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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 #2

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This is an important paper for several reasons. First, it provides a much more detailed picture of the descent of mesospheric air containing meteoric smoke particles (MSPs) in the winter polar vortex. Second, it provides a clearer picture of the role of MSPs in polar stratospheric clouds. Third, the measurements can be used to estimate the input rate of cosmic dust into the atmosphere, which is a highly uncertain quantity. I would therefore like to see the paper published, but there are several issues which need to be addressed first.

The first concerns the nature of the flux of interplanetary dust particles (IDPs), and the formation and transport of MSPs. Most of the mass entering the atmosphere is carried

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by particles around 10 microgram in mass (100 micron in radius). The bulk of these particles ablate, producing a vapour of metal atoms. Over several days, this vapour is oxidized and polymerises to form MSPs, initially around 1 nm in radius (these are the particles measured by rocket-borne detectors). IDPs smaller than about 0.1 microgram (20 micron radius) do not ablate, and these particles sediment rapidly into the troposphere (the statement at the top of page 9854 is incorrect). In contrast, MSPs are too small to sediment, and are transported by the residual circulation. These particles descend in the polar vortex over several months, during which time they coagulate to become larger than 10 nm. In fact, it takes about 5 years for these particles to reach the Earth's surface (Dhomse et al., GRL 2013). This is because of the nature of the meridional circulation, which causes the particles to "wash" back and forth between the polar vortices. Eventually, they escape into the lower mid-latitude stratosphere, and then enter the troposphere. These processes have been modelled using 2D (Megner et al., JGR 2008) and 3D (Bardeen et al., JGR 2008; Saunders et al., ACP 2012; Dhomse et al., 2013) models. None of these studies are cited in the present paper, though they are central to interpreting the measurements.

Another point that needs to be made in the paper is that small MSPs can accumulate in sulphate particles (and PSCs) in the lower stratosphere. Thus the technique used here, which drives off the volatiles to leave a refractory residual, measures the sum of MSPs that have accumulated in each stratospheric aerosol, which is therefore not a measure of the size distribution of MSPs entering the lower vortex from the mesosphere.

p. 9870, line 8. Refer to the modelling studies above to give more detail to this statement about the range of particle sizes observed.

p. 9876. Step 3 of this procedure is unclear. What does a "range of mean particle volumes ..." actually mean? Is this as a function of height? It sounds dangerous to take means of volumes because of the non-linearity involved in the volume distribution of a population of aerosols.

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p. 9877. Statement (d) needs some references to the “literature”

p. 9879, lines 12 - 29. This is a critical part of the discussion, yet is very brief. The estimated global input rate is enormous - see the review by Plane (Chem. Soc. Rev. 2012) which shows that the existing range of estimates is 3 - 300 t d⁻¹, whereas the estimate proposed here is 550 - 1700 t d⁻¹ !! If the authors examine the modelling studies above, they will see that MSPs spend a much longer time in the middle atmosphere than the assumption that the measurements here represent a single season's input. There is also a very brief statement about non-cosmic refractory particles contributing - is there something more to say about that?

Minor points

The authors refer to micrometeorites (e.g. line 25 on page 9852) entering the atmosphere. In fact, (micro)meteorites are interplanetary dust particles which survive entry and eventually reach the earth's surface intact. The term used to describe IDPs entering the atmosphere is meteoroids.

p.9857, line 8: N₂O is actually produced in the mesosphere by energetic particle precipitation, so this sentence needs to be rephrased. The mesospheric source is probably minor, so the interpretation in the paper of low-N₂O air coming from the mesosphere should be fine.

p. 9859, line 20: "led", not "lead"

p. 9867, line 26: "monotonically", not "monotonously"

p. 9871, line 10: how were the grey lines in Fig. 6 calculated?

p. 9874, line 22: explain what "vertical dispersion" means.

p. 9876, line 22: "particle's density"

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