Origin of fast fluctuation of energetic electron precipitation: Data-driven simulations using the ERG plasma wave observations

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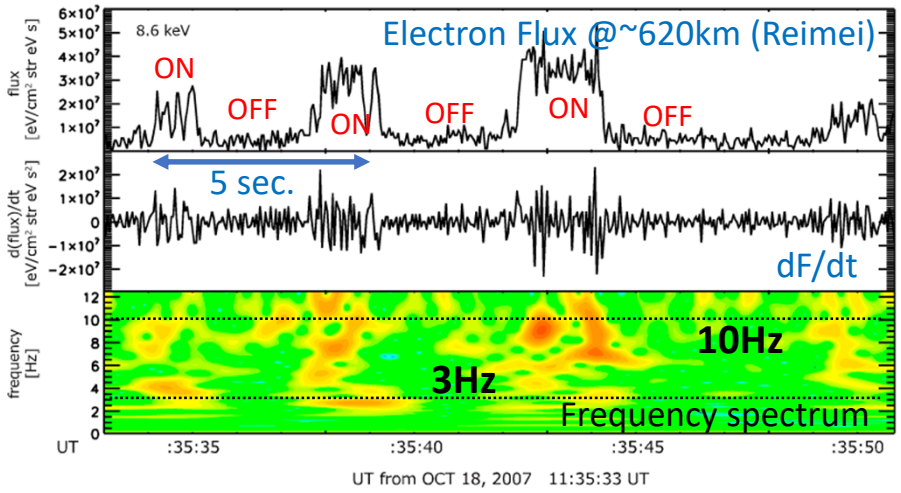
Outline

- Target
  - Energetic electron precipitation by whistler chorus waves (Pulsating Aurora and/or relativistic electron microbursts)
- Data
  - PWE burst data of ERG satellite
- Technique
  - A data driven simulation with linearized two-fluid equations along a field line
  - Equation of motion of energetic electrons in wave fluctuations propagating along the field line
- Results
  - **Electron precipitation in broad energy range from several keV to MeV into the atmosphere.**
  - **A few Hz modulation in a burst precipitation in keV range.**
  - **A few tens Hz modulations are also embedded in the burst, especially at relativistic energies.**

Precipitation in different energy

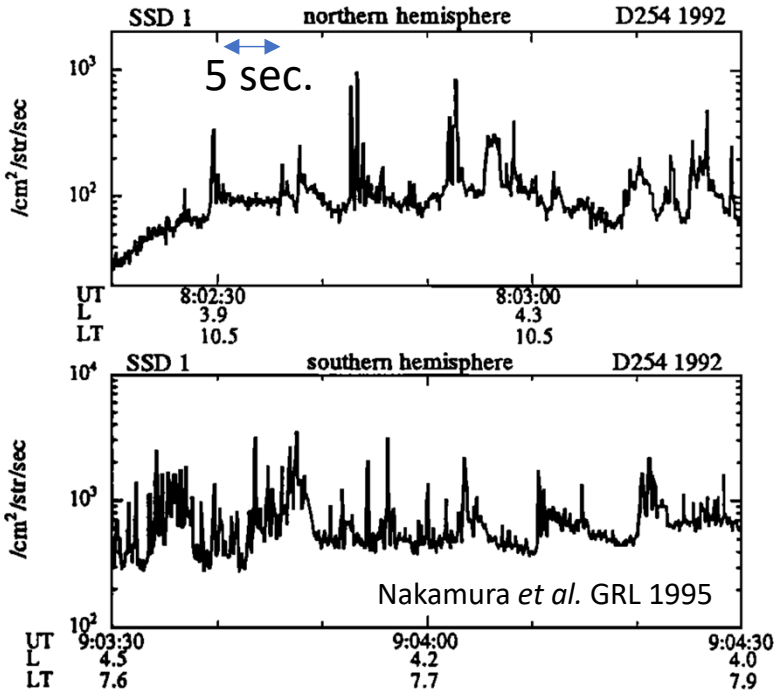
Precipitation for relativistic electron microbursts

(a) Precipitation for pulsating aurora



Miyoshi *et al.* JGR 2015

Precipitation burst + internal modulation
(a few seconds burst + a few Hz modulation)

