THUNDERSTORM CHARACTERISTICS OF SUMMER PRECIPITATING SYSTEMS DURING CHUVA-GLM VALE DO PARAIBA FIELD CAMPAIGN

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1. INTRODUCTION

CHUVA (**C**loud processes of t**H**e main precipitation systems in Brazil: A contrib**U**tion to cloud resol**V**ing modeling and to the GPM (Glob**A**l Precipitation Measurement)) is a project that will carry out seven field experiments to investigate the different precipitation regimes in Brazil. The objective of these field experiments is collect detailed information about the different precipitation regimes found in Brazil and their associated physical processes in support of the GPM program. This information will improve the quality of precipitation estimation and the knowledge of cloud microphysical processes of several different types of convective systems in Brazil, from warm clouds and local thunderstorms to squall lines, frontal and mesoscale convective systems. For more details on the CHUVA experiment see Machado et al. (2012) and http://chuvaproject.cptec.inpe.br/.

The fourth field experiment was conducted in southeast Brazil, at Vale do Paraiba and São Paulo metropolitan region from November-2011 through March-2012. To depict precipitating weather systems, CHUVA uses a XPOL Doppler Radar, 2 MiniRain Radars, 6 disdrometers, 10 rain gauges, 1 microwave radiometer MP3000, 1 Lidar, a GPS network for water vapor retrievals. This particular experiment was called CHUVA-Geostationary Lightning Mapper (GLM) Vale do Paraiba and in addition to characterize the precipitating systems observed in Southeast Brazil it also collected lightning proxy data for the upcoming geostationary lightning imagers (GOES-R GLM and MTG LI) using 10 lightning locating systems (LLS) (LMA, LINET, TLS200, ENTLN, RINDAT, STARNET, WWLLN, GLN, ATDnet, GLD360), high-speed cameras, and the TRMM-LIS satellite. Figure 1 shows the distribution of CHUVA-GLM Vale field experiment.

CHUVA-GLM provided a comprehensive database of thunderstorm development and characteristics for the first time in Brazil, where a large variety of cloud systems were sampled: cold fronts, squall lines, the South Atlantic Convergence Zone (SACZ) and local convective systems. Microphysical characteristics (such as hydrometeor identification and ice/water mass) of these summer 2011-2012 precipitating systems can be inferred from the X-Pol and 3 operational S-band radars, and the LLS provide detailed information about the storms electrical activity (such as charge centers and lighting propagation processes).

The Sao Paulo Lightning Mapping Array (SPLMA) was deployed at the metropolitain region of Sao Paulo city using 12 sensors in a baseline of 15-20km. The Lightning Mapping Array was developed by the New Mexico Institute of Mining and Technology (Rison et al. 1999), based on the Lightning Detecting and Ranging (LDAR) system developed to be used at the NASA Kennedy Space Center (Maier et al. 1995). The LMA system locates the peak source of impulsive VHF radio signals from lightning in an unused television channel by measuring the time-of-arrival of the magnetic peak signals at different receiving stations in successive 80 μs intervals. Hundreds of sources per flash can be detected in space and time, allowing a three-dimensional (3-D)

