Breakout Session Report
ARM/ASR User and PI Meeting
March 16-20, 2015

Session Title: Deep Convection
Session Date: Thursday, March 19, 2015
Session Time: 1:30–3:30 p.m.
Summary Authors: Jiwen Fan and Adam Varble

Description

This session covered modeling and observations of the microphysical, macrophysical, and dynamical characteristics of deep convection, with a focus on microphysics-dynamics interactions. This also includes the effects of aerosols on deep convection and deep convective cloud effects on aerosols.

Main Discussion

The purpose of this session was to bring together Cloud Life Cycle (CLWG) and Cloud-Aerosol-Precipitation Interactions (CAPI) working groups to build off of the joint session from the 2014 Fall Meeting and particularly focus on measurement needs for better understanding relationships between environmental conditions (including but not limited to aerosols) and deep convective macrophysical, microphysical, and dynamical properties.

The session started with two invited talks, given by Bob Houze (with input of S. Powell, E. Zipser, and A. Varble) and Zhanqing Li (with input of D. Rosenfeld and J. Fan). These talks summarized the measurement needs and challenges for furthering our understanding of deep convective clouds' relation to the large-scale environment with Houze's talk focusing on non-aerosol aspects and Li's talk focusing on aerosol aspects. We then had six short talks, with a nice diversity of perspectives from micro- to macro-scales, and from cloud-resolving modeling to cumulus parameterization in climate models. We had a brief discussion about key measurements needed, the ways in which ARM measurements can be better used, and the potential need for a field campaign study dedicating to deep convective interactions with the large-scale environment with a focus on aerosols.

Issues

We had some technical issues in the beginning so we started at 1:38 p.m. and ended at 3:38 p.m. with only about 20 minutes dedicated to discussion. Many people left the session before this discussion time because this was the last session of the meeting, which somewhat defeated the purpose of having a big joint CLWG-CAPI session to establish areas of agreement from which interest or focus groups could be created at future meetings. More time should be set-aside for future deep convection sessions given the substantial interest in this topic.

Needs

Many key data sets needed to understand the relationships between convective system properties and environmental characteristics are either lacking or too sparse; two invited talks and two short presentations reflected this. See below for more specifics. Most of us agree that vertical velocity and microphysical properties are the most important missing measurements. Prioritization of other measurements listed below needs to be discussed more at a future meeting.

1. Important measurements for fully understanding deep convective clouds in relation to their large-scale environment:

   a. Environmental
      i. Full tropospheric winds, temperature lapse rates, and humidity close to the system as a function of time
      ii. Clear-air vertical velocity on small (e.g., gravity wave) and large (e.g., Kelvin wave) scales (prior to [destabilization] and after [convective response] convective initiation)
      iii. Radiative fluxes (causing destabilization on slower time scales prior to convection and during decaying stages)
      iv. Cloud condensation nuclei (CCN) and ice nucleation (discussed more in point 2)
   b. In-cloud (important for cloud water budget and heating distribution):
      i. 4-dimensional (i.e., 3-dimensional domain plus time evolution) convective vertical velocities
      ii. Microphysical processes; hydrometeor mass and size
2. Critical needs/desires for understanding aerosol interactions with deep convection:
   a. Aerosol – radiation interactions:
      i. Vertical profiles of aerosol absorption/scattering properties, especially throughout the planetary boundary layer (currently no good data)
      ii. Atmospheric stability, cloud base height and updraft speed (recommend integrating with satellite data to obtain regional/global context)
   b. Aerosol – cloud interactions:
      i. Closure between aerosol, CCN, and cloud base drop size distribution (only occasional aircraft data; recommend new approaches such as combining satellite and ground-based remote-sensing measurements)
      ii. 3-dimensional vertical velocity with corresponding microphysics and CCN data.
      iii. Rain initiation, cloud glaciation, and ice nuclei as a function of temperature.
      iv. Hydrometeor size and fall velocity (to study aerosol impacts on stratiform/anvil and validate microphysical invigoration).

The above list is a tall order for even an ARM megasite, but ARM is in a position to perform and validate many of these retrievals. Some people in the session felt that ARM retrievals should be used to validate satellite retrievals so that the full spectrum of convective and environmental properties can be represented in an analysis rather than the limited conditions at one site. This full spectrum is important to any extension to representation of convective systems in global climate models.

Future Plans

Warm-based and low vertical wind shear deep convective cases with polluted and clean aerosol conditions (likely from GoAmazon2014/15) may serve as good future cloud-resolving model/limited area model/single-column model intercomparison studies, and this idea should be discussed further at the next meeting.

A joint CLWG and CAPI session that takes advantage of the range of expertise on deep convection is desirable. However, this joint session is predicated upon these two working groups benefiting from hearing from or working with one another. This is only the second time having the joint CLWG-CAPI deep convection session, but it is unclear whether the two working groups can meaningfully bridge their differences in how they generally view the relative impacts of different environmental properties on deep convection in a session that is only two hours and covers a topic as broad as deep convection. It is recommended that, besides a general joint CLWG and CAPI on deep convection, sessions for potential

interest groups focused around specific aspects of deep convection that are of interest to the CLWG and CAPI people should be discussed.

Participants of the session are keen on formulating a plan for a future deep convective intensive operational period (IOP) and the specific location and objectives of such an IOP need further discussion at the next meeting.

Action Items

Work toward more routine, validated retrievals of deep convective vertical velocity and hydrometeor properties as well as environmental aerosol properties (including single-scattering albedo and CCN) with quantified uncertainties.