

# A statistical study of Pc1 waves observed at Jang Bogo Station, Antarctica

Hyuck-Jin Kwon<sup>1</sup>, Khan-Hyuk Kim<sup>2</sup>, Geonhwa Jee<sup>1</sup>, Jeong-Han Kin<sup>1</sup>, Changsup Lee<sup>1</sup>

<sup>1</sup>Korea Polar Research Institute, Korea, <sup>2</sup>School of Space Research, Kyung Hee University, Korea



## Abstract

Search-coil magnetometer (SCM) was installed at Jang Bogo Station (JBS), Antarctica in the late of 2016 to measure magnetic field variations in the polar cap and/or cusp region. We have used 1-year's data from JBS to statistical study of Pc1 pulsations. The whole year data allow us to analyze seasonal and magnetic local time (MLT) dependence and investigate the possible generation processes of Pc1 waves. The occurrence of events is strong near the magnetic local noon and the ratio is predominantly during summer season then winter season. This seasonal and MLT distribution is due to the relative position of cusp. The interesting feature is that there are no such dependences for high coherence and polarized events. We suggest that the high coherence (and polarized) waves may be not directly propagated from space, but propagated through the ionosphere, because the cusp is a region of energy input from space to the ground. We will more detail discuss using in-situ measurements of magnetic field and plasma composition by SWARM and DMSP and ground magnetic field measurements by other stations.

