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Department of Physics and Astronomy

A comparison of neutral mass density perturbations and DC Poynting flux estimates, sorted by IMF clock angle

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2017 CEDAR Workshop
New Challenges in High-Latitude Ionosphere-Thermosphere Coupling
Keystone, Colorado, USA
June 21, 2017

SIU
Norwegian Centre for International Cooperation in Higher Education

Estimates of DC Poynting Flux with SuperDARN and AMPERE

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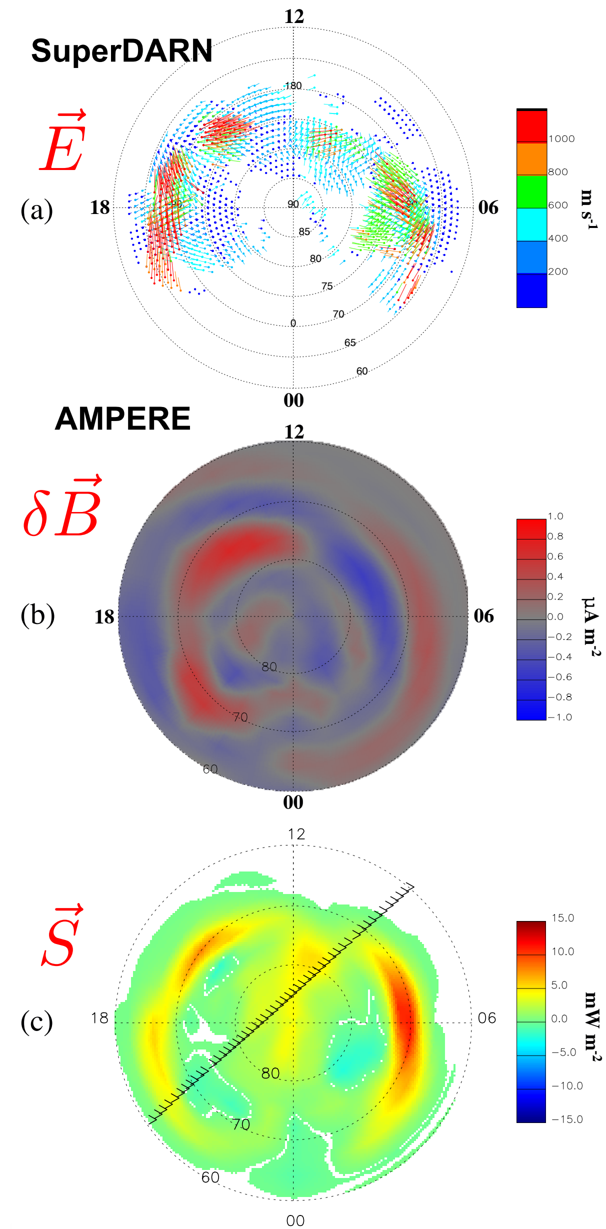
- In this work: we seek to understand the influence of DC Poynting flux, $\vec{S}$, on the high-latitude thermosphere.
- Compare CHAMP estimates of $\Delta\rho$ to $\vec{S}$.
- Estimates of perturbation Poynting flux, $\vec{S}$, are provided by combining SuperDARN and AMPERE data products.
    - Large scale: "DC", $\vec{S}$, generated by Birkeland current system.
- SuperDARN and AMPERE data for January 1, 2010 — December 31, 2012 analyzed.
- CHAMP data for 2001—2010.
- Binned with equal area grid above 60° MLAT.
    - 2° in MLAT per bin.
- Only considered electric field estimates associated with SuperDARN velocity measurements.
- Only considered times where IMF was steady for 30 minutes (for $\Delta\rho$ and $\vec{S}$).



Waters, C. L., Anderson, B. J., Greenwald, R. A., Barnes, R. J., & Ruohoniemi, J. M. (2004). High-latitude poynting flux from combined Iridium and SuperDARN data. Annales Geophysicae. http://doi.org/10.5194/angeo-22-2861-2004

