Recent observations from the Greenland Sea: Seasonal to interannual variability of temperature and salinity and implications on water mass formation

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ABSTRACT

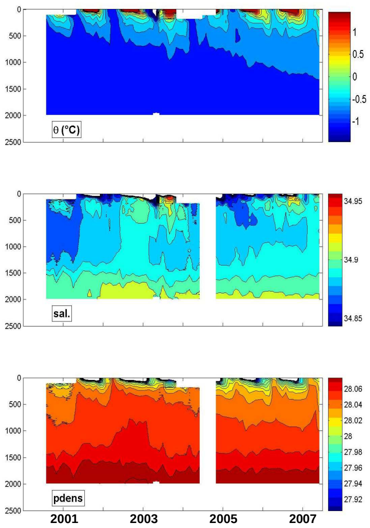
The Greenland Sea gyre is known for open ocean convection triggered by extreme heat loss to the atmosphere in winter. Since the late 1980's, convection activity decreased and reached only intermediate depths.

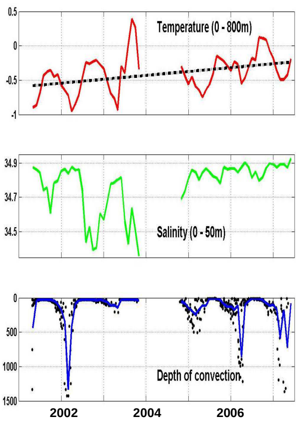
Data from ARGO floats and a profiling mooring, from 2000 to 2007, provide a hydrographic time series longer and of significantly higher temporal resolution than any timeseries discussed before of that region. It enables us to describe the typical seasonal cycle and associated interannual variability of temperature and salinity for the last decade. The development of heat and freshwater content of the gyre is analysed with respect to the atmospheric forcing and lateral advection.

II. HYDROGRAPHY

Timeseries of potential temperature, salinity and density for the Greenland Sea April 2001 to May 2007 (monthly mean profiles of float and profiling-mooring data)

- Seasonal cycle of temperature (warming phase from April to September, cooling phase from October to March)
- Seasonal cycle of freshwater input: maximum in late summer
- Warming trend for the whole period
- Increasing salinity at 500 to 1500 dbar for the whole period



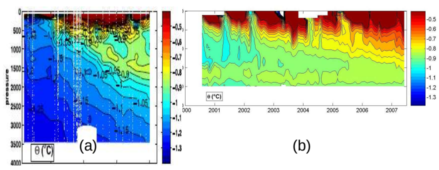


Between 0 and 800dbar an overall **warming trend** of **0.05°C/year** is observed. There is no similar trend in the heat fluxes between ocean and atmosphere, therefore heat must be transported into the region by lateral exchange with the boundary current. **Extreme freshwater inputs** have been observed in **autumn 2002 and 2003**.

Convection depths vary between 1335dbar (winter 01/02) and 145dbar (winter 02/03).

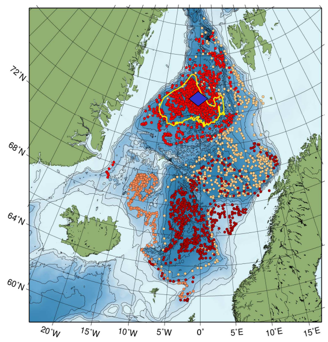
Deep convection is suppressed by extreme freshwater inputs and the overall warming trend.

The **intermediate T_{max}** has developed in the early 90s, **descending from 1990 to 2001 from 500 to ~1700m**. From 2001 to 2007 the depth of the T_{max} stayed constant and **at the end** of the timeseries the **signal got lost in the overall warming trend**. This is supported by observations with deep CTDs (AWI-BHV summer survey 2007[1]).

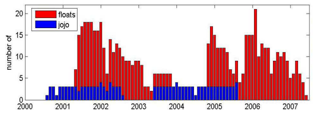


Development of intermediate T_{max}, as observed from CTD ((a) Karstensen et al. 2005[2]) and float measurements (b) .

I. DATASET



Top: ARGO-float profiles in the Nordic Seas 2001-2007, inside yellow contour: Greenland Sea, blue Diamond: Yoyo-mooring



Bottom: number of cycles per month in the Greenland Sea

The float dataset in the Nordic Seas consists of 3800 profiles measured since the first deployments in 2001. Starting in the Greenland Sea, since 2005 also the Norwegian and Lofoten Basin are maintained and since 2006 also the Iceland Sea.

Here only the float data from the Greenland Sea are analysed, which are appr. 500 profiles in 6 years giving a mean of 10 profiles per month (within the closed f/H-contour – yellow).

Data gaps are closed with a 10-day subsample of the AWI-Yoyo-mooring-data[1] from the central Greenland Sea (position: blue diamond).

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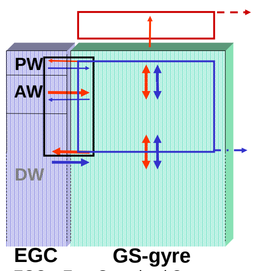
III. HEAT CONTENT BUDGET



EGC – East Greenland Current
GS – Greenland Sea

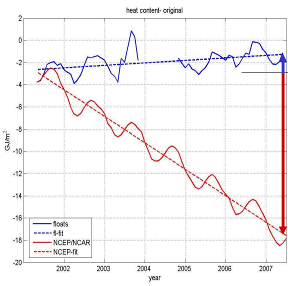
$Q_{NCEP/NCAR}$: development of heat content of the GS from surface flux data (NCEP/NCAR)

Q_{float} : development of heat content in the upper 1000m from monthly mean float profiles

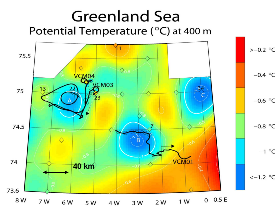
$Q_{fl} - Q_{NCEP/NCAR}$ (difference between observed and estimated heat content) gives the order of lateral exchange between gyre and boundary.

A compensating heat flux of 84 W/m^2 is needed to close the budget. This is equivalent to 5*10^{20} J/year for the total gyre area.

How is the budget closed? (see VI)



VI. EXCHANGE GYRE - BOUNDARY



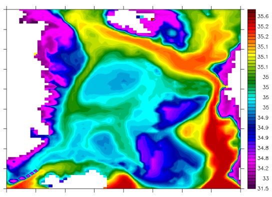
Pot. temperature and float tracks in the region of the Polar Front (separating the Greenland Sea and the East Greenland Current)
P. Lherminier et al., 1999[4]

How is the heat budget closed?

Due to eddy fluxes.

Observations as well as eddy-resolving models show the typical structure.

First estimates from mooring data from the East Greenland Current support the needed magnitude of exchange.



NAOSIM 0.0825°resolution
R. Gerdes, F. Hacker, pers. com.[3]
Salinity at the depth of intermediate T_{max}

REFERENCES

[1] G. Budeus, Alfred-Wegener-Institut, Bremerhaven, German

[2] Karstensen, J., P. Schlosser, D. W. R. Wallace, J. L. Bullister, J. Blindheim , Water mass transformation in the Greenland Sea during the 1990s. Journal of Geophysical Research, 2005.

[3] R. Gerdes, F. Hacker, Alfred-Wegener-Institut, Bremerhaven, Germany

[4] P.Lherminier, Gascard, J.-C., Quadfasel, D., 1999. The Greenland Sea in Winter 1993 and 1994: preconditioning for deep convection. Deep-Sea Research.1999

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