Recent Findings on Characteristics of Chorus waves observed on THEMIS

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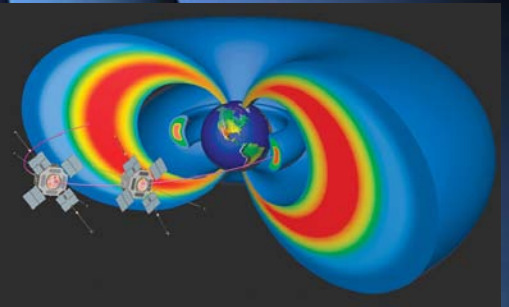


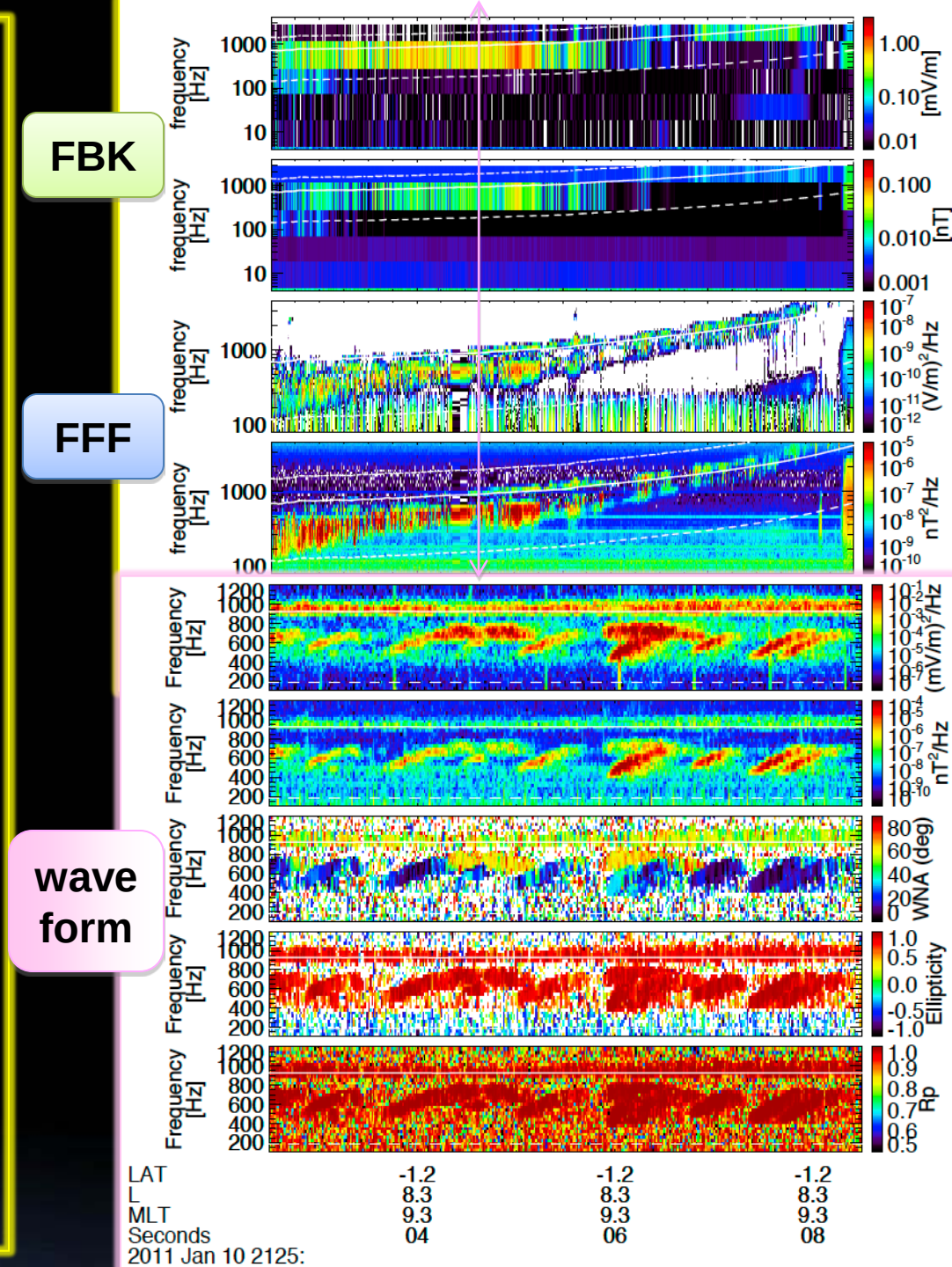
We acknowledge all THEMIS team for providing data.

Outline

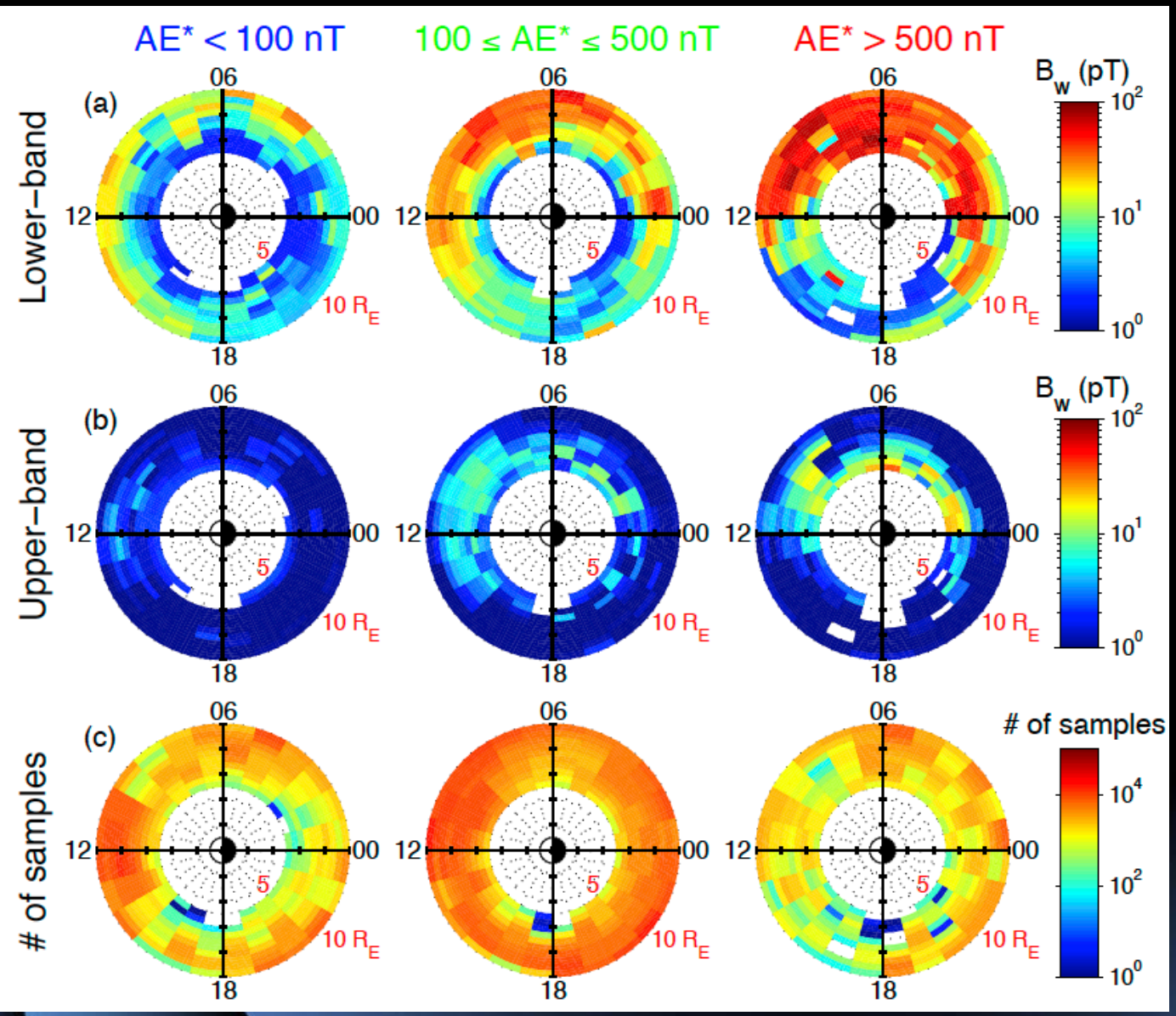
- Global distribution of chorus wave amplitudes, in particular the large amplitude chorus
- Wave normal angle distribution of lower-band and upper-band chorus
- Evolution of chorus amplitude distribution at various phases of CIR-driven storms
- Typical properties of various whistler-mode waves

