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# Plasma waves causing REP events at ISS

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and Arase satellite collaboration

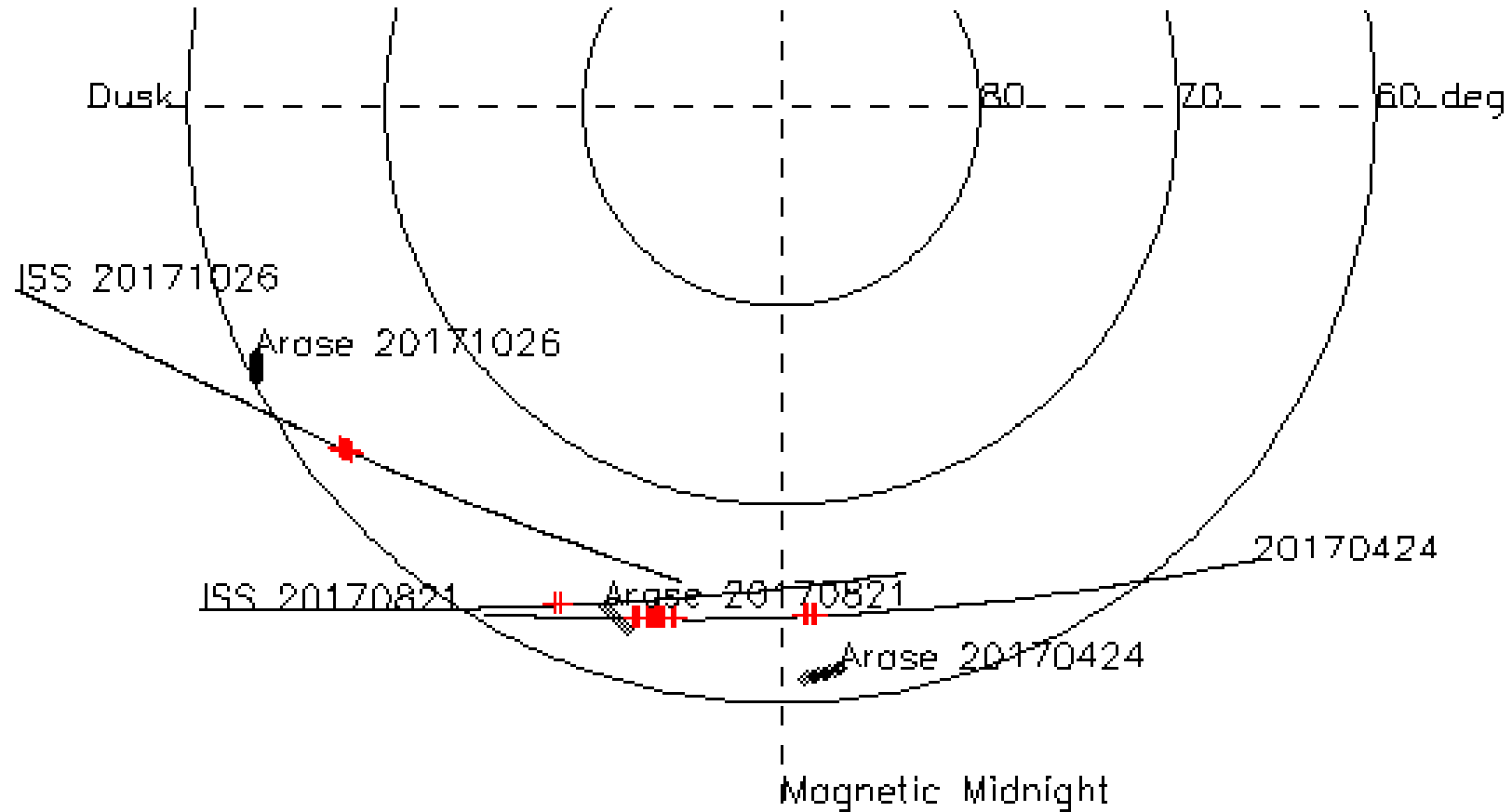
Paper submitted to JGR Space Physics (Special issue of Arase satellite)

