Calculating Hemispheric Power and Joule Heating using Defense Meteorological Satellite Program (DMSP) F-13 data

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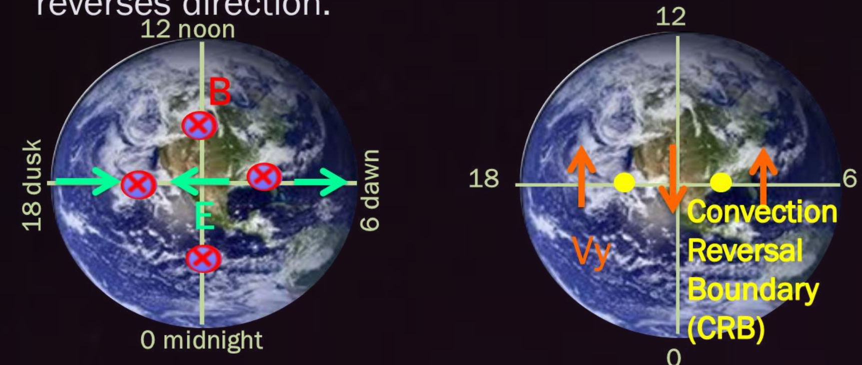
I .Introduction

- *DMSP F13 satellite (1995)* was launched into a Sun synchronous, polar orbit in 6-18 local time frame.
- We use data from 2 DMSP instruments:
  (1) Special Sensor Precipitating Electron and Ion Spectrometer (SSJ/4)
  (2) Ion Drift Meter (IDM)

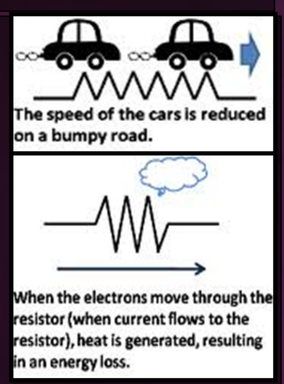
DMSP Satellite

- *Interplanetary Magnetic Field (IMF)* is the Sun's magnetic field carried by solar wind.
- *Ion drift velocity* (Vi) = (ExB)/B^2 where E is Electric Field and B is Earth's magnetic field.
- *Vy* is the horizontal cross-track ion velocity.
- *Convection Reversal Boundary (CRB)* is where Vy reverses direction.



- *Weimer 2005* is an empirical model of the high-latitude ion drift velocity .
- *TIEGCM* (Thermosphere-Ionosphere-Electrodynamics General Circulation Model) is a numeric model for Earth's upper atmosphere.
- *Hemispheric power* is the spatially integrated energy flux of precipitating electrons.

- *Joule heating (QJ)* is the heat loss due to passage of electric current through a conductor.
- In the ionosphere, it occurs due to the friction of ions moving through neutral atoms.

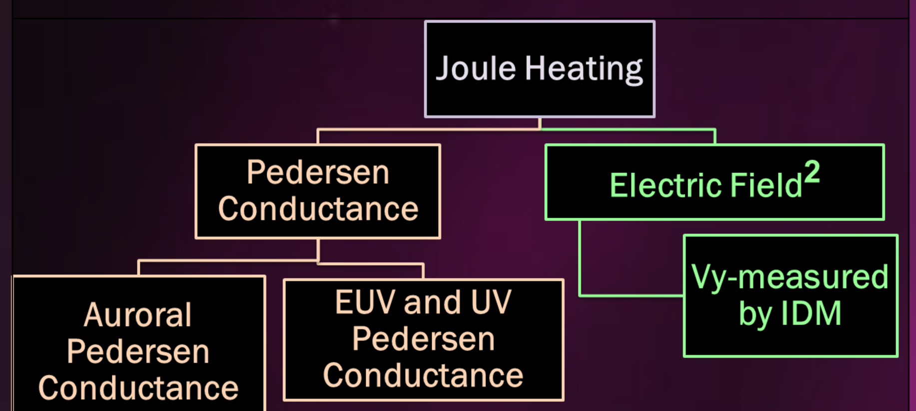


Importance

1. Joule heating is usually the largest heat source in high-latitude regions. During geomagnetic storms, Joule heating can exceed the global solar heating from UV/ EUV radiation [Knipp et al., Solar Physics, 2004].
2. Joule heating is the largest source of uncertainty in energetics of the thermosphere.

