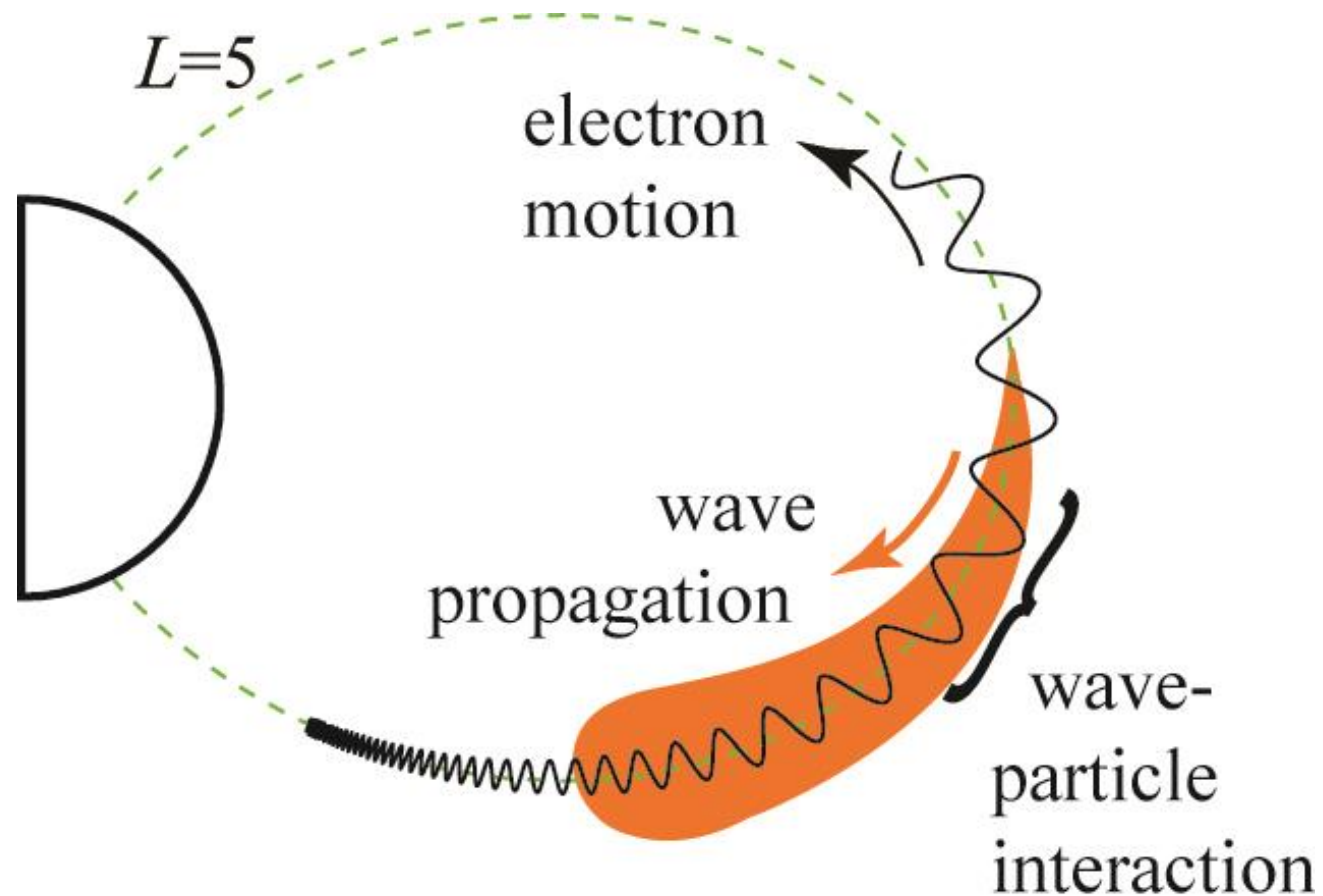


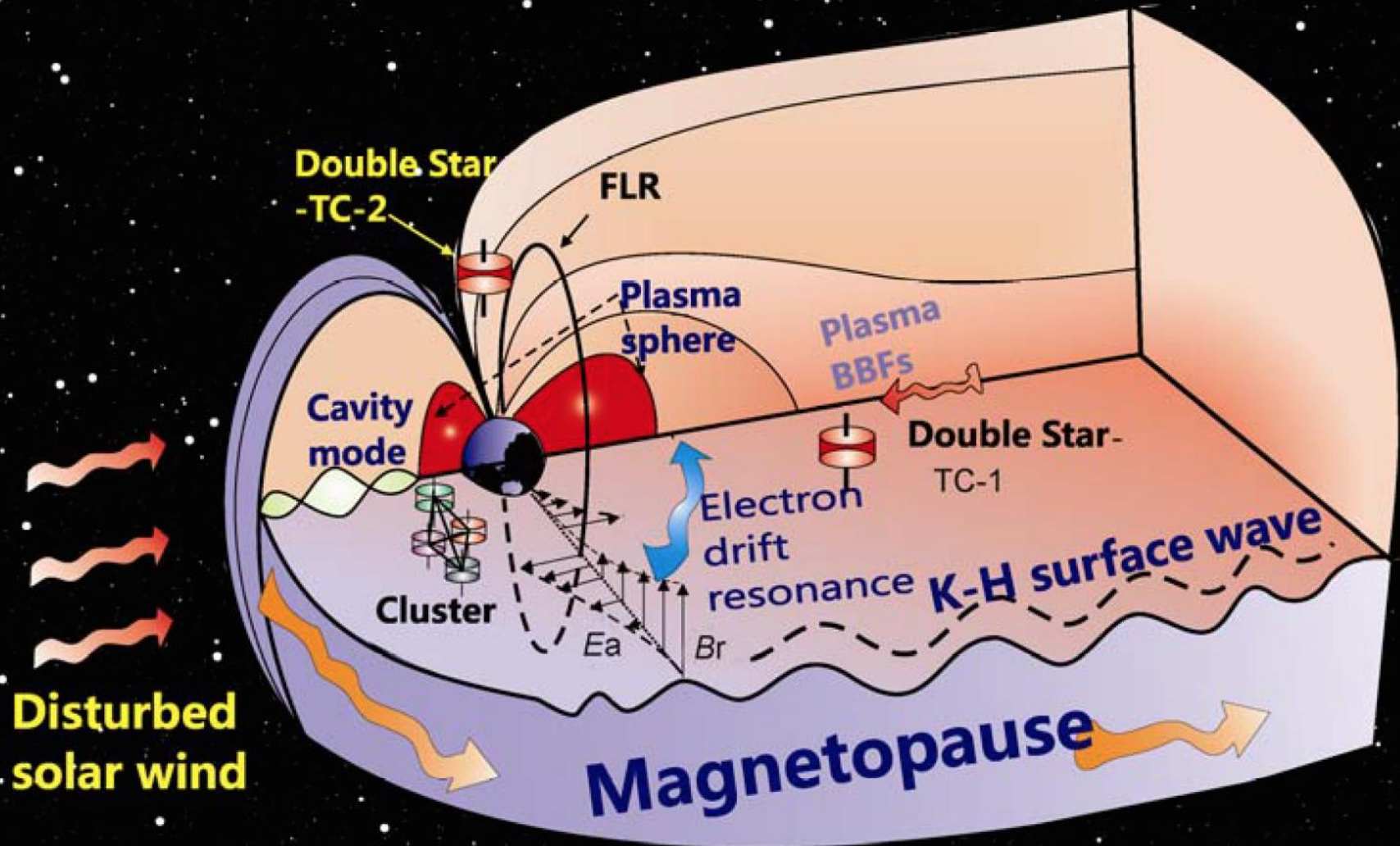
Space Physics Master's Course

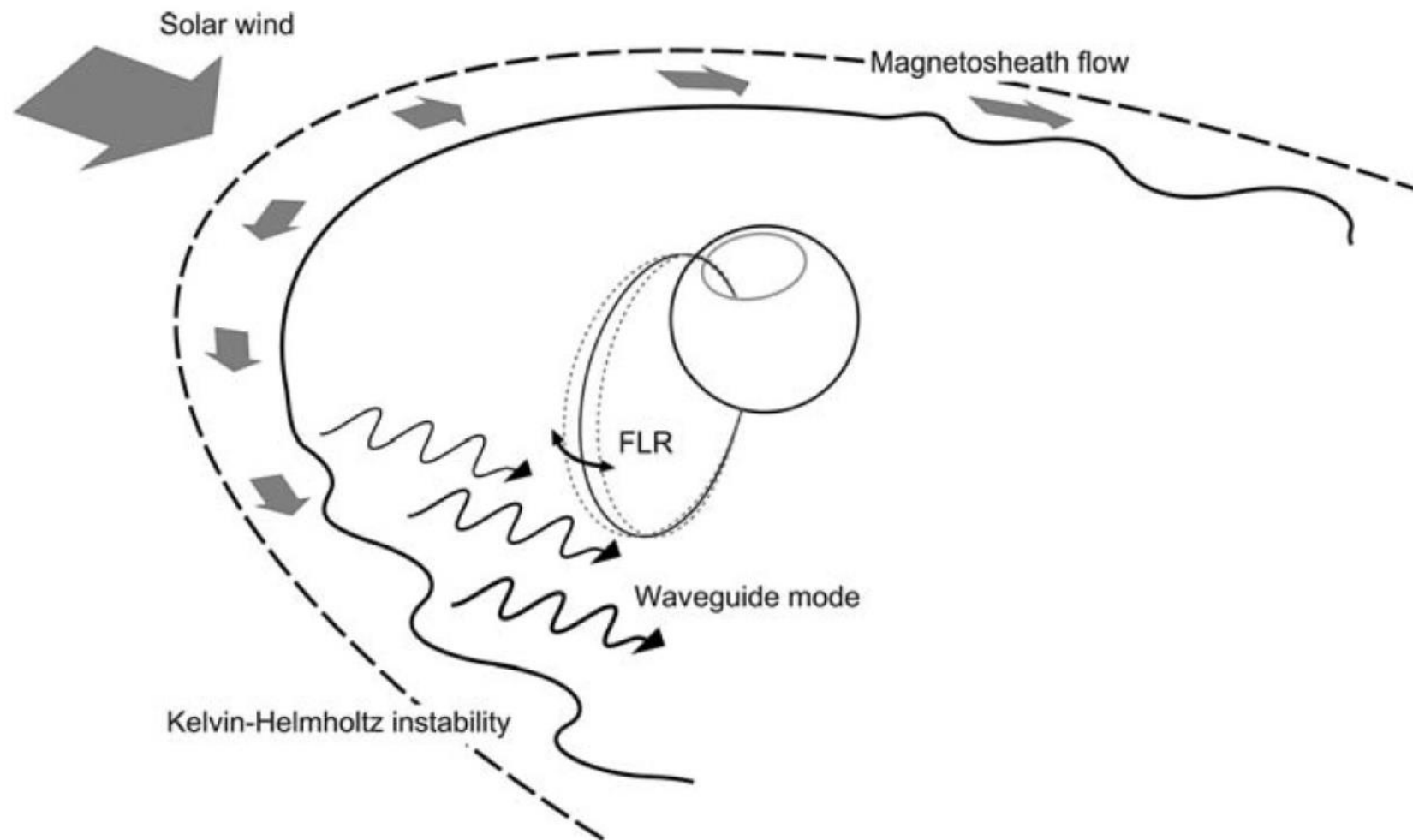
Lecture 1 1

Waves

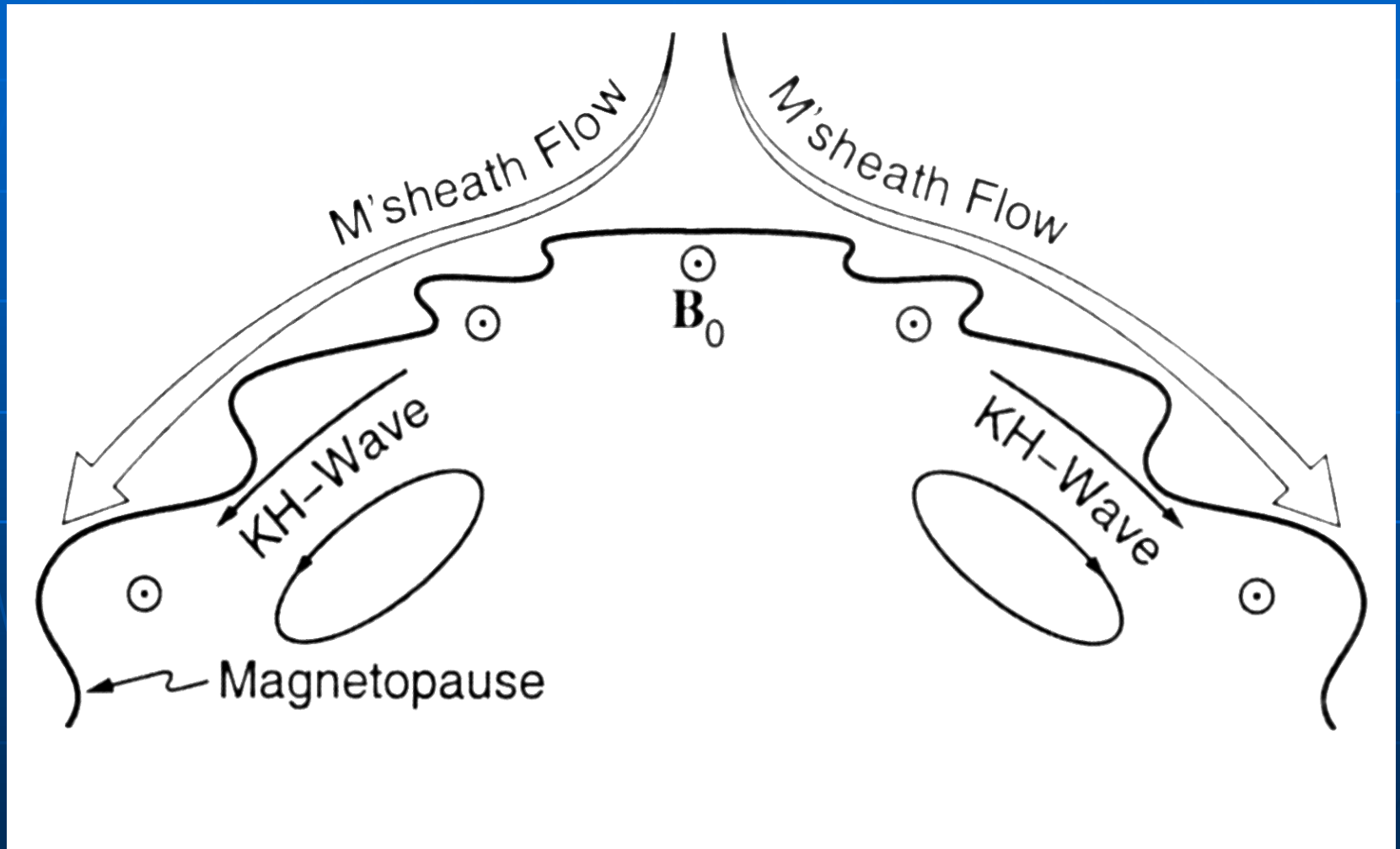