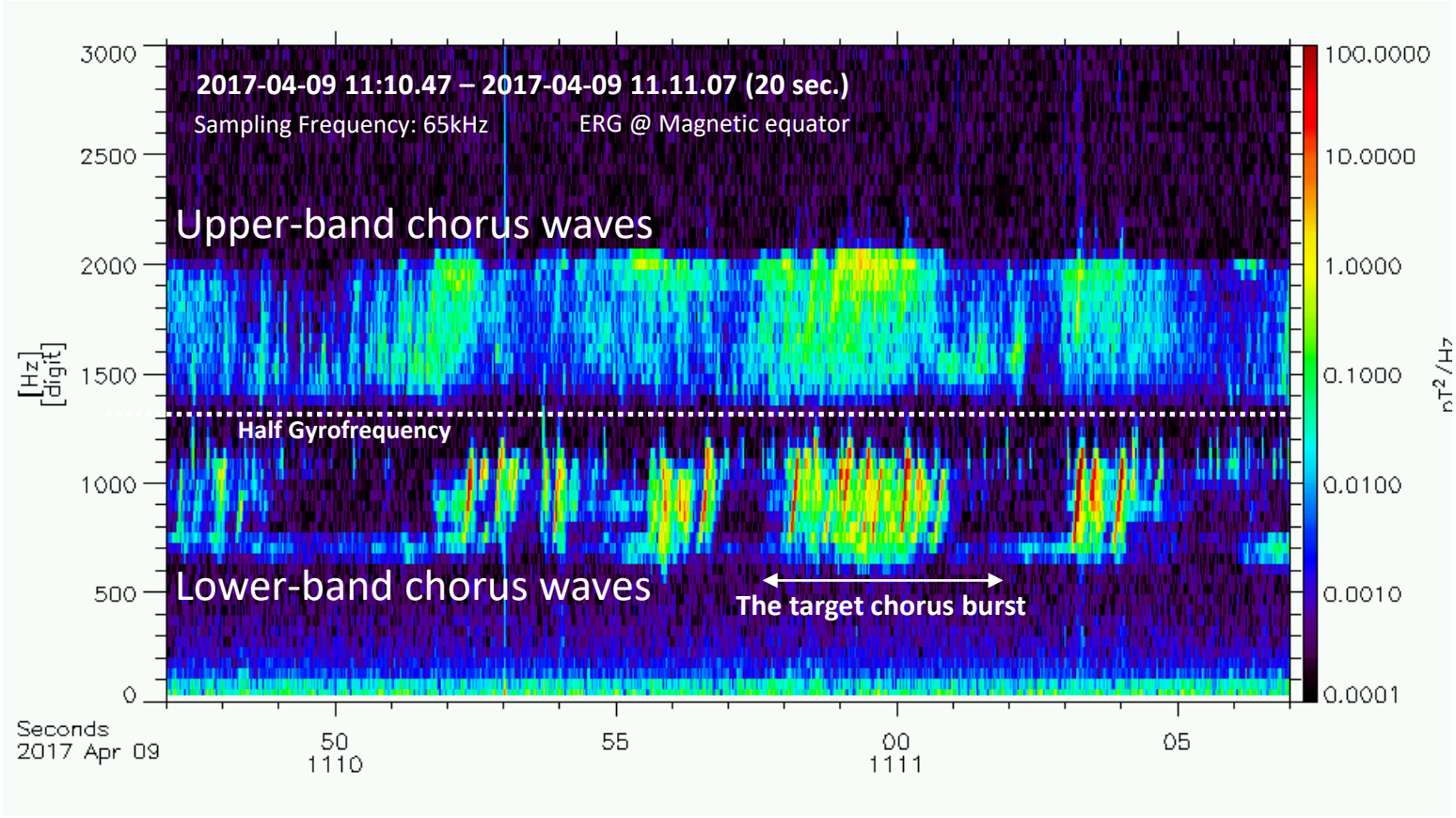


Intermittent precipitation
(a few hundred milliseconds bursts)

Whistler chorus waves

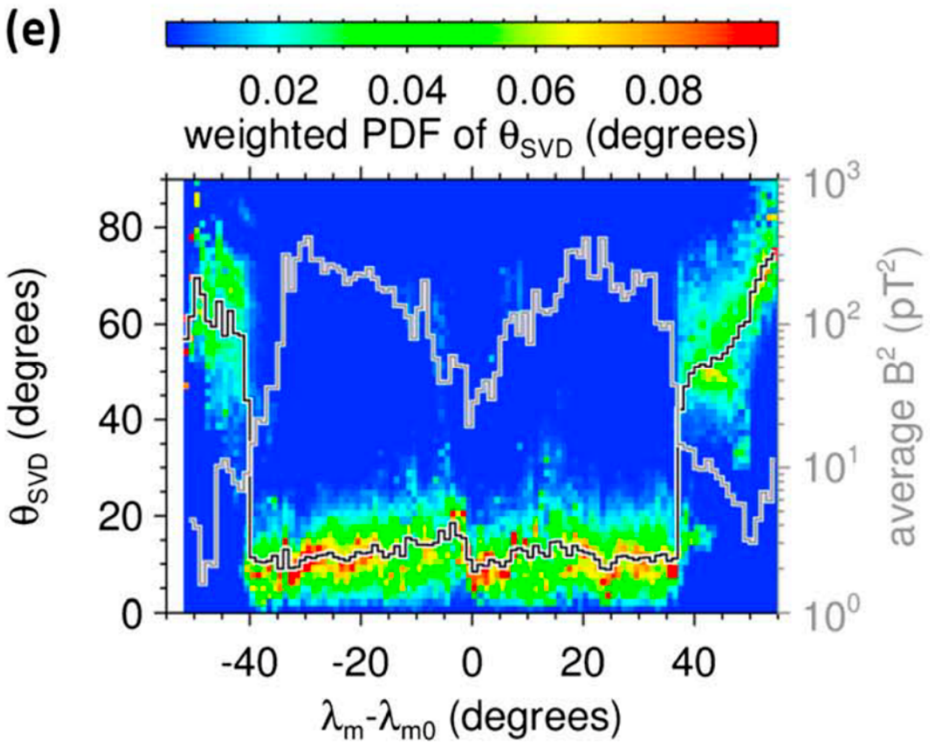
MGF data:
- Electron cyclotron frequency: 2.6kHz
- L_m = 6.95

Arase PWE Burst data:



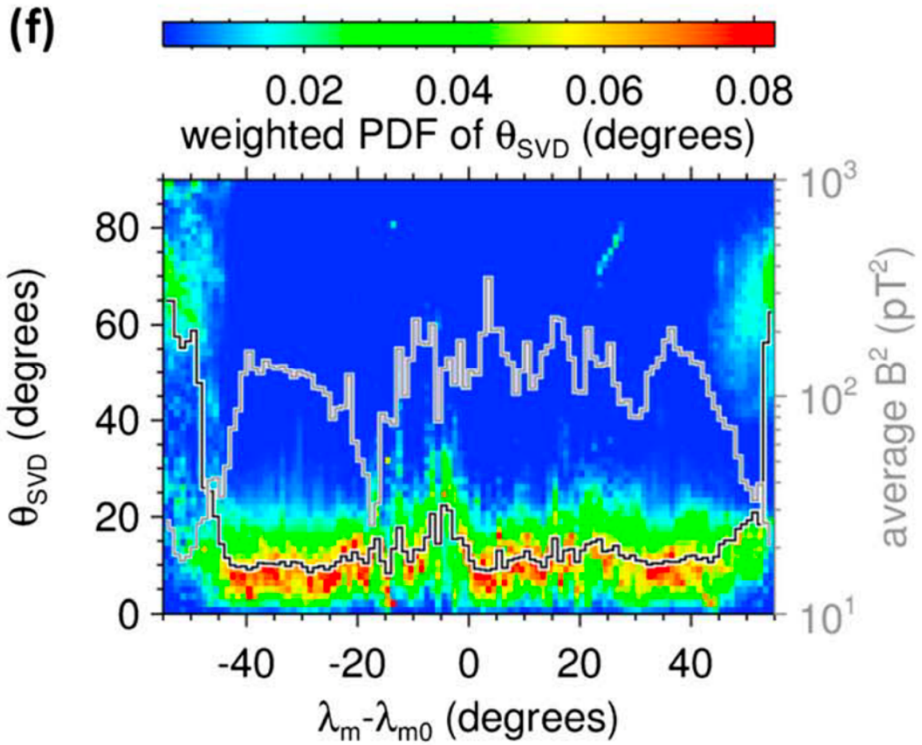
Propagation angle of lower band chorus waves

PDF weighted by squared amplitude



Magnetic dipole latitude shifted to magnetic equator

4.0 < L* <= 5.5



Magnetic dipole latitude shifted to magnetic equator

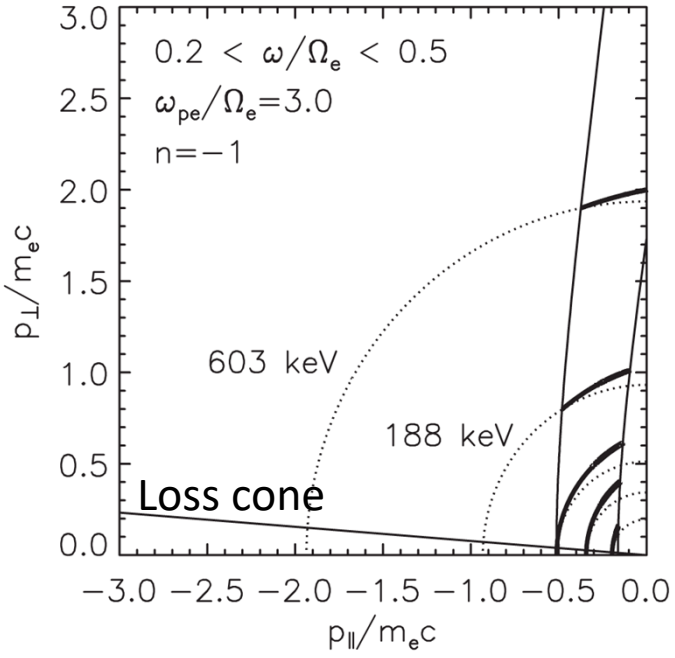
5.5 < L* <= 7.0

Santolik *et al*. GRL 2014

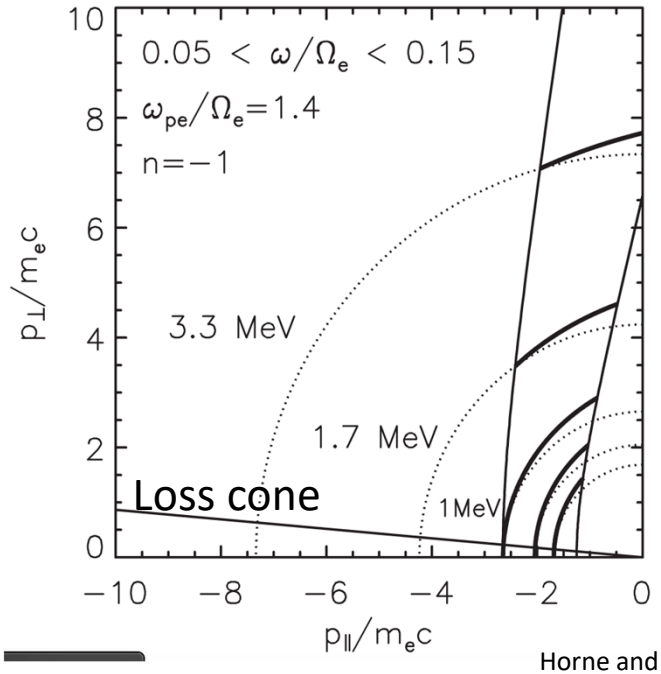
Resonant curves in momentum space

Dotted lines: Constant energy
Solid lines: Resonant curves

Equator@L=4.5



$\lambda = 25deg.@L = 4.5$



Horne and Thorne GRL 2003

Higher energy electrons at loss cone angle can resonate with whistlers at higher latitudes.

