Low level moisture convergence and precipitation anomalies over Central South America during the ENSO events of the period 1960-1998

Guillermo J. Berri and Germán Bertossa

Department of Atmospheric and Oceanic Sciences, University of Buenos Aires

National Research Council of Argentina

Ciudad Universitaria, 1428 Buenos Aires, Argentina

Tel/Fax 54 11 4756 3356/3364 Extension 23

Email: berri@at.fcen.uba.ar

1. Introduction

The purpose of this analysis is to explore the relationship between the low level moisture transport convergence and precipitation anomalies over Central South America (CSA) during the ENSO events of the period 1960-1998. Droughts or intense precipitation have a serious impact on the economy of the region and ENSO events are one of the major causes of such anomalies. Understanding how the moisture transport anomalies are related to precipitation anomalies can bring some light on the dynamics of precipitation variability in the region.

2. Data and Methodology

The region of study is a box delimited between 40^oS-10^oS and 75^oW-35^oW. We use the general balance equation for the atmospheric water vapor which can be expressed as (Peixoto and Oort, 1992):

$$P - E = -\frac{\partial W}{\partial t} - \nabla.Q \qquad (1)$$

where E is the evaporation rate, P is the precipitation rate, W is the total precipitable water and Q is the vertically integrated horizontal water vapor flux which is defined as:

$$Q = \left(g\rho_w\right)^{-1} \int_{p=1000hPa}^{p=700hPa} qvdp \qquad (2)$$

where v is the horizontal velocity vector, q is the specific humidity, g is the acceleration of gravity and ρ_w is the density of water. According to Peixoto and Oort (1992) for a sufficiently long period such as a month, the time rate of change of W can be neglected. Since the calculations are carried out on a monthly basis during the period 1960-1998, the balance between E, P and the divergence of the water vapor flux is achieved in equation (1). Monthly mean values of specific humidity, zonal and meridional winds components and surface latent heat flux are obtained from the NCEP Reanalysis. The evaporation rate E is obtained as the ratio between the latent heat flux and vaporization latent heat (Labraga et al. 2000) We consider the vertically integrated water vapor flux only up to 700 hPa level, since the contribution of the upper levels is negligible. The wind components and specific humidity for the calculations of equation (2) are taken at the following standard pressure levels: 1000 hPa, 925 hPa, 850 hPa, 700 hPa. The monthly precipitation data are obtained from the UEA-CRU database (New, Hulme and Jones, 1999). All of these data are available on a uniform 2.5^{o} lat x 2.5^{o} long grid resolution.

Convergence/divergence in the water vapor fluxes are computed by centered differences. Anomalies in the moisture transport and the term P-E are obtained as the difference between the mean value for El Niño and La Niña years, with respect to the mean value of the period 1960-1998. Table 1 shows the El Niño and La Niña years considered in this study. This monthly analysis is carried out consecutively from October of the year of onset to April of the following year.

El Niño years:	1963/64 – 1965/66 – 1969/70 – 1972/73 – 1976/77 – 1977/78 – 1982/83 –
	1986/87 – 1991/92 – 1992/93 – 1994/95 – 1997/98
La Niña years:	1964/65 – 1970/71 – 1973/74 – 1975/76 – 1988/89 – 1995/96 – 1998/99

Table 1. El Niño and La Niña selected years

3. *Results*

La Niña composite (Figures 1a and 1b), shows in general in several months, negative *P–E* anomalies associated with moisture transport (*MT*) divergence $(-\nabla.Q < 0)$ in southeastern CSA, that includes northeastern Argentina, Uruguay and southern Brazil (AUB). December is characterized by a sort of moisture transport corridor that extends from NW to SE across Bolivia, Paraguay and southern Brazil up to the Atlantic Ocean. This corridor is characterized by positive *P-E* anomalies and *MT* $(-\nabla.Q > 0)$**,** and flanked to the north and the south by large regions with strong precipitation deficit. In January, this corridor appears more clear and extended over wider regions towards southeastern CSA, where the largest precipitation anomalies are located. In January there is a moisture transport contrast between the northeastern *MT* divergence region and the *MT* convergence region located to the south. In February a *MT* divergence region appears in Uruguay which displaces the convergence regions to the north in the following months. This is connected with negative *P-E* anomalies over the same region of *MT* divergence which grow in size during the following months.