How “Killer” Electrons Form in Space





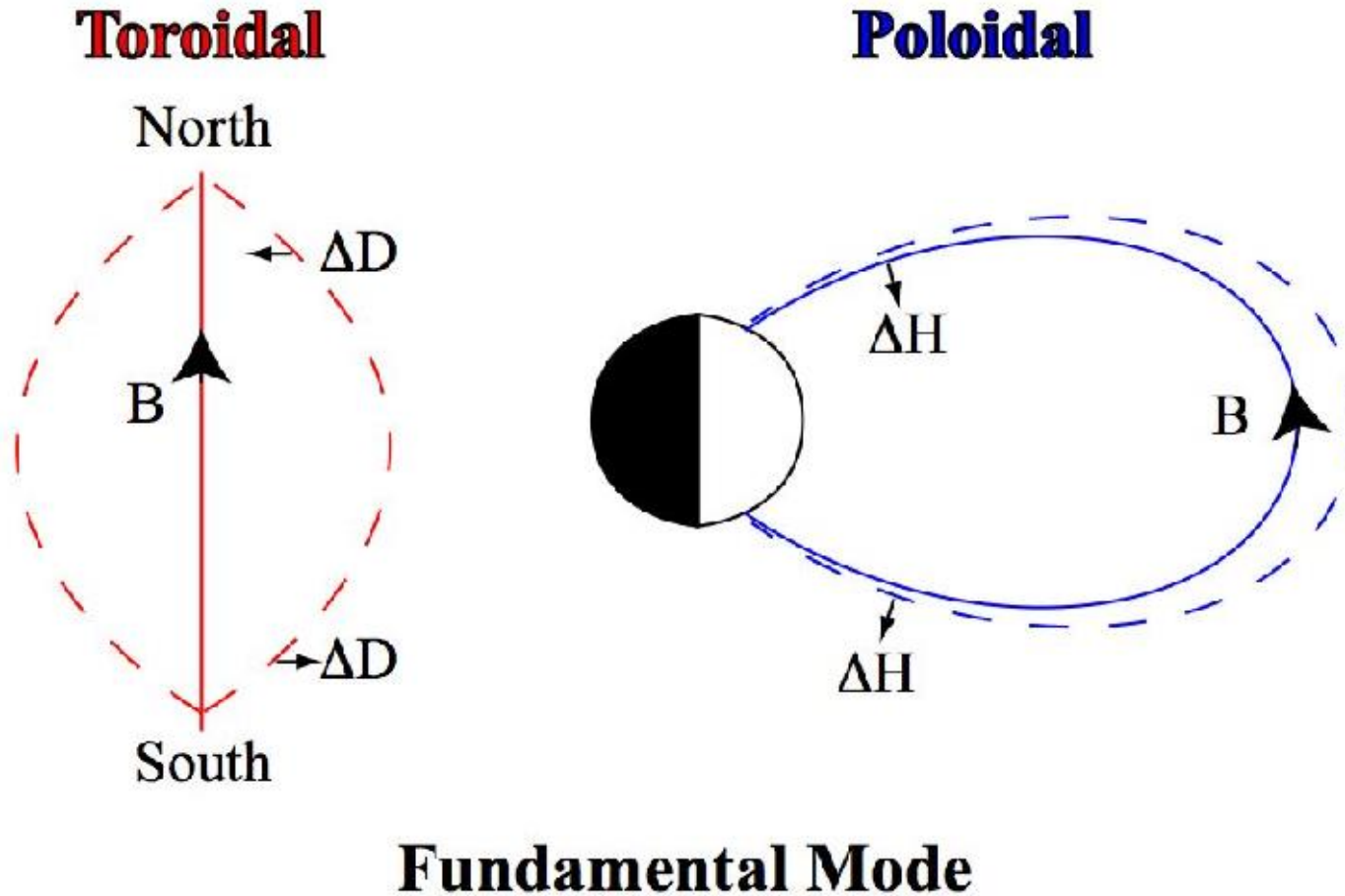
Growth of Magnetopause K-H Waves





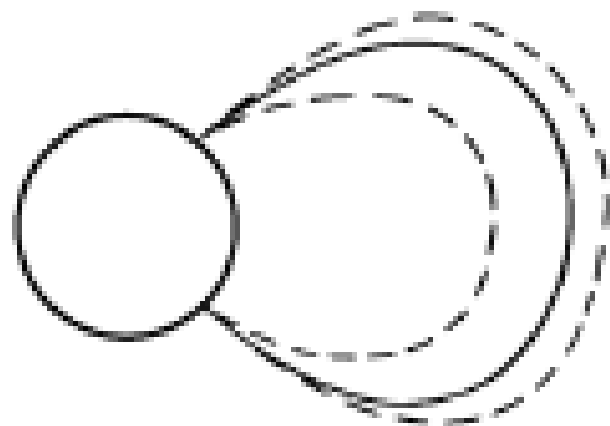


Toroidal and Poloidal Modes



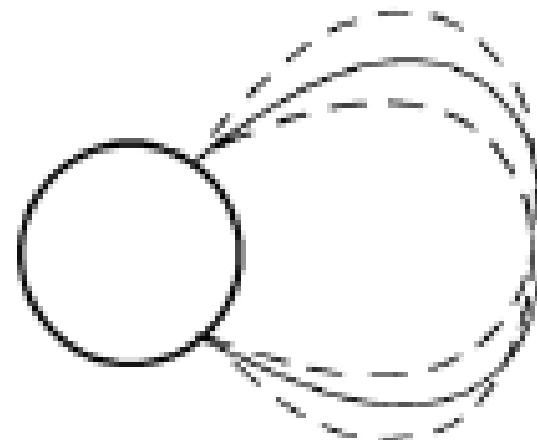
(a) Fundamental (odd)

