DETAILED MODELLING OF CIRRUS CLOUDS
an intercomparison of different approaches for homogeneous nucleation.

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Abstract:
We developed a cirrus model with detailed microphysics including homogeneous nucleation, depositional growth of ice crystal and riming of supercooled droplets on ice crystals. The model treats the particle distribution as two-dimensional, which allows to keep the information on the aerosol particles which are in GCM or in NWP and determines the solute concentration of the liquid phase. To get accurately the number of crystals, homogeneous nucleation must be determined very carefully during the short period of cirrus formation. The formation period is limited by the consumption of water vapour by the strong depositional growth of ice new small crystals. Therefore, these processes should be treated individually. There are several approaches for the treatment of homogeneous nucleation. A comparison of these schemes has been published in Lin (JAS, 2002). A major problem in this intercomparison for homogeneous nucleation is that the models involved also used different description on ice particles. Thus this intercomparison does not allow a conclusion on which process - nucleation or deposition - is responsible for the different results. That’s why we’ve implemented into our model three different schemes of nucleation for supercooled acid sulphuric solution droplets: the classical approach of Tabazadeh (GRL, 2000), the effective temperature model of DeMott (GRL, 1997), and the laboratory data set of Koop (Nature, 2000). We’ve also implemented a riming scheme based on the numerical solution of Bott (JAS, 2000) for two-dimensional particle distributions. We’ve seen that in pure cirrus conditions riming is negligible to explain the ice particle size as well as the amount of the residual aerosol mass.

Fig. 1: Sensitivity of the product of nucleation, riming and deposition for the gain of ice mass (10^{-9} g cm^{-3} s^{-1}) as a function of the fluxes for three different schemes of nucleation for the three different parameterisations of homogeneous nucleation. The black bars following the scheme proposed by Tabazadeh (GRL, 2000), the red bars following the works of DeMott (GRL, 1997) and the green bars following the data set of Koop (Nature, 2000).

Fig. 2: Contribution of the deposition, nucleation and riming processes for the gain of ice mass (10^{-9} g cm^{-3} s^{-1}) for the three different parameterisations of homogeneous nucleation as a function of the altitude of the cirrus, with the accommodation factor.

Fig. 3: Model integration for three different parameterisations at -45°C and -65°C. DeMott’s and Tabazadeh’s parameterisations depend on the C020 factor (above) and -65°C (below) for the three different parameterisations.

Conclusion:
With our detailed cirrus model for crystal growth we compared three different parametrisations for nucleation, and found the effect of solute concentration on the formation of ice crystals in cirrus clouds. We’ve also implemented a riming scheme based on the numerical solution of Bott (JAS, 2000) for two-dimensional particle distributions. We’ve seen that in pure cirrus conditions riming is negligible to explain the ice particle size as well as the amount of the residual aerosol mass.

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