Radiation Belts and Ring Current
The Energetic Geospace

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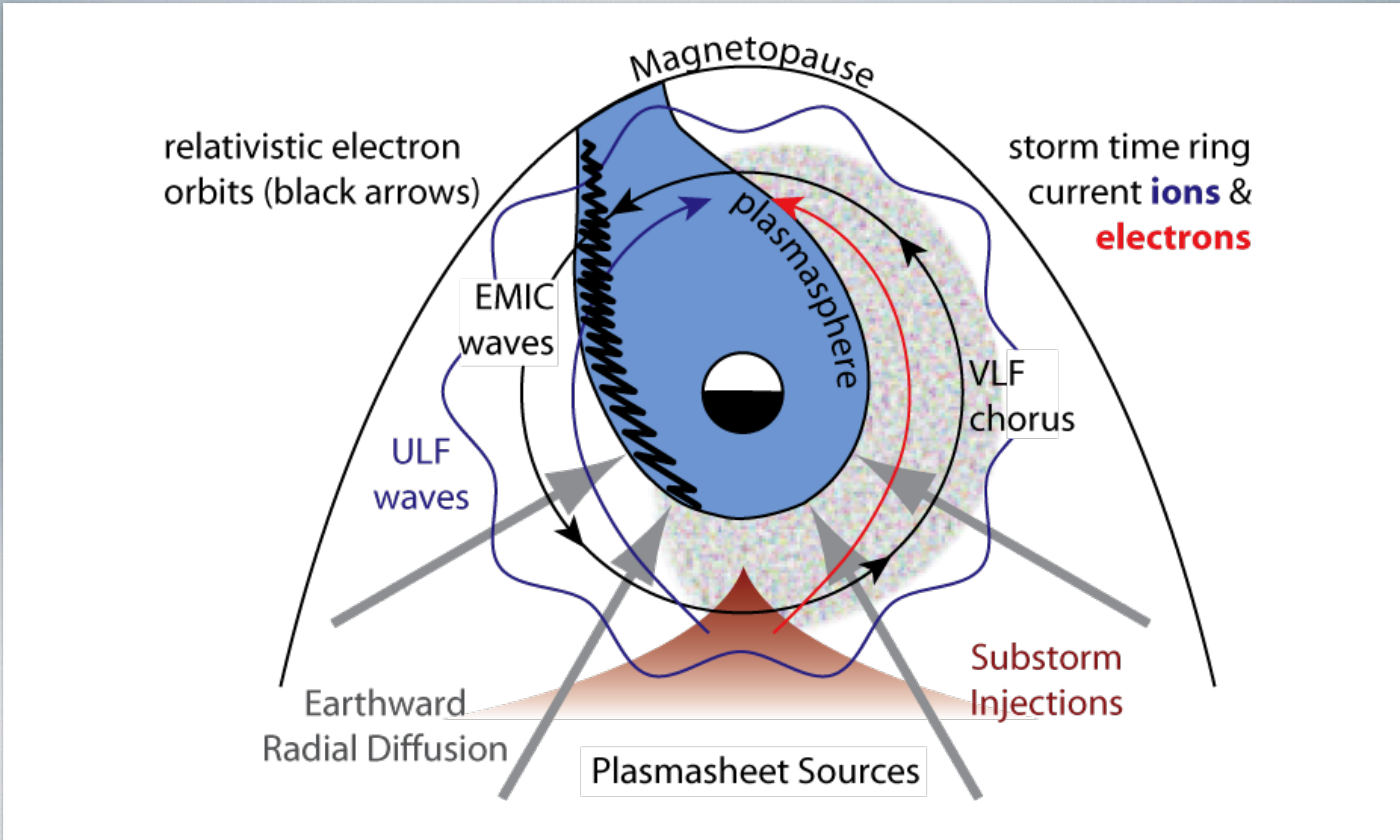
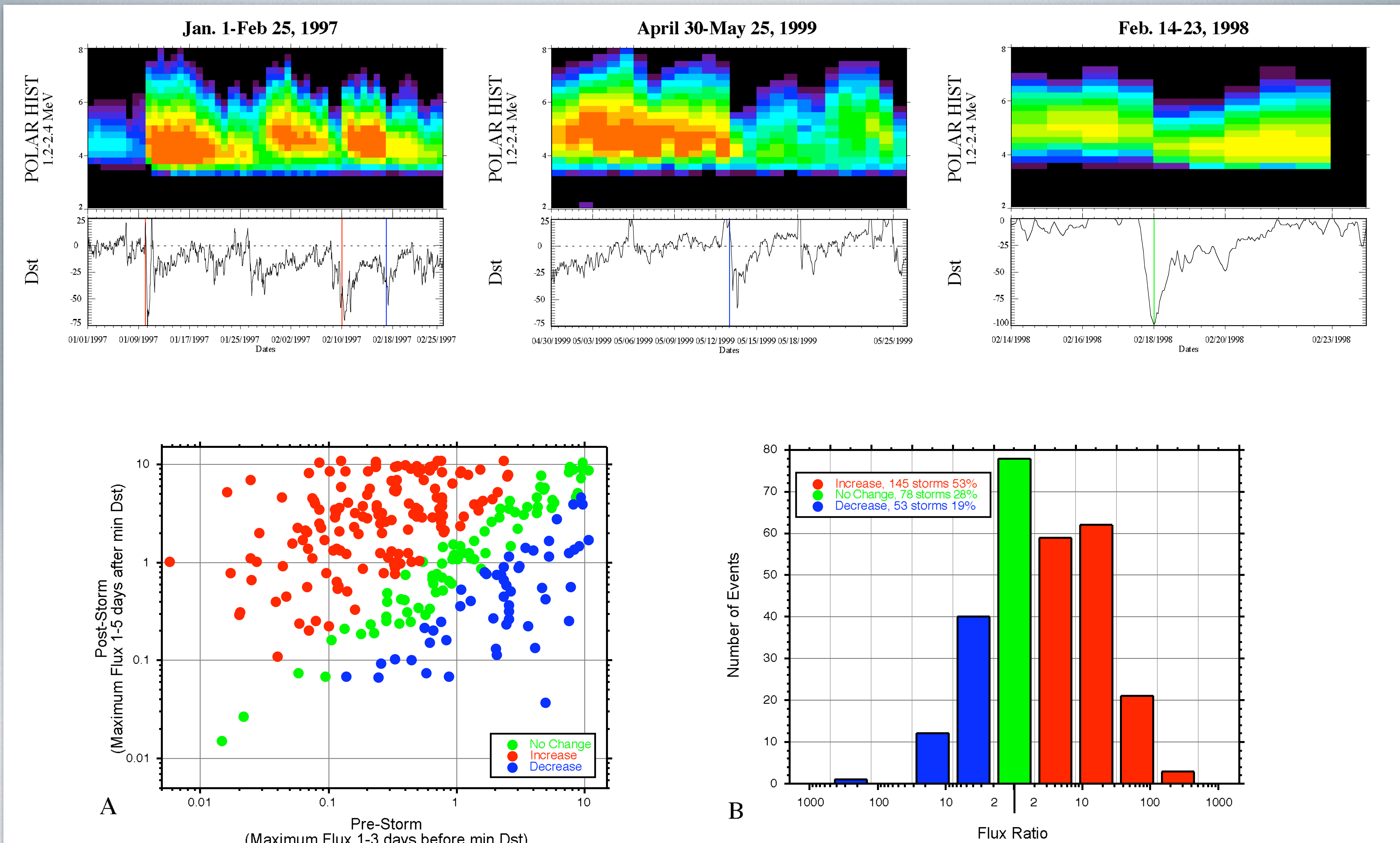
Geospace revisited: Cluster/MAARBLE/Van Allen Probes
September 2014, Rhodes Greece

