



Antarctic Climate & Ecosystems CRC

Climate Variability & Change Program

The Southern Ocean provides a critical link in the global ocean circulation that distributes heat around the Earth, stores heat and carbon in the ocean, provides nutrients to fuel Antarctic ecosystems, and supplies oxygen to the deep ocean. Present climate models indicate that this circulation is sensitive to climate change. A change in Southern Ocean currents would likely have profound impacts on climate, ocean uptake of carbon dioxide and marine ecosystems both in the Southern Ocean and globally.

Researchers in the ACE CRC Climate Variability and Change Program are helping Australia plan for future changes by improving our ability to simulate and predict the impact of Southern Ocean processes on climate, sea level rise, marine ecosystems and the marine carbon cycle.

Program Leader

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Background

Ocean currents

Global ocean currents help make our planet liveable by carrying heat from the tropics towards the poles, smoothing out differences in temperature. Ocean temperatures also strongly influence patterns of rainfall and the formation and intensity of storms such as tropical cyclones. Ocean currents maintain life in the sea by supplying nutrients to surface waters and oxygen to the deep ocean.



Strong Southern Ocean winds drive the world's largest ocean current, the Antarctic Circumpolar Current (ACC). The ACC flows from west to east around Antarctica and is the major connection among the Pacific, Indian and Atlantic Oceans.

Differences in water density caused by variations in water temperature and salinity drive a global system of currents known as the overturning circulation. The overturning circulation links the surface layers of the ocean with the deep ocean and controls how much heat and carbon are stored in the ocean. This circulation has profound effects on global and regional climate.

Climate models suggest that the overturning circulation is sensitive to climate change. Historical evidence collected from ice and sediment cores suggests that collapse of the overturning circulation in the past has been associated with large and abrupt climate changes. Future changes in the overturning circulation are therefore likely to have major impacts on global and regional climate and ecosystems.

Sea ice

Cold air temperatures cause the surface of the ocean near Antarctica to freeze in winter. Antarctic sea ice covers an area of about 20 million square kilometres at its maximum extent in the winter, an area larger than the Antarctic continent and nearly three times the area of Australia. Approximately 80% of this ice melts each summer.



The seasonal formation and melting of sea ice is the dominant factor controlling the salinity and density of surface ocean waters in the polar regions. Changes in the amount of sea ice may therefore alter the overturning circulation and affect global heat transfer and climate stability. Because sea ice is very reflective, a decrease in sea ice in response to global warming will increase the amount of energy absorbed by the earth, driving further warming and changes in ocean circulation.

Sea ice also creates a physical barrier that limits the exchange of CO₂ between the atmosphere and ocean surface. Changes in sea ice cover may drive changes in the ocean carbon cycle and affect the ocean's absorption of atmospheric CO₂ generated by human activities. This, in turn, would likely have significant effects on the ocean ecosystems around the globe (see *Ocean Control of Carbon Dioxide Program* for more details).

Changes in sea ice may also affect krill populations because krill feed on algae found on the underside of sea ice during winter. This could lead to further changes in ecosystems and fisheries dependent on krill (see *Antarctic Marine Ecosystems Program* for more details).

Program Objectives

To characterise the variability of Southern Ocean currents, sea ice and climate and to understand their causes.

Variability in the physical environment of the Southern Ocean influences regional and global climate, the distribution and productivity of marine organisms, the ocean uptake and storage of carbon dioxide, and the rate and pattern of sea level rise. Understanding this variability in the coupled ocean-atmosphere-ice system is essential for all of the ACE CRC research programs.

Our present understanding of Southern Ocean variability is limited, primarily due to the lack of observations of remote regions. ACE CRC researchers are using new tools such as robotic floats, highly accurate satellites and improved numerical models, as well as ship-based measurements collected over the last decade, to investigate variability in the Australian sector of the Southern Ocean.

To determine the likelihood and impact of significant changes in the Southern Ocean physical environment.

Changes such as a slow-down in the Southern Ocean overturning circulation, a decrease in the extent of sea ice, or an alteration in circulation patterns in the atmosphere and ocean would have substantial impacts on Antarctic ecosystems

and Australian and global climate. We need to determine the risk of such changes in order to develop robust management strategies for Southern Ocean marine living resources and to guide planning for response to future changes in climate and their impacts.

To combine state-of-the-art ocean observations and numerical models to provide simulations and forecasts of ocean currents and sea ice for Southern Ocean applications.

Researchers at the ACE CRC are combining field observations with advanced models of the ice-ocean-atmosphere system to project potential changes to ocean circulation under a range of credible climate change scenarios.

These projections can be used in ecosystem prediction, marine resource management, marine impact studies, initial state estimates for climate models, search and rescue, guidance for safe Antarctic shipping operations, and research into ocean dynamics.

Recent Achievements

ACE CRC researchers successfully drilled a 120 metre core from Law Dome in Antarctica that represents some 650 years of climate history. This will provide a new record for exploring climate characteristics, especially the proxy for sea ice extent (methanesulphonic acid, MSA), through the last several centuries and so provide an important context for very recent changes in climate.

A large array of current meter moorings was recovered from east of the Kerguelen Plateau. The data from that array are allowing us to make the first direct estimates of the transport and dynamics of the deep boundary current in this region, a key component of the deep part of the overturning circulation.

An expedition in January 2005 found evidence for rapid and widespread freshening and cooling of the deep Southern Ocean south of Australia. The observations show that the southern end of the overturning circulation is responding to changes in the high latitude freshwater balance and rapidly transmitting these climate signals to the deep ocean.

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