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The vapor pressure over nano-crystalline and amorphous ice

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It is known that at ambient pressure the crystallization of amorphous ices proceeds via the formation of nano-crystallites. This fact, however, is not considered in many studies on amorphous and crystalline ices formed from the amorphous phase even though it has important implications on various ice properties. As an example, we show in this contribution, that the saturation vapor pressure over nano-crystalline ice is elevated by a factor of two to three compared to the assumed saturation vapor pressure of cubic/hexagonal ice between 135 K and 160 K due to the high curvature of the nano-crystallites. We then analyze heat capacity measurements of amorphous and crystalline ices from the previous five decades on the premise of nano-crystallite formation. We show that heat capacity data has to be re-interpreted and that the free energy difference between amorphous and hexagonal ice is substantially higher than previously assumed. Taking these findings we propose a new parameterization for the saturation vapor pressure over amorphous ice for temperatures below 200 K. As nano-crystalline ice and amorphous solid water are stable for hours below 160 K and 135 K, respectively, both phases have to be considered for ice cloud processes occurring at or below these temperatures in planetary atmospheres, for instance in the mesospheres of Earth and Mars.

Significance statement

We present a new and substantially higher parameterization for the vapor pressure over amorphous solid water below 200 K which is based on own measurements of nano-crystalline and amorphous ice and studies from the last five decades. The result has important implications on processes in cold ice clouds.

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