We Want To Disentangle This Picture



Reeves, SW 2007; after Summers et al., 1998

And Ultimately Predict Storm-Time Responses



Reeves et al., GRL, 2003

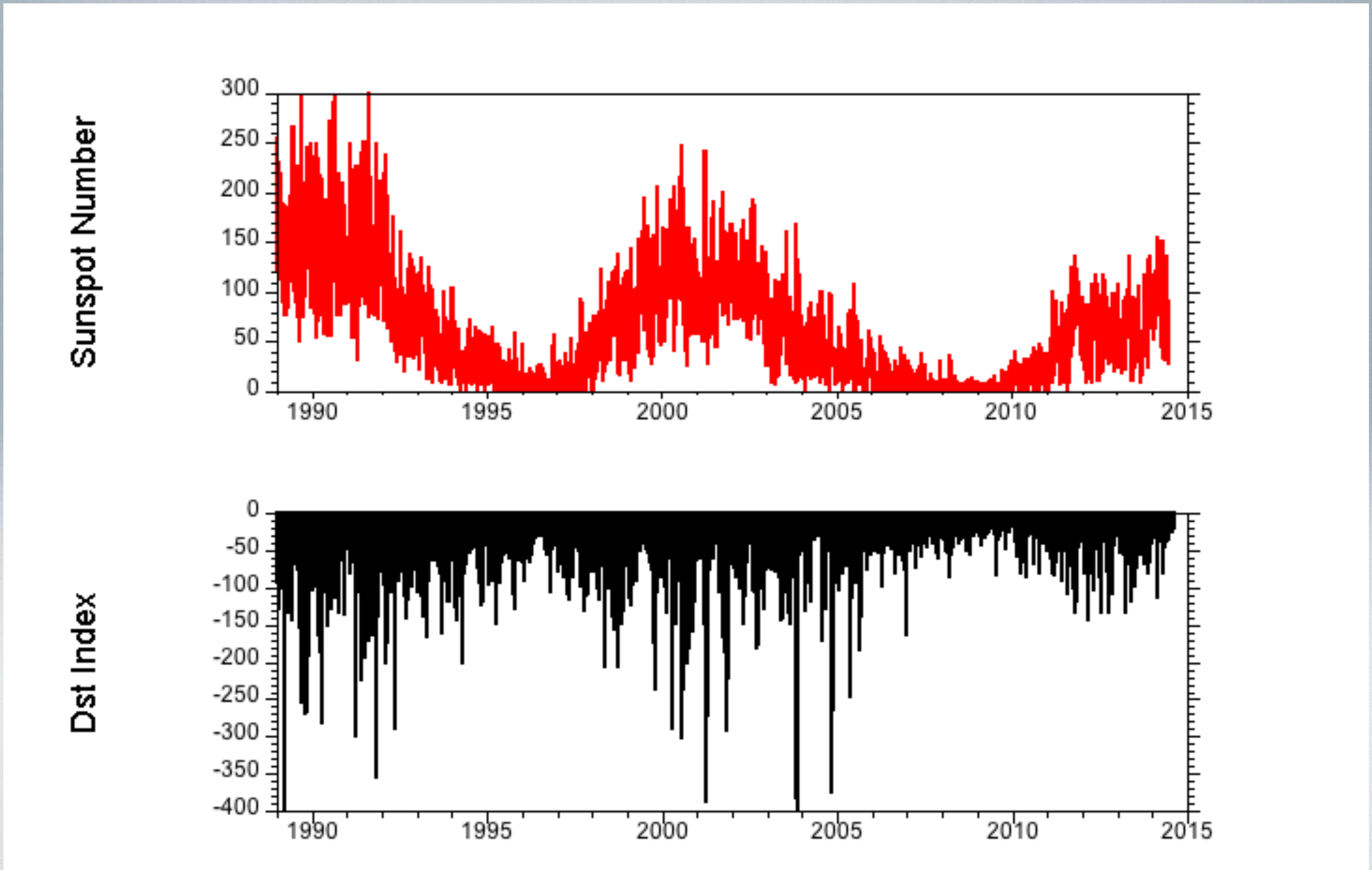
My Outline

Van Allen Probes Overview
Energetic Geospace Events
Event-Specific Modeling

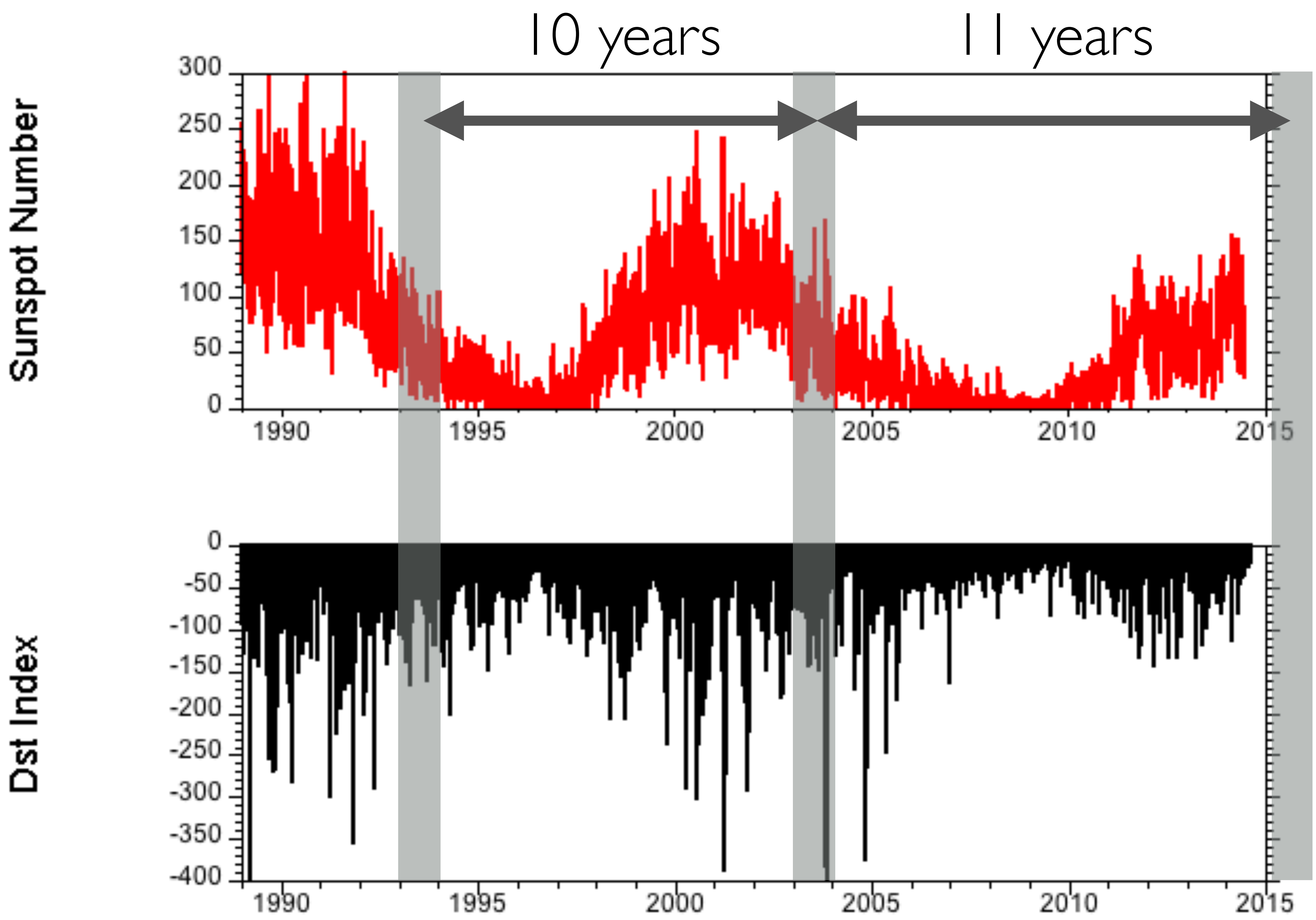
A Statistical Look

now that Van Allen Probes has precessed through all local times

Solar & Geomagnetic Activity

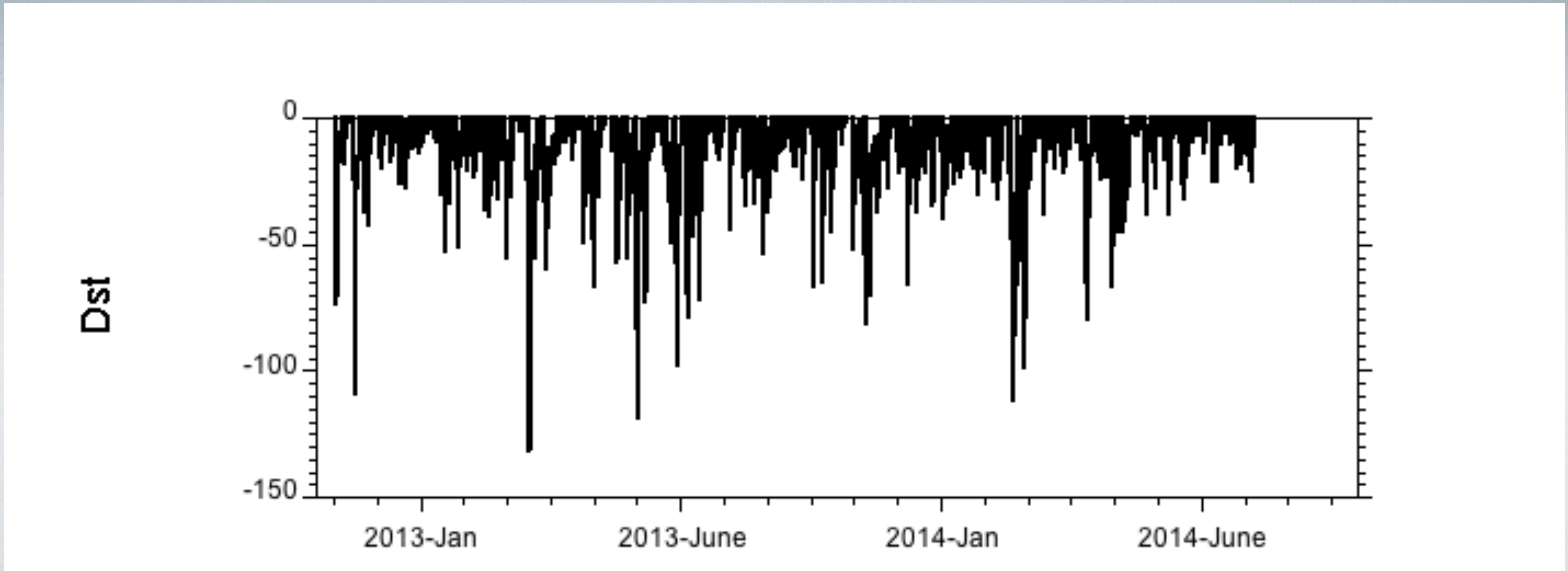


Solar & Geomagnetic Activity

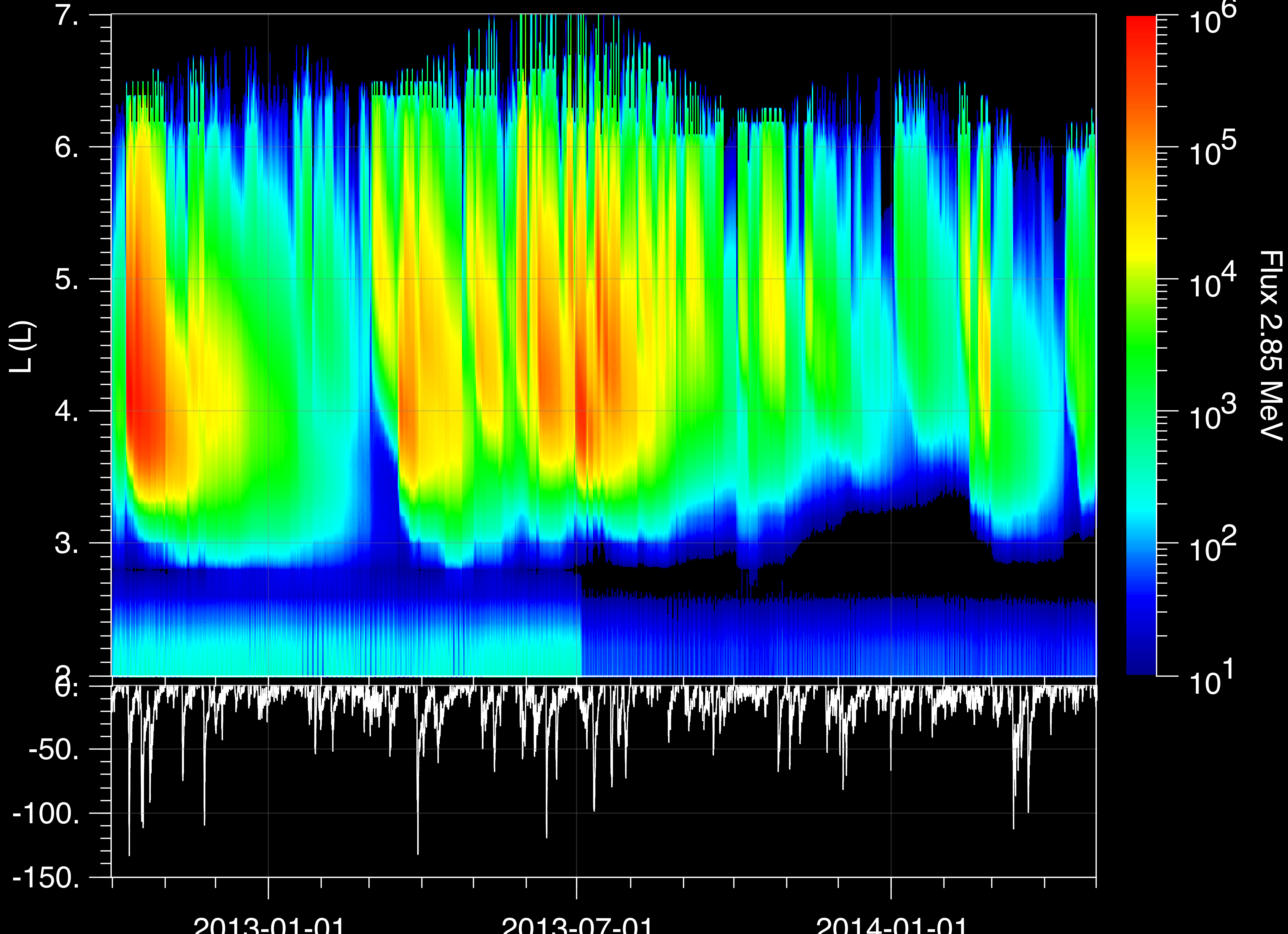


Dst below -50 nT less than 3% of the time

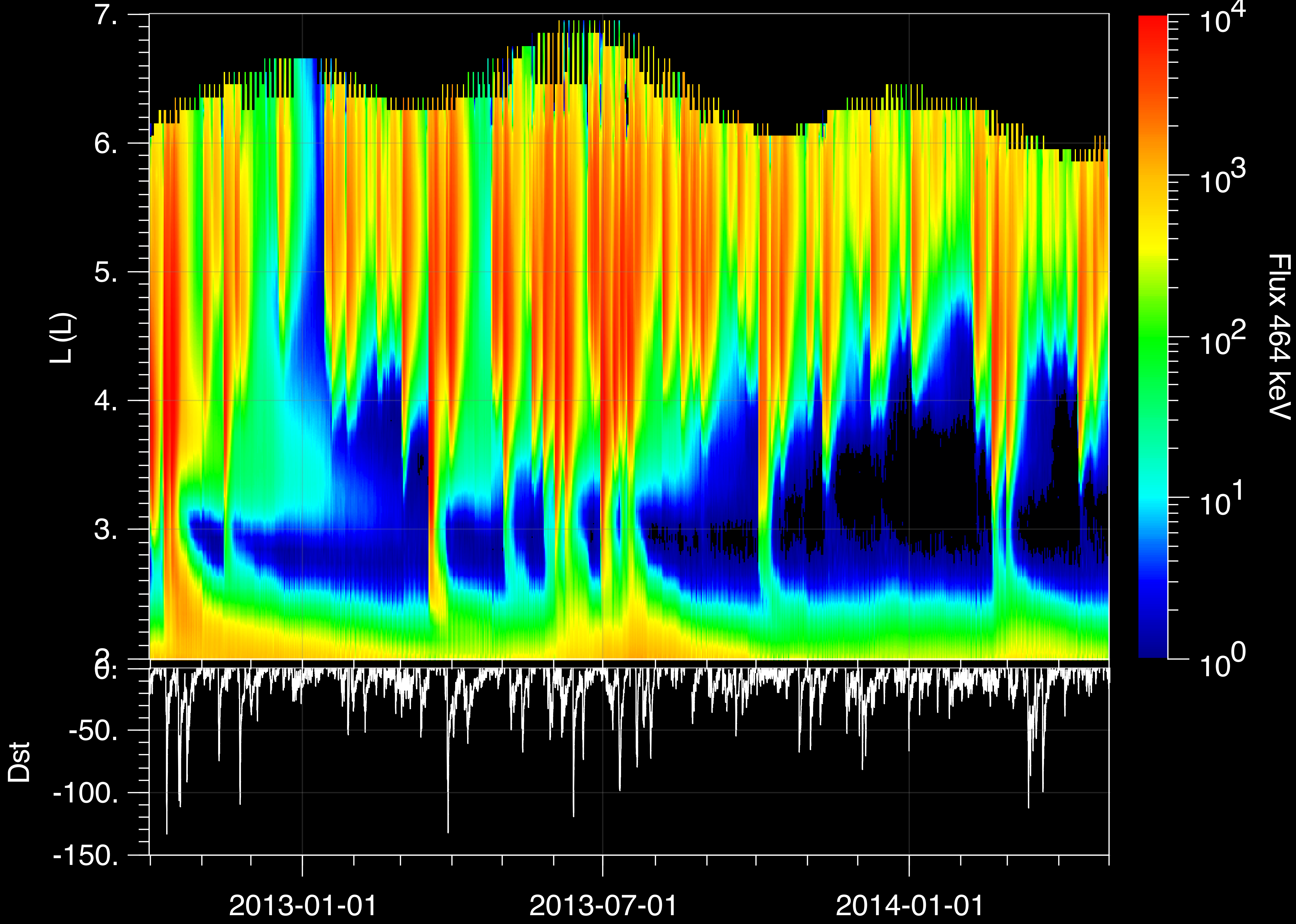
Dst Range	Number (hr)	Percent
-125 to -150	2	0.02
-100 to -125	14	0.14
-75 to -100	59	0.60
-50 to -75	218	2.22
-25 to -50	1158	11.81
0 to -25	8357	85.21



