Accumulation of Atlantic Water in the Lofoten Basin

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Background

The inflow of Atlantic Water from the North Atlantic into the Norwegian Sea is of vital importance for the climate in that region. Not only are the variation of the inflow and its properties important but also the interior distributions of the Atlantic Water within the Nordic Seas (Norwegian, Iceland and Greenland sea). The Norwegian Sea is influenced by both northward Atlantic Waters and Arctic water masses that enters via the Iceland and Greenland Seas. In the Lofoten Basin, Atlantic Water (salinity above 35), reaches down to 700-800 m depth (e.g. Mauritzen, 1996; Blindheim and Rey, 2004) while in the Norwegian Basin AW reaches down to about 500 m at maximum (e.g. Mork and Blindheim, 2000; Orvik et al. 2001).

The variability of the Atlantic Layer in the Lofoten Basin is studied using historical hydrographic observations in the Gimsøy section (see Figure 1 for location). With the use of the salt diffusion equation, the salinity variability, as function of z, is modelled by prescribing the variability at 100 m depth.

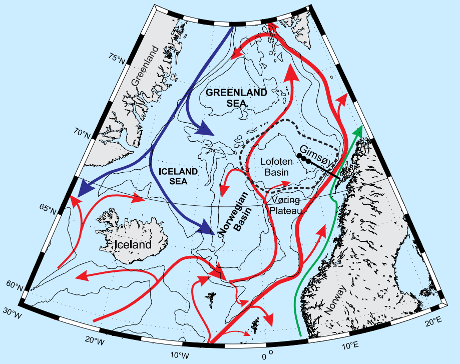
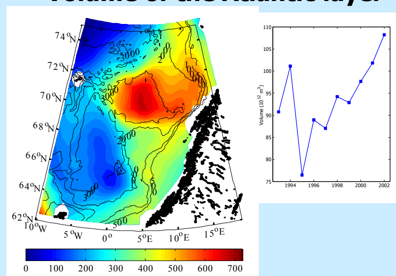


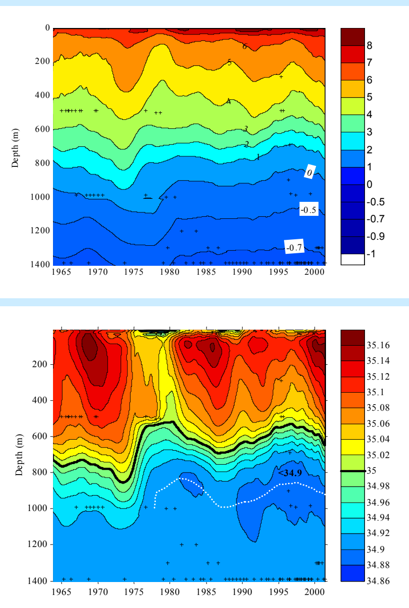
Figure 1. Schematic overview of the major current branches in the Nordic Seas. The dashed line is the 2500 m isobath.

Volume of the Atlantic layer



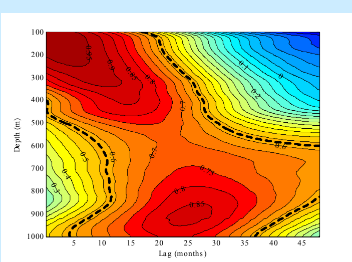
Left figure: the thickness of the Atlantic layer (salinity>35), averaged from 1993 to 2002 has a clear maximum in the Lofoten Basin and is topographic influenced. Right figure: The volume of the Atlantic layer in the Lofoten Basin, bounded by the 2500 m isobath, has increased by 50% from 1995 to 2002.

Observed interannual variability



Potential temperature and salinity in the Gimsøy section, averaged over the three most western stations (see Figure 1).

In the 1960s and to mid 1970s the Atlantic layer was at the deepest, reaching down to about 800 meters depth. The freshening of the upper layer in the end of 1970s was during the GSA period (Dickson et al. 1988). At present there is a trend with a deepening of the layer to similar depths as in 1960s.



The correlation between the salinity at 100 m depth with salinity at deeper depths shows a local maximum at 900 m depth (r=0.85), with a time lag of ~2 years.

The model

The salinity is modelled by the diffusion equation

$$\frac{\partial S}{\partial t} = \frac{\partial}{\partial z}\left(K\frac{\partial S}{\partial z}\right)$$

and divided into a temporal-mean and an anomaly:

$$S(z,t) = \bar{S}(z) + S'(z,t)$$

Similar as in Fjeldstad (1933) and Sverdrup et al. (1942) the anomaly is represented as a sum of harmonic terms

$$S' = \sum_{1}^{N} a_n e^{i\sigma_n t}$$

The diffusion coefficient, K(z), is calculated from

$$K\frac{\partial \bar{S}}{\partial z} = c$$

Choosing c=1.0e-6 gives an appropiate K.

Boundary condition

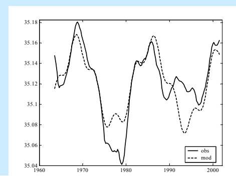
At 100 m depth the salinity anomaly is prescribed as a sum of harmonic terms

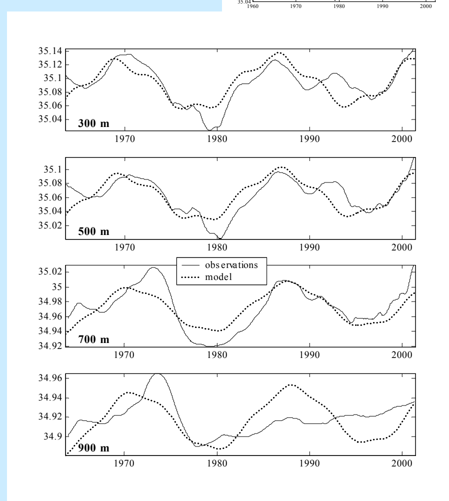
$$S' = \sum_{n=1}^{N} \tilde{a}_n e^{i\sigma_n t}$$

Mixed boundary condition is used at 1000 m depth

$$p\frac{\partial S'}{\partial z} + qS' = 0$$

The modelled salinity at 100 m depth, using only two Fourier components (periods at 17 and 4.5 years), plotted with the observed salinity.





Observed and modelled salinity at 300, 500, 700 and 900 m depths using p=1 and q=0 (dS′/dz=0).

There is a good fit between the modelled and observed salinity. However, the condition (dS′/dz=0) overestimate the variability at 900 m depth. The S′=0 condition is better at 900 m depth but underestimate the variability at shallower depths (not shown). Also, using a constant K would give nearly similar results (not shown) as using K=K(z).

Concluding remarks

- The thickness of the Atlantic layer is topograhic influenced in the Lofoten Basin.
- The volume of the Atlantic layer in the Lofoten Basin has increased with 50% from 1995 to 2002.
- In 2002 the thickness of the layer was about similar large as in the 1960s.
- The salinity variability is modelled by the diffusion equation and by prescribing the salinity at 100 m depth as a sum of only two Fourier components.

References

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