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THE DYNAMICS OF LATE 20TH CENTURY CHANGES IN THE SOUTHERN HEMISPHERE CIRCULATION

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1. INTRODUCTION

In spite of its relatively symmetric surface compared to the high latitude Northern Hemisphere, Southern Hemisphere circulations arising from long-term zonal anomalies are still important (e.g. van Loon and Jenne, 1972). These asymmetries influence low-frequency disturbances in the mean zonal flow e.g. the observed split in the mid-latitude jet over New Zealand (Trenberth, 1980), and through influences on high latitude meridional flow zonal anomalies directly influence heat fluxes and sea ice distribution (Raphael, 2003).

Analyses of the climate record have indicated that changes have occurred in the SH circulation during the late 20th Century, and in particular there are indications of a sudden shift in circulation patterns during the late 1970s (e.g. Thompson et al, 2000; Meehl et al, 1998). Relatively little research has been done on changes in the zonally asymmetric circulation, but there are indications that following the late 1970s there were significant changes in the evolution of zonal wave 1 (ZW1) (Raphael, 2003).

In this research, observation-based data is used to investigate possible changes in the ZW1 mean and variance for the late 20th Century. Furthermore, possible forcing mechanisms of ZW1 are investigated in an attempt to explain possible causes of ZW1 changes, and also potential effects for the SH circulation.

2. METHOD

The ZW1 signal was obtained by applying a zonal Fast Fourier Transform (FFT), for each month of the NCEP/NCAR Reanalysis 1960-2004 monthly mean SH 500hPa geopotential height field. By applying the FFT at each time interval of the dataset, information about the temporal evolution at each spatial location was retained. The analysis showed quasi-stationary subtropical and subpolar ZW1 patterns, consistent with previous studies (van Loon and Jenne, 1972, Trenberth, 1980). Time series of the phase, amplitude and ridge latitude were created for both the subpolar and subtropical waves. These time series were then investigated for evidence of change in the ZW1 mean and variability.

Relationships between the wave parameters, and between the waves and other atmospheric and surface fields, were explored using cross correlations of the time series. To avoid spuriously high correlations, the annual cycle was removed from the data prior to cross correlation.

3. RESULTS

For the subpolar wave, apparent trends were found in amplitude and phase. The subtropical wave showed a slight decrease in amplitude. However, in each case the changes were small compared with the ZW1 variability.

Spectral analysis was applied to decadal subsets of the time series. There was a tendency towards increased dominance of the annual cycle for the subtropical wave, for both amplitude and phase. There were also changes in the interannual variability of the subtropical wave. Decadal changes were also found for the subpolar wave, but were not as linear and were quite different to the subtropical wave. During the 1980s, a significant reduction in the interannual variability of amplitude and phase was balanced by an increase in the annual and semiannual cycles.

Cross correlation indicated that the subtropical amplitude and phase were significantly correlated at lag zero with the subpolar wave amplitude and phase. Both waves exhibited a significant negative correlation between their own amplitude and peak latitude, indicating a poleward tendency during periods of high amplitude. Despite an apparent covariance on annual and interannual timescales, when the annual cycle was removed from the data neither wave showed a significant correlation between amplitude and phase. This implies that whilst both parameters exhibit a strong seasonal cycle, phase and amplitude are not directly modulated.

Cross correlation and composites were used to explore the dynamical interactions with SST and zonal and meridional wind. Findings will be discussed in greater detail during the presentation. However, initial results indicate an atmosphere-ocean teleconnection with El Niño-Southern Oscillation (ENSO) through a disturbance in the SH gyre currents, and through the atmospheric Pacific South American mode (PSA).

4. REFERENCES

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