THEMIS Wave Data

- THEMIS A, D, E; outside pp and inside mp; 5-10 R_E; all MLT; mostly |MLAT| < 20°
- FBK data (2007/07/01- present) 4 sec time resolution
- FFF data (2010/05/01- present) high-resolution wave spectra data
- Waveform data (2007/07/01- present) sampling rate: up to ~16 kHz



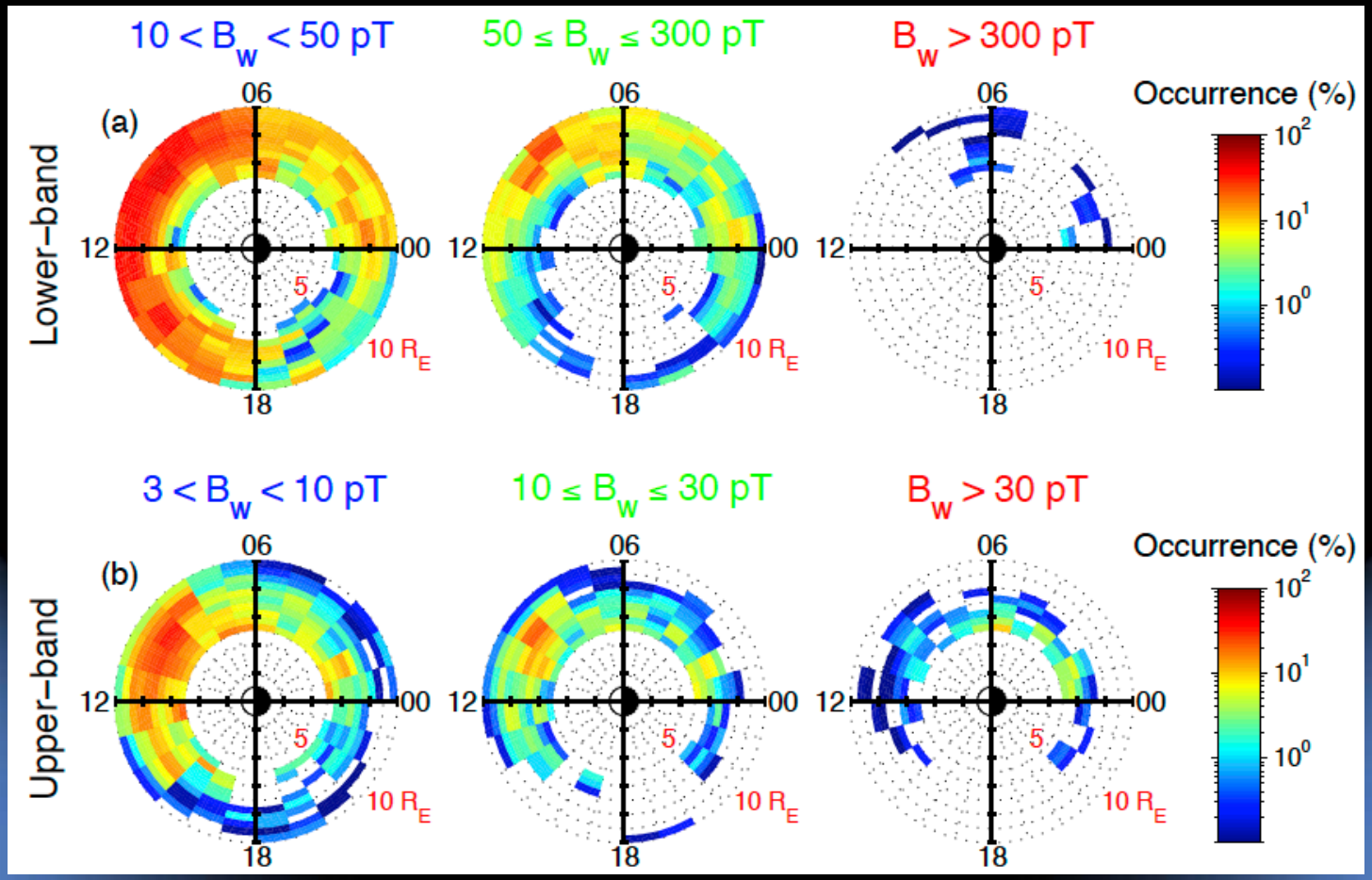
Global distribution of chorus B_w (FFF)



- B_w depends on AE*
- B_w near midnight is more closely related to AE*.
- On the dayside, modest LB is observed even during quiet times.
- UB is much weaker and more confined to lower L (<8).
- Both LB and UB are observed from premidnight to afternoon

[*Li et al.*, 2011]

