The North Atlantic Eastern Boundary: Observations from Moorings at Goban Spur 2016-2019

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Introduction

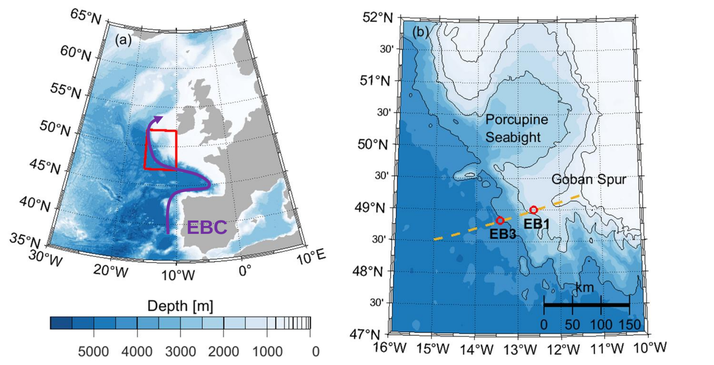
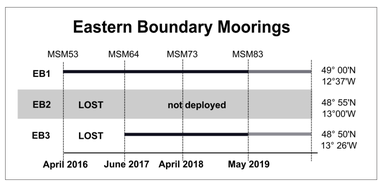


Figure 1 Top **:** Map of (a) the Eastern North Atlantic (b) positions of moorings EB1 and EB3 and the cruise track for the hydrographic sections (orange)
. Black contour in (b) are 500, 1000, 2000 and 4000 m isobaths **Right:** Table of Mooring positions, deployment period and cruises



Main objectives

- Capture strength and variability of the Eastern Boundary Current (EBC)
- Monitor variability in transports and water mass properties associated with northward spreading of subtropical waters along the EB
- Analyse variations in fractions and mixing of source water masses feeding the North Sea

Ship-based observations

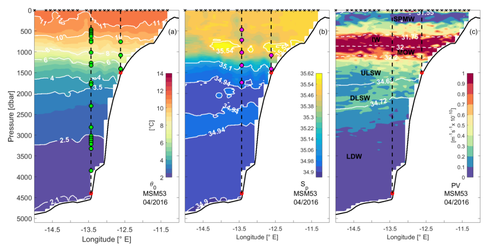


Figure 2 **(a)** Potential Temperature, **(b)** Practical Salinity and **(c)** Potential Vorticity PV from CTD casts during cruise MSM53 in April 2016. Vertical dashed lines and red squares at the bottom indicate the positions of moorings EB1 and EB3. The crosses at the top of each plot mark the positions of the CTD stations. The white contour lines show (a) isotherms and (b) isohalines. Solid white contour lines in (c) indicate the $\sigma_{1.5}$ isopycnals, the dashed white contour lines indicate the σ_1 isopycnals. SPMW = Subpolar Mode Water; IW = Intermediate Water; MOW = Mediterranean Outflow Water; ULSW = Upper Labrador Sea Water; DLSW = Deep Labrador Sea Water, LDW = Lower Deep Water. The green circles in (a) depict the positions of moored temperature sensors. The magenta circles in (b) mark the positions of moored conductivity sensors

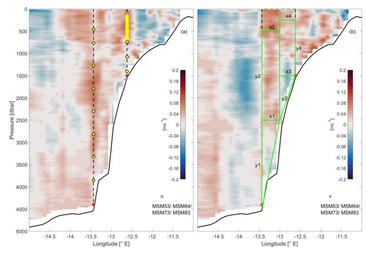


Figure 3 Section of de-tided **(a)** across-slope and **(b)** along-slope velocity components averaged from four repeated LADCP sections during cruises MSM53 (2016), MSM64 (2017), MSM73(2018) and MSM83 (2019). Vertical dashed lines and red squares indicate the positions of moorings EB1 and EB3.
The yellow circles in (a) depict the position of moored current meters. At EB1 an upward looking ADCP is installed at about 750 m. Green lines in (b) show the areal scaling used for transport estimates.

