Atmos. Chem. Phys. Discuss., 15, C516–C520, 2015
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Atmospheric Chemistry and Physics Discussions

Interactive comment on "In-situ single submicron particle composition analysis of ice residuals from mountain-top mixed-phase clouds in Central Europe" *by* S. Schmidt et al.

Anonymous Referee #1

Received and published: 2 March 2015

The authors have provided a detailed account of ice particle residue (IPR), hydrometeor, and aerosol measurements at the Jungfraujoch station during the winter of 2013 using single-particle measurements and a series of different inlets. Results show the differentiation in IPR type dependent on cloud and meteorological conditions, and aerosol source, in comparison to the background aerosol composition. The authors found that IPR were generally enriched in organic material at higher temperatures, and partly internally mixed with black carbon. Minerals and lead were also observed to be dominant in the IPR, but at lower temperatures. Although these results provide another useful reference for ice nucleation measurements in the literature, the manuscript suf-

fers from a few issues discussed below. After these issues are addressed, I believe this manuscript is suitable for publication in ACP.

General concerns:

The new findings are not emphasized or discussed enough. The authors demonstrated that mineral dust serves as ice nuclei (IN), however the finding that OC was found on most of the IPR is interesting and a somewhat novel finding. Could it be that the organic material is biological in origin? This is hinted at in the discussion, but should be emphasized. Could they be organic particles that contributed to riming versus ice nucleation? This could most certainly happen during the residue drying process and should be noted. Discussing these IPR in more detail in addition to focusing on their sources using the HYSPLIT analysis would be beneficial and enable the uniqueness of the results to stand out.

The general region of air mass origin is discussed, however, there seems to be a dearth of discussion on the potential sources of the IPR. What types of possible sources are found in each of the different transport regions, such as in Figs 3 and 6?

The abstract is essentially a list of results. The authors could revise to provide more context as to why their observations and measurements are important on a broader scale. For instance, the abstract could be started with a few sentences on the motivation for the study. The remainder of the sentences are predominantly composed of results, but can the authors provide a few sentences on why these findings are important? What do they mean in general? Closing with a more general statement on their importance would help as well.

Please define acronyms before using them. Once, defined no need to redefine (i.e., JFJ is defined twice. Also, please define the acronym for the field campaign (i.e., CLACE).

Where interstitial aerosols investigated? It has been shown that these types can vary

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quite drastically from ice residues and clear air aerosol. It would be interesting to comment on this if they were indeed measured. If not, please clarify. The contribution of residues from rime droplets to the full ice crystals is not discussed. Surely, some if not most of the ice crystals analyzed have been rimed, which is an efficient process in a mixed-phase cloud system. The authors need to address the contribution of rimed species to the original ice nucleus residue.

Specific comments:

Page 1, line 26: 200-900 nm is referring to IRP after drying, correct? Please confirm in text.

Page 1, line 28: Out of curiosity, how did the clear air temperature compare?

Page 1, line 29: State that "background aerosol" refers to cloud free air aerosol. Were interstitial aerosols measured? Also, reiterate that both composition and size were determined for background aerosol.

Page 2, lines 6-9: Instead of providing ranges for some species and averages for other, be consistent with provide either an average with a standard deviation or range for each type.

Page 2, lines 17-18: Saying aerosols affect solar and thermal radiation is vague. Perhaps use the term radiation budget, or explain these a little more.

Page 2, line 28: It would benefit the authors to explain the Wegener-Bergeron-Findeisen process here, and that the riming of ice crystals from supercooled droplets is what causes enhanced precipitation.

Page 3, line 4: What do the authors mean by important? Technically, biological particles are the most efficient, but dust is the most abundant. Please clarify.

Page 4, line 16: What temperature was the inlet heated at? Wouldn't there be an issue with low molecular weight organics or nitrate/sulfate evaporating from the residues in

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the inlet?

Page 5, line 20: Is this referring to the inlet system of the ALABAMA or the OPC?

Page 5, lines 17-27: The size ranges defined do not correspond to that of the abstract. Why is only 200-900 nm presented? How can 200 nm be achieved if the lens only measures down to 250 nm? What are the two values for transmission efficiency for?

Page 6, line 2: Why are only supercooled droplets >5 um removed?

Page 6, line 4: How do the ice crystals not stick to the surface of the plates? Does the ice from the supercooled droplets freeze fast enough? Is there any loss of ice crystals to the chilled plate?

Page 7, line 17: Rename section to “Additional instruments” or “Supplemental instruments”.

Page 7, line 21: Why was 20 chosen as the threshold, and is this unit correct? Shouldn’t it be something along the lines of g m-3?

Page 7, lines 30 and on: No need to introduce SEM if there are no results discussed in the current manuscript.

Page 8, line 23: What was the percentage of residues that were classified out of all residues measured?

Page 9, lines 22 and on: The BioMinSal type presented here is very similar to the residues observed by Creamean et al. (2013). This is a great finding in that this type has been observed elsewhere. The authors should reference Creamean et al. (2013) and perhaps provide a brief discussion on their similarities.

Creamean, J.M., et al. "Dust and biological aerosols from the Sahara and Asia influence precipitation in the western US." Science 339.6127 (2013): 1572-1578.

Page 10, line 14: Make the title more proactively descriptive, i.e., “Ice particle residue

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composition and potential aerosol sources".

Page 10, lines 22-25: The event classification is somewhat vague. More information is needed to differentiate these events. What were the temperature ranges of each? What was the wind direction? Etc?

Page 11, line 3: So, the ISI measures IN and CCN, correct? This is what I gathered from the methods. How do the authors eliminate contribution from CCN/droplets? This should be clarified.

Page 11, line 18: What were the initialization parameters for HYSPLIT (starting altitude, times initialized, hours back, etc)? These should be provided in the text.

Page 11, lines 18-31: It would be helpful to provide the average temperature or wind direction for the events in Fig 3 (or any figures with pie chart comparisons for that matter).

Page 12, line 8: Were the lead artifacts a large percentage of the particles (provide the percentage)?

Page 12, line 15: Why were these events chosen? A sentence or two describing the reasoning for showing these is warranted.

Page 13, line 19: Clarify that these are referring to background aerosol measurements.

Page 13: More discussion is needed on why the events are so different. Is it due to temperature, wind direction, air mass source, etc.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 4677, 2015.