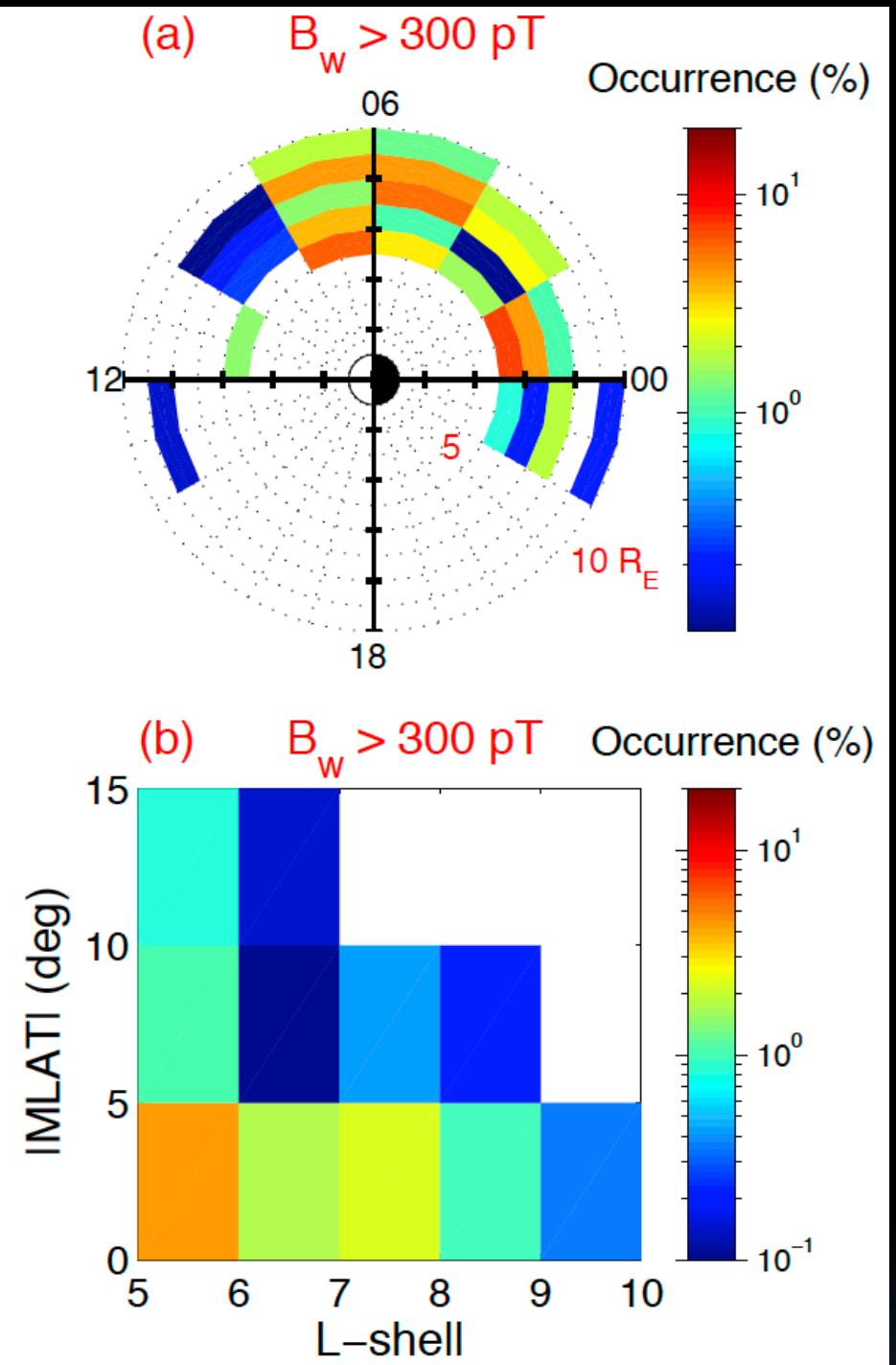
Occurrence of chorus waves for various wave amplitudes (FFF)



•LB: occurrence rate of large amplitude chorus (> 300 pT) is very small, while modest chorus is distributed over a broad MLT range with higher occurrence.

•UB: strong chorus is from premidnight to dawn, while weak chorus extends further into afternoon.

[*Li et al*., 2011]



Occurrence of large-amplitude chorus (waveform)

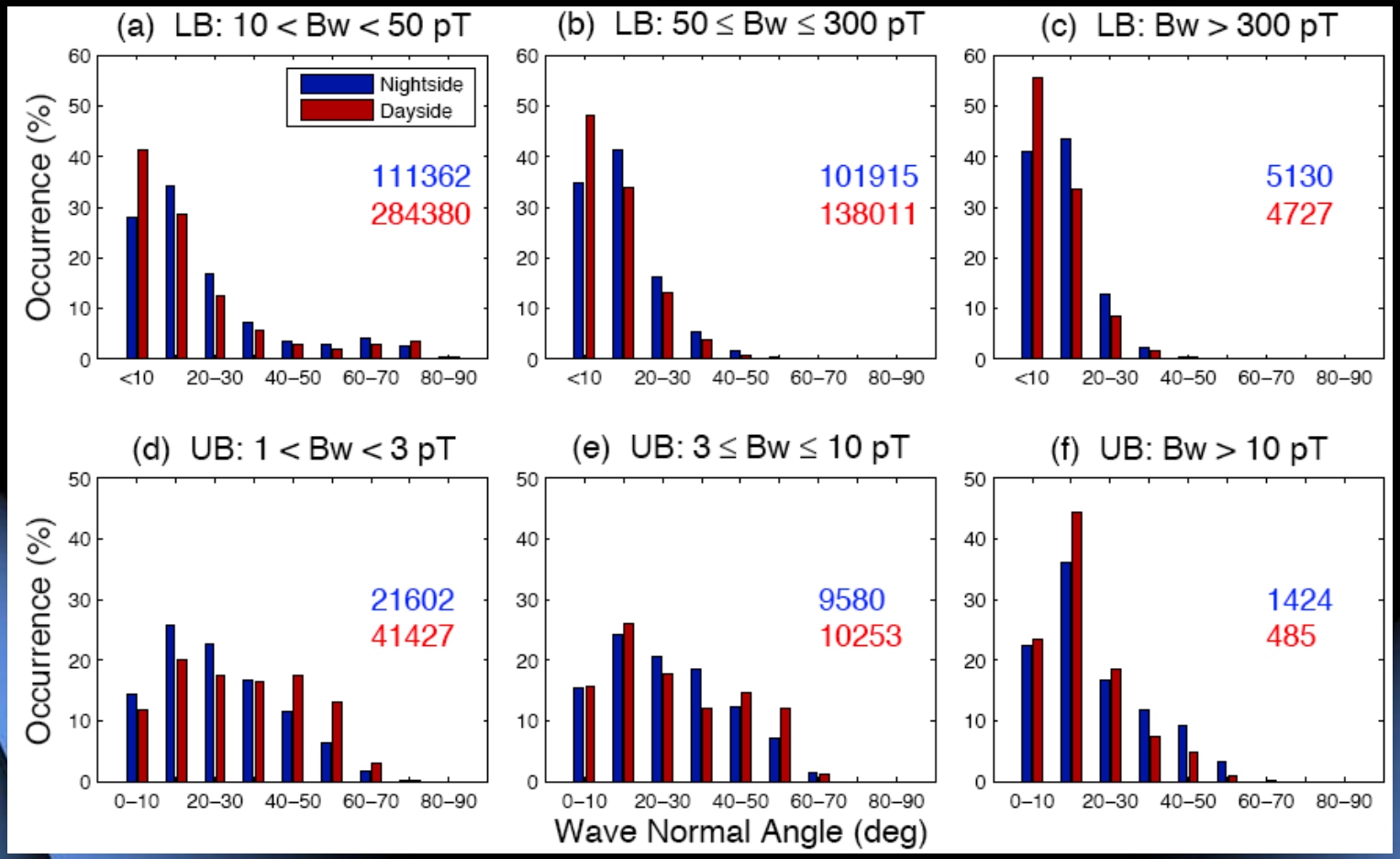
- Occurrence is high from premidnight to postdawn up to a few %.
- Preferentially observed at lower L-shells
- Higher occurrence closer to the equator.
- Occurrence rate is higher than that obtained from FFF data, which may confirm that high resolution waveform data are essential to capture large amplitude chorus.

