VARIATION IN ANTARCTIC CIRCUMPOLAR CURRENT INTENSIFICATION THROUGHOUT LATE PLEISTOCENE GLACIAL-INTERGLACIAL CYCLES

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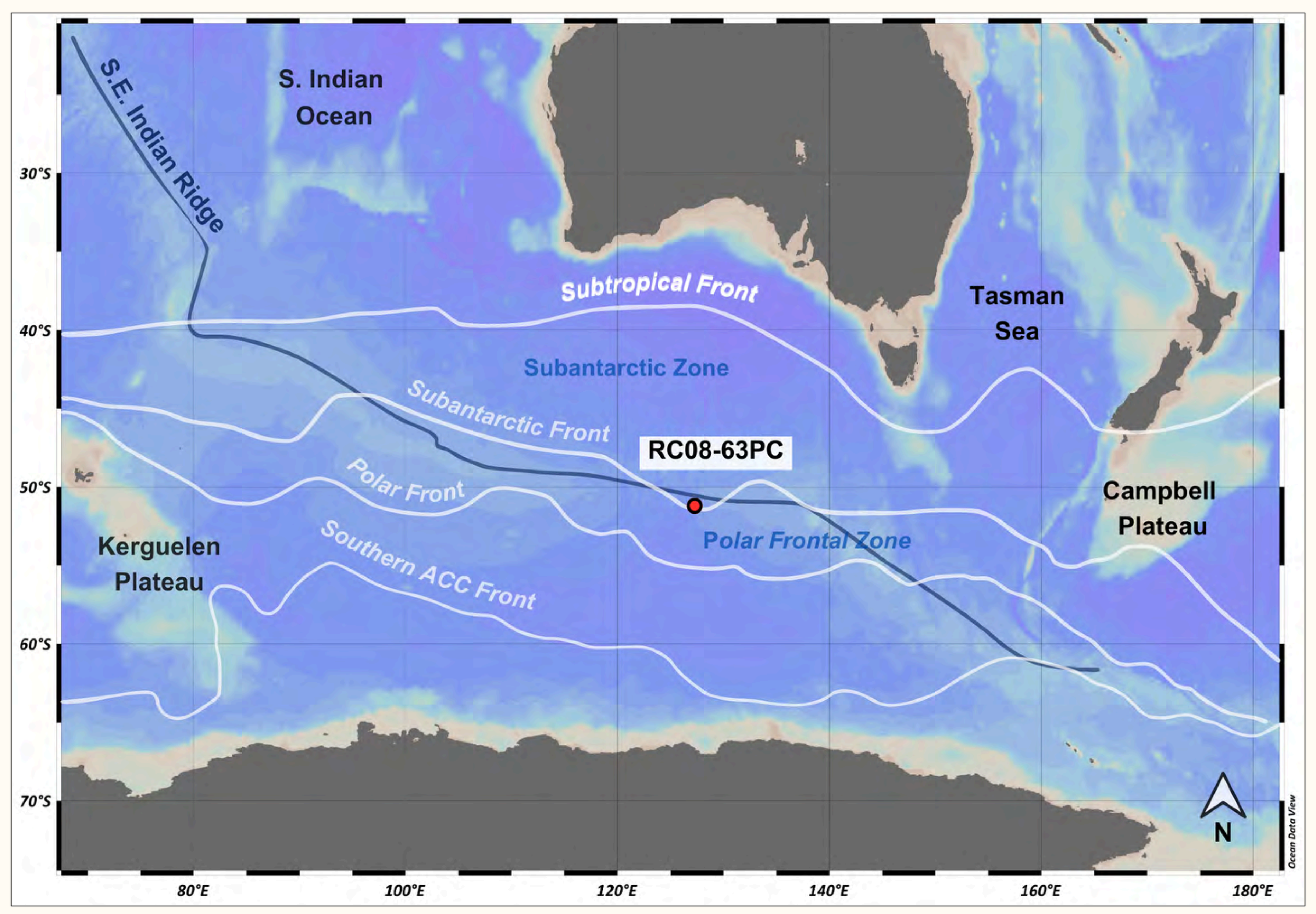
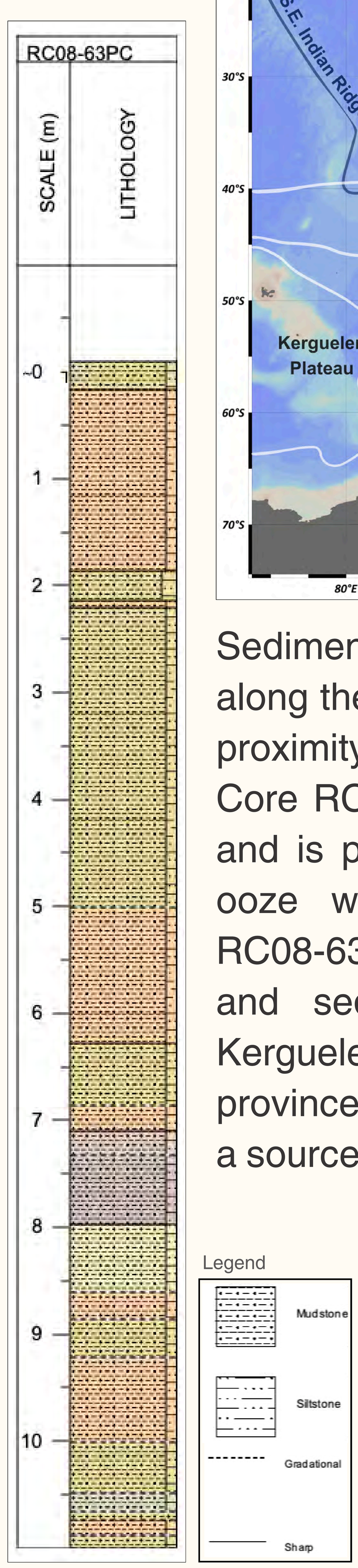
Introduction

