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Comment on egusphere-2022-203

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Referee comment on "Meteor radar vertical wind observation biases and mathematical debiasing strategies including the 3DVAR+DIV algorithm" by Gunter Stober et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-203-RC2, 2022

This paper brings a thorough insight into the Meteor Radar vertical wind measurements and provides mathematical justification for the general assumption of zero vertical wind velocity in classical horizontal wind analysis. The intrinsic bias in the meteor radar system is analyzed in detail. The two debiasing algorithms presented in this paper show a significant improvement compared to the least-squares method. The 3DVAR+DIV algorithm can produce horizontal divergence and relative vorticity to identify coherent structures, which has good research potential.

The only problem is that the correctness of the vertical velocity retrieved by the algorithm can't be verified in an accurate and straightforward way. This is a difficult challenge for almost every observing method. Nevertheless, the author has tried several ways to indirectly prove the improvement in vertical velocity measurements. Moreover, some clarifications of equations and figures are not that clear in this paper. To avoid confusion and make the paper eminently readable, the author shall improve it in the revised version.

Overall, this paper will be good for publication after some minor or moderate revisions.

Major Comments:

- In Figure 1, large vertical velocities up to 10 m/s are obtained using the synthetic data with zero vertical wind. Thus, the author concludes that only sampling biases might explain it, considering that exact radial velocities and interferometric locations are well

determined. Before drawing a conclusion, is it possible to take a detailed look at those extreme values in vertical wind velocity histograms? Because velocities up 10 m/s is far away from the zero vertical velocity setting. So checking these cases one by one might help you to rule out some other assumptions and provide more proof of your conclusion.

- The huge difference in the zonal wind between monostatic MR and passive receiver is worth noting. Based on the geographic map, three stations have similar longitude, but there exists a 1°latitude difference between each station. Will it possibly account for the less affected meridional winds and discrepancy in zonal winds? What's more, the comparison of the radiant map is not that clear. Because the source radiant is small compared to the relatively large map.

- The usage of the Spatio-temporal Laplace filter is pretty good in debiasing the measurement of vertical winds. Histograms of vertical wind velocities in Figure 5 and Figure 6 show a huge improvement compared to the standard least-squares method. Zero vertical wind synthetic data are used to prove that the new algorithm effectively mitigates the overestimation of the least-squares method. But I have a question about whether the newly debiasing algorithm is able to solve larger vertical wind velocity if the synthetic data is set with relatively large vertical wind velocity.

In Figure 6, a comparison of histograms of model results and retrieval algorithm might only illustrate that the distribution of vertical winds has similar statistical moments. Considering the comparison of individual observations is not feasible as the author has mentioned. If larger vertical wind velocity can be solved, it will provide much confidence in the correctness of this algorithm.

Minor Comments:

Lines 59-61: Try to rephrase the sentence to avoid double ‘which’.

Line 80: In the title of Table 1, MRs of Nordic Meteor Radar Cluster better be remarked in parentheses.

Line 91: define any acronym before the first usage. The NORDIC is already used in the abstract.

Similar errors can also be found on Line 109, World Geodetic System (WGS84)

Line 97: ‘minimize the residuals of the projection’ is better?

Line 97: is it better to change ’radial wind’ to ‘radial velocity?

Similar expression can be found on line 135, etc.

Line 100: off-zenith angle is not often used, may be try zenith angle directly. This should define the same angle, although they seem different.

Line 142: physically

Similar errors can be found through the paper, such as mathematical and physical consistent. Please correct them in the revised paper.

Line 174: change to ‘monostatic meteor radar’ for the direct meaning and unified expression.

Figure 4: the missing of degree symbol on the declination axis label

Lines 244-245: Figure 5 also includes the results using TDF data. You should add it to the sentence.

Lines 314-315: ‘a vertical dimension of approximately 20-40 km’ ? I suppose the original meaning should be the horizontal dimension, i.e. the area of a grid cell.

Figure 7: typos: change ’merid measurement response’ to ‘meridional measurement response’

Second, zonal and meridional wind field are plotted separately in two panels, but with same 2D wind vectors. It's kind of confusing at first look. Why don't use the pattern of Figure 4 in (Stober,2021a), since no specific points are mentioned concerning the difference between zonal and meridional results.

Figure 9: the left column represents vertical and the right column represents vertical (div), but no explanations are given for the exact meaning. Though I notice it is mentioned after Figure 10 on line 363.

Line 394-395: try to rephrase the sentence. For example, the distribution of vertical velocities inferred by the meteor radar and the UA-ICON model

Line 395-397: The meaning of this sentence is not that clear to me. Since the debiasing algorithm has been applied to the data to obtain a more statistically accurate vertical velocity, it's not that appropriate to say your results are 'residual bias vertical velocity'. After all, we can't solve the vertical velocity 100 percent right.

Line 447: change 'associated due to' to 'associated with'

Lines 495-496: Based on the assumption that the scattering center will change along the meteor trail, you have mentioned that forward scatter systems are more prone to this effect compared to monostatic systems. So why only monostatic meteor radars are faced with the additional challenge?

Line 504: do you mean sigma, i.e. the standard deviation? sigma squared is the variance.