El Niño composite (Figures 2a and 2b) shows predominantly positive *P-E* anomalies associated with MT convergence over AUB, in contrast with the results observed in the La Niña composite. In November, the region with *P-E* anomalies grows in size and in December they move southwestward to

3

central-northern Argentina, flanked to the north by a large region with precipitation deficit to the North of AUB. March presents similar characteristics to December. On the other hand, January and February show large regions with positive *P-E* anomalies over northeastern CSA and regions with negative precipitation anomalies concentrated over northwestern CSA. January presents a distribution of maximum and minimum *P-E* anomalies similar to December of La Niña composite, although with opposite signs. In every month, from October to April, we find predominantly positive *P-E* anomalies over AUB and November is the month that presents the most extension of those anomalies over that region. In general, the relationship of the type *MT* convergence (divergence) / positive (negative) *P-E* anomalies is not so well-defined as in the case of La Niña composite.

4. *References*

Labraga J.C., O. Frumento, and M. López, 2000: *The atmosphere water vapor cycle in South America and the tropospheric circulation.* J. of Climate*, **11**,1899-1915.

New, M., M. Hulme, and P. Jones, 1999: *Representing twentieth-century space-time climate variability. Part I: Development of a 1961-90 mean monthly terrestrial climatology*. J. Climate, 12, 829-856.

