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INTER EL NIÑO VARIATIONS IN THE WINTER ATMOSPHERIC CIRCULATION OF THE SOUTH PACIFIC PART I: OBSERVATIONS

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1. INTRODUCTION

Considerable evidence now exists that while the winter season (June-August) extratropical circulation of the South Pacific in some El Niños is strongly modulated by Rossby wave trains (RWTs) (Karoly, 1989), many exceptions occur (Marshall and King, 1998; Harangozo, 2000, 2002). In such cases ridging in the southeast Pacific, a hallmark of RWTs (Karoly, 1989; Renwick, 1998), disappears as in the 1983 winter (Fig. 1). This inter-El Niño variability does not appear to be closely tied to tropical sea surface temperatures (SSTs) because the expected RWT response can fail to occur even when these are anomalously high (Harangozo, 2000, 2002).

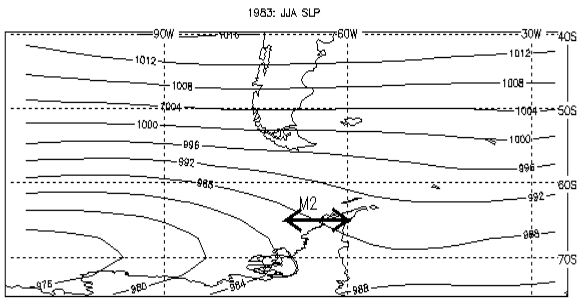

Fig.1. 1983 winter (June-August) mean SLP in the southeast South Pacific from the Australian analyses. The double headed arrow shows the location of the M2 index (see text). This index is negative for this case with northerly winds in the Antarctic Peninsula.

This study hypothesises that strong modulation of the South Pacific extratropical circulation by RWTs in austral winter only occurs when deep convection intensifies in the climatologically preferred region of the equatorial Pacific at and west of the dateline.

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2. METHOD

This paper studies El Niños occurring in the austral winters during 1976-98. They occurred in 13 winters as listed by Trenberth (1997) and updated to include the 1997-98 event. Another winter (1980) when a weak El Niño appeared to occur (Harangozo, 2000) is also included. Tropical OLR (W m^{-2}) data, a proxy for tropical convection, has been averaged for each winter season. Negative OLR anomalies indicate intensified deep convection.

Following Harangozo (2000, 2002), an index of the winter mean meridional geostrophic wind in the Antarctic Peninsula area of the southeast Pacific known as 'M2' (Fig. 1), is used to gauge the modulation of the South Pacific extratropical circulation by RWTs. M2 is the SLP $_{65^{o}S,\,75^{o}W}$ - $SLP_{65^{o}S,\,60^{o}W}$ (Fig. 2).

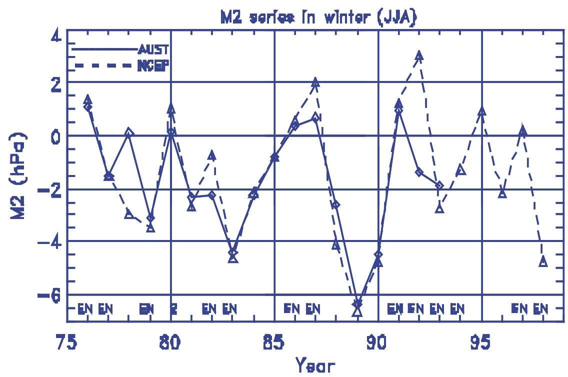

Fig. 2. Time series of the M2 index for winter from 1976-98 from Australian analyses and NCEP reanalyses. EN indicates El Niños. Positive values denote southerly flow. ? indicates a weak El Niño in 1980.

Positive M2 indicates mean winter southerly flows that are associated with ridging in the southeast Pacific. M2 has been derived from Australian sea level pressure (SLP) analyses up to 1993 and thereafter from NCEP reanalyses. Fig. 2 shows southerly flows only occurred in El Niños except in 1995. This case is excluded because the NCEP data appear to be incorrect in this winter. NCEP data in the Antarctic Peninsula region are known to be problematic in the 1990s (Marshall, 2002) and the 1992 NCEP case of southerly winds also appears to be physically unrealistic in terms of the sea ice and climate conditions in the Antarctic Peninsula in this winter.

