Antarctic Circumnavigation Expedition ("ACE")

"Southern Ocean westerly winds and the global CO_2 sink"

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Project description

Concentrations of CO2 in the atmosphere have increased since AD 1750 as a result of human activity (IPCC 2013). This is linked to warming of the atmosphere and oceans, changes in climate, recession of ice sheets and sea level rise (IPCC 2013), with potential substantial social and economic impacts (IPCC 2014).

More than one quarter of the CO_2 emitted to the atmosphere from fossil fuel burning and other human activities is absorbed by the world's oceans, substantially slowing the rate of climate change. Of the oceans, the Southern Ocean plays a major role accounting for 43% of the global oceanic anthropogenic CO_2 uptake. It does this because the efficiency with which the ocean absorbs CO_2 at the surface (e.g. by diffusion and the biological pump) exceeds the release of old carbon from the deep ocean to the atmosphere (e.g. via upwelling and out gassing; Toggweiler et al. 2006).

The capacity of the Southern Ocean to absorb anthropogenic CO_2 has recently been limited (according to some models) by an observed increase in the strength of the Southern Hemisphere Westerly Winds (SHW). This is causing enhanced mixing, drawing CO_2 saturated deep waters to the surface, limiting the capacity of the ocean to absorb CO_2 from the atmosphere. The positive climate feedback between winds and CO_2 means that the ocean may no longer function as a net sink of CO_2, driving up atmospheric greenhouse gases and accelerating rates of global warming. Thus reconstructing past changes in the strength and position of the SHW is now a major priority for palaeoclimate science.

Recognising the urgency of this issue we have instigated a series of linked projects studying the history of the SHW in their core belt around the Southern Ocean. Working on the sub-Antarctic islands we have developed and tested novel diatom and testate amoebae based proxies for past wind strength together with standard measurements of aerosols (local/distal mineral dust particles, sea salt sprays). These proxies are present in lake sediments and peats which have accumulated on the west coasts of sub Antarctic islands. These can be extracted and radiocarbon dated to provide reconstructions of changing wind strength through time.

We have focused on the major transition into the current interglacial and changes in the last 1000 years; periods associated with major shifts in atmospheric CO_2 concentrations. Our wind reconstructions are compared with independent (e.g. ice core) records of CO_2 and temperature and past ocean upwelling (from marine sediment cores). These data are being compared against Global Circulation Model runs to help understand the drivers of past changes in the SHW and atmospheric CO_2.

We have worked with various national programmes (UK, Chile, Australia, South Africa, France) to access islands in the sub-Antarctic (South Georgia, Nightingale I, Tristan da Cunha, Isla de Los Estados, Isla Navarino, Cape Horn, Macquarie Island, Campbell Island, Marion Island, Kerguelen, Crozet, Amsterdam); but each of these national programmes have logistical constraints and substantial geographical (and temporal) gaps remain. ACE offers a unique opportunity to fill in these gaps with new sampling efforts particularly in the Atlantic and Indian Ocean sectors (west coast South Georgia, Crozet, Kerguelen, Heard) and build a more complete understanding of the behaviour of the SHW in their core belt.

Specific objectives

i) To derive multi-proxy records of past changes in SHW intensity based on biological and chemical proxies of changing aerosol inputs on the west coasts of the sub-Antarctic islands.

ii) To combine these wind strength reconstructions with existing SHW observational data from Southern Hemisphere continental records.

iii) To use GCM simulations to help understand the patterns seen in the observational data and understand the drivers of past changes in the SHW.