P13R.10 THE MORPHOLOGY OF TROPICAL RAINFALL SYSTEMS AND THEIR HYDROLOGICAL SIGNIFICANCE

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1. INTRODUCTION

The present work analyses the spatial structure and temporal variability of rainfall systems over Eastern São Paulo State (ESPS), Brazil. Fig.1 shows an ACQUA image of ESSS centered in the São Paulo Weather Radar (SPWR). Light brown areas are urban environments, the largest been the Metropolitan Area of São Paulo (MASP). It is affected by floods and water shortage at the same time, a paradox that can be explained by the relief, its orientation, vegetation, proximity to the ocean and other physiographical features that tend to influence and affect weather systems over the ESPS. Available measurements of rainfall systems of the SPWR between 1998 and 2003 were classified according to their spatial patterns: isolated convection, squall lines, cold fronts, rain bands and sea breeze fronts. Monthly frequencies of each type were then obtained and analyze.

Figure 1: Visible image of Eastern São Paulo State, Brazil obtained with the ACQUA satellite. The 240-km circumference indicates the surveillance area of the São Paulo Weather Radar (SPWR).

2. METHODOLOGY

Maps of radar-derived rainfall rates at 3-km altitude within 240-km radius (Fig. 1) were obtained for a total of 827 days, or 145,194 maps. Each event was analyzed through an animation loop of rainfall rate maps at 5 minute intervals to visually identify and characterize the weather system. Fig. 2 shows an example of each weather system. Most isolated convective events occur between 13:30 LT and 18:30 LT that agrees with the daily heating cycle. Convective cells form over the continent and move slowly eastward. Often, they merge in their later stage of development and form extensive areas of stratiform rainfall. Sea breeze convective events move westward faster than isolated convective systems. They can also form weaker bands of stratiform rainfall in some instances. Most of them develop between 14:30 LT and 19:00 LT and tend to intensify and organize lines along the cost by the Serra do Mar Ridge (Fig. 2). Squall lines were observed at any time, but more often between 15:00 and 17:00 LT and lasted from 4 to 12 hours. They move to any direction but preferably Northeastward and Southeastward, perpendicular and parallel to moving and stationary cold fronts, respectively. Disperse bands are in general associated with stationary fronts that can last longer than five days. Preferably, they move eastward or southeastward. Some are associated with decaying squall lines that reach the radar surveillance area early in the morning and dissipate in a matter of a few hours. Cold fronts move across the radar surveillance area in about 18 hours on average. In some instances, these baroclinic zones become stationary for few days and are classified as a South Atlantic Convergence Zone (SACZ) if they last more than 5 days. In this case, they produce several disperse rain bands.

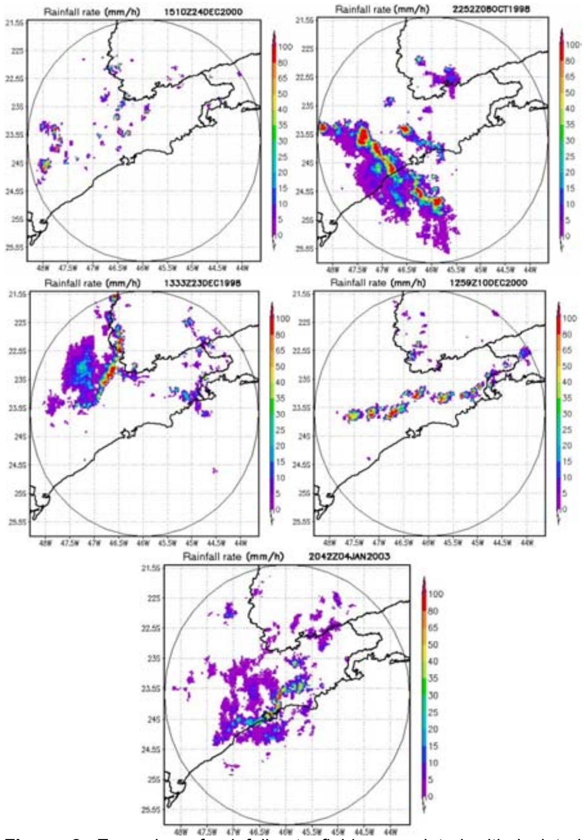

Figure 2: Examples of rainfall rate fields associated with isolated convection (top left), cold front (top right), squall line (middle left), sea breeze (middle right) and disperse bands (bottom) as estimated with the SPWR. Longitudes, latitudes, geographic contours, dates and rainfall rate color scale are indicated.

3. RESULTS

Fig. 3 shows monthly averages of days of rain. It indicates an annual cycle with a peak in January. Fig. 4 shows monthly frequencies of the five different types of rainfall systems, namely, isolated convection, sea breeze, squall line, disperse band and cold front. Isolate convection

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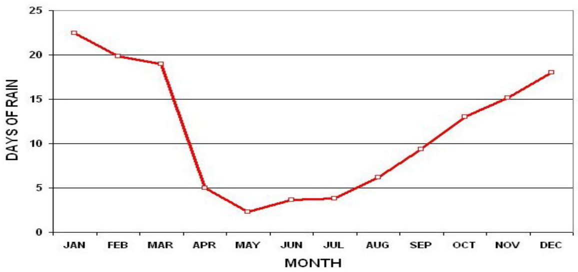

Figure 3: Monthly average number of raining days between 1998 and 2003 as measured with the SPWR.

is the most frequent between November and April. Sea breeze events have higher frequency from January to April. Although with lower frequency, they tend to be associates with floods in the MASP. On the other hand, cold fronts systems are dominant between May and October.

