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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieving horizontally resolved wind fields using multi-static meteor radar observations" *by* Gunter Stober et al.

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The authors thank the reviewer for this suggestions and comments about the paper. We followed the suggestions and modified or added the requested information. The changes are labelled in the revised version. Some paragraphs are expanded, as this was suggested by the second reviewer. We attached a pdf with all the changes that we included in manuscript generated by difflatex.

Comment: page 5, line 11: Is an observed meteor assigned to a grid point or a grid cell? I assume the latter, such that it is assigned to multiple grid points, using the weighting mentioned in equation (1)? Pls clarify.

Reply: Correct. The term grid cell is more adequate to describe the procedure. We

changed it throughout the manuscript.

Comment: page 5 line 12: What do you mean by '1 hour window shifted by 30 minutes'?

Reply: We rephrased this passage. Usually the data is analyzed using some oversampling. That means a 30 minutes temporal resolution is achieved with an one hour window. We now changed this by introducing the Gaussian weights as equation. The vertical resolution is truncated plus/ minus 1.5 km above the reference altitude.

Comment: page 5, line 13: 'vertical averaging kernel' (avk) is commonly used as a diagnostic quantity in 1-dim constrained retrieval schemes. It cannot be 'used'. Is the regularization chosen in such a way that the avk has a halfwidth of 3 km? Or does this refer to the grid cell spacing in the vertical? Pls clarify. I also like to see an avk plot for a few typical cases

Reply: Thanks for pointing at the not optimal explanation. We use a Gaussian weight within a certain time and altitude bin. It is not the same as the averaging kernel in retrievals. The weights are estimated depending on the total shear, thus, are not constant. This Gaussian weighting seems to be usable to account for the randomness in the temporal and spatial sampling and add to the total error balance.

Comment: page 5, line 20: Pls justify the choice of p (=0.2). Why not 1?

Reply: We added a sentence explaining our reasoning behind the value of 0.2. There was not yet a deeper investigation whether this can be further optimized. As we measure the distance in m, a value of p=1, would lead to a vanishing impact of measurements at the edge of each cell. So the value of 0.2 ensures that even the meteors are between two grid cells have still a reduced but non-negligible impact.

Comment: page 6, equation 6: It is difficult to understand the logic behind this representation. Pls specify L in another way and explain the logic behind. Is the regularization the same for all grid points?

Reply: Indeed, is the representation of the smoothness matrix not easy. We added a scheme explaining the ratio behind our smoothness matrix. The L matrix contains entries for each wind component. Basically it is a diagonal matrix with filled side diagonals for each component. At the edges the matrix looks different, as the number or neighbor grid cell decreases. The matrix is set up as a new set of linear equations minimizing the difference between the selected grid cells for each component.

Comment: page 7, line 3: How is this considered within the inversion algorithm in detail?

Reply: We added a short sentence how the mesoscale constrain enters the retrieval. We set up a matrix with diagonal elements pre-describing a solution for this grid cell weighted by the regularization strength.

Comment: page 7, line 4: Did you consider to adapt the regularization matrix in such a way that the regularization is much stronger (and more extended in space or time) for those cells, which do not coincide with a meteor trail? This is a common technique in other applications using inverse modeling.

Reply: We thank the reviewer for this suggestion. Indeed, we did conduct some very basic tests with 'local' or 'regional' varying regularization strengths, but did not yet integrate them in the analysis. As we are going to increase the number of system with time and thus domain area such regional dependent regularization strengths seem to be useful.

Comment: page 7, line 13: How is the variance (of a single measurement?) defined? Or is it the variance of all measurements within a grid cell? It is common that sigma_i considers other sources of uncertainty as well, in addition to pure statistical measures. Please specify it in more detail.

Reply: We rephrased this part to avoid misunderstandings. We use two types of retrievals- on is now called full wind retrieval were each meteor is used with statistical

uncertainties in the radial velocity, angles, and wind components. The other retrieval is called 'packed' wind retrieva. In this case we compute a total wind velocity variance for each grid cell as weight. The errors due to angles and the wind components are treated the same way. Thus, the sigma_i is always a total error budget considering many different sources of errors.

Comment: page 7, line 21: How is the measurement space weighting factor sigma_i considered in the inversion formalism, if it depends on the position of the measurement and the position of the unknown(s)? What is a 'sufficient' number of unknowns?

Reply: The spatial weighting is just one quantity of many in the total error budget for each grid cell. In the packed wind retrieval at least 2 meteors are required. The full wind retrieval just requires one meteor per grid cell.

Comment: page 9, line 4. I suggest to explain 'virtual radar location' in the text instead of in the figure caption.

Reply: The term virtual radar location is explained in the text (page 10 line 09-20).

Comment: page 11, line 4: Please be more quantitative here. Do you need more stations in the given volume/ area? What would be the gain in spatial resolution, if, e.g., the number of stations would be doubled?

Reply: As suggested by the reviewer, we included some explicit numbers of how the meteor counts would affect the analysis. At present an increase would mainly be used to increase the temporal resolution. We aim to achieve 10-15 minutes as soon as our new planned stations are going to become available. An increase of the spatial resolution requires maybe a factor 4-8 more meteor counts.

Comment: page 19, Fig. 5: A difference plot for the two final iterations would be good to assess the differences of the two approaches.

Reply: We introduced two names for the different weighting approaches and compare them as sequence as well as with a scatter density plot.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2018-93/amt-2018-93-AC1-supplement.pdf

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