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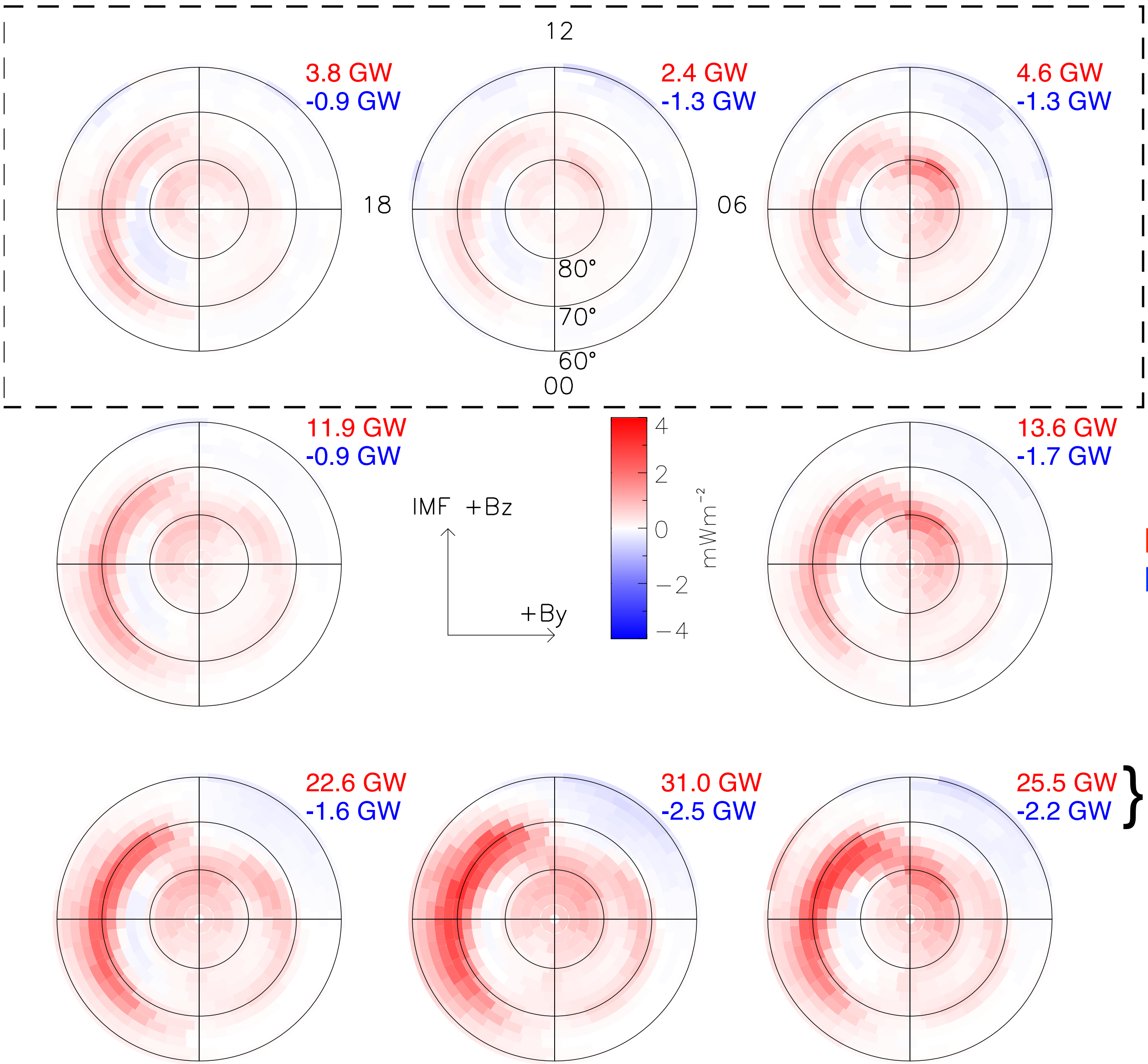