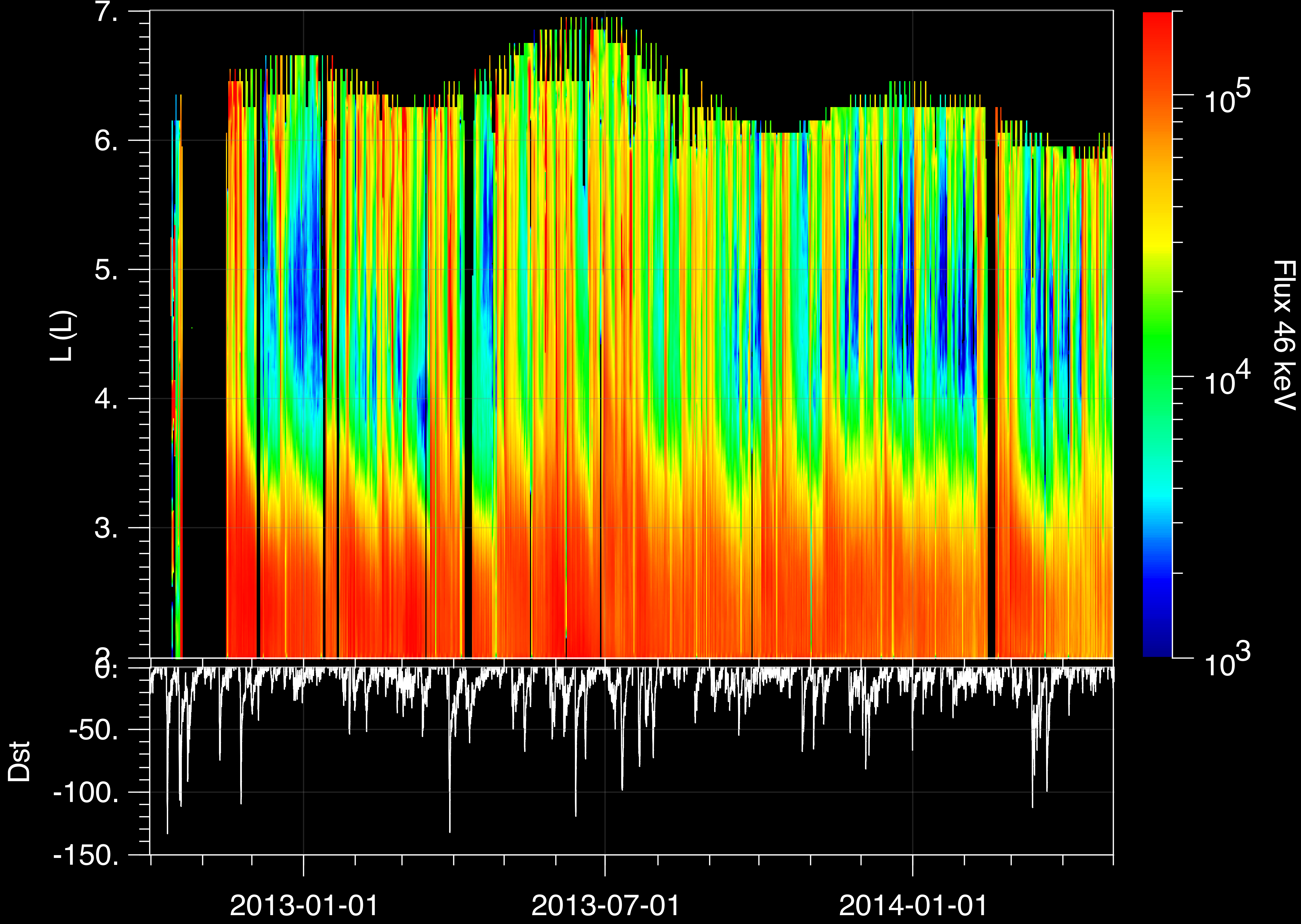
REPT Electrons 3 MeV



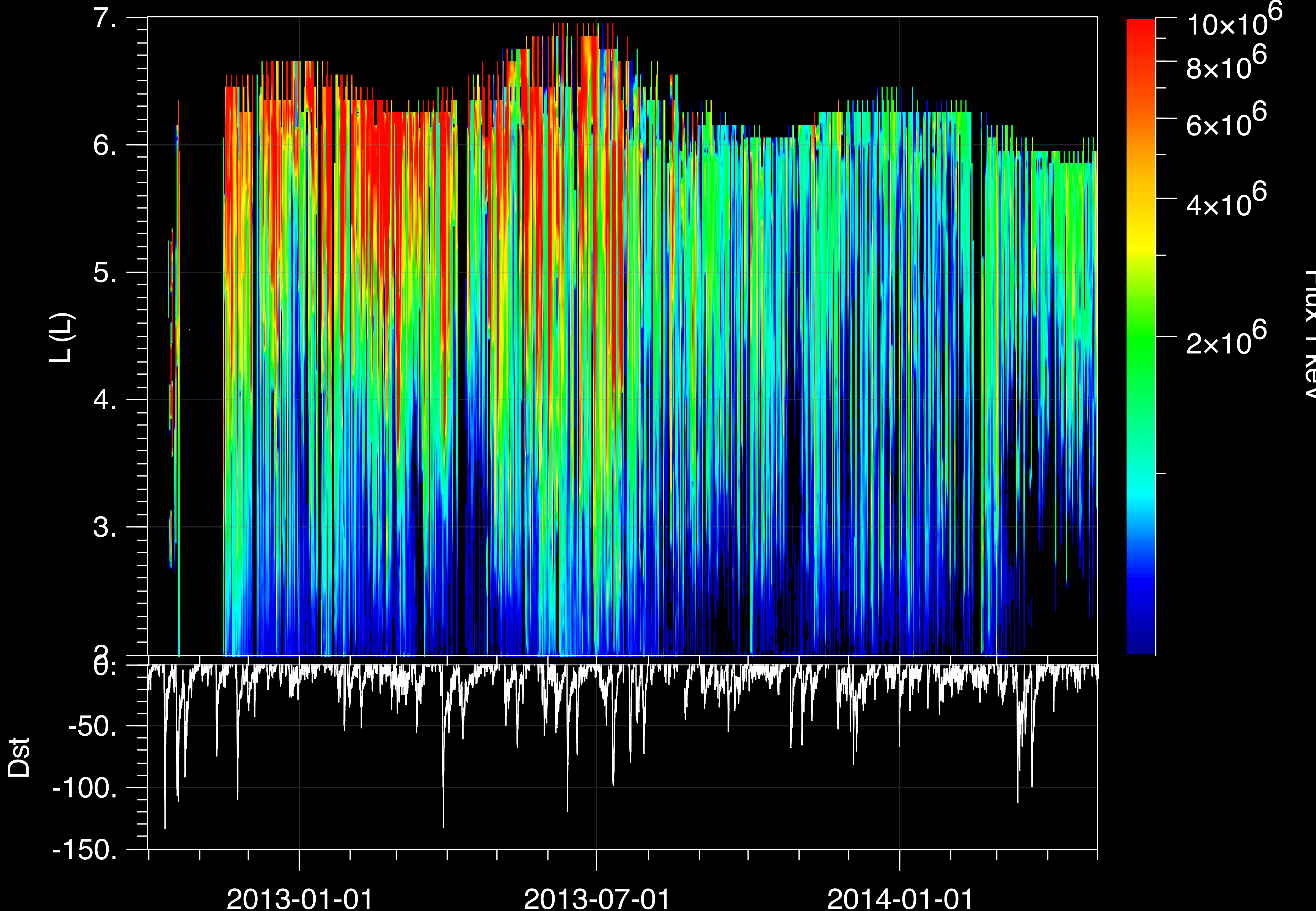
MagEIS Electrons 500 keV



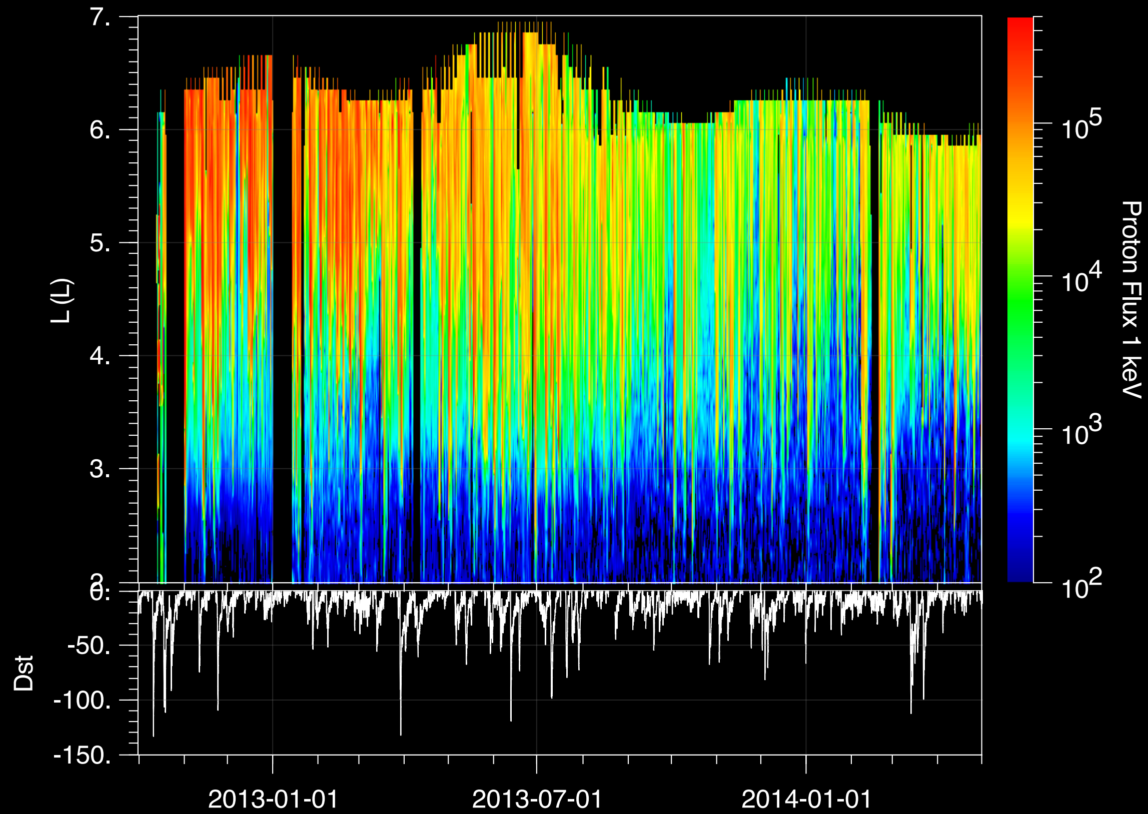
HOPE Electrons 50 keV



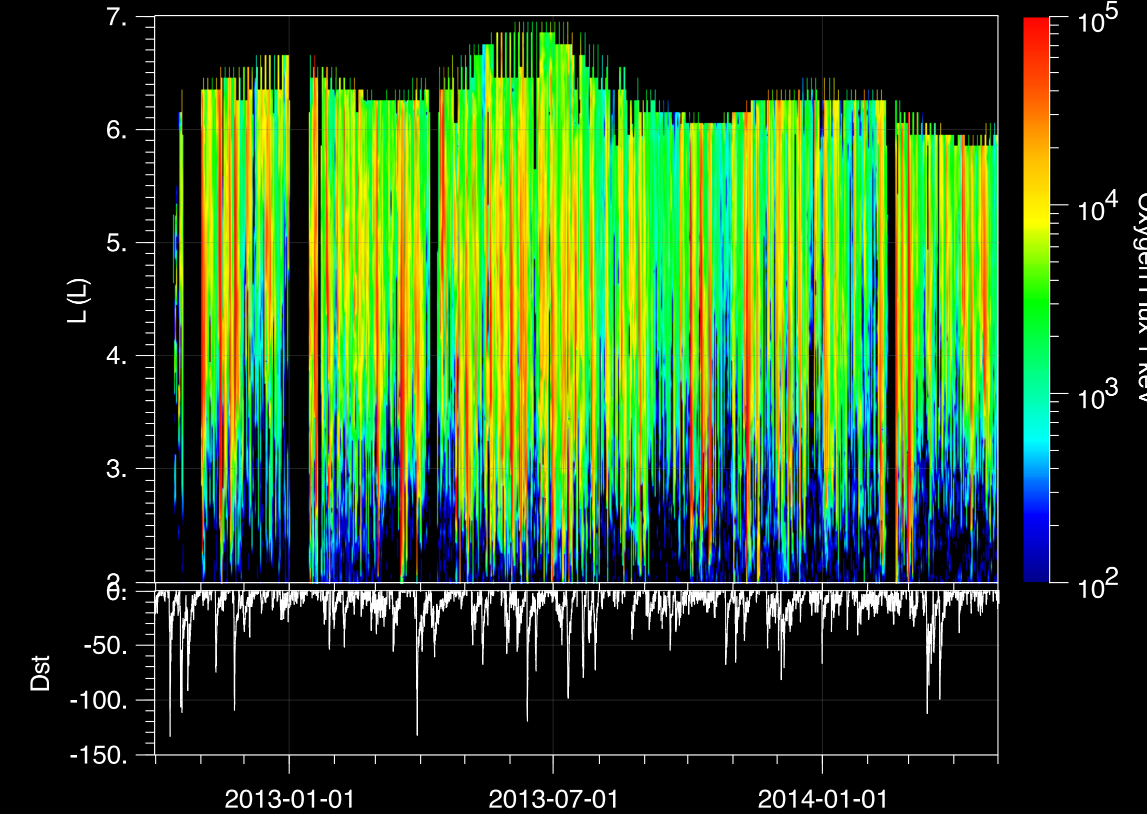
HOPE Electrons 1 keV



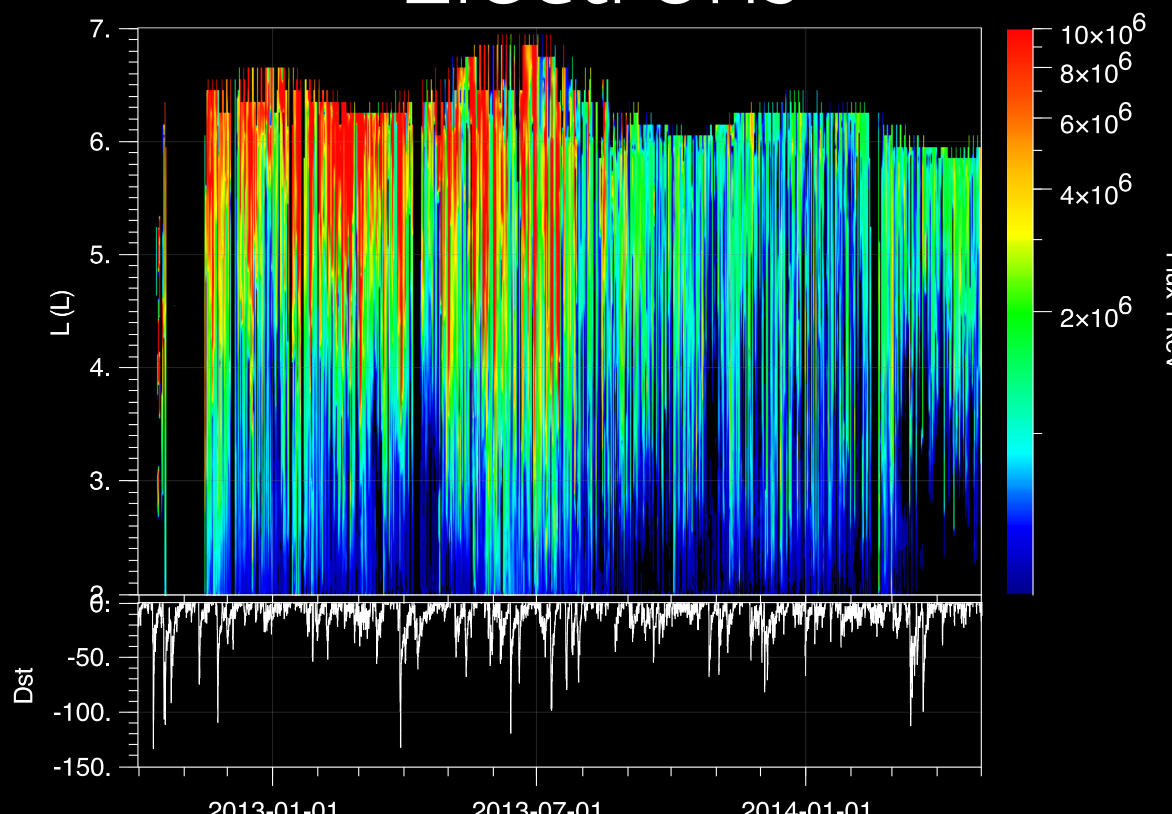
Protons



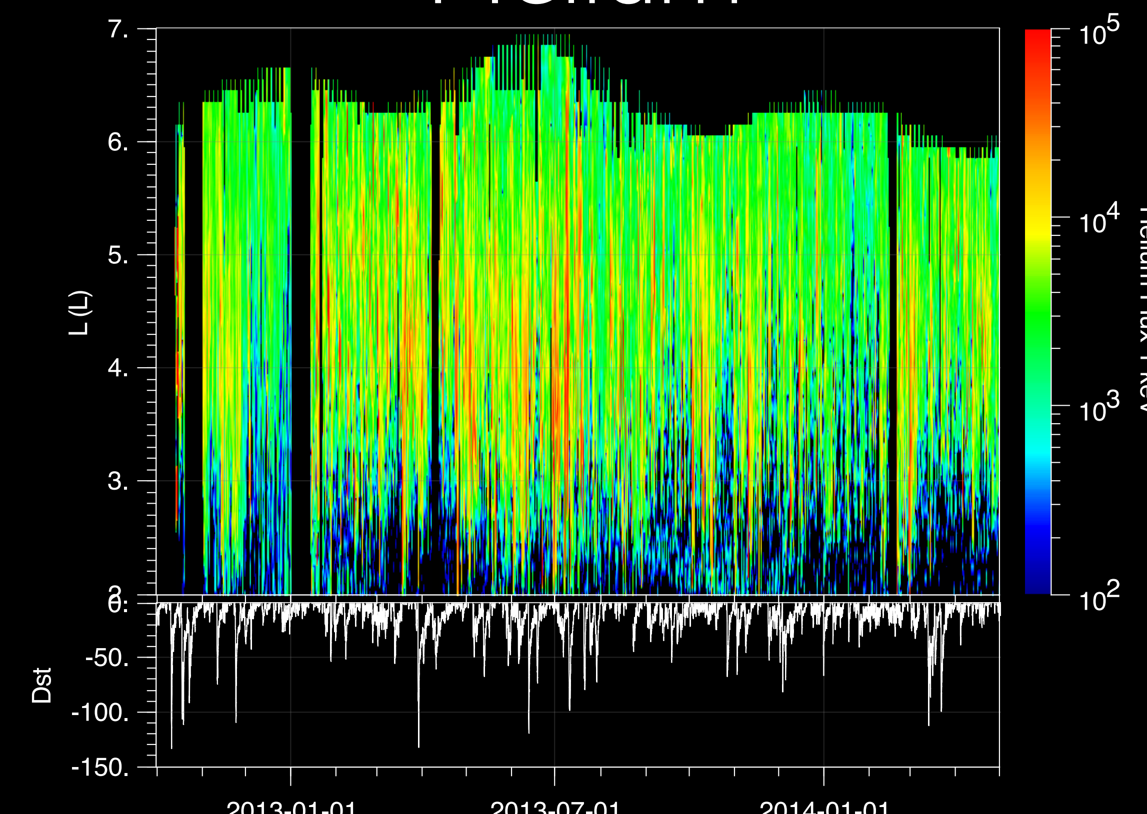
