A cloud-scale lightning data assimilation technique and the explicit forecast of lightning with full charging/discharge physics implemented within the WRF-ARW model

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To improve forecast of convection, two new assimilation techniques of total lightning data at cloud-resolving scales have been developed. The first is a direct forcing technique (implemented the WRF-ARW) for initiating and maintaining convection. The second uses the Ensemble Kalman Filter (EnKF) method, which can modulate convection and help suppress spurious convection. The first method was used in the case of the 24 May 2011 Oklahoma tornado outbreak, which was characterized by an exceptional synoptic/mesoscale set-up for the development of long-lived supercells with large destructive tornadoes. This case was selected because of the availability of high fidelity data collected by the dense network of the Oklahoma Mesonet, which is vital for accurate model validation. Lightning data assimilation forced deep, moist precipitating convection to occur in the model at roughly the locations and intensities of the observed storms depicted in the NSSL NMQ radar reflectivity mosaic product. The nudging function for the total lightning data locally increases the water vapor mixing ratio (virtual potential temperature) via a computationally inexpensive smooth continuous function using gridded pseudo-GOES-R resolution (9 km) flash rate and simulated graupel mixing ratio as input variables. The assimilation of the total lightning data for only a few hours prior to the analysis time significantly improved the representation of the convection at analysis time and at the 1-hour forecast within the convective permitting/resolving grids (i.e., 3/1 km). Although this case was primarily an analysis rather than a forecast, this simple, computationally inexpensive assimilation technique showed promising results and, hence, potential for real-time/operational applications.

To demonstrate its utility, the second part of this talk will present preliminary results of the recent implementation of the lightning assimilation scheme within the operational WRF-NSSL daily 4 km forecast runs.

The EnKF method uses relationships between lightning flash rate and graupel mass or storm volume as an observation operator for total flash rate. Tests have been carried out using Observation System Simulation Experiments (OSSEs) and real-data (pseudo-GLM derived from LMA), particularly the 8 May 2003 Moore, OK, supercell storm.

Lightning threats are currently diagnosed from model variables known to be well correlated with the occurrence of lightning (e.g., graupel mixing ratio, ice water content). To alleviate this need and provide a more physically sound approach to this problem, a full charging/discharge model is currently being implemented into the NSSL two-moment microphysics scheme within the WRF-ARW model. Preliminary results from benchmark simulations of the 24 May case will also be presented.