Examination of Cross-Scale Coupling During Auroral Events using RENU2 and ISINGLASS Sounding Rocket Data

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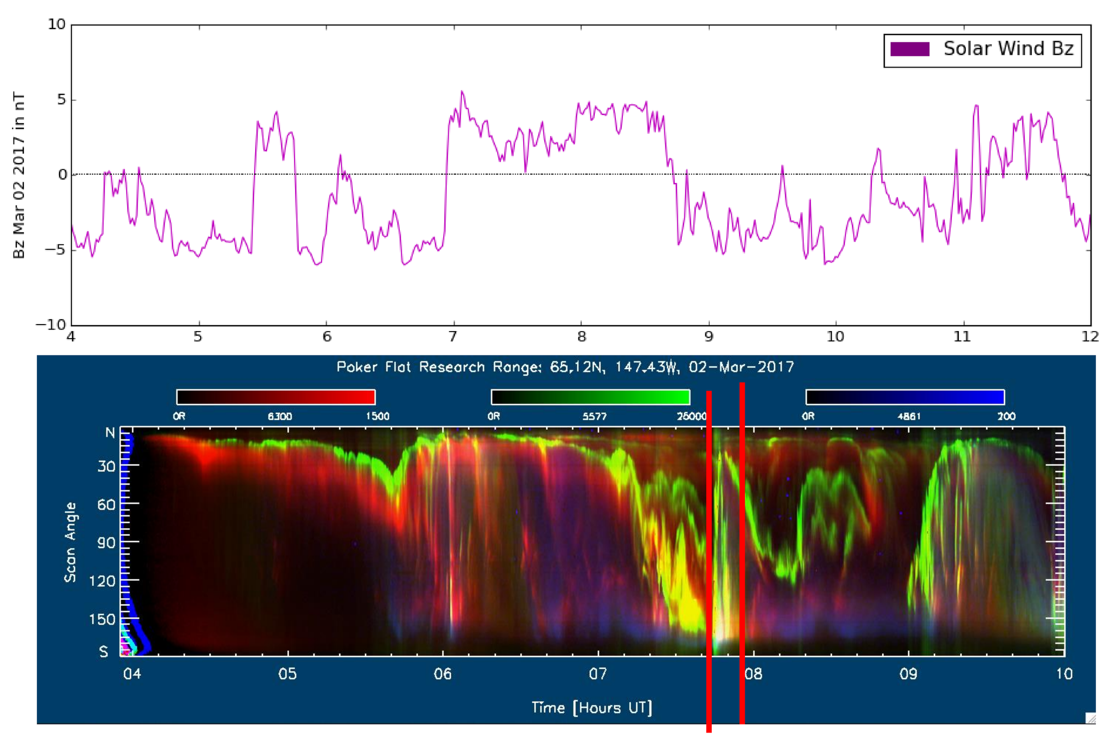
Abstract

The RENU2 sounding rocket (launched from Andoya rocket range on December 13th, 2015) observed Poleward Moving Auroral Forms within the dayside cusp. The ISINGLASS rockets (launched from Poker Flat rocket range on February 22, 2017 and March 2, 2017) both observed aurora during a substorm event. Despite observing very different events, both campaigns witnessed a high degree of small scale structuring within the larger auroral boundary, including Alfvenic signatures. These observations suggest a method of coupling large-scale energy input to fine scale structures within aurorae. During RENU2, small (sub-km) scale drivers persist for long (10s of minutes) time scales and result in large scale ionospheric (thermal electron) and thermospheric response (neutral upwelling). ISINGLASS observations show small scale drivers, but with short (minute) time scales, with ionospheric response characterized by the flight's thermal electron instrument (ERPA). The comparison of the two flights provides an excellent opportunity to examine ionospheric and thermospheric response to small scale drivers over different integration times.

