A decade of East Reykjanes Ridge Current observations: velocity structure and transport variability

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Introduction

The cyclonic horizontal circulation of the subpolar North Atlantic acts as an important conduit of the Atlantic Meridional Overturning Circulation (AMOC) due to the progressive water mass transformation along the complex subpolar boundary current system[1]. Flowing southwestward along the eastern flank of the Reykjanes Ridge in the Iceland Basin, the East Reykjanes Ridge Current (ERRC) is a key link in this subpolar AMOC pathway by carrying modified subtropical waters and deeper Icelandic Slope Water before retroflecting towards the Irminger Sea[2].

Goal

Describe and quantify the ERRC velocity structure and transport variability using an unprecedented decade-long continuous moored measurements, complemented by quasi-synoptic CTD and LADCP profiles near 59°N.

Dataset: OSNAP + OVIDE

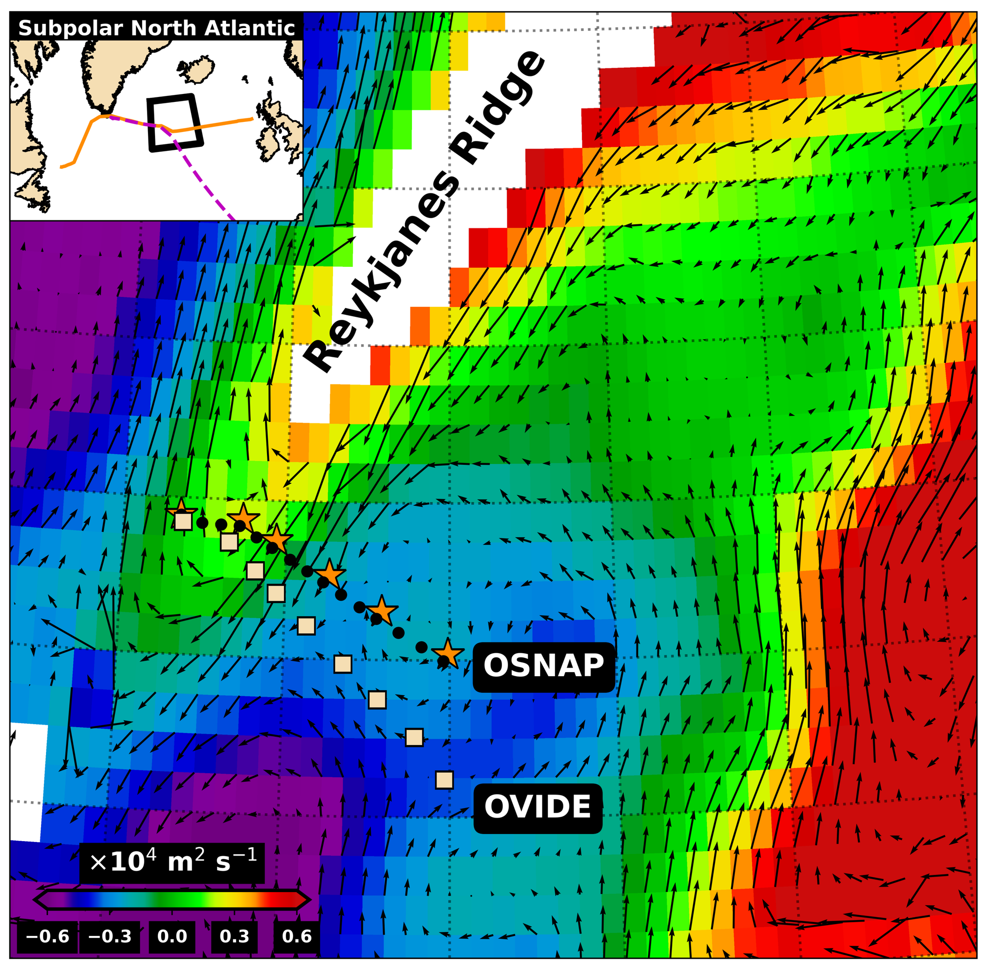


Fig.1 Locations of OSNAP and OVIDE observations used in this study overlayed on the mean upper-ocean circulation. The ERRC is represented by the southwestward-pointing vectors along the eastern flank of the Reykjanes Ridge. Stars, circles, and squares represent the locations of the OSNAP moorings, OSNAP CTD/LADCP stations, and OVIDE CTD/LADCP stations, respectively. Black vectors and color shading show the Argo-derived[3] 2004-2016 mean absolute geostrophic currents and streamfunction, averaged above the σ_0 =27.80 kg m^{-3} isopycnal[2].

