LIFE CYCLE ANALYSIS OF THE SALLJEX CONVECTIVE SYSTEMS

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1. INTRODUCTION

Velasco and Fritsch (1987) made one of the first analyses about convective systems over South America. Based on satellite images they identify areas where mesoscale convective complexes (MCC) are observed more frequently. Southeast South America is one of these areas. In continental areas the convective system (CS) genesis has usually been related to a low level jet bringing moist and warm air from low latitudes. This condition is similar to that observed by Maddox (1980) in central portion of the United States during warm season. Although some studies have shown the importance of low level jet in the convective system genesis, as revealed by Salio et al (2007) this systems could also be produced in others synoptic situations.

Moreover, most of the studies were dedicated to systems observed over land, and, there is little information about CS with oceanic origin. Such systems have a significant impact in the energy and water cycle.

The aims of this study are to analyze CS genesis conditions, and to explore life cycle and diurnal variations of initiation, maturity and dissipation periods considering CS with continental and oceanic origin. This study is based on the large and long lived convective systems observed in summer 2002/2003 during the South America Low Level Jet Experiment (SALLJEX).

2. DATA AND METHODOLOGY

The SALLJEX (South American Low-Level Jet Experiment) field campaign was conducted between November 15, 2002 to February 15, 2003, on the region of Bolivia, Paraguay, central and northern Argentina, western Brazil and Peru, who suffer the direct influence of SALLJ (Vera et al, 2006). Beyond the data sets from SALLJEX network, special CPTEC (Brazilian Center of Weather Forecasting and Climate Studies) reanalysis (merging NCEP and SALLJEX dataset) was used to characterize different dynamic and thermodynamic conditions observed before and at the genesis of CS (Herdies et al., 2007). The CPTEC reanalysis cover the period between December 15, 2002 and February 15, 2003, our analisis will be restricted to this period.

Full resolution Infrared satellite images (4 km horizontal resolution at subsatellite point and thirty minutes intervals) from CPC/NCEP/NWS (Climate Prediction Center/National Centers for Environmental Prediction/National Weather Service) were used to identify convective systems (Janowiak et al. (2001), see also http://lake.nascom.nasa.gov/)

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A satellite image tracking scheme called ForTraCC (Forecasting and Tracking the evolution of Cloud Clusters) was applied to the images to identify and track convective systems over South America and Atlantic Ocean (Vila et al, 2008). A temperature threshold of 235K was used to define CS and 210K to delimit convective cells (CC) merged inside the CS, CS is defined as a cluster larger than 150 pixels. The analysis was limited for CS with life cycle longer than 6 hours. However, even considering long lived systems, we do not make any distinction of system classification: Mesoscale Convective System (MCS), Mesoscale Convective Complex (MCC) or Instability Lines (IL).

This study is focused on the systems whose genesis happened southward of 20°S, following them from the initiation, when a cluster match the defined thresholds and is larger than 150 pixels, the mature phase, when the CS achieves its largest horizontal extension, until the dissipation, when it loses minimum cluster size and does not comply temperature limit condition. This procedure permitted to verify CS displacement from the genesis to end life.

3. RESULTS

During the sixty analyzed days a total of 120 systems were detected on the continent and 44 in the Atlantic Ocean southward of 20°S. Hence, from the total of subtropical CS, almost 73% had their origin over the continent and 27% over the Atlantic Ocean (Figure 1).

In spite of the different quantities of CS in continent and ocean, systems with shorter duration are plentiful compared to long live ones in both areas. As showed in Figure 2, we can see a logarithmic decay in the distribution. The systems with life cycle less than 12 hours represent approximately 65% (64%) of the continental (oceanic) CS.

Results also indicate that continental systems tend to have longer duration (one of the events lived for more than 55 hours) than oceanic ones (maximum duration was 33.5 hours). However, as mentioned before, long lived systems are rare events, only 7.5% (4.5%) of continental (ocean) origin CS had life cycle over 24 hours. Although the ocean is a constant source of moisture, in the continent the conditions are not uniform and thus topography, differential heating and other mechanisms can act as a trigger to the formation and/or to maintain the CS. These factors may explain the longevity and the large number of the continental systems.

The analysis of the distribution of convective systems in accordance with the time of first detection shows that in the continent (FIGURE 3) around 52% of the systems are formed during the interval between 15:00 to 20:30 UTC. Although a fair number of systems forms at the end of the night and morning, between 00:00 and 05:30 UTC (~26%), the daytime warming appears to be an important factor in the formation of such systems in continental sub-tropical South America. On the other hand, as mentioned by Velasco and Fritsch (1987) the katabatic flow from the Andes Mountains and the nocturnal convergence in Parana River valley may explain systems genesis between 18:00 to 20:30 UTC.

