Tropical forcing of Circumpolar Deep Water inflow and outlet glacier thinning in the Amundsen Sea Embayment, West Antarctica, and its relationship to “global warming”

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Ice shelves and glaciers along the margin of the Antarctic ice sheet are thinning rapidly. The greatest thinning rates are occurring in the Amundsen Sea and western Antarctic Peninsula sectors of West Antarctica (Rignot et al., 2008). This region has also experienced significant climate changes, including rising temperatures (Vaughan et al., 2003; Steig et al., 2009), and declines in sea ice (Parkinson et al., 2002), both a result of changing atmospheric circulation (Fogt and Bromwich, 2006; Turner et al., 2009; Ding et al., 2011). There is good evidence that the climate and ice sheet changes are linked by the wind-driven intrusion of warm Circumpolar Deep Water (CDW) onto the continental shelf, which melts the ice shelves from below (Dinniman and Klinck, 2004; Thoma et al., 2008; Jenkins et al., 2010; Bindschadler et al., 2011).

These recent changes in atmospheric circulation in West Antarctica have not happened in isolation. It is well established that the direct radiative effects of both greenhouse gas increases in the troposphere and ozone depletion in the stratosphere have contributed to decreasing pressure over the Antarctic continent and a resulting increase in the circumpolar westerlies (Kushner and Held, 2001; Thompson and Solomon, 2002; Alabaster and Meehl, 2006) and intensification of the circumpolar current (Polvani et al., 2011). These changes are limited, however to austral summer, while in the Amundsen Sea Embayment, the largest changes in the local wind stress in the have occurred in fall and early winter (Steig and others, 2011). The evidence for a significant influence on circulation from the direct effects of radiative forcing, whether ozone-related or from tropospheric greenhouse gases, is equivocal at best (*cf.* Turner et al., 2009; Sigmond and Fyfe, 2011; Blanchard-Wrigglesworth et al., 2011). On the other hand, it is clear that the significant rise in temperatures in the equatorial Pacific in the last 30 years has contributed to circulation changes over the Amundsen Sea, especially in austral winter and spring, via increased poleward-propagating Rossby waves (Schneider and others; 2011; Ding and others, 2011). The local ASE wind stress is significantly correlated with surface temperatures and rainfall (a measure of atmospheric divergence) over the central tropical Pacific, and this relationship is easily reproduced in atmospheric general circulation models. To the extent that recent changes in ASE glaciers a response to wind-driven ocean circulation changes, tropical forcing has therefore played a leading role.

It remains an open question whether the anomalously warm decade of the 1990s in the tropics reflects anthropogenic climate change (e.g. Trenberth and Hoar, 1997), or is simply ódecadal variabilityô(e.g. Latif et al., 1997). However, it is unequivocal that the 1990s (and 2000s) were the warmest decade of the last century in the tropical Pacific, and ice core evidence shows that, for West Antarctica, the 1990s were the most anomalous decade of the last 150 years (at least). Recent, large changes in Amundsen Sea climate, oceanography and ice dynamics are thus intimately tied in with the large-scale warming of the planet.