THE MID-DEPTH CIRCULATION OF THE NORDIC SEAS

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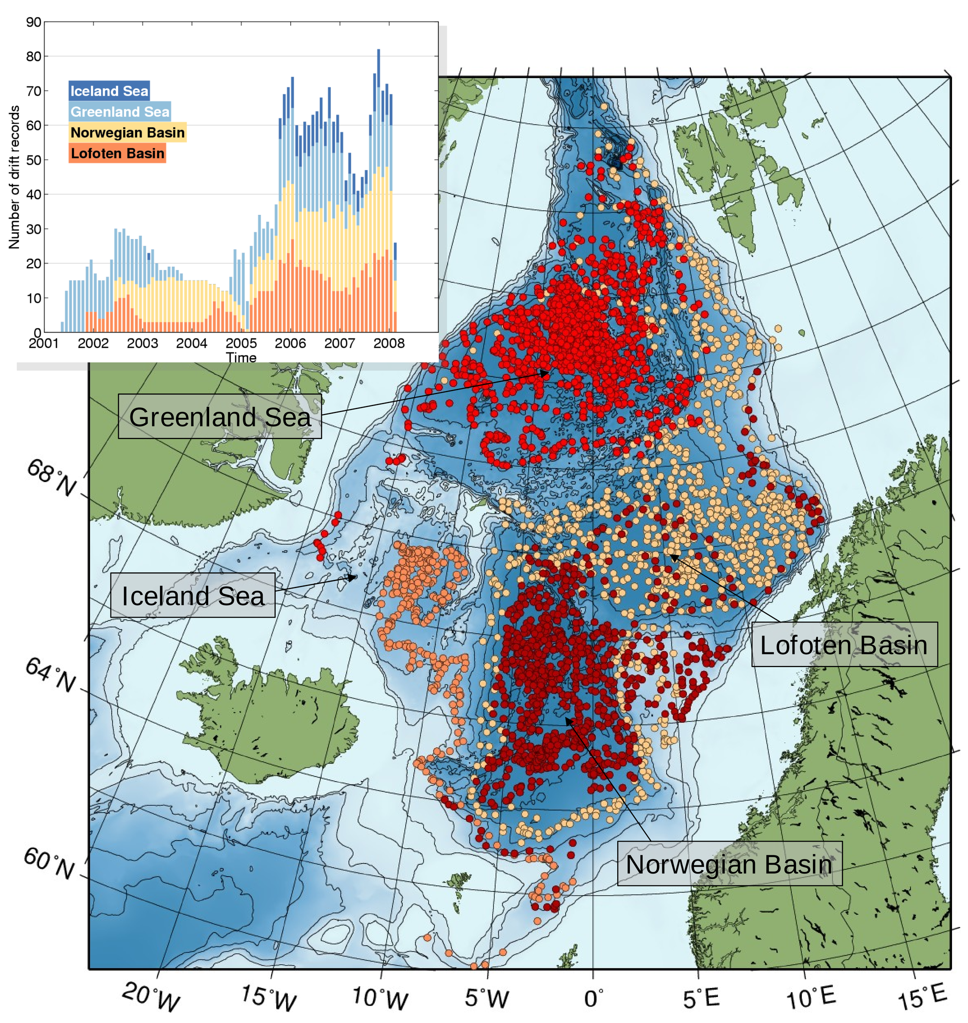
ABSTRACT

The circulation of the Nordic Seas advects warm and saline waters to regions of water mass transformation and supplies the dense overflows that feed the North Atlantic Deep Water. This makes it an important element of the meridional overturning circulation.
The interior flow pattern of the Nordic Seas is separated into cyclonic gyres in the four deep basins. This general picture was refined with recent data from Argo profiling floats. We use Argo float surface positions, collected from 2001 till now, to infer the subsurface float displacements at parking depths of 1000 and 1500 m, respectively.
The multi-year mean circulation of the Nordic Seas at mid-depth is obtained from the space-time average of the float drift velocities. Cyclonic gyres with strong topographic steering are found in the deep basins. Spatial averages over the Greenland Sea and the Norwegian Basin show a seasonal variation of the gyre speeds with maxima in winter. We find that a large fraction of this variability is driven by surface wind forcing.

