

# Shorter contributions

## Pressure behaviour of the subtropical Atlantic anticyclone and its influenced region over South America

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### Introduction

The atmospheric pressure variability over the southern hemisphere subtropics in the Atlantic ocean, and its influenced area on the South American coast, have a key role on the wet circulation and precipitation over the subcontinent (Pittock 1980; Minetti and Vargas 1983a). Long time series of pressure observations over the ocean are not available since the pressure there is difficult to observe directly. The pressure measurements come from islands not well distributed over the ocean. However, data uniformly distributed over the southern hemisphere in time and space have been compiled by Harnack and Harnack (1984) in the form of sea-level pressure maps, for the period from 1956 to 1980. Using this information, the pressure series of meteorological stations on the South American coast (MSCP) will be correlated with the pressure at the centre of the subtropical anticyclone (ACP). To the extent that the MSCP are representative of the ACP, coastal data which are available for a much longer period may be used to infer the behaviour of the ACP.

### Data and method

Data from the monthly sea-level pressure maps published by Harnack and Harnack (1984) were used. These pressure maps are gridded every 10 degrees of latitude and 20 degrees of longitude. The ACP have been computed from an average of the pressures enclosed in the quadrilateral (20°-30°S, 0°-20°W) where the anticyclone centre is located most frequently (Taljaard et al. 1969).

The relationship between the ACP and the pressure at each grid-point, both deseasonalised, was investigated through a correlation analysis (Brooks and Carruthers 1953), and maps of isocorrelation fields were drawn. To determine the homogeneous areas of ACP variability for each month the isocorrelation line significant at a 5 per cent level ( $r=0.4$ ) was drawn. The isocorrelation line with  $r=0$  was also indicated to locate the area where the space-time variability regime changes its sign.

In a time series analysis of the ACP and the MSCP, correlograms and power spectra were computed (Tukey 1950), together with polynomial fitting, to analyse low frequency fluctuations (Conrad and Pollack 1950). A 13-month moving average was used to filter the seasonal variability.

### Results and conclusions

#### Spatial correlations

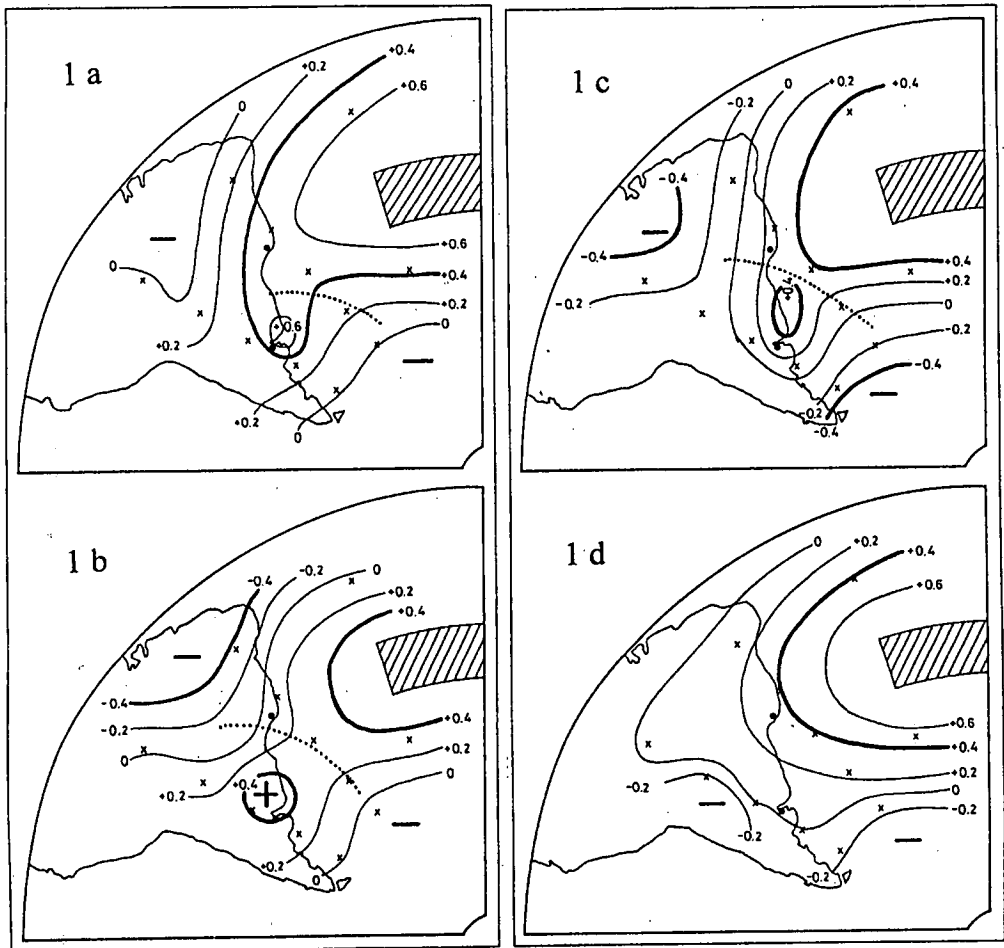
Figures 1(a) to 1(d) show the quadrilateral 10°-20°S, 0°-20°W, where the centre of the anticyclone is located (Taljaard et al. 1969), and the isocorrelation lines between the ACP and peripheral regions for the months December, January, June and July. These figures delineate areas of homogeneous space-time variation associated with ACP variation.