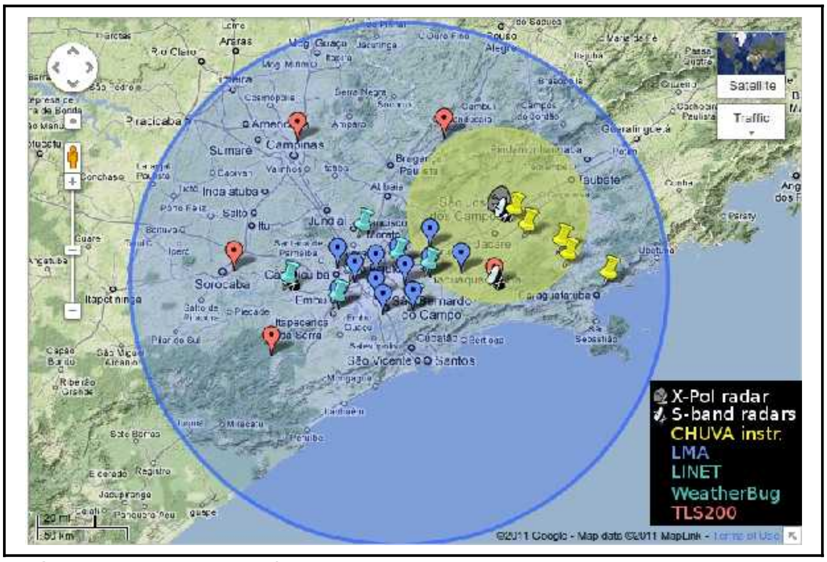


Figure 1 – CHUVA-GLM Vale do Paraíba field campaign experiment coverage and instruments. Blue, pink and cyan pins represent the 4 total (intracloud and cloud-to-ground)lightning deployed for this experiment. Yellow pins are the CHUVA sites with disdrometers, pluviometers, radiometers, lidars, etc.The yellow circle is the Dual-Pol X-band radar 50km coverage area, and the blue circle is the SPLMA 250km coverage.

