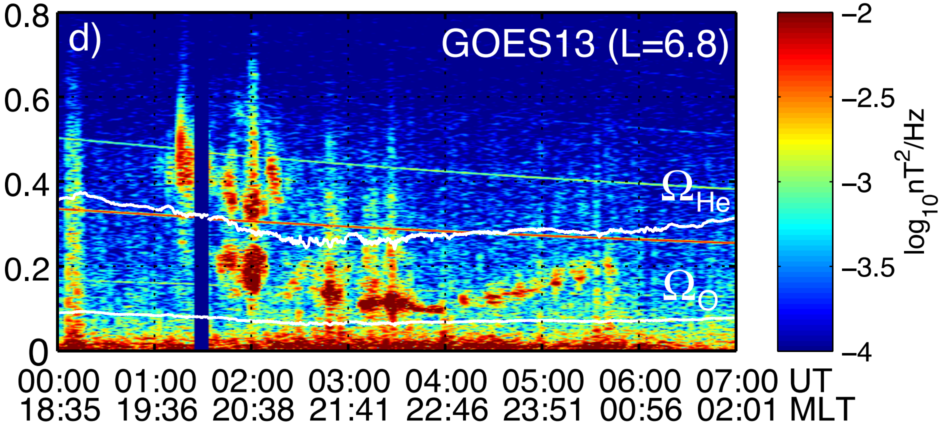
Jaw-dropping ~~Long-term~~ correlation of EMIC wave activity and radiation belt flux variations

Maria Usanova, Alexander Drozdov, Ian Mann, Yuri Shprits, Andy Kale

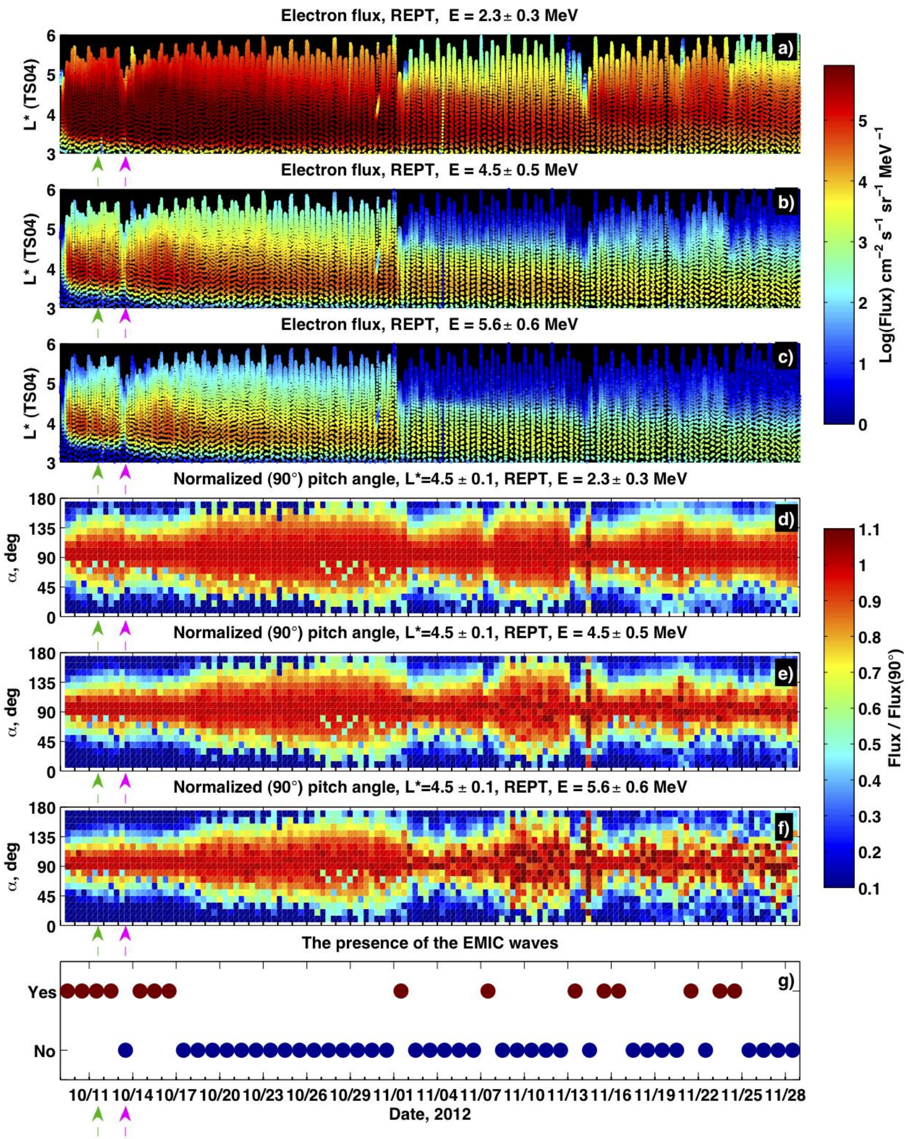
Background: EMIC waves



Geosynchronous magnetic field measurements. Usanova et al.; AGU monograph, 2016

- Transverse plasma waves generated by wave-particle interaction (ion cyclotron instability)
- Energy source: 10 - 100 keV protons with $T_{perp} > T_{para}$
- Typical amplitudes in space: ~1 - 10 nT in B, ~1 mV/m in E.
- Three bands below H^+, He^+, O^+
- Typical frequencies: 0.1 - 5 Hz
- Can interact with energetic ions and ~MeV electrons if Doppler-shifted wave frequency matches the particle cyclotron frequency
- Can cause precipitation of both ~10-100 keV protons and ~MeV electrons (Miyoshi et al., 2008)

Electron pitch-angle scattering by EMIC waves



- Differential electron flux as a function of L* (a-c), and differential flux as a function of PA L*=4.5 (d-f) in the 2.3, 4.5, and 5.6 MeV energy channels and EMIC wave occurrence from L~4-4.5 on the ground from October 9 to November 29, 2012.

- EMIC waves scatter low-pitch angle particles but cannot interact with > ~45 degree pitch-angle electrons.

- Other waves modes (e.g., hiss) are required to act simultaneously with EMICs to remove the core 90-degree population.

