Hydrodynamics of the Indian Ocean Sector of Coastal Antarctica, with focus on Sea Ice

Objectives of the study

- **Monitoring the austral summer characteristics of the coastal current, its branded nature, intensity, and transport by using Expendable CTD data;**
- **Computation of annual upper-ocean heat and salt content in the coastal Antarctica by synergistic use of buoy data and expendable probe profiles;**
- **Computation of thickness of fresh water discharges during sea-ice melt to coastal Antarctic waters and its influence on geostropic circulation;**
- **Water mass distribution and their mixing characteristics; and**
- **Role of atmospheric and ocean forcing on sea ice extent and thickness**

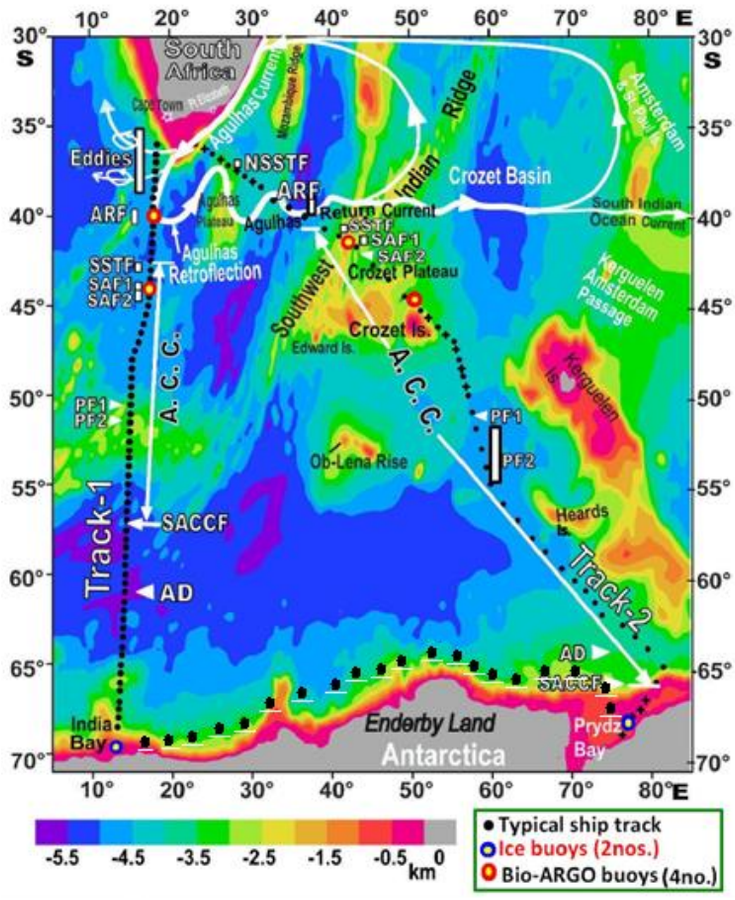
Rationale

Close to Antarctica, the interaction between the cyclonic circulation of Weddell Sea gyre and the coastal Antarctic current promotes mesoscale circulation. The annual cycle of freezing and melting of sea ice supplies brine and freshwater, respectively, which significantly modify the thermohaline circulation with a formation of salt/ temperature wedges and tongues. The southwestern Indian Ocean (IO) is important region because of a number of reasons related to meteorological and oceanographic features. The region exchanges a large amount of heat with the atmosphere, which is received largely from the warm (16°–26°C) and saline (35.5 psu) Agulhas Current which get trapped in Agulhas Retroflection (AR). Among the world oceans, about 67% of total water volume with temperatures between –2° and 2°C is found in the southwest IO, as this region lies immediately downstream of the Weddell Sea, where most of this water is formed. In the subtropical, wind-driven, anticyclonic gyre of the south IO most of the water recirculates in the western and central parts of the south IO basin. The warming of the Southern mid-latitude ocean over the past decades due to the austral summertime strengthening of the circumpolar westerly winds and a weakening of the mid-latitude westerlies extending from stratosphere to the surface, have forced the southward shift and spin-up of the subtropical gyre thereby, advecting more warm water and increasing the heat content southward. The warmer waters erode the coastal ice sheet protruding seaward thereby causing more ice to discharge into the ocean which contributes to the rise in the global sea level.

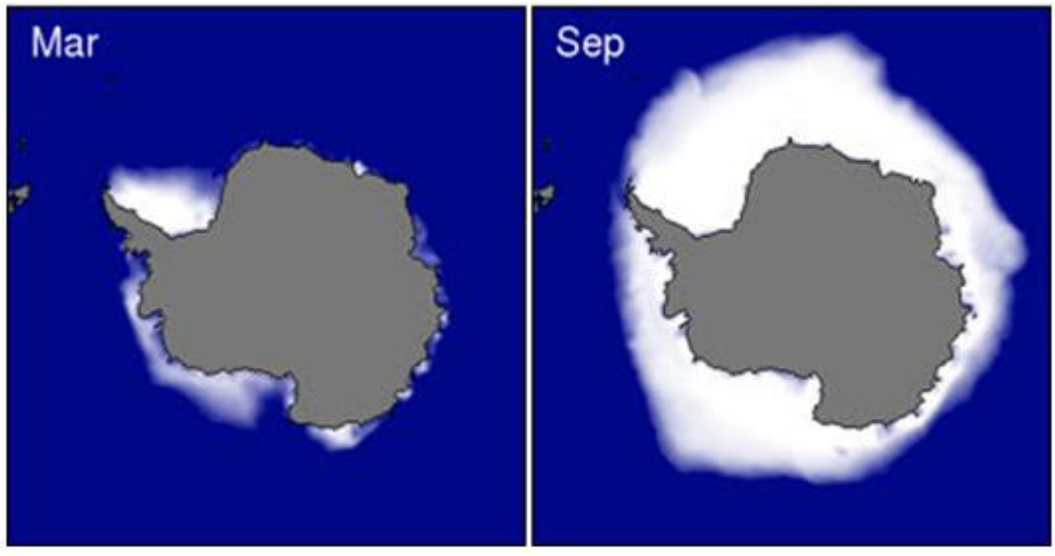
Contribution to the hydrographic database

