FIELDS OF CIRCULATION ASSOCIATED WITH SHOWALTER INDEX VALUES IN CENTER NORTH ARGENTINA

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1. INTRODUCTION

The estimation of the atmospheric instability with the use of instability index, requires generally of calculations based on different thermodynamic parameters (Showalter 1953; George 1960; Boyden 1963; Jefferson 1963 a y b). Different index of atmospheric instability, obtained from the daily data of radiosonde, measure the potential development of severe weather conditions (in different degrees) and are considered representative of conditions on the synoptic scale. Its use for evaluating the presence of convection, has been a starting point in forecasting convection for many decades.

The objective of this work is to study the variability of the annual frequency of the daily extreme values of the Showalter Index and its relation with the fields of circulation in the troposphere.

In Argentina Moyano C. *et al* (1972) analyzed the representativeness of the instability index in forecasting storms during February 1969 to September 1970. Another application of different instability index can be found in S. Simonelli (2000), where they were used as a forecasting tool for convection occurred in the area of Mendoza. Catuogno G. (1982) conducted an analysis of seasonal and geographical distribution of Whiting K index and their relationship with the occurrence of storms and precipitation in Argentina. Rosso L. *et al* (1987) analyzed diverse indices of instability and its roll as predictores of the ocurrence of precipitation in Ezeiza during the period 1976/1978. They found that rates of Showalter (SI), LIFT (LI) and potential wet bulb are the best predictors of convective events for the sample during the period of convective activity in the region under study, although the Whiting K index was identified as more suitable for the period December to February.

At the international level were systematic reviews of the implementation of the indices of instability related to the comparison of different rates of convective instability applied to developments on the mainland of Greece (Dalezios and Papamanolis 1991). DeRubertis (2006) makes a climatic study of several indices of instability for the area of the United States, from daily values during the period 1973 – 1997, for different regions from the United States. At the same time it makes an evaluation of the importance of the inhomogeneity introduced in the behavior of the indices, in the light of changes in the humidity and temperature sensors in the different models from radiosondes.

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2. DATA AND METHODOLOGY

The data used for this study were daily radiosonde of stations in Argentina: Resistencia (L27 ° 27'S; 59 ° 03'W), Cordoba (31 ° 19'S, 64 º 24'O) and Santa Rosa (36 ° 34'S '; 64th 16'O),figure 1, at 12 Z, during the period 1973-2005,from September to April the following year, obtained from the website of the University of Wyoming(http://weather.uwyo.edu/upperair/sounding.html).Extreme values were defined as those contained in the rate at 1% of the distribution in each of the extrems.We also performed a spatial analysis of the fields of geopotential height anomalies apart from the NCEP/ NCAR reanalysis, 500 and 850 hPa, to be known as the movement is associated with each station, in connection with the extreme values of the index.This will build the composite with the dates of the index values stable or unstable separately. The used methodologies were: analysis of the annual frequency for each one of the weather stations, analysis of tendency, composites of fields of atmospheric circulation and test of Fisher (Panofsky 1965) for slopes of the tendencies and method of Cluster.

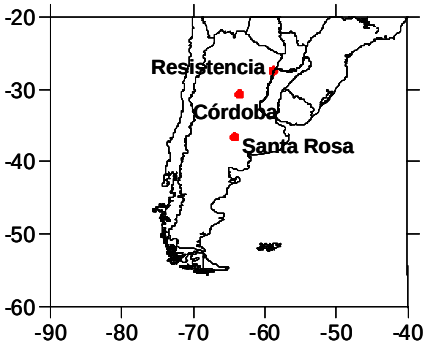

Figure 1**:** *Location of the reference stations*

3. RESULTS

We performed the distribution function of the daily values of the Showalter Index (SI) for each station, the extremes were identified, resulting two data sets of 100 cas, one of stable cases and the other of unstable cases for each one of the stations. Since this series was made all the analysis and were analyzed the circulation at differente levels in the the troposphere associated with these conditions.

Analysis of annual frequency and linear trend

Figure 2 shows the sequence of annual frequency of extreme values of SI selected for all seasons throughout the study period.
During the period analizaed in general for stable cases there is an increase and for unestable cases there is a decrease at Córdoba and Resistencia stations. At Santa Rosa the situation is opposite.
The increased frequency of extreme cases is unstable at the Córdoba showing maximum annual values of up to 9 for the year 1983 and then a rapid decline at the end of the period.
Resistance station shows a growth of the stable cases towards the end of period with a maximum in the frequency of 10 cases during year 1995.