- moorings capture variety of watermasses
- Patches of salinity maxima/minima and sloping isopycnals indicate presence of eddies
- Narrow bands of currents
- Slope Current east of EB1 not captured or only partially
- horizontal scaling for transport estimates is half the distance between moorings (30 km)
- use uppermost velocity measurements for unresolved near-surface flow

Transport

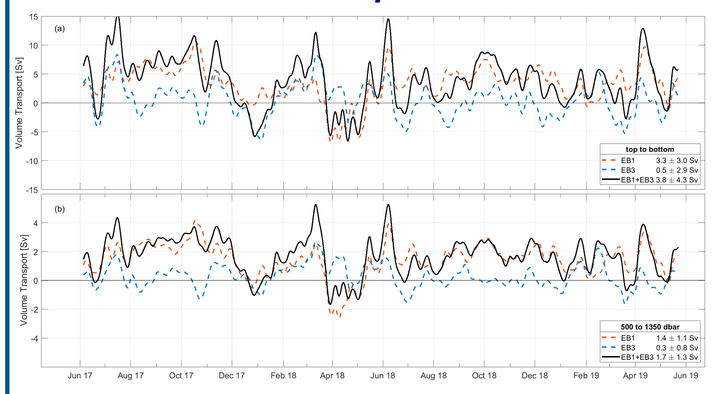
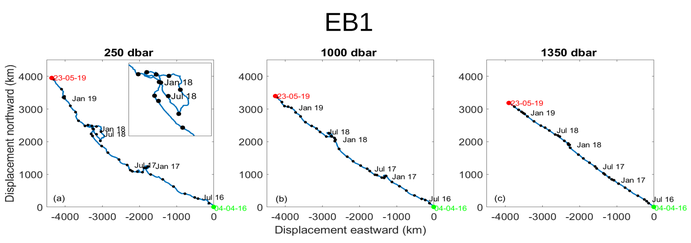


Figure 4 Volume transport time series from 10-day low-pass filtered along-slope velocity integrated
(a) from top to bottom and **(b)** from 500 to 1350 dbar. Transports are estimated for EB1 (red), EB3 (blue) and both combined (black).

- On average poleward volume transport of 3.8 Sv for period 2017-2019
- Large variations of >10 Sv within few weeks
- Occasional equatorward transport of about 5 Sv
- Periods when EB1 and EB3 transports co-vary out of phase

Current variability

EB1



EB3

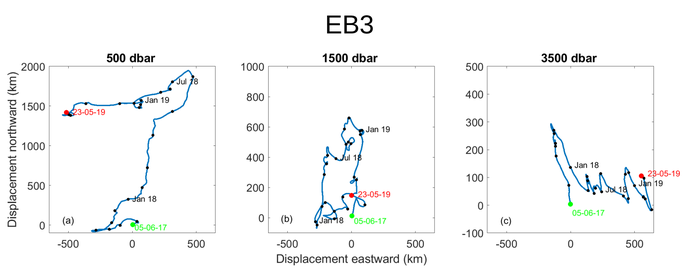


Figure 5 Progressive vector diagram of velocity time series at mooring EB1 (upper columns) and EB 3 (lower columns) at different pressure levels from from April 2016 to May 2019 (1145 days) for EB1 and from June 2017 to May 2019 (718 days) for EB3. Each dot represents a month. Note the different scales of the northward displacement in the individual subplots for EB3.

- Difference in flow characteristics between EB1 and EB3
- Flow variations indicate presence of eddies

At EB3
- near zero mean flow with dominant across-slope variation
- Baroclinic current structure
- Periods of transport into interior at EB3 in upper water column
- Periods of transport into interior at EB3

At EB1
- On average along-slope poleward flow with dominant along-slope variation
- Barotropic current structure

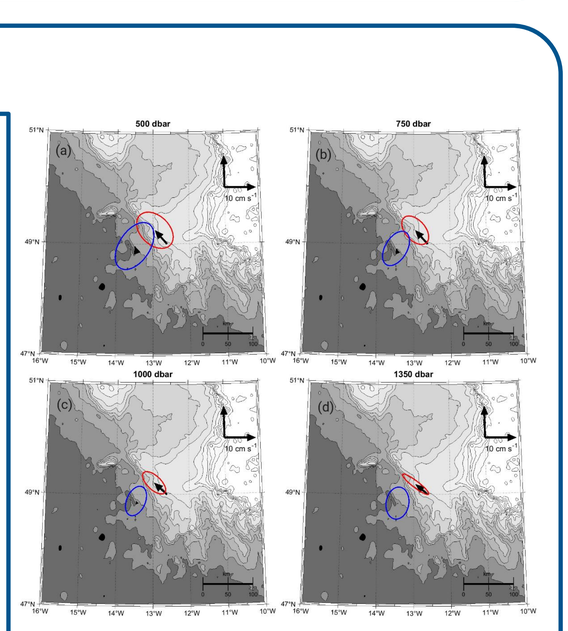


Figure 6 Bathymetric map with mean velocity vectors and standard deviation ellipse for EB1 (red) and EB3 (blue) at (a) 500 dbar , (b) 750 dbar, (c) 1000 dbar and (d) 1500 dbar for the overlapping period from June 2017 to May 2019 (718 days).

