Moving From Establishing Model Deep Convective Biases Toward Constraining Their Causes

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MODEL DEEP CONVECTIVE BIASES

High-resolution simulations of deep convective systems are used for improving cumulus parameterizations or replacing them in coarser grid models, but exhibit a high bias in convective reflectivity across a range of CRM, LAM, and LES models, microphysics schemes, and case studies around the world.

These same high-resolution simulations often exhibit larger than observed regions of high reflectivities and rain rates with a low bias in stratiform precipitation.

There are several causes of deep convective precipitation biases that interact in complex ways and are unconstrained by observations.

HYDROMETEOR PROPERTIES

Number of predicted PSD moments, assumed PSD shape, and assumed mass-size relationships strongly impact reflectivity values.

TWP-ICE 50° and 90° Percentile Updraft Max. Reflectivity

CAUSES OF DEEP CONVETIVE PRECIPITATION BIASES

VERTICAL VELOCITY

Simulations significantly overestimate peak updraft core vertical velocities and peak at higher altitudes.

Decreasing grid spacing slightly improves results, but convergence to observations appears unlikely.

TWP-ICE Condensate (filled) and Vertical Velocity (contoured)

MICROPHYSICAL PROCESSES

Microphysics schemes fail to reproduce large ice concentrations in mixed phase regions of updraft cores observed in recent tropical field campaigns.

Sedimented rear inflow for WRF simulations of the 20 May 2011 MCJ event appears amplified relative to radar observations. In general, squall and supercell modes seem to appear more frequently in cloud-resolving simulations than observations. Are mesoscale circulations biased too strong?

CONSTRAINING BIAS CAUSES WITH STRATEGIC OBSERVATIONS OF PROCESSES

Convection exhibits a wide variety of properties around the world with sensitivity to many environmental variables. Many regimes need to be observed so that parameterizations work everywhere.

AIRCRAFT OBSERVATIONS ARE CRITICAL

Radar measurements can be trained to extend these in situ measurements, and therefore, in situ measurements increase the value of radar measurements.

Observing impacts of vertical velocity on microphysics and vice versa requires frequent sampling of the same cell so that interactive processes can be inferred. This is the strategy for the CACTI field campaign.

CONCLUSIONS

Convection precipitation biases consistent across a range of models and microphysics schemes have several complexly interacting causes including hydrometeor properties, vertical velocity, microphysical processes, and mesoscale circulations. To eliminate these biases requires constraining all of these causes, which can only be done by strategically observing deep convective processes with radars, gathering in situ measurements from aircraft, and performing representative comparisons between model output and observations that take into account the non-determinism of deep convection and its wide variety of properties around the world.


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FUTURE WORK

The role of amplified mesoscale circulations in producing model precipitation biases and the causes of amplification will be further explored. Measurement strategies targeting convective processes will be further developed and potentially tested ahead of the 2018-19 CACTI field campaign in Argentina.