First Results from the Dissipation Electrostatic Analyzer

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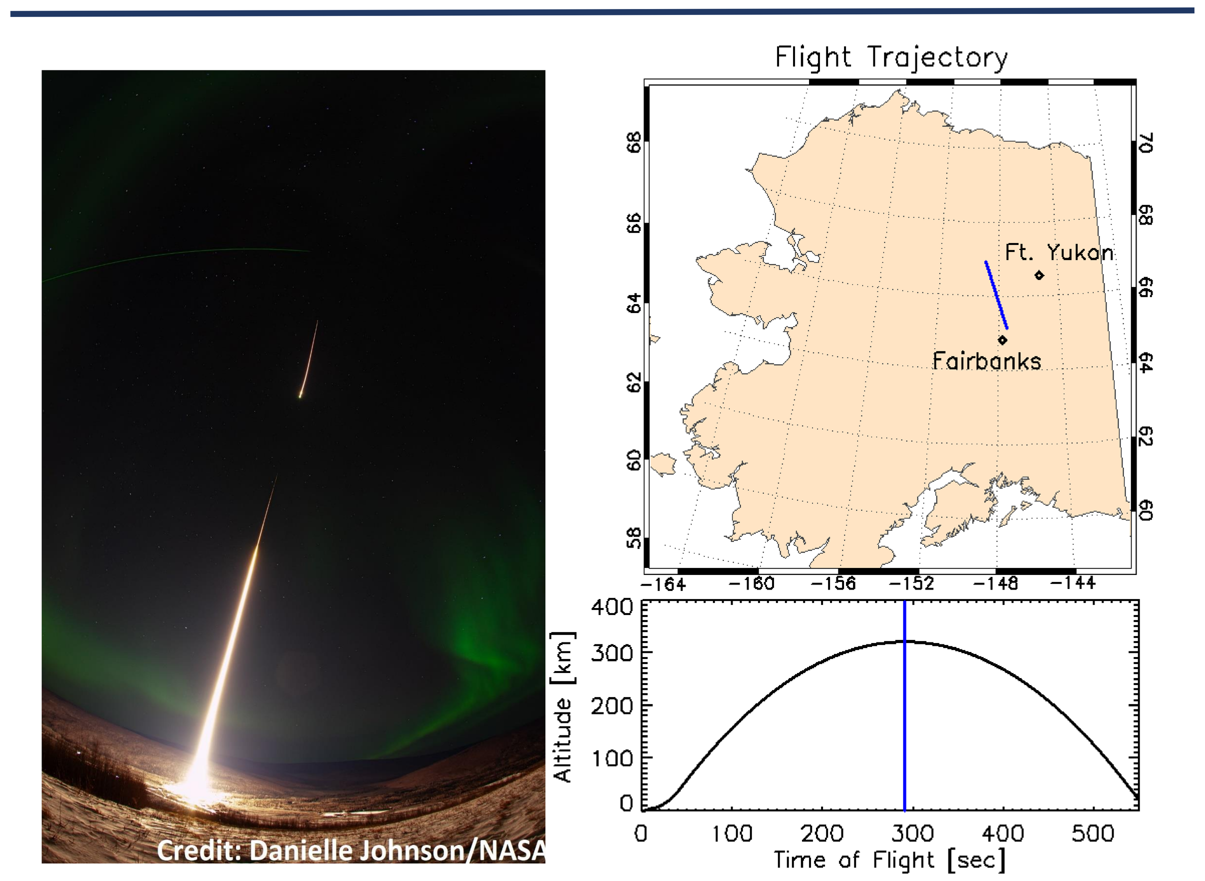
Introduction