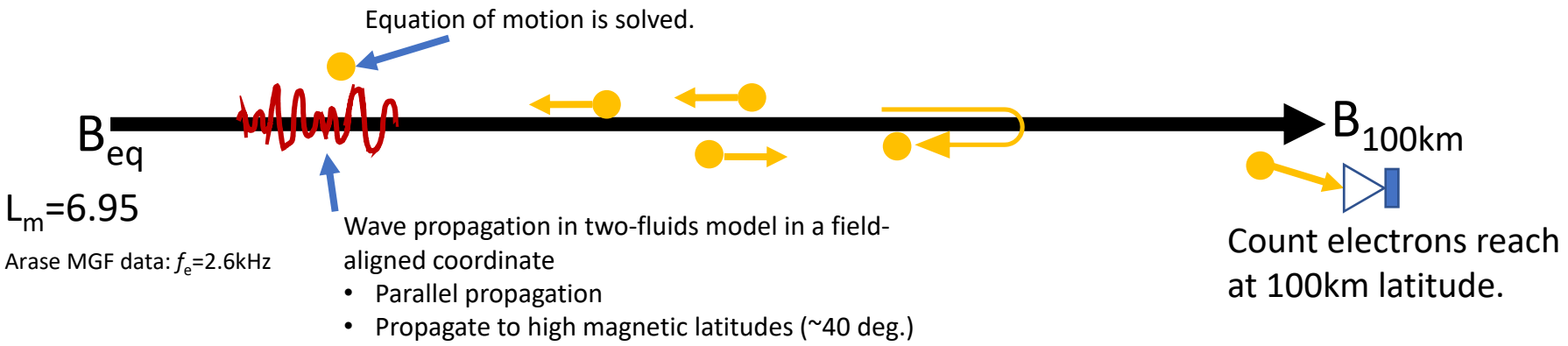
Q.

Is it possible to demonstrate characteristics of electron precipitation at keV and relativisitic energy range by whistler chorus waves?

Numerical approach

- Test particle model in a field-aligned coordinate

- Import observed whistler chorus waves
  - Arase PWE wave form data (65kHz)
  - Solve two fluids equations for applied waves

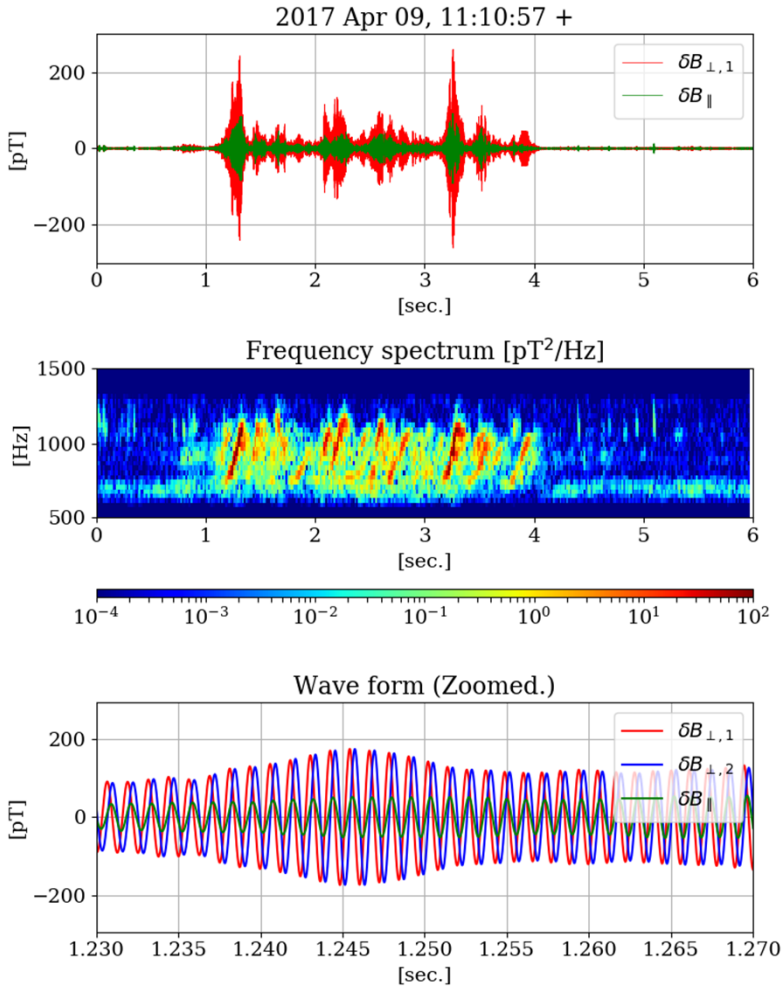


Observed data → Data for simulation

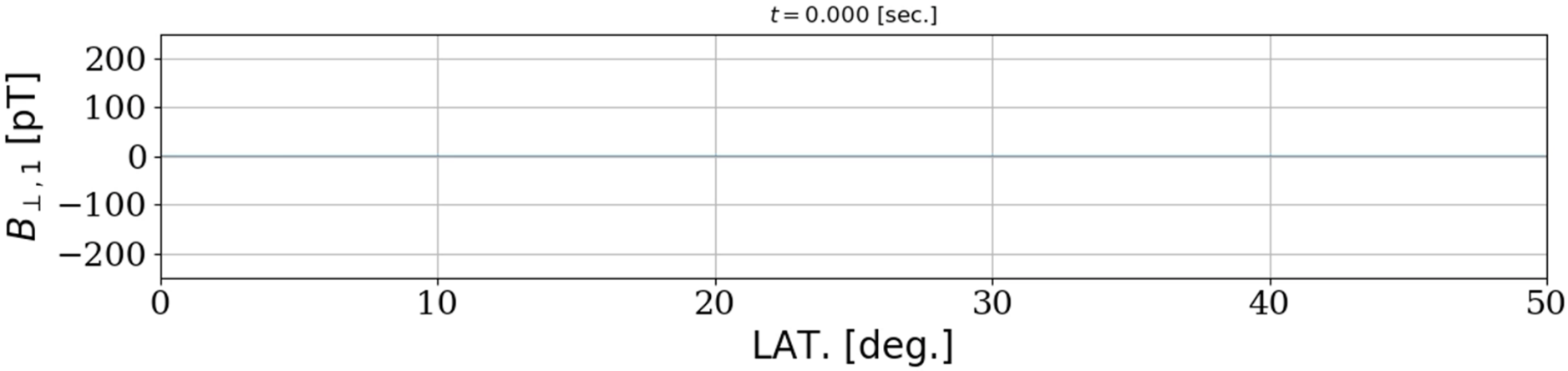
- Filtering and coordinate transform
  - Band path filtering to get lower-band chorus only
  - B-field-aligned coordinate