Peixoto, J.P., and A.H. Oort 1992: *Physics of Climate.* American Institute of Physics, 520 pp.
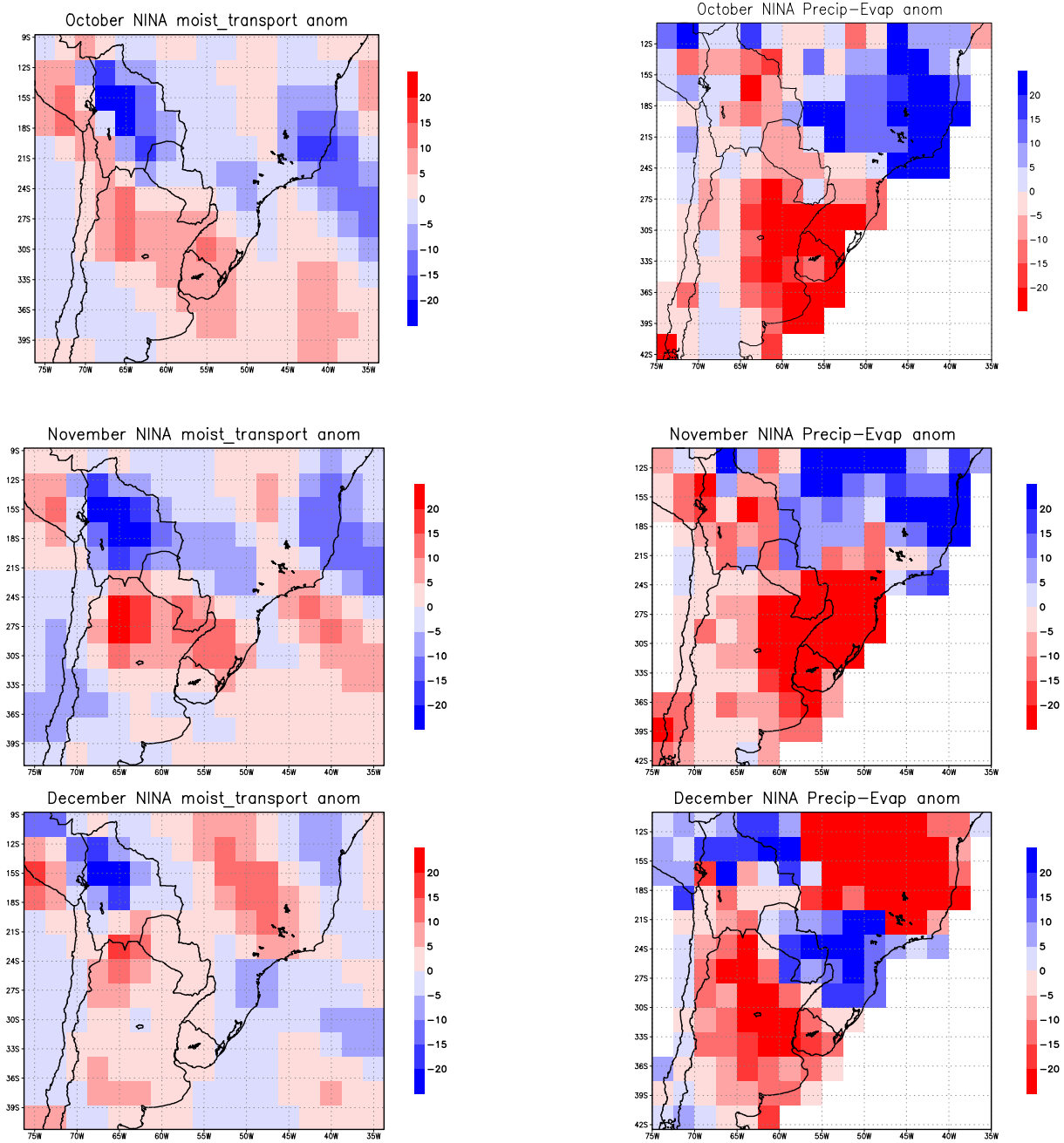
Fig 1a. Monthly moisture transport anomalies (left panel), and precipitation-evaporation anomalies (right