Ground-based optical and ULF/ELF/VLF wave measurements at subauroral latitudes prepared for the ERG project

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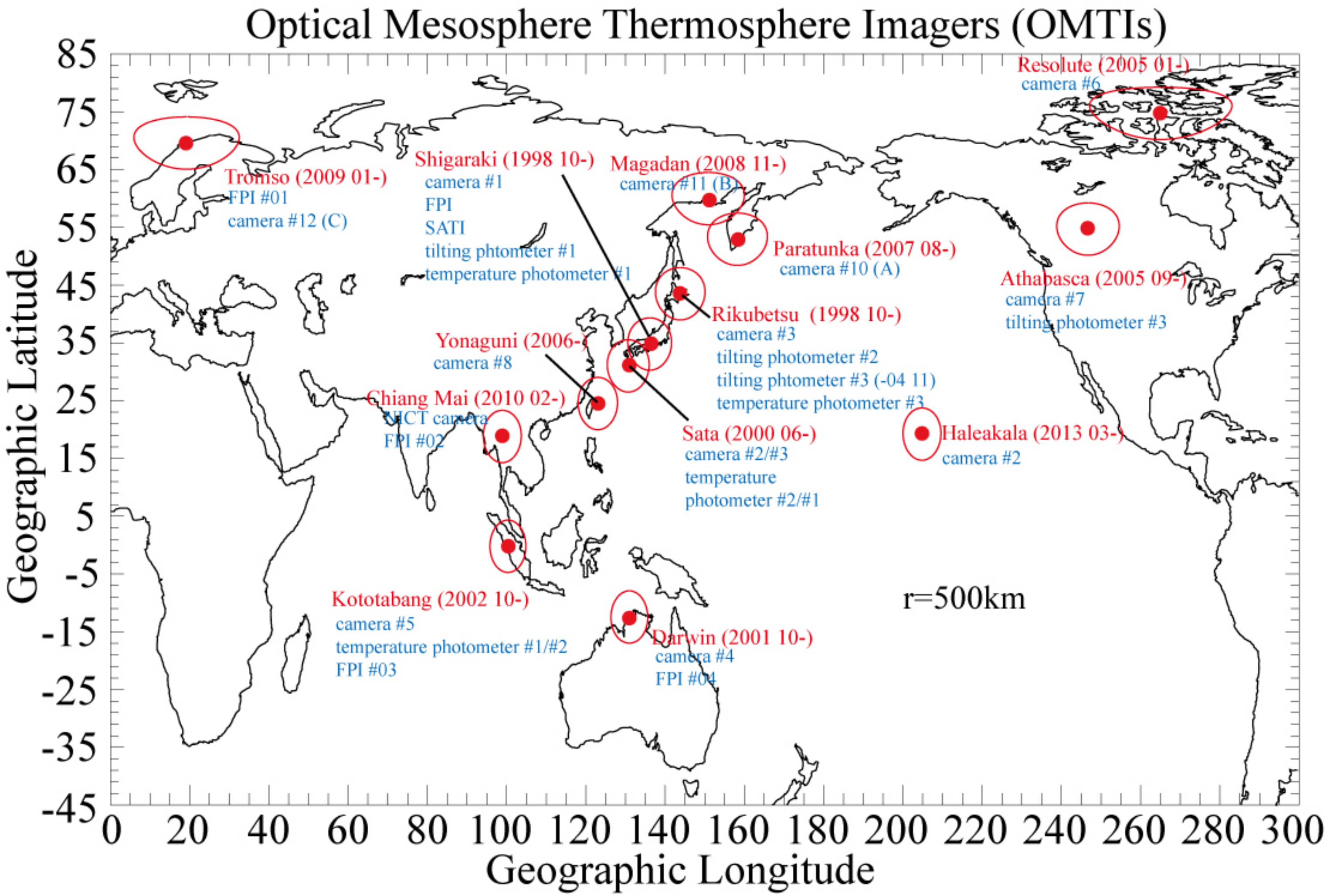
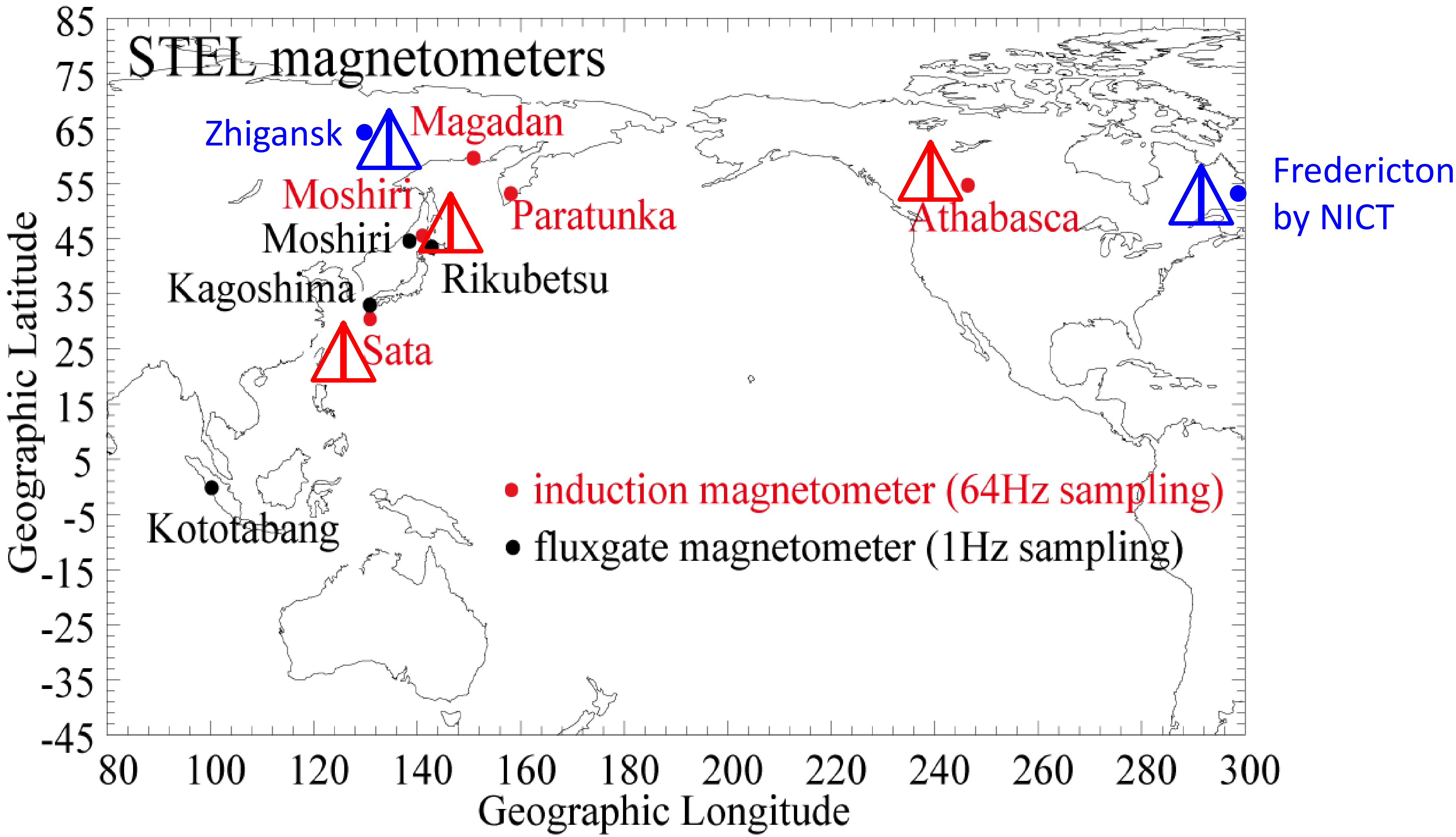
Optical Mesosphere Thermosphere Imagers (OMTIs)



OMTIs optical imager network operated by STEL, Nagoya University: airglow/aurora imagers, Fabry-Perot interferometers, meridian-scanning photometers, and airglow temperature photometers

Contact: Kazuo Shiokawa (PI, shiokawa at stelab.nagoya-u.ac.jp)

Web page: http://stdb2.stelab.nagoya-u.ac.jp/omti/index.html



STEL magnetometer network operated by STEL, Nagoya University: fluxgate and induction magnetometers

Contact: Kazuo Shiokawa (PI, shiokawa at stelab.nagoya-u.ac.jp)

Web page: http://stdb2.stelab.nagoya-u.ac.jp/magne/index.html

CDF database construction usable by TDAS is underway.

Routine measurements at Athabasca (L=4.4), Canada

by Athabasca Univ., STEL, Nagoya Univ., Kanazawa Univ., and Tohoku Univ.

* **all-sky airglow imager: 5577, 6300, 4861, 5893, 8446**
  time resolution 1.5-10 min (STEL)
* **meridian-scanning photometer: 5 points in the sky, 4861, 4278 (STEL)**
* **induction magnetometer: 64Hz sampling, peak at 5Hz (STEL)**
* **all-sky EMCCD camera: 5577, 6300, BG3,**
  time resolution: a few sec (Athabasca Univ.)
* **LF standard radio wave receiver (Tohoku Univ.)**
* **2ch VLF Antenna 100kHz sampling (STEL/Kanazawa Univ.)**
* **1ch riometer (STEL)**
* **EMCCD Camera: BG3, ~100Hz sampling (STEL)：from 2014 winter**

Contents

(1) Aurora/Airglow Imagers

- MSTID motion → monitoring of penetrating electric field
- auroral fragmentation into patches → balooning/interchange?
- SAR arc → plasmasphere-ring current interaction

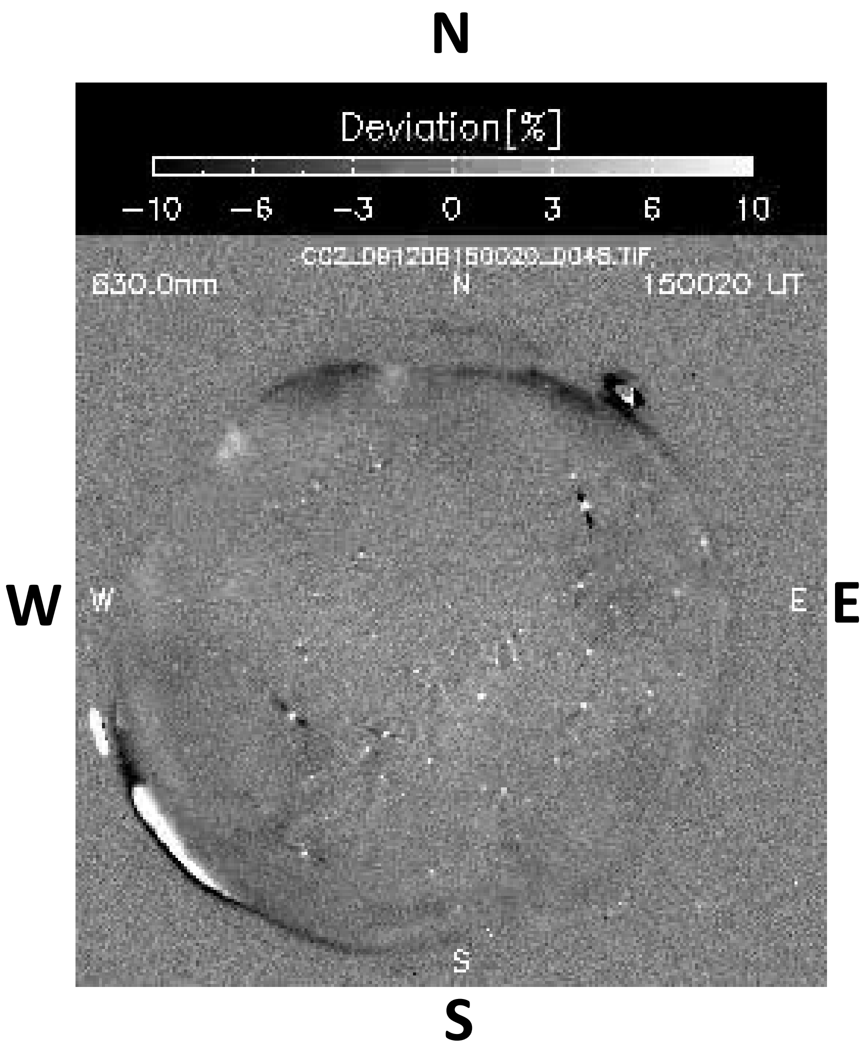
(2) Induction magnetometers

- isolated proton aurora → monitoring of wave-particle interaction
- Pc1 polarization characteristics (dependence on frequency and distance from the source)
- Pc1 pearl structure (amplitude modulation of EMIC waves) → Ionospheric beating versus magnetospheric processes

