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Quantifying North Atlantic Current carbon transport

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Background

The North Atlantic Ocean plays an important part in the global carbon cycle. Although it comprises only 15 % by surface area, it stores 23 % of the oceanic anthropogenic carbon (Khatiwala et al., 2013). Despite this, several key questions regarding the North Atlantic carbon cycle exist. For example, only one estimate of the transport of carbon by the important Atlantic Meridional Overturning Circulation (AMOC) exists (Alvarez et al., 2004). As this was from a single hydrographic section, we have no information on the representativeness of this estimate or how it may vary temporally. This is particularly important in light of new results from the Overturning in the Subpolar North Atlantic Programme (OSNAP) which show that the AMOC is highly variable (Lozier et al., 2019).

To fill this knowledge gap, we deployed a number of chemical sensors on a mooring in the eastern portion of the trans-Atlantic OSNAP mooring array in July 2017 (mooring EB1, Figure 1). This instrumentation comprises of several dissolved oxygen sensors as well as a pH sensor, and was placed to capture a branch of the North Atlantic Current, a component of the AMOC upper limb, which flows through the Rockall Trough. Results from OSNAP show transport of the North Atlantic Current through this basin is highly variable (mean ± standard deviation, 6 ± 2.6 Sv) and a major contributor to the Nordic Seas (Houpert et al., 2020). In 2020, this instrumentation was expanded to a second mooring in the Iceland Basin (IB4, Figure 1). In order to calculate the transport of carbon, we use data from the moored instruments along with water samples collected on a hydrographic transect along the OSNAP mooring array. The MASTS MBF grant was used to help pay for the analysis of water samples collected during research cruise DY120 for dissolved inorganic carbon (DIC) and total alkalinity (TA).

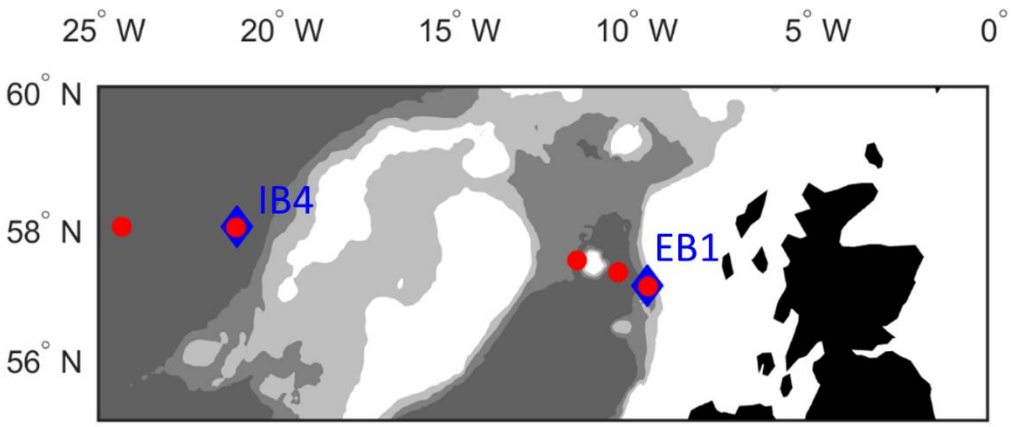

Figure 1. Map showing the hydrographic stations where water samples were taken for carbon analysis during cruise DY120 (circles) and the location of the moored chemical sensors (diamonds) in the Rockall Trough (EB1) and Iceland Basin (IB4).

Use of funds

The mooring turnaround cruise, DY120, was delayed from August 2020 to October 2020 due to covid. Additionally, there were time-constraints on the cruise, sampling was cut back to only that deemed essential, and scientist and technical berths were reduced to half. Despite this, the cruise was highly successful with a near-perfect data return from moored instruments and the occupation of several hydrographic stations where samples were taken for carbon analysis (Figure 1). These water samples were analysed thanks to the MASTS MBF grant in conjunction with funding received from a SAGES Small Grant and the EU Horizons 2020 iAtlantic project.

The DIC profiles (Figure 2) show low concentrations in the surface mixed layer with higher concentrations below this. The lower oxygen layer, which is centred upon approximately 1000 m in the Rockall Trough and 750 m in the eastern Iceland Basin, is associated with higher DIC values, probably as a result of decomposition of organic matter at this depth. Below this layer, concentrations decrease before increasing again below 2500 m in the Iceland Basin. TA profiles are more uniform throughout the water column although lower concentrations are seen at mid-depth and higher concentrations are associated with the deepest waters in both the Rockall Trough and Iceland Basin.