Oxygen



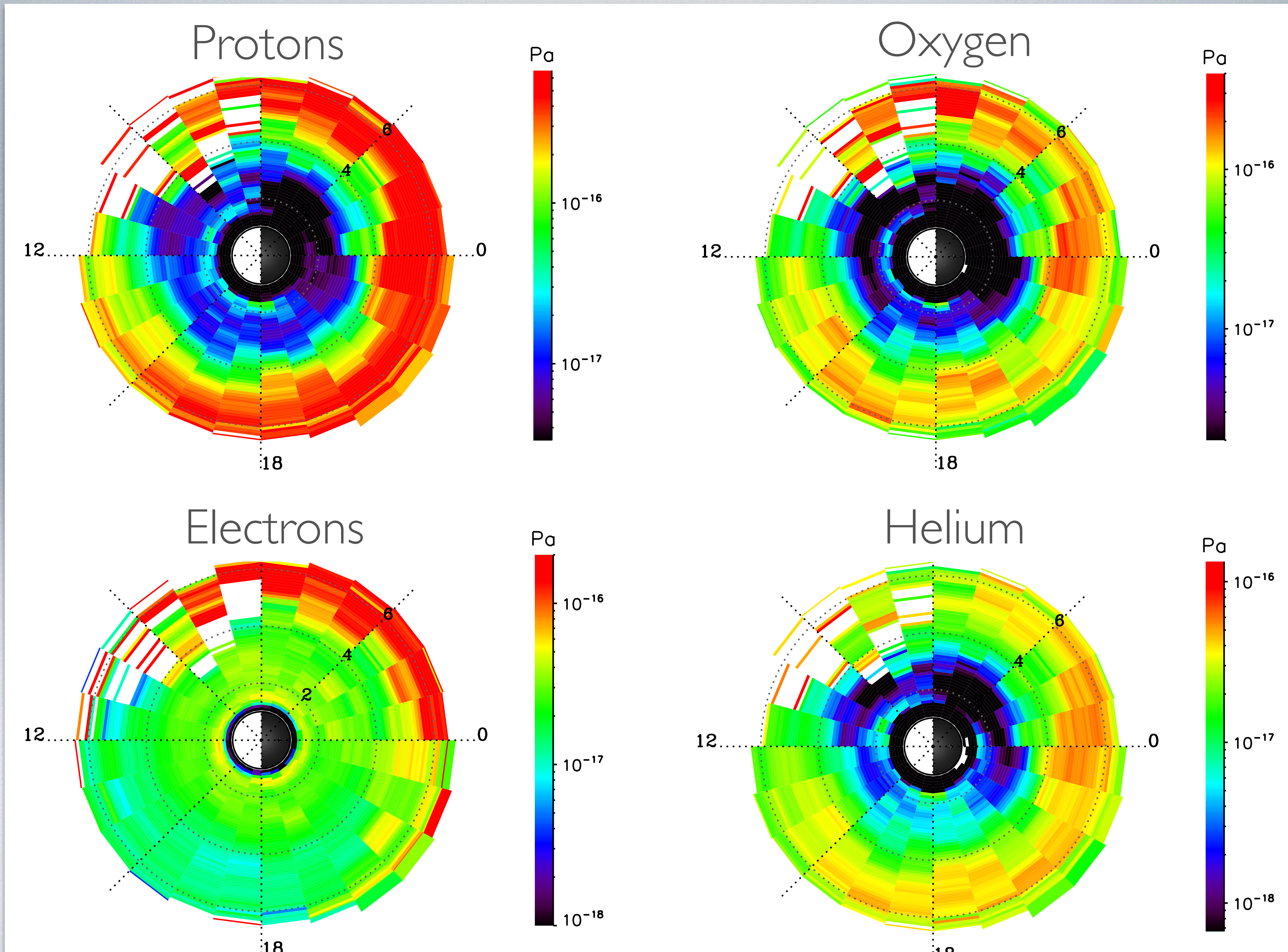
Electrons



Helium



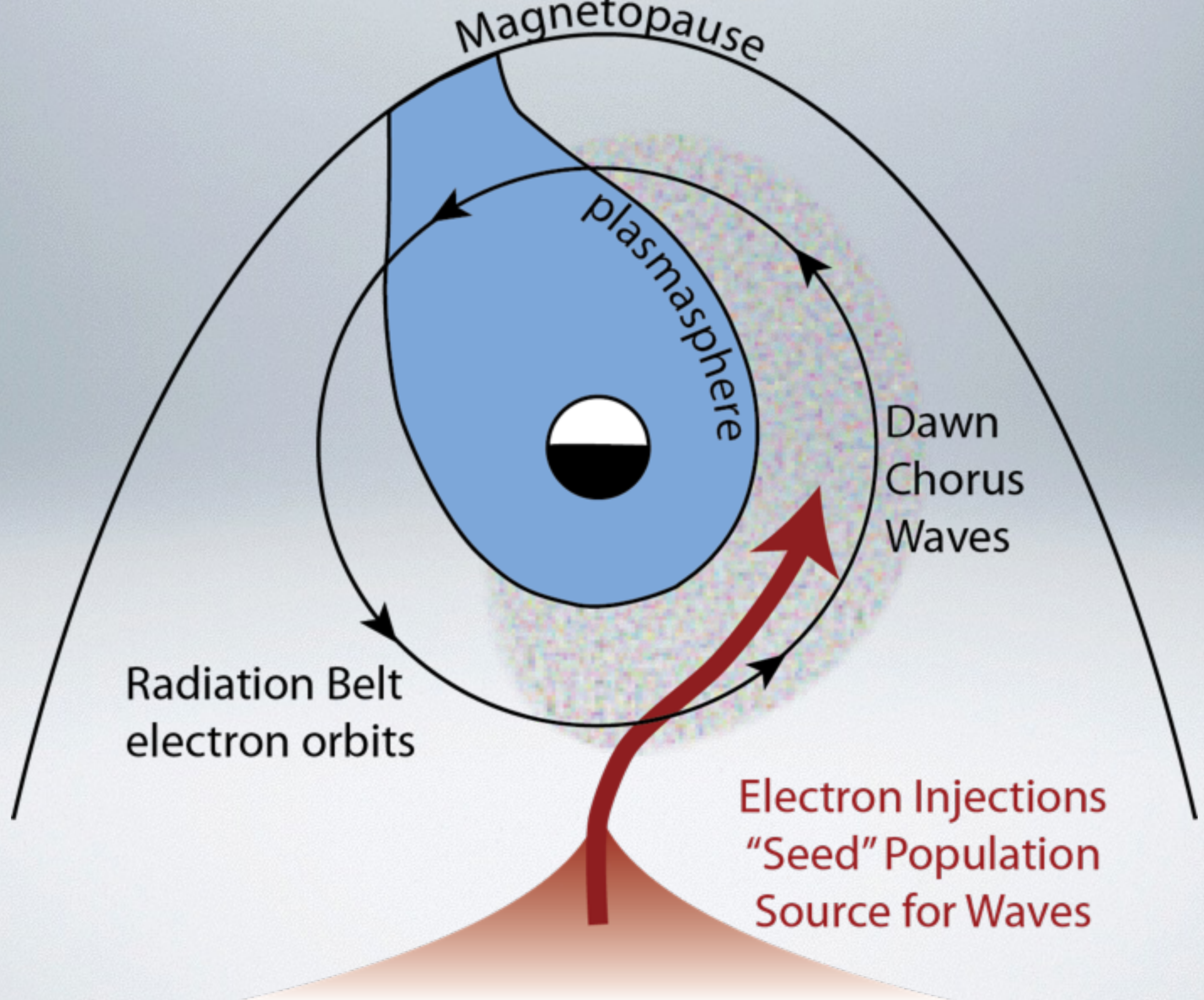
Pressure by Species AE > 100nT



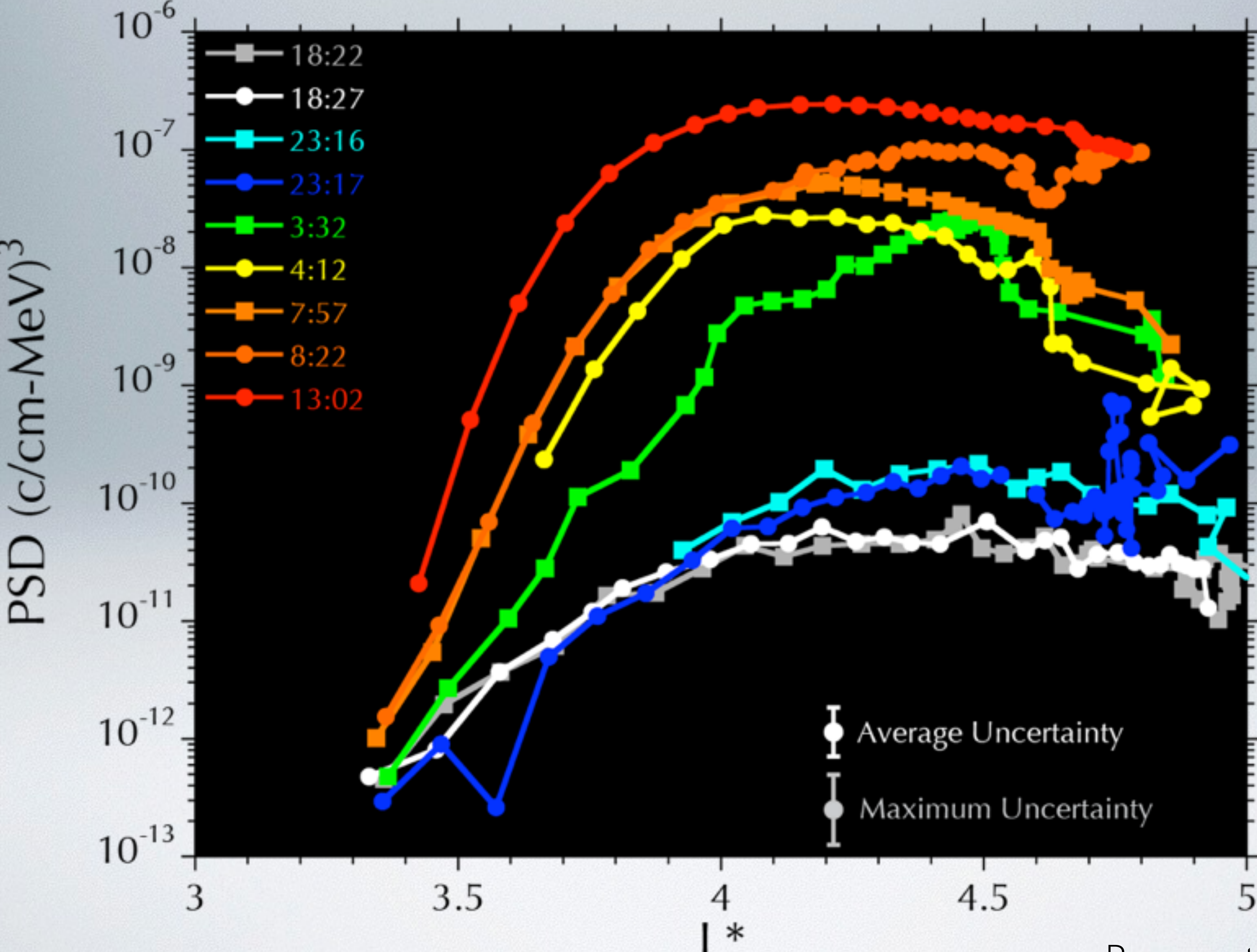
Energetic Geospace Events

detailed analyses of storm-time energization, losses, transport, plasma instabilities, and wave-particle interactions