Doubled to make visible

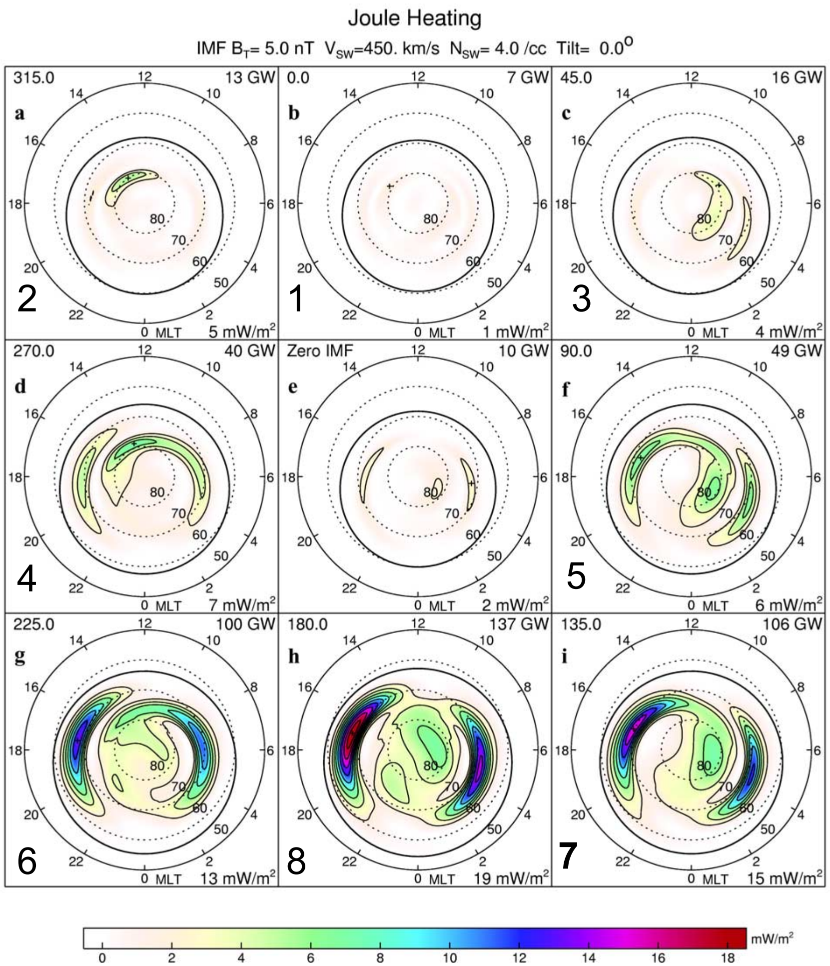
} Integrated $\vec{S}$

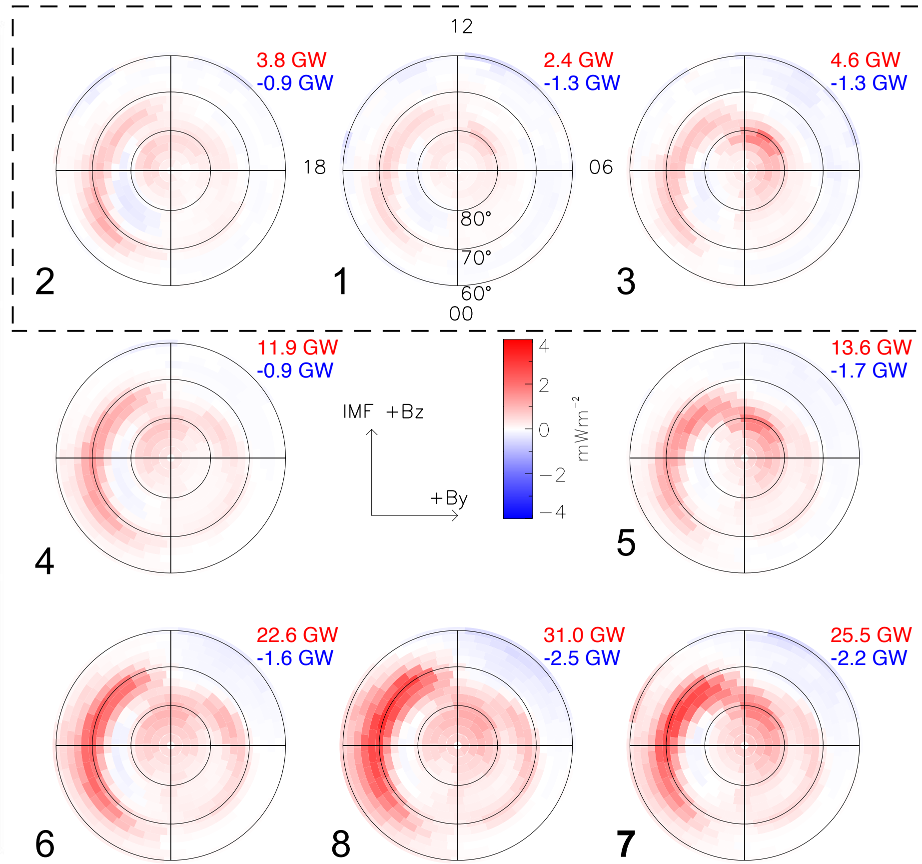
Red - into thermosphere

Blue - out of thermosphere

Estimates of DC Poynting Flux with SuperDARN and AMPERE

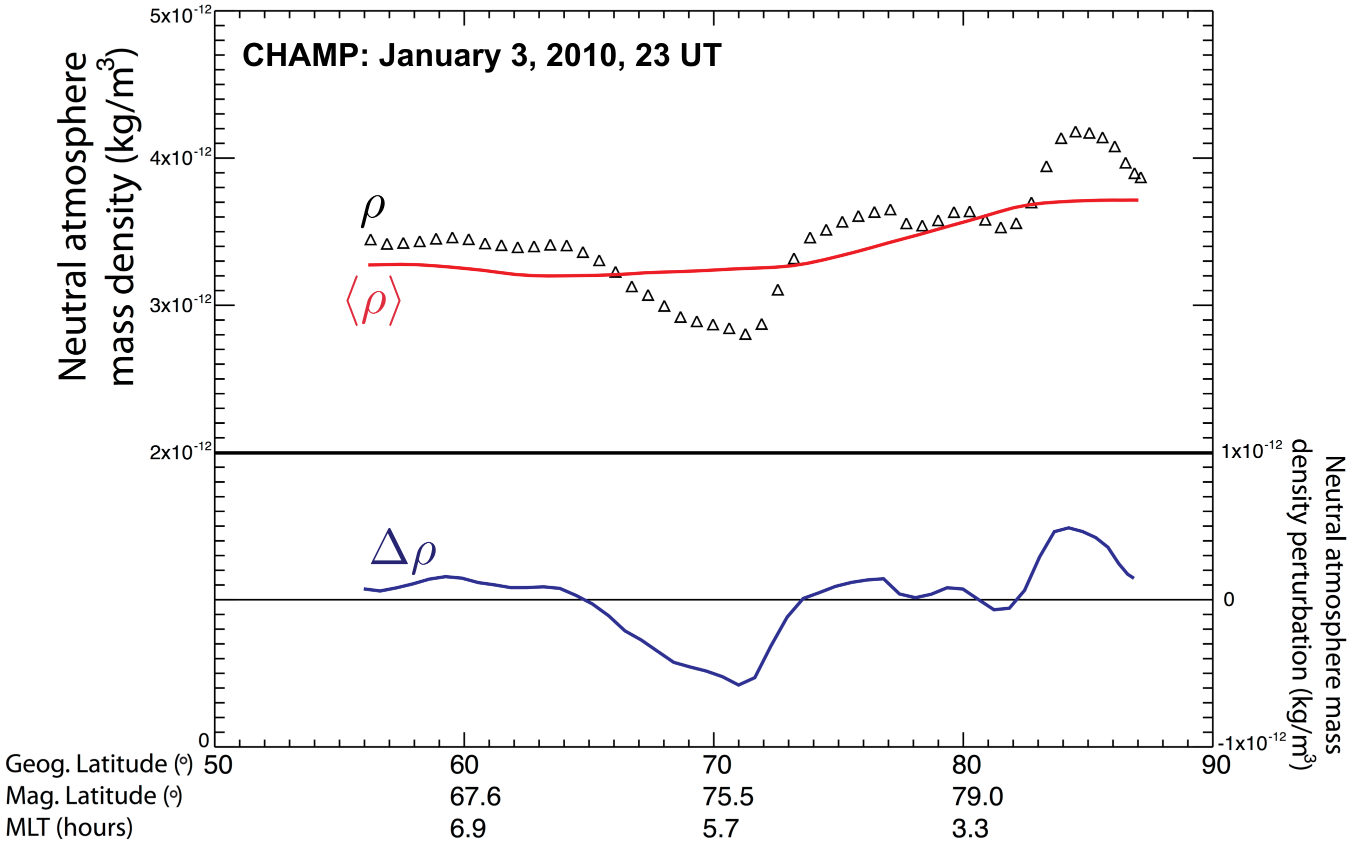
- Structure of $\vec{S}$ agrees well with Weimer [2005].
  - Magnitude and integrated values of $\vec{S}$ *do not* agree with Weimer [2005].
  - Reason: different spatial resolution of measurements.
  - Better agreement with Cousins et al., [2015] and Gary et al., [1995].





Weimer, D. R. (2005). Improved ionospheric electrodynamic models and application to calculating Joule heating rates. Journal of Geophysical Research, 110(A5), A05306. http://doi.org/10.1029/2004JA010884

Estimates of neutral mass density perturbations with CHAMP



$$\Delta\rho = \frac{(\rho - <\rho>)}{<\rho>}$$

- 2001—2010 CHAMP dataset was analyzed.
  - 5-minute running average of ρ was used, $<\rho>$.
- Only considered times where IMF was steady for 30 minutes.
  - 20 minutes before CHAMP measurement, 10 minutes after.

