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Evolution of the reservoir of volatiles in the protosolar nebula

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How volatiles were incorporated in the building blocks of planets and small bodies in the protosolar nebula remains an outstanding question. Some scenarios invoke the formation of planetesimals from a mixture of refractory material and amorphous ice in the outer nebula while others argue that volatiles have been incorporated in clathrate or pure condensate forms in these solids. Here we study the fate of volatiles (H_2O, CO, CO_2, CH_4, H_2S, N_2, NH_3, Ar, Kr, Xe, and PH_3) initially delivered in the forms of amorphous ice or pure condensates to the protosolar nebula. We investigate the radial distribution of these volatiles via a transport module coupled with an accretion disk model. In this model, multiple icelines are considered, including the condensation fronts of pure condensates, as well as those of clathrates when enough crystalline water is available at given time and location. Our simulations show that a significant fraction of volatiles can be trapped in clathrates only if they have been initially delivered in pure condensate forms to the disk. Under specific circumstances, volatiles can be essentially trapped in clathrates but, in many cases, the clathrate of a given species coexists with its pure condensate form. Those findings have implications for the compositions of giant planets and comets.