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How detailed do cloud microphysics need to be in climate models?

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Clouds are of major importance for the climate system, but the radiative forcing resulting from their interaction with aerosols remains uncertain. To improve the representation of clouds in climate models, the parameterisations of cloud microphysical processes (CMPs) have become increasingly detailed. However, more detailed climate models do not necessarily result in improved accuracy for estimates of radiative forcing (Knutti and Sedláček, 2013; Carslaw et al., 2018). On the contrary, simpler formulations are cheaper, sufficient for some applications, and allow for an easier understanding of the respective process' effect in the model.

This study aims to gain an understanding which CMP parameterisation complexity is sufficient through simplification. We gradually phase out processes such as riming or aggregation from the global climate model ECHAM-HAM, meaning that the processes are only allowed to exhibit a fraction of their effect on the model state. The shape of the model response as a function of the artificially scaled effect of a given process helps to understand the importance of this process for the model response and its potential for simplification. For example, if partially removing a process induces only minor alterations in the present day climate, this process presents as a good candidate for simplification. This may be then further investigated, for example in terms of computing time.
The resulting sensitivities to CMP complexity are envisioned to guide CMP model simplifications as well as steer research towards those processes where a more accurate representation proves to be necessary.

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