Estimates of neutral mass density perturbations with CHAMP

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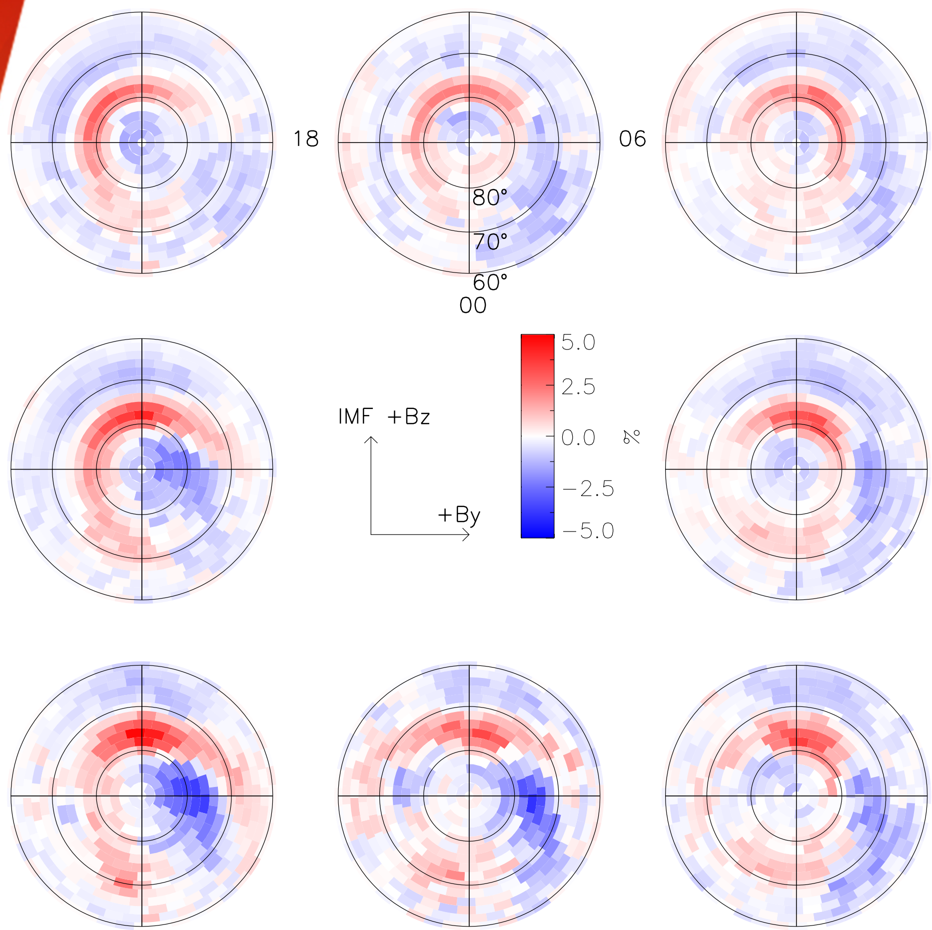
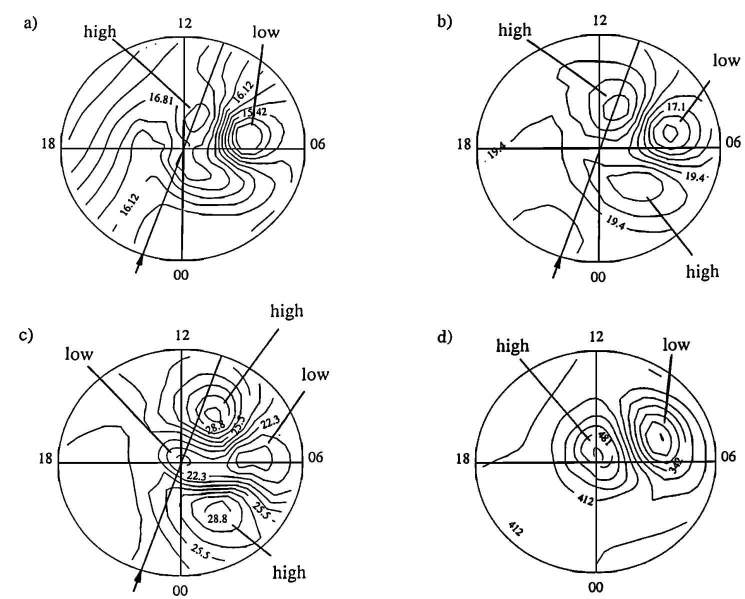
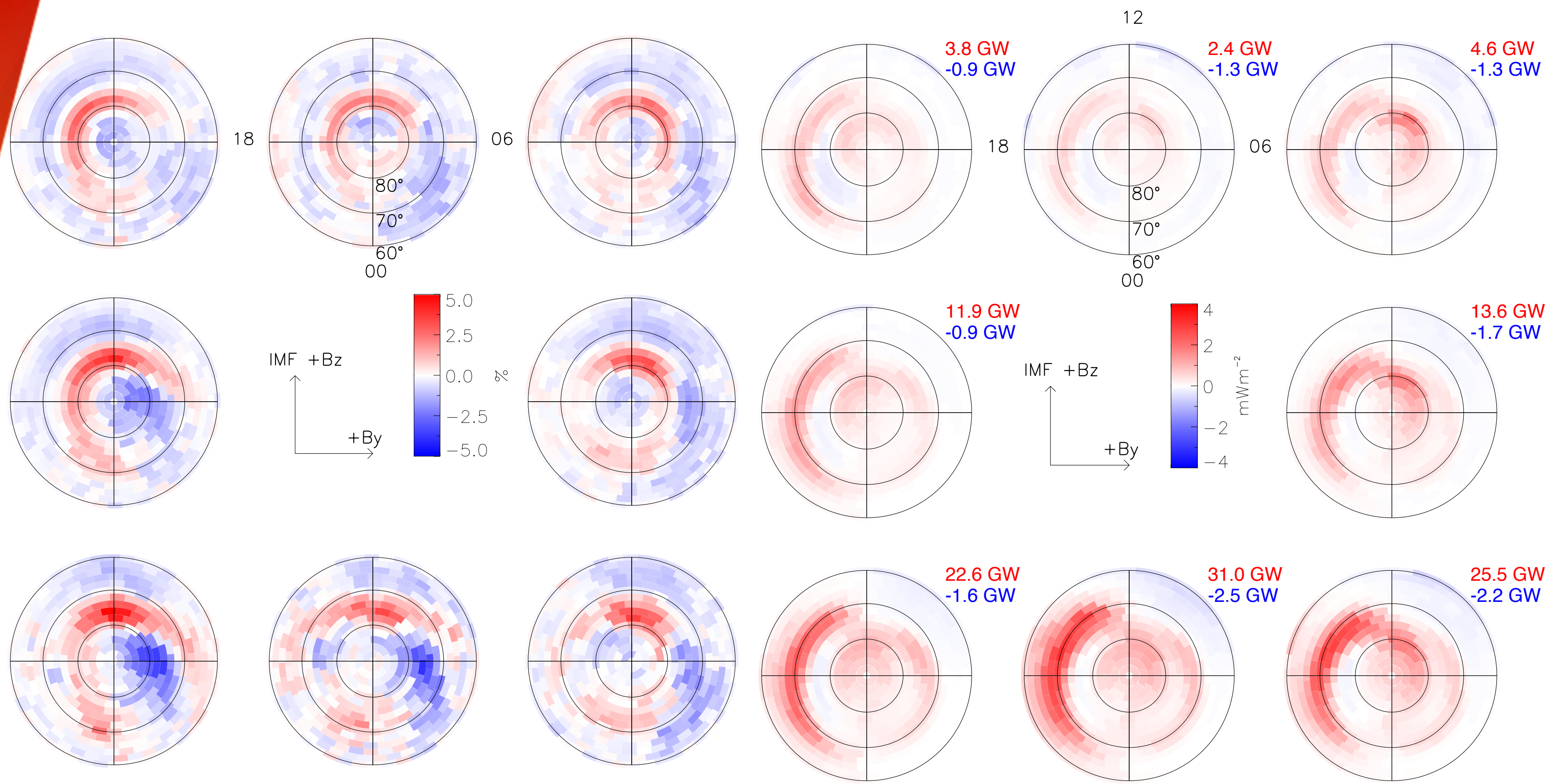
- Clear thermospheric structures.
- Large dawn sector depletion.
    - IMF clock angle dependence evident.
- Signature of cusp effect clear.
- Thermospheric structure very similar to that modelled by *Crowley et al., [1996]*