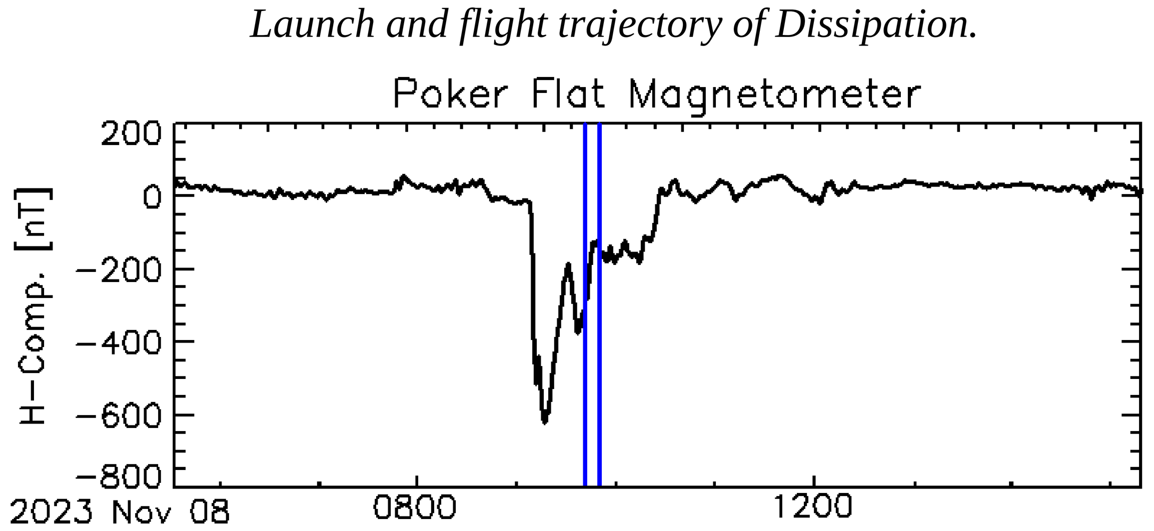
The energy input from the Sun into the near-Earth space environment is primarily deposited, stored, transformed, and dissipated in the lower thermosphere-ionosphere (~100-250 km) region. The dissipation of the varying energy inputs in this region drive neutral/ionospheric winds and density structures. When the flow of charged and neutral particles are not aligned, collisions between them causes frictional heating, also known as Joule heating [1]. The effect of Joule heating on the neutral atmosphere remains mostly uncharacterized.

The Dissipation sounding rocket campaign aimed to study the thermospheric response, namely changes in neutral composition, densities, temperature, and flow dynamics, to Joule heating as a function of external forcing using in situ measurements and launching into active auroral conditions. An electrostatic analyzer (ESA) was included in the instrument suite to characterize the energy input from precipitating electrons. These measurements are used to calculate the ionization rate from the precipitating electrons, a significant source for the Joule heating rate.

Launch!



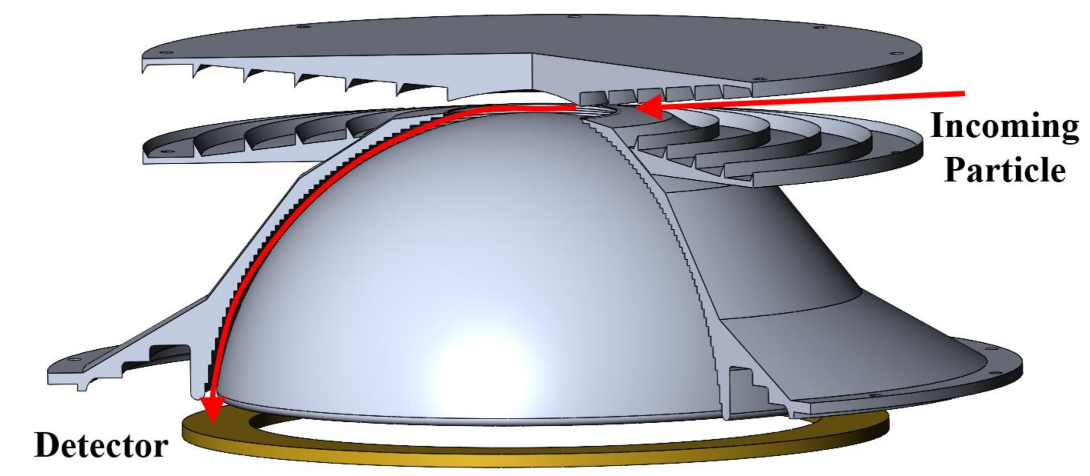
Launch and flight trajectory of Dissipation.