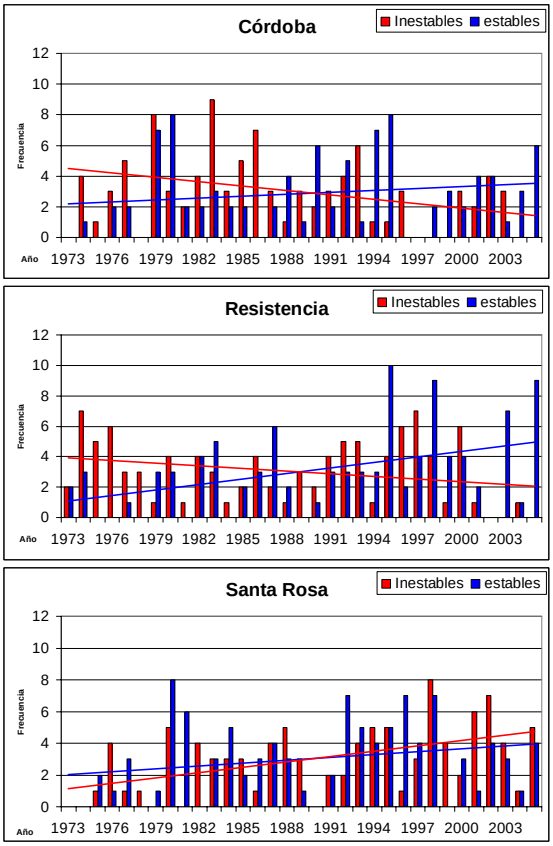

Figure 2: Annual frequency of cases Stable and unstable for 3 seasons

The station that shows the lowest annual frequency is Santa Rosa, with a different behavior to others. This station shows lower frequencies than the rest of the stations both marches increased over the study period.
In all cases, the plotted and trend line can be seen crossing each other around the year 1990.
The trend lines shown in Table 1, where tested using the Fisher test to identify whether the slopes were significant at 5%. The correlation coefficients are shown in Table 2. For all cases of stability all stations have a positive slope, the largest case in Santa Rosa and the lower slope in Cordoba.
The unstable cases show a negative slope, except at the Santa Rosa station. The linear trend for unestable cases show the most outstanding form in Cordoba and the lowest in Resistencia. The r values that are in red on the table 2 indicate significant at 5%.
All stations have at least one significant value. For Resistance and Santa Rosa stability cases has increased significantly to 5%, while for Cordoba, instability significantly decreased 5%.

Station	Stable	Unstable
Resistencia	Y = 0,120 X +0,954	Y = - 0,058 X +3,983
Córdoba	Y = 0,040 X +2,169	Y = - 0,095 X +4,577
Santa Rosa	Y = 0,113 X +1,025	Y = 0,059 X +1,983

Table 1: Trend lines for the cases of stable and unstable weather station.

Station		Stable	Unestable
Resistencia	r	0,41	0,27
Córdoba	r	0,16	0,38
Santa Rosa	r	0,48	0,25

Table 2: r values for the cases of stable and unstable weather station.

Fields of Circulation

Figure 3 shows daily mean circulation fields composite for the days when SI has extreme values for Cordoba station.
In all the cases of stable extreme index the circulation in 500 hPa level showes a dipole with a cyclonic circulation center at east coast extended to Atlantic ocean, and an antyciclonic center located to the southwest, at Pacific Ocean.
For 850hPa level the anticyclonic circulation is located over the continent, covering the south, and leaves from the Argentine north with a cyclonic center at east. This circulation advects anomalous cold winds and low humidity from higher latitudes which stabilize the lower layers

of the atmosphere leading to stability in the area of Cordoba.