Poloidal

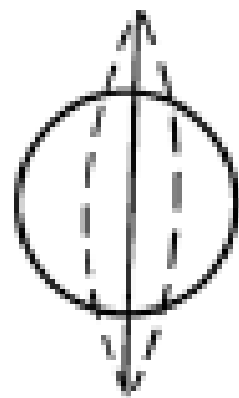


(b) Second harmonic (even)

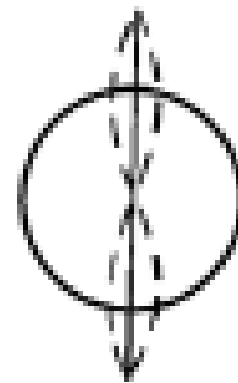
Poloidal



Toroidal

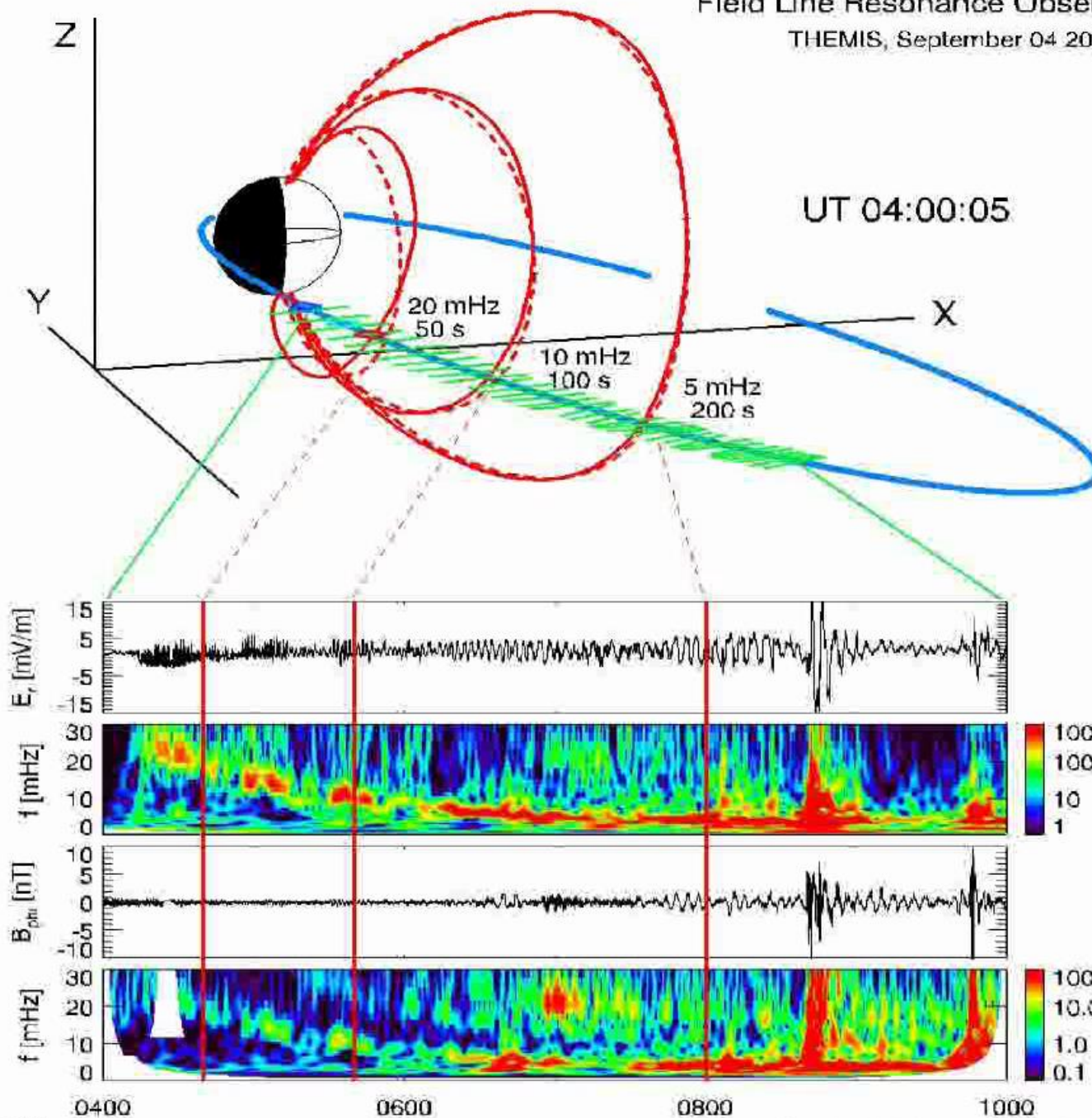


Toroidal



Field Line Resonance Observations

THEMIS, September 04 2007

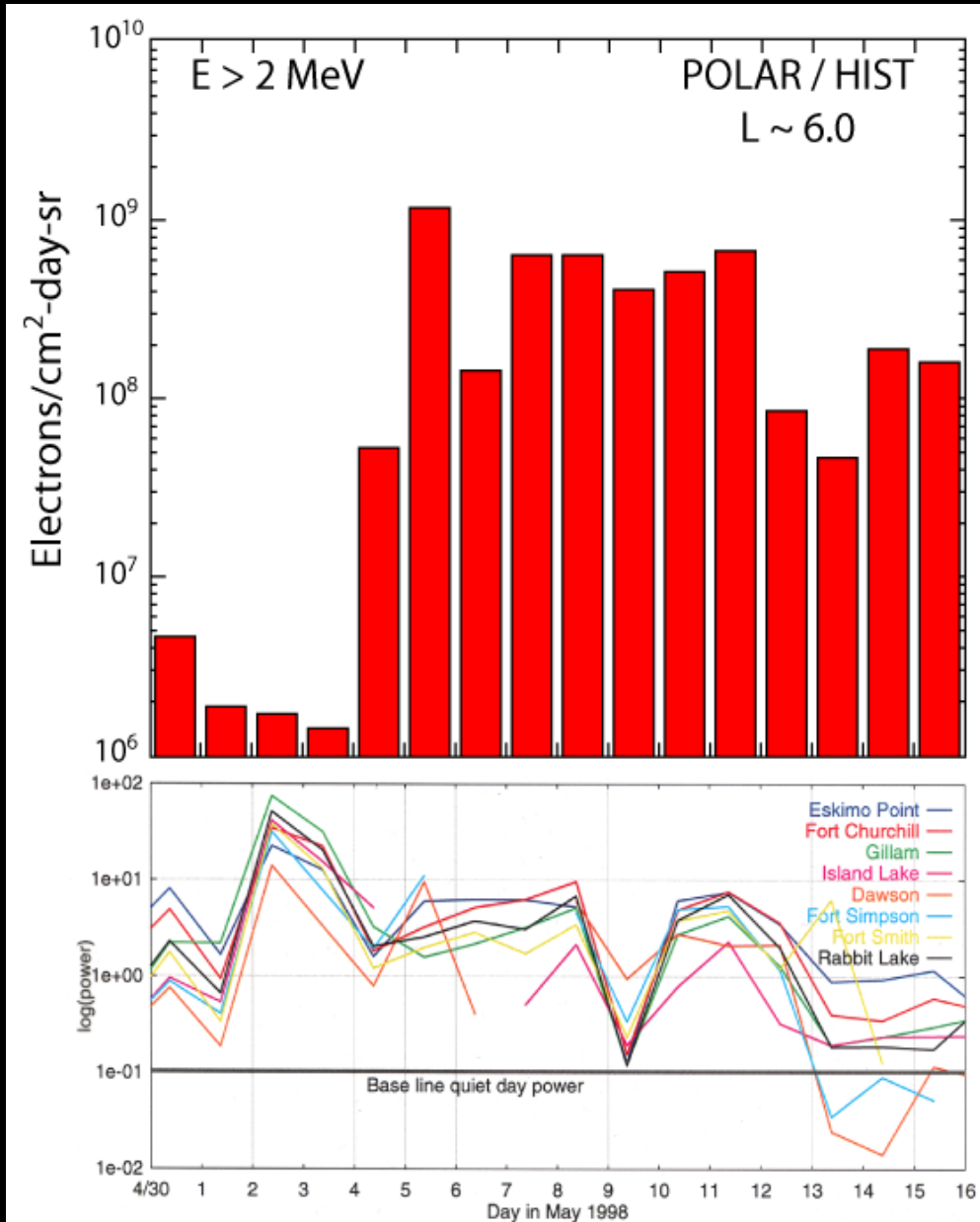


hhmm
2007 Sep 04

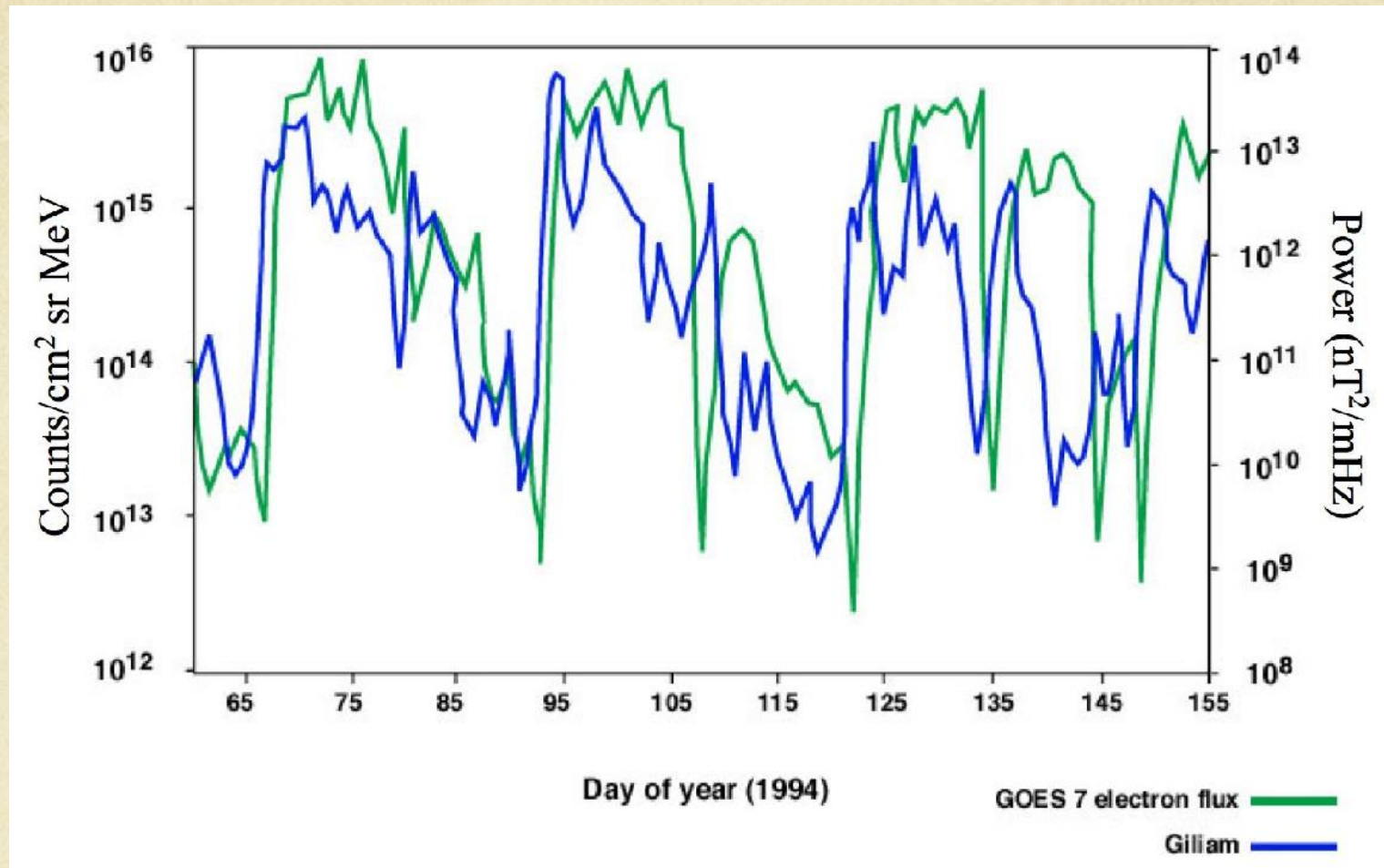
Theodore Sarris, Jan. '09 (sarris@lasp.colorado.edu)

