High Latitudes

New insight from new kind of observations

Seasonal to interannual variability of temperature and salinity in the Nordic Seas: heat and freshwater hudgets

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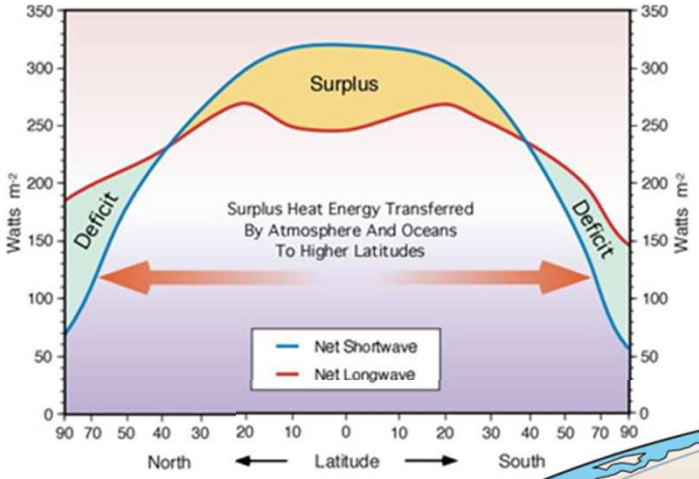
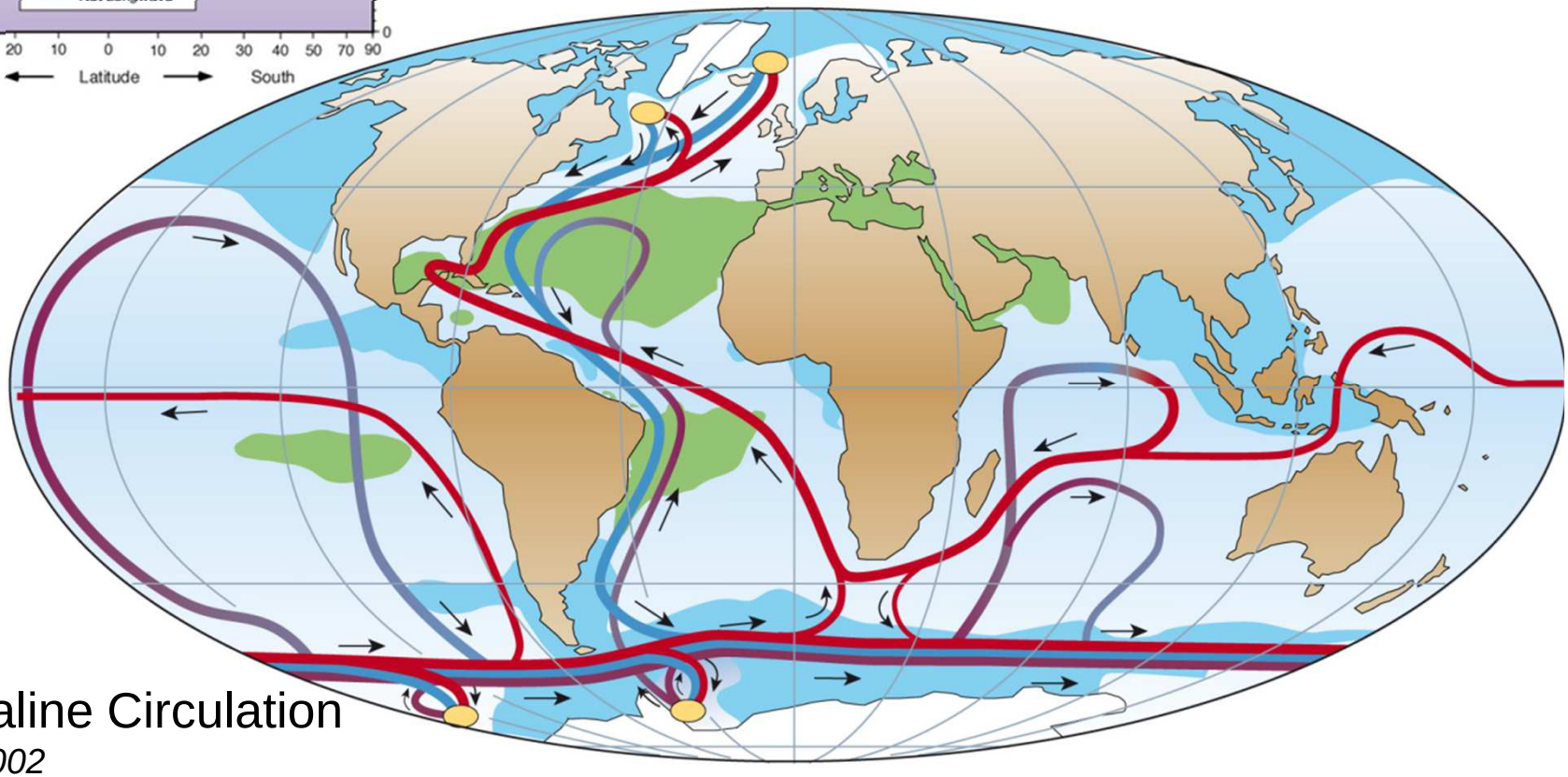
This work is financed by national funding from the DFG (SFB 512 E2) and BMBF (NA) and European funding (MERSEA, THOR, NACLIM).

