THE Effect of wind shear on thunderstorms lightning ACTIVITY: a CASE STUDY IN THE AMAZON BASIN

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Some studies show the existence of a correlation between vertical wind shear and updraft intensity on the thunderstorm development while other works have shown that stronger updrafts enhance the formation of graupel and hail (rimming and accretion of super-cooled water on ice particles), that in turn increases the lightning activity in the thunderstorm. On radar measurements though, vertical wind shear is identified by the cloud tilting on radar reflectivity cores. Upon this fact, vertical wind shear could be estimated from the tilting angle that a vertical precipitating radar echo presents.

In the Amazon basin, it has been observed severe thunderstorms (more than 100 lightning strokes/minute) despite the fact that this region is in the tropics where barotropic instability predominates and wind shear is not so strong as observed in the extra-tropics and mid-latitudes. Taking into account this puzzle, this study proposes to understand how lightning activity responds to the vertical wind shear to further develop a relationship between updraft intensity and lightning flash rates.

For this study, radar measurements from Manaus S-Band weather radar and 3D lightning observations of LINET available during the period of August-September of 2014 as part of the CHUVA Project’ s field campaign are augmented to depict the relationship between shear and lightning flash rate. As a first result, 3D convective cores defined by 45 dBZ have been tracked using 3D CAPPI with 2 km x 2 km horizontal and 1 km vertical resolution on a squall line observed on September 8th, between 18:00 UTC and 21:36 UTC. For example, Figure 1 shows a time series of the mean echo top, vertical tilting angle (shear), total 45 dbZ rain volume and the volume above the height of 5 km and observed total lightning flash rate. It is important to state that three distinct convective cores were tracked since the main precipitation cell merges or dyes and those transitions are indicated by vertical lines. Overall, the first core was already decaying, presenting an echotop that oscillated between 6 km and 7 km, mean echo height of 3 km and low flash rate of 6 flashes/min for the entire squall line (20 dBZ). Its tilting initially was around 0° and at 18:24 has slightly increased to about 4°. The second core was still developing until 19:00, peaking at 2500 km^3 total volume, about 750 km^3 mixed phase volume and an echotop above 14 km and mean height of 4 km, an indicative of deep convection. However, tilting angle and flash rate were low until 19:30, with values around 2.5° and 40 flashes/min, respectively. After 19:30, the echo top height falls to around 6 km (3 km mean) and then slightly increases to 7km from 19:48 to 20:00, followed by a tilting angle increase of approximately 5.5° and flash rate reaching more than 100 flashes/min as it crosses Solimões river. Finally, the third core presented a maximum flash rate of more than 600 flashes/min that was followed by a sudden increase on the echotop around 9 km, total volume of ˜2500 km^3 and ˜500 km^3 in the mixed phase. The tilting angle increased from 1° in the maximum activity to 4.5° in the decaying stage. A possible explanation for this sudden lightning activity would be the interaction between gust fronts from this core with one from another nearby core (later the two merged) and the fluvial breeze circulation of the Solimões river that is oriented almost perpendicular to prevailing wind direction and storm motion besides been considerably wide (˜1km).

For the conference, we will extend the analysis to CAPPIs with horizontal resolution of 5 km x 5 km and 1 km in the the vertical in order to verify if TRMM PR measurements are suitable to identify vertical shear, so we could test if it is possible to use this methodology to extend to other regions in the tropics.

Keywords: wind shear, lightning, flash rate, convection, thunderstorm, tropical