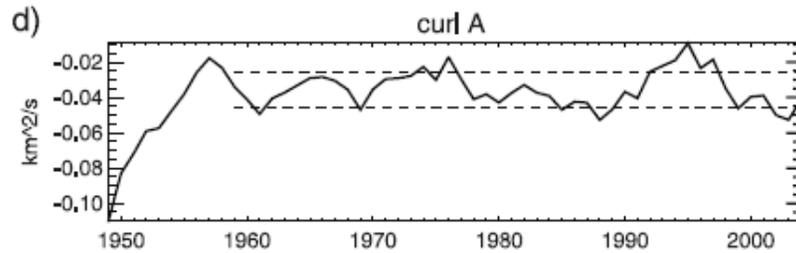
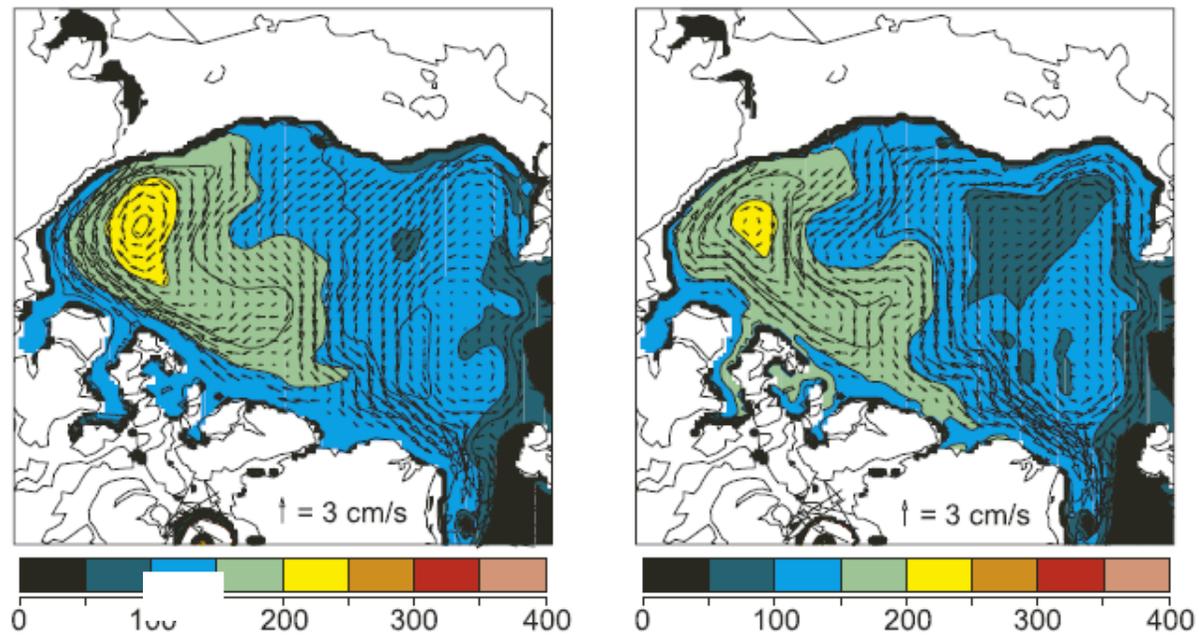
# Associated SLP anomaly

Intensity of Amerasian Basin  
AWL flow  
and surface layer curl



Karcher et al., JGR 2007

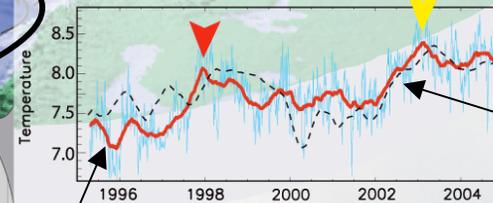
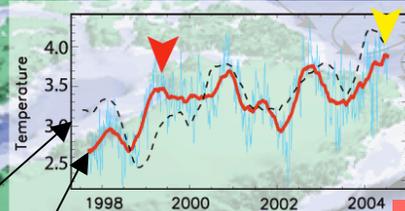
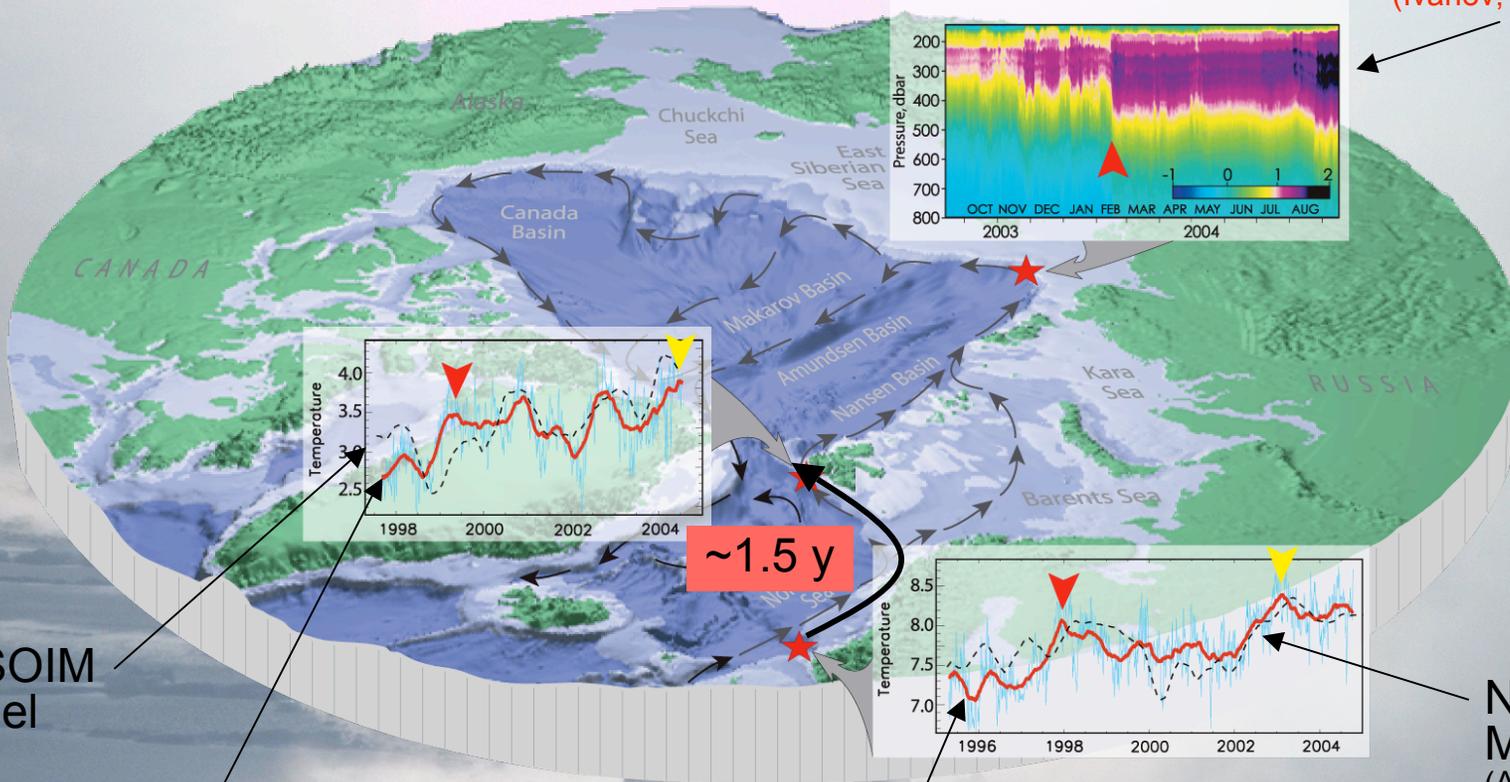
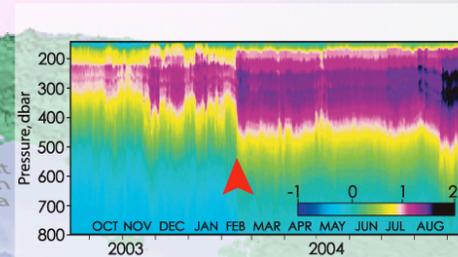
# Upper AW interface height for strong and weak BG



Karcher et al., JGR 2007

# Temperature of intruding Atlantic Water 1996 - 2004

NABOS  
Observations  
(Ivanov, Polayakov)



NASOIM  
Model  
(AWI)

NASOIM  
Model  
(AWI)

VEINS/ASOF  
Observations  
(Beszcynska et al)