Tropical OLR data has been composited for the El Niño winters with southerly (6 cases) and northerly (8) winds in the Antarctic Peninsula. Composites of OLR anomalies (from 1974-2000 mean) are also produced for all winters of northerly winds and for La Ninas.

3. DEEP TROPICAL CONVECTION

In El Niños with mean seasonal southerly winds in the Antarctic Peninsula in winter a belt of below-normal OLR is centred on and just north of the equator between 160-180^o E and at 1-5^o N further east (Fig. 3a). The equatorial OLR reduction is statistically significant at less than the 5% level using a Student *t*-test east. In contrast, in El Niños with northerly winds (Fig. 3b) OLR is around normal in the equatorial central Pacific. Instead, a negative OLR anomaly locates at 5-7^o S between 160^o E and 165^o W. This anomaly is weaker than for southerly winds and only statistically significant in a small area. In the case of northerly winds in all years OLR is normal throughout the tropical central Pacific (not shown). In La Ninas (Fig. 3c) the equatorial OLR anomaly pattern in Fig. 3a is reversed with negative anomalies again being strongest on the equator around the dateline.

These results reveal a reorganization of Pacific deep tropical convection between those El Niños with strong modulation of the South Pacific extratropical circulation by RWTs and other cases. Specifically, winter southerlies only occur when a negative OLR anomaly is centred on the equator at and just west of the dateline. This is true in all southerly cases. By contrast, in El Niños with northerly winds a negative OLR anomaly is generally centred south of the equator. In some cases the negative anomaly extends to the equator but is strongest at 5-8^o S. In the case of 1982, again with northerlies (Fig. 1), there is a broad negative OLR anomaly extending from 3^o N - 12^o S rather than being centred on the equator. This reorganization of deep convection between southerly and northerly cases is also seen in spring (not shown).

Present results thus support the hypothesis that seasonally intensified deep convection in the equatorial region around and west of the dateline is pivotal to the South Pacific extratropical circulation in El Niños. Two observations support this. First, negative OLR anomalies centred on the equator in winter fail to develop in this area in other years. It is known (Rasmusson, 1991) that deep convection only extends to the central Pacific in El Niños. The key importance of this region is also supported by Fig. 3c showing a withdrawal of deep convection here in La Ninas. Again the positive OLR anomaly is strongest on the equator west of the dateline.

Two other studies support this interpretation. Mo and Higgins (1998) studied the intraseasonal modulation of the South Pacific winter circulation by RWTs that they referred to as the Pacific South American (PSA) pattern. They found (their Fig. 3) an equatorially-centred OLR reduction at 160-180^o E in the positive phase of one of their PSA modes compared to its negative phase. Their Fig. 5 shows large, statistically significant, negative OLR anomalies developing in this equatorial area 6-15 days before the PSA pattern reaches its positive peak. Likewise, Kidson et al. (2002) also recently showed negative OLR anomalies in this area in the austral winter when compositing for moderate El Niños. Their composite 1000 hPa height field (their Fig. 8) for these El Niños shows a wave train extending to the southeast Pacific and Antarctic Peninsula.

The OLR data also point toward an explanation of two other features of the varying South Pacific extratropical response to El Niños. The first is that strong modulation of the winter and spring circulation by RWTs can occur even when negative equatorial OLR anomalies are not strong. Cases include the 1986 winter and 1976 spring (not shown) when southerlies occurred in the Antarctic Peninsula. This suggests that the location of deep convection may be as important as its intensity. The other feature is the strong seasonal northerlies in the Antarctic Peninsula in some El Niños, akin to some La Ninas such as in 1988 and 1989. The three El Niño winters with strongest northerlies in 1979, 1983 and 1998 (Fig. 2) were all associated with normal equatorial OLR. Strong northerlies also occurred in the 1987 spring (Harangozo, 2002) with a negative OLR anomaly centred south of the equator.

