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Cloud-radiation parameterizations and cloud-climate feedbacks: Impressive recent progress but challenging tasks ahead

R. C. J. Somerville

Scripps Institution of Oceanography, University of California, San Diego, USA
(rsomerville@ucsd.edu / Phone: 1-858-534-4644)

The sensitivity of modern climate models to changes in atmospheric greenhouse gas concentrations depends strongly on cloud-radiation parameterizations and their consequences for cloud-climate feedbacks. In recent years, these parameterizations have become much more physically comprehensive. As an example, treatments of radiative properties of clouds in many models have evolved to include extremely detailed cloud microphysics. Cloud parameterization development has been greatly facilitated by results from cloud-resolving models, single-column models, and other small-scale simulations. Invaluable observational data from field campaigns or dedicated long-term observational sites, such as the Atmospheric Radiation Measurement (ARM) Program sites, have also contributed greatly toward progress in model representations of cloud-radiation processes. Despite significant progress, there is still a large range of climate sensitivity among models which differ mainly or only in their cloud-radiation scheme. Furthermore, the task of determining the relative realism of differing cloud-feedbacks arising from competing cloud-radiation parameterizations is still difficult. This paper surveys recent progress and identifies key issues for future research.