Variability in the Teleconnection Between ENSO and West Antarctic Climate

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The atmospheric coupling between ENSO and Antarctica is not well characterized, though it has been the subject of considerable study (Turner 2004). Importantly, climate models do not reliably reproduce the differences in ENSO response at high latitudes, and, as such, without more detailed understanding of the linkage between the tropics and high latitudes, estimates of high latitude climate from climate models could be misleading. The primary reason for the poorly defined teleconnection is the fact that no two ENSOs are alike; geographically similar events can have seasonal differences and seasonally similar events will differ geographically. These are the rudimentary differences in the tropics from one event to the next but there is also high latitude decadal variability in ENSO that is highlighted by Zhang et al (1997) who exposed what is now recognized as the Pacific Decadal Oscillation (PDO). The PDO index indicates the magnitude of the leading mode of variability of north Pacific SST, north of 20 degrees N. In the southern hemisphere, there is not a similar proxy yet established for an analogous decadal oscillation. Though such a decadal oscillation hasn't been specifically identified in the south, the ITASE 2001-5 ice core (Steig, et al 2005), extracted from Antarctica near the Pacific, isotope signal correlated with the Southern Oscillation Index (SOI- an ENSO proxy) shows decadal variability that appears representative of a South Pacific decadal oscillation, perhaps coupled to the PDO. In the current study, 20th century sea level pressures from the Hadley Center are analyzed to establish their correlation with ENSO and the $\delta^{18}O$ isotope in the ITASE 2001-5 ice core in three distinct quasi-decadal epochs of high ENSO activity. These correlations are established with the intent of understanding climate variability from Antarctic proxy records with a GCM with stable water isotope fractionation through simulating tropical and perhaps global atmospheric teleconnection to Antarctica on ENSO and longer timescales.

Figure 1 shows, for three approximately 20 year epochs, the correlation between the isotope records from an ice core in West Antarctica and the SLP data. The ENSO signals were the subject of the initial investigations into the ITASE 2001-5 ice core signals. The core is dated at monthly intervals for approximately the past 200 years and the SOI dated at monthly intervals is available from the 1870's to present, allowing us to focus on the Semptember-November statistics when ENSO events are typically mature and the influence of ENSO on Antarctic is strongest (Fogt and Bromwich, 2006). Analysis of the ice core record with a 20 year moving correlation window identified an apparent oscillation in the correlation in the 20th century where at the beginning of the century there is a positive correlation, in the middle of the century it is negative, and at the end of the century it returns to positive. Since the SOI is positive for the La Niña conditions, this observation suggested that at the beginning and end of the centuries the anomalously high $\delta^{18}O$ signals were attributable, at least in part, to La Niña, while in the middle of the century they were attributable, at least in part, to El Niño. This result is affirmed by correlating the $\delta^{18}O$ signal with spatial patterns of SST and SLP which show circulation anomalies around Antarctica in phase with expected teleconnections. Wavelet analysis of the $\delta^{18}O$ and SOI showed that there were epochs at the beginning, middle, and end of the century that ENSO was especially active, shown by higher amplitudes in the 3-6 year periods of SOI spectrum and during these times there are higher amplitudes of the 3-6 year periods in the $\delta^{18}O$ spectrum. For the purpose of isolating the variance associated with ENSO, the data were separated both into the three epochs (1902-1920, Figures 1a and d; 1938-1960, Figures 1b and e; 1970-1995, Figures 1c and f) of high ENSO activity and into variability associated with ENSO frequencies (3-6 years) and lower frequencies (greater 6 years). The high frequency correlations show an ENSO related (Turner 2004) pressure anomaly of the western Antarctic Peninsula while the low frequencies show, among other features, a trend toward lower pressure at the south pole that may be associated with ozone loss (Thompson and Solomon, 2002).

This work establishes the patterns, and changes in patterns, that link ENSO to the Antarctic, and which should be reproduced in GCMs if models are to adequately account for tropical variability on the

high latitudes. The SLP-$\delta^{18}O$ correlation maps of the ENSO band of 3-6 years will be the primary target for the ENSO teleconnection to Antarctica in ongoing GCM experiments, while the lower frequency variability will be targeted for simulating features such as the decadal variability and secular trends that imply changing climate.

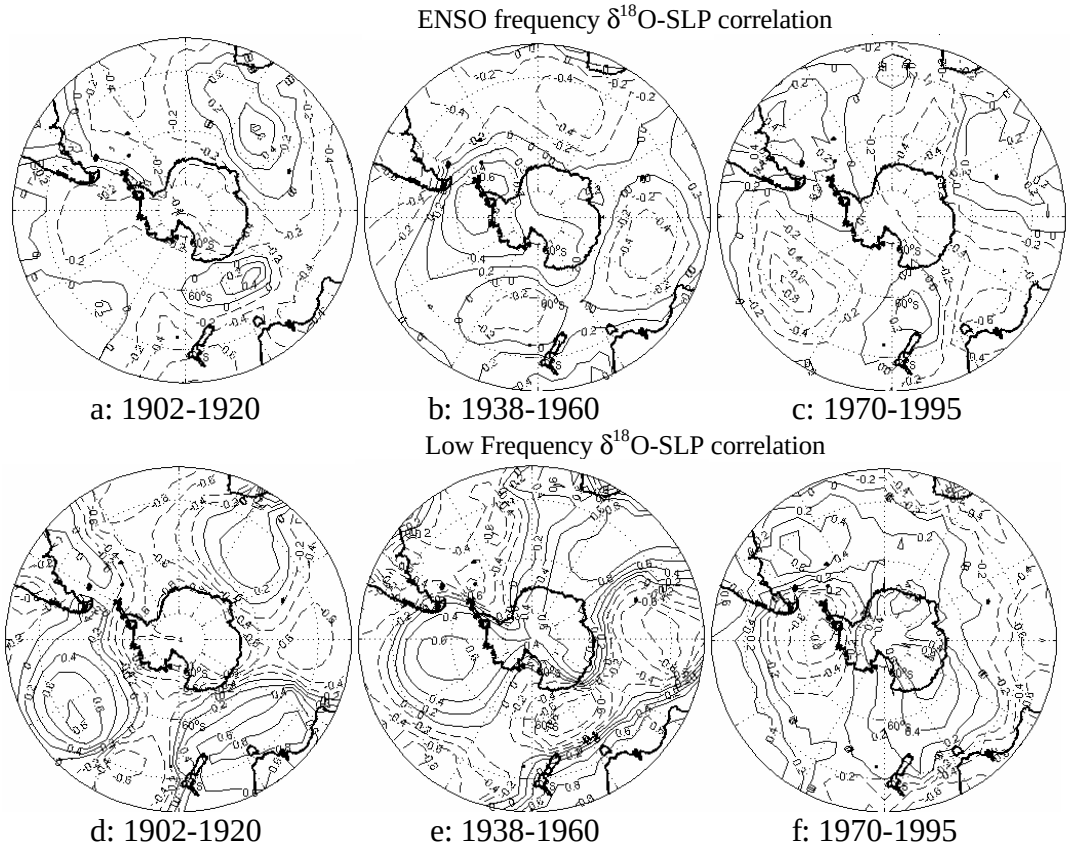

Figure 1: d^{18}O Correlated with SLP for three 20th century epochs of high ENSO activity. (a-c) Band Pass Filtered for ENSO frequency band of 3-6 year periods. (d-f) Low Pass filtered for periods longer than 6 years.

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