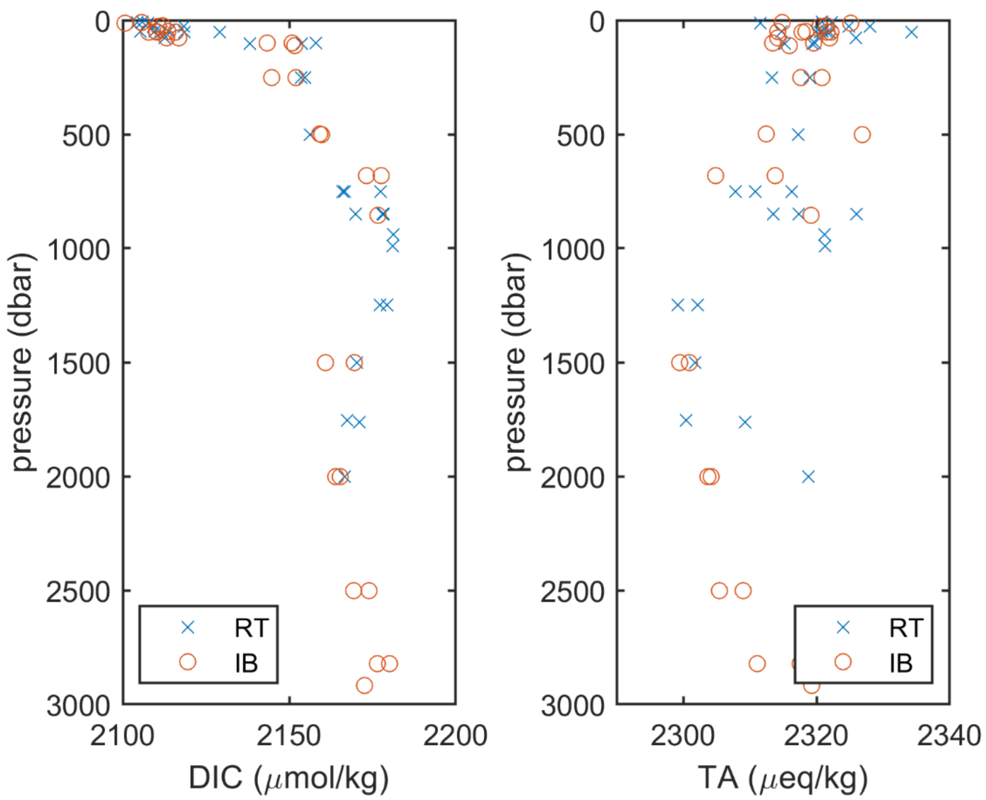

Figure 2. Profiles of Dissolved Inorganic Carbon and Total Alkalinity collected during DY120. Blue crosses show samples collected in the Rockall Trough and orange circles those collected in the Iceland Basin.

Future work

The DIC and TA samples will be used two-fold. Firstly, samples closest to mooring EB1 will be used, along with nutrient data, to derive pH and calibrated the moored pH sensors in-situ. This is particularly important due to the two-year deployment length. Secondly, all DIC and TA samples will be used to derive equations that explain these variables in terms of temperature, salinity and dissolved oxygen concentrations. These equations, which are derived by step-wise linear regression, will be applied to data from the moored CTD and dissolved oxygen sensors in order to derive high-frequency time-series of carbon parameters (DIC, TA, pH, pCO_2, C_{anth}). Carbon transports will then be estimated by multiplying the volume transports, estimated by the OSNAP project, by the time-varying carbon fields. This will give a long-term (2017-2020) transport of carbon by the Rockall Trough branch of the North Atlantic Current for the first time, as well as providing the first estimates of intra-annual to seasonal variability. Data including the Iceland Basin branch of the North Atlantic Current, as measured by mooring IB4, will be available after the next turn-around cruise in 2022.

Acknowledgements

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References

Alvarez, M., F. Perez, H. Bryden and A. Rios, 2004, Physical and biogeochemical transports structure in the North Atlantic Subpolar Gyre, *Journal of Geophysical Research: Oceans*, **109**, doi:10.1029/2003JC002015.

Houpert, L., S. Cunningham, N. Fraser, C. Johnson, N. Holliday, S. Jones, B. Moat and D. Rayner, 2020, Observed variability of the North Atlantic Current in the Rockall Trough from four years of mooring measurements, *Journal of Geophysical Research: Oceans*, **125**, doi:10.1029/2020JC016403.

Khatiwala, S., T. Tanhua, S. Mikaloff Fletcher, M. Gerber, S. Doney, H. Graven, N. gruber, G. McKinley, A. Murata, A. Rios, and C. Sabine, 2013, Global ocean storage of anthropogenic carbon, *Biogeosciences*, **10**, 2169-2191, doi:10.5194/bg-10-2169-2013.

Lozier, M., F. Li, S. Bacon, F. Bahr, A. Bower, S. Cunningham, M. de Jong, L. de Steur, B. de Young, J. Fischer, S. Gary, B. Greenan, N. Holliday, A. Houk, L. Houpert, M. Inall, W. Johns, H. Johnson, C. Johnson, J. Karstensen, G. Koman, I. Le Bras, X. Lin, N. Mackay, D. Marshall, H. Mercier, M. Oltmans, R. Pickart, A. Ramsey, D. Rayner, F. Straneo, V. Thierry, D. Torres, R. Williams, C. Wilson, J. Yang, I. Yashayaev, and J. Zhao, 2019, A sea change in our view of overturning in the subpolar North Atlantic, *Science*, **363**, 516-521, doi:10.1126/science.aau6592.