High-resolution ocean temperatures and Polar Front latitudinal migration assessment based on radiolarian and diatoms assemblages in the Kerguelen Plateau region, Southern Ocean, over the last 360 kyrs

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Climate-driven latitudinal migrations of the Antarctic Circumpolar Current (ACC) frontal system strongly impact nutrient redistribution and primary productivity in the Southern Ocean (SO), and thereof the partitioning of CO_2 between the ocean and the atmosphere. The identification of the modern Antarctic Polar Front (APF) is most robustly based on sea-surface heights (Sokolov and Rintoul, 2009) or the presence of a sub-surface temperature minimum (Park et al., 2019), two metrics that current proxies can't reconstruct in the past. Another less robust identification of the modern APF is based on narrowing of the surface thermal gradient between 2.5-5.5°C (Belkin and Gordon, 1996; Anilkumar et al., 2006; Luis and Sudhakar, 2009). This metric is generally used to infer past migrations in the APF. This study aims to provide a new method to accurately estimate the past APF location through the reconstruction of sub-surface temperatures, based on radiolarian assemblages and transfer functions (sub-STrad). The reconstruction of sub-STrad (200 m as the calibration depth) is possible because radiolarians live at intermediate depths (100-400 m) in the SO (Abelmann and Gowing 1997; Boltovskoy 2017). The new sub-STrad record is compared to sea-surface temperatures reconstructed from a diatom-based transfer function (SSTdiat, 10 m as the calibration depth). Sub-STrad and SSTdiat were reconstructed at 0.5 – 1.5 kyr temporal resolution over the past 360 kyrs (sub-STrad) and 150 kyrs (SSTdiat), in core MD11-3353 retrieved on the western Kerguelen Plateau in the Southern Indian Ocean (SIO). The results suggest that the APF, now flowing south of Kerguelen Islands, shifted north of the Kerguelen Plateau during glacial periods. The Plateau was thus in the Antarctic Zone experiencing particularly cold glacial conditions allowing the Kerguelen ice-sheet to develop. During climate optima, reached during the early phase of interglacial periods, the APF probably flowed through the Fawn Trough at ~ 56 °S. The 2-3 °C constant difference between the Sub-STrad and SSTdiat in core MD11-3353 and published Polar Front Zone records is consistent with the vertical gradient observed in the modern ocean (2-3 °C degrees difference between 0 and 200 m). Although interpretations of APF past migration based on sub-STrad and SSTdiat agree well in the specific case of core MD11-353, surface water proxies should not be relied upon as a sole indicator for frontal migrations as they can be influenced by low latitudes currents or other processes affecting their capacity to record the climate signal (Civel-Mazens et al., submitted). As such, sub-STrad appear to be the most direct and reliable method to document past APF location in the SIO.

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