An Investigation of the Kinematic and Microphysical Control of Lightning Rate, Extent and NO_X Production using DC3 Observations and the NASA Lightning Nitrogen Oxides Model (LNOM)

Lawrence Carey[1], William Koshak[2], Harold Peterson[3], 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 Deep Convective Clouds and Chemistry (DC3) experiment seeks to quantify the relationship between storm physics, lightning characteristics and the production of nitrogen oxides via lightning (LNO_x). The focus of this study is to investigate the kinematic and microphysical control of lightning properties, particularly those that may govern LNO_x production, such as flash rate, type and extent across Alabama during DC3. Prior studies have demonstrated that lightning flash rate and type is correlated to kinematic and microphysical properties in the mixed-phase region of thunderstorms such as updraft volume and graupel mass. More study is required to generalize these relationships in a wide variety of storm modes and meteorological conditions. Less is known about the co-evolving relationship between storm physics, morphology and three-dimensional flash extent, despite its importance for LNO_x production. To address this conceptual gap, the NASA 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 rate, 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 multicell thunderstorms over Northern Alabama on two days during DC3 (21 May and 11 June 2012) in which aircraft observations of NO_x are available for comparison. The LNOM lightning characteristics and LNO_X production estimates are compared to the evolution of updraft and precipitation properties inferred from dual-Doppler and polarimetric radar analyses applied to observations from a nearby radar network, including the UAH Advanced Radar for Meteorological and Operational Research (ARMOR). Given complex multicell evolution, particular attention is paid to storm morphology, cell mergers and possible dynamical, microphysical and electrical interaction of individual cells when testing various hypotheses.