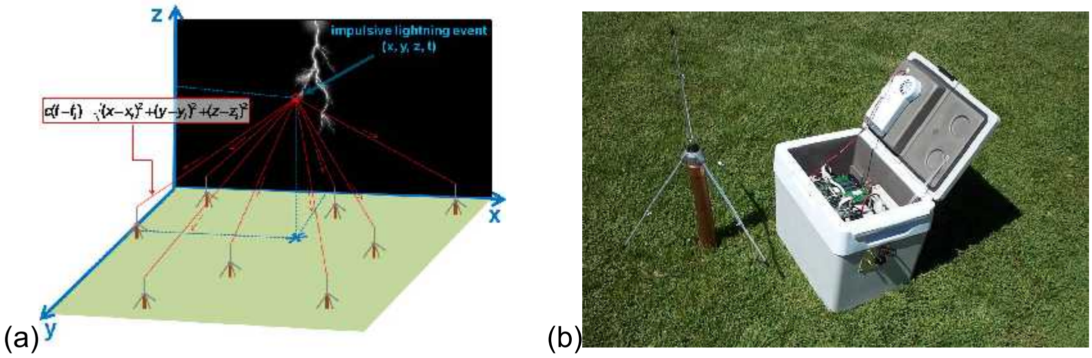
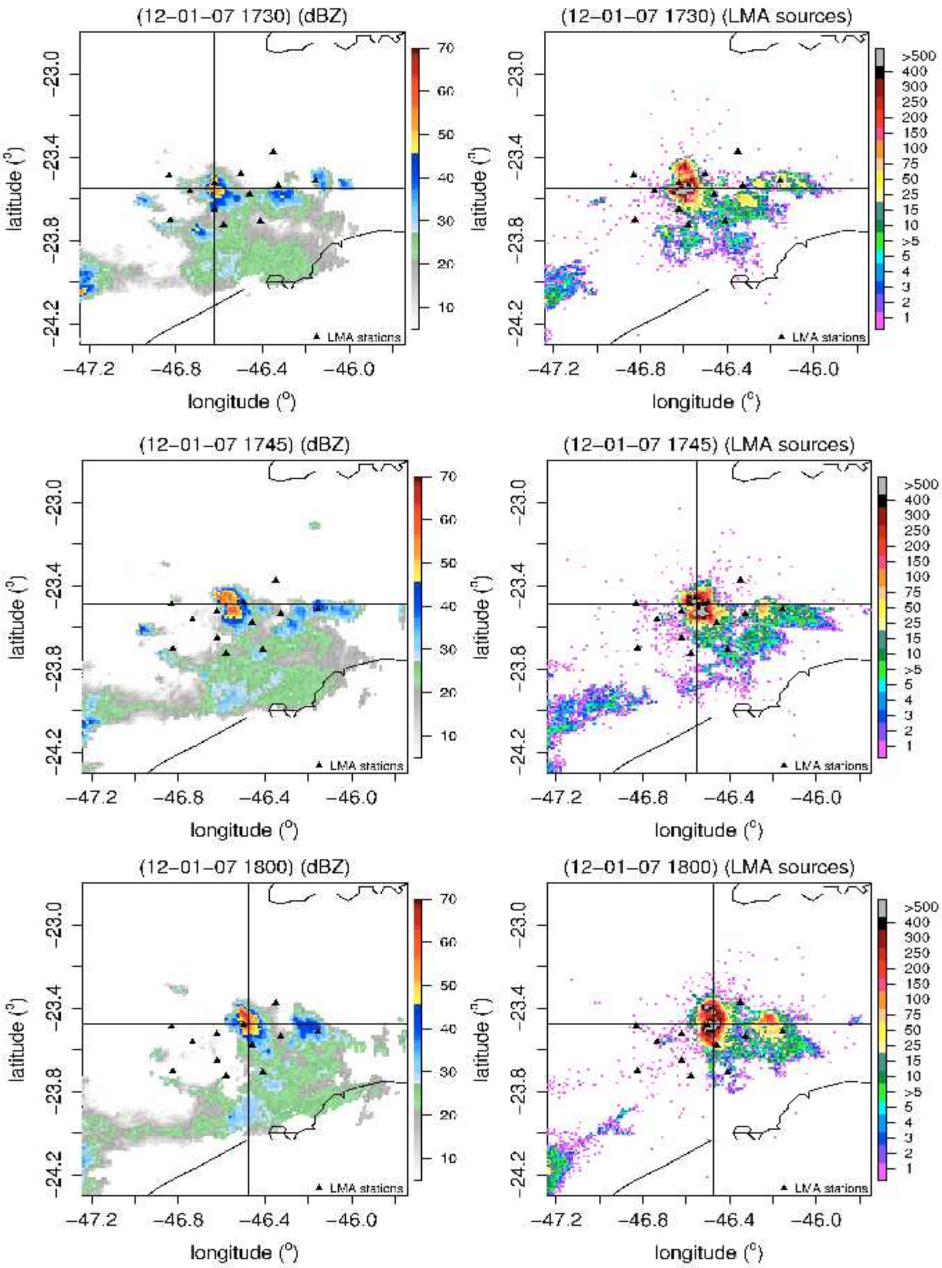
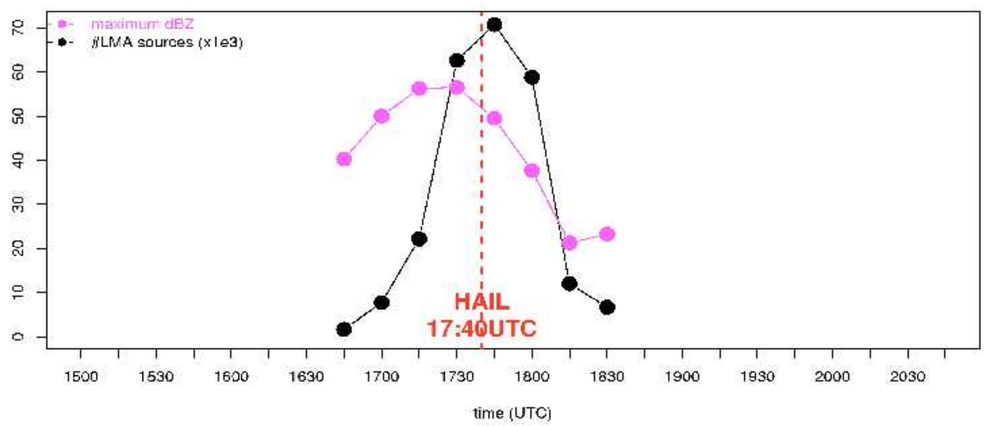


Figure 2 – (a) Illustration of the time-of-arrival technique used by the LMA system. The times (t_i) when a signal is detected at N≥4 stations are used to solve for the 3D source location (x, y, z, t) of the impulsive breakdown processes associated with a discharge. (b) Portable LMA station electronic box and antenna.

