Air-snow exchange of bromine, ozone and mercury in the springtime Arctic simulated by the 1-D model PHANTAS – Part 1: In-snow bromine activation and its impact on ozone

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Toyota et al developed and utilized a 1-D model with embedded multiphase air-snowpack physicochemistry to more accurately and precisely quantify polar tropospheric ozone and atmospheric mercury depletion events – notably, denoted ODEs and AMDEs, respectively. Their first companion manuscript describes the model construct and focuses on bromine activation/release and its impact on polar tropospheric ODEs. In addition to the Thomas et al's MISTRA-SNOW model, Toyota et al's model represents (to my knowledge) the most robust 1-D with embedded/coupled multiphase physicochemistry to date. This manuscript was undoubtedly a pleasant read as it is transparent in exemplifying its advances and constraints (which plague the modeling community). Still, as Toyota et al elegantly presents in their manuscript, notable and significant steps forward in the field of air-snow-ice multiphase modeling. It is rare that I have no major/minor constructive comments/suggestions to make in regard to a manuscript; I, therefore, highly recommend this manuscript for publication.