panel). Composite of La Niña events during October, November and December of the period 1960-1998
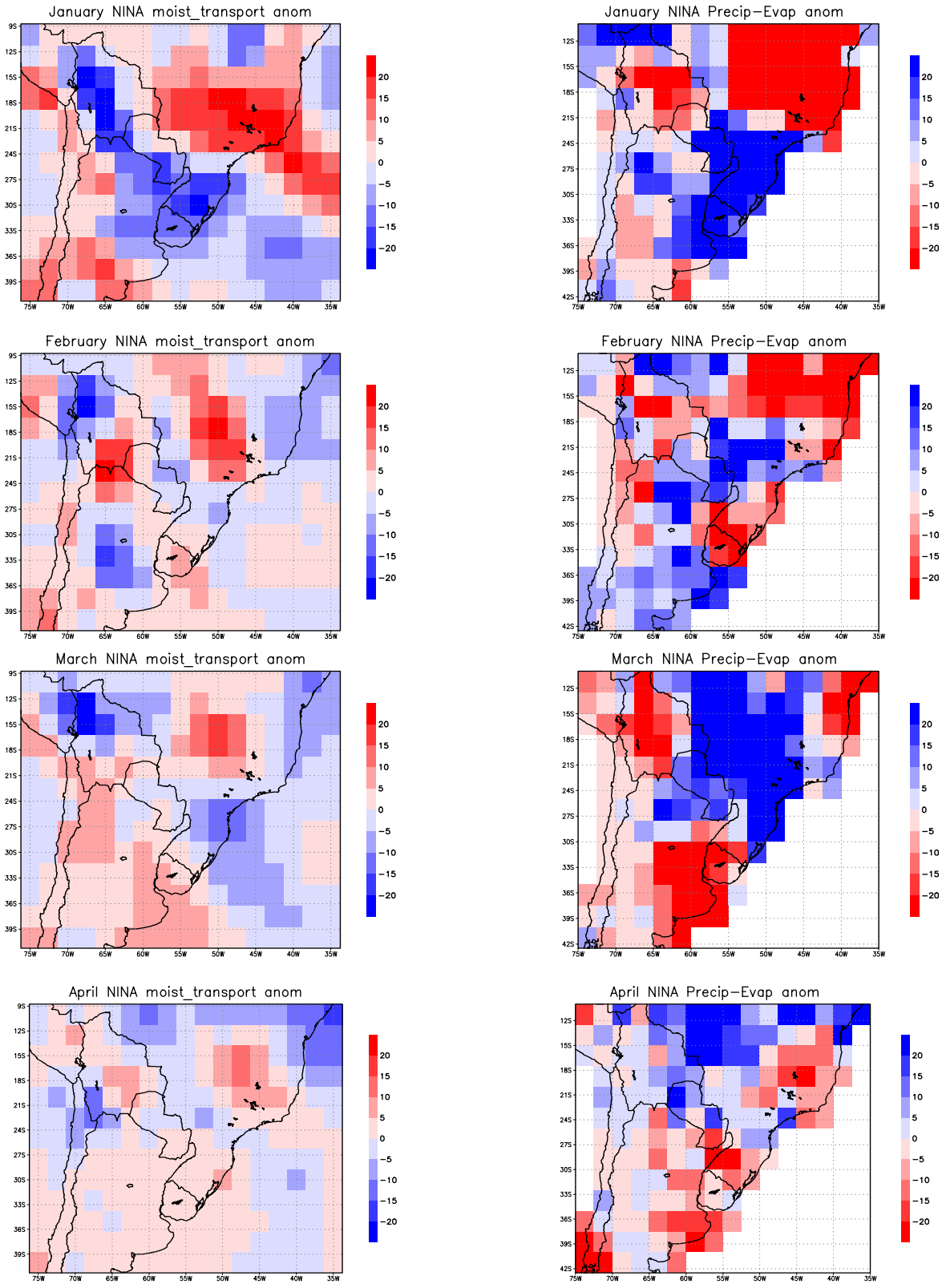
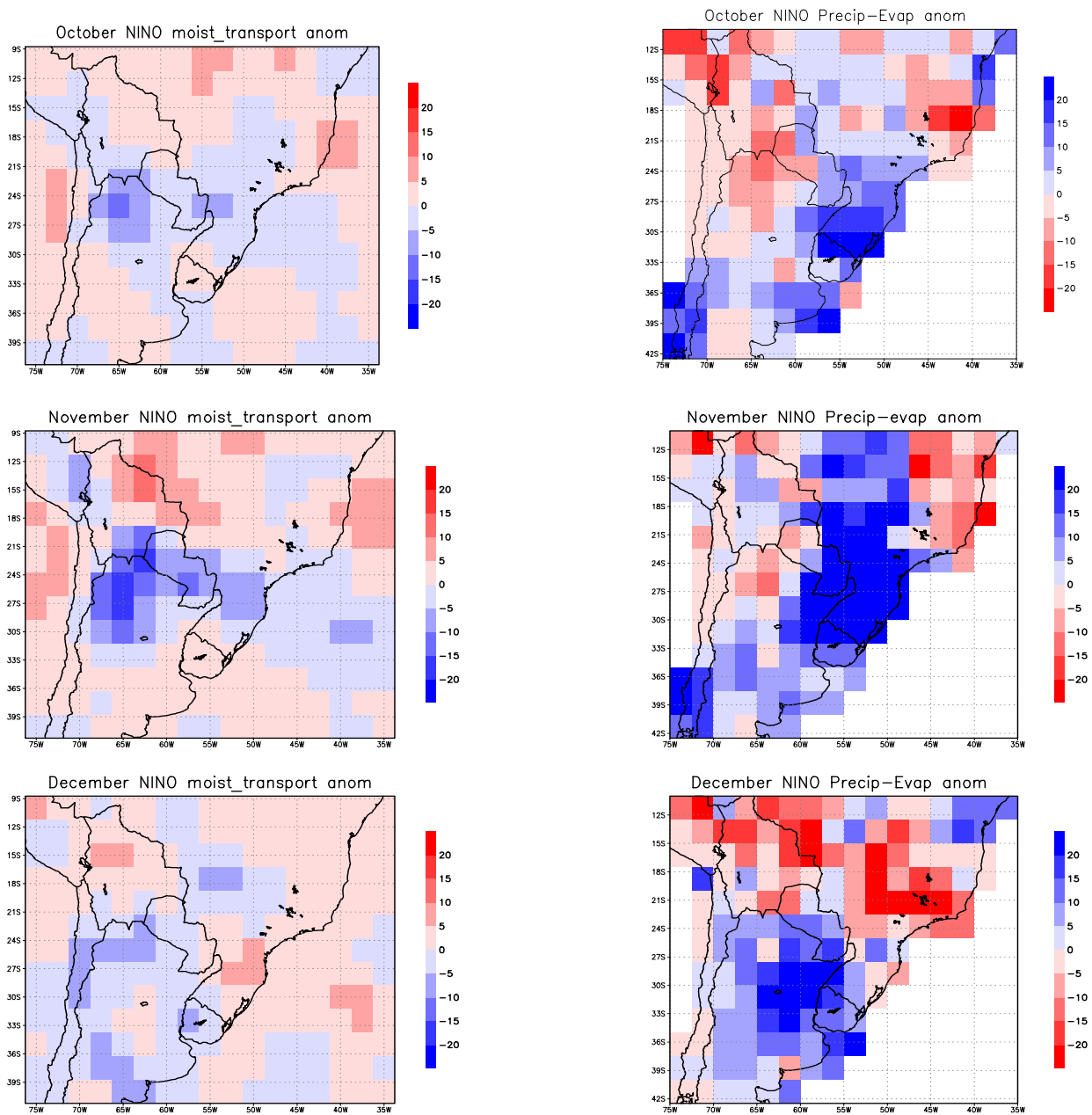*Fig 1b. Same as figure 1.a for January, February, March and April.*

