Session Title: Improving understanding of deep convection life cycle with novel measurement and modeling approaches
Session Conveners: Zhe Feng (PNNL), James Marquis (PNNL)
Session Date: Wed; 23 June 2021
Session Time: 11 AM EST
Number of Attendees: Approximately 140
Summary Authors: Marquis, Feng

Main Discussion

Our session involved both invited and solicited talks, targeting an integrated observations-modeling analysis techniques-driven agenda. Collectively, these talks assessed unknowns and uncertainties involved with modeling and observing deep moist convective cloud microphysics, updraft dynamics, entrainment processes, and aerosol properties. Follow-up discussion focused on the use of techniques highlighted by the speakers and others for potential future research applications, particularly those that merge observations and models, or utilize simulations or theory to guide future observing strategies.

Many attendees were interested in deep convective LASSO modeling specifics and capabilities, particularly commenting on the need for sub-1-minute temporal resolution of 100-m LES output to track updraft structures evolving on short time scales. Further, there was some discussion of the potential to use a high-density 4D lightning mapping array to verify convective structure in the LASSO simulations. Given the focus on very high-resolution models (LES, ~100m grid spacing) and analysis of physical processes derived from them, discussion briefly recognized the need to reconcile fine-scale processes with the current paradigm of regional and global climate models that only run at 3-5 km grid-spacing or coarser, likely through the modification of model parameterizations. Though, it was unclear how to better link process understanding gained from analyzing LES simulations to kilometer-scale model biases.

Given that many critical measurements cannot be effectively collected with current observing strategies or instrument availability, discussion recognized the value to have an open source radar simulator code that can be applied to convection-resolving models, including LASSO, to replicate observations from simulations. The use of these simulators in OSSEs was recognized as a potentially powerful tool for guiding future observing efforts, although there are unmet challenges in potentially running these simulators online during model integration to allow more frequent output better representing real world measurements than currently possible with post processing using many required 3D variables. The value of Lagrangian tracking convective cell morphological and microphysical properties with scanning radars also was recognized by many as a method to infer observable analogs of properties that are not currently directly observable (e.g., updraft sizes and intensities, precipitation and entrainment properties). Many expressed a desire to try methods similar to the presented FLEXTRKR methodology in future field campaigns and simulations, and the potential need to compare various tracking methodologies. Although, attendees recognized there is still much research to be done using comprehensive cell tracking databases that combine multiple observations to maximize the use of collocated data for understanding convective processes, such as the efforts being pursued with CACTI observations.

Needs

Multiple attendees recognized a strong need for in-cloud microphysical and in/near-cloud thermodynamic observations. Abandoned efforts on a deep cumulus-penetrating aircraft was mentioned as being particularly disappointing, with a sentiment that substantive advances in deep convection science are inhibited by a lack of this capability. Penetrations targeting typical tropical oceanic deep convection, which contains weaker updrafts than land convection with no hail and no lightning (i.e., relatively low hazard risk), as has been done by many research aircrafts, was mentioned as a more viable starting point for such in-situ observations. The use of unmanned aerial vehicles (UAVs) was discussed as a potential tool for penetrating comparatively strong clouds and updrafts, but the discussion about actionable UAV implementation, partly on specific instrumentations and regulatory limits (e.g., maintaining line of sight on land) was inconclusive. For both activities, better coordination with surface-based remote sensing techniques targeting cloud evolution is needed with consideration of new techniques to quantify updraft size, shape, and strength, which is poorly measured in low sample sizes currently despite its critical importance to cloud evolution.

Another highlighted need was an enhanced mesoscale meteorological network during field campaigns, rather than point observations at a single or a few locations. Atmospheric state variable profiling capability at ~30 km spacing and at least hourly sampling within the target area surrounding AMF sites may be necessary to adequately characterize mesoscale variability in deep convective environments. There was debate among attendees over prioritizing meteorological observations over a similarly enhanced network of surface property measurements. An argument for prioritizing meteorological data was that environmental metrics such as CAPE, CIN, LCL, LFC, vertical wind shear, vertical humidity structure, and mesoscale vertical motion are recognized by the operational weather forecasting community as being data most directly connected to deep convective cloud initiation and growth. Thus, quantification of surface and aerosol interactions with convective clouds is hindered without better control of these conditions. However, improvements in both networks may be valuable.

Some attendees suggested a need to fund and focus science efforts on more observational work to balance the heavily model-development community efforts with insufficient connection to observations, especially those collected by the ARM program.

Future Plans

If applicable

Action Items

If applicable