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Aerosol effects on clouds and precipitation during the 1997 smoke episode in Indonesia

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Abstract. In 1997/1998 a severe smoke episode due to extensive biomass burning, especially of peat, was observed over Indonesia. September 1997 was the month with the highest aerosol burden. This month was simulated using the limited area model REMOTE driven at its lateral boundaries by ERA40 reanalysis data. REMOTE was extended by a new convective cloud parameterization mimicking individual clouds competing for instability energy. This allows for the interaction of aerosols, convective clouds and precipitation. Results show that in the monthly mean convective precipitation is diminished at nearly all places with high aerosol loading, but at some areas with high background humidity precipitation from large-scale clouds may over-compensate the loss in convective rainfall. The simulations revealed that both large-scale and convective clouds' microphysics are influenced by aerosols. Since aerosols are washed and rained out by rainfall, high aerosol concentrations can only persist at low rainfall rates. Hence, aerosol concentrations are not independent of the rainfall amount and in the mean the maximum absolute effects on rainfall from large scale clouds are found at intermediate aerosol concentrations. The reason for this behavior is that at high aerosol concentrations rainfall rates are small and consequently also the anomalies are small. For large-scale as well as for convective rain negative and positive anomalies are found for all aerosol concentrations. Negative anomalies dominate and are highly statistically significant especially for convective rainfall since part of the precipitation loss from large-scale clouds is compensated by moisture detrained from the convective clouds. The mean precipitation from large-scale clouds is less reduced (however still statistically significant) than rain from convective clouds. This effect is due to detrainment of cloud water from the less strongly raining convective clouds and because of the generally lower absolute amounts of rainfall from large-scale clouds. With increasing aerosol load both, convective and large scale clouds produce less rain. At very few individual time steps cases were found when polluted convective clouds produced intensified rainfall via mixed phase microphysics. However, these cases are not unequivocal and opposite results were also simulated, indicating that other than aerosol-microphysics effects have important impact on the results. Overall, the introduction of the new cumulus parameterization and aerosol-cloud interaction reduced some of the original REMOTE biases of precipitation patterns and total amount.

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