Using total lightning data from GLM/GOES-R to improve real-time tropical cyclone genesis and intensity forecasts

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Abstract

Several studies have documented lightning and electrification in and around the eyewall of tropical cyclones (TCs). Although determining how lightning is related to intensification and weakening of the TC core has been hampered by the relatively small number of TCs in which instruments capable of detecting total lightning activity were available, both theory and observations suggest that total lightning flash rates in the core depict when and where hot towers develop there. The purpose of the proposed work is to improve our knowledge of these relationships and to use them to improve our ability to forecast the genesis and intensity of changes in the nature of TCs. Two lines of research are proposed to achieve this objective.

The first line of research, led by Dr. Fierro, builds upon recent TC modeling research involving Dr. Fierro and upon the previous development involving several collaborating researchers at the National Severe Storms Laboratory (NSSL) to implement explicit electrification physics and lightning within the WRF-ARW model. We propose to investigate lightning in numerical simulations of TCs and to use the relationships tested in these simulations and verified by comparison with TC observations to develop total lightning predictors that can be used to assimilate total lightning observations directly into NHC's statistical prediction model (SHIPS). Total lightning is emphasized because it is much better correlated to convective strength than cloud-to-ground lightning is. Lightning information is particularly critical in regions where radar data are scarce, such as over oceans where all TCs develop and eventually intensify.

The second line of proposed research, led by Dr. DeMaria, is to develop an asymmetric total lightning predictor for the operational Rapid Intensification Index (RII) for TCs by using retrospective studies of the relatively large sample of tropical mesoscale convective systems (tropical depressions, tropical storms and TCs) evolving over the Gulf of Mexico and the Caribbean during the 2012-2014 hurricane seasons. An experimental version of the RII that includes lightning density input from the ground-based World Wide Lightning Location Network (WWLLN) has already been developed and is being tested in the Satellite Proving Ground at the National Hurricane Center (NHC). However, the WWLLN dataset is still dominated by cloud to ground strikes, and is not an optimal proxy for the Geostationary Lightning Mapper (GLM). The next step towards a version of the RII with GLM input is to test input from the EarthNetworks® lightning data, which provides total lightning observations. Inter-comparisons with the WWLNN data will be performed to begin development of a total-lightning RII. Also, the proper utilization of the total lightning requires an improved understanding of the relationships between storm intensity (and RII) and total lightning, which will be achieved through the high resolution simulations by Dr. Fierro.

The chief rationale for developing enhanced operational predictors for total lightning arises from the upcoming launch of the GLM on the Geostationary Operational Environmental Satellite R series (GOES-

R) in FY2016. The GLM will be capable of mapping both cloud-to-ground and in-cloud lightning day and night, year-round, with a spatial resolution of 8 and 12 km over the Americas and surrounding oceans.