Figure 3 – Snapshots of a video testimony from the 07 January 2012 hailstorm and flooding in Guarulhos, SP, Brazil. (http://www.youtube.com/watch?v=9Y3AEZzK-9k)



(a)



(b)

Figure 4 – (a) Radar reflectivity (dBZ) CAPPI at 3km height and LMA lightning source density (number of sources in 1x1 km grid), and (b) time evolution of the maximum reflectivity and number of LMA lightning sources of the severe storm cell that produced hail and flooding in Sao Paulo and Guarulhos on 07 January 2012. The vertical and horizontal lines at (a) indicate the location of maximum at (b).

lightning map to be constructed with nominally<50 m error within 150 km (Goodman et al. 2005). Figure 2a illustrates the time-of-arrival approach used in the LMA system. Global Positioning System (GPS) receivers at each station provide both accurate signal timing and station location knowledge required to apply this approach. Figure 2b is a picture of a portable LMA station hardware.

2. PRELIMINARY RESULTS

From November 2011 to March 2012, several severe weather cases were observed during this experiment, where hail, damage winds and flooding were reported over the metropolitan area of Sao Paulo City and across state of Sao Paulo. Localized and a few organized convective systems were responsible for hail precipitation from pea to tennis ball sizes. Brazil national weather service does not hold an official weather phenomena reporting database. Therefore, during this field experiment we had collected severe weather reports based on city of Sao Paulo Civil Defense service, media news (newspaper and TV) and internet searching from social network reports. Up to the time that this manuscript was written, we had identified 24 hail and damaging wind reports over the metropolitan area of Sao Paulo.On 07 January 2012 a convective system produced pea sized hail and flooding in Sao Paulo and Guarulhos, SP. Guarulhos the hailstorm lasted for about 15 minutes from 15:40 to 15:55 local time (1740 1755 UTC). Several video testimonies from this hail and flooding event can be found on the internet (Figure 3). Figure 4 shows a sequence of the operational S-band radar reflectivity and the SPLMA lightning source density. This convective system initiated southwest of Sao Paulo city and traveled troughout Sao Paulo and Guarulhos with reflectivity above 40 dBZ from 14:00 LST to 18:00 LST, reaching values as high as 59 dBZ at 15:15 LST when hail was reported downtown Sao Paulo. Half an hour later hail and flooding was repoted in Guarulhos when a maximum of LMA sources was observed (Figure 4). This maximum of lighting sources is known as “lightning-jump” and has been associated with severe weather, including tornados (Schultz et al., 2009; among others). Figure 5 shows the accumulated LMA source density plot in a latitude-longitude, latitude-height and longitude-height views. It can be seen that the lightning activity had two major regions of sources at ~7 and 10 km of height, where

