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HIGH-RESOLUTION NUMERICAL SIMULATIONS OF CONVECTION INITIATION OVER THE SIERRAS DE CÓRDOBA MOUNTAINS IN ARGENTINA

Allocation: Illinois/500 Knh
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EXECUTIVE SUMMARY

Previous studies using satellite and radar data show that some of the most intense convective storms initiate over and near the Sierras de Córdoba (SDC) mountain range in Argentina. However, gaps in data and knowledge exist as to how these storms initiate, which contribute to poor predictability of these storms. This study aims to understand the mesoscale processes involved in the initiation of deep moist convection in the region. The study uses quasi-idealized numerical modeling of a real case along with data obtained during the RELAMPAGO–CACTI field experiments in Argentina.

RESEARCH CHALLENGE

This study aims to understand how the background flow responds to the daytime heated terrain of the SDC, and how low-level convergence is generated. Improving the understanding of the mesoscale processes involved in the initiation of these storms has the potential to improve numerical weather forecasts in the region. This could help in providing timely warning for these storms, thus mitigating potential damage to life and property by severe storms. The issue is not only important from a theoretical and scientific point of view but also for many communities around the SDC and in the downstream regions where these storms propagate.

METHODS & CODES

The research team is conducting quasi-idealized simulations of convection initiation using Cloud Model 1 (CM1) [1] to enhance the understanding of the physical processes involved. CM1 is a three-dimensional, nonhydrostatic, nonlinear numerical model used for idealized studies of atmospheric flows. It contains several physics packages for parameterizing subgrid turbulence, radiation, cloud microphysics, and the like. The preconvective thermodynamic and kinematic environment for these simulations was taken from one of the Intensive Observation Periods (IOP) of the RELAMPAGO–CACTI field experiment, which was conducted in November–December 2018. This IOP involved complex interactions among the northerly South American low-level jet, thermally driven upslope flows, outflow boundaries from previous convection, and the SDC terrain. The team has conducted simulations of increasing complexity to parse the contributions of various physical processes to convection initiation. The researchers are also using data collected during RELAMPAGO to validate these model runs.

RESULTS & IMPACT

The research team carried out three simulations: (1) with no background winds to isolate the contribution of daytime upslope flows to Convective Initiation; (2) with background winds; and, (3) with background winds with a cold pool. In the third simulation, a cold bubble with a temperature perturbation of -10K was dropped at the southern end of the SDC to mimic the cold pool generated by a previous thunderstorm. Radiation and surface fluxes were turned on in all the simulations. Preliminary results indicate that the background winds advect the heat and moisture fluxes away from the terrain, causing a smaller increase in convective available potential energy and a smaller decrease in convective inhibition when compared to the simulation with no winds. As shown in Fig. 2, convergence lines and convective cells develop along the high terrain in the simulation with no winds. In the simulation with background winds, a convergence line develops to the south of the main SDC ridge, initiating convection upon interacting with the terrain. In the third simulation, no convection developed at the boundary of the cold pool.

Future simulations will involve parameterizing the effect of synoptic-scale heat and moisture advection and imposing it on the thermodynamic environment in the simulation.

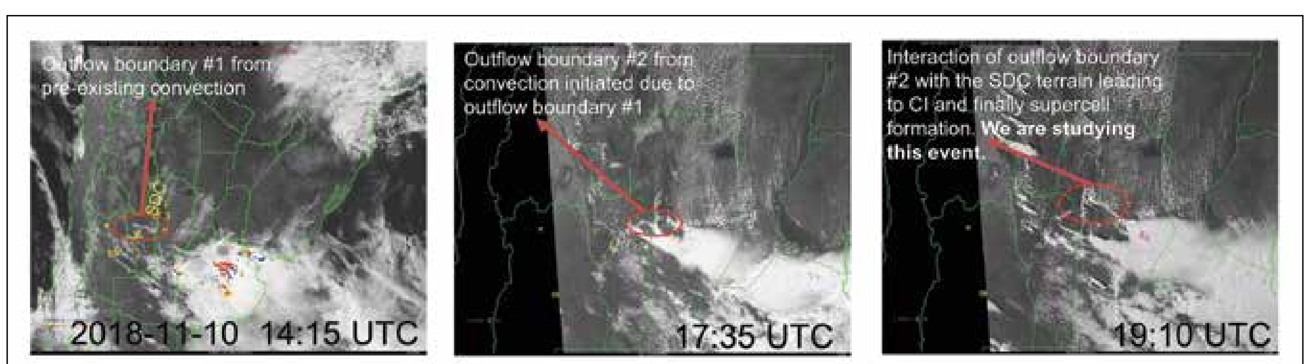

Figure 1: GOES-16 visible satellite imagery at different times, leading up to the initiation of a supercell. The location of the Sierras de Córdoba mountains is indicated in the figure.

