Assessing linkages between climate variability in high-latitudes and the tropics with ENSO forcing in GCM simulations of polar climate proxies

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The coupling between climate variability and change at high latitudes and the tropics is not well understood. Teleconnection patterns have been used to explain covariation between Arctic sea ice and the monsoon (e.g., Chang *et al.*, 2003), while some studies suggest a tropical driver of high latitude conditions (e.g., Turney *et al.*, 2005). Nonetheless, it is clear that the implied linkages give rise to regionally organized patterns of climate variability that play an important role in climate reconstruction because local influences on proxies could otherwise be incorrectly interpreted as global change. To this end, it is unclear if the strength of the coupling, and the structure of teleconnection patterns, remains constant in the presence of natural and anthropogenic forcing. As a case in point, Schneider *et al.* (2005) have shown that climate change inferred from isotope proxies in Antarctica differs from that of the Southern Hemisphere and global instrumental records. Their analysis shows that a substantial part of this change is associated with changes in the mean amplitude of the Southern Annular Mode, but also implicates change associated with the El Niño-Southern Oscillation (ENSO). Both of these regional patterns are known to be an important aspect of Antarctic climate (Turner *et al.*, 2005).

The NCAR Community Atmosphere Model Version 3 (CAM3) is used to develop an understanding of the coupling between the tropics and high latitudes by simulating the stable water isotope composition of polar snow for different phases of ENSO and investigating the physical mechanisms that drive the associated isotopic changes. To do so, the circulation associated with ENSO must first be reproduced. Forcing ENSO conditions by prescribing SST anomalies produces an acceptable representation of geopotential height anomalies associated with El Niño when compared to NCEP reanalysis (Figure 1). Similar results are found with La Niña forcing. With an emphasis on accurate simulation of circulation and water transport in the Antarctic, an additional experiment is forced by introducing a bias directly into the surface pressure tendency equation. Specifically, the surface pressure anomalies associated with ENSO from the NCEP reanalysis are used to nudge the surface pressure toward the observed conditions over a relaxation time of one day. A long relaxation time corresponds to a weaker forcing, and a short time to strong forcing. This method has the advantage that when used with a slab ocean model the land sea contrasts and stationary planetary waves are not artificially amplified as they are when fixed SSTs are used. Figure 1 shows that while this method results in broad agreement with the observed anomalies, the initial results do not reproduce the details of the observed anomalies as well as the experiment in which the SSTs were prescribed. This is in part due to a spatially uniform relaxation time that is tuned for midlatitude conditions. This acts to overemphasize the tropical influences relative to the mid and high latitudes and introduces a strong wave-like structure near the Antarctic Peninsula. Further refinement of the technique will vary the relaxation time with latitude that mimics the latitude dependent adjustment timescales of geophysical flows, and thereby constrain the high latitude circulation more reliably.

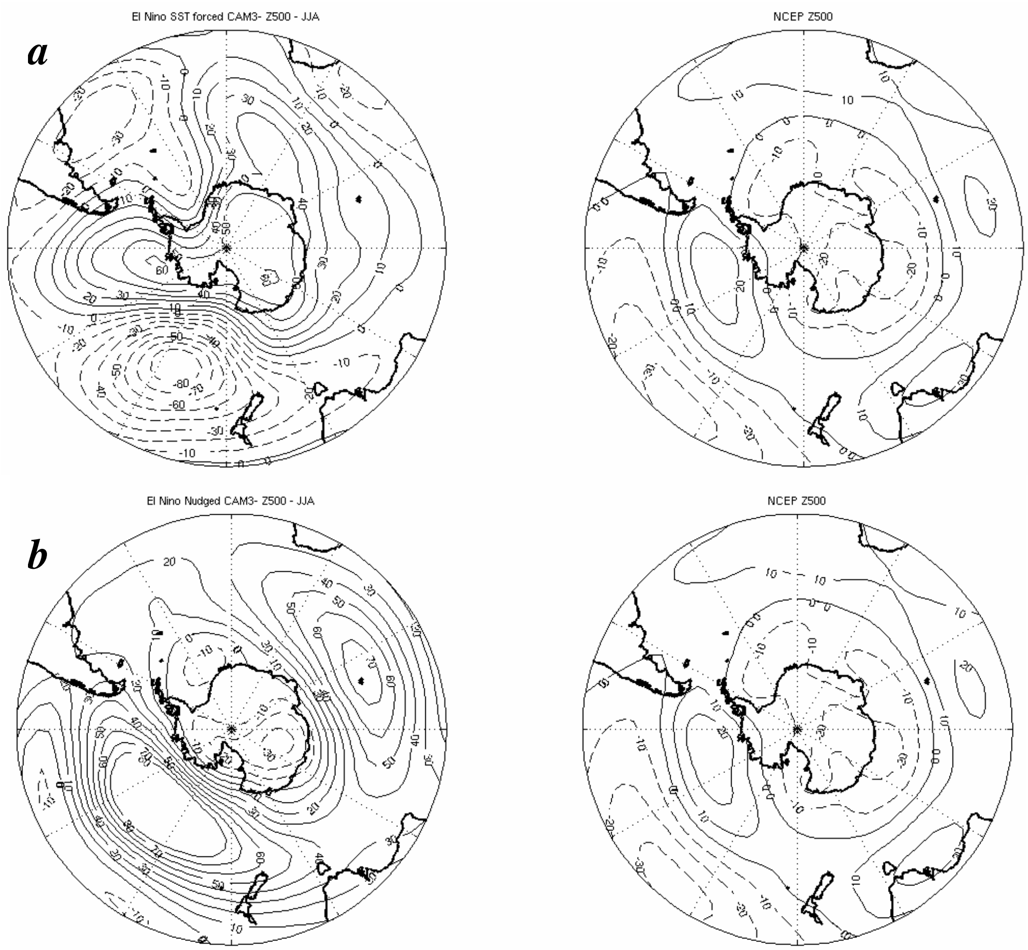

Figure 1: June-July-August average 500 hPa geopotential height anomalies associated with El Niño from 10-year CAM3 simulations forced with observed a) SST anomalies and b) surface pressure anomalies and the slab ocean model. Right panel shows equivalent anomalies from the NCEP Reanalysis as verification. The contour interval is 10 meters and negative contours are dashed.

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