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Generalisation of the parametrisation for homogeneous ice nucleation due to gravity waves

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The microphysical properties of cirrus clouds and their interactions with local dynamics, such as gravity waves (GW), are not well understood (Gasparini et al. [2018], Joos et al. [2014]), leading to significant uncertainties in climate effect estimations. Accurate representation of ice formation processes and ice number concentration prediction is crucial for understanding the cirrus lifecycle (Krämer et al. [2020]), the structure of the tropopause layer, and the radiative budget (Matus and L'Ecuyer [2017]).

The present work complements (Dolaptchiev et al. [2023]) and is designed to further refine and generalize their approach, incorporating variability in the ice mean mass during cirrus evolution. Extending the results from (Baumgartner and Spichtinger [2019]), which are dedicated to homogeneous nucleation due to constant updraft velocities, we incorporate GW dynamics into the asymptotic approach. Previous studies Gierens et al. [2003] have shown that the deposition coefficient significantly impacts the nucleation process and is dependent on the mass of ice crystals. Numerical parcel model simulations in (Dolaptchiev et al. [2023]) also demonstrate that mean mass variability significantly affects cloud ice number concentration predictions, especially under conditions with a higher number of per-existing ice particles. In order to generalize the parameterisation introduced by (Dolaptchiev et al. [2023]), a correction to the parameterisation to account for changes in mean mass is proposed.

The suggested correction to the deposition term is based on underlying physical differences in the deposition process. The proposed approach is validated through ensemble calculations and tested for robustness with larger time steps. Recommendations for the optimal time steps for the representation of individual nucleation events, combined with sufficiently good captured statistics of post-nucleation ice number concentration occurrences, are provided. Incorporating mean mass variation leads to a better representation of predicted ice number concentrations, enhancing our understanding and modeling of cirrus clouds.

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