Geospace Revisited, Rhodes, Greece September 15-20, 2014

Recent progress in understanding the origin of plasmaspheric hiss

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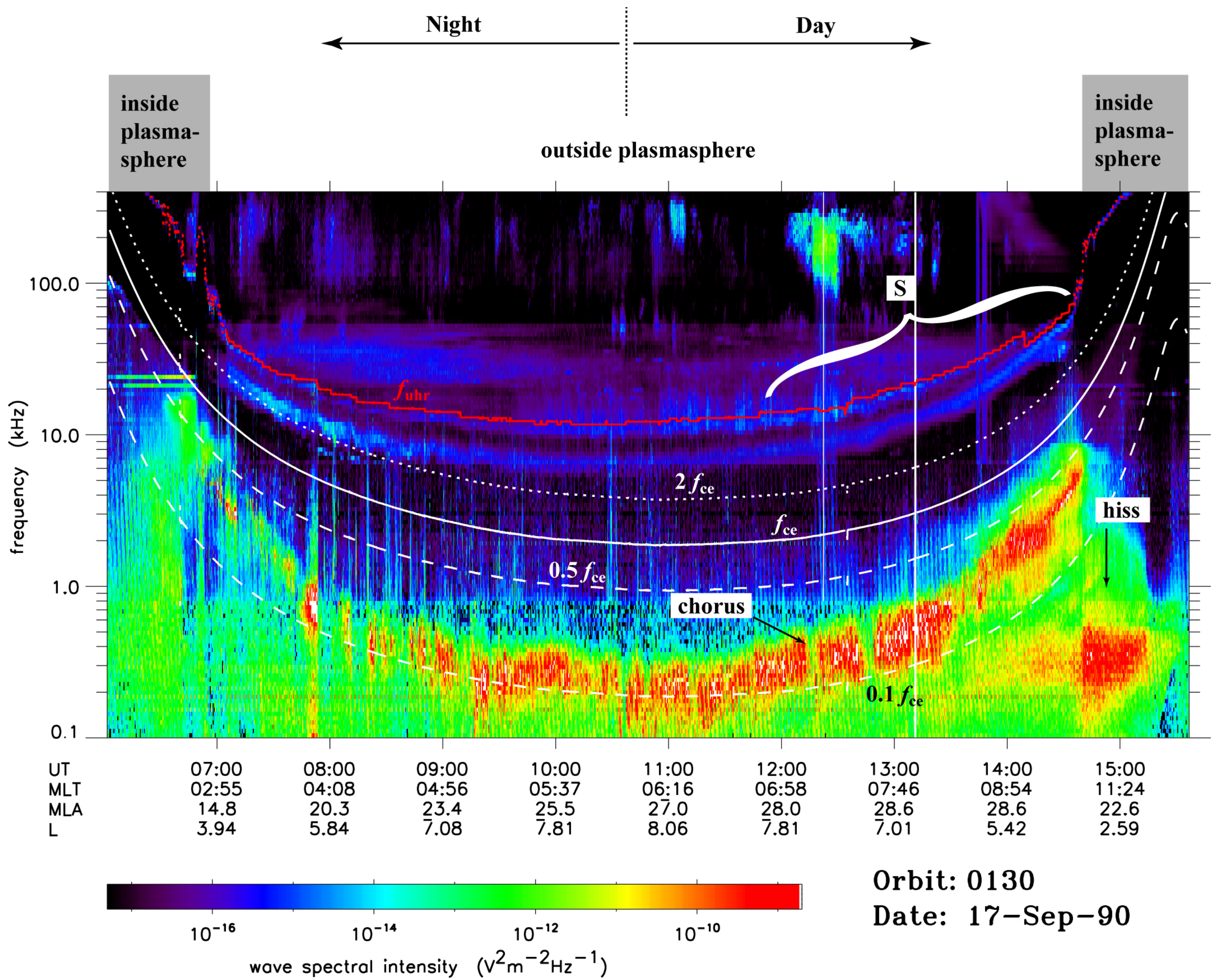
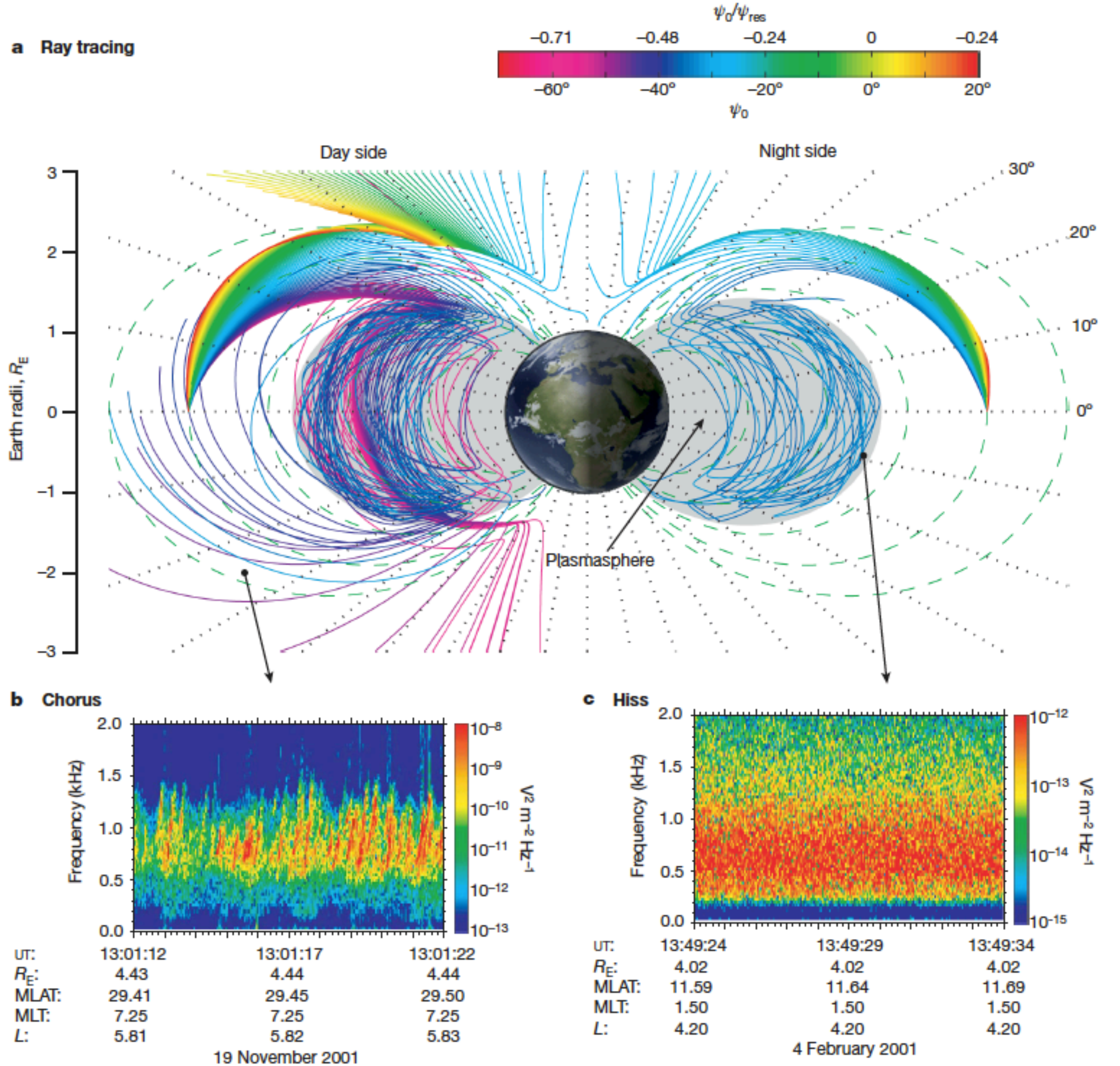
CRRES orbit view



