**P1.4** PERSISTENT POSITIVE ANOMALIES IN THE SOUTHERN HEMISPHERE CIRCULATION

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## 1. INTRODUCTION

Persistent positive anomalies (PPAs, or "blocking") are an important feature of intraseasonal variability in the extratropical atmospheric circulation. PPAs can have significant effects on seasonal-mean climate, and their formation and breakdown are well-known to be challenging problems for medium-range forecasting.

The climatology of PPAs has been documented for the Southern Hemisphere by a number of authors over the last two decades (Trenberth and Mo 1985). The New Zealand (NZ) region has often been identified as one of the main locations for blocking activity. However, recent studies suggest that the southeast Pacific, west of southern Chile, is the main Southern Hemisphere blocking region (Renwick and Revell 1999).

This paper describes a survey of persistent anomalies in the Southern Hemisphere mid-high latitudes, based on a long time series of daily data. It identifies the southeast Pacific as the region of most frequent blocking activity, discusses the relative influence of tropical forcing at different longitudes, and suggests an explanation for the apparent discrepancy discussed above.

## 2. DATA AND ANALYSIS

The main data used are a 43-year daily time series of 500 hPa heights (H500) from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalyses (Kistler et al. 2001). Fields were projected from their original 2.5° latitude-longitude resolution onto a polar stereographic grid covering all latitudes south of 20°S. The average grid spacing is around 4° of latitude.

A number of authors have discussed the nature of trends and possible discontinuities in the NCEP/NCAR Reanalyses. To partially side-step the issue of long-term trends, and to focus more of interannual variability, a linear trend was removed from the H500 fields at each grid point. The approach and result is as discussed in Renwick and Revell (1999). A daily mean climatology was also calculated at each grid point by harmonic analysis, retaining 12-month and 6-month terms. The climatology and linear trend were removed from the H500 data, leaving the de-trended, de-seasonalized height anomalies.

Questions may still remain about the veracity of the H500 data at high southern latitudes, especially over the sparsely-observed southern oceans. A notable problem for daily time series is the incorrect handling of "PAOB" data from the late 1970s through the early 1990s. However, the reanalyses are still one of the best syntheses of available observations, and the effect of the above problems on the long-term statistics presented here is presumed to be small.

A number of objective definitions of blocking exist, related either to reversals in the meridional geopotential gradient (Lejenäs 1984), or to the existence of persistent geopotential anomalies (Dole and Gordon 1983). The latter approach is adopted here, allowing a characterization of blocking in two dimensions.

Persistent anomalies are defined at a point by a height anomaly exceeding a magnitude threshold (typically 100 m) and a duration threshold (typically 5 days). A number of threshold combinations have been tried, but all results reported here are based on the 100 m/5 days criteria. Daily time sequences of persistent anomaly events are summed into monthly totals, for analysis of interannual variability. The height field is used, in preference to stream function, as the focus is on the middle to high latitudes.

Monthly PPA totals are analyzed with a cluster analysis, based on Euclidean distance and the convergent K-means approach (Kidson 2000). The method starts from a series of random seeds and converges to a limit of one cluster, using between to within cluster variance to define merges. The final cluster selection is made visually, based on consistency across a series of trials starting from different seeds.

## 3. CLIMATOLOGY

The overall annual frequency of PPAs in the Southern Hemisphere is shown in Fig. 1.A broad maximum in occurrence lies from south of NZ to the southern Atlantic, with its axis near 60°S. Such a pattern is reproduced using different threshold criteria, and is also seen at 1000hPa. Seasonal variation in the shape of the pattern of Fig. 1 is small, being most intense and poleward in the cool months (primarily Jun-Sep), and weaker and farther equatorward in the warm months (primarily Dec-Mar).

A clear peak in occurrence is evident across the south Pacific in all seasons (not shown). The maximum lies near 120°W, in the main blocking region identified by Renwick and Revell (1999). The maximum frequency occurs early in the southern winter, especially May and June, although PPAs are relatively common in all seasons except late summer (Jan-Mar).

