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HE24C-2894:

Monitoring one of the tipping points of the AMOC

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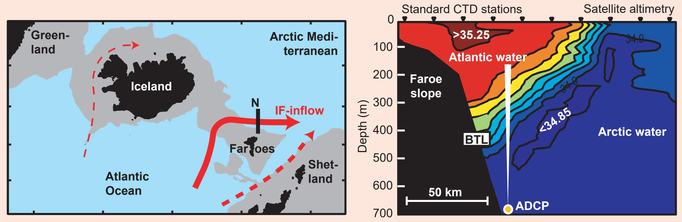
For two decades, we have monitored two branches of the AMOC that are coupled through a positive feedback loop with the potential for a tipping point

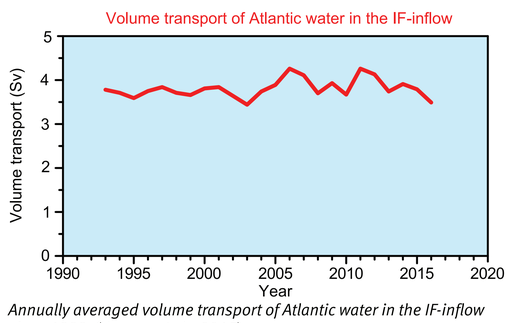
1 Atlantic inflow

The Atlantic inflow to the Arctic Mediterranean is the main oceanic heat conveyor towards the Arctic.

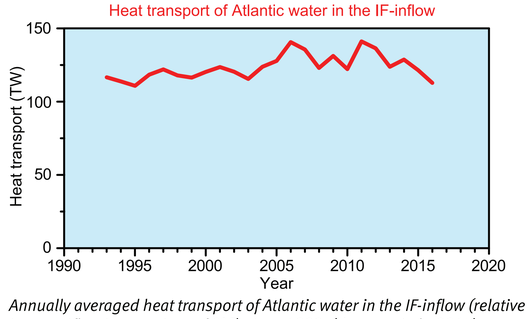
We monitor the strongest Atlantic inflow branch: IF-inflow.



The inflow, which passes between Iceland and Faroes (IF-inflow), is the strongest of the three Atlantic inflows (red arrows). We monitor it on section N (right panel) with moored ADCP and bottom temperature logger (BTL) combined with regular CTD cruises and satellite altimetry (Hansen et al., 2015).



Annually averaged volume transport of Atlantic water in the IF-inflow since 1993 (Hansen et al., 2015).

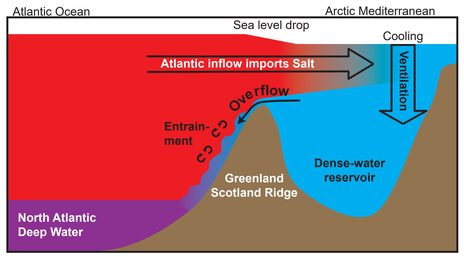


Annually averaged heat transport of Atlantic water in the IF-inflow (relative to an outflow temperature of 0°C) since 1993 (Hansen et al., 2015).

- The volume transport of IF-inflow has been stable since 1993.
- Heat transport increased until early 2000s, then decreased.

3 The coupling

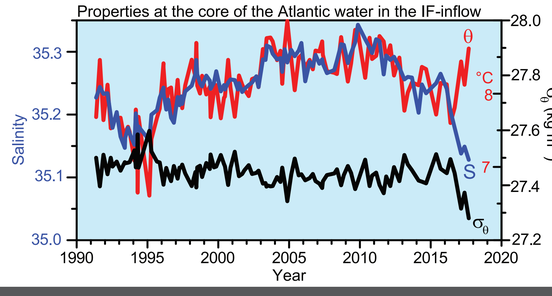
Stommel's (1961) salt-advection feedback loop couples Atlantic inflow and overflow, opening the potential for a tipping point (Sgubin et al., 2017).