Absolute Dynamic Topography (ADT)

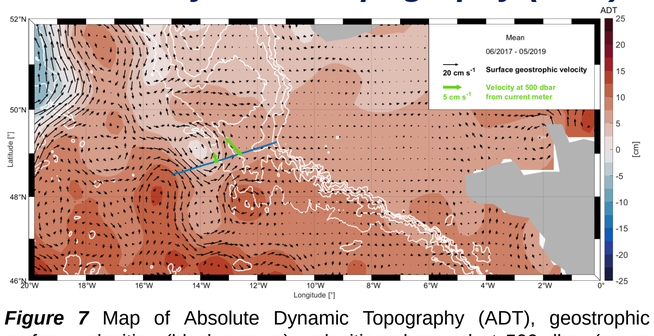
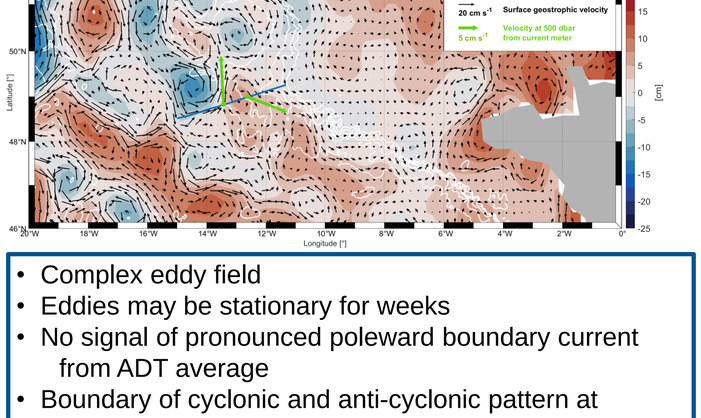


Figure 7 Map of Absolute Dynamic Topography (ADT), geostrophic surface velocities (black arrows), velocities observed at 500 dbar (green arrows). top: averaged for the overlapping mooring period from June 2017 to May 2019 (718 days) and bottom: during a period of equatorward flow at EB1.
White contour lines indicate 500, 1000, 2000 and 4000 isobaths. The blue line indicates the ship section.



- Complex eddy field
- Eddies may be stationary for weeks
- No signal of pronounced poleward boundary current from ADT average
- Boundary of cyclonic and anti-cyclonic pattern at mooring array

Water mass variability

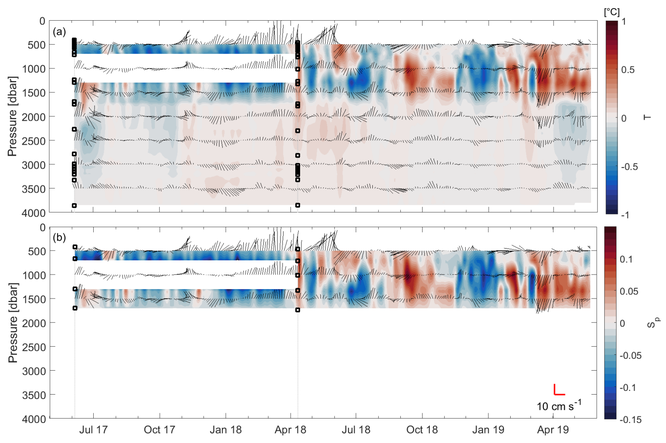


Figure 8 Hovmoeller diagrams of 10-day low-pass filtered (a) temperature anomaly and (b) salinity anomaly for EB3. Anomalies are relative to the mooring period from April 2018 to May 2019. Sticks of 10-day low-pass filtered velocity are superimposed with one stick per 3 days. Black squares indicate the positon of the instruments during mooring periods. There are no data at 1000 m for deployment period 2017/18.