OSNAP (2014-2024)

- **Hydrographic and velocity moorings:** Five (5) moorings equipped with MicroCATs, currentmeters, and ADCPs. Before 2018, only the two moorings closest to the Reykjanes Ridge crest and the easternmost mooring in Fig.1 measured the full water column. After 2018, all five moorings covered the full water column.
- **CTD and LADCP casts:** Seven (7) summer repeated CTD and LADCP high-resolution transects.

OVIDE (2002-2023)

- **CTD and LADCP casts:** Ten (10) summer repeated CTD and LADCP high-resolution transects.

Approach

1. **ERRC mean velocity structure and transport:** Obtained from moored and shipboard velocity observations, as well as geostrophic velocity estimate from shipboard data (CTD+SADCP) (Fig. 2 and Table 1).
2. **ERRC transport:** We calculated the mooring-derived time-varying transports between 2018-2024 and estimated geostrophic transports between 2014-2024. ERRC was defined as the southwestward flow above the overflow waters (i.e., σ_0 >27.80 kg m^{-3}) across the mean jet area between 31.2°W-29.5°W (Fig. 3).
3. **ERRC transport variability:** We quantified the ERRC transport variability time scales using Welch's power spectra with size-varying 50% overlap windows to better estimate the spectral properties on a wide range of scales (Figs. 3b and 4b).
4. **ERRC transport anomalies dynamics:** We conducted EOF analysis on the 2018-2024 moored velocity data as part of an early-stage investigation of the ERRC variability dynamics (Fig. 4).

