P1.8 PLANETARY AND SYNOPTIC SCALE INTERACTIONS IN SOUTHEAST PACIFIC BLOCKING USING POTENTIAL VORTICITY DIAGNOSTICS.

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1. INTRODUCTION

Climatological studies of Southern Hemisphere (SH) blocking events have shown that these events do not occur as often as their Northern Hemisphere (NH) counterparts (e.g. Lejenas, 1984). Wiedenmann et al. (2002) demonstrate that blocking in the South Pacific sector occurs as frequently and is as persistent as North Pacific blocking events. However, blocking events are rare in other regions of the SH, and these events are weaker across the entire SH than their NH counterparts. Wiedenmann et al. (2002) also demonstrate that, during the last 30 years, there has been a significant decrease in the frequency of blocking events. This result is consistent with the long-term trends in SH 500 hPa heights found by Renwick and Revell (1999).

The differences in climatological behavior of blocking events may be the result of differences in the underlying dynamics involved in the growth and maintenance of these events. This may be true especially when comparing the degree to which planetary and synoptic-scale forcing play a role in the lifecycle of blocking events. It has been acknowledged that blocking events may have more than one formation mechanism (Li et al., 1999). It has also been demonstrated that the relative importance of synoptic and planetary-scale forcing is different for the growth and maintenance of North Atlantic and North Pacific blocking events (e.g., Nakamura et al., 1997, Colucci, 2001). However, it appears that the interactions between the large-scale and the synoptic-scale transients are important in all the NH and SH regions discussed here (e.g., *for the SH* Trenberth, 1986; Marques and Rao, 1999). In addition, there are comparatively few case studies of individual SH blocking events in the published literature (e.g., Berbery and Nunez, 1989).

Thus, the goal of this study is to describe the extent to which the synoptic-scale transients play a role in the lifecycle of South Pacific blocking events in order to determine whether or not these events are similar to their North Pacific counterparts. The methodologies used here will be similar to those found in Lupo and Smith (1998) (scale partitioning) and Lupo and Bosart (1999) (Potential Vorticity diagnostics). This study will lay the groundwork for comparisons with blocking events in the SH Atlantic and Indian Ocean basins in order to ultimately determine why blocking events are very rare in these regions.

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2. ANALYSES AND METHODS

2.1 Analyses

The data set used in this study was the National Centers for Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR) gridded re-analyses (Kalnay et al., 1996). These data are archived at NCAR and were obtained from their mass-store facility in Boulder, CO. The re-analyses used here are 2.5^{o} by 2.5^{o} latitude-longitude gridded analyses available on 17 mandatory levels from 1000 to 10 hPa at 6-h intervals. These analyses include standard atmospheric variables such as geopotential height, temperature, relative humidity, vertical motion, *u* and *v* wind components, a set of various surface fields, and tropopause information. Mandatory pressure level data were interpolated quadratically in ln[p] to 21 levels in 50 hPa increments from 1050 to 50 hPa. Interpolating quadratically in ln[p], as opposed to linearly produces more robust profiles, particularly for the *u* and *v* wind components, that more closely resemble raw sounding information (Lupo and Bosart, 1999).

2.2 Methods

The blocking criterion of Lupo and Smith (1995) was used in this study, and this can be summarized as a combination of the Rex (1950) subjective criterion and the Lejenas and Okland (1983) objective criterion, with the exception that a "block" is defined as persisting for five days or more. The Rex (1950) criterion used subjective map analysis, and it is desirable that highly meridional split flow persists for 10 days or more. The Lejenas and Okland (1983) criterion is a zonal index plotted on a time-longitude or Hovmoller diagram, and persistent weak or negative "non-translating" values represent blocking.

