

# Space weather, SOTERIA and Swarm

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**National Science Foundation, USA**

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**CCMC, NASA Goddard Space Flight Center, USA**





# The SOTERIA consortium

- Catholic University Leuven, Belgium
- University of Graz , Austria
- Davos Schweizerisches Forschungsinstitut ,Switzerland
- Konkoly Observatory, Hungary
- CNRS, France
- Royal Observatory of Belgium, Belgium
- Observatoire de Paris, France
- Space Research Centre, Polish Academy of Sciences, Poland
- Research Institute for Particle and Nuclear Physics, Hungary
- DTU, Denmark
- University of Oulu, Finland
- University of Göttingen, Germany
- University of Zagreb, Croatia
- NOVELTIS, France
- P.N. Lebedev Physical Institute, Russia
- IEEA, France



# Focus

## A selected set of important Space Weather Parameters

- CME arrival time
- L1 Solar wind parameters
- SEP flux
- Magnetopause location
- Radiation belt flux and Ring Current
- Geomagnetic activity, Dst
- Auroral oval position, GIC
- Ionospheric Joule Heating
- Ionospheric Scintillations/TEC



# Main Soteria Space Weather Objectives

- Space weather monitoring
  - What is the coupling between **FOCUS parameters**?
  - Can we improve current monitoring of selected **FOCUS parameters** (Dst, Auroral oval position, others?) based on ESA satellite missions and ground-based data?
- Space weather prediction of the parameters
  - Which are the major factors of impact?
  - How well does current models predict the **FOCUS parameters**?
  - Can we suggest improvements? New data assimilation schemes?

Requires real-time data products

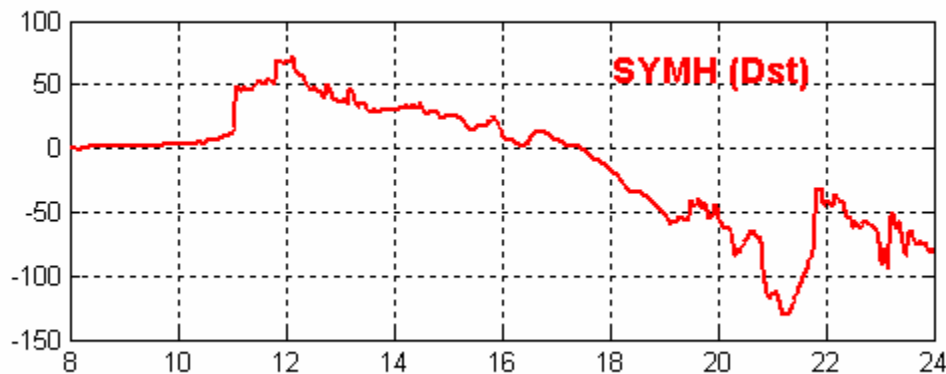
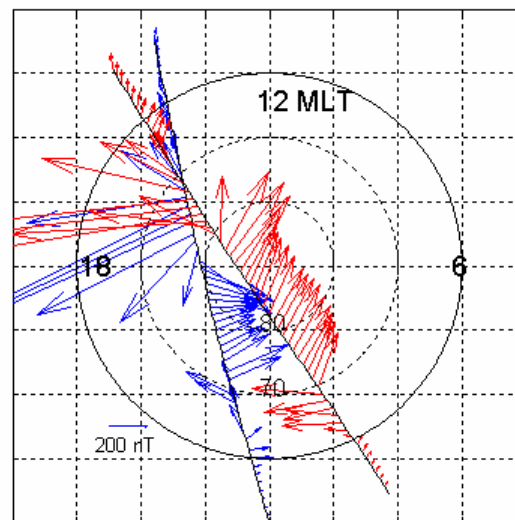
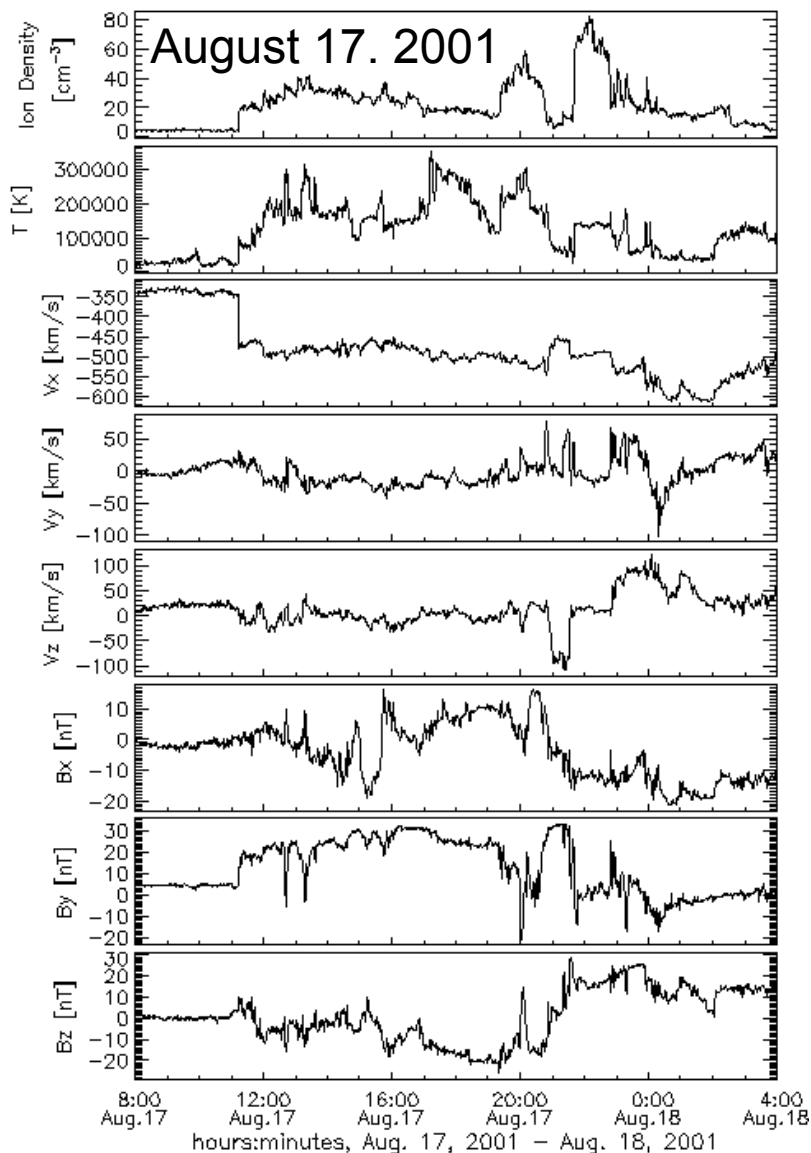