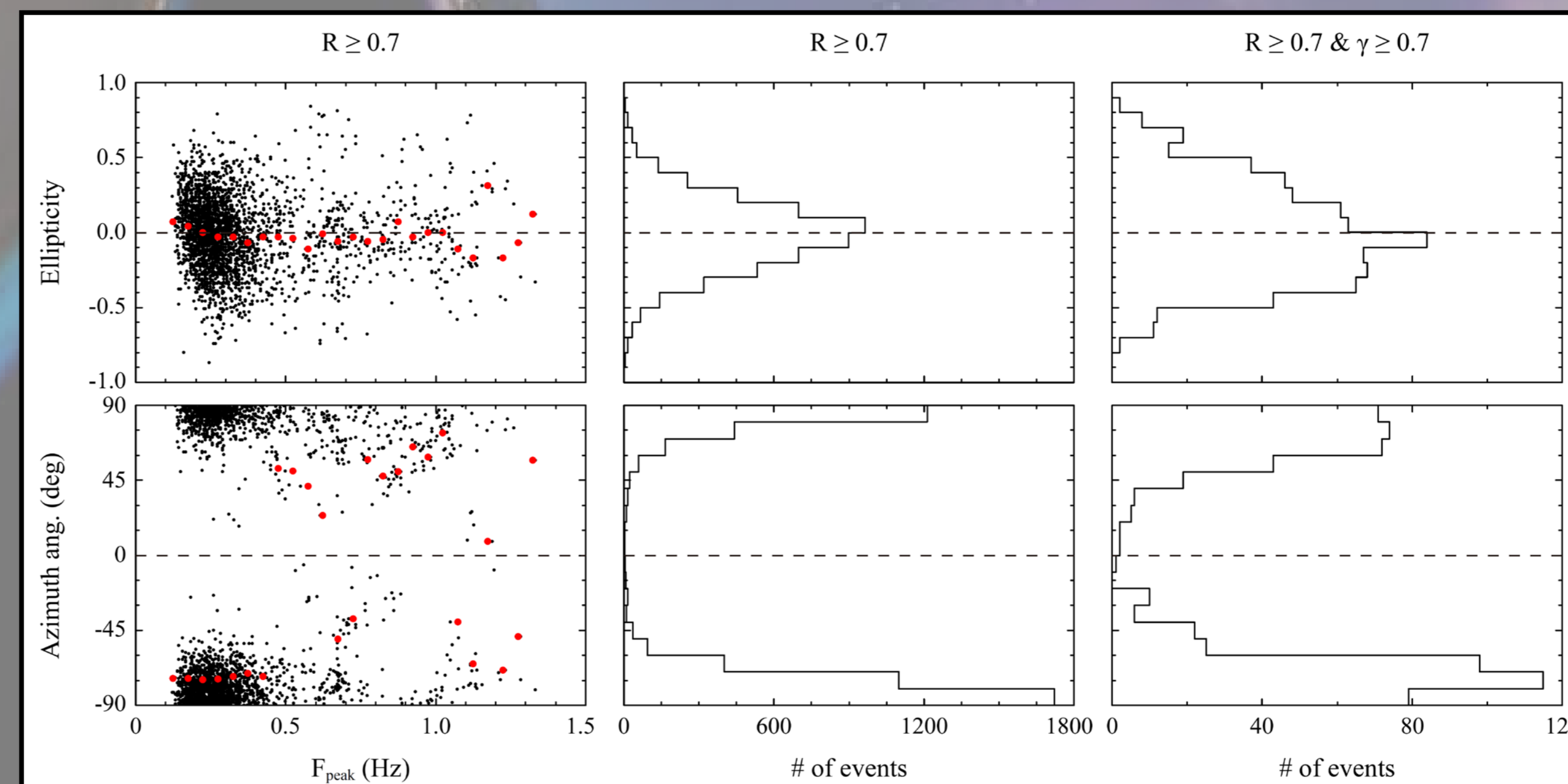
## Data set



- Coordinates
  - Geo:  $-76.62^\circ / 164.22^\circ$
  - Mag:  $-79.87^\circ / 306.44^\circ$
  - MLT  $\sim$  UT + 15hr
- Search-coil magnetometer
  - Bi-axial (X and Y on the horizontal plane)
  - Sampling rate: 10Hz

Figure 1. Antarctic stations

## Characteristics of polarization



- Most high polarized Pc1 waves show linear ( $\epsilon \sim 0$ ) polarization with E-W direction.
- Corresponding characteristics of polarization for high coherence ( $\gamma \geq 0.7$ ) events.

Figure 6. Polarization of Pc1 waves.

## Distribution of Pc1

### Event selection

- Time window: 180 sec / non-overlapping
- Frequency criteria
  - $F_{peak} \geq 100$  mHz (no upper limit)
- Power criteria
  - $P_{tr} = P_x + P_y$
  - $P_{tr}(peak) \geq 0.0005$

