Past unknowns for an unknown future

Florence Colleoni[1]

[1]Centro Euro-Mediterraneo sui Cambiamenti Climatici (Bologna, Italy); flocolleoni@gmail.com

Abstract

When the COP21 Paris agreement targets a global mean annual temperature changes not beyond +2°C above pre-industrial one, little is known about the past responses of Greenland and Antarctica to natural climate fluctuations. Based on recent investigations, +2°C seems to be a threshold for the tipping point of Greenland and Antarctica (DeConto and Pollard, 2016). Unlike Greenland, Antarctic ice sheet (AIS) glacial inception occurred under climate conditions warmer than today, with pCO2 atmospheric concentration almost twice as large as today (Zacchos et al., 2008). Thus, for a long time, Antarctica was thought to be relatively insensitive to the on-going climate changes (Solomon et al., 2007), with a small or no contribution to 20th century global mean global sea level change. The analysis of marine sediment cores reveal that both West and East Antarctic ice sheet repeatedly lose a large part of their mass over the last 5 Million of years (Naish et al., 2001, Naish et al., 2009). However, ice sheet models still disagree on the mechanisms that triggered those collapses and do not converge on how much mass was lost (e.g., De Boer et al., 2014).

The exercise of past reconstructions requires the synergy between the different fields of Earth sciences. To provide clues on the past AIS dynamics, numerical ice sheet models need initial conditions, essentially: (1) atmospheric conditions to compute the surface mass balance and the thermodynamics of the ice sheet; (2) oceanic conditions to compute the basal melting occurring under the marine terminating part of the AIS (ice shelves and glaciers) and the induced retreat of the grounding line; (3) the bedrock morphology beneath the ice sheet and on the surrounding continental shelf that influences the basal sliding and thus the AIS flow. Those initial conditions are the ones that hold the largest uncertainties especially in the case of past reconstructions. Over the past decades, the paleoclimate community produced various climatic, geological and ice sheet reconstructions of past key periods (Eocene/Oligocene; Miocene ; mid-Pliocene; LIG; LGM; mid-Holocene) of Antarctic ice sheet history in the framework of international joint-effort projects based on the data-model comparison approach (e.g. Jousseaume 1995, Pollard and co., 2000, Haywood et al., 2010; de Boer et al, 2014, Lunt et al., 2012,). The outcomes of those projects pointed out some gaps in the models physics and in the distribution of available data to constrain them. On top of that, the interplay between the timescales and the spatial resolution at which the feedbacks occur between the AIS and the other components of the climate system plays an essential part in the interpretation of the data, in the simulation of AIS dynamics and in the understanding of the relative importance of all climatic-geological-dynamical mechanisms involved in the evolution of such a large ice sheet through time.

Keywords: paleoclimate, past ice-sheet dynamics, past atmosphere dynamics, past ocean dynamics, past seafloor bathymetry, climate feedbacks, geological feedbacks

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