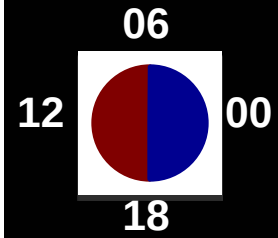
[*Li et al*., 2011]

Wave normal angle distribution for various wave amplitude ranges (waveform)

LB

UB

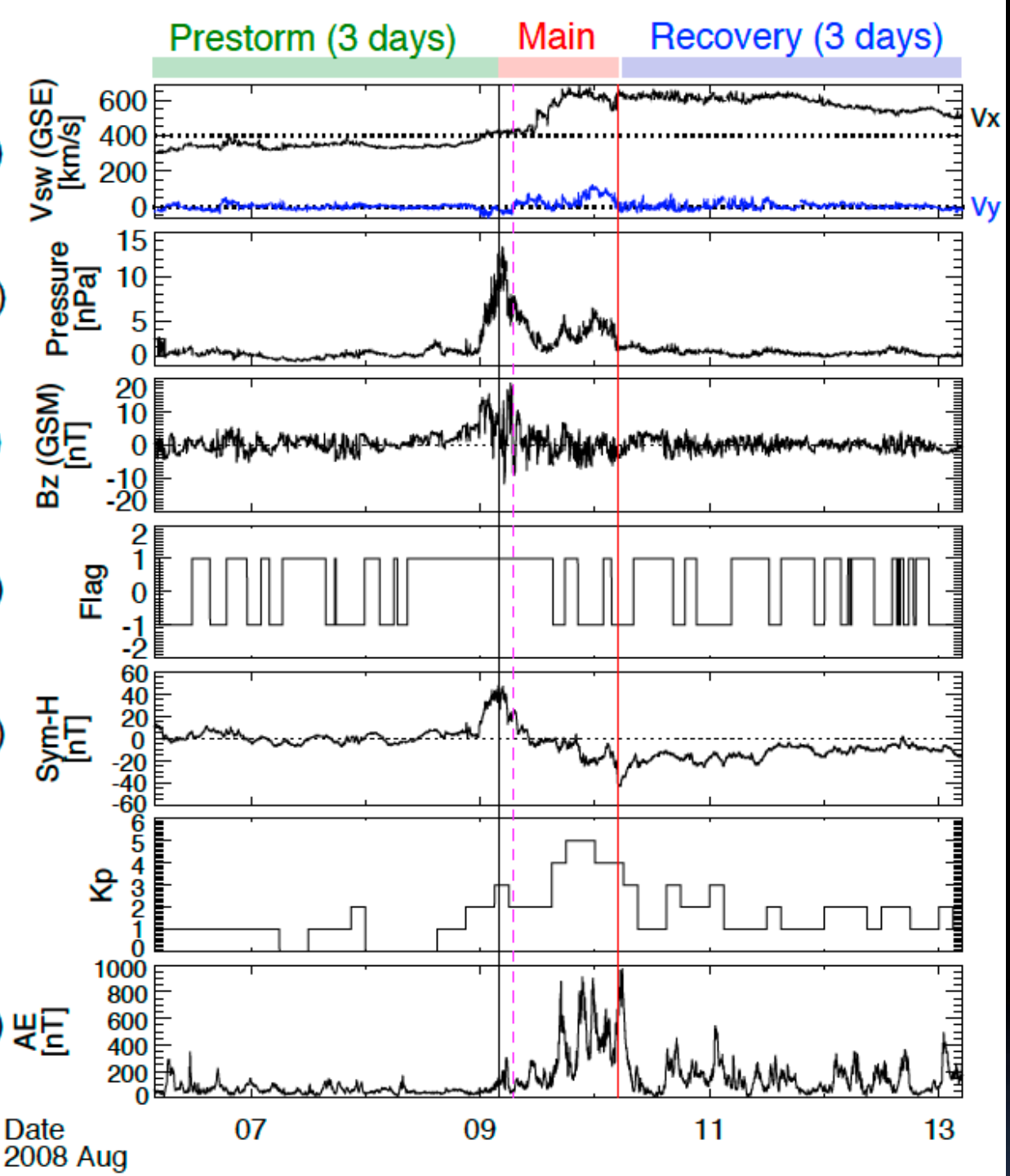




✧**LB:** Majority of WNAs are less than 20° ; WNA tends to be smaller as B_w increases; WNA on the dayside is generally smaller than on the nightside.

✧**UB:** WNA of UB is generally larger than LB, distributed in a broad range, while strong UB still peaks at 10-20° .