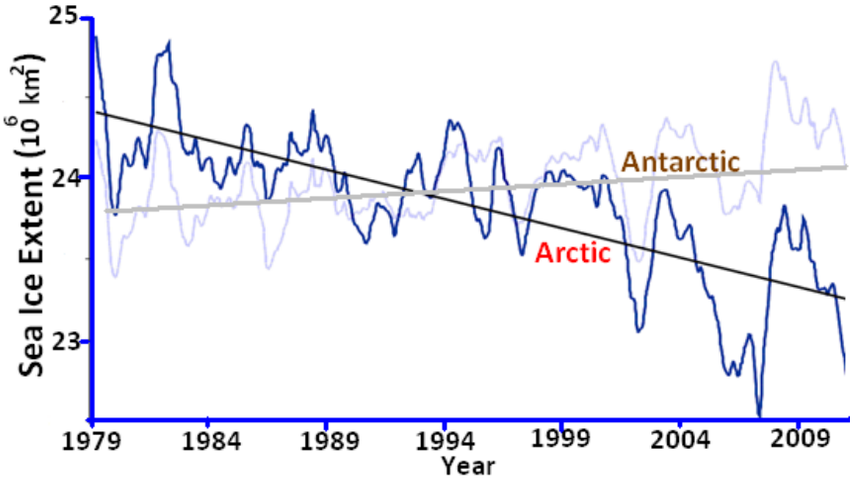
Expendable CTD-based temperature and salinity profiles recorded in the southwestern Indian Ocean and in the coastal Antarctica are regularly recorded in the Indian Scientific Expedition to Antarctica, in the upper 1000 m and achieved at INCOIS, since last 4 years. These data will serve as reference for tuning ocean models and for validation of sea surface temperature and sea surface salinity. ARGO and ice buoys deployed at selected frontal locations will provide data all round the year and will contribute to this data base

A typical ship track along which Expendable CTD stations are occupied



Antarctic Sea Ice Extent during Austral Summer and Winter Seasons





Theme: How topographic meandering of Antarctic Circumpolar Current and Antarctic Circumpolar Wave (ACW) affect sea ice extent in Indian Ocean

- **In the Indian Ocean, between 40-80°E the circuit of ACW is disrupted, which has been attributed to warmer sea surface temperature (SST). This enhanced SST is due to the topographic meandering of the ACC, which transports warm water southward and reduces sea-ice extent in the region between 20° and 80°E. The southward meandering of the ACC resulted in a west-east SST front, with warm waters to the east and cooler waters to the west.**
- **The anomalies associated with the ACW are unable to negotiate the topographic meandering primarily due to two reasons. First, as the ACC is steered south, eastward propagating anomalies are also advected southward, deviating from its original east-west path. Furthermore, a reduction in amplitude of positive SIC is observed as it interacts with the warmer waters to the east. Similar to oceanic ACW anomalies, atmospheric anomalies are also distinct west of International dateline.**
- **Deceleration of oceanic ACW anomalies by topographic meandering of the ACC results in a weakening of atmospheric anomalies as well by the interaction with atmospheric vertical velocities. This totally decouples the ACW anomalies in the Indian Ocean sector and makes further eastward propagation impossible. Away from the Indian Ocean region vertical advection is found to be lower and marked by positive zonal velocity of the ACC. This promotes the ACW propagation in the Pacific sector and the Weddell Sea.**

Theme: Does coastal pressure and wind Impact Sea ice variability in Antarctica?

- **A new local forcing index - Polar Coastal Index (PCI), which is normalized mean sea-level pressure difference between 90°S and 65°S, is found to modulate the regional pressure gradients and coastal winds which induce changes in the Antarctic sea ice extent.**
- **The coupling/correlation between PCI and meridional component of coastal wind is strong for the East Antarctica which decreases along the West Antarctica. The westerly zonal winds in the Ross Sea induce upwelling which promotes more sea ice, while the southerly meridional winds facilitate northward sea ice expansion in Ross Sea, Indian Ocean and western Pacific Ocean sectors.**

Theme: Hydrodynamics between Africa and Antarctica during Austral summer of 2008 and 2009: Results of the IPY project

This work highlights the impact of enhanced positive Antarctic Oscillation in 2009 on hydrographic fronts, upper ocean heat/salt content and geostrophic transport in the Indian Ocean sector of the Southern Ocean.

- **Geostrophic transport, relative to 1000 m, indicates that Antarctic Circumpolar Current (ACC) flow decreased by 2.5 Sv in 2009 compared to that in 2008.**
- **In 2009, the along track Heat Content (HC) and Salt Content (SC) for the upper 750 m of the water column decreased each by 1% compared to those in 2008.**
- **In the ACC domain, the HC and SC dipped by 36% and 40% in 2009, respectively.**
- **The HC and SC associated with Agulhas Retroflection Front increased in 2009 by 1% and 2%, respectively, due to an enhanced Agulhas transport of warm and saline water from the tropics by 2%.**