# Detailed study of CME events

August 17, 2001



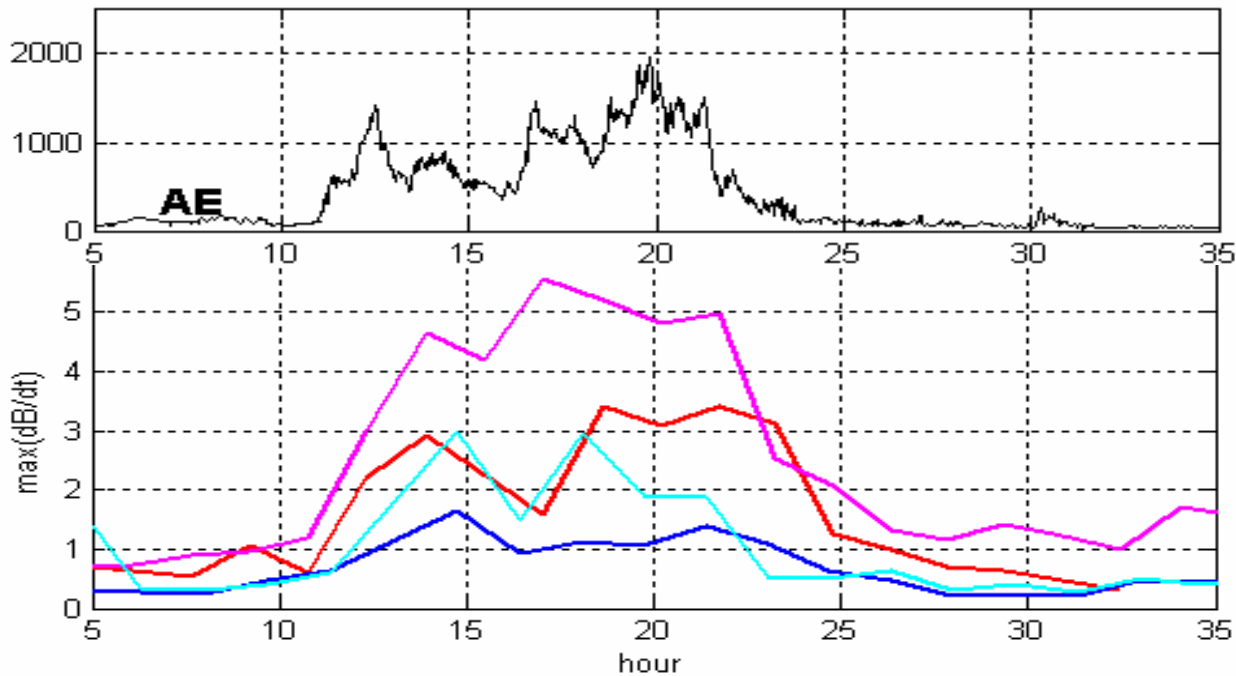
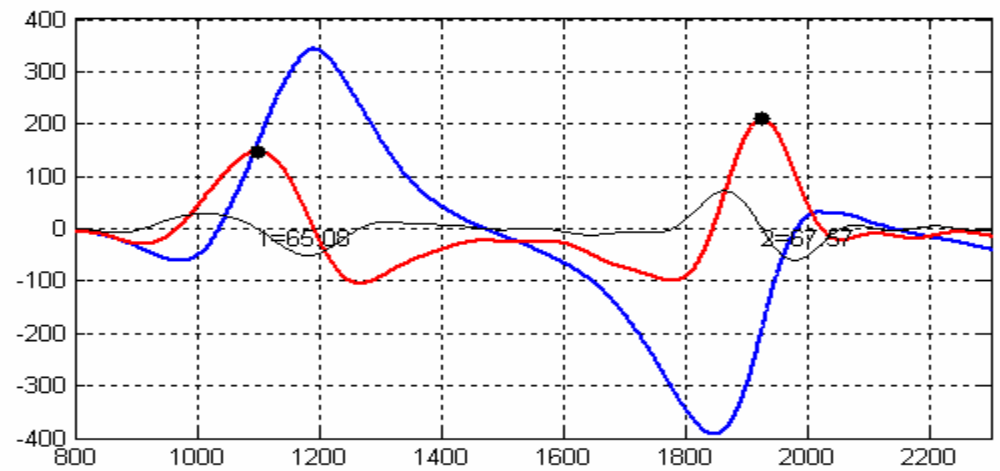
Ørsted and CHAMP