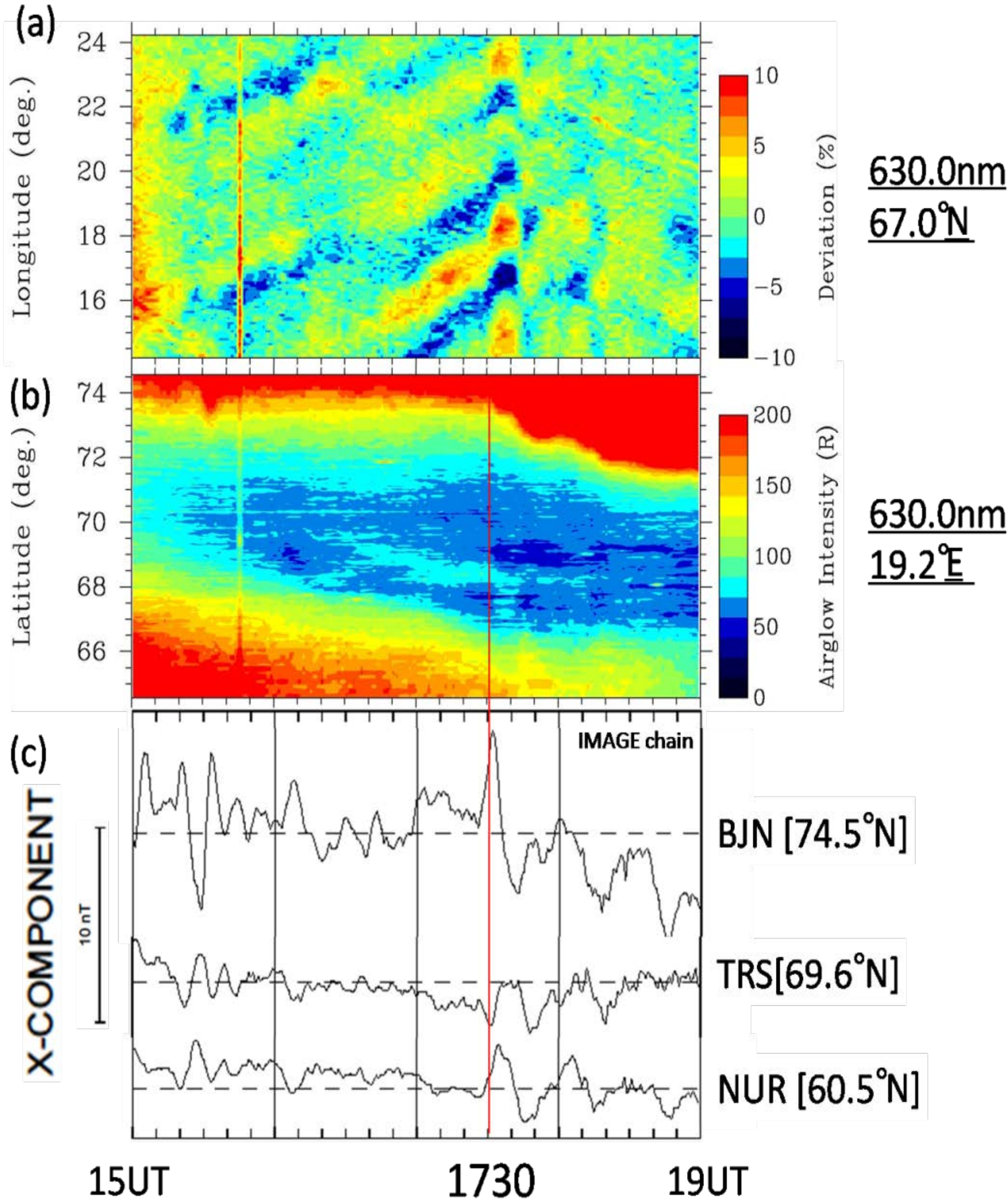
(3) ELF/VLF receivers

- temporal variation of QP emission and falling tone emission
- positive correlation of frequency sweep rate and intensity for QP
- correlation between EMIC and chorus wave intensity
- bursty patch emission and ssc-triggered emission
- frequency and temporal dependence of chorus polarization
- correlation with pulsating aurora – 30-40s switching of interaction

Tromsoe, Dec.8, 2009
15-19 UT (16-20 LT)

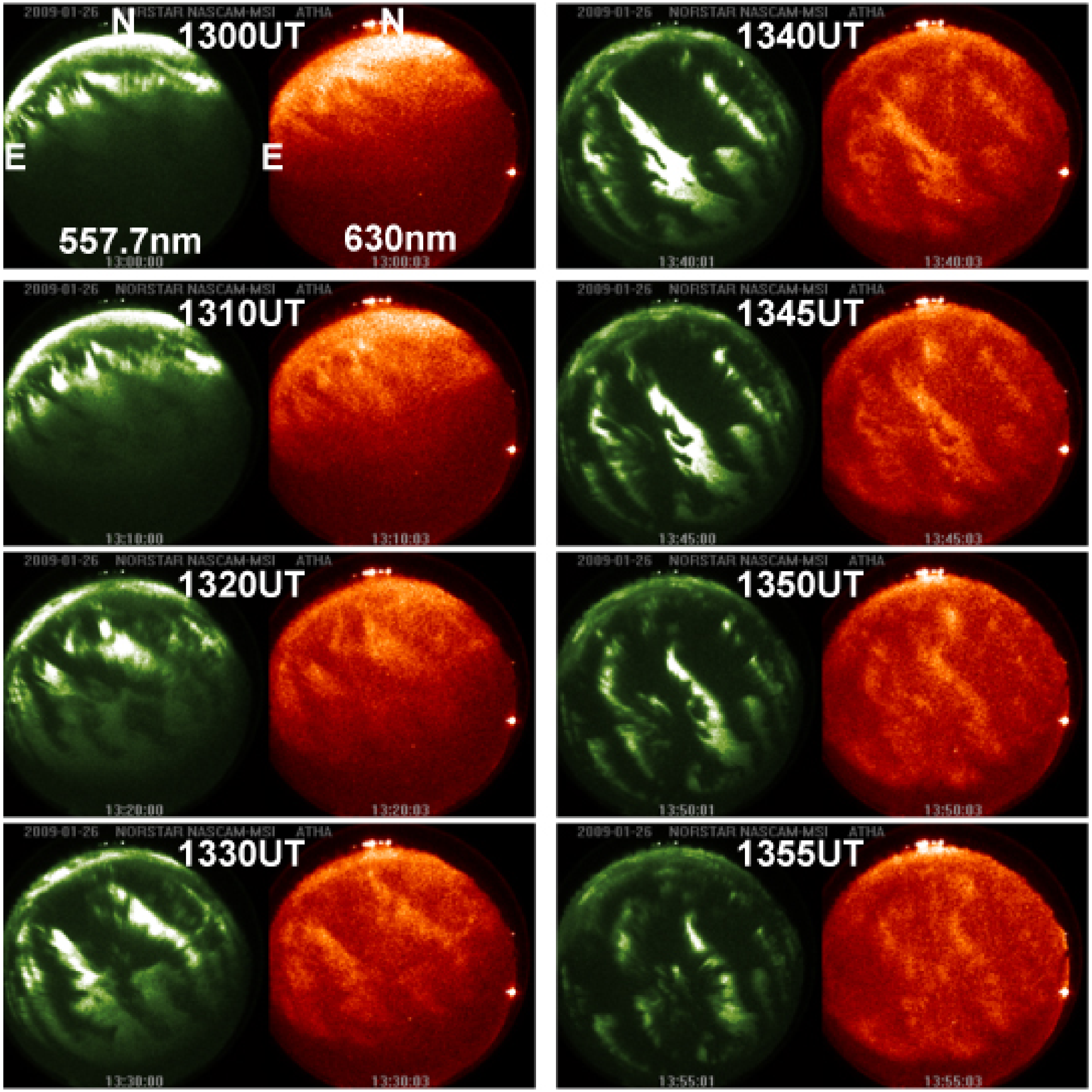


Penetration of auroral E-field (MSTID motion)



Shiokawa et al. (JGR, 2012)

Auroral fragmentation into patches



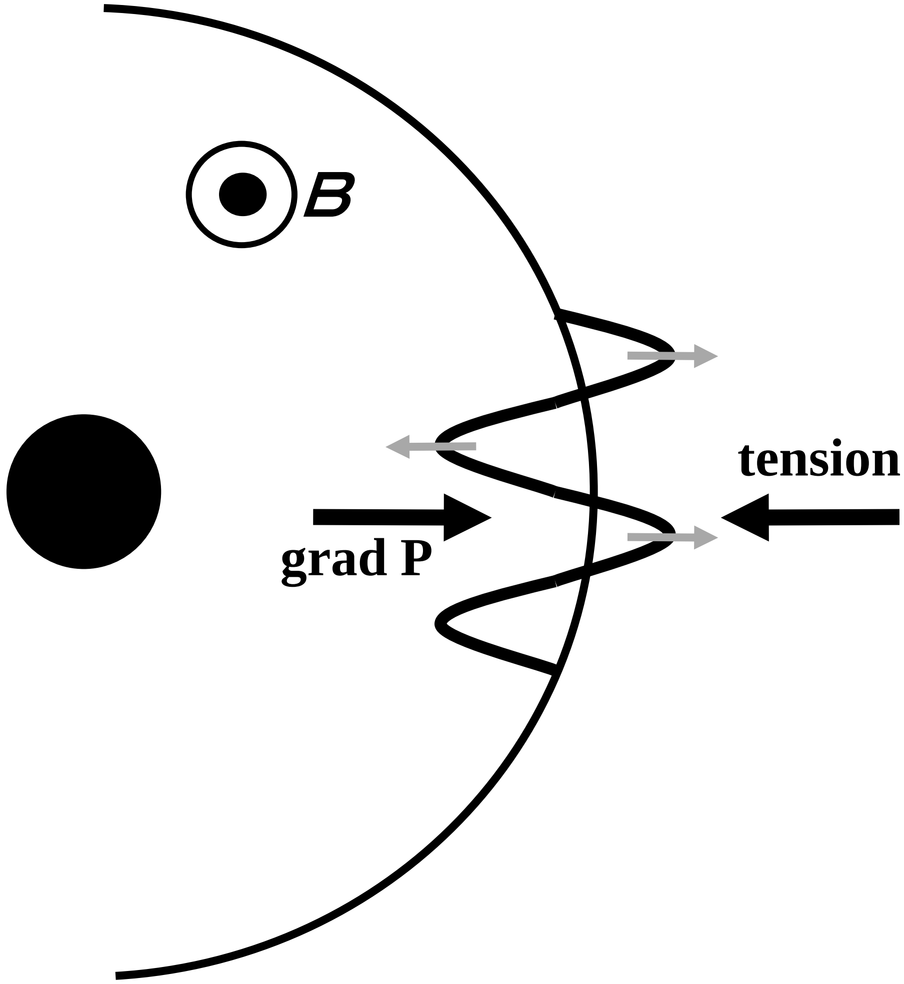
equatorward expansion speed ~150 m/s at 1300-1330UT

