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SEASONAL CHARACTERIZATION OF THE DIURNAL CYCLE OF CONVECTION FREQUENCY OVER SOUTHEASTERN SOUTH AMERICA UNDER DIFFERENT LOW-JET CONDITIONS.

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1. INTRODUCTION

Numerous places of the world display a variability during the day in the convection occurrence. Wallace (1975) presented evidences of the time of onset of convection over the US, showing on the Rocky Mountain area a high frequency of occurrence during afternoon, while in the Great Plains the convection displays a nocturnal character. Garreaud and Wallace (1997) using satellite information centered their study in the Amazon region and over the Altiplano, showing that the formation of convection on these areas happens predominantly in the afternoon. Studies in Argentina made by Paegle et al (1977), using present weather data (WMO code "ww") during summer, found that stations in western Argentina exhibit generally a maximum in convective activity in the late afternoon or early evening. In the central region, a nocturnal maximum predominates that extends towards Buenos Aires, while in the Atlantic coast convective activity dominates during afternoon. Some of these results can be observed in figure 4 of Garreaud and Wallace (1997) in a study of the diurnal cycle of summer convection, where on the eastern slope of the Andes is noticeable the formation of convection during the early night, although in this picture no differences are evident between the nocturnal and diurnal behavior over northeastern and central Argentina.

Salio (2002) showed the distribution of convection frequency calculated using phenomena related to convection identified in present weather data, collected by the Argentine Weather Service at its surface station network, on synoptic situations under the influence of a low level jet during spring and summer. Both Chaco Jet Events (CJE) and the events of low level jet that do not reach 25°S (NCJE), conform the sample of South American Low level Jet events (SALLJ), were included in this study. Figure 1 represents schematically in the two upper panels these two different circulation patterns. During CJEs the convection fundamentally appears in nocturnal and dawn hours (6 – 12UTC) mainly in the northeast and center of Argentina, while during NCJE an absolute maximum is observed at 18UTC (afternoon hours) in the same position. In addition, summer convection on the eastern slope of the Andes intensifies showing also an afternoon maximum during the NCJE. Nicolini et al (2004) characterized the synoptic patterns that dominate three types of low level jet categories that affect the area of Southeastern South America (SESA).

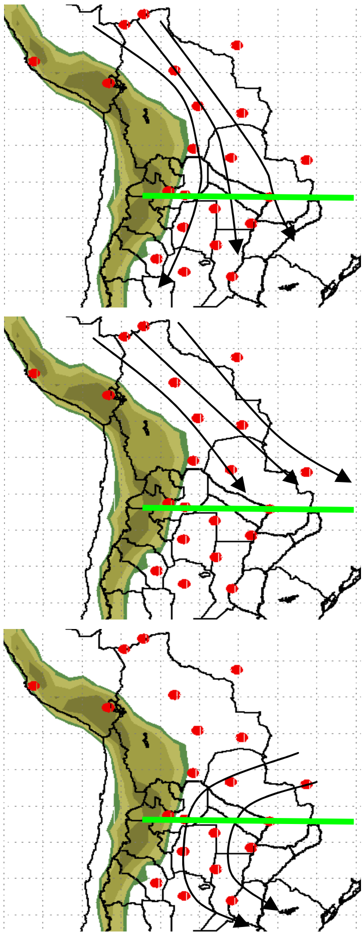

Figure 1: Scheme of the circulation of the wind in low levels under three characteristic low level jet events over Southeast South America. Chaco Jet Event is outlined at the top, on the center No Chaco Jet Event and at the bottom the Low Level Jet Argentina scheme. The area shaded in light blue display the isotach of 12ms^{-1}. The green line indicates the latitude of 25°S.

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The observational SALLJEX data evidenced the existence of a subtropical low-level jet immediately east of the Andes (western and central Argentina), not related to SALLJ, associated with the western sector of a postfrontal anticyclone. These events were denominated Low Level Jet Argentina (LLJA, low panel in Fig. 1).
The objective of the present work is to characterize the diurnal cycle of the convection frequency and explore seasonal changes during the year. Given previous evidences of the existence of a close relationship between convection and low-level jet conditions a distinction is made between different synoptic situations.

2. METHODOLOGY

IR satellite images with high temporal and horizontal resolution are used to determine the convection frequency from September 1, 2000 to Sep 30, 2003 (http://lake.nascom.nasa.gov/, Janowiak et al. 2001), over the area between 10ºS-40ºS and 40ºW- 75ºW. Convection frequency represented by an IR brightness temperature below 218 ºK is calculated over the whole domain during each season and during the different situations that present a low level jet over SESA. The frequency of convection allows the description of the geographical patterns associated with the evolution of convection during the whole day.

