

Manuscript title: Enhancements of the refractory submicron aerosol fraction in the Arctic polar vortex: feature or exception?

Authors: Weigel et al.

This paper has been considerably improved and the authors have taken on board many of the recommendations/suggestions of the reviewers. The addition of sub-headings has made the paper much easier to digest, and the re-worked estimate of the meteoric input is much improved. However, there are still a number of corrections needed, although these are of a relatively minor nature.

Line 43, 76-78 and 807: The paper refers to the recent review by Plane (2012) which suggests that the meteoric input is in the region $10\text{-}100\text{ t d}^{-1}$, so why then state that 110 t d^{-1} is the “expected” value in the abstract and elsewhere? The Love and Brownlee estimate was obtained by assuming a velocity distribution for the particles hitting an impact detector, and the particle masses are very sensitive to the assumed distribution. If the mean velocity is shifted from $18\text{ to }30\text{ km s}^{-1}$, the mass input would drop by an order of magnitude (see work by Janches and Mathews). The abstract should state the input estimated in the present study.

Line 66 and 81: inconsistent size limits for IDPs – which, by the way, are somewhat artificial definitions.

Line 99: the AIDA chamber study described in Saunders et al (2010) did not look at H_2SO_4 uptake.

Line 139: Section 1.2, not 1.3

Line 147: EEPs cover the precipitation of both electrons and protons – so SPEs are a subset of EEPs.

Line 225: EUPLEX has been mentioned in the abstract but not defined in the text before this point. Since the campaigns are defined in Section 3, each mention prior to that point should include a reference to the appropriate subsection of Section 3.

Line 295: add a reference for ERA-Interim

Line 404: this sentence is confusing. The variability of N_{10} particle densities is larger below 440 K than the slight decrease, which is only discernible because the variability is smaller above 440 K .

Line 455: Is it “30-50” or “30-60”?

Line 677: the statement “where the relative isolation of the vortex supports chemical reactions” requires explanation. As it stands, it makes no sense!

Line 684: replace “eminently” with “particularly” or “especially”

Line 728: using the size distributions of stratospheric aerosol does certainly provide an upper limit to the meteoric mass. But surely this upper limit can be reduced by having some idea of the volume of volatile to non-volatile material in the aerosol? Even if this is not known from the measurements, a sentence stating that this is the case would be helpful here.

Line 765: how do you know the VCSA uncertainty is up to 50%, is this just a guess?

Line 979: “entire”

Line 778-779: – Not sure what is meant by this sentence. What does “ranges” mean?

Line 818-823: it is of course the case that the rate of deposition of meteoritic debris at the surface must equal the input at the top of the atmosphere. However, according to the 3D models the amount of material that descends in the polar vortex is not all removed at the end of the winter. Some of it is transported back into the mesosphere by the reverse circulation during the summer, and then descends in the vortex in the opposite hemisphere. This can happen several times, which explains why the average time the material spends in the atmosphere is 4 – 5 years (as referenced in the paper which refers to the study of Dhomse et al. (2013)). Thus, the accumulation at the base of the vortex during one winter, which is used to obtain the meteoric input, is actually an upper limit.

Line 832 – ‘if adjusted for a size range of $d_p > 10$ nm’ is the total mass used here the sum of only the particles > 10 nm in the Bardeen size distribution? Elsewhere in the current paper it is argued that particles would agglomerate on evaporation of liquid droplets, such that particles which Bardeen simulated as smaller than 10 nm would be detected by COPAS. This point needs to be clarified.

Line 837: maximum, not minimum?

Line 841-843: see earlier comment about the size distribution of the refractory material being shifted to significantly smaller size than the stratospheric sulphate aerosol. Confusingly, this is recognised in lines 851-852!

Line 873: should read “consist of, or contain, non-volatile material”

Equation 1: state how the mid-latitude N_2O was chosen at the different theta levels.

Page 10: Figures 2 – 4 are not properly discussed in the text. Some of the panels are not referred to at all.