[*Li et al*., 2011]

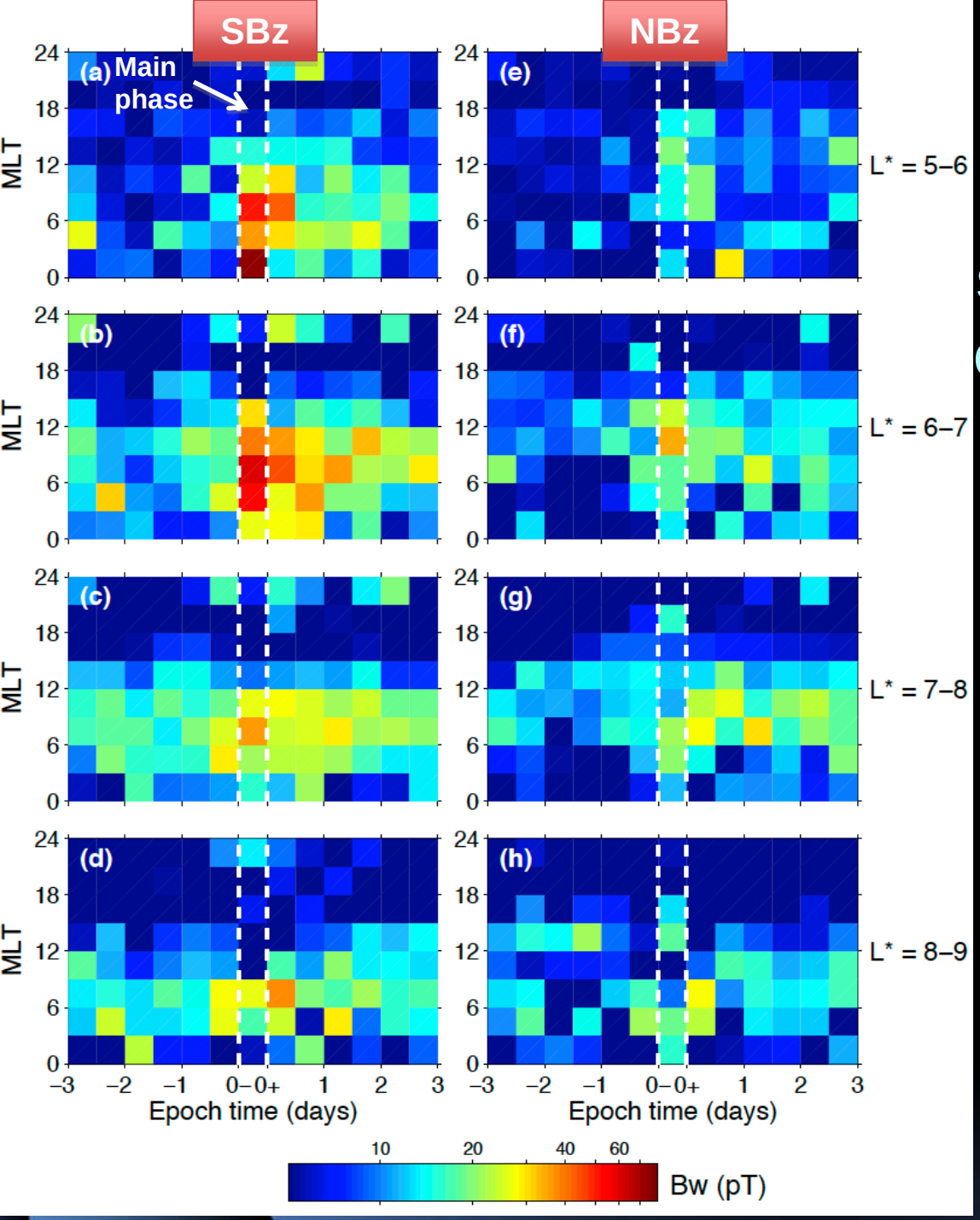


One example of CIR storm

Superposed epoch analysis

- ✧3 days before + main phase + 3 days after
- ✧2007/07/01 – 2011/10/01
- ✧72 CIR storms
- ✧Categorize CIR events by IMF B_z southward or northward

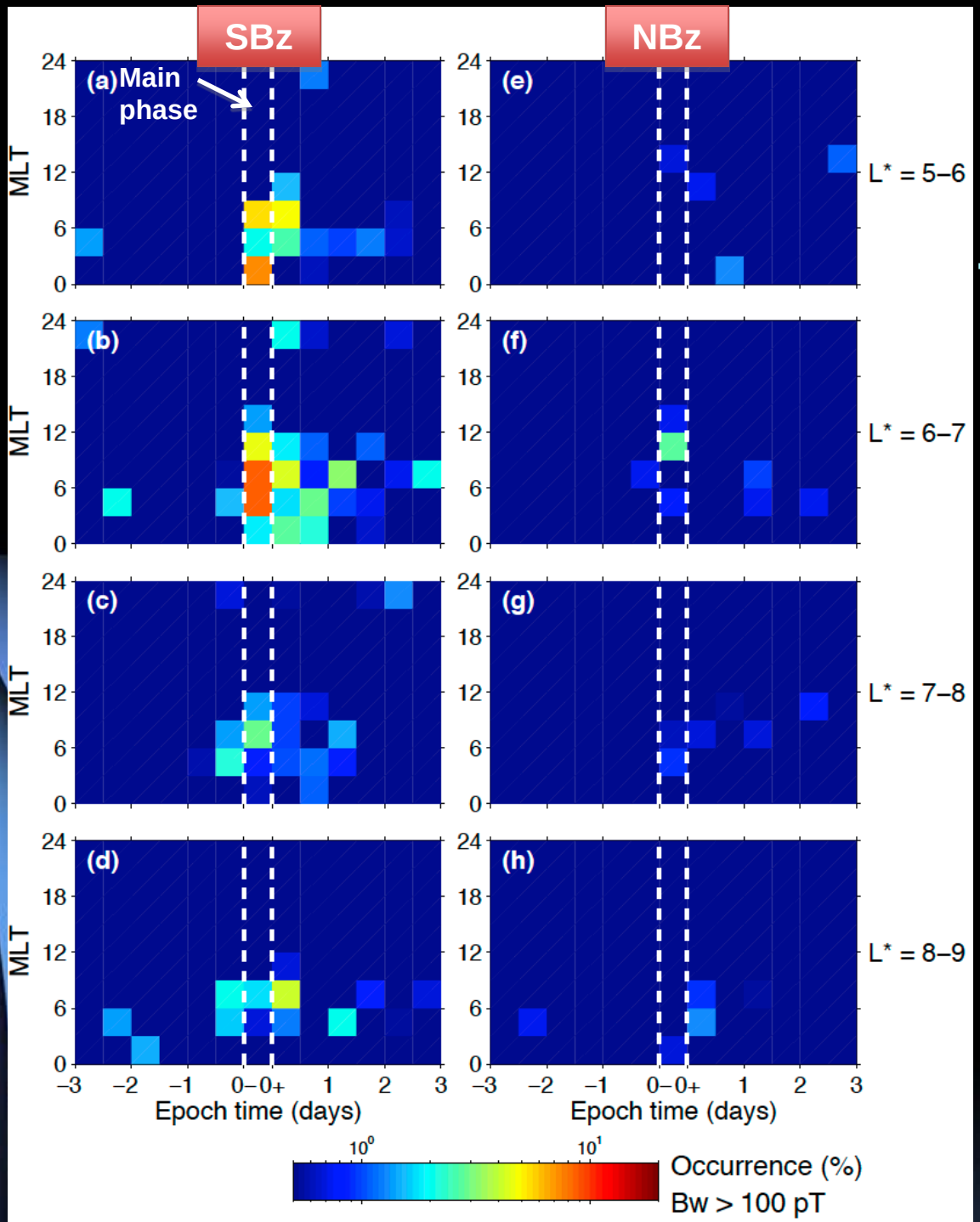
Flag
1: mean(Bz) in the previous 2.5 hour > 0
-1: < 0



