Iron biogeochemistry differs within and outside of a Southern Ocean eddy

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Mesoscale eddies are ubiquitous in the Southern Ocean and play a major role in the transfer of heat and carbon between the atmosphere. Southern Ocean cold-core eddies are typically defined by strong clockwise rotation and by cool temperature and negative sea-surface height anomalies. These eddies typically have closed circulation leading to distinct biogeochemical properties compared to external waters. The concentration of dissolved iron in remote Southern Ocean surface waters, away from continental and island input sources, is typically sub-nanomolar (60-200 pmol kg^{-1}). Here, we probed the biogeochemical cycling of iron within a subantarctic cyclonic cold core eddy during the austral autumn in 2016. In-eddy dissolved iron concentrations were low with concentrations ranging between 18 and 33 pmol kg^{-1} between 15 and 200 m. Out-eddy dissolved iron concentrations were higher with concentrations ranging between 35 to 68 pmol kg^{-1} across a similar depth range. In-eddy primary production was also low. However, phytoplankton iron to carbon uptake (Fe:C) ratios were elevated 2-6 fold compared to populations in surrounding waters. These higher Fe:C ratios were indicative of up-regulation of iron acquisition processes by phytoplankton to enhance iron bioavailability. This is supported by measured (+1.3‰ at 40 m cf. 0‰ at 150 m) and modelled iron isotope values, which are isotopically heavy in the euphotic zone. Below the euphotic zone, in-eddy microbial recycling of iron was evident and coincided with maxima in heterotrophic bacteria and recycled nutrients. Because eddies are omnipresent within the Southern Ocean, iron limitation of phytoplankton be more severe than previously measured or modelled.