II .Research Strategy

Framework for calculation & analysis



- Joule heating ≈ Electric field ^{2} * Pedersen conductance
- Particle or auroral Joule heating (QJP) ≈ Electric field^2 * Auroral Pedersen conductance

GOALS

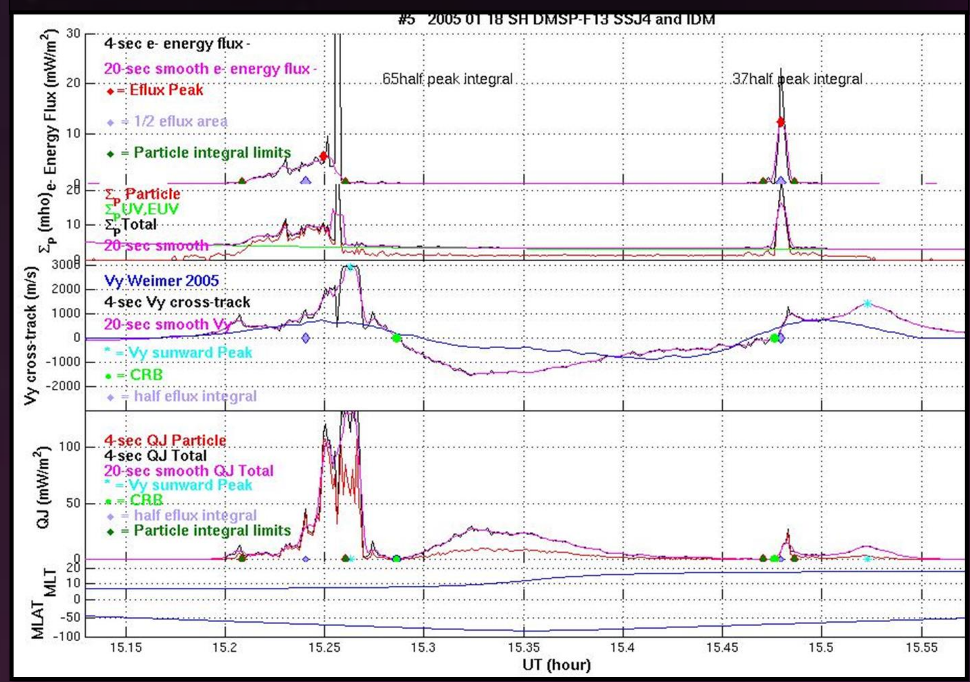
1. Analyze local time variation in Joule heating.
2. Study the spatial distribution of Joule heating . by comparing Joule heating in the polar cap (anti-sunward ion flow) with equatorward Joule heating (sunward ion flow).
3. Analyze the relative locations of electron energy flux and Vy.
4. Quantitatively compare hemispheric power, particle Joule heating, and total Joule heating for different IMF values.

