Convection and Surface-Atmosphere Interactions

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Updates on recent research

- 17 flash talks: 8 on dataset development and data analysis; 9 on modeling (evaluation, sensitivity)
  - MCS data development (Feng) and analysis of MCS characteristics (Feng, Liu), environments (Song, Pokharel) and role in land-atmosphere interactions (Hu)
  - Analysis of combined /complementary datasets: monsoon precipitation and local SST (Ramesh), marine air temperature (Junod), and precipitation and wood density (Negron-Juarez)
  - Model sensitivity to: resolution and physics parameterizations (Sakaguchi, Barthelmie, Rahimi), energy conservation (Harrop), and LULCC scenarios (Bukovsky)
  - Evaluation of high/variable resolution simulations (Feng) and convection permitting simulations (Qin, Ma) and development and demonstration of model diagnostics on convection and tropical precipitation (Hagos)
- Check out the flash talk slides and pre-recorded longer presentations!

Research gaps and opportunities (1)

- Understand and quantify local-to-large scale environmental conditions (atmosphere, surface) that impact different types of convection – where and when convection and storms occur and why
  - AI/ML offers opportunities to take advantage of heterogeneous datasets from different sources (remote sensing, in-situ, field campaigns, model outputs) to investigate complex spatiotemporal relationships for advancing earth system predictability
  - Develop indices (parallel to TC) to connect large-scale climate conditions and modes of variability with convection
  - Consider stochasticity and natural variability in developing relationships between storm environments and convection development
  - Develop framework to study interactions between convection and environments (precursors vs. feedbacks)

Research gaps and opportunities (2)

- Determine where improved observations and representations of land/ocean processes are needed to better understand and model the impacts of surface-atmosphere interactions on convection
  - Land subsurface processes (e.g., groundwater table dynamics, plant hydraulics and root depth, subsurface lateral flow)
  - Ocean processes (e.g., SST gradients, upper ocean stratifications)
- Develop combined datasets to investigate interactions between convection and other processes for:
  - Process understanding (e.g., dynamic/thermodynamic environments, latent heating, surface fluxes, cloud macro- and microphysics quantities, aerosols)
  - Model evaluation (e.g., evaluation of joint PDF and relationships)
  - Analysis of impacts (e.g., impacts of convection on energy infrastructure, agriculture, tree mortality)

Research gaps and opportunities (3)

- Convection permitting and cloud resolving models (CPMs and CRMs) have been important tools for convection research, but more efforts are needed in model development, model evaluation and intercomparison to enhance their usefulness
  - Evident improvements (e.g., PDF of rainrates, MCS characteristics) but still limited skill in certain aspects (e.g., summer MCS in the US) and diverse model behaviors
  - Process interactions are important in CPMs and CRMs (e.g., aerosol-cloud interactions, land-atmosphere interactions) for improving modeling of convection and precipitation
  - Observational needs (e.g., high resolution data) to support evaluation of global CPMs and CRMs
  - Computational resources to support (CPM/CRM) modeling

Research gaps and opportunities (4)

- General modeling needs:
  - Ensemble simulations to address the chaotic behaviors of convection
  - More process-oriented metrics for model evaluation of convection and its environments
  - Model diagnostics to understand model biases and convection response to forcing
  - Community inputs and coordination on model outputs for evaluation and diagnosis
- Address uncertainty:
  - Observational data uncertainty – e.g., comparison of satellite, radar, in-situ precipitation estimates
  - Feature tracking (e.g., MCS, severe storms) and implications to process understanding and modeling

Questions?

Research goals (3-5 years)

- 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.

Research goals (5-10 years)

- 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.