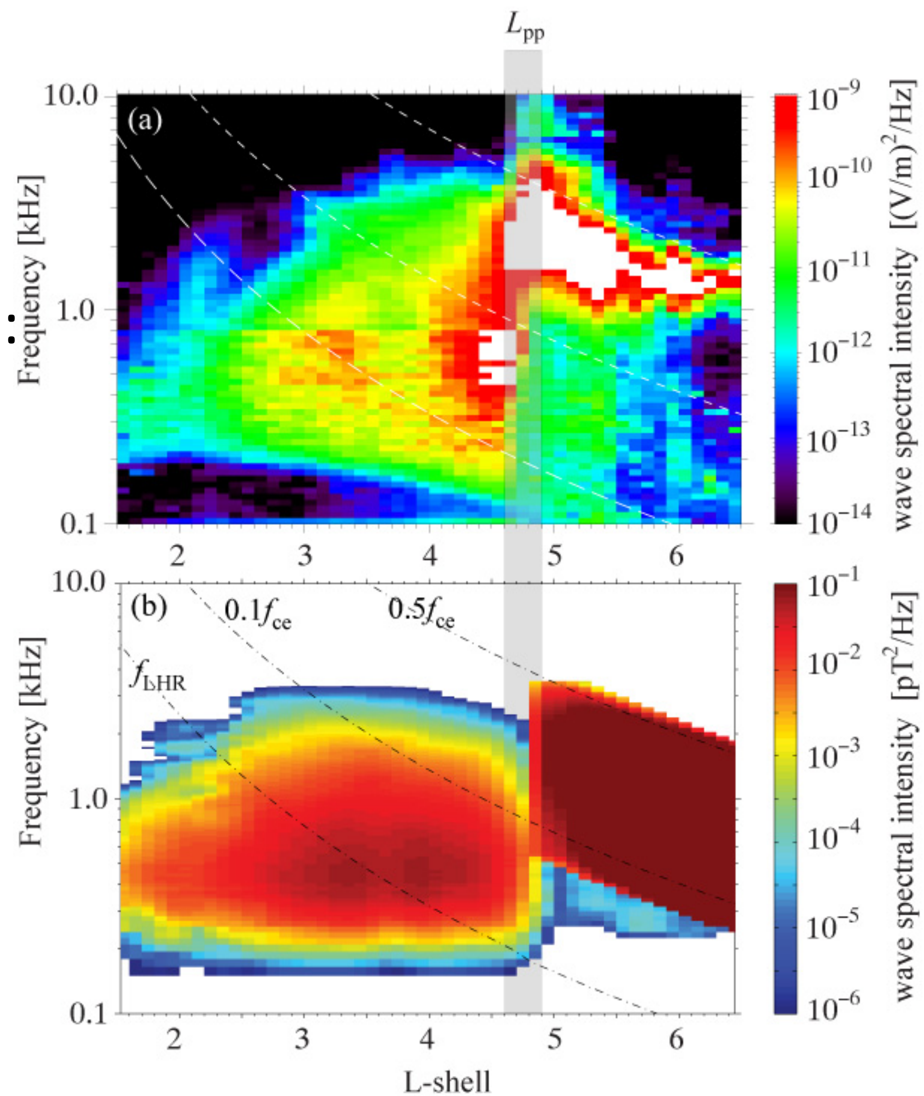
1. The origin of plasma-spheric hiss



Bortnik et al. [2008] *Nature*, 452(7183)

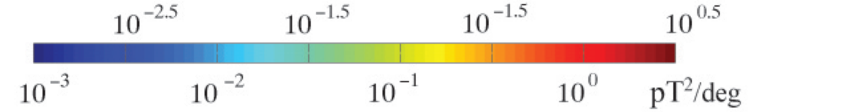
Simulated power distributions

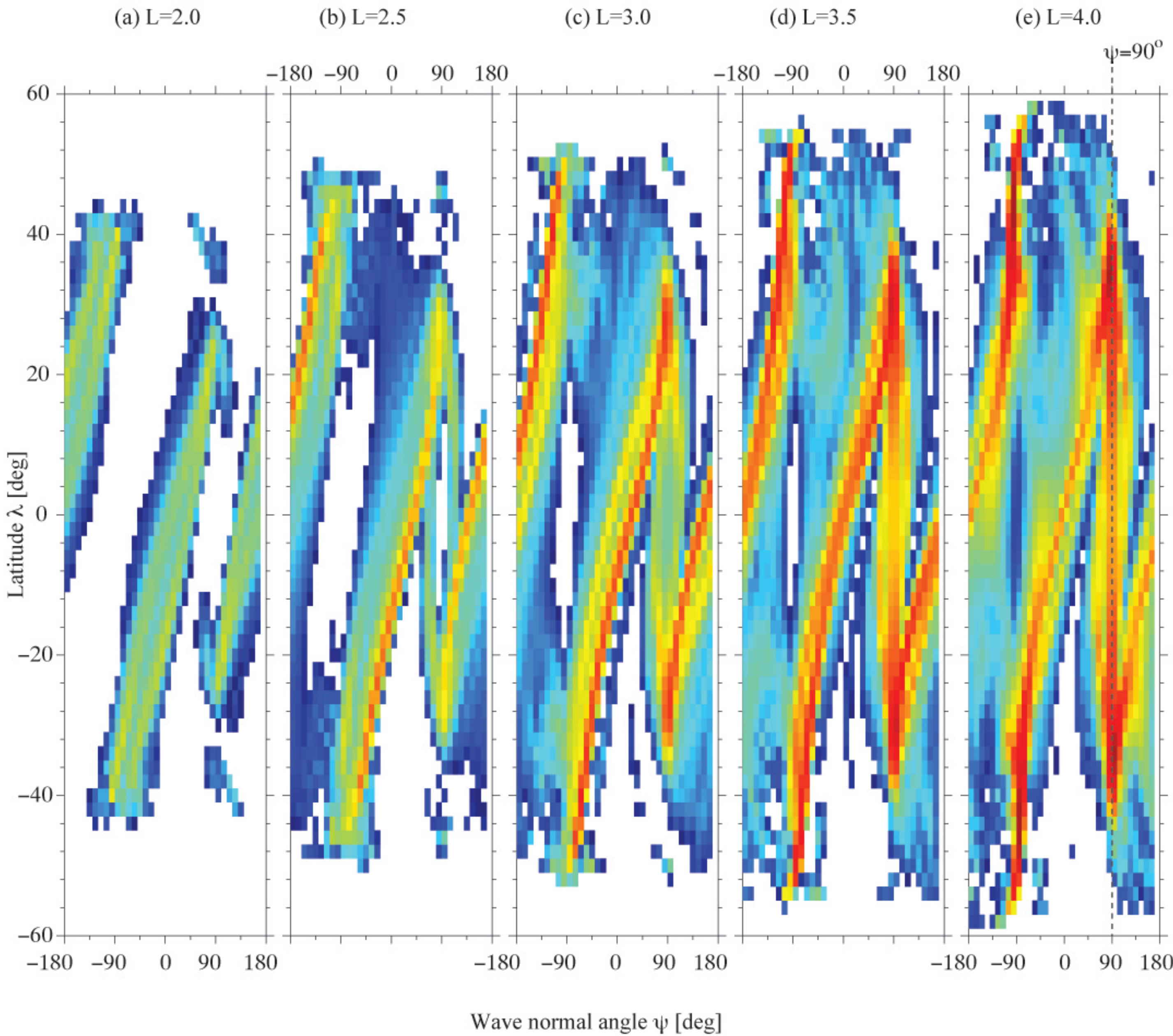
- Ray trace thousands of rays, L=4.8-8, all angles, power-weighted.
- Agreement with observation:
  - Correct peak power
  - Bandwidth decrease at low L
  - Two zone structure
  - Correct spatial confinement
- Disagreement:
  - Power peak near Lpp
  - Too weak (factor ~3-5)
- Cause of error?



Wavenormals

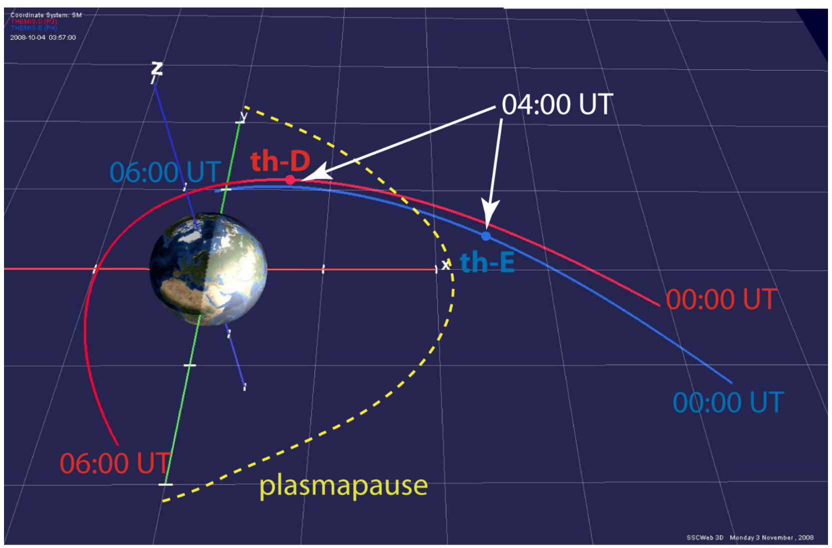
- Consistent with literature!
- EQUATOR:
  - Bimodal near p' pause
  - Field-aligned deeper in
- OFF -EQ:
  - oblique



