Shorter contribution

A meridional circulation index and the precipitation in Argentina

Introduction

In this paper the relationship between a meridional circulation index around southern South America and the rainfall at selected meteorological stations in Argentina is studied. For this purpose daily analyses at 1200 UTC from the European Centre for Medium Range Weather Forecasts (ECMWF) are used, for the period from 1980 to 1988, together with rainfall data provided by the Servicio Meteorológico Nacional of Argentina.

Characteristics of the meridional circulation index

In order to determine the behaviour of the long waves around southern South America an index M, which compares the geopotential height, H, of the 500 hPa level in the Pacific and Atlantic Oceans at 40°S, is defined by:

$$M = H(40°S,90°W) - H(40°S,40°W)$$

where M and H are in geopotential metres (gpm). The value of M gives an indication of the mean meridional circulation between the abovementioned longitudes. An index of 10 gpm corresponds to a meridional flux of 0.2 m/s from the south if M is positive. The average value of M is +26.2 gpm, corresponding to a ridge in the Pacific Ocean as has been indicated by various authors, e.g. Trenberth (1980), Kousky and Bell (1992), and Alessandro (1995).

In spite of the nine-year period, the average monthly values of M show appreciable irregularities. For this reason the annual harmonic (Fourier) has been determined. This curve shows a maximum value of 51 gpm in January and a minimum of 11 gpm in July (Fig. 1). The daily standard deviation is 154 gpm and the persistence does not exceed three days, showing a strong influence of the short waves.

To evaluate larger waves, moving daily averages of M, over ten days, have been calculated as recommended by Namias and Clapp (1944). The averaging was applied twice. Anomalies of the moving ten-day averages were then calculated with respect to the original monthly means of the nine-year period. All of the following discussion applies to the smoothed values of M, and to anomalies of the smoothed values.

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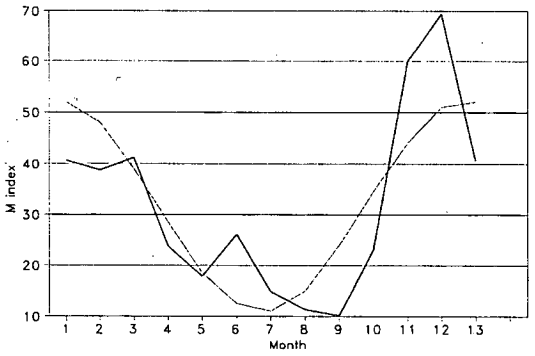
Fig. 1 **Average monthly values of M (gpm) for the period 1980-1988 (light line) and its first harmonic (dark line).**



Relation between meridional index and the atmospheric circulation over Argentina

A positive anomaly of the meridional index at 500 hPa is associated with a strengthening of the ridge over the Pacific Ocean or the appearance of a trough over the Atlantic. It indicates southerly meridional circulation at that level, normally associated with anticyclones, which coming from the Pacific cross the country from southwest to northeast, and decay over the Atlantic. Northerly winds advecting moisture from the tropics are suppressed. An example of this situation is given in Fig. 2 for 22 September 1980 (M = +190 gpm).

A negative meridional index indicates a ridge over the Atlantic or a trough over the Pacific and gives rise to an anomalous northerly meridional circulation. In this case high pressure systems intensify to the east of the continent with an increased advection of moisture from the north. Frequently, low pressure systems cross the southern part of Argentina or form over the northeastern part of the country. See for instance the situation on 14 September 1984 (Fig. 3) (M = -80 gpm).

Patterns of anomalous precipitation in response to M

To study the association between the meridional index and precipitation, nine stations have been selected, corresponding to different climatic regimes in Argentina. Their coordinates and heights are given in Table 1. Annual mean precipitation and mean amounts accumulated over ten days, not taking into account the time of the year, are also shown.

Anomalies of the precipitation were accumulated for ten-day non-overlapping periods. There were 52 cases with $M > +\sigma$ and 55 with $M < -\sigma$. Figure 4 shows the

Fig. 2 **Synoptic situation at 1000 hPa on 22 September 1980 (ECMWF), corresponding to strong positive meridional index (units gpm).**

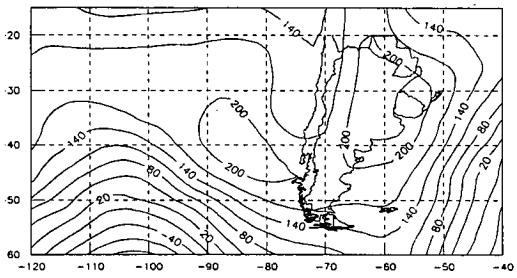
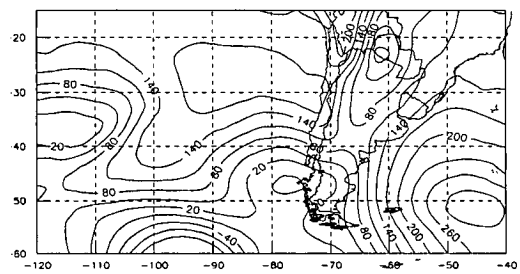


