Ann. Geophys. Discuss.,
https://doi.org/10.5194/angeo-2020-11-AC2, 2020
© Author(s) 2020. This work is distributed under
the Creative Commons Attribution 4.0 License.

Annales Geophysicae Discussions

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

**Sam Tuttle et al.**

b.s.lanchester@soton.ac.uk

Received and published: 27 May 2020

We thank the referee for the very positive and helpful review. Our response to comments are below, preceded with –.

Summary: In this article a method for estimating plasma drift around active aurora is presented using multispectral imaging and modelling. This builds on previous work on inferring electric fields in the ionosphere using imaging of the aurora. Two significant advances are made here. One is presenting several important considerations and improvements–such as being able to actually do this during the brightening of the arc which is critical. The other is the thoughtful charting of the necessary future steps. The current steps are clearly explained, including possible errors and future improvements



and the conclusions are consistent with the analysis. Moreover, it is easy to understand why the high spatial and temporal resolution is paramount in understanding auroral arc formation and why we are still not there. This work makes an essential contribution to that path and should be published with the most minor of adjustments.

$_I t is important to include is a statement explaining the motivation to invest in this method. It is hint$

– Given the importance of this point we have added the following sentences within the text.

In Abstract: They exhibit order-of-magnitude changes on temporal and spatial scales of seconds and kilometres which are not easy to measure; knowing their true magnitude and temporal variability is important for a theoretical understanding of auroral processes.

In Conclusions: Such high temporal resolution estimates of electric fields are a fundamental building block for the theory of auroral currents.

Also we have added to the Introduction (now line 49) the following sentence: These results demonstrated the need for a new method to estimate electric fields, and were key to the development of the method that is described here using high temporal resolution optical measurements.

The following sentence is already at the end of the Introduction (now line 64): The instrument used is the Auroral Structure and Kinetics (ASK) instrument, which was designed for the purpose of measuring plasma flows in a small 3.1×3.1 field of view around the magnetic zenith.

Very Minor:

line 19: Please quantify or qualify "close".

– 'of km scale' has been included in the abstract (responding to Ref 1) and the wording changed here to 'in the region surrounding' as this paragraph discusses several

different scales used by other methods.

line 30: Missing reference. Perhaps Clayton'18? – Latex error fixed.

line 109: Year missing from last reference. – Latex error fixed.

line 65: Please add a short explanation as to why that was not possible in order to make a better connection to your next point.

– Additional words (now line 69) are: They inferred electric fields of a few tens of $mV\,m^{-1}$ as an auroral event subsided. However, this method is limited by the fact that tracking is not possible during the main brightening because the motions of the source and the plasma cannot be separated without solving the continuity equation for the ions. The present method, referred to as the "flow model", overcomes the limitations of the above study through the following steps.

line 66: It would be good to add the specifics of the emissions as relevant in at least (1), (4), (5) for easier reference, particularly for the un-initiated.

– Emissions have been added in each case.

line 148: Please check for consistency against lines 90, 102, 103. Maybe further clarification is needed in one or all of those places.

– We have added to the words at line 97 (original line 90) to make clear that the brightness of the N2 emission does not vary with energy. The 777.4 nm emission results from both high and low energies through different processes, and with different sensitivities to energy, which is written at line108, and consistent with line 155 as follows:.

155 (148 original) ..the 673.0 nm (N2) and 777.4 nm (O) images, which measure the presence of high energy precipitation,

97 (90 original)...and their brightness exhibits little dependence on the energy of the precipitating electrons.



108 (102 original) ...the excitative process to be more sensitive to low energy precipitation and the dissociative process to be more sensitive to high energy (> 1 keV) precipitation. This energy dependence results in emission from all precipitation energies, but it is more responsive to low energy precipitation than the 673.0 nm emission.

line 150: Are these not W-E keograms? Is there another reason why they are called stack plots and the term keogram is not avoided (is it because we usually see N-S and E-W)? Either way is fine of course.

– Yes they are W-E keograms so have added for clarity.

line 214: Extra parentheses and some step missing?

– Thankyou for noticing two stray brackets

line 278: Should this have been referenced in line 126?

– No, this reference is not relevant to height integrating the emission profiles in the 1D model, which is a much simpler procedure.

---

Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2020-11, 2020.