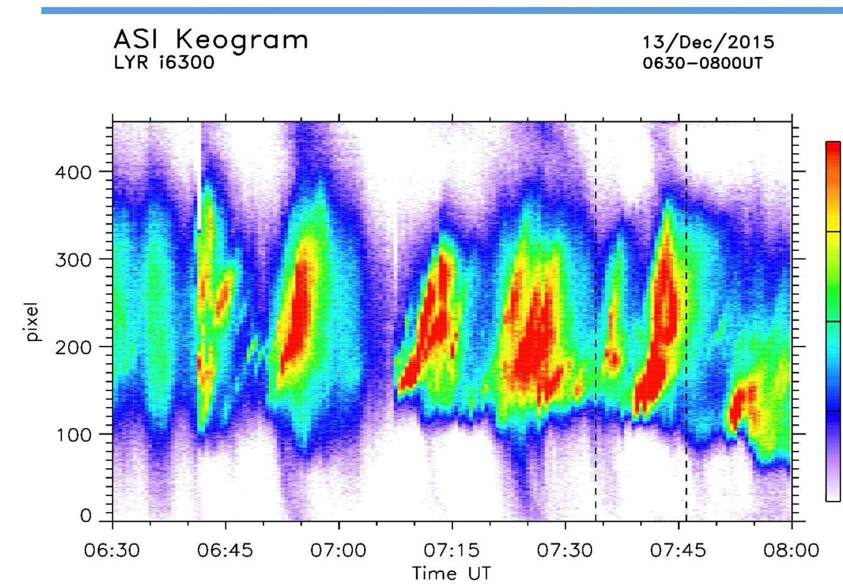
Mission Context

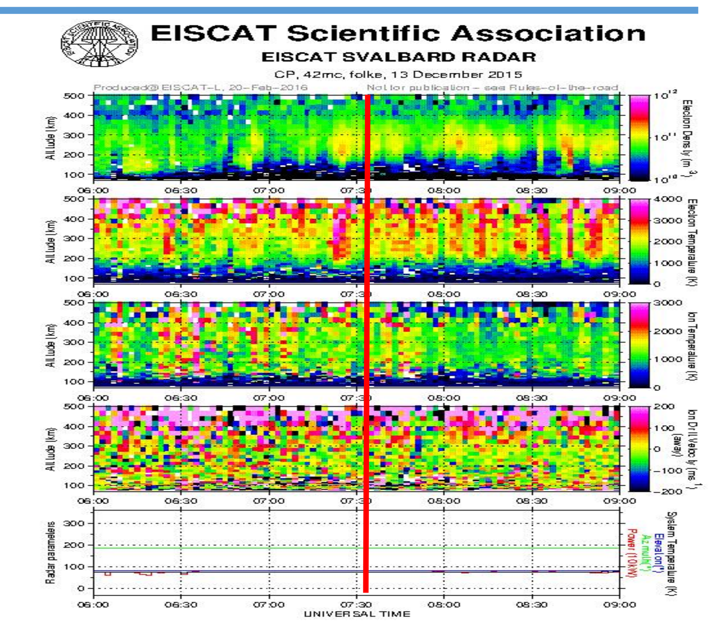
ISINGLASS-B

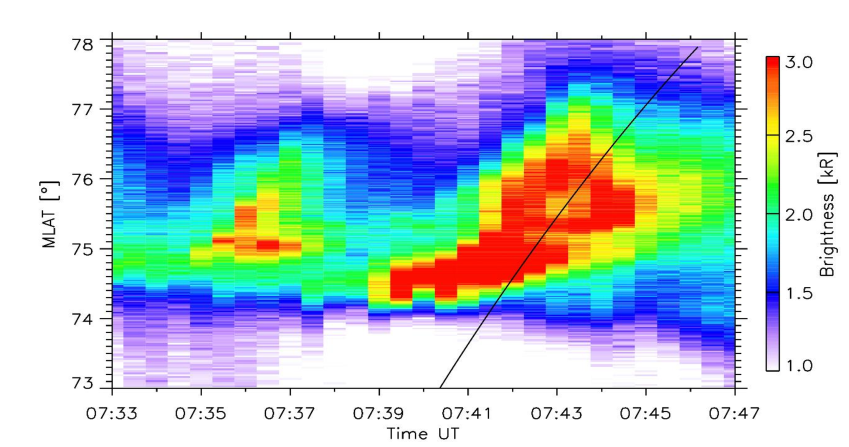


TOP: Solar Wind Bz conditions pre and post launch (7:50UT). Loading phase from ~6 UT until northward turning at 6:55 UT
BOTTOM: Keogram from Poker Flat shows red, green and blue emission lines. Red lines indicate flight time.

