Case Study Of Mesoscale Convective Complexes: Preliminary Results With Assimilation Of Radar Data

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ABSTRACT

Mesoscale Convective Complexes (MCC) are responsible for intense storms in southern region of Brazil. Usually, the MCC events can cause significant damage and are related to strong winds, atmospheric electrical discharges, heavy rain, and, in more extreme cases, even hail. This work presents a detailed study of these events based on radar data assimilation. In numerical weather prediction, an adequate radar data assimilation leads to better representation of the MCC, improving the forecast of this event. Moreover, an accurate forecast model is an important tool for the meteorologist. Thus, in order to demonstrate the importance of data radar assimilation in a correct way, the results of operational models of CPTEC (Center for Weather Forecasting and Climate Research) and the radar data assimilation with WRF are compared for the western of Paraná state and southeastern of Paraguay. The results of this work may contribute to improve the alerting systems of this kind of event with better accuracy and in advance, reducing losses caused by landslides, destruction of plantations, falling trees, and others.

INTRODUCTION

The Mesoscale Convective Systems (MCS) are phenomena responsible for intense precipitation events over short periods. These phenomena can be subdivided into squall lines, and MCCs. One of the preferential regions of MCCs occurrence in South America is that of the Paraná River basin, where such systems are rapidly formed and can last several hours (Velasco & Fritsch, 1987). This system's main source of heat and humidity the South American low-level jet (SALLJ). In the period analyzed by Sakamoto (2009) less than 30% of SCMs have been formed in days with LLJ, but the analysis of back-trajectories of moisture particles showed that 68% of continental convective systems presented moisture sources north of 20°S - with the north and south tropical Atlantic, Amazon and central Brazil the main regions of origin. This proves that the MCCs can be formed without setting the SAJJL, but that the major source of moisture comes from lower latitudes than the latitude at which the system is formed.

In addition, the study and monitoring presented in this work deals with an area that has important power transmission lines and also lodges the Paraná River basin, one of the major hydroelectric powergenerator from all over Brazil - and both are impacted by weather systems, especially the MCS. Consequently, it is necessary to implement a modern hydrometeorological monitoring system and also improve the knowledge of these phenomena in order to mitigate the damage caused by the severe weather that affect the state of Parana and Paraguay.

MATERIALS AND METHODS

The MCC is a classification of MCS based on infrared satellite images, that meets the criteria defined by Maddox (1980) - in which the system must have: eccentricity $\geq$0.7, area$\geq$100,000 km² with brightness temperature (Tb) lower than -32°C, and the system also have inner region area 50.000km² with Tb$\leq$-52°C, and all of the aforementioned criteria must remain for 6 hours or more. The MCCs are by a quite organized and almost circular convection. The Tb thresholds for classifying these systems are arbitrary and different thresholds are defined in the literature. Nieto Ferreira et al (2003) consider the Tb thresholds of -40 and -62°C, since temperatures above these thresholds provide systems with large area and different points of convection. This definition is justified by the detection possibility of each isolated system, which allows a better definition of each convective core.

The ETA model is a weather numerical modeling which became operational in 1993 at National Centers for Environmental Prediction (NCEP) and its vertical coordinate η (ETA) named the model which is function of pressure level and surface high. It is installed on CPTEC since 1996 with order to complement the numerical weather prediction and it has horizontal resolution of 15 km and 22 vertical levels. The Brazilian developments on the Regional Atmospheric Modeling System (BRAMS) it is a regional weather prediction modeling processed in daily weather forecast and weather research, at CPTEC/INPE, with horizontal resolution of 5 km and 19 vertical levels.

The WRF model was ran with horizontal resolution of 2km without radar data assimilation and with data assimilation for region of interest between 20º-30°S of latitude and 50º-65°W of longitude.

