Subpolar Atlantic meridional heat transports from OSNAP and ocean reanalyses

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OSNAP

The Overturning in the Subpolar North Atlantic Program (OSNAP) is a sustained, international ocean observing initiative that provides comprehensive measurements of the Atlantic Meridional Overturning Circulation (AMOC), integrated meridional heat and freshwater fluxes in the subpolar North Atlantic since 2014 (Lozier et al., 2017).

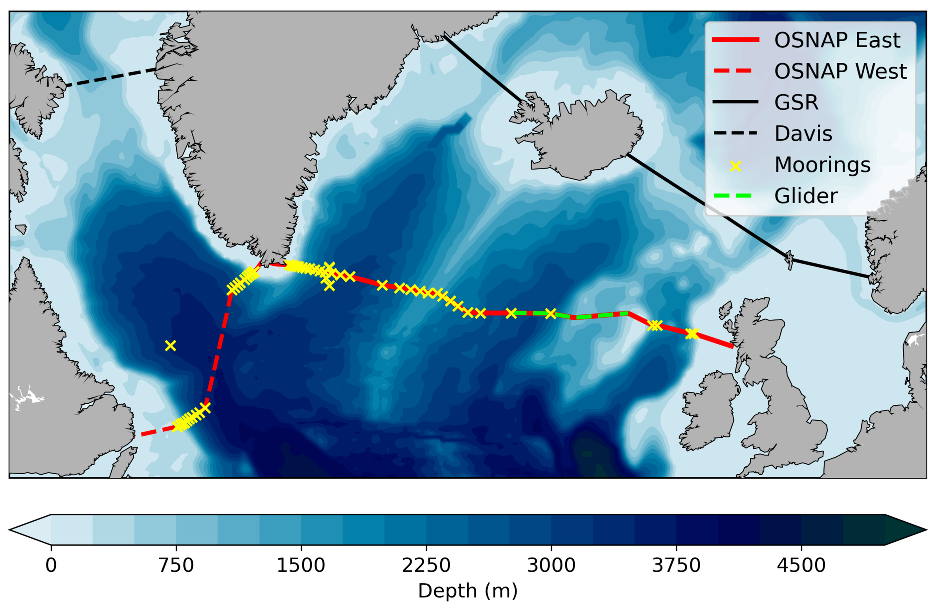


Fig.1 Map of the OSNAP region, showing bathymetry and locations of moorings and gliders used in the observation-based products. The Greenland–Scotland Ridge (GSR) is a mooring line used to derive an independent heat transport estimate (see Fig. 3, bottom).

Methods - StraitFlux

- Calculations of oceanic transports consistent with discretization schemes of reanalyses
- Analyses of ocean's vertical structure and flow patterns through cross-sections
- Analysis of Meridional Overturning Circulation at desired sections
- Calculations at mooring lines allow for direct comparisons to observations

