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Modeling West Antarctic Ice Sheet growth and retreat through the last 5 million years

D. Pollard (1) and R.M. DeConto (2)

(1) Earth and Environmental Systems Institute, Pennsylvania State University, University Park, Pennsylvania, USA (pollard@essc.psu.edu), (2) Department of Geosciences, University of Massachusetts, Amherst, Massachusetts, USA (deconto@geo.umass.edu)

The West Antarctic Ice Sheet (WAIS), grounded mostly below sea level and fringed by floating ice shelves, is considered to be vulnerable to future anthropogenic warming. However, projections of its future behavior are hampered by limited understanding of past variations and the main forcing mechanisms. Here a combined ice sheet-shelf model with imposed grounding-line fluxes following C. Schoof (J. Geophys. Res., 2007) is used to simulate Antarctic variations over the last 5 million years. We argue that oceanic melting below ice shelves is an important long-term forcing, controlled mainly by far-field influences that can be correlated with deep-sea-core benthic delta O18 records. Model West Antarctic configurations range between full glacial extents with grounding lines near the continental shelf break, intermediate states similar to modern, and brief collapses to isolated ice caps on small West Antarctic islands. Transitions between these states can be relatively rapid, taking one to several thousand years. Several aspects of our simulation agree with a sediment record recently recovered beneath the Ross Ice Shelf by ANDRILL (MIS AND-1B core), including a long-term trend from more frequently collapsed to more glaciated states, and brief but dramatic collapses at Marine Isotope Stage 31 (around 1.07 Ma) and other super-interglacials. Higher-resolution nested simulations over the Ross Embayment and Pine Island/Thwaites drainages resolve ice streams, outlet glaciers, and details of shelf flow. Although our forcing parameterizations are not directly applicable to future change, we examine the amounts of WAIS retreat from modern conditions caused by prescribed increases in sub-ice oceanic melt rates.