1. The Mean ERRC

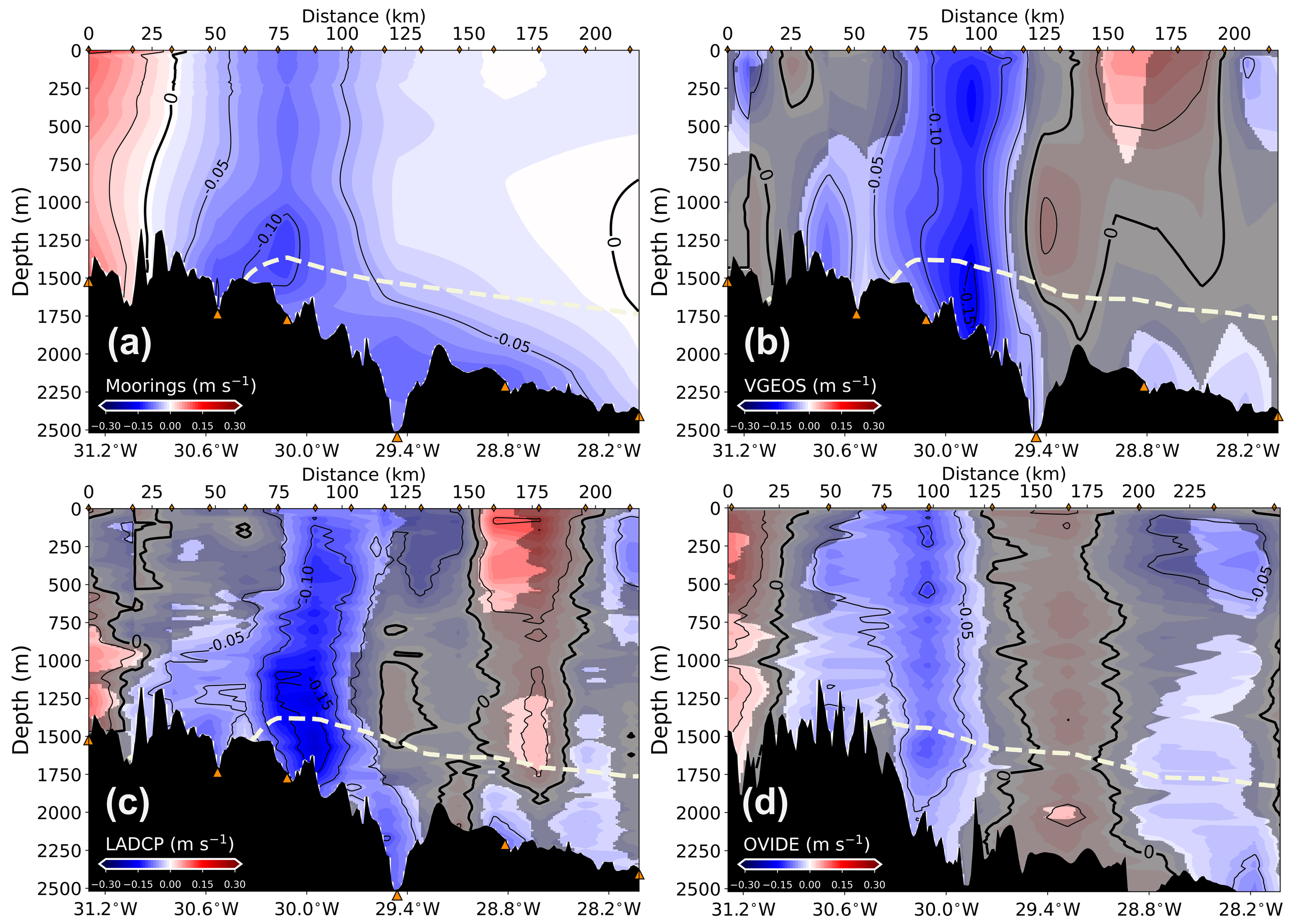
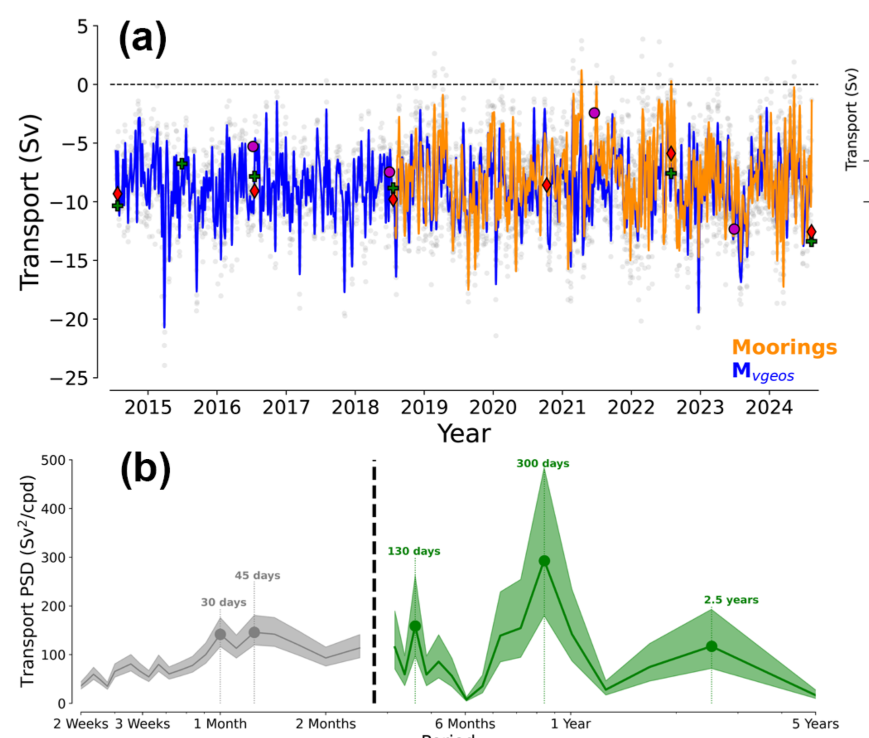