Acceleration by Chorus Waves



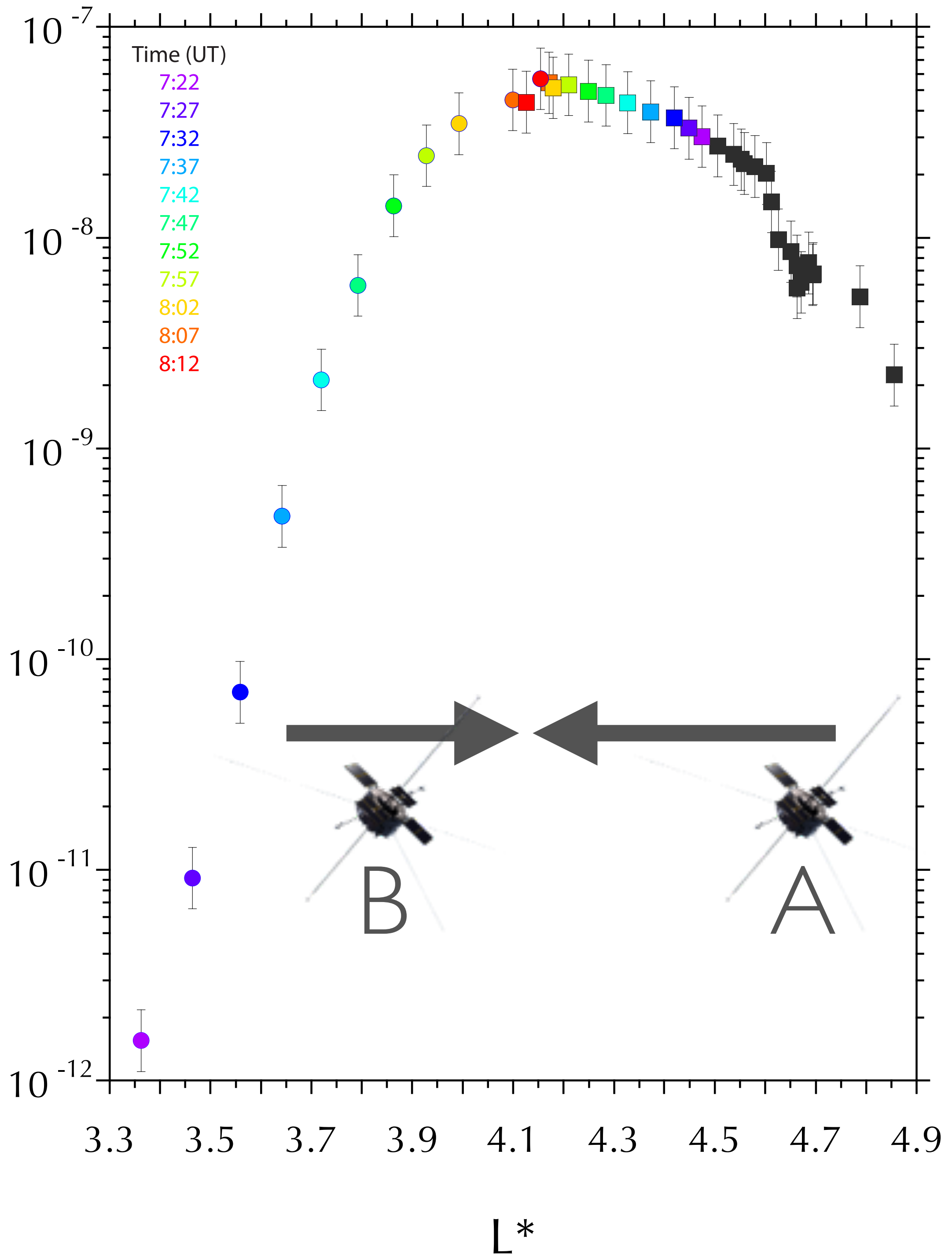
October 2012: PSD Peaks



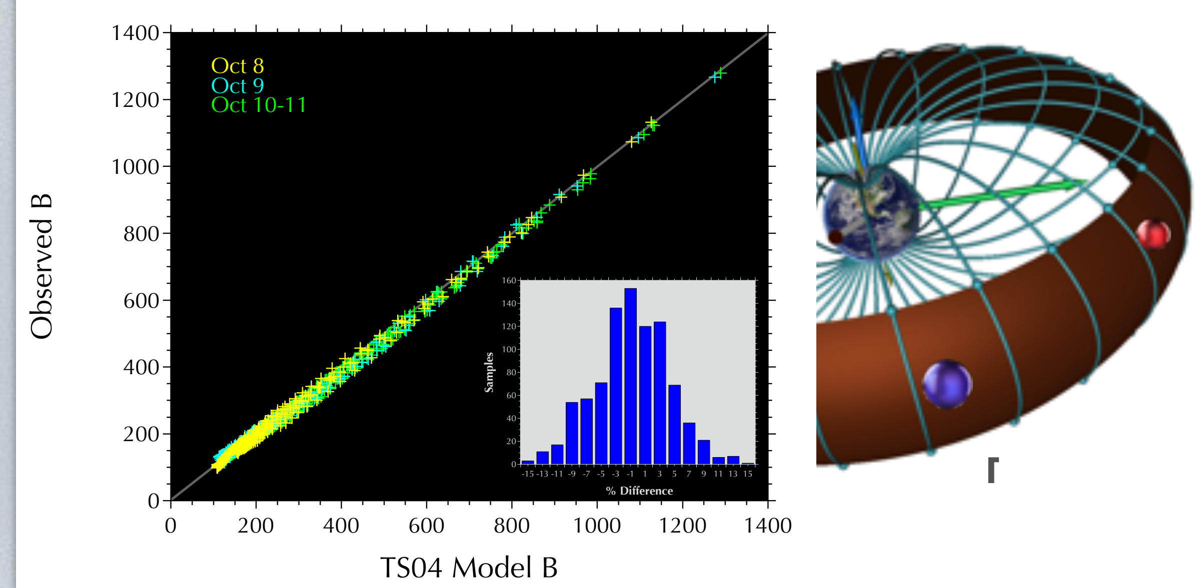
Reeves et al., Science, 2014

Definitive Evidence forLocal Acceleration

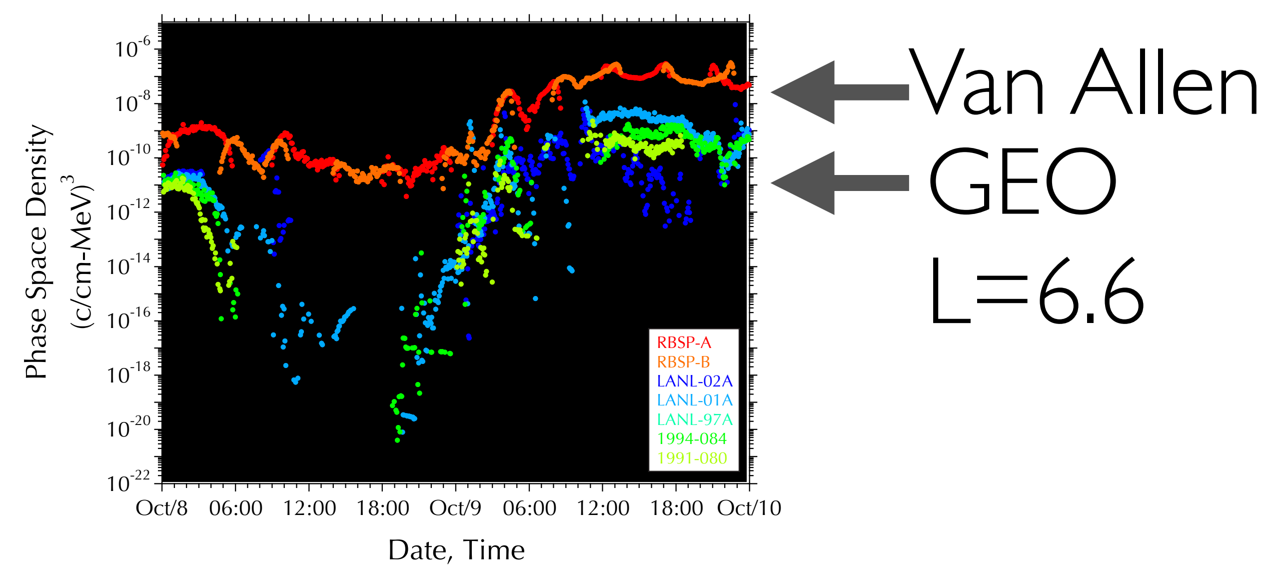
Simultaneous Measurements



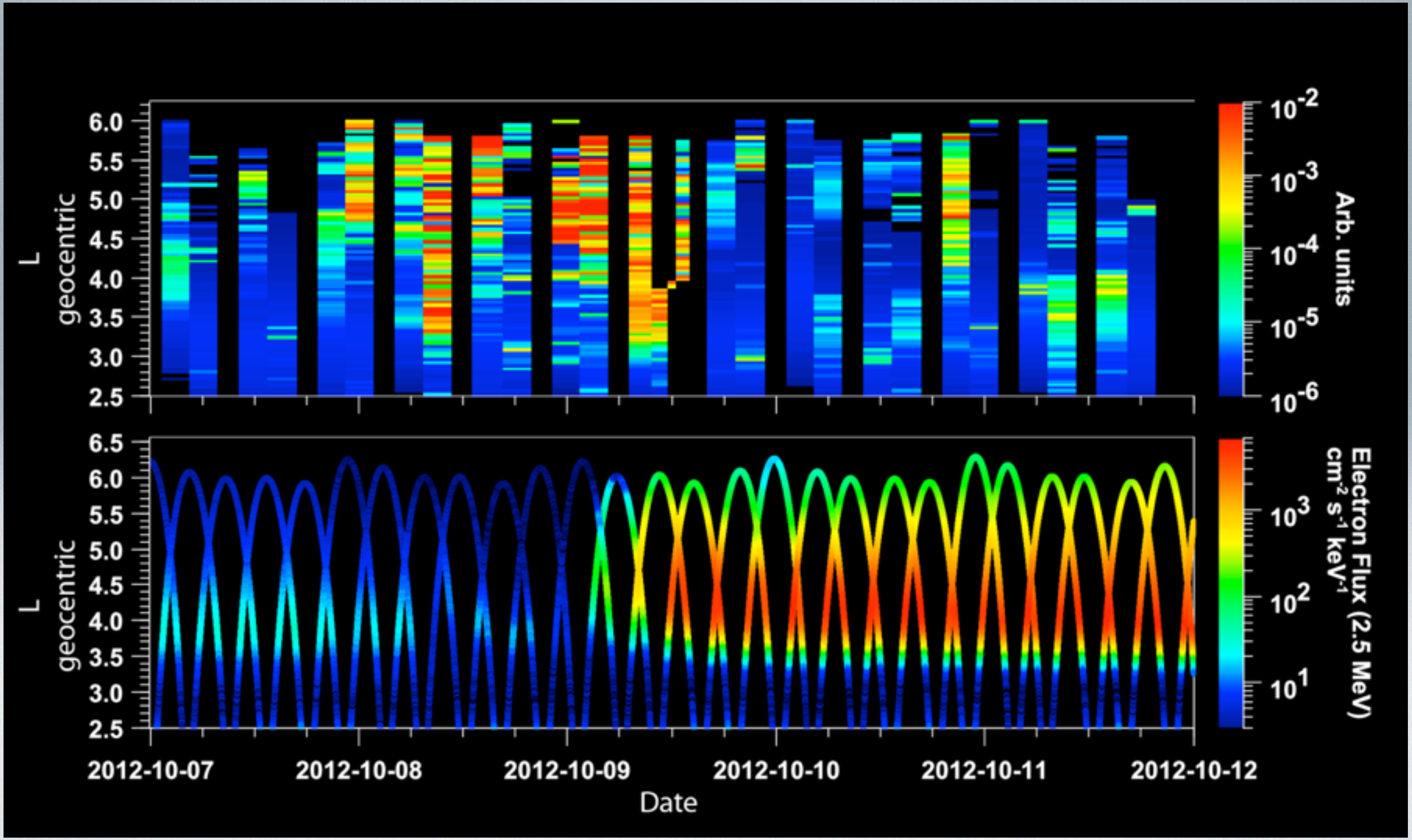
Uncertainty Analysis



Outer Boundary Measurements



Increasingly Strong Evidence that Chorus Produces Local Acceleration

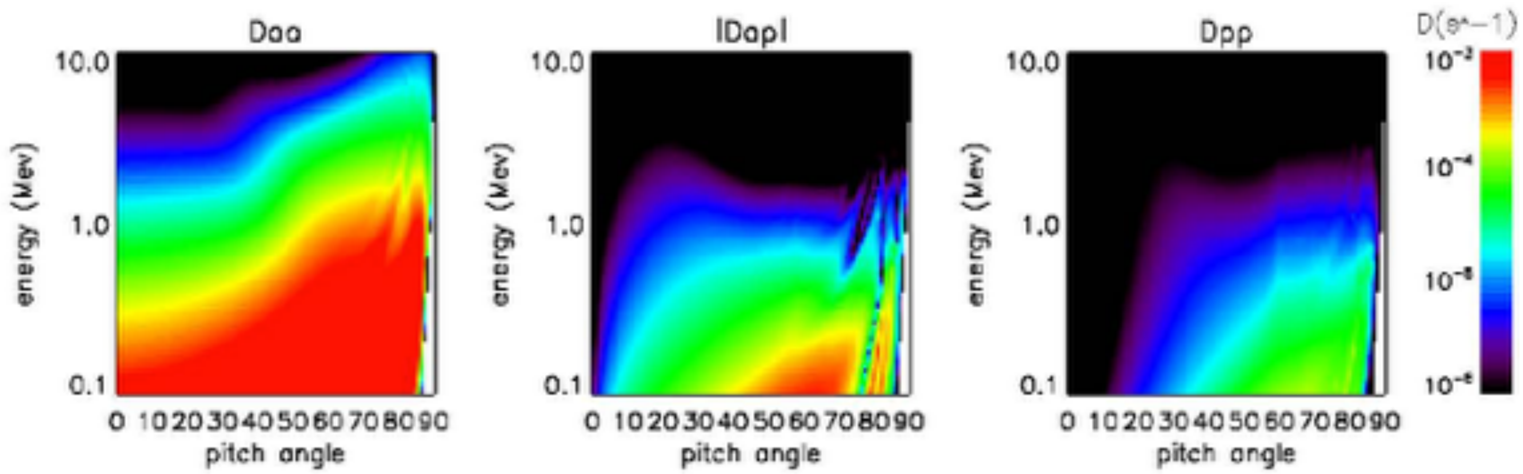


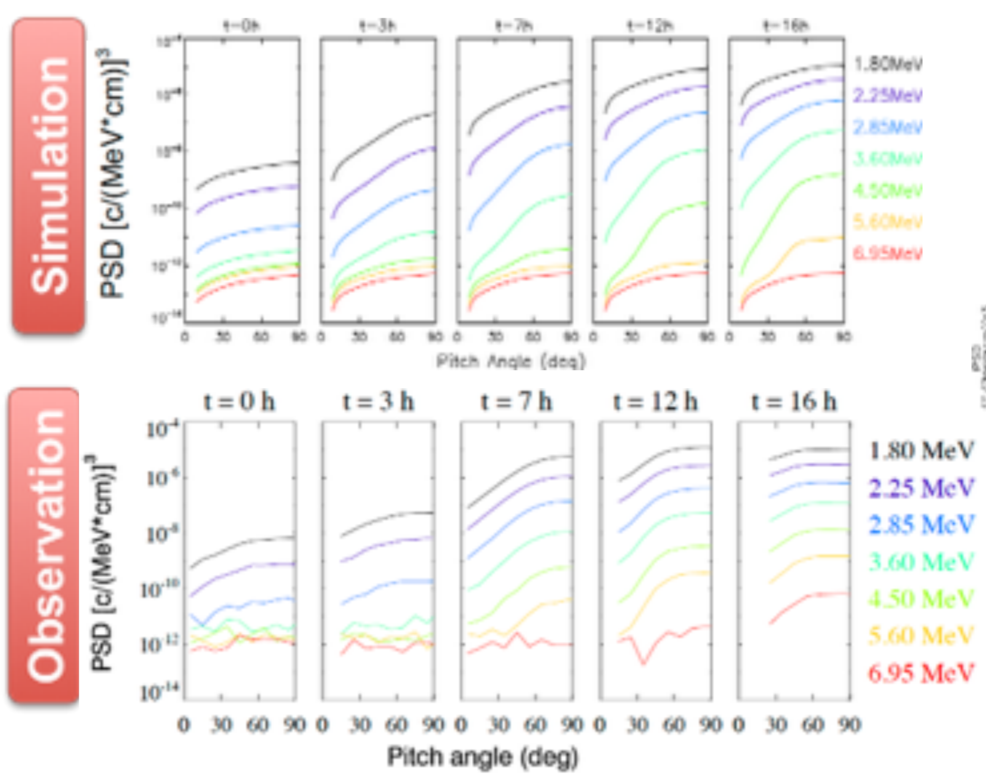
