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A study of aerosol indirect effects and feedbacks on convective precipitation

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Atmospheric aerosols from natural and anthropogenic origin are present in the troposphere of the Mediterranean basin and continental Europe, occasionnally reaching very high concentrations in air masses with a strong content of aerosols related to mineral dust emissions, wildfires, or anthropogenic contamination [1]. On the other hand precipitations in the Mediterranean basin need to be understood precisely since drought and extreme precipitation events are a part of Mediterranean climate which can strongly affect the people and the economic activity in the Mediterranean basin [2].

The present study is a contribution to the investigations on the effects of aerosols on precipitation in the Mediterranean basin and continental Europe. For that purpose, we used the Weather Research and Forecasting Model (WRF) parameterized with the Thompson aerosol-aware microphysics schemes, performing two sensitivity simulations forced with two different aerosol climatologies during six months covering an entire summer season on a domain, covering the Mediterranean basin and continental Europe at 50 km resolution. Aerosols may affect atmospheric dynamics through their direct and semidirect radiative effects as well as through their indirect effects (through the changes of cloud microphysics). While it is difficult to disentangle these differents effects in reality, numerical modelling with the WRF model make it possible to isolate indirect effects by modifying them without affecting the direct or semidirect effects of aerosols in an attempt to examine the effect of aerosols on precipitations through microphysical effects only.

Our first results have shown two opposite responses depending whether the precipitation are convective or large-scale. Since convective precipitations seem to be clearly inhibited by increased concentrations of cloud-condensation nuclei, we attempted to understand which processes and feedbacks are involved in this reduction of parameterized convective precipitations when the concentrations of cloud-condensation nuclei are increased. We diagnosed a complex feedback chain beginning from the reduction of mean droplet radii, yielding an increase of atmospheric stability and also lowering the humidity available in the planetary boundary layer for the formation of convective clouds and precipitations. These results suggest that the microphysical effect of aerosols may contribute to a reduction of convective precipitation mostly through modifications in thermodynamic vertical profiles.

References

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