# Questions

- Q1: All of the REP events are caused by EMIC waves?
  - Electromagnetic ion-cyclotron waves = EMIC waves
  - EMIC waves efficiently scatter MeV electrons into the atmosphere
  - Both REP events and EMIC waves are excited at pre-midnight sector
    - [Kataoka et al., 2016 GRL](#)
- Q2: Some REP events are caused by whistler mode waves?
  - Whistler mode waves scatter sub-MeV electrons into the atmosphere
- Arase satellite observed plasma waves in the magnetosphere.
  - Final answers are NO for Q1, and YES for Q2
    - [Kataoka et al., 2020 JGR, submitted \(this study\)](#)

Pre-midnight

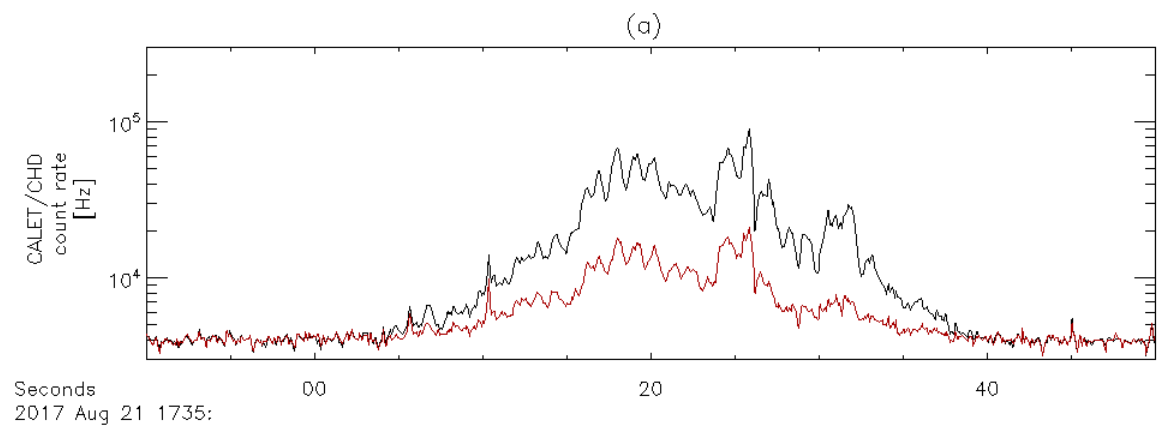
# REP events near the Arase footprints



**Figure 1.** The ISS orbit (black curves) and the Arase footprint (diamonds) during the 10 min time intervals of three selected REP events. The AACGM coordinate system was used to show the polar map, center is the south pole (CGMLAT = -90 deg), 12 MLT is to the top, and 18 MLT is to the left. The red plus signs indicate the large count rate ( $>5 \times 10^4$  Hz) of CHD-X.

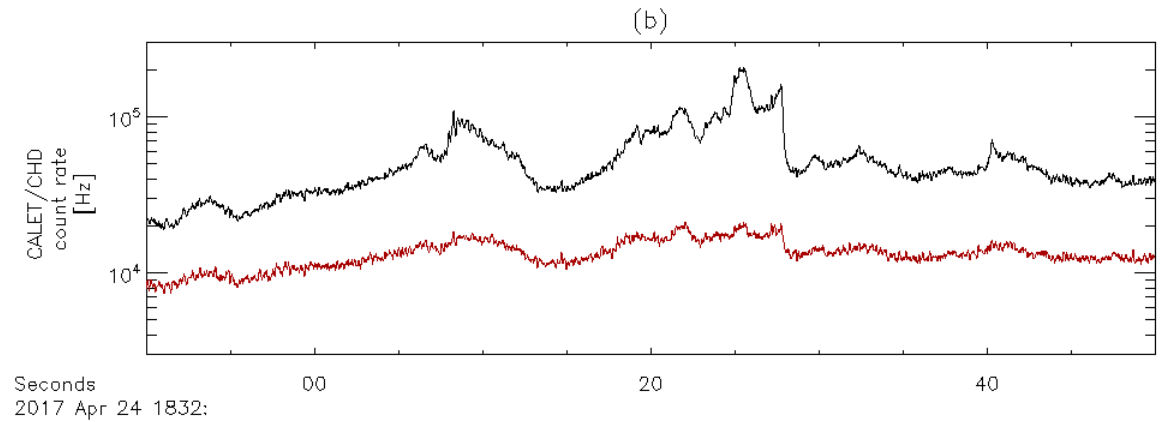
(a) quasi-periodic ( $\sim 1$  Hz) REP event