east-west scale size ~50-100km

azimuthal m number ~180-360

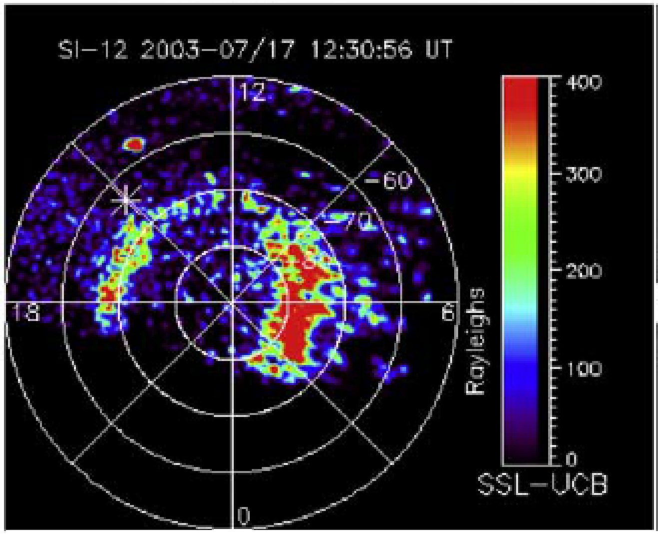
Shiokawa et al. (JGR, in press, 2014)

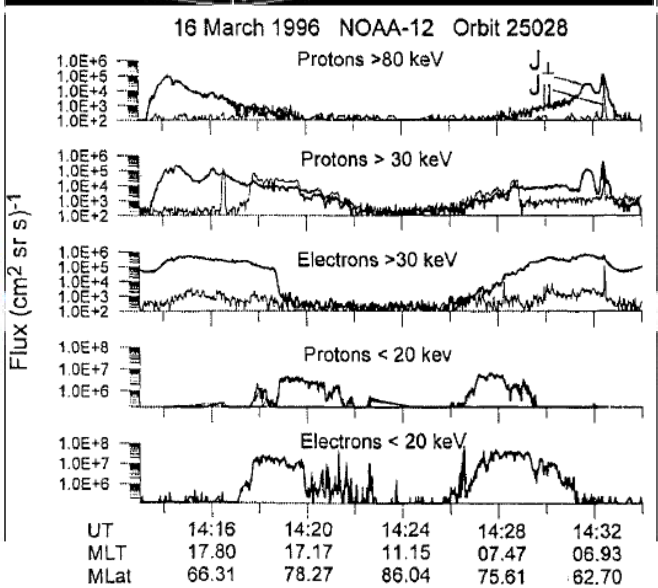
Auroral fragmentation into patches



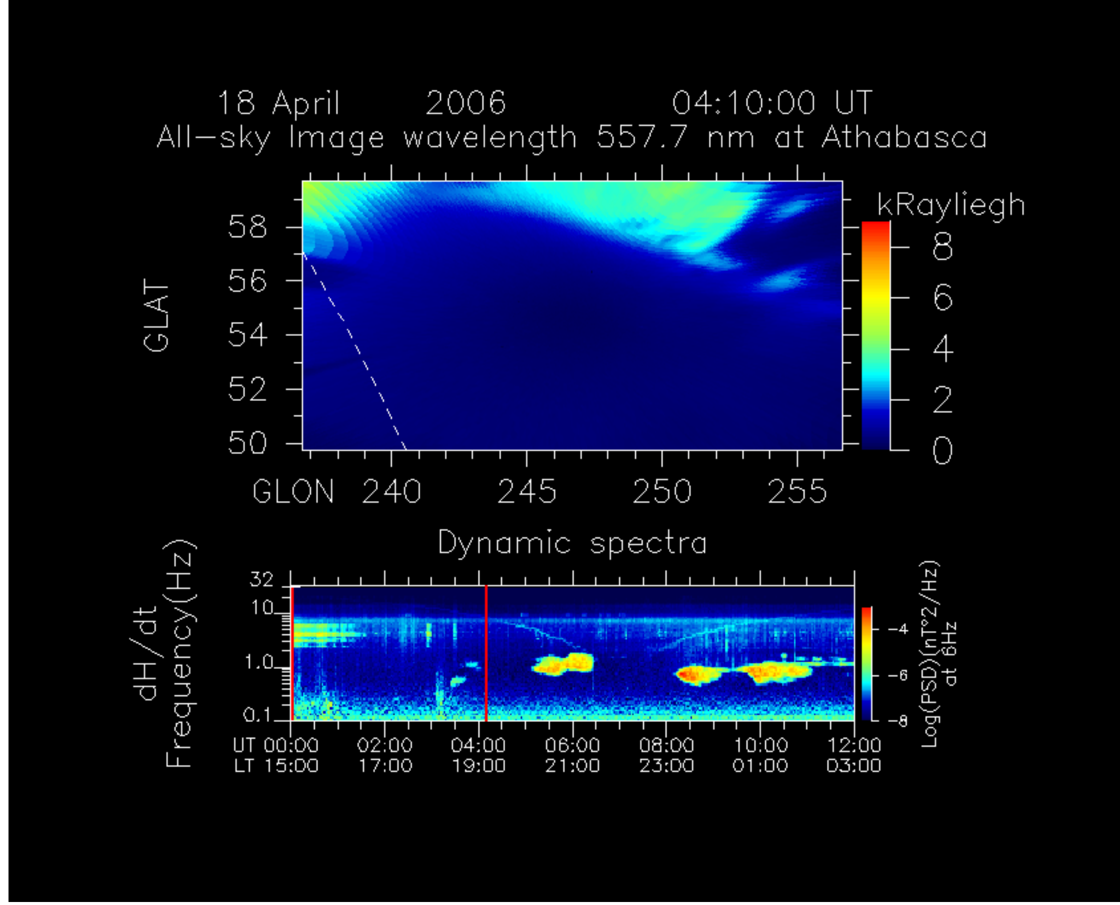
Interchange/ballooning instability

Isolated proton aurora and Pc1/EMIC waves

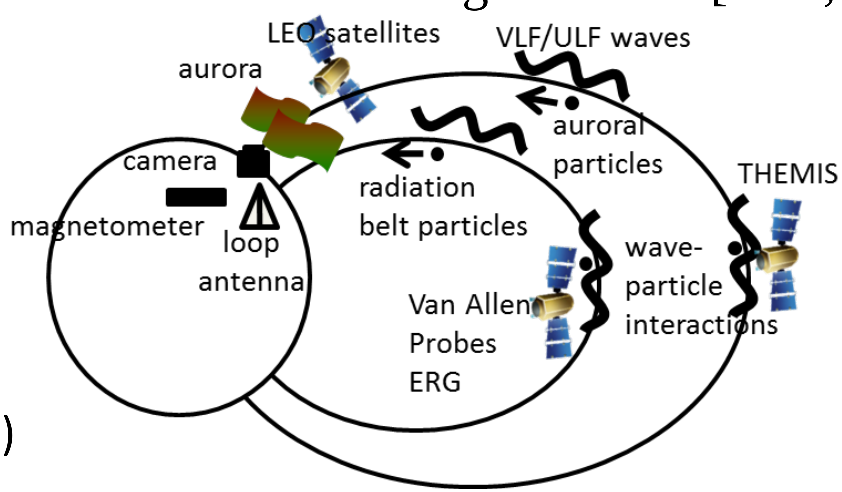




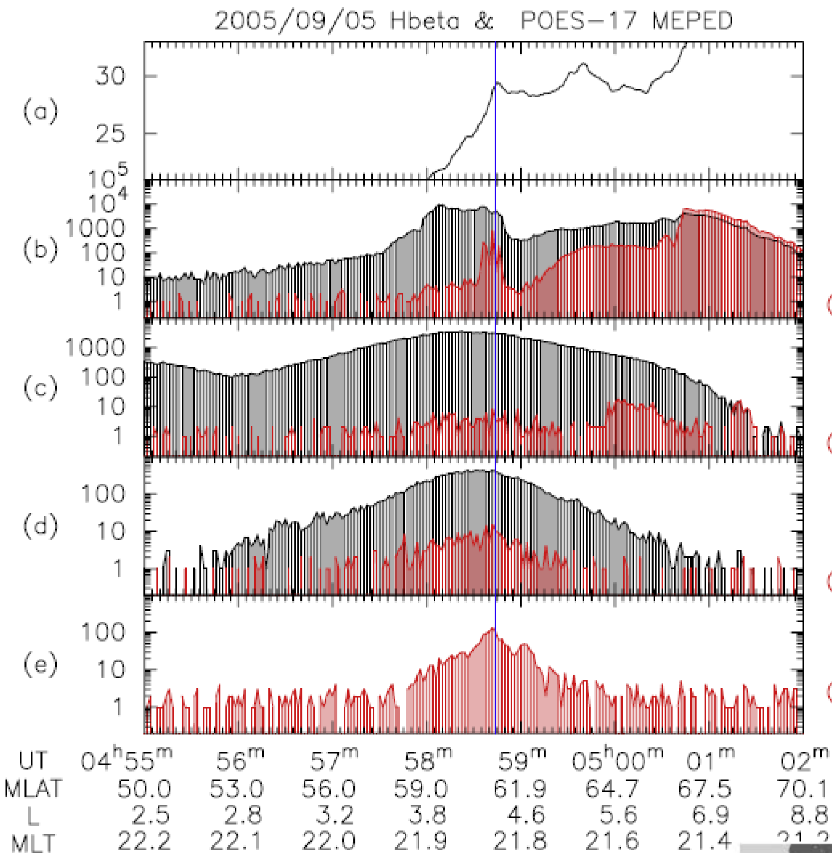
Yahnin et al. (GRL, 2000; JGR, 2007)



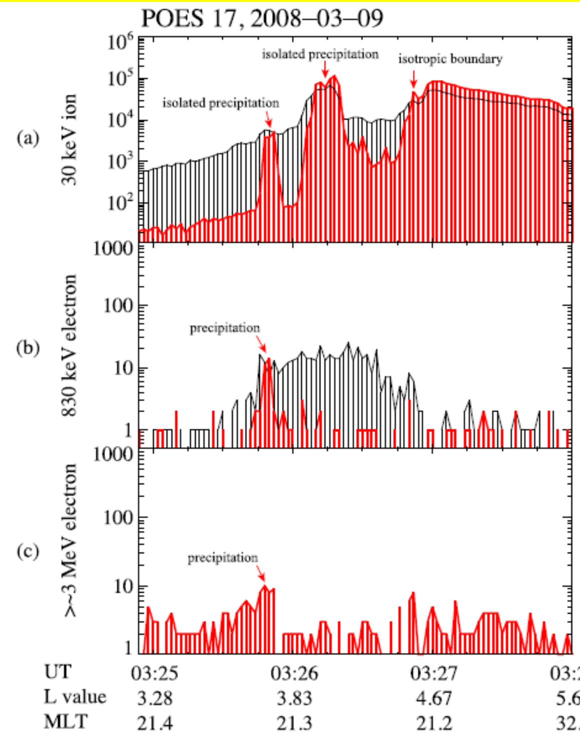
Sakaguchi et al. [JGR, 2007; 2008]