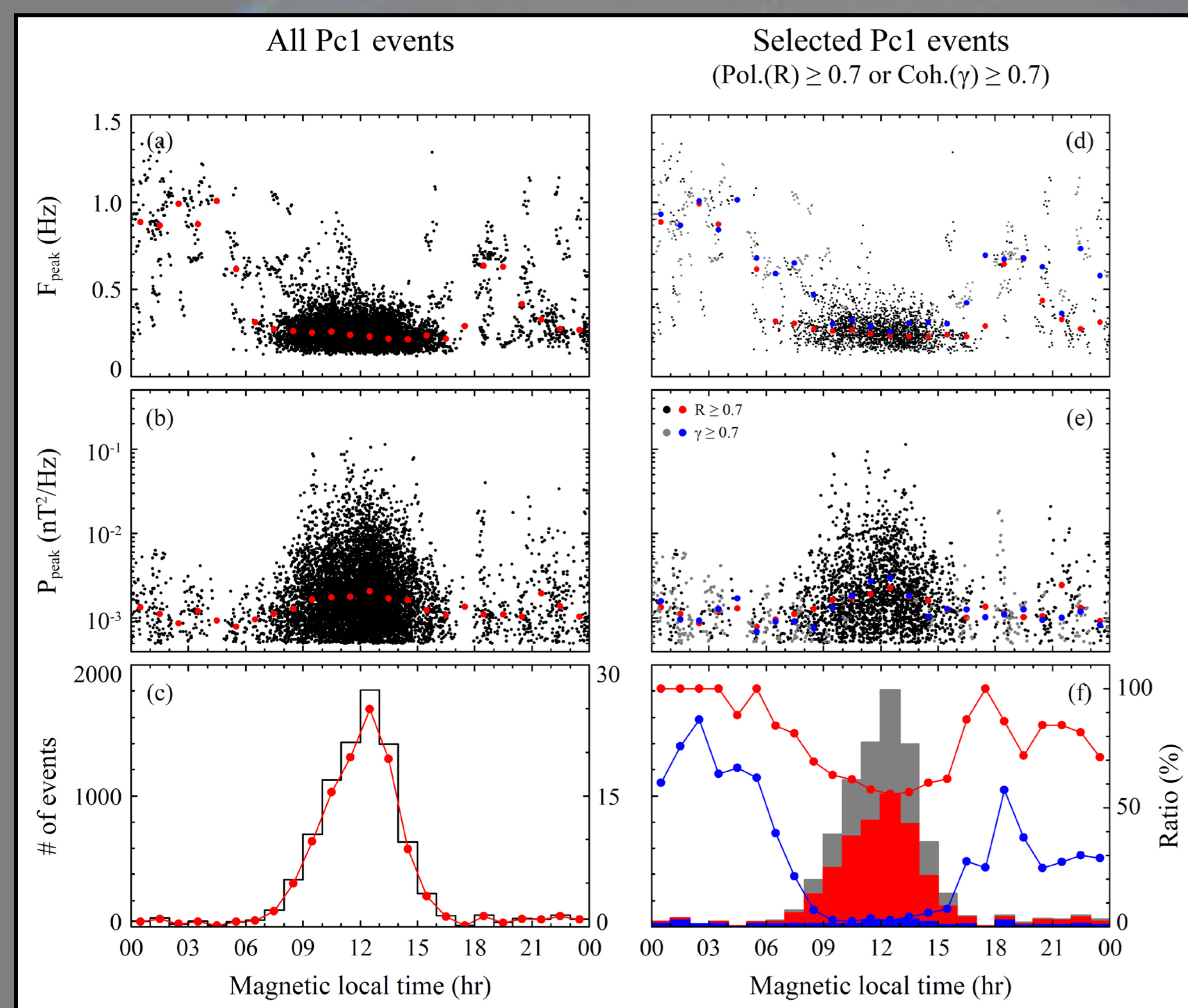


Figure 2. MLT distribution of Pc1 waves.

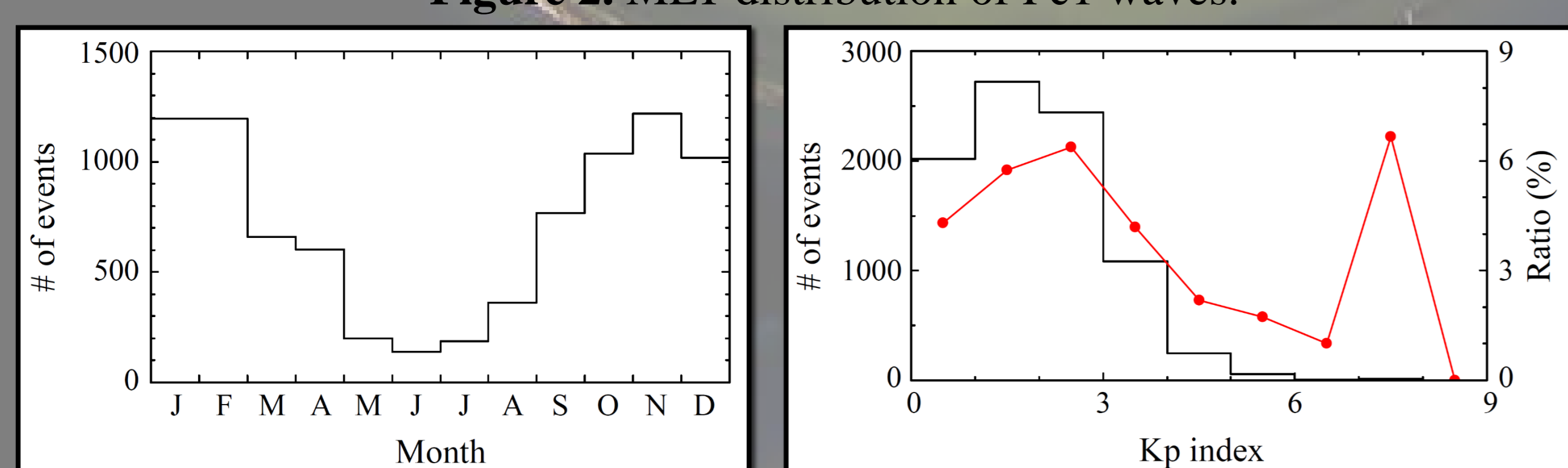


Figure 3. Seasonal distribution.

