IODP Proposal Cover Sheet

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Southern Ocean Climate Evolution

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Title	Plio-Pleistocene Paleoceanography of the Southwestern Indian sector of the Southern Ocean (PePSI-SO)
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Abstract

The Southern Ocean (SO) is a key region with profound influence on climate variability throughout the Cenozoic. Because the SO redistributes heat, fresh water, carbon and nutrients around the global ocean and it plays a key role in the climate system. The growth of ice sheets in the Antarctic continent and changes in sea ice in the surrounding ocean are important variables in earth's climate system. Upwelling of deep waters in the Antarctic Circumpolar Current (ACC), in particular, is a key process of the meridional overturning circulation (MOC) as it constitutes the return path for deeply-sequestered carbon and nutrients towards the surface and hence important in the partitioning of carbon between the ocean and the atmosphere. Furthermore, physical and biogeochemical processes modulate nutrient export through SO-sourced intermediate waters that ventilate 75% of the world's thermocline, thus playing a vital role in influencing low-latitude productivity and ecosystems.

The western Indian sector of the SO, located at the confluence of the SO overturning cells and the MOC return surface flow, is a key region to document the links/teleconnections between the SO, global ocean/atmospheric circulations and hence climate. It provides a unique opportunity to obtain exceptionally high-resolution sediment records to document and unravel the interaction and feedbacks between atmosphere, ocean and cryosphere from millennial to orbital-timescales during the late Neogene and Quaternary, focus on past 6 Ma.

Specifically, the proposal aims to further constrain (A) past changes in the upwelling and latitudinal position of the Antarctic Circumpolar Current (ACC); (B) the dynamic controls of circum-Antarctic deep ocean ventilation/overturning circulation; (C) their link to the global ocean circulation; (D) past changes in the sea ice coverage and dust inputs; and (E) their implications for the marine biogeochemical cycles of carbon and nutrients. The anticipated results will elucidate the evolution of the SO carbon cycle, identify potentially dominant physical and biogeochemical mechanisms of change, document past oceanic bipolar teleconnections in relation to global MOC dynamics and provide constraints on its future evolution in response to anthropogenic warming.

Our scientific objectives relate to the IODP Science Plan 2013-2023 Challenge 1 (climate response to elevated levels of atmospheric CO2), Challenge 2 (ice sheets and sea level response to warming climate) and Challenge 4 (ocean resilience to chemical perturbations) within the Climate and Ocean Change theme.

The present PePSI-SO pre-proposal is an emanation of two recently submitted pre-proposals (824-pre and 863A-pre), which resubmission was encouraged by the SEP.

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Scientific Objectives

The main objective of the PePSI-SO proposal is to drill five high sediment accumulation sites located in the Southwestern Indian sector of the Southern Ocean (SO) to document climate variability in the SO and associated interactions and feedbacks between the atmosphere, ocean and cryosphere on a variety of timescales spanning the Middle Miocene to Holocene. The targeted drill sites will fill an important gap in our knowledge providing SO records covering the Middle Miocene cooling (~14 Ma), Late Miocene Carbon Shift (8-6 Ma), the Pliocene climate optimum (5.3-3.3 Ma), the Late Pliocene global cooling (3.3-2.6 Ma) culminating with the onset of northern hemisphere glaciations, the mid-Pleistocene transition (MPT: 1250-700 ka) and the mid-Brunhes Transition (~0.43 Ma) when profound, large-scale climate changes have occurred. Glacial/Interglacial variability and ocean processes could be studied on millennial time scales here.

Within this framework, our investigations will contribute to further understand the following specific processes:
-Dynamic fluctuations of the ACC and associated meridional frontal migrations in relation to global circulation (Agulhas Leakage, AMOC) and climate change;
-Changes in inter-ocean surface and deep water transport during periods of climate change;
-Variability in sea-ice extent in the Indian Ocean Sector and its implications for air-sea gas exchange and the partitioning of CO2 between the atmosphere and the ocean interior;
-Changes in biological export productivity in relation to dust input, upwelling intensity, nutrient inventory and sea ice extent.

Non-standard measurements technology needed to achieve the proposed scientific objectives

Proposed Sites (Total proposed sites: 8; pri: 5; alt: 3; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
DCR-03A (Primary)	-43.6600 44.7317	2632	600	0	600	1) Reconstruct the glacial-interglacial variability of the ACC and its associated fronts (STF, SAF and PF) 2) Reconstruct the long-term changes of the ACC and its associated fronts (STF, SAF and PF) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE) 3) Heat and salt transport between the Indian Ocean and the Atlantic Ocean 4) Reveal the northern limit of winter sea-ice expansion
DCR-04A (Alternate)	-43.5467 45.0666	2823	600	0	600	1) Reconstruct the glacial-interglacial variability of the ACC and its associated fronts (STF, SAF and PF) 2) Reconstruct the long-term changes of the ACC and its associated fronts (STF, SAF and PF) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE) 3) Heat and salt transport between the Indian Ocean and the Atlantic Ocean 4) Reveal the northern limit of winter sea-ice expansion
DCR-02A (Primary)	-45.6898 44.3773	1844	800	0	800	1) Reconstruct the glacial-interglacial variability of the ACC and its associated fronts (STF, SAF and PF) 2) Reconstruct the long-term changes of the ACC and its associated fronts (STF, SAF and PF) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE) 3) Heat and salt transport between the Indian Ocean and the Atlantic Ocean 4) Reveal the northern limit of winter sea-ice expansion
DCR-01A (Alternate)	-46.0223 44.3280	2445	700	0	700	1) Reconstruct the glacial-interglacial variability of the ACC and its associated fronts (STF, SAF and PF) 2) Reconstruct the long-term changes of the ACC and its associated fronts (STF, SAF and PF) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE) 3) Heat and salt transport between the Indian Ocean and the Atlantic Ocean 4) Reveal the northern limit of winter sea-ice expansion
COR-03A (Primary)	-51.5000 41.6000	3113	800	0	800	1) Meridional migration of the ACC and its associated fronts (SAF, PF, and SB) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE), glacial-interglacial cycles, and millennial climate change. 2) History of sea-ice expansion/retreat
COR-01A (Primary)	-54.3001 39.7206	2840	1000	0	1000	1) Meridional migration of the ACC and its associated fronts (SAF, PF, and SB) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE), glacial-interglacial cycles, and millennial climate change 2) History of sea-ice expansion/retreat 3) To constrain the timing of unconformity on the Conrad Rise and revel relationship with the widely recognized hiatus in the Southern Ocean
COR-02A (Alternate)	-54.1398 39.9458	2675	800	0	800	1) Meridional migration of the ACC and its associated fronts (SAF, PF, and SB) since the warm Pliocene through the major climatic events (late Pliocene global cooling, MPT and MBE), glacial-interglacial cycles, and millennial climate change 2) History of sea-ice expansion/retreat 3) To constrain the timing of unconformity on the Conrad Rise and revel relationship with the widely recognized hiatus in the Southern Ocean

Proposed Sites (Continued; total proposed sites: 8; pri: 5; alt: 3; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
EAP-01A (Primary)	-58.9830 37.6330	5289	400	0	400	1) Detect the meridional oscillation of the SB and PF in response to the warm Pliocene to late Pliocene global cooling, and to other climatic events (MPT, MBE, and G-I cycles) 2) Understand interaction between the ACC and the Weddell Gyre 3) Reveal the dynamics of Antarctic Bottom Water production and its response to sea-ice expansion/retreat since the late Miocene