Over the South American coast there are two meteorological stations with a long data record, Rio de Janeiro and Buenos Aires (locations indicated by dots). The first location is close to 20°S, 40°W, and has a data record that more than covers the period of the Harnack and Harnack (1984) maps. The correlation between the pressure at 20°S, 40°W and the ACP is shown in Table 1 and is the same as that between Rio de Janeiro and the ACP.

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**Fig. 1** Isocorrelation fields for the months of (a) December, (b) January, (c) June, and (d) July. The quadrilateral enclosing the Atlantic subtropical anticyclone center, the nodes with information (crosses), Rio de Janeiro and Buenos Aires (dots), are located.



Buenos Aires has no grid-point close to it, so the correlations were calculated between the ACP and Buenos Aires itself. The results are also shown in Table 1.

The high correlation period for Buenos Aires from December to March can be explained by the trajectory of the moving anticyclones which during these months come from the southwest to this region and join the subtropical anticyclone of the southern Atlantic ocean. These high correlations can also be seen in Figs 1(a) and 1(b) over the Rio de la Plata. The maxima in correlations between the ACP and the South American coast during August may be related to high pressures

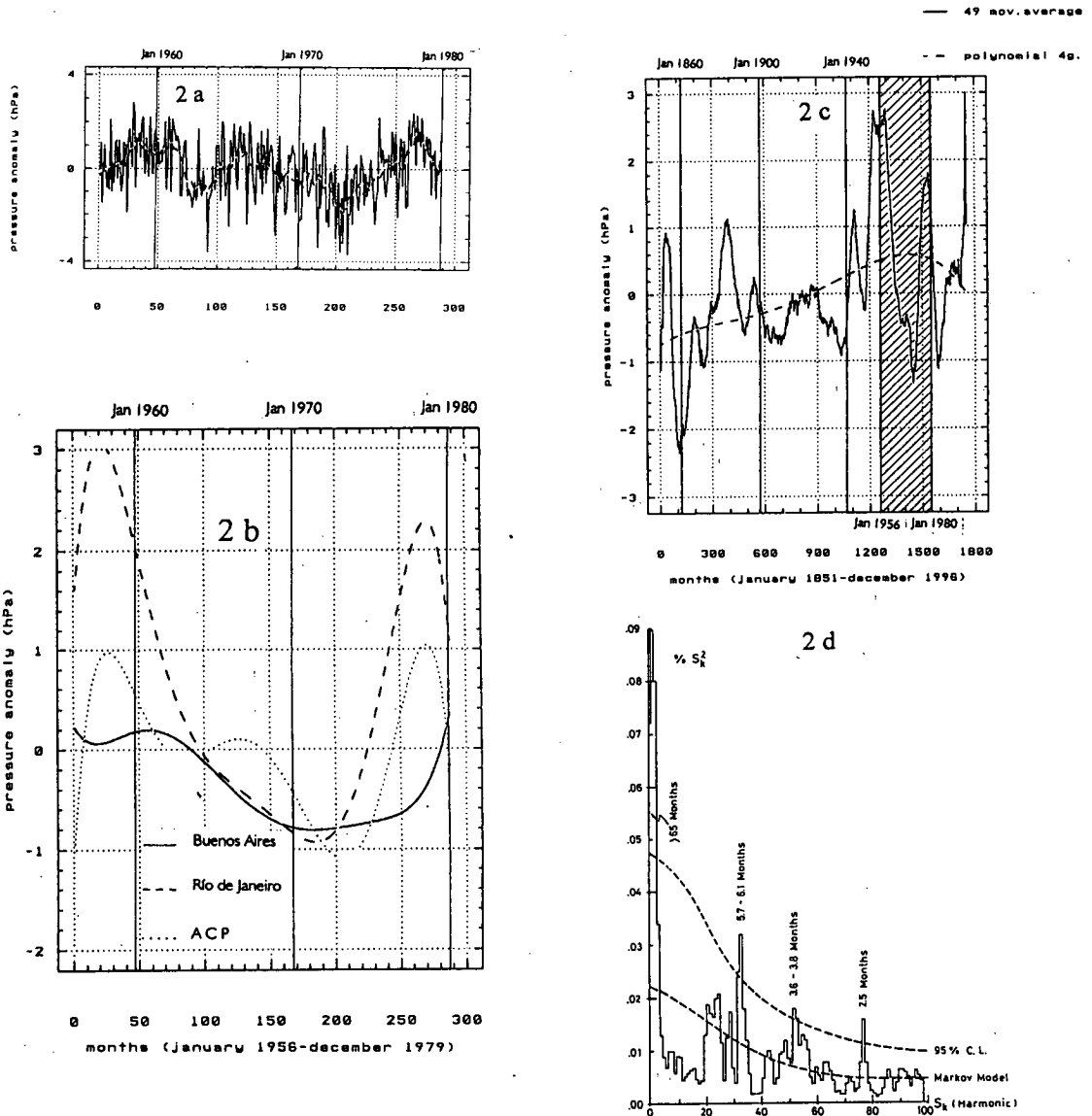
over the coastal region associated with a precipitation minimum in August (Hoffman and Flores 1989). It can also be seen from the maps that the pressure in the north and northeast of Brazil is generally inversely associated with the ACP.

