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A multi-component aerosol-cloud parameterisation for global climate modelling

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Modelling the simultaneous activation and growth of aerosol species under typical marine stratiform clouds conditions is very important for a better understanding of the aerosol indirect effect. The development of parameterisations for Global Climate Models (GCMs) of the microphysics of clouds and their interactions with aerosols is a major challenge for climate modellers. The aerosol responses are linked to future climate change predictions via the cloud droplet number concentration (CDNC) and an accurate estimation of this number is essential. At the moment there are several parameterisations available, but most of them consider a maximum of two chemical compounds at any specific size. Moreover, some parameterisations rely on simple monotonic functions to relate the CDNC to aerosol number concentrations.

This study proposes a parameterisation for the aerosol activation in the case when three different aerosol species are considered, namely sulphate, sea-salt and biomass smoke. A detailed microphysical chemical parcel model shows that the activation in this three-component system differs significantly from current parameterisations, as non-linear responses of the CDNC to the aerosol mass loadings occur in regions of the activation domain. Investigations on the sensitivity of the activation with respect to the initial aerosol distribution and on the effect of the sea-salt film mode on the activation process are also included.

The parameterisation of the non-linearities that characterize the relation linking the CDNC to the aerosol mass concentration in an activation domain large enough to include a wide range of aerosol loadings is in itself a difficult and complex numerical problem. Interpolation methods adapted to this problem are tested and proposed as an efficient technique for the three-component aerosol-cloud parameterisation into

GCMs. A comparison of different interpolation methods in terms of accuracy and computational efficiency is also presented.

The numerical results obtained show that this approach provides realistic results for a wide range of aerosol mass loadings and offer an efficient and improved parameterisation ready for implementation into GCMs.