EGU21-133
https://doi.org/10.5194/egusphere-egu21-133
EGU General Assembly 2021

Evaluation of the impact of assimilating spaceborne (GLM) total lightning data and radar data on short-term forecasts of convective events in the 3DVAR framework

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The GLM instruments aboard the GOES-16 and 17 satellites provides nearly uniform spatiotemporal coverage of total lightning over the Americas and adjacent vast oceanic regions of the western hemisphere. This work summarizes recent efforts from our group at CIMMS/NSSL geared towards the evaluation of the potential added value of assimilating GLM-observed total lightning data on short-term, convection-allowing scale (dx = 2-3 km) forecasts for higher impact weather events. Results using data assimilation (DA) approaches ranging from single deterministic three-dimensional variational (3DVAR) methods applied in real time to experimental ensemble-based VAR hybrid methods (3DEnVAR) will be highlighted.
The lightning data assimilation (DA) scheme in these frameworks follow the same core philosophy wherein background water vapor mass mixing ratio is adjusted (increased) locally at or around observed lightning locations, either throughout the entire atmospheric column or within a fixed, confined layer above the lifted condensation level. Toward a more systematic assimilation of real GLM data, emphasis will be directed toward: (i) sensitivity tests with deterministic 3DVAR experiments aimed at evaluating the impact of the horizontal decorrelation length scale, DA cycling frequency as well the length of the accumulation window for the lightning data, (ii) aggregate statistics from real time CONUS-scale experiments over the Spring 2020 and (iii) preliminary results employing ensemble of 3DEnVARs with hybrid (static + flow dependent) background error covariances.
Aggregate statistical results from all deterministic 3DVAR exercises in (i) and (ii) revealed that the assimilation of either radar (radial wind and reflectivity factor) or total lightning (GLM) resulted in overall notably more skillful, shorter term (0-3 h) forecast of composite reflectivity fields, accumulated rainfall, as well as individual storm tracks – with optimal skill obtained when both radar and lightning data were assimilated. In (iii) forecast impacts related to the following will be summarized: (1) the respective weights assigned to the flow-dependent component and static components of the background error covariances, (2) the inclusion of three time-level sampling for each member during each cycle and (3) the usage of Gaussian noise coupled with a fixed 3 to 12 h spin-up period prior to the beginning of the cycled 3DVAR.