Usanova et al., GRL 2014

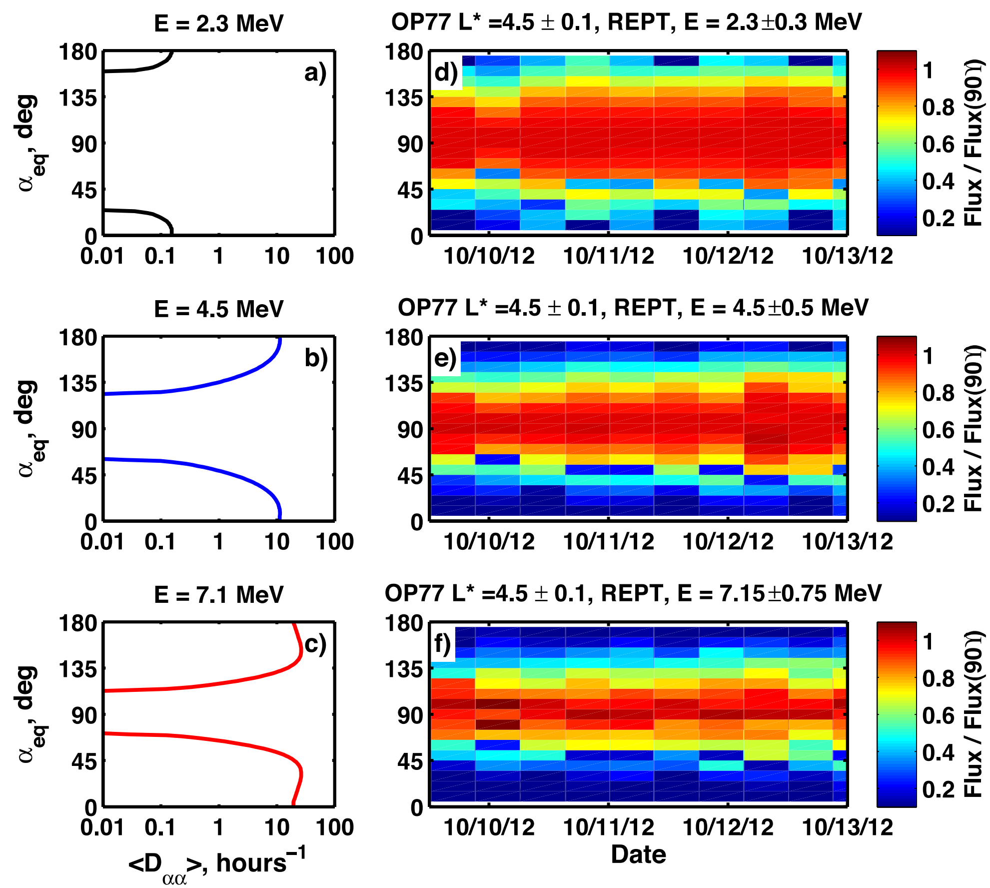
Computed electron pitch-angle diffusion coefficients

Parameters for the electron pitch-angle diffusion estimate:
B=330 nT
n_e=150 cm^{-3}
B_{EMIC}=2 nT
f_{EMIC}=0.7-1.1 Hz – Van Allen Probes

delta MLT: 6 hours - ground

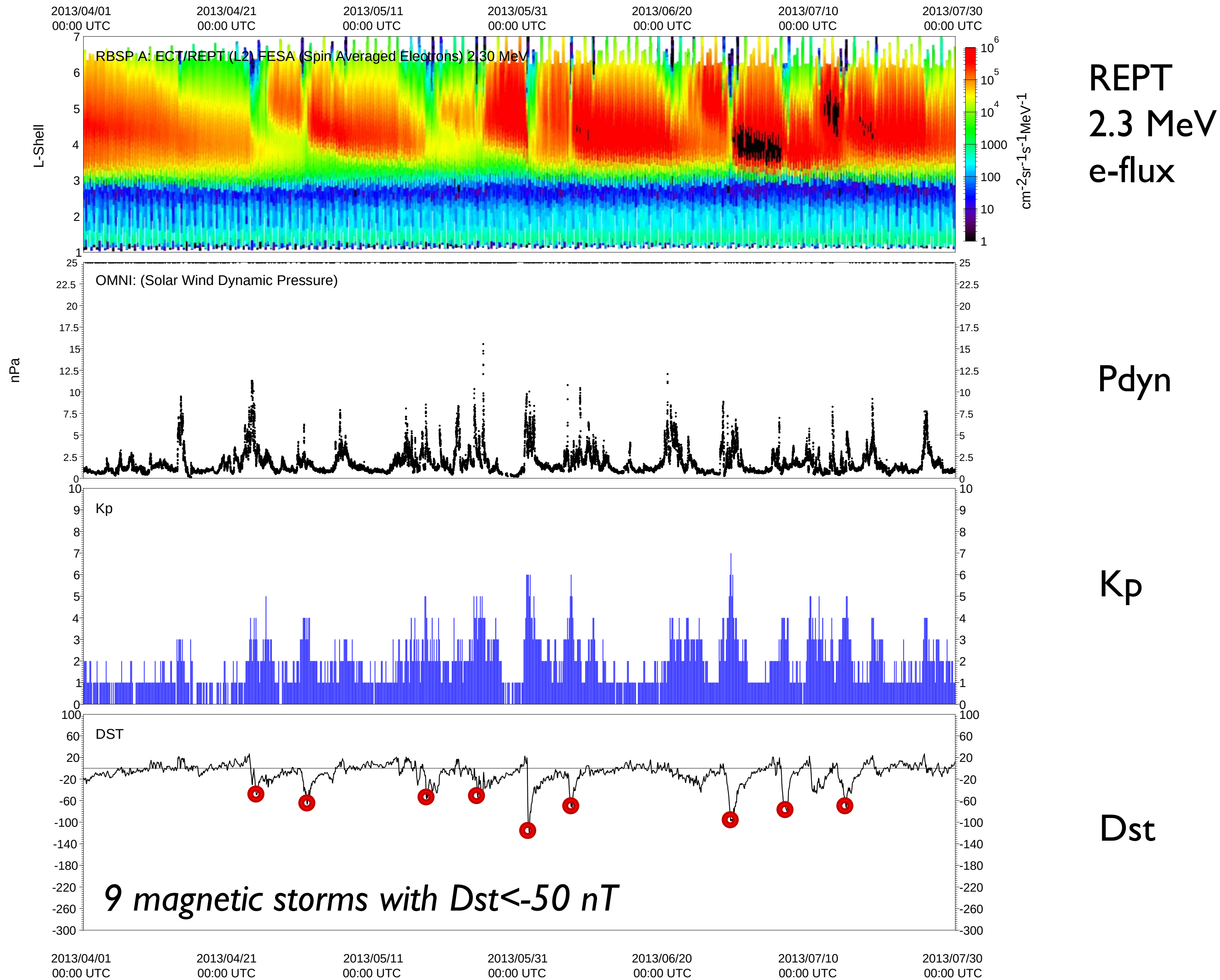
Ion composition:
70% H^+; 20% He^+; 10% O^+

Computed pitch-angle diffusion coefficients (a-c) and observed normalized electron flux as a function of pitch-angle (d-f) in the 2.3, 4.5, and 7.15 MeV for October 9-13, 2012.