In the case of the ocean, the diurnal cycle does not seem to clearly affect the formation of systems. The maximum genesis occurs in the late night and in the beginning of the morning, with a maximum between 03:00 and 05:30 UTC (FIGURE 3).

As we saw in FIGURE 3, systems can be generated during all period of the day however, not all of them survive during night. Actually, CS´s with nocturnal life cycle represent a little portion in this data set. Assuming as nocturnal system those that could survive until at least 12 UTC of next day, in the universe of 120 (44) continental (oceanic) systems only 12.5% (11.4%) were considered as nocturnal system. Despite their restricted number, these nocturnal systems are among those with longer life cycle. In average, continental (oceanic) nocturnal CS has a life cycle of ~27 hours (~24 hours), compared to diurnal CS that present in continent (ocean) a life cycle of approximately 10.3 hours (10.6 hours) duration.

FIGURE 4 shows the times of initiation, maximum area and dissipation of the nocturnal CS with continental and oceanic origin. In both cases, the period of genesis goes mainly from 12:00 UTC to 23:30 UTC. It indicates that the diurnal heating appears to be an important factor in the genesis of convective systems observed in South America and near ocean. In relation to the time of maximum horizontal extension, it is observed that the continental CS reaches their mature stage between 00:00 and 14:30 UTC, with a peak around 06:00 to 08:30 UTC. Most of the oceanic systems also reached its mature stage in the same period. This result agrees with Velasco and Fritsch (1987) which observed maturation phase peak during around 03 hours local time.

Regarding the dissipation period, the distribution seems to be a little more regular throughout the day, though they were more frequent after 12 UTC, again, in agreement with Velasco and Fritsch (1987).

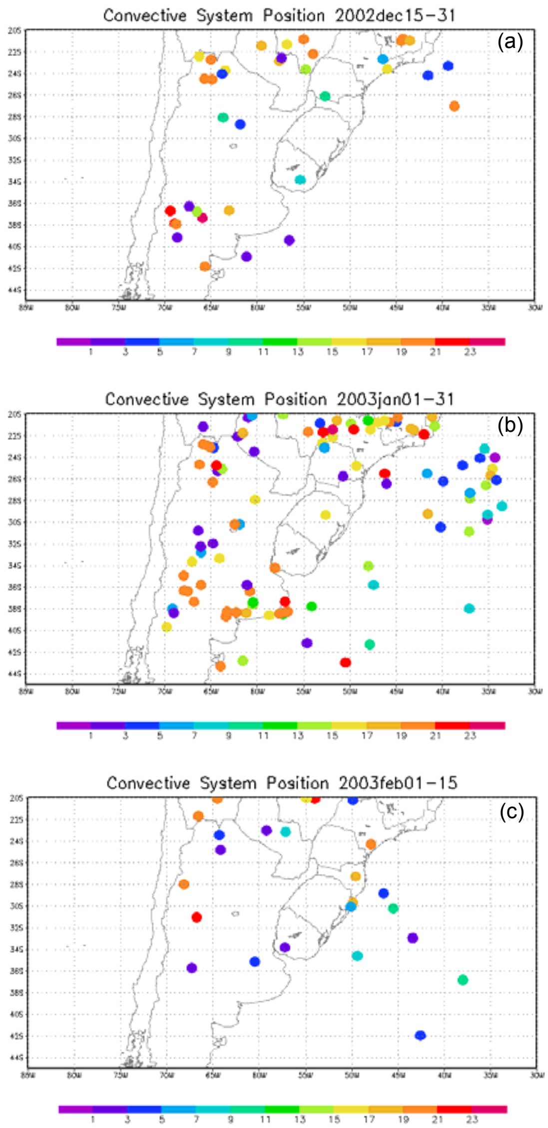

FIGURE 1 – Convective system position: (a) 1 to 15 December 2003; (b) 1 to 31 January 2003: (c) 1 to 15 February 2003. Colors indicate initial detection time (UTC).

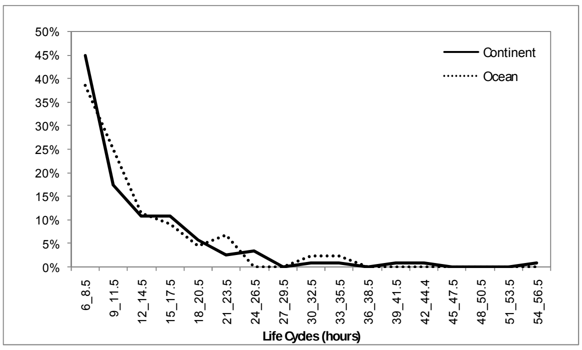

FIGURE 2 – Distribution of continental (continuous line) and oceanic (dotted line) convective systems according to their life cycles (in hours).