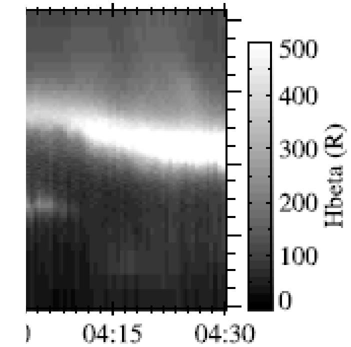
Isolated proton aurora and Pc1/EMIC waves

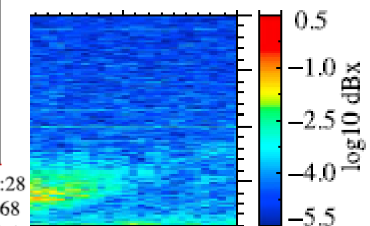


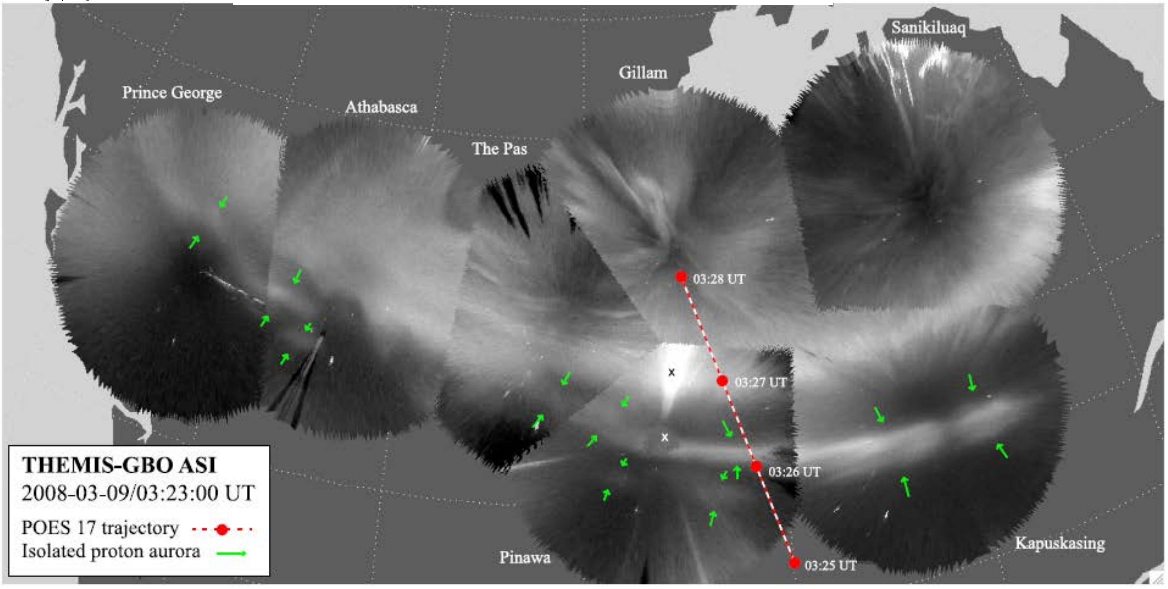
Miyoshi et al. (GRL, 2008)



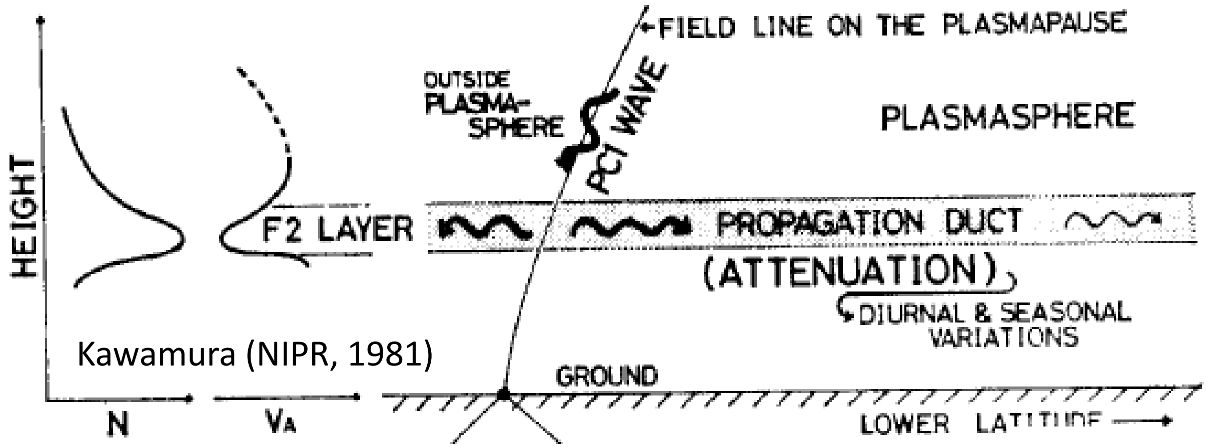
Sakaguchi et al. (JGR, 2012)





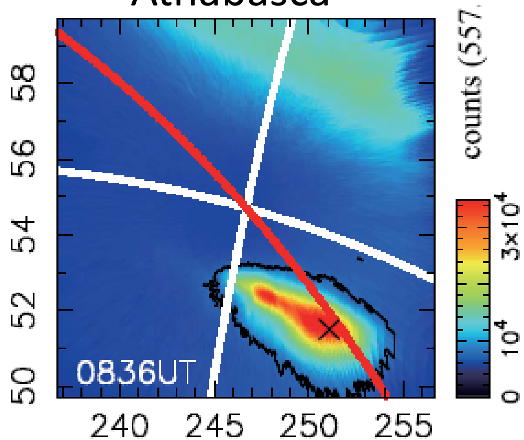


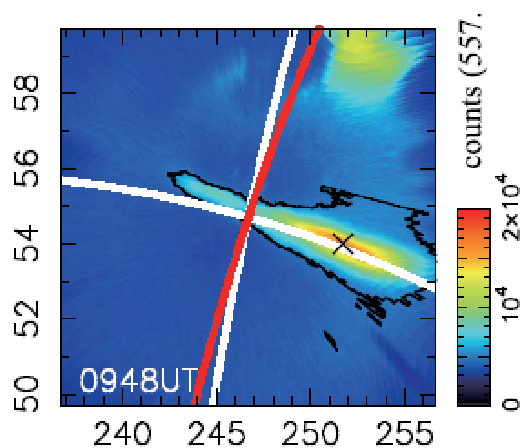
Isolated proton aurora and Pc1/EMIC wave polarization

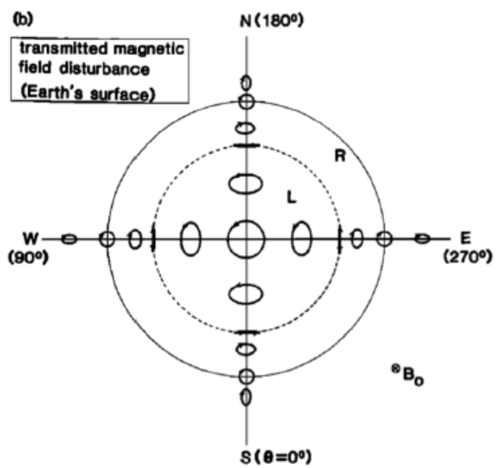


Kawamura (NIPR, 1981)

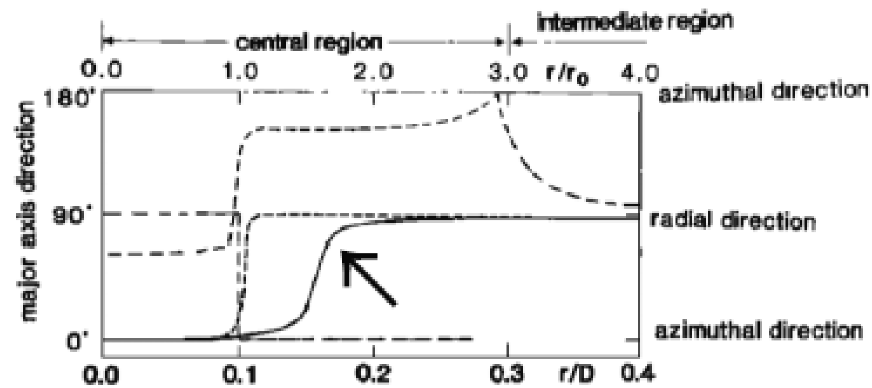
Athabasca

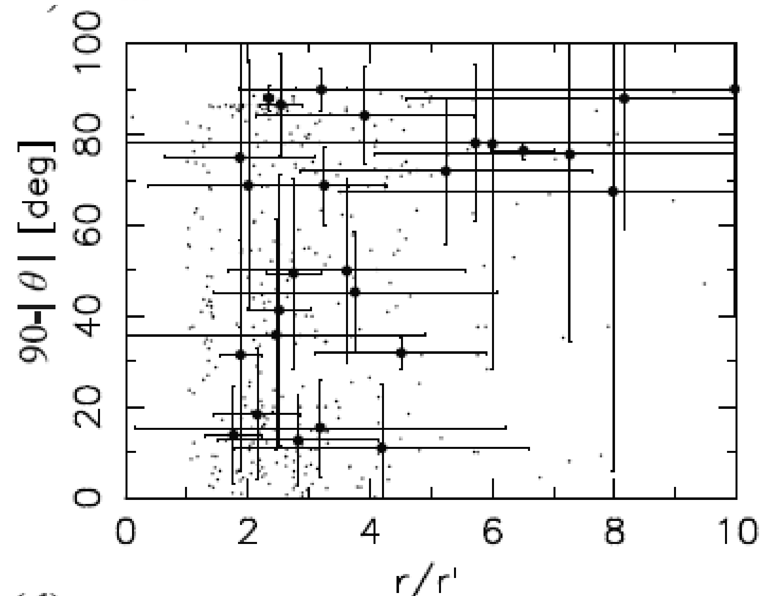






Fujita and Tamao (1988)

