

***Interactive comment on* “The rate of water vapor evaporation from ice substrates in the presence of HCl and HBr: Implications for the lifetime of atmospheric ice particles” by C. Delval et al.**

C. Delval et al.

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Answer to Referee Comment by Anonymous Referee no. 1 in regards to "The rate of water vapor evaporation from ice substrates in the presence of HCl and HBr: Implications for the lifetime of atmospheric ice particles" By C. Delval, B. Flückiger and M. J. Rossi Ms-Nr. 2003-023

We thank referee no. 1 for his careful reading of the manuscript and the constructive criticism accompanying it. Largely as a result of his efforts we are now able to submit a significantly improved and amended manuscript to which we have added one Figure and one Table together with additions to the text where the need for clarification and detail was the largest according to the referee. In the following we point out the changes made to the original manuscript in the sequence of the referee's remarks. - The study

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by Diehl et al. has now been referenced as it is directly related to the present work. However, we would like to point out that Diehl et al. do not give any useful quantitative information: one does not know how many molecules are adsorbed on the ice, and only net evaporation rates are given. The present work gives elementary rates after separation of the net into condensation and evaporation processes at a given number of contaminant HX molecules adsorbed onto the ice. We admit that in the case of HBr only upper limits are given. However, we take exception to the statement that the "conclusions drawn from the present study remain somewhat speculative" as we give an accurate expression as to how one may calculate the NET evaporation rate as a function of relative humidity (paragraph above equation (5)). - An ice film thickness of 1 mm is correct. Table 1 lists 1000 nm for an optical density of 1.08 at approximately 3230 cm^{-1} . - The experimental procedure surrounding the production of the ice film and the dosing with HCl is now accurately described in detail in additional text in front of Figure 2. We have distinguished between the stirred flow and the static reactor technique that have been used at low ($T = 190\text{K}$) and high ($T > 190\text{K}$) temperature, respectively. - Equation (2) has been corrected: sorry for this embarrassing typo! - The difference between fluxes and rates including their corresponding units are clearly indicated in explanations after equation (3). However, k_{cond} is a first order rate constant in s^{-1} and does not depend on the water partial pressure, which we clearly point out. - The referee is correct in pointing out that the ice that is not affected by HX is evaporating at the evaporation rate characteristic of pure ice. Additional text now stresses these facts in conjunction with the discussion of Figure 8. However, the spatial extent of this effect is by no means insignificant ("and only a minor surface fraction with the mixture is evaporating at significantly lower rates.") as Table 2 clearly shows an effect stretching over 250 (crystalline hydrate) to 500 nm (amorphous layer) out of a total of 1000 nm. Nevertheless, in the interest of brevity we refrained from putting this fact into the abstract. - Figures 6 and 7 now give a sense of the uncertainty in the evaporative flux. By all means it is possible to translate these numbers into a typical atmospheric situation at a given T and rh ! For the first time our work provides a microscopic rate

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constant for water condensation and the H₂O evaporation rate, and not just its ratio, i. e. the vapor pressure P_{vap}! Of course, P_{vap} is a powerful constraint that we also use in our evaluation of the kinetics. We have repeatedly confirmed that the H₂O saturation vapor pressure is maintained even for the situation when all the underlying pure ice was evaporated. - The importance of the decrease of the evaporation rate on the chemistry of the stratosphere has been discussed in more detail. The importance of this effect scales with the duration during which the ice is in contact with HCl whose concentration is roughly 10% of that for HNO₃ (1 ppb vs. 10ppb in the stratosphere). For HBr the numbers are smaller (few ppt). However, our work shows that a monolayer or two of HCl can slow down the H₂O evaporation rate of an ice slab of 250 nm thickness which is a large effect compared to the quantities needed to form defined crystalline NAT or NAM. For HBr the smaller atmospheric concentration is offset by the larger effect on the H₂O evaporation rate. - The temperature of the PTFE insulation of the cryostat in operation is now given and never goes below 250K. - Torr is the pressure unit used throughout with the conversion between Torr and mbar given in the text. - All the minor comments and technical questions were resolved. Hats off to the referee for his diligence!

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 2179, 2003.

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