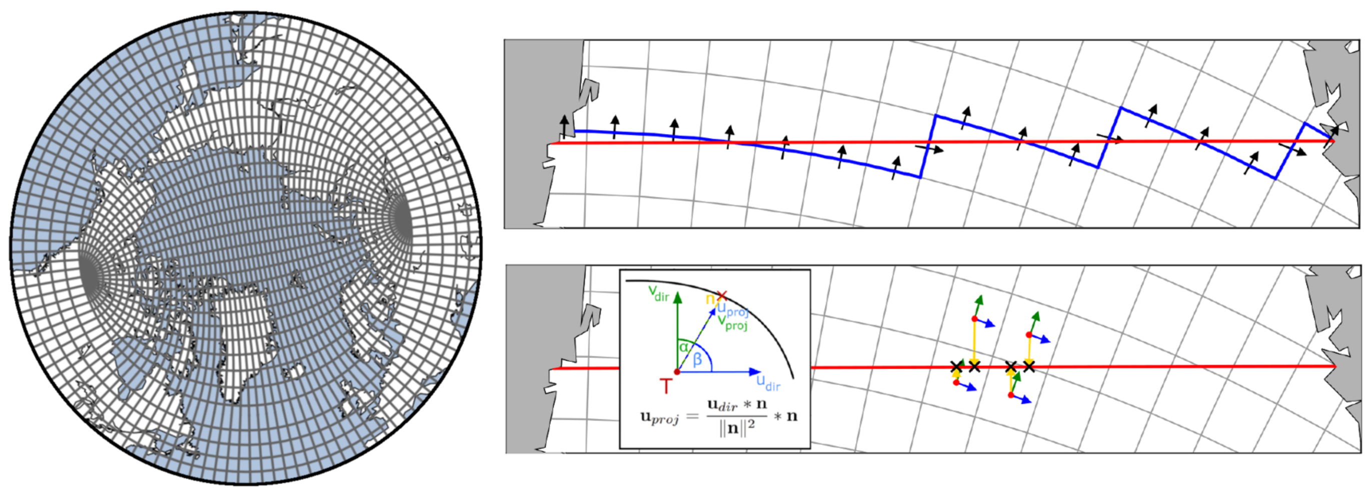


Fig. 2 Example of a tripolar curvilinear gird (left) and computation methods in StraitFlux.

Results

Heat Transports:

While mean OHT values at OSNAP East are broadly consistent between observations and reanalyses, notable differences emerge in terms of variability—particularly, a pronounced peak in 2015 present in observations is not captured by any of the reanalysis.

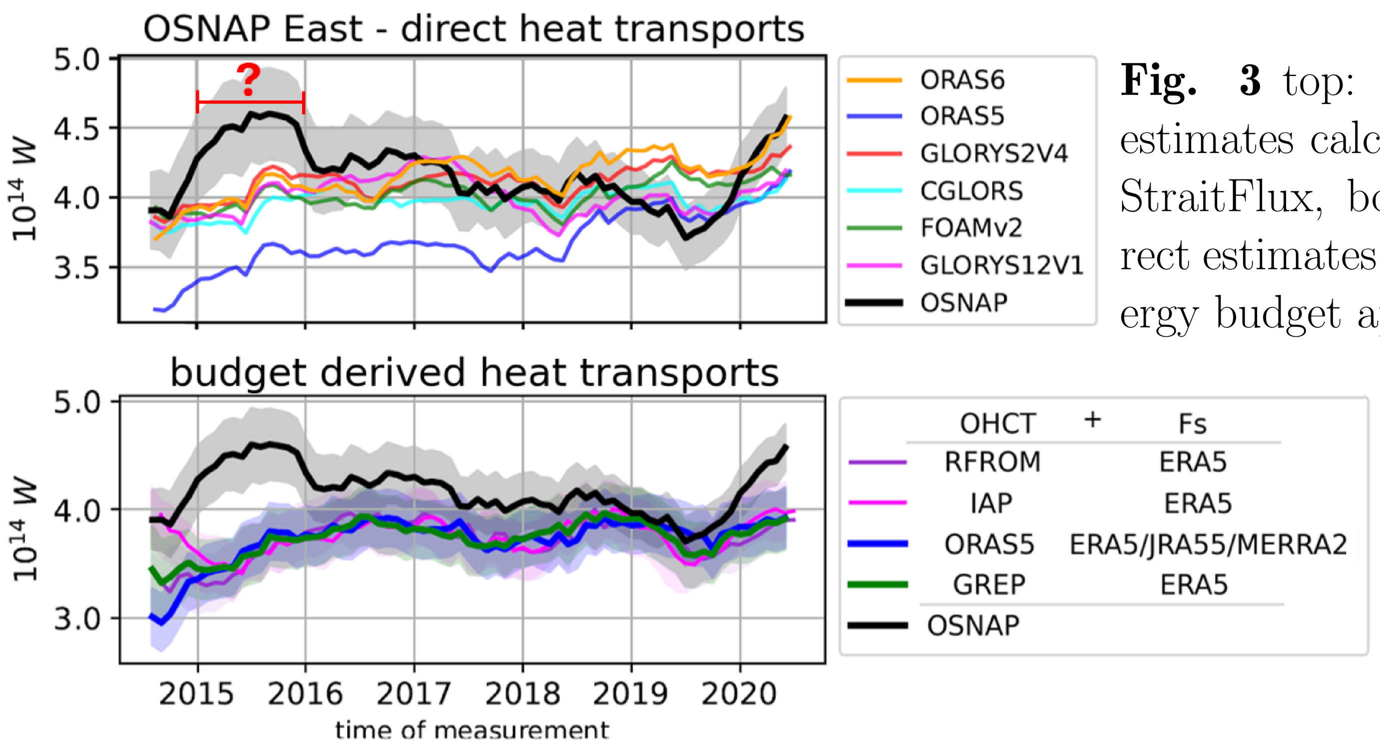


Fig. 3 top: direct OHT estimates calculated using StraitFlux, bottom: indirect estimates using an energy budget approach

A largely independent estimate of OHT is derived from the ocean heat budget by combining observed transports at the GSR with integrated surface fluxes and heat content changes south of it. It shows variability consistent with the direct reanalyses estimates.

