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Redistribution of trace gases by convective clouds - mixed-phase processes

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Abstract. The efficiency of gas transport to the free and upper troposphere in convective clouds is investigated in an axisymmetric dynamic cloud model with detailed microphysics. In particular, we examine the sensitivity of gas transport to the treatment of gas uptake by different ice hydrometeors. Two parameters are used to describe this uptake. The gas retention coefficient defines the fraction of dissolved gas that is retained in an ice particle upon freezing, which includes also the riming process. We also define a gas burial efficiency defining the amount of gas entrapped in ice crystals growing by vapour diffusion. Model calculations are performed for continental and maritime clouds using a complete range of gas solubilities, retention coefficients and burial efficiencies. The results show that the magnitude of the gas retention coefficient is much more important for gas transport in maritime clouds than in continental clouds. The cause of this difference lies in the different microphysical processes dominating the formation and evolution of hydrometeors in the two cloud types. For highly soluble gases, the amount of gas transported to the free troposphere in maritime clouds falls approximately linearly by a factor of 12 as the retention coefficient is varied between 0 and 1. Gas transport is relatively insensitive to the magnitude of the gas burial efficiency. However, the burial efficiency strongly controls the concentration of trace gases inside anvil ice crystals, which subsequently form cirrus clouds.

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