Atmos. Chem. Phys. Discuss., 10, C12557–C12561, 2011
www.atmos-chem-phys-discuss.net/10/C12557/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Charge induced stability of water droplets in subsaturated environment" *by* J. K. Nielsen et al.

J. K. Nielsen et al.

jkn@dmi.dk

Received and published: 19 January 2011

Final response to referee # 2

Referee # 2 recommends acceptance, provided some specific clarifications are addressed. Here we go through the points.

"(1) While the overall flow of the writing is very good,[...] The reading will be easier if they can provide more background before jumping to the statement." We consider this as a general critique which is detailed by the referee in the proceeding paragraphs.

"(2)Line 21, p.25744: "these measurements must prompt speculations", could you provide some of these speculations?"

In Nielsen et al. (2007) a measurement of tropical stratospheric ice is interpreted as an incidence of very small (few micron) ice particles which had been in stratosphere for several hours. We have calculated that even a small temperature fluctuation below 1 K, which is probably inevitable near tropical convection, would cause these particles to sublimate almost instantaneously, within 12 seconds. So it seems a little mysterious that they still exists after several hours.

In Khaykin et al. (2009) a similar measurement was done, and in this case the humidity was measured in situ. We have calculated that the RH_i was only 0.4 at the time of the measurement. Thus we speculate that something has to stabilize these particles. We have been reluctant to put it explicitly in the article because it is quite controversial, and could as such actually undermine the clear experimental rationale of the article. We can elaborate a little on it, but still emphasize that it only serves as a motivation for the experiment.

"(3)Can you provide a simple sketch of the EDB with the indication where the water drops and the ice surfaces are so that the readers don't have to look up in other journals?"

We shall do that.

"(4) Equation (1): please define $\mu_0(T)$, K_B and e(r) here. I know you have defined e(r) later,but this is where it appears first."

Point taken!

"(5) Line 8, p. 25746: ' For droplet radii above 1 μm' are you making the assumption that the surface energy effect is less important for larger drop cases? If so, maybe you should cite, e.g., Prupapcher and Klett (1997), to justify the statement."

Referee # 1 also commented on the exclusion of the Kelvin effect. We have decided to include it and show that it is neglectable.

"(6)Line 10: 'saturation pressure over a plane liquid water surface' but I thought you are talking about a spherical drop?"

Even at a radius of 5 μm the curvature and surface energies are of no importance. We will deal with this question along with the former question in the final version.

"(7) Line 19: right before the equation, you may need to add 'RHw can be expressed' ".

Absolutely.

"(8)Line 21: Why does σ_q have to be the same on all droplets?"

This is a consequence of the theory: For a given RH there is a fixed equilibrium σ_q given by equation (4). If a droplet had say a lower surface charge density it would be out of equilibrium and start to shrink until its surface charge density had equilibrated. We can certainly write that in the paper.

"(9) Line 1, p.25748: how do you make sure that the drop is in an environment of saturation vapor pressure over ice?" This is the basic concept of the experiment. Since the interior of the cell is covered with ice we assume that the gas in the cell compartment is saturated with respect to ice. However, as it turns out that there are temperature gradients in the cell there may be a slight difference between the RH$_i$ in the center and the RH$_i$ on the wall, and therefore we have to fall back on estimating the RH from the evaporation velocity. But still the ice on the cell walls ensure that the Rh is close to RH$_i$. We will expand a little on this in the paper.

"(10) Line 18, p. 25749: please explain Coulomb fission."

We shall do that.

(11) Sec. 5, Perspectives: since you really want to apply the conclusions to the case of ice(though you say you are not making any claim yet), it's useful to provide a short discussion here why or why not your conclusions may apply there. Charges on ice lattice may behave differently than that on water and hence the effect may or may not be the same.

It is a good question raised by referee #2. It is hard to access, but we will elaborate a little on it. We can at least say that provided that sphericity is maintained the theory for ice and liquid water are completely identical. Note that the theory is derived solely from gas phase physics. The surface charge cannot have any influence on the bulk phase because the interior electric field is zero. The presence of surface charge could perturb the surface energy, but since the surface effect is completely overruled by the dipole charge interaction we can safely assume that a charge induced perturbation of the surface energy density will still not contribute to the partial pressure of water.

However, the presence of charge will most likely tend to make ice particles less spherical, because features sticking out from the ice surface will hold most electric charge and would therefore be preferred by the water dipoles in a condensation process. Seen from a distance the charged ice particle as a whole will still be subject to an increased water vapor pressure. The only question is how much the geometry will perturb the process. Rather than guessing about that we would prefer to examine it experimentally in future.

On behalf of all authors, Johannes K. Nielsen

References

Khaykin, S., Pommereau, J.-P., Korshunov, L., Yushkov, V., Nielsen, J., Larsen, N., Christensen, T., Garnier, A., Lukyanov, A., and Williams, E.: Hydration of the lower stratosphere by ice crystal geysers over land convective systems, Atmospheric Chemistry and Physics, 9, 2275–2287, 2009.

Nielsen, J. K., Larsen, N., Cairo, F., di Donfrancesco, G., Rosen, J. M., Durry, G., Held, G., and Pommereau, J. P.: Solid particles in the tropical lowest stratosphere, Atmospheric Chemistry & Physics, 7, 685–695, 2007.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 25743, 2010.