Positive feedback loop:

- *Atlantic inflow imports salt to Arctic Mediterranean.*
- *Salt increases density and stimulates dense-water formation.*
- *Dense-water renewal generates overflow.*
- *Overflow exports water from Arctic Mediterranean, which generates a sea level drop across the ridge.*
- *Sea level drop drives Atlantic inflow*

4 The controller



De-seasoned salinity (blue), potential temperature θ (red), and potential density σ_θ (black) at the core of Atlantic water in the IF-inflow from individual CTD cruises since 1991 (Larsen et al., 2012). Traditionally, salinity and potential temperature have co-varied. Lately, salinity has continued to decrease whereas potential temperature increased, leading to exceptionally low densities.

5 Tipping point, how close?

During the last two decades, the huge dense-water reservoir of the Arctic Mediterranean has maintained stable overflow and Atlantic inflow.

This has been aided by increasing inflow salinities.

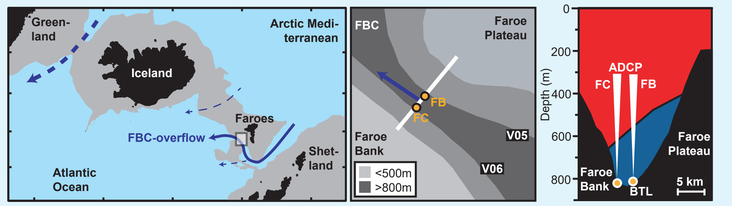
Decreasing inflow salinities since 2010 will weaken the positive feedback loop.

Therefore it is essential that we monitor all the overflow and Atlantic inflow branches.

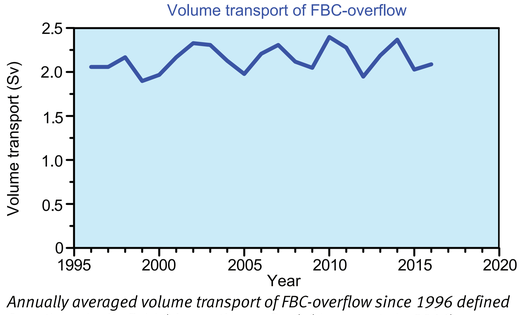
2 Overflow

The overflow (with entrainment) is the main source for the deep limb of the Atlantic Meridional Overturning Circulation (AMOC).

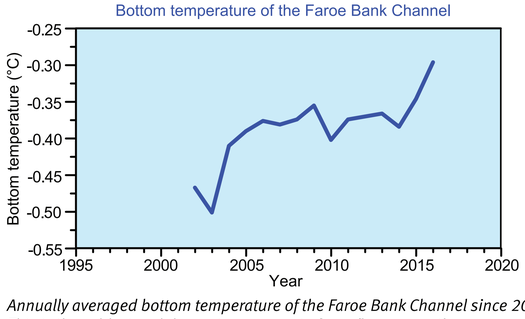
We monitor the densest overflow branch: FBC-overflow.



The FBC-overflow is one of four overflow branches (blue arrows). It passes through the Faroe Bank Channel (FBC), the semitransparent square on the left panel, which is expanded in the middle panel. The long-term ADCP mooring sites, FB and FC, are located over the sill on a section (white line in middle panel) shown on the right panel. V05 and V06 indicate two standard CTD stations, occupied several times a year (Hansen et al., 2016).



Annually averaged volume transport of FBC-overflow since 1996 defined from the velocity field (kinematic overflow) (Hansen et al., 2016).



Annually averaged bottom temperature of the Faroe Bank Channel since 2002. This is the coldest and densest component of overflow across the Greenland-Scotland Ridge. The warming has been accompanied by increasing salinities, keeping the density stable at least until 2015 (Hansen et al., 2016).

- Volume transport of FBC-overflow has been stable since 1996.
- The coldest overflow has warmed, but density is stable, so far.

Funding has been obtained from the Environmental Research Programme of the Nordic Council of Ministers (NMR) 1993–1998, from national Nordic research councils, from the Danish Energy Agency, and from three European projects: The NACLIM project has received funding from the European Union 7th Framework Programme (FP7 2007-2013), under grant agreement n.308299. The AtlantOS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633211. The Blue-Action project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727852.

References: Hansen et al. (2015): doi:10.5194/os-11-743-2015. Hansen et al. (2016): doi:10.5194/os-12-1205-2016. Larsen et al. (2012): doi:10.1093/icesjms/fss028. Sgubin et al. (2017): doi:10.1038/ncomms14375. Stommel (1961): Tellus, 13, 224–230.

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