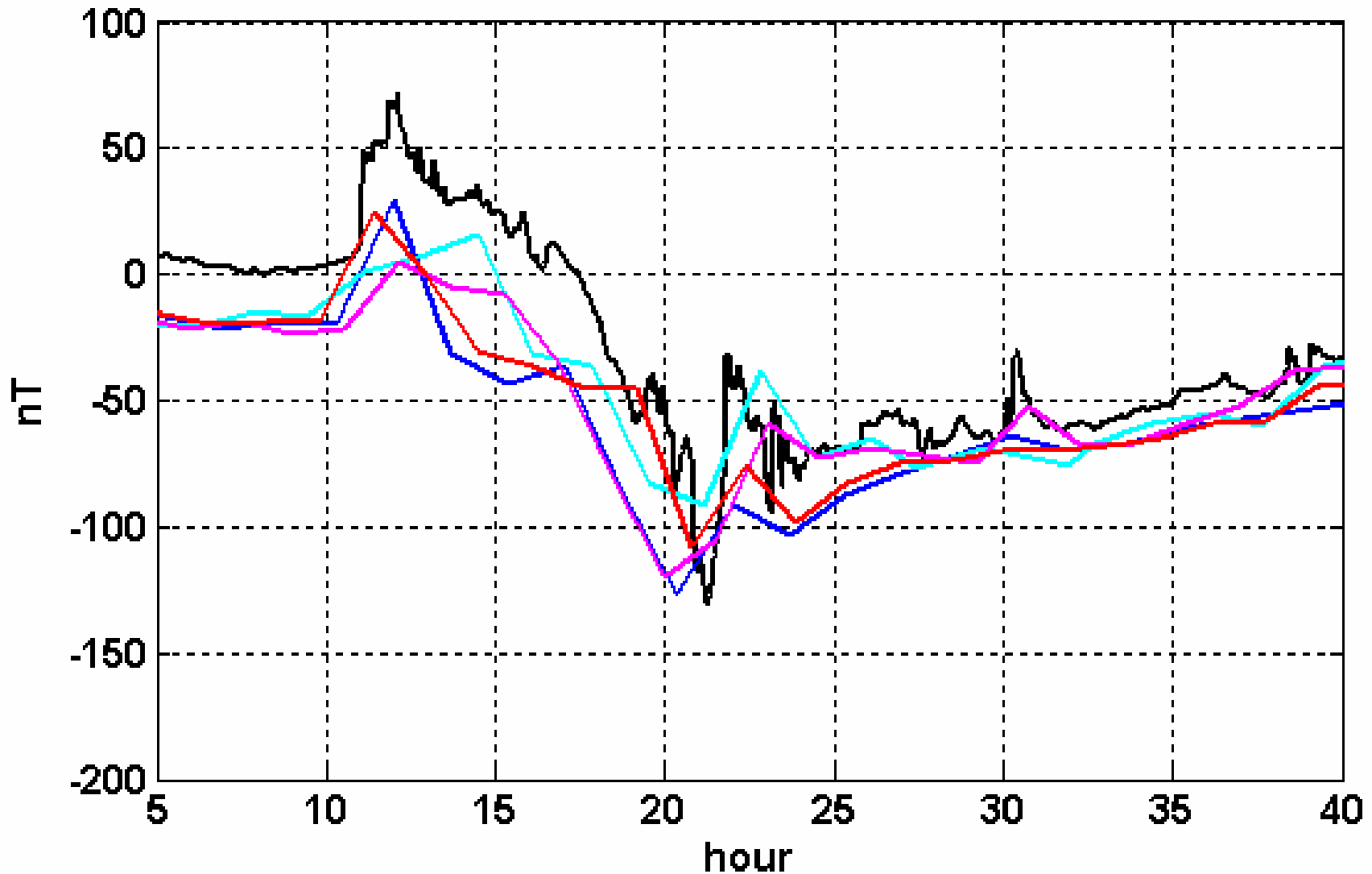
# Auroral electrojets

observed with  
Ørsted and CHAMP

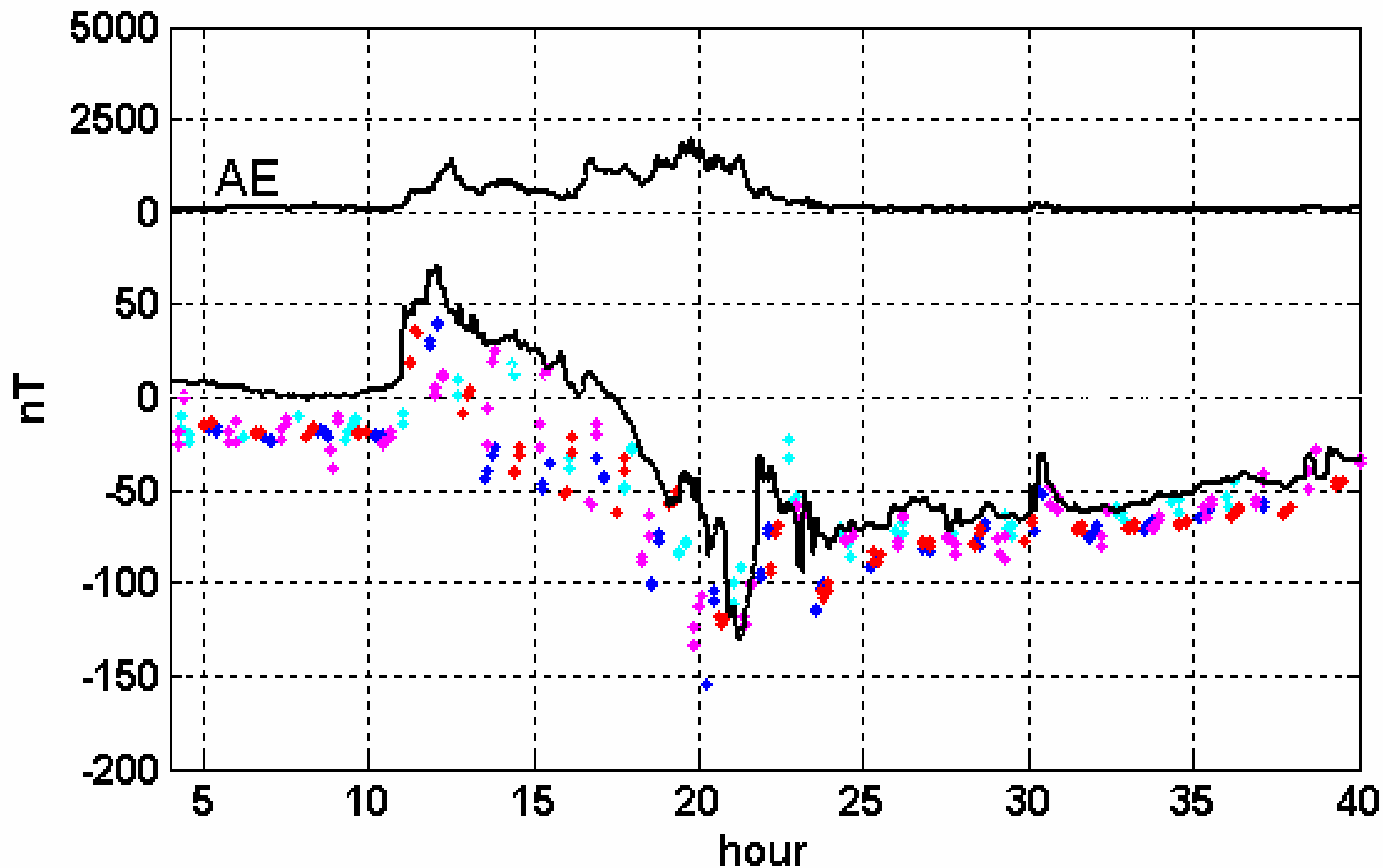
- Latitude
- Intensity



# Bz between $-50^\circ$ and $50^\circ$ magnetic latitude Ørsted and CHAMP measurements

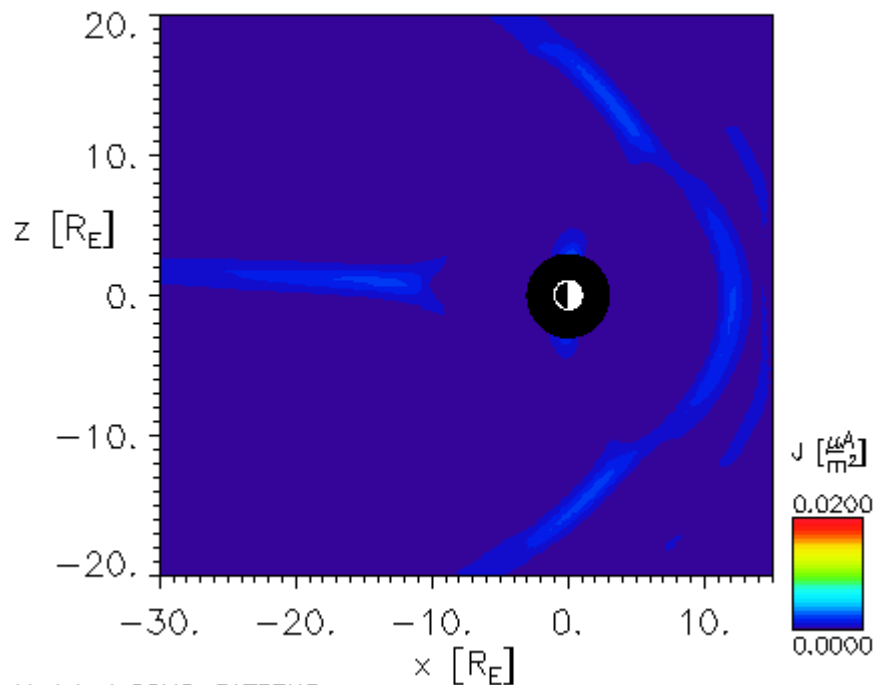


