Importance of Satellite Data in space weather modelling

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Introduction & Objectives

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- Solar Terrestrial Environment
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  - Present Research
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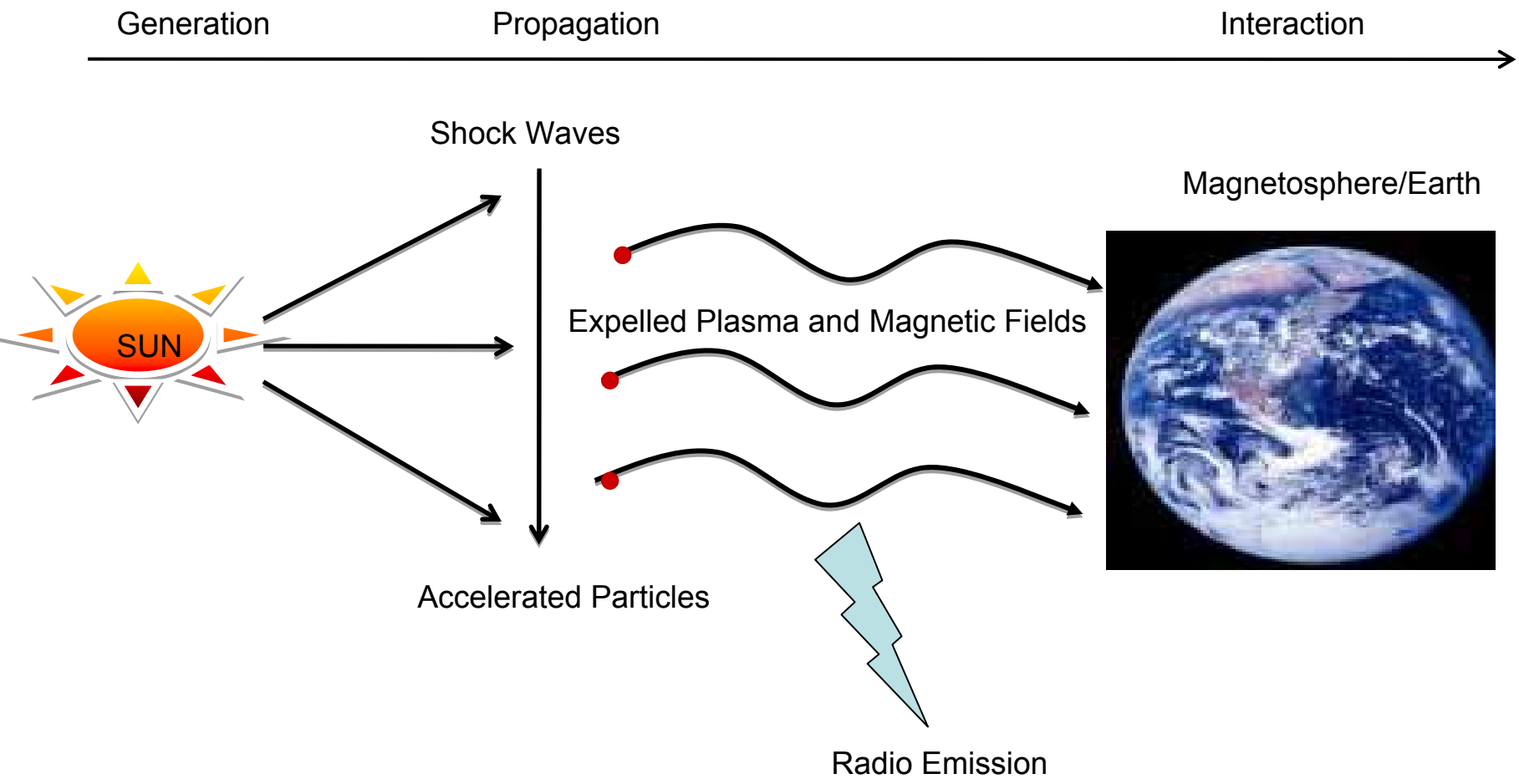
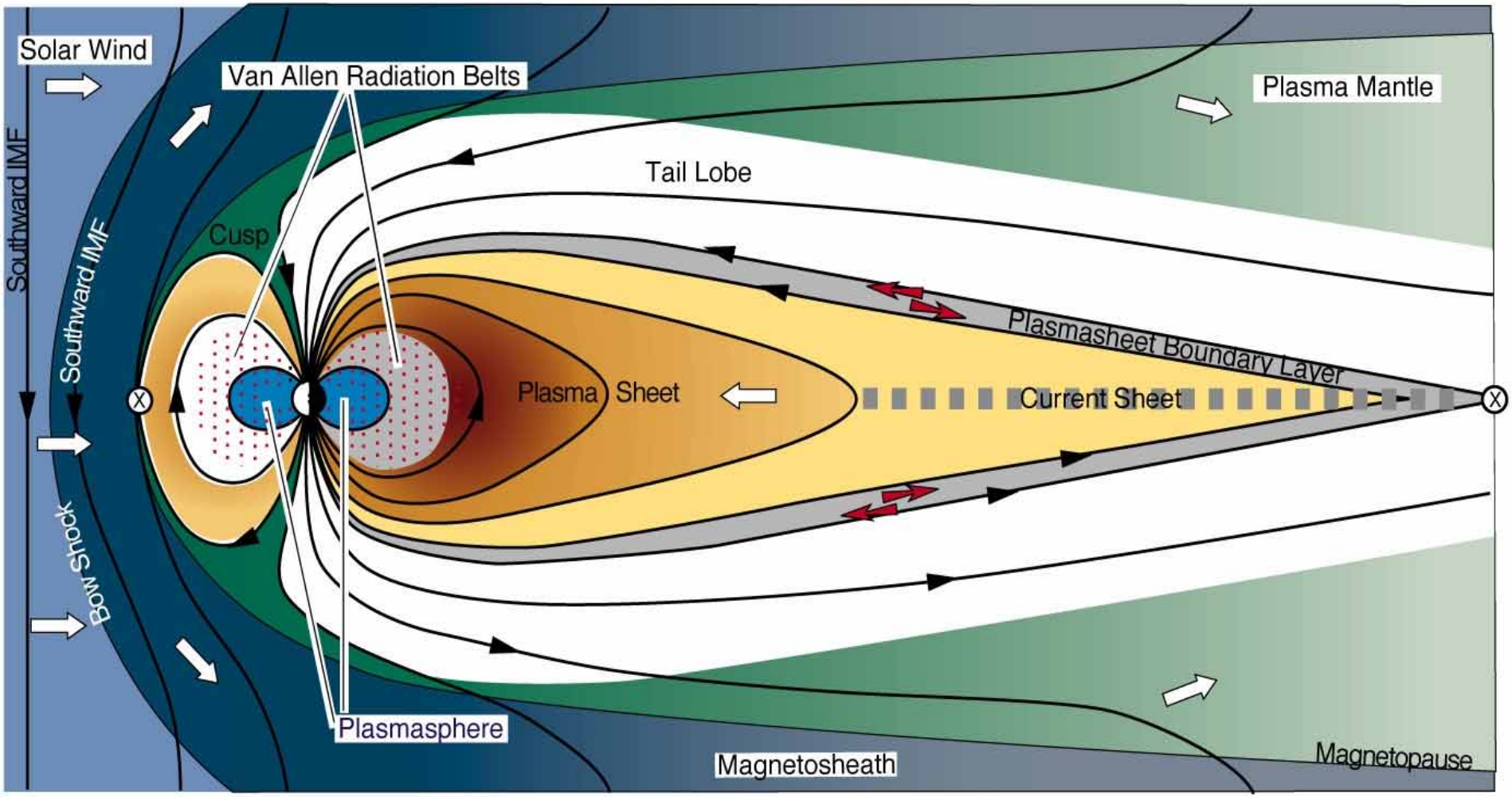
Space Weather Dynamics