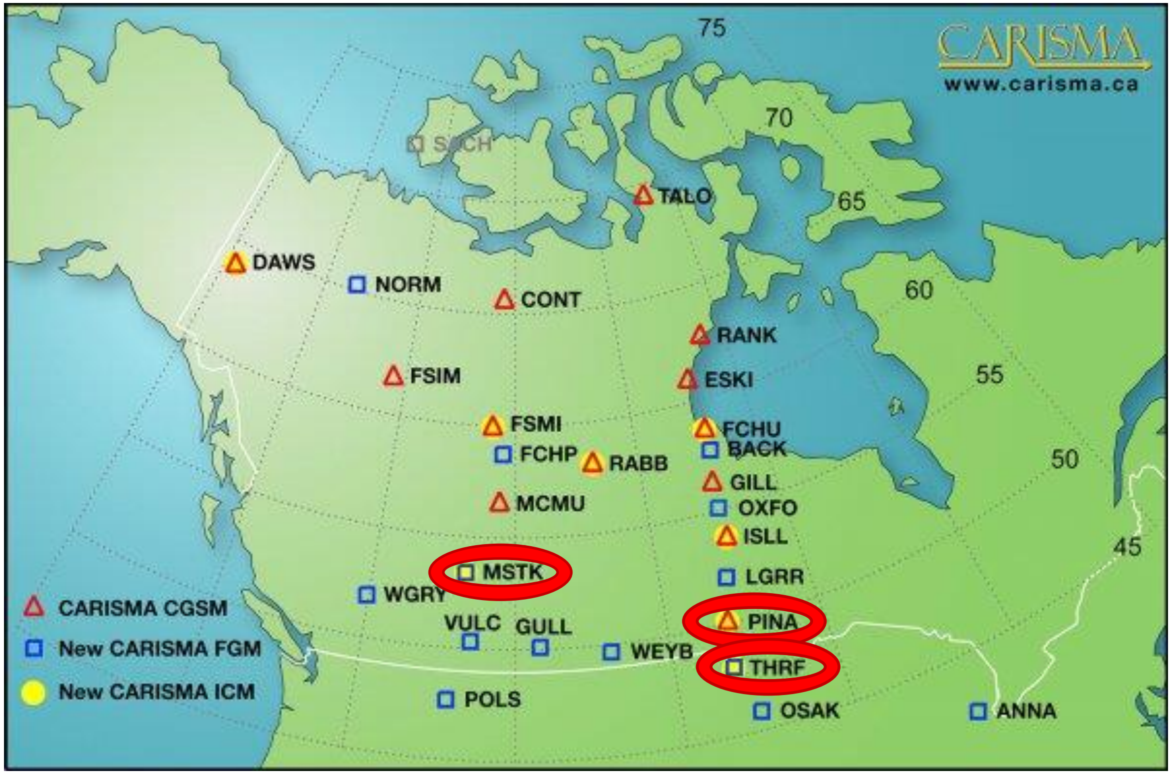


Usanova et al., GRL 2014

4 months: 1 Apr – 31 July, 2013



CARISMA magnetometers

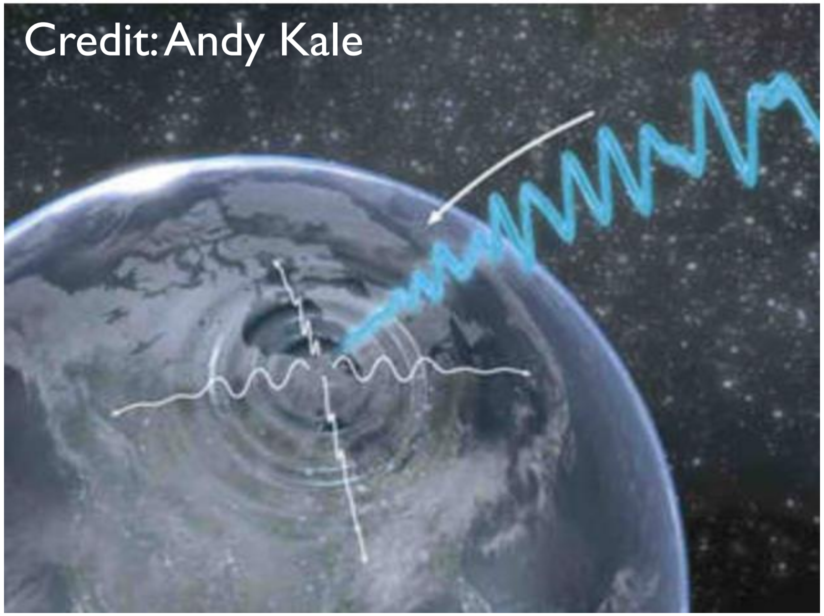


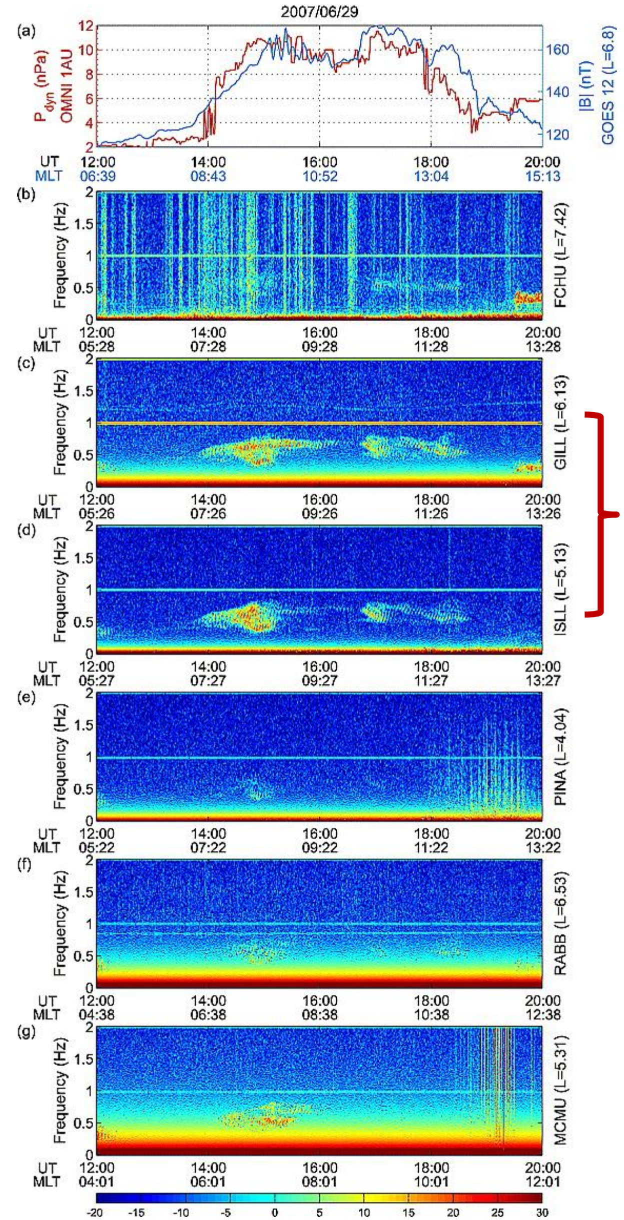
www.carisma.ca

Search coils:
THRF L=3.58
PINA L=4.06
MSTK L=4.22

- CARISMA (Canadian Array for Realtime Investigations of Magnetic Activity)
- Spans a range of longitude from Dawson City, YK to Rankin Inlet, NU and a range of latitude from Taloyoak, NU (69.54°N) to Ann Arbor, MI, USA (42.417°N)
- 27 fluxgate (4Hz), 8 new induction coil (50Hz) magnetometers