III. Motivation

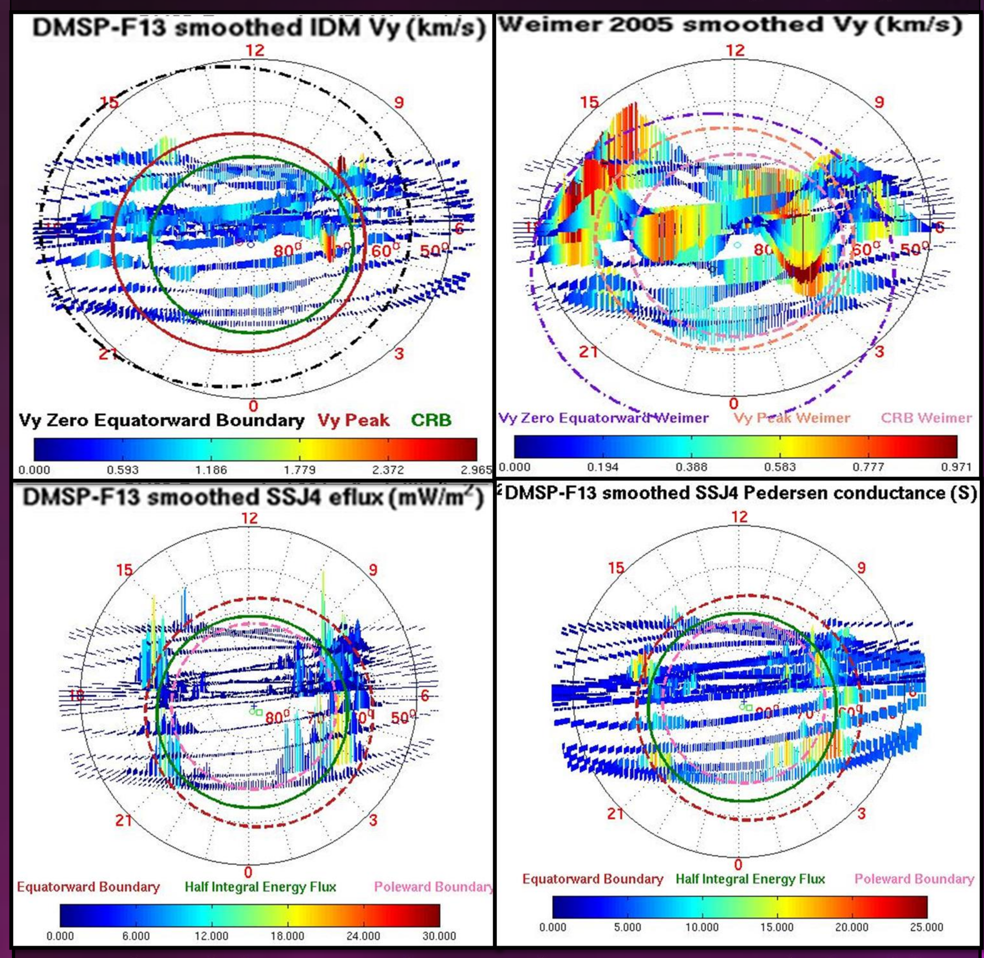
We aim is to improve the parameterization of the aurora in TIEGCM so that Joule heating is approximately correct.

IV .Results

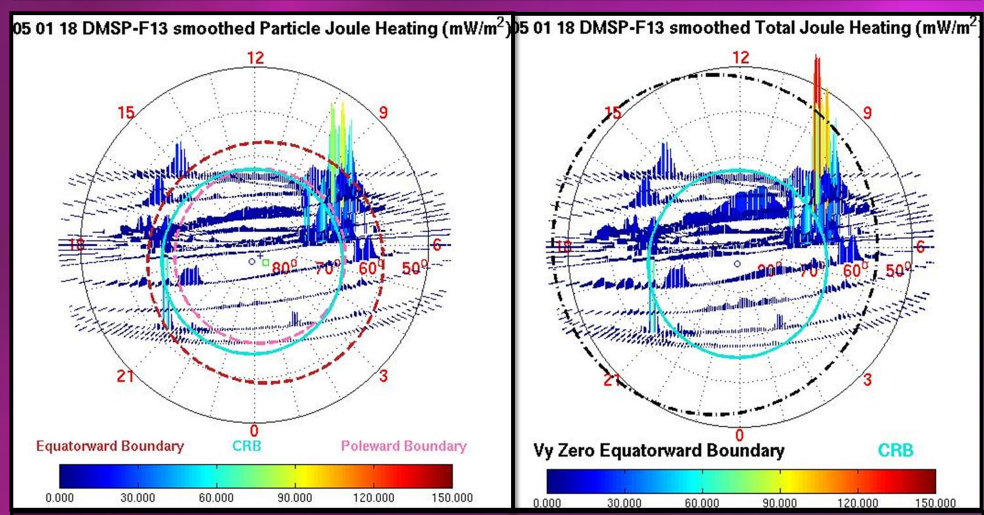
Single day analysis: One Orbit (Jan 18, 2005, Ap=84)



Single day analysis: All Orbits (Jan 18, 2005)