Horizontal component of the disturbed magnetic field measured by the Poker Flat magnetometer. Blue lines indicate the launch and flight time of Dissipation.

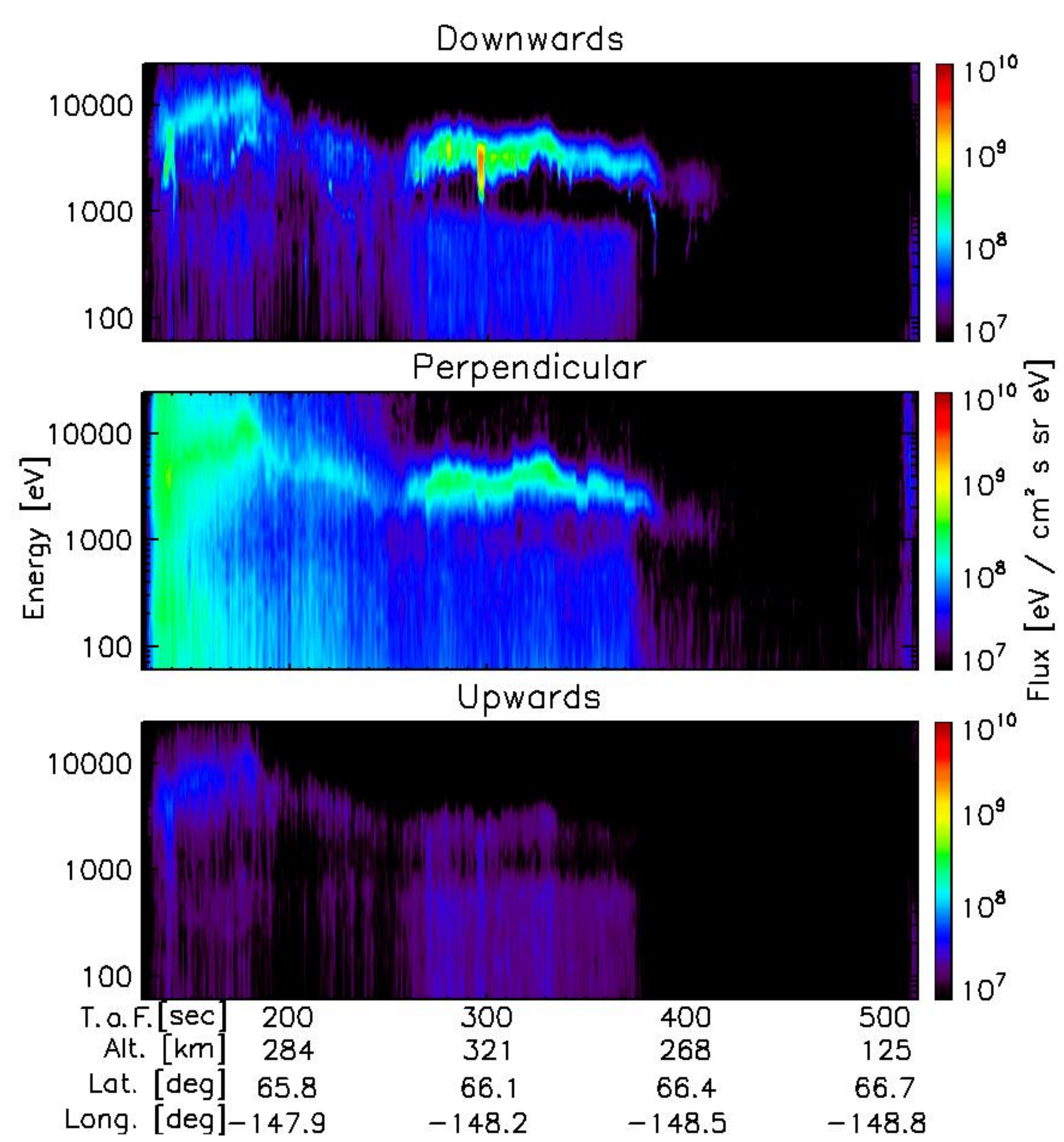
- Dissipation launched from Poker Flat, AK on Nov. 8, 2023
- The flight lasted 549 seconds and reached an apogee of 321 km
- It flew through a well developed auroral substorm
- Ground-based instruments included All-sky cameras, a Fabry-Perot interferometer, and the Poker Flat Incoherent Scatter Radar (PFISR)

