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***Interactive comment on* “Enhancements of the refractory submicron aerosol fraction in the Arctic polar vortex: feature or exception?” by R. Weigel et al.**

Anonymous Referee #1

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This paper presents a summary of observations of particle concentrations for particles > 10 nm and their non-volatile fraction, N10nv. The essential observation is that the N10nv concentration steadily increases with potential temperature and with decreasing mixing ratios of the tracer N2O. All of this suggests a source region for N10nv from above, with the most likely source subsidence of mesospheric meteoritic material. The authors then use their measurements to infer a global polar influx of meteoritic material into the lower stratosphere and thence, after vortex breakup, into the mid latitudes. Within the range of uncertainties these estimates are consistent with other estimates of global meteoritic influx.

[Full Screen / Esc](#)

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[Interactive Discussion](#)

[Discussion Paper](#)



While the results are interesting and should be published, the authors require the reader to do a lot of work to understand their arguments. The text suffers from awkward phrasing and from ubiquitous multi-line parenthetical comments, which contain important information. The effect of this is to cause the reader to read and then re-read the text as it becomes clear the parenthetical expression is more than a parenthetical expression, but a statement in its own right. I initially tried to ignore this style, since I don't have the time to offer the stylistic corrections required. Finally the style got to me and I offer just a few suggestions of how the text could be clarified and made more concise, two essential ingredients for scientific writing. I hope the authors will take these few suggestions to heart, and use them to critically review the rest of the text with the reader in mind, and not just to insure that they include all the assumptions/caveats of their analysis at every turn.

Finally the authors may be interested in including a reference to, and discussion of, similar measurements made in the Antarctic as presented by Campbell and Deshler, 2014.

Here are my detailed comments organized by line number with the somewhat major suggestions intermixed with the simpler requests. Some of the simpler comments are either suggestions or a restatement of an awkward phrase the authors should correct.

9853.15-21 – What do “those bodies” and “they” refer to? The text suggests particles less than a mm are not heated by friction, now here it seems to suggest they are, and that particles less than 10⁻⁵ kg are fully vaporized. I am confused.

9857.18 ... or from

9865.4-5 ... are compared in Fig. 5 in ... The authors should mention that in many cases the percentile bars do not exceed the data points.

9866.21 The 75th percentile just barely exceeds 75% if you look really closely. This sentence is a stretch and not that important so should be deleted.

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9866.25-9867.2 Very awkward language. Try the following. The contribution of volatile and semi volatile particles is accounted for with the mixing ratio difference given as $N_{10} - N_{10nv}$. Coated non-volatile particles greater than 10 nm will be included in N_{10} , but once their coating is removed they will not be sensed in N_{10nv} . Thus this measurement cannot tell the difference between volatile and partly volatile particles which are near 10 nm.

9868.1-16 This is an odd paragraph. The first sentence provides the obvious general observation most important for this paper that N_{10nv} and f increase with decreasing N_{2O} and thus increasing altitude. Then the discussion starts at the base of the profile, near the tropopause, and works its way up until the first sentence is essentially repeated. Do we need all this intermediate discussion? If so make a choice and start from the bottom and arrive at the top, but don't repeat the point. Also while it may be obvious to the authors that these high values of N_{10nv} near the top indicate downward transport, this has not shown to the reader up to now, and thus is speculation. It should be indicated as such, or proven, or left out here.

9869.3 Do the authors mean above 250 C?

9869.5 Scarce or non-existent? There is a difference. Have such particles ever been chemically analyzed?

9869.22 January of the year 1990 or January 1990? If I remember correctly these measurements by Hofmann et al. were at much higher altitude than the observations here and by Wilson et al.

9871.6 What has a tropospheric origin, the particles or the sink?

9871.26-9872.2 The parenthetical statement is confusing and unnecessary. The last sentence is very awkward.

9870.21 – 9871.9 This section is hard to follow. The justification for the imaginary grey curves is not well explained. There are no data to support the grey lines, and 5

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separate considerations, used to establish the lines, are too many to be fully satisfied or understood by the reader. Plus the conclusions from this section are not necessary for the overall result of the paper. Remove this discussion and the grey lines in Fig. 6.

9875.5 “Particle volume ratios per air mass”. What does ratios mean here? Isn’t the calculation, the particle volume per mass of air, or aerosol volume mixing ratio?

9875.11 The authors should work harder on their English to make it more concise and simpler and thus more easily understandable. For example, “Total particle volumes and total particles masses (under consideration of a range of densities for the particulate material . . .,” could be restated, Total particle volumes and masses for a range of particle densities.

9878.7 Don’t the authors mean, mesospheric air down to levels of 500 K?

9878.11 Here and elsewhere what is meant by “vertical dispersion”? What is causing this? What is the direction of motion and how is it different than the vortex subsidence?

9879.1 Is the air mass really twice as large between 67 and 1 hPa compared to 100 to 67 hPa. This surprises me, although I didn’t do the calculation, which is straight forward, so why do the authors state considering? This sounds like an assumption.

9878.26 – 9879.11 Here is another example of the convoluted, and unnecessarily complicated language used by the authors. I provide my last example of how this could be rewritten so that the reader does not have to read and re-read the whole section to understand it.

Assuming the simulation of Plumb et al., 2002 to be realistic, and the fact that the air mass between 67 and 1 hPa is twice the air mass between 100 and 67 hPa, we estimate that at the end of the Arctic winter about 10–30% of the mesospheric air mass contribution to the whole vortex volume resides in the measurement region below 470 K (see Fig. 6 in Plumb et al., 2002). Assuming that the increase in the observed particle mass between 100 and 67 hPa from mid December to late winter, 32×10^6 kg

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for RECONCILE, can be attributed to fresh mesospheric particles, and that the outflow of these particles at the vortex bottom is negligible, compared to the import from aloft, leads to a mesospheric particle influx over the whole vortex of $107\text{--}320 \times 10^6$ kg for the RECONCILE winter 2009/2010.

The reader can then easily see where the numbers come from and this doesn't have to be spelled out in a parenthetical comment.

9879.12 “ranges at about” but no range is given. Thus, “is about” makes sense, ranges about does not.

9879.13-14. deposited? Do you mean deposited here and elsewhere? Where does the $40e6$ come from? I assume it is $110e3$ per day times a fraction of the year. But why not use $1.1e5$ kg/day and $4e7$ kg? Then it is easy to see that $4e7 = 1.1e5 \times 365$?

9879.19-23 Try. . . This discrepancy is within the range of our estimate . . . the minimum of the uncertainties (cf. . . .ESSenC). In addition the remnants . . .

9879.25 Try . . . Finally parts of the refractory aerosol in the Arctic vortex may originate from sources . . . mesosphere. Thus our . . . provide a highly uncertain upper limit, as our assumption is the observed refractory matter is solely of . . .

9880.8 The authors should be a bit more careful in separating the increases discussed by Wilson et al. near 20 km, and those discussed by Hofmann et al., which are quite a bit higher and the character of the increase is significantly different. The former a steady increase with altitude, while the latter a sudden rapid increase in a layer which then relaxes again. In addition the authors may want to mention the recent work of Campbell and Deshler, 2014.

9880.22 What does the etc. refer to?

Campbell, P., and T. Deshler (2014), Condensation nuclei measurements in the midlatitude (1982–2012) and Antarctic (1986–2010) stratosphere between 20 and 35 km, J. Geophys. Res. Atmos., 119, doi:10.1002/2013JD019710.

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Discussion Paper

C2917