I. DATASET & METHOD



51 floats were deployed in the four basins of the Nordic Seas from 2001 to 2007. In total, more than 3100 profiles were recorded by Argo floats within the area until end of 2007. Most floats were set to a parking depth of 1000 m, seven floats have parking depth of 1500 m.

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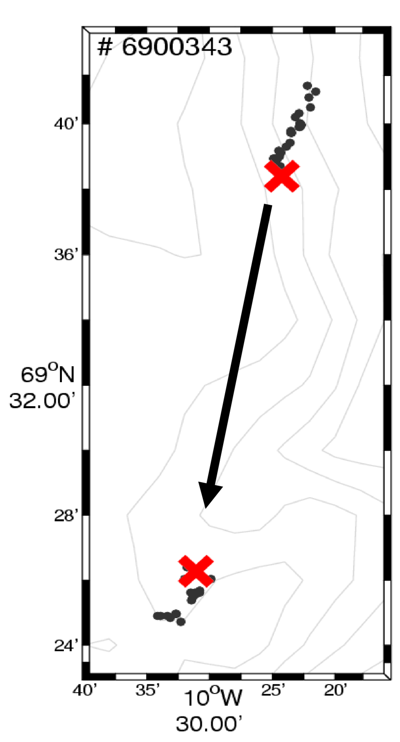
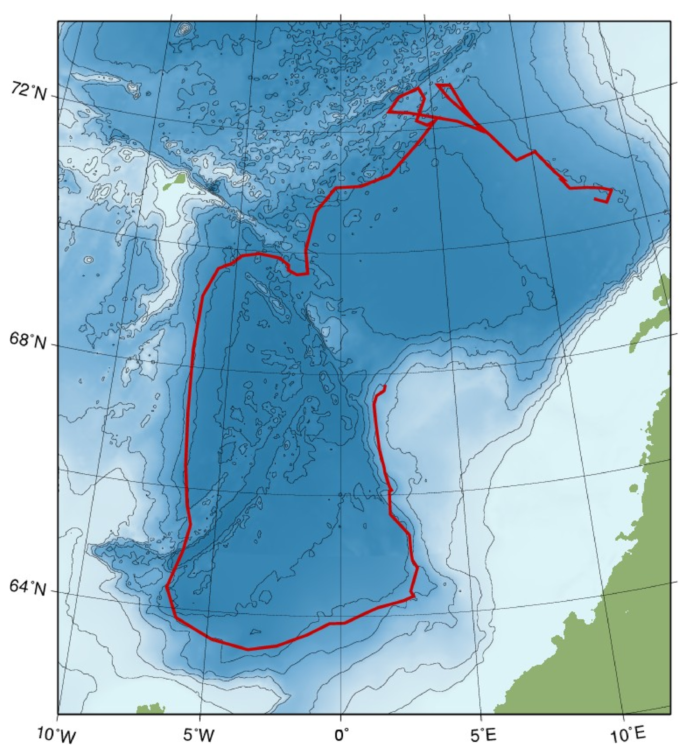
The position of an Argo float is fixed several times during its stay at the sea surface for data transmission. We use the last position of one cycle and the first position of the following cycle to calculate the drift at the float parking depth of 1000 and 1500 m.

The uncertainty in the drift calculation – deriving from inaccuracy of the position fix and velocity shear between surface and depth – is estimated to be less than 15% of the subsurface drift.