Wave ducting in the ionosphere





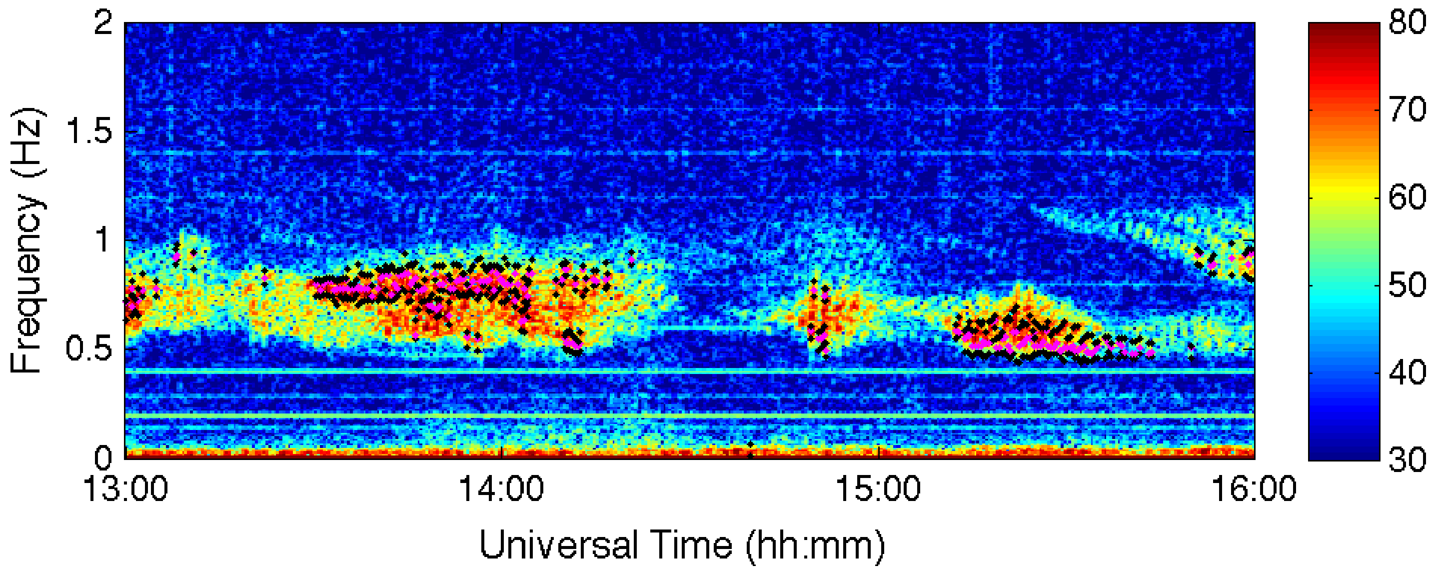
As the wave propagates away from the source footprint, its amplitude decreases.

Having multiple latitudinally separated stations, it's possible to pinpoint the source location (Usanova et al., GRL 2008).

Compressions can generate EMIC waves in the inner magnetosphere.

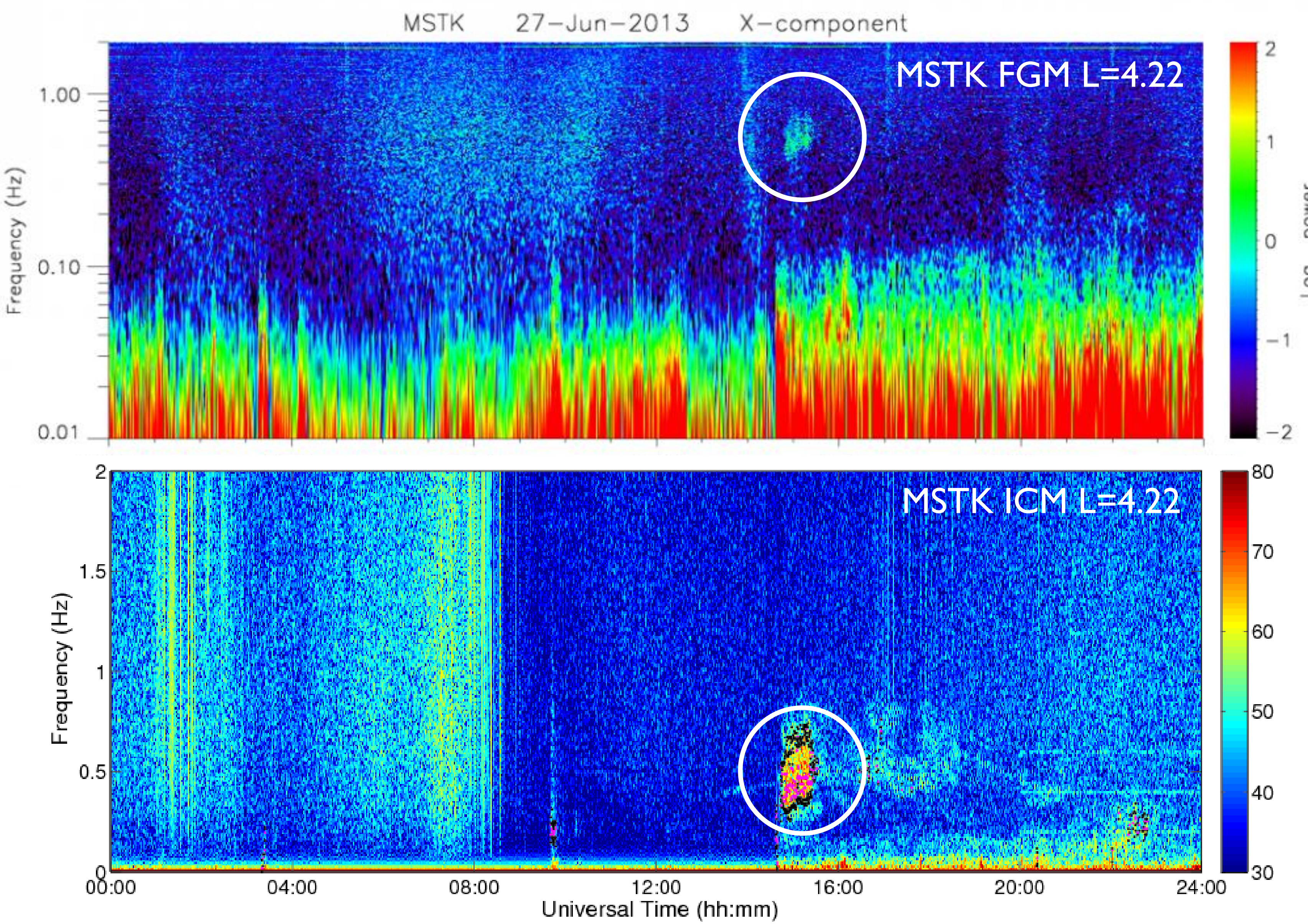
Automated EMIC wave selection algorithm

The automated detection algorithm by Bortnik et al., 2007 identifies spectral peaks that stand out (at least one magnitude greater in spectral power) above the noise based on the sliding window FFT.

