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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Feldspar minerals as efficient deposition ice nuclei" *by* J. D. Yakobi-Hancock et al.

Anonymous Referee #1

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J. D. Yakobi-Hancock, L. A. Ladino, and J. P. D. Abbatt have undertaken a study of ice nucleation by feldspar minerals. Ice nucleation is a topic of contemporary interest given the importance of ice nucleation on cloud formation and therefore as an agent of indirect climate change. Feldspar minerals have recently gained attention in the work of Atkinson et al., published this June in Nature. Atkinson et al., similar to this work but using a different technique, showed a relatively high freezing temperature of ∼-15 deg. C for feldspar minerals.

Here, Yakobi-Hancock et al. perform experiments at somewhat lower temperature (-40 deg. C), thereby moving from Atkinson's more mixed-phase to a cirrus regime. The data are acquired with a different technique than Atkinson et al., a continuous flow diffusion chamber. The data are compared to a cloud seeding agent, lead iodide. A

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correlation of ice nucleation with feldspar is found and this complements the work of Atkinson et al.

The text is rather awkwardly written, there is a poorly supported use of wet-disperse aerosol, and the concluding paragraphs are not adequately supported or referenced. None the less, I think the authors can make the required changes and I recommend this work as both applicable for, and publishable by, ACPD.

Comments:

A major weakness of this manuscript is the lack of clarity on washed versus unwashed samples. This is actually found in three places: (1) Experimental Procedure (Page 5, line 13), : Page 6, line 3, and Section 3.3. Please move this important topic in its entirety to the Experimental section and not interspersed through the text. Specific suggestion : The authors need to comprehensively show what washing does or does not do to the samples. Ideally, Table 1 should include onsets for both wet and dry dispersion. Currently , the authors state (page 15, line 3) "the washing procedure appears to alter their IN efficiencies to some degree. However, it does not alter the general conclusions about whether a particle is a good IN or not." – please explain, quantitatively, what "to some degree" means; leave it to the reader to judge if this does or does not alter the conclusions by presenting comparable data. If the authors are going to use wet dispersion, please prove from the onset that it doesn't alter the sample (as an aside, can the authors explain why wet generation was used at all? The authors here and in recent literature (Ladino and Abbatt, JGR, 2013) seem to indicates this changes surface character. I assume it is for ease of sample aerosolization but please specifically state.) 200nm particles of mineral dust are exceedingly uncommon and often correspond to solution droplets (suggested by the reference above) when using wet dispersion. Can the authors comment if this might be the case here? Page 15, line 26 Two issues with this paragraph. First, the line "Although it is beyond the scope of this paper, it is well known that clay minerals undergo exchange between soluble cations and hydronium ions in solution, which may then affect their surface compo-

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sitions, and hence IN activity." : This is NOT beyond the scope of the paper which should be apparent since the authors discuss it here as relevant. Please eliminate this qualifier. Second, the line "...most particles, especially those that participate in ice formation in the upper troposphere, are thought to pass through regions of water saturation before reaching altitudes at which cirrus clouds forms (Wiacek et al., 2010)." – this line is from a modeling study and appears unsupported by field data. For example, the recent paper from Cziczo et al. Science, 2013 indicates most IN don't appear to have significant surface modification / coating. This also seems to stand in direct opposition to this manuscript, which (per the title) is on deposition nucleation (that is to say, particles without surface water nucleating ice). It only appears to support the use of wet-dispersion which, as mentioned above, likely imparts surface changes. I don't think this justification is well supported and this paragraph should be removed. In conclusion to this point regarding wet-dispersion: this would be a stronger paper if it used dry dispersion, not wet. That would seem the more consistent process for deposition nucleation. The authors at the bare minimum need to clearly describe the difference in dry and wet dispersion and eliminate unclear attempts to justify the latter.

A second major comment regards Sections 3.1, 3.2 : This is titled "IN properties of pure compounds" but actually seems to include considerable information on mineral structure. Suggest separating mineral structure to the previous section (Experimental, perhaps a sub-section on samples) and restrict this section to a discussion of results (which is the stated subject of Section 3). As currently constituted this section incorporates elements of sample description, presentation of results and discussion. The content is good but confusing.

Note also : The wording of this section is rather long (5 full pages of text on pure compounds). The manuscript appears rather lopsided with only 4 figures of data. The text could be shortened quite considerably.

A third major comment regards the awkward final paragraph which seems an attempt to indicate importance of this work: "Another conclusion from this work is that many

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species, such as metal oxides and carbonates, are poor deposition IN. Given that many metal oxides are formed by mining and smelting activities, it seems unlikely that there is an anthropogenic effect on ice nucleation through the release of such species to the atmosphere. On the other hand, if cloud seeding were to proceed under deposition mode conditions, for example in the seeding of cirrus clouds, it appears that feldspar minerals would be a good option; there would be no need to turn to an anthropogenic compound such as lead iodide." First, do smelting and mining only form metal oxides and carbonates? Can references be provided? How much is known about the abundance of metal aerosol in the atmosphere, specifically if the materials here are relevant compositions? Second, the authors should also reference Cziczo et al., 2013 here which discusses metal oxide particles found in cirrus clouds. It seems (as with Atkinson et al.) this work might have helped motivate this study; regardless it should be referenced either here or earlier. Third, the statement regarding relative abundances and activities is unsupported. The authors reference Hoose and Moehler, 2012 in the introduction who describe that relative emission rates and atmospheric lifetimes (ability to act as a CCN or IN) is what sets abundances in the atmosphere. Specifically, the authors should consider that feldspar might be so effective an IN that it is often removed before entering the free troposphere. The laboratory data here don't address this and the lines above should convey this uncertainty (instead of making unsupported statements). Finally, why are there statements on cirrus cloud seeding? Is this a geoengineering proposal? If so please explicitly state this. Has someone proposed use of lead iodide to seed cirrus? If kept please reference suggestions of cirrus cloud seeding and the climate effect. Suggestion: Either remove this paragraph or comprehensively expand it. It appears an awkward collection of unsupported lines that try to increase the importance of this work. If the authors wish to keep any of these concluding statements (1: metal oxide abundance, 2: metal oxides as IN, 3: cirrus cloud seeding) then they need to break these into separate, fully referenced (and much more fully developed) paragraphs.

Editorial note: This manuscript would read more clearly if the authors could restrict (ide-

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ally eliminate) the repeated use of un-quantified qualitative terms. I note the repeated use of “very”, “slightly”, “significant”, “large”, “most efficient”, etc. all used without a quantitation. Please either add quantitation or eliminate.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 17299, 2013.