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The importance of mixed-phase clouds for climate sensitivity in the global aerosol-climate model ECHAM6-HAM2

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Clouds are important in the climate system because of their large influence on the radiation budget. On the one hand, they scatter solar radiation and with that cool the climate. On the other hand, they absorb and re-emit terrestrial radiation, which causes a warming. How clouds change in a warmer climate is one of the largest uncertainties for the equilibrium climate sensitivity (ECS). While a large spread in the cloud feedback arises from low-level clouds, it was recently shown that also mixed-phase clouds are important for the climate sensitivity. If mixed-phase clouds in the current climate contain too few supercooled cloud droplets, too much ice will be in the form of liquid water in a warmer climate. This overestimates the negative cloud phase feedback and underestimates ECS in the CAM5 global climate model (GCM) as shown by Tan et al. (2016). Here we are using the newest version of the ECHAM6-HAM2 GCM.

Although we also considerably underestimate the fraction of supercooled liquid water in the ECHAM6-HAM2 GCM, we do not obtain any increase in ECS in simulations with more supercooled liquid water. This is caused by smaller changes in the cloud optical depth feedback in these simulations in ECHAM6-HAM2 than in CAM5, partly because of the better representation of mixed-phase clouds in ECHAM6-HAM2 in the present-day climate. Therefore, we cannot confirm that an underestimation in the supercooled liquid water fraction goes along with an underestimation of ECS. We can, however, confirm that ECS increases by approximately 30% between a simulation with only ice in the mixed-phase temperature range between 0 and -35ºC and only supercooled liquid water in this temperature range, because of the absence of the negative cloud phase feedback in the latter simulation.