MMM SEMINAR SERIES

Tropical Cyclogenesis Predictability and Shallow Cumulus Organization from the Perspective of Multiscale Processes

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Convective organization occurs at various scales in different cloud systems. The spatial inhomogeneity of the clouds suggests that convective organization can be viewed as interactions of multiscale processes. This seminar combines my recent and ongoing studies that use the System of Atmospheric Modeling (SAM) with different domain sizes and resolutions to study tropical cyclogenesis predictability and explore mesoscale organization of marine shallow cumuli from this perspective.

In the first part, a near-global aquaplanet cloud-resolving model (NGAqua) is used to investigate tropical cyclogenesis and its predictability. This study analyzes an ensemble of three 20-day NGAqua simulations, with initial white-noise perturbations of low-level humidity. Tropical cyclones (TCs) in NGAqua develop spontaneously from the northern edge of the intertropical convergence zone (ITCZ), where interactions between large-scale flows and tropical convection provide necessary conditions for barotropic instability. Zonal bands of positive low-level absolute vorticity organize into cyclonic vortices, some of which develop into TCs. A vortex-following framework analysis shows that vertical stretching of absolute vorticity due to convective heating contributes positively to TCs' vorticity spinup. A case study and composite analyses suggest that sufficient humidity is key for convective development. Tropical cyclogenesis in these three NGAqua simulations undergoes the same series of interactions. The locations of cyclonic vortices are broadly predetermined by planetary-scale circulation and humidity patterns associated with ITCZ breakdown, which are predictable up to 10 days. Whether and when the cyclonic vortices become TCs depend on the somewhat more random feedback between convection and vorticity, which occurs at a much smaller scale.

In the second part, Lagrangian large eddy simulations of trade cumulus organization observed during the Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign (ATOMIC) are presented. ATOMIC was designed to understand the relationship between shallow convection and large-scale environments in the trade wind region. It is the U.S. counterpart of the European field campaign called EUREC^{4}A and took place in January – February 2020. The simulations presented here are driven with ERA5 reanalysis large-scale meteorology and ATOMIC in-situ aerosol data. The results are used to explore different states of trade cumulus organization and address the transition between different states from the perspective of multiscale processes.

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For Zoom information, please contact
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Seminar will also be live webcast
https://operations.ucar.edu/live-mmm