Radiation belt formation

Association of MeV
electrons with ULF
waves / **radial diffusion**
[Baker and Daglis, 2006]



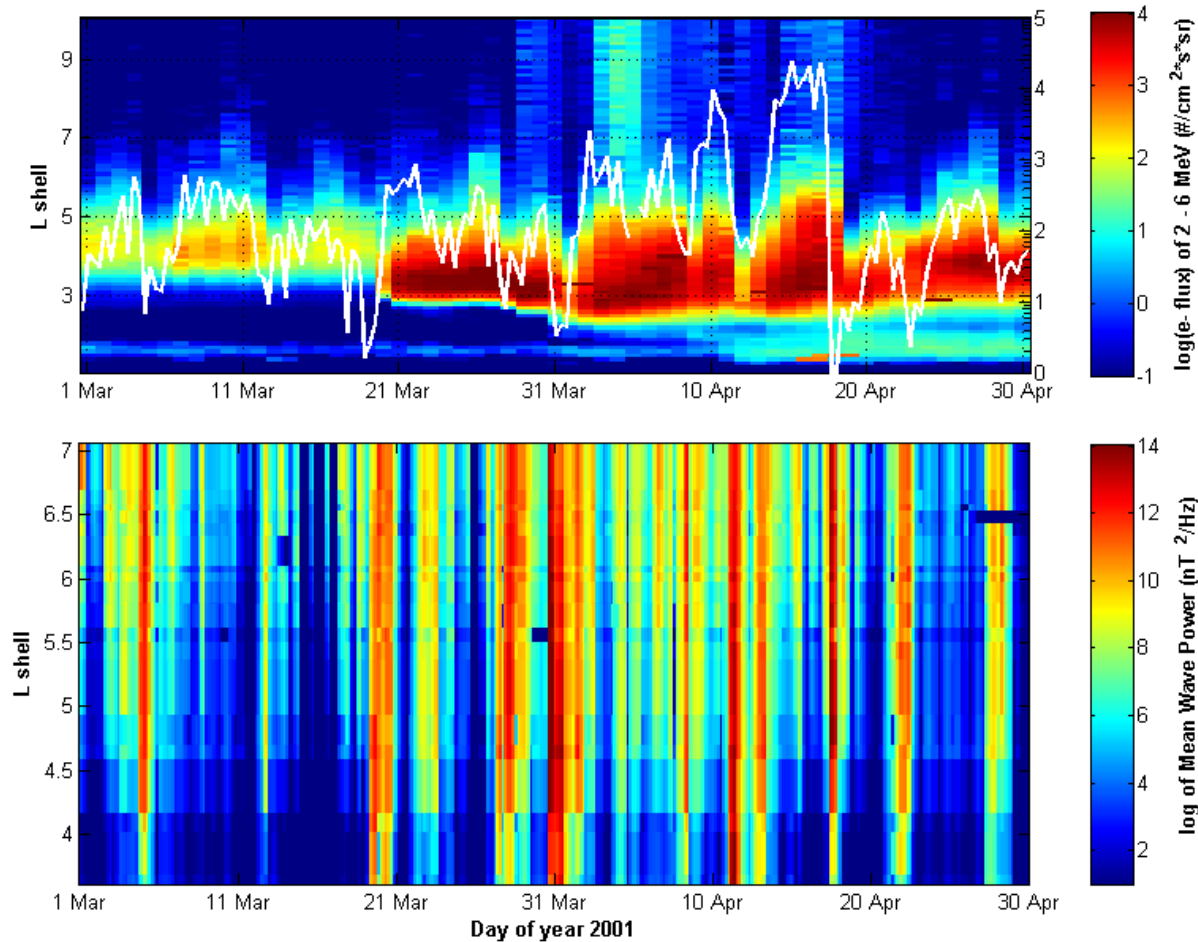
Pc5 waves – RB connection



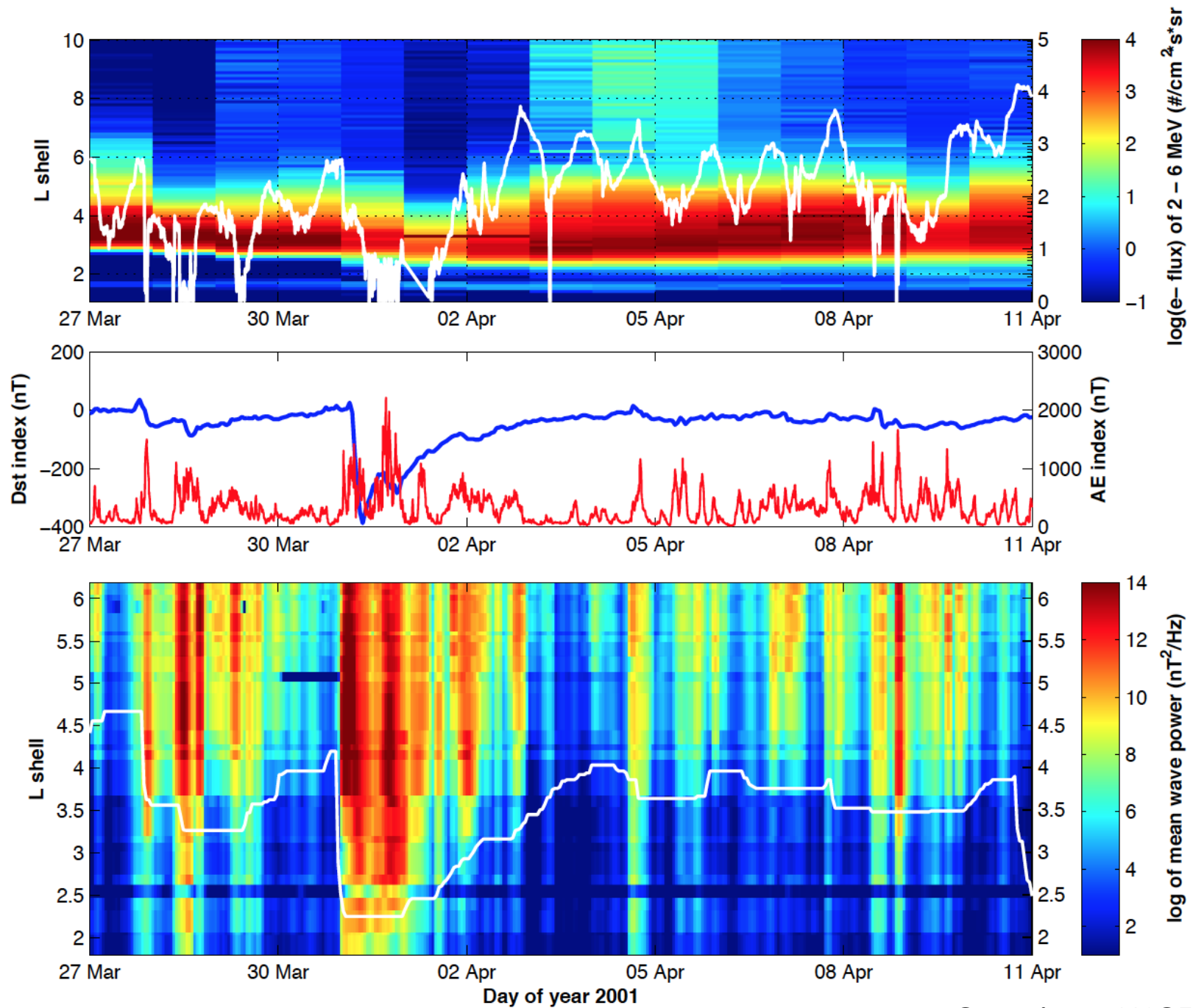
Rostoker et al., 1995

Increases in the Pc5 wave power
observed by ground magnetometers match
increases of the relativistic electron flux observed by GOES-7

