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Atmospheric Measurement Techniques Discussions

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.

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This is an interesting paper which shows convincingly how the effective resolution of radar targets with large backscatter cross-section, such as PMSE layers, can be significantly improved by modularising the radar aperture and using MIMO (multi-input, multi-output techniques) combined with high-resolution image processing strategies, such as Capon and Maximum Entropy. The resulting improvements in image resolution are quite striking, even for a relatively small modular radar aperture such as MAARSY, and clearly open up the possibility of understanding the structure and dynamics of PMSE layers at higher temporal and spatial resolution, with the potential to

add to the current understanding of the physics of these layers. The techniques themselves are well described and in the case of the image processing strategies, have been extensively documented in previous literature. The implementation is seemingly based on earlier experiments at Jicamarca, which have attracted quite a lot of interest in the community.

The results clearly show intensity variations in the PMSE layers corresponding to wave-like 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. 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. 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. 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. The text implies that some of them may be meteor echoes, but this point is not discussed in detail. 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 artefacts that might occur in these images and the ways that they have been excluded in the processing. Some imaging artefacts have already been identified in Figure 2, for example.

Despite these minor concerns, the paper makes it very clear that the improved resolution offered by MIMO and Maximum Entropy can give real advantages and insights, though these come at the cost of processing speed, so that this technique is not suited to real-time applications. Some pragmatic suggestions are presented, which might point the way toward a strategy for identifying intervals suitable for full image processing, based on more computationally efficient strategies. Additionally the discussion of potential tracking algorithms is interesting and is something that would be worth exploring in future studies.

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