Dissipation Electrostatic Analyzer Preliminary Results

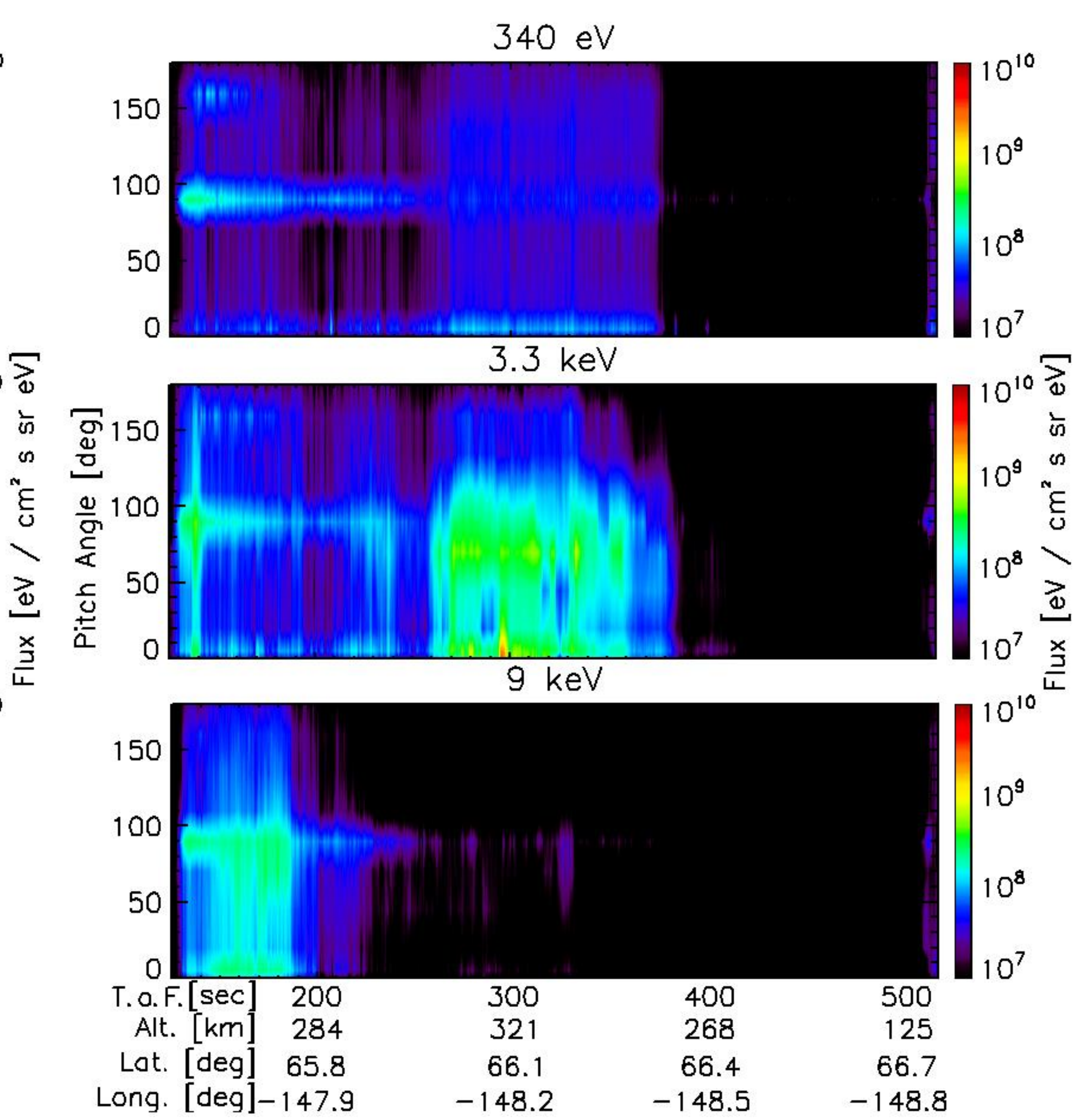


Conceptual schematic of a typical top-hat ESA [2]. ESAs measure plasma distributions, both flow direction and particle energy. Particles enter and are guided by electric potentials generated by the inner hemisphere to be measured by a detector system, a microchannel plate. This ESA measured electrons from ~50 eV to 25 keV across all pitch angles, sampled every 50 ms.