# Coupling between high latitude and low latitude

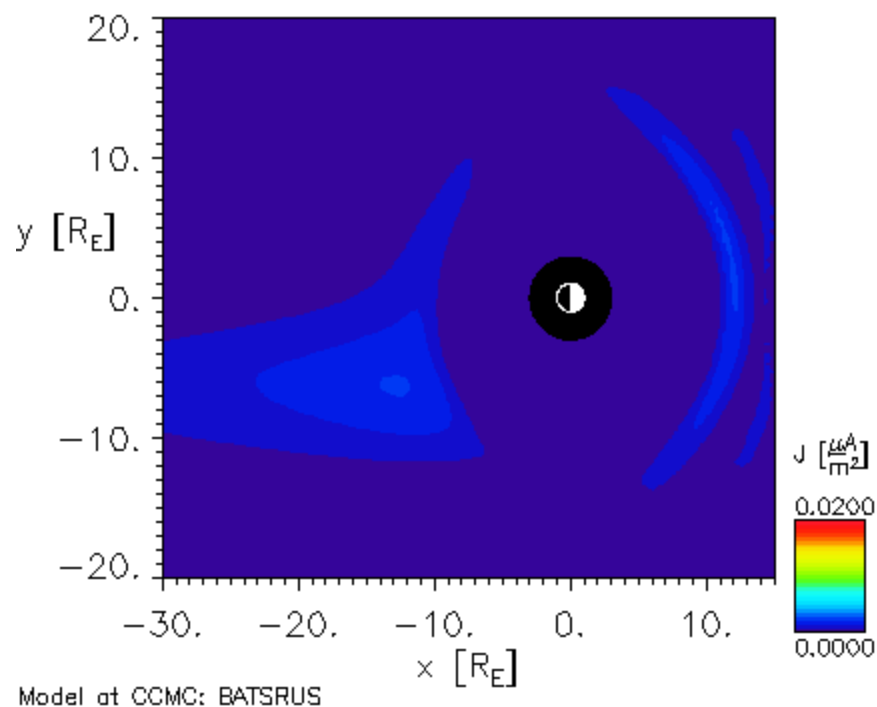


Coupled global MHD and inner magnetosphere models ( )

08/17/2001 Time = 08:00:00 UT  $y = 0.00R_E$

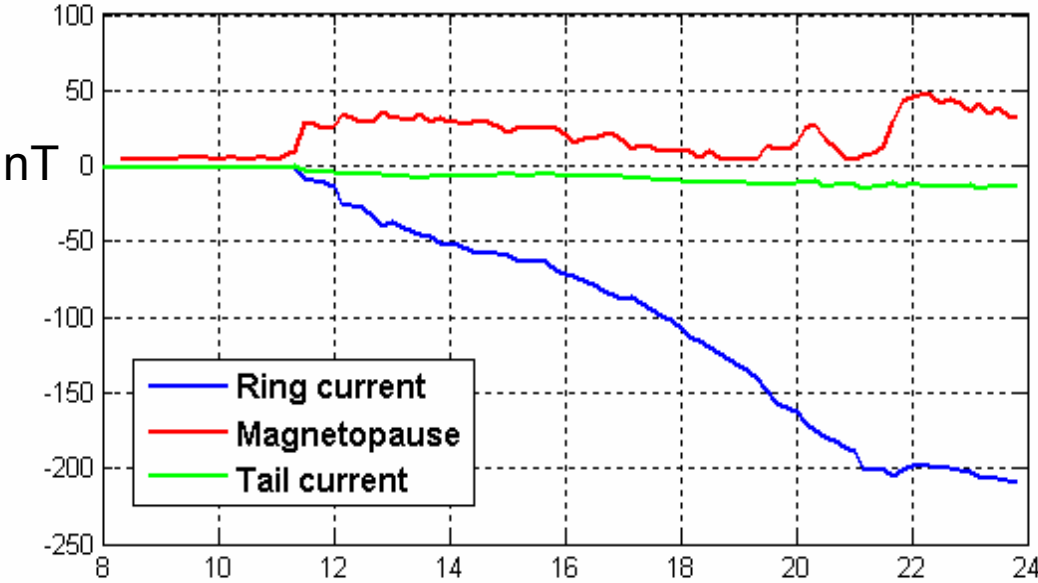
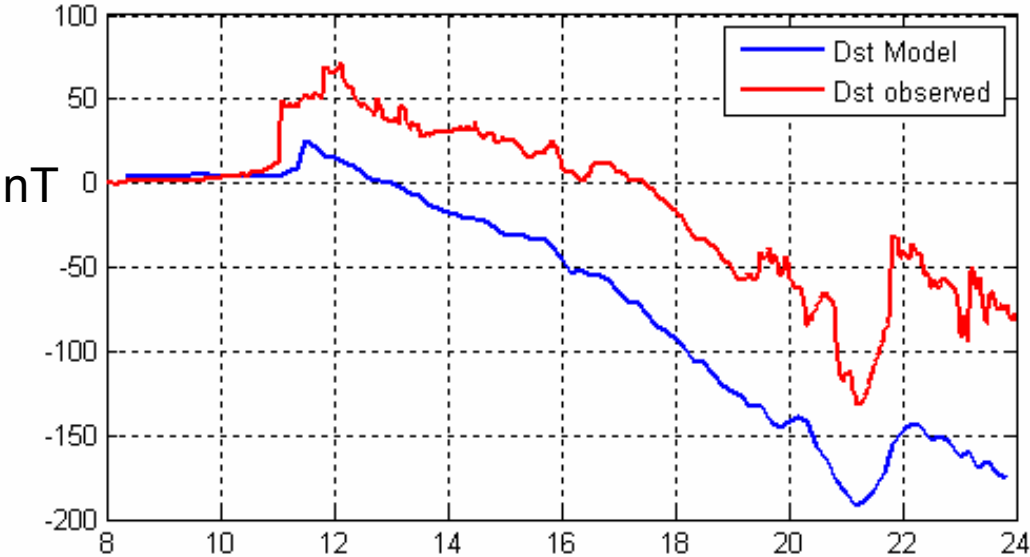


