Midsummer circulation in subtropical South America and related precipitation patterns.

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Introduction

Sea surface temperature (SST) in the western subtropical South Atlantic (WSSA) modulates the interannual SACZ position and intensity (Barros et al, 2000). In addition and independent of the SACZ intensity or position, the SST in WSSA has a direct effect on the precipitation of this region with SST positive (negative) anomalies associated to enhanced (reduced) precipitation (Barros et al, 2000). Because of this and of the indirect effect through the SACZ, summer precipitation in eastern SA correlates positively and significantly with the SST in the western subtropical South Atlantic (WSSA), reaching up to 0.8 in some areas (Doyle and Barros, 2000). These results are consistent with the correlations between precipitation in Uruguay and southern Brazil and the SST in the Southwestern Atlantic Ocean during summer months (Díaz et al., 1998).

Nogués-Paegle and Mo (1997) documented a seesaw pattern on the SACZ in which each phase lasts about 10 days. They found that events with strong (weak) convective activity over the SACZ were associated with negative (positive) rainfall anomalies in the subtropical region to the south of the SACZ. A strong SACZ is likely associated with enhanced subsidence south of the SACZ as it was found in numerical experiments (Gandú and Silva Díaz, 1998). In addition, the convective seesaw variability is accompanied by a change in the direction of the low level circulation from the tropics, which flows eastward (southeastward) at about 20°S in the case of strong (weak) SACZ events and by an eastward (westward) shift of the South Atlantic subtropical high (Nogués-Paegle and Mo, 1997).

In this paper we will show that this dipole, present in the synoptic scale, is also present in the climatic scale and is associated to anomalies in the southwestern Atlantic sea surface temperatures.

Data and Methodology

Daily tropospheric variables (*u, v, q, geopotential height)* were taken from the NCEP/NCAR reanalysis (Kalnay et al. 1996) with a resolution of 2.5° latitude by 2.5° longitude. The moisture transport was calculated integrating the daily product *qv* between surface and 700 hPa. These values were then averaged for every month.

Total monthly precipitation data have been taken from 107 records for Argentina, Brazil, Paraguay and Uruguay, available from the National Meteorological Service, the Monthly Climate Data for the World of the National Center for Atmospheric Research (NCAR) and from the Institute of Agricultural Research of Rio Grande do Sul and from the brazilian National Agency of Electricity.

Monthly Sea surface temperature data for the Atlantic Ocean from 10°S to 40°S, and from the South American coast to 10°E, were obtained from the Comprehensive Ocean-Atmosphere Data Set (COADS) (Woodruff et al 1987).

Results

The analyses are focused on January as the month representative of the midsummer conditions. A canonical correlation analysis (CCA) between SST of the western South Atlantic north of 40° S and precipitation over SSA was carried out to study how these fields are statistically related. Previously, a principal component analysis (PCA) was performed separately in the SST and in the precipitation field, retaining the components which accounted for 80 % of the variance in each case.

The second canonical pattern highlights a dipole structure in the precipitation field with centers in the SACZ area and in SSA. The correlation pattern with SST has the same sign over practically the whole region, a large area with significant values and a maximum centered at about 23° S near the coast. High SSTs are associated with increased precipitation in the southern center of the dipole and with the opposite behavior in the northern center.

The composites of water vapor transport, precipitation, geopotential height and wind, corresponding to the warmest and coldest cases have been compared to explore how the interannual rainfall and circulation varies with the SST averaged over this region. We have considered the warmest cases to be those in which this temperature is higher than its mean plus its interannual standard deviation. Similarly, the coldest cases were considered as those in which this temperature was less than its mean minus the interannual standard deviation.

The results from these composites are summarized in figure 1 which presents an illustrative scheme of the mean low-level flow and precipitation anomalies in subtropical SA corresponding to extreme SST in the WSSA. In the W case, the main flow from the tropics has a southeastward direction starting at 10°S and converges with the west flow at 35°S over the ocean. In the C case, the flow from the tropics turns to the east toward the SACZ, whereas to the south of it there is an anticyclonic circulation with westward flow north of 35°S.