The Antarctic Circumpolar Current (ACC) is an integral component to the global climate system. It is responsible for water mass distribution in the Indian, Pacific, and Atlantic oceans. The eastward flow of the ACC is driven by prevailing westerly winds which, along with thermohaline circulation and net changes in buoyancy, controls ACC intensity. Its system comprises three primary fronts, the Subantarctic Front (SAF), the Polar Front (PF), and the Southern ACC Front (SACCF). The area between the PF and SAF is termed the Polar Front Zone (PFZ), where the area between the SAF and STF is termed the Subantarctic Zone (SAZ), see Figure 1.





Sediment core RC08-63PC (Figure 2), was collected along the flank of the Southeast Indian Ocean Ridge in proximity to the ridge axis at 3,442-meter water depth. Core RC08-63PC lies along the flow path of the SAF and is primarily composed of diatom and calcareous ooze with intermittent manganese nodules. Core RC08-63PC was collected along a bathymetric high and sediment drift deposit, down-current of the Kerguelen Plateau (KP). The KP is a large igneous province that contains titanomagnetic minerals, and is a source of magnetic minerals to the study region.

Figure 1 (top): Study site map depicting ACC surface water mass fronts and RC08-63PC core location in relation to the KP, Southeast Indian Ridge and Antarctica.
Figure 2 (left): Lithologic core description of RC08-63PC.

Purpose

Identifying when the ACC changes through relatively warmer and colder periods has implications for understanding oceanic circulation under projected warming and emissions scenarios outlined by the International Panel on Climate Change (IPCC). Estimates suggest a warming rate of 0.2°C per decade, with global temperature reaching 1.5°C above pre-industrial levels by the beginning of the next decade (Figure 3). Such warming has the potential to impact thermohaline circulation leading to changes in deep water mass gradients and shifting of surface ocean fronts. As such, understanding the temporal dynamics of the ACC throughout glacial-interglacial cycles (e.g., Marine Isotope Stages) and past climate analogue state (i.e., super-interglacials) provide insight on what to expect under anthropogenically forced climate change.