Evolution of chorus wave amplitude (B_w) during CIR-driven storms – superposed epoch analysis (FBK)

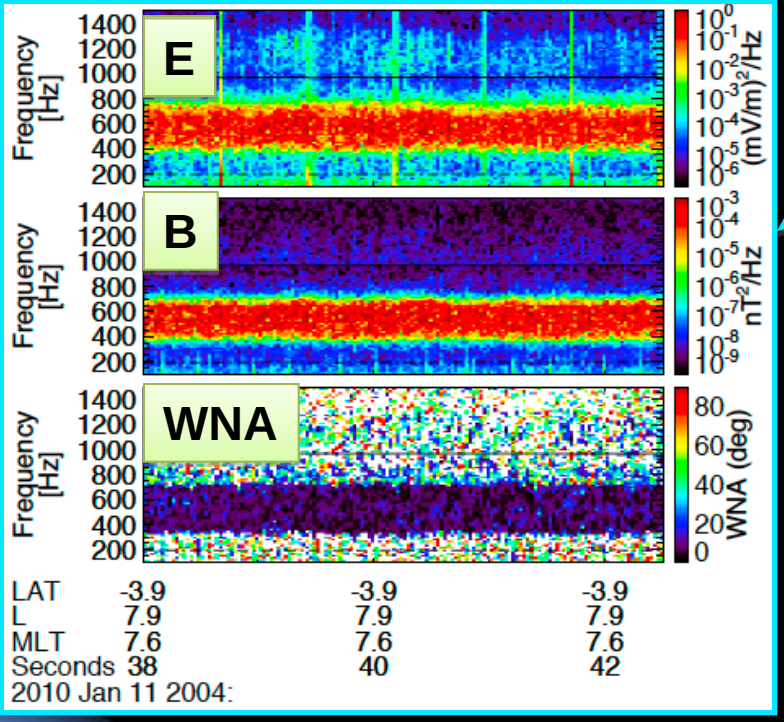
- ✧In SBz, B_w is weak during prestorm, increases at 0-12 MLT during the main phase, and gradually decreases during the subsequent recovery phase.
- ✧B_w during the recovery phase is stronger than that during prestorm.
- ✧At L* < 7, B_w at 0-12 MLT peaks in the main phase.
- ✧Compared to SBz category, in NBz category B_w is much weaker at L* < 7, but is comparable at L* > 7.

Evolution of occurrence rate of strong chorus for B_w > 100 pT (FBK)

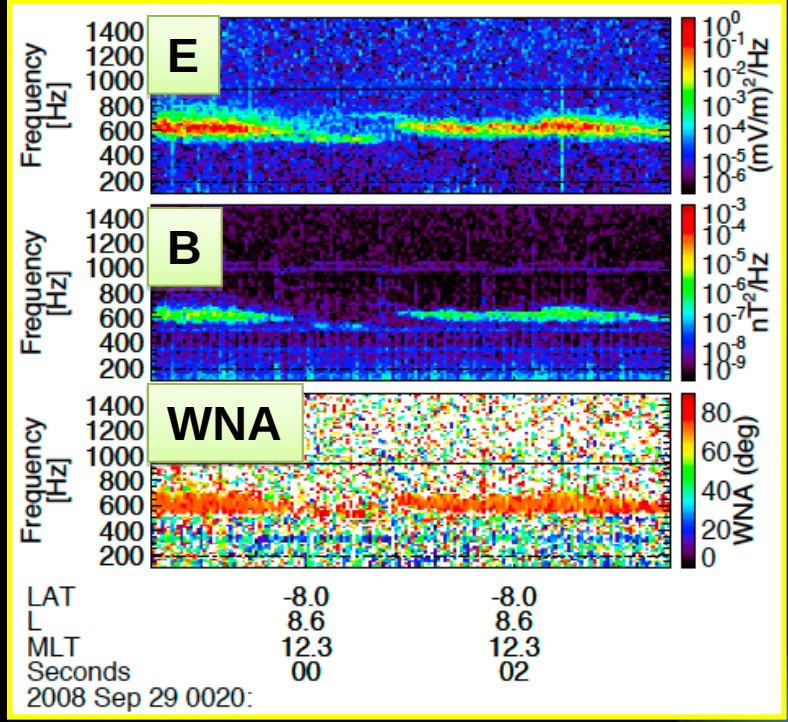


Strong chorus waves are observed with highest occurrence rate at

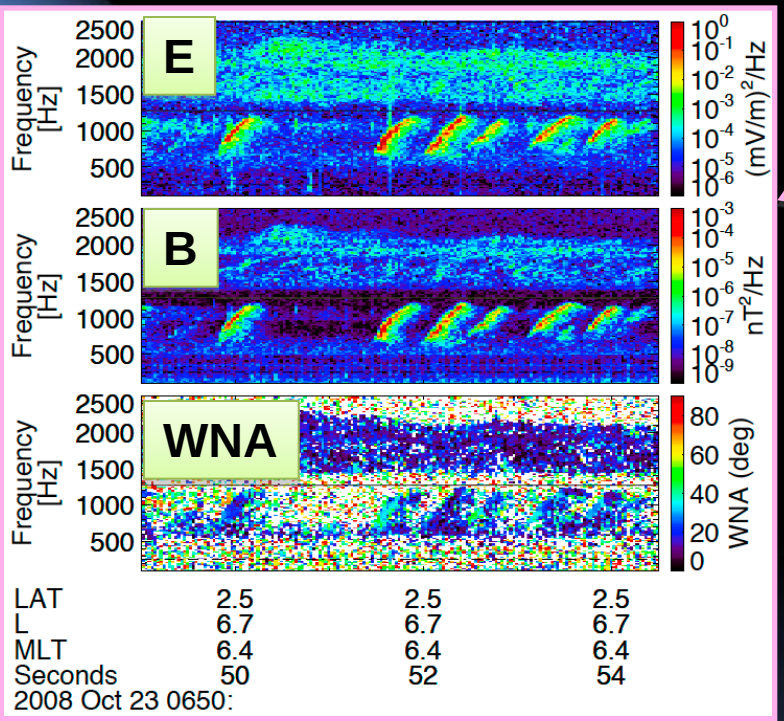
- ✧the main phase
- ✧SBz
- ✧0-9 MLT
- ✧L* < 7



