What Argo floats can tell us about the Nordic Seas' mid-depth circulation

Erika Giorgi, Kjetil Våge, Stefanie Semper, Ailin Brakstad, Anna-Marie Strehl
erika.giorgi@uib.no

Bjerknes Centre for Climate Research

Abstract

The general surface circulation of the Nordic Seas consists of poleward-flowing (relatively) warm waters from the Atlantic and a return flow along the East Greenland Current with colder and fresher waters, together with transformed Atlantic waters sub-surface. The transformation of inflowing Atlantic waters to denser and colder waters is important the overflows that supply the lower limb of the AMOC. However, the mid-depth circulation of these waters in the Nordic Seas, particularly the exchange between the various basins, is not well-known. Here, we use Argo floats drifting at 1000 m depth to provide an overview of this mid-depth circulation, gaining a better understanding of the pathways of dense-water from the formation regions towards the overflows.

Where do they come from and where do they go?

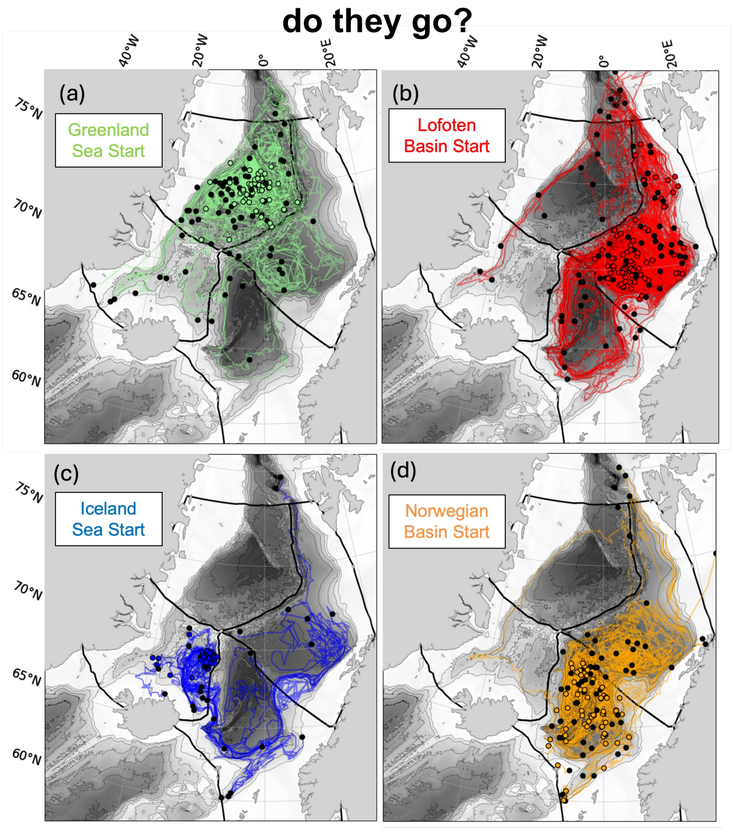

Figure 1: Trajectories of all Argo floats in the Nordic Seas starting in the (a) Greenland Sea, (b) Lofoten Basin (c) Iceland Sea and (d) the Norwegian Basin. Open circles are starting positions, closed black circles are end positions.

The life cycle of an Argo float

- Argo floats are autonomous instruments that typically drift at **1000 m depth** and take vertical profiles of the water column every ~10 days, obtaining data such as temperature and salinity
- They **drift freely with the currents** and transmit their data via satellite when surfacing – they therefore need ice free conditions!
- Many floats have been deployed in the Nordic Seas since the early 2000s (Figure 1), mostly in the centre of the basins, where they remain for most of their lifetimes - on average five years [3]
- The Argo data is freely accessible [5]

