Inferring Antarctic ice sheet contributions to past interglacial sea level highstands from far-field sea level reconstructions

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Abstract

Over the last century, sea-level rise has been dominated by thermal expansion and glacier loss, but mass loss from the Greenland and Antarctic ice sheets is expected to exceed other contributions to future sea-level rise under sustained warming. However, a noted challenge to providing robust projections of future sea-level rise comes from the assumptions made about potential contributions from the Antarctic ice sheet. Given the present uncertainties regarding the physics of rapid ice sheet retreat, a complementary approach to modeling is to draw upon observations of sea-level rise during past warm periods. In fact, far-field sea level reconstructions have been cited as some of the primary evidence for past retreat of the Antarctic ice sheet beyond its present volume during past warm periods such as the Last Interglacial. The premise of this approach is that integrating far-field sea level reconstructions with models of sea level, ice sheets, and climate can help us to better resolve the expected response of the Antarctic ice sheet to future sea-level rise.

I will summarize the state of knowledge for far-field sea level reconstructions during the Pliocene and Last Interglacial periods, the resulting inferences of Antarctic contributions, and the associated the uncertainties. In the past, Antarctic contributions to total sea-level rise have often been made indirectly, that is to say, on the basis of peak sea level values that cannot be satisfied by invoking other sources (e.g., mountain glaciers, Greenland, thermal expansion). More recently, glacial isostatic adjustment (GIA) models and statistical analyses have permitted a quantitative approach to identify the geographic source of the meltwater through a “fingerprinting” analysis that assess the geographic pattern of the sea-level rise signal. This approach is most effective with a diverse geographic spread of far-field data and with a large meltwater signal. An additional factor that is now being explored is the subtle effect of dynamic topography that may influence the vertical position of far-field sea level indicators, even over shorter (~100,000-yr) timescales. Finally, I will emphasize that even in the face of existing uncertainties and challenges to interpreting the far-field sea level reconstructions, that they remain valuable and relevant for understanding both past and future sea level change. However, they are most valuable when they can be evaluated alongside contemporaneous climate reconstructions from both terrestrial and marine records within a robust chronological framework. The comparison of contemporaneous sea level and climate reconstructions is integral to interpreting the significance of the sea level (and ice sheet) changes. Hence, developing robust chronologies to enable this inter-comparison as well as developing more high-latitude paleoclimate reconstructions are critical to advancing our knowledge.

Keywords: Last Interglacial, Pliocene, GIA, dynamic topography