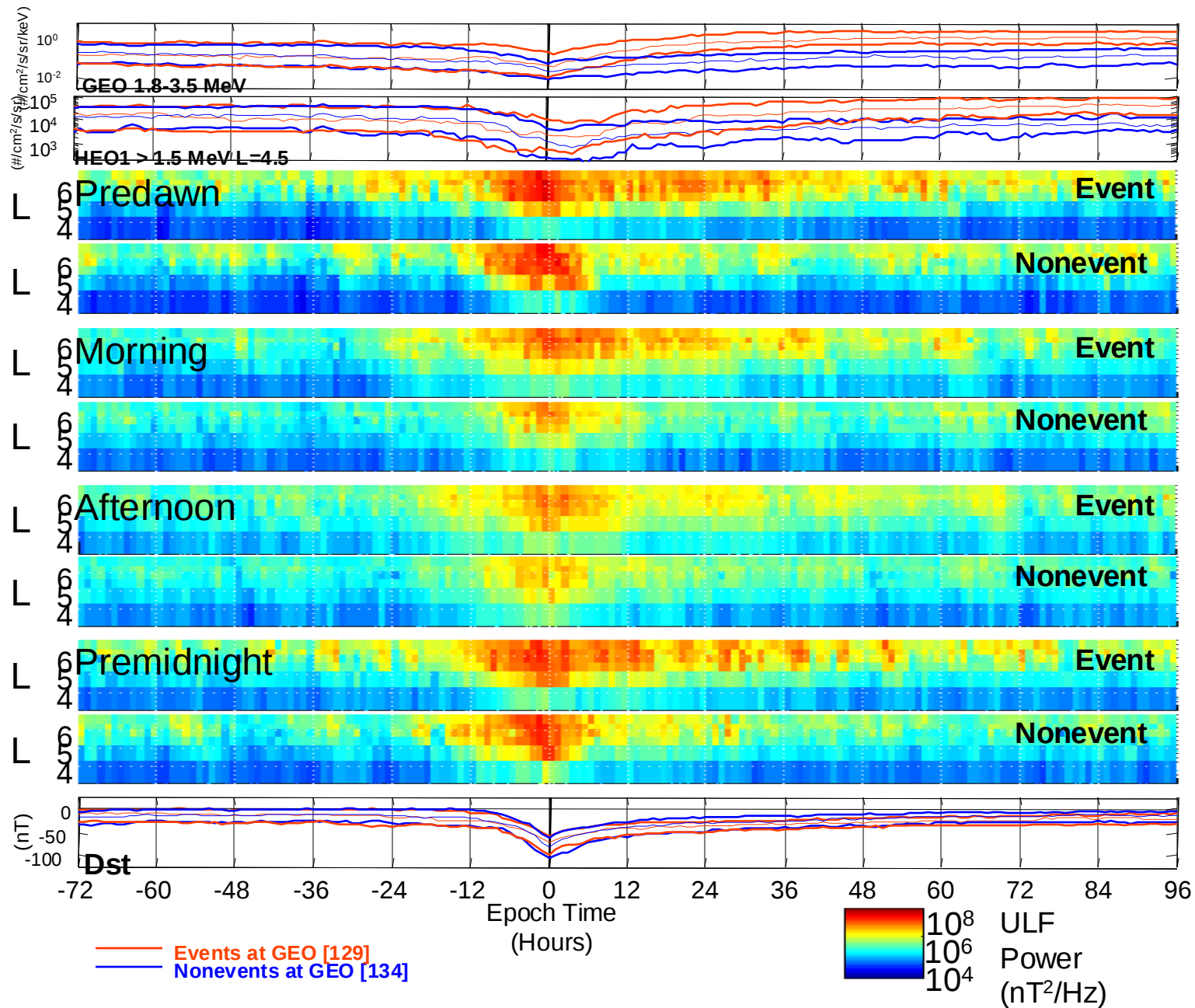
Pc5 waves – RB connection

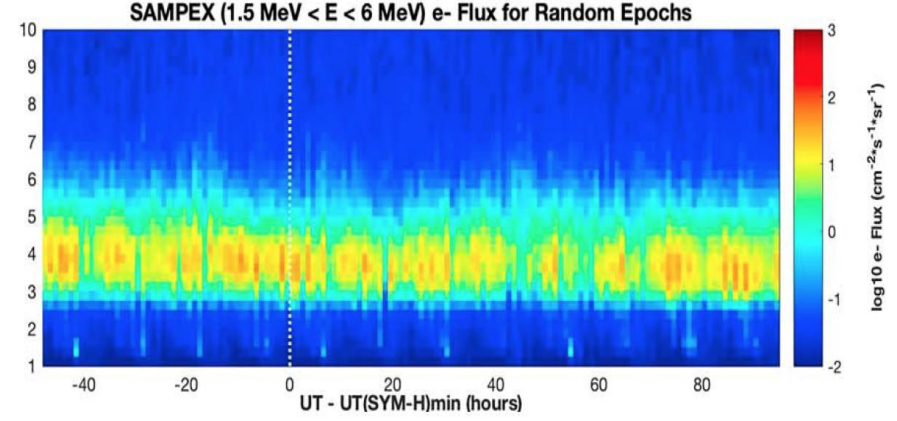
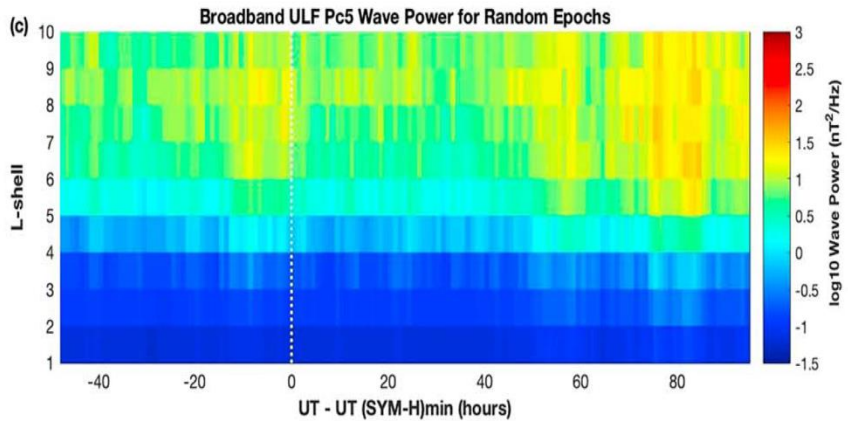
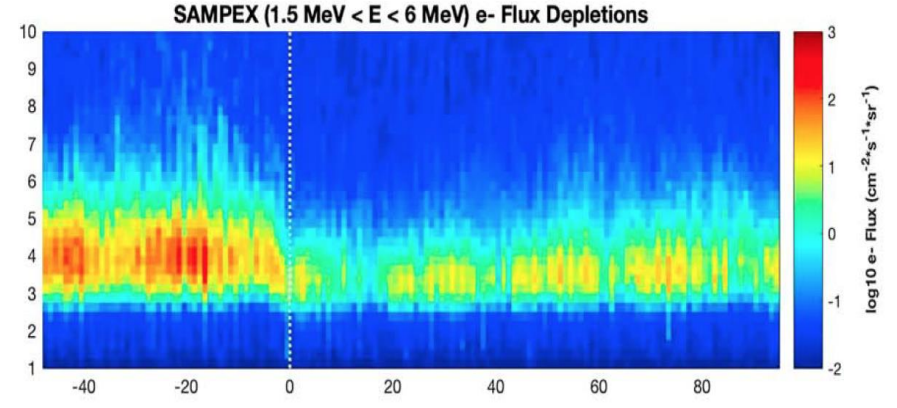
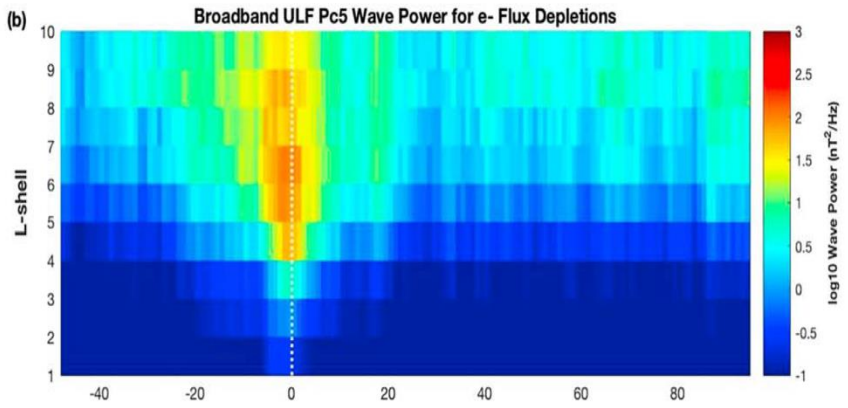
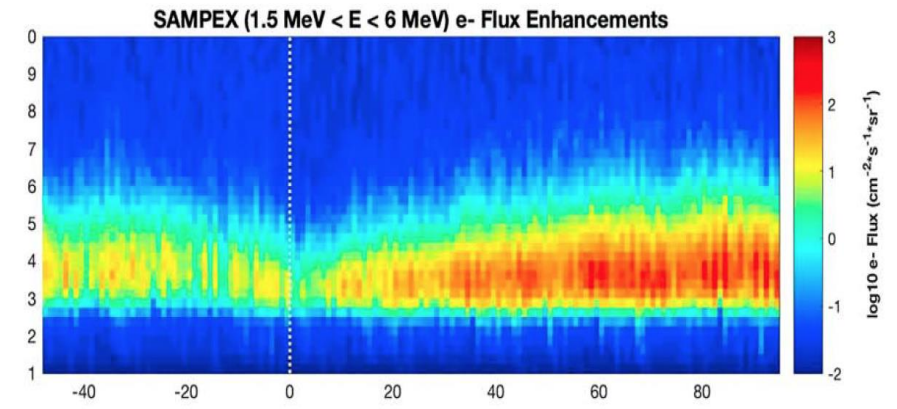
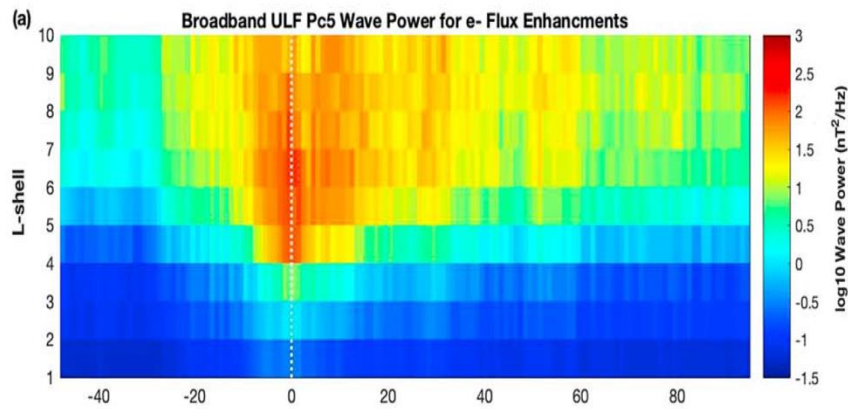