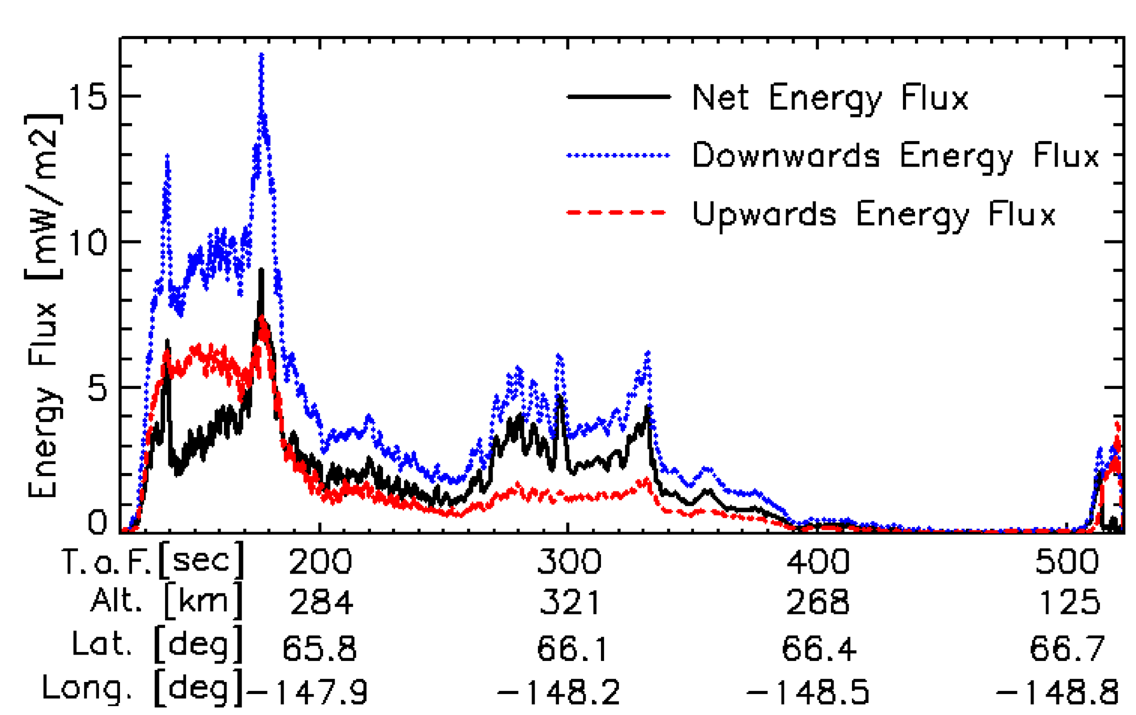
- Two prominent regions of electron precipitation encountered during the flight
- The first region is primarily characterized by downwards-propagating higher-energy electrons (~5-20 keV)
- The second region is populated by downwards-propagating, middle-energy electrons (~1-5 keV)
- Inverted-V structure within the second region near ~280 s and ~320 s; potentially the same structure encountered on both the up- and down-leg of the flight
- Evidence of back-scattered electrons in the second region; low-energy (<1 keV) particles seen across pitch angles
- Downwards-propagating energy flux and downwards net field-aligned currents peak in the two regions