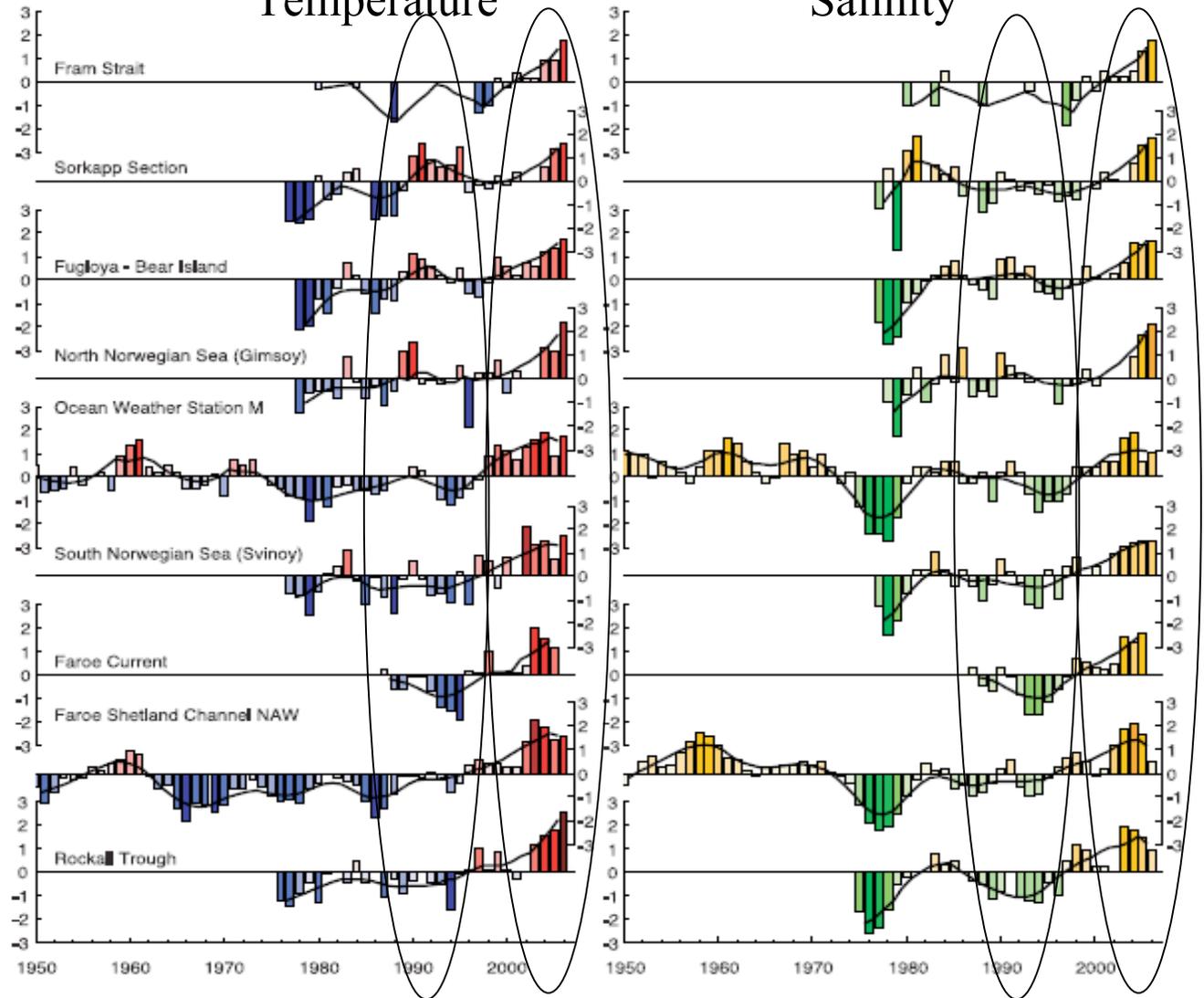
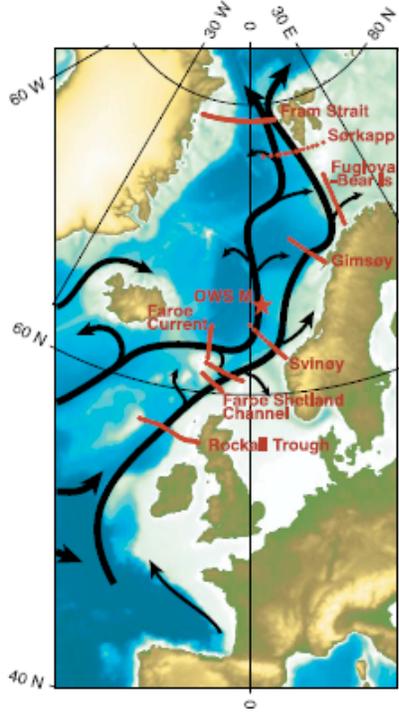
VEINS/ASOF  
Observations  
(Orvik and Skogseth)

from Polyakov et al., GRL, 2005

# Normalized Anomalies

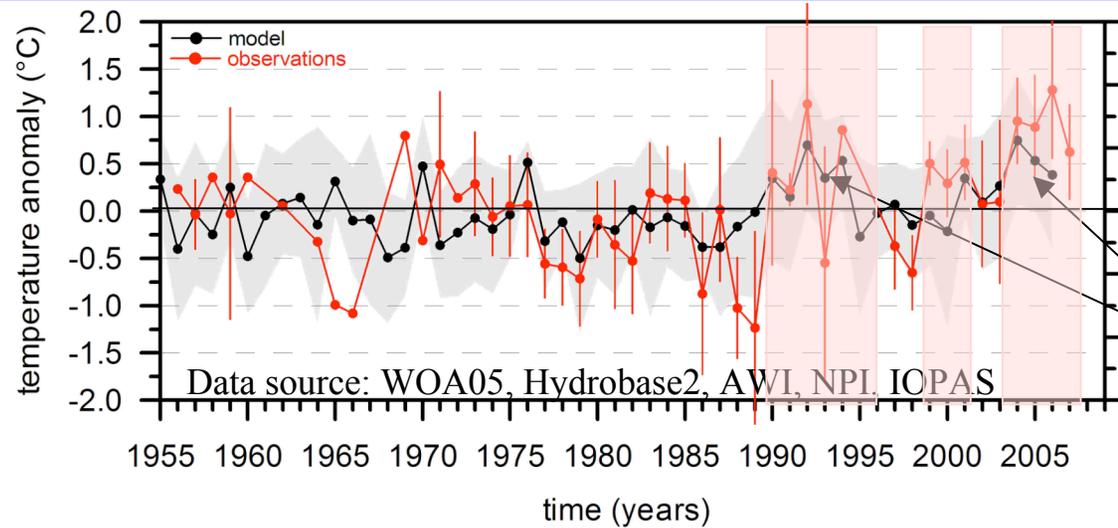
## Temperature

## Salinity

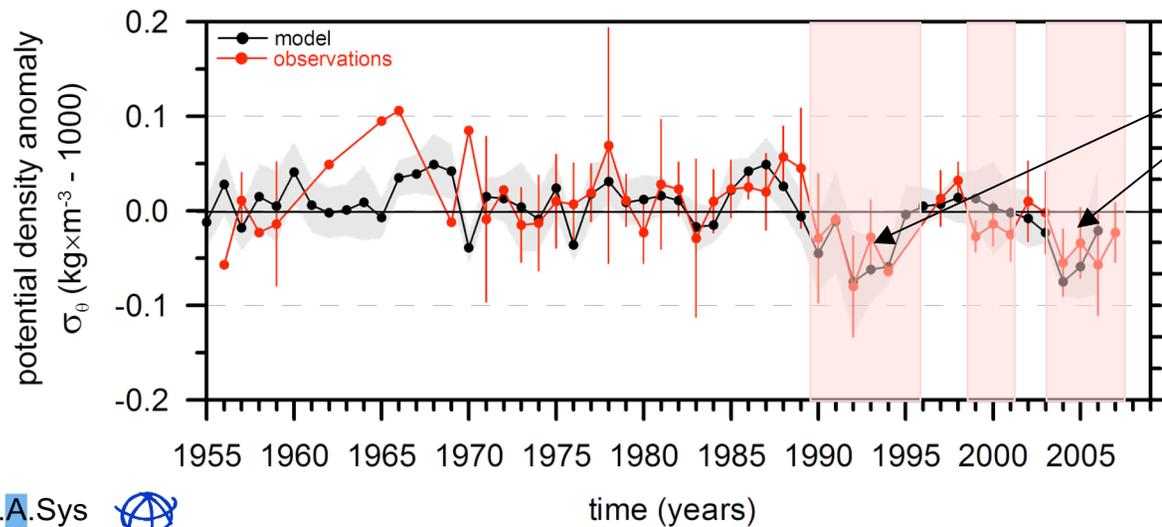


Holliday et al., 2008

# Observed and simulated 250-350m pot.temp and $\sigma_\theta$ anomalies in Fram Strait (WSC):

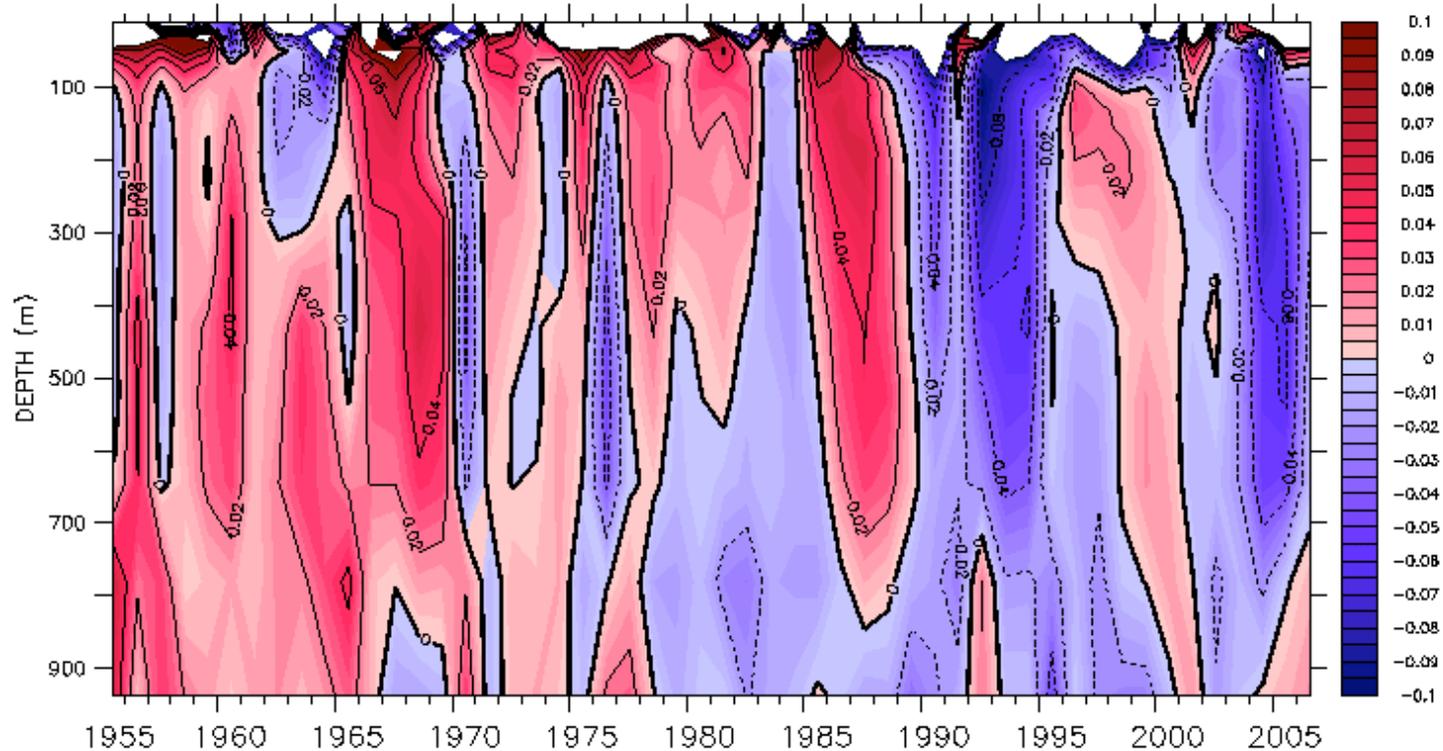


No density compensation!



