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Factors Determining the Impact of Aerosols on Surface Precipitation from Clouds: An Attempt at Classification

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Abstract

The simulation of the dynamics and the microphysics of clouds observed during the Large-Scale Biosphere–Atmosphere Experiment in Amazonia—Smoke, Aerosols, Clouds, Rainfall, and Climate (LBA–SMOCC) campaign, as well as extremely continental and extremely maritime clouds, is performed using an updated version of the Hebrew University spectral microphysics cloud model (HUCM). A new scheme of diffusional growth allows the reproduction of in situ–measured droplet size distributions including those formed in extremely polluted air. It was shown that pyroclouds forming over the forest fires can precipitate. Several mechanisms leading to formation of precipitation from pyroclouds are considered.

The mechanisms by which aerosols affect the microphysics and precipitation of warm cloud-base clouds have been investigated by analyzing the mass, heat, and moisture budgets. The increase in aerosol concentration increases both the generation and the loss of the condensate mass. In the clouds developing in dry air, the increase in the loss is dominant, which suggests a decrease in the accumulated precipitation with the aerosol concentration increase. On the contrary, an increase in aerosol concentration in deep maritime clouds leads to an increase in precipitation. The precipitation efficiency of clouds in polluted air is found to be several times lower than that of clouds forming in clean air. A classification of the results of aerosol effects on precipitation from clouds of different types developing in the atmosphere with high freezing level (about 4 km) is proposed. The role of air humidity and other factors in precipitation's response to aerosols is discussed. The analysis shows that many discrepancies between the results reported in different observational and numerical studies can be attributed to the different atmospheric conditions and cloud types analyzed.

Keywords: Aerosols, Cloud microphysics, Precipitation, Deep convection, Numerical analysis

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