Synoptic situations are detected using GDAS, considering a criterion similar to Bonner (1968) already used in Salio et al (2002). During the period studied, SALLJ events stratified in CJE and NCJE have been diagnosed using GDAS (see Table 1), 23 per cent of the days correspond to CJE events with higher frequency during winter and spring. In contrast, NCJE has a higher frequency during the warm season. LLJA events are equally distributed during all seasons with a frequency of around 17 per cent. The remaining days are called NOLLJ events, which cover an extensive variety of synoptic situations, representing 47 per cent of the three years studied.

In order to compare different behaviors in diurnal convection cycle during the different synoptic situations associated with a low level jet, fractional area coverage by temperatures lower than 218 ºK are calculated over three regions of SESA. The latitude extension of these regions is 23°S to 40°S, and this zonal extension of SESA is further divided in three areas: western (65-60°W), central (60-55°W) and eastern (55-50°W).

	SON	%	DEF	%	MAM	%	JJA	%	Total
CJE	75	25	56	21	53	19	83	30	267
NCJE	41	14	40	15	29	11	25	9	135
LLJA	53	17	38	14	51	18	53	19	195
NOLLJ	134	44	136	50	143	52	115	42	528
Total	303	100	270	100	276	100	276	100	1125

Table 1: Number of days where a low level jet type is detected over Southeastern South America and their corresponding frequency of occurrence.

3. RESULTS

3.1 Seasonal characteristics of the diurnal cycle of convection frequency over SESA.

Convection frequency patterns reproduce the seasonality characterized by the advance and retreat of the Intertropical Convergence Zone during the year, specially during the warm season (Fig. 2). This is clearly evident in the intensity of the frequency of convection over tropical areas during summer, showing a maximum in the hours of maximum radiative heating over Brazil and the Altiplano. On the other side, the low lands of Bolivia are characterized by the presence of nocturnal convection. During winter, the presence of temperatures lower than 218K is unusual over the whole region. This last finding leads to exclude this season from this work due to the small number of systems which comply with the imposed criterion of temperature threshold.

Over the subtropical areas, the behavior during the different seasons is principally characterized by a nocturnal (12Z) maximum of frequency centered close to 32°S-58°W. This maximum has an extreme intensity during spring and attains a lower intensity during fall and summer. There is a different behavior over the southern area of Brazil and Uruguay respect to Argentina. While in the first area, convection frequency is present during the whole day, with higher frequency in nocturnal and predawn hours; at 18Z over Argentina (except its northeastern border) convection frequency declines during all seasons.

The eastern slope of the Andes over SESA region presents a diurnal cycle mainly characterized by a nightfall maximum especially evident during summer.

Hourly Hovmoller diagrams, centered on the region of the nocturnal maximum (Fig. 3), show the dependence of diurnal evolution of convection with latitude and longitude during the different seasons.