The diagnostic techniques used here are described in Lupo and Bosart (1999). Briefly, the potential vorticity (PV) framework is used as the analysis and map display tool, which includes the use of dynamic tropopause (DT) maps. PV will be calculated on 300 hPa surfaces since the PV distribution on this surface, under most circumstances, will resemble the PV field on an isentropic surface (see Lupo and Bosart, 1999 and references therein). As such, this PV calculation is still an effective diagnostic tool and is give here as:

$$PV = g\left[\hat{k}\cdot\left(\frac{\partial\vec{V}}{\partial p}\times\nabla\theta\right)+\zeta_a\frac{\partial\theta}{\partial p}\right] \quad (1)$$

Where ζa is the absolute vorticity vector along the vertical axis, and θ,g, and V hold their conventional meaning. Then, the change in block center point PV was calculated assuming that this quantity is conserved (e.g., Lupo and Bosart, 1999). Thus, the development of a particular blocking event is equivalent to the advection of 500 hPa PV,

$$\frac{\partial PV}{\partial t} = -\vec{V} \cdot \nabla PV \quad (2).$$

In examining these blocking events and assessing the role of the synoptic-scale versus that of the planetary-scale, it was necessary to partition the re-analyses into synoptic and planetary-scale components following the methodology of Lupo and Smith (1998) and references therein. The filtered analyses were used in partitioned forms of (1) and (2) derived by substituting for each variable X;

$$X = \overline{X} + X' \quad (3),$$

where the first (second) term on the right-hand-side of (3) is the planetary (synoptic)-scale component, respectively. Thus, a scale partitioned form of (2) is given by;

$$\frac{\partial PV}{\partial t} = \left.\frac{\partial PV}{\partial t}\right|_P + \left.\frac{\partial PV}{\partial t}\right|_S + \left.\frac{\partial PV}{\partial t}\right|_I = P + S + I \quad (4),$$

where P, S, and I are the planetary-scale, synoptic-scale, and scale interaction vorticity tendency, respectively. The forcing term in (2) mathematically gives rise to scale interaction terms via the product rule (e.g. see Colucci, 2001). Finally, all results were subjected to filtering in order to remove small-scale signal and noise that is inherently present due to analysis and computational error.

3 SYNOPTIC ANALYSIS

The blocking events chosen for study were two Southeast (SE) Pacific region events that occurred during July and August 1986. The characteristics of these events are shown in Table 1. Both events were long-lived and classified as strong blocking events when compared to their SH counterparts (see Wiedenmann et al., 2002). Blocking events in the SE Pacific have been studied by Renwick and Revell (1999), who found

Table 1. The characteristics of the two blocking events chosen for study here (*for BI see* Wiedenmann et al., 2002).

Event	Dates (Start / Termination)	Days	Block Intensity (BI)
1	23 Jul – 2 Aug	10.5	3.64
2	3 Aug – 16 Aug	13.5	4.06

that Rossby wave propagation from the convectively active South Pacific Convergence Zone (SPCZ) Region. Additionally, the two events studied here were also analyzed by Marques and Rao (1999), but using different techniques. They found that synoptic-scale transients were important contributors in the life cycle of these events.

A synoptic analysis of the first blocking event reveals that the block development phase was associated with a cyclone that developed at a marginal rate between 0000 UTC 21 July and 0000 UTC 23 July 1986. This synoptic analysis used 500 hPa and 1000 hPa surface NCEP re-analysis maps available on the world wide web through the website (http://www.cdc.noaa.gov/cdc/data.nmc.reanalysis.html). The development phase of this blocking event possessed all the characteristics of blocking events studied by Lupo and Smith (1995, 1998) and references cited therein. Namely, the cyclone event developed within one-half wavelength upstream of the incipient blocking event. The synergistic strengthening of the cyclone, the upstream ridge, and a jet maximum on the western flank of the blocking event likely contributed to enhancing the anticyclonic vorticity advection field. This transport of anticyclonic vorticity advection into the blocking region was found in previous studies to be a key component in the development or intensification of blocking events. It should be noted however, that as of this writing, the dynamic analysis of the blocking events described here is just now underway.

During the maintenance period of this event, two other cyclones interacted with this blocking event and caused intensification. Finally, this blocking event decayed during the first 2 days of August, and decay was not associated with upstream cyclones (e.g. Lupo and Bosart, 1999). Additionally, the configuration of this blocking event was that of a dipole-type blocking event (Fig. 1).

