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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Liquid-like layers on ice in the environment: bridging the quasi-liquid and brine layer paradigms" *by* M. H. Kuo et al.

J. Thomas

jenniet@atmos.ucla.edu

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I would like to generally express my support for this manuscript, while also noting that it needs some revisions to be published in ACP. This is the type of analysis that is needed to bridge the gap between the experimentalists and modelers involved in the snow chemistry community. It is necessary to have clear, well documented, expressions for the liquid layer thickness for inclusion in snow chemistry models, even if these expressions are currently imperfect. As the knowledge of the surface of ice increases, these expressions can be refined in the literature and snow chemistry models. There is currently no clear consensus on what should be used and this paper would help to provide a starting point for correct representation in models. In general, I encourage the authors to take their analysis further so that it can be published.

The current version of the manuscript needs some modifications, including potentially a change in the title (as noted by the reviewer). However, this would be a welcome addition to the literature to clarify the difference between the liquid like layer present internally within ice (due to thermodynamics) and the liquid like layer present at the surface (due to surface anisotropy).

I have a few specific comments:

The authors should discuss the experimental techniques used to measure the QLL on pure ice and why there is such disagreement in the results. Helping modelers to determine the best measurement for inclusion in snow chemistry models is one of the major values of this paper. Suggesting a reasonable range of error for their equations would also be helpful.

In equation 2, this is expressed in terms of the water mole fraction. The equation would be more useful in my opinion if expressed in terms of the solute mole fraction. As noted above, it would also be helpful to discuss in detail the error associated with using this equation.

Given recent evidence for snow chemistry in regions without a brine layer (for example Summit, Greenland), the authors should discuss the situation for regions with lower total ion loading specifically in the paper.

It would be helpful to discuss how to treat systems including more than one anion (HNO3 and HCl or HNO3 and HBr, for example) as well as how to treat systems without ions (organics).

In models, the liquid layer thickness doesn't have a lot of meaning without also defining geometry. What is the total brine volume associated with this thickness? What exactly does liquid layer thickness mean for brine layers? For the surface of snow grains, the situation is also complicated and a discussion of how to use the liquid layer thickness to calculate a liquid fraction warranted.

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I encourage the authors to discuss the recent work using XPS and NEXAFS to look at the surface of ice. How does this work fit into their model?

It is somewhat confusing for me that the detection limit for the ellipsometry measurements is 80 nm. Many of the values in Figure 4 predict a thickness less than this measurement. Therefore, there is often a QLL present below the detection limit. Can this be clarified in the context of figure 3? A detailed discussion of all of the measurement techniques and what they measure would add significant value to this manuscript.

I would encourage the authors to change the words “surface brine layer” to “brine layer”. There is no reason why this is limited to the surface.

There is another review on this in Physics Today called "Why is ice slippery?" (Rosenberg, 2005). I noticed this is not mentioned. This has a figure very similar to Figure 4 with all of the experimental data summarized. The authors should cite this paper and mention how their analysis adds value to what is already in the literature.

In figure 6, the authors should clarify what is meant by NaCl concentration. Is this the concentration in a melted solution? What is the corresponding concentration in the brine layer and in the surface layer?

In snow chemistry models it’s important to know both the thickness and the chemical composition of the QLL and BL. Demonstrating that the thickness and derived concentrations are reasonable are both essential points that should be made in the revised version.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 8145, 2011.

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