Dr. Keisuke Hosokawa
Editor
Annales Geophysicae

Dear Dr. Hosokawa:

Please find attached a revised version of our manuscript, “Effect of neutral winds on the creation of non-specular meteor trail echoes”, which we are submitting for your consideration for publication in Annales Geophysicae. The text (in blue) has been added to the revised manuscript. The line number indicated in the responses below is with respect to the marked-up version of the revised manuscript using track changes generate using *latexdiff* in LaTeX.

Our revision to address the issue raised by the reviewer is listed below. We hope these responses are useful in your final evaluation.

Thank you for considering our manuscript.

Sincerely,
Julio Urbina

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

---> lines 187-189 and Figure 8: Is it possible to derive the neutral wind from the non-specular meteor echoes by using the method proposed by Oppenheim et al. (2009) and thus demonstrate the neutral wind shear? By using the meteor head echo, the meteoroid properties (e.g., mass, velocity) could also be derived. This provides a good chance to verify the simulation results

---> Response: This is an excellent observation. That would be the next step. It isn’t a trivial problem since neutral winds estimates proposed in Oppenheim et al. (2009) need to be validated with other techniques first. We indicated that that is our intention in lines 211-212 of the manuscript.

This reviewer is not satisfied with the authors' response to the above comment. It is not difficult to verify the simulation results based on the cases shown in Figure 8 through a further analysis. Experimental evidence is needed for the simulation results of effects of meteoroid mass and neutral winds on the creation of non-specular meteor trail echoes. This reviewer cannot recommend the paper for publication in its present form.

Response:

The comments of this reviewer seem to ignore the main message of the manuscript and bring a criticism to our manuscript as if the subject matter of the paper were the full verification of computer simulations against a specific example given in Figure 8. The full analysis of Figure 8 is in itself another full research paper. These are the reasons why we think this is the case:

1) The reviewer criticizes us for not using the proposed method in Oppenheim et al. (2009) to validate the results shown in Figure 8. The reviewer claims that it is not difficult to verify the simulation results. That criticism is very unfair, very puzzling and out of place since Figure 8 was not the main focus of this manuscript. Clearly, the method described in Oppenheim et al. (2009) to estimate neutral wind values from non-specular reflections is not applicable for the event we observed in Figure 8 since the Oppenheim et al. (2009)'s approach was developed for very short uncoded pulses of 1μs and an inter-pulse period spanning 60 km (See Oppenheim et al. (2009), Section 2). However, the radar observations shown in Figure 8 were collected using 13-baud Barker code of 1μs baud length (Section 2, Chau et al. (2007), Section 2). This very clear distinction seems to have been missed by the reviewer.
2) In radar remote sensing research, coded pulses are used to improve the range resolution without losing the maximum average power of the transmitter. In most radar observations, when the targets are assumed quasi-stationary, the decoding procedure is performed by correlating the radar echoes with an identical replica of the code used for transmission (e.g. Farley, 1985a). In the case of meteor-head echo observations, the large Doppler shift does not allow the use of a simple correlation with the transmitter pulse shape (e.g., Wannberg et al., 1996).
3) In Oppenheim et al. (2009), Section 2, first paragraph, third sentence, the authors acknowledge that "*These experiments were unusual in that we used only a short uncoded pulse of 1 microsecond and an inter-pulse period spanning 60 km."*
4) In addition, the method in Oppenheim et al. (2009) has limited applications and would not work for meteor trails that last less than 3 seconds such as the event shown in Figure 8 of our manuscript. This limitation is stated in Section 3 of Oppenheim et al. (2009), second paragraph: "*While Figure 3 shows a clear overall slope, enabling us to make an accurate determination of the horizontal wind speed, the signal includes substantial deviations from this trend (eg., see the phases changes at 6s). These deviations make it challenging to obtain wind data from meteor trails lasting less than 3 seconds. A close inspection of these deviations shows that they result from coherent phase changes which include as many as a dozen radar pulses. If this resulted from actual motions of the meteor, it would imply that the meteor moves over a km in about 25 ms, a velocity exceeding 50 km/s, clearly an unphysical result*."
5) Another important limitation in Oppenheim et al. (2009), is indicated in Section 2.2, second paragraph, third sentence: "*Between 94 and 103 km all the*

meteors give similar velocities at a given height. Above this height, the '07 data shows a considerably larger range of wind speeds. The '07 zonal wind data between 103.5 and 105 km altitude derives from only one meteor and ranges between -80 m/s and +40 m/s, and shows an implausible amount of variability. Above that altitude, between 105 and 109 km, we have 2 meteors which have roughly the same mean of 35 m/s, but one meteor shows quite a lot of shear while the other indicates a relatively constant wind profile. Further experimentation and refinement of the data analysis technique should enable us to improve this…"

6) In Li et al.(2012), the authors demonstrate experimentally the limitations of the method reported in Oppenheim et al. (2009) to estimate neutral winds. Li et al. (2012) showed that the comparison of the mean meridional neutral wind using Oppenheim et al. (2009)'s method (utilization of non-specular trails) and specular meteor wind generally shows good agreement below 96 km but above 96 km this is not the case. The events we showed in Figure 8 of our manuscript occurred above 96 km. We have added this reference in the manuscript as indicated in item (9), below.

7) Our paper mainly concerns simulations of the effect of neutral winds on the creation of non-specular meteor trail echoes, with research methodologies that are comparable to those reported in: i) Dyrud et al.(2002) L. P., Oppenheim, and ii) Hinrichs et al. (2009), to name a couple. More important, we believe the research reported in our manuscript will motivate new discussion on the physics of meteors in topics such as fragmentation, sputtering, etc. Due to the nature of our fast simulations, it is possible to construct much needed global studies of the meteor impact on the Earth's Upper Atmosphere.
8) In trying to address the concern raised by this reviewer, we carefully reviewed our radar observations and concluded that it is no possible to use the method reported in Oppenheim et al. (2009) by reasons stated above but also because this method needs to be verified independently with both the Jicamarca High-Power Large Aperture radar and an all-sky meteor radar. In addition, the Oppenheim et al. (2009)'s method needs to be examined carefully when the occurrence of multiple head-echoes and non-specular echoes occur simultaneously, etc. This effort in itself is a big research project that is outside the scope of our manuscript.
9) We have included the following statement near lines 210-212 to capture briefly the reasons stated above: Since the events shown in Figure 8 last less than 3 seconds and therefore the method described in Oppenheim et al., (2009) to estimate neutral winds would not work, we expect to carry out both uncoded and coded radar experiments using Jicamarca High-Power Large Aperture radar and an all-sky meteor radar, to compute neutral wind amplitudes using meteor trails similar to the approach described in (Oppenheim et al., 2009, 2014) and in Li et al. (2012)to establish a complete understanding and characterization of non-specular echoes.

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