RENU2

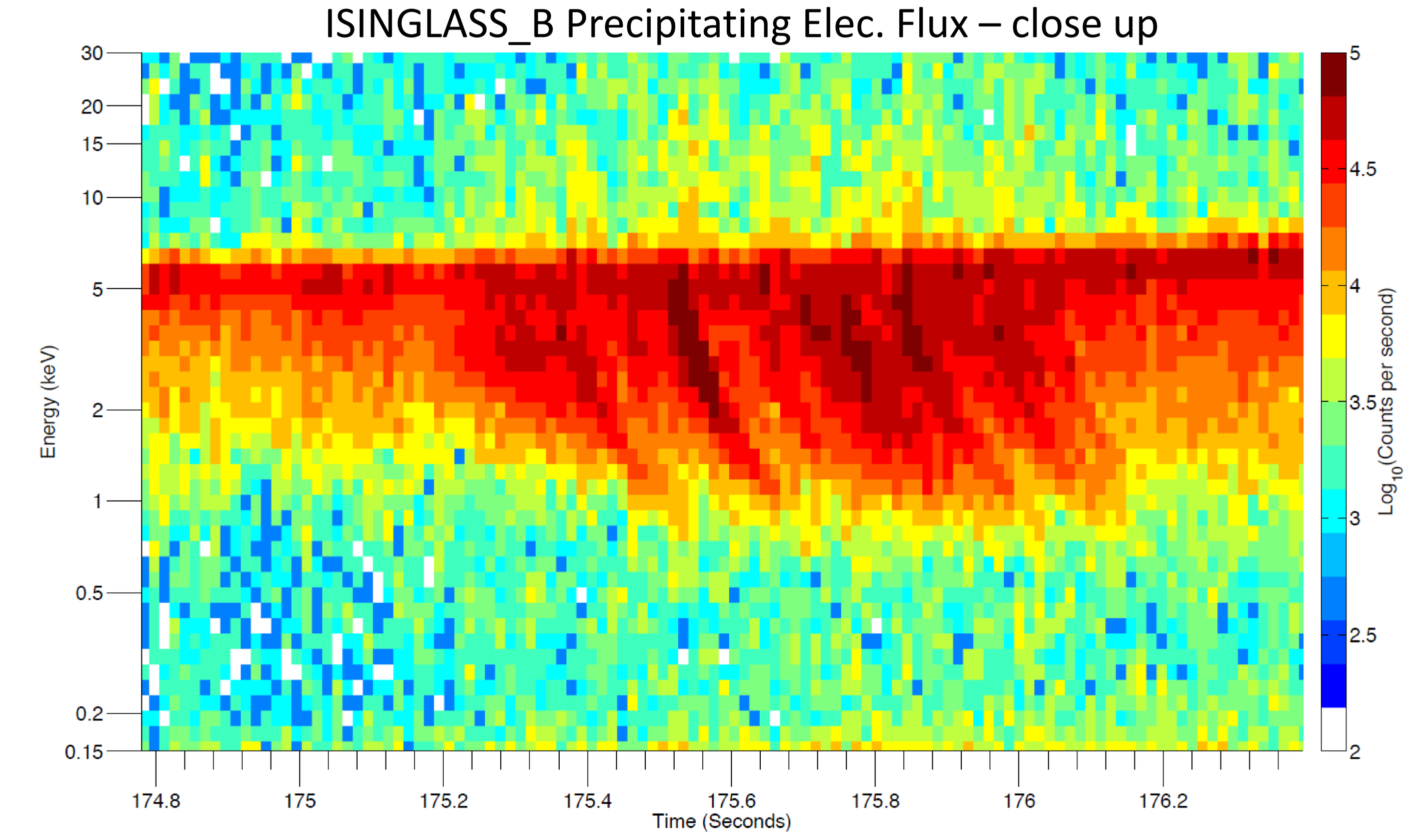




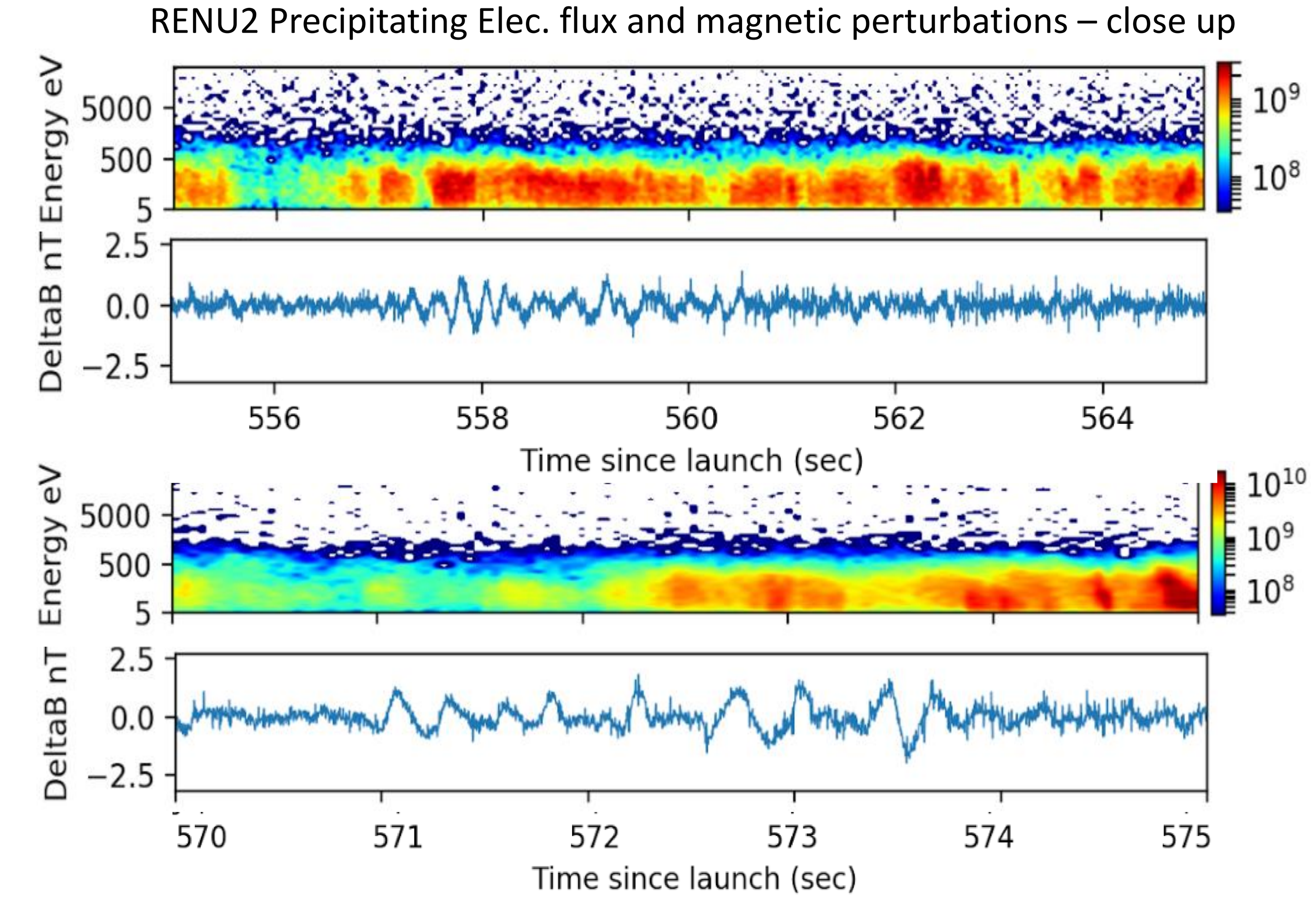


LEFT: Keograms depict time history of PMAFs and close up of PMAF which RENU2 flew through (bottom panel). **ABOVE:** EISCAT shows time integrated heating effects of PMAFs, red line indicates RENU2 launch. Of note for RENU2, panel 4 shows signatures of upwelling at 400km.