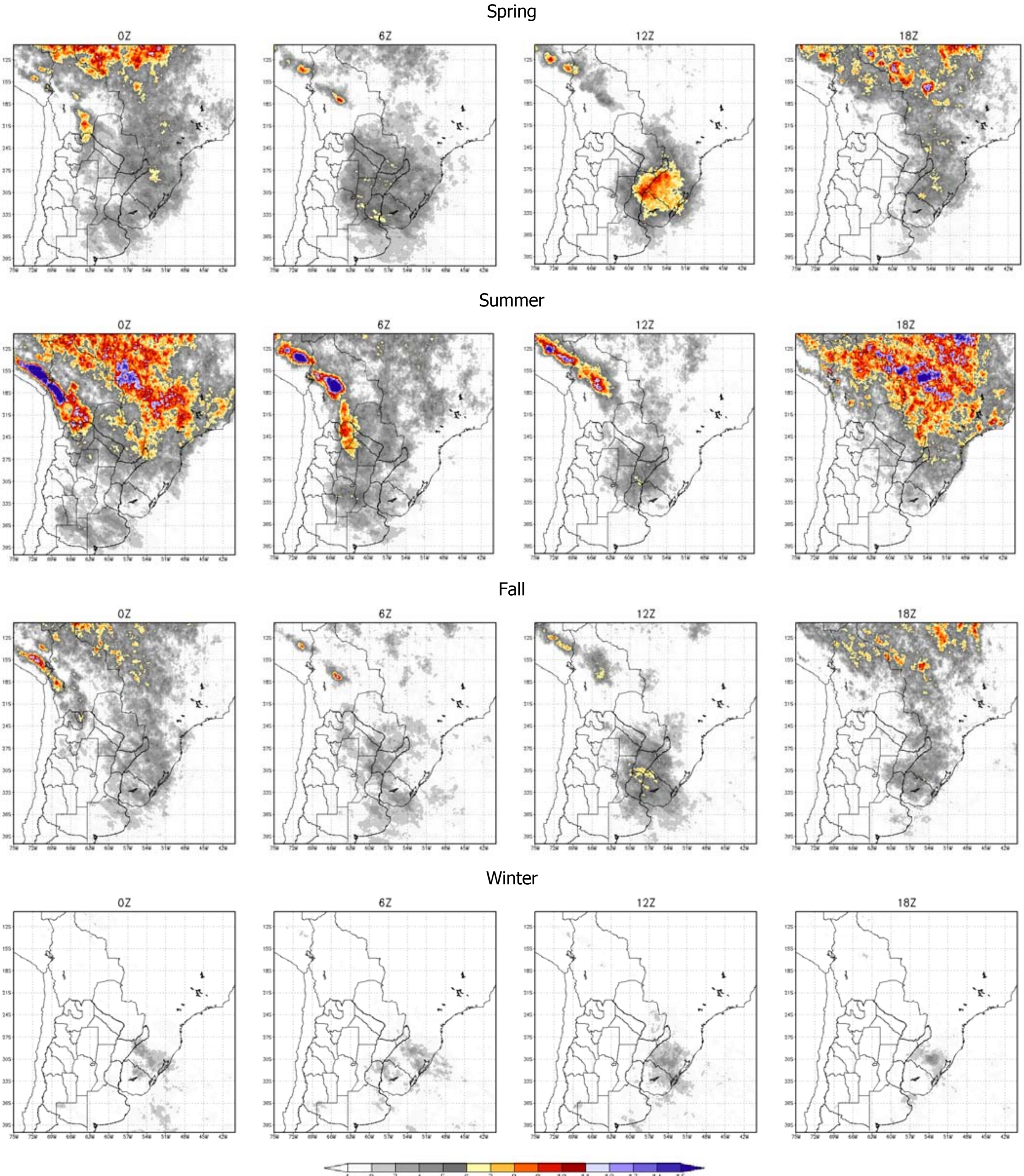

Figure 2: Convection frequency (in percentage) every 6 hours during spring, summer, fall and winter

Spring is the season characterized by the strongest subtropical maximum in convection frequency. Convection starts at 2Z close to the Andes and moves/develops eastward reaching the maximum frequency between 9Z to 12Z. As we mentioned before, convection eastward 58°W is present all day with a preferential nocturnal maximum, and the period of time during which convection is present decreases to the west lasting only 4 hours close to the slope of the Andes. In the latitudinal diagram it is possible to depict (right panels), again, the period between 18 to 21Z characterized by the absence of convection and the nocturnal maximum at 58°W.

The principal difference in summer respect to spring is the lower intensity of the nocturnal maximum of frequency and the presence of a secondary maximum in the afternoon northward 26°S and eastward 53°W that tends to decay toward the night.

Convection over SESA during fall presents no evidences of convection over the slope of the Andes and is clear dominated by the nocturnal maximum.

3.2 Diurnal cycle evolution under different synoptic situations.

The fractional area coverage by temperatures lower than 218K over three subtropical boxes over SESA is shown in fig. 4, 5 and 6 for the different seasons.

The convection located south of 23°S shows a strong relationship to the SALLJ events and displays an evidently nocturnal character during spring and fall especially over the western and central area; while in summer a different behavior is observed since two phases of maximum convection are present: one nocturnal and another in the afternoon is evident specially in the eastern. This behavior shows a strong relationship between the time of the maximum in the low level jet and convection during the night whereas in the evening during summer the convection is influenced by the radiative heating. The nocturnal maximum over eastern Argentina and the daytime maximum over the slopes of the Andes is coherent with the organized convection trajectories toward the east – northeast found in previous studies (Velasco and Fristch, 1987 and Salio et al, 2006).

The area associated with convection during LLJA do not depict a diurnal cycle in all areas and the percentage is lower than 10%. Despite the presence of a low level jet and its associated convergence, the situation is characterized by the presence of an intense high pressure system and therefore the domain of stable conditions over SESA (Nicolini et al, 2006).

NOLLJ events depict a diurnal cycle only during summer showing a nocturnal maximum in the western region starting to build up in the afternoon, while in the central and eastern region the maximum is evident only in afternoon hours possible due to the radiative heating.