=> EMIC waves identified



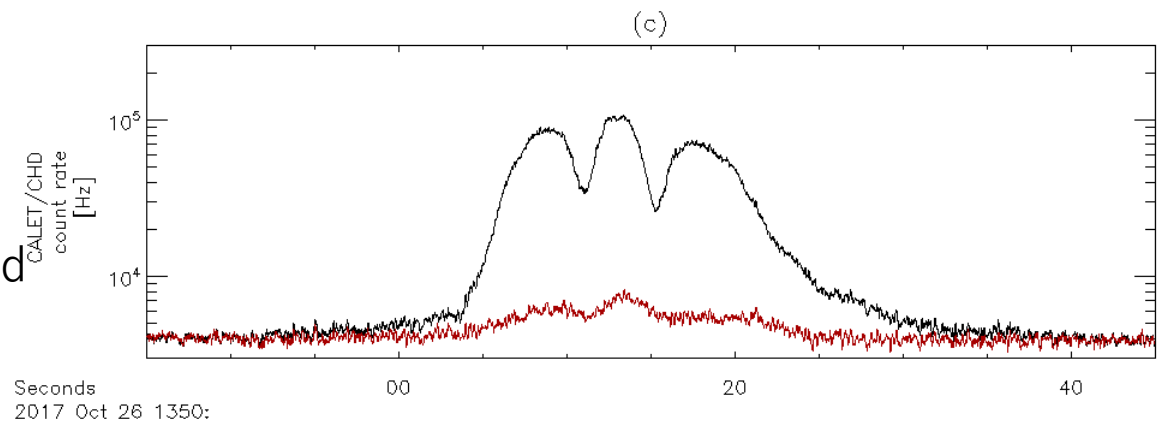
(b) irregular REP event

=> Whistler mode chorus waves identified