Background: the „Global Conveyor“



Energy balance at the top of the atmosphere

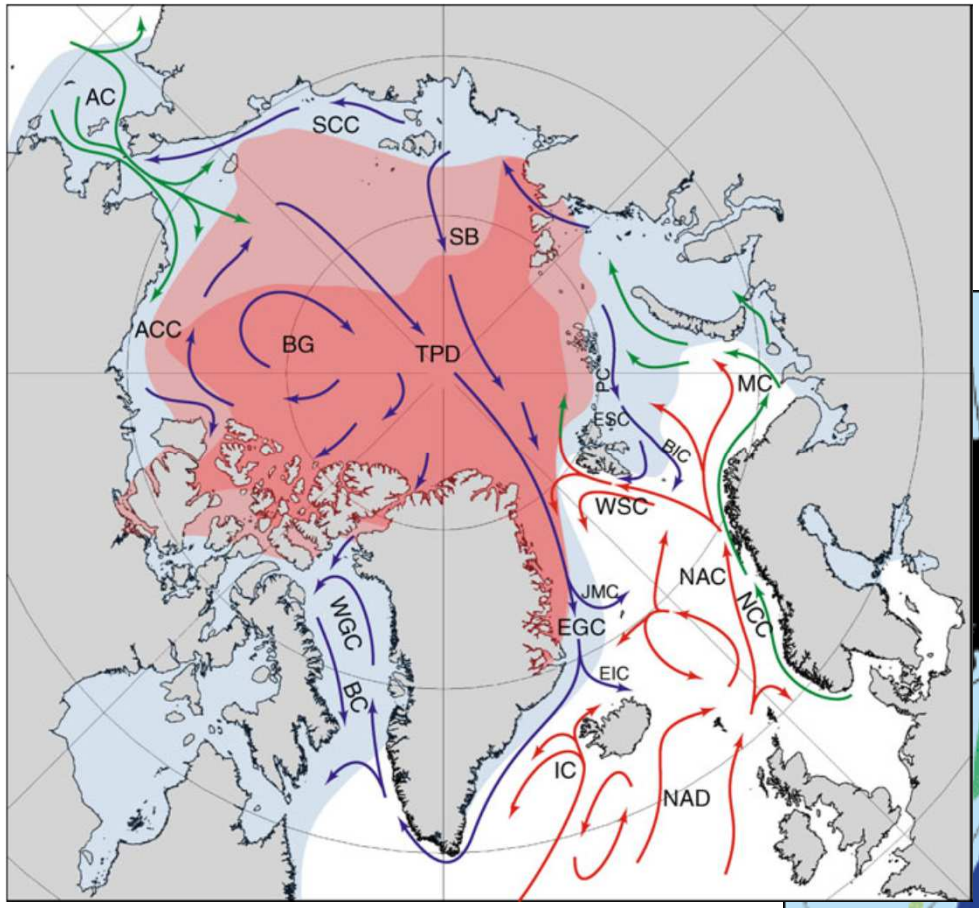
Pidwirny, Budinova, 2010



Scheme of the Global Thermohaline Circulation

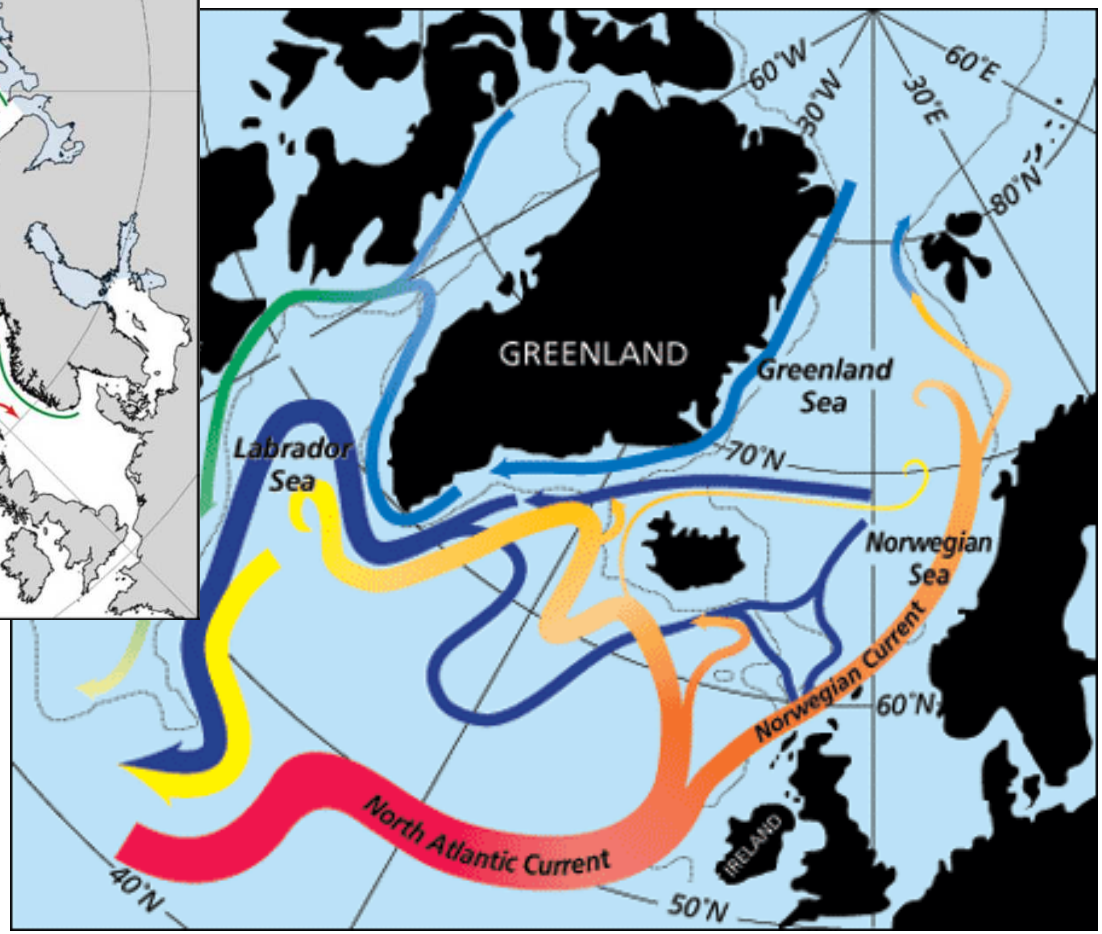
Rahmstorf, 2002

Background: circulation and ice coverage



Sea Ice coverage
in the Arctic Mediterranean
blue-max, red-min

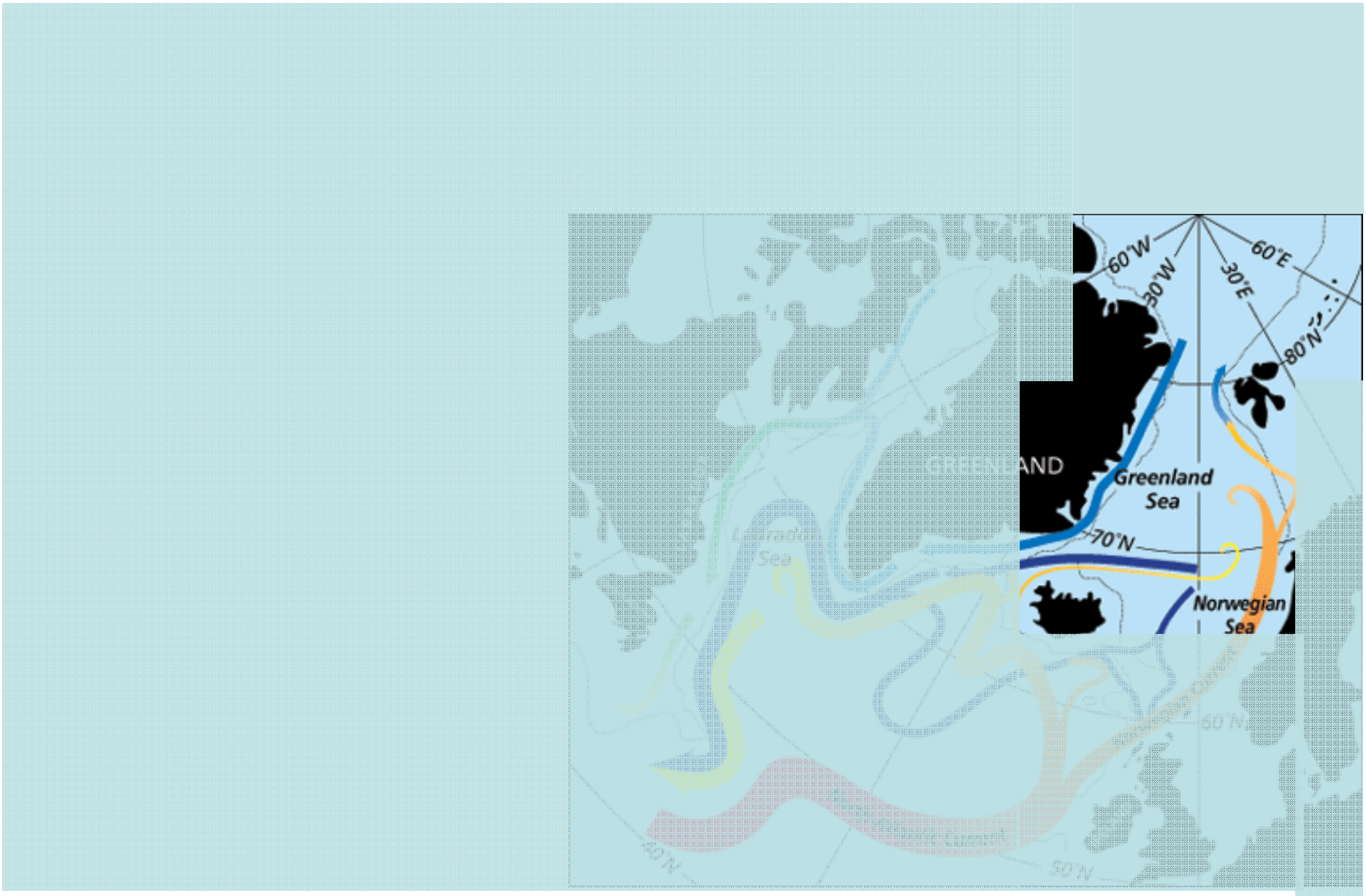
Rudels et al., 2012



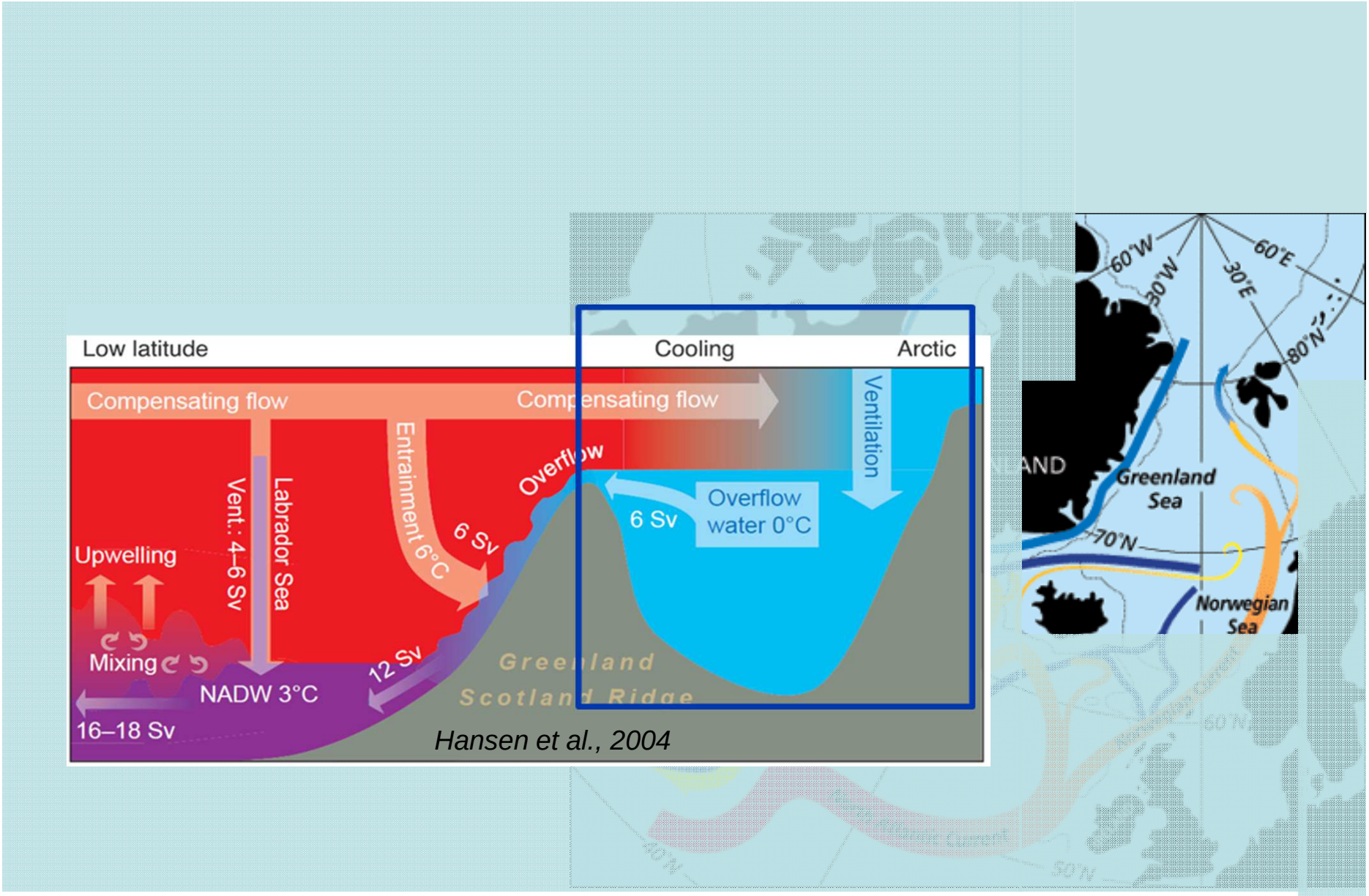
McCartney et al., 1997

Background: focus on the Nordic Seas..

Background: focus on the Nordic Seas and the Arctic Ocean

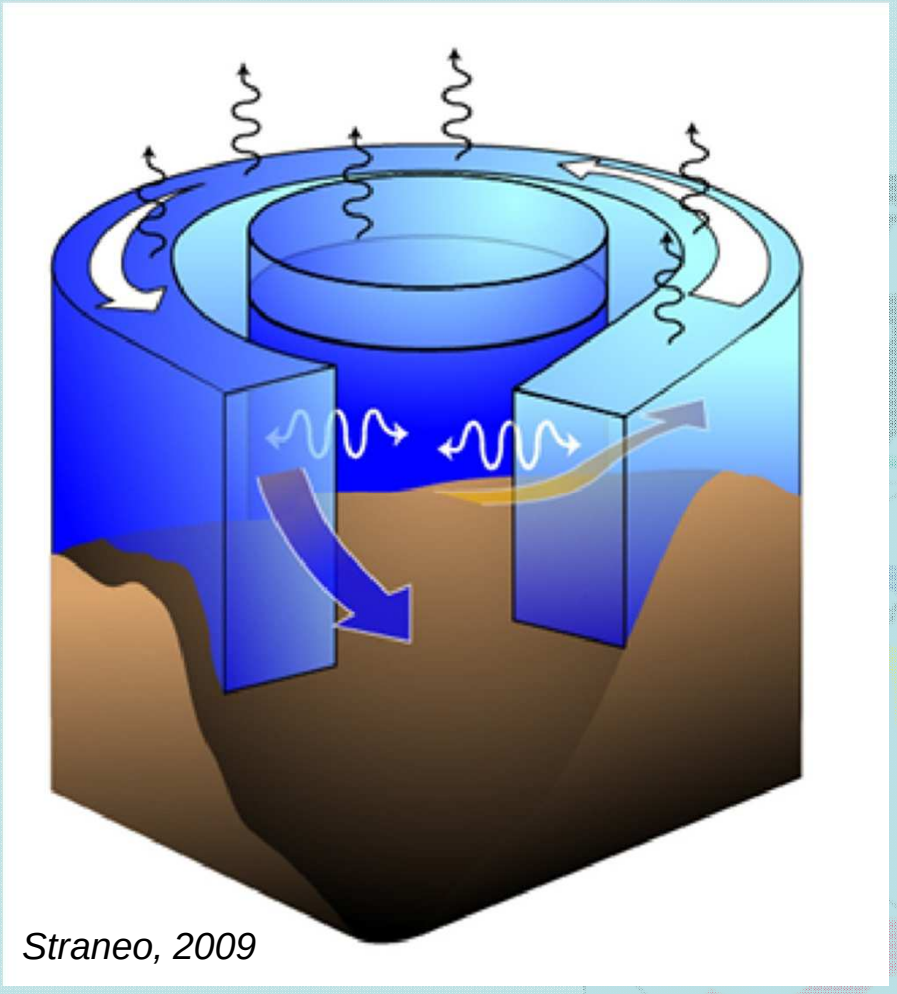


Background: ventilation of deep waters

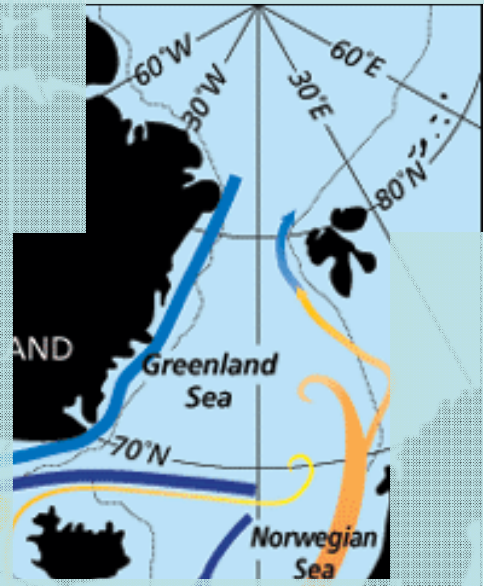


Hansen et al., 2004

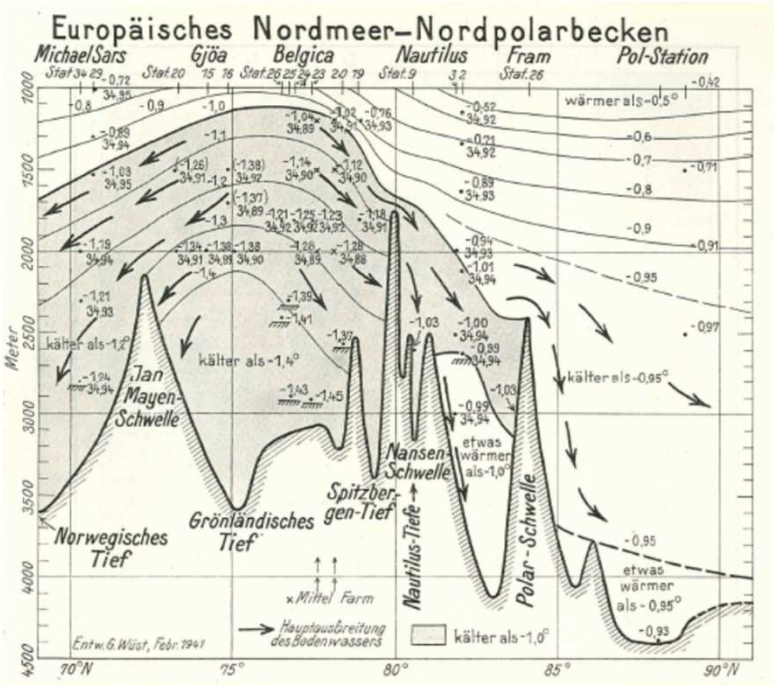
Background: interplay of boundary currents and gyres in the interior



Straneo, 2009

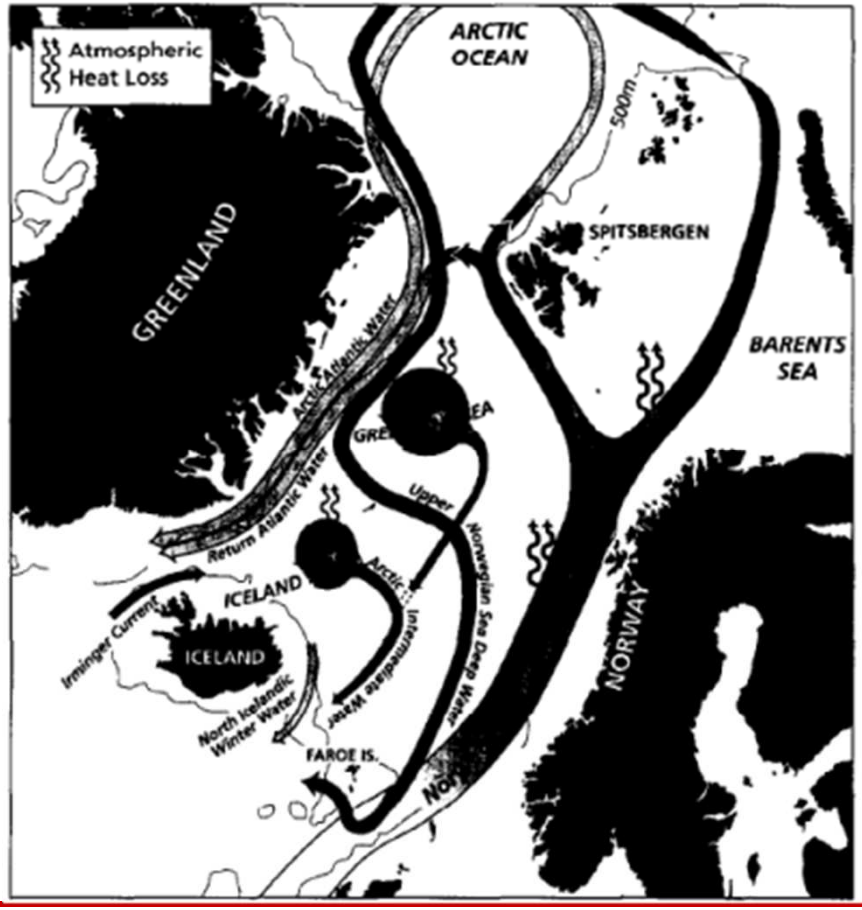


Background: investigations from the past



Traditional view of intermediate to deep water renewal in the Greenland Sea and spreading to the overflow into the North Atlantic and into the Arctic Ocean

