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Recurring northward flow events in the East Greenland Current:
A new pathway for Atlantic heat into the Arctic
by R. McPherson, W.-J. von Appen, L. de Steur, L. Becker, M. Ionita, T. Krumpen, G. Spreen, and F. Heukamp

In this manuscript, episodic flow reversals in the East Greenland Current in western Fram Strait are documented using mooring data. A reorganization of the current through coastal upwelling caused by anomalous southerly winds are hypothesized to cause the flow reversals. Long-lasting reversals may have ramifications for Arctic Ocean heat budget and sea-ice extent. I think this is an interesting manuscript that provides important nuance to the exchange between the Arctic Ocean and the Nordic Seas. The analysis is thorough and the text and figures are clear and easy to understand. I have only a few remarks that I hope the authors will take into account.

General comments:

To test your hypothesis that episodes of anomalous southerly winds cause the reversals, I suggest that you identify all cases in the ERA5 reanalysis from the 1997-2019 period characterized by persistent southerly winds in Fram Strait of sufficient duration and strength, and then use the mooring data to determine whether each of those events did indeed cause a flow reversal. If that is the case, it would substantially strengthen your hypothesis. If not, at least it would demonstrate that southerly winds alone are not sufficient to cause the flow reversals. That would also have implications for the hypothesized increased frequency of such events (section 5.3). Are southerly winds in Fram Strait, presumably a necessary condition for flow reversals, becoming more prevalent?

If 8 deep-reaching events were identified in the Fram Strait Outflow Observatory, perhaps a composite analysis of all events centred around the peak of the event ± 1 month before and after, both in the oceanic velocity and temperature fields as well as the atmospheric pressure and wind fields, could shed more light on the typical development of events and how they form?

Based on the progressive vector diagram and the assumption that the velocity recorded at the mooring location was constant for the duration of the event, a distance of 750 km farther north, nearly reaching 86°N, was estimated (section 3.3 and discussion). The assumption of constant speed is discussed, but there's also an implicit assumption that the direction is constant. I think you should also clarify whether you think the flow of Atlantic Water would continue northward into the central Arctic Ocean, which would entail crossing lines of constant f/H (Nøst and Isachsen, 2003), or follow the Greenland slope around the northern end of Greenland.

The pathway for the Atlantic Water north of Fram Strait may also have implications for the impact of the flow reversals. Do the moored records indicate that a similar amount of AW returns when the circulation reverts back to its long-term mean state following an event, which may not be unlikely if the AW remains along the Greenland slope. Or does most of the AW that flowed into the Arctic Ocean not return, which may imply substantial diversion of AW into the central Arctic Ocean?

While it is true that the flow reversal events provide new understanding of the variability of the EGC, I think care should be taken not to overstate these results. Figure 6 and line 785 demonstrate that there is still a net southward transport in the EGC, even during reversal events. It may be more correct to state that they add nuance to the "conventional picture of the EGC as a persistent, year-round southward boundary current" rather than upending this picture. You may not have stated it so bluntly, but it is how I interpret that passage.

The proposed forcing mechanism (section 5.1) appears to be a standard coastal upwelling scenario (e.g., Pickart *et al.*, 2009; Håvik and Våge, 2018; Pacini and Pickart, 2023). It is not very clear from the discussion what distinguishes your proposed forcing mechanism from coastal upwelling, if anything.

Within the framework of the Thermodynamic Equation of SeaWater 2010 (TEOS-10), the preferred thermodynamic pair would be Absolute Salinity and Conservative Temperature (e.g., Figures 2 and 4). I suppose that Absolute Salinity and potential temperature can considered together, but in that case this combination should be justified. Please also note that Absolute Salinity has the unit g/kg (e.g., paragraph starting on line 290), unlike practical salinity Absolute Salinity is not unitless.

Detailed comments:

Line 24:
There is a preposition missing near the end of this line.

Line 130:
Please elaborate why the 79°N mooring has been maintained given that NPI's Fram Strait Outflow Observatory is located only 18 km farther south.

Line 161:
Perhaps events should be defined by northward velocities significantly greater than 0 m/s, not just greater than 0 m/s, where measurement, statistical, and other uncertainties are taken into account?

Line 223:
There is a preposition missing from this line.

Line 396:
It looks like the most pronounced temperature difference between the long-term May mean and the 2019 event was offshore of the flow reversal. In fact, the temperature field (Figure 6a, c) looks very similar at the location of the reversal. If that's generally the case, would such events rather entail Arctic Atlantic Water sloshing back and forth through Fram Strait than a poleward transport of Atlantic Water?

Line 447:
What do you mean by Arctic outflow in the context of lateral density gradients? It appears to be something else than the front between AW and PW.

Line 453:
I think a reference detailing how eddies from the eastern Fram Strait interact with the EGC should be included here.

Line 457:
Could you please clarify how you estimate the diameter of eddies, by considering the product of the northward velocity and the duration of the event, if the northward flows had been generated by eddies? Presumably, this would not apply to the case of semi-stationary eddies.

Line 485:
"Farther south" would be more correct than further south.

Lines 504-507:
I suggest consistently using the past tense to describe past events, as was done in the rest of this paragraph.

Lines 583 and elsewhere:
I would write “Arctic Ocean”. The Arctic, by itself, is ill-defined and has multiple interpretations.

Line 620:
It should be: “...boundary current system than **have** previously been described...”

Figure 1:
Please include in the caption a definition of all acronyms introduced in this figure.

Figure 2c:
Have the vmADCP velocities shown in this figure been de-tided using a tidal model? If not, how strong are the tidal currents at this location?

Figure 6:
Please mark the locations of the moorings.

Figure A1:
Perhaps consider showing a wind rose plot rather than time series in Figure A1. Such a figure would be easier to digest than time series of both u and v as well as providing additional statistical information.

References

Håvik L, Våge K. 2018. Wind-driven coastal upwelling and downwelling in the shelfbreak East Greenland Current. *Journal of Geophysical Research: Oceans* **123**: doi:10.1029/2018JC014 273.

Nøst OA, Isachsen PE. 2003. The large-scale time-mean ocean circulation in the Nordic Seas and Arctic Ocean estimated from simplified dynamics. *Journal of Marine Research* **61**: 175–210, doi:10.1357/002224003322005 069.

Pacini A, Pickart RS. 2023. Wind-forced upwelling along the west Greenland shelfbreak: Implications for Labrador Sea Water formation. *Journal of Geophysical Research: Oceans* **128**: doi:10.1029/2022JC018 952.

Pickart RS, Spall MA, Torres DJ, Fratantoni PS, Goldsmith RA, Yang J. 2009. Upwelling on the continental slope of the Alaskan Beaufort Sea: storms, ice, and oceanographic response. *Journal of Geophysical Research* **114**: C00A13, doi:10.1029/2008JC005 009.