On the effects of aerosols on cloud lifetime and precipitation in the Mediterranean region

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Aerosols affect climate directly by absorbing and scattering solar radiation and indirectly through their influence on clouds and precipitation. The latter issue has received a great deal of attention because its magnitude could be as large and of opposite sign to the effects of the greenhouse gases. Aerosols are known to affect precipitation development by changing cloud properties such as cloud drop and ice crystals size and concentrations, cloud dimensions and cloud lifetime. All these changes have direct influence on the radiation flux and consequently on climate.

The Mediterranean region is affected by aerosols from different sources (e.g. pollution, mineral dust and sea salt) whose effects on clouds could lead to increasing or decreasing static stability and thus influencing total precipitation and lifetime of clouds. The complexity of the climate system in this region, the diversity of air-masses sources, and the scarcity of water make the Mediterranean region an interesting natural laboratory for studying the mutual interactions of aerosol and clouds and their effects on precipitation generation and cloud lifetime. Any climatic change might have critical effects on this semi-arid region because fresh water is mostly supplied by precipitation, which occurs in a limited time during winter.

The TAU -2D single cloud model with detailed description of the cloud microphysical processes was used with a number of initial thermodynamic profiles that are typical for summer and winter conditions in the Mediterranean region in order to study how Cloud Condensation Nuclei (CCN) concentrations affect precipitation and cloud lifetime. Two types of clouds were investigated: small warm (only water drops) summer cumulus clouds and mixed phase winter convective clouds.

The simulations show that under the same meteorological conditions, polluted mixed phase convective clouds that contain large CCN concentrations (1350 cm^{-3}) produce 16 times less precipitation than clean clouds having small CCN concentrations (100 cm^{-3}). The results show that rain falling from clean clouds starts 16 minutes earlier, and cover about 10% wider area than that from polluted clouds. These results are in agreement with former modeling and experimental studies

The study shows also that while the lifetime of mixed phase convective clouds is longer in polluted clouds, the reverse is true for small warm cumulus clouds. A possible explanation for the difference between these cloud types can be attributed to the

major role of evaporation in dissipating small cumulus clouds with no ice. In polluted small warm cumulus clouds, the higher CCN concentrations lead to the production of smaller droplets, which can evaporate faster than in the clean clouds where larger droplets are produced. Furthermore, the enhanced evaporation in polluted clouds leads to enhanced entrainment of environmental air.

The above results demonstrate that in order to better understand the role of clouds in the climate picture, the microphysical processes in the clouds need to be considered in addition to the meteorological conditions that determine the potential for cloud and storm development.