Updraft and Downdraft Core Kinematics of Mesoscale Convective Systems as Revealed by Radar Wind Profilers

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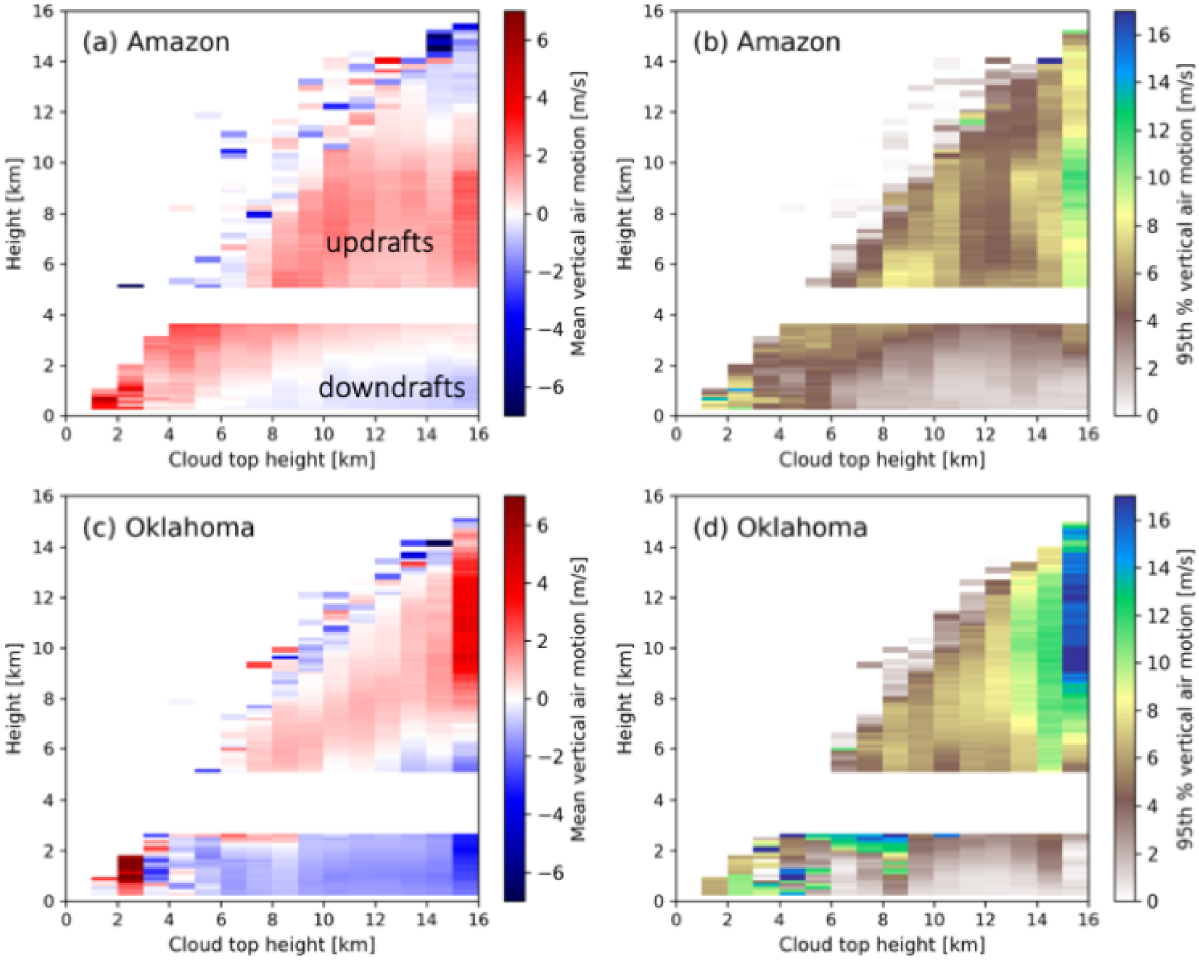
Mesoscale Convective Systems (MCSs) regulate the global energy cycle through their extensive cloud coverage and the exchange of latent heat, and are associated with a large proportion of extreme precipitation events. One of the most fundamental properties of these MCSs is the convective vertical air motions, in the form of up- and downdrafts. These motions are among the most difficult aspects of MCSs to measure, and our lack of information on these drafts inhibits proper representation of MCSs in numerical weather and climate prediction models. This motivates exploring potential new high-resolution observations of convective properties to better constrain model depictions of MCSs.

This study presents a unique multi-year dataset from ground-based radar wind profiler (RWP) measurements, operated by the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) Climate Research Facility, to address deficiencies in our understanding of MCS convective kinematic structures. We contrast updraft and downdraft core properties from RWPs collected within mature MCSs over tropical and mid-latitude continents. Multi-instrument datasets from the ARM Southern Great Plains site in Oklahoma, U.S. (16 events) and the ARM Mobile Facility deployment to Manaus, Brazil (GoAmazon2014/5, 46 events) are investigated. Oklahoma MCSs are observed having more intense and larger convective up- and downdraft cores than Amazon MCSs, leading to larger mass flux. Updraft/downdraft intensity is found to be positively correlated with core size, and increases with altitude. Most variability in core properties is observed within the deeper (higher cloud top) parts of the MCSs. To highlight the potential usefulness of these unique observations, we present a model-observational inter-comparison of convective core properties, as simulated with 5 idealized (WRF) MCS events for environments consistent with SGP conditions. These simulations are performed across a wide range of model grid-spacings (Δx = 4 km–250 m) to explore the ability of models to capture these convective core processes. The higher resolution simulations (< 1 km) better capture the convective updraft core size-intensity/mass flux relationships, but underestimate convective downdraft intensity and probability.

Overall, these analyses of RWP measurements provide important constraints for convective simulations, as well as validation for vertical air motion retrievals from other space- and ground-based platforms.

Keywords: Radar Wind Profiler, Mesoscale Convective System, Convective Vertical Velocity


(a) Amazon
updrafts
downdrafts
Height [km]
Cloud top height [km]
Mean vertical air motion [m/s]
(b) Amazon
95th % vertical air motion [m/s]
(c) Oklahoma
(d) Oklahoma