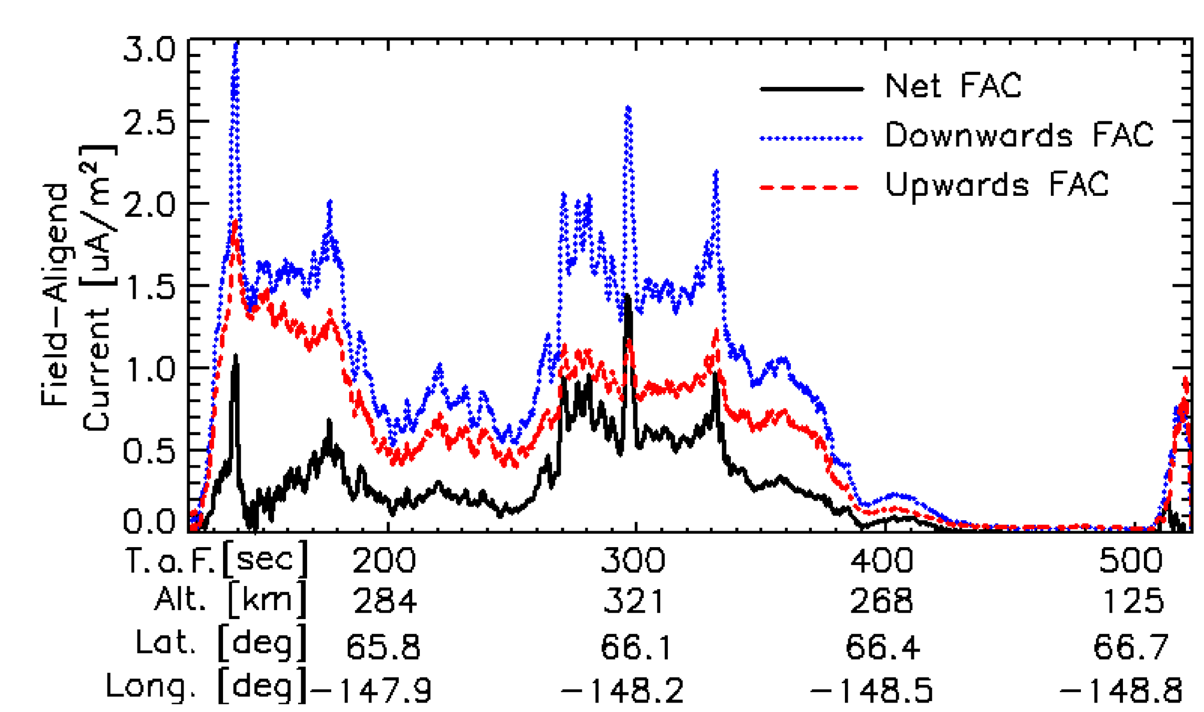
Energy Spectra for electrons traveling (top) downwards, (middle) perpendicular, and (bottom) upwards along the magnetic field.



Pitch Angle Spectra for electrons with energies (top) 340 eV, (middle) 3.3 keV, and (bottom) 9 keV.



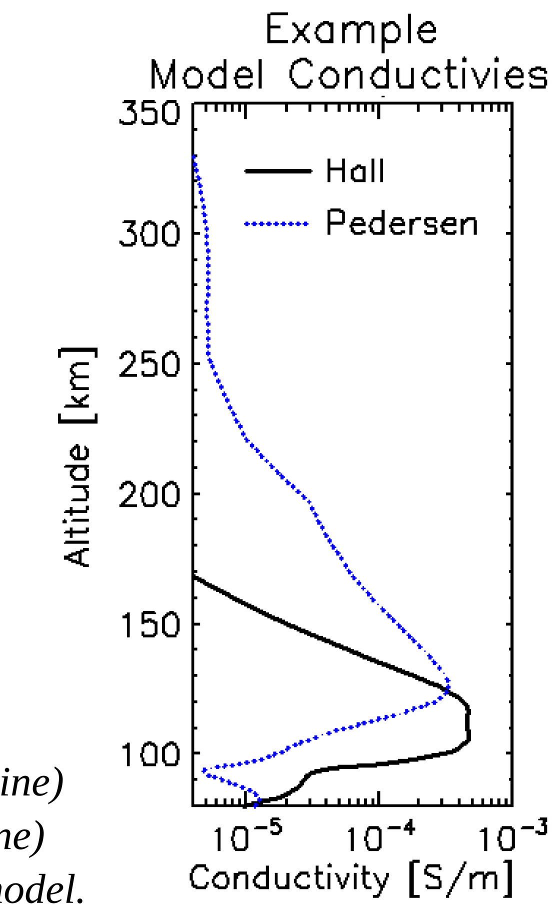
Precipitating electron energy flux along the magnetic field. (black, solid) net, (blue, dotted) downwards, and (red, dashed) upwards flux.