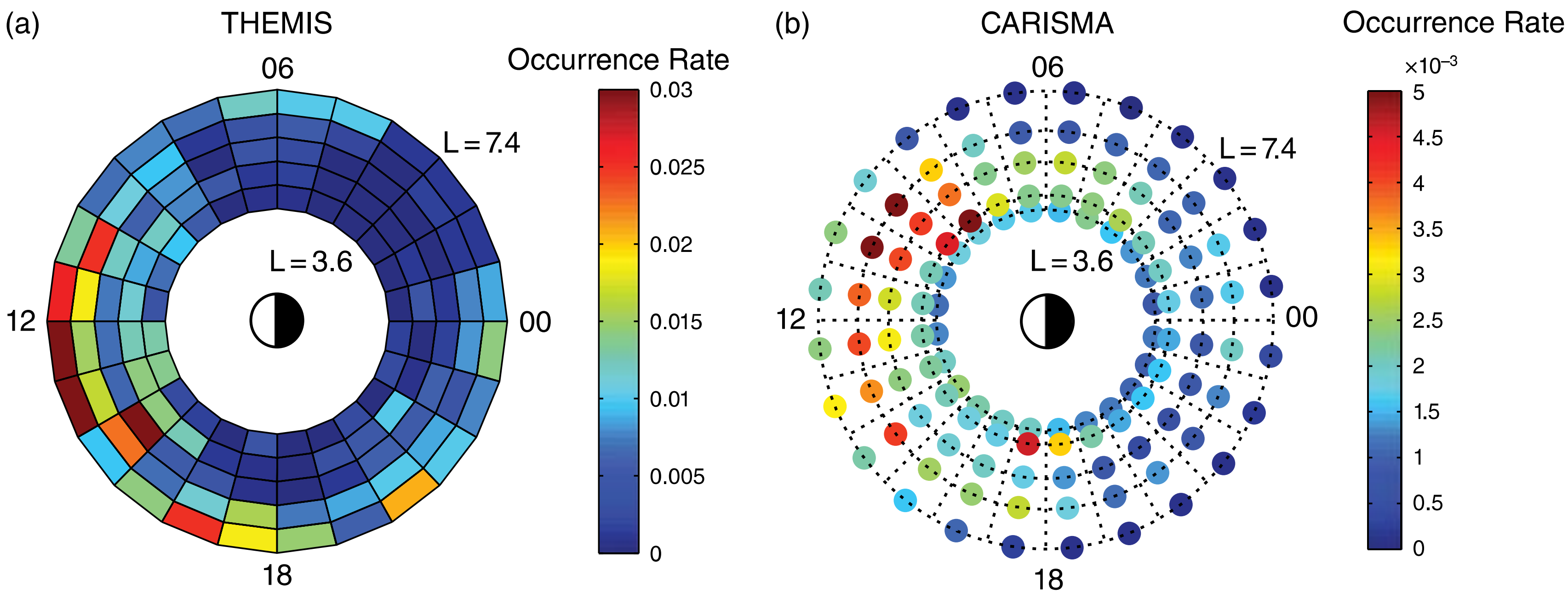


Example of peak selection from the Ministik Lake station on 2012/10/11

Fluxgate vs searchcoil



Ground vs space

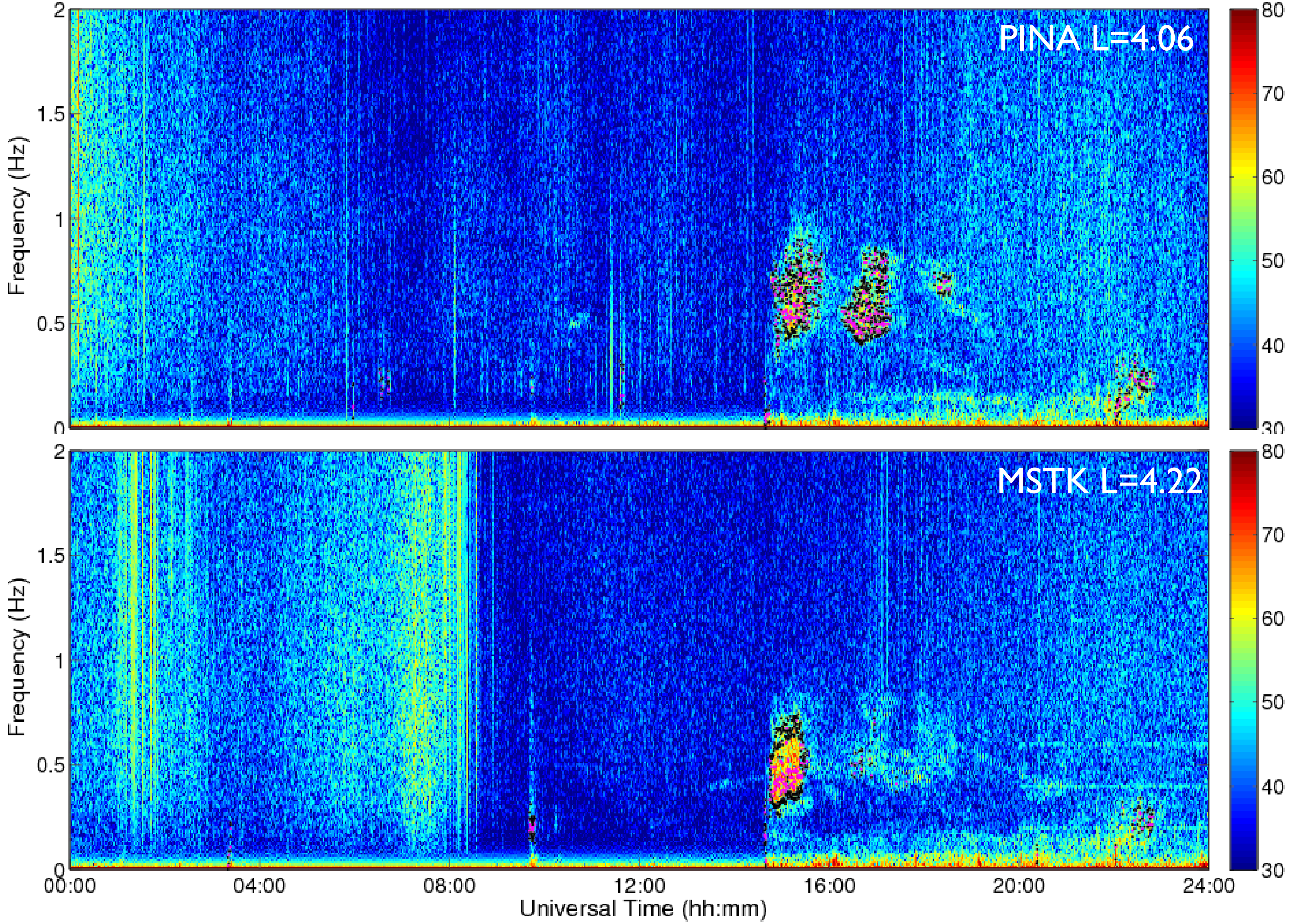


