Gulf Stream Eddies as an important source of dissolved Fe to the North Atlantic Subtropical Gyre

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The subtropical North Atlantic Gyre is an oligotrophic region, important for the fixation of atmospheric nitrogen by diaztotrophs. Typically it has been assumed that the high iron (Fe) requirements of these organisms, as well as other phytoplankton in this region, have been satisfied by large deposition fuxes of Fe-bearing atmospheric dust transported from the nearby Sahara. However, dust supply is highly episodic, varying with season and storm activity, resulting in highly variable dissolved Fe concentrations in surface Atlantic waters. Furthermore, the subsurface ocean in this region is low in dissolved Fe and dissolved nutrients due to the proliferation of nutrient-poor Subtropical Mode Water. In winter, subsurface dissolved Fe concentrations can even approach levels shown to limit phytoplankton growth.

Here, we present the first observation of a Gulf Stream cold-core ring carrying dissolved Fe from Fe-rich Slope Water into the Fe-depleted gyre. This ring was serendipitously sampled during the 2011 US GEOTRACES GA03 section cruise, as were the Slope Sea waters that get transported by such rings. From these data, we deduced that Fe concentrations are roughly twice as high within cold core rings compared to subtropical gyre waters of the same density. Combining these observations with a recent satellite-based dataset of mesoscale eddy activity in the region to estimate the size and number of rings crossing the Gulf Stream per year, we estimate that cold-core rings transport $0.3\pm0.2\times10^{8}$ moles $year^{-1}$ of dissolved Fe into the gyre.

This ring-driven flux is comparable in order of magnitude to our best estimate of soluble Fe flux from atmospheric dust fluxes to the region (0.4×10^{8} to 8.6×10^{8} mol Fe/yr; median of 2×10^{8} mol Fe/yr), which is based on a new compilation of observational and model based estimates. Ring transport also carries phosphate and nitrate into the gyre, at nutrient ratios that could support diazotrophy. We thus argue that ring-mediated transport is an important and previously-overlooked supply mechanism of Fe to the subtropical gyre, especially to the region immediately south-west of the Gulf Steam, where ring-derived flux may rival atmospheric supply.