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The SCAR Antarctic Climate Evolution (ACE) Programme

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Background

The present Antarctic ice sheet has existed for approximately 34 million years. Understanding the response of the Antarctic ice sheet to climatic forcing is essential because changes in the ice sheet can have major impacts on global sea level and can impact the entire climate system through a wide range of physical and chemical feedbacks.

ACE Objectives

The SCAR Antarctic Climate Evolution (ACE) Programme represents the interests of a large land and marine geoscience research community focusing in deciphering the record of the onset and the response of the Antarctic ice sheets to past climate changes across a range of timescales. ACE coordinates the integration between geophysical and geological records of past ice sheet behavior and coupled climate, ocean, and ice sheet models.

Introduction

Polar ice is an important component of the modern climate system, affecting global sea level, ocean circulation and heat transport, marine productivity, air-sea gas exchange, and planetary albedo. Since mid-Permian (~270 Ma (million years ago)) times, parts of Antarctica became reglaciated only ~34 Ma, whereas full scale, permanent Northern Hemisphere continental ice began only ~3 Ma (e.g., Zachos et al., 2008). State-of-the-art climate models (e.g., DeConto and Pollard, 2003a, 2003b; Huber et al., 2004; DeConto et al., 2007; Pollard and DeConto, 2009) combined with paleoclimatic proxy data (e.g., Pagani et al., 2005) suggest that the main triggering mechanism for inception and development of the Antarctic ice sheet were the decreasing levels of CO_2 (and other greenhouse gas) concentrations in the atmosphere. Opening of critical Southern Ocean gateways played only a secondary role (e.g., Kennett, 1977; DeConto and Pollard, 2003a; Huber et al., 2004).

With current rising atmospheric greenhouse gases resulting in rapidly increasing global temperatures (Intergovernmental Panel on Climate Change [IPCC], 2007; www.ipcc.ch/), studies of polar climates are prominent on the research agenda. Understanding Antarctic ice sheet dynamics and stability is of special relevance because, based on IPCC (2007) forecasts, atmospheric CO_2 doubling and a 1.8°–4.2°C temperature rise is expected by the end of this century. The lower values of these estimates have not been experienced on our planet since 10–15 Ma, and the higher estimates have not been experienced since before the ice sheets in Antarctica formed.

Since their inception, the Antarctic ice sheets appear to have been very dynamic, waxing and waning in response to global climate change over intermediate and even short (orbital) timescales (e.g., Wise et al., 1991; Zachos et al., 1997; Pollard and DeConto, 2009). Yet, not much is known about the nature, cause, timing, and rate of processes involved. ACE aims include developing a clearer understanding of the paleoclimatic variations and the geological consequences of the transition from a vegetated to an ice covered continent and the response of the Antarctic ice sheets to past climate changes across a range of timescales. This understanding will aid development of models to predict Antarctica's responses to future changes in climate.

ACE Data-Model Philosophy

The ACE science plan depends on a range of regional field programmes including onshore and offshore geophysical and geological records, such as: field geology; ocean-ice shelf-continental drilling, and marine and airborne geophysical surveys. In addition, ACE has established linkages to other communities, including the ice core, the physical oceanography and the glaciological community, for data-model exchange and comparisons that are useful to ACE objectives. The ACE programme links the geophysical surveys and

geological studies on and around the Antarctic continent with ice sheet and climate modeling studies. These studies are designed to investigate climate and ice sheet behavior in both the recent and distant geological past, including times when the global temperature was several degrees warmer than today. Future scenarios of global warming require constraints from past history that will reveal potential timing frequency and site of future changes.

ACE Structure

The ACE Programme is structured in subcommittees focusing in critical paleoclimate science challenges that were identified in the ACE science plan. The subcommittees provide the overall leadership, direction and management for their respective topics. They contribute to the overall understanding of the Antarctic's climate evolution by encouraging and facilitating communication and collaboration among research scientists working on any aspects of Antarctic climate evolution pertinent to the respective topic. The subcommittees also ensure that activities within each committee are communicated and wherever possible integrated with those of other time-based, modeling and process-oriented themes of the ACE programme.

ACE achievements

ACE has developed an Earth System approach in understanding Antarctica's paleoclimate and glacial evolution. This has involved a data-model philosophy, which allows for explanations about factors/mechanisms for our observations from field data. The work conducted by ACE is highlighting the relevance that deciphering past climate change and ice sheet evolution on timescales of thousands, hundreds of thousands, and millions of years has in understanding climate and ice sheet variability, and the forcing mechanisms that control future change and the responses to change.

ACE has mobilized fundamental advances in our knowledge regarding for example:

- the importance of atmospheric CO_2 levels (e.g., DeConto and Pollard, 2003a, 2003b) ,compared to other factors such as plate tectonics and changes in ocean circulation, in the growth of the present ice sheet;
- the stability of the West Antarctic ice sheet over the last 5 million years. In particular the dramatic variability of the West Antarctic Ice Sheet and its impact on sea level (e.g., Naish et al., 2009);
- climate variability over the past 53 million years of Antarctic history including a tree-ring-like resolution record of the past 10,000 years (e.g., Escutia et al., 2011);
- constraints on the paleo-topography (e.g., Wilson and Luyendyk, 2009) and the paleo-bathymetry of the Antarctic continent and surrounding continental margins in relation to geological controls on ice sheet evolution and stability.

Publications and Outreach

ACE has produced 4 Special publications in Palaeogeography, Palaeoclimatology, Palaeoecology and Global and Planetary Change, and one ACE monographic book, in Developments in Earth and Environmental Sciences (Elsevier). In addition, ACE-related publications in peer reviewed high-impact journals, including Nature and Science, are numerous. Media coverage (i.e., press, radio, and TV) of ACE activities is extensive. Documentaries in ACE activities are available in YouTube. For further details see: http://www.ace.scar.org/.

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