# P2.6 TELECONNECTION BETWEEN TROPICAL WEST PACIFIC CONVECTION AND COLD SURGES IN THE SOUTHERN SOUTH AMERICA DURING AUSTRAL WINTER

Gabriela V. Müller* Tercio Ambrizzi** Mario N. Nuñez* Simone E. T. Ferraz**
*Centro de Investigaciones del Mar y la Atmosfera CONICET-UBA. Argentina
** Instituto de Astronomia, Geofisica e Ciencias Atmosfericas IAG-USP. Brasil

## 1. INTRODUCTION

In the Southern Hemisphere the main wave activity occurs around the subtropical and subpolar jets which may act as waveguides (Ambrizzi et al. 1995, Ambrizzi and Hoskins 1997). During the Austral winter, synoptic waves propagate through the South Pacific Ocean following these main trajectories, being faster over the subpolar regions and slower around the subtropical latitudes (Berbery and Vera 1996). This behavior corresponds to the patterns observed some days before a general freezing event occurs over the region known as Pampa Humeda. As the waves get closer to the Andes, they tend to spread meridionally on a NW-SE orientation, moving towards the NW of the Andes lee side. Once the wave crosses the Andes, it goes northward, consistent with the concept of Rossby wave dispersion on the sphere Hsu (1987).

As many studies have already shown, the cold surges over the South American continent during winter are usually followed by changes in the atmosphere circulation at low, middle and high levels on synoptic and planetary scales. In particular some works for the South and Southeast of Brazil (Krishnamurti et al. 1999, Marengo et al. 2002), have demonstrated that there is some indication of possible precursor mechanisms prior to freezing events. For instance, the cold waves propagate from the south Pacific to the southwest extreme of South America, move towards the north of the continent, and sometimes reach tropical regions, being responsible for a rapidly drop in temperature over these areas.

## 2. METODOLOGY

Using the same criteria considered by Müller et al. (2000), we define general freezing days as those which we have above 75% of the meteorological stations with minimum temperatures below 0° over the Pampa Humeda region.

Between the period of 1961 and 1990, we have separated the winters where the numbers of freezing events were above or below average, considering one Standard deviation. Therefore it was possible to identify the years of extreme general freezing events. The years of the freezing cases above one standard deviation are 1970, 1976 and 1988; and below one standard deviation are 1968, 1973, 1982 and 1986.

The baroclinic model used in the present study was originally developed by Hoskins and Simmons (1975), and extensively used in the study of large scale circulations forced by convective sources (e.g. Ambrizzi and Hoskins 1997). It is a primitive equation model with a global domain, spectrally truncated with a total zonal wavenumber 31 (T31) and 12 vertical levels. The model includes horizontal and vertical diffusion and Newtonian cooling. As initial conditions in the baroclinic model meridional and zonal wind, air temperature and geopotential are used. The basic data comes from the NCEP-NCAR reanalysis available in a 2,5°x2,5° grid and obtained from the NOAA-CIRES Climate Diagnostics Center website www.cdc.noaa.gov.

The model was integrated for 15 days and perturbated with a heating source. The basic state used in the experiments corresponds to a mean flow based on the composites of the freezing events selected. Several sensitivity tests related to the position, amplitude and vertical profile of the heating forcing were carried out.

## 3. RESULTS

The numerical experiments have shown that when the heating forcing is placed in a favorable location and with precise amplitude, Rossby waves are generated and propagate in a manner similar to the wave patterns observed during freezing episodes over South America. OLR composite field for the above average cold events indicated a strong negative anomaly in the tropical west Pacific (figure not shown) around (160°E 10°S). Numerical simulations considering different forcing amplitudes and specially positioned at this location were carried out. Fig.1 shows the day 12 integration of the meridional wind anomaly at 250 hPa for the heating located at the same position of the OLR negative anomaly field. One can clearly see a distinct planetary wave pattern emanating from the heating source and propagating towards the South America. From the observational analysis (not shown), a few days prior to the cold event, a couple of well defined wave patterns are also found. They propagate around the subtropical and subpolar jets, having different velocities by arriving in phase at the west of the South American continent and coinciding with the general freezing event over the Pampa Humeda. The numerical results and observational analysis indicate an increase of the wave amplitude soon after it crosses the Andes. This anticyclone perturbation is responsible for the rapid drop in temperature over the region, which combined with the effect of radiative loss and cold air advection from the south creating the necessary conditions for general freezing episodes over center-east of Argentina. In accordance to the climate-synoptic classification from Müller et al. (2002), the above description is one of the most frequent patterns responsible for the cold surges over Pampa humeda.

