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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Using spectra characteristics to identify ice nucleating particle populations during winter storms in the Alps" *by* Jessie M. Creamean et al.

Anonymous Referee #2

Received and published: 14 December 2018

Summary:

The results presented by M. Creamean and co-authors give insights into potential sources of INPs at the High Altitude Research Station Jungfraujoch. The study was conducted in winter and investigates freezing spectra of aerosol particles as derived from aerosol, cloud rime, and snow samples. The results from this study give an interesting insight into INP characteristics during this specific time at Jungfraujoch, however, my concerns center mostly around the methods used, which impact the interpretation of the results. After addressing these concerns and better highlighting the limitations of the study, the manuscript will be suitable for publication in ACP.

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Major remarks:

- The results presented by Creamean et al. are based on a limited set of data with respect to sampling time. E.g. none of the southeasterly samples are within the free troposphere. This results in a confusion of air mass characteristics by wind direction versus in-or-out of boundary layer conditions. As such I believe the air masses cannot be distinguished as function of wind direction, which is one of the main findings of the authors. I suggest to better indicate which air mass is transported in the free troposphere and which is impacted by the boundary layer.

- Jungfraujoch is regularly exposed to short-term emissions from touristic activities, as e.g. tobacco smoke, emissions from helicopters and snow cats, as summarized in Bukowiecki et al., 2016. Such local emissions can lead to short-term peak concentrations of aerosol particles. Did you consider such emissions, especially with regard to the 24-hr aerosol sample? If not, this limits the interpretation of the results and should be pointed out.

- Tracing air mass origin with the HYSPLIT model has some limitations in a complex terrain as Jungfraujoch. Another powerful tool to determine source emission sensitivities is FLEXPART, which is specifically improuved for the site (e.g. Pandey Deolal et al., 2014). Given the spatial resolution of HYSPLIT I find it hard to thrust interpretations based on such results alone.

- To my understanding the collection of cloud rime should only result in impaction of liquid water droplets on the collection plate, which freeze upon collision. In case that the cloud temperature is colder than the activation temperature of INPs, such samples should not contain ice-active particles. However, INP concentrations are very high in rime samples, and orders of magnitudes higher than the aerosol sample INP concentration. Please explain why this is the case.

Specific remarks:

Page 1, title: Please specify that you investigate freezing spectra characteristics; readers outside of the INP community might get confused.

Page 1, lines 26 – 28 (and page 8, lines 284 – 285): I believe that with the methods used here, you can not clearly identify biological, dust, or a mixture between the two. To make such connection in field studies would require a proper assessment of the aerosol particle population and/or of the ice residuals with respect to the biological and dust particle concentration.

Page 1, line 30: This statement needs a reference.

Page 1, lines 33 – 34: The statement on the microphysical impact on precipitation formation in mixed-phase clouds needs a reference.

Page 3, lines 86 – 87: Before you defined “warm temperature INPs” as INPs active > -15°C (page 2, line 72). Please be consistent.

Page 3, lines 97 – 98: Given the different temporal and spatial resolutions of your aerosol, cloud rime and snow samples, how can you explain the exchange of INPs into air, cloud, and precipitation? E.g. a 24-hr aerosol sample might not be dominated by the INP population which caused cloud and precipitation formation. Also, clouds might from far away from the site, as well as precipitation particles before reaching the ground.

Page 3, line 111: Please indicate if you refer to volume or mass/standard flow.

Page 4, line 116: What is the collection efficiency of the drums? Is there a size dependency, e.g. an increased loss due to reflection on the stages for larger particles?

Page 5, line 164: You introduce 222Rn as abbreviation for radon, but you do not use it consistently in the text. Or do I miss a major difference between “radon” and “222Rn”?

Page 5, line 177: You do not use the abbreviated “TSP” thereafter, therefore I suggest to not introduce it.

Page 5, line 177: I do not under stand why an increase in the 48-hour total suspended particle concentration is of interest in this study; given the time resolution of your rime and snow sample is on the order of hours, an overlap between a detected SDE (> 4 hours) and your sample might have occurred.

Page 5, lines 168 – 169: In previous studies several approaches have been used to assess boundary layer contact of the air mass arriving at Jungfraujoch. To make the distinction between boundary layer influence and free tropospheric conditions more reliable I suggest to use an additional method, as e.g. described by Herrmann et al., 2015.

Page 6, lines 200 – 201: This is very vague, and not well quantified. A statistical analysis of e.g. mean travel height of the back trajectories for both wind directions would be helpful.

Page 6, line 220: What is the correlation coefficient? Is the relationship statistically significant?

Page 7, line 221: How do you determine upslope winds out of figure 1b?

Page 7, lines 236 – 237: Please add another reference for this quite general statement.

Page 7, line 252 – 257: Figures 6c-h are hard to understand in the way they are visualized. Given that you do not observe any relationship between INP concentration and air temperature/wind speed, I suggest to show these results in in the supplementary material.

Page 9, line 300: I cannot identify the freezing spectra for this case study. Please highlight this in e.g. figure 7.

Page 9, lines 300 – 302: I find it hard to follow your argumentation since you do not know the source region and transport pathway of the cloud.

Page 9, lines 331 – 333: In order to strengthen this finding, you could include meteo-

rological maps indicating frontal systems.

Page 10, lines 354 – 368: This main part of your conclusion is rather open discussion, perspective and recommendation. I do not see relevant conclusions based on the presented results in this section.

Page 18, figure 1: Apparently, the rime and snow collection time was often longer than the actual occurrence of the cloud event, since the grey shading in figure 1a indicated that the cloud events were lasting shorter than the sampling period (figure 1b). If so, please specify in the text.

Page 18, figure 1: The labels of the y-axis should not only contain the units, but also the property (e.g. “relative humidity (%)”)

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