Improving the Numerical Simulation of Squall Lines

Contributors

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Research Highlight

Squall lines with trailing stratiform precipitation are common in both the mid-latitudes and tropics. These systems produce copious amounts of precipitation and occasionally severe weather. Because of their extensive size and frequent occurrence they are also important in redistributing energy in the atmosphere via convective and mesoscale transport and latent heating/cooling. However, their structure and characteristics often are represented poorly in numerical cloud and weather models.

A major uncertainty in these models concerns the treatment of cloud and precipitation microphysics. The microphysics impacts squall lines via latent heating, melting of ice particles, and evaporation of rain. To test how different approaches in treating the microphysics impacts numerical simulation of squall lines, the researchers used a two-dimensional cloud model coupled with different microphysics parameterizations of varying complexity. The simple parameterization predicts the bulk water content of various cloud and precipitation types (cloud water, rain, snow, etc.). The more complex parameterization predicts bulk water contents as well as the particle concentrations, allowing for a robust treatment of the population of cloud and precipitation particles.

The researchers found that the more complex microphysics scheme produced a much more widespread region of trailing stratiform precipitation in the idealized squall line simulation compared with the simpler scheme, as well as different distributions of latent heating and overall storm strength. The primary reason for these differences is the treatment of rain, with the more complex scheme producing higher drop concentration in the leading edge of the squall line and lower drop concentration in the trailing stratiform region, relative to results using the simpler scheme. The distribution of these rain characteristics using the more complex scheme is consistent with observations in real squall lines.

These results suggest the importance of realistically treating the rain microphysical characteristics when simulating squall lines.

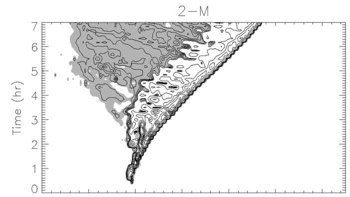

Image 1. These figures show the time evolution of surface precipitation rate along the horizontal model axis X, using the more complex microphysics scheme (2-M, Image 1 above) and the simpler scheme (1-M, Image 2 below). Regions with precipitation rate between 0.5 and 5 mm/hr are gray-shaded to highlight the stratiform precipitation region.

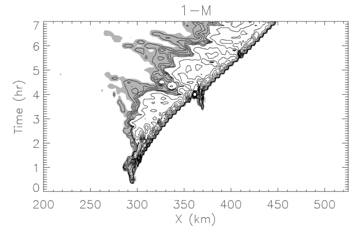

Image 2. These figures show the much more extensive stratiform precipitation region produced by the more complex scheme relative to the simpler scheme.

Reference(s)

Morrison HC, G Thompson, and V Tatarskii. 2009. "Impact of cloud microphysics on the development of trailing stratiform precipitation in a simulated squall line: Comparison of one- and two-moment schemes." Monthly Weather Review, 137, 991-1007.

Working Group(s)

Cloud Modeling