---

*Corresponding author address*: Gabriela Müller, Centro de Investigaciones del Mar y la Atmósfera, Pabellón II 2° Piso, Ciudad Universitaria, (1428) Buenos Aires Argentina**.**
e-mail: muller@at1.fcen.uba.ar

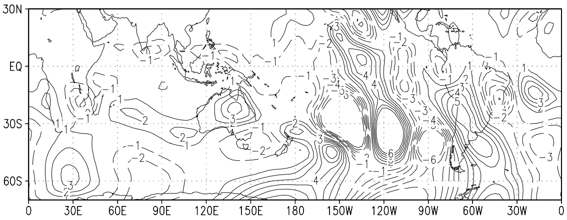


*Figure 1: Meridional wind anomaly at 250 hPa of the day 12 integration for the experiment with one standard deviation above average mean flow.*

On the other hand, for similar numerical experiments but using the mean flow from the years that the general freezing events were below average, the planetary wave patterns were very different (Fig.2). The wave trajectories do not seem to favor the occurrence of freezing events. It is clear from Fig.2 that there was not a coupling between the subtropical and subpolar waves.

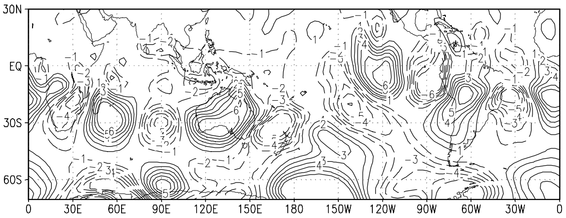


*Figure 2 Meridional wind anomaly at 250 hPa of the day 12 integration for the experiment with one standard deviation below average mean flow.*

These results suggest that the presence of strong convection in some regions of the tropical west Pacific may produce Rossby waves which can be trapped inside the subtropical and subpolar waveguides, arriving in a right phase over South America and originating freezing episodes over large regions of Argentina. However, it seems that if there is not a coupling between both waves prior to there arrival at the continent, there are less chance of cold events occurrences.

## 4.CONCLUSIONS

Our numerical experiments suggest that a convective forcing with a right amplitude and placed in a precise position generates Rossby wave patterns which can play an important role in producing cold surges and freezing events over the Pampa Humeda. Thus, the results indicate that quasi stationary Rossby waves emanating from the western tropical Pacific during wintertime might represent an important mechanism from tropical-extratropical interaction that affects weather and climate in Argentina and possibly southeast South America in general (Marengo et al., 2002).

In particular, for the center-east of Argentina, known as Pampa Humeda, our numerical and observational studies show that for the years when the number of cold events were above average, there is a convergence pattern of the subtropical and subpolar jets in this region. Therefore, synoptic systems are conducted through the continent, with cold air advection from the south-southwest direction. On the other hand, when there is below average cold surges over the center-east Argentina, the subtropical and subpolar jets show a divergent pattern, with seems unfavorable for synoptic systems penetration. Thinking in terms of the wave theory and from the comparison of the observational and numerical results it is suggested that freezing events may occur when the subtropical and subpolar waveguides are in the right phase, which allow the incursion of large amplitude troughs from the south part of South America.

**Acknowledgments**:

This work is supported by the IAI-CRN-055 and ANPCyT 07-6335 grants. TA was also supported by CNPq (301111/93-6) and FAPESP.

## REFERENCES

Ambrizzi T, Hoskins BJ, Hsu HH., 1995: Rossby wave propagation and teleconnection patterns in the austral winter. *J Atmos. Sci.*, **52**, 3661-3672.

Ambrizzi T, Hoskins BJ., 1997: Stationary Rossby - wave propagation in a baroclinic atmosphere. *Q. J. Met. Soc*., **123,** 919-928.

Berbery EH, Vera CS., 1996: Characteristics of the Southern hemisphere winter storm track with filtered and unfiltered data. *J. Atmos. Sci.,* **53**, 468-481.

Hoskins, B.J., and A.J. Simmons, 1975: A multi-layer spectral model and the semi-implicit method. *Q.J.R.Meteorol.Soc*., **101**, 637-655.

Hsu HH., 1987: Propagation of low-level circulation features in the vicinity of mountain ranges. Mon. Wea. Rev., **115**, 1864-1892.

Krishnamurty TN, Tewari M, Chakraborty DR, Marengo JA, Silva Dias PL, Satyamurti P., 1999: Downstream amplification: A possible precursor to major freeze events over south-eastern Brazil. *Weather Forecasting* **14**, 242-270.

Marengo JA, Ambrizzi T, Kiladis G, Liebmann B., 2002: Upper-air wave trains over the Pacific Ocean and wintertime cold surges in tropical-subtropical South America leading to Freezes in Southern and Southeastern Brazil. *Theor. Appl. Climat.,***74**, 243-247.

Müller GV, Nuñez MN, Seluchi ME., 2000: Relationship between ENSO Cycles and Frosts Events within the Pampa Húmeda Region. *Inter. Jou. of Clim.* **20,** 1619-1637.

Müller GV, Compagnucci RH, Núñez MN, Salles MA. 2002. Surface Circulation associated to frosts in the wet Pampas. *Inter. Jour. of Clim.* Accepted.