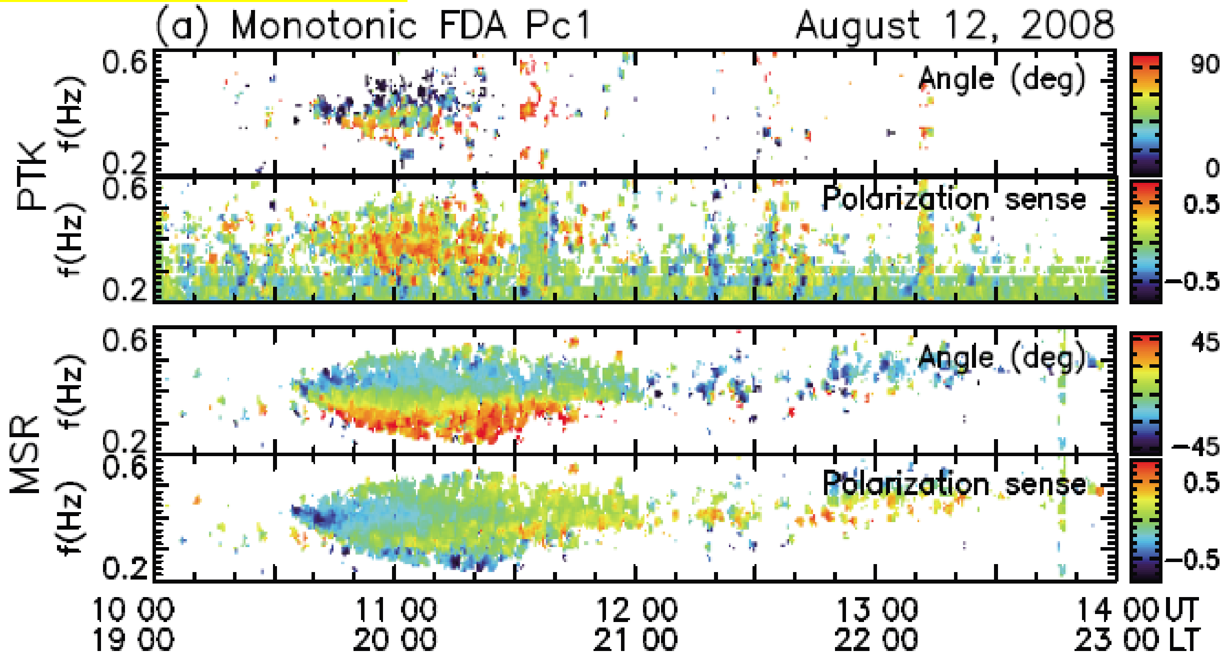


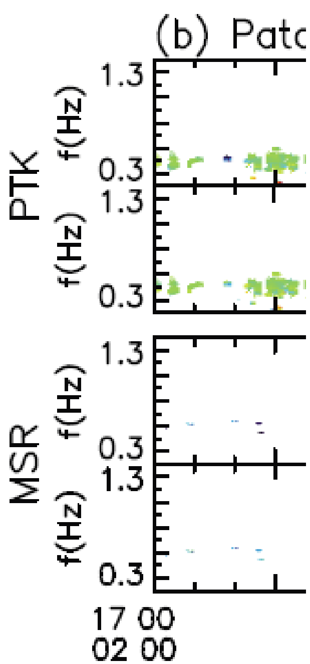


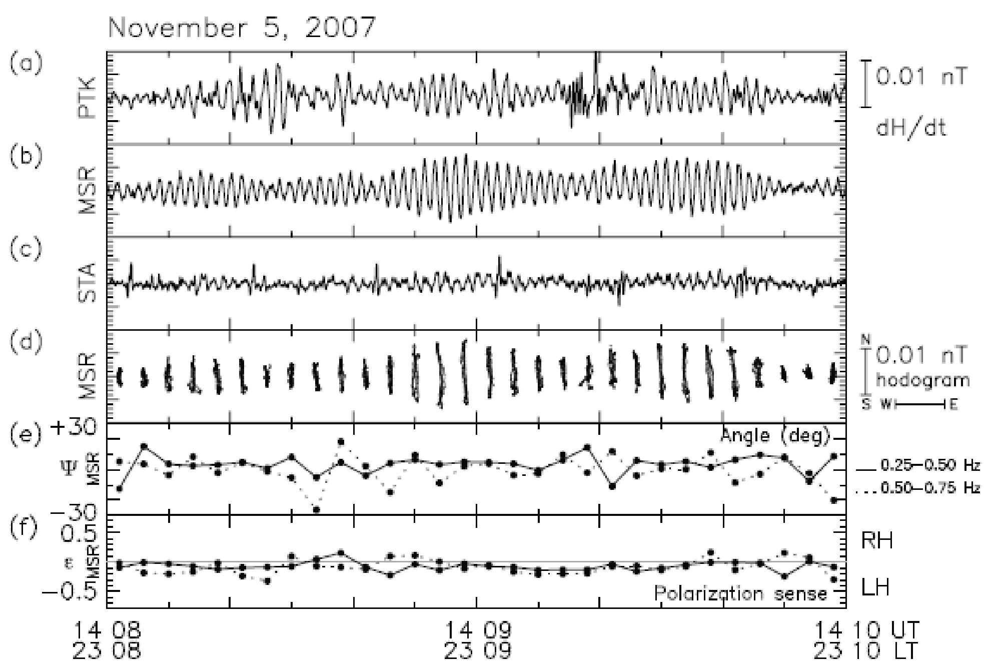
Nomura et al. (JGR, 2012)

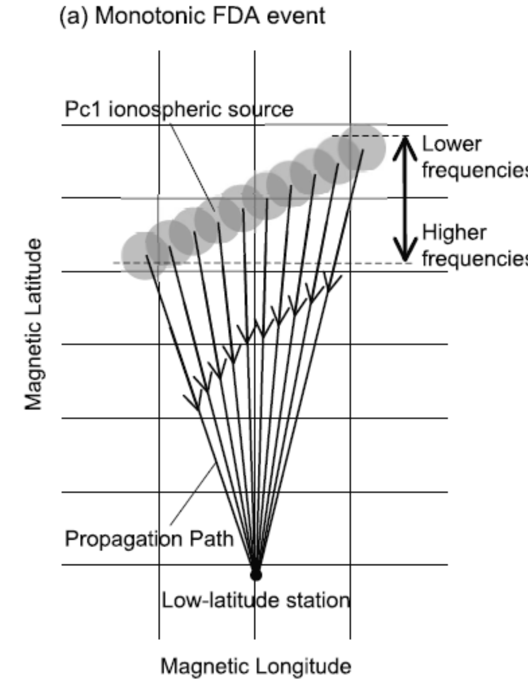
Pc1 polarization

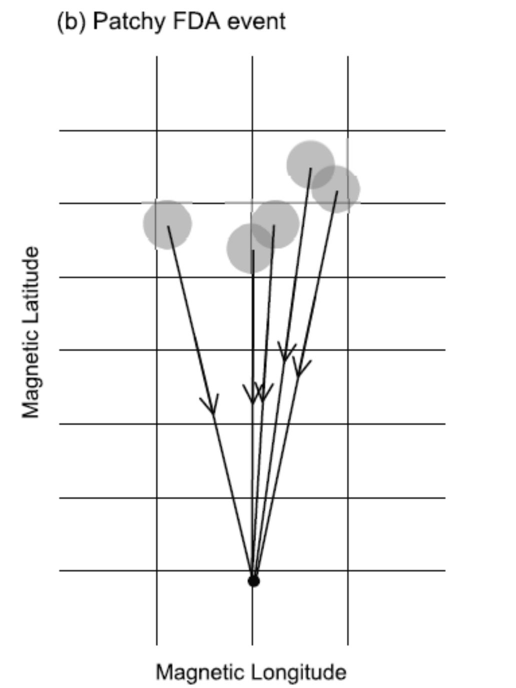
Nomura et al. (JGR, 2011)



