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Paleoclimate perspectives on Antarctic ice sheet sensitivity

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Near- and long-term future projections of global mean sea level rise (SLR) are hampered by a lack of understanding of the potential dynamic contribution of the polar ice sheets, and in particular the Antarctic ice sheets. With the completion of the Intergovernmental Panel on Climate Change's Assessment Report a major challenge continues to be placing an upper bound in sea-level projections for 2100 and beyond. The so-called "deterministic" approach which sums observed- and model-projected trends in the known contributions (e.g. ice sheet and glacier surface mass balance, ocean thermal expansion and ground water storage changes) implies a "likely" upper bound of +100cm by 2080-2100. The "semi-empirical" approach which scales past observed sea-level change to mean surface temperature, and uses this relationship to scale future temperature scenarios, predicts a significantly higher upper bound of up to ∼2m by 2100. The discrepancy between the two approaches may in part reflect the poorly understood contribution of ice dynamics – that is the rate of flow of ice sheets into the ocean. An ensemble of Antarctic ice sheet models produces highly divergent results for future sea-level projections, primarily because of uncertainties around the mass changes in the East Antarctic Ice Sheet with some models showing increased precipitation driving a positive mass balance overall, even with loss of the marine-based West Antarctic Ice Sheet (WAIS). Current best estimates suggest a 10-20cm dynamic ice sheet contribution by 2100 to global SLR.
Of concern is that marine based ice sheets are highly sensitive to increases in ocean temperature at their margins and rapid disintegration may ensue if the ice sheets grounding lines retreat into deep sub-glacial basins. Recent studies show the highest rates of ice sheet thinning and retreat are occurring at locations around the WAIS where the surface ocean has warmed, and that some WAIS loss may now be irreversible.
Geological records allow the equilibrium sensitivity of polar ice volume and global sea-level change to be reconstructed and assessed during past warm climates and deglaciations, that may be representative of our future climate trajectory. In this talk I will focus on ice sheet responses to climate forcing during: (1) The mid-Pliocene warm period ∼3 million years ago when the world was 2-3°C warmer, and atmospheric carbon dioxide concentrations were 400ppm. (2) The Last Interglacial Period ∼ 125,000 years ago when the world was 1-2°C warmer. (3) The warming period from the Last Glacial Maximum ∼20,000 years ago to our present interglacial. All three past times provide natural experiments with insights into the future response of the polar ice sheets to global warming.