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The heterogeneous formation process of clouds below 150K

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Heterogeneous H2O nucleation studies below 150K are rare, but important to understand the formation of cold ice clouds in terrestrial atmospheres, e.g. polar mesospheric clouds on Earth or water ice clouds on Mars. We use a time-of-flight mass spectrometer to study H2O adsorption, critical saturation and subsequent growth on sub 4nm iron oxide and silica particles levitated in a modified ion trap where the particles are exposed to a well-defined H2O supersaturation between 125K and 150K. In this contribution, we determine the binding energy/desorption energy of water molecules on the particle material, which allows us to parameterize the amount of water molecules which are adsorbed on a surface as function of temperature and saturation. In addition, we are able to evaluate for the temperature dependent sublimation flux of water molecules from the particle and conclude that the deposited ice polymorph is amorphous solid water (ASW). We show that for all temperatures under investigation, H2O growth is activated as soon as the equilibrium saturation over the curved particle surface including the amount of adsorbed water molecules (Kelvin effect) is exceeded. We present a method to predict critical saturations needed for cloud formation below 150K.

Significance statement

We present measurements of H2O adsorption, critical saturation and growth on small nanoparticles below 150K in order to understand the formation of cold ice clouds. We show that ASW is deposited as soon as the equilibrium saturation over the particle surface including the amount of adsorbed water molecules is exceeded.

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