$$B_{\parallel} < B_{\perp}$$

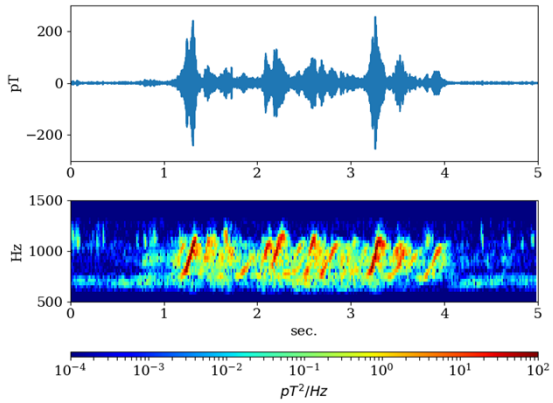
Wave vector is quasi-parallel to the background magnetic field (<10 deg.)



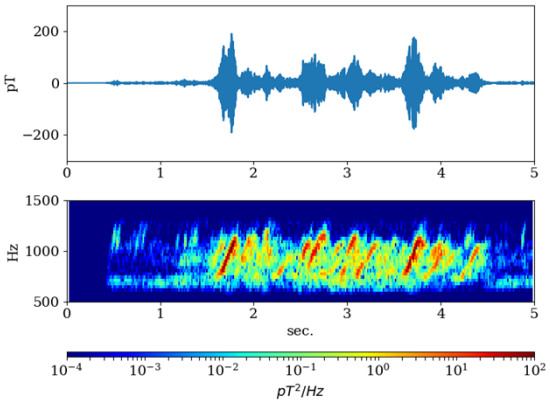
Wave propagation



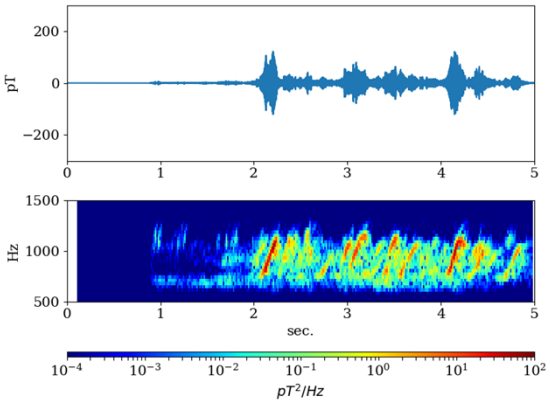
Lat. = 0.1 deg.



Lat. = 13.3 deg.