Fig 2a Monthly moisture transport anomalies (left panel), and precipitation-evaporation anomalies (right panel). Composite of El Niño events during October, November and December of the period 1960-1998
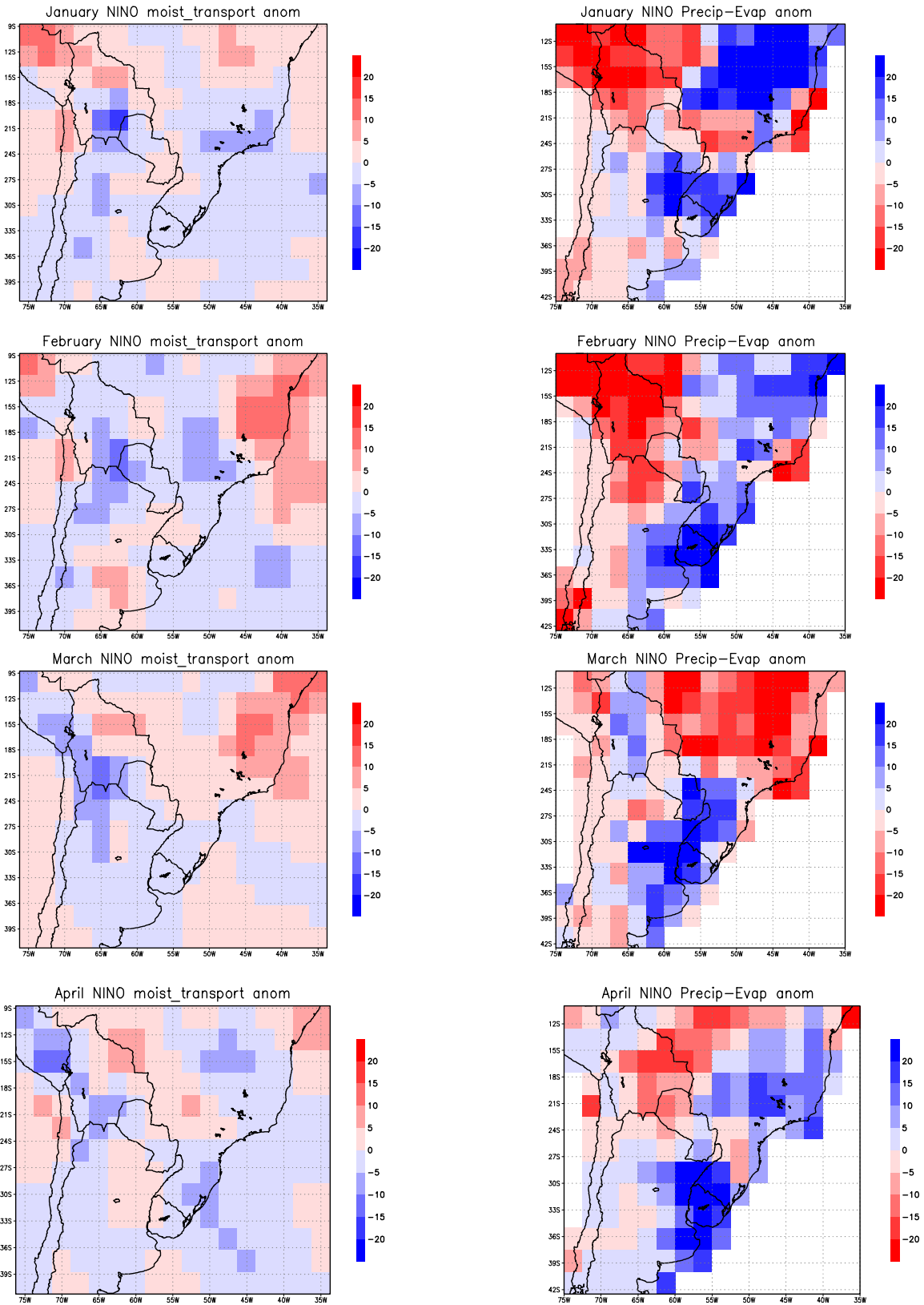
Fig 2b. Same as figure 2.a for January, February, March and April