Finally, the association between the pressures at Buenos and Rio de Janeiro, and the ACP in some months, may permit their use as a series representative of the ACP. The correlation of the monthly data matrix of Buenos Aires and Rio de Janeiro with that of the ACP for the total period 1956-1979 ( $n=276$ ) was  $r=0.21$  and  $0.40$  respectively, both significant at a 5 per cent level.

**Table 1. Correlations between the monthly ACP (average 20° -30°S, 0° -20°W) and (a) the monthly pressure at 20°S, 40°W, (b) the monthly pressure at Buenos Aires. Period 1956-1979. Bold numerals denote significance at the 5% level.**

Month	J	F	M	A	M	J	J	A	S	O	N	D
20°S,40°W	.19	.34	.20	.32	-.01	.29	.39	.52	.12	.35	.36	.51
Buenos Aires	.54	.46	.47	-.25	-.26	.35	-.16	.40	.18	.08	-.04	.61

**Fig. 2 (a) Pressure anomaly series (solid line) and its 13-month moving average (dashed line) of the ACP over the period 1956-1979; (b) sixth-order polynomial adjusted to the pressure anomaly series of the ACP (dotted line), Rio de Janeiro (dashed line), and Buenos Aires (solid line); (c) 49-month moving average and fourth-order polynomial adjustment of the Rio de Janeiro MSCP, over the period 1851-1996; (d) power spectrum of the monthly mean pressure anomaly in the Atlantic quadrilateral. A fitted Markov model is presented with its confidence limit at a 95% level.**



### Time series

The ACP, Rio de Janeiro and Buenos Aires monthly deseasonalised pressures were each found to be auto-correlated to lags of 19, 17 and 10 months respectively. This high persistence and low variability is characteristic of regions close to the subtropical anticyclone. Buenos Aires has a larger random component since it is located closer to the westerly migratory systems of high latitudes and the corresponding climatic regime.

Figure 2(a) shows the monthly ACP with its 13-month moving average. The MSCP from Buenos Aires and Rio de Janeiro have the same low frequency oscillations as those of the ACP in the period 1956-1979. Figure 2(b) shows sixth-order polynomials fitted to each of the ACP, Rio de Janeiro and Buenos Aires series. The minimum pressure during 1970-1971, and the lateral maxima can be seen. For a better long-term perspective, Fig. 2(c) depicts a 49-month moving average of the deseasonalised 1851-1996 series of Rio de Janeiro, with the period 1956-1971 shown dashed. A fourth-order polynomial was fitted to the series to analyse it over the long-term range.

There could be inhomogeneities introduced by changes in the location of the meteorological stations or changes in their formulae to reduce the pressure to sea level. However the pressure increase during the 1950s is corroborated by (a) the wet advection increase over the Argentine plain (Vargas et al. 1995), (b) continental cooling in South America (Minetti and Vargas 1983b) and (c) cloudiness and precipitation increase over most of Argentina (Minetti and Vargas 1996).

The pressure minimum at the end of the 1960s and the beginning of the 1970s is coincident with strong droughts in the subtropical Argentine plain (Campagnucci and Vargas 1983; Minetti 1989). This phenomenon also occurred over the eastern edge of the Atlantic ocean anticyclone in South Africa (Tyson 1981). The reverse situation occurred during the second half of the 1970s and the beginning of the 1980s, with anticyclonic maxima in the Atlantic ocean and a strong wet period over Argentina (Minetti and Sierra 1984; Hoffman et al. 1987).

Figure 2(d) shows the power spectra of the ACP in the period 1956-1979. A Markov red noise structure can be seen, with persistence (spectral peaks at low frequencies - periods greater than 65 months) explaining 25 per cent of the variance. Significant peaks of high frequency correspond to periods of 5.7-6.1 months, 3.6-3.8 months and 2.5 months. A quasi-period of 20 years, although not very clear, can be detected in Fig. 2(c) of the Rio de Janeiro

series. This period is more clear in the August and December series, when the ACP variability is propagated over the Brazilian coast, also reaching the Rio de la Plata.

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