Referee report on the paper amt-2020-278

"Investigating the Dust Flux in the Meteoric Smoke Sampler (MESS) Instrument for Sampling Dust in the Mesosphere"
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submitted for publication in AMT

The paper aims at presenting a novel rocket-borne instrument for sampling of Meteoric Smoke Particles (MSP) in mesosphere and justifying its aerodynamic properties. The authors present some results of aerodynamic simulations for neutral gas surrounding the instrument flying at supersonic velocities and for MSP-flow through this environment into the instrument.

The paper is well structured and the results are clearly present. Nevertheless, there are some points which can be addressed in the frame of this study. Therefore, I recommend minor revision.

Herewith I suggest some possible improvements to be considered for the revised version of the manuscript. Since Copernicus publisher will anyway make language corrections, I will ignore typos and some weird formulations.

1. Results of DSMC simulations of the environment (Fig. 1 or 3 & 4) may additionally include flow streamlines to make it more clear for the reader to understand the deflection of MSPs by the surrounding gas flow.

2. The results demonstrated by Fig. 3 & 4 will be easier to understand if colorbars will be on the same scale (one color scale for all these plots).

3. Taking neutral temperature and density from MSISE-90 model as input for simulation is acceptable, however natural variability of these parameters must be taken into account. Thus, for instance, rocket-borne measurements at high northern latitudes [e.g., *Lübken et al.*, 1999; *Strelnikov et al.*, 2013] as well as e.g., lidar measurements in Antarctica [*Lübken et al.*, 2015] show temperature variability of ∼40-50 K at altitudes of interest for the manuscript. Also the neutral density variability as can be seen in Fig. 9 of *Strelnikov et al.* [2013], makes $4{\cdot}10^{20}$ to $7{\cdot}10^{20}\,\mathrm{m}^{-3}$ and approximately $1.5{\cdot}10^{20}$ to $3{\cdot}10^{20}\,\mathrm{m}^{-3}$ at 80 and 85 km altitude, respectively. This variability will contribute to uncertainties of the derived results (which is not addressed in the manuscript).

4. Simulation of MSP flow (Sec. 3.2) must be described in more details. For instance, that you (probably) start particle tracking (solving Eq.1) outside the shock front and stop if some conditions are met. This should further clarify, e.g., what happens to MSPs which do not hit the collecting surface (which I have not understood after reading the entire manuscript). You could also specify the grid used for these calculations, etc.

5. Sec. 3.4 (Mass Estimate) contains two parameters: filling factor α and the collection efficiency σ, which must be explained.

6. MSP trajectories in Fig. 5 & 6 are difficult to see (may be use of different colors can improve).

7. The manuscript makes an impression that only a single run of MSP flow simulation was made. This makes the results not quite reliable. Since these simulations have a probabilistic character, a certain number of trajectories must be calculated to gather an appropriate statistics. Thus, e.g., for assessment of MSP collection efficiency *Asmus et al.* [2017] simulated trajectories for 4000 particles.

8. The same is also true for the fragmentation study shown in Fig. 8; i.e. statistics and uncertainties are not shown.

9. The sentence in P.12 L.180: *"The particles that are stopped will likely remain in the instrument, and could reach the collection area."* need some explanation. Why and how it happens? Why not blown away during payload precession?

10. In Sec. 4.3 (Estimate of collected mass) authors refer to a model study by *Kiliani et al.* [2015] in context of justification for their choice of MSP parameters, which is not appropriate. Please, refer to original measurements.

11. Also, in many places of the manuscript references are missing. E.g., P.7 L.104 (existence of NLC/PMSE conditions), P.9 L.135-136 (for MSP densities), P.11 L.171 (typical MSP size), and similar statements where a certain value (so-called typical) is assigned to some parameter.

12. P.13 L.189 *"traversed volume is..."* units are missing.

13. p.13 L.193 I do not understand the statement *"The secondary particle, or annular sampling area is A_f"* and A_f is not defined.

14. Also in this discussion (Sec. 4.3) uncertainties are not addressed.

15. *"Heating of the particles"* (e.g. P.13, L.191) is often mentioned in the manuscript, but never explained: why and how much (how fast) to expect.

16. P.13 L.209 must be Fig. 10

17. Discussion may address many uncertainties. E.g., angle of attack, which is somehow mentioned in the manuscript, but not quantified. Such values would help to define flight parameters needed for a judgment whether the instrument is suitable for a particular mission. For example, what is the critical angle of attack, what are velocity limits (rocket apogee) for presumably satisfactory MSP collection in the given altitude region. How the results are sensitive to sizes of ice particles? Will any PMSE be enough for a successful MSP sampling or bigger particles (NLC) are needed.

18. The conclusion inferred from simulations and often mentioned in the manuscript, that MSP collection is more efficient at 85 km compared to 80 km is already long time a well known result [e.g., *Horanyi et al.*, 1999; *Hedin et al.*, 2007; *Strelnikova et al.*, 2009; *Asmus et al.*, 2017].

19. Abbreviations MAGIC (instrument) and TEM (grids) in the beginning of the manuscript are not described.

References

Asmus, H., T. Staszak, B. Strelnikov, F.-J. Lübken, M. Friedrich, and M. Rapp, Estimate of size distribution of charged MSPs measured in situ in winter during the WADIS-2 sounding rocket campaign, *Ann. Geophys.*, pp. 979–998, doi:10.5194/angeo-35-979-2017, 2017.

Hedin, J., J. Gumbel, and M. Rapp, On the efficiency of rocket-borne particle detection in the mesosphere, *Atmospheric Chemistry & Physics*, *7*, 3701–3711, doi:10.5194/acpd-7-1183-2007, 2007.

Horanyi, M., J. Gumbel, G. Witt, and S. Robertson, Simulation of rocket-borne particle measurements in the mesosphere, *Geophysical Research Letters - GEOPHYS RES LETT*, *26*, 1537–1540, doi:10.1029/1999GL900298, 1999.

Kiliani, J., G. Baumgarten, F.-J. Lübken, and U. Berger, Impact of particle shape on the morphology of noctilucent clouds, *Atmos. Chem. Phys.,*, *15*, 12,897–12,907, doi:10.5194/acp-15-12897-2015, 2015.

Lübken, F.-J., M. Rapp, J. Siebert, and K. H. Fricke, The thermal and dynamical state of the upper atmosphere during the first flight of the NLTE campaign, in *Proceedings of the* 14^{th} *ESA Symposium on European Rocket and Balloon Programmes and Related Research*, vol. ESA SP–437, edited by B. Kaldeich-Schürmann, pp. 363–368, Potsdam, Germany, 1999.

Lübken, F.-J., J. Höffner, T. P. Viehl, E. Becker, R. Latteck, B. Kaifler, D. Murphy, and R. J. Morris, Winter/summer transition in the Antarctic polar mesopause region, *J. Geophys. Res.*, *120*, 12, 394–12,409, doi: 10.1002/2015JD023928, 2015.

Strelnikov, B., M. Rapp, and F.-J. Lübken, In-situ density measurements in the mesosphere/lower thermosphere region with the TOTAL and CONE instruments, in *An Introduction to Space Instrumentation*, pp. 1–11, TERRAPUB, doi:10.5047/aisi.001, 2013.

Strelnikova, I., et al., Measurements of meteor smoke particles during the ECOMA-2006 campaign: 2. Results, *Journal of Atmospheric and Solar-Terrestrial Physics*, *71*(3-4), 486–496, 2009.