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Modelling of contrail cirrus in a climate model: microphysical and optical properties

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Contrail cirrus is the largest climate forcing component of aviation. Current estimates using a climate model rely on an approach parameterizing contrail microphysical processes based on ice water content alone. A microphysical two-moment-scheme (prognostic ice water content and ice particle number density) allows a more realistic representation of the microphysical and optical properties of contrail cirrus. That implies a better estimate of their radiative forcing and its sensitivity to changes in ice particle number concentration.

We modify the cloud scheme in ECHAM5-HAM by changing the nucleation parameterization consistent with a fractional coverage. Afterwards the contrail cirrus module (Burkhardt and Kärcher, 2009) developed for one-moment microphysics is implemented in ECHAM5 and extended with a two-moment-scheme. An exact description of contrail cirrus volume is important for a realistic characterization of the microphysical and optical properties of contrail cirrus. Therefore, parameterizations for the growth of the contrail cirrus volume due to diffusion, wind shear and sedimentation are implemented. The fields of ice water content, ice particle number concentration, cloud coverage and the frequency of ice supersaturated regions are validated and microphysical and optical properties of contrail cirrus are studied. In an idealized experiment the relative importance of microphysical processes is evaluated. As a consequence of the improved parameterization of microphysical processes the optical depth of contrail cirrus is higher in regions with high flight density than it was in earlier studies (Burkhardt and Kärcher, 2011) due to the high ice particle number concentrations on the main flight routes. Microphysical and optical properties of contrail cirrus turn out to be strongly dependent on the initial ice particle number. Reducing the latter leads to an overall decrease of contrail cirrus optical depth and visible coverage.