Mean circulation at 1000m depth from Argo floats

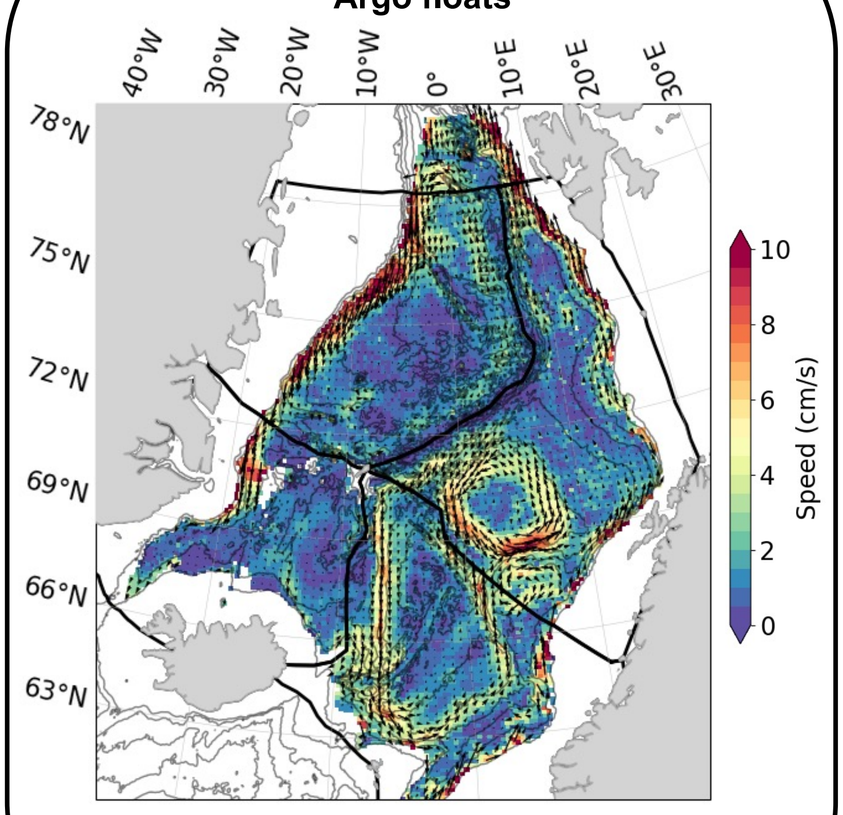

Figure 2: Time-mean (2001-2023) mid-depth circulation of the Nordic Seas. Thick black lines separate the basins. The arrows show the velocity.

Interbasin exchange

- Most of the exchange occurs along the **boundary current**, with the flow closely following bathymetry or passing through gaps in ridges
- The **East Greenland Current** is mainly responsible for the transport of floats from the Greenland Sea toward Denmark Strait (Figure 5)
- The **Iceland-Faroe Slope Jet** transports several floats from the Iceland Sea toward the Norwegian Basin (Figure 3)
- Some floats are transported toward the **Greenland-Scotland Ridge,** where dense waters overflow into the Subpolar North Atlantic, but the sill depths are too shallow for the floats to cross

Different or similar to the surface circulation?

- The general mid-depth circulation of the Nordic Seas is similar to the surface circulation, with **fast boundary currents** and **weaker interior flow**, also shown in some previous studies [1,2]
- There is significant **topographic control** of the mid-depth circulation, with high velocities along the Norwegian rim and in the central Lofoten Basin that are not observed at the surface. The northwards flowing Norwegian Atlantic Frontal Current is also not visible at depth [4]
- The circulation is largely **cyclonic**, corresponding to the surface wind forcing, both on large scale and within the basins themselves [1]

Iceland Sea ↔ Norwegian Basin

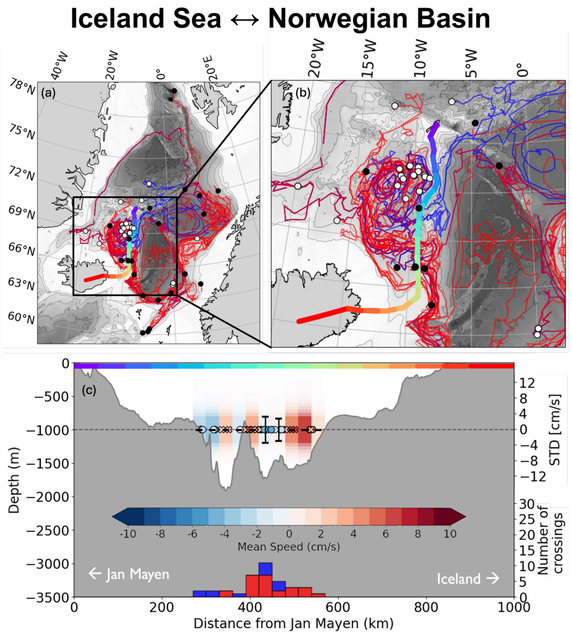

Figure 3: Floats crossing the section from **Jan Mayen to Iceland**. Red colours represent floats entering the Norwegian Basin from the Iceland Sea and vice versa for the blue colours. (a) and (b) show the trajectories of the floats crossing the section with white circles indicating start of the float trajectory and black circles the end. (c) shows the mean velocities and standard deviation in 30-km bins. The number of crossings is shown as a histogram.