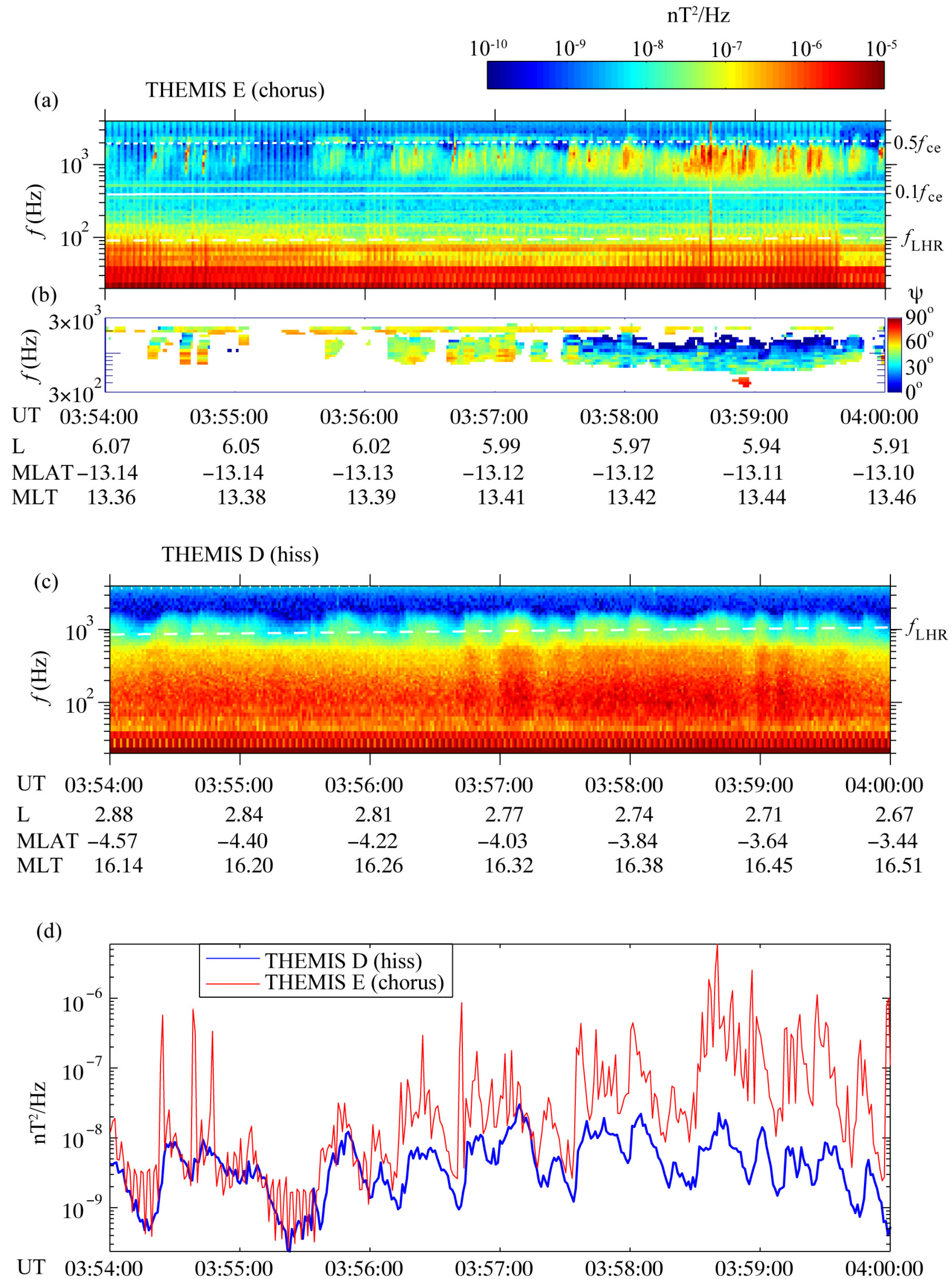


2. Coincident Observations of chorus and plasmaspheric hiss

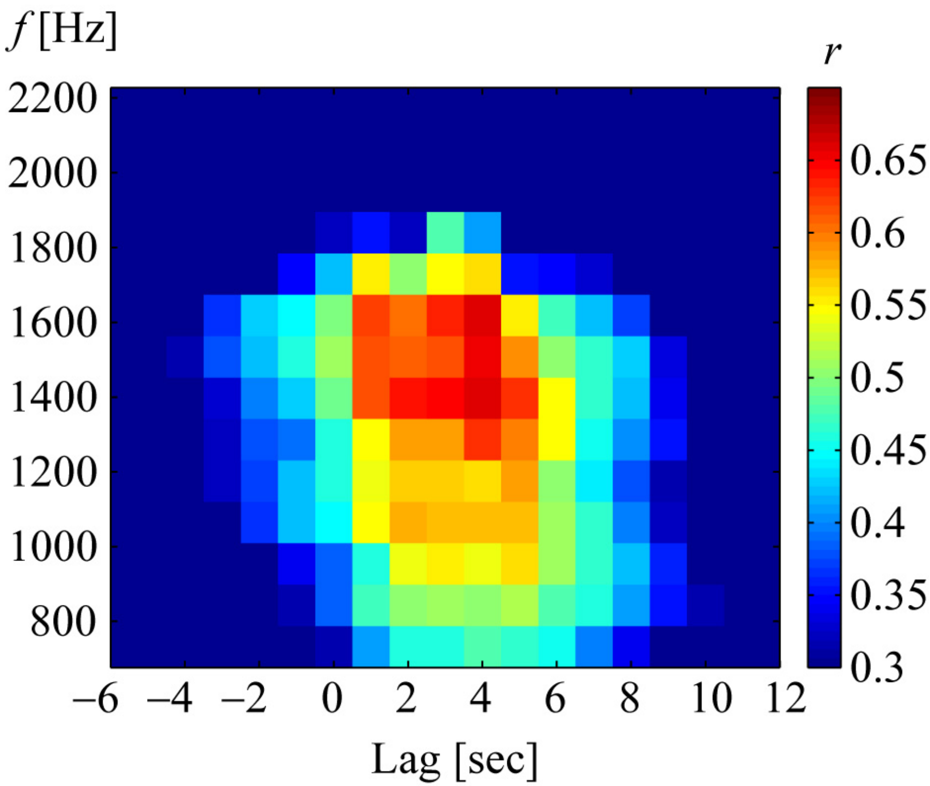
October 4th, 2008



Bortnik et al. [2009], *Science*, 324 (5928)



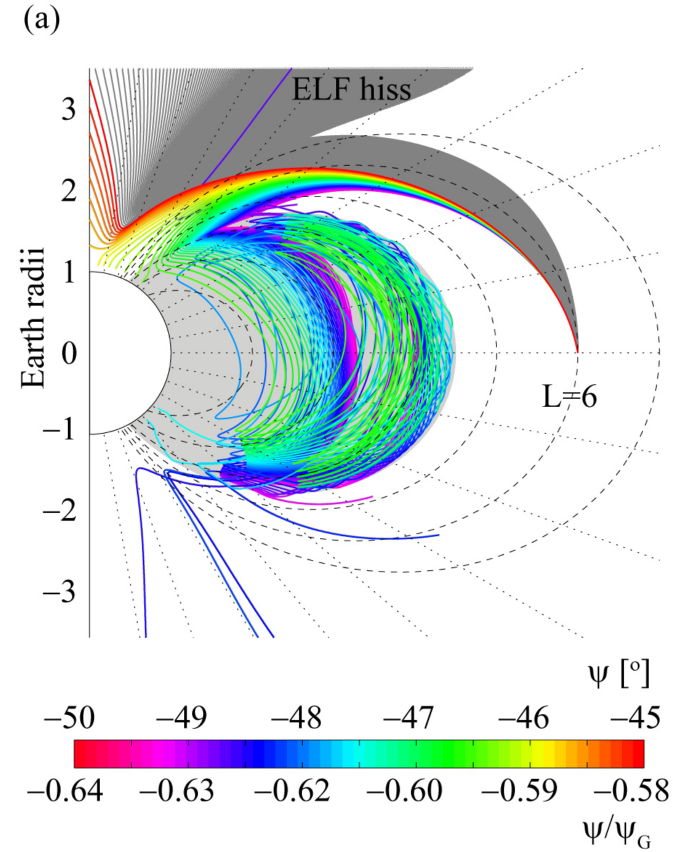
Cross covariance analysis

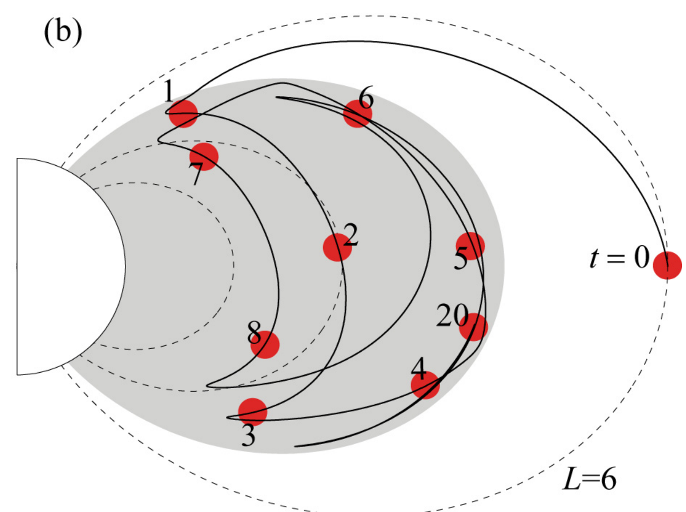


- Bin-wise cross covariance analysis
- Normalization: autocorrelation at zero-lag = 1
- Highest correlation (r=0.7), at lags ~1-7 sec, peak ~4 sec.