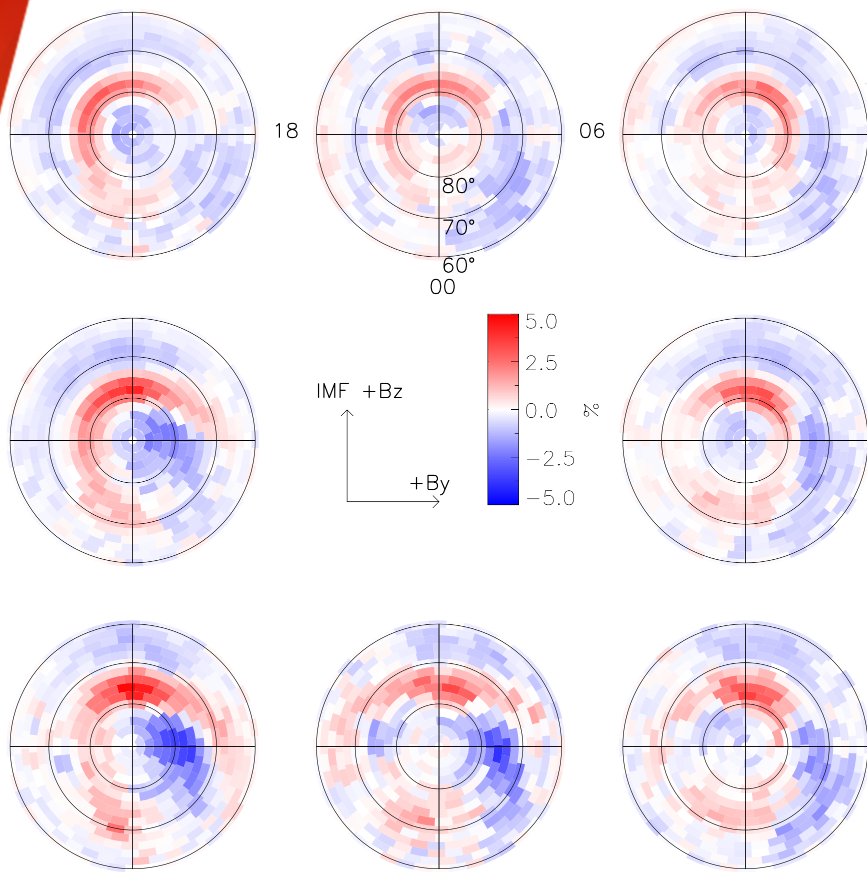
Crowley, G., Schoendorf, J., Roble, R. G., & Marcos, F. A. (1996). Cellular structures in the high-latitude thermosphere. Journal of Geophysical Research: Space Physics, 101(A1), 211–223. http://doi.org/10.1029/95JA02584

