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The effects of aerosols on precipitation and dimensions of subtropical clouds: a sensitivity study using a numerical cloud model

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Abstract. Numerical experiments were carried out using the Tel-Aviv University 2-D cloud model to investigate the effects of increased concentrations of Cloud Condensation Nuclei (CCN), giant CCN (GCCN) and Ice Nuclei (IN) on the development of precipitation and cloud structure in mixed-phase sub-tropical convective clouds. In order to differentiate between the contribution of the aerosols and the meteorology, all simulations were conducted with the same meteorological conditions. The results show that under the same meteorological conditions, polluted clouds (with high CCN concentrations) produce less precipitation than clean clouds (with low CCN concentrations), the initiation of precipitation is delayed and the lifetimes of the clouds are longer. GCCN enhance the total precipitation on the ground in polluted clouds but they have no noticeable effect on cleaner clouds. The increased rainfall due to GCCN is mainly a result of the increased graupel mass in the cloud, but it only partially offsets the decrease in rainfall due to pollution (increased CCN). The addition of more effective IN, such as mineral dust particles, reduces the total amount of precipitation on the ground. This reduction is more pronounced in clean clouds than in polluted ones.

Polluted clouds reach higher altitudes and are wider than clean clouds and both produce wider clouds (anvils) when more IN are introduced. Since under the same vertical sounding the polluted clouds produce less rain, more water vapor is left aloft after the rain stops. In our simulations about 3.5 times more water evaporates after the rain stops from the polluted cloud as compared to the clean cloud. The implication is that much more water vapor is transported from lower levels to the mid troposphere under polluted conditions, something that should be considered in climate models.

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