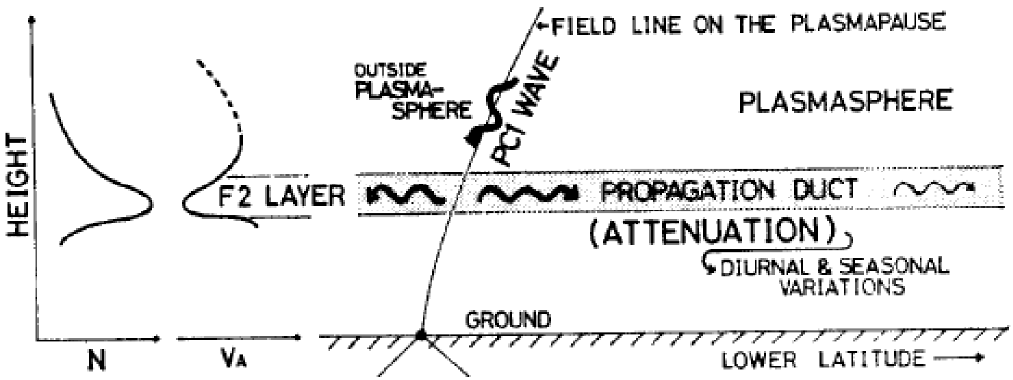


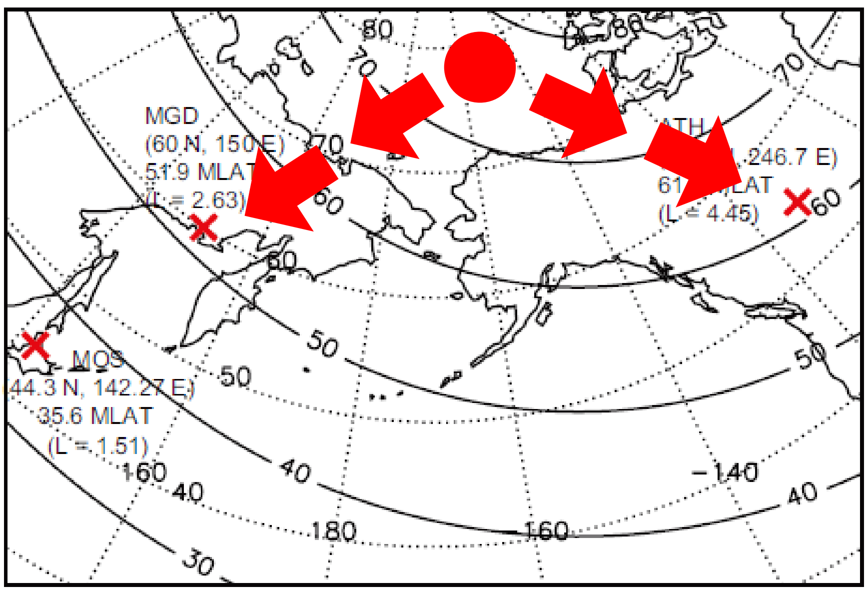


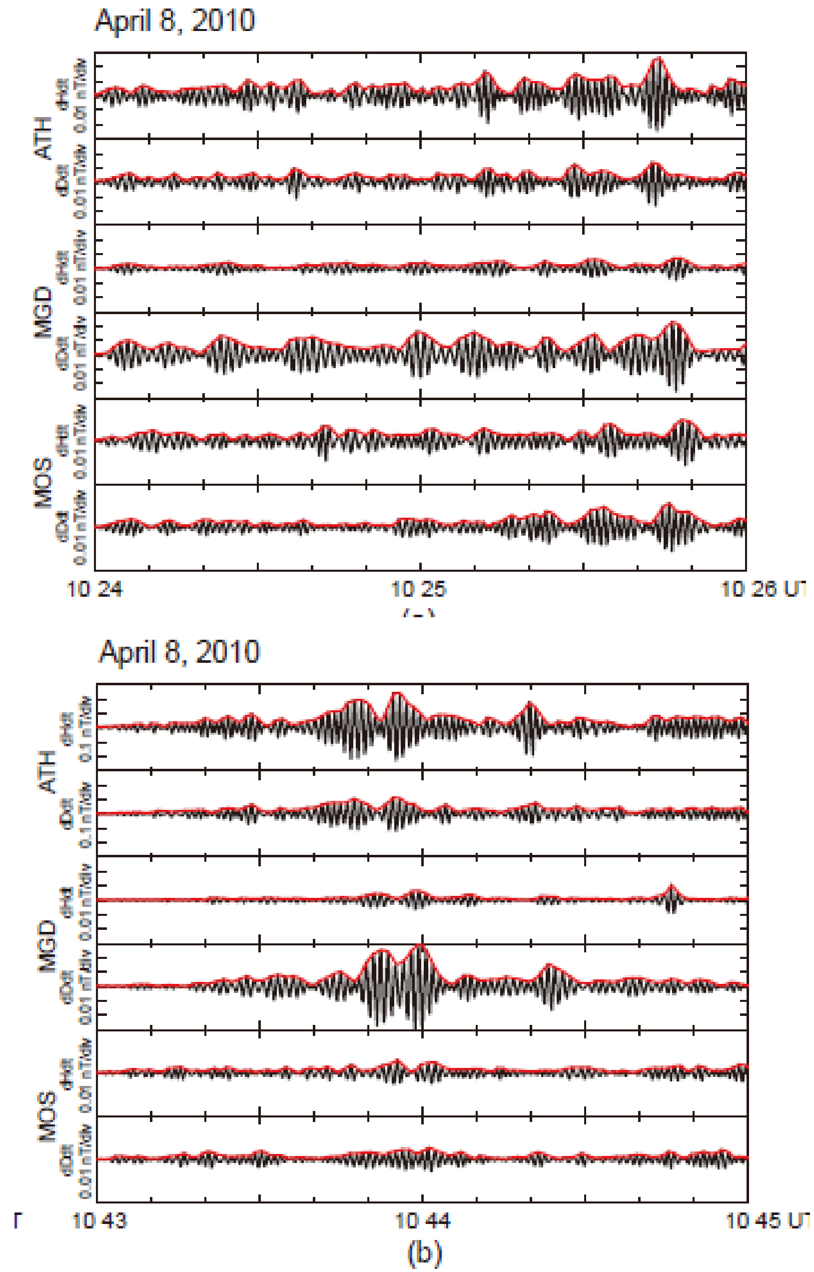




Pc1 Pearl Structure by ionospheric beating



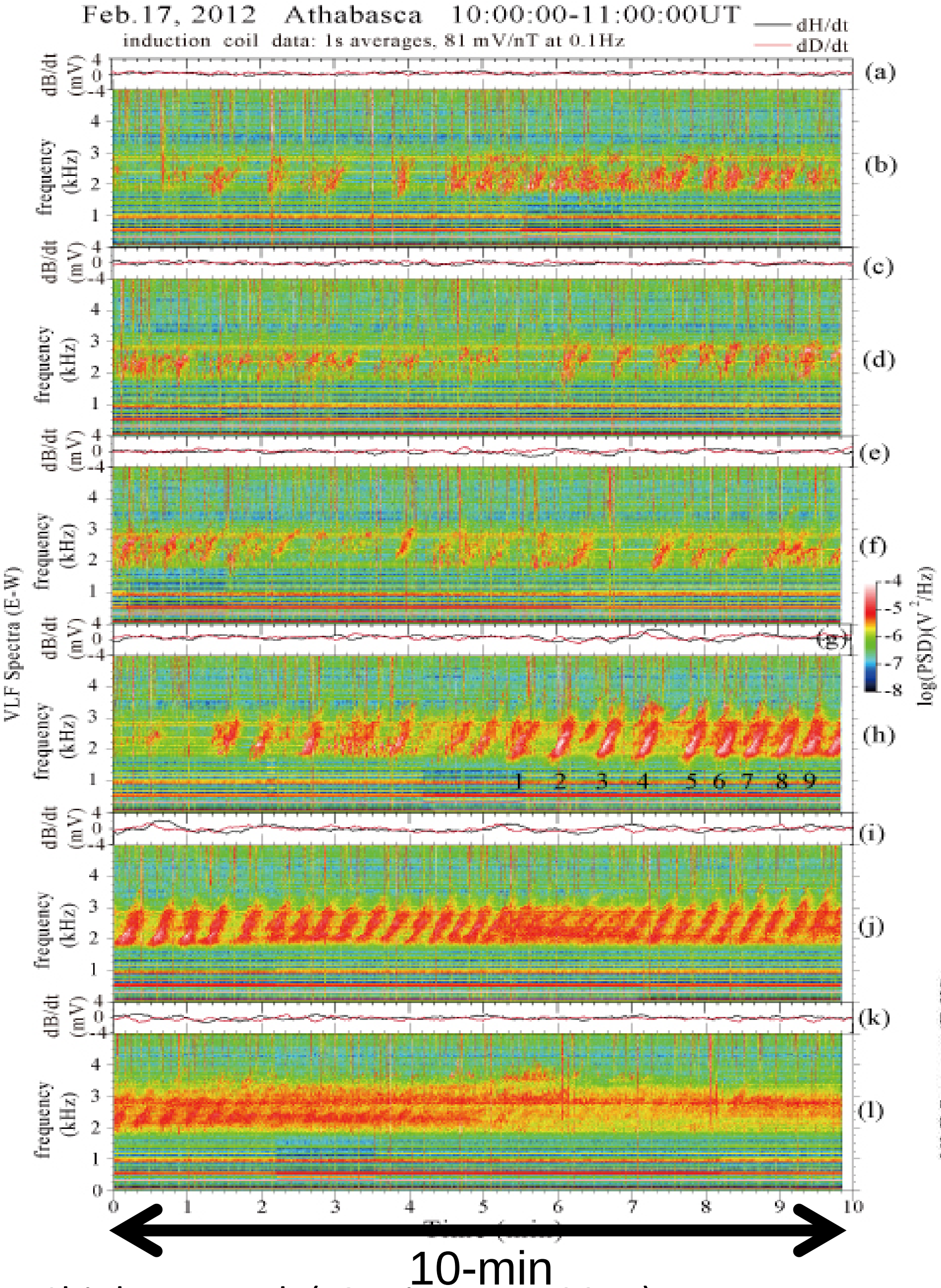


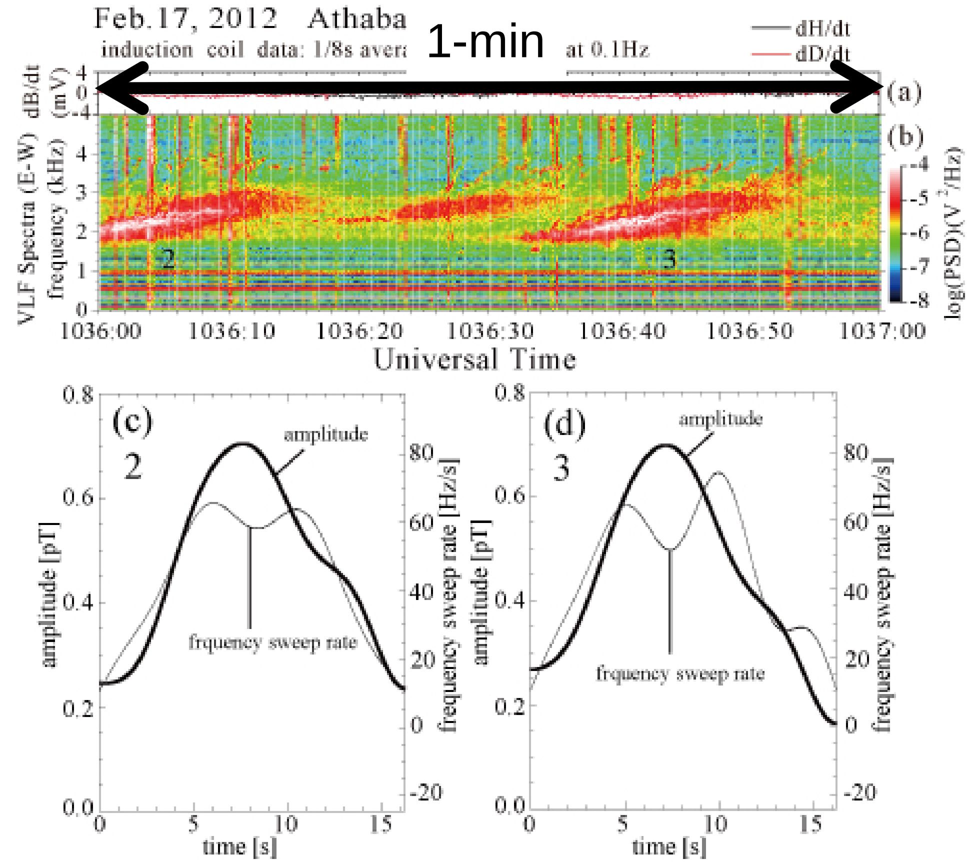


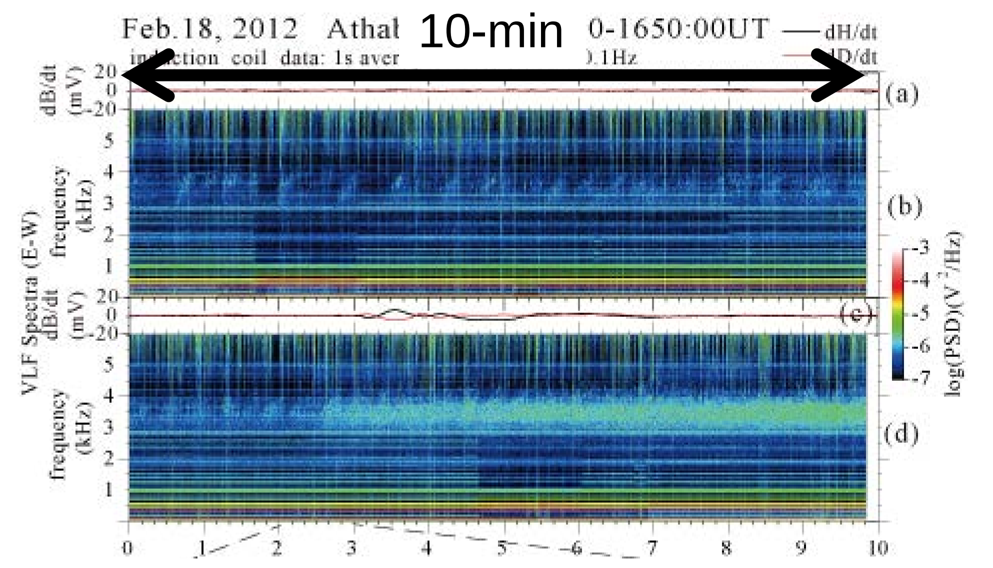
Beating during duct propagation in the ionosphere.

Jun et al. (EPS, in press, 2014)

QP emission / SC-triggered emission

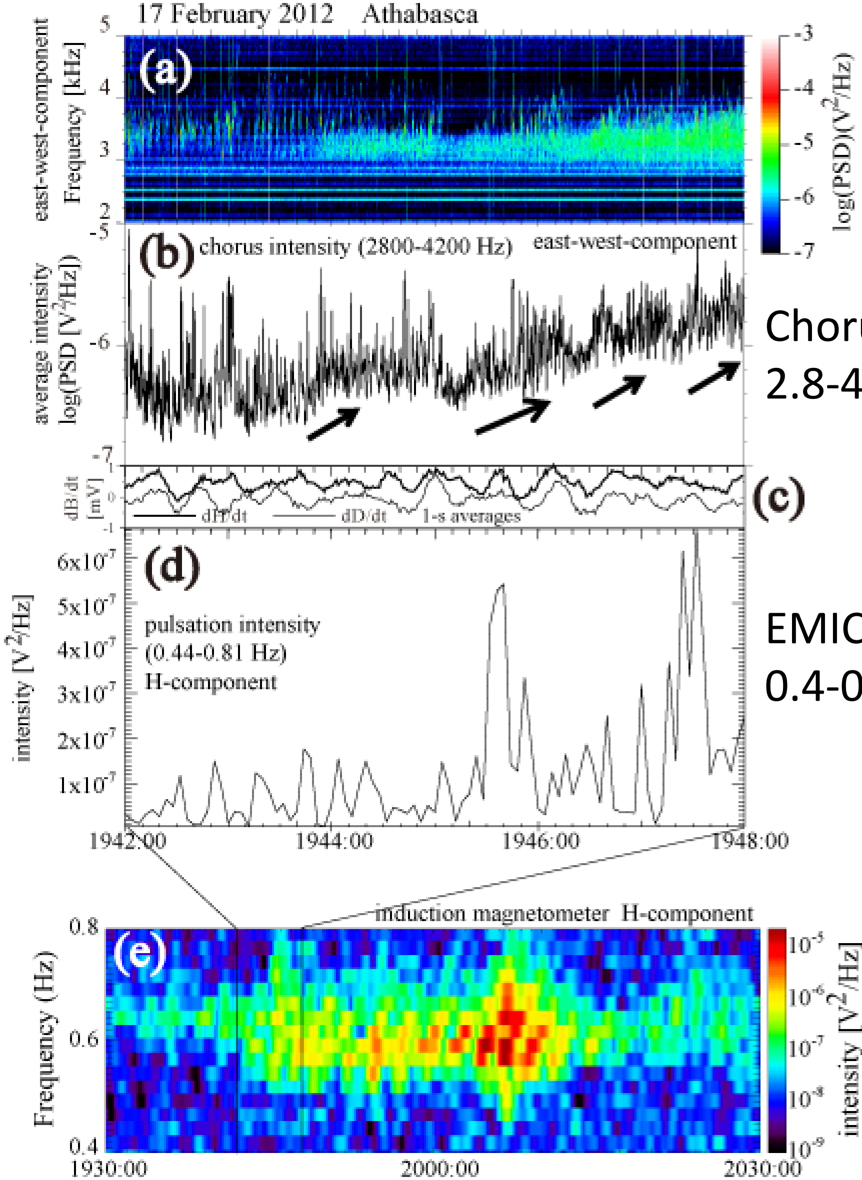






Shiokawa et al. (JGR, in press, 2014)