Latitudinal distribution of electron fluxes > 2 MeV and Pc5 wave activity during the period from 1 March to 30 April 2001 [Georgiou et al., 2015]

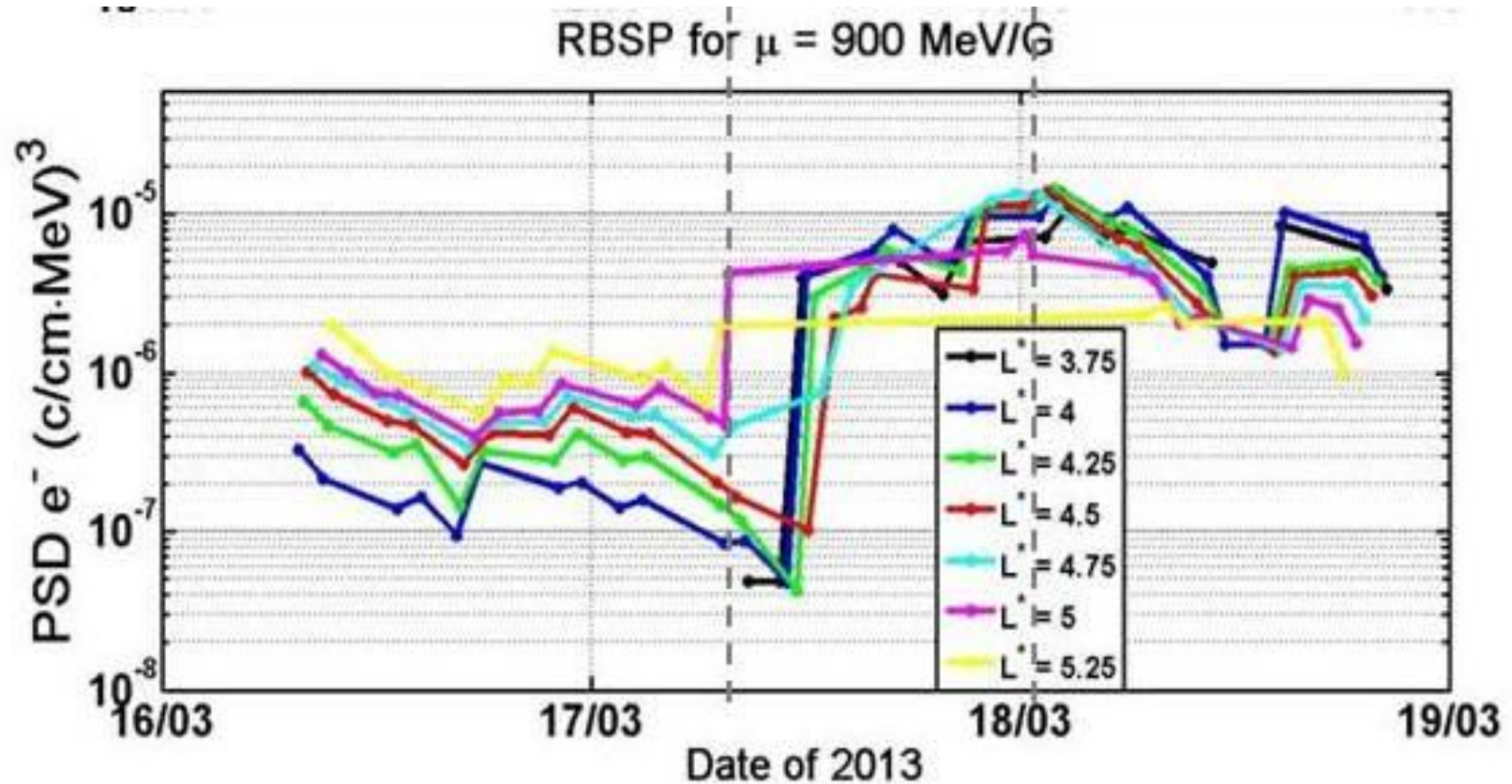


Geospace Storms and Radiation Belts





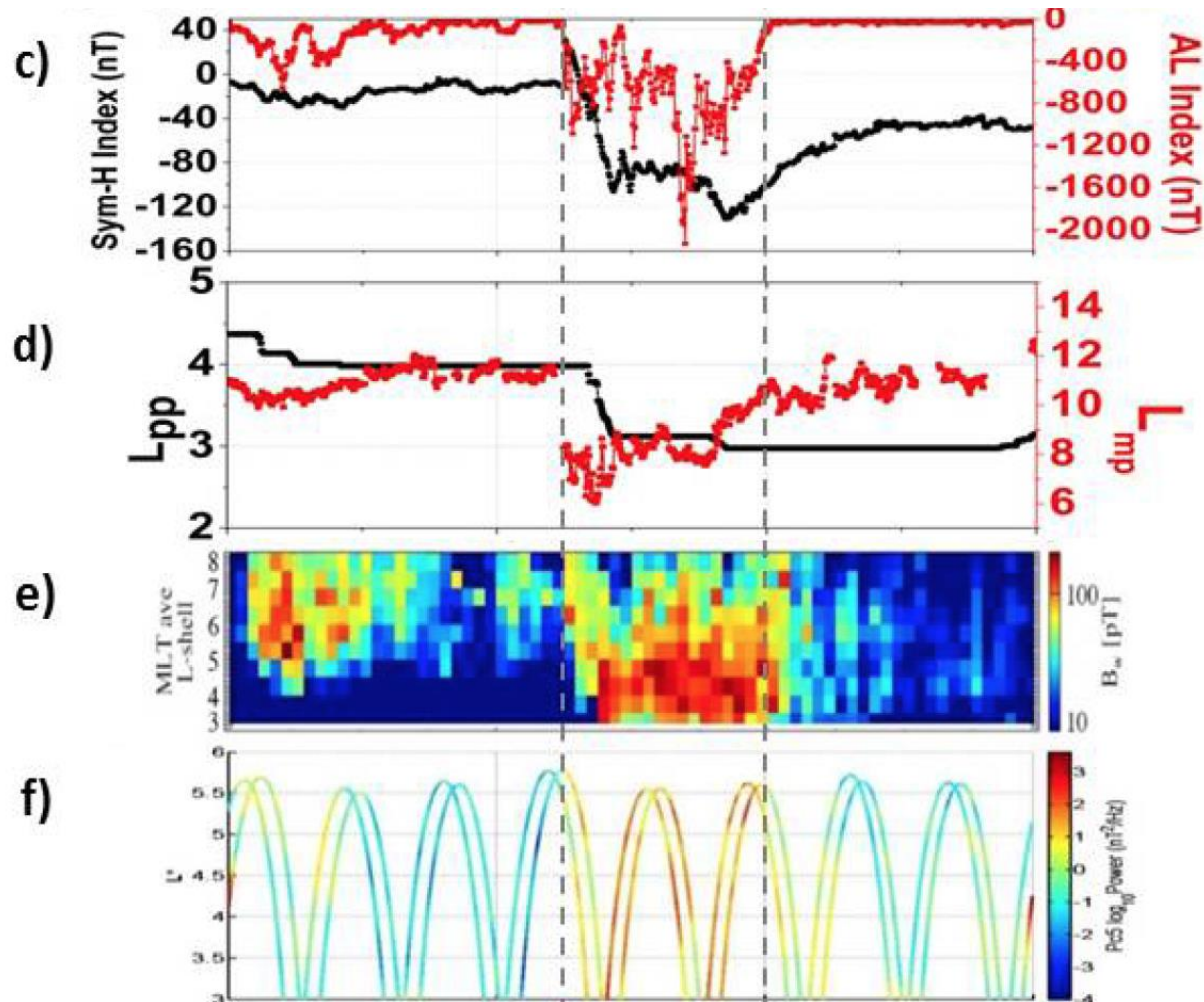
Waves synergy and RB acceleration



Pc5 and Chorus synergy in March 2013 storm

Enhancement of relativistic electrons, Katsavrias+, ANGE02015