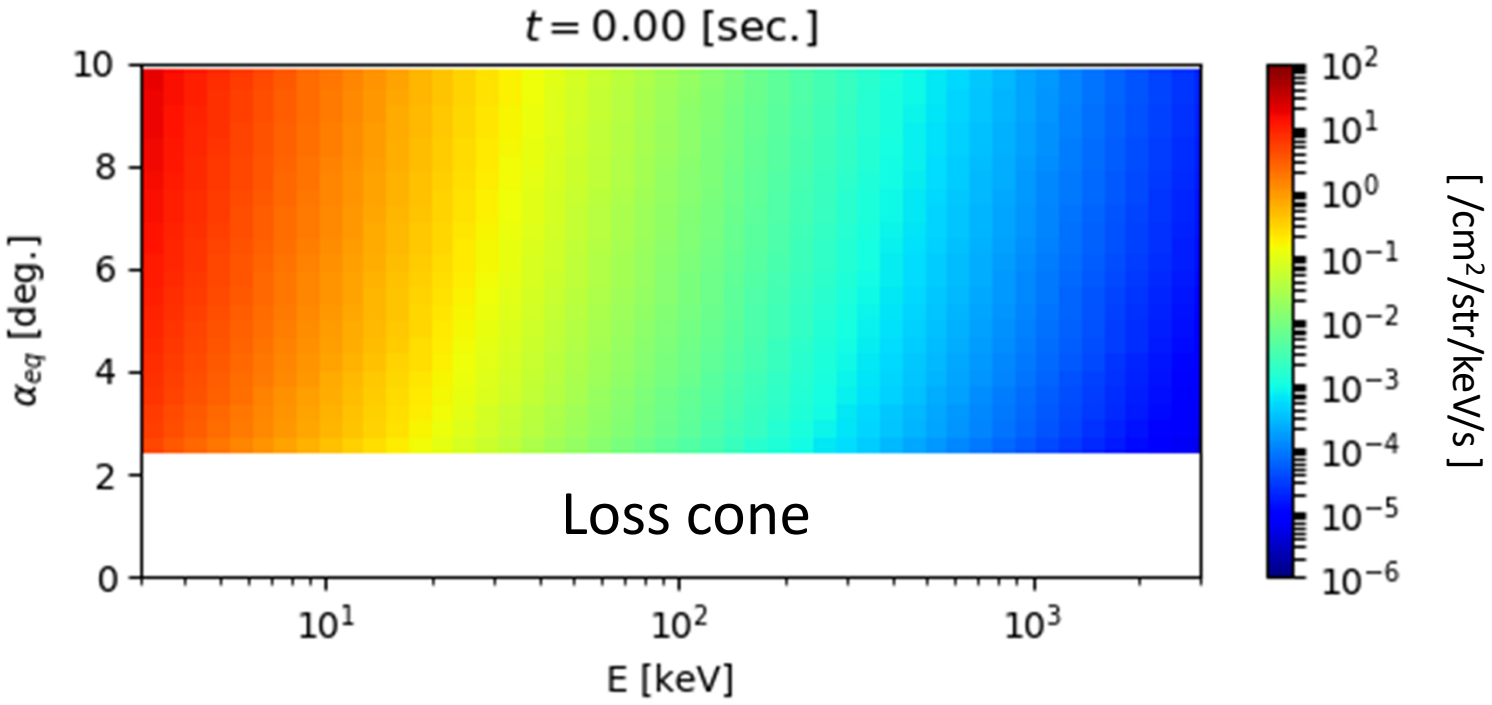


Lat. = 37.2 deg.



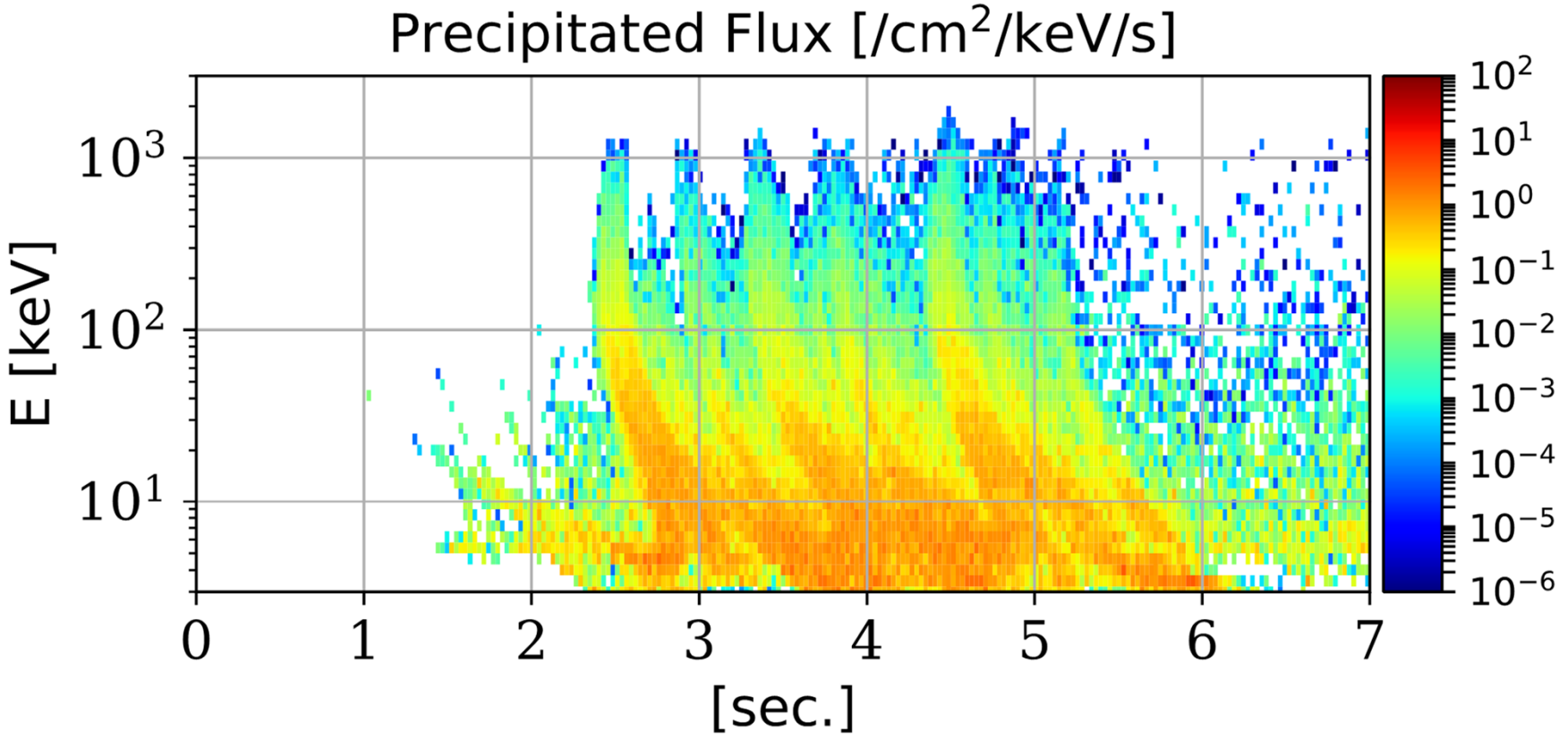
Initial flux distribution

$$j_{init}(E, \alpha_{eq}) = j_o \sin\alpha_{eq} \left(\frac{E}{1keV}\right)^{-2}$$