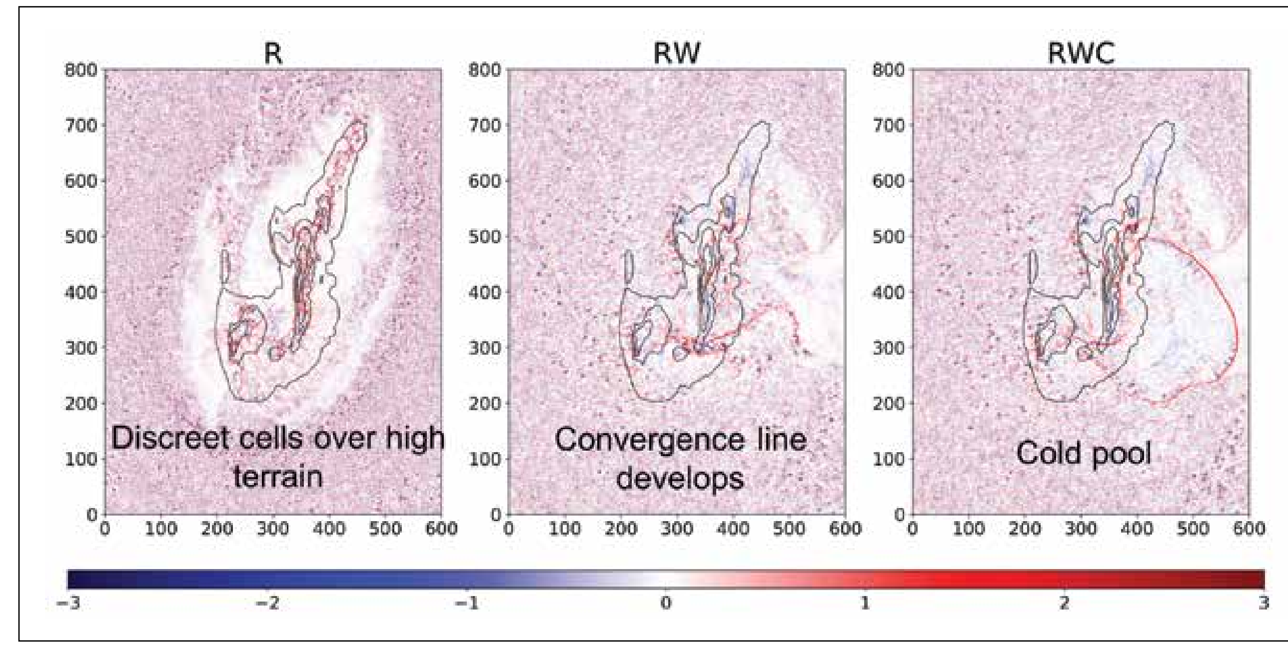

Figure 2: The vertical velocity field at model level 5 (500 meters above ground level) at 19:40 UTC (about eight hours after the start of the simulation).

WHY BLUE WATERS

Blue Waters has the capacity to provide the sheer amount of computational power required to conduct these simulations. Additionally, the high-resolution model output needs tens of terabytes of space, which Blue Waters has provided. Further, the Blue Waters staff was very prompt in responding to all queries. The research team had some issues compiling the code on Blue Waters, but the staff helped the team through the process.

PUBLICATIONS & DATA SETS

I. Singh and S. W. Nesbitt, "High-resolution simulations of orogenic convection initiation over the Sierras de Córdoba Mountains," presented at the 18th American Meteorological Society Conf. on Mesoscale Processes, Savannah, GA, U.S.A., Jul. 29–Aug. 1, 2019, poster no. 40.