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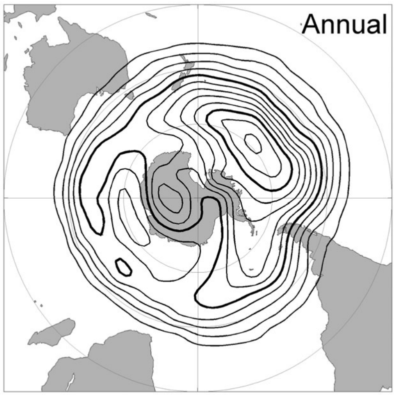


Figure 1: Mean annual frequency of PPA events (100m/5d thresholds) at 500hPa. Contours are numbers of days per year, contour interval is 5, with 25 and 50 contours thickened.

## 4. CLUSTERS AND INTERANNUAL VARIABILITY

A cluster analysis was applied to seasonal (3-month total) PPA counts, starting from sets of 50 random seeds (seasons). The metric used was Euclidean distance, based on normalized counts (each field was divided by the hemispheric total number of PPA counts for the season). Results were visually compared for consistency at each step between 12 and 2 clusters.

Best results were found for three clusters. The most populated cluster (47% occurrence) showed only weak PPA activity, with a dominance of zonal flow. The remaining two clusters showed peaks in PPA activity over the southeast Pacific (cluster 2) and near NZ (cluster 3). Figure 2 shows the mean of clusters 2 and 3.

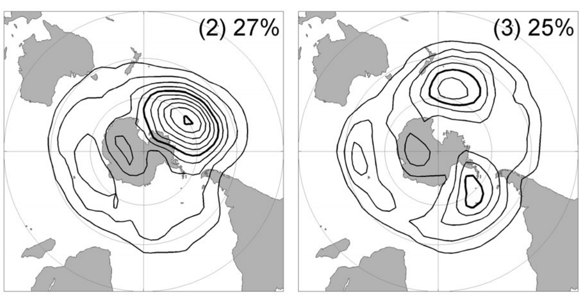


Figure 2: Mean PPA counts for clusters two (left) and three (right). Contours are numbers of days per month, contour interval is 1, with 5 and 10 contours thickened. Frequency of occurrence is shown in the top right of each panel.

It is apparent that PPAs near NZ tend to occur as part of a zonal wave number three pattern, with regions of persistent ridging also over the south Atlantic and to a lesser extent over the Indian Ocean. Cluster two has a broad peak in occurrence in the cool months, being most common from April to September. Cluster three has a sharper peak in winter (June-July especially).

There is strong interannual variability in the occurrence of each cluster. In the cool season months, their occurrence is related to tropical variability. Cluster 2 tends to occur more frequently in El Niño events, when anomalous tropical diabatic heating is concentrated near the Dateline. Cluster 3 tends to occur more frequently in La Niña events, when anomalous tropical diabatic heating is concentrated north of Australia. The approximate 60° longitude shift in the location of the tropical heating anomaly matches well with the shift in the longitude of the main center of action in each cluster. Differences in the zonal wave number of the response may be related to changes in wave propagation characteristics across the wintertime “split jet” region about and east of NZ (Renwick and Revell 1999).

## 5. SUMMARY

Persistent positive anomalies in the mid-tropospheric circulation of the Southern Hemisphere tend to occur most frequently in a broad region across the southern Pacific Ocean. Events over the eastern Pacific (where PPA occurrence is most frequent) tend to occur in isolation, while those near New Zealand tend to occur as part of a zonal wave number 3 pattern. Both types of PPA patterns appear to be at least partially forced by tropical diabatic heating anomalies.

The existence of two preferred patterns for PPA (blocking) occurrence over the SH may help explain discrepancies between recent studies of blocking and those carried out in the mid-1980s. Earlier work tended to rely on the Australian Bureau of Meteorology analyses, which have been shown to lack variability over the southern Pacific, especially in the east. Such a deficiency would tend to emphasize cluster 3 at the expense of cluster 2, and label the NZ region as the most common blocking region, rather than the more “popular” southeast Pacific.

## 6. *References*


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