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How does a Homogeneous Nucleation Event respond to changes of Parameterizations of Water Activity and Saturation Vapor Pressure?

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Homogeneous nucleation of ice crystals via freezing of small supercooled solution particles represents a major pathway in the formation of cirrus clouds with high ice water content at low temperatures. A reasonable physical explanation of this type of freezing is provided by Koop's nucleation theory, relating the homogeneous nucleation rate to the water activity of the solution particles. While the homogeneous nucleation rate encodes the probability of freezing of solution particles, the water activity represents the ratio of water vapor saturation pressures over the solution to that over pure water in Koop's portrayal.

By using the ice microphysics model "CLaMS-Ice", we investigate the effect of various formulations of the water activity and the water vapor saturation pressure on the resulting cirrus clouds. Although CLaMS-Ice is a two-moment bulk model, it implements a comparatively detailed ice microphysics formulated by Spichtinger and Gierens. Such a microphysics scheme is suitable to be implemented in full three dimensional atmospheric models in contrast to even more detailed bin microphysics schemes.

We performed sensitivity simulations over a wide range of temperatures and vertical velocities by using two different direct parameterizations of water activity based on thermodynamic models in addition to the one used by Koop. Also, three different formulations of the water vapor saturation pressure are applied in the simulations. The results are evaluated regarding the predicted number of ice crystals and the ice onset humidities. In particular, one major finding is that the freezing thresholds are increased compared to Koop's freezing lines.