08/17/2001 Time = 08:00:00 UT  $z = 0.00R_E$



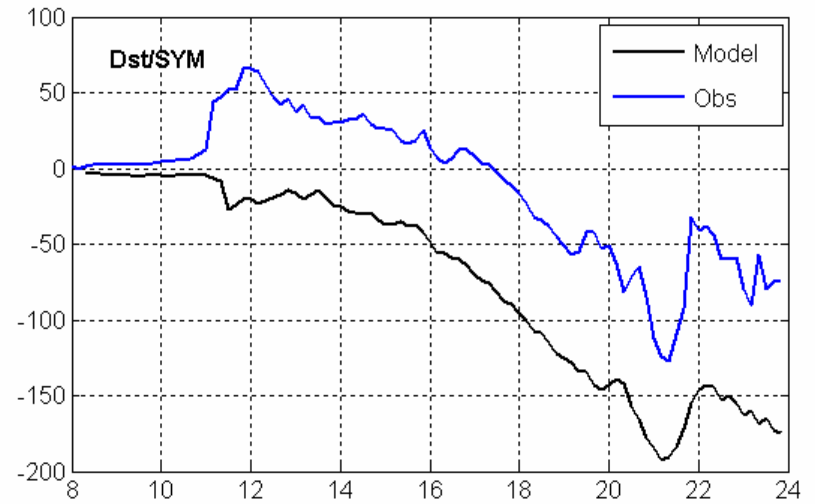
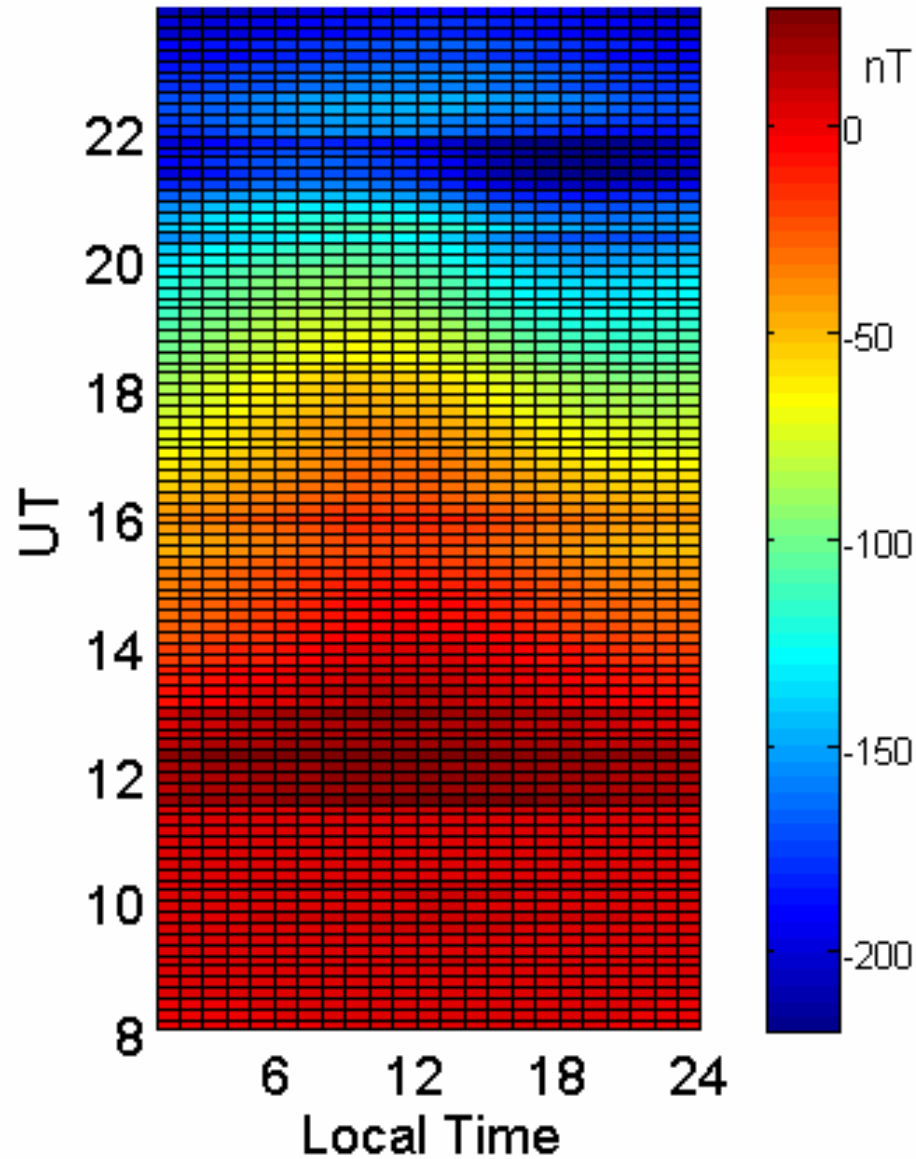
# Dst – Model estimate