Fig.2 Mean cross-sectional velocity transects across the eastern flank of the Reykjanes Ridge. The ERRC jet is a narrow (∼100 km wide), southwestward-flowing current with multiple velocity cores between 0 and 1500 m depth. (a) OSNAP moored current meter and ADCP observations (2018-2024). (b) OSNAP CTD-based geostrophic summer observations (2014-2024). (c) OSNAP LADCP summer observations (2014-2024). (d) OVIDE LADCP summer observations (2002-2023). White dashed lines show the σ_0 =27.80 kg m^{-3} isopycnal, computed from moored MicroCATs in panel (a) and CTDs in (b)-(d). Negative velocity indicates southwestward flow. Orange diamonds and triangles mark the CTD/LADCP stations and moorings, respectively. Shaded areas indicate where the mean velocity magnitude is less than its standard error of the mean.

Table 1 Mean transport estimates across the OSNAP and OVIDE lines above the σ_0 =27.80 kg m^{-3} isopycnal from the different datasets shown in Fig. 1. The uncertainties are the transport's 95% confidence interval. Negative transports indicate southwestward flow.

Dataset	ERRC jet 31.2°W-29.5°W	ERRC jet + interior flow 31.2°W-28°W
Moorings (2018-2024)	-8.03±0.9 Sv	-9.62±1.0 Sv
Moorings$_{vgeos}$ (2014-2024)	-8.76±0.4 Sv	-11.27±0.9 Sv
LADCP (2014-2024)	-8.88±1.8 Sv	-8.86±2.5 Sv
VGEOS (2014-2024)	-9.51±1.6 Sv	-8.39±2.8 Sv
OVIDE (2002-2023)	-7.18±1.7 Sv	-10.69±3.2 Sv

2. The ERRC Transport Variability



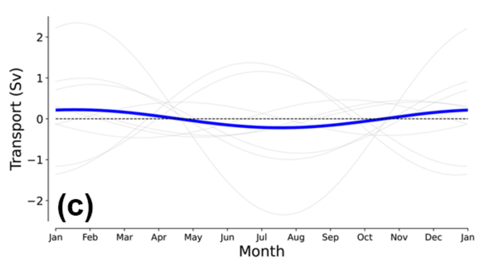


Fig.3 Analysis of the ERRC transport variability across the OSNAP line showing that the jet presents transport oscillations on weekly to interannual time scales, its variability is dominated by oscillations on quasi-annual time scales, it consistently flows southwestward, and its seasonality is weak.

(a) ERRC transport calculated from direct velocity observations (2018-2024) and geostrophic estimates (2014-2024). The small gray circles, green crosses, red diamonds, and large magenta circles are the OSNAP daily moored geostrophic transports, OSNAP LADCP-based, OSNAP CTD-based geostrophic, and OVIDE LADCP-based summer transport estimates, respectively. (b) Welch's power spectra of the 2014-2024 geostrophic estimates using a half-year-long (gray curve) and a five-year-long (green curve) 50% overlapping windows. (c) Annual (thin gray lines) and mean (thick blue line) seasonal cycle of the ERRC transport.