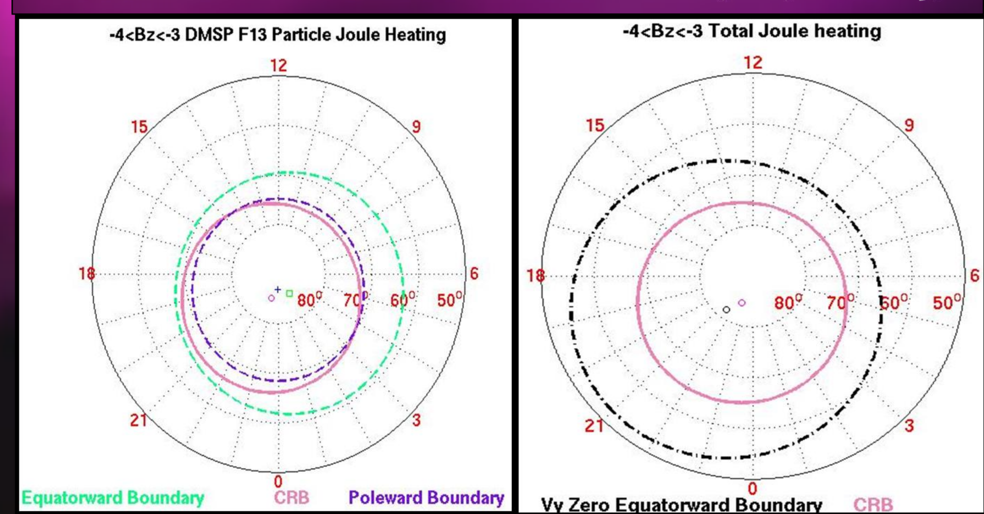


Particle Joule heating and Hemispheric Power are calculated for the region between the Poleward and Equatorward boundary.



Region inside CRB circle has *poleward Joule heating* due to anti-sunward ion flow, whereas the region between Vy Zero Equatorward Boundary and CRB has *equatorward Joule heating* due to sunward ion flow .

Multiple day Circle Fit Results (Jan-June 2005)

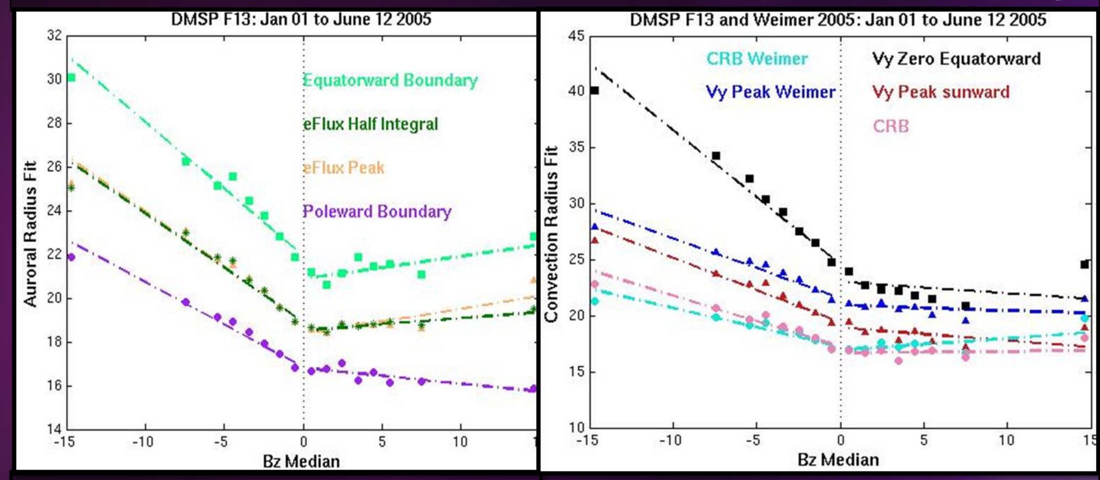


Area for particle Joule heating is bigger on the dawn side compared to the dusk side.

Area for Total Joule heating is bigger on the dusk side compared to the dawn side.