Model – Obs  
comparison

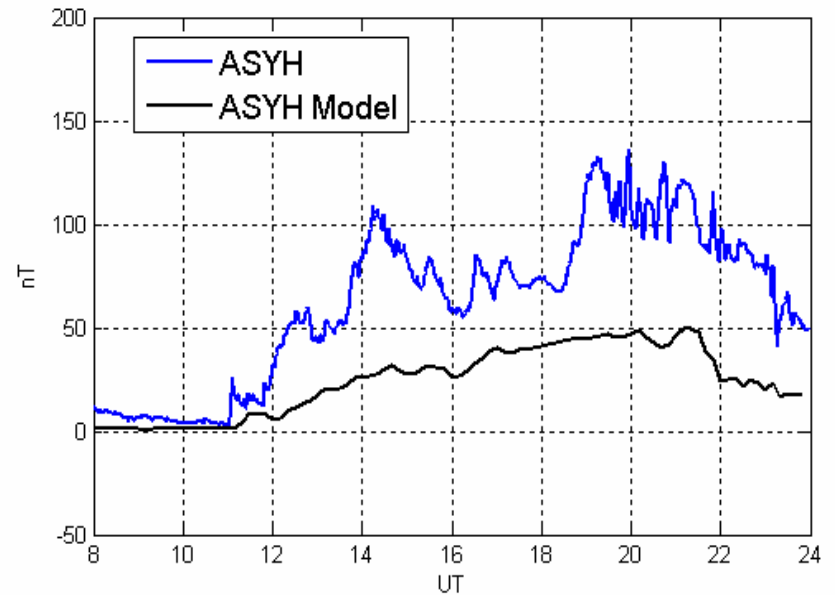


Model –  
Different  
contributions

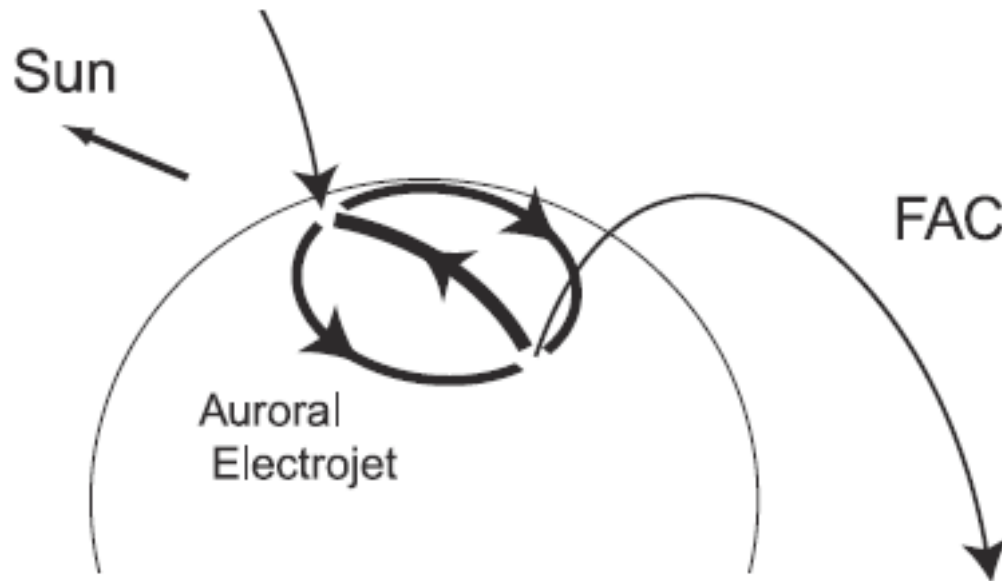
# $\Delta H$ in low latitude region



# Ring current asymmetry ASYH



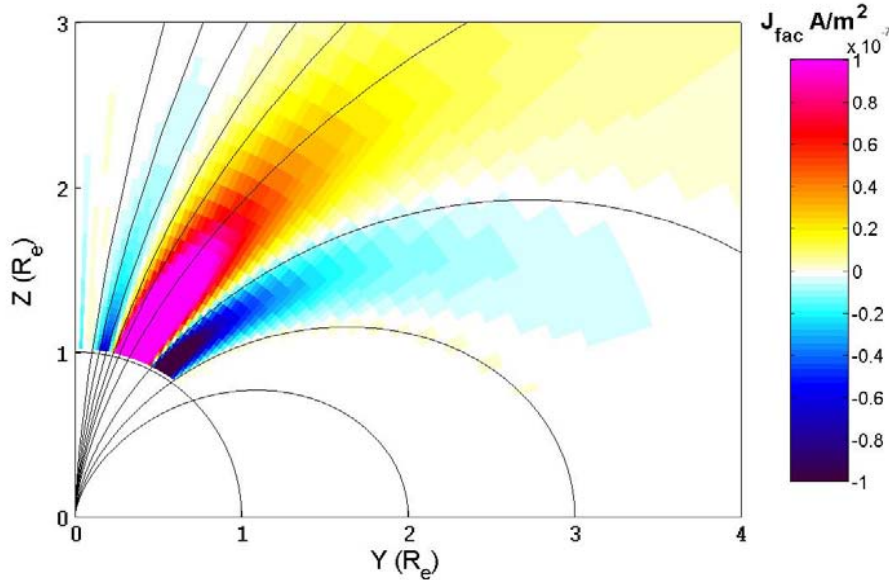
”Birkeland currents as the cause of the low latitude asymmetric disturbance field” Crooker and Siscoe, 1981



# 3D statistical model of high-latitude FACs

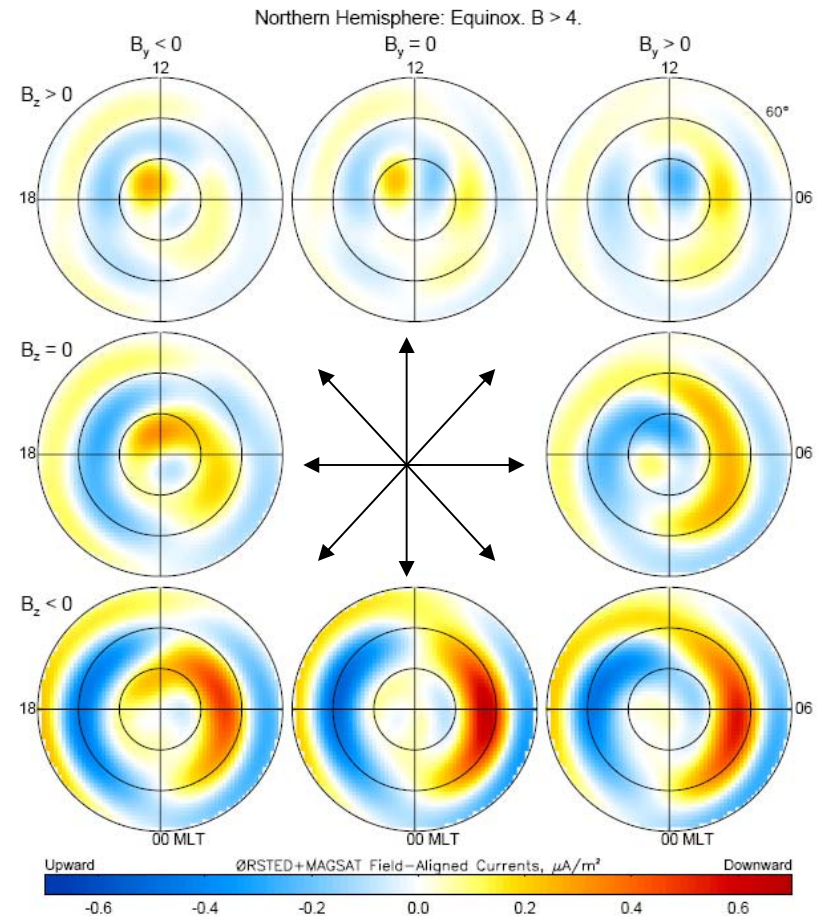
$$\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}(\mathbf{r}') \times (\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} dV'$$

