Simulation of a supercell storm in clean and dirty atmosphere using weather research and forecast model with spectral bin microphysics

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Article first published online: 14 OCT 2009

DOI: 10.1029/2009JD011827

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Issue

Journal of Geophysical Research: Atmospheres (1984–2012)

Volume 114, Issue D19, (/doi/10.1002/jgrd.v114.D19/issuetoc) 16 October 2009

Additional Information

How to Cite

Khain, A., and B. Lynn (2009), Simulation of a supercell storm in clean and dirty atmosphere using weather research and forecast model with spectral bin microphysics, J. Geophys. Res., 114, D19209, doi:10.1029/2009JD011827 (http://dx.doi.org/10.1029/2009JD011827).

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Publication History

1. Issue published online: 14 OCT 2009
2. Article first published online: 14 OCT 2009
3. Manuscript Accepted: 9 JUL 2009
4. Manuscript Revised: 8 JUN 2009
5. Manuscript Received: 30 JAN 2009

- Abstract
- Article (/doi/10.1029/2009JD011827/full)
- References (/doi/10.1029/2009JD011827/references)
- Supporting Information (/doi/10.1029/2009JD011827/suppinfo)
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Keywords:

supercell storms; aerosol effect; spectral microphysics; deep convection; numerical mode

[1] The development of supercell storms was simulated using a 2-km-resolution weather research and forecast (WRF) model with spectral (bin) microphysics (WRF-SBM) and a recent version of the Thompson bulk-parameterization scheme. The simulations were performed in clean, semipolluted, and dirty air under two values of relative humidity, conditionally referred to as low and high humidity. Both SBM and the Thompson scheme simulated the development of supercell storm with storm splitting. Both SBM and the Thompson scheme demonstrated that an increase in relative humidity by ~10% invigorates convection and increases precipitation by factor of 2, i.e., to much larger extent than can be achieved by variations of the aerosol concentration. At the same time the storms simulated by the schemes are quite different. The maximum updrafts in the Thompson scheme are about 65 m/s, and the left-moving storm prevails. The SBM predicts 35 m/s maximum updrafts, and the right-moving storm prevails in the SBM simulations. While the bulk scheme predicts decrease in precipitation in clean air at both low and high humidity, the SBM indicates decrease precipitation in polluted air under low humidity and increase in precipitation under high humidity. The SBM scheme shows a substantial effect of aerosols on spatial distribution of precipitation, especially in the low-humidity case. The sensitivity of the Thompson scheme to aerosols turns out to be much less than that of SBM. The difference in the results (vertical velocities, microphysical cloud structure, and precipitation) obtained by different schemes is much larger than the changes caused by variation of the aerosol concentration within each scheme. However, the average amount of precipitation in the Thompson scheme in each simulation was about twice that of the corresponding SBM simulation. The possible reasons for such difference are discussed. A scheme for classifying aerosol effects on precipitation from clouds and cloud systems is also discussed.

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Index Terms:

- Aerosols and particles (/agu/search/easi/results?originPage=taxonomyBrowse&searchRow.searchOptions.indexTerms=http://psi.agu.org/taxonomy5/0305&searchRow.searchOptions.indexTermNames=Aerosols and particles)
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