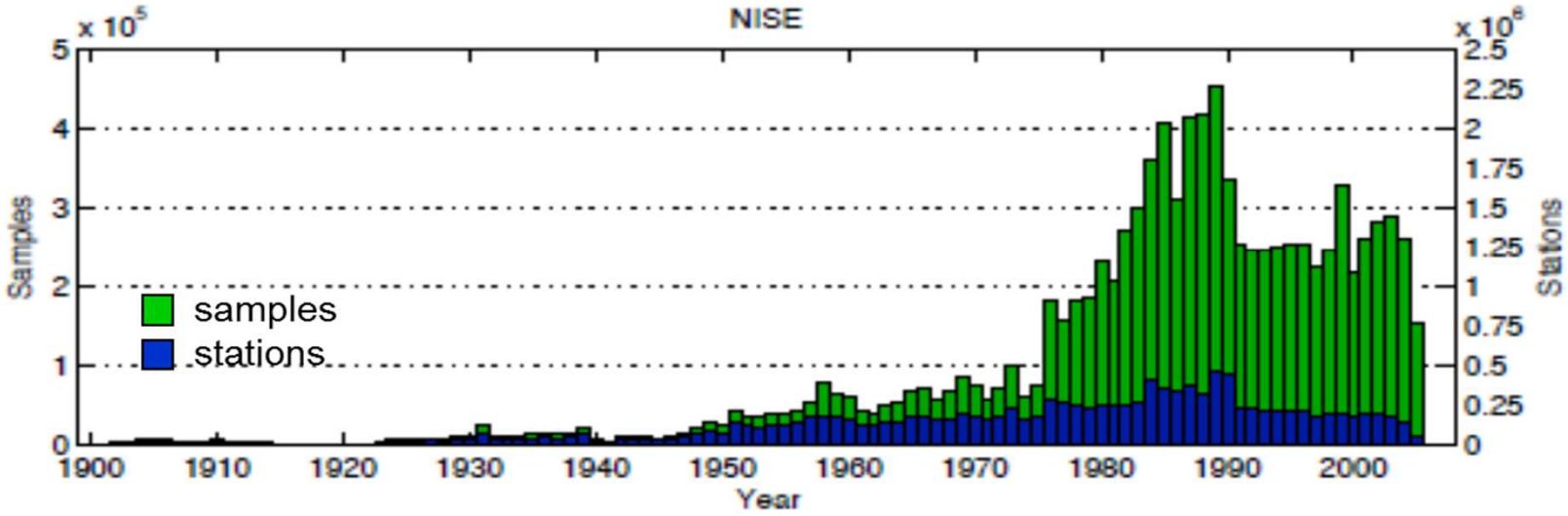
Wüst, 1942



Alternative circulation scheme for the feeding of the overflow into the North Atlantic

Mauritzen, 1996

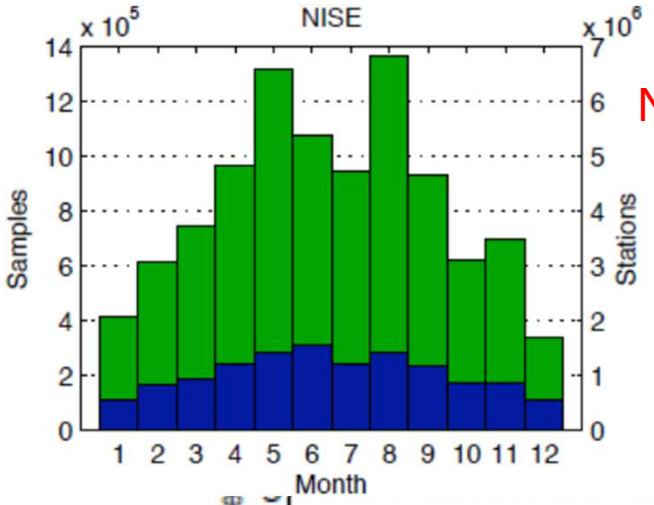
Background: historical to recent hydrographic observations



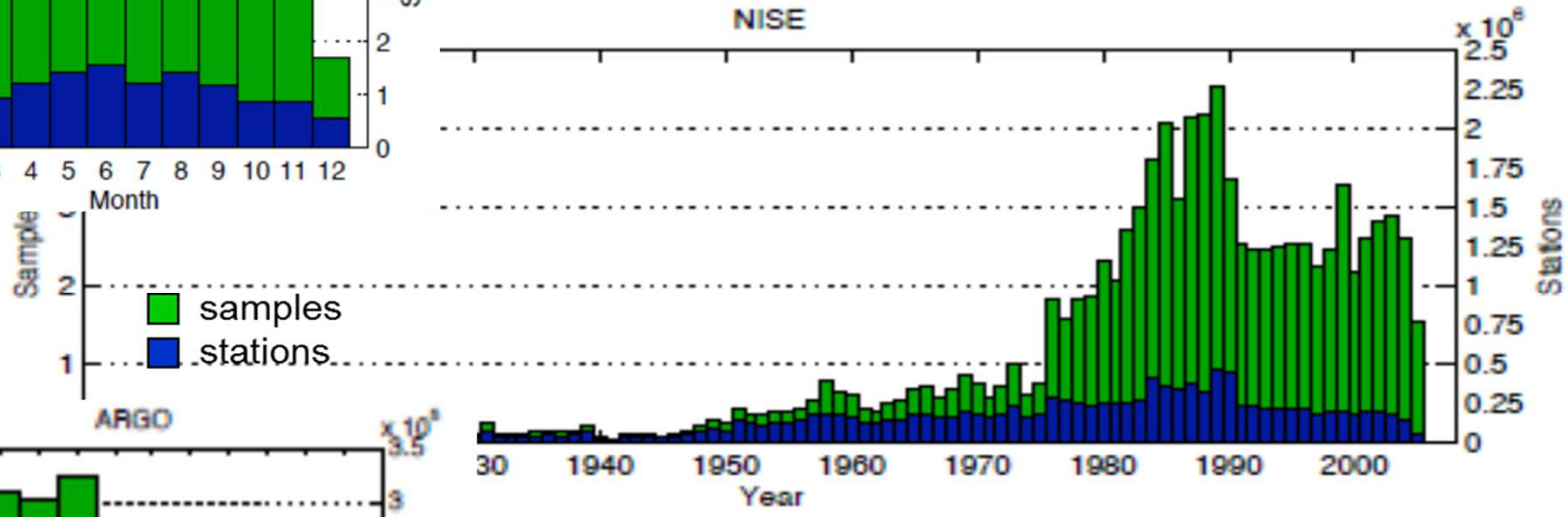
Hydrographic observations in the Nordic Seas since the beginning of the 20. Century

NISE dataset, technical rep. 2008

Background: historical to recent hydrographic observations

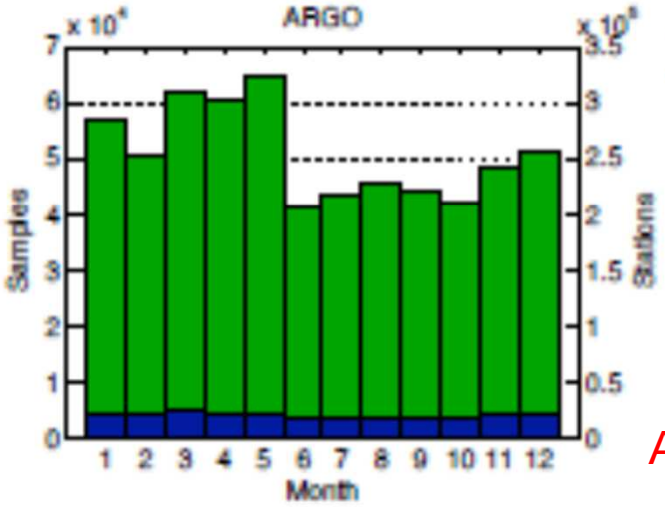


NISE: 13% winter obs (DJF)



Hydrographic observations in the Nordic Seas since the beginning of the 20. Century

NISE dataset, technical rep. 2008



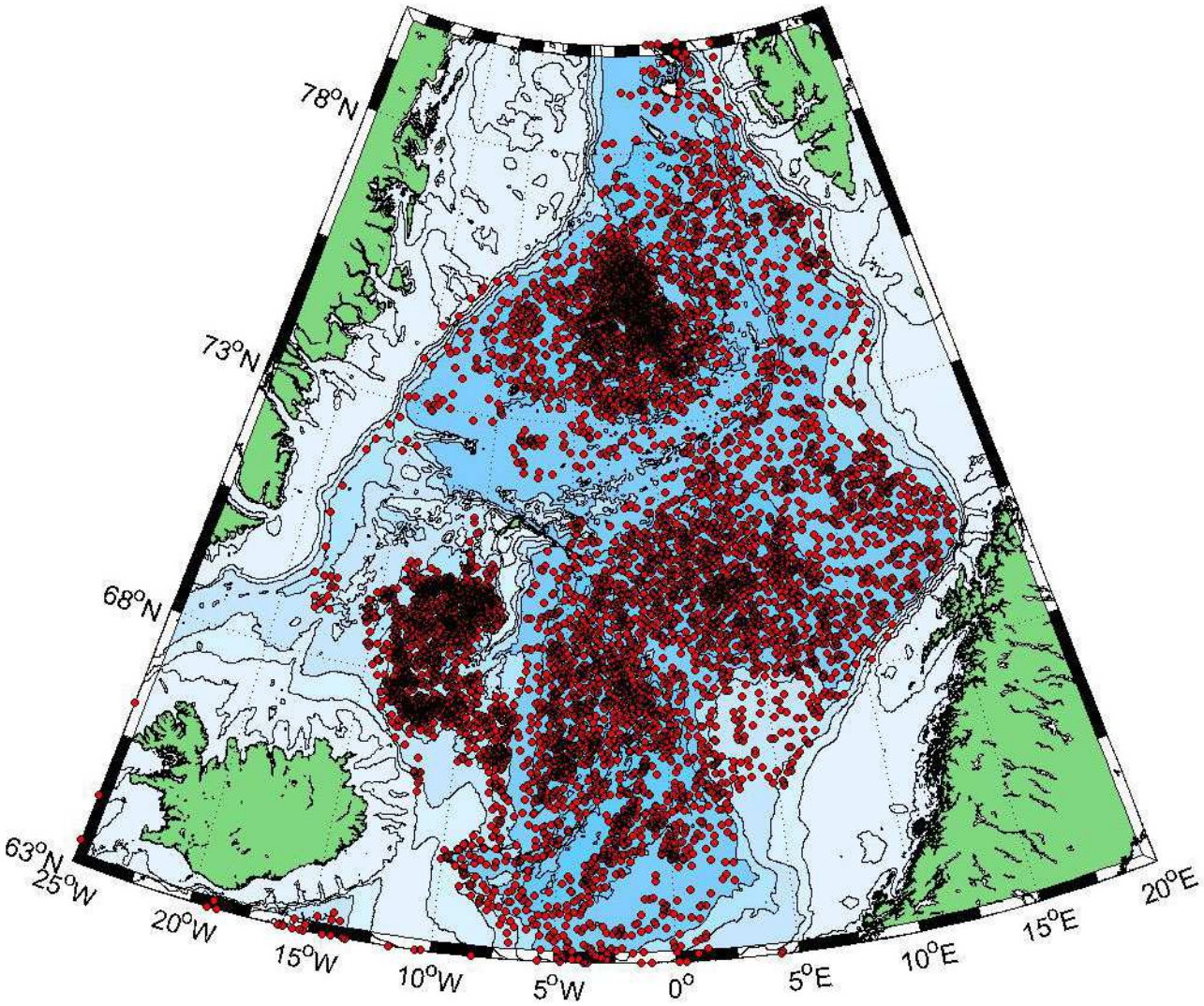
Argo: 25% winter obs (DJF)

Background: CTD surveys versus new observation methods

Ship-based in situ monitoring of water mass transformation in the High Latitudes is severely hampered by the harsh local winter conditions..

… but observations from autonomous profiling instruments gain new insight!

Outline of the session „High Latitudes“



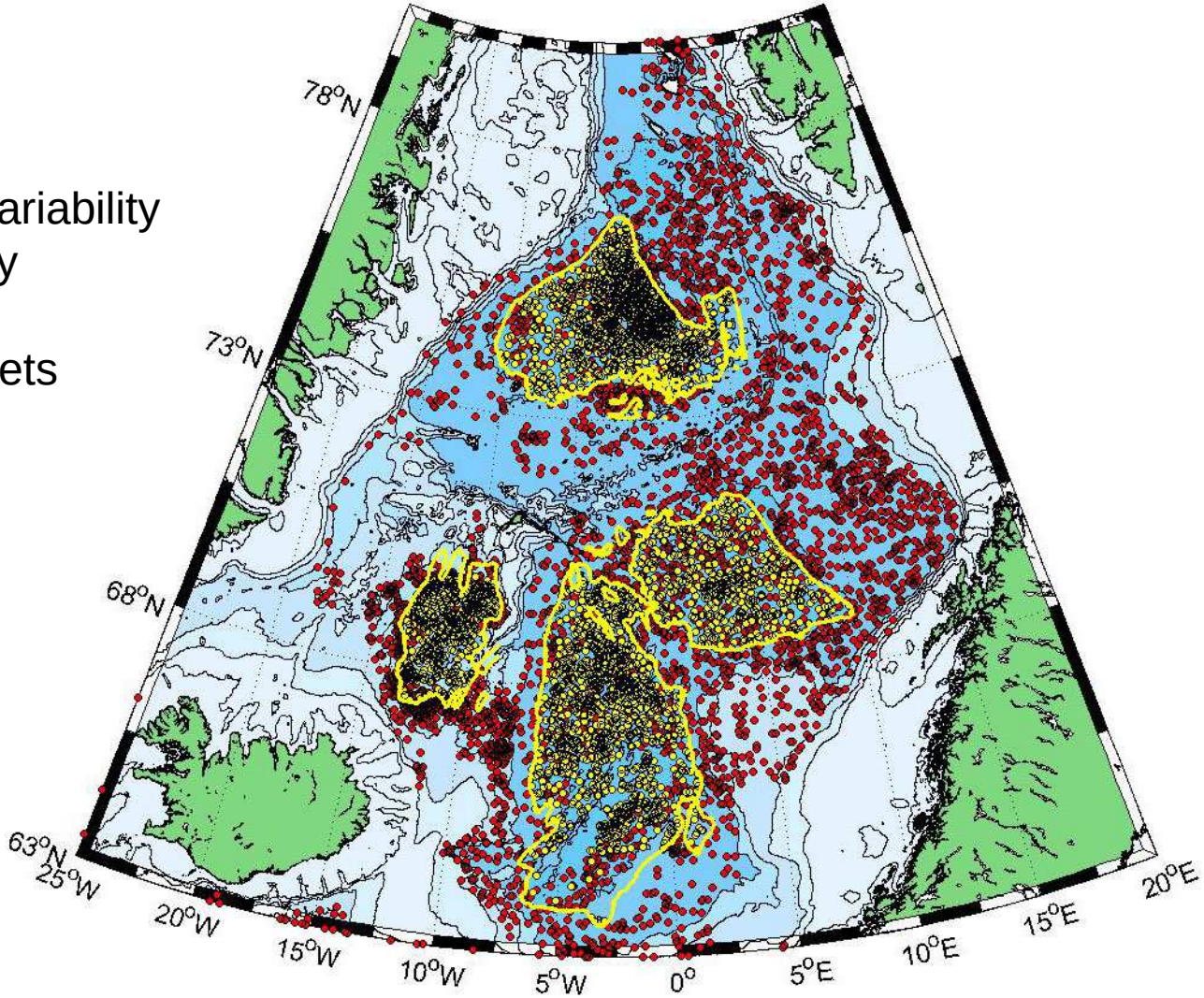
Argo float profiles in the Nordic Seas since 2001