Waves synergy and RB acceleration

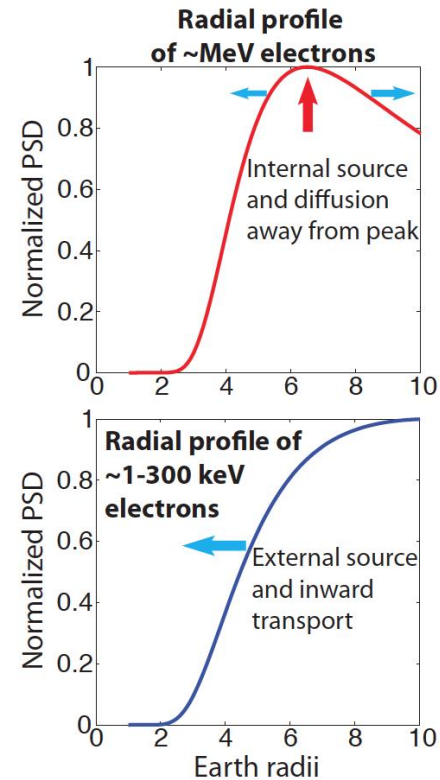
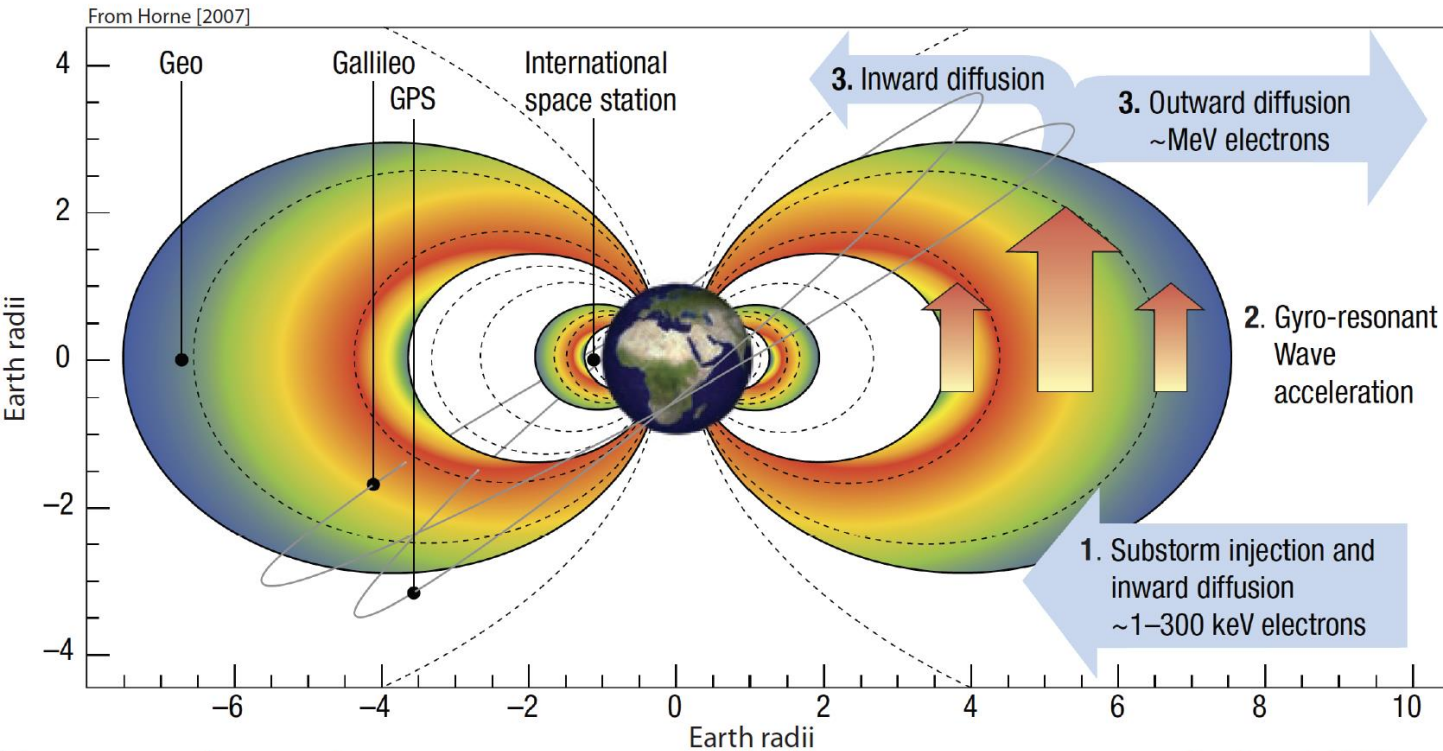


17 March 2013 Storm, Pc5 and Chorus synergy
Katsavrias+ ANGEO2015

Waves synergy and RB acceleration

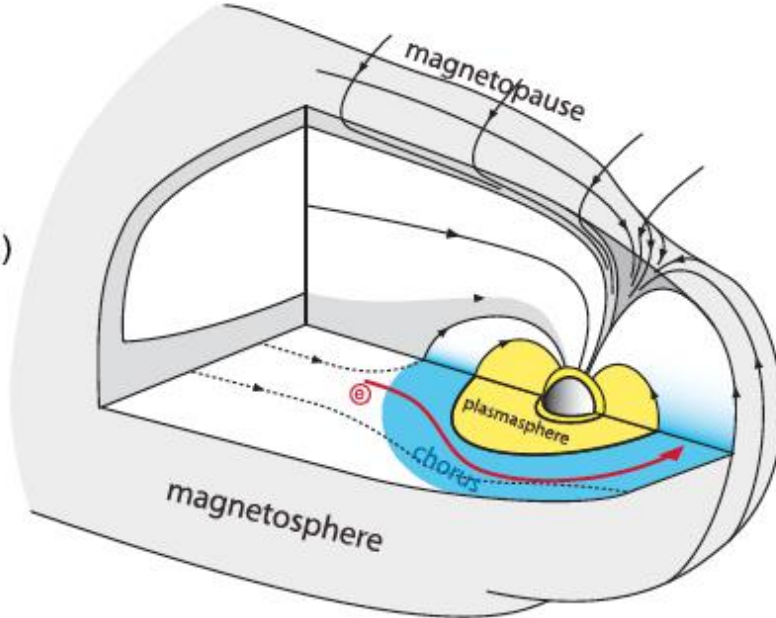
a) Concept Schematics

Electron acceleration in the outer radiation belt

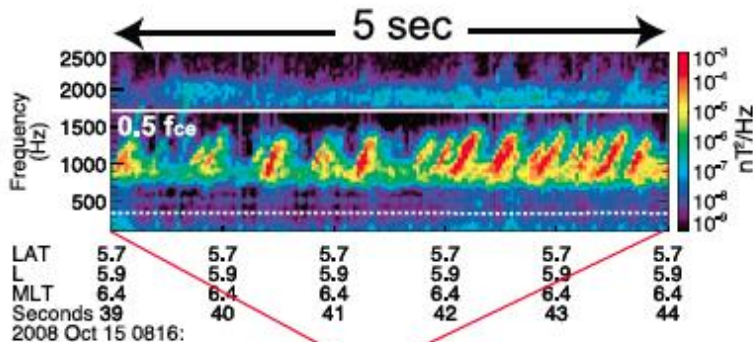


Chorus characteristics

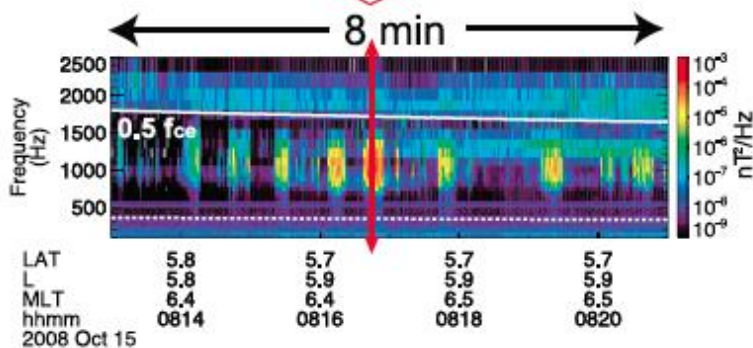
(a)