Fig. 3 **Synoptic situation at 1000 hPa on 14 September 1984 (ECMWF), corresponding to strong negative meridional index (units gpm).**



distribution of the average anomalies of precipitation accumulated in ten days, (a) for the cases of $M > \sigma$ and (b) for $M < -\sigma$. In Fig. 5, percentage deviations from normal are analysed (a) for $M > +\sigma$ and (b) for $M < -\sigma$.

In Figs 4(a) and 5(a) it is seen that strong positive anomalies of M are associated with negative deviations of the precipitation throughout the country. The association is strongest in the southeastern part of Buenos Aires under the direct influence of transient anticyclones. Another strong deficit is seen in the Andes mountains region, a result of the subsidence associated with the Pacific ridge, suppressing orographic precipitation. The influence of the positive M is weakest in the northwest and west of the country. Here rainfall occurs mainly during the summer and increased easterly winds (Fig. 2) advect moist air masses promoting some thermal-orographic precipitation.

Figures 4(b) and 5(b) show above-normal precipitation is associated with negative meridional index values. The increase of precipitation is most pronounced in the eastern part of Buenos Aires, being double the normal. The strong northeasterly winds (Fig.3) advect moisture which triggers good frontal precipitation. As has been stated by Wölcken (1954) frontal precipitation is most important in the abovementioned area. Again the north and west of the country is the exception. A strong northwestern low is associated with lower precipitation in that region (Lichtenstein 1981).

Conclusions

A meridional index at 500 hPa taken at 40°S between 90 and 40°W, is positive throughout the year, corresponding to a ridge in the Pacific Ocean. It is at a maximum in January and a minimum in July. Strong positive anomalies of the index are associated with negative anomalies of the precipitation and vice versa. The association is strongest over the eastern part of Argentina, and is weakest over the northwest and west of the country.

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Table 1. Selected stations showing average annual precipitation (mm) and the corresponding value for ten days.

Station	*Latitude (S)*	*Longitude (W)*	*Height (m)*	*Av. ann. precip.*	*Precip. 10 days*
Bariloche	42°06'	71°10'	840	714.5	19.6
C. Rivadavia	45°47'	67°30'	46	228.2	6.3
Cordoba	31°24'	64°11'	474	869.7	23.8
Corrientes	27°28'	58°49'	62	1645.5	45.1
Ezeiza	34°50'	58°32'	20	1022.3	28.0
Mendoza	32°50'	68°47'	703	223.1	6.1
Neuquen	38°57'	65°08'	270	182.6	5.0
Salta	24°51'	65°29'	1221	836.8	22.9
Sta Rosa	36°34'	64°16'	191	726.2	19.9

Fig. 4 **Anomalies of precipitation (mm) accumulated during ten days. (a) For all cases when the index $M > +\sigma$. (b) For all cases when the index $M < -\sigma$.**