Figure 4. Kp distribution

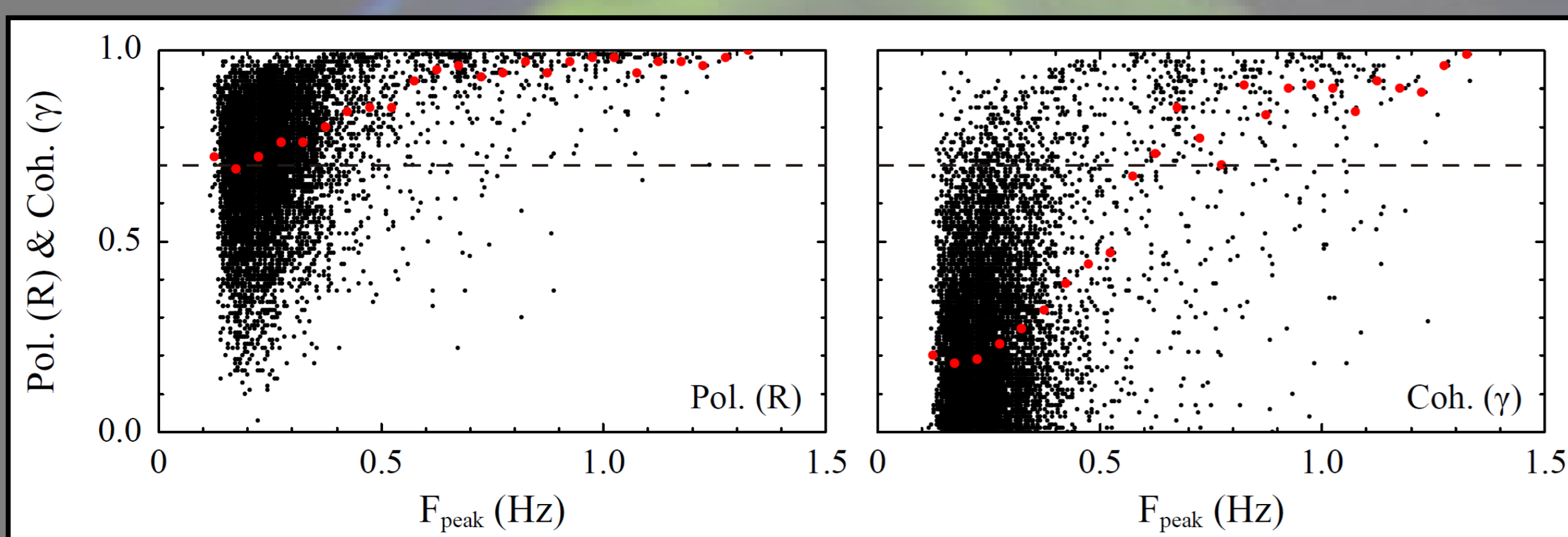
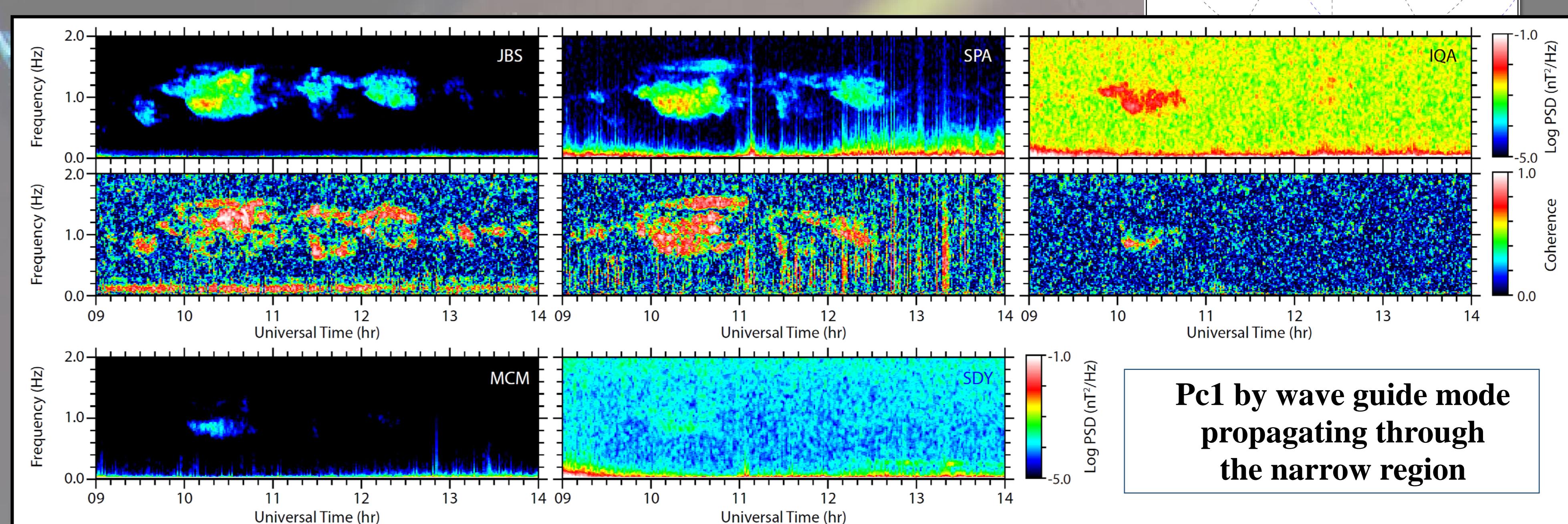


