## J5.10 THE INTERANNUAL VARIABILITY OF SOUTH AMERICAN MONSOON AND RAINFALL IN SUBTROPICAL SOUTH AMERICA

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### 1. INTRODUCTION

The interannual variability of the onset and end of the convective season over South America is linked to the variability of rainfall in subtropical South America, east of the Andes (Gonzalez et al 2002). This paper explores how this variability is related to the seasonal change of the low-level circulation.

### 2. DATA AND METHODOLOGY

Convection over tropical South America was studied using OLR measurements, obtained from polar NOAA operational satellites, averaged on a 2.5º latitude-longitude array for the period 1975-97. OLR was computed for each of the 73 pentads of each year. Rainfall series were taken from 107 stations located between 22ºS and 40ºS in subtropical South America, east of the Andes. Precipitation series were averaged on an array of three-degree latitude by three-degree longitude to smooth singularities proper of single raingauge measurements. Low-level moisture transport, the product of specific humidity and the wind vectors (q*V), was calculated using the NCEP/NCAR daily reanalysis (Kalnay et al. 1996). This transport was calculated daily at each level, and integrated vertically from surface to 700 hPa.

The onset and end dates of the convective season were calculated for each box point in a 2.5° latitude-longitude array. The onset was defined as the first pentad when OLR falls below 240 W/m², and, OLR in 10 out of the 12 preceding (and subsequent) pentads was above (below) 240 W/m². Similarly, the end date was defined as the first pentad when OLR was greater than 240 W/m², and the OLR in 10 out of the 12 preceding (and subsequent) pentads was below (above) 240 W/m² (Kousky 1988). As the convective season moves southeastward from early September onward, and starts to withdraw to the north in April, its onset and demise differ when they are calculated in different regions. The intention here is to treat the onset and the end of convection as an overall large-scale feature. Thus, the onset and end dates calculated for each grid point in a 2.5° latitude-longitude array were averaged in the area between the equator and 15ºS, and 45º and 75ºW. However, the extreme northwest of this area, west of 60°W and north of 5°S was excluded, because in some years it was impossible to meet the requirements to determine the onset or the end date. These averages will be hereinafter referred to as the onset and end dates. This area was selected because it has the maximum convection during the summer and the greater OLR annual variability in South America south of the equator (Gonzalez and Barros, 1998). The mean onset date for the period 1975-97 was in the pentad 54 of the year, that is, on September 23rd, with a standard deviation of 11 days, and the mean end date was in the pentad 27.5, that is, on May 14th, with a standard deviation of 9 days.

The relation between the interannual variability of the monsoon end date and the subtropical rainfall in May is explored using the composite rainfall for years in which the monsoon end has occurred early or late. The years were classified in three groups with early, normal or delayed end dates, respectively. The limit between normal cases and delayed (early) was fixed at the average end date plus (less) half the interannual standard deviation of the end date. Thus, the years 1980, 1981, 1983, 1984, 1987, 1990, 1992 and 1993 were grouped as the early end set and the delayed end set was composed by the years 1977, 1979, 1986, 1989, 1991, 1994, 1995 and 1996. The same methodology was applied to onset dates. Therefore, the composites for September rainfall were calculated with years 1979, 1982, 1984, 1986, 1992 and 1996 that had an early onset of the tropical convection and with years 1975, 1976, 1981, 1987, 1989, 1994, 1995 and 1997 that had a delayed onset.

### 3. RESULTS

The onset (end) date is positively (negatively) correlated with September (May) precipitation in southern Brazil. The composite differences between early and delayed onsets and ends are consistent with these correlations (Fig 1). The South Atlantic convergence zone (SACZ) is a feature that accompanies the summer convection in South America from its early stages until its end (Kousky 1998; Gonzalez and Barros 2002). In addition, the SACZ causes compensatory subsidence to the south of it (Gandú and Silva Días 1998). Thus, the sooner (later) the convection starts, the lower (higher) the monthly precipitation is to the south of the SACZ (Fig 1a). Similarly, during the end of the convective season, more (less) precipitation should be expected with an early (delayed) end (Fig. 1b).