ISINGLASS_B Precipitating Elec. Flux – close up



RENU2 Precipitating Elec. flux and magnetic perturbations – close up

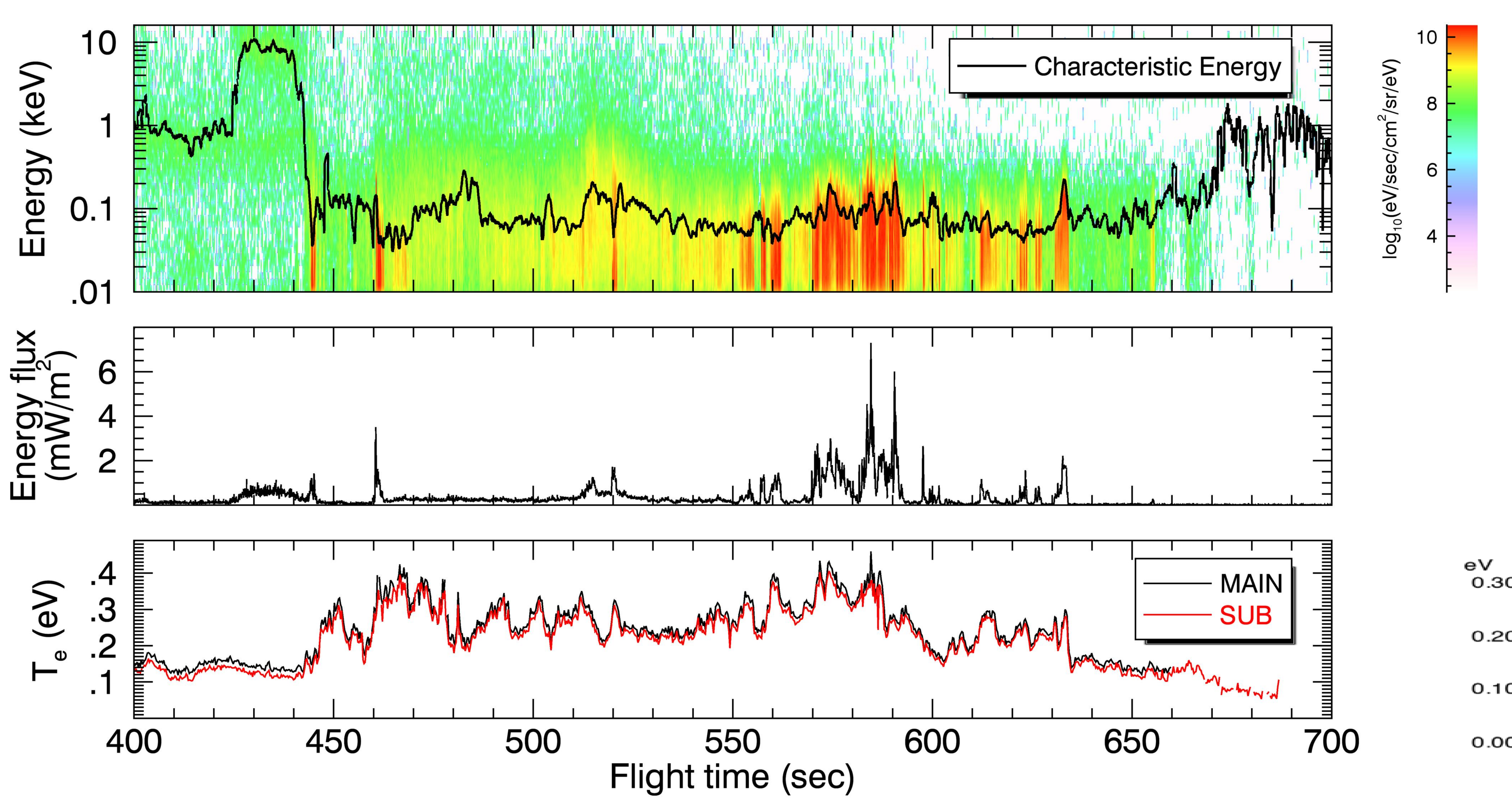


Selected close-ups (ISINGLASS – Top, RENU2 – Bottom four panels)