Usanova et al., AGU monograph, 2016

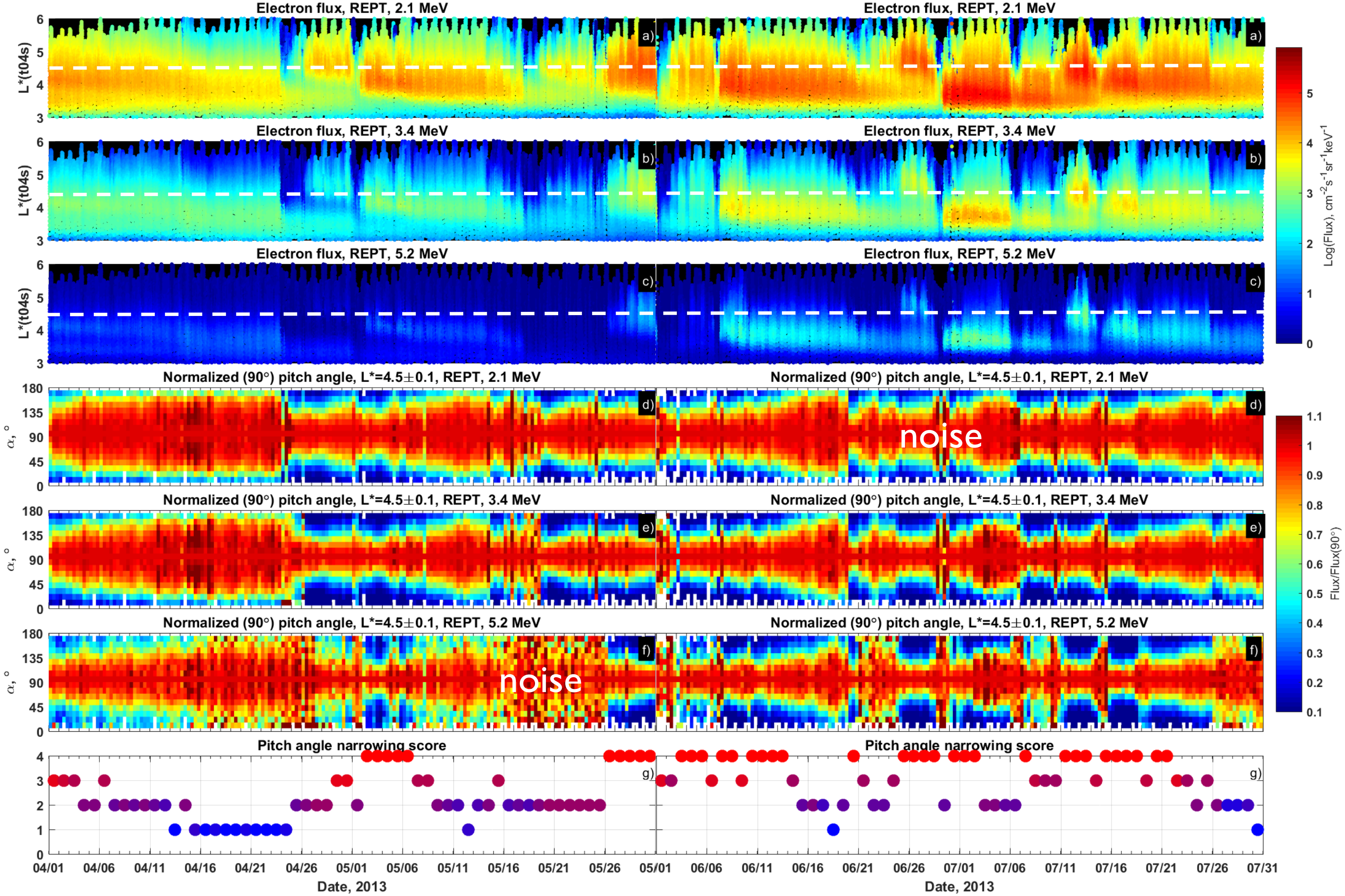
CARISMA and THEMIS FGM statistics of EMIC wave occurrence 2007-2011.

Occurrence distributions look different!