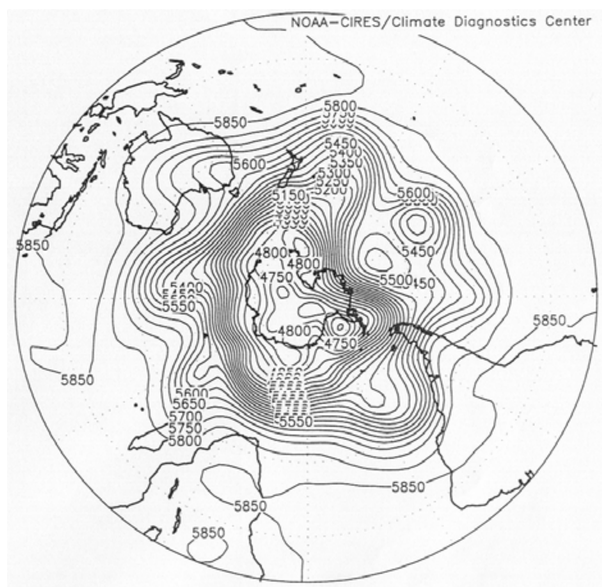

Figure 1. The 0000 UTC 28 July 1986 500 hPa NCEP re-analysis plot for the Southern Hemisphere. The contour interval is 60 dam.

As the first blocking event decayed, a second blocking event developed roughly 40^{o} longitude upstream of the decaying event described above, and was associated with a rapidly developing cyclone during the 0000 UTC 2 August to

0000 UTC 3 August 1986 period. This event is considered a second event, as it appears that the event develops in the same manner as described above for the first event, but apart from this latter event. These blocking events also impart distinctly separate signatures on a time-longitude (Hovemoller) plot in a similar manner to two North Atlantic blocking events described by Fig. 1. in Lupo and Smith (1995). To bolster our contention that this second event is a new event, we found that this event spent most of its lifecycle configured as a Rex-type blocking event (Fig. 2). Finally, this blocking event interacted with 4 additional upstream cyclones during the maintenance period of the blocking event, and was stronger overall than the first blocking event.

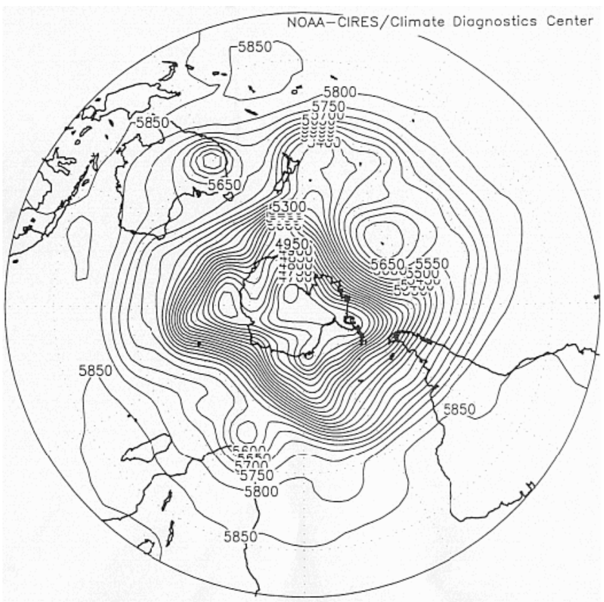

Figure 2. As in Figure 1, except for 0000 UTC 5 August 1986.

4. SUMMARY AND CONCLUSIONS

A diagnostic study of two SE Pacific blocking events is described here. These two strong and long-lived blocking events are winter season blocking events that occurred in an episodic manner during a four week stretch in July and August 1986. Using the NCEP re-analyses and the diagnostic techniques of Lupo and Smith (1998) and Lupo and Bosart (1999), a PV analysis was carried out using the full data fields and partitioned (synoptic- and planetary-scale) data fields. However, as of this writing, the dynamic analysis is just now underway. Nonetheless, a synoptic analysis of these blocking events demonstrates that each event conforms to the block development and intensification paradigms described by Lupo and Smith (1995, 1998) and references cited therein.

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