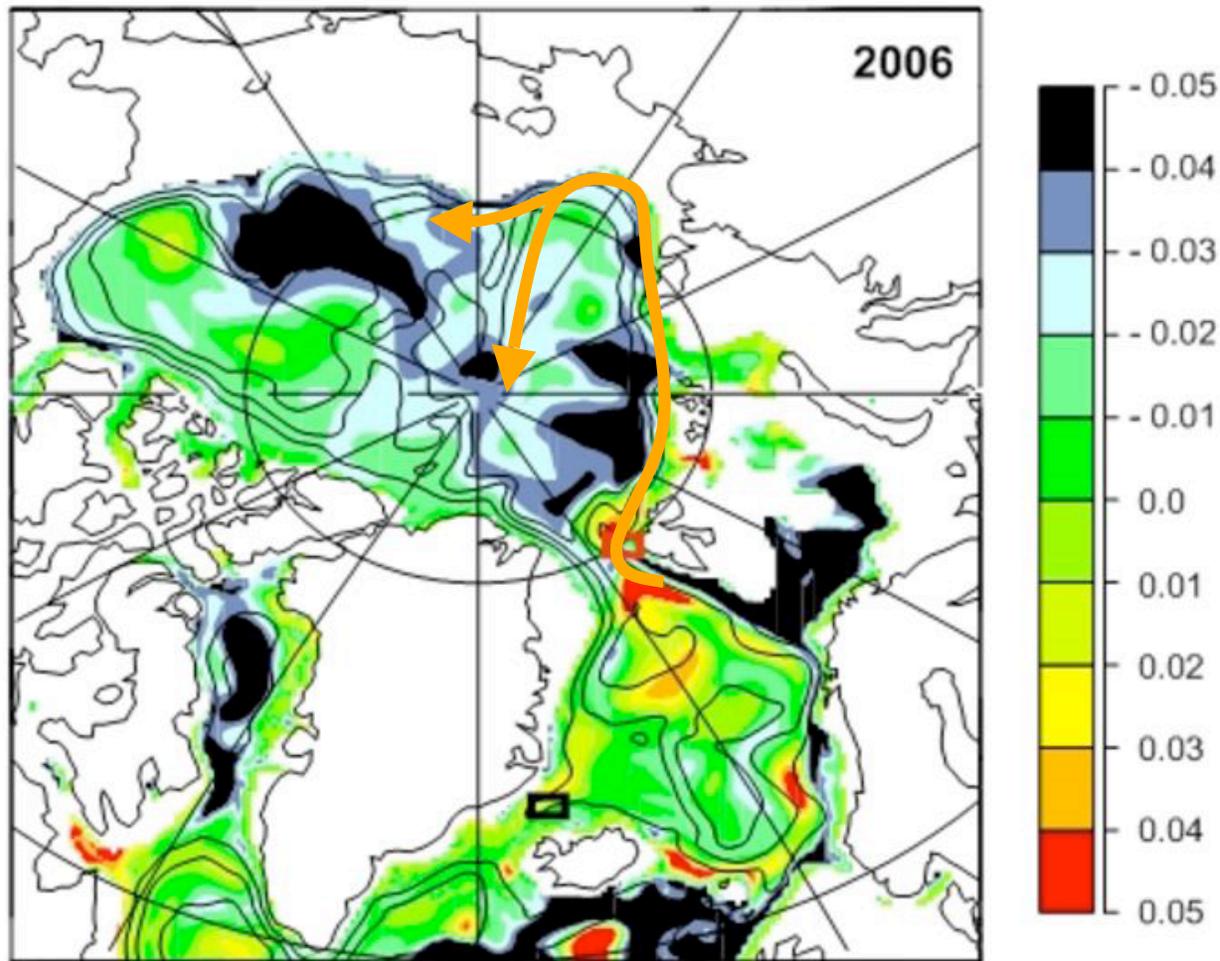
# Simulated $\sigma_\theta$ anomaly in Fram Strait

(WSC):