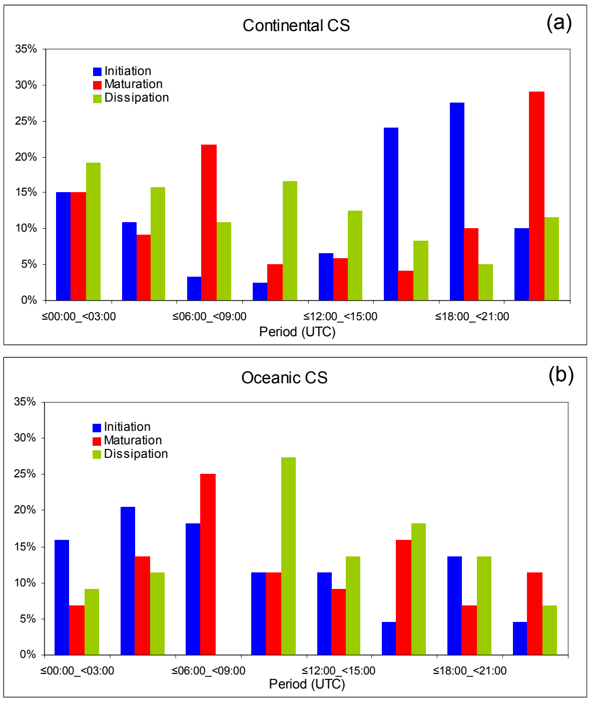

FIGURE 3 – Distribution of convective systems according to their initiation, mature and dissipation periods (UTC): (a) in Continental area: (b) in Oceanic area.

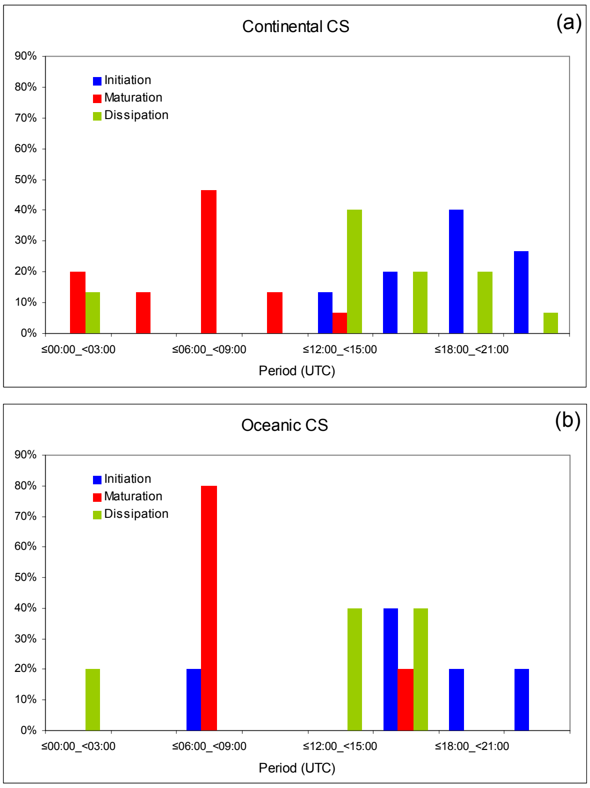

FIGURE 4 – Distribution of nocturnal convective systems according to their initiation, mature and dissipation period (UTC): (a) in Continental area: (b) in Oceanic area.

4. CONCLUSION

Results indicated that continental CS´s are more numerous than oceanic ones. The continental systems are mainly generated in the afternoon or early evening, their mature phase can happen at night or early morning, and the dissipation happens during all day long. In case of oceanic systems the genesis and mature phases are more frequent during night and early morning, and dissipation is observed all day with a peak at the end morning.

In average, continental and oceanic origins systems present similar life cycle duration. However, long lived CS initiated over land presents longer life cycles when compared to the oceanic ones. Nocturnal systems are less common events and they are among those that have longest live in both areas.

Although it was not shown here, it was found that the Atlantic Ocean and tropical regions act as the main sources of moisture in the genesis of continental convective systems with nocturnal life cycle. This agrees with the recent results of Drumond et al (2008). It is also worthy mentioning that thermodynamics analysis (not shown) suggest that the nocturnal systems generated during afternoon (12:00 to 17:30 UTC) are initiated in an atmosphere with high moisture flux (from Atlantic Ocean) and a relative low CAPE when compared to CS´s detected initially between (18:00 to 23:30 UTC). This feature is currently under investigation and it will be presented elsewhere.

Acknowledgments
Meiry Sakamoto thanks to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) by PhD scholarship and to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) by the scholarship granted for studies at University of Vigo in Spain. Tércio Ambrizzi thanks supports received from CNPq and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP). SALLJEX was supported by PACS-SONET, FAPESP 01/13816-1, NSF ATM0106776, NASA NAG5-9717, NOAA PID-2207021 e NA03OAR4310096.

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