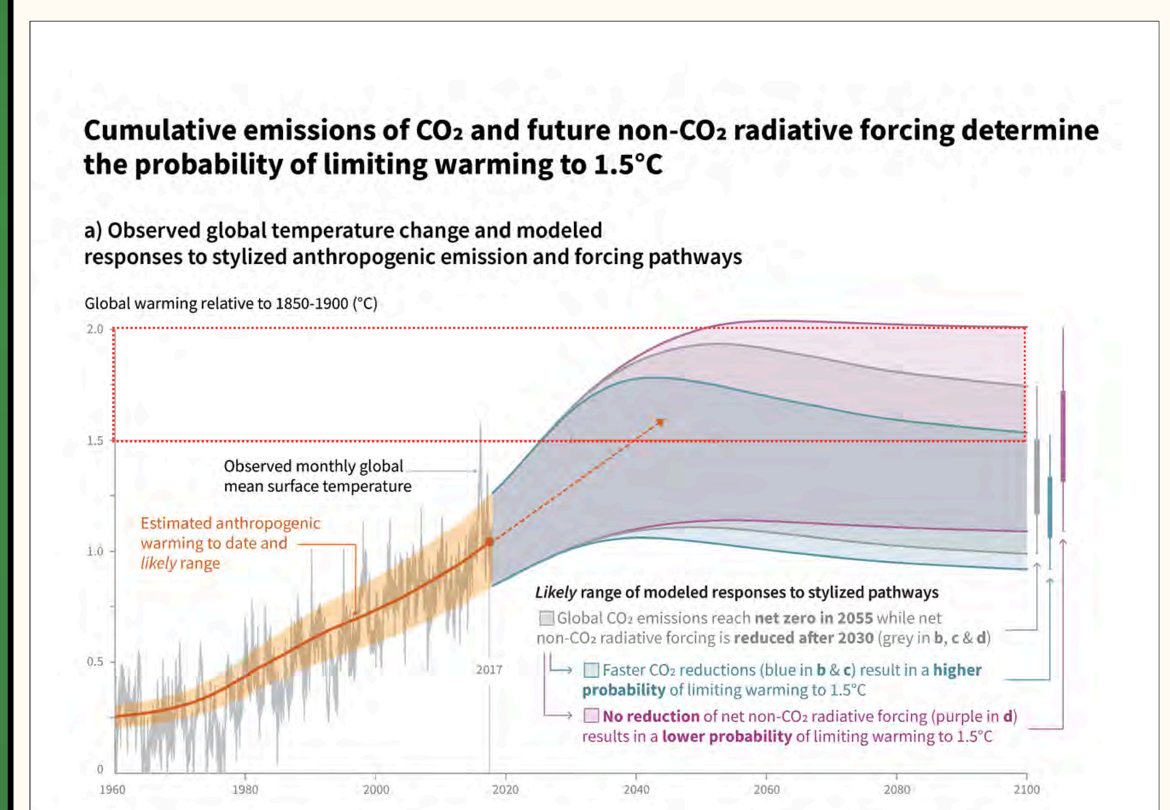
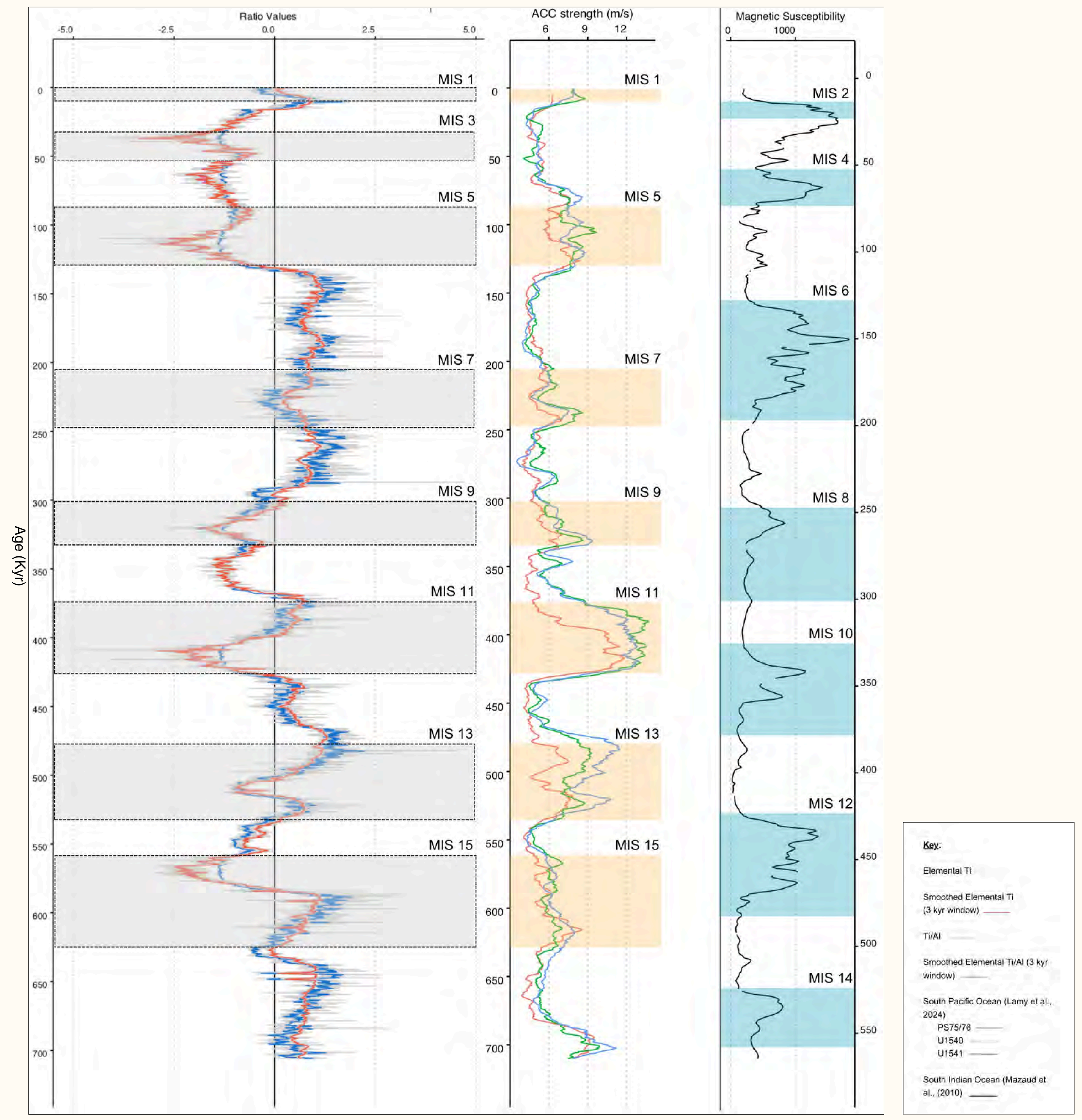