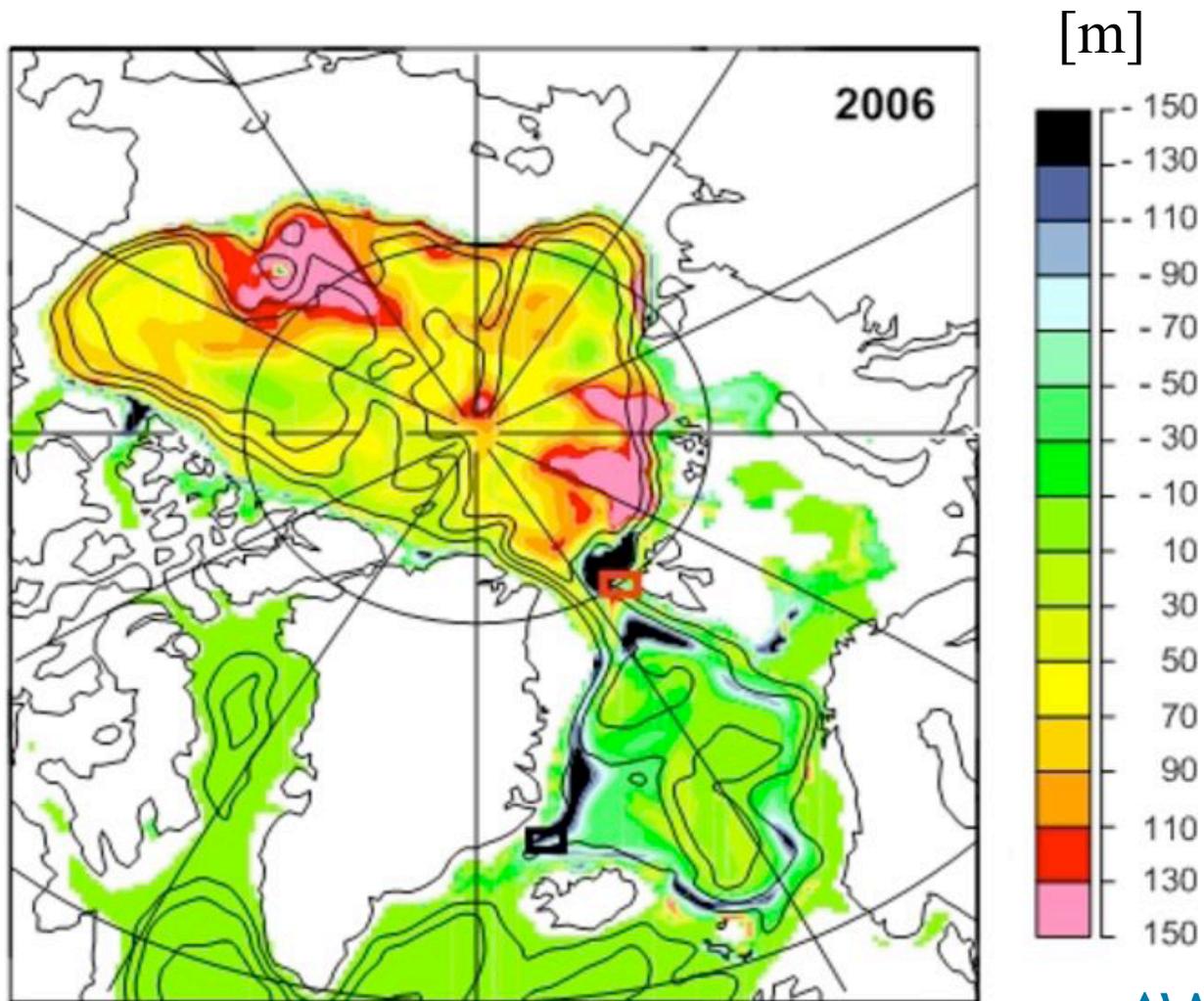


Hovmoeller diagram of pot. density anomaly  
for model domain MK mai-oct mean

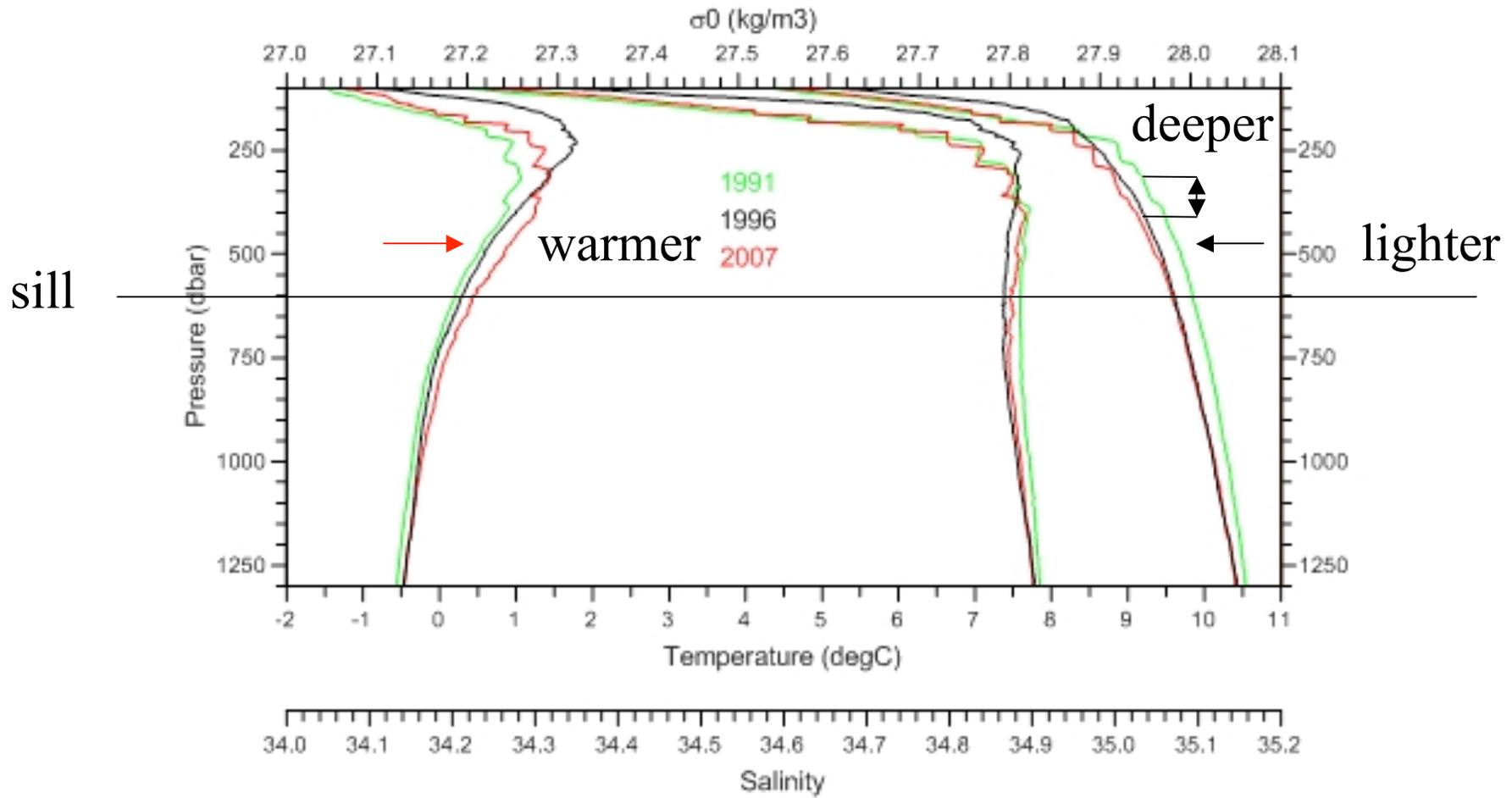
# Atlantic water layer $\sigma_0$ anomaly (rel to 1960-89mean)



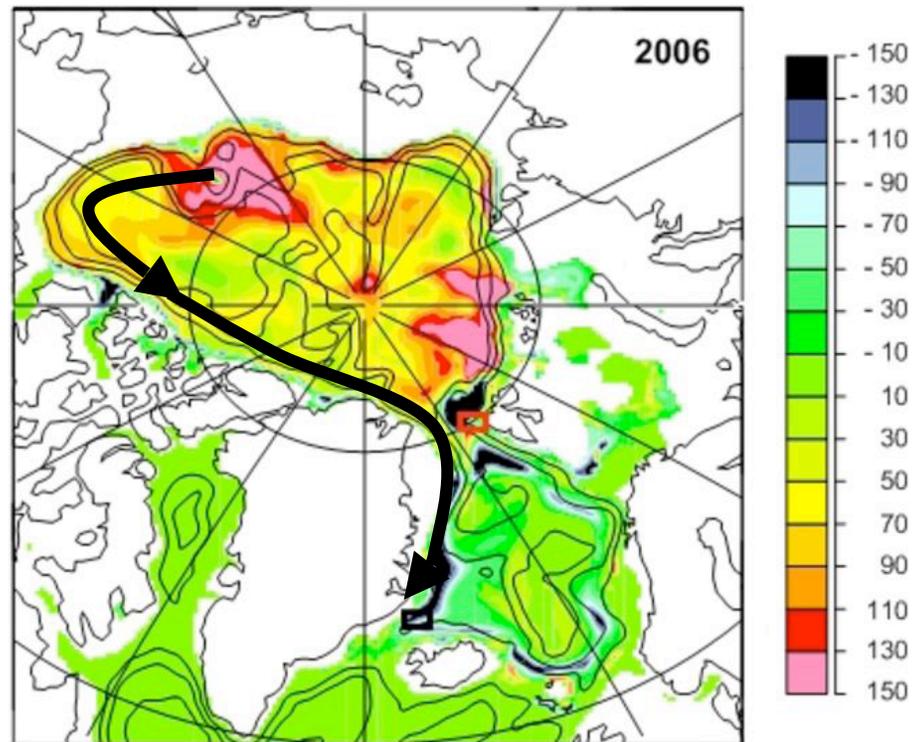
$\sigma_0 = 28.0$  depth anomaly  
(rel to 1960-89mean)



Observed Tpot, S, pot. density  
close to the North Pole

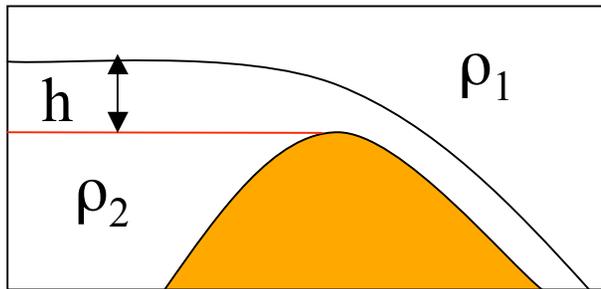


Hypothesis:  
the isopycnal anomalies will leave the Arctic  
and reach DSO



When will the anomalies leave the Arctic?  
Which path might they take?  
What are potential consequences?

# Hydraulic control of flow through straits e.g. Denmark Strait



$$Q = \Delta\rho / \rho \cdot g h^2 / 2f$$

[Whitehead, 1998]

