The WRF Lightning Forecast Algorithm for GLM: Refinement and Incorporation into Convection-allowing Ensemble Forecasts

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The Lightning Forecast Algorithm (LFA), a simple empirical technique developed for use within the Weather Research and Forecasting (WRF) model to estimate total lightning flash rate densities in storms, has been subjected to extensive pseudo-operational testing for the past two years. Early in 2010, the LFA was added to the daily 36-h WRF runs performed by the National Severe Storms Laboratory (NSSL). Furthermore, in 2011, the LFA was incorporated into the WRF ensembles executed by the Center for the Analysis and Prediction of Storms (CAPS) for use in the Hazardous Weather Testbed (HWT) Experimental Forecast Program (EFP). The LFA was also added in 2011 to the High Resolution Rapid Refresh (HRRR) 15-h WRF runs conducted hourly by NOAA's Global Systems Division. The goal of this research is to analyze the voluminous data from these simulations and assess the robustness of the LFA, make appropriate refinements to it as needed, and develop an understanding of its sensitivities to choices of model microphysics and other parameterizations.

Detailed inspection of results from the NSSL runs has revealed false alarms in precipitating cold stratiform systems, and a tendency to underestimate the peak intensities of the most intense warm-season storms. To address these issues, adjustments to the LFA code have been introduced and implemented in the 2012 WRF runs at NSSL and CAPS. The modifications reflect the findings that the graupel flux-based threat is more accurate over a wider range of conditions than the vertical ice integral-based threat, and that it is safe to raise the lower bound threshold for graupel flux threat to a level that eliminates most of the wintertime false alarms. The realism of the new LFA output from 2012's WRF forecasts will be examined later this year, and any further refinements added in 2013.

The LFA was also included in 14 compatible members of the 2011 CAPS WRF ensembles, so that the sensitivity of the diagnosed lightning flash rate densities to model parameterization choices could be assessed. In these CAPS studies, the LFA was applied uniformly to the output of each of

the participating WRF simulations, without any attempt to optimize the LFA within the specific context of the microphysics and physics schemes used. Maxima, minima, ranges and interexperiment standard deviations of the peak lightning flash rate densities from each day's set of simulations were then tallied. For the graupel flux-based threat, the data show standard deviations around 3 fl/sq km/(5 min), with a slight tendency to increase for the strongest storms. Although the interexperiment standard deviations are larger in an absolute sense for high flash rate storms, they are larger in a relative sense for weak storms. These results offer a method for quantifying the observed sensitivities, and can be useful to forecasters who are interested in the uncertainties ascribable to the LFA lightning threats, as they are incorporated into an increasing number of convection-allowing models.