Figure 3: IPCC Special Report Global Warming of 1.5°C figure depicting monthly global mean surface temperature from 1960 to 2017 (grey lines) with estimated anthropogenic warming and likely range and estimated timing in which 1.5°C warming would be achieved (orange). Super-interglacial warming is estimated to represent a 1.5°C to 2.0°C increase in background warming represented by red dotted line.

Methods

XRF is a non-destructive analytical tool in which materials, such as sediment, are subject to incident x-ray energy. This, in turn, causes excitation of atoms leading to the release of electrons and the emission of characteristic wavelengths specific to certain elements. In 2018, faculty from Binghamton University and Colgate University collected qualitative elemental data at a 2.5 mm resolution from Core RC08-63P using a Cox Analytical ITRAX XRF core scanner. Twenty-six elements were measured and count data was subsequently normalized and standardized for data visualization and interpretation. Initially, a correlation matrix of standardized elemental values were to determine which elemental ratios or values can be used as proxies for ACC strength (e.g., elemental Ti, and Zr/Rb). Elemental ratios were then plotted against age to determine variations in strength through time.

Results & Discussion



Elemental Ti and Ti/Al are interpreted as higher values indicating a flux of Ti-containing minerals. This increased input could be the result of intensified erosion of the KP and transport of dense, Ti-containing minerals due to a stronger ACC. Time intervals in which Ti/Al values decreased could be indicative of a decrease in transport and deposition of denser minerals or lithic fragments relative to lighter minerals, containing Al. Overall, the signals in the RC08-63PC core do not display a clear pattern of strengthening/weakening that is synchronous to glacial-interglacial cycles. Certain intervals containing significant variations in elemental Ti or Ti/Al are not confined to specific MIS events. On the other hand, specific peaks or troughs align with the estimated timing of MIS events. For example, a decline in values from ~130 kyr to ~80 kyr corresponds with MIS 5.

When compared to published datasets, sites in the South Pacific, along the SAF, depict clear intensification of the ACC during interglacial periods while South Indian sites suggest the opposite. The differences in these records could be the result of the proxies used, local bathymetry, or regional processes. In order to unravel the signals in our record, we will conduct time series analysis and tune our preliminary age model.