Regions of the Magnetosphere

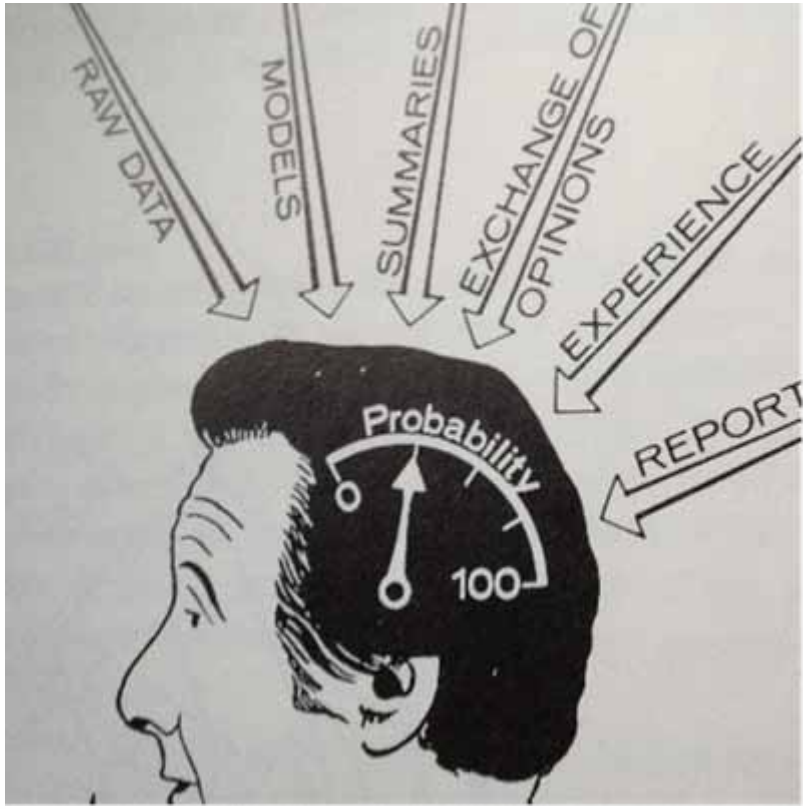


Sun-Earth Environment

- The sun Earth environment is made of couplings:

✓ Solar Interior-Solar Atmosphere
✓ Solar Atmosphere-Solar Wind
✓ Solar Wind-Magnetosphere
✓ Magnetosphere-Ionosphere
✓ Ionosphere-Atmosphere

Data VS Model!



Models

- Ways of making sense out of data (J.Hughes)

- Inputs are usually:
- ✓ Time (MLT or UT),
- ✓ Geographic location,
- ✓ solar activity factors
- ✓ Space borne and ground based data

Data

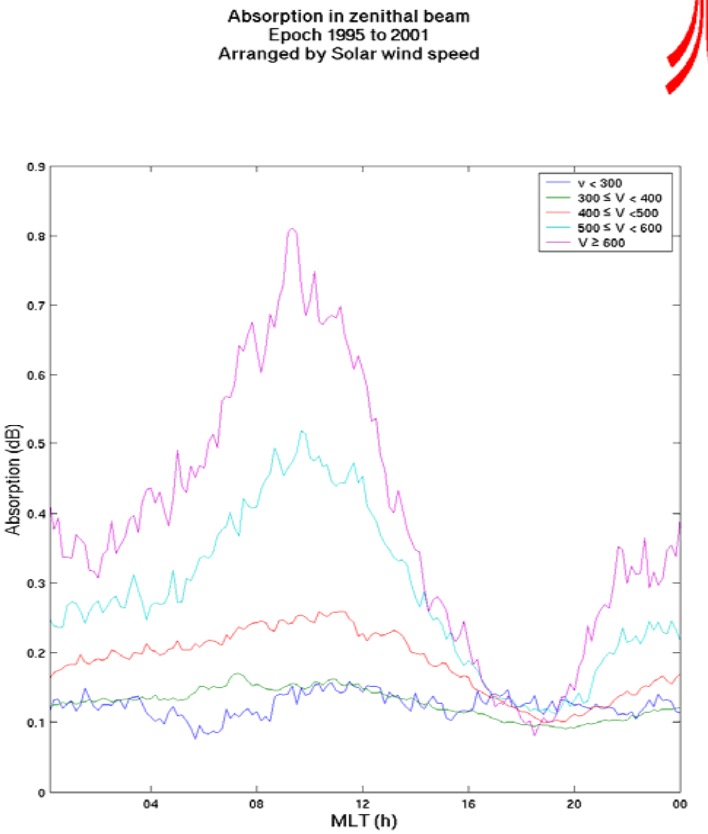
- Serve as inputs to scientific models, gives sense to model
- Informs on space situation awareness
- Concerns: Sources, Accuracy, Calibration and Analysis.