Ray tracing

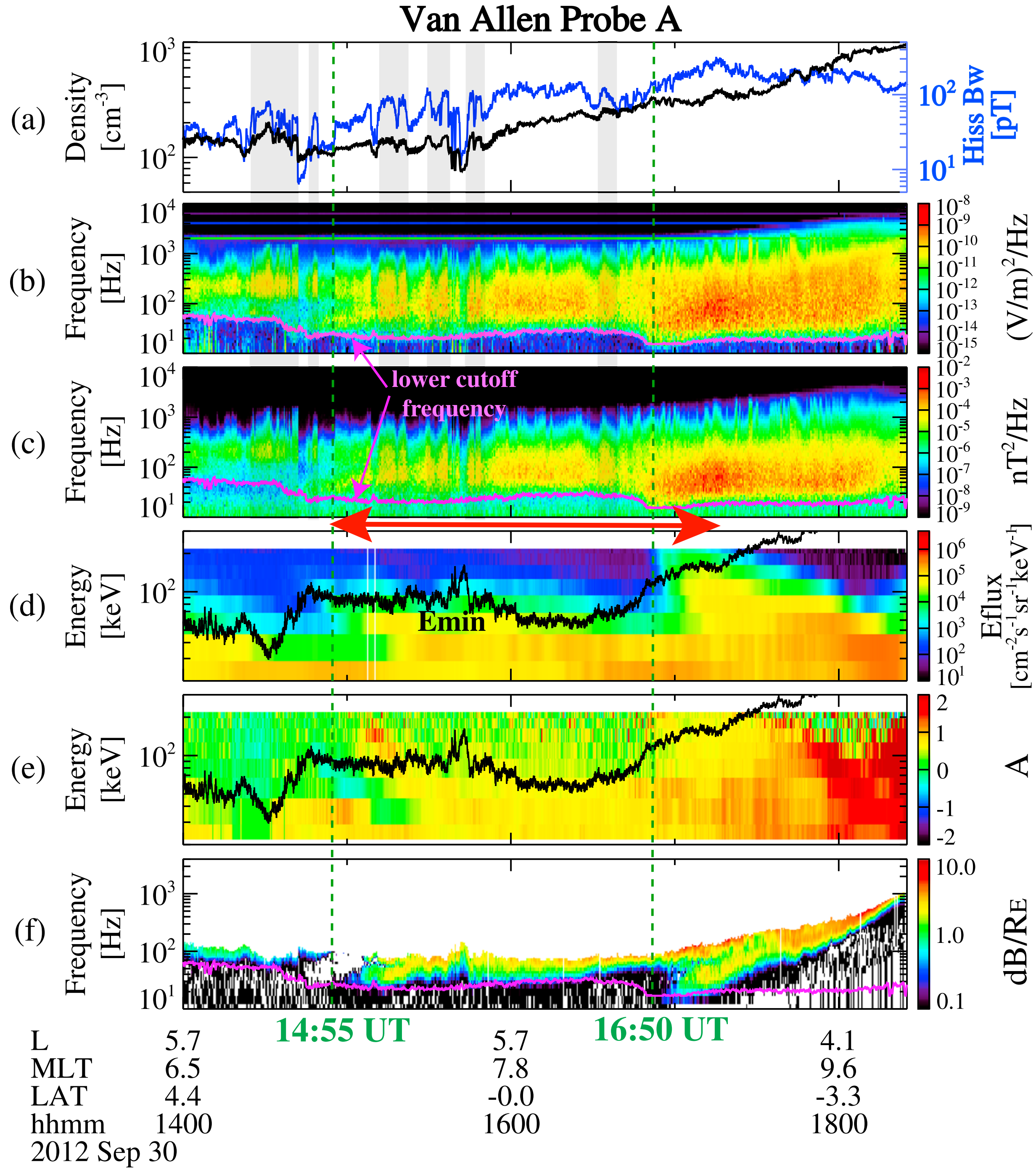
- Ray trace all rays in allowable angles, include L-dependent Landau damping
- Key-range (colorbar), ~ -50 to -45, L=6
- Timescale:
  - 1 s, enter plasmasphere,
  - 2 s, 1st EQ crossing
  - 3.2 s, magnetospheric reflection
  - 7.7 s, second EQ crossing



