PETASCALE MODELING OF CONVective STORMS UNDER CLIMATE CHANGE AND VARIABILITY

Allocation: Blue Waters Preference/240 Ksh
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EXECUTIVE SUMMARY

This research seeks to answer the basic question of how present-day extreme storm events might be altered by human-induced climate change. The pseudo-global warming (PGW) methodology has been adapted for this purpose. Modified atmospheric states drawn from global climate model (GCM) output were used to constrain an ensemble of Weather Research and Forecasting (WRF) model simulations of select extreme events. Highly resolved grids allow for process-based analyses of the simulated events; ensembles of such simulations facilitate quantification of uncertainty.

Our most recent work has focused on hail storms and tornadoes spawned by landfalling hurricanes. The severe hail events considered thus far are more intense but generate less-extensive and fewer hail swaths under PGW. Simulations of Hurricane Ivan (2004) are showing that the conditions under PGW promote a relatively more intense hurricane at landfall, and lead to a much higher incidence of mesoscale vortices with tornadic potential.

RESULTS & IMPACT

Exemplifying the hailstorm results are the simulations of the May 19, 2013, outbreak of tornadoes, damming wind, and hail. The radar reflectivity portrays the structure of the individual hail-producing storms in the CTRL simulation. Figure 1 is a simulated radar reflectivity from a high-resolution WRF model simulation of the May 19, 2013, outbreak of tornadoes, damming wind, and hail. The radar reflectivity portrays the structure of the individual hail-producing storms in the CTRL simulation.

In addition to continued analyses of the hailstorm and hurricane simulations described above, we are currently developing the capability to employ the Model for Prediction Across Scales (MPAS) for studies of convective storms under climate change and variability. MPAS is one of the emerging global atmospheric models with variable-resolution grids and provides us with the ability to isolate effects of low- and high-latitude processes (e.g., from Arctic sea ice and tropical oceans) on deep convective storms that are well resolved in middle latitudes. With the assistance of National Center for Supercomputing Applications personnel, the MPAS model codes have recently been compiled on Blue Waters, and MPAS experimentation is currently under design.

WHY BLUE WATERS

The relatively small size of thunderstorms and the ranges of relevant scales within tropical cyclones, coupled with their episodic occurrence, necessitates a research approach that can account for temporal scales from decades to minutes and spatial scales of thousands of kilometers to hundreds of meters. In other words, we require very large geographic domains that have fine grid point spacings and long-time integrations with high rates of model output. Moreover, quantifications of uncertainty require that such realizations be repeated over multiple experiments. The Blue Waters allocation is providing us with the resources needed to achieve this unprecedented level of climate simulation.

Figure 1: Simulated radar reflectivity from a high-resolution WRF model simulation of the May 19, 2013, outbreak of tornadoes, damming wind, and hail. The radar reflectivity portrays the structure of the individual hail-producing storms in the CTRL simulation.

Figure 2: Bar graph showing the domain-wide grid point hail occurrence on May 19, 2013, under PGW. The values represent fractional changes relative to the CTRL simulation. The PGW experiments are across three microphysical schemes (Morrison: MO, Milbrandt-Yau: MY, NSSL: NS) and three GCM drivers (GFDL, MIROC, and NCAR).

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