Greenland Sea ↔ Lofoten Basin

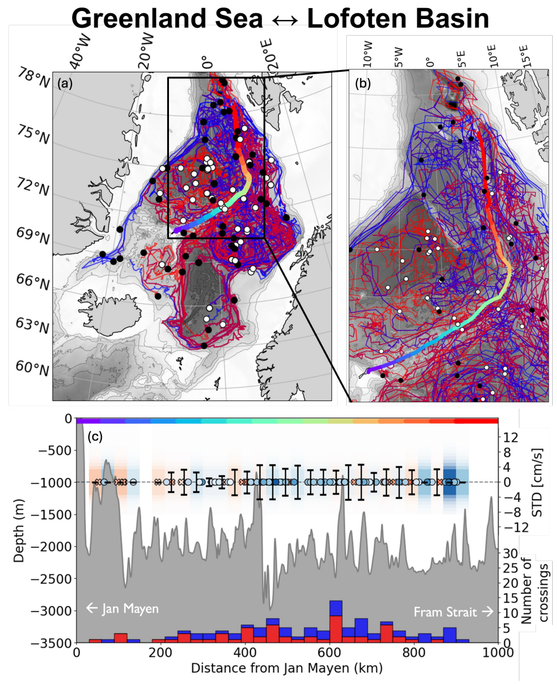

Figure 4: Same as Figure 3 but for floats crossing the section from **Jan Mayen to Fram Strait.** Red colours represent floats entering the Lofoten Basin from the Greenland Sea and vice versa for the blue colours.

Greenland Sea ↔ Iceland Sea

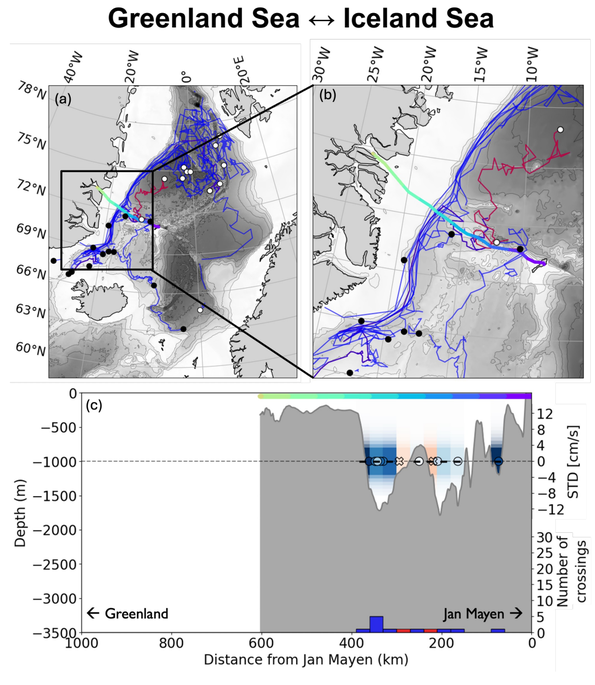

Figure 5: Same as Figure 3 but for floats crossing the section from **Jan Mayen to Greenland.** Red colours represent floats entering the Greenland Sea from the Iceland Sea and vice versa for the blue colours. Note the distance axis is reversed.

Lofoten Basin ↔ Norwegian Basin

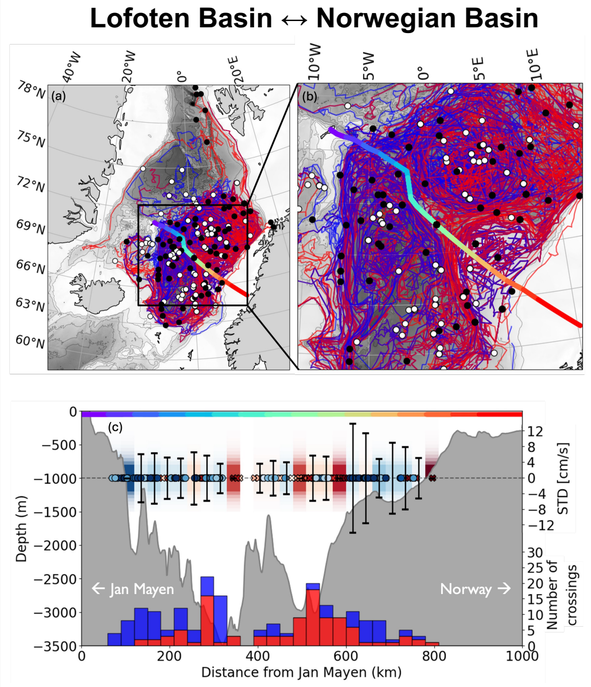

Figure 6: Same as Figure 3 but for floats crossing the section from **Jan Mayen to Norway.** Red colours represent floats entering the Lofoten Basin from the Norwegian Basin and vice versa for the blue colours.

References

[1] Voet et al., 2010. The mid-depth circulation of the Nordic Seas derived from profiling float observations. *Tellus A: Dynamic Meteorology and Oceanography*, *62*(4), pp.516-529.
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[3] FAQ. *Argo* https://argo.ucsd.edu/faq/.
[4] Huang et al., 2020. Sources and upstream pathways of the densest overflow water in the Nordic Seas. *Nature Communications*, *11*(1), p.5389.
[5] Argo (2000). Argo float data and metadata from Global Data Assembly Centre (Argo GDAC). SEANOE. https://doi.org/10.17882/42182.

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CONTACT INFORMATION
Allégaten 55, NO-5007 Bergen | Tel: +47 55 58 98 03 | Fax: +47 55 58 43 30 | post@bjerknes.uib.no | **bjerknessenteret.no**