Reeves et al., Science, 2014

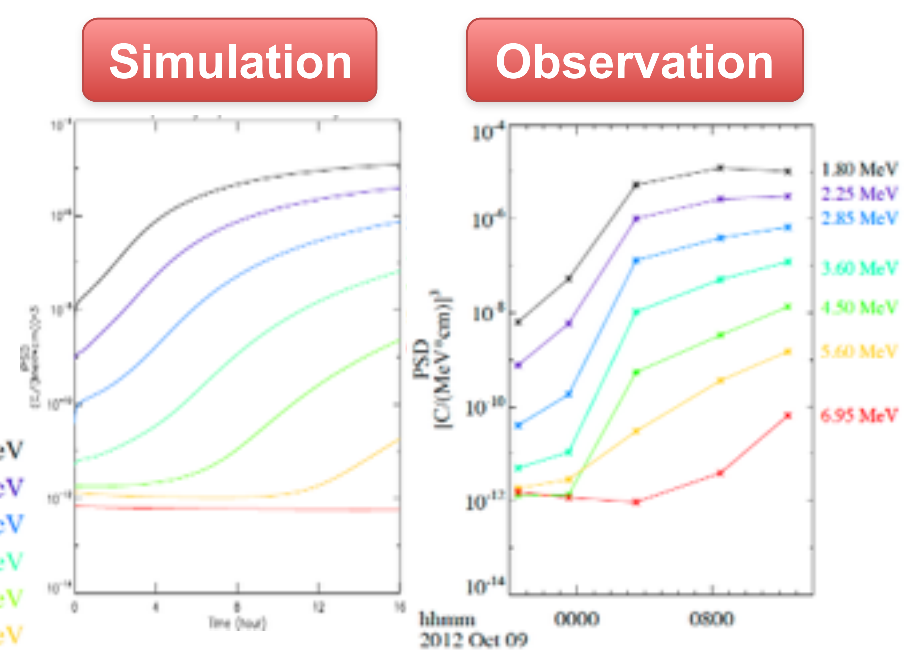
Chorus: Theory and Observations

2D Simulations match spectrum & pitch angle distributions

Diffusion Coeff. from Observed Chorus Waves

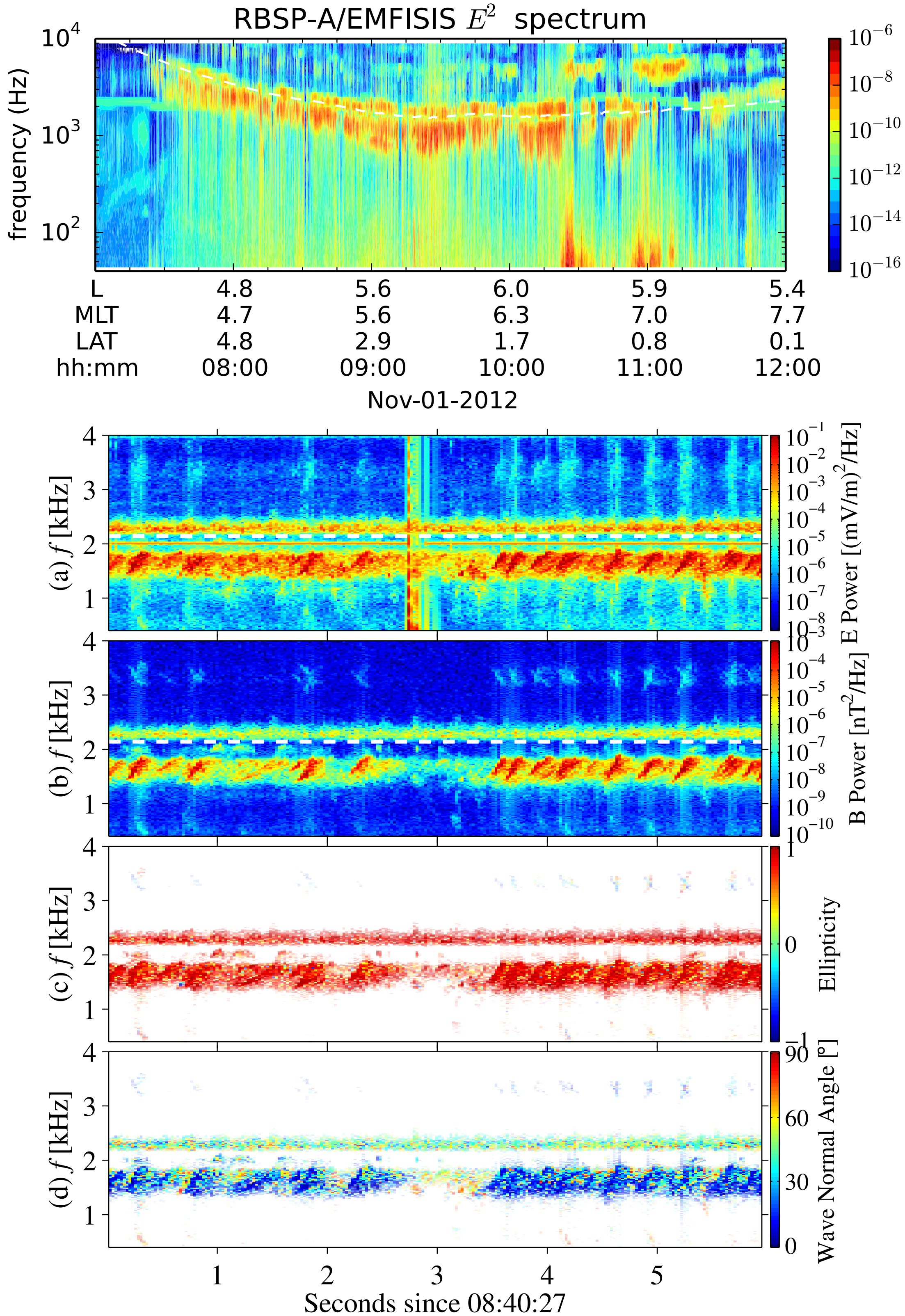




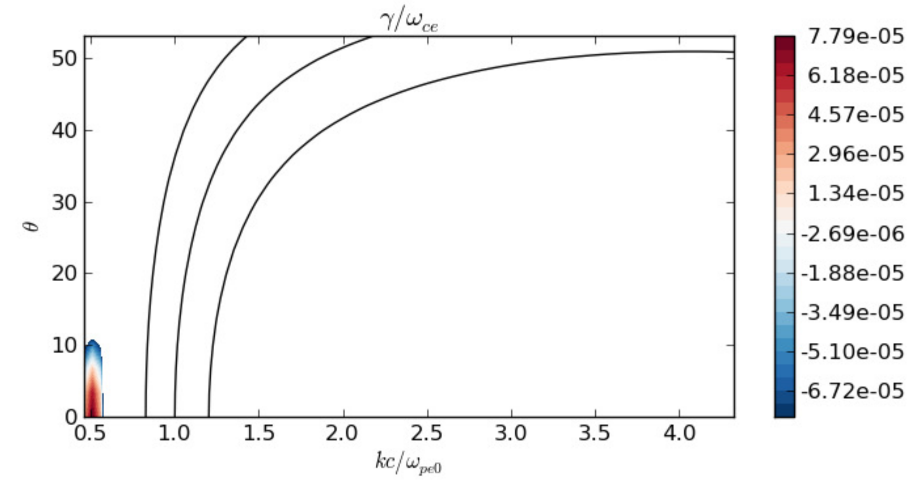


Thorne et al., Nature 2013

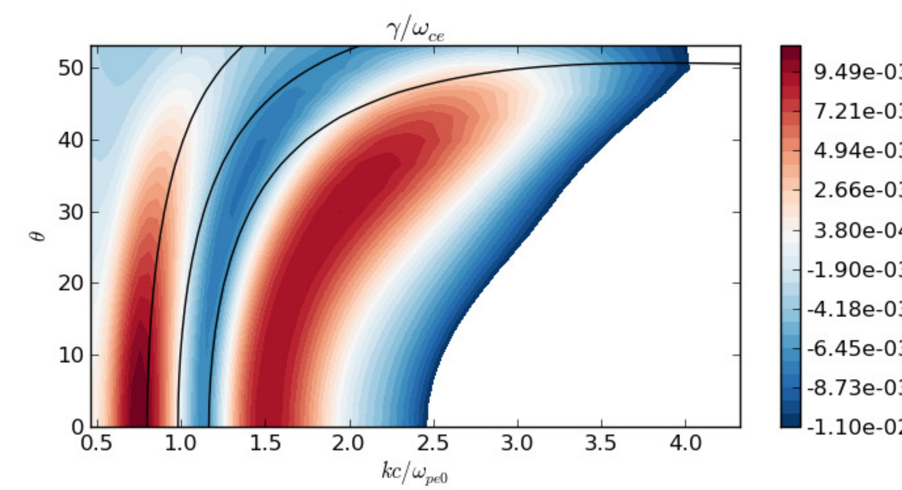
Chorus Wave Growth Rates



Single Component fit to HOPE data



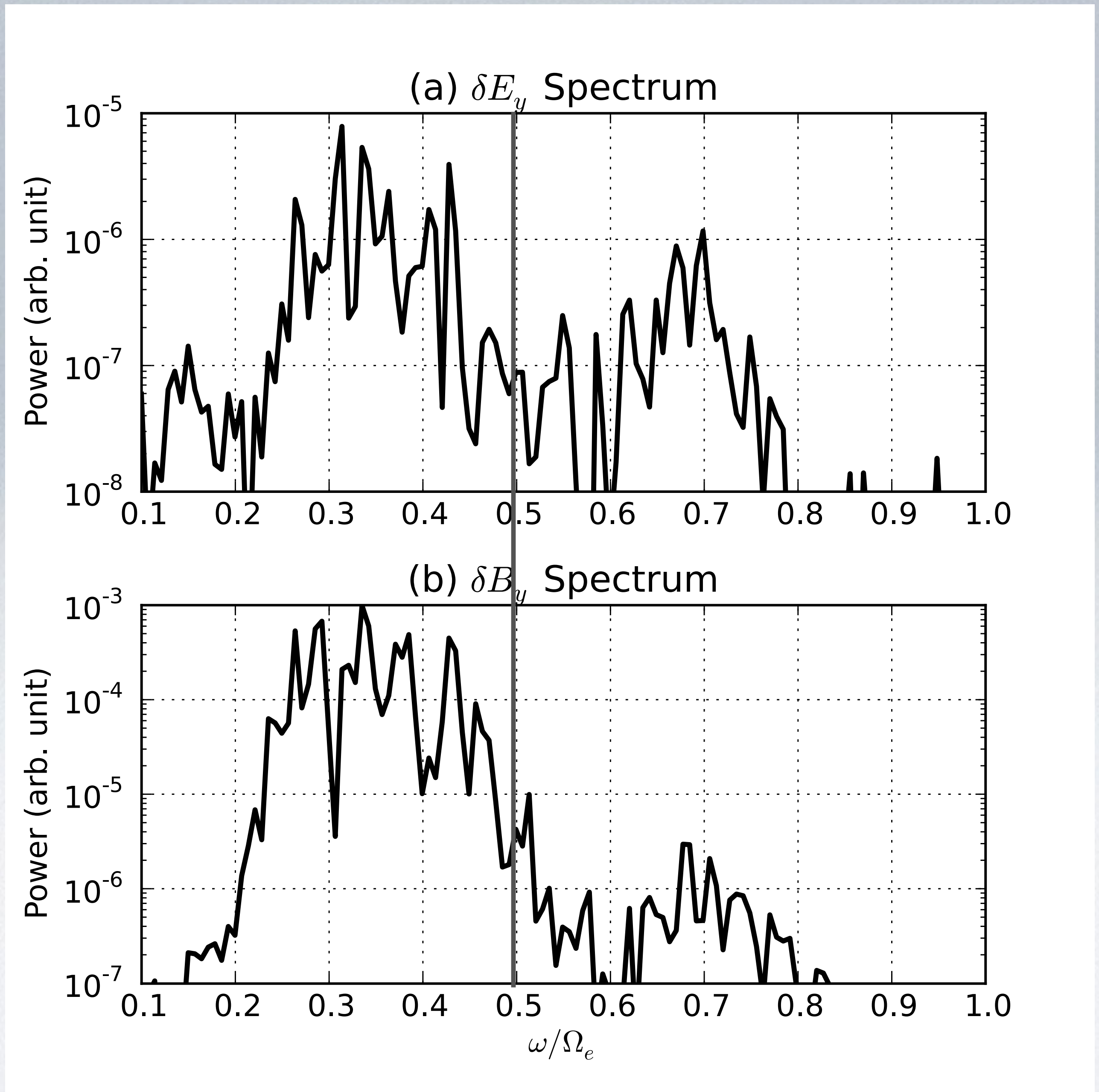
2-Component fit to HOPE data



Fu et al., JGR 2014