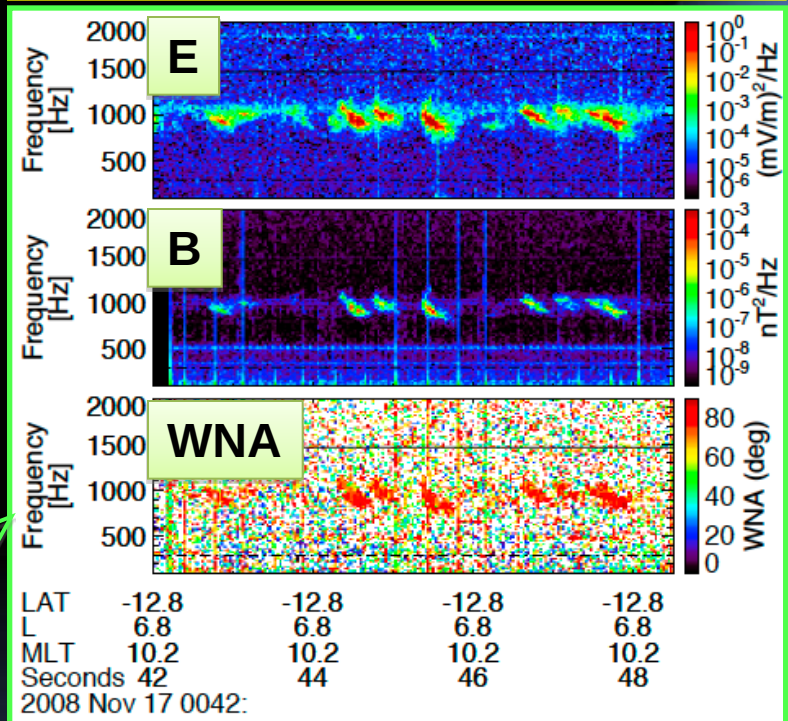
Hissy-like (broad band)



Hissy-like (narrow-band)

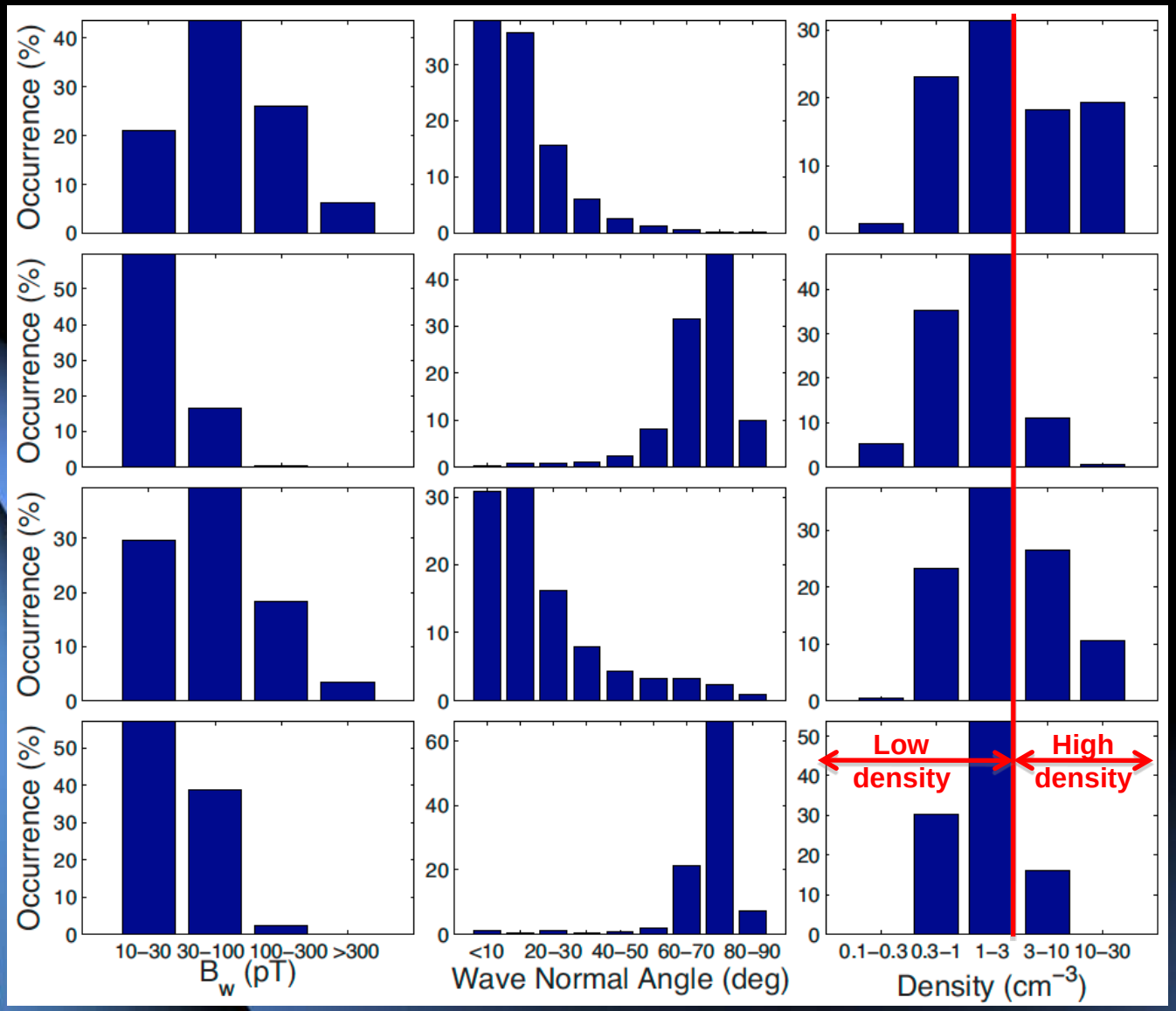


Discrete (rising tone)



Discrete (falling tone)

Typical properties of various emissions (waveform)



