High spatio-temporal resolution measurements of Joule heating using SuperDARN and the SCANDI Fabry-Perot interferometer

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1. Introduction

- Joule heating is controlled by the frictional interactions of charge carriers (plasma) and neutrals in the high latitude thermosphere
- Ground based radar network, SuperDARN, can tell us about the plasma. The SCANDI Fabry-Perot interferometer tells us about the neutrals via auroral airglow emission.
- Examples of 2D, high spatio-temporal resolution Joule heating images have been created by finding events with high amounts of overlapping SuperDARN and SCANDI data
- SCANDI is located on Svalbard and most commonly operates in a 61 zone configuration, obtaining a maximum of up to 61 neutral wind vectors using fitting techniques from Conde & Smith [1998].
- Two SuperDARN radars overlook Svalbard, Hankasalmi in Finland and Pykkvibaer in Iceland. These provide the fitted plasma velocities.

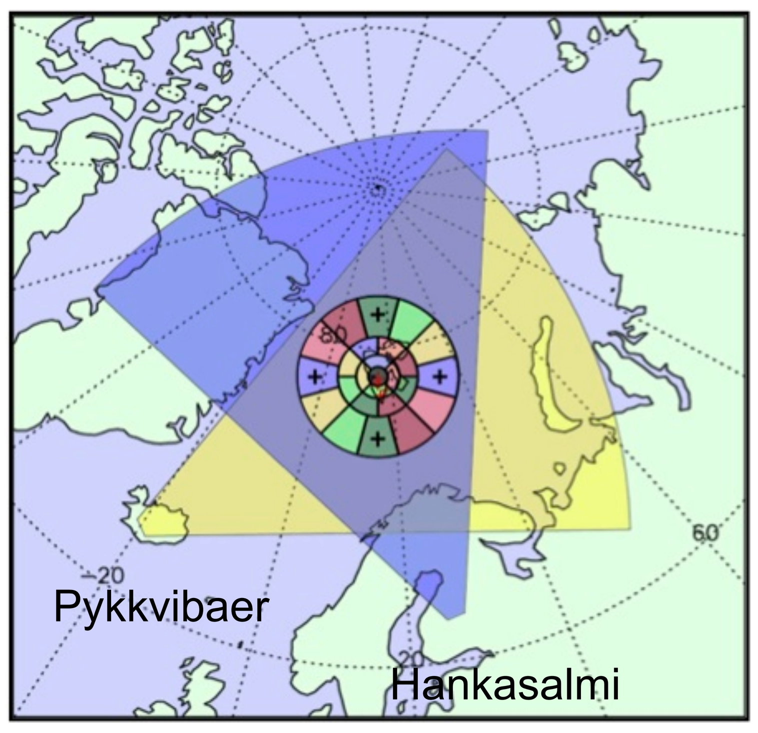


Figure 1. SCANDI and SuperDARN locations adapted from Aruliah et al. [2009]

2. Coverage

- SCANDI has been in operation since 2007, allowing 10 years of winter-time data
- There are not always direct SuperDARN velocity measurements in the SCANDI FOV, but but we use the SuperDARN "map potential" technique to intelligently interpolate over areas without data [Ruohoniemi & Baker, 1998].
- After filtering SCANDI data for clear skies and goodness of fit ($0.5<\chi^2<1.5$), the number of SuperDARN plasma vectors in the SCANDI FOV is shown in figure 2.