For the unstable cases the patterns of circulation in 500hPa are associate also to a dipole but in inverted phase to the previous cases. In this situation the mean circulation presents a weak anomalous anticyclonic circulation at east coast at the Atlantic Ocean, and a cyclonic circulation anomaly located on the southern continent and over the Patagonia. In 850 hPa, the anticyclonic circulation affected all of Argentina associated with advection from the north with high temperatures and moisture available for convection, an important factor in the development of instability in these regions. Comparing the composites for the stable and unstable cases is common to find the dipole phase, inverted in a more meridional position. The relative position of the dipole at both levels is the same but moved northward or southward. Figure 4, shows the composite of circulation for Resistencia station in both levels. At 500 hPa, for cases of SI stable, appears a center of cyclonic anomaly in the north, and an anticyclonic center in the south of the continent. The dipole anomaly in this circulation composite is similar to the situation discussed in Cordoba. In 850 hPa the anticyclonic anomalous circulation extends over the south of Argentina. If we analyze the field of 500 hPa for SI unestable cases the configuration of circulation anomaly is different from the previous case. An anomalous cyclonic circulation dominates Argentina, with its center on Patagonia and stretches from the Pacific Ocean to the Atlantic Ocean. At 850 hPa this configuration is maintained but weakened.

In figure 5, shows the circulation anomaly fields in Santa Rosa. At 500 hPa for SI stable cases again the mean circulation field is very similar to those shown in Cordoba and Resistencia. The circulation for Santa Rosa shows a center of negative anomalies at the Atlantic Ocean and east of de continent and another positive center of anticyclonic anomalies to the south. At 850 hPa anticyclonic circulation anomaly is located over the continent by moving the center of ciclonic anomalies almost entirely to the Atlantic Ocean.

The mean circulation field in Santa Rosa at 500 hPa for unstable SI shows a weak central anomalous anticyclonic circulation over the center of Argentina spread north over the Atlantic Ocean, and cyclonic anomaly center to the southwest extended over the Pacific Ocean. At 850 hPa the configuration is similar but weaker and in phase with the 500 hPa level.

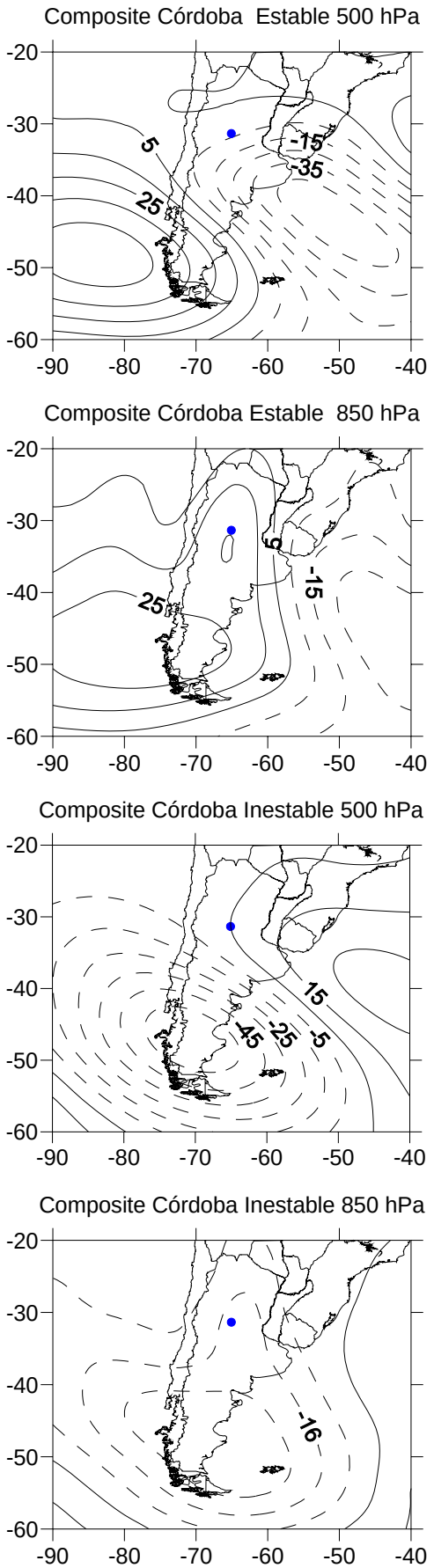

Figure 3: Composite cases of stable and unstable to Cordoba in the levels of 500 and 850 hPa

The atmospheric structure is more baroclinic for stable cases than for unestable cases of index values.