In the W cases, there are positive rainfall anomalies in northeastern Argentina and southern Brazil, in the path of the mainstream of the low-level moisture transport. In the C case, the positive anomalies are in the SACZ, which in this case is shifted northward of its mean position while negative anomalies are observed in northeastern Argentina and Southern Brazil. These negative anomalies are a consequence of the subsidence and the suppression of the water vapor transport from the tropical continent. On the other hand, in western Argentina there are positive anomalies in precipitation favored by the transport of moisture from the Atlantic Ocean over this otherwise arid region.

References

- Barros, V. M. González, B. Liebmann and I. Camilloni, 2000: Influence of the South Atlantic convergence zone and South Atlantic sea surface temperature on interannual summer rainfall variability in southeastern South America. Theor. Appl. Climatol., 67, 123-133.
- Díaz, A. F., C. D. Strudzinski and C. R. Mechoso, 1998: Relationships between precipitation anomalies in Uruguay and Southern Brazil and sea surface temperature in the Pacific and Atlantic Oceans. J. Climate, 11, 251-271.
- Doyle, M and V. Barros 2000: Relación entre la precipitación estival y patrones de circulación. CD- ROM of the XI Brazilian Congress of Meteorology. Rio de Janeiro, Brazil. Brazilian Meteorological Soc., 5 pp.
- Gandú, A. W. and P. L. Silva Diaz, 1998: Impact of tropical heat sources on the South American tropospheric circulation and subsidence. J. Geoph. Res., 103, d6, 6001-6015.
- Kalnay, E., M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Sha, G. White, J. Woollen, Y. Zhu, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K. C. Mo, C. Ropelewski, J. Wang, A. Leetmaa, R. Reynolds, R. Jenne, y D. Joseph, 1996: The NCEP/NCAR 40-year Reanalysis Project. Bull. Amer. Meteor. Soc., 77 (3) 437 – 471.
- Nogués-Paegle, J. and K. C. Mo, 1997: Alternating wet and dry conditions over South America during summer. Mon. Wea. Rev., 125, 279 - 291.
- Woodruff, S. D., R. J. Slutz, R. L. Jenne and P. M. Steurer, 1987: A comprehensive ocean-atmosphere data set. Bull. Amer. Meteor. Soc., 68, 1239 -1250.

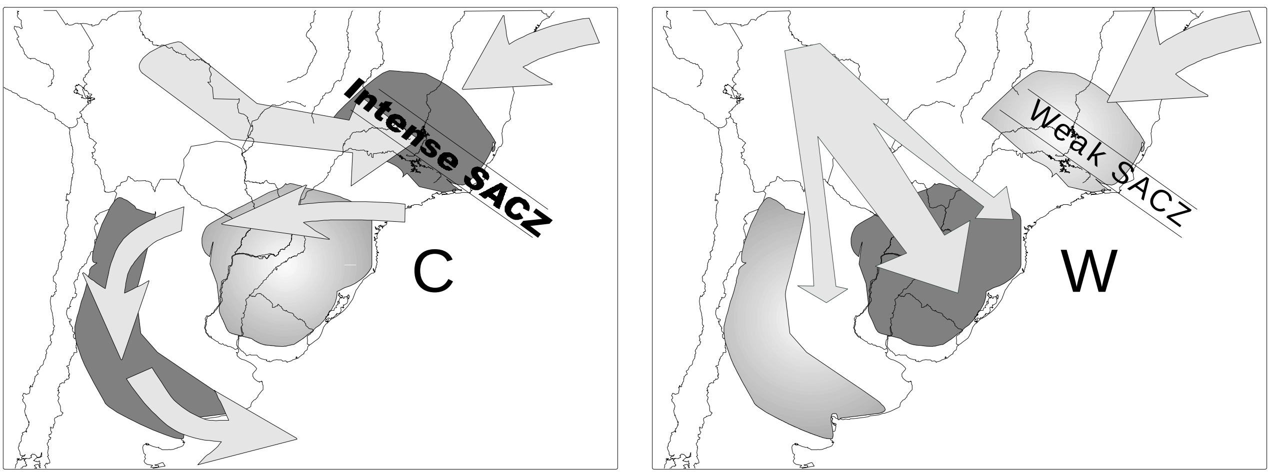

Figure 1: Scheme of the low-level water vapor transport and precipitation maximums (dark shadow) and minimum regions (light shadow) in January for (a) cold SST years and (b) warm SST years.