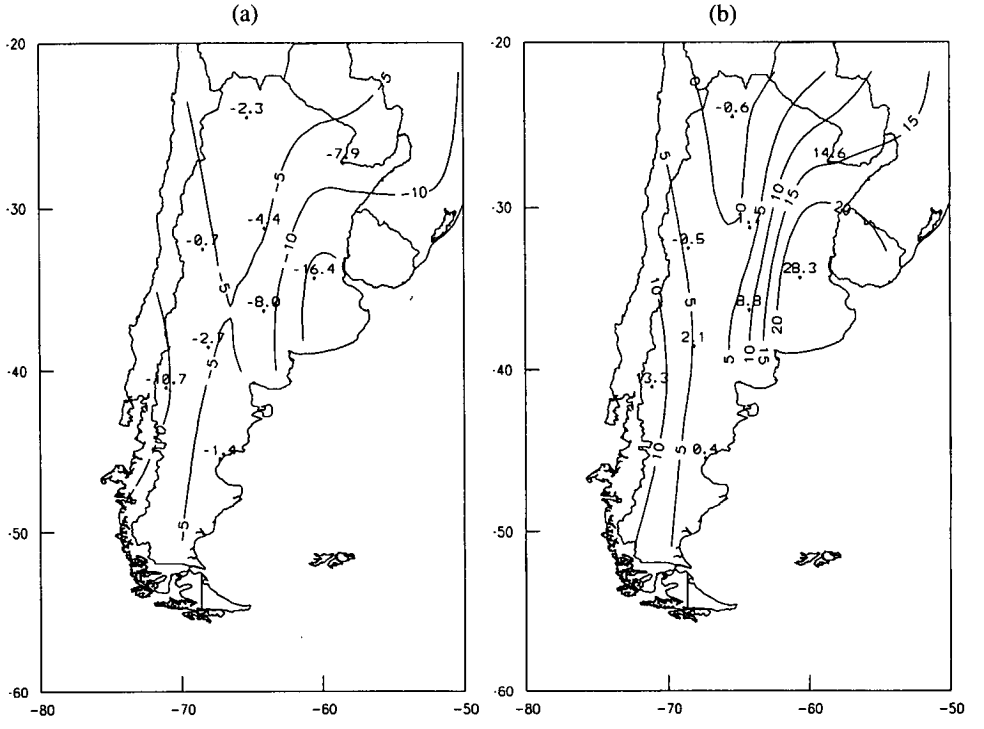
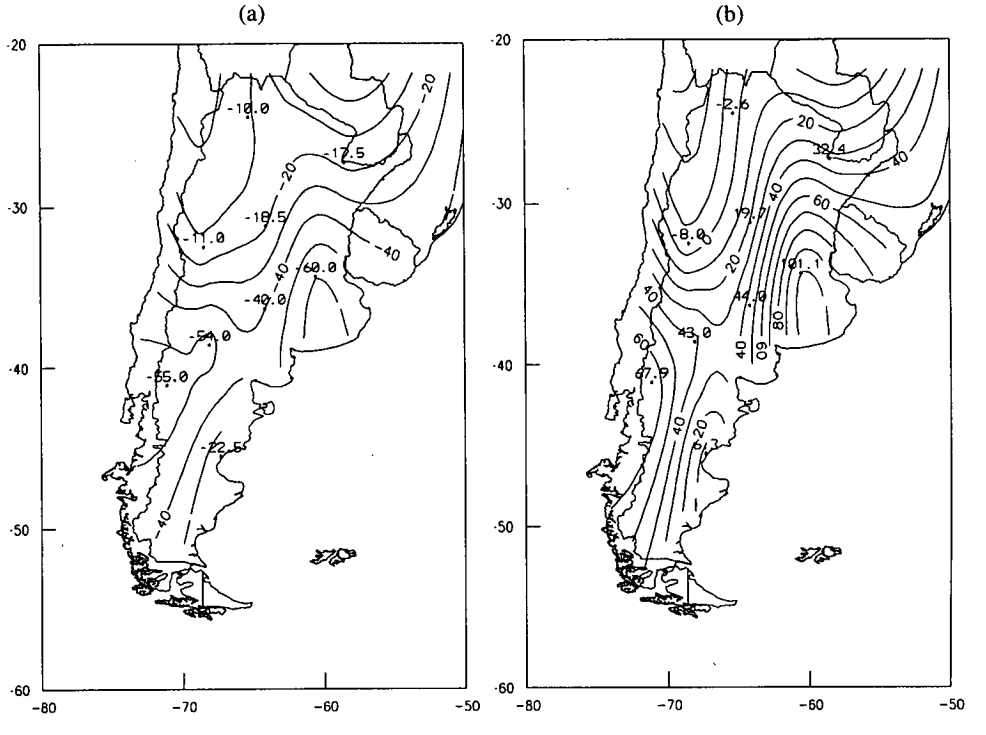


Fig. 5 **Percentage deviation of precipitation from normal for (a) $M > +\sigma$ and (b) $M < -\sigma$.**



References

Alessandro, A. P. 1995. Algunos aspectos de la influencia del continente sudamericano en la circulación regional. *Meteorologica, 20*, 85-94.

Kousky, V.E. and Bell, G.D. 1992. Atlas of the Southern Hemisphere, *NOAA Atlas No. 9*.

Lichtenstein, E. R. 1981. La depresión del Nordeste Argentino. Tesis de Doctorado, Universidad de Buenos Aires, 45-57.

Namias, J. and Clapp, P. F. 1944. Studies of the motion and development of long waves in the westerlies. *J. Met., 1*, 57-66.

Trenberth, K.E. 1980. Planetary waves at 500 mb in the Southern Hemisphere. *Mon. Weath. Rev., 108*, 1378-89.

Wölcken K. 1954. Algunos aspectos sinópticos de la lluvia en la Argentina. *Meteoros, 4*, 327-66.