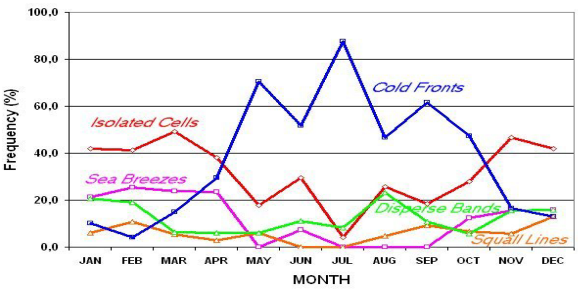

Figure 4: Monthly frequencies of rainfall systems associated with cold fronts, isolated convection, sea breezes, disperse bands and squall lines as monitored within the surveillance area of the SPWR between 1998 and 2003.

Fig. 5 shows monthly frequencies of convective and stratiform rainfall events. Convective and stratiform rainfall events are dominant in spring and summer and in fall and winter, respectively. The relative increase of stratiform events in January and February are associated with episodes of SACZ. The frequency of convective events is maximum in March (82.6%), while for stratiform ones is July (91.7%).

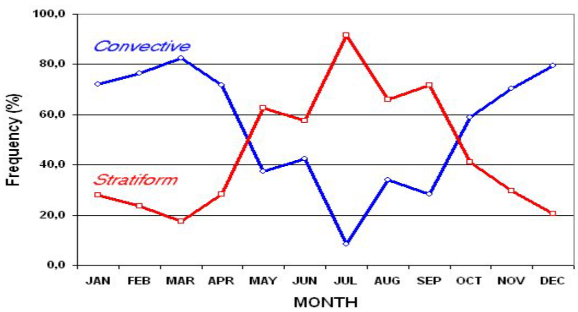

Figure 5: Similar to Fig. 4, except for convective and stratiform rainfall systems.

Fig. 6 shows the total rainfall accumulation of see breeze events that caused severe flood in the MASP. A precipitation high center over 650 mm is apparent over the MASP. In these cases, the see breeze interacts with the heat island of the MASP (Pereira Filho, 1999). Squall lines tend to be associated with moving cold fronts in the warmer season, except in February. Stratiform rainfall systems tend to be controlled by cold fronts, especially in the fall and winter.

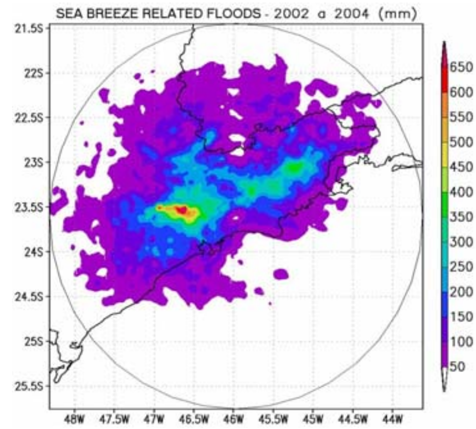

Figure 6: Total rainfall accumulation for precipitation systems associated with sea breeze events that caused flood in the Metropolitan Area of São Paulo. Latitudes, Longitudes, and color scale indicated.

4. CONCLUSION

Convective and stratiform systems show both an annual cycle in frequency lagged by four months. Convective and stratiform systems are dominant in the warm and cold season, respectively. The morphology and time evolution of each category also depend on the topography, associated circulation and source of moisture. Specifically over the Alto Tietê River Basin, the most populated watershed in Brazil, major floods tend to be associated with long lived stratiform rainfall systems produced by synoptic features and remote sources of moisture. Furthermore, most flash floods tend to be linked to convection induced by the heat island of the MASP and the sea breeze circulation. Moreover, the observed dominance of isolated convection and decrease in stationary fronts linked to disperse bands between 1998 and 2003 are consistent with the depletion of water in most reservoirs within that basin. For instance, the rainfall accumulation field over the Jaguari River Basin in Fig. 6 (about 100 km North of the SPWR) was less than 100 mm while in the MASP it was above 650 mm. This basin supplies water to half of the population of the MASP.

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REFERENCES

Gandu, A. W. and Silva Dias M. A. F., 1984: Types and sizes of radar echos associated with rainfall events in the Eastern part of São Paulo State. 3rd Brazilian Meteorological Meeting, Belo Horizonte, proceedings, V.1, 449-456. In Portuguese.

Pereira Filho, A. J. and P. T. Nakayama, 2001: Intercomparison of radar Rainfall Estimates and Rain Gage Measurements in São Paulo, Brazil. 5th International Symposium on Hydrological Applications of Weather Radar. Kyoto, Japan.

Pereira Filho, A. J., 1999: Radar measurements of tropical summer convection: urban feedback on flash floods. 29th radar conference, AMS, Montreal, Canada. Paper 17.4.

Pereira Filho, A. J., R. Hallak e M. T. L. Barros, 2004: Social, economical and hydrometeorological aspects of floods in the Metropolitan Area of São Paulo between 2000 and 2004. 1st Brazilian Symposium on natural disasters – geo-environmental risks and heavy rainfall episodes. Florianópolis, Brazil. In Portuguese.