Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-258-AC2, 2018

Atmospheric Measurement Techniques Discussions
Open Access

Interactive comment on "Enhancing the spatio-temporal features of polar mesosphere summer echoes using coherent MIMO and radar imaging at MAARSY" *by* Juan Miguel Urco et al.

Juan Miguel Urco et al.

miguelcordero191@gmail.com

Received and published: 30 November 2018

We thank the referee for his valuable and positive comments and suggestions. We think they will help to improve the quality and understanding of this paper. Here we would like to comment on some of the concerns.

1) The results clearly show intensity variations in the PMSE layers corresponding to wavelike activity, which are plausibly linked to generation by the Kelvin-Helmholtz Instability and display wind-related dynamics. This dynamics is, however, somewhat puzzling, because in one example the waves seem to drift with the background wind, while in a second case they do not.

Printer-friendly version

Discussion paper

R: As a first approximation, we attribute the first event to a KHI event (drifting with the wind) and the second event to a propagating gravity wave event (not drifting with the wind). Further investigation of this data is needed to explain the physical mechanisms behind these two events. This explanation is not included in this paper, however, we are planning to explore this data with more detail in the near future.

2) I found the discussion about the relationship between the phase front orientation, the drifting of the wave field and the strength and direction of the background wind somewhat confusing, because I was unsure exactly how to interpret Figure 7. The text seems to indicate that the "arrow slope" indicates the magnitude of the wind velocity, when this is normally the arrow length. Hence I am unsure how to interpret the arrow length and direction in terms of vector velocity.

R: We will modify the text accordingly to make this statement clearer. The main reason why we didn't use the standard convention ("arrow length") is that the plot axis is "Time" vs "Distance". Usually, the arrow length convention is used in plots "Distance" vs "Distance", where the arrow length indicates how much a point displaced in each direction for a certain time. In Figure 7,b the Y-axis is distance (East-West) and the X-axis is time so the velocity is equal to delta(y) divided by delta(x), the arrow slope. For example, analyzing Fig 7(b) the arrow indicates that a point displaced approx. -9km in the Y direction and 5min in the X direction, it means the velocity is equal to -9km/5min = -30m/s. We will add a table with the wind values to avoid miss-interpretation.

3) For example in event 1, the wind is apparently northward, but in Figure 7(b) the zonal wind vectors also appear substantial (at least the arrows are long in Fig 7b, which shows the zonal component). Also, in Figures 7(b) and 7(c), there appears to be wave front structure in both the meridional and zonal directions, whereas one might expect a KHI wave field driven by a meridional wind to have zonally-oriented phase fronts. I think this figure needs a clearer explanation to make it more intuitive to the reader.

R: We will explain better these results in the revised version. In the KHI event for example, indeed the displacement of the structures and the wind coincide, in the zonal component, since there is a wave structure (a finite wavelength). In the case of the meridional component, the structure elongated almost across the field of view, without noticeable smaller scales. Therefore, the expected meridional drifting of the structures is not clearly observed within our field of view.

4) Nonetheless the results are clearly very interesting and seem to offer significant potential for a more physics-based study. The MIMO technique combined with Maximum Entropy imaging clearly shows smaller structures than the SIMO techniques, or even MIMO plus Capon (such small structure are notable in Figures 3d, 8c, and 9c), the authors should perhaps say something about their persistence and statistical significance.

R: We are showing a conservative version of our results by using a relatively large SNR threshold, therefore increasing the statistical significance of our results. The persistence of our results can be clearly observed in the animations attached to the paper, where structures are persistent in time and space modulated by the governing background dynamics. As in any ill-posed inverse problem, the algorithm used works under certain conditions or assumptions. In the case of Capon, the performance will get worse as the number of targets increase. It is already known that in a full-filled scenario the errors and artifacts using Capon are high. On the other hand, when MaxEnt is used the errors and artifacts are low if the image is uniform, even if it is full-filled. As long as the image is more uneven the errors and artifacts will increase. The only way to avoid this problem is having more measurements than unknowns. In the future, we are planning to use Compressed Sensing (CS). The idea of CS is to find a domain ("sparse domain") where the number of unknowns (non-zero values) is less than the number of measurements. The key point here is to find the most suitable Sparse Domain or Dictionary for our data. Previous works have used a Wavelet domain as a dictionary having similar results than MaxEnt. We want to find a Wavelet-like domain optimized for our atmospheric images to improve the results. We will add a comment on this in the discussion.

5) The text implies that some of them may be meteor echoes, but this point is not discussed in detail.

R: Meteor echoes could indeed be observed in the PMSE region, but the great majority of them occur outside this window. When a meteor echo occurs in the PMSE altitude region, which is seldom, they will be short-lived (less than a few 100 milliseconds). Their effect can be easily removed. In previous studies without imaging they were removed just from their time occurrence, now with imaging, we can exclude them from both time and angular occurrence.

6) As a reviewer who is not familiar with the precise details of the implementation, but knows about image reconstruction algorithms in general, I have a feeling that something more might be said about the kinds of artifacts that might occur in these images and the ways that they have been excluded in the processing. Some imaging artifacts have already been identified in Figure 2, for example.

R: Thanks for the good suggestion. We will add some text about the technique and the possible artifacts in the final version, as we mentioned above, we are considering a conservative approach by using a relatively large SNR threshold. As a general comment, we can see two main issues in the imaging problem (1) Point Spread Function-(PSF) and (2) image smearing. In the case of PSF, ideally one would like to have a delta function, but in practice, a PSF will have sidelobes, that could create angular artifacts. With MIMO we are improving the PSF by reducing the sidelobes and making the mainlobe narrower. Image smearing has not been included in this work and it will be analyzed in a future work, but it is basically due to the drifting of the structures as they are being imaged.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-258, 2018.