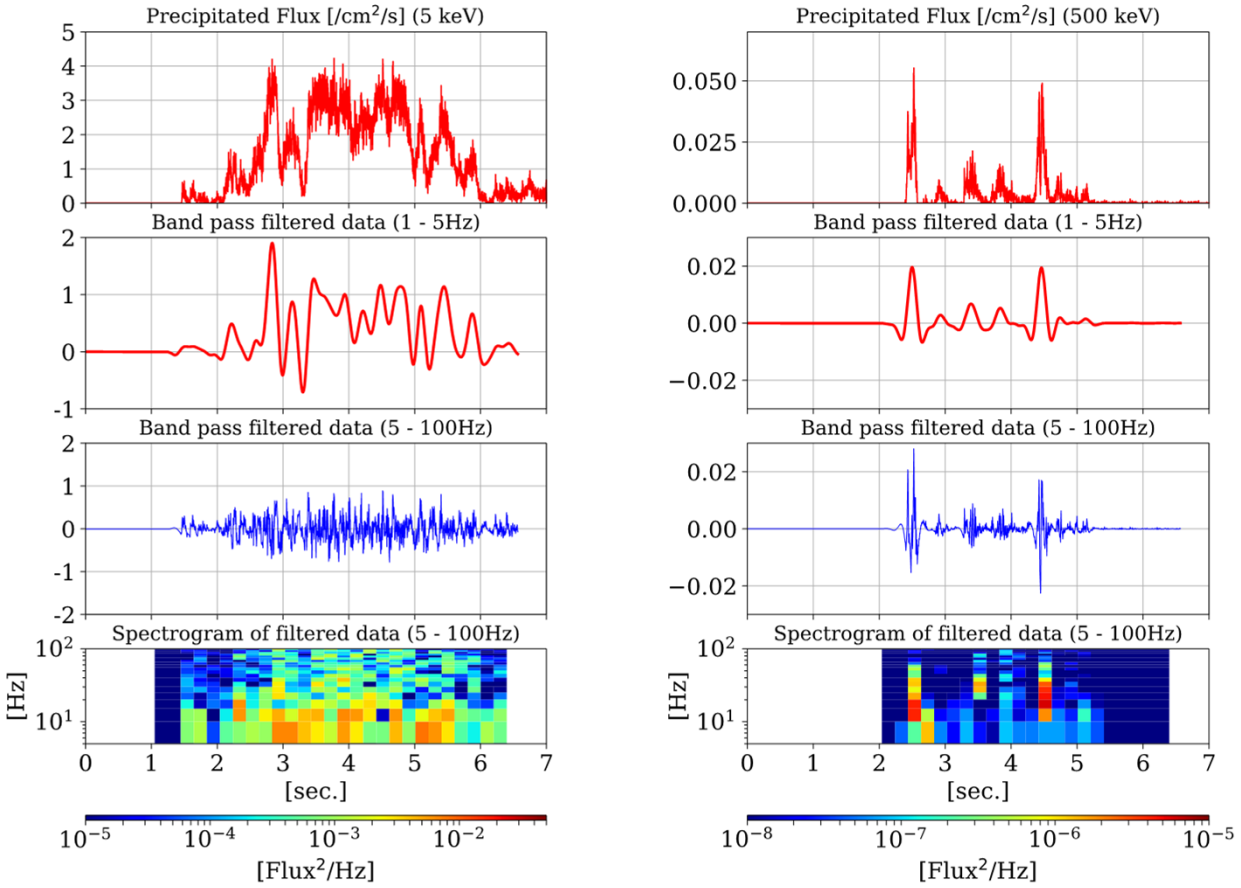


Note. This is a preliminary flux model. The flux distribution obtained form ERG should be applied in future.

Precipitation spectrum



Precipitation flux modulation at two energies (5 and 500keV)

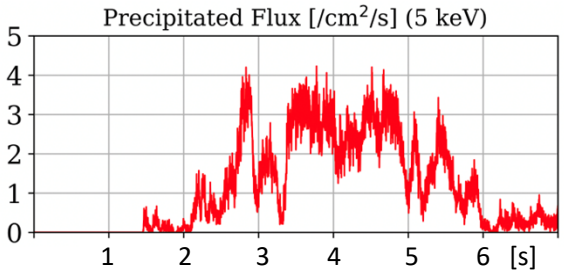


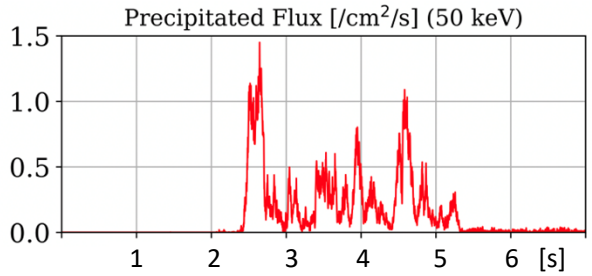
Sampling freq. = 500 Hz

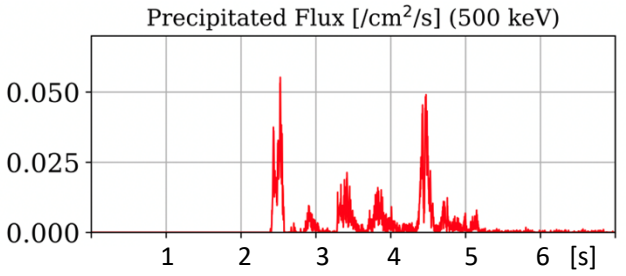
Energy dependence of electron precipitation

Precipitation burst + internal modulation
(a few seconds burst + a few Hz modulation)