V .Key findings

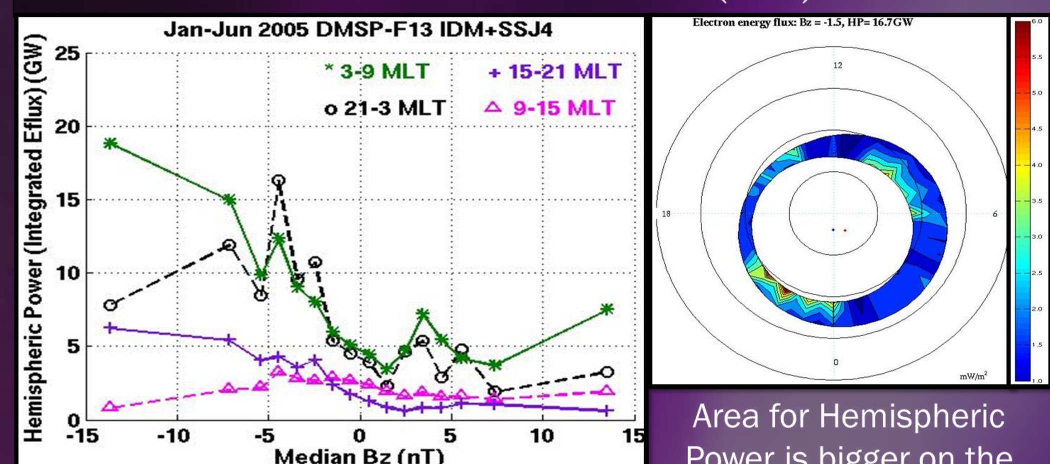
Multiple day results for Radii: Jan-June 2005



Difference between the radii of Equatorward and Poleward Boundaries increases with the absolute value of Bz.

Difference between CRB and Vy Zero Equatorward radii rises as Bz decreases. *Thus, Joule heating area is inversely related to Bz.*

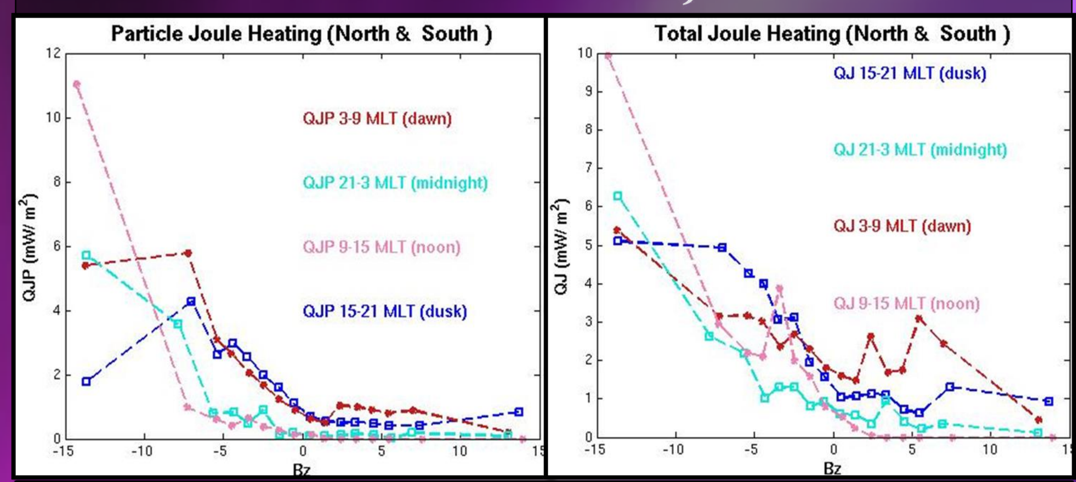
Hemispheric Power (HP)



HP is highest on the dawn side, and HP for the dusk side is relatively small.

Area for Hemispheric Power is bigger on the dawn side compared to the dusk side.