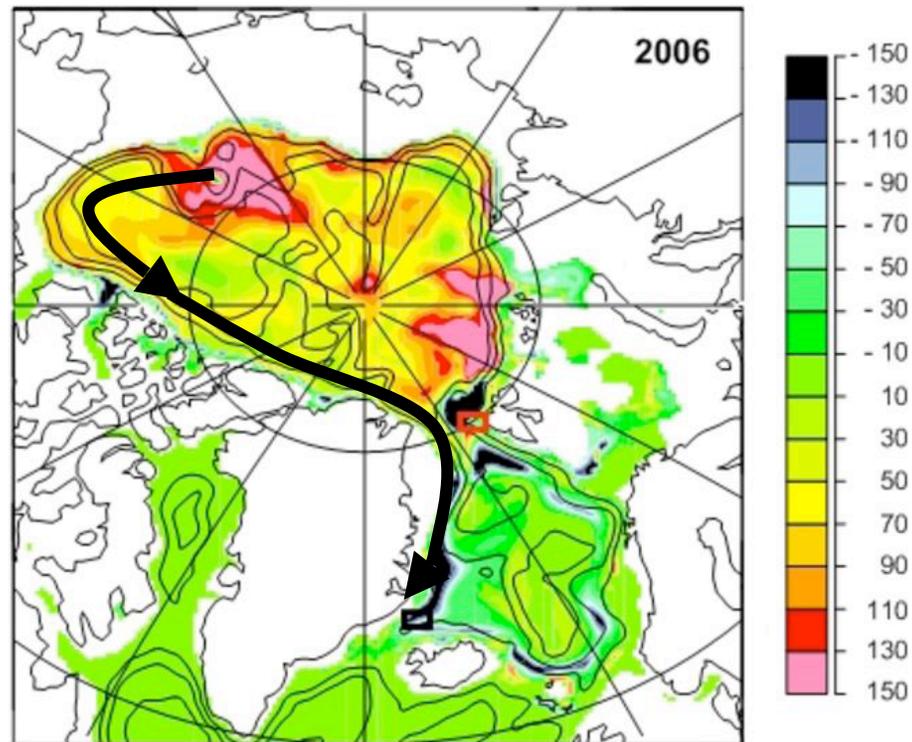
Density difference  
across the sill

**LINEAR**

Interface height  
above the sillheight

**QUADRATIC**

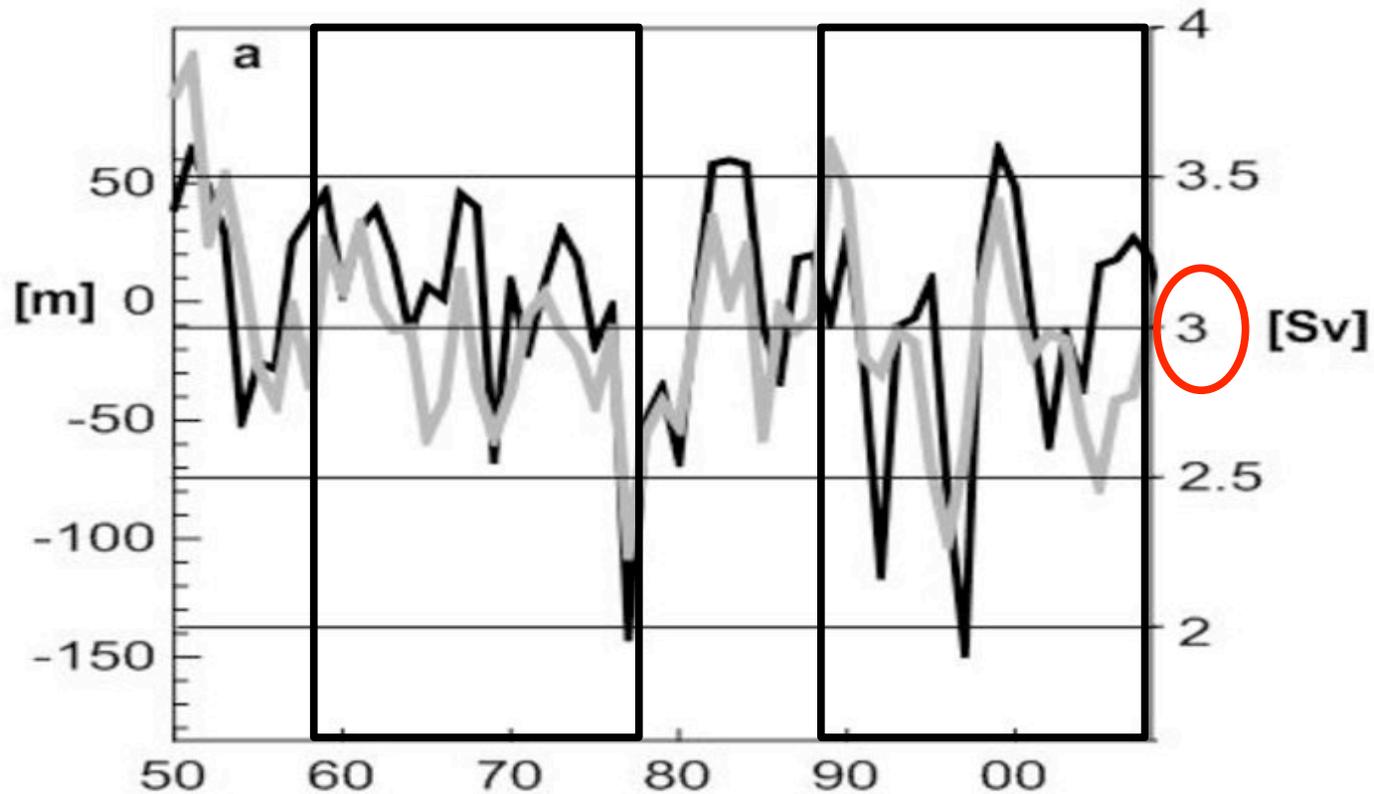
Hypothesis:  
the isopycnal anomalies will leave the Arctic  
and reach DSO



## Overflow and upstream interface height

Grey: Denmarkstrait Overflow  $> 28.0$

Black:  $\sigma_0 = 28.0$  depth anomaly

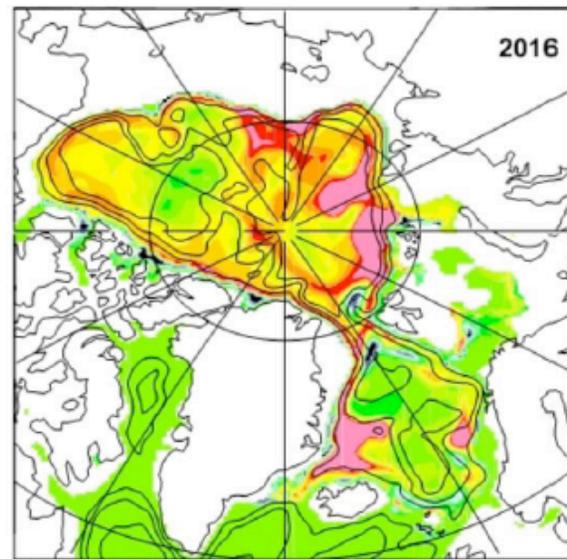
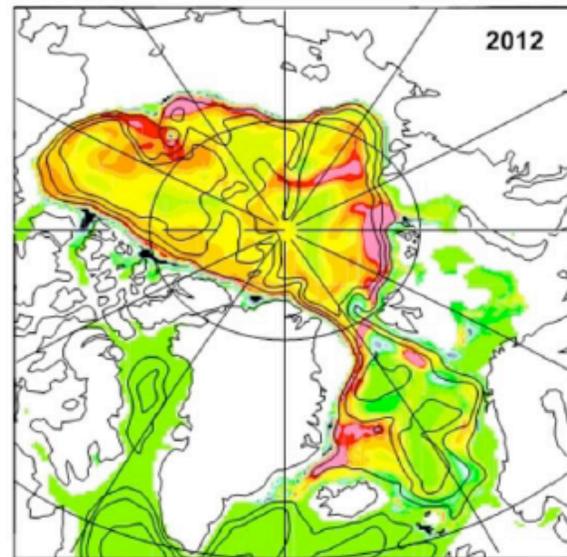


Extension experiments repeating:

