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Evaluation of a statistical cloud parametrization for global climate models

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Clouds play a major role in weather and climate. Precipitation originates from them, and they strongly alter the planet's albedo depending on their microphysical characteristics. In numerical modeling of weather and climate it is therefore crucial to appropriately represent clouds in the atmospheric system. Different parametrizations and the lack of understanding of clouds are known to be one of the main reasons for uncertainties in up to date global climate simulations (Randall et al. 2007). In current climate models the subgrid-scale variability of total water is only crudely taken into account. A more detailed consideration of this subgrid-scale variability (e.g. by application of a more realistic probability density function) might improve the representation of clouds. The statistical cloud scheme (Tompkins 2002) implemented in ECHAM5/6 (Roeckner et al. 2003) uses the beta distribution and defines the function through mean total water mixing ratio, mean cloud water mixing ratio and two additional prognostic equations for the second and third order moments of the distribution.
Another advantage of a statistical scheme is the potential scale independency. With regard to the new generation of global climate models employing local grid refinement the need for scale independent parametrizations grows. Especially the numerous connections to other processes through the prognostic equations makes it necessary to have a detailed evaluation of the behavior of the scheme on different scales.

We started with a theoretical testcase and assumed a perfectly beta distributed total water mixing ratio in a gridbox to investigate first only the characteristics of the beta function at different resolutions. In this theoretical experiment additionally to the mean each value of the total water mixing ratio is known. This gives us the possibility to calculate exact values of the remaining parameters (e.g. skewness, variance, cloud cover). If we now divide the distribution (or the gridbox) in several parts and repeat the calculations, we can investigate the behavior of the moments and the cloud cover with respect to changing resolution. The development of this and more simple theoretical testcases shall provide a deeper knowledge of the scheme and the constraints that an appropriate cloud scheme should fulfill.
We will present first results of this theoretical experiments using the beta distribution and also of the investigation of scale independency of the Tompkins scheme within the global climate model ECHAM6.

Reference

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