Outline of the session „High Latitudes“ I

focus on the deep basins:

Seasonal to interannual variability
of temperature and salinity
in the Nordic Seas:
heat and freshwater budgets

Katrin Latarius



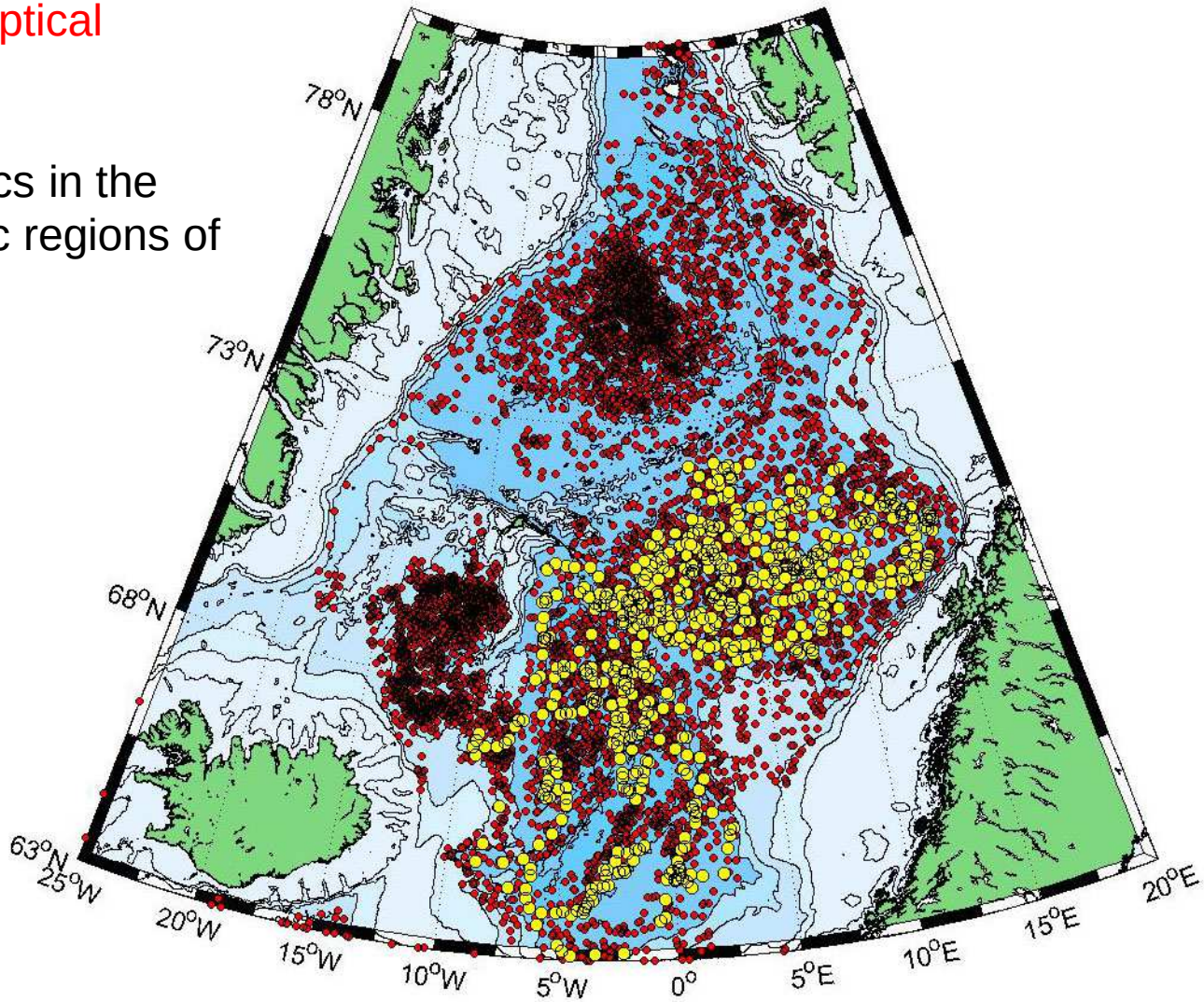
Argo float profiles in the Nordic Seas since 2001

Outline of the session „High Latitudes“ II

floats equipped with bio-optical sensors:

Seasonal particle dynamics in the euphotic and mesopelagic regions of the Nordic Seas

Giorgio Dall‘Olmo
and Kjell Arne Mork



Argo float profiles in the Nordic Seas since 2001

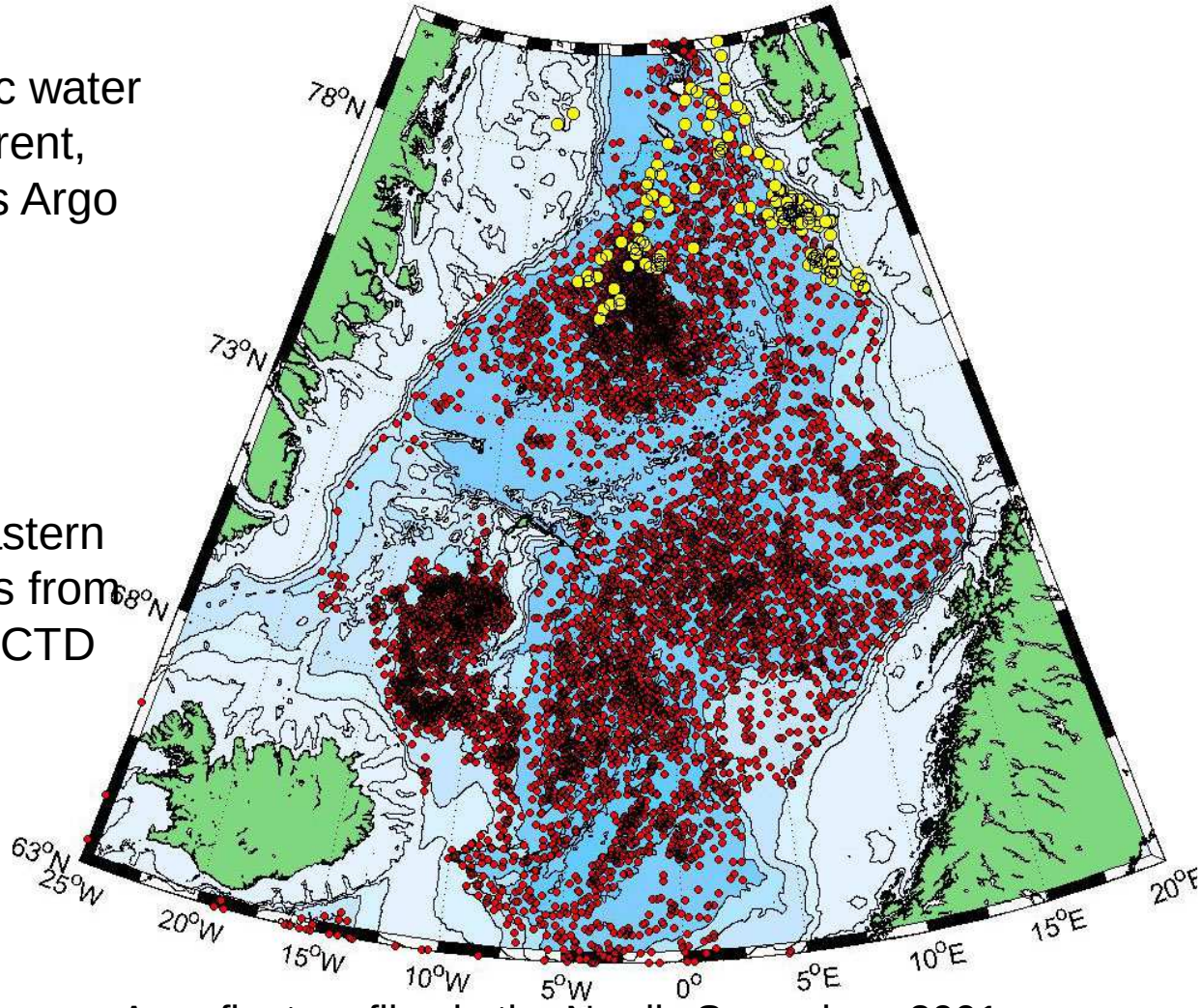
Argo-floats and CTD
In the NE-Nordic Seas

Transformation of the Atlantic water in the West Spitzbergen Current, synoptic observations versus Argo floats results

Waldemar Walczowiski

Physical processes in the eastern Greenland Sea, observations from Argo floats accompanied by CTD surveys

Ilona Goszczko



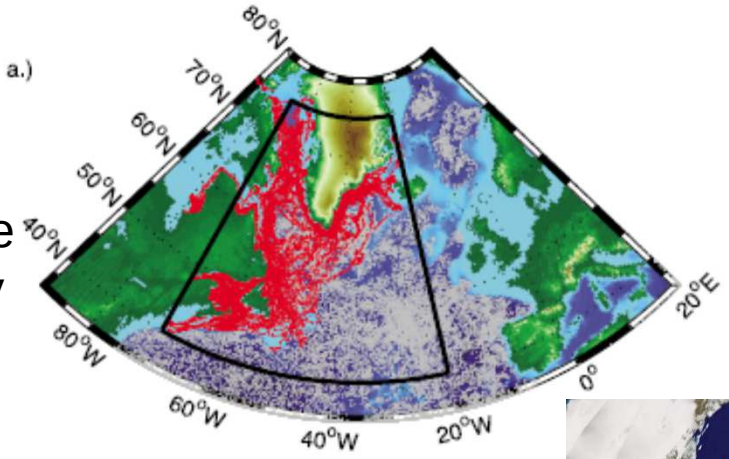
Argo float profiles in the Nordic Seas since 2001

Outline of the session „High Latitudes“ IV

Marine mammal-borne sensor and Argo data:

Temperature signature of High Latitude Atlantic boundary currents revealed by marine mammal-borne sensor and Argo data

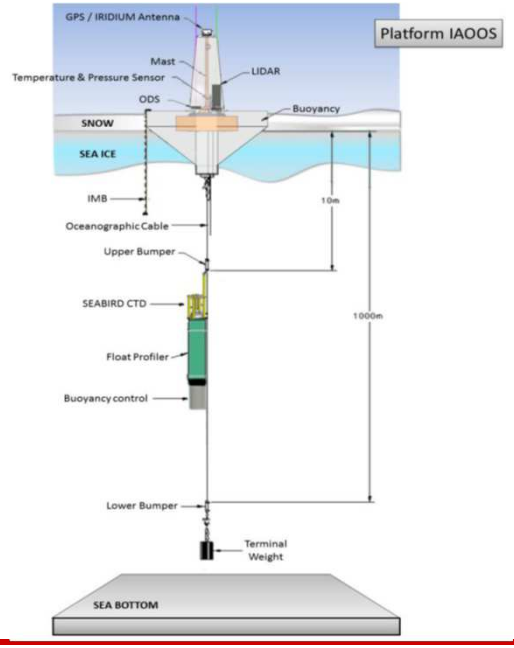
Jeremy P. Grist et al.



Argo floats in the Arctic:

Contribution of the IAOOS project. First results.

Christine Provost et al.

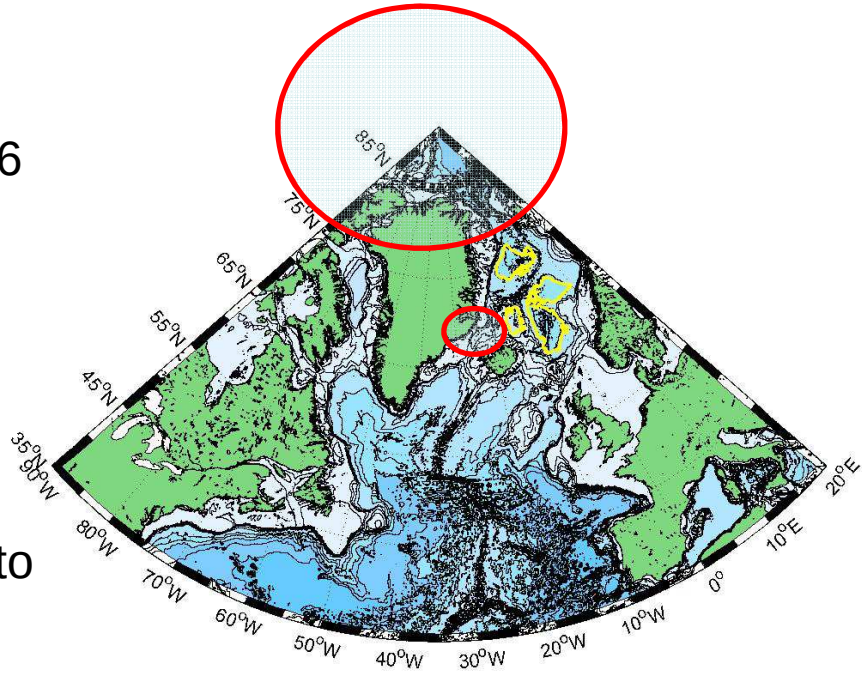


Outline of the session „High Latitudes“ V

CTD and mooring data:

Seasonal cycle of pan-Arctic volume,
heat and freshwater fluxes during 2005-2006

Tsubouchi Takamasa et al.