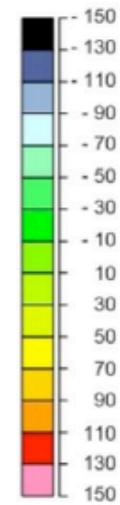
A 1959-1978

B 1989-2008

Extension  
Experiment B



Isopycnal  
depth anomaly

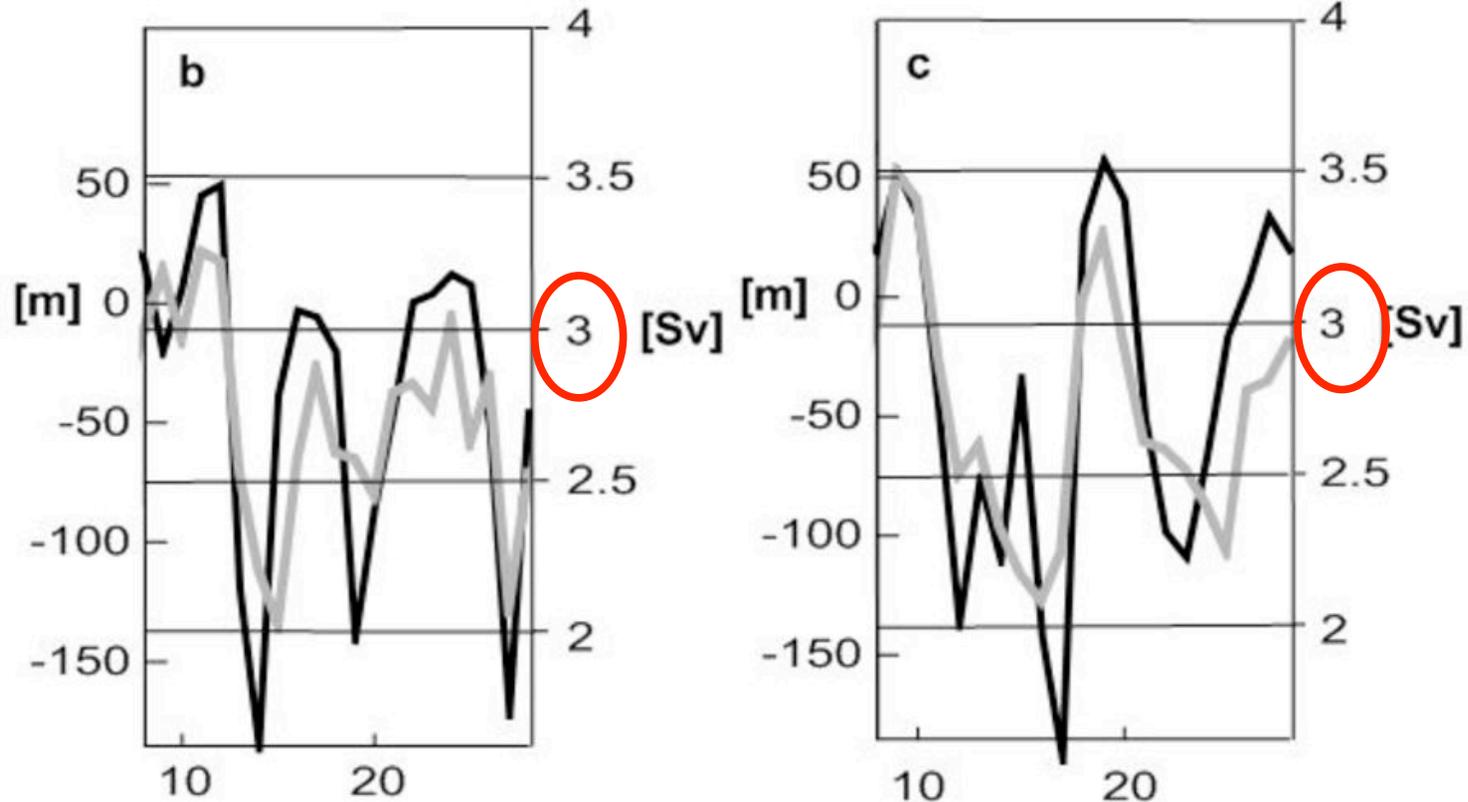


# Overflow and upstream interface height

Grey: Denmarkstrait Overflow  $> 28.0$

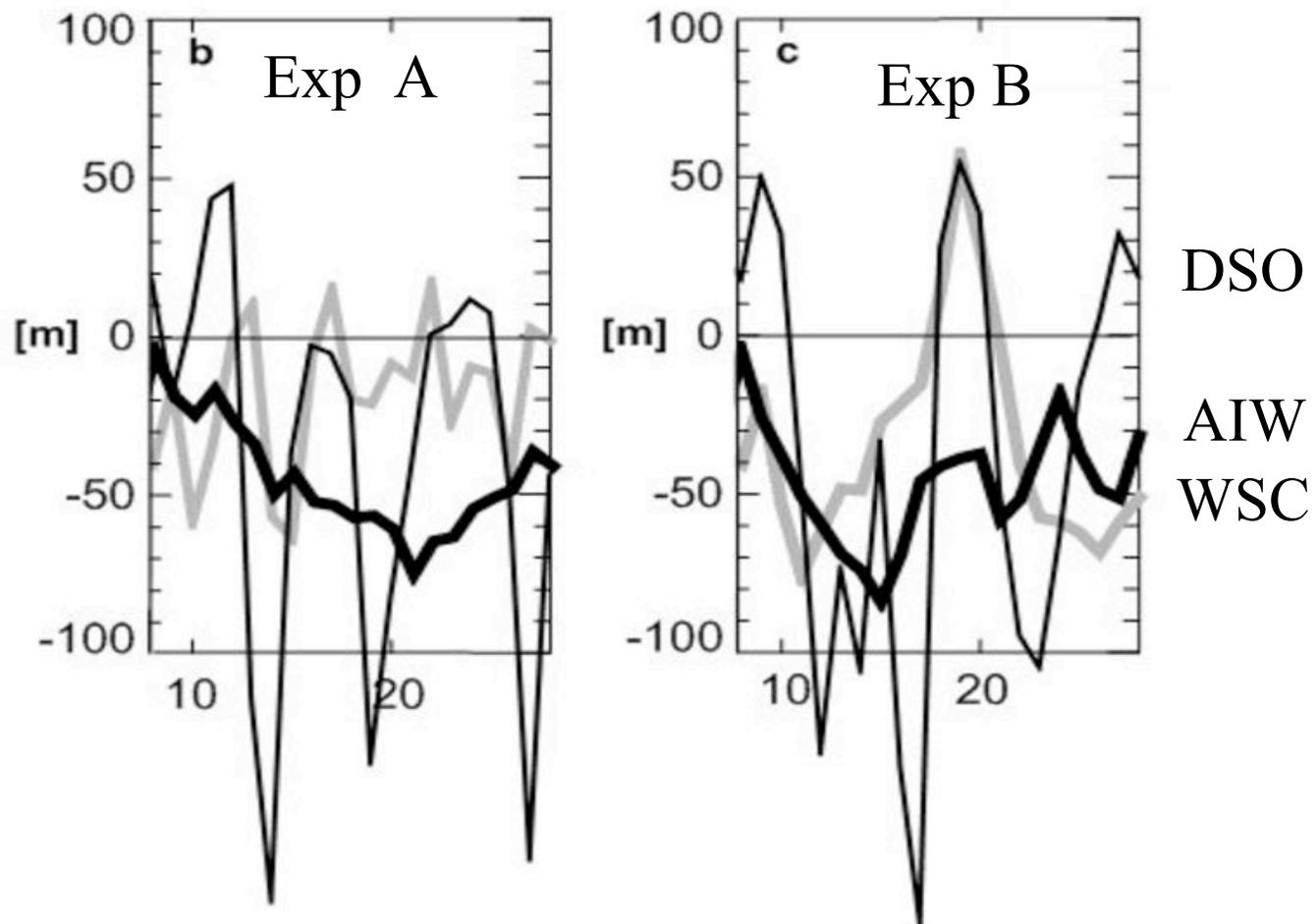
Black:  $\sigma_0 = 28.0$  depth anomaly

## Extended Runs 2009 - 2028



**DSO interface height**  
 $\sigma_0 = 28.0$  depth anomaly  
**Superposition of WSC, AIW and local processes**

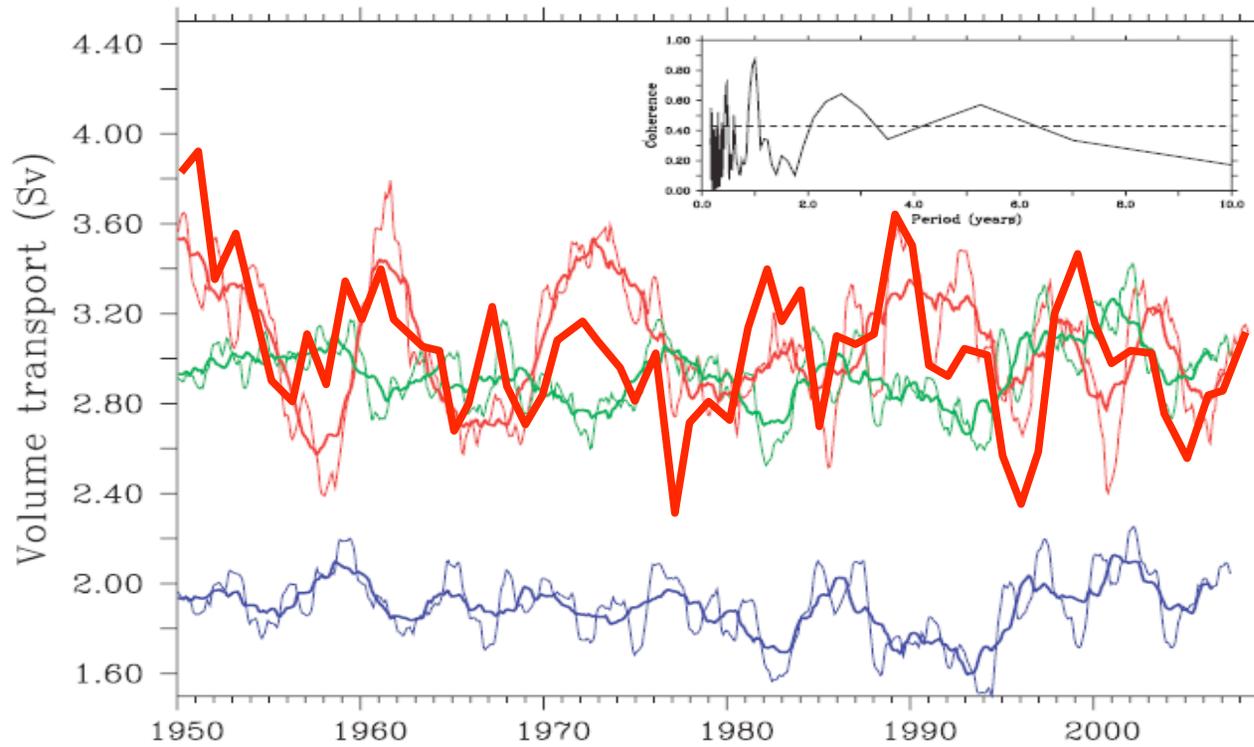
**Extended Runs 2009 - 2028**



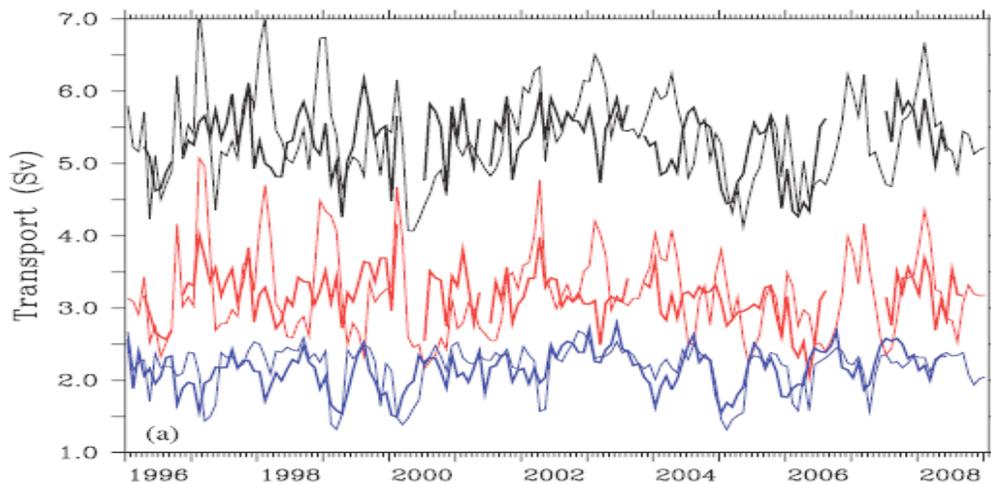
## **Conclusions:**

- **Non density compensated warm inflow for most of past 2 decades**
- **Large pools of low density/low interface height on slow Arctic passage**
- **When reaching the southern Nordic Sea a significant influence on overflows is possible**
- **Projected arrival over next 10-15 years with a significant reduction of baseline overflow volume for several years**