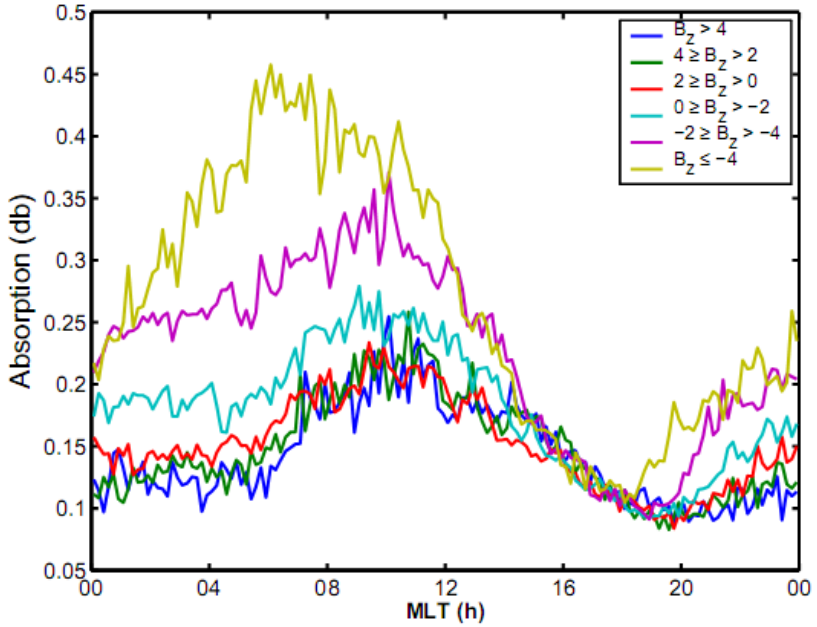
Absorption: What it is and why we care!

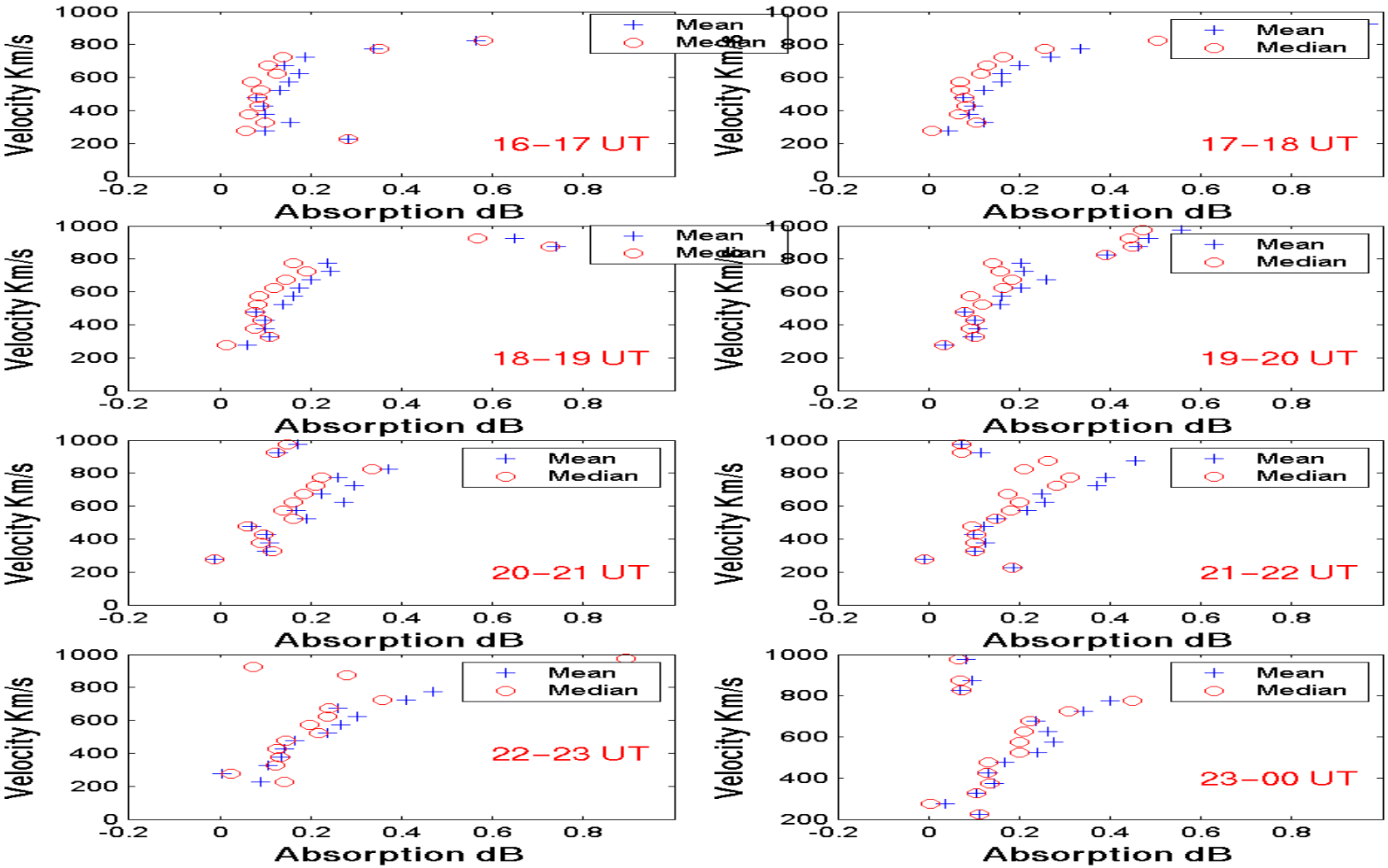
- it is an indicator of an enhancement of electron density in the D-region of the ionosphere. Mostly due to electrons with energy in excess of ~30 keV precipitating from the magnetosphere.
- Radio propagation is via the ionosphere and absorption mutilates.