Figure 5. Frequency distribution

- Maximum occurrence ratio (# of events) near magnetic local noon.
- Strong attenuation in nighttime sector.
- Low frequency and strong Pc1 during daytime.
- High coherence Pc1.
  - Peak ratio in the post-midnight.
  - Minimum ratio near magnetic noon.
- Most Pc1s are occurred during summer season.
- Negative relation between occurrence ratio and Kp index.
- High R and  $\gamma$  in the high frequency range.

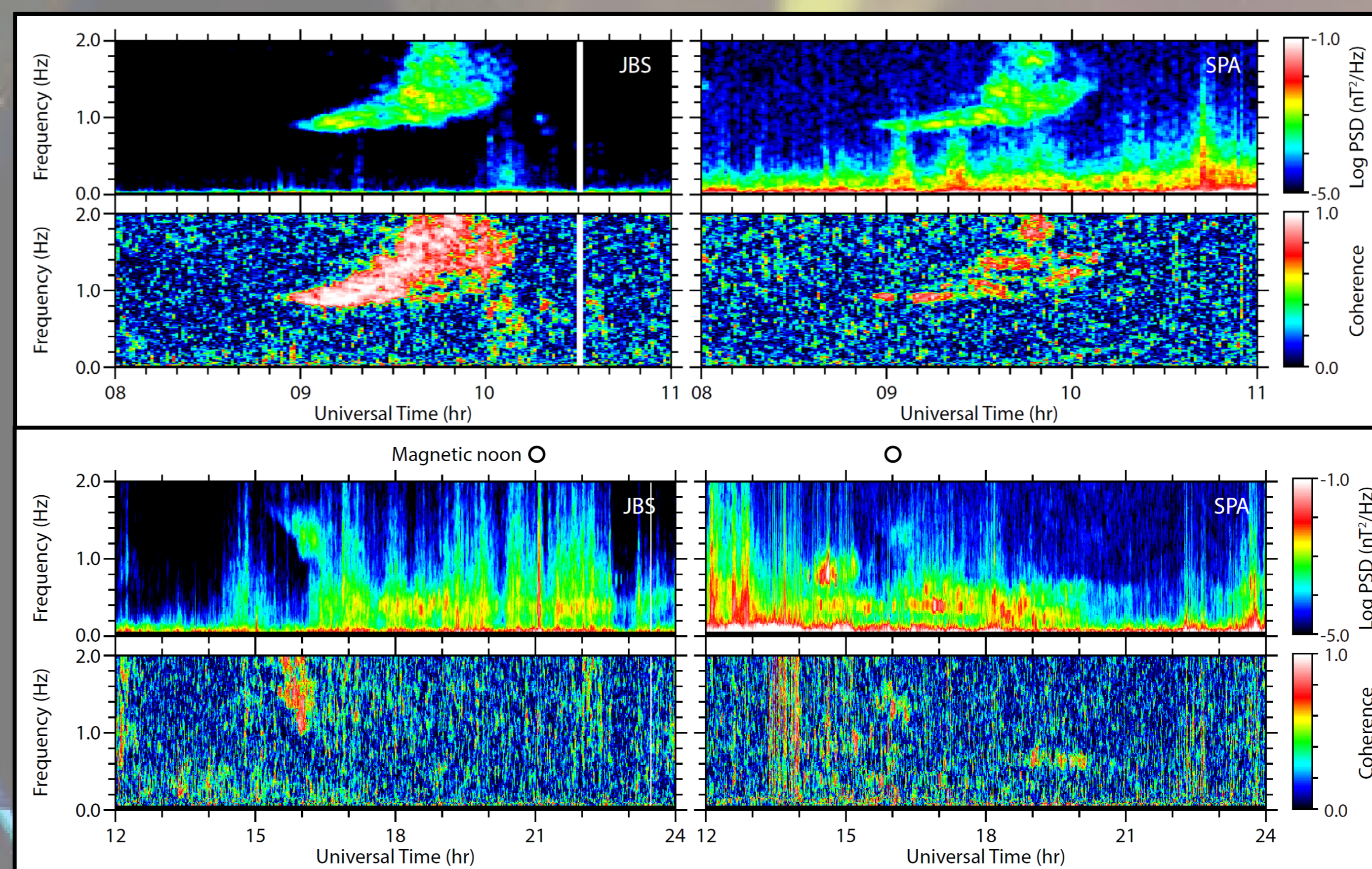
## Case events

### 27 April, 2017



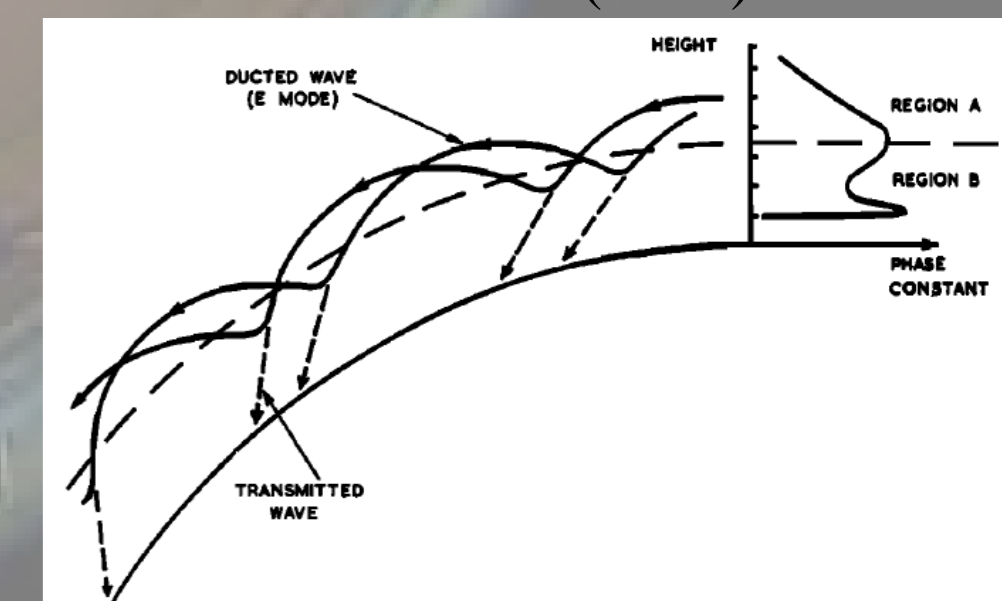
Pc1 by wave guide mode propagating through the narrow region