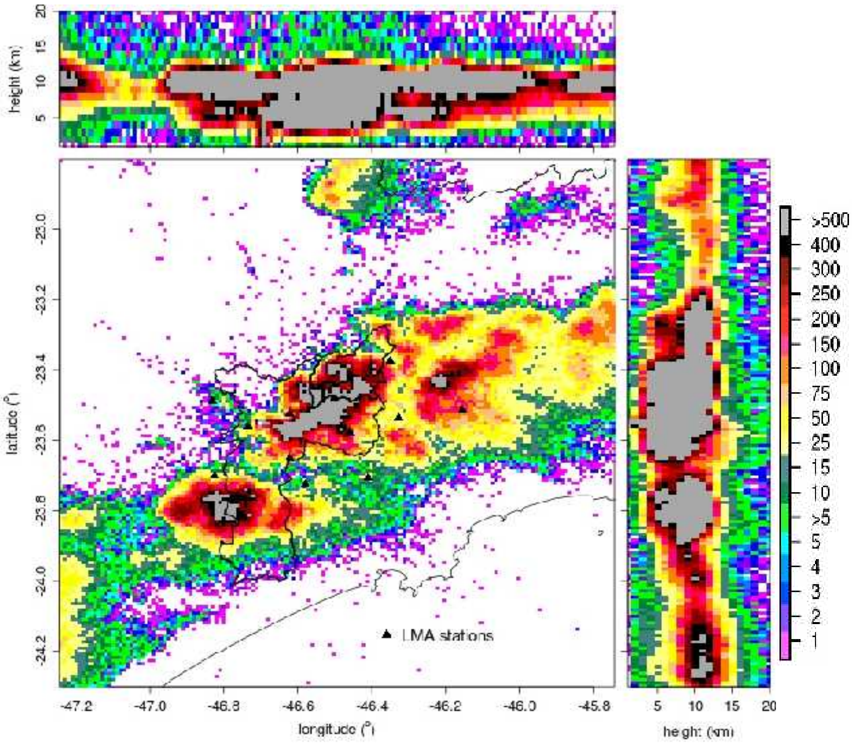


Figure 5 – Accumulated LMA lightning source density (number of sources in 1x1 km grid) from 07 January 2012 13:00-18:59 LST (1500-2059UTC) at a plan (latitude-longitude) view, as well as latitude-height and longitude-height views. Black solid lines indicate Sao Paulo and Guarulhos city boundaries.

mixed ice phase collision rebounding of ice particles occur and thunderstorm electrical charge centers are built. It can also be seen that thunderstorms extended up 18 km of height (LMA source density >5 in Figure 5).

A lightning-jump was observed during all the severe weather reported. This feature is a useful tool for warning issues. Moreover, the SPLMA map in detail all the convective-core cells of the thunderstorms in near real time. The last 10 minutes of SPLMA lightning data was updated to the CHUVA nowcasting website (SOS, Machado et al., 2012) every 5 minutes, giving the civil defense, management organizations, power companies and the public in general real time information about convection and lightning threat.

3. CONCLUSIONS

The total lightning information provided during the CHUVA-GLM Vale do Paraiba field campaign showed that lightning channel mapping and detailed information on the locations of cloud charge regions. The real-time availability of LMA observations contributed a lot and supported improved weather situational awareness for the mission execution as well for civil defense warnings and nowcasting. The measurements obtained from SPLMA provided for the first time total lightning measurements in conjunction with Meteosat SEVIRI observations, which is the proxy data for the future GOES-R Advanded Baseline Imager. Proxy data for the GLM sensor will be developed using the SPLMA generating a unique and valuable proxy data sets for both GLM and ABI sensors in support of several on-going research investigations, and nowcasting tools.

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REFERENCES

Goodman, S. J., and co-authors (2005): The North Alabama Lightning Mapping Array: Recent severe storm observations and future prospects. Atmos. Res., 76, 423-437.

Machado, L. A. T*.,* A. Calheiros, E. Mattos, I. Costa, D. Vila, R. Albrecht, C. Morales, C. Angelis, M. Silva Dias, G. Fisch (2012): Tropical Cloud Processes : First Results from CHUVA Project. Proceeding of the 16th International Conference on Clouds and Precipitation (ICCP2012), 30 July – 03 Augst 2012, Leipzing, Germany. (*this issue*)

Maier, L., C. Lennon, T. Britt, and S. Schaefer (1995): LDAR system performance and analysis, in Proceedings of the International Conference on Cloud Physics, Am. Meteorol. Soc., Boston, Mass., Dallas, Tex., Jan 1995.

Rison, W., R. J. Thomas, P. R. Krehbeil, T. Hamlin, and J. Harlin (1999): A GPS-based three-dimensional lightning mapping system: Initial observations in central New Mexico, Geophys. Res. Lett., 26, 3573– 3576.

Schultz, C. J., W. A. Petersen, L. D. Carrey (2009): Preliminary Development and Evaluation of Lightning Jump Algorithms for the Real-Time Detection of Severe Weather. J. Appl. Meteorol. Climatol., 48, 2542-2563.