

The Kinematic and Microphysical Control of Lightning Rate, Extent and NO_x Production

Session Topic: Lightning Effects on Atmospheric Chemistry

Lawrence Carey¹, William Koshak², Harold Peterson³, Retha Matthee¹ and A. Lamont Bain¹

¹ Department of Atmospheric Science, University of Alabama in Huntsville (UAH), 320 Sparkman Drive, Huntsville, AL, 35805, larry.carey@nsstc.uah.edu

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 relationships between storm physics, dynamics, lightning characteristics and the production of nitrogen oxides via lightning (LNO_x). Ultimately, these relationships can be used to parameterize LNO_x in numerical cloud models lacking explicit prediction of cloud electrical and lightning processes. The specific 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 northern Alabama during DC3. Prior studies have demonstrated that lightning flash rate and type are 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 obvious 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 NetworkTM (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.