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The formation of cubic ice under conditions relevant to Earth's atmosphere

B. J. Murray, D. A. Knopf and A. K. Bertram

Department of Chemistry, University of British Columbia, Vancouver, Canada
(bmurray@chem.ubc.ca)

It is often assumed that the only natural phase of ice that forms on Earth is that of hexagonal ice (ice Ih). However, the rare observation of haloes around the sun at 28^o and cloud particles of cubic habit indicates that the metastable crystalline form of ice, cubic ice (ice Ic), may form in the upper troposphere and stratosphere. The conditions used to produce ice Ic in previous studies are most likely never experienced on Earth outside the laboratory, since they usually involve extremely fast cooling rates. Here we show, using X-ray diffraction, that cubic ice forms when micrometer-sized pure water and aqueous solution droplets freeze homogeneously using a modest cooling rate (10 K min^{-1}). In fact, ice Ic is the dominant product when NaCl, $(NH_4)_2SO_4$, $(NH_4)_3H(SO_4)_2$ and HNO_3 solution droplets freeze at temperatures below 190 K, and pure water droplets freeze to a significant proportion of ice Ic at 235 K. These results strongly suggest that cubic ice will form in the atmosphere, where it may influence the formation of ice clouds and the water vapour pressure within these clouds. These results also offer significant insights into the crystallization of ice, a process that occurs widely in nature.