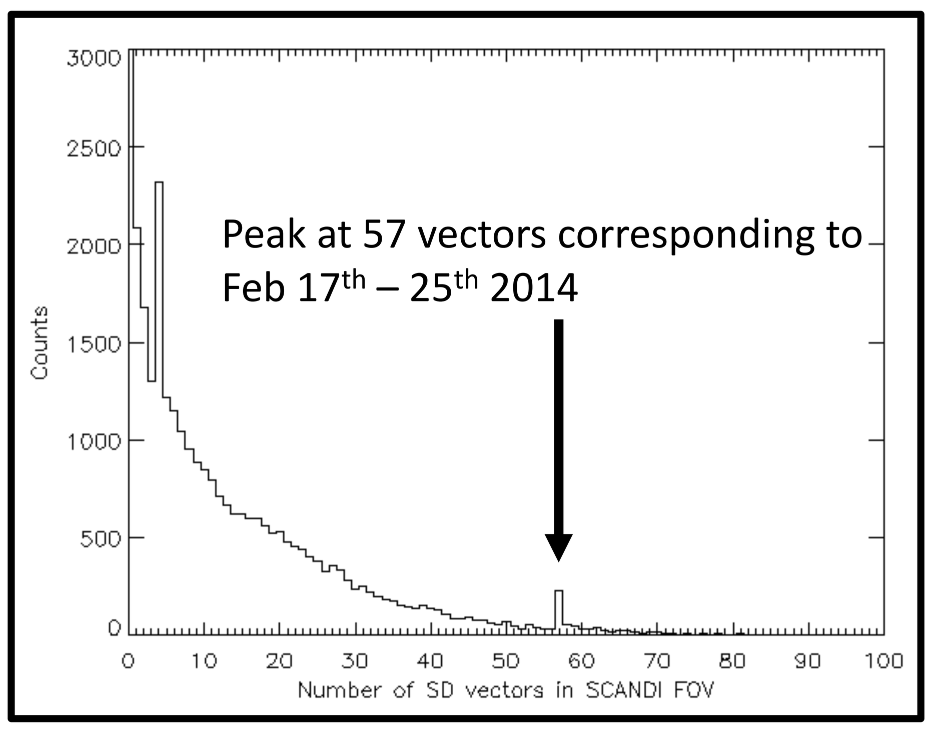


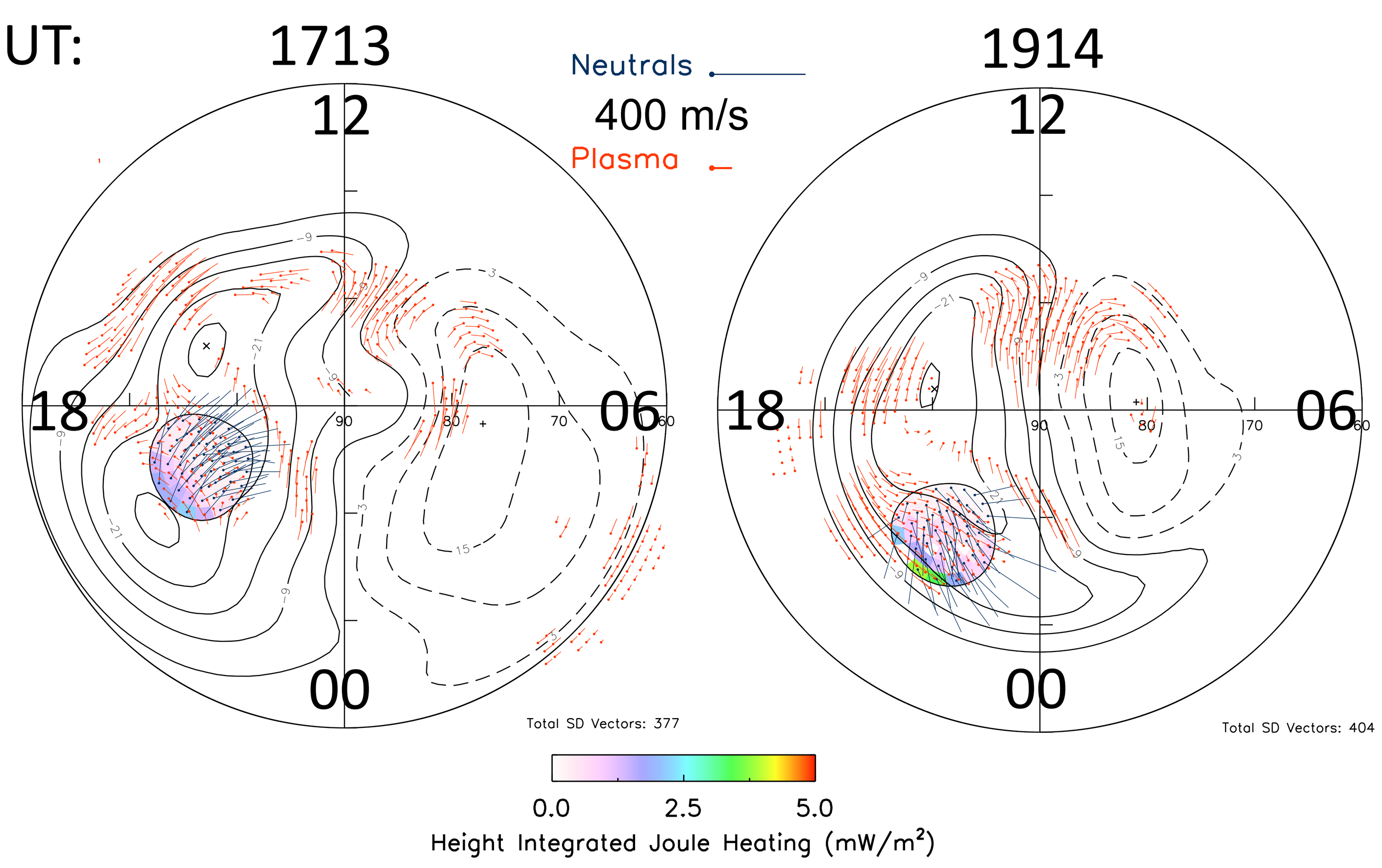
Figure 2. The number of measured SuperDARN plasma vectors within the SCANDI FOV for a filtered dataset. There is a peak labelled which corresponds to 8 consecutive days of excellent data coverage for both SuperDARN and SCANDI.