### 03 Nov, 2017 (09 UT – Wave guide / Local daytime – Cusp Pc1)



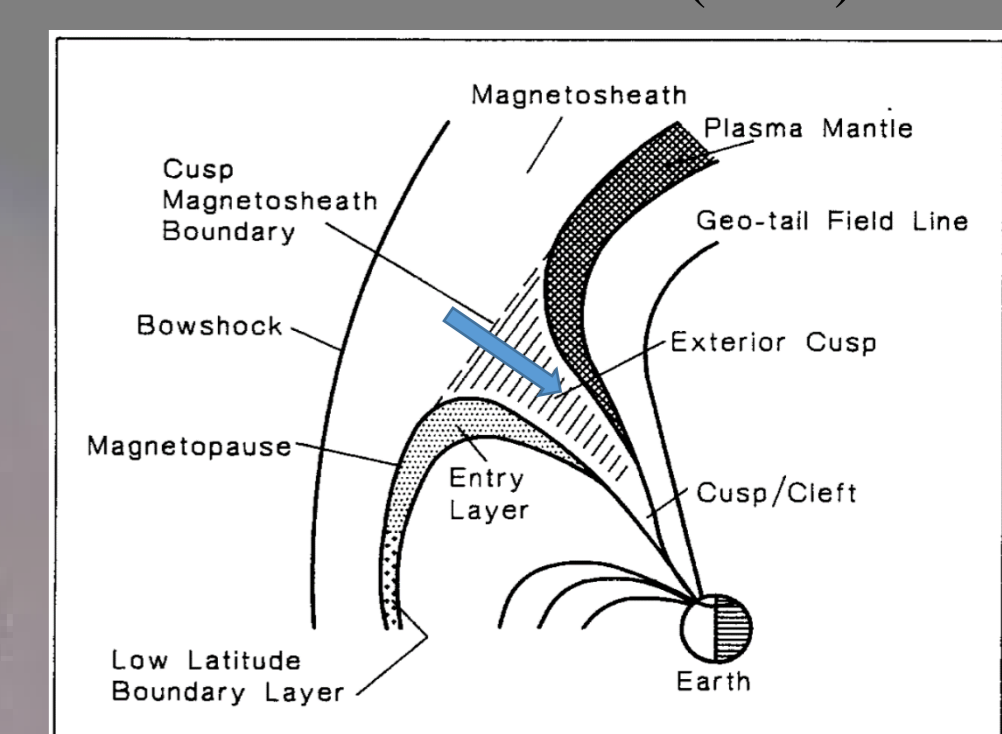
### Wave guide

Manchester (1966)



### Cusp Pc1 wave

Morris and Cole (1991)



## Discussion and Summary

- We statistically investigated the characteristics of Pc1 waves at JBS in 2017.
- The maximum occurrence ratio: magnetic noon, summer season
  - Effect of relativistic location between JBS and cusp
- No clear predominant peak of occurrence ratio for high coherence Pc1.
- The occurrence ratio decreases as Kp index increases → cusp expands to equatorward.
- Most polarized Pc1 waves represent linear polarization along E-W direction.
- High coherence Pc1s are detected other ground stations on both hemispheres. Those waves could be generated at the equator region of inner magnetosphere, then propagate to both hemisphere and converted to ducted waves.
- Daytime Pc1 events with low coherence are simultaneously occurred at SPA during local daytime. Those waves maybe directly come from outer magnetosphere through cusp region associated with the propagation of energetic particles.
- Future works: comparison with measurements of magnetic field on the ground and plasma flux in space.

**Question: Is there any relation between coherence and the wave guide mode?**