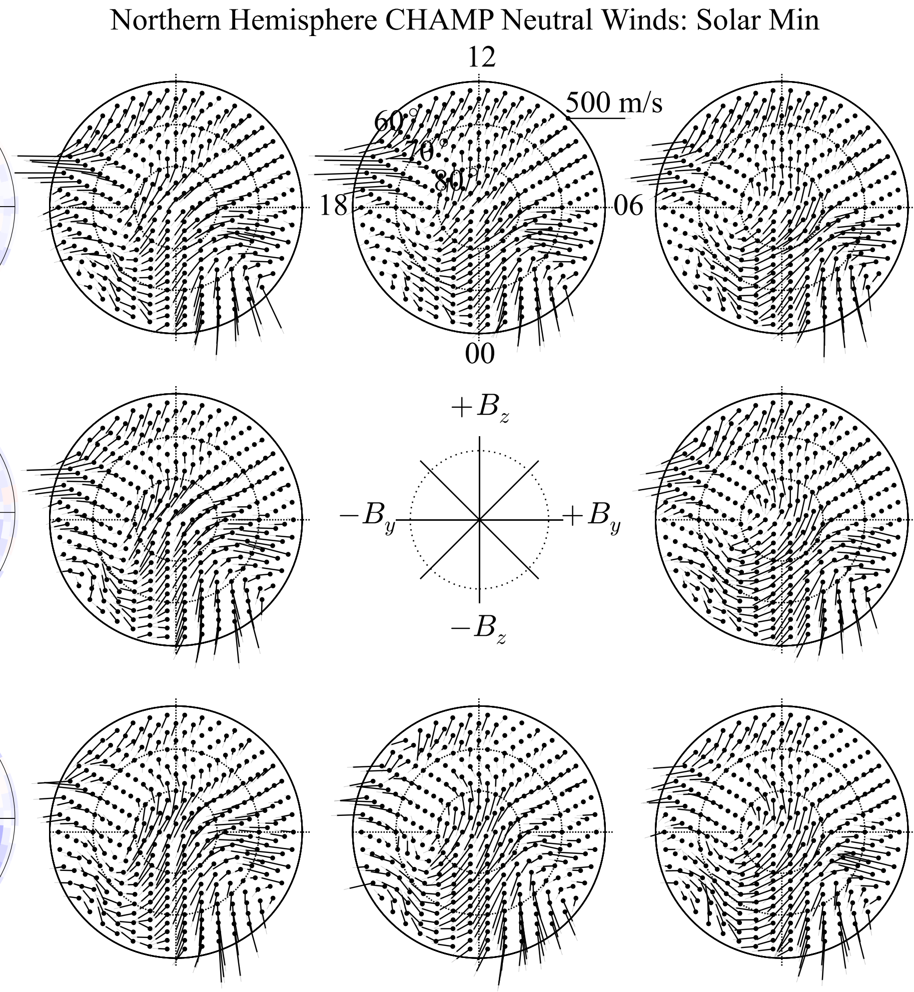
Comparing $\Delta\rho$ to $\vec{S}$



- A direct comparison between the two would be ill-advised.
- Thermospheric winds must also be considered!