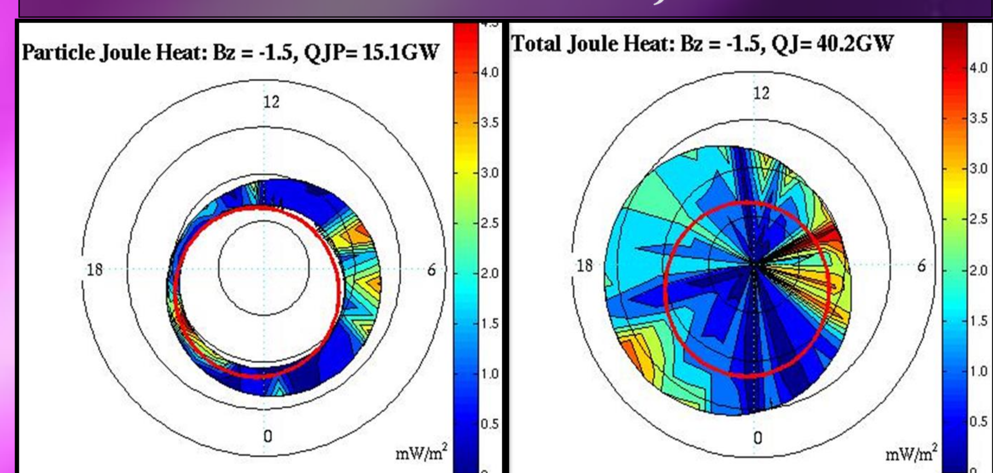
Average Particle & Total Joule heating



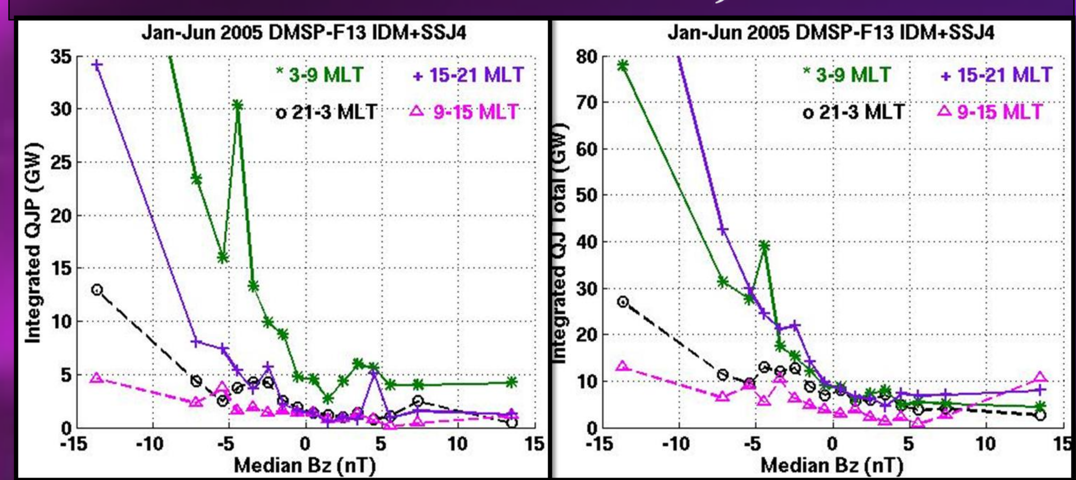
Average particle Joule heating on dawn side is almost equal to that on the dusk side.

Average Joule heating for dawn is greater than that for dusk when Bz>o, & vice versa for Bz<o.

Area for Particle & Total Joule heating



Integrated Particle & Total Joule heating

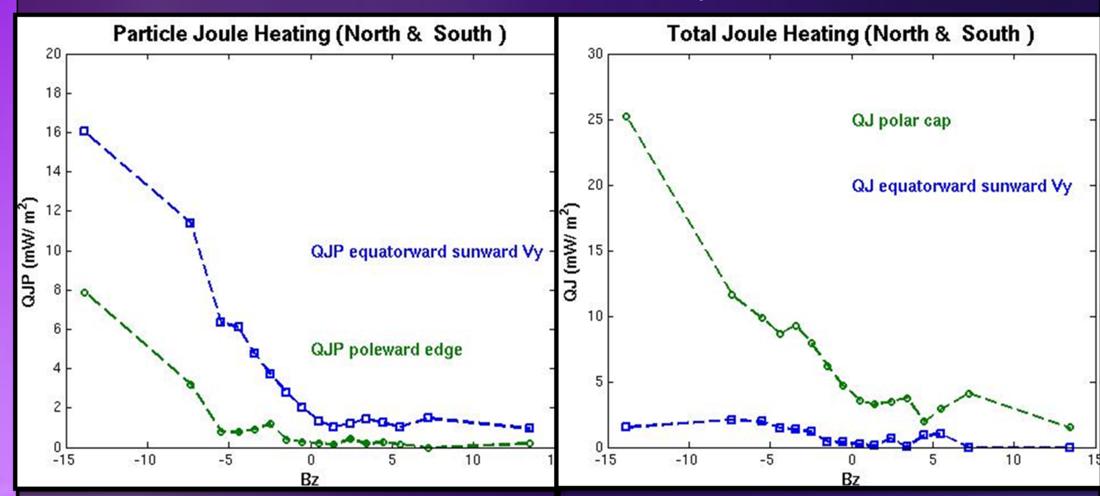


Integrated particle Joule heating is higher on the dawn side than on the dusk.

Integrated QJ on the dawn side is almost equal to QJ on the dusk side.

