Atmosphere-ocean changes in the Pacific Southern Ocean over the past 1 Million years and implications for global climate

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Atmosphere-ocean interactions play an important role for understanding processes and feedbacks in the Southern Ocean (SO) that play a key role for explaining the variability in atmospheric CO_2 concentrations. The most important atmospheric forcing at high and mid-latitudes of the Southern Hemisphere is the westerly wind belt (Southern Westerlies) which strongly impacts the strength and extension of world's largest current (the Antarctic Circumpolar Current (ACC)), upwelling of deep-water masses, and also controls the back-flow of intermediate waters to the tropics. In order to address orbital and millennial-scale changes of the Southern Westerlies and the ACC, I will present sediment proxy records for surface ocean changes, current strength, and terrigenous sediment input (including mineral dust) from the Pacific SO including the Chilean Margin and the northern Drake Passage.

The Drake Passage (DP) represents the most important oceanic gateway along the pathway of the world's largest current, the Antarctic Circumpolar Current (ACC). Resolving changes in the flow of circumpolar water masses through the DP is crucial for advancing our understanding of the Southern Ocean role in affecting ocean and climate change on a global scale. Based on grain-size and geochemical properties of sediment records from the southernmost continental margin of South America , we reconstruct changes in DP throughflow dynamics over the past 65,000 years. In combination with published sediment records from the Scotia Sea, we argue for a considerable total reduction of DP transport and reveal an up to ~40% decrease in flow speed along the northernmost ACC pathway entering the DP during glacial times. Superimposed on this long-term decrease are high-amplitude millennial-scale variations, which parallel Southern Ocean and Antarctic temperature patterns. The glacial intervals of strong weakening of the ACC entering the DP imply a reduced Pacific-Atlantic exchange *via* the DP ("cold-water route"). The conclusion is that changes in DP throughflow play a critical role for the global meridional overturning circulation and interbasin exchange in the Southern Ocean, most likely regulated by variations in the westerly wind field and changes in Antarctic sea-ice extent.

The reduced Drake Passage throughflow was accompanied by a pronounced northward extension of the Antarctic cold-water sphere in the Southeast Pacific sector and stronger export of northern ACC surface and intermediate water into the South Pacific gyre. These oceanographic changes are consistent with reduced westerly winds within the modern maximum wind strength zone over the subantarctic ACC and reduced wind forcing due to extended sea-ice further south. Despite of reduced winds in the core of the westerlies, we observe 3-fold higher dust deposition during glacial periods in the Pacific SO. This observation may be explained by a combination of factors including more expanded arid dust source areas in Australia and a northward extent or enhancement of the westerlies over Southeast Australia during glacials that would plausibly increase the dust uptake and export into the Pacific SO. Such scenario would imply stronger westerlies at the present northernmost margin of the wind belt coeval with weaker core westerlies and reduced ACC strength including Drake Passage throughflow during glacials.