Broad band

Narrow band

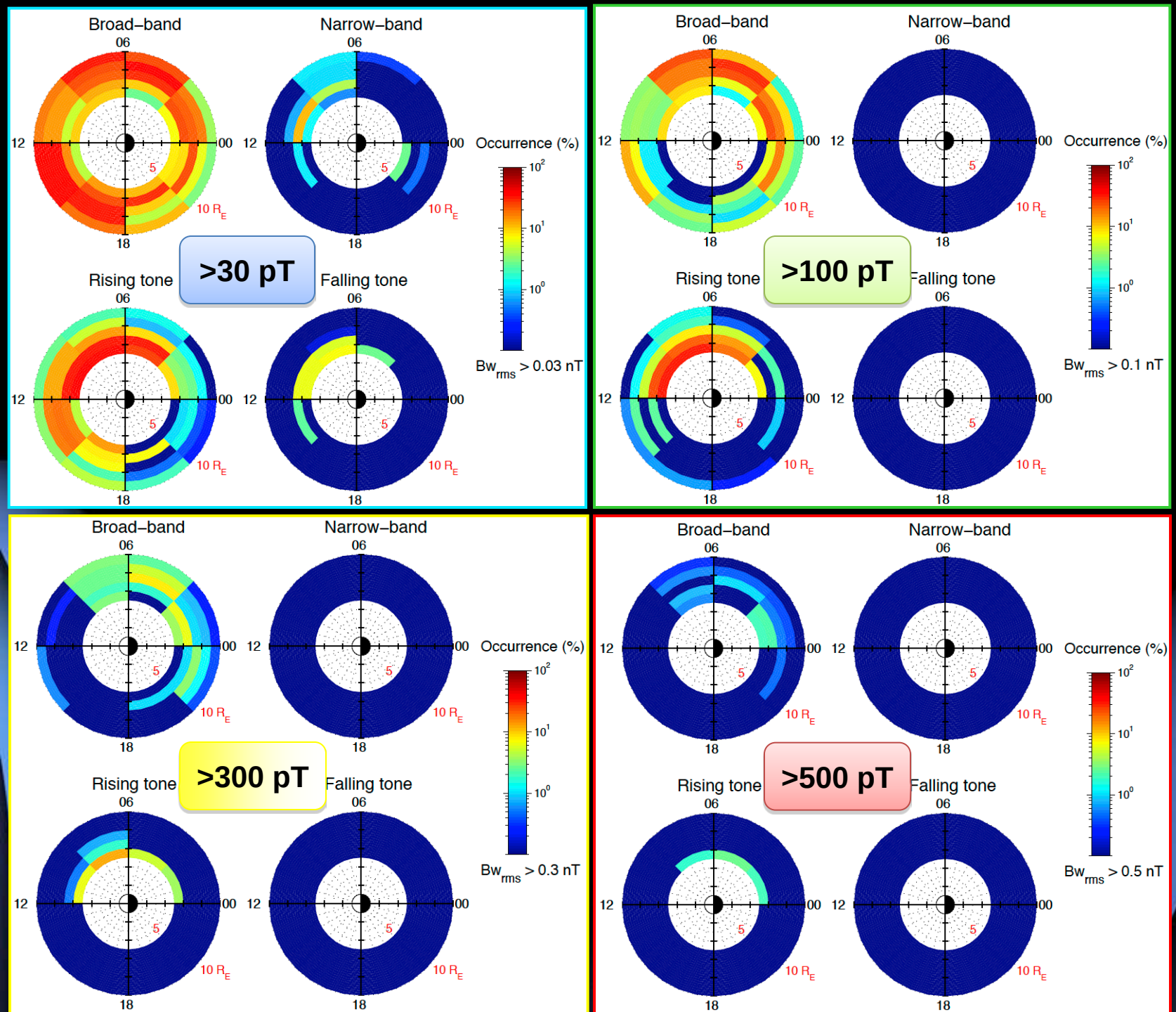
Hissy-like

Rising tone

Falling tone

Discrete

Occurrence rate of 4 types of emissions at various wave amplitudes in L-MLT domain (waveform)



SUMMARY

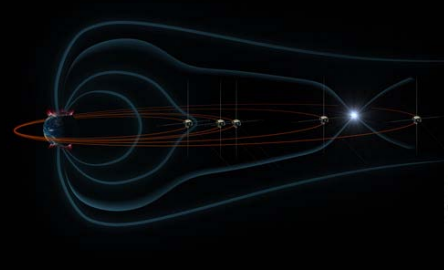
- Using THEMIS data, we provided more complete coverage of chorus wave amplitude distributions including large amplitude chorus, which has not been covered by previous satellites.
- Majority of WNAs of LB chorus are less than 20° and they tend to be smaller as B_w increases; WNA of UB is generally larger than LB, distributed in a broad range, while strong UB still peaks at 10-20° .
- During CIR-driven storms, chorus wave amplitudes peak in the main phase at L* < 7 and are stronger under SBz than NBz IMF orientation.
- B_w of broad-band waves and rising tones are stronger than narrow-band and falling tones; broad-band and rising tones are typically quasi field-aligned (<30°), while narrow-band and falling tones are preferentially very oblique. Broad-band waves are distributed in a broad range, while rising tones prefer to occur lower L.

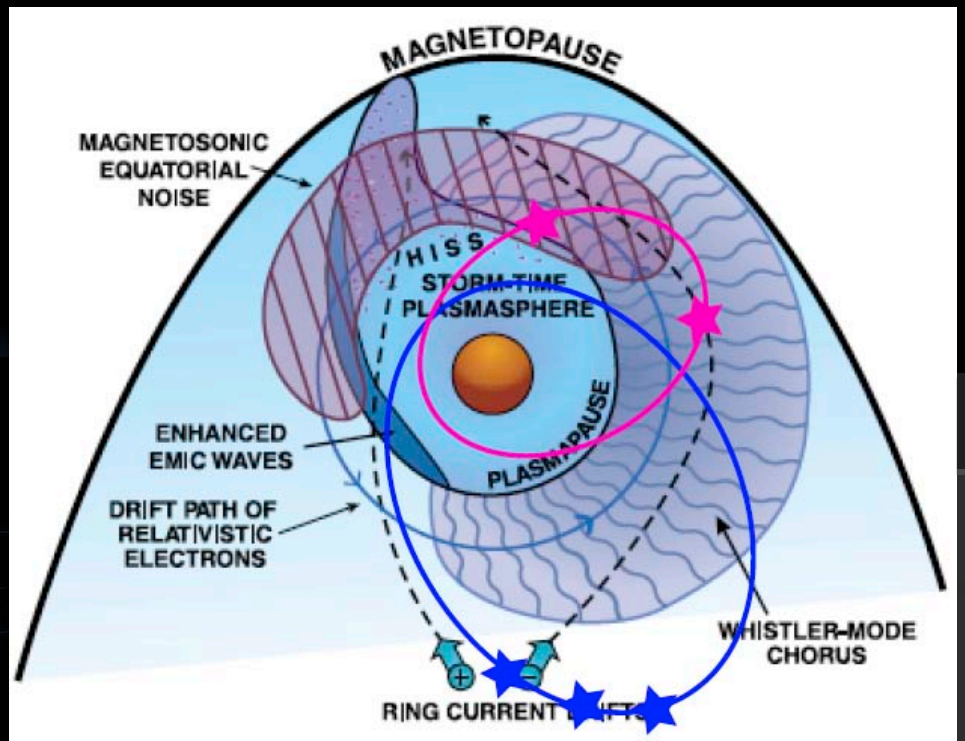
OPEN QUESTIONS

✧Generation of upper-band chorus and the gap at 0.5 f_{ce}

✧Generation mechanism of rising/falling tones and hissy-like emissions (what controls their emission types?)

THEMIS





RBSP