Chorus and EMIC correlation

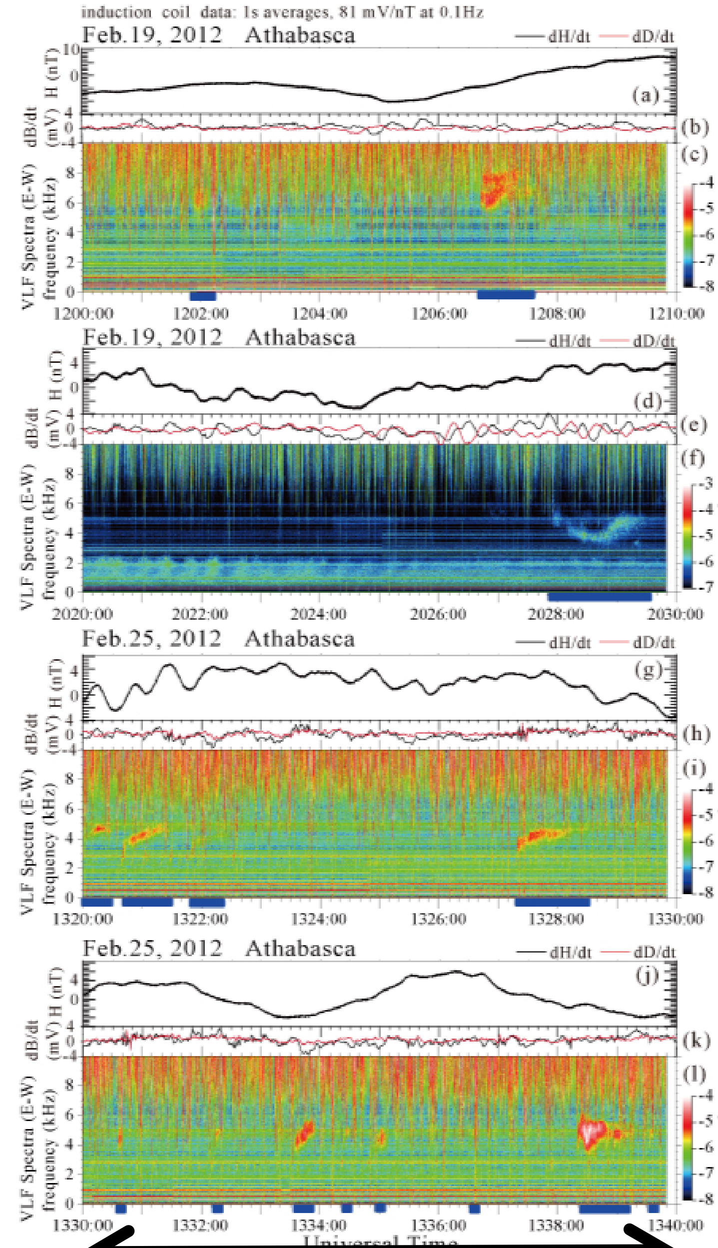


Chorus
2.8-4.2kHz

EMIC
0.4-0.8Hz

1-hour

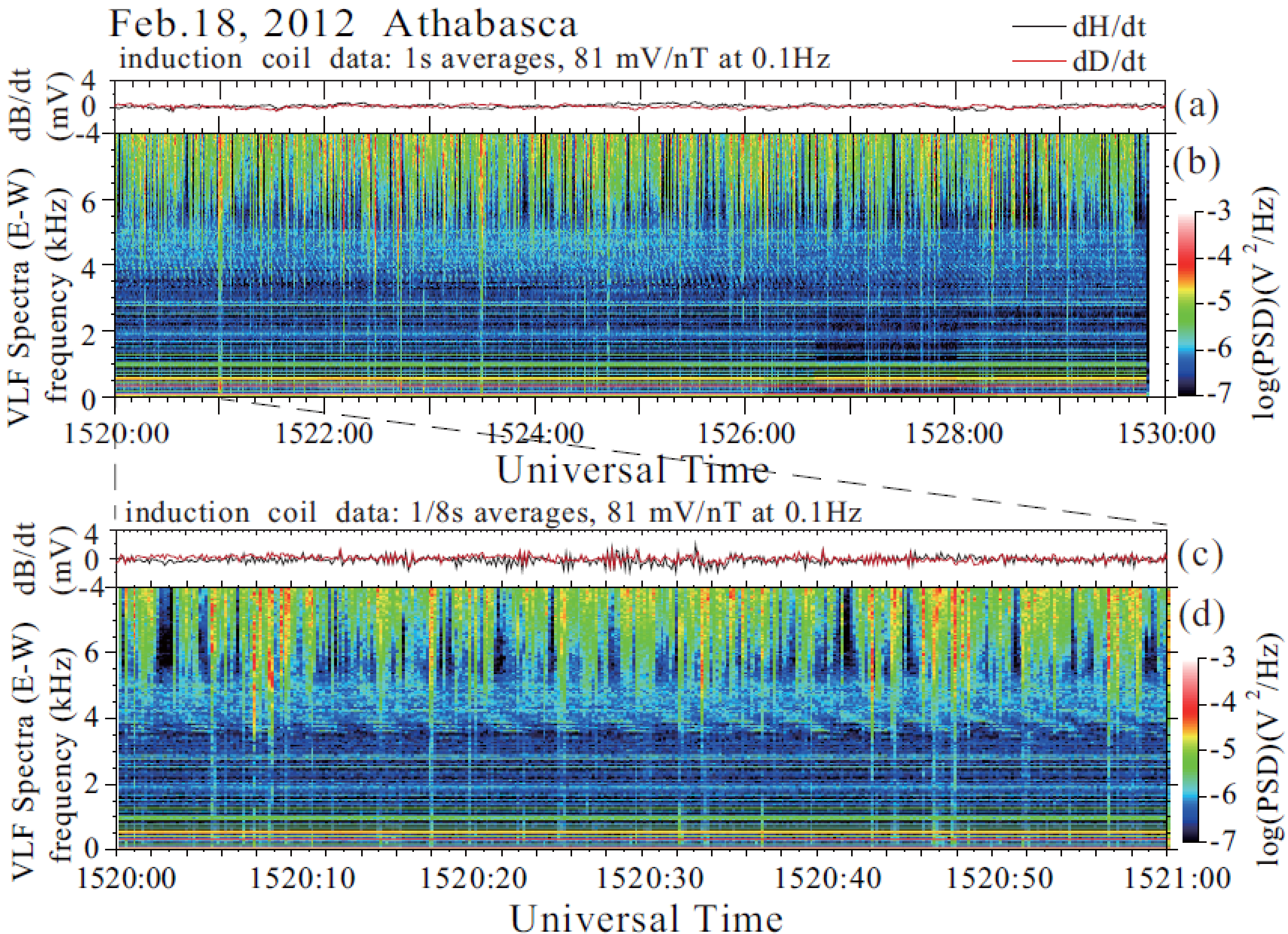
Bursty patch emissions



10-min

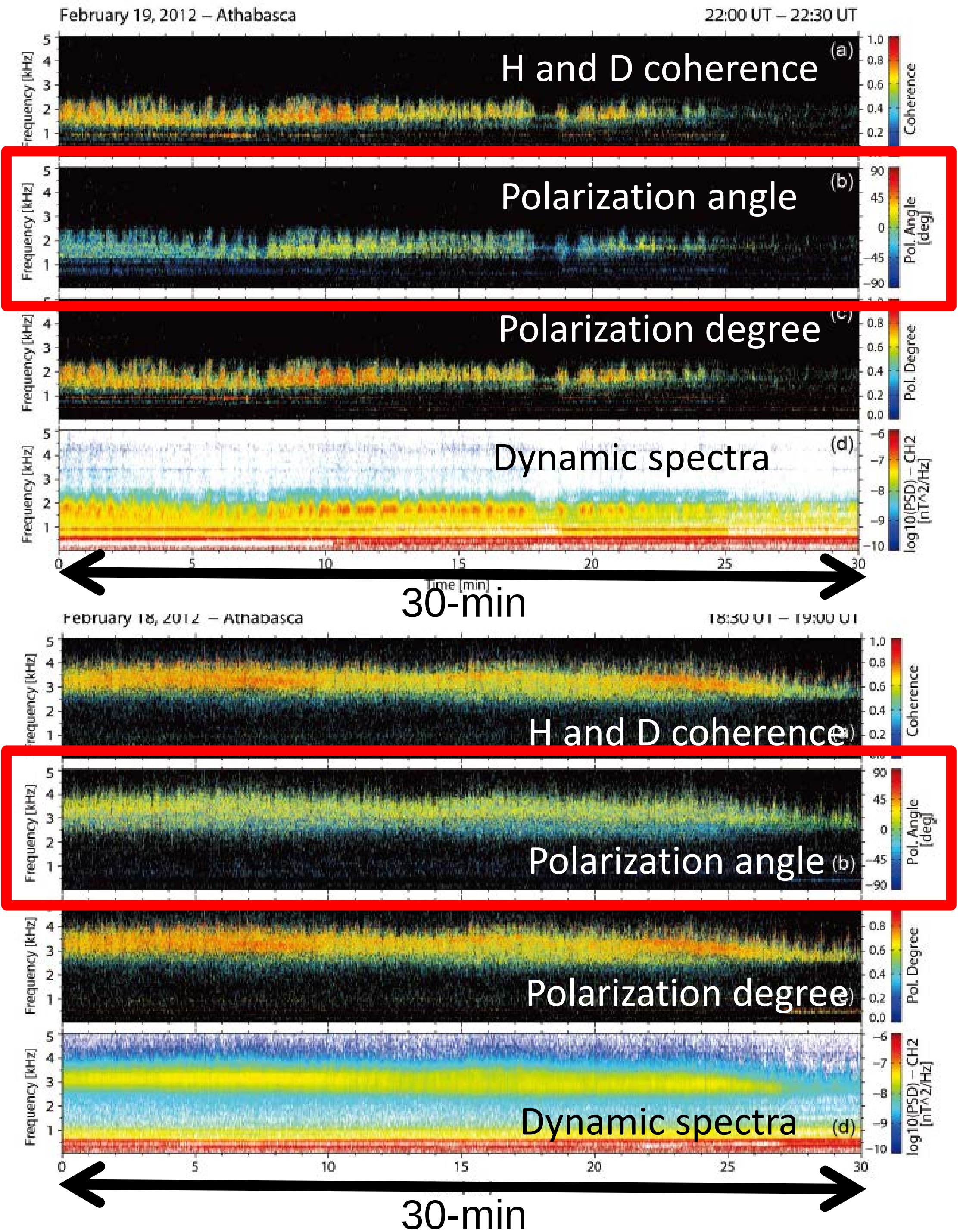
Shiokawa et al. (JGR, in press, 2014)

