EGU24-6302, updated on 16 Feb 2025
https://doi.org/10.5194/egusphere-egu24-6302
EGU General Assembly 2024

Relationships between growing cloudy updrafts, deep convection initiation, and orographic flow

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Shallow cumulus cloud fields often organize and deepen within regions of mesoscale ascent associated with orographic flows. However, there is significant uncertainty in the relative roles of mesoscale and cloud-scale factors ultimately controlling the location of orographic deep convection initiation (DCI). These factors include spatial heterogeneity of the magnitude of mesoscale vertical mass flux associated with orographic convergence, near-cloud convective ingredients (e.g. CAPE, CIN, LFC, and shear), and entrainment effects. More fundamentally, it is not well understood how these factors influence the initial width and strength of low-level cloudy updrafts, which are increasingly cited as important governors of their ultimate depth potential. Thus, it is important to better understand these relationships for increased predictability of DCI.

Numerous DCI events observed along the Sierras de Córdoba range during the Cloud, Aerosol, and Complex Terrain Interactions (CACTI) project were modeled by the U.S. Department of Energy's LES ARM Symbiotic Simulation and Observation (LASSO) team. In this study, we examine the connection between low-level cloudy updrafts, DCI, and the ascent associated with the mesoscale orographic circulation using LES with 100-m and 500-m grid spacing across multiple days. We hypothesize that the width and strength of low-level cloudy updrafts and the probability of DCI events along the ridge are proportional to the width, strength, and depth of the local orographic convergence. To test this, we examine correlations between the width and depth of developing cloudy updrafts and the: i) 3D structure of the evolving orographic ascent, and ii) convective meteorological ingredients (e.g., convective available potential energy, convective inhibition, level of free convection, moisture, etc.).

Preliminary results indicate that DCI events do not always occur in regions of the strongest or widest orographic ascent along the mountain range. Further, the strength and width of low-level cloudy updrafts that precede DCI are only weakly correlated with most orographic ascent metrics. Overall, the apparent relative roles of mesoscale ascent and convective sounding parameters governing DCI varied significantly across case days. Near-cloud relative humidity located near and just above the level of free convection steadily increased with time during each afternoon, likely owing to orographic vertical moisture flux and/or cloud detrainment. Thus, in addition to highly

varied roles of the background conditions, the fate of individual growing cloudy updrafts may further depend on complex cloud-scale factors, such as entrainment and microphysical processes.