## Upward continuation of FACs



*Vennerstrom et al. 2007*

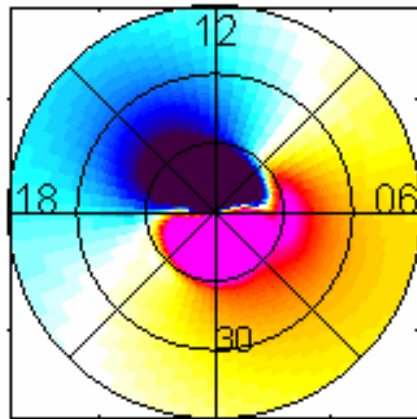
## IMF-dependence



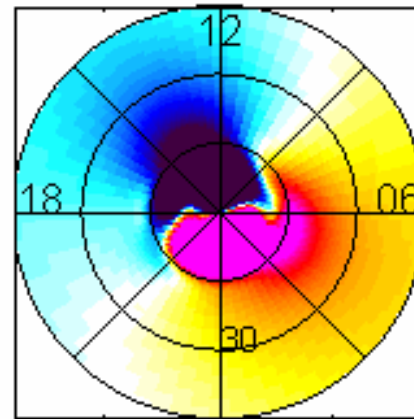
*Papitashvili et al., GRL 2002*

# $\Delta H$ in low latitude region (FACs), Moderate activity $B_z < 0$

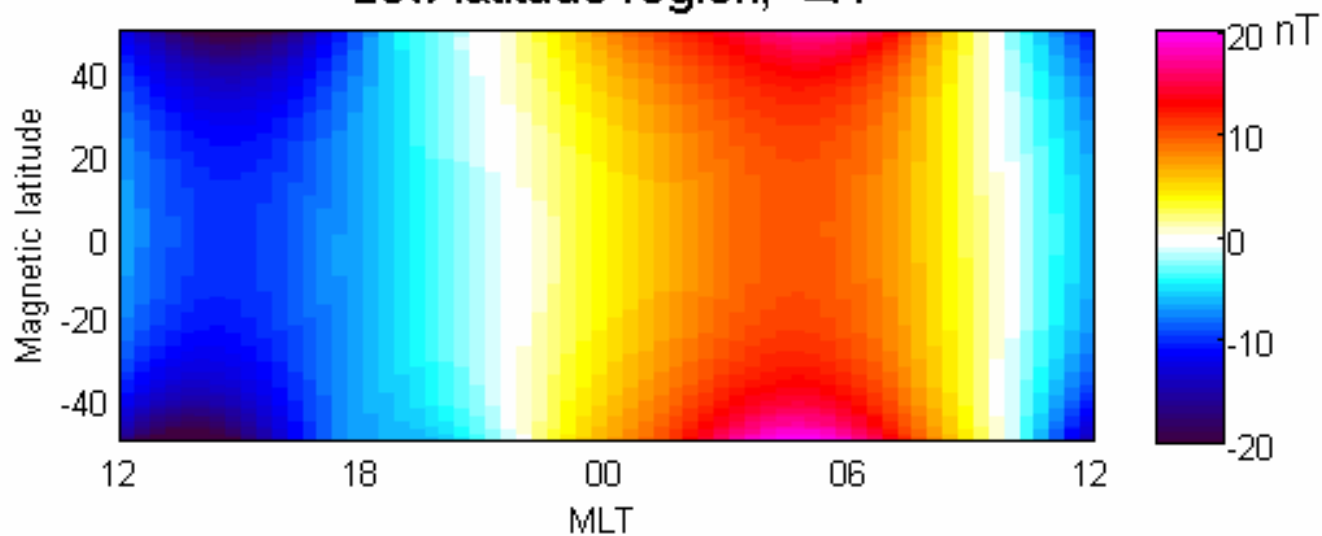
### Northern hemisphere



### Southern hemisphere

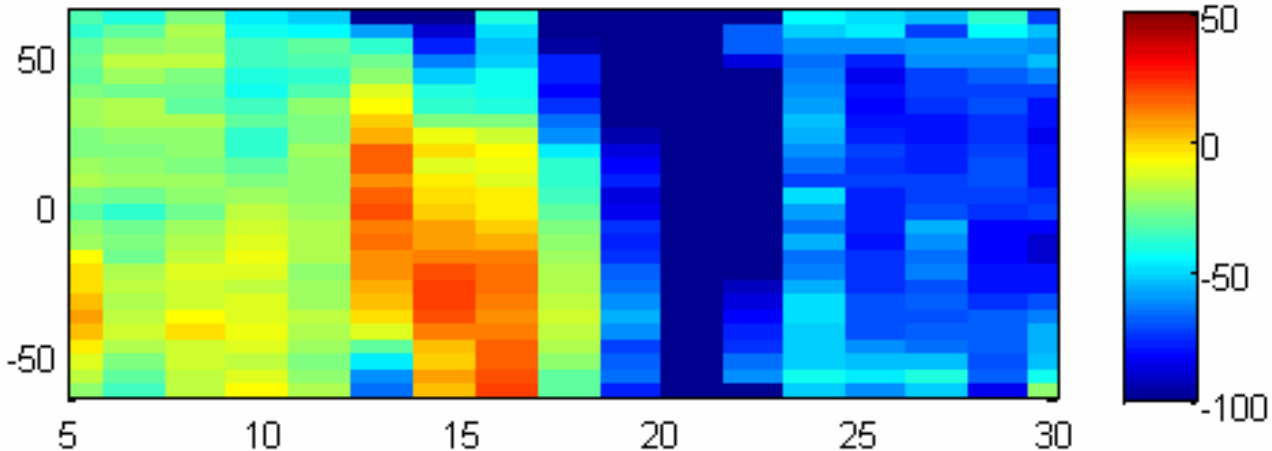


### Low latitude region, $\Delta H$

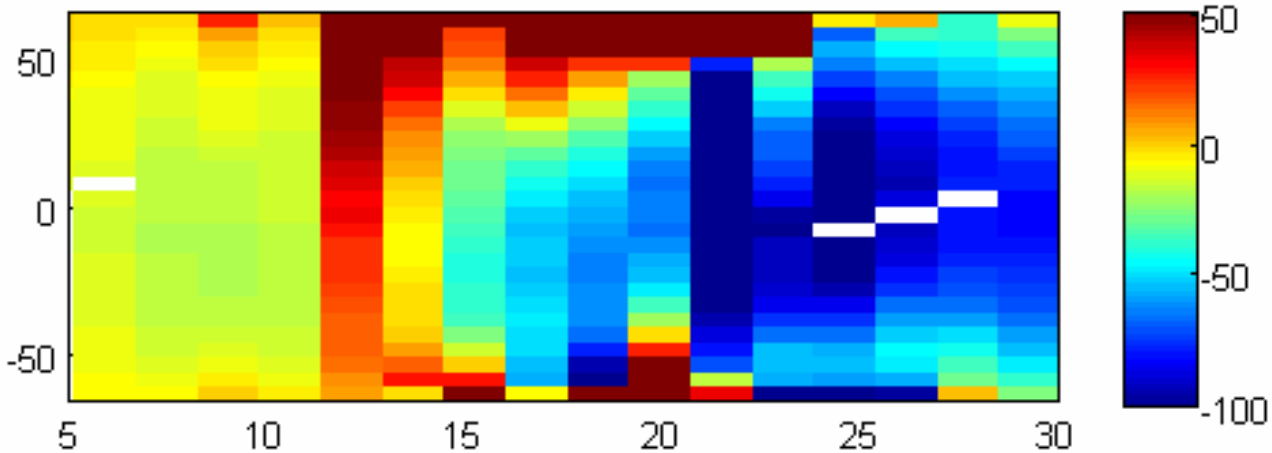


# Note effect of distant FACs

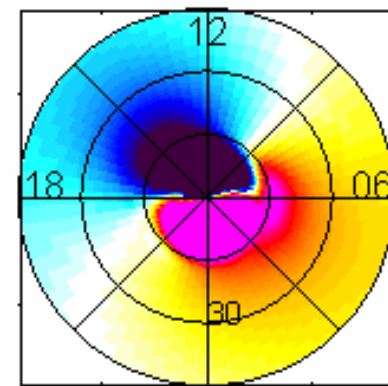