Fu et al. PIC Simulation

Simulated Spectrum using
2-component fit to HOPE observations

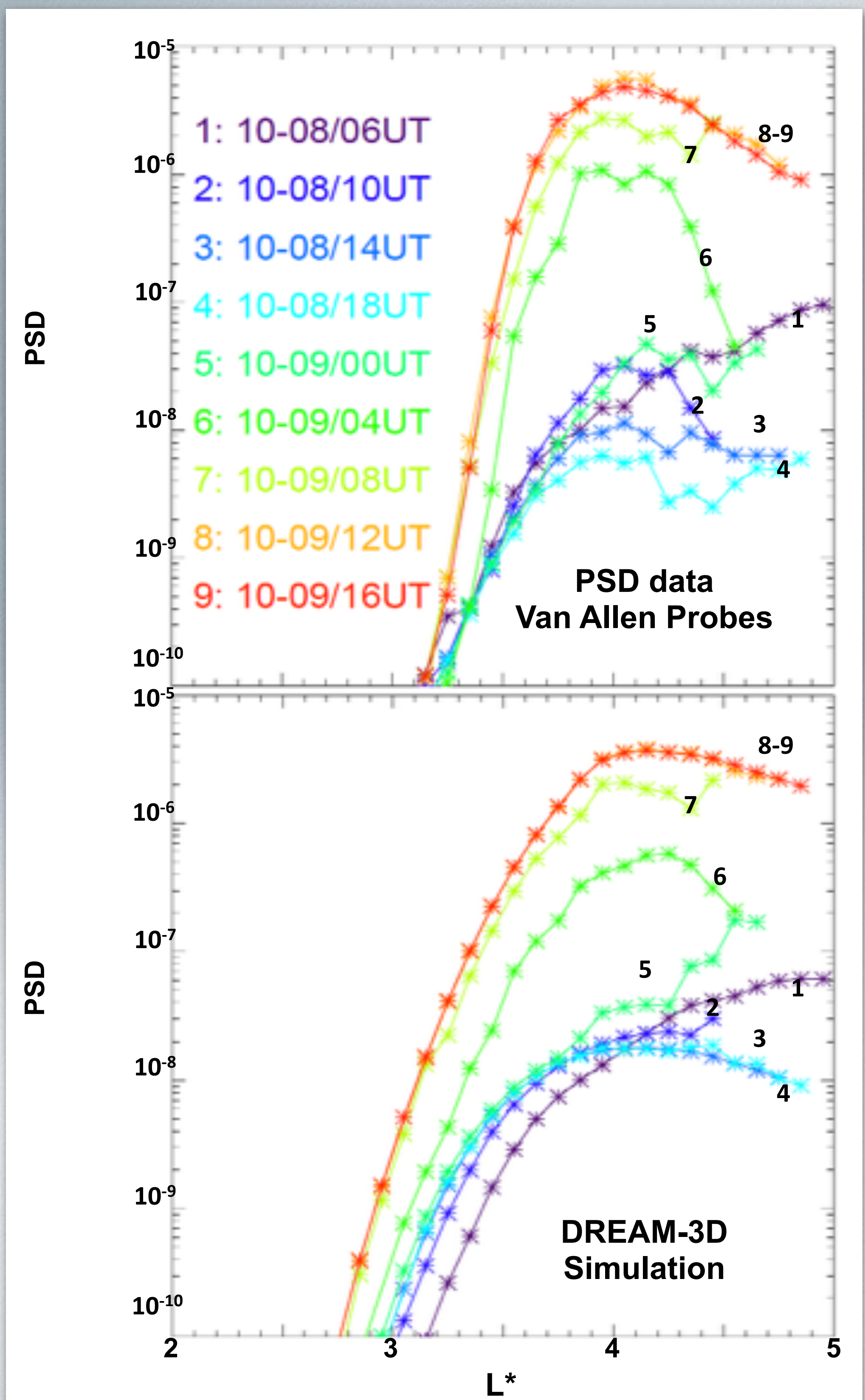


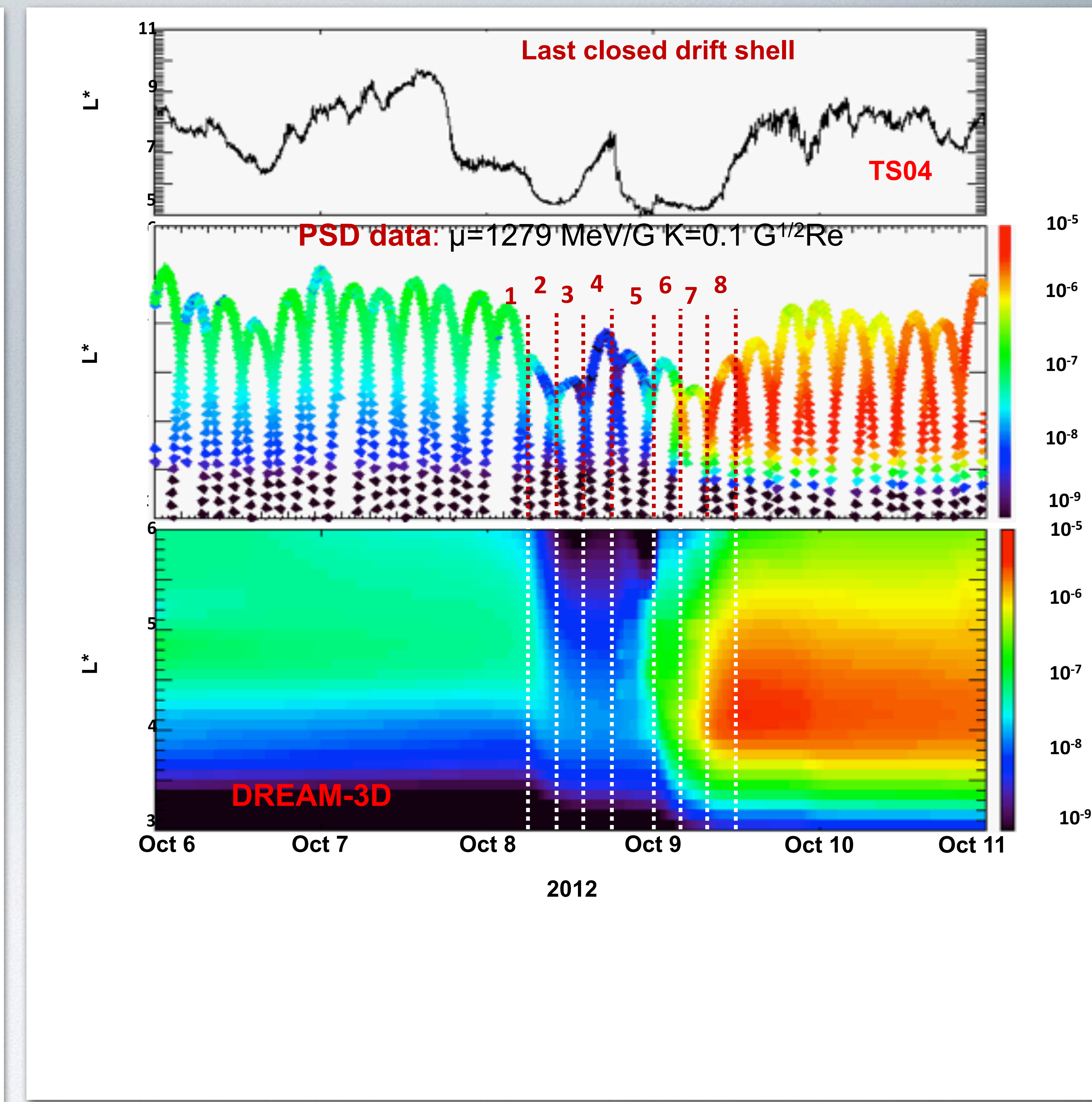
Fu et al., JGR 2014

Event-Specific Modeling

new global models can now be driven by measured conditions to test competing processes

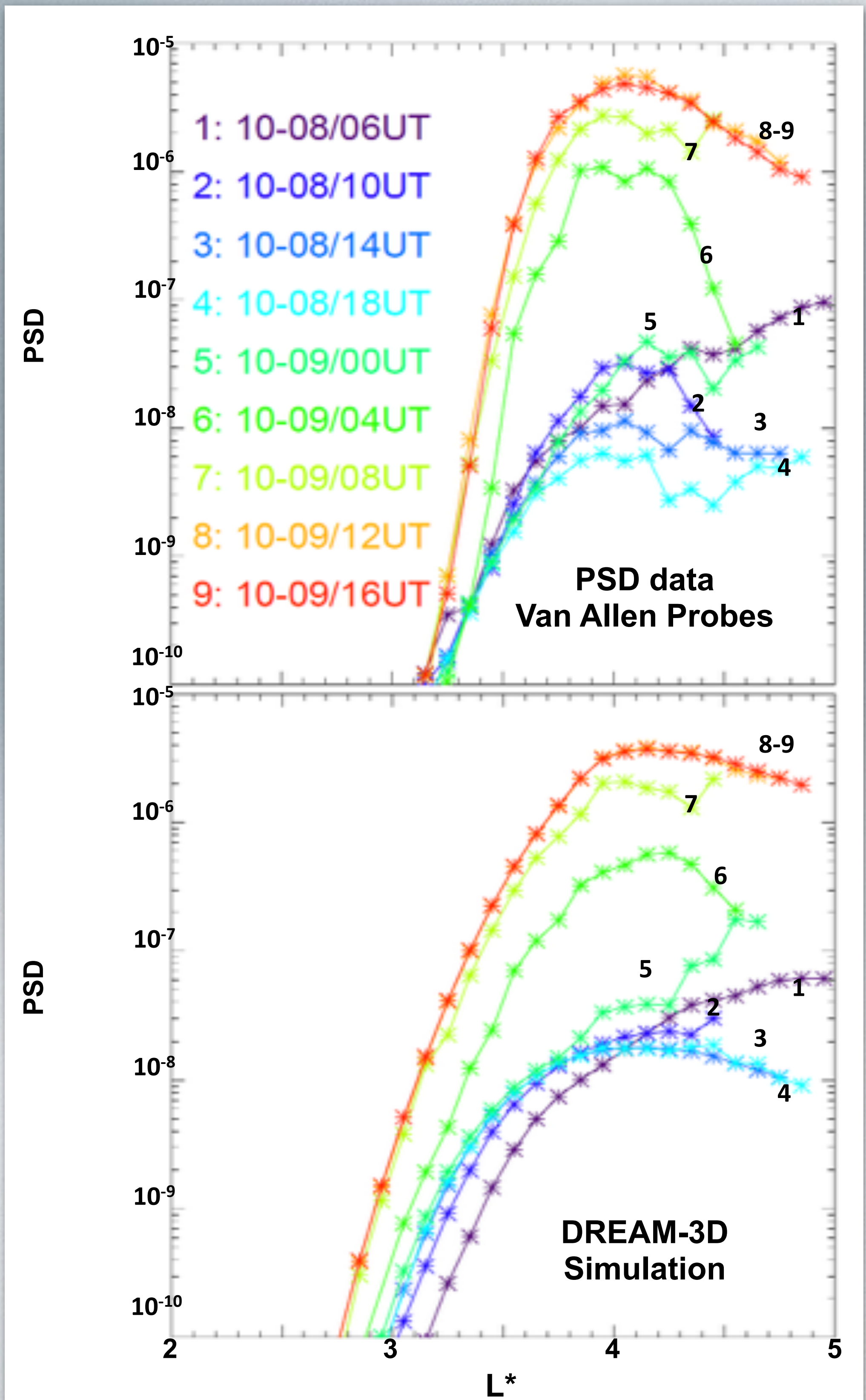
Global Simulations: DREAM-3D

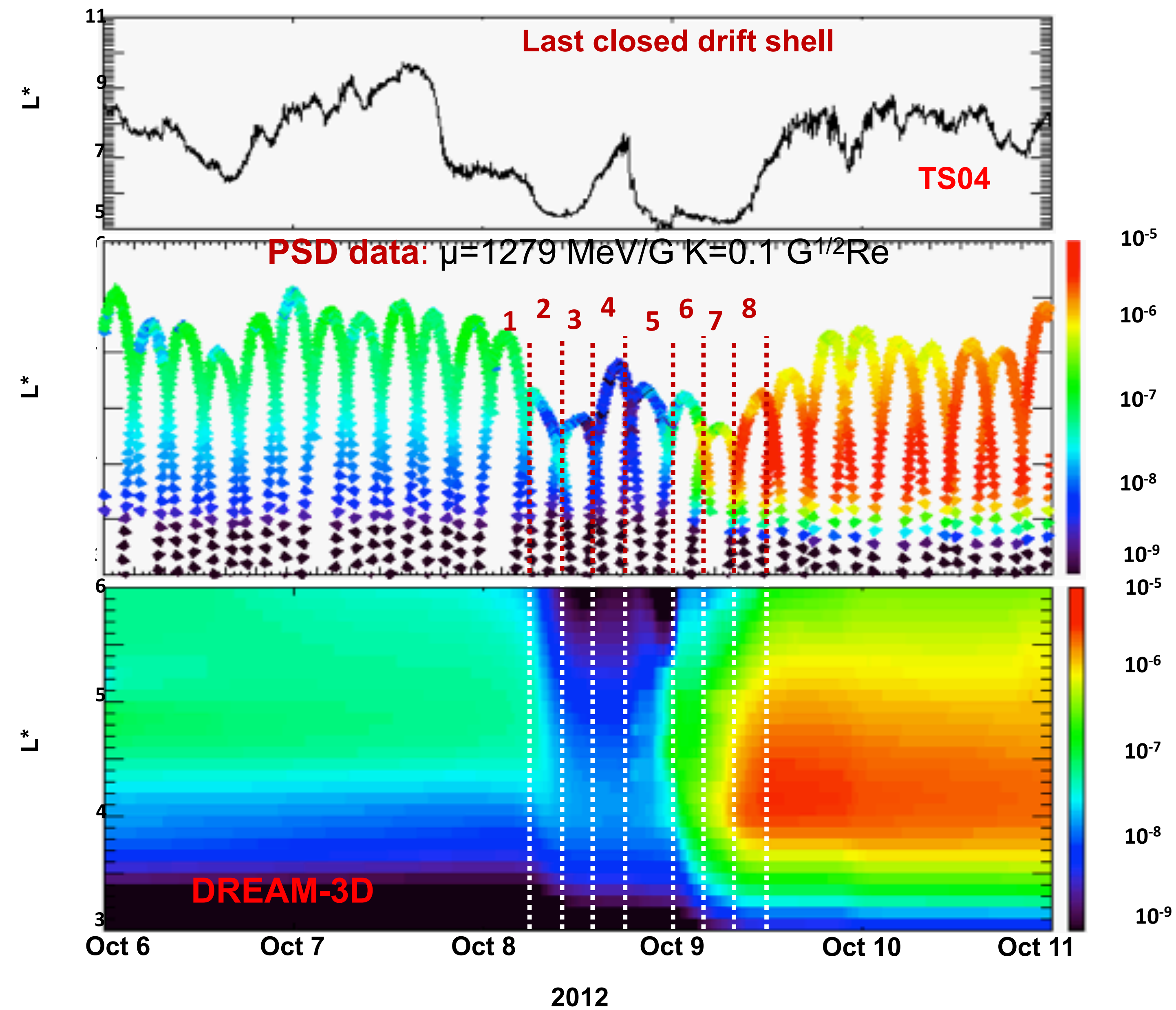




Tu et al., GRL 2014

Global Simulations: DREAM-3D





But… does good agreement mean the model is right?

