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# Intercomparison of aerosol-cloud-precipitation interactions in stratiform orographic mixed-phase clouds

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Anthropogenic aerosols serve as a source of both cloud condensation nuclei (CCN) and ice nuclei (IN) and affect microphysical properties of clouds.
Increasing aerosol number concentrations is hypothesized to retard the cloud droplet collision/coalescence and the riming in mixed-phase clouds, thereby decreasing orographic precipitation.

This study presents results from a model intercomparison of 2D simulations of aerosol-cloud-precipitation interactions in stratiform orographic mixed-phase clouds.
The sensitivity of orographic precipitation to changes in the aerosol number concentrations is analyzed and compared for various dynamical and thermodynamical situations.
Furthermore, the sensitivities of microphysical processes such as collision/coalescence, aggregation and riming to changes in the aerosol number concentrations are evaluated and compared.

The results of the model intercomparison suggest that the sensitivity of orographic precipitation to aerosol modifications varies greatly from case to case and from model to model.
Neither a precipitation decrease nor a precipitation increase is found robustly in all simulations.
Qualitative robust results can only be found for a subset of the simulations but even then quantitative agreement is scarce.
Estimates of the second indirect aerosol effect on orographic precipitation are found to range from -19∼\% to +3∼\% depending on the simulated case and the model.

Similarly, riming is shown to decrease in some cases and models whereas it increases in others which implies that a decrease in riming with increasing aerosol load is not a robust result.
Furthermore, it is found that neither a decrease in cloud droplet coalescence nor a decrease in riming necessarily implies a decrease in precipitation due to compensation effects by other microphysical pathways.

The simulations suggest that mixed-phase conditions play an important role in reducing the overall susceptibility of clouds and precipitation with respect to changes in the aerosols number concentrations.
As a consequence the indirect aerosol effect on precipitation is suggested to be less pronounced or even inverted in regions with high terrain (e.g. the Alps or Rocky Mountains) or in regions where mixed-phase microphysics climatologically plays an important role for orographic precipitation.