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Introduction of a simplified version of the Soccer ball model

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Heterogeneous ice nucleation, a primary pathway to form ice in the atmosphere, directly influences cloud physical processes, precipitation formation, global radiation balances, and therefore Earth's climate (e.g., Cantrell and Heymsfield, 2005). Since more than 60 years many efforts have been made to describe this process theoretically. In this context two contrary hypotheses have been developed: In the first case heterogeneous ice nucleation has been described as being stochastic (i.e. time dependent), in direct analogy with homogeneous nucleation, in the second case as being singular, with ice nuclei (IN) initiating freezing at deterministic temperatures. Experimental results obtained in various research groups could be explained either with the stochastic or the singular description.

In a recent study, the Soccer ball model was introduced which bridges these two hypotheses providing a phenomenological explanation for the seemingly contradictory experimental results obtained. The model takes into account multiple nucleation sites on individual particles characterized by different contact angles θ (Niedermeier et al., 2011).

In the original Soccer ball model, the contact angle distribution, which is a normal distribution, is discretized between 0 and π and through uniformly distributed random numbers each nucleation site is associated with a specific contact angle ('random sampling'), and is therefore fairly time consuming and hardly usable in atmospheric modelling applications.

Herewith, a new (modified) version of the Soccer ball model will be introduced. The model parameters are still the average number of surface sites n_{site} per particle, the mean contact angle μ_θ and the width of the contact angle distribution σ_θ. In the new version each particle is assigned $n = n_{\mathrm{site}}$ contact angles weighted by the probability density function so that the uniformly distributed random numbers are not needed anymore. This means the new model describes the mean ice nucleation behaviour of the particle population. It will be shown that for equal parameter settings both methods lead to similar results whereas the new formulation is simpler and computationally more efficient without losing accuracy.

Furthermore a sensitivity study concerning the dependence of the heterogeneous nucleation process on temperature and time will be performed for parameter settings which are based on experimental data (e.g., Arizona Test Dust, Birch pollen washing water and SNOMAX) determined with the Leipzig Aerosol Cloud Interaction Simulator (LACIS, Hartmann et al., 2011).

References

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