Absorption Type	Occurance Time	Causes	Index of prediction	Precursor	Expected Intensity	Latitude	Duration
SCNA	Anytime	SID(Enhanced changes in solar wind)	f.10	solar flare	not yet known	Auroral zone	several minutes
SCA & SIA	Day time	Sudden changes in solar wind pressure	Solar wind parameters	Geomagnetic SSC	0.1-7dB	Auroral zone	Few tens of minutes
PCA	Day time	Ionization in the D-region	pfu & SSN	Major solar flare	less than 1dB weak, less than 2dB Medium, greater than 2dB Strong	Polar cap &Auroral zone	Several days 1-2 weeks
Midnight auroral Absorption	Midnight	precipitation of auroral electron in the energy range of 10-100KeV	Dst	Not yet known	Quite intense	Auroral zone	Few minutes to few tens of minutes
SVA	Day time	Precipitation of electron in the range 30-300KeV to the D & lower E regions	Dst	Injection of intense cloud of energetic electron during auroral substorm expansion phase	0-5dB	Auroral zone	Half an hour to few hours
Relativistic Electron Precipitation	Noon	Hardness of electron energy spectra & ionization	Dst	Eastward drifting energies electron turning into stable population with relatively hard spectrum (30KeV-1MeV)	Noticeable intensity	Auroral zone	Few Minutes
Westward Travelling Surge	Midnight	Rapid wavy motion of auroral arcs lying in the evening sector	Dst	Auroral substorm	few dB	Auroral zone	few minutes to few tens of minutes

Absorption for different Solar wind speed and IMF z-component (A.J Kavanagh et al 2001)






Absorption vs Solar Wind Velocity
January 1995–2006, Hours 16–00
Velocity Km/s
Absorption dB
Mean
Median
16–17 UT
17–18 UT
18–19 UT
19–20 UT
20–21 UT
21–22 UT
22–23 UT
23–00 UT