Model study:

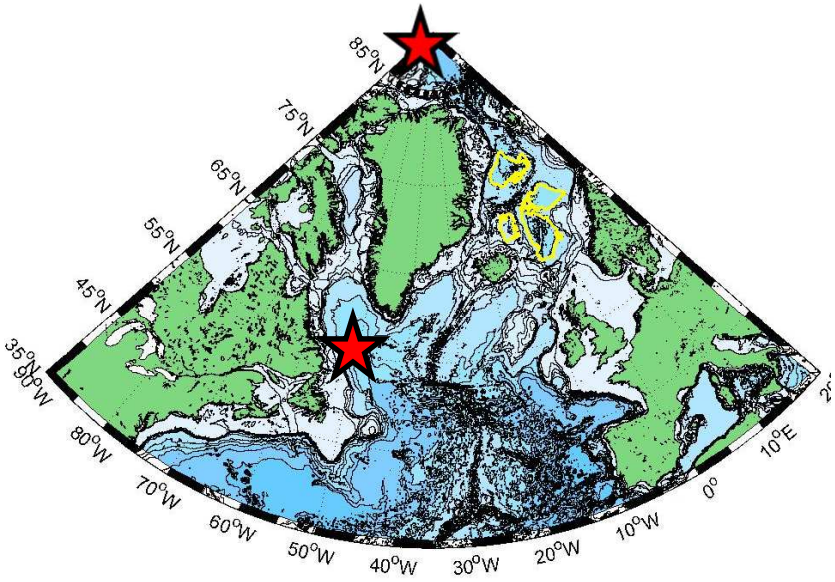
The North Icelandic Jet and its contribution to the Denmark Strait overflow water in a high-resolution ocean model

Carlo Corsaro and Andreas Sterl

Deep convection observation with Argo floats:
Heat and freshwater budget of the Labrador Sea

Lena M. Schulze et al.

Technical development of Argo floats
for arctic deployments:
New PROVOR float dedicated
to challenging sensors and complex missions:
opportunities for arctic deployments



Edouard Leymarie et al.

Challenging deployment of biogeochemical ARGO floats in the Arctic ice edges: need for an efficient sea-ice detection system.

Claudie Marec et al.

Outline of the 2. part of this talk

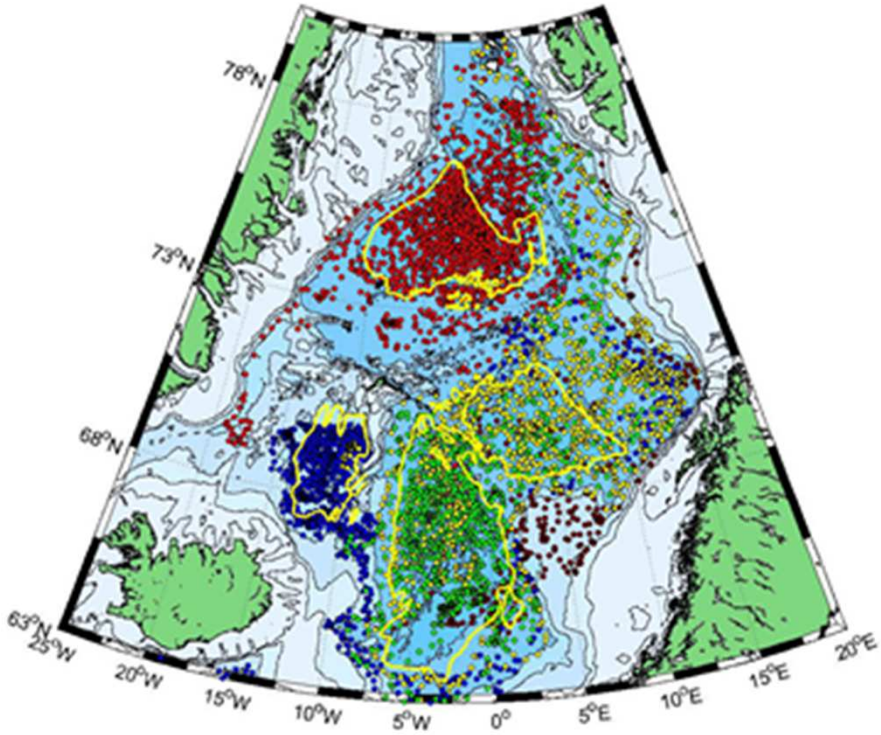
Analyses of Argo float profiles from
the deep basins of the Nordic Seas

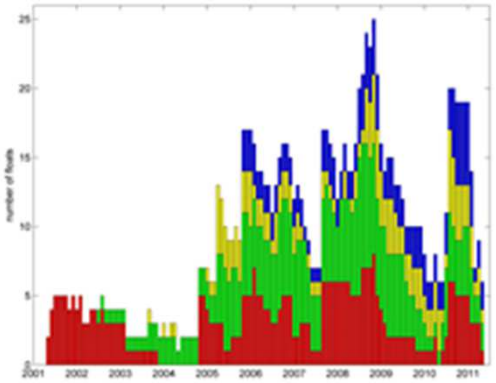
I. the seasonal signal

Motivation: measurements from floats are equally distributed during the year

II. heat and freshwater budgets

Motivation: budgets give insight in the relative importance of the deep basin to the total water mass transformation





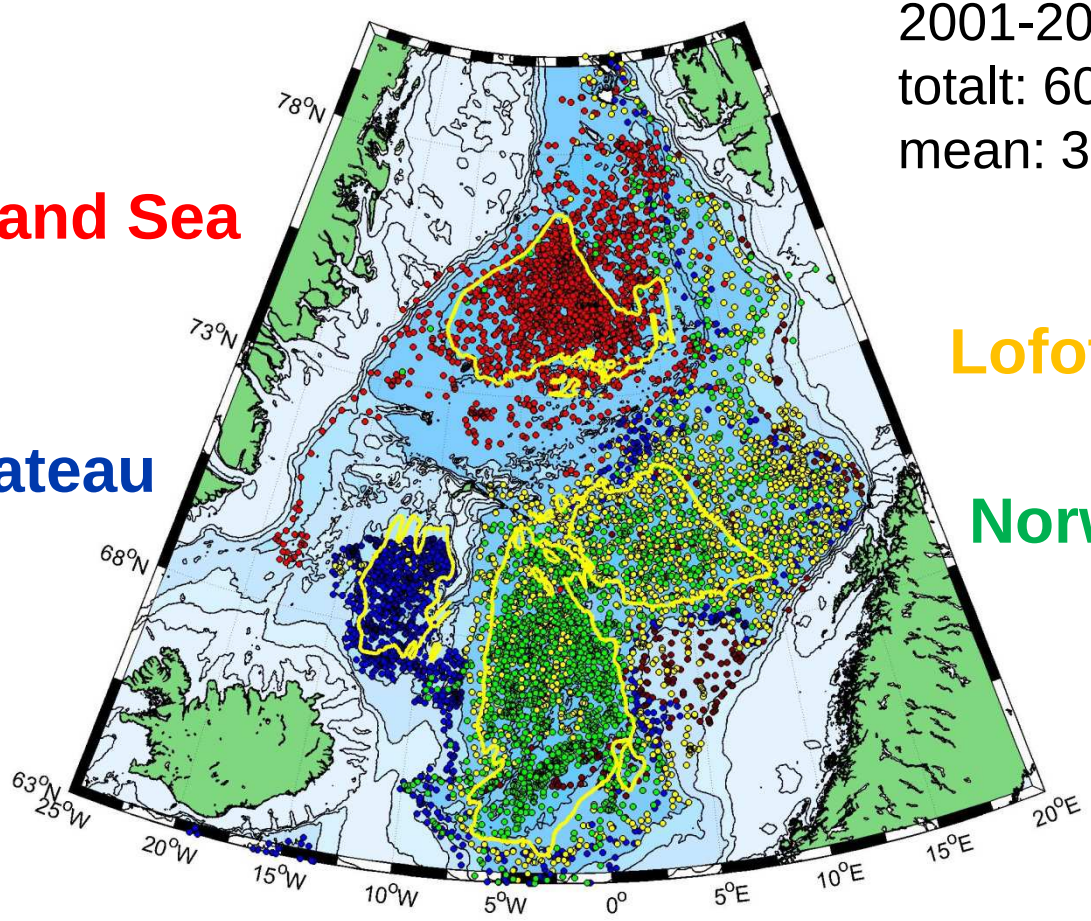
Argo-Float-Profiles
2001-2012
totalt: 6000 (4000)
mean: 3-4 floats per basin
and month

Greenland Sea

Iceland Plateau

Lofoten Basin

Norwegian Basin



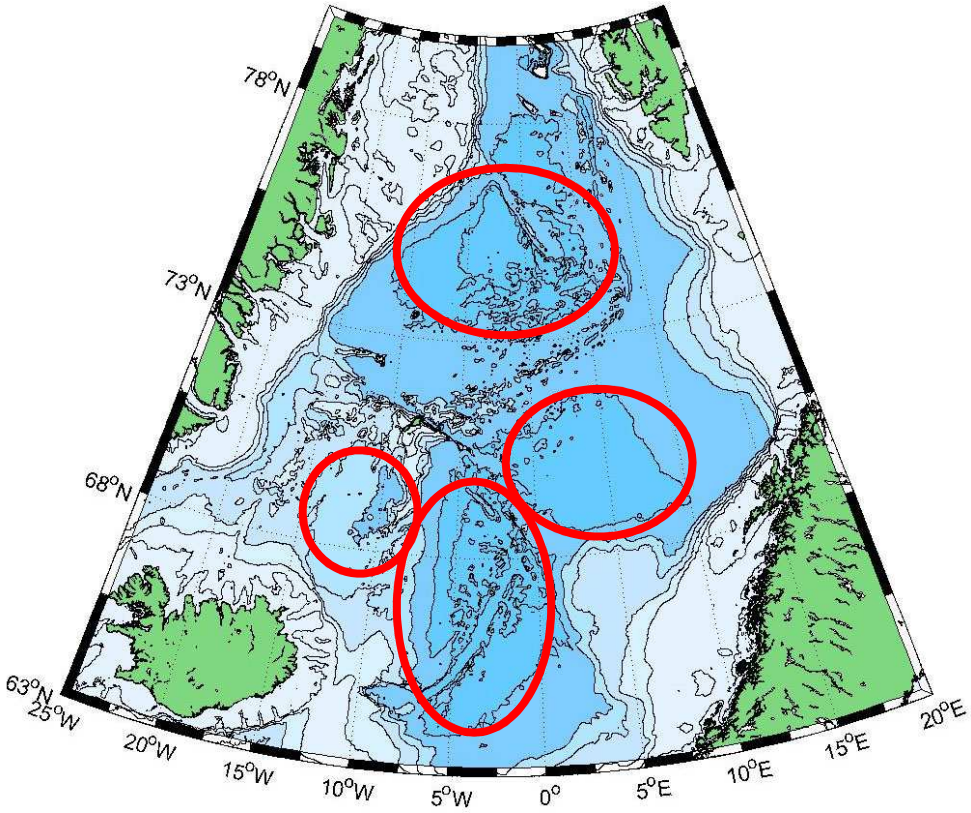
Measurements are concentrated
on the deep basins of the Nordic Seas

basins: ~ 400 km x 400 km

mesoscale: ~ 5 – 20 km
(Rossby-radius)

3-4 profiles
per month and basin

~ 30 km distance between
consecutive profiles
from individual float

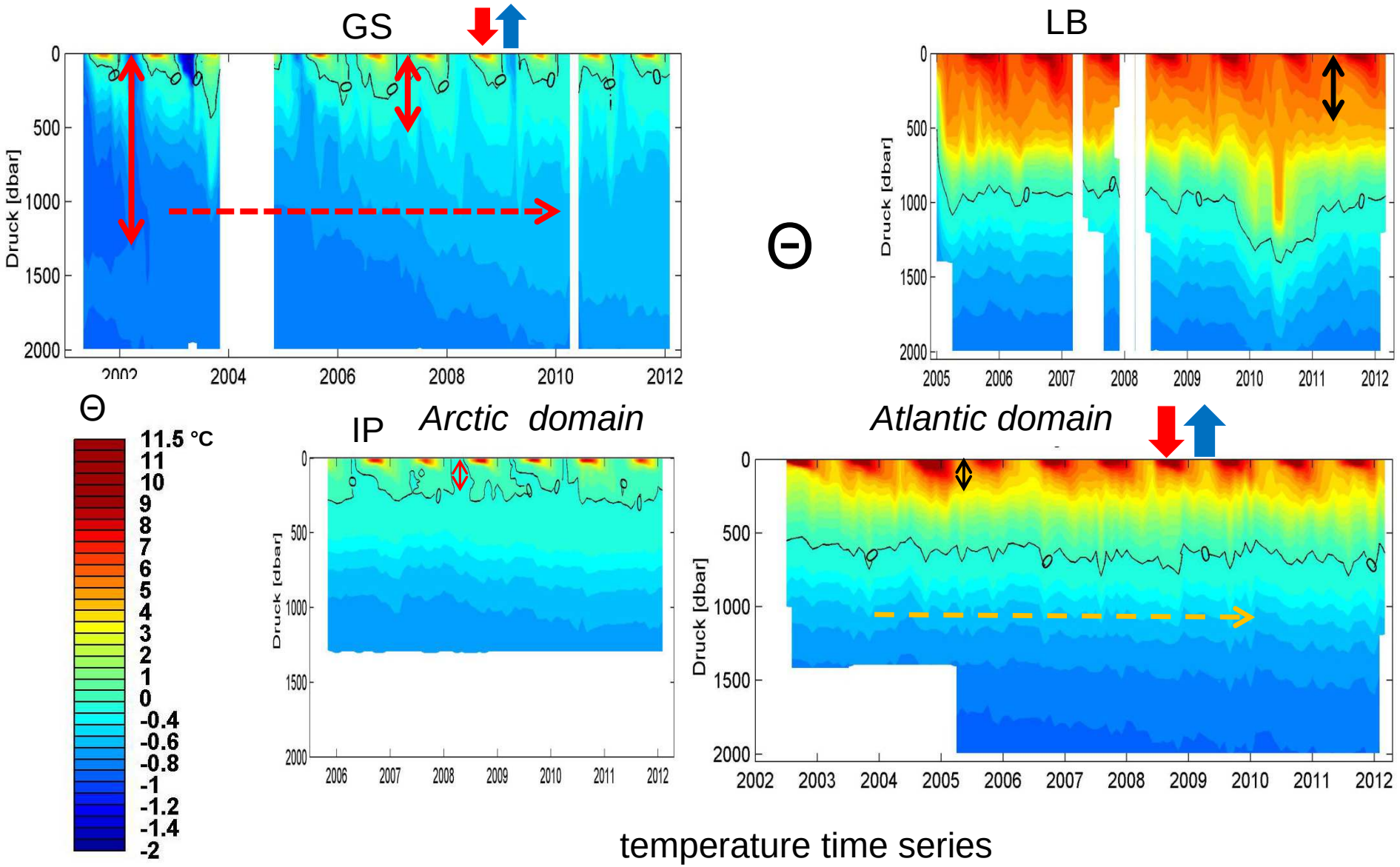


large-scale (basin-wide) hydrographic development is resolved

- on a monthly basis (seasonal signal)
- long term development witihin observation period (~ 10 years)