The WRF model made data assimilation of polarimetric doppler radar data from the *Dirección Nacional de Aeronautica Civil* (DINAC). This radar is located in Asunción (Paraguay) (Latitude: 25.33°S, longitude: 57.52°W and altitude: 118.0m) with a wavelength of 5.4cm, 11 elevations and pulse width of 0.8µs and data coverage over 250 km. The radar data was assimilated into the forecasting model by WRFDA (WRF Data Assimilation) as used for Vendrasco (2015). The variables used for data assimilation were reflectivity and radial wind. The PPI is a product in which the variable is plotted in a plan centered on the radar and his plan is set to an angle of elevation. As increasing distance from the radar it increases the height of the data analyzed. PPIs were generated and assimilated as vertical profiles.The PPI assimilation has a great advantage compared to CAPPI assimilation because PPI has not errors associated with interpolation made to projection in the plan (CAPPI) and therefore decline the noise in the model.

For the preliminary study were made comparisons between the performance of models and precipitation estimates with the TRMM 3B42 (version 7) in 3-3 hourly (Huffman et al, 2007). The run of ETA and BRAMS models were analyzed for the model initialized to 00Z of november, 01st.

The identification, calculations of eccentricity, area and tracking of the system were performed by McIDAS software (Man computer Interactive Data Access System) version V, based on the criteria used for Maddox(1980). Other figures and computations to analyze the models were generated by the software Grid Analysisand Display System (GrADS). Interpolation functions were used to calculate the various resolutions of the models and the accumulated rainfall during periods of 00-06Z, 00-12Z, 06-12Z and 06-18Z of november,01st.

RESULTS AND DISCUSSION

The results show the synoptic conditions and satellite imagery, and then the numerical analysis with rainfall forecast fields.

