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Influence of aerosol vertical distribution on radiative budget and climate

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Aerosols interact with shortwave and longwave radiation with ensuing consequences on radiative budget and climate. Aerosols are represented in climate models either using an interactive aerosol scheme including prognostic aerosol variables, or using climatologies, such as monthly aerosol optical depth (AOD) fields. In the first case, aerosol vertical distribution can vary rapidly, at a daily or even hourly scale, following the aerosol evolution calculated by the interactive scheme. On the contrary, in the second case, a fixed aerosol vertical distribution is generally imposed by climatological profiles.
The objective of this work is to study the impact of aerosol vertical distribution on aerosol radiative forcing, with ensuing effects on climate. Simulations have thus been carried out using CNRM-CM, which is a global climate model including an interactive aerosol scheme representing the five main aerosol species (desert dust, sea-salt, sulfate, black carbon and organic matter). Several multi-annual simulations covering the past recent years are compared, including either the prognostic aerosol variables, or monthly AOD fields with different aerosol vertical distributions. In the second case, AOD fields directly come from the first simulation, so that all simulations have the same integrated aerosol loads.
The results show that modifying the aerosol vertical distribution has a significant impact on radiative budget, with consequences on global climate. These differences, highlighting the importance of aerosol vertical distribution in climate models, probably come from the modification of atmospheric circulation induced by changes in the heights of the different aerosols. Besides, nonlinear effects in the superposition of aerosol and clouds reinforce the impact of aerosol vertical distribution, since aerosol radiative forcing depends highly upon the presence of clouds, and upon the relative vertical position of aerosols and clouds.