Recent case study analysis have shown that SALLJ events and convection occur together during consecutive days. Essentially, convection over SESA is regulated by the persistence of the low level jet during almost one day (Borque et al, 2006 and Salio et al 2006). Future progress is needed in order to understand how the convection develops over SESA and evolves in long SALLJ events.

ACKNOWLEDGMENTS
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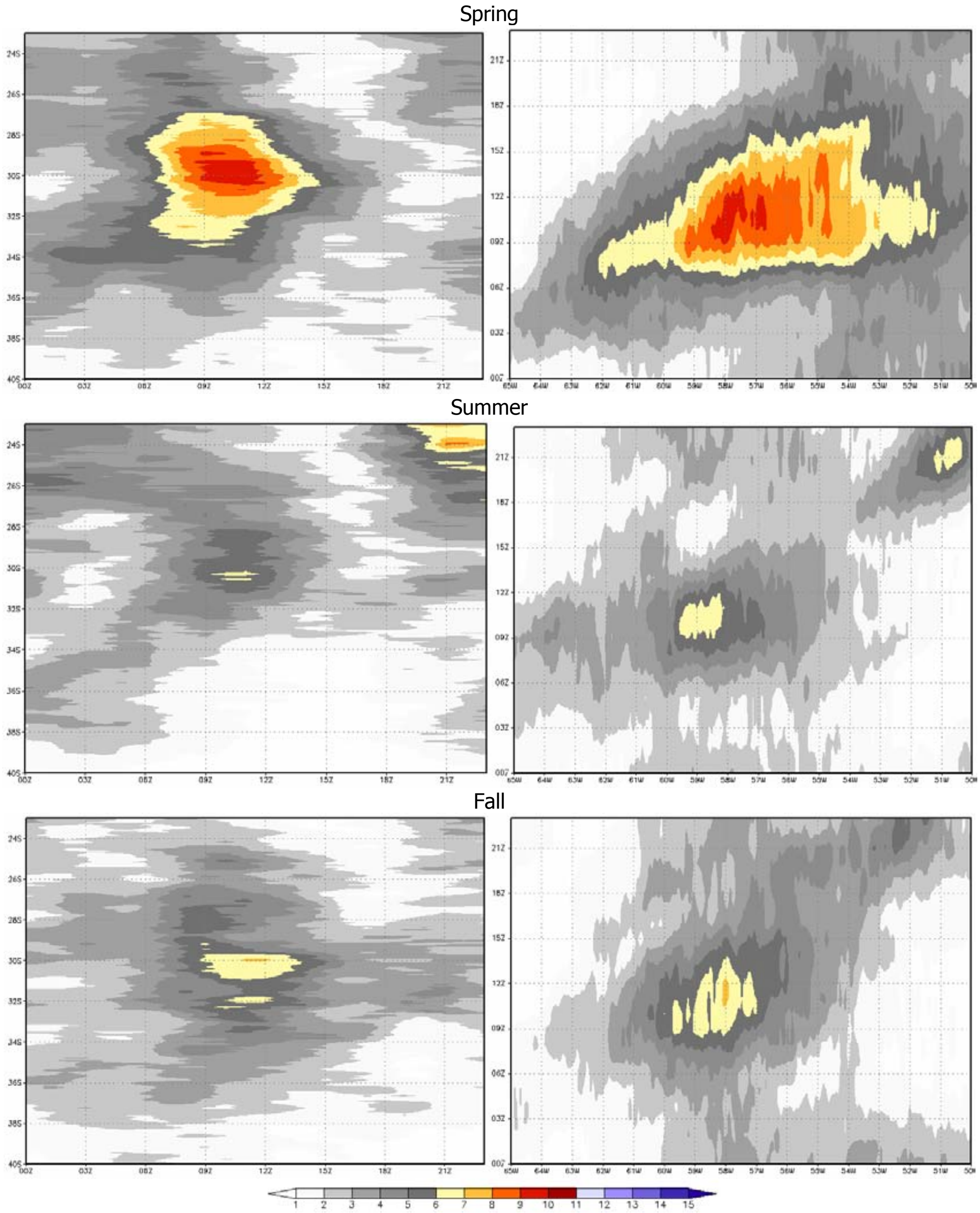

Figure 3: Hovmoller diagrams of the frequency of convection at 58°W (left column) and 30°S (right column) every one hour during spring, summer and fall.

