# A COMPARATIVE ANALYSIS BETWEEN WEATHER RADAR IMAGES AND DENSITY FIELDS OF LIGHTNING OCCURRENCES FOR SEVERE CONVECTIVE EVENTS

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***Abstract***

*This work provides a brief discussion about the comparison between CAPPI weather radar images and the corresponding fields of density of occurrence of cloud-to-ground lightning generated by the software tool EDDA. It is possible to correlate the precipitating structures observed in the radar images to the denser areas in the density field of occurrence. Such density fields were already employed as a mean for monitoring convective events in areas that are not covered by weather radars.*

**Keywords:** *meteorological radar, atmospheric electrical discharges, convective systems*

## 1. Introduction

The visualization of the density field of cloud-to-ground lightning occurrences can be useful for monitoring severe convective activity, since it provides a smooth two-dimensional field of the lightning occurrences for a given time interval. These occurrences are tipically very sparse in time and space. The corresponding density field is generated by the EDDA software from lightning data provided by the RINDAT sensor network. Most of the Brazilian territory is convered by this network. EDDA stands for Estimator of Density of Atmospheric electrical Discharges, in Portuguese. Its output format is compatible with the GRADS visualization software, commonly employed in Meteorology. In addition, the EDDA software provides near real time processing according to the availability of lightning data making possible to generate animations that show the temporal evolution of the lightning occurrence density field. The radar data employed in this work were provided by 3 weather radars located in the São Paulo State. Constant Altitude Plan Position Indicator (CAPPI) images were derived from the radar data and a small set of severe convective events was then selected from the CAPPI images. The corresponding images for the lightning density of occurrence were also generated. A comparative analysis of both sets of images from each convective event showed a correlation between the precipitating structures observed in the radar images and the more intense parts of the discharge density field of occurrence. Such correlation suggests that lightning density of occurrence fields may be useful to monitor convective activity in quasi real time in areas where a weather radar coverage is not available. It can be concluded that the EDDA software has a potential use for operational Meteorology, particularly for nowcasting.

## 2. Weather radar

Weather radars allow to observe the vertical profile of clouds by measuring the cloud reflectivity (in dBZ) by scanning the sky in both azimuth and elevation. Constant Altitude Plan Position Indicator (CAPPI) images are 2D horizontal intersections of the 3D reflectivity measurements. The reflectivity values are mapped to the precipitation rate by a assumed R-Z relation. However, radar mesurements are limited to a short range (tipically 240 km) since the line of sight of its beam gets higher and higher due to the Earth surface curvature (CALHEIROS, 2009). Nowadays the use of weather radar for the monitoring and study of atmospheric precipitation is widespread and most countries may afford to have high temporal and spatial resolution weather radars, but only USA, Europe and some countries make use of a network of weather radars with full geographical coverage.

The weather radar data employed in this work were provided by the IPMET/UNESP (IPMET, a Meteorology research institute linked to the São Paulo State University, UNESP) weather radars of Presidente Prudente, and Bauru and a weather radar of DECEA (Brazilian Air Force) in São Roque. All the radars are located in the São Paulo state and the processsing of their data provided Constant Altitude Plan Position Indicator (CAPPI) images.

## 3. The EDDA software tool

It is very difficult to keep track of the occurrences of cloud-to-ground lightnings, since they are very sparse in time and space. Therefore, it is also difficult to associate lightning occurrences to convective events. In 2005, an innovative approach was adopted to tackle this issue, the grouping of lightning occurrences by means of a common spatial analysis technique, the kernel estimation (POLITI, 2005). Initially, this technique was implemented in the MatLab language, in order to generate a field of density of lightning occurrences. Later, a C/C++ version was also developed (CAETANO, 2009). The current implementation is the EDDA software tool (STRAUSS, 2010). This name stands for Estimator of Density of Atmospheric electrical Discharges, in Portuguese. The density of occurrence of lightnings is estimated from the individual lightning records provided by the RINDAT network (Brazilian Lightning Detection Network) (NACCARATO, 2009) for the area and time interval specified by the user. The kernel function can be selected, being the Gaussian normally employed. Specific parameters can be chosen, in order to adjust the spatial and temporal scale of observation.

The denser areas were denoted as Nuclei of Electrical Activity (NAE’s), and are associated to the convective clouds that generated the lightnings. Since the weather radar detects precipitating structures that are typically convective clouds, it is expected to find some correlation between such structures and the NAE's (CAETANO, 2010).

The EDDA software was designed for meteorological data mining purposes and allows to easily generate a temporal sequence of fields of occurrence of lightnings. It is also possible to visualize animations that show the temporal evolution of the density field. Outputs are given in ASCII format and also in bynary file grid format, that is suitable for the GRADS visualization tool, commonly used in Meteorology.