3. The ERRC Velocity Anomalies:

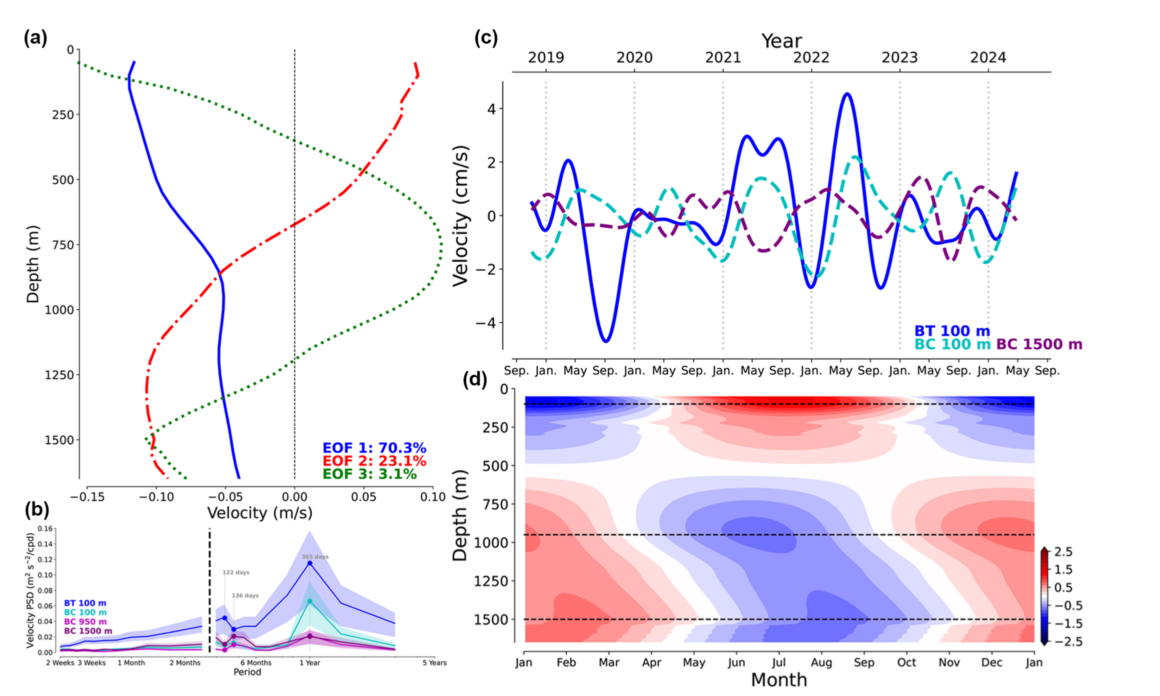


Fig.4 EOF analysis of the velocity horizontally averaged within the jet domain, showing that the ERRC velocity (and transport) anomalies are mainly barotropic, with baroclinic anomalies being dominated by its seasonal cycle. (a) Amplitudes of the first 3 modes of variability: EOF 1 ("barotropic-like" mode), EOF 2 ("first baroclinic" mode), EOF 3 ("second baroclinic mode), with their respective explained variance percentage. (b) Welch's power spectra of the 2018-2024 velocity time series using a half-year-long and a three-year-long 50% overlapping windows of the barotropic (BT = mode 1) and baroclinic (BC = mode 2 + mode 3) velocities at different depths. (c) 180-day low-pass filtered time series of the BT and BC modes at different depths. (d) Seasonal cycle of the BC modes. Horizontal dashed lines represent the depths shown in (b).

Summary and conclusions

1. The mean ERRC is a ∼100 km wide barotropic jet flowing southwestward along the Reykjanes Ridge carrying ∼7-9 Sv.
2. The ERRC transport varies on weekly to interannual time scales with negligible mean seasonal cycle. Transport variability is dominated by quasi-annual time scales, and the jet rarely meanders out of the area where the mean current is found.
3. The ERRC velocity and transport anomalies are predominantly barotropic with negligible mean seasonal cycle. Differences between dominant time-scales seen in the BT and ERRC transport spectra are within uncertainties and likely reflect the length of the time series used.
4. Baroclinic velocity anomalies do not significantly contribute to the ERRC overall transport, and their variability is dominated by a seasonal cycle that strengthens and weakens the ERRC above ∼600 m in the winter and summer, respectively.

Acknowledgments

We thank the many scientists, engineers, and mariners from many institutions worldwide who supported OSNAP and OVIDE over the years by developing instruments and collecting, processing, and publishing the data we used in this work. The Reykajnes Ridge OSNAP array is funded by the US National Science Foundation under Award OCE-1948198. T. C. B. also thanks the additional support from the University of Maine's School of Marine Science and the Office of the Vice President for Research. OVIDE is funded by Ifremer and CNRS in the frame of the OHIS French RI and EuroGO-SHIP grant agreement no.10109469.

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