A "Little" Respect: Droplet Nucleation Finally Included in Global Climate Model

Research Highlight

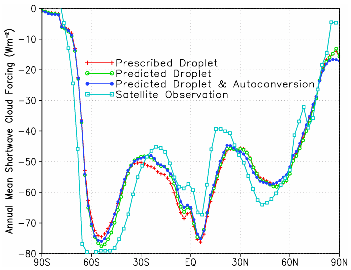
Tiny aerosol particles, whether in solid (smoke, dust) or liquid (sea-salt, sulfuric acid) form, are continually present in Earth's atmosphere as the result of either natural or man-made processes. These particles affect Earth's climate in two ways: directly, through scattering and absorption of solar and infrared radiation, and indirectly, by influencing the creation (or nucleation) of cloud droplets, leading to increased surface area and reflectivity of clouds. To what extent these different aerosol effects impact the Earth's energy balance is a subject under much investigation by the climate research community. However, until now, the treatment of droplet nucleation has been largely ignored by one of the most widely used computer models for simulating climate change. Without such a treatment, affects from man-made aerosols on droplet number and hence, climate, cannot be determined.

Researchers funded by the Department of Energy's Atmospheric Radiation Measurement Program developed a treatment of droplet nucleation and applied it to the Community Atmosphere Model (CAM) from the National Center for Atmospheric Research. In coupling the droplet nucleation scheme with aerosols in CAM, the simulated energy balance of the climate#a critical measure of model performance#is very close to the energy balance simulated with droplet number prescribed at a distribution of highly tuned values. This agreement also holds when the dependence of droplet "autoconversion" (merging of droplets#a key process for precipitation formation) on droplet number is treated.

Previously published research* in this area identified the importance of improvements to a number of factors when simulating droplet nucleation, particularly with respect to the relationship between aerosol, cloud updraft velocity, and droplet number concentration. These findings led to the current effort to fine tune the associated droplet nucleation parameters within CAM. In particular, the lower boundary of updraft vertical velocity was adjusted to improve the agreement of droplet prediction for current aerosol emissions. Thus, CAM can now use the predicted droplet number to treat indirect effects of aerosols, an important climate forcing mechanism that has been neglected in all previous climate simulations by CAM.

* Ghan, S. J., L. R. Leung, R. C. Easter, and H. Abdul-Razzak, 1997: Prediction of droplet number in a general circulation model. **J. Geophys. Res.**, 102, 21,777-21,794.

* Ghan, S. J., R. C. Easter, E. Chapman, H. Abdul-Razzak, Y. Zhang, R. Leung, N. Laulainen, R. Saylor and R. Zaveri, 2001: A physically-based estimate of radiative forcing by anthropogenic sulfate aerosol, **J. Geophys. Res.**, 106, 5279-5294.



Reflection of sunlight by clouds simulated with predicted droplet number with (dark blue) and without (green) the autoconversion feedback agrees remarkably well with the reflection simulated with prescribed droplet number (red). Satellite observations (light blue) are shown for comparison.

Reference(s)

Contributors

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Working Group(s)

Cloud Modeling