Dayside H, CHAMP



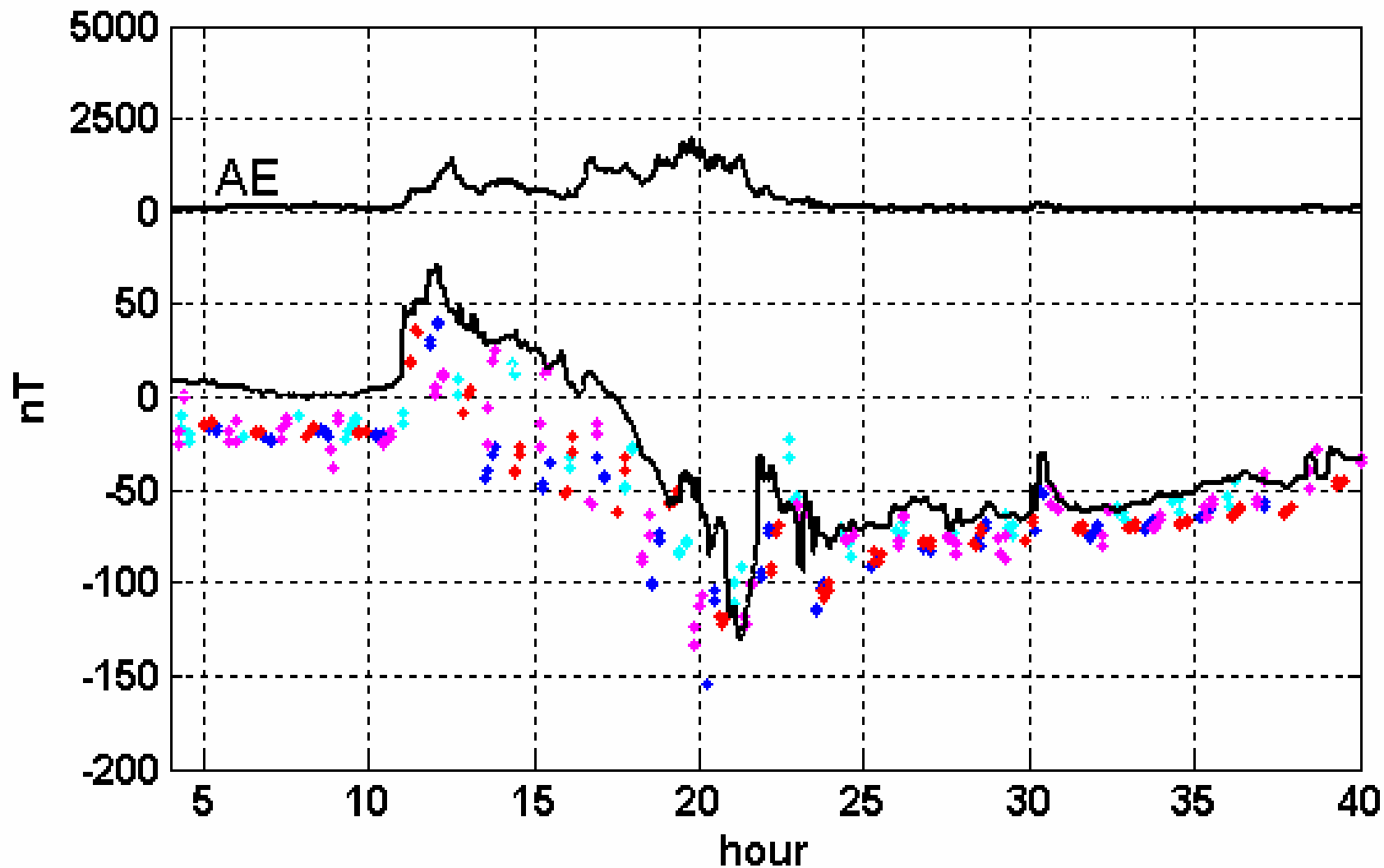
Nightside H, CHAMP



Northern hemisphere



# Coupling between high latitude and low latitude



# Summary

- Swarm has a significant potential for space weather monitoring real time
- Emphasis should be on products where satellite data has an advantage over ground-based monitoring.
- We suggest in particular as new products:
  - Auroral oval/electrojet latitude
  - Partial ring-current or high-low latitude "coupling index"
  - Dst