Field-aligned currents. (black, solid) net, (blue, dotted) downwards, and (red, dashed) upwards current.

Electron Transport Model

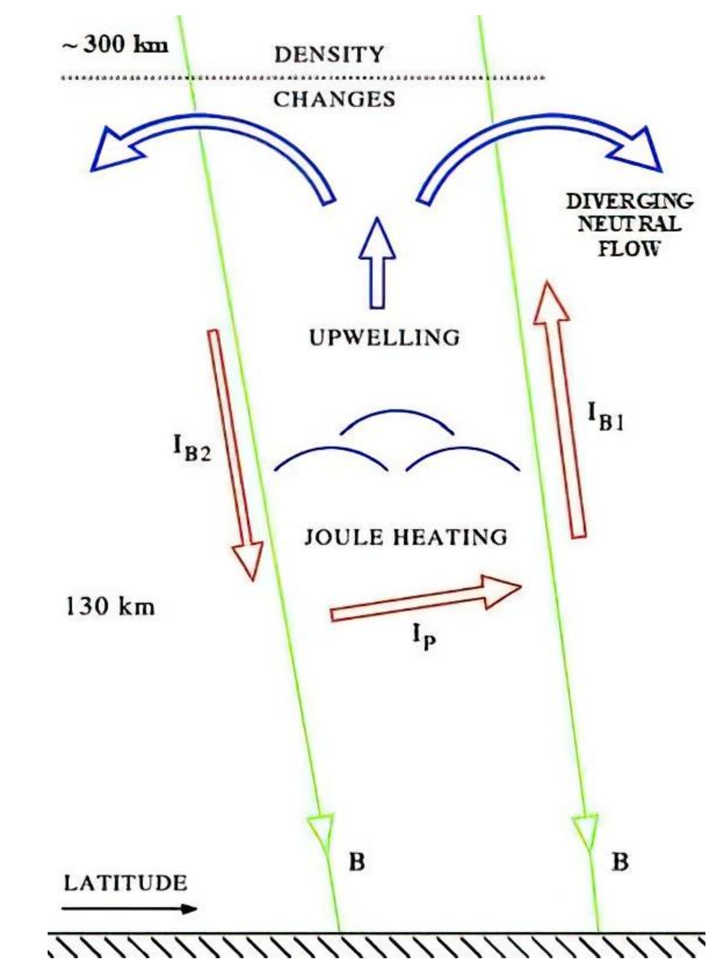
- The measured electron flux will be used as an input into an electron transport model
- For example, the Global Airglow (GLOW) model [3] simulates electron transport and airglow emission in the thermosphere (~80-640 km)
- Modeled conductivities, electron densities, and ionization rates will help inform the Joule heating science of Dissipation



Preliminary Hall (black, solid line) and Pedersen (blue, dashed line) conductivities from the GLOW model.

Joule Heating

- Dissipation aimed to characterize Joule heating and its impact on the thermosphere
- Electric fields close Magnetospheric currents in the lower thermosphere
- Precipitating particles deposit energy at similar altitudes
- Neutral upwelling to higher altitudes
- Composition changes as the heated gas rises
- Diverging neutral wind at higher altitudes



Conceptual diagram of Joule Heating (adapted from [4]).

Summary

Key Points:

- Dissipation launched successfully into moderate auroral activity to study Joule heating and its effect on the neutral atmosphere
- The electrostatic analyzer on-board measured two prominent regions of precipitating electrons during the flight

Future Work:

- Fold-in ESA and other instrument measurements into an electron transport model to estimate the Hall and Pedersen conductivities encountered during the flight
- Collaborate with the wider science team to answer Dissipation's science objectives

References

[1] Cole, K. D., 1962, doi:10.1071/PH620223
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[3] Solomon, S. C., 2017, doi:10.1002/2017JA024314
[4] Prölss, G.W., et al., 2011, doi:10.1007/s10712-010-9104-0