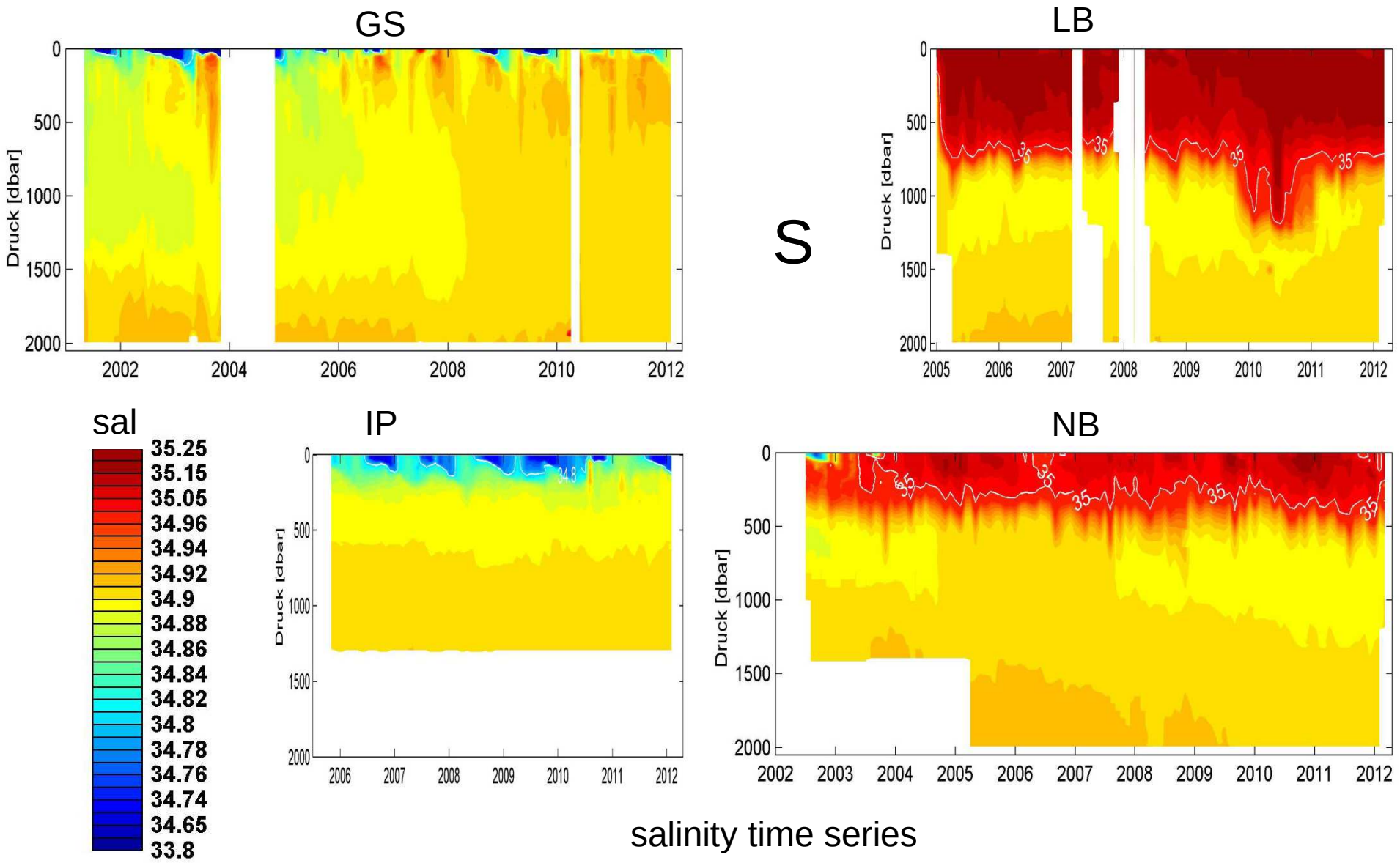
mesoscale variability is not resolved, but appears as „noise“ on the large-scale observations

I: large-scale hydrography - temperature



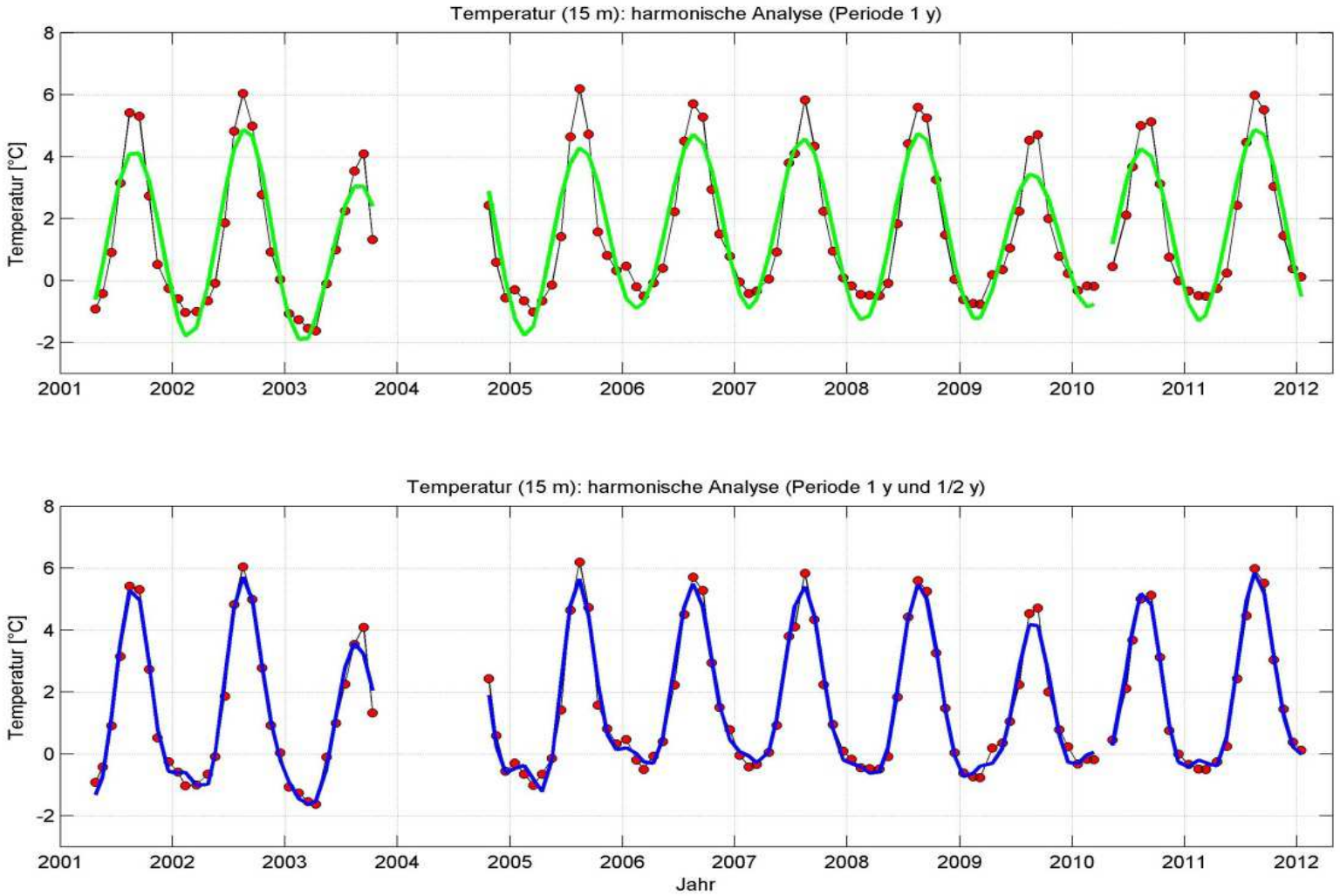
temperature time series

I. large-scale hydrography - salinity



salinity time series

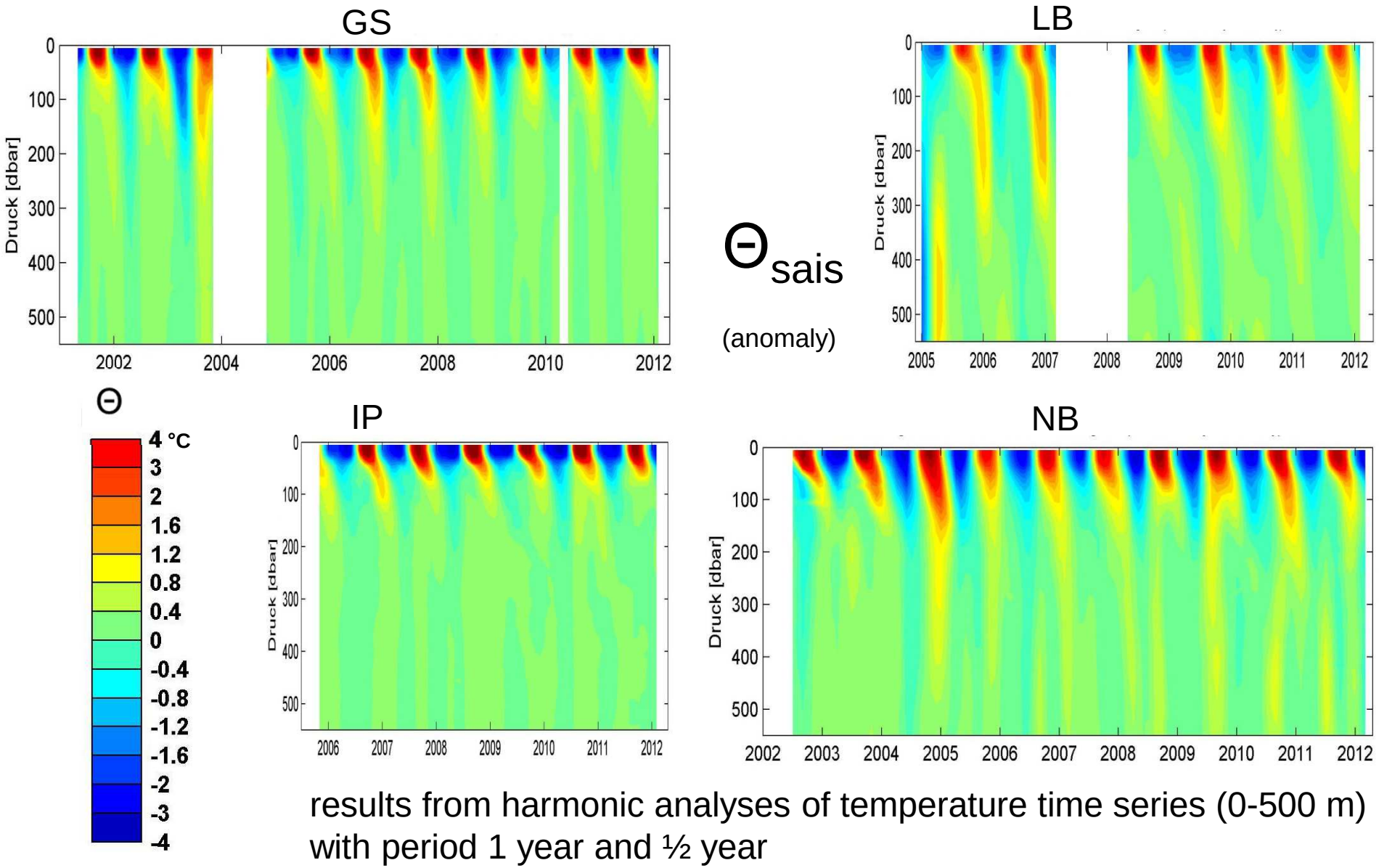
I: the harmonic analyses



harmonic analyses of temperature time series (here Θ at 15m)