East	OSNAP	ORAS6	ORAS5	CGLORS	FOAMv2	GLOR2V4	GLOR12V1
μ	417 ± 27	415	369	398	402	412	402
r	-	-0.06	-0.07	0.02	-0.05	0.04	0.37

Mean values and correlation coefficients for 2014-2020 OHT for OSNAP East.

Glider Region dicrepancies:

Discrepancies in variability between OSNAP and reanalyses mainly come from Glider region (North Atlantic Current inflow region at eastern Iceland basin and Hatton Bank).

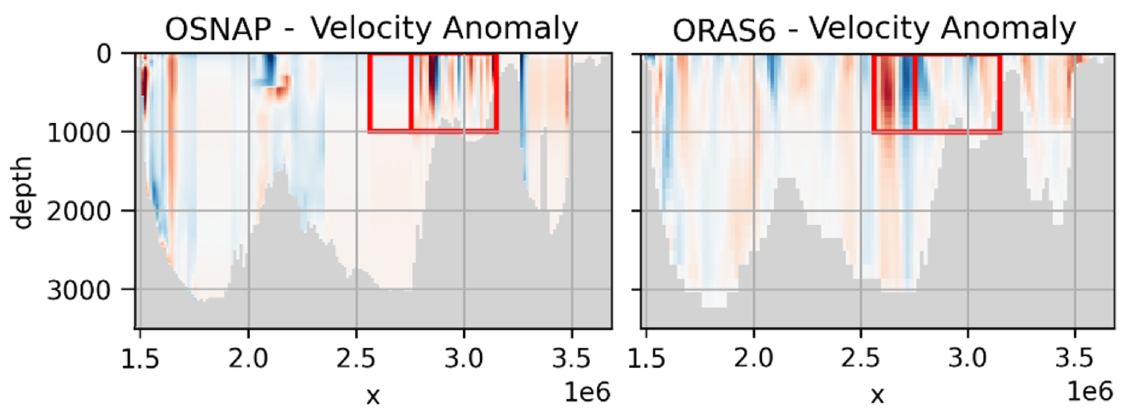
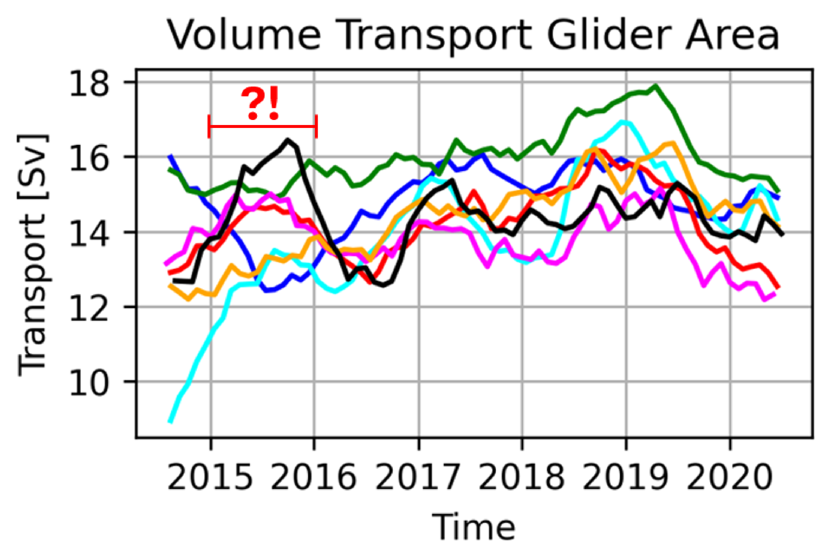


Fig. 5 Cross-sections of velocity anomalies for 2015. Red box shows glider area in the OSNAP product.



