4.203 Deep Convective Transport, Lightning NOx Production, and Wet-Scavenging in Mid-latitude Deep Convection: Combining Modeling and Observations from DC3.

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Abstract:

Research aircraft sampled the low-level inflow and upper tropospheric outflow associated with thunderstorms over the central and southern United States during the Deep Convective Clouds and Chemistry (DC3) field program in May and June 2012. WRF and WRF-Chem simulations of selected storms were conducted at cloud-resolved and cloud-parameterized resolutions and used to examine convective transport, entrainment and detrainment in detail for a supercell, a mesoscale convective system, and an air mass storm. Analysis of vertical flux divergence showed that deep convective transport in the supercell case was the strongest per unit area. The cloud-resolved simulations constrained by aircraft chemical observations and flash rates from ground-based lightning mapping arrays were also used to determine the best methods for estimating lightning flash rates and lightning NO_x production for the supercell case. A flash rate parameterization scheme based on upward cloud ice flux provided the best representation of lightning activity. The observations and the cloud-resolved simulations were used to evaluate convective transport in simulations at 12- and 36-km resolution that employ parameterized convection. A key finding from the simulations at these resolutions is that convective transport of trace gases to the upper troposphere is best represented when the transport scheme for tracers is consistent with the scheme used for water vapor. The approach used to retain soluble species on frozen hydrometeors in the wet scavenging algorithm associated with parameterized convective transport was also investigated. Using the convective transport, wet scavenging, and lightning NO_x algorithms discerned to yield best results for the supercell storm, the model was run at 36-km resolution to estimate upper tropospheric ozone production downwind of this storm over the following day. Results were compared with aircraft flight data from the downwind region, which showed a 15-20 ppbv increment in ozone compared with the air exiting the storm.