# Denmarkstrait Overflow (red): NAOSIM/MIT-HH/Obs

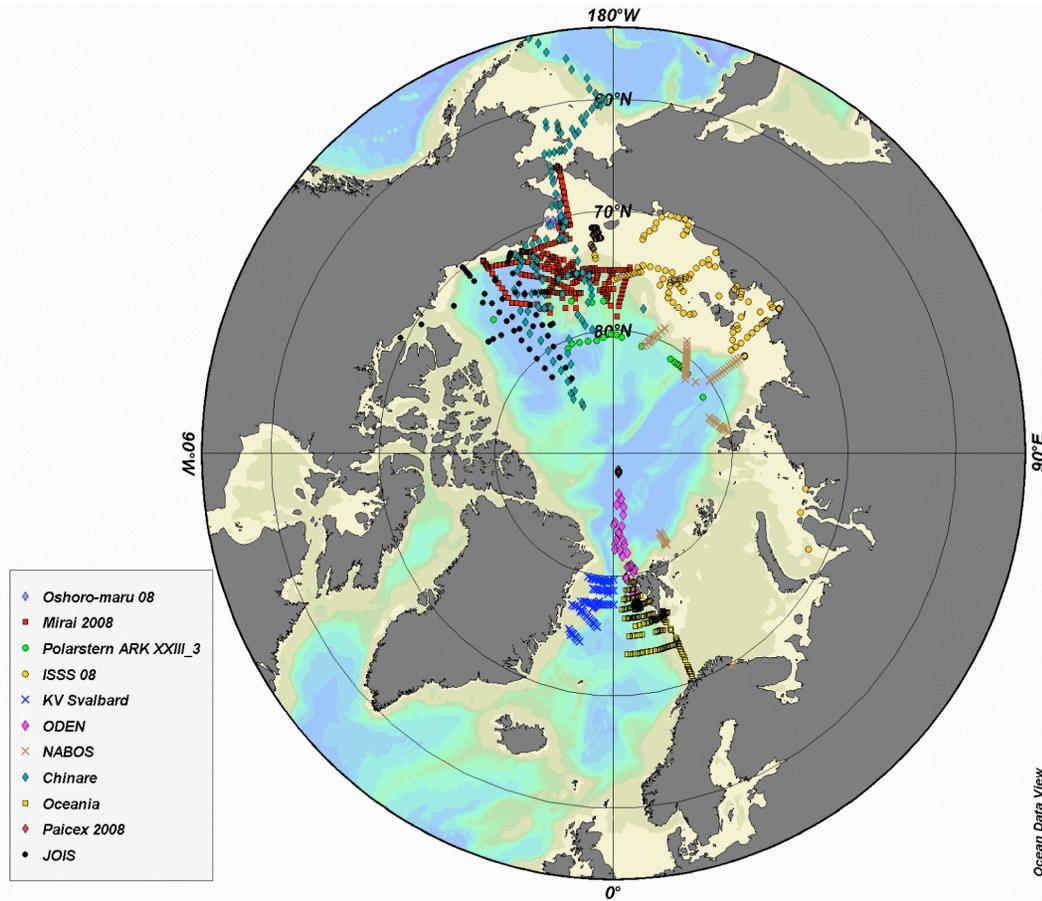


NAOSIM

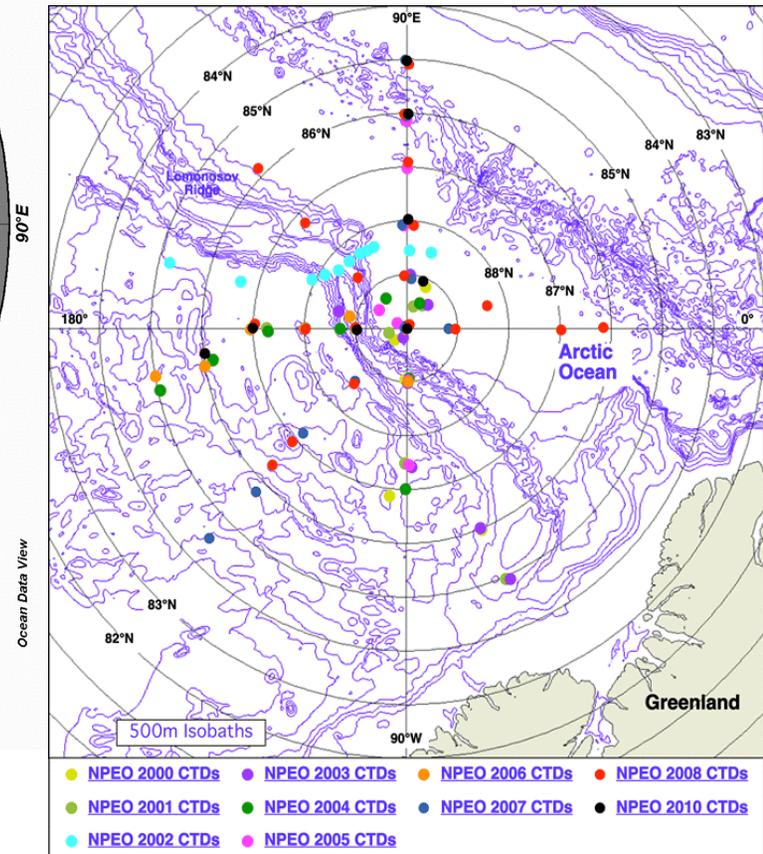


from Serra et al., 2010

# Important: Long term moorings and repeat profiles



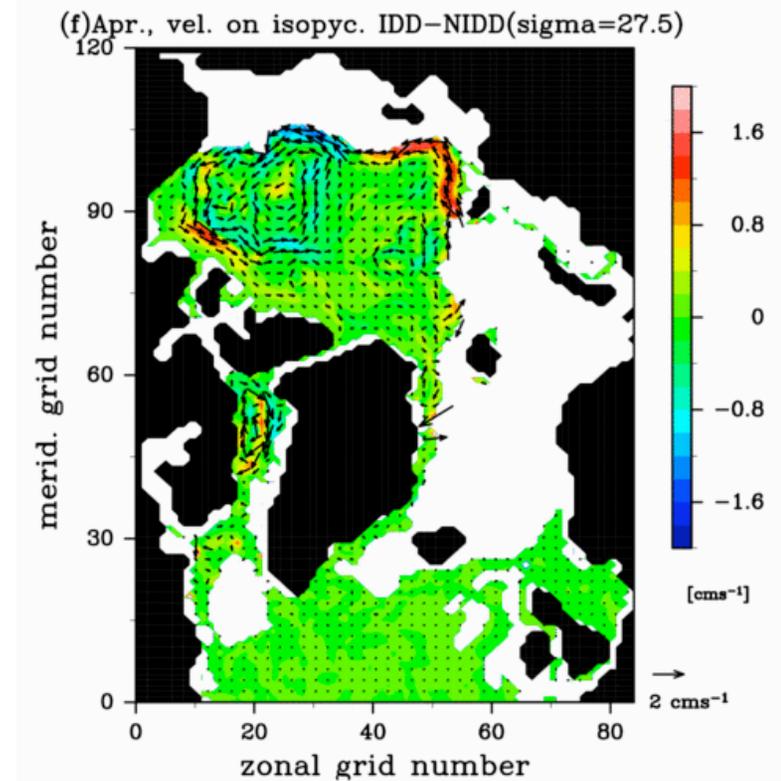
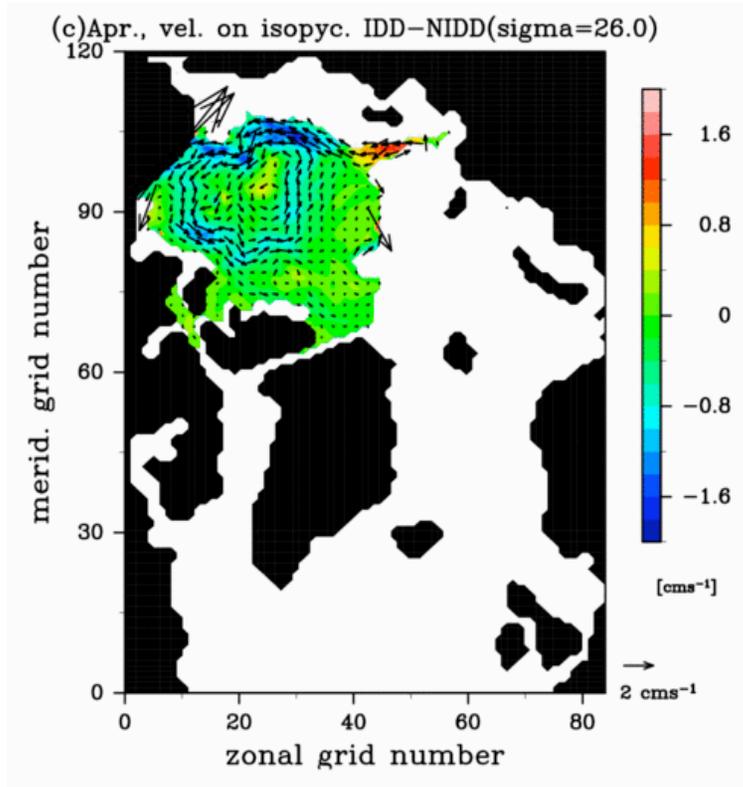
## NPO 2000-2010



IPY 2008

# Icedrift Data Assimilation experiment for Mar-May/2010

Mean velocity above and below pycnocline  
IDD - NIDD



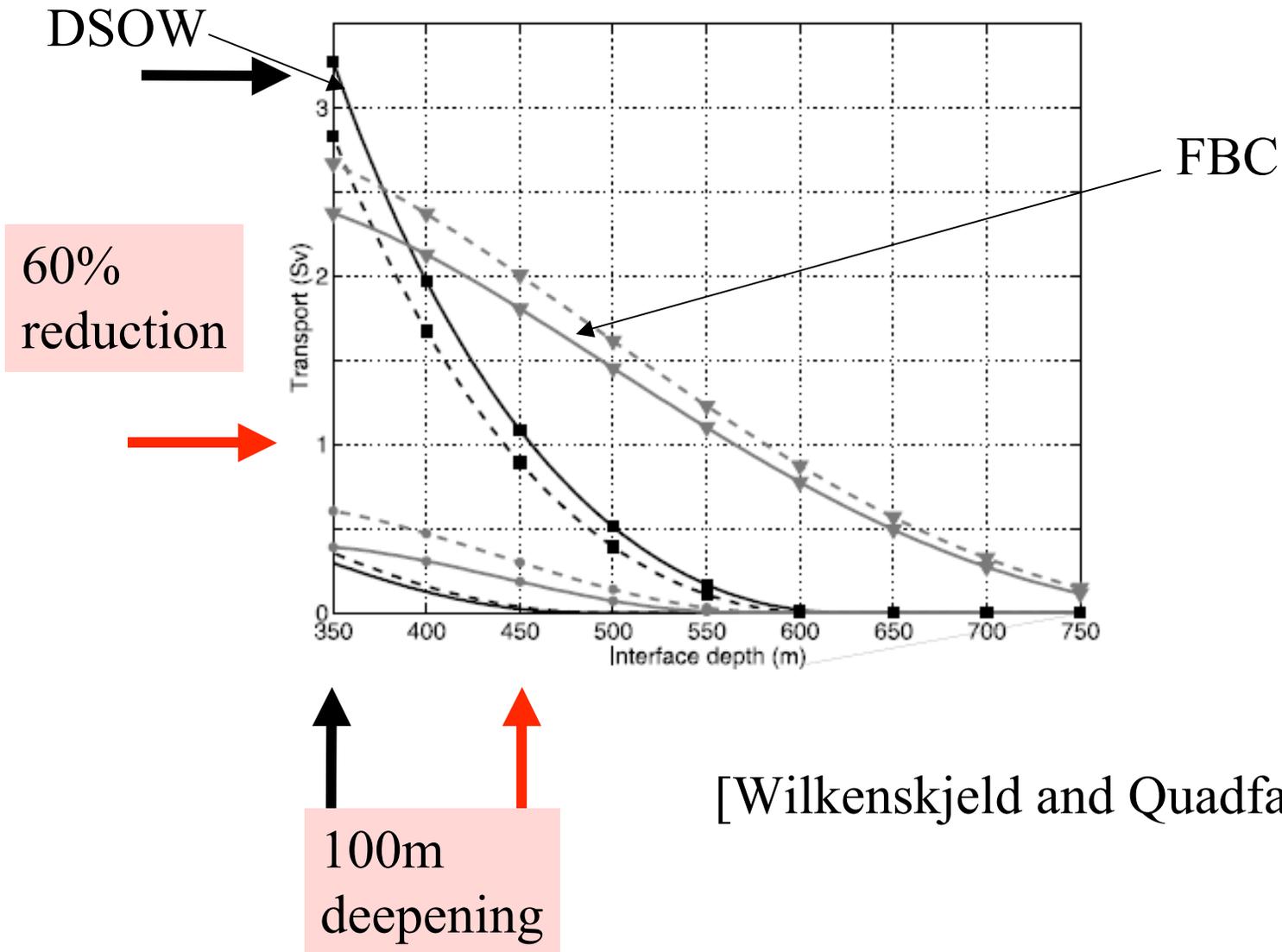
Reduction of Beaufort Gyre and  
Enhancement of cyclonic AW circulation