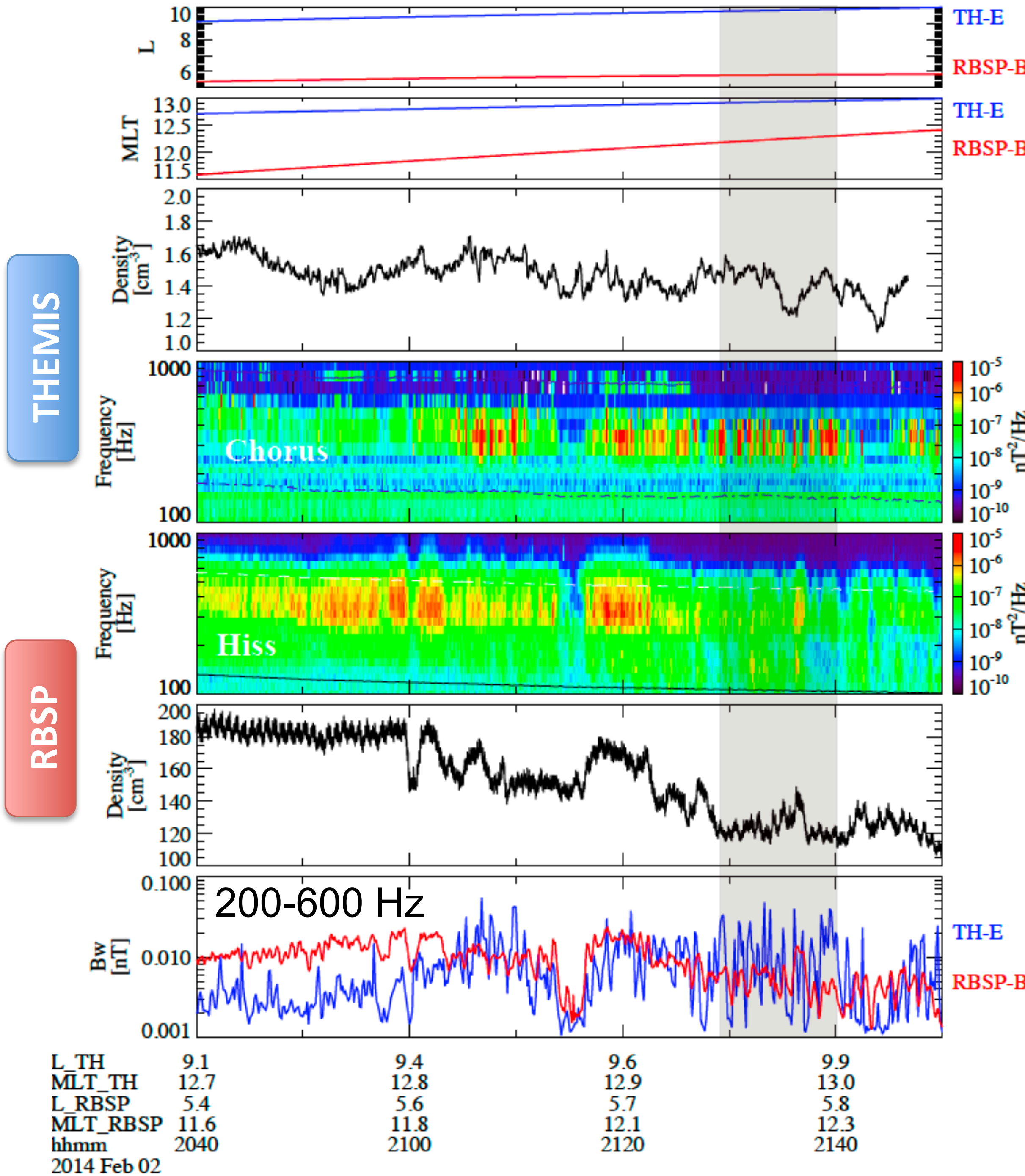


3. Low frequency hiss

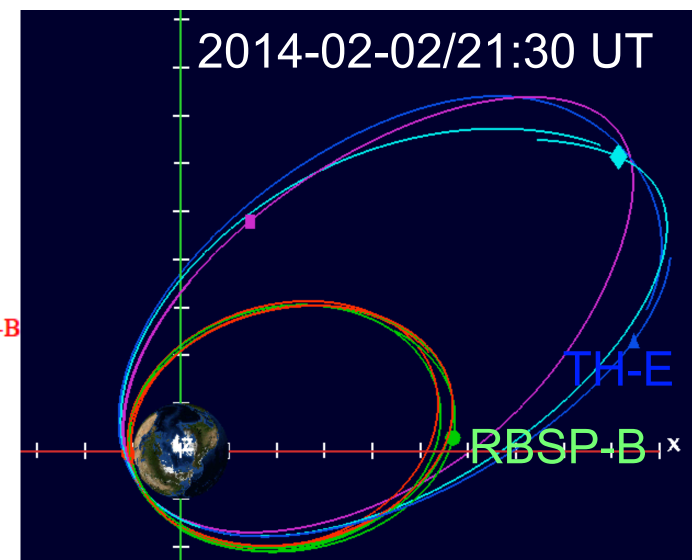
- Average peak frequency ~50 Hz
- Generated locally due to injection of ~100 keV electrons



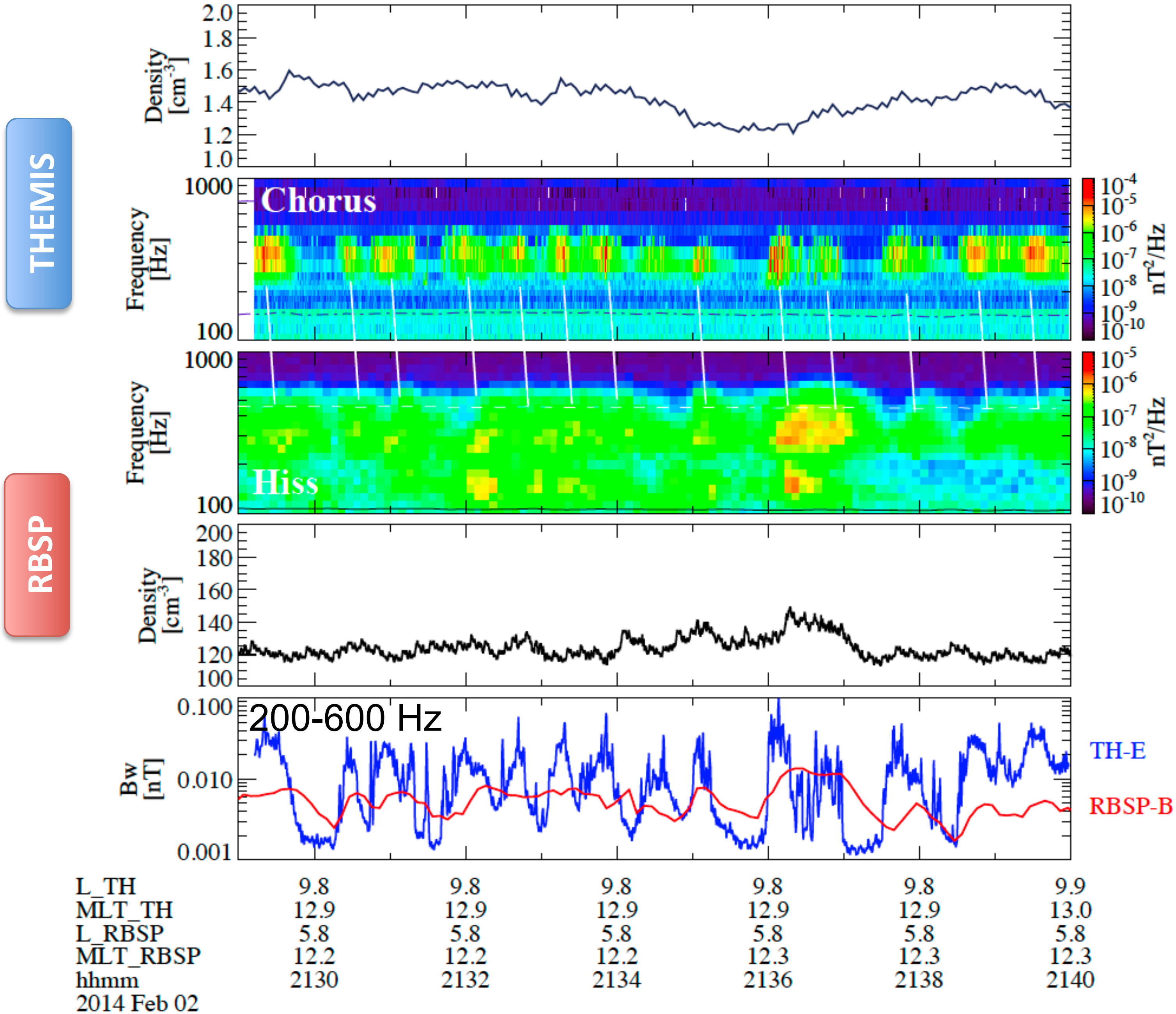
4. Coordinated event between THEMIS and RBSP



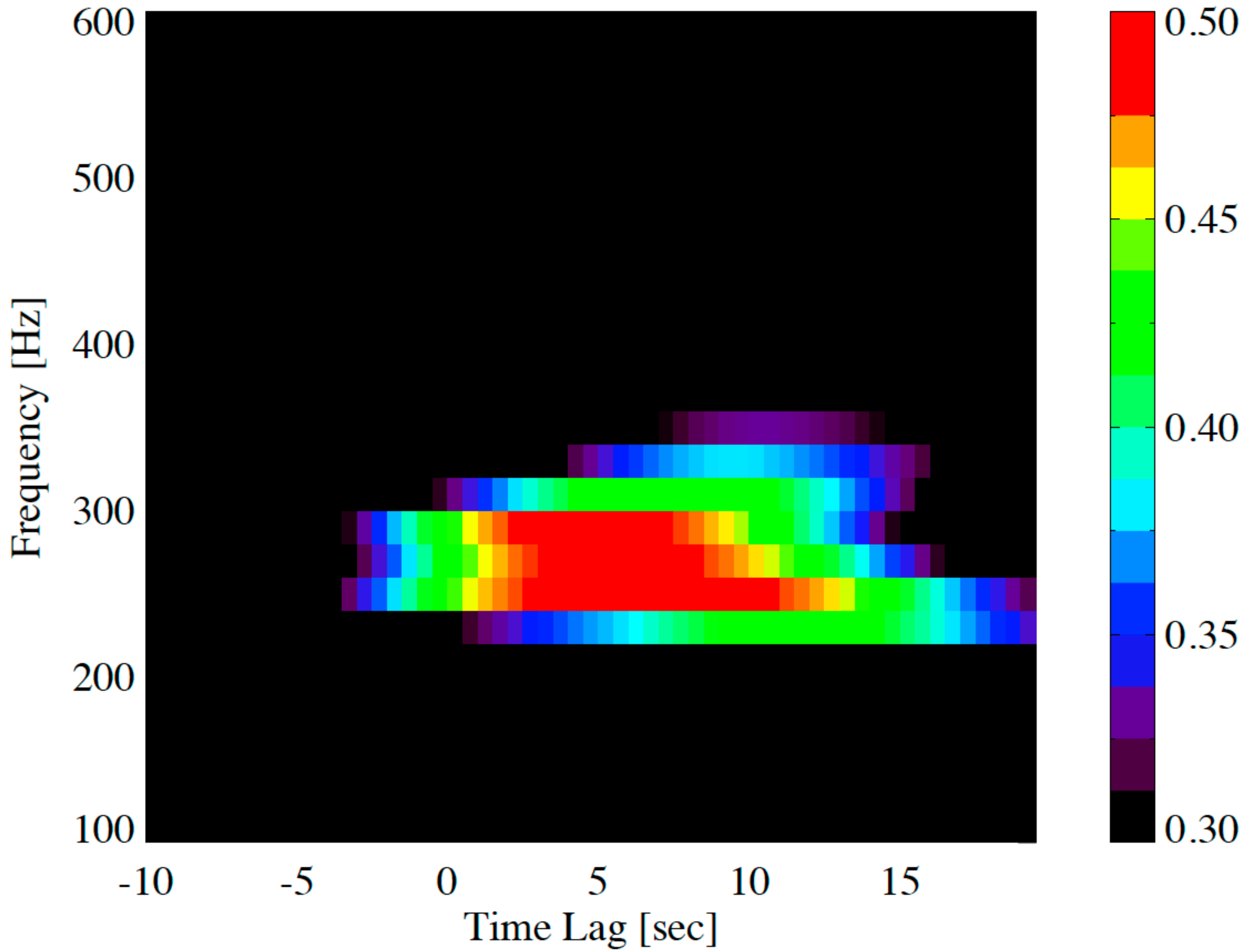
- THEMIS (9-10 R_E): Chorus
- RBSP (5-6 R_E): Hiss



