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Effects of airborne particles on cloud processes and precipitation

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Airborne particles of natural or anthropogenic origin can serve as cloud condensation nuclei (CCN) and ice nuclei (IN). The amount of particles that will nucleate and form cloud droplets depends on number concentration, size distribution and chemical composition. Changes in the partitioning between hygroscopic and non-hygroscopic particles can affect the cloud cover, radiative properties and precipitation. Moreover, several other environmental parameters such as atmospheric conditions and surface properties play an important role on cloud processes. Several sensitivity tests and case studies have been simulated with the Integrated Community Limited Area Modeling System (ICLAMS) (an extended version of the Regional Atmospheric Modeling System, RAMS). The model is able to simulate the complex interactions between aerosols and cloud processes. In general, increased concentrations of particles delayed the initiation of precipitation and limited the rainfall heights. The size distribution of the particles was also found to be important. Adding GCCN to polluted clouds promoted early-stage rain while adding GCCN to pristine clouds had no significant effect on precipitation. Moreover, topographic variability had a strong effect on the spatial distribution and the amounts of precipitation. The role of dust and soot as IN and the competition between homogeneous and heterogeneous ice formation mechanisms has been also investigated for various types of clouds. Simulation of a case study over the Eastern Mediterranean showed that increased concentrations of hygroscopic dust particles resulted in stronger convection. The clouds reached higher tops and initiation of precipitation was delayed by one hour. Comparison of model results with surface observations of precipitation indicated a strong link between dust concentrations and rainfall amounts. The model results clearly illustrated the highly non-linear response of precipitation to aerosol properties. More intense combined modeling and observational surveys are needed to reduce the uncertainty on these mechanisms and to improve our knowledge on atmospheric chemistry and meteorology interactions.