This anti symmetric behavior is not observed in Uruguay and in most of subtropical Argentina, where higher precipitation were observed in the composites of both the early onset and end dates than in their respective delayed composites (Fig. 1). The composite low-level moisture flow in September for years with early and delayed onset indicates that there is a decreased (increased) advection of

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moisture from the tropical continent towards subtropical Argentina, and Uruguay when an early (delayed) onset takes place (not shown). The low-level flow moves westward in early onset cases than in delayed ones but no difference in latitude was found between both composites (González et al 2002). This seems to be related to the features of the

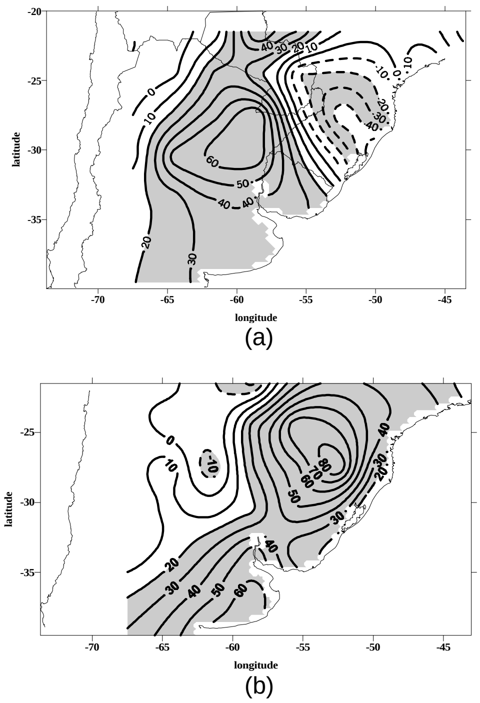


Figure 1: Composite September rainfall difference between years with early end and those with delayed one (a) and idem for May rainfall and onset cases (b). Significant areas at the 90 % level shaded.

transition of the low-level circulation over South America during the austral spring that are characterized by a westward shift of the southward flow, without change in the latitude of the easterly flow at equatorial latitudes. The modification of the low-level water vapor advection is important over subtropical Argentina because humidity seems to be the limiting factor for rainfall during the early spring.

The composite low-level moisture flow of May (not shown) shows that the South Atlantic High is more pronounced over the continent and reaches lower latitudes in years with early end. At the same time there is not change in the longitude of the southward flow, which is then more intense over subtropical Argentina. This is also consistent with the seasonal change in the circulation as the low-level flow pattern moves towards the north first and then eastward. As a result, and far from the influence of the subsidence, there is an enhancement of the May precipitation in Uruguay and in the southern part of the subtropical Argentina, Fig. 1b. A conceptual model synthesis of the former concepts, is shown in Fig. 2.

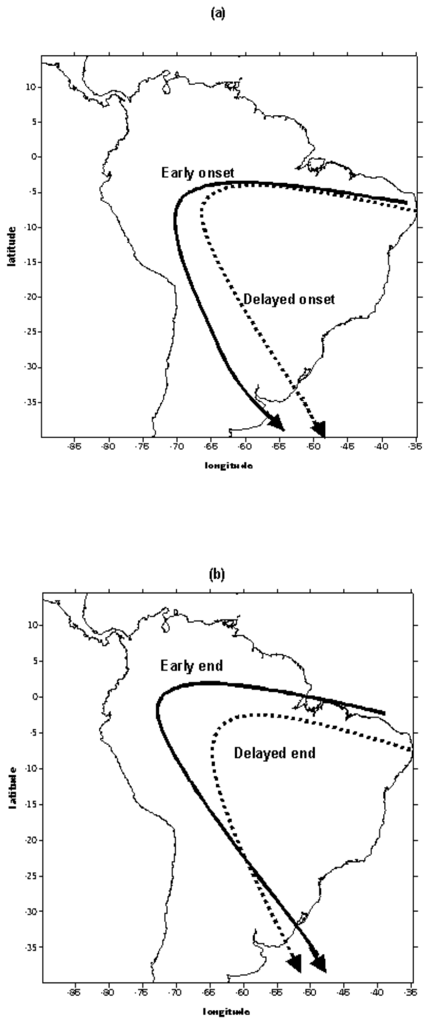


Figure 2: conceptual models for onset (a) and end (b).

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