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The North Atlantic anthropogenic carbon conveyor: temporal variability of within-ocean transports and their sensitivity to the meridional overturning circulation

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The North Atlantic plays a critical role in the global carbon cycle both as a region of substantial air-sea carbon dioxide uptake and as a location for the transfer of CO_2 to depth on climatically-important timescales. However, while surface flux variability is relatively well constrained, our understanding of the changing deep carbon distribution is restricted to sub-decadal repeat hydrographic sections, and for anthropogenic carbon (C_{anth}), integrated multi-decadal basin-scale estimates.

Here, we present the first observation-derived high-resolution estimate of short-term meridional carbon transport variability and long-term trends across the subtropical North Atlantic. Historical hydrographic data-based estimates of C_{anth} are used to generate predictive regressions that, combined with RAPID mooring and ARGO float-derived transport estimates, create a 10-day frequency interior ocean carbon flux time-series for 2004-2012.

The mean net C_{anth} transport across this timeframe is found to be relatively independent of calculation method and robust at 0.18 PgC yr^{-1} northwards, with poleward advection of high C_{anth}shallow waters outweighing the predominantly southwards transports of low concentrations at depth. Substantial seasonal, sub-annual and interannual transport variability is observed that is highly sensitive to the strength of the overturning circulation. While the recently identified multi-year decrease in MOC strength similarly impacts C_{anth} transports, its full effect is masked by the northwards transport of increasing surface C_{anth} levels. A comparison with historical estimates of the regional carbon sink reveals an intrinsic relationship between air-sea uptake, ocean transport and heat fluxes, which will become more important as the ocean responds to a changing global climate.