During the burst period of THEMIS



Correlation coefficient between chorus and Hiss



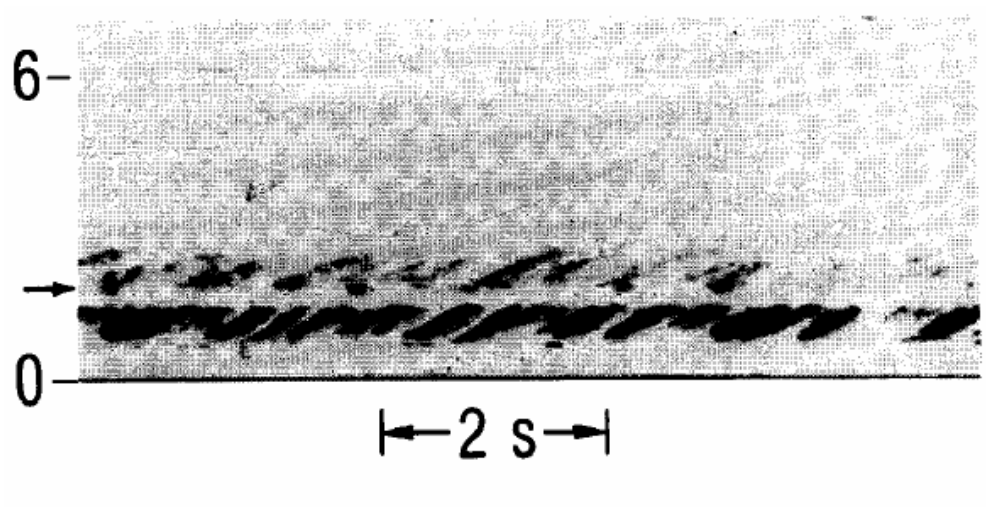
- Highest correlation obtained over 220-300 Hz with a time delay of ~6 s
- Suggests that hiss is likely to be originated from chorus.

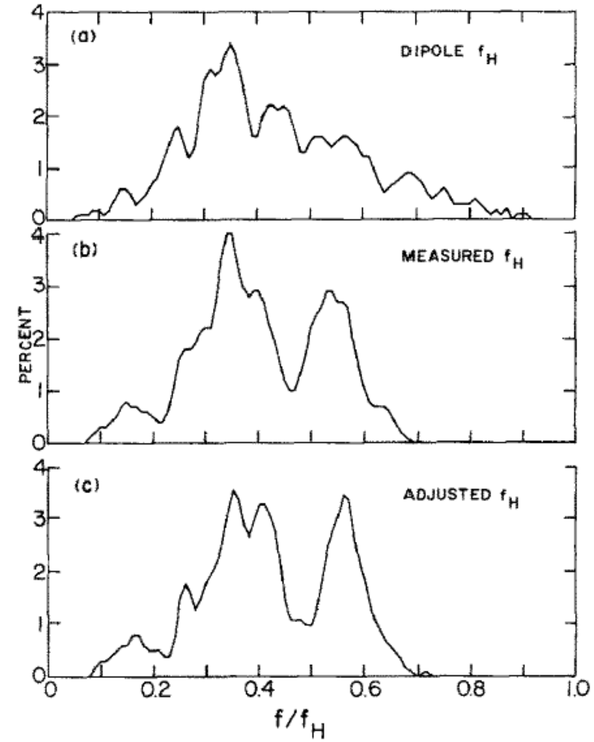
Summary

- Plasmaspheric hiss is a complicated emission– could have multiple sources
- Chorus source of plasmaspheric hiss accounts for many properties
- Coincidence THEMIS observation consistent with theory
- New coincident observation THEMIS-Van Allen Probes show chorus able to propagate into plasmasphere from very high L-region

BACK UP SLIDES

Chorus general characteristics





- Sequence of narrowband tones, df/dt ~ 0.2-2 kHz/sec
- Rising (P~77%), falling (P~16%), hooks etc. (P~18%)
- Bimodal distribution, ~$0.34f_{ce}$ (lower) ~$53f_{ce}$ (upper)
- Persistent gap at ~$0.5f_{ce}$

Tsurutani and Smith [1974, 1977]; Burton and Holzer [1974]; Burtis and Helliwell [1969, 1976]; Koons and Roederer [1990]

- Dear Jacob Bortnik: We are pleased to inform you that the abstract listed below was accepted for the AGU Chapman Conference on Low-Frequency Waves in Space Plasmas. The conference will be hosted in Jeju Island, Republic of Korea from 31 August - 5 September 2014.
- Abstract ID: 1572
- Abstract Title: The curious relationship between chorus and plasmaspheric hiss waves
- Presentation Type: Oral
- Session Title: Waves in the Inner Magnetosphere II
- Date/Time: Thursday, 4 September 2014; 8:30 AM - 10:10 AM
- The full meeting itinerary including specific presentation times will be available in the coming week. To view detailed information about the conference including registration and housing, please visit the conference website at http://chapman.agu.org/spaceplasmas/.
- If you have any questions regarding the program, please contact abstracts@agu.org.
- Sincerely,
  The Low-Frequency Waves in Space Plasmas Chapman Program Committee

- **The curious relationship between chorus and plasmaspheric hiss waves**
- **Jacob Bortnik**1, Lunjin Chen2, Wen Li1, Richard M Thorne1, Vassilis Angelopoulos3 and Craig Kletzing4, (1)UCLA, Los Angeles, CA, United States, (2)University of Texas at Dallas, Richardson, TX, United States, (3)UCLA---ESS/IGPP, Los Angeles, CA, United States, (4)Univ. of Iowa, Iowa City, IA, United States
- **Abstract Text:**
- Plasmaspheric hiss is a wideband, incoherent, whistler-mode plasma wave that is found predominantly in inner magnetospheric high-density plasma regions such as the plasmasphere or plasmaspheric drainage plume. The origin of plasmaspheric hiss has been a topic of intense study and controversy ever since its discovery in the late 1960s. A recent set of modeling studies have shown that a different plasma wave, namely whistler-mode chorus, could be responsible for creating plasmaspheric hiss by propagating from its source region in the equatorial plasmatrough, and into the plasmasphere. Early observations made on the THEMIS spacecraft have shown excellent consistency between models and data, but later results concerning the nature of chorus waves and pulsating aurora, the discovery of low-frequency hiss, and coincident observations between high L-shell chorus and hiss have shown that there are facets of the chorus-hiss connection that are still a puzzle. In this talk, we briefly review the chorus-hiss connection mechanism and focus on recent results and open questions.