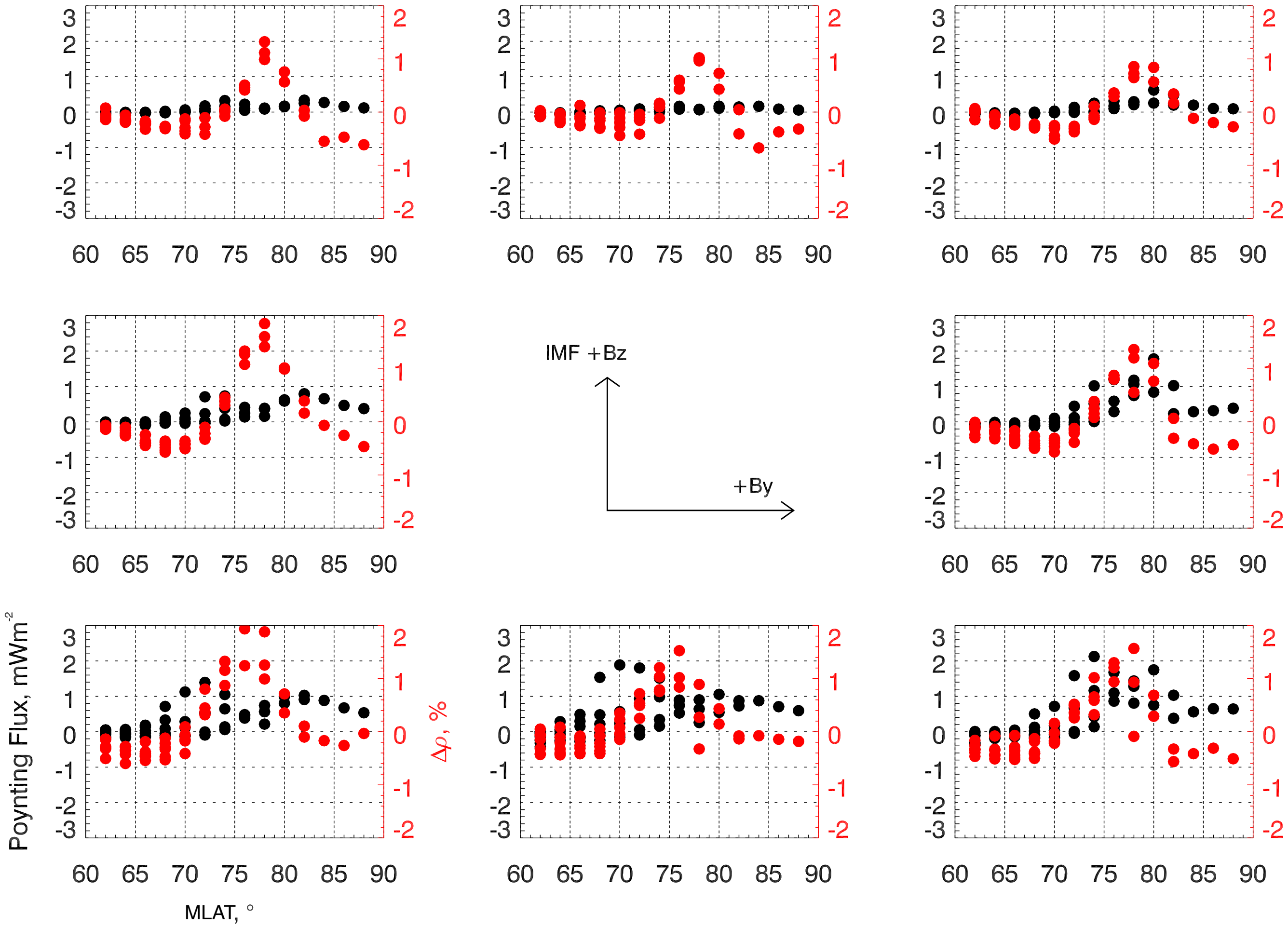
Considering the thermospheric winds





Bjoland, L. M., Chen, X., Jin, Y., Reimer, A. S., Skjæveland, Å., Wessel, M. R., … McWilliams, K. A. (2015). Interplanetary magnetic field and solar cycle dependence of Northern Hemisphere F region joule heating. Journal of Geophysical Research: Space Physics, 120(2), 1478–1487. http://doi.org/10.1002/2014JA020586

10 — 14 MLT sector: comparing $\Delta\rho$ to $\vec{S}$



- Narrow down to consider only estimates in the 10 — 14 MLT sector.
  - Very little structure (convergence/divergence/vorticity) in wind field.
  - Comparing $\Delta\rho$ (red) to $\vec{S}$ (**black**), one sees that the cusp density enhancement is always present, event when $\vec{S}$ is negligible.

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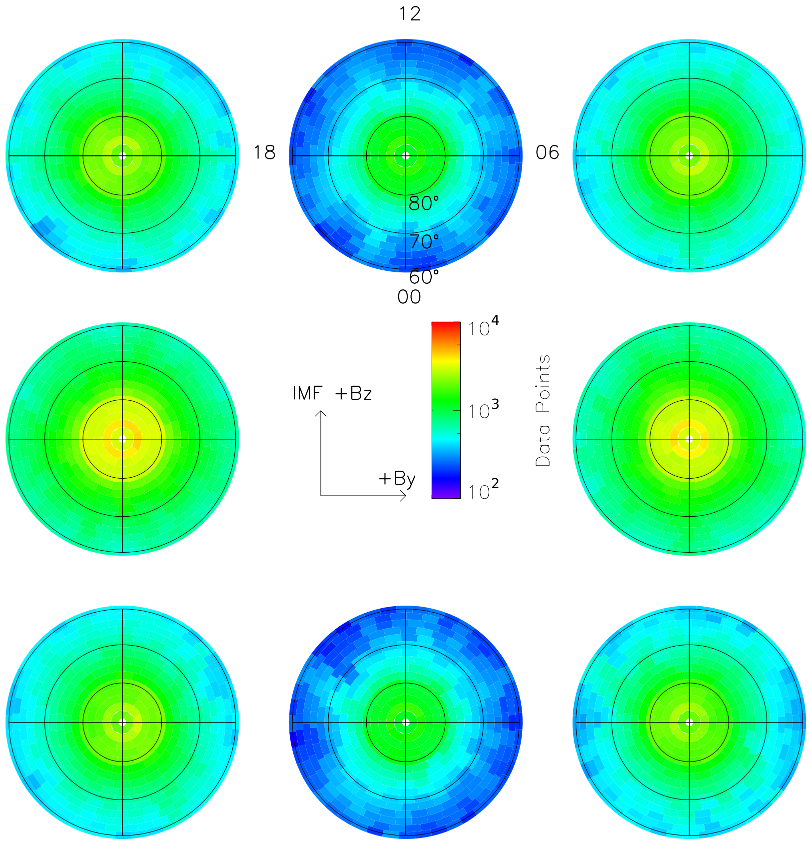
Summary and Conclusions

- 9 years of CHAMP data and 3 years of SuperDARN/AMPERE data were analyzed to gain a better understanding of the relationship between $\Delta\rho$ and DC $\vec{S}$.
  - Maps of $\vec{S}$ agree with previous work.
  - Maps of $\Delta\rho$ show structuring and correlation with IMF clock angle.
- It is difficult to compare both quantities without considering the thermospheric winds.
- In the 10—14 MLT sector, where the wind fields lack divergence/convergence, the cusp mass density is persistent.
  - Observed for all IMF clock angles.
  - Present even when DC $\vec{S}$ is not.
- DC $\vec{S}$ not a significant player for cusp density enhancement.

CaNoRock STEP School
Kananaskis, Canada
November, 2013

Estimates of DC Poynting Flux with SuperDARN and AMPERE

CHAMP
2001 — 2010



SuperDARN/AMPERE
January 1, 2010 — December 31, 2012