- Strongest variability in the layer of Mediterranean Outflow Water
- No consistent connection between current variability and temperature and salinity variations

At EB1
- For the period 2016-2019 positive linear trends in temperature and salinity

At EB3
- between 2017-2019 positive trends in temperature and salinity down to 1500 m
- Negative trend in temperature at 3500 m

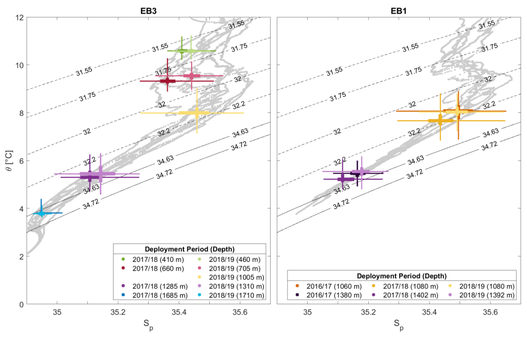
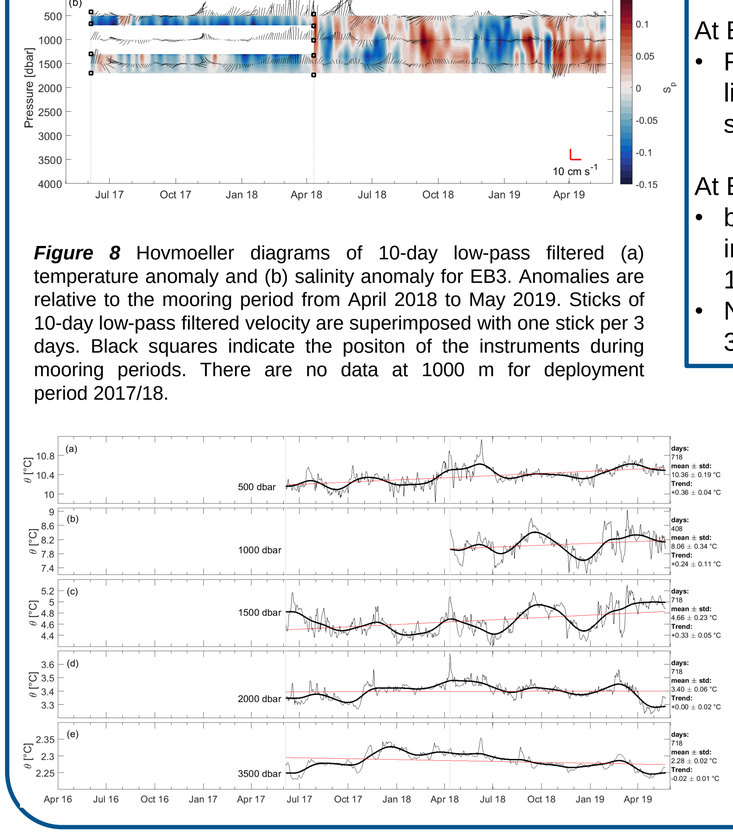


Figure 9 θ/S diagram for (a) EB3 and (b) EB1. Colors indicate different mooring periods and instrument depths. Thin lines give the minimum/ maxmium, thick lines are the 25/75 per-centiles centered around the median. The dashed contour lines indicate the$\sigma_1$isopycnals and thesolid contour lines indicate the$\sigma_{1.5}$isopycnals as in Fig. 2. Grey lines are profiles of CTD casts in close vicinity to the moorings.



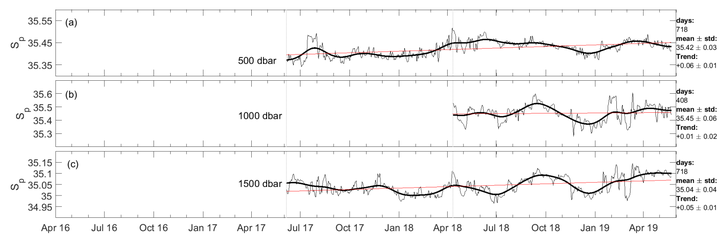


Figure 10 Time series of potential temperature (left) and practical salinity (right) for mooring EB3 (. Thin (thick) lines are daily (90 day low-pass-filtered) values. The red line is a fit from linear regression. Mean and standard deviation (std) and trend with the 95% confidence interval are stated on the right side of the plots.

Work in progress!

Summary

- Analysis of the deep North Atlantic Eastern Boundary Current
- Two moorings near Goban Spur moorings between 2016 to 2019
- Mean poleward volume transport of 3.8 Sv with strong variations
- Combination with SSH data reveals complex current structure with signature of eddies
- Positive trends in temperature and salinity in upper and intermediate water column
- Monitoring program ongoing

Acknowledgements

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