II. TOPOGRAPHIC STEERING

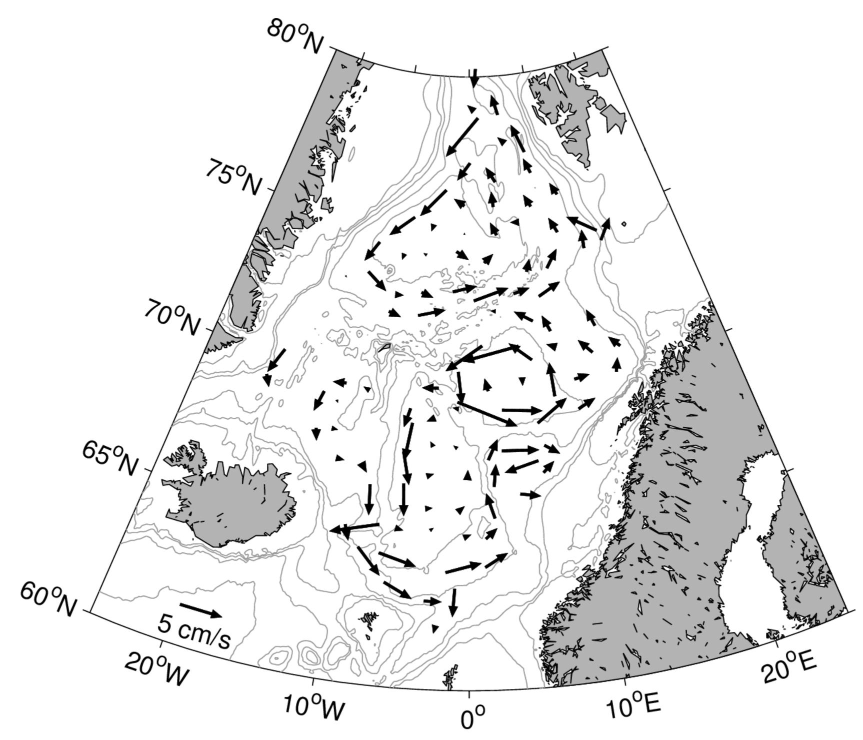
The floats tend to stay in the basin they were deployed in. Single float trajectories show a strong topographic steering of the float and thus of the flow it is indicative for.



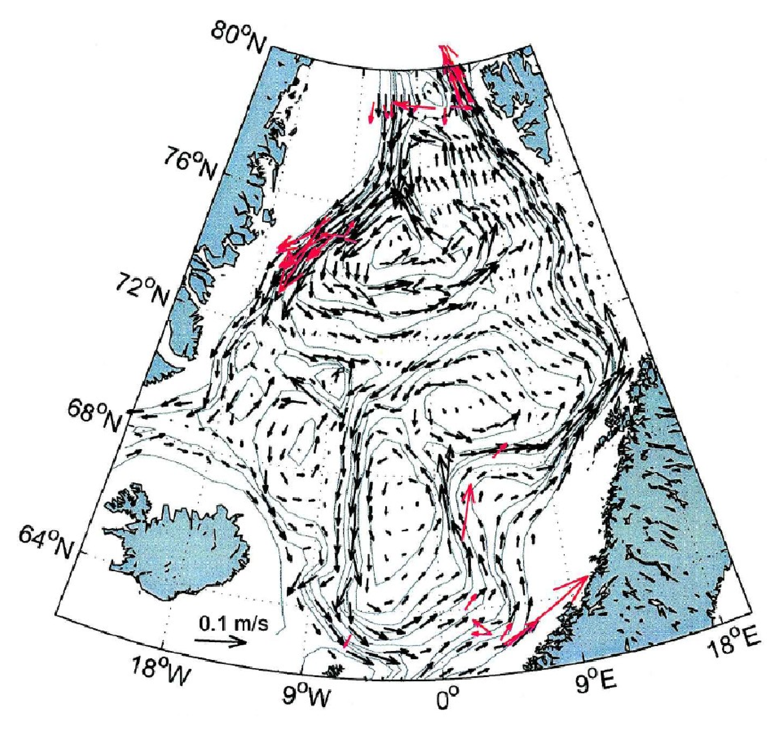
III. TIME-MEAN MID-DEPTH CIRCULATION

The mean mid-depth circulation scheme is obtained by mapping all subsurface float displacements onto a rectangular grid with a spacing of 110 km. The mapping procedure accounts for the topographic steering of the flow.

