Convection and Surface-Atmosphere Interactions – Breakout Discussion

Grand Challenge Question:

How do cloud microphysics, atmospheric dynamics, surface fluxes and their multiscale interactions influence the predictability of mesoscale convection and its impact on surface conditions and land-atmosphere interactions from synoptic to interannual time scales?

Science Questions:

- How do cloud microphysical processes influence the macro-physical properties and lifecycle of mesoscale convection?
- How do the spatial and temporal variability of surface fluxes influence mesoscale convection and its predictability during the warm season?
- How do mesoscale convection and atmospheric circulation interact locally and remotely to limit the predictability of precipitation from synoptic to interannual time scales?
- How does the frequency, intensity, and timing of precipitation from mesoscale convection impact the surface water balance and its influence on surface temperature and runoff?

Update Description of Challenges and Current Research in RGMA

Update Short Term (3- 5 years) Research Goals

- Improve the availability and synergistic use of a variety of measurements from field campaigns to in-situ and remote sensing platforms of microphysical processes, latent heating, dynamics, and thermodynamics environment to understand convective microphysics feedbacks on cloud-scale and large-scale dynamics.
- Leverage Atmospheric Radiation Measurement (ARM) and other BER investments in observation (e.g., data from Next Generation Ecosystem Experiments) with data-fusion techniques to improve estimates of surface fluxes of energy and water in order to better constrain observation and modeling of surface-atmosphere interactions and their roles in the development and evolution of mesoscale convective systems over land and ocean through local and non-local processes including feedbacks.
- Improve understanding of the key microphysical, surface, dynamic and thermodynamic processes that influence the development of MCSs during spring and summer and differentiate the predictability of different types of MCSs in the two seasons.

- Determine sensitivity of convection over continental regions to fluxes of water/energy from the land surface, to determine where we need improved surface representation (where it is sensitive, and how sensitive it is).
- Validate satellite data with radar estimates globally in regions where available. Use of doppler radar to investigate different precipitation types including hail.
- Combining datasets to look more directly at interactions (e.g., MCSs on tree mortality, hail impacts in energy, agriculture, insurance). The need for joint distributions e.g. wind speeds and hail. Datasets for climatology (long-term) and forecasting (short-term).
- How large-scale variability influences the environmental conditions that impact convection.
- Identify specific regions where more data is needed to assess MCSs in the US and worldwide.
- Importance of regional scale models for relevant spatial scales and convection permitting simulations. Use of regional model ensembles.
- Be able to accurately diagnose model water and energy budgets for all components and across a variety of timescales. [Bryce]

  - **E3SM Experiments**

  - **Use of CMIP data**

  - **Use of ML/AI**
    - Use of ML to assess the local scale conditions as well as large-scale environment influence on convection.

  - **Metrics for CMEC**
    - Soil moisture - surface temperature bias assessment

Update Long Term (10 years) Research Goals

- Develop a modeling hierarchy, including single-column models, limited area models, and multiscale and uniform/variable resolution global models for the atmosphere coupled to land-surface models with simple-to-complex representations of processes to improve understanding of model biases in the simulation of MCSs and land-atmosphere coupling, and to test hypotheses of convection-surface and convection-circulation interactions.
- Improve the characterization of MCSs, including their three-dimensional structure, across a variety of different climate regimes, and hence understanding of the roles of MCSs in the global and regional water and energy cycles.

- Elucidate the roles of different MCS characteristics (e.g., size, intensity, and propagation speed) and land-surface conditions in the development of convective events that are most conducive to extreme precipitation and flooding.
- Develop a better understanding of the major mechanisms that control how MCSs respond to warming and the implications for the global and regional water cycles and hydrologic extremes.
- Observational needs for assessing global CRM simulations (e.g., soil moisture)
- Ongoing need for long-term data sets also for use for V&V for regional modeling - i.e. continuing development of ASOS, radar, satellite and ground-based remote sensing datasets
- Be able to conserve water and energy in models regionally as well as globally. Additionally more rigorous treatments of energy need to be tested to know which processes are sensitive to which assumptions. [Bryce]

  - **Intercomparisons**

  - **E3SM Experiments**

  - **Use of ML/AI**

  - **Cross-cutting Ideas**