The kinematic and microphysical control of storm integrated lightning flash extent

Lawrence Carey[1], William Koshak[2], Harold Petersen[3], Elise Schultz[1], Chris Schultz[1,2], Retha Matthee[1], and Lamont Bain[1]

[1] Department of Atmospheric Science, University of Alabama in Huntsville (UAHuntsville), Huntsville, AL

[2] Earth Science Office, NASA Marshall Space Flight Center (MSFC), Huntsville, AL

[3] Universities Space Research Association (USRA), Huntsville, AL

The objective of this preliminary study is to investigate the kinematic and microphysical control of lightning properties, particularly those that may govern the production of nitrogen oxides (NO_x) in thunderstorms, such as flash rate, type and extent. The mixed-phase region is where the noninductive charging (NIC) process is thought to generate most storm electrification during rebounding collisions between ice particles in the presence of supercooled water. As a result, prior radar-based studies have demonstrated that lightning flash rate is well correlated to kinematic and microphysical properties in the mixed-phase region of thunderstorms such as updraft volume, graupel mass, or ice mass flux. There is also some evidence that lightning type is associated with the convective state. Intracloud (IC) lightning tends to dominate during the updraft accumulation of precipitation ice mass while cloud-to-ground (CG) lightning is more numerous during the downdraft-driven descent of radar echo associated with graupel and hail. More study is required to generalize these relationships, especially regarding lightning type, in a wide variety of storm modes and meteorological conditions. Less is known about the co-evolving relationship between storm kinematics, microphysics, morphology and three-dimensional flash extent, despite its importance for lightning NO_x production. To address this conceptual gap, the NASA MSFC Lightning Nitrogen Oxides Model (LNOM) is applied to North Alabama Lightning Mapping Array (NALMA) and Vaisala National Lightning Detection Network™ (NLDN) observations following ordinary convective cells through their lifecycle. LNOM provides estimates of flash type, channel length distributions, lightning segment altitude distributions (SADs) and lightning NO_x production profiles. For this study, LNOM is applied in a Lagrangian sense to well isolated convective cells on 3 April 2007 (single cell and multi-cell hailstorm, non-severe multicell) and 6 July 2007 (non-severe multi-cell) over Northern Alabama. The LNOM lightning characteristics are compared to the evolution of updraft and precipitation properties inferred from dual-Doppler and polarimetric radar analyses applied to observations from a nearby Doppler radar network, including the UAHuntsville Advanced Radar for Meteorological and Operational Research (ARMOR, C-band, polarimetric). The LNOM estimated SAD and lightning NO_x production profiles are placed in the context of radar derived profiles of vertical motion, precipitation types and amounts. Finally, these analyses are used to determine if storm integrated flash channel extent is as well correlated to volumetric updraft and precipitation ice characteristics in the mixed phase region as flash rate for these individual convective cells.