Western region: 23 - 40°S – 65 - 60°W

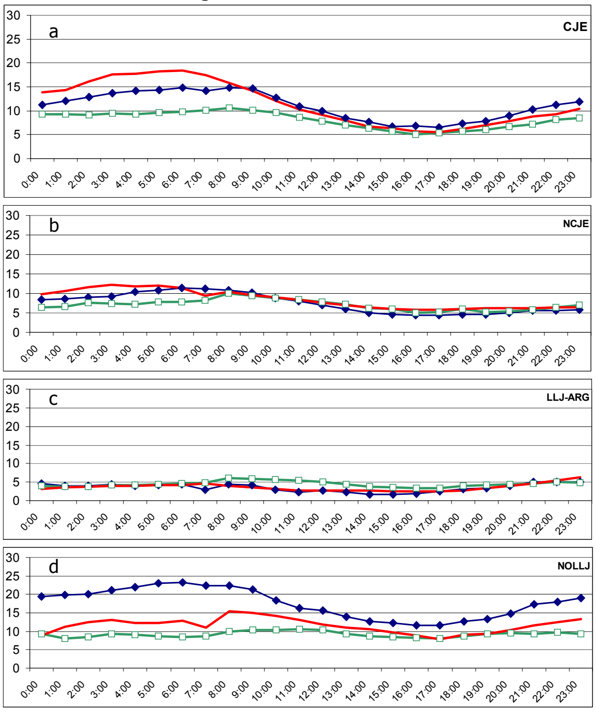

Figure 4: a) Fractional area coverage by temperatures lower than 218 ºK for spring (red), summer (blue) and fall (green) over western area of SESA during CJE, b) idem a) for NCJE, c) idem a) for LLJA and d) idem a) for NOLLJ.

Central region 2: 23 - 40°S – 60 - 55°W

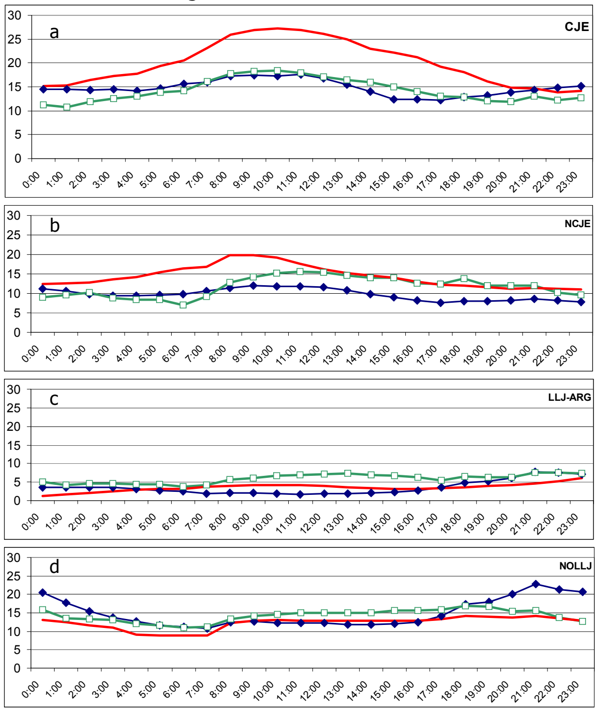

Figure 5: idem Figure 4 for central region of SESA

Eastern region 3: 23 - 40°S – 55 - 50°W

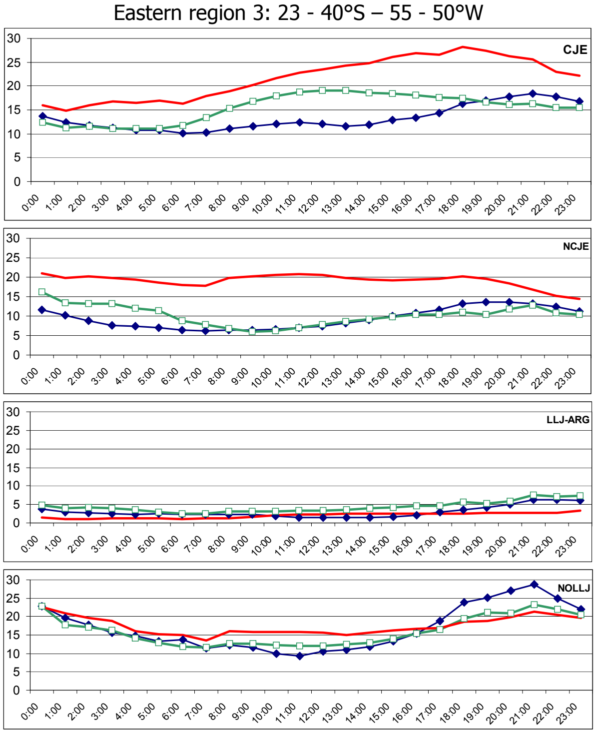

Figure 6: idem Figure 4 for eastern region of SESA.