We find cyclonic gyres in each of the subbasins that are intensified towards the edge of the basins. This picture of the mid-depth circulation compares well with current meter observations and results of a diagnostic model [1].



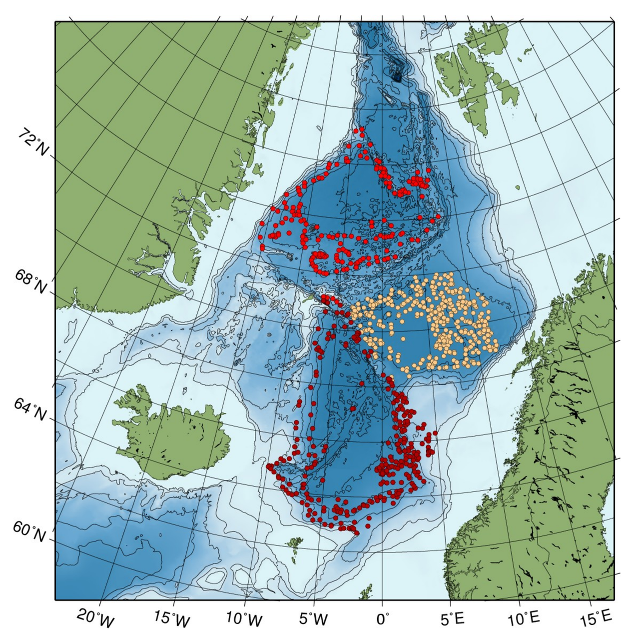
Mean mid-depth circulation from Argo float displacements.

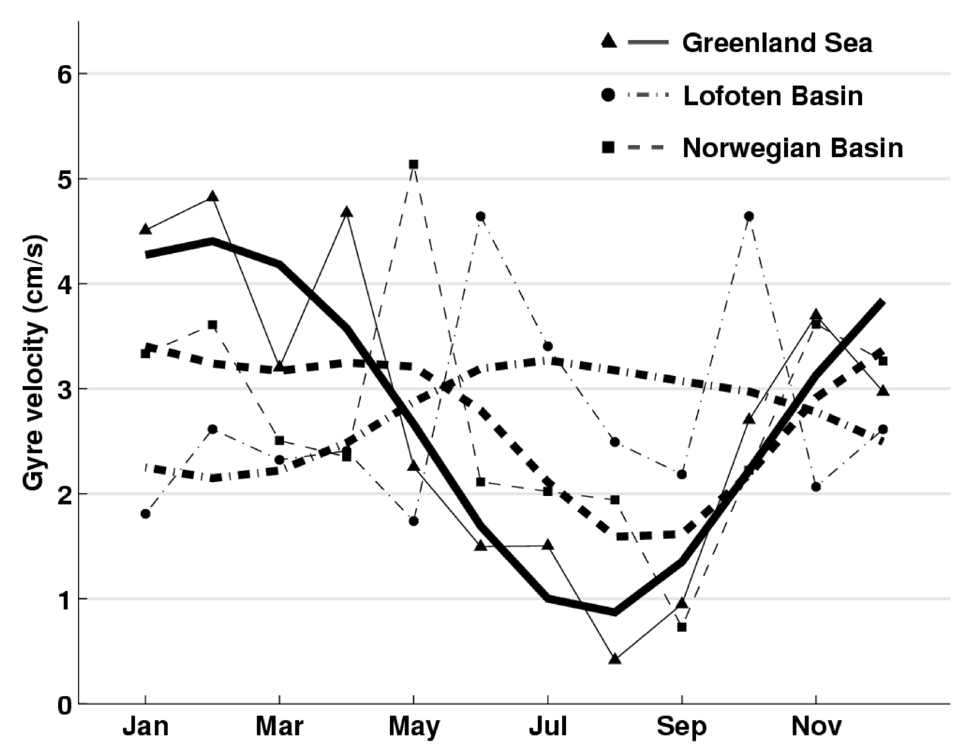


Bottom velocities in a model with simplified dynamics [1]. Red arrows show current meter records.