Solar Wind-Magnetosphere Coupling Functions

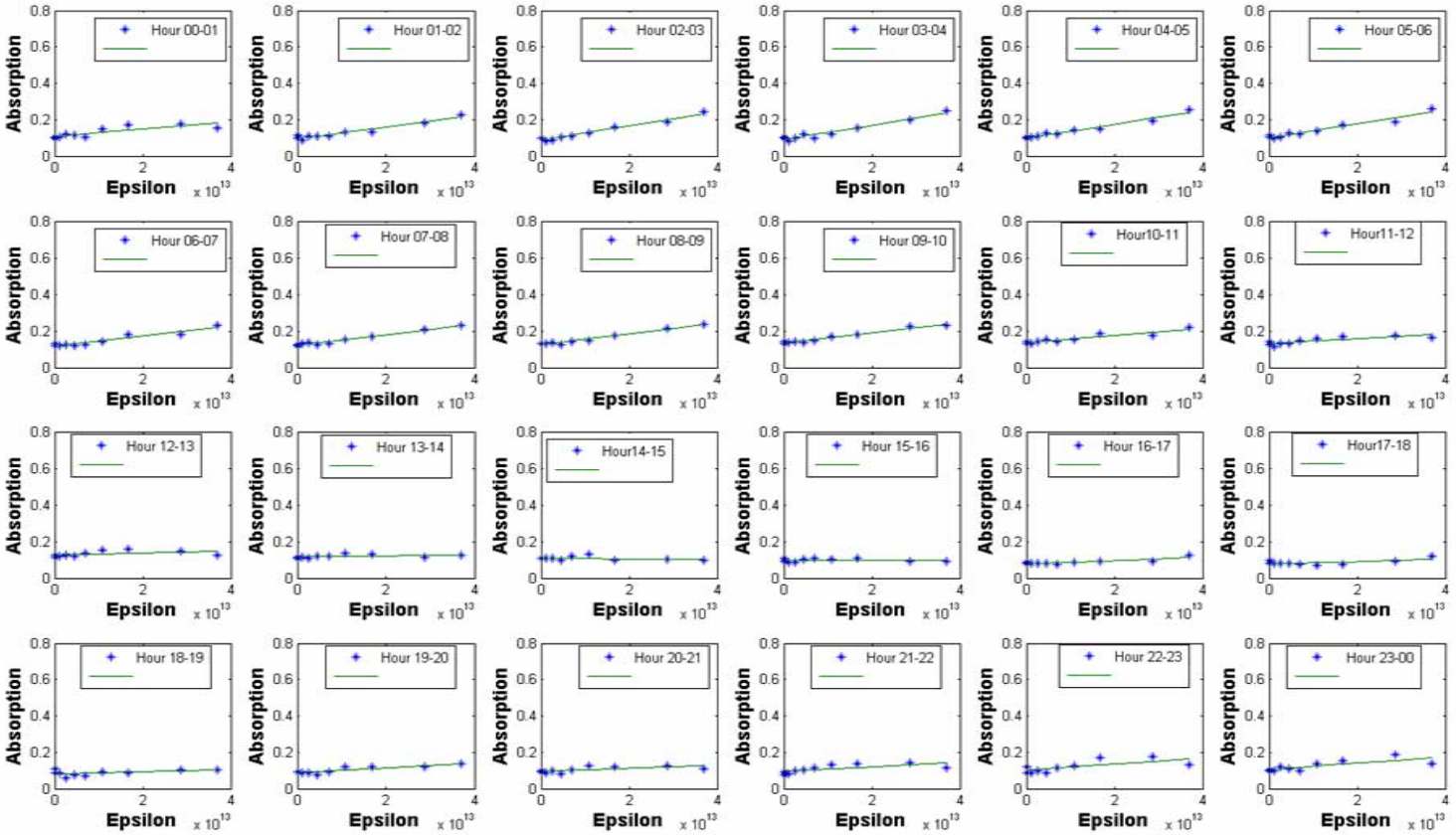
- Aim: Quantifying transferred energy , momentum and Mass

S/N	Name	Coupling Function	Reference
1	I_B	VB_s	Burton et al [1975]
2	ε	$VB^2 sin^4(\theta/2) {l_o}^2$	Perreault and Akasofu[1978]
3	E	$VB_T sin^2(\theta/2)$	Kan & Lee [1979]
4	I_V	$n^{1/6} V^{4/3} B_T sin^4(\theta/2)$	Vasyliunas et al [1982]
5	I_N	$V^{4/3} {B_T}^{2/3} sin^{8/3}(\theta/2)$	Newell et al. [1982]
6	I_w	$VB_T sin^4(\theta/2)$	Wygant et al [1983]
7	I_{SR}	$P^{1/2} VB_T sin^4(\theta/2)$	Scurry and Russell [1991]
8	I_{TL}	$P^{1/2} VB_T sin^6(\theta/2)$	Temerin and Li [2006]
9	F_k	$_{a}V_{sw}\{[(kB_y)^2 + B_z^2]^{1/2} - B_z\}^{1/2}$	Lyatsky et al [2007]
10	P	$V^{\frac{4}{3}} B^{\frac{2}{3}} sin^{\frac{8}{3}}\left(\frac{\theta}{2}\right)$	Newell et al [2007]