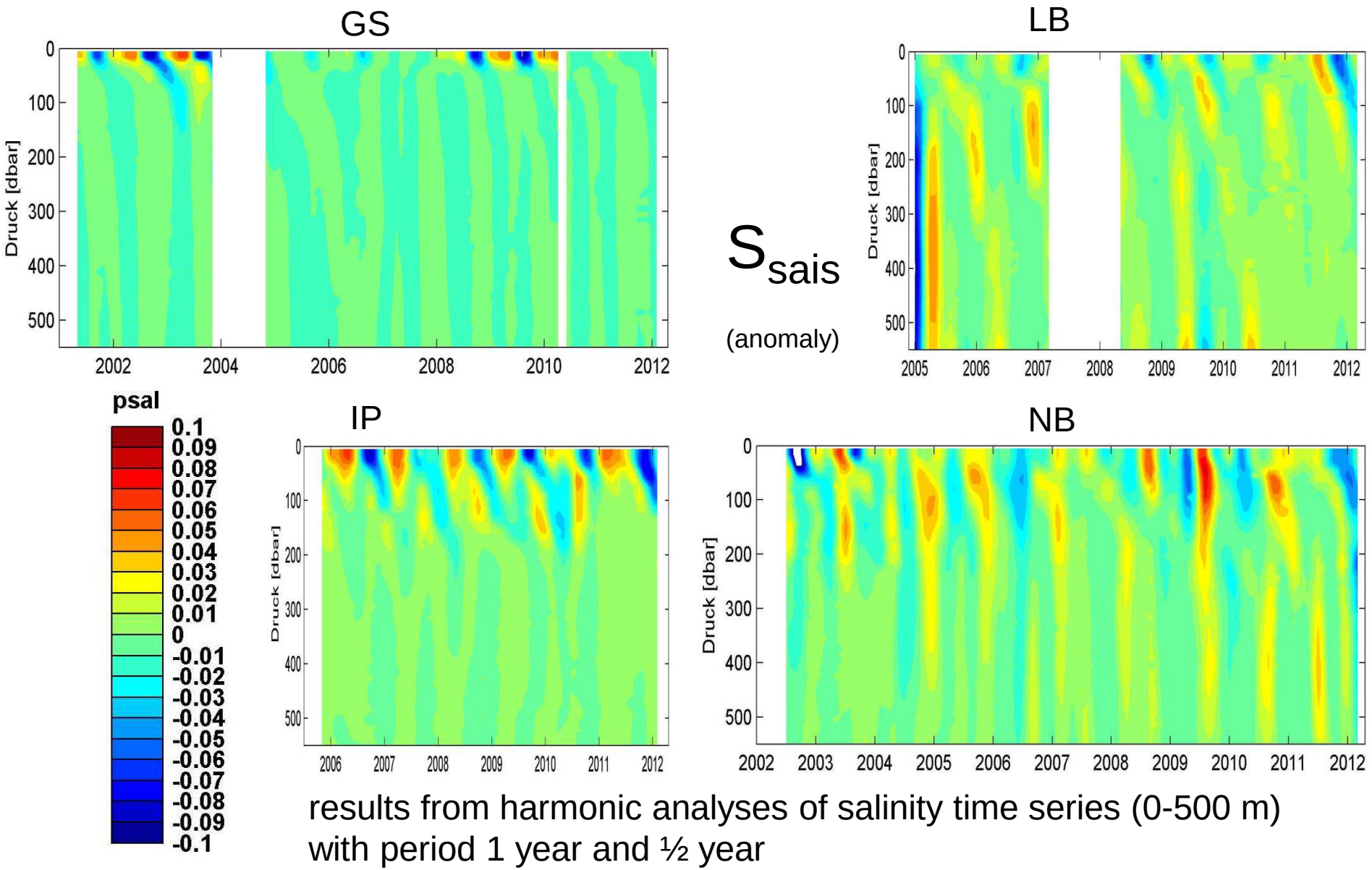
original data — period 1 year — period 1 year and ½ year

I: the seasonal signal - temperature



results from harmonic analyses of temperature time series (0-500 m) with period 1 year and ½ year

I: the seasonal signal - salinity



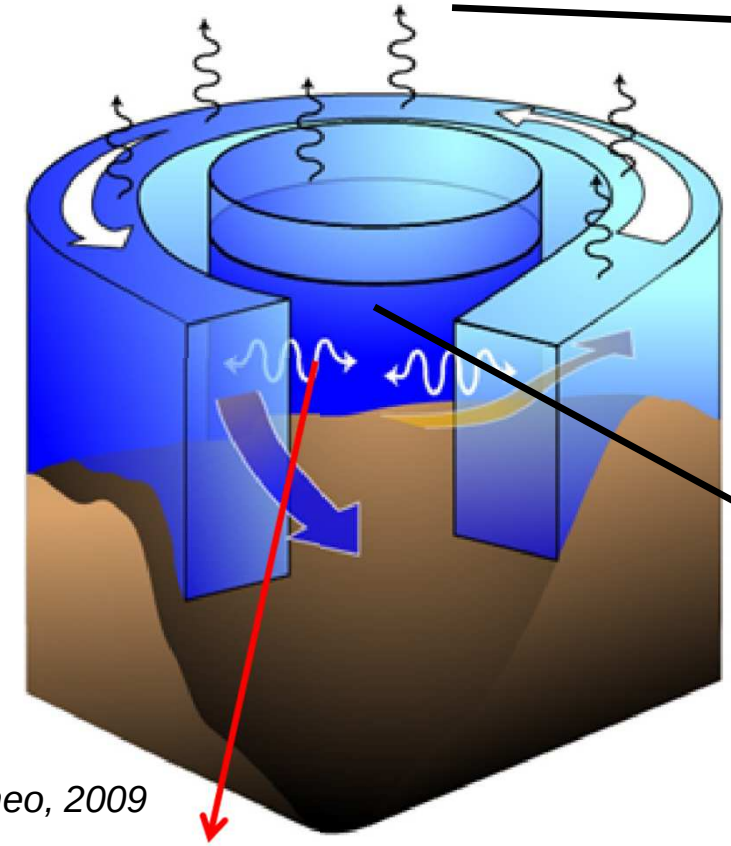
results from harmonic analyses of salinity time series (0-500 m) with period 1 year and ½ year

Results

upper 500 m dominated by seasonal signal

a detailed description of the seasonal signal in the deep basins is given

knowledge of the seasonal signal can be used for the interpretation of historical hydrographic data in relation to the long term development (seasonal bias of historical data → aliasing)



Straneo, 2009

the seasonal cycle of heat and freshwater fluxes is given by NCEP with corrections according to Renfrew et al. (2002)

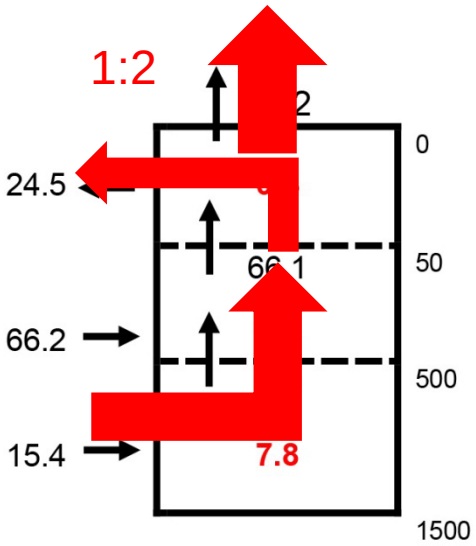
the development of the heat and freshwater content in the ocean is determined from the Argo float profiles
(mean annual cycle)

residuum: lateral exchange and vertical mixing

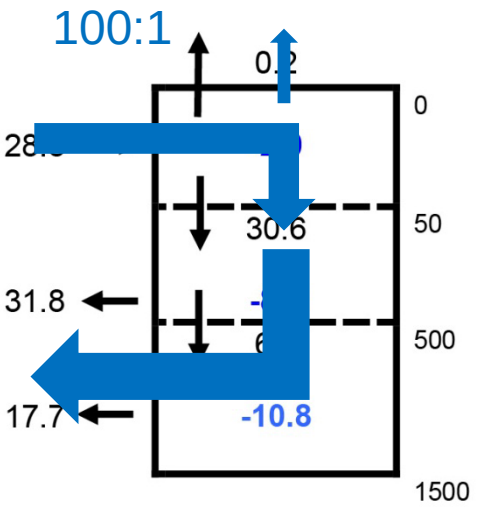
lateral exchange – contribution to the water mass transformation

→ with a number of assumptions lateral exchange and vertical mixing are separeted from each other

annual heat budget [W/m²]



GS



annual freshwater budget [mm/month]

The relation between lateral exchange in the upper 50m and exchange with the atmosphere is different for the 4 basins.

Lateral exchange 50-800m: contribution of the basins to the water mass transformation from Atlantic water into overflow water.

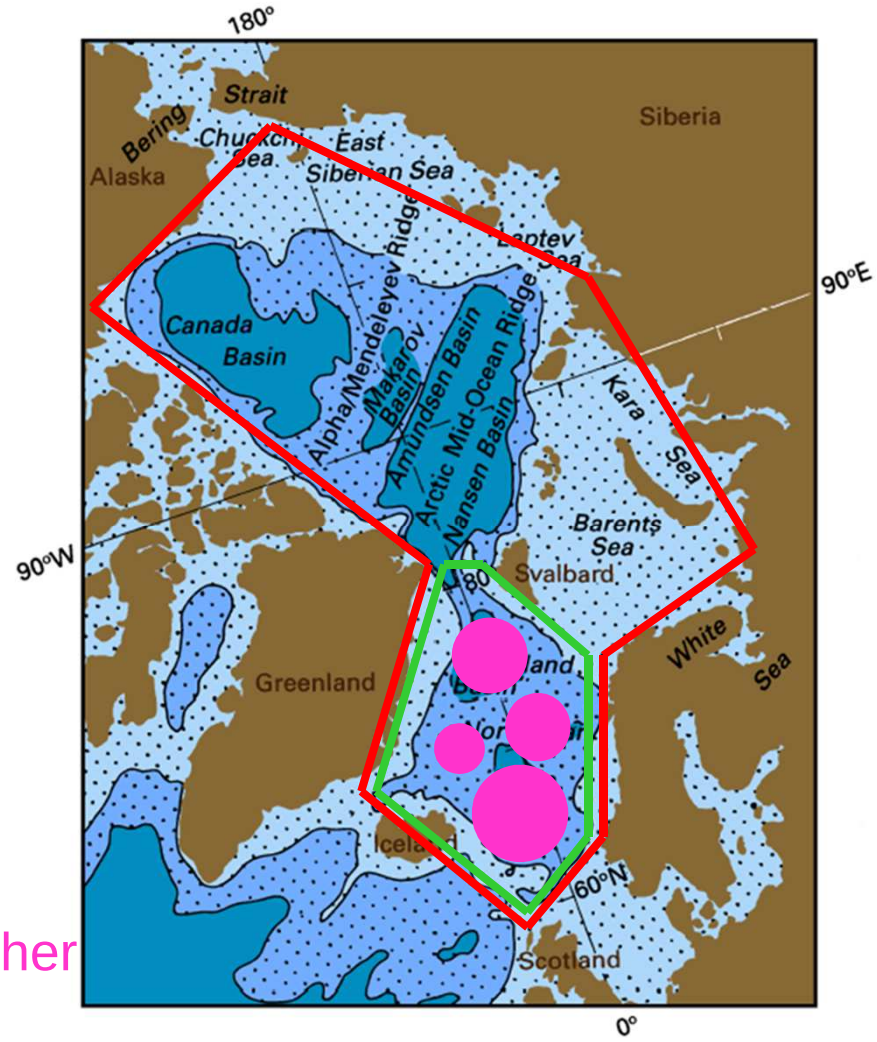
This contribution is understimated when taken only fluxes between ocean and atmosphere into account.

contribution of the deep basins
of the Nordic Seas

1. to total transformation
   in the Arctic Mediterranean

2. to transformation
   in the Nordic Seas

3. the four basins in relation to each other



II: contribution of the deep basins to the total water mass transformation

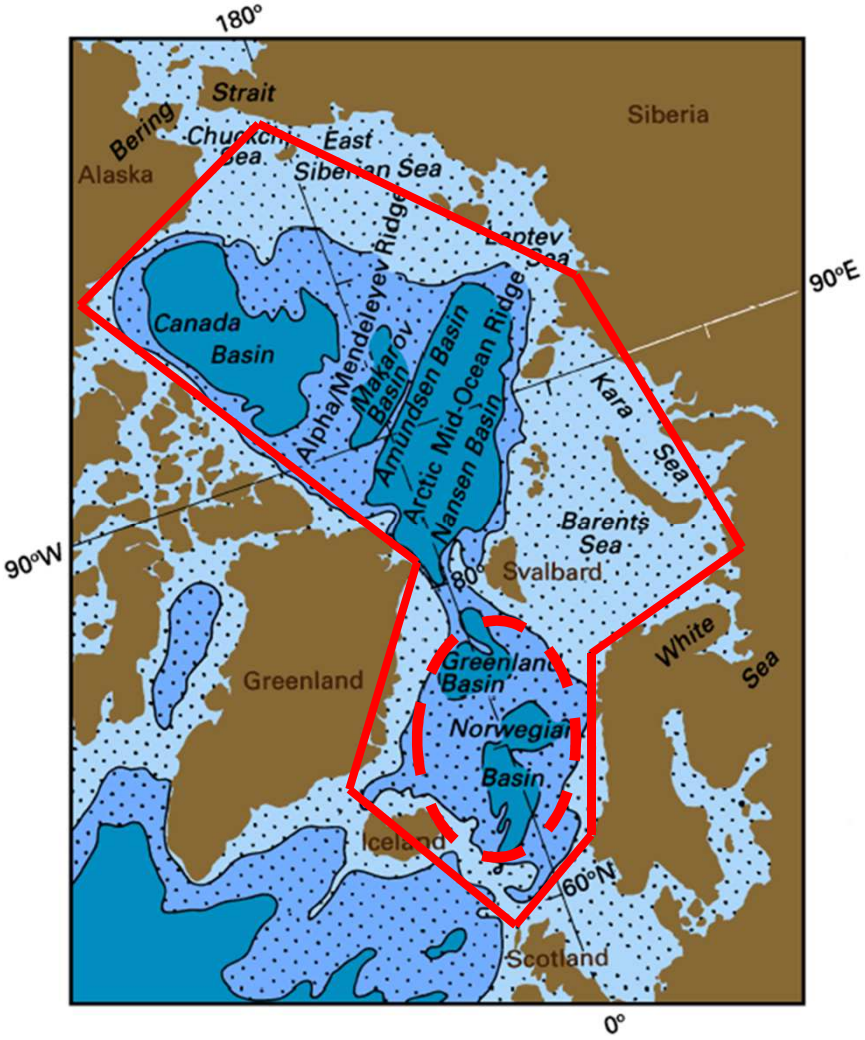
from
Atlantic water inflow (9°C, 35.33)
to overflow (0.2°C, 34.9)