Tu et al., GRL 2014

Event-Specific Simulations

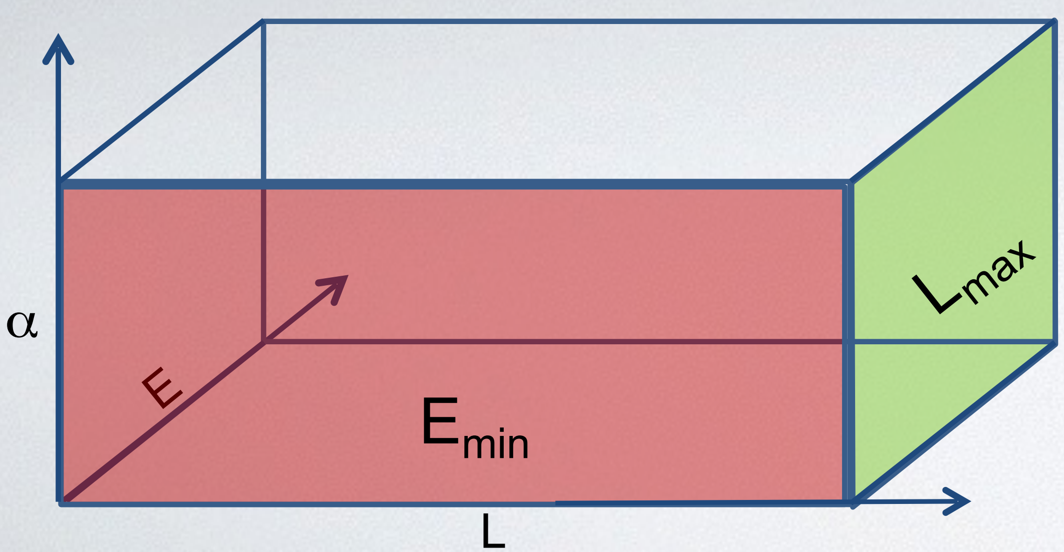
Assumed Parameters

Boundary Conditions

$\alpha=0$ PSD=0 (atmosphere)
$\alpha=\pi/2$ $dPSD/d\alpha=0$
L=1 PSD=0 (atmosphere)
$E=E_{max}$ PSD=0

background plasma density

Computational volume



Event-Spectific
Data-Driven Parameters

Boundary Conditions

$E = E_{min}$ Observed MagEIS 100 keV electrons
$L = L_{max}$ Last Closed Drift Shell (magnetopause)

Processes

Loss to time-dependent LCD (magnetopause)
Loss to L-dependent atmospheric loss cone

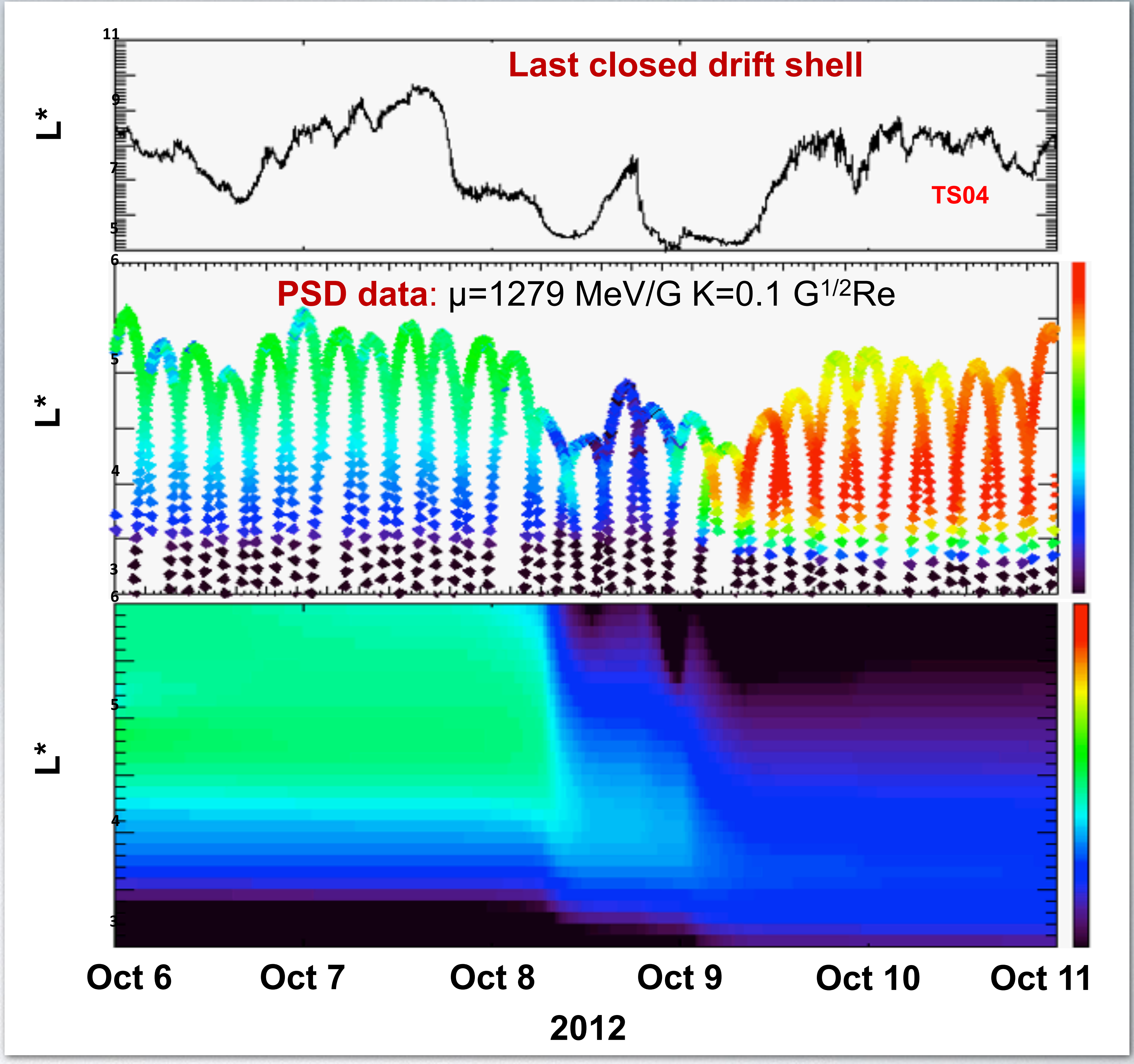
Observed chorus amplitude and frequencies
Derived chorus L and MLT distribution

Kp dependent radial diffusion

Losses in the first Dst dip

Outward Radial Diffusion to the (event-specific) LCDS (magnetopause) explains the rapid loss of electrons in the first phase of the storm

- Open boundary at L*=11
- Short lifetimes outside last closed drift shell (magnetopause)
- Radial Diffusion Only



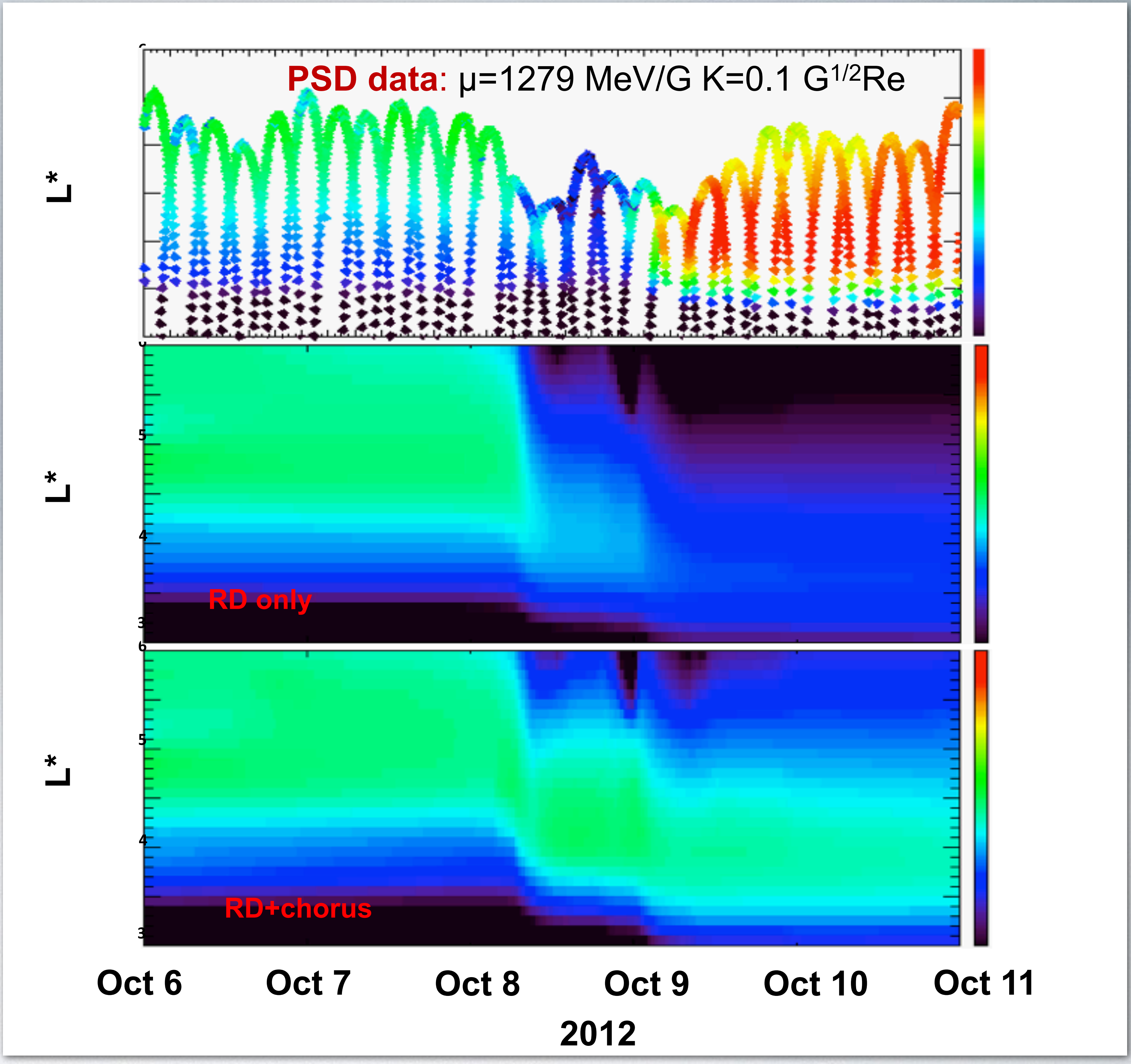
Tu et al., GRL 2014

Adding Chorus Acceleration

We calculate D_{LL} and D_{aa} from the event-specific chorus model

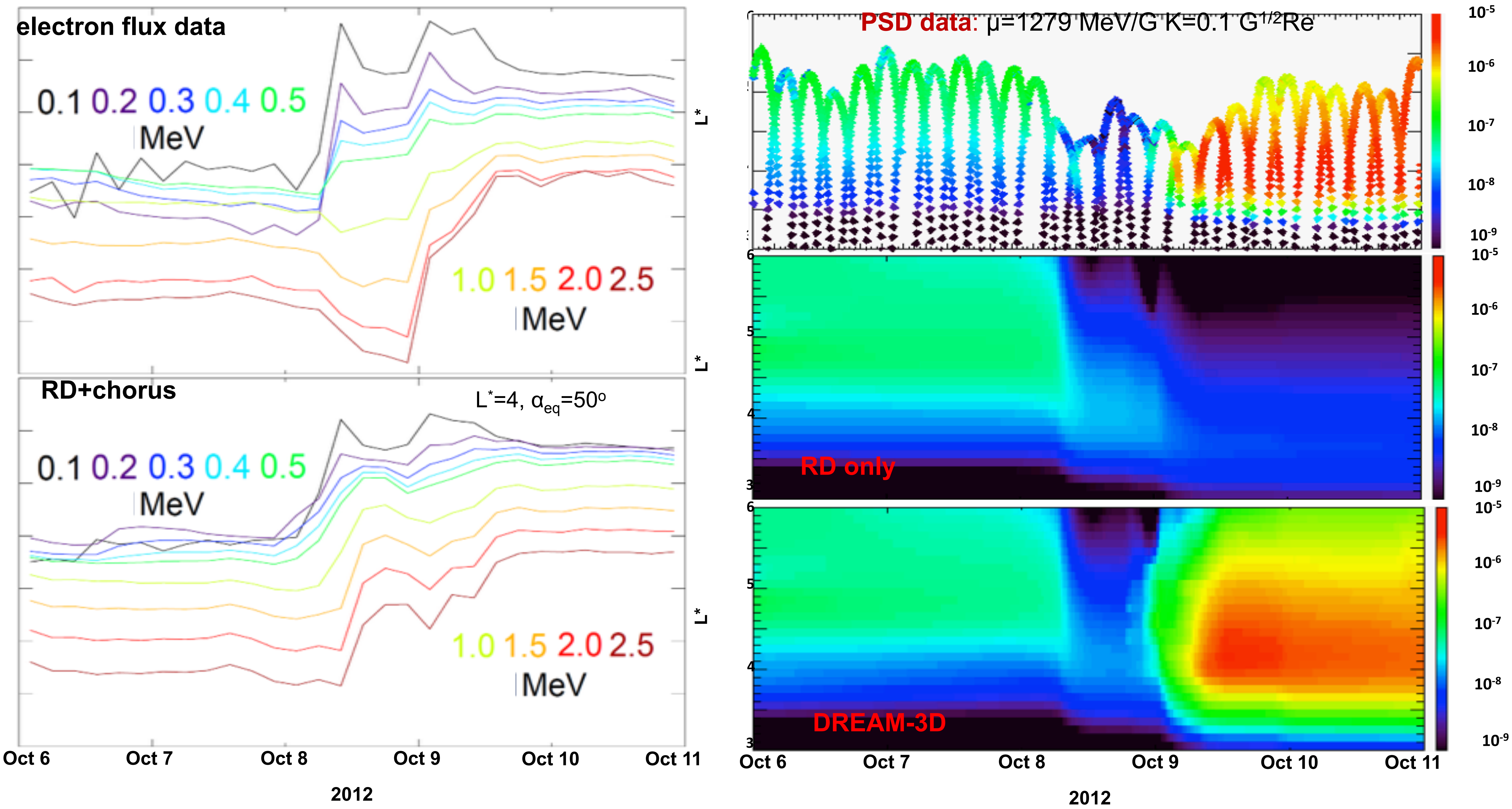
Adding chorus waves produces acceleration but much less than observed

Using the Meredith statistics is worse. Observed waves are 10x the statistical model



Tu et al., GRL 2014

Adding Observed 100 keV Flux



Tu et al., GRL 2014

Conclusions

- In the two-year Van Allen Probes prime mission we sampled all local times with unprecedented measurements of waves, relativistic electrons, ring current ions, composition & plasma distribution. We are only now digesting the results.

- At the same time the Van Allen Probes enabled detailed, quantitative analyses of storm-time energization, losses, transport, plasma instabilities, and wave-particle interactions

- New global models can be run with observed simulation boundary conditions, seed population, magnetopause, wave distributions etc. This allows quantitative testing of the effects of and relative importance of different processes in specific individual radiation belt events.