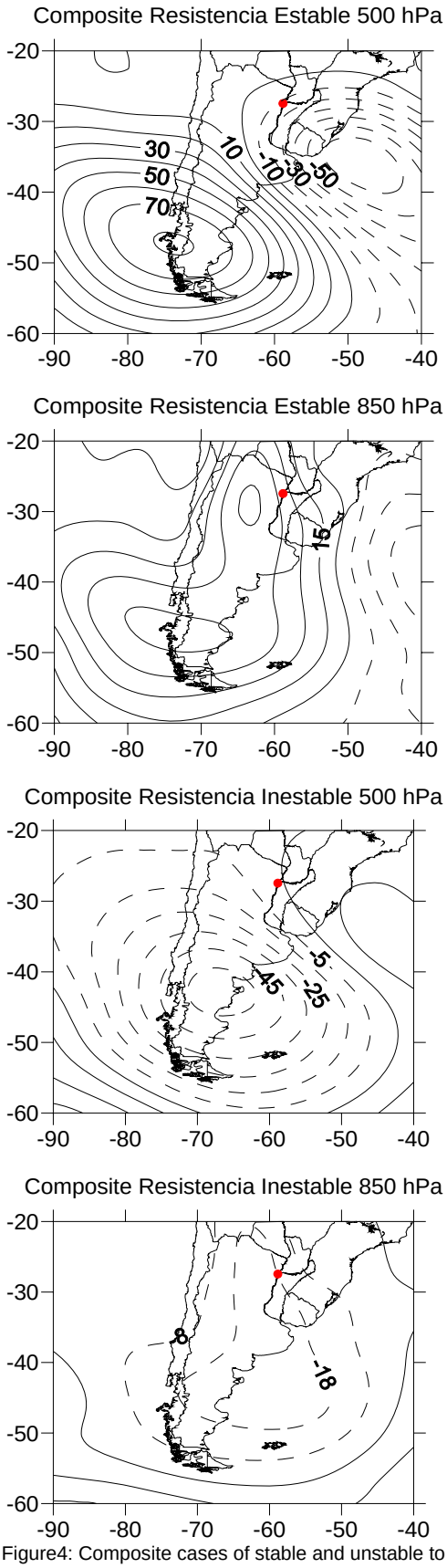

Figure4: Composite cases of stable and unstable to resistance levels of 500 and 850 hPa

The unstable SI cases analyzed are allways located close to the center of negative anomalies.

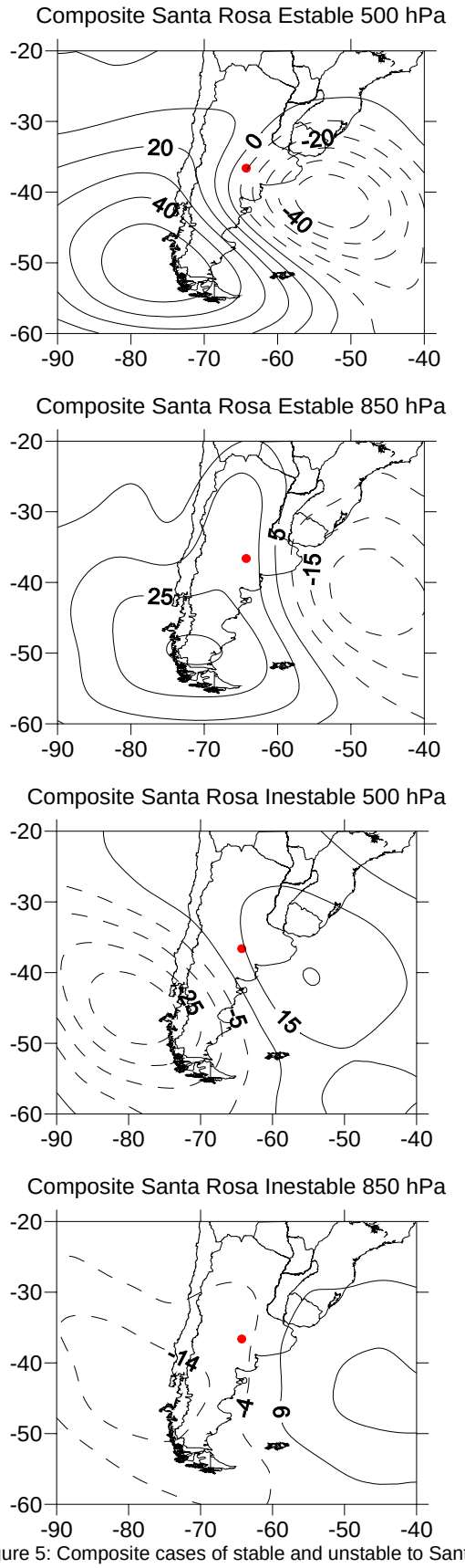

Figure 5: Composite cases of stable and unstable to Santa Rosa in the levels of 500 and 850 hPa