ΔT=8.8.K
ΔS=0.43

deep basins of the Nordic Seas

ΔT=1.4 K	17%
ΔS=0.03	7%

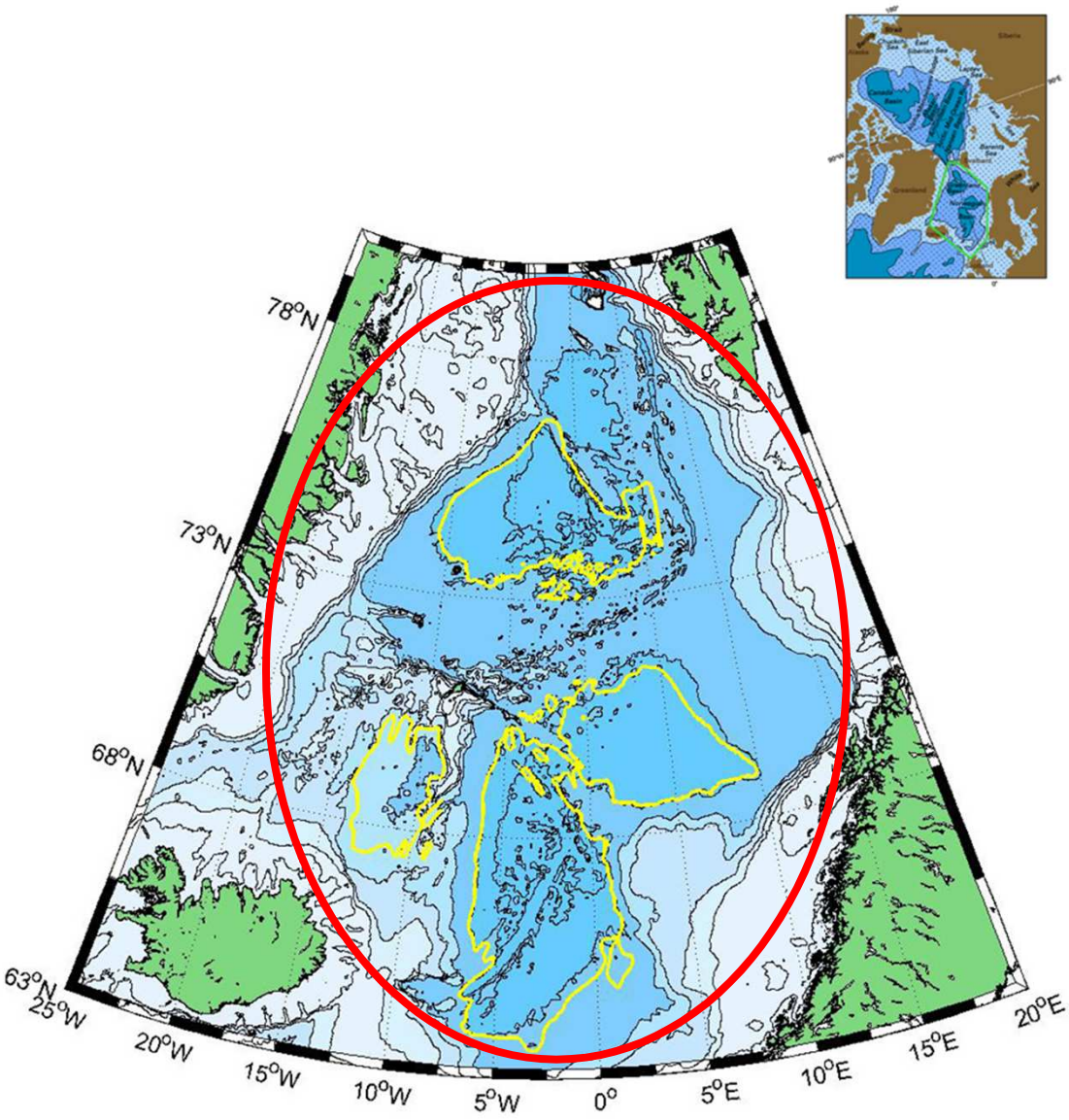
although only 4% of total area



transformation
in the whole Nordic Seas

ΔT=3.5 K

(from atmospheric fluxes;
Simonsen & Haugan, 1996;
Segnan et al., 2012)



transformation
in the whole Nordic Seas

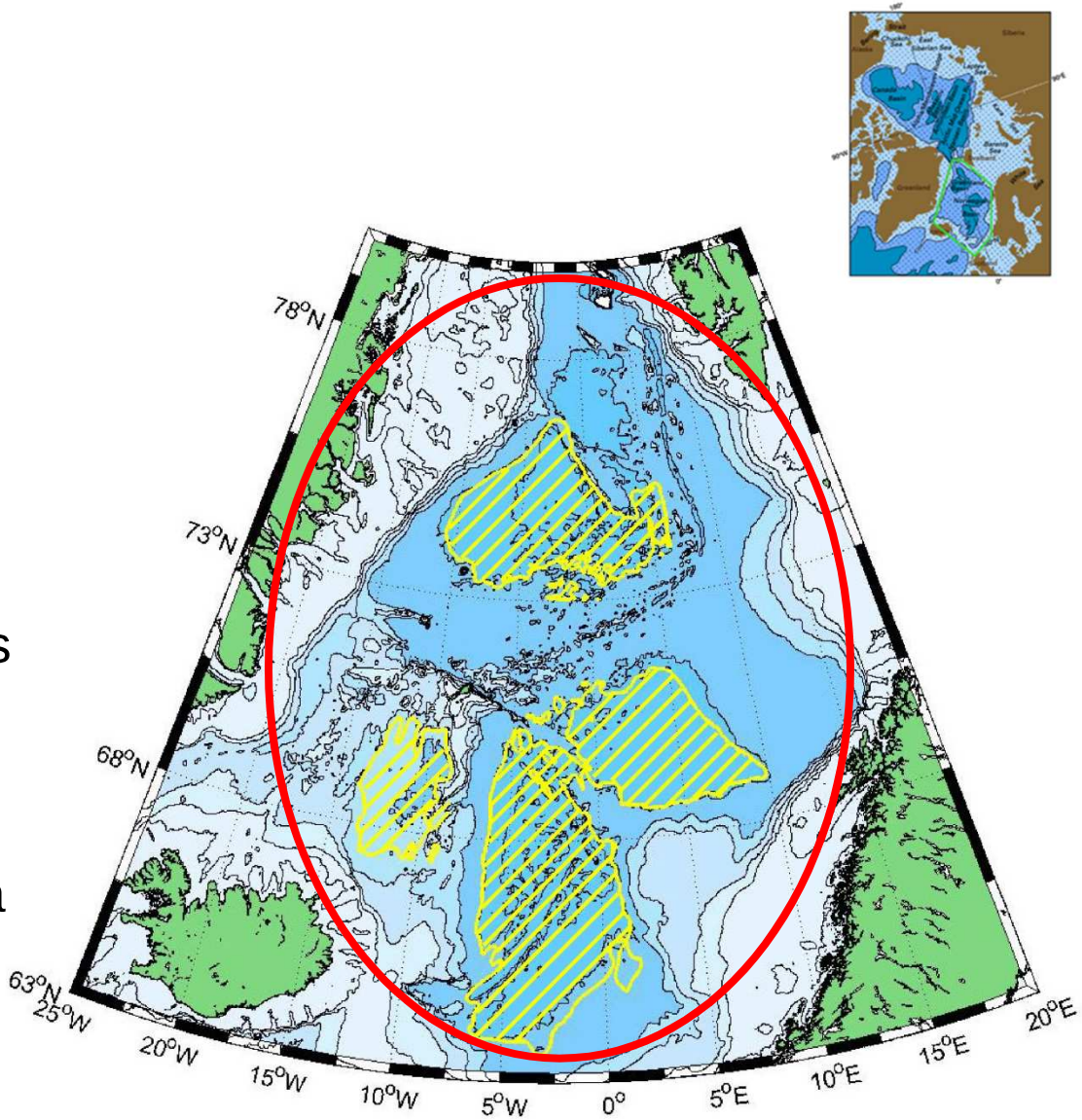
$\Delta T=3.5$ K

(from atmospheric fluxes;
Simonsen & Haugan, 1996;
Segnan et al., 2012)

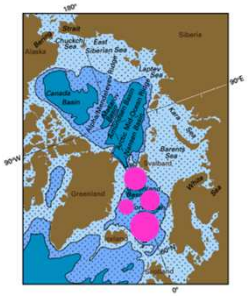
deep basins of the Nordic Seas

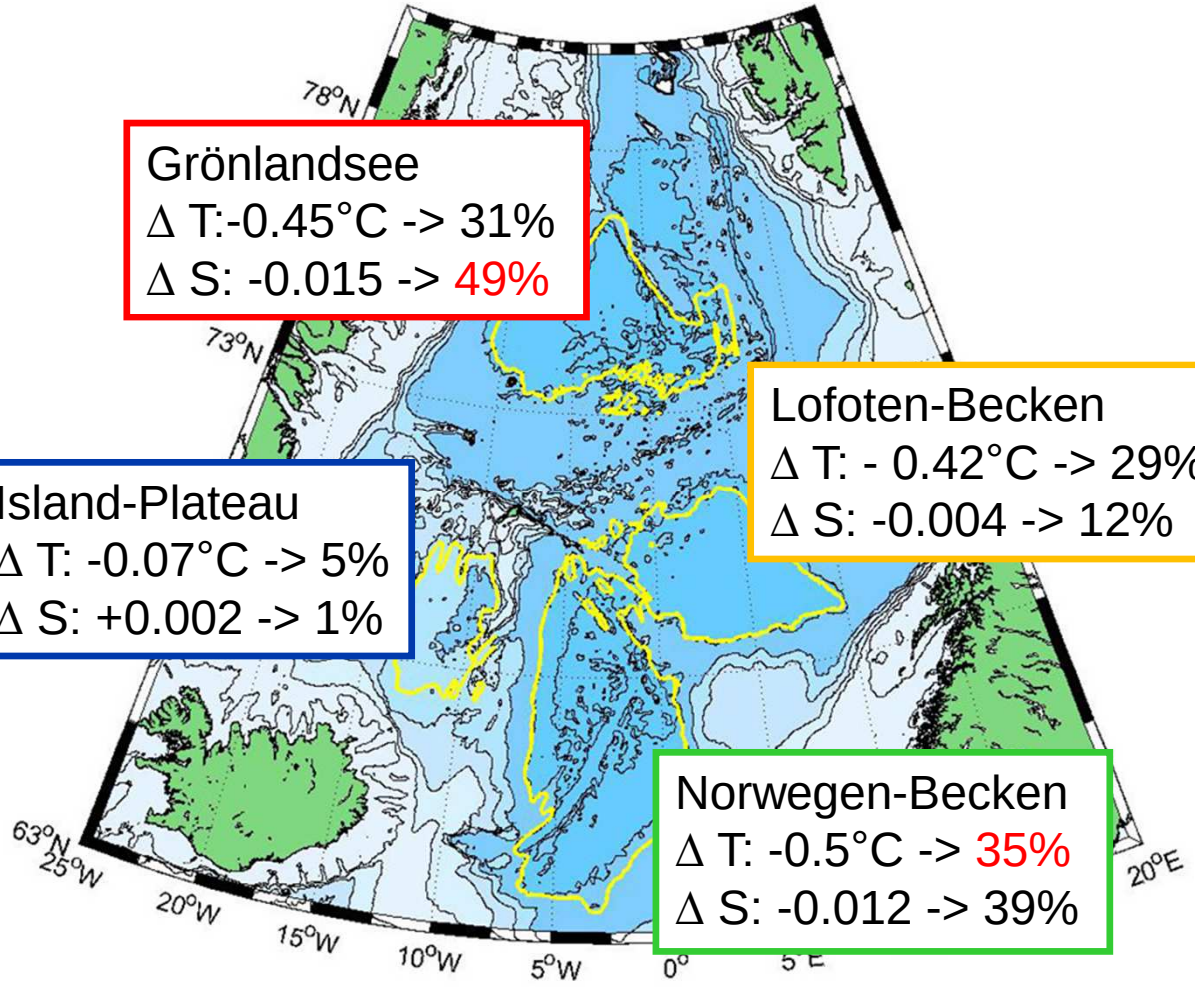
$\Delta T=1.4$ K 40%

although only 20% of total area



II: importance of the individual basins





Grönlandsee
Δ T:-0.45°C -> 31%
Δ S: -0.015 -> 49%

Lofoten-Becken
Δ T: - 0.42°C -> 29%
Δ S: -0.004 -> 12%

Island-Plateau
Δ T: -0.07°C -> 5%
Δ S: +0.002 -> 1%

Norwegen-Becken
Δ T: -0.5°C -> 35%
Δ S: -0.012 -> 39%

Δ T: 36%
Δ S: 49%

west:
important for
salinity characteristic

Δ T: 64%
Δ S: 51%

east:
for densification

Results:

Heat and Freshwater Budgets:

Heat, imported in all four basins below 50m depth,
is released laterally in the upper 50m and to the atmosphere.
Heat loss to the atmosphere is dominant.

Freshwater is imported into the basins in the upper 50m and from the atmosphere.
The lateral import is dominant.
Below 50m freshwater is exported laterally from the basins.

The transformation in the basins in direction to overflow water is underestimated, when taking only atmospheric fluxes into account.

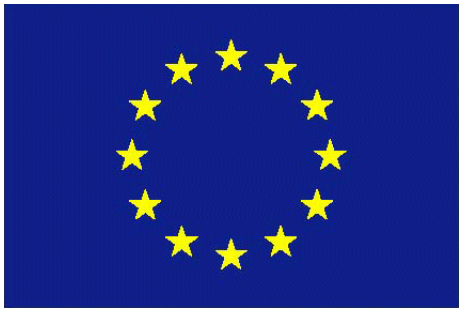
With the budget calculation the contributions of the basins
to the **water mass transformation** can be determined.

The basins contribute
17% (temperature) and 7% (salinity)
to the **total transformation in the Arctic Mediterranean**
although they account for only 4% of the total area.

Within the Nordic Seas
the deep basins contribute approx. 40%,
although they account for only 20% of the area.

More than 50% of the transformation takes place
in the eastern Nordic Seas.
Additional input of freshwater at first reaches the western Nordic Seas
and thus influences only less than half of the transformation.

End



The research leading to these results has received funding from the European Union 7th Framework Programme (FP7 2007-2013), under grant agreement n.308299

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