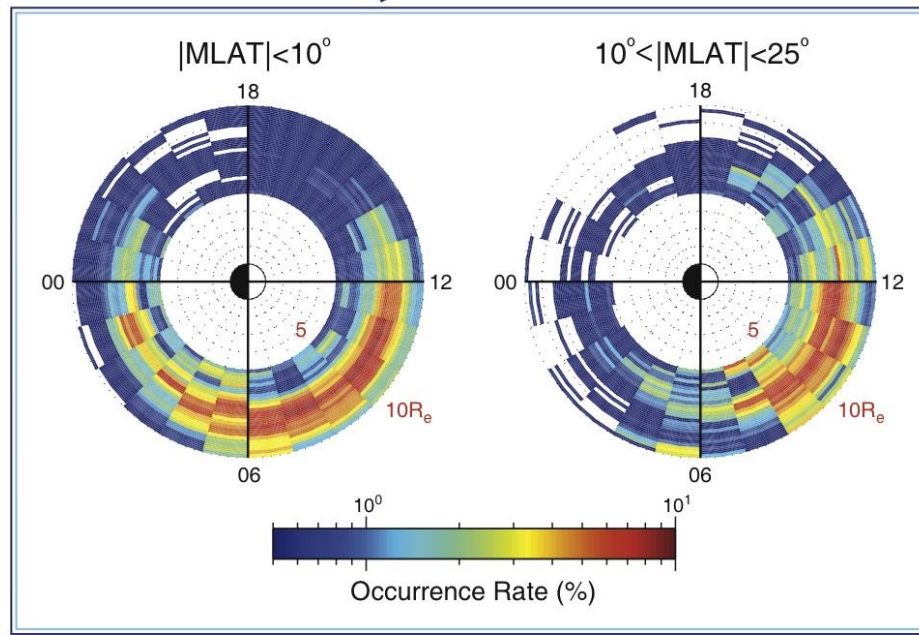
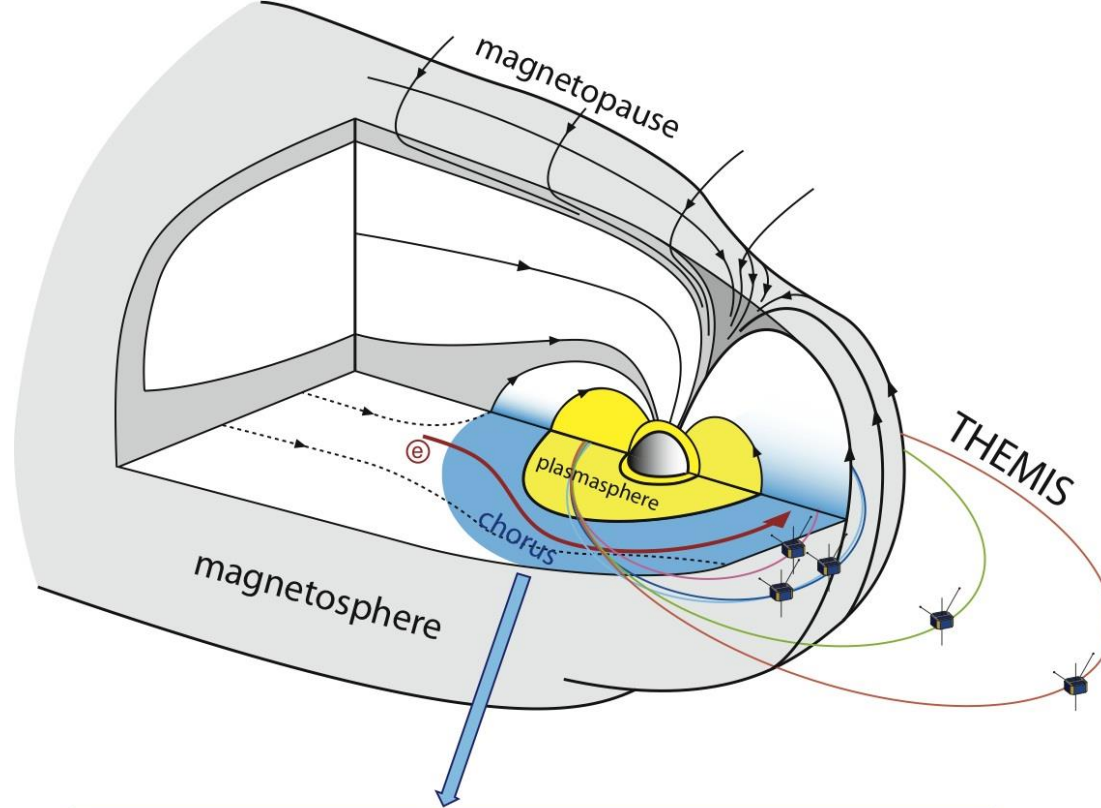
(b)



(c)

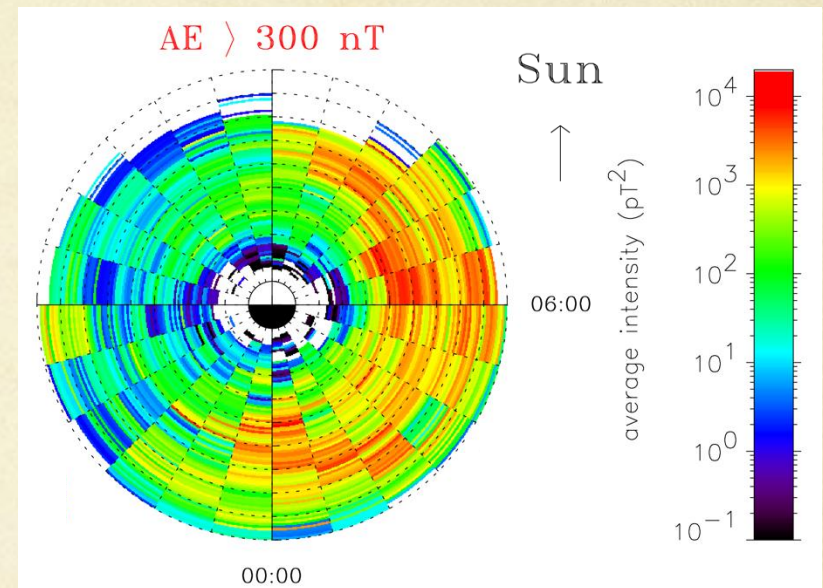


- Found outside plasmasphere on **dawn-side**
- Due to unstable, drifting plasmasheet electrons
- Multi-scale structure in space and time



Chorus and Magnetic Storms

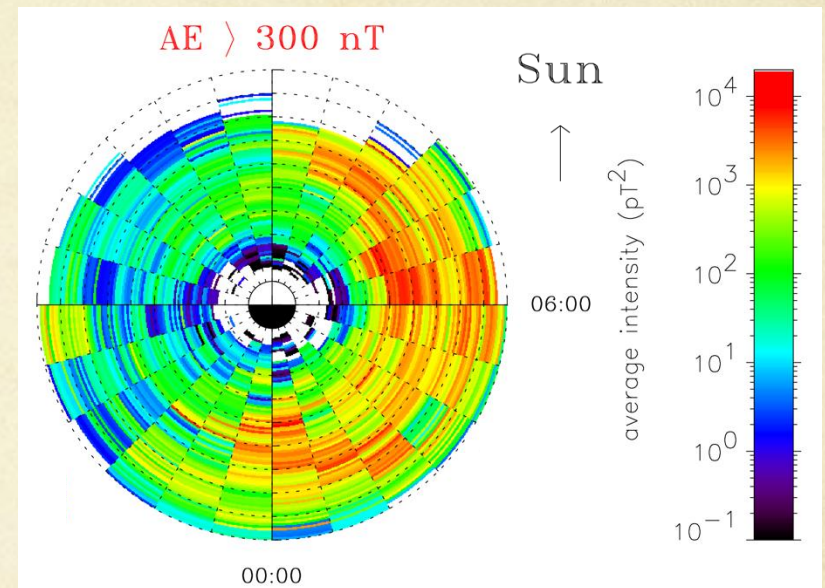
- Chorus emissions are enhanced during geomagnetic storms, because they are driven by ring current electrons
- The waves are strongest on the **dawn-side** at 4-9 Earth radii, as can be seen from this statistical survey using data from 7 satellites



Meredith *et al.*, 2012

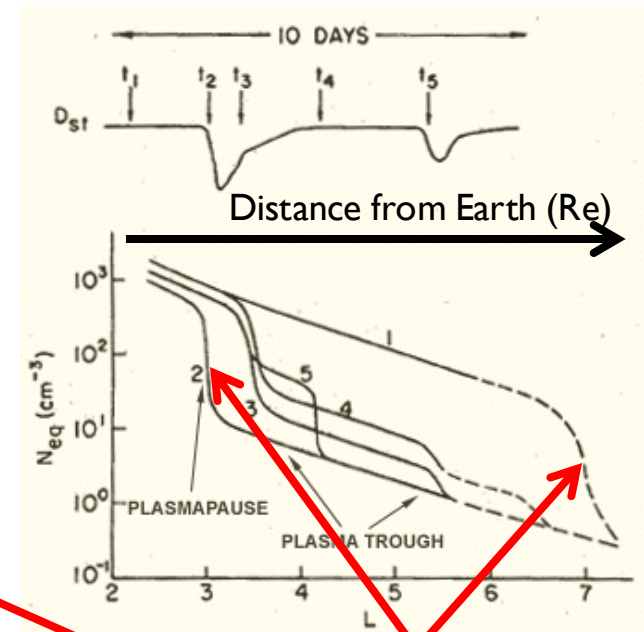
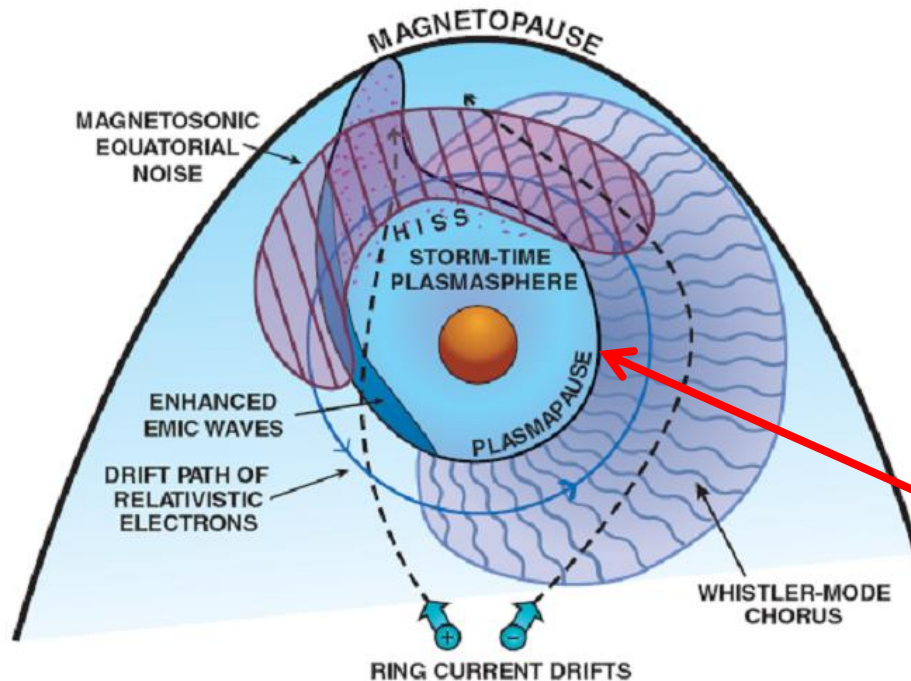
Chorus and Magnetic Storms

- Chorus waves accelerate electrons to relativistic energies
- We use global maps such as these in computer models to produce space weather forecasts



Meredith *et al.*, 2012

What drives strong and weak diffusion?



There are many different waves, which drive weak and strong diffusion depending on storm levels

Wave penetration is dependent on the **position of the plasmapause**