An Analysis of the Incorporation of Lightning into the Nowcasting of Enhanced Frozen Precipitation

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ABSTRACT

The major goal of this research is to investigate the potential of using cloud-to-ground (CG) lightning data in the nowcasting of winter storms. Incorporation in this context means comparing lightning data with other data sets just like a forecaster would do on an interactive workstation at an NWS Forecast Office, at the Storm Prediction Center (SPC), at an AF Weather Regional Hub such as the one at Sembach Airbase in Germany, or at some other location. The first three objectives focus on the relationship of lightning data to satellite imagery, radar data, and model output parameters (respectively) in nowcasting (within 500 km and 6 hours) of heavy frozen precipitation. Hypotheses regarding these first three objectives are: (1) Lightning will occur in areas of satellite detected clouds where vertical motions perceived by satellite-derived radiation can be visualized; (2) lightning can detect areas of high upward vertical motion related to large radar reflectivity returns in winter storms, and lightning should exist slightly upstream of the radar echoes; and (3) model output would help locate features such as moisture flow, the advection of warm theta-e air, areas where elevated or slantwise convection may develop, etc. The final objective involves the compilation of all the results of the case study analyses and a determination of if and when CG lightning data can be used in conjunction with other data sources to nowcast enhanced frozen precipitation.

Major findings of this research are: (1) Lightning activity (as defined by 10x10 km bins) often occurs on the most intense gradient of cloud top temperature fields, 100-200 km equatorward of the coldest cloud area; (2) Bursts/progression of lightning activity identify oncoming heavy snow and ice more efficiently and faster (i.e., with 1-2 hours more lead time) than NEXRAD data; (3) Lightning activity (observed via the progression of lightning packets within a high qE tongue) (a) improves the identification of the enhanced moisture flux into winter storms, and (b) enhances the forecaster interpretation of model-derived strong vertical motion fields (more than 7 microbars/sec) within 500 km and 6 hours upstream of heavy snow and ice; (4) Lightning activity not only identifies the strength and location of strong low-level moisture flow (as defined by a tongue of enhanced low-level theta-e and southerly winds exceeding 35-40 kt) into a winter storm, but also depicts strong lifting along tight low-level theta-e gradients where lifting may be in doubt; and (5) Lightning provides a more valuable nowcasting tool for winter type precipitation as one proceeds from the East Coast to the Western Plains.