Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.30597

Using Nutrient Tracers to Quantify Water Mass Mixing in the Western Indian Ocean

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The distribution and mixing of water masses in the Indian Ocean are fundamental to global ocean circulation and climate variability. This region regulates the exchange of heat and salinity with the Pacific Ocean through the Indonesian Throughflow and is shaped by climate variability patterns such as the Indian Ocean Dipole. However, quantitative assessments of water mass composition and inflow pathways in this region remain limited. This study investigates the distribution of major water masses along the 67°E meridional transect from the equator to 27°S using chemical tracers derived from nitrate, phosphate, and silicate, along with temperature and salinity. By applying Optimum Multiparameter Analysis (OMPA) , we quantitatively estimated the mixing fractions of key water masses, including Antarctic Intermediate Water (AAIW) , Subantarctic Mode Water (SAMW) , Red Sea Overflow Water (RSOW) , and Circumpolar Deep Water (CDW) . The OMPA results revealed that AAIW accounts for approximately 30–40% of the water mass composition at intermediate depths (~1000 m) , while RSOW contributes around 20–25% in the northern part of the study area. At greater depths (>2000m) , CDW dominates with a fraction exceeding 50%, highlighting its major role in deepwater circulation. Furthermore, our OMPA results revealed that SAMW is transported northward following isopycnal layers and that the volumetric distribution of SAMW decreases from over 60% at 25°S to less than 20% at 15°S. The total volume of SAMW was estimated to be approximately 2. 1×10^{15} m^3 , consistent with previous studies. This study provides a quantitative assessment of water mass distribution in the western Indian Ocean, offering a foundation for future research on ocean circulation, which influences the transport of various materials, including carbon dioxide and nutrients.