## 4. Correlation results

A particular severe convective event of January 20th, 2010, was selected to be shown as a case study. The EDDA software generated the field of density of lightning occurrences for a 10 minute interval and a 0.02 degree grid. This field was plotted like level curves over the CAPPI image using the same temporal and spatial resolution as show the in Figure 1.

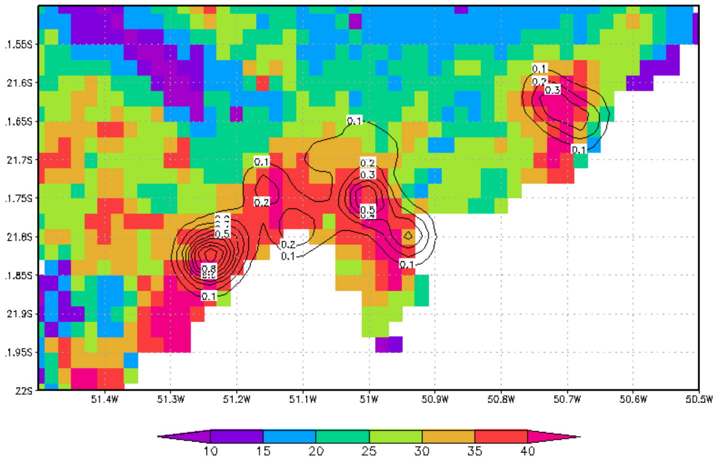
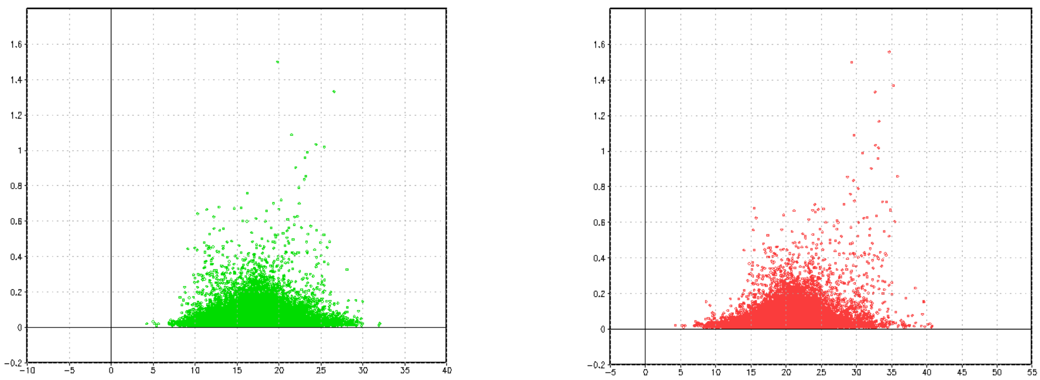



Figure 1 – CAPPI image showing the reflectivity field (in dBZ) overlaped with the NAE's level curves.

Considering the same selected convective event, scatter plots were derived to analyze such correlation was possible to distingshi in the CAPPI image the areas corresponding to convective clouds from the ones corresponding to stratiform clouds (STEINERS, 1995). A pair of scatter plots is presented in Figures 2(a) and 2(b), for stratiform and convective clouds, respectively. However, instead of a 10 minute interval, a pixel wise average of the above-threshold densities was performed for all 10 minute intervals of the same day, i.e. all pixel that presented lightning occurrences in some time interval were considered. A Gaussian distribution can be observed in both scatter plots (please note that the reflectivity scales in both figures are also different). In Figure 2(a) (stratiform clouds), the higher density of lightning occurrences corresponds to a reflectivity range of 15-20 dBZ, while in Figure 2(b) (convective clouds), corresponds to a range of 20-25dBZ. The latter values are usually associated to convectiveclouds.



(a) (b)

Figura 2 - Scatter plot of the normalized density of lightning occurrences versus the radar reflectivity (in dBZ) for (a) stratiform clouds and (b) convective clouds for

January 20th, 2010.

## 5. Final remarks

A comparison between CAPPI weather radar images and the corresponding fields of density of occurrence of cloud-to-ground lightning was performed for a small set of convective events. It was possible to correlate the precipitating structures observed in the radar images with the denser areas in the density field. Since it was possible to distinguish stratiform from convective clouds, scatter plots of the distribution of the lightning occurrence density versus the radar reflectivity were made for both types of clouds. It is possible to correlate higher reflectivity values to lightning occurrence in convective clouds and lower values to lightnings in stratiform clouds. The scatter plots of the average density of occurrence versus the reflectivity show Gaussian distributions for both the stratiform and convective clouds. However, such correlation needs to be further investigated.

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