Access regions

- Ray trace ray populations

L = 3.8 to 7, step 0.1 L

$\psi = -\psi_{res}$ to ψ_{res} ; step = 0.5°

Frequency: 0.1 to 0.45 f_{ce} ;

- Access to plasmasphere:

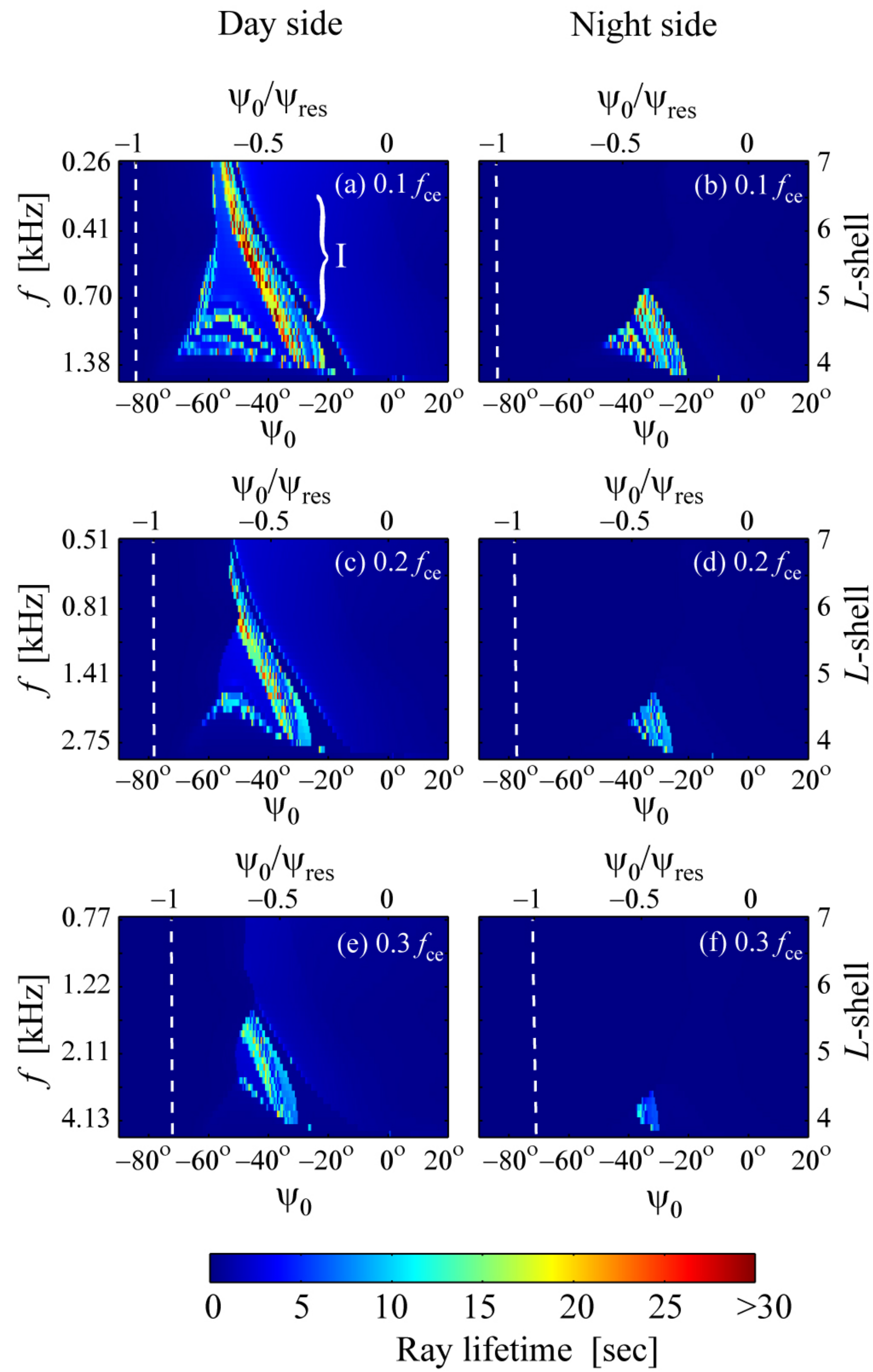
Low frequency, 0.1 f_{ce} ;

Dayside stronger than night

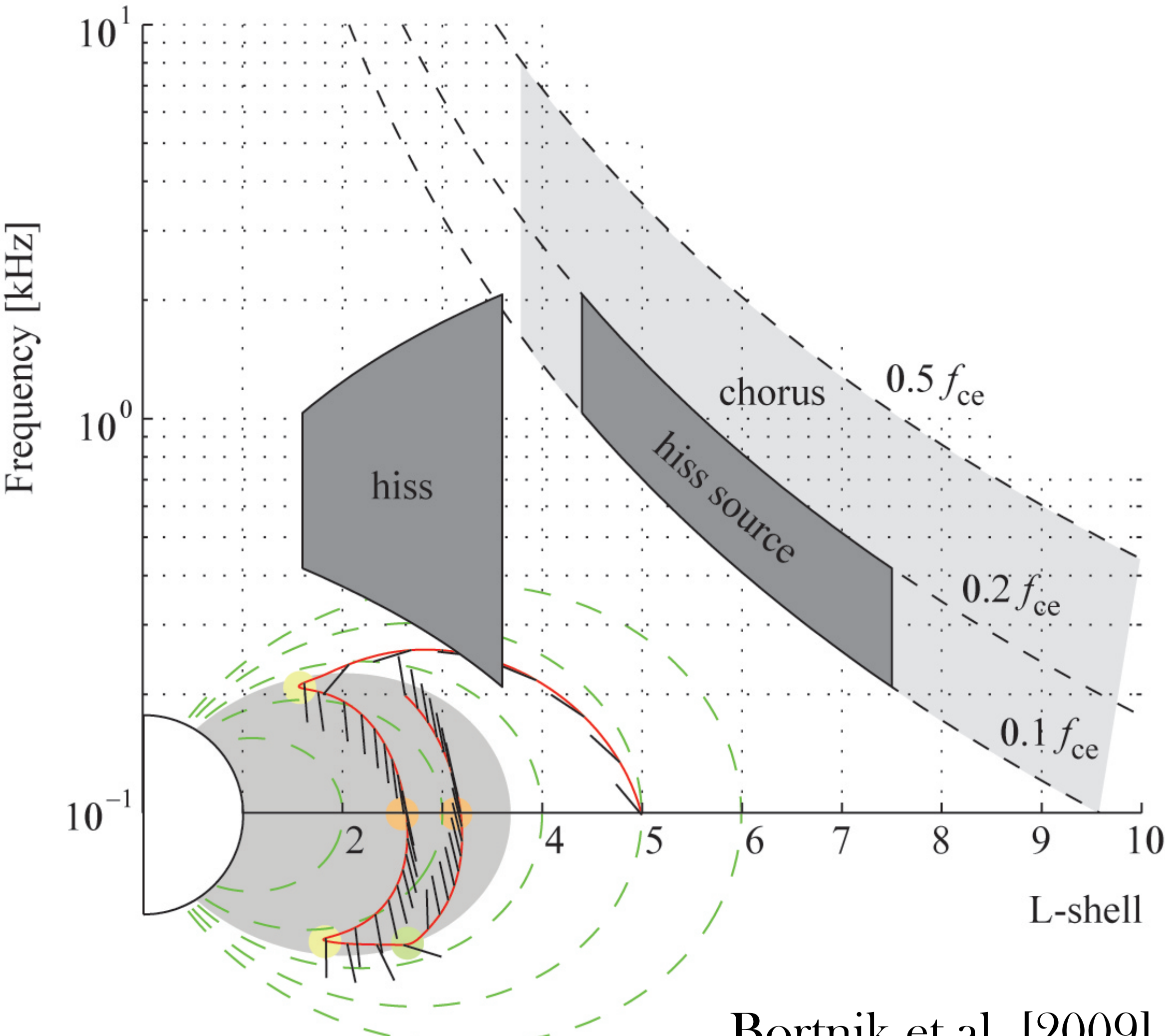
Negative wave normals (moderate)

Longest lifetimes in the range

f = ~ 0.2 - 1 kHz



Evolution of discrete chorus emissions into the plasmaspheric hiss continuum



Bortnik et al. [2009], *JASTP*

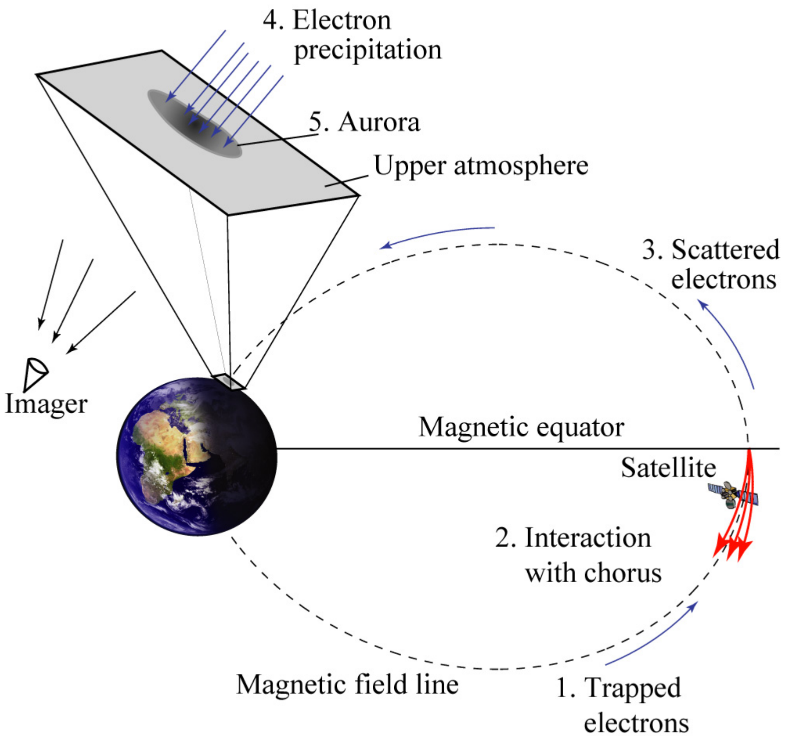
Chorus ➔ hiss:

- Avoids Landau damping
- Propagates into plasmasphere at high latitudes
- Low frequencies
- Range of L-shells
- Range of wave normals

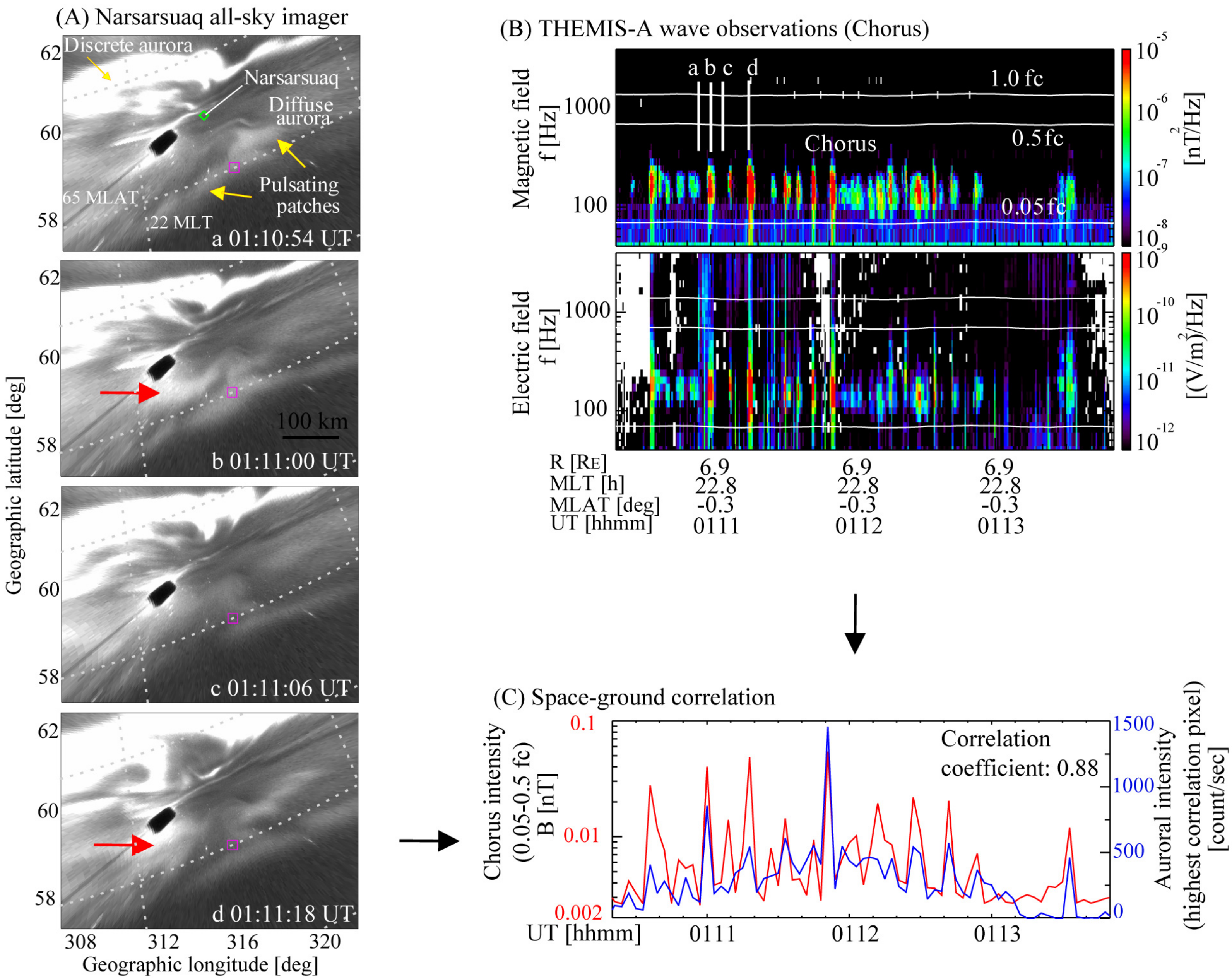
Statistical characteristics reproduced

3. Chorus and the pulsating aurora

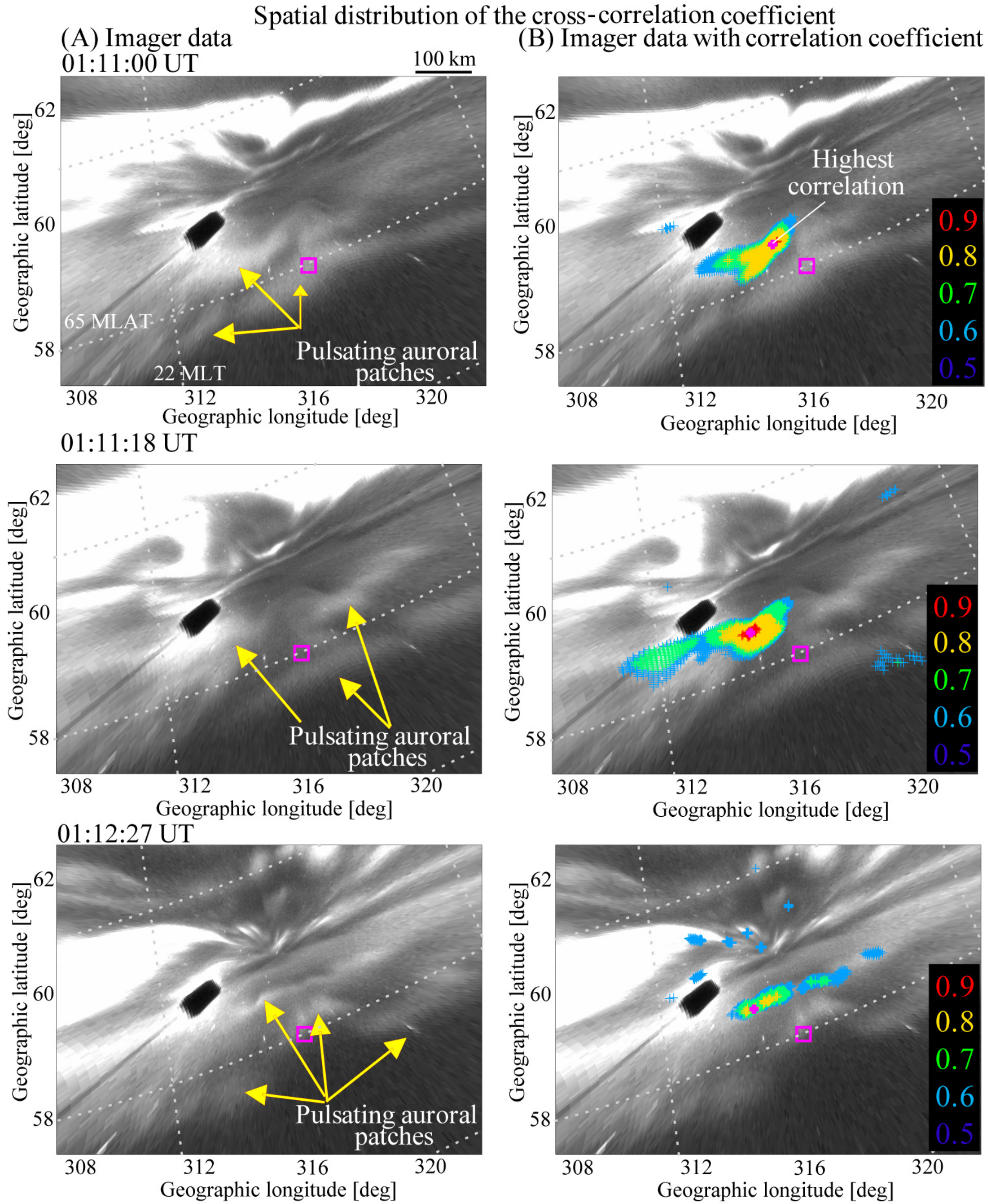
- Described in 1963 "auroral atlas"
  - Luminous patches that pulsate with a period of a few to 10's of seconds
  - Scale, ~10-100 km
  - Precipitating electrons E>10 keV



TH-A, Nar-ASI conjunction 15 Feb 2009



- Map of cross-correlation coefficients
- >90% correlation
- Location roughly stationary



Nishimura et al. [2010], *Science*, 330 (81)