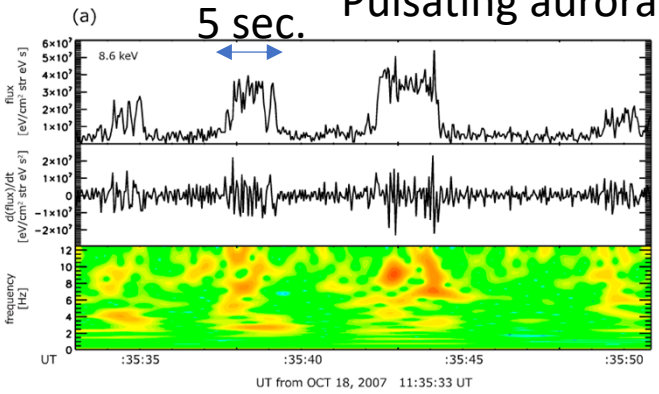
Intermittent precipitation
(a few hundred milliseconds bursts)





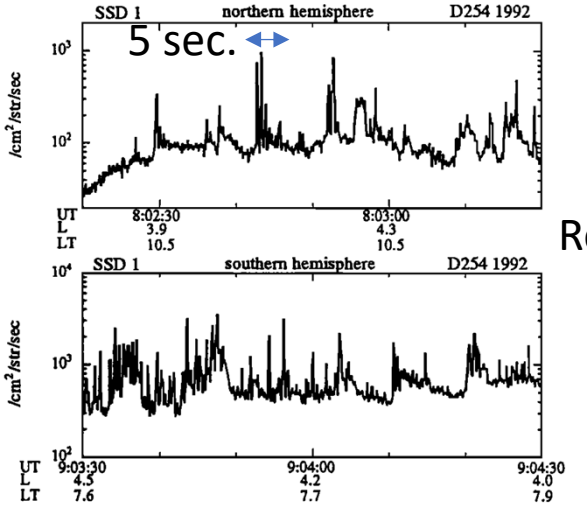


Pulsating aurora



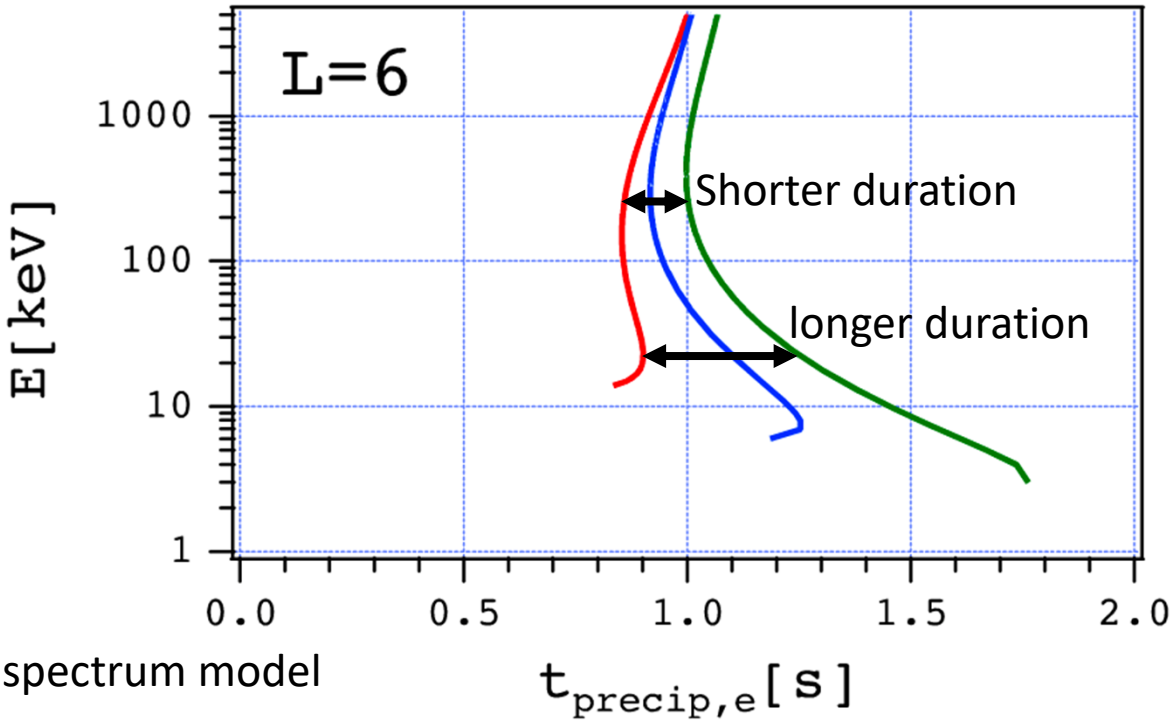
Miyoshi *et al.* JGR 2015

Relativistic microbursts



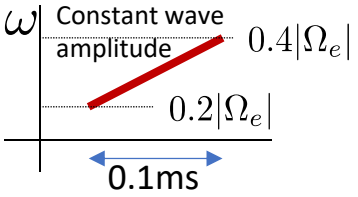
Nakamura *et al.* JGR 1995

Theoretical approach



Saito *et al.* JGR 2012

Chorus wave spectrum model



Time of electron precipitation after a whistler chorus wave is launched at the equator.

Summary

- Study electron precipitation in broad energy by the observed whistler chorus burst

- From observations
  - At lower energies: Burst + internal modulation
  - At higher energies: Intermittent bursts
- Numerical results
  - At lower energies: Burst + internal modulation
  - At higher energies: Intermittent bursts

- **A parallel propagating whistler chorus burst can demonstrate characteristics of two types of precipitation: Precipitation for pulsating aurora and relativistic electron microbursts**

Microbursts can be a high energy tail of pulsating aurora.