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Winter Copper and Nickel distributions from the Indian sector of the Southern Ocean.

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Concentrations of copper and nickel were measured in the Indian sector of the Southern Ocean during austral winter for the first time. Seven depth profiles, between 41 and 58°S, were collected along the 30°E longitude (GEOTRACES GIpr07 transect) in July 2017 aboard the SA Agulhas II. These measurements, combined with previous data from the Southern Ocean, allowed a comprehensive investigation into Cu and Ni biogeochemical cycling over seasonal transitions. Dissolved copper (dCu) ranged between 0.54-3.30 nmol/kg and dissolved nickel (dNi) ranged between 1.98-8.21 nmol/kg. Vertical profiles displayed nutrient-type behaviour where both metals had minima in surface waters of the Sub-Tropical Zone (STZ) and maxima in bottom waters of the Antarctic Zone (AAZ). With depth, distinct metal versus phosphate (PO4) relationships were observed in each of the intermediate and deep water masses suggesting that dCu and dNi distributions at depth were largely the result of physical water mass mixing. For particulate copper (pCu) and nickel (pNi), the composition was majorly biogenic however localised lithogenic inputs were attributed to potential hydrothermal activity near to the Indian mid-Ocean ridge (up to 0.002 and 0.003 nmol/kg for Cu and Ni respectively) and transport of continental sediment via Agulhas waters (up to 0.002 and 0.004 nmol/kg for Cu and Ni respectively). Vertical profiles of pCu and pNi contrasted their respective dissolved phases and generally showed near surface maxima, up to 0.07 nmol/kg for both metals, indicating that biological uptake and subsequent remineralisation are ongoing during winter, although not to the extent observed during spring/summer. Indeed, winter phytoplankton biomass (inferred from chl-*a* concentrations) overlapped with the lower end of summertime values. Furthermore, the surface ratios of pCu and pNi to phosphorus (P) increased southwards, from 1.14 to 3.60 mmol/mol for pCu:P and 1.43 to 2.14 mmol/mol for pNi:P, implicating a host of potential driving factors including metal availability and local phytoplankton community composition. Calculated vertical attenuation factors (*b* values) for pCu (0.02), pNi (0.24) and P (0.41) suggest that Cu and Ni have longer remineralisation length scales than P, providing a mechanism as to why profiles of pCu:P and pNi:P increased with depth.