- Temperature anomalies are similar for the 2015-2016 period in observations and reanalyses
- A positive velocity anomaly seen in observations, but absent in reanalyses, drives a bias in volume transports and consecutive heat transports.

Fig. 6 Volume transports in the glider area.

Cross-sections:

reanalyses broadly capture the vertical structure of temperature and velocity, but notable biases remain, with cold biases in basin interiors, warm biases along continental slopes and highly dynamical regions, and discrepancies in current positioning and strength. The absence of mooring observations in key regions adds further uncertainty.

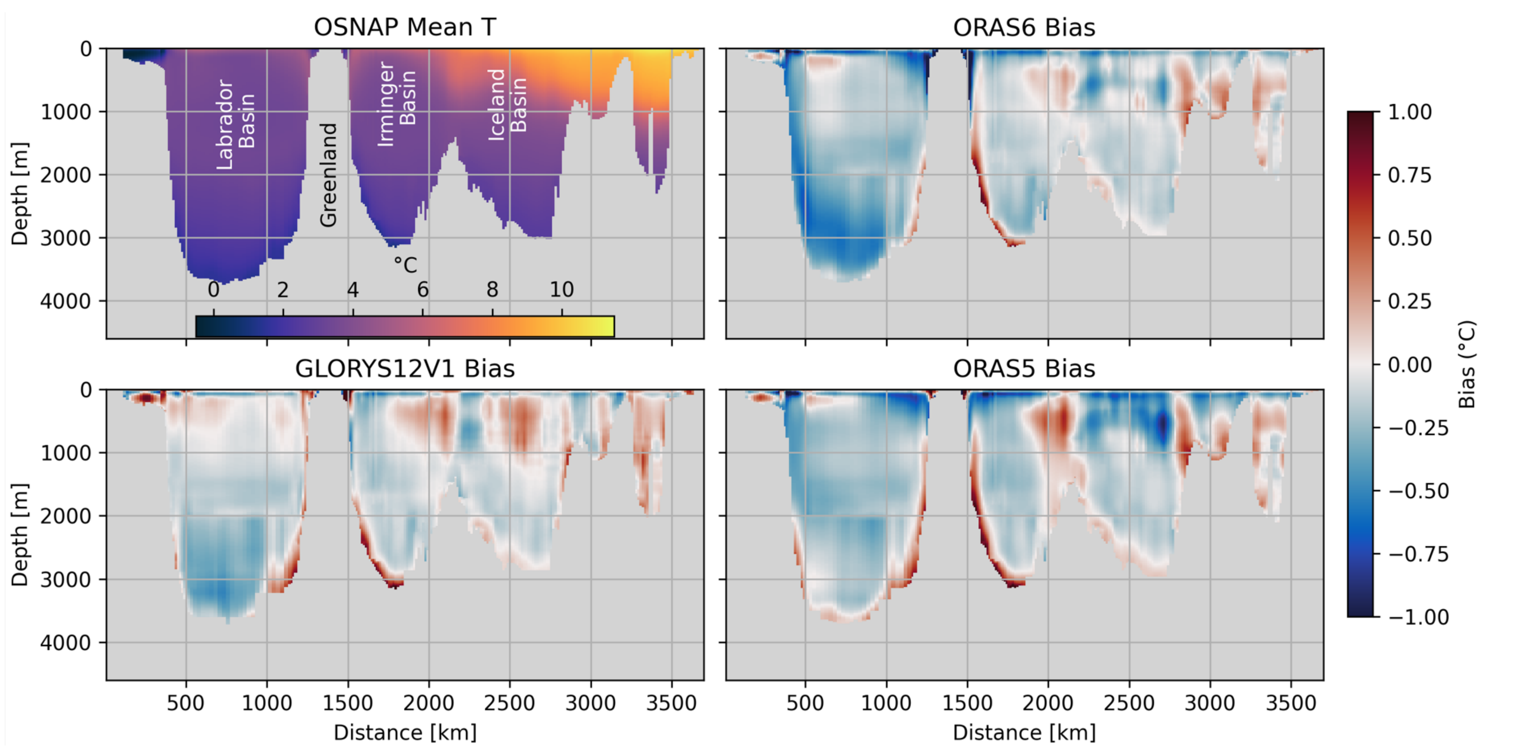


Fig. 4 Mean OSNAP temperature cross-section and biases for GLORYS12V1, ORAS5 and ORAS6.