4. CONCLUSIONS

It has been found that seasonal deep convection in the climatologically preferred equatorial region at and west of the dateline varies considerably between El Niños in austral winter. Only in those El Niños where a negative OLR anomaly is centred on the equator does there appear to be strong modulation by RWTs. This only appears to be the case in about half of all those winters occurring during El Niños.

The reasons for the variability in OLR in the equatorial Pacific near the dateline are unclear. Further analysis suggests that tropical SSTs have little direct effect on OLR here. Equatorial OLR west of the dateline is very weakly correlated with local SSTs and SSTs here exceed the critical value of 28 ^{o}C required for deep convection in most El Niños. OLR at and west of the dateline is strongly correlated with SSTs further east. The relation of OLR here to SSTs thus appears to be more complex than previously envisaged and points to the likely importance of the tropical atmospheric circulation as well as SSTs in modulating tropical deep convection.

Acknowledgements

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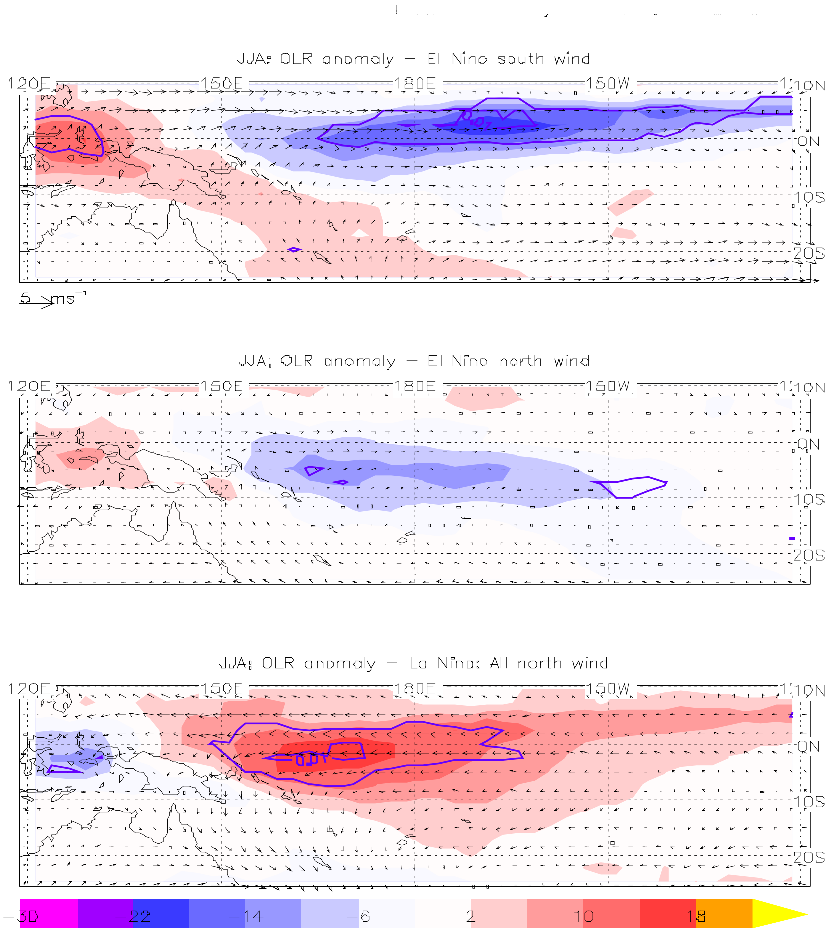

Fig. 3. Averaged OLR anomalies for composites of a) El Niños with southerly winds in the Antarctic Peninsula in austral winter, b) El Niños with northerly winds and c) all La Nina cases. The areas enclosed by thick blue lines are regions where differences in OLR from the long-term mean are statistically significant at <5% level (<1% level for a second blue contour). 850 mb vector wind anomalies from ECMWF reanalyses are also shown.