Analysis of Cluster

A classification was performed using the K-Meads, for identify situations of circulation associated with each of the cases SI stable and SI unstable in the 500 level of hPa. For 850 hPa is the composite chart of the same days each cluster in the previous step. For each station were obtained 3 cluster and the table 3 shows the frequency of days associated each cluster.

For reasons of space in figure 6 only are the 3 to cluster of the station Resistance for IF the Stable ones.

Station	Resistencia		Córdoba		Santa Rosa	
Cluster	Est	Inest	Est	Inest	Est	Inest
Cluster I	35	32	30	44	38	39
Cluster II	27	35	32	27	32	29
Cluster III	38	33	38	29	30	32

Table 3: Number of fields for each cluster, for each station

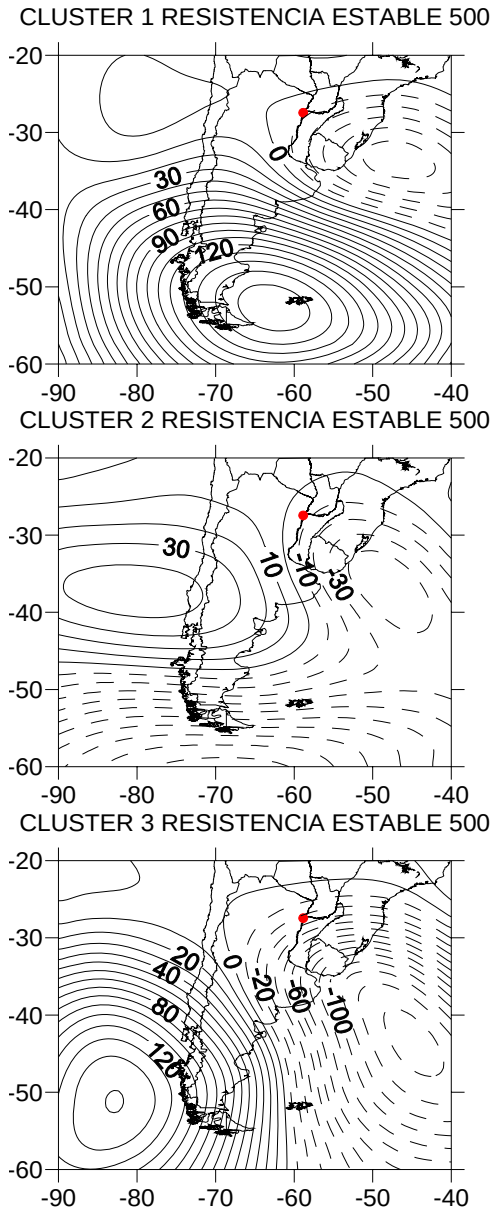

Figure 6: Composite circulation anomalies associated with each cluster, in case of resistance Stable at 500 hPa.

4. CONCLUSIONS

The characteristics of instability from the index Showalter from radiosonde data daily, 12 Z, during the 1973-2005 period, from September to April next year for weather stations: Resistance, Cordoba and Santa Rosa Aero to April next year for weather stations: Resistance, Cordoba and Santa Rosa Aero, they show to the tendency straight lines a crossing around year 1990.

Resistance and Santa Rosa the stability has increased significantly to 5%, whereas for Cordova, instability significantly decreased 5%.

The fields of anomaly of circulation of geopotencial height in the 500 and 850 levels hPa, referred to those of extreme values of the index were presented.

The circulation fields of cases associated to extremes values of stability of the SI in 500 hPa present a dipole with a center of low pressure on the Patagonia region in Argentina and a system of high pressure on the Atlantic Ocean near Uruguay, with predominance of flow from the south. At 850 hPa appears a system of low pressure extended mainly over the continent.

For the unstable cases in 500 hPa, present a dipole with an opposed phase: a high pressure center in the south of the country and a center of low pressure on the Atlantic Ocean with predominance of flow from the north. At 850 hPa the field presents a system of high pressure located over the continent.

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