Meridional Overturning Circulation

MOC estimates from reanalyses show better agreement and correlation with OSNAP observations than heat transport estimates.

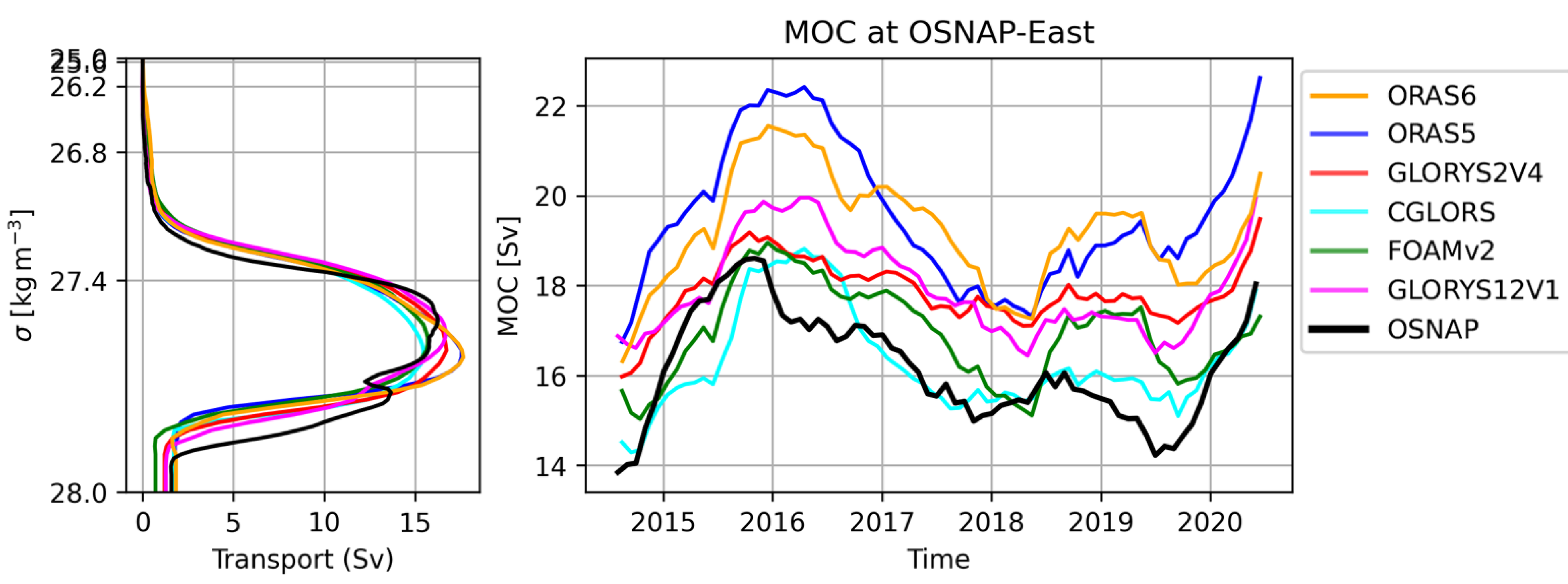


Fig. 7 AMOC streamfunction and MOC time series in density space at OSNAP East.

East	ORAS5	CGLORS	FOAMv2	GLOR2V4	GLOR12V1	ORAS6
r adj.	0.84	0.77	0.77	0.91	0.84	0.78

Correlation coefficients for MOC at OSNAP East.

Conclusions - OHT discrepancies

- OSNAP heat transports show a pronounced peak in 2015.
- The peak is not reproduced by two largley independent OHT estimates: direct reanalysis transports and heat budget-derived transports.
- This discrepancy is linked to velocity anomalies in the OSNAP glider area.
- **How reliable are OSNAP velocity estimates in the glider region?**

Winkelbauer et al. (2024): StraitFlux, https://doi.org/10.5194/gmd-17-4603-2024.
Lozier et al. (2017): OSNAP, https://doi.org/10.1175/BAMS-D-16-0057.1.
Winkelbauer et al. (in preparation): Heat transports from OSNAP and ocean reanalyses