from H. Sumata et al.

## **How to go on:**

- **Repeat sections in the interior Arctic**
- **Monitor propagation of 90s, 2000s peaks (and background!)**
- **Outflow monitoring north and west of Fram Strait**
- **'All hands on deck'**
  - **Synthesis (a story of > 2 decades)**
  - **Hydrography and tracers**
  - **Combined observational and modelling approach**
  - **Data assimilation and quantitative network design (propagation of uncertainties, optimize network for given cost and given scientif. Target, cooperation of obs and mod necessary!)**

Change in Overflow volume for different Interface heights based on two layer approach:

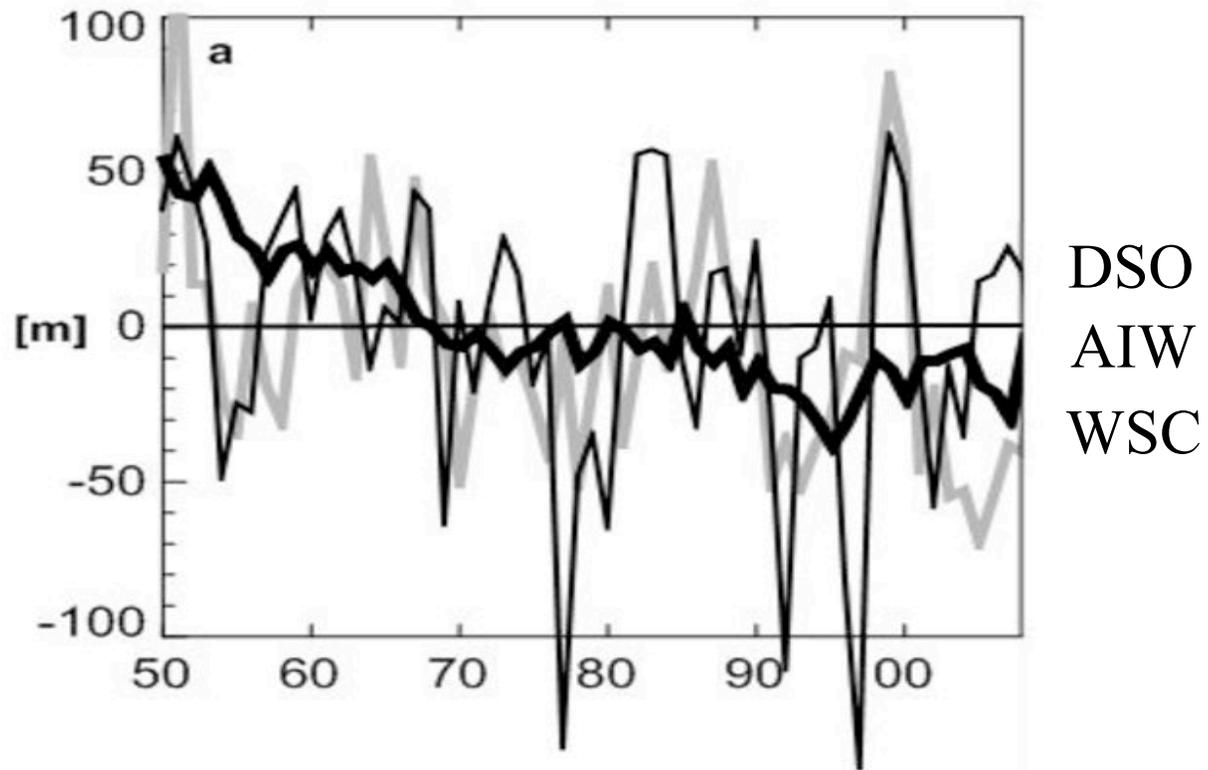


[Wilkenkjeld and Quadfasel, 2005]

# DSO interface height

$\sigma_0 = 28.0$  depth anomaly

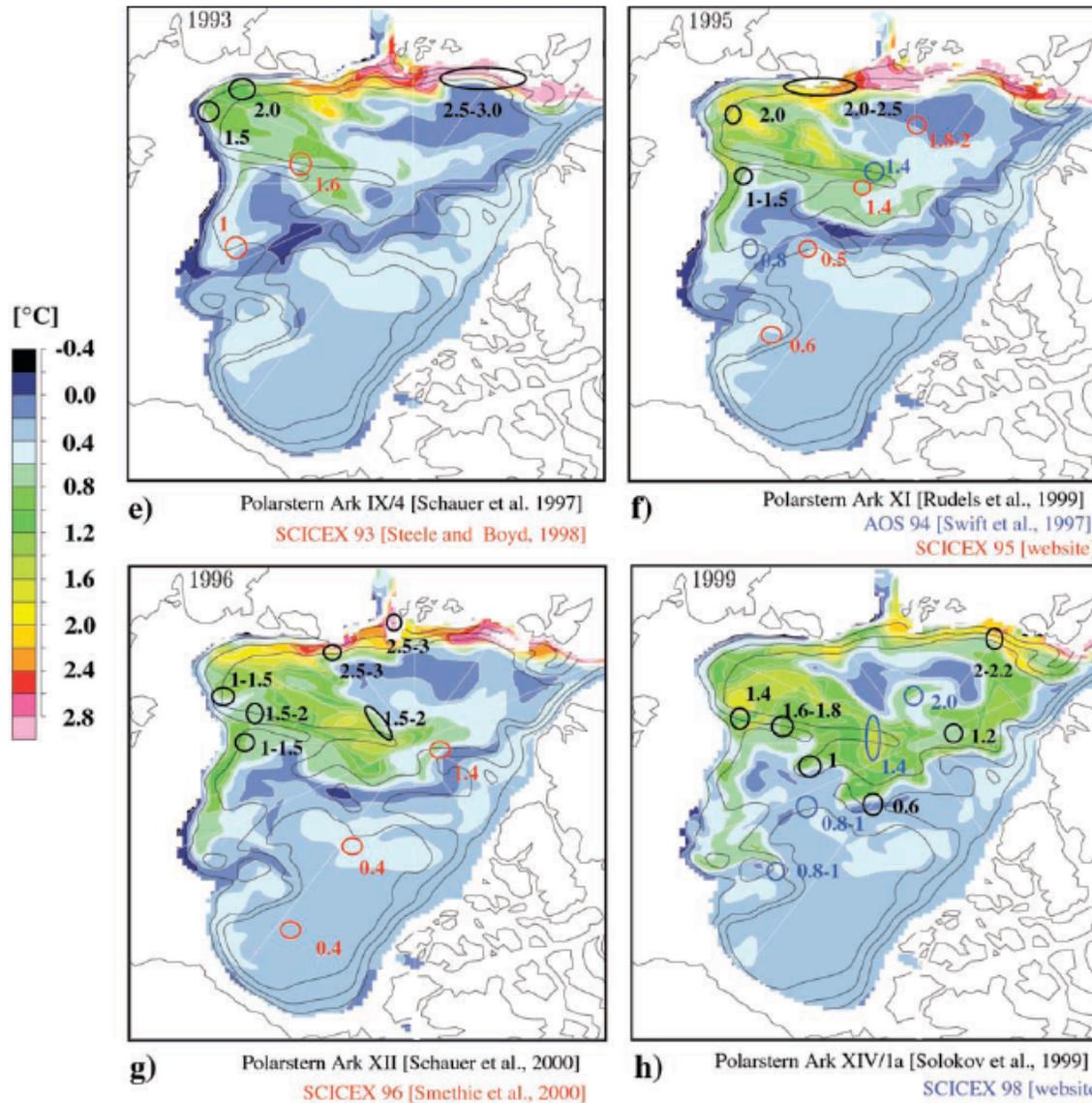
## Superposition of WSC, AIW and local processes



# Spreading of the 90s warm event into the basins

## Pot. Temperature at the Tmax 1993 - 99

Color: Model  
Numbers: Obs



NAOSIM



(from Karcher, Gerdes, Kauker, Köberle, 2003)