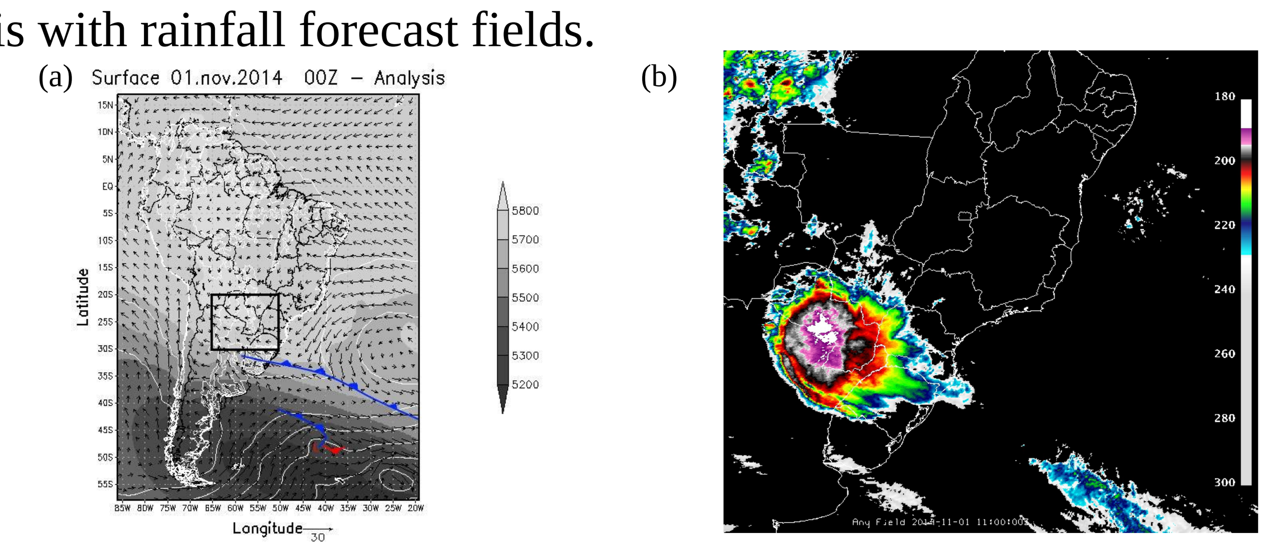
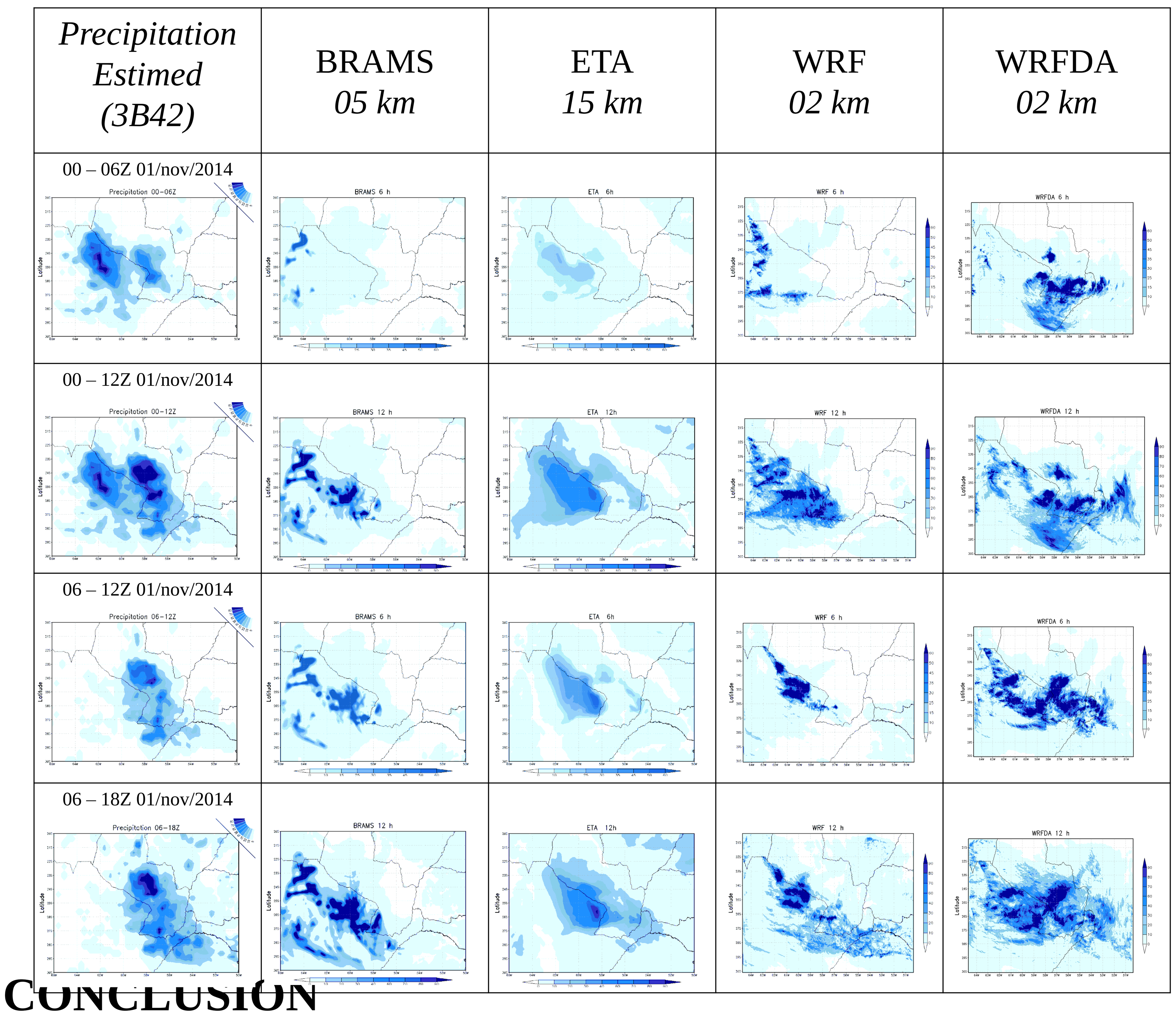


FIGURE 1: (a) Surface analysis at 01/nov/2014 at 00Z .(b) Enhanced Infrared Satellite at 09Z, 01/nov/2014.



CONCLUSION

The MCC occurred on November 1, 2014, and the evaluation of the models is very important to know what are the limitations of the models for the study area. All models had difficulty in setting the location and intensity of precipitation associated with the CCM. The areas with the highest rates of accumulated rainfall in the period were in Paraguay and the models predominantly indicated the northeastern border with Argentina and Paraguay. The ETA model underestimated the event precipitation values and BRAMS and WRF models overestimated. The WRFDA achieved the best results especially for the first 6 hours, indicating the improvement associated assimilation of radar data, surface and upper air.

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