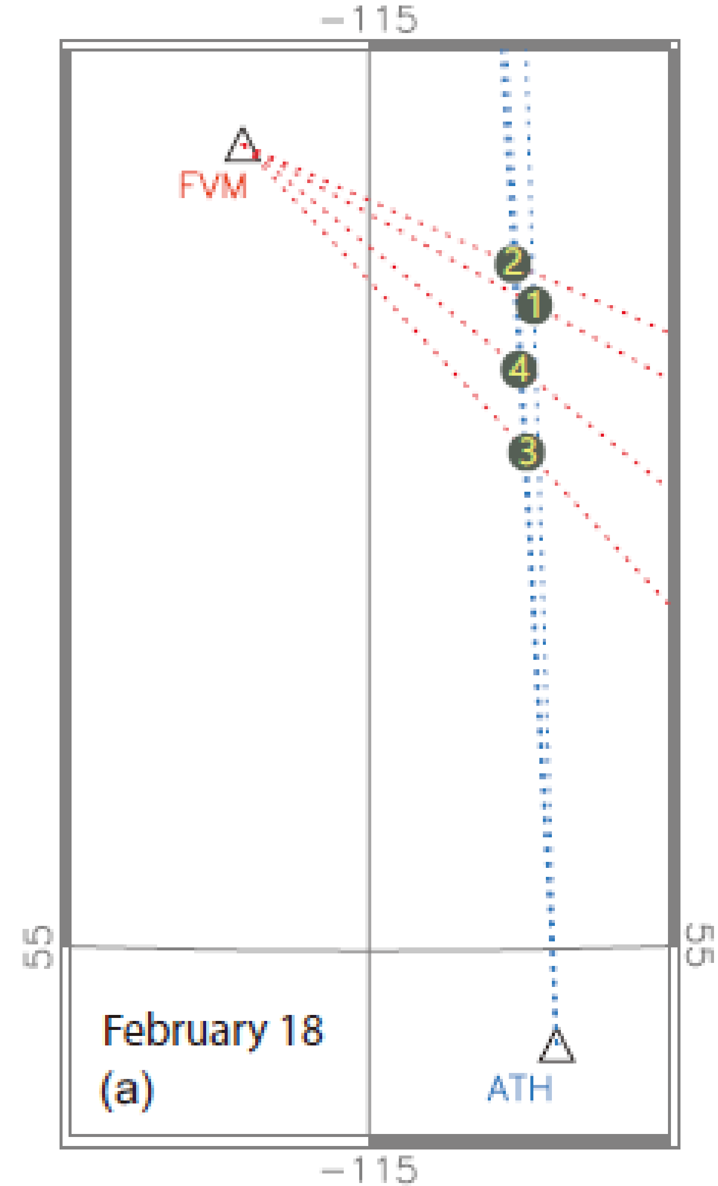
Falling tone chorus with sweep rate change from 0.7kHz/s to 0.05 kHz/s in 10 min



Shiokawa et al. (JGR, in press, 2014)

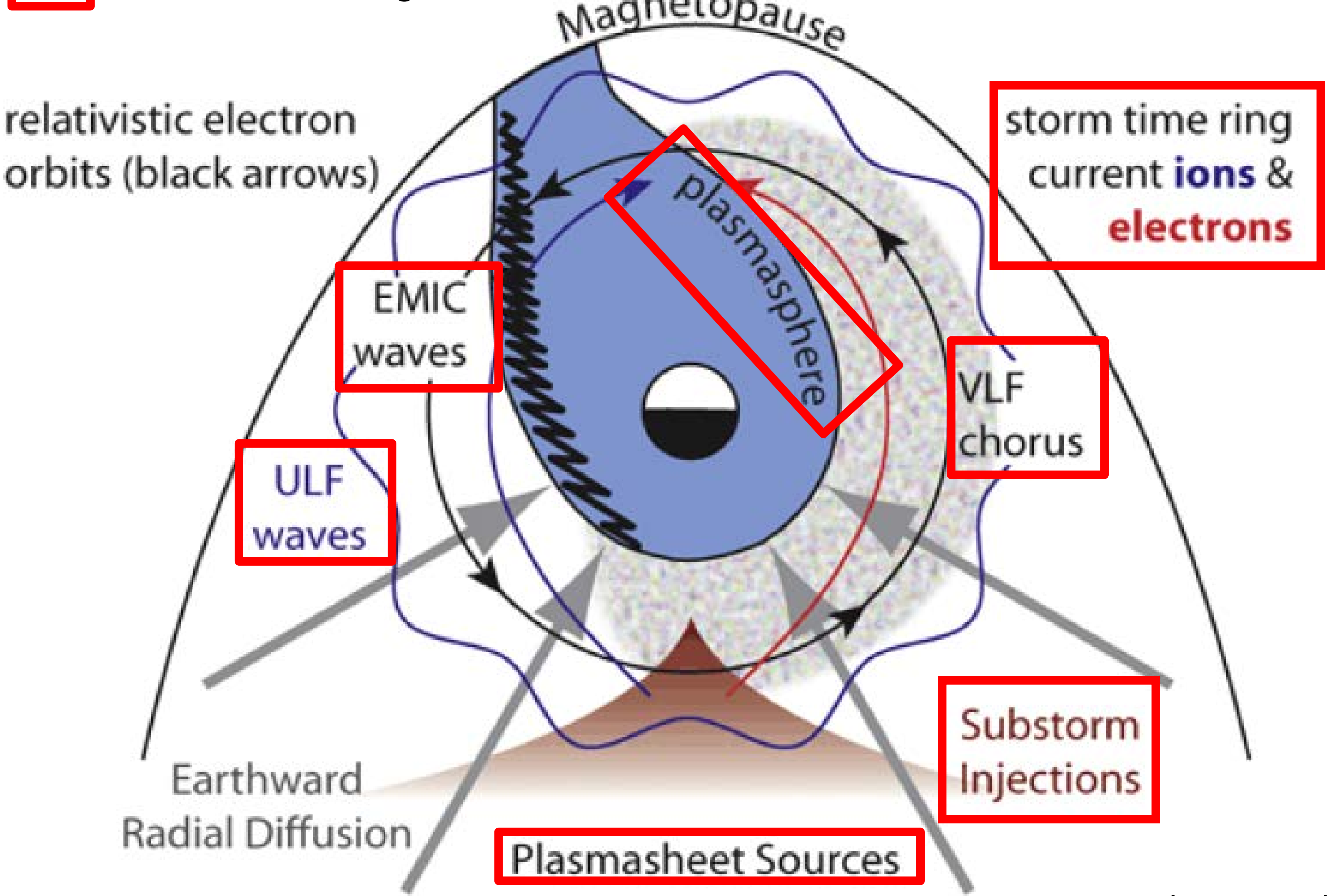
Chorus polarization analysis



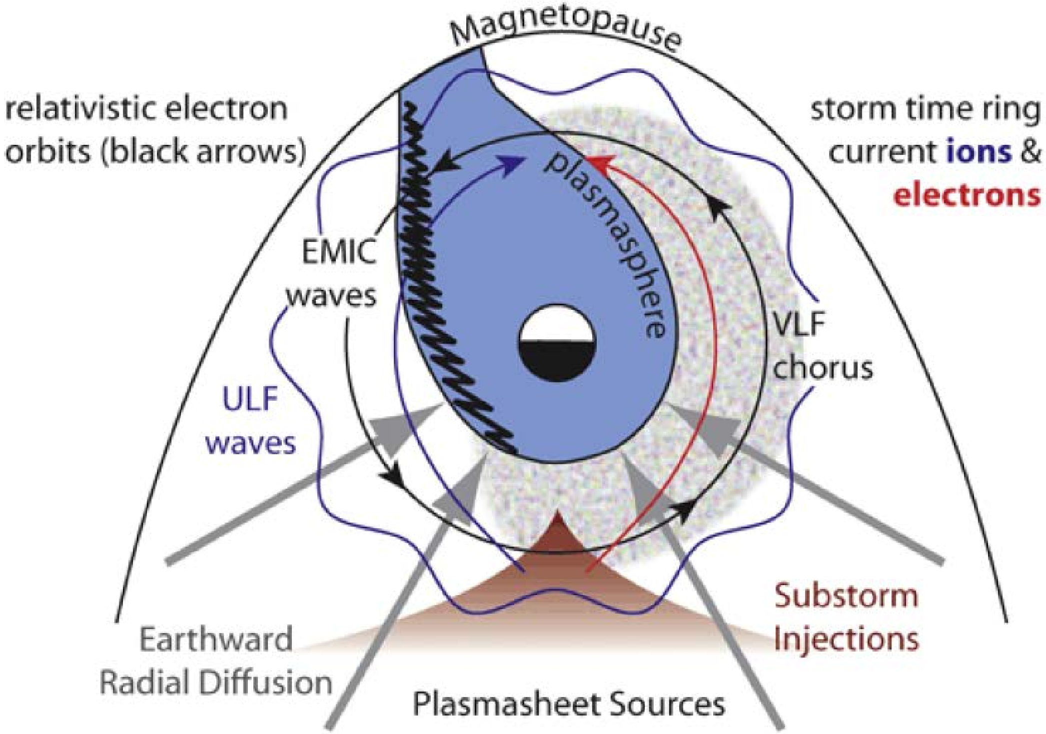


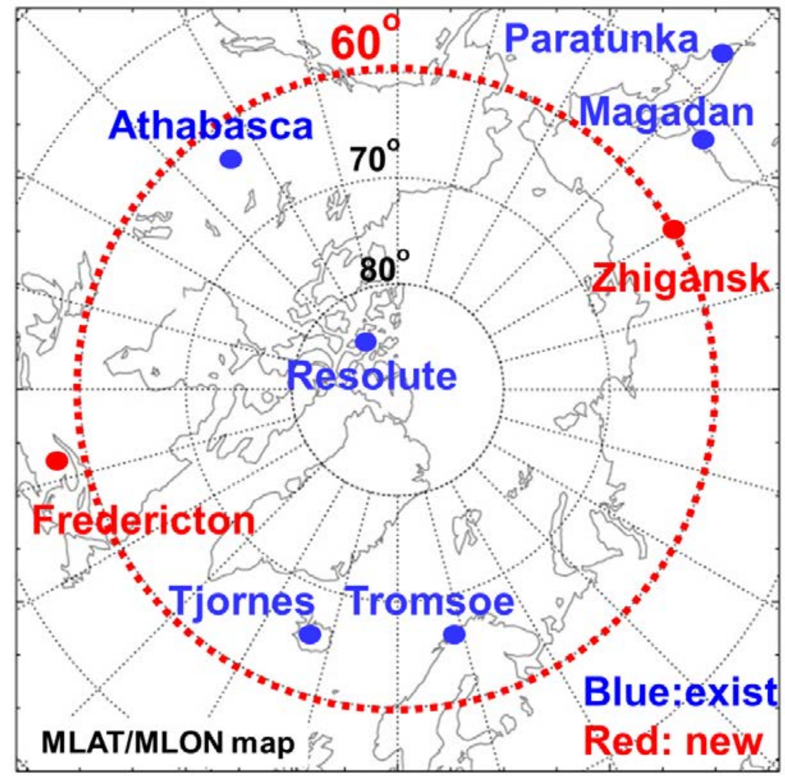
Martinez et al. (EPS, in press, 2014)

