Stable oxygen, hydrogen isotope ratios and salinity variations of the surface Southern Indian Ocean waters

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Stable isotope (δ¹⁸O and δD) and salinity measurements were made on the surface waters collected from the Southern Indian Ocean during the austral summer (25 January to 1 April 2006) onboard R/V Akademik Boris Petrov to study the relative dominance of various hydrological processes, viz. evaporation, precipitation, melting and freezing over different latitudes. The region between 41°S and 45°S is a transition zone: the region lying north of 41°S is dominated by evaporation/precipitation process whereas that south of 45°S (up to Antarctica) is dominated by melting/freezing processes. Further, the combined study of stable oxygen and hydrogen isotope (δ¹⁸O and δD) confirms that the Southern Indian Ocean evaporates in non-equilibrium conditions.

Keywords: Global meteoric water line, mass spectrometry, Southern Indian Ocean, stable oxygen and hydrogen isotopes.

The Southern Ocean, defined as the region between the south of 60°S and Antarctica, is an important region that affects the climate of the earth. The main bottom and intermediate water masses of the world ocean originate here. The Antarctic Zone of the Southern Ocean refers to the vast area between the polar front and the Antarctic continent. The surface water in this zone, characterized by a commonly observed summer minimum surface temperature, is the Antarctic Surface Water (AASW). The thermohaline structure of this water mass is determined by seasonally changing air–sea interaction (air–sea fluxes of momentum, heat and fresh water), advection, and formation and melting of sea ice. Despite its close relationship with changing atmospheric conditions, the vertical and horizontal structures of AASW of the Indian sector of the Southern Ocean, as a whole, have not been studied to any extent, although some detailed studies exist for limited locations.

Stable isotopes of oxygen and hydrogen have been used as reliable tracers for hydrological processes for long. In the modern ocean they have been used as tracers for melting of sea ice, glacial and river run-off, deep ocean water masses and deep-water formation processes. The isotopic compositions at various stages of the hydrological cycle help constrain different water masses and their movement. Isotopic compositions of ice cores have become the most important tools for palaeo-temperature reconstructions. The variation in the isotopic composition of deep-sea water is relatively smaller than that in freshwater and mainly determined by freshwater input and mixing between water masses.

Several expeditions have been made earlier to explore the Indian Ocean and the Southern Ocean. But due to high spatial and temporal variability this region needs more studies to characterize its physical (such as temperature and salinity), chemical and isotopic properties adequately. Some studies have shown that due to global warming, parts of Antarctic ice sheet are melting and the Southern Ocean is getting more and more melt water. This makes the isotopic study of the Southern Ocean all the more urgent. Combined study of stable hydrogen (δD) and oxygen (δ¹⁸O) isotopes and salinity can be ideal to monitor various processes happening in the oceans. Here new δD and salinity data pertaining to the Indian sector of the Southern Ocean are presented and discussed (details of the oxygen isotope data are presented elsewhere).

About a hundred samples of ocean surface water were collected during the second expedition to the Southern Ocean and Larsemann Hills, Antartica onboard R/V Akademik Boris Petrov (25 January to 1 April 2006). A vast area (from 13°N to 68°S and 48°E to 77°E) was covered for sampling. Surface sea water samples were collected with the help of a small, clean plastic bucket. Before sample collection, the bucket was rinsed with the surface water of the sampling site. This collected water was stored in 100 ml plastic bottles with tight-fitting double caps to prevent evaporation. Bottles were filled up to the brim to facilitate easy identification of any later evaporation/leakage and taped at the neck as a further precaution. Salinity (in Practical Salinity Units, psu) was measured with a salinometer (Autosal) onboard with an accuracy of 0.001‰. When the water temperature was