27 June 2013 - examples

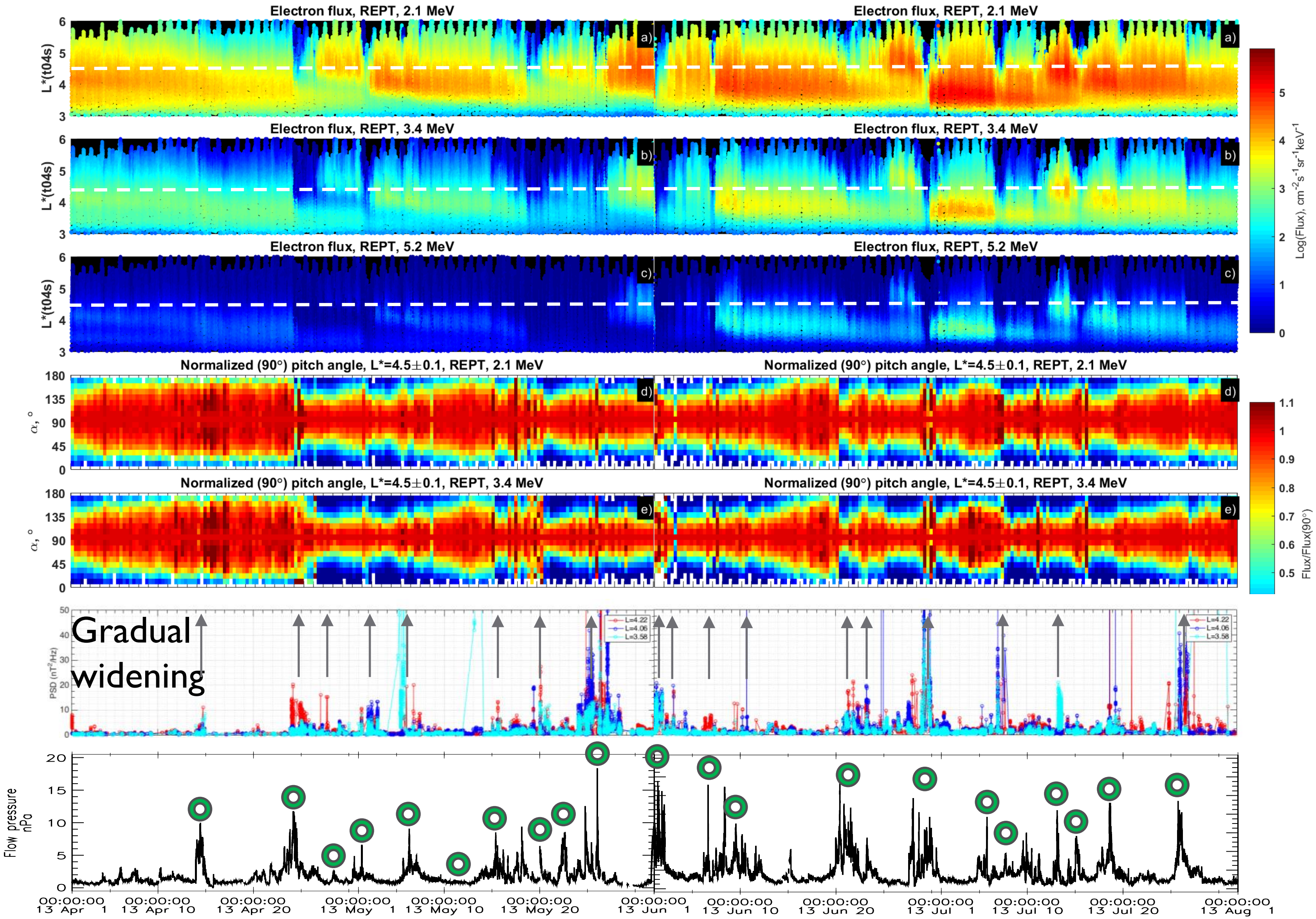


REPT: 1 Apr – 31 July, 2013

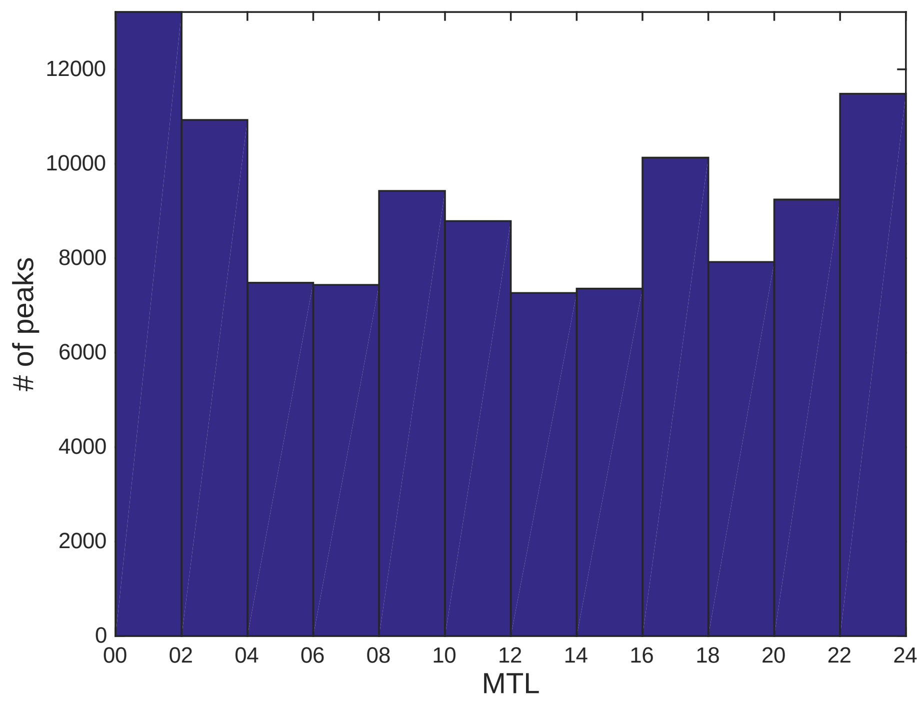


Sharp narrowings in PAD and dropouts

REPT: 1 Apr – 31 July, 2013

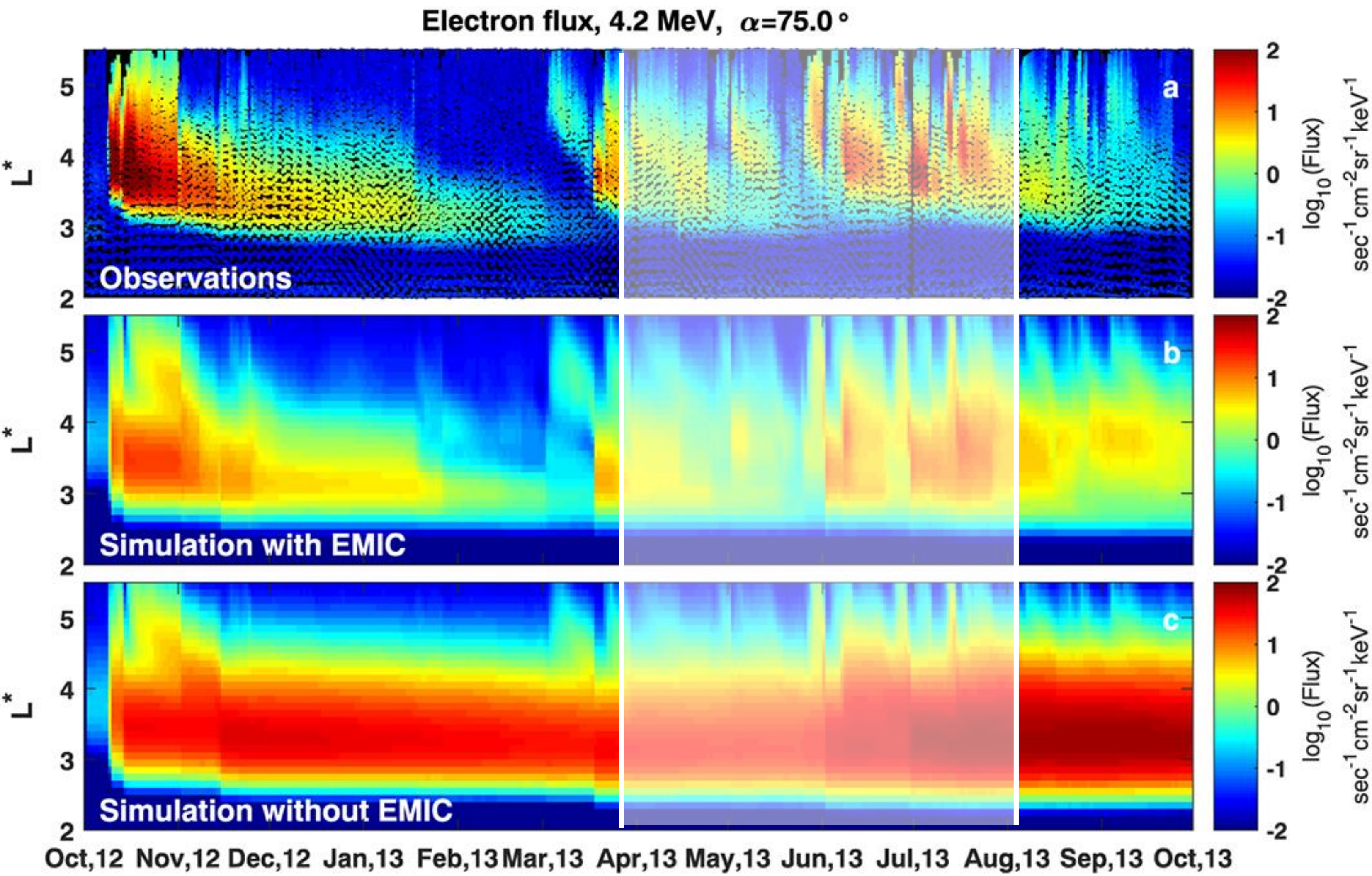


Wave MLT distribution



Wave activity observed in all MLT sectors:
no preference for duskside plasmapause