V .Key findings (continued)

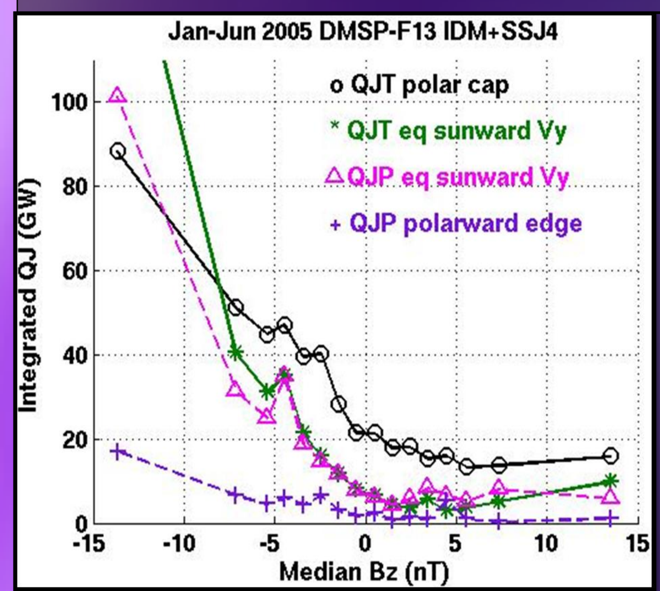
Average Particle & Total Joule heating



Average equatorward particle Joule heating for sunward Vy is greater than average poleward particle Joule heating.

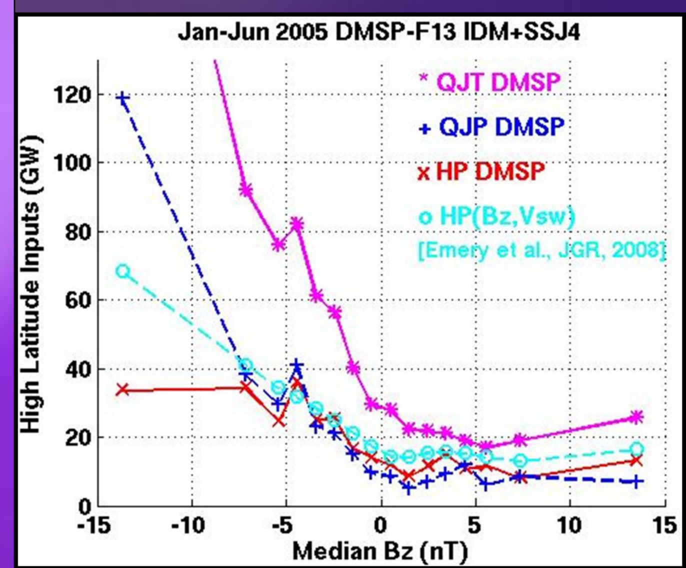
Average Joule heating in the polar cap for anti-sunward Vy is greater than the average equatorward Joule heating .

Area Integrated Particle & Total Joule heating



- Integrated QJ in the polar cap is more than integrated equatorward QJ for sunward Vy.
- Integrated equatorward QJP for sunward Vy is more than integrated poleward QJP.
- On the equatorward side, QJP is mostly equal to QJ, indicating the importance of the auroral Pedersen conductance.

Integrated Joule heating vs. Hemispheric Power



- Integrated total Joule heating is much higher than Hemispheric Power.
- Integrated Particle Joule heating has almost the same magnitude as Hemispheric Power .

VI .Conclusions

Total Joule Heating (QJ)	*Particle Joule Heating (QJP)*
Average QJ: when Bz>0, Dawn side>Dusk side when Bz<0, Dawn side<Dusk side	Average QJP: Mostly, Dawn side≈ Dusk side.
Integrated QJ: Dawn side ≈ Dusk side , even though dusk area is mostly greater than dawn area	Integrated QJP: Dawn side>Dusk side since dawn area is larger than dusk area
Average QJ: Poleward>Equatorward Integrated QJ: QJ>>HP Poleward>Equatorward. On equatorward side, QJP≈ QJ.	Average QJP: Equatorward>Poleward. Integrated QJP: Equatorward>Poleward. QJP≈HP
Area for QJ increases as Bz becomes more negative.	Area for QJP and HP increases as the absolute value of Bz increases.

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