3. Calculation

$$\Sigma Q_J = \Sigma_P E^2 + 2\Sigma_p \mathbf{E}\cdot(\mathbf{V_n}\times\mathbf{B}) + \Sigma_p(\mathbf{V_n}\times\mathbf{B})^2$$

- ΣQ_j - Height Integrated Joule heating
- **E** - Electric field from SuperDARN: $\mathbf{E} = -\mathbf{V}\times\mathbf{B}$
- $\mathbf{V_n}$ - Neutral winds from SCANDI
- **B** - Magnetic field from IGRF model [Thébault et al., 2015]
- Σ_p - Pedersen conductivity from Solar zenith model [Rich et al., 1987] and auroral model [Hardy et al., 1987].
- Joule heating is increased the stronger the difference between the neutral and plasma velocities are.

4. February 21st, 2014 Event – Neutral flow switch



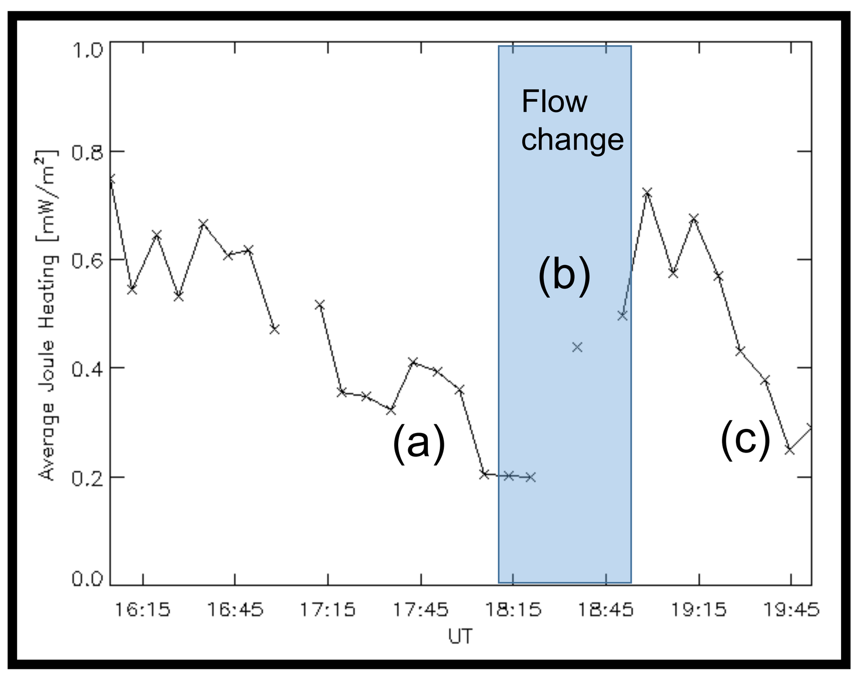
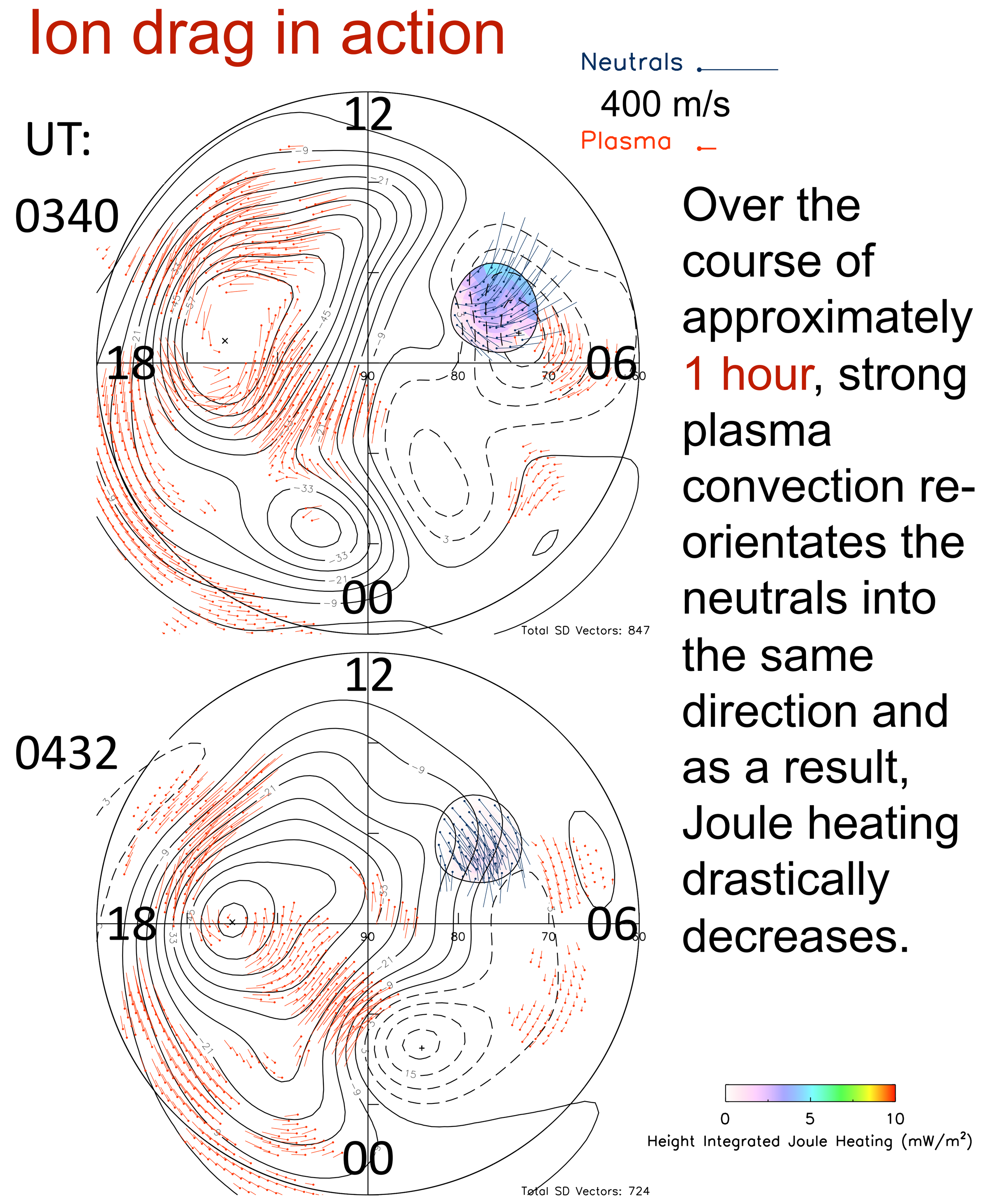


Figure 3. A time series of how the average Joule heating changes within the SCANDI FOV.

- The decrease in Joule heating indicates neutrals pulled into direction of plasma via ion-drag – (a), (c) in Figure 3.
- The sudden change of neutral direction increases Joule heating, especially at lower latitudes – (b) in Figure 3.
- This indicates some stronger control over neutrals than ion-neutral drag, such as Coriolis forces or solar pressure gradients driving the neutrals from the plasma configuration and increasing Joule heating. This is significant because Ion-neutral drag is often seen as the dominant force affecting neutrals.

5. December 7th, 2013 Event – Ion drag in action



Over the course of approximately 1 hour, strong plasma convection re-orientates the neutrals into the same direction and as a result, Joule heating drastically decreases.

References

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6. Future work

- Using the full overlapping SuperDARN and SCANDI data sets, a statistical analysis of Joule heating in the 70-80° magnetic latitude range will be preformed and compared to previous modelling efforts.
- All-sky auroral emission data can be used to derive high resolution 2D conductivities as a replacement for statistical models.