VERB simulations

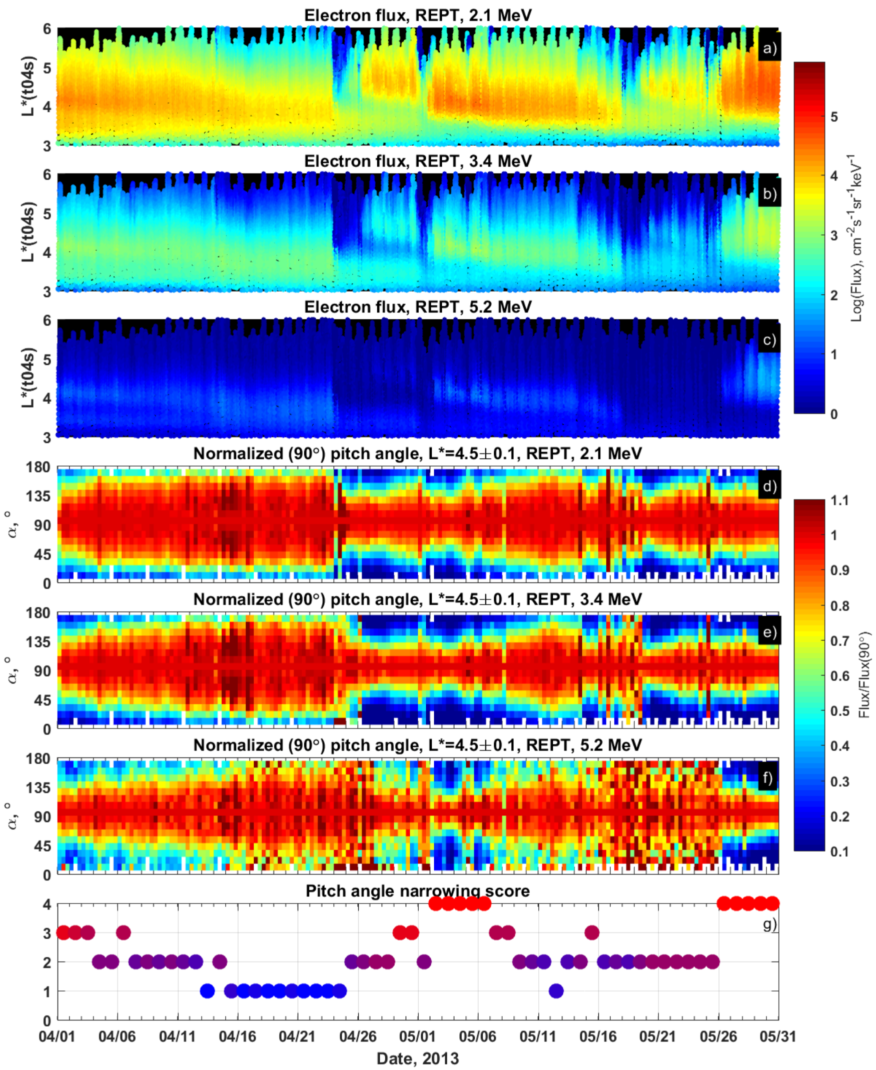


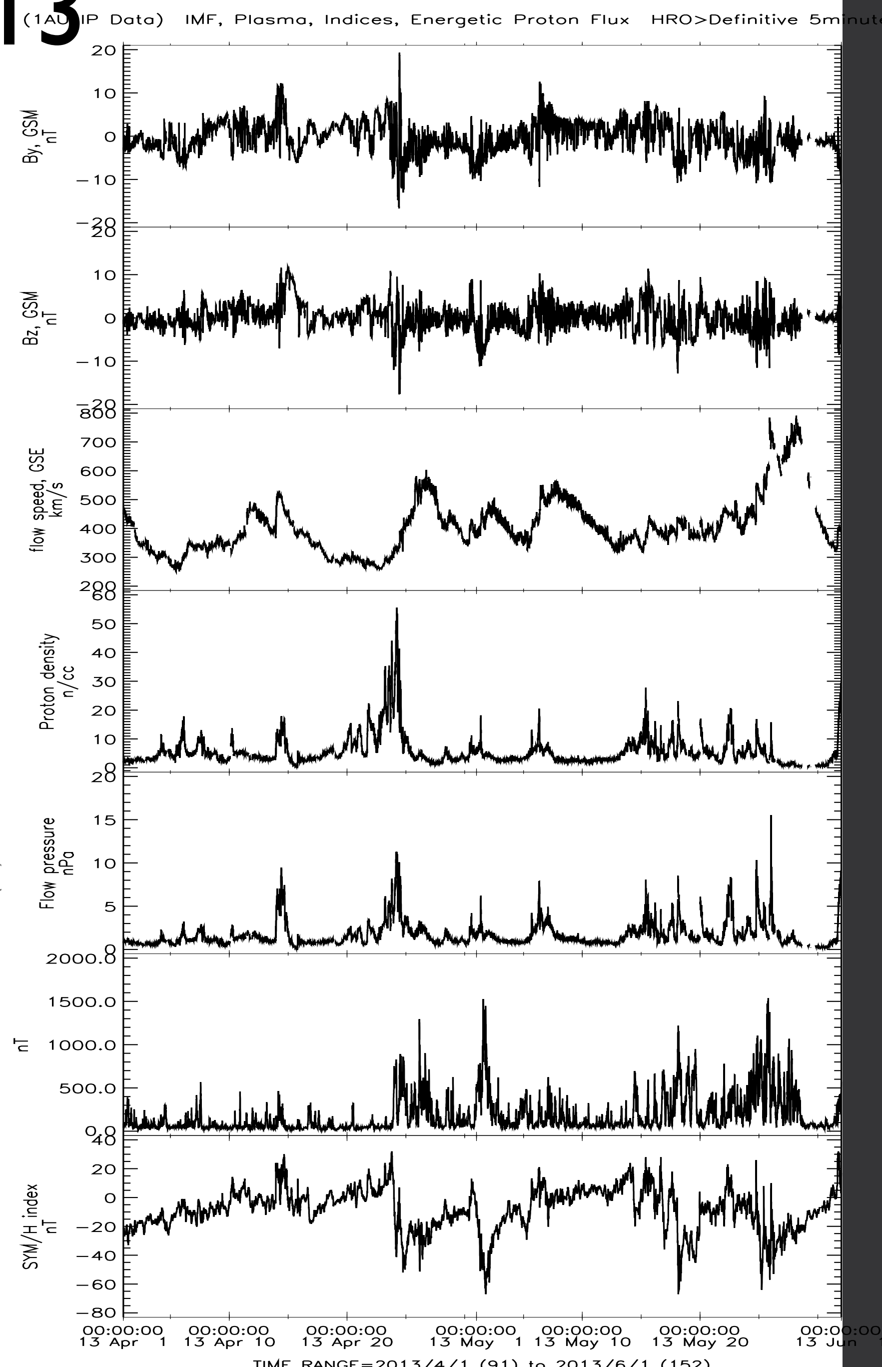
Drozdov et al., JGR 2017: VERB simulations with EMIC wave occurrence parametrized by Pdyn (Pdyn>3 nPa) – best agreement with observations.

Summary

- We looked at correlation of REPT fluxes/PADs with ground EMIC wave power at L~4.
- We used an automated EMIC wave selection algorithm by Bortnik et al., 2007.
- EMIC wave activity is consistently seen on the ground during increased Pdyn.
- Observed in all MLT sectors.
- The wave intervals coincide with narrowings in REPT PADs.
- No obvious correlation between ground EMIC wave power (as long as it exceeds some threshold) and Pdyn magnitude nor PAD narrowing degree.

1 Apr – 31 May, 2013





1 June – 31 July, 2013