IV. SEASONAL VARIABILITY & FORCING

Monthly mean velocities of the subbasin gyres are defined as the average over all velocities – the component along bathymetry only – recorded in the rim areas of the subbasins during one month. The area between the 2000 and 3000 m depth contour is chosen to represent the rim of the gyres.

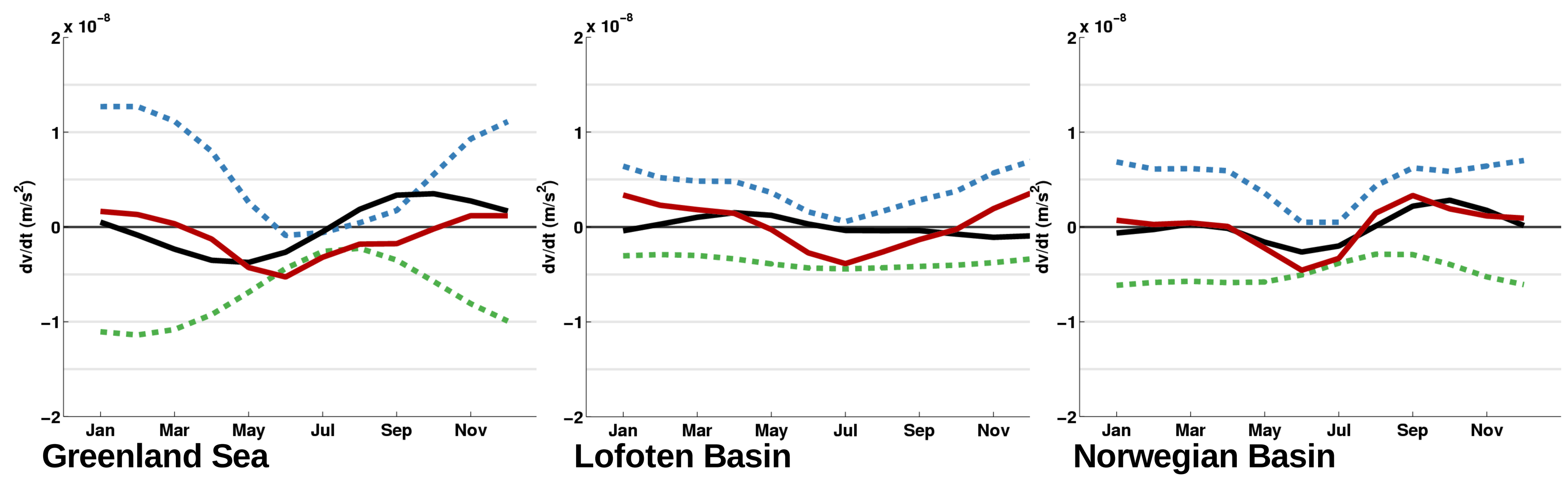




A smoothed version of the monthly mean gyre velocities shows a seasonal cycle with maxima in late winter and minima in late summer for the Greenland Sea and the Norwegian Basin. For the Lofoten Basin no such seasonal cycle is evident.

The temporal change of the subbasin gyre velocity calculated from the sum of wind forcing (NCEP) and bottom friction agrees with that seen in the **float observations** for the Greenland Sea and the Norwegian Basin.

$$\frac{\partial}{\partial t}\oint_C \vec{v}\,d\vec{r} = \int_A \frac{\nabla\times\vec{\tau}_w}{H\rho_0}\,dA - \oint_C \frac{\vec{\tau}_b}{H\rho_0}\,d\vec{r}$$



In the Lofoten Basin, buoyancy fluxes are expected to play an important role in the forcing, as the wind field is not able to explain the observed change in the circulation on the seasonal scale.

REFERENCES
[1] Nøst & Isachsen, The large-scale time-mean circulation of the Nordic Seas and Arctic Ocean from simplified dynamics. Journal of Marine Research, 2003.

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