P1.32 Evolution of lightning in eastern Pacific Tropical Cyclones as they approach the coast of Mexico

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1. Introduction

Cumulonimbus clouds are present in tropical cyclones, both in the inner core as well as the outer bands and may reach 16km in vertical extent. Their bases are typically found only a few hundred meters above the sea level, with temperatures that may exceed 20C, while their tops can have temperatures as low as -90C. Since the liquid water in the droplets does not freeze at 0C, and there can be a large volume in the cloud where high concentrations of super-cooled droplets are present and co-located with ice crystals and graupel. Lightning in clouds is the result of interactions between hydrometeors, and laboratory studies over the years have indicated that the collisions between low-density ice crystals and high-density growing graupel (by accretion of super-cooled droplets) results in a systematic charge separation, with graupel acquiring negative charge.

Molinari et al (1994, 1999) analyzed the spatial distribution of lightning in TCs that were approaching the US coastline. They found 3 distinct regions: the outer bands (an annulus of radius 200-300km) with the largest density of flashes, a region with minimum lightning in a ring between 100-200km and the inner core with a secondary maximum.

Khain et al (2010) based on results from numerical simulations, have put forward the hypothesis that as the system moves closer to land, the circulation advects continental cloud condensation nuclei (CCN) and possibly also ice nuclei, therefore affecting the microphysical processes that were taking place further offshore.

Lightning in the inner core of tropical cyclones has been associated with intensification by Lyons and Keen (1994) and Fierro et al (2007).

3. Data and methodology

We utilize the official Best track database from the National Hurricane Center to determine the trajectory, maximum wind speed and minimum pressure of cyclones that approach the coast of Mexico.

The lightning data is obtained from the World Wide Lightning Location Network (WWLLN), based on the detection of spherics associated with lightning by over 40 stations distributed over the globe and coordinated by Dr. Holzworth at the University of Washington. The detection efficiency and accuracy of the data (Rodger et al., 2005; Lay et al, 2007; Abarca et al 2010) has shown that the data is good enough to be used in these type of studies.

We initially considered 13 cyclones in the eastern Pacific basin whose centers made landfall between 2005 and 2011, as well as those that we have called "land-grazing", in which only outer bands made landfall. We have divided the lightning data for each of them into an internal circle with a radius of 111 km and 2 surrounding annuli of 111km and 166km, respectively.

The sample was then increased to include 8 cyclones that made landfall over the Yucatan peninsula and the Mexican coast of the coast of Mexico between 2005 and 2009, to compare the trends.

2. Objectives

- To characterize the evolution of lightning as tropical cyclones approach the coast of Mexico before landfall
- To evaluate if there is a relationship with distance from the coast, to support the continental CCN hypothesis
- To evaluate if there is a relationship between inner core lightning and intensification.

4. Results

4.1 Selected Pacific case studies: Rick 2009

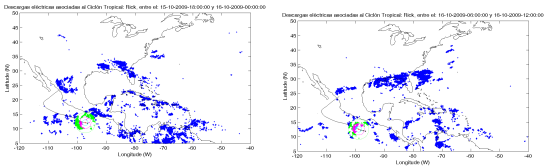


Figure 1. The best trajectory of Rick is shown as the black line. Rick made landfall in Sinaloa, after recurving, a typical late season trajectory. The concentric circles define the inner core (light blue), inner band (pink) and outer band (green). The coloured dots correspond to lightning events within each region during a period of 6hrs. These figures are 12 hrs apart. Most of the lightning is observed in the outer band region and ahead of the center of the hurricane, consistent with Molinari et al (1994 & 1999). Very few flashes are observed in the inner region. The blue dots depict the lightning observed in the same period, but not directly related to the hurricane.

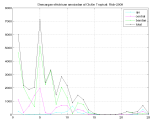


Figure 2. Shows the time evolution of the flashes as a function of region.

4.2 Selected Pacific case studies: Frank 2010

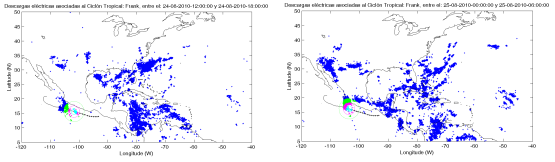


Figure 3. The best trajectory of Frank is shown as the black line. Frank did not make landfall. The concentric circles define the inner core (light blue), inner band (pink) and outer band (green). These figures are 12 hrs apart. Most of the lightning is again observed in the outer band region and ahead of the center of the hurricane. The later period indicates increased flashes in the inner region.

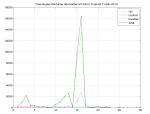
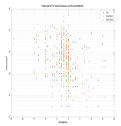


Figure 4. Shows the time evolution of the flashes as a function of region.

4.3 Composite of Lightning vs. Intensity

Pacific over ocean



Pacific over land

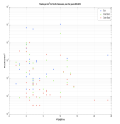
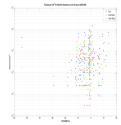


Figure 5. Flash density as a function of cyclone deepening in 6 hrs for Pacific cases before and after landfall.

Atlantic over ocean



Atlantic over land

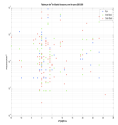


Figure 6. Same as Fig. 5 but for Atlantic cases.

5. Conclusions

- Most of the lightning is observed in outer bands
- There is no unique relationship between flash density and distance from the coast
- Flash density is larger when cyclones are deepening

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