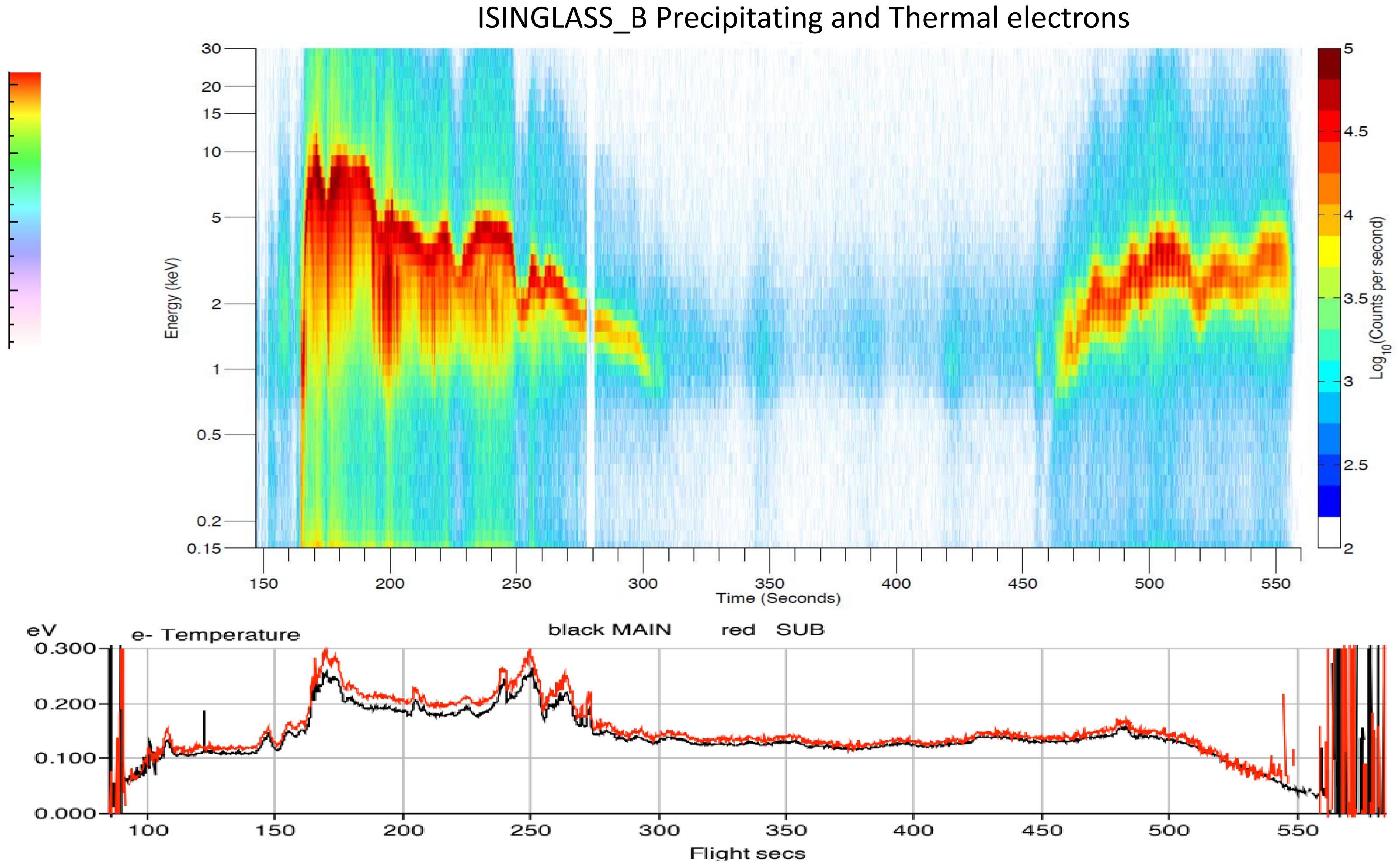
- Selected ISINGLASS close-up shows some time dispersion in electrons from approx. 5 down to 1 keV.
- Selected RENU2 close-ups of electron data shown alongside in-situ magnetic field perturbations. Little to no visible time dispersion is seen, however, enhancements in electron flux seem to have some correlation with periodic/wave behaviour visible in the magnetic field.

In-Situ electron data – characterizing ionospheric response to different scale drivers

RENU 2 Electron Data



ISINGLASS_B Precipitating and Thermal electrons



<u>RENU2 -- instrumentation</u>

- Precipitating electron data recorded by EPLAS instrument, an electrostatic top hat analyzer providing 360 degree FOV with 10 degree resolution.
- EPLAS records energies from .01 to 14.7 keV every .042s
- ERPA records thermal electrons (.01 – 3 eV) and is essentially a faraday cup with a swept retarding potential.

<u>ISINGLASS -- instrumentation</u>

- Precipitating electron data recorded by APES instrument
- APES looks up the local field line with a 10 degree half width aperture and records energies from .15 to 30 keV
- ERPA records the thermal electrons (same as RENU2

<u>RENU2 -- Observations</u>

- Precipitating electrons recorded during RENU2 observations predominantly around 100 eV
- Particle fluxes on the order of 10^10 counts/s/cm^2
- ERPA sees a fast response of ambient ionospheric electrons to enhanced particle flux as well as an integrated heating effect.

<u>ISINGLASS -- Observations</u>

- Precipitating electrons recorded during ISINGLASSB observations predominantly between 1-10 keV; several orders of magnitude greater than RENU2
- Particle fluxes on the order of 10^5 counts/s/cm^2
- ERPA sees less structure overall in the ambient electron response. Very little heating outside the enhanced flux regions (arc boundary) and less structure inside of arc, with lower heating overall.

Future Work

- While these two data sets can provide great insight into how the ionosphere responds to drivers of different spatial, temporal and energy scales, work remains to be done
- In-situ fields from ISINGLASSB needs to be carefully de-trended to be able to gain insight into the role that (possible aflven) waves play during PMAF events compared to more traditional substorm aurora
- Comparison of the total precipitating energy fluxes between and deposition scale heights between the two data sets. Since the precipitating energies are so different, this suggests that different regions of the ionosphere are effected. This could have consequences for other processes such as convection or upwelling.