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Interactive comment on "Horizontal electric fields from flow of auroral $O^+(^2P)$ ions at sub-second resolution" *by* Sam Tuttle et al.

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We thank the referee for the very positive and helpful review. Our responses to the comments are below.

General comments

This work continues the efforts in the community of understanding the link between dynamic auroral features and the electric fields in the ionosphere connected to the electrodynamics of ionosphere-magnetosphere system. The work combines new techniques with existing techniques to come up with a new method of estimating ionospheric horizontal electric fields at high temporal resolution, associated with dynamic auroral features. The electric fields are inferred from plasma flow velocity which is

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Discussion paper

got through a combination of ground based optical observations (ASK) at high spatial (100m) and temporal (0.05s), and modelling. Usually, these high temporal variations of the electric field (plasma flow velocities) associated with the dynamic auroral features are a challenge to capture. This paper precisely presents steps to derive the plasma velocities incorporating cross validation with observations at different stages. In addition to the high resolution, by use of optical emissions observations at three wavelengths, it is possible to separate the brightening due motions of the source are from motion of the plasma. This has been a challenge in earlier work. Throughout the work presented, different steps have been taken to minimize the uncertainties, one of which is the correction of the position of the magnetic zenith.

Generally, the proof of concept has been precisely presented and supported by the large degree of agreement with observations for the case study used. Possible suggestions for improvement of method are also well presented. The work presented in this article is well written and important to the community. I have a few suggestions and comments.

Specific comments

For the title, may be add the word ‘temporal’ before ‘resolution’

– This has been added

In lines 350-352 and 406-407 and Figure 8, It is stated that the superDARN velocity is representative of the background velocity based on the close agreement in magnitude and direction with average for period before and after brightness enhancement (i.e., outside shaded period on color bar in figure 8). However, this is true for direction but not clear for magnitude. Suggestion: Add an extra line in figure 8 or separate figure with just the black dashed line and a line showing the average for the period before and after the brightness enhancement (period outside the shaded period on color bar of figure 8). The close agreement with the background flow will be clearer to see.

– Thankyou for pointing out the need for a clearer emphasis of this comparison. On considering the various options, we decided that drawing one average value from the optical method to compare with one average from SuperDARN would involve several assumptions and approximations (as commented in the Discussion at lines 353-). Since the general comparison is valid within the constraints mentioned, we have added the actual numbers to be compared in the Discussion (line 360) as follows:

The optically derived velocities vary between 0.4 and 1.2 km s-1 in the few seconds either side of the arc brightening, compared with the average value of 0.6 km s-1 from SuperDARN.

Technical corrections

Line 2: Replace the word ‘beside’ with another word like ‘associated with’

–To keep the notion of the proximity of the measured electric field to the arc we have written ‘in the region close to (km scale)’. Note that Ref 2 required clarification of ‘close’ at start of introduction, which we prefer to change to ‘in the region surrounding’ as the distances there refer to various scales (as in other work).

Line 30: Missing reference – Latex error fixed

Figure 1: Add a vertical axis label for panels d-f – The label ‘pixels’ has been added to all panels.

Figure 9: Mention what numbers 1-4 mark in the figure caption. – Added to caption: The vectors labelled 1–4 are those closest to ASK as listed in Table 1.

Figure 10: Mention that the orange circle marks the ASK field of view – The caption has been changed to include the information that the orange circle marks the position of ASK (note: not the size of the field of view).

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