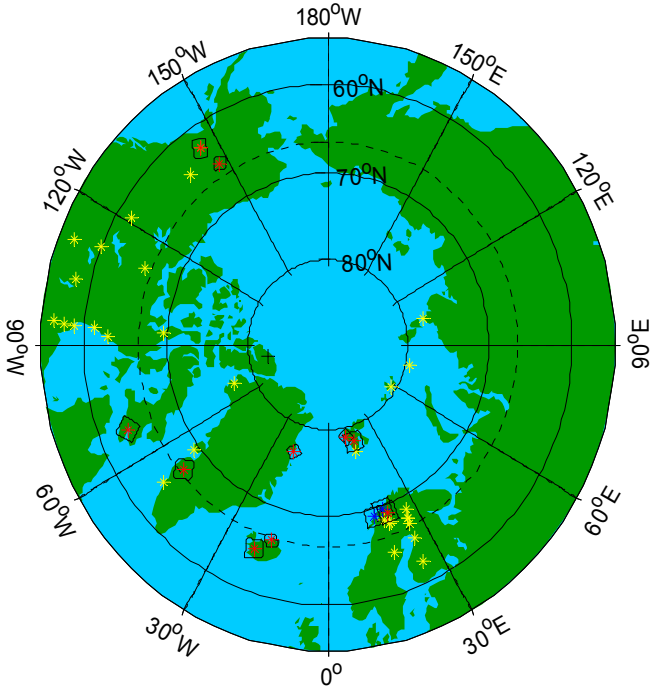
Epsilon Parameter

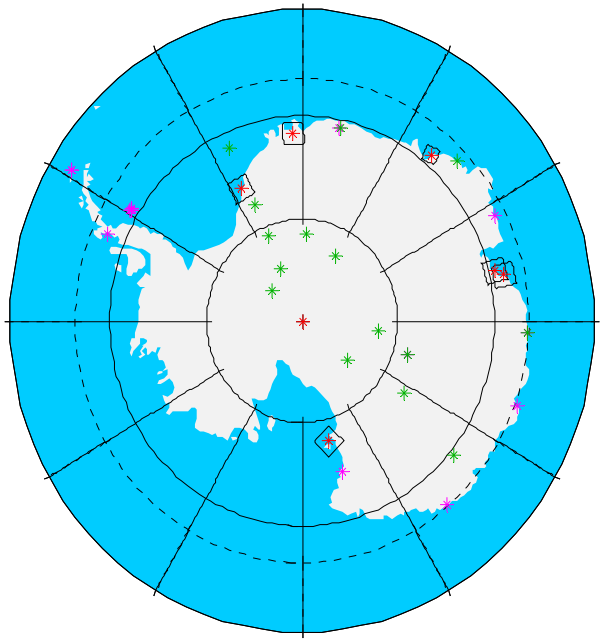
- A quantitative measure of the energy input to the magnetosphere.The magnetosphere is regarded as a driven system rather than an unloading system
- Mathematically: $\varepsilon = VB^2 \sin^4(\theta/2) * {}^2 \ell_o^2 \text{ergs}^{-1}$
- **V= Solar Wind Velocity, B=Total IMF, θ=clock angle, ℓo=7RE**
- (after Akasofu 1983)

Hourly variation of Epsilon with Absorption



Global Riometer Array





Summary

- Current models of absorption based on Kp values are somewhat unreliable since low absorption is possible during high geomagnetic activities
- An hourly AA model has been derived as a function of SW and Epsilon Parameter.
- There is a need to improve this still further by inclusion of other factors such as time history of SW instead of the instantaneous value.
- A truly global forecasting AA model is possible with available data from Global Riometer array (Gloria).

Thank You!