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Long- and Short-Time Scale Glacial Isostasy of the Antarctic Peninsula and Impact on GRACE Science

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The ice cover grounded to the Antarctic Peninsula (AP) today represents but a small fraction of water attached to the continent of Antarctica ($\leq$ 0.3 % by mass). However, the more northern latitude of the Peninsula renders its grounded water mass many times more volatile that is ice mass locked in the thick ice sheet cover south of 70-75˚S. If ice on the entire Peninsula were to waste into the oceans it would cause 0.18 $\pm$ 0.03 meters of sea-level rise (m.s.l.r.), large ($\sim$ 6 - 7 x) in comparison to the total sea-level equivalent holding capacity of Patagonian ice masses, but quite small in comparison to West Antarctica south of 75˚S ($\leq$ 1/25th). The amplitude of the Peninsula's annual water cycle is also anomalous: $\approx$ 0.5 Terra tones per year (Tt / yr, 1 Tt = 10^{12}tones) or roughly a 1.39 mm / yr sea-level equivalent. While there is evidence that the Peninsula glaciers have been in retreat due to regional atmospheric and oceanic warming for the past half-century (Cook et al., 2005), or more, there has been a more recent acceleration of ice streams due to the loss of ice shelf buttressing in Graham Land. Rignot et al. (2008) determined that ice stream accelerations imply a 50-60% increase in the rate of ice loss from West Antarctica since 1996 to a level of about 0.132 Tt / yr, possibly accounting for 1/3 - 1/8th of the global non-steric sea-level rise (e.g., Cazenave et al., 2008). Estimates of Peninsula loss have risen even more dramatically and after 2005 are near 0.06 Tt / yr (Pritchard and Vaughan 2007; Rignot et al., 2008) As is the case for the smaller outlet glacier of southern Greenland (e.g., Howat et al. 2008), smaller glaciers of the AP are capable of responding to climate change on a relatively rapid time scale in comparison to continental ice sheets. In as much as the mass of AP collapse now appears ever more prominently in GRACE time-variable gravity data, and as a destablizing shelf-unbuttressing of tide water glaciers now drifts southward (e.g., Smith et al. 2007; Khazendar et al. 2007), it is important to place bounds on the secular gravitational signature of solid Earth viscoelastic isostatic flow. We examine recent developments in regional paleogeomorphologic and glacial history together with a broad range of earth parameters. For the regional slab window environment it is a safe assumption that the upper mantle viscosity is a factor of 2 or more reduced below that of Fennoscandia (Klemann et al., 2007). The water mass equivalent of the isostatic bedrock response is investigated thoroughly, as are numerical experiments in which quasi-exponential ice loss is assumed during the next century.