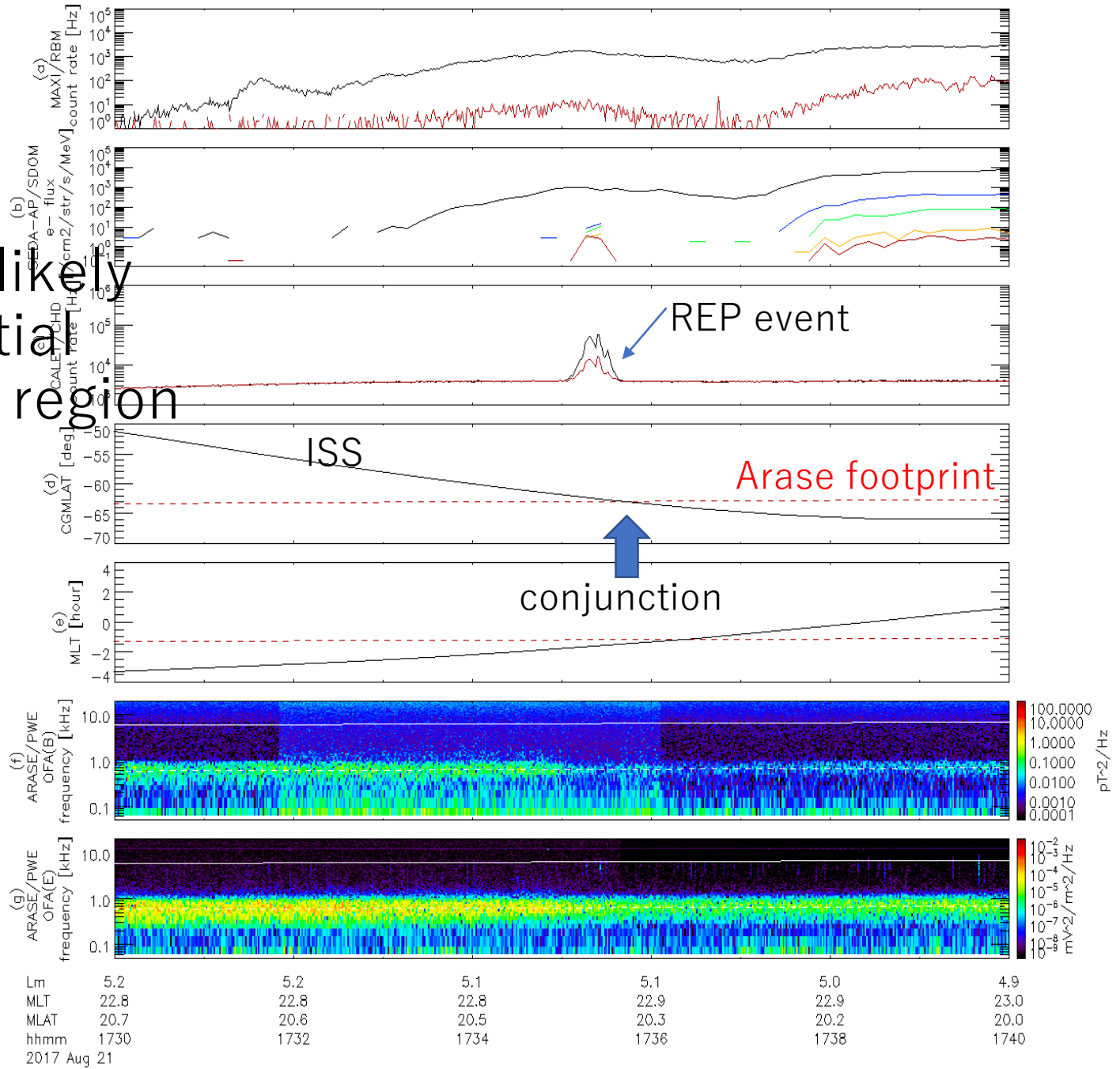
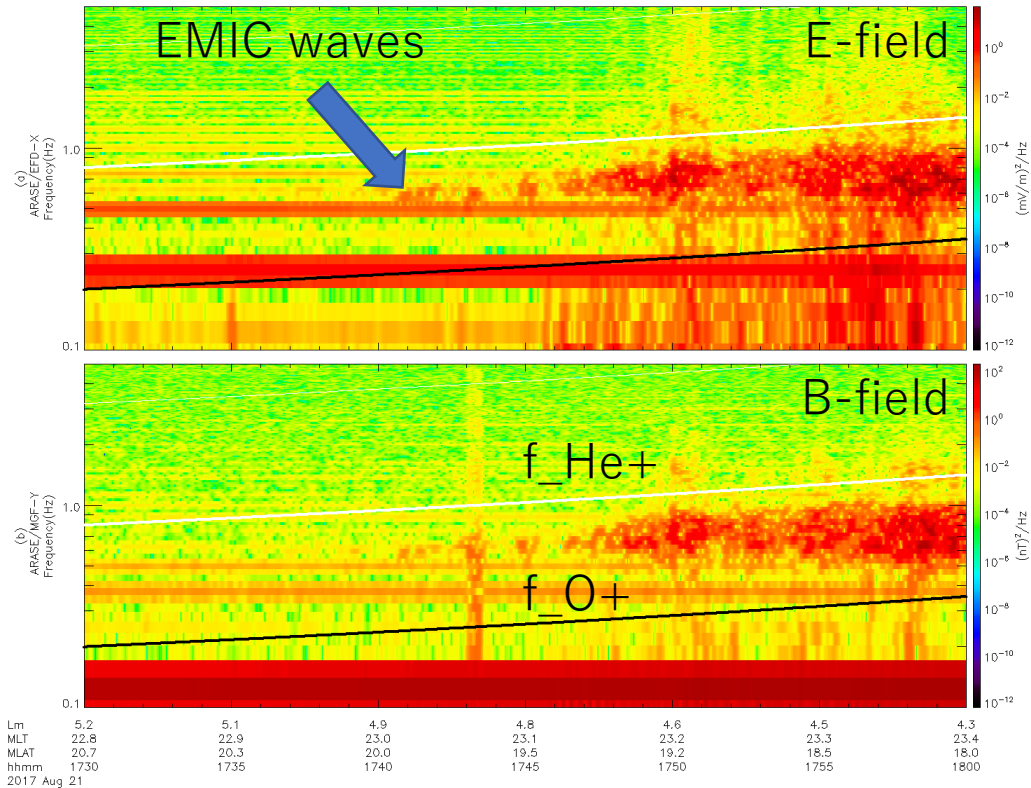
(c) smooth REP event

=> Whistler mode electrostatic waves identified



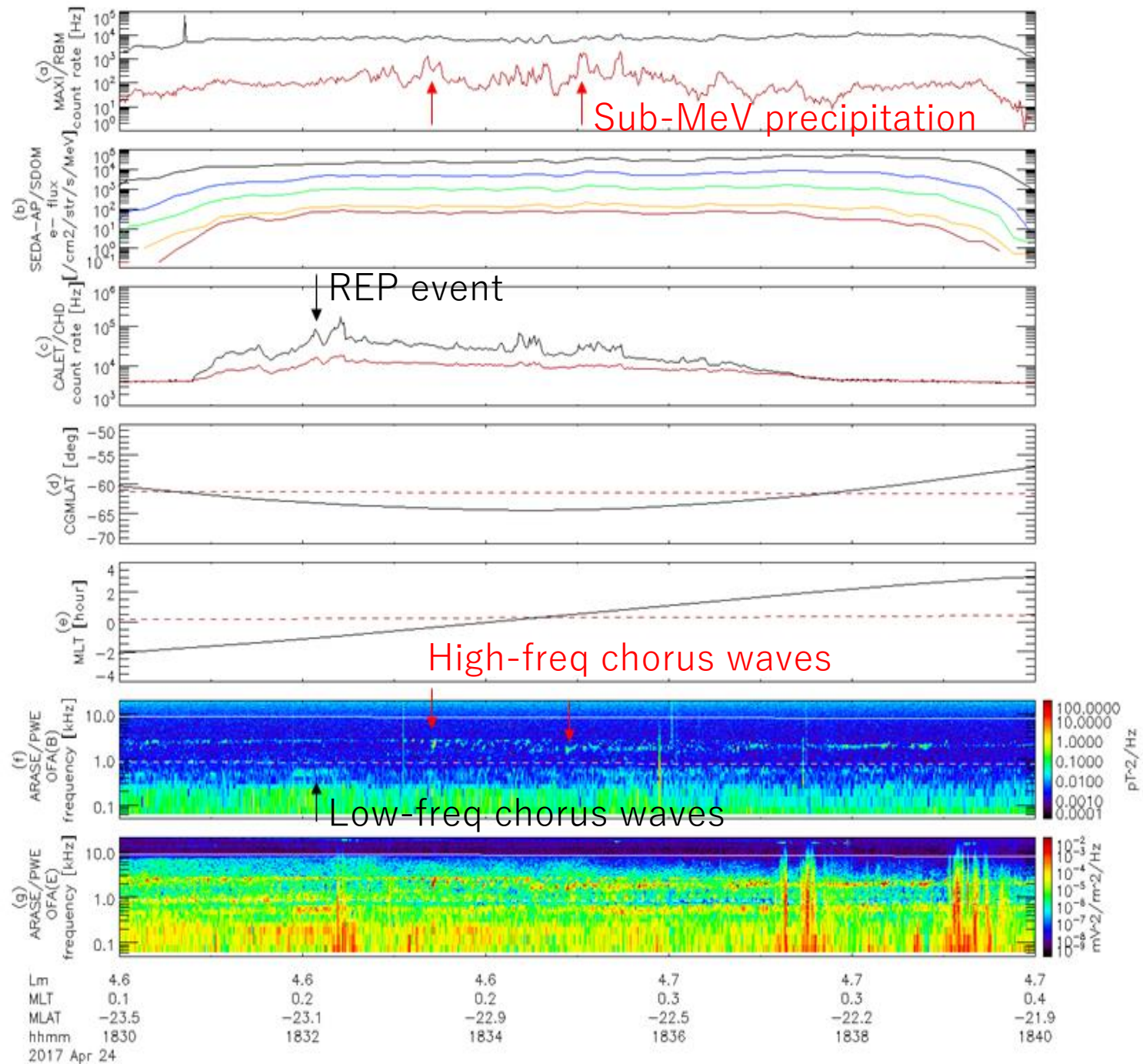
# (a) EMIC event

- Both ISS and Arase sat. likely passing through the spatial structure of active EMIC region



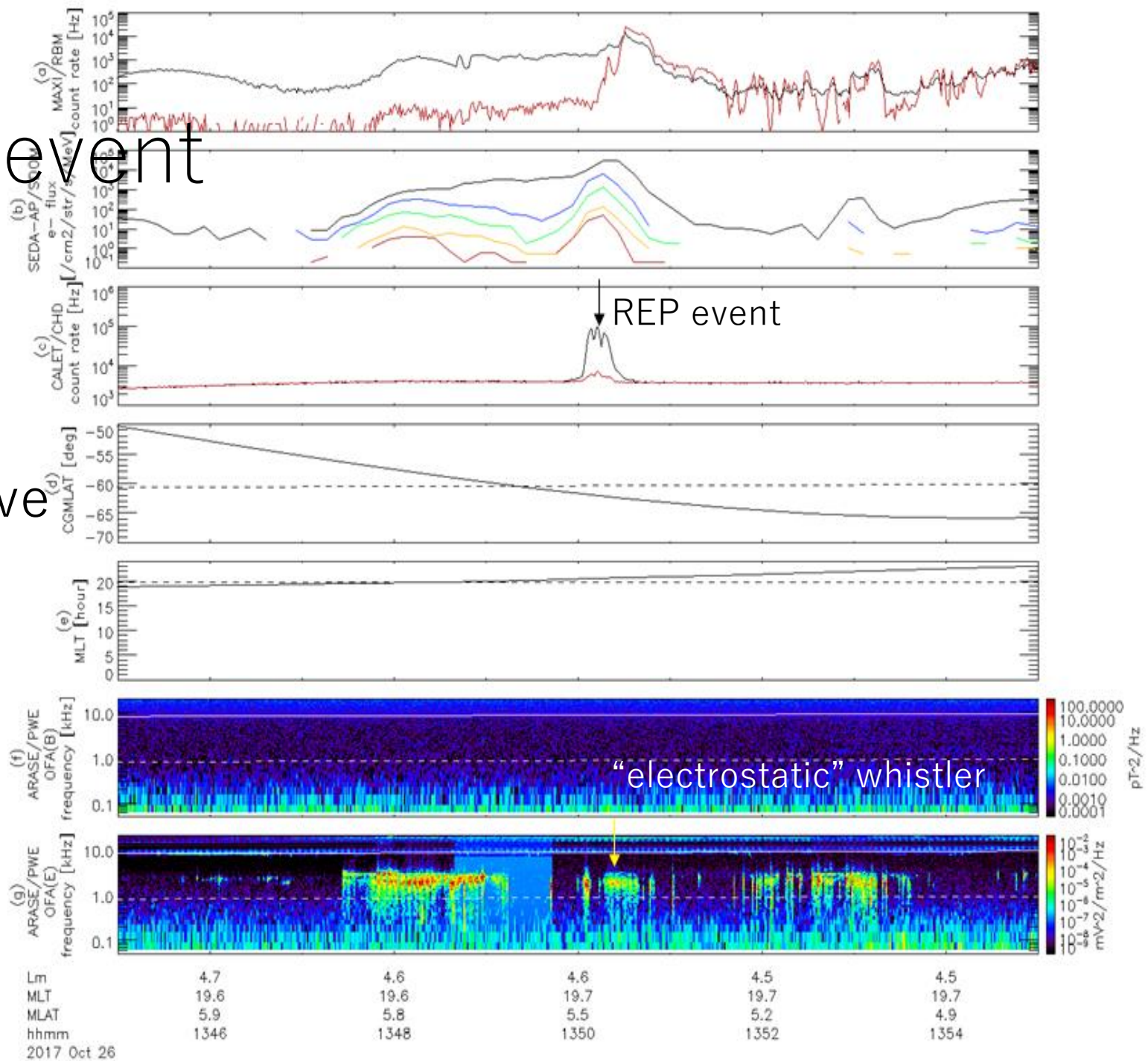
# (b) Chorus event

- Correlations found bet. REP count rates and chorus wave amps.
- Low freq => MeV
- High freq => sub MeV
  - Consistent with resonant scattering of whistler mode waves



# (c) Electrostatic event

- Smooth oscillations ( $\sim 0.2$  Hz) are found in both REP count rates and whistler mode wave amplitudes.
- First example to show “electrostatic” waves can cause REP event.



# Summary

- Pre-midnight REP events had been simply interpreted to be associated with EMIC waves (e.g., Kataoka et al., 2016).
- In fact, this study (Kataoka et al., 2020) provided such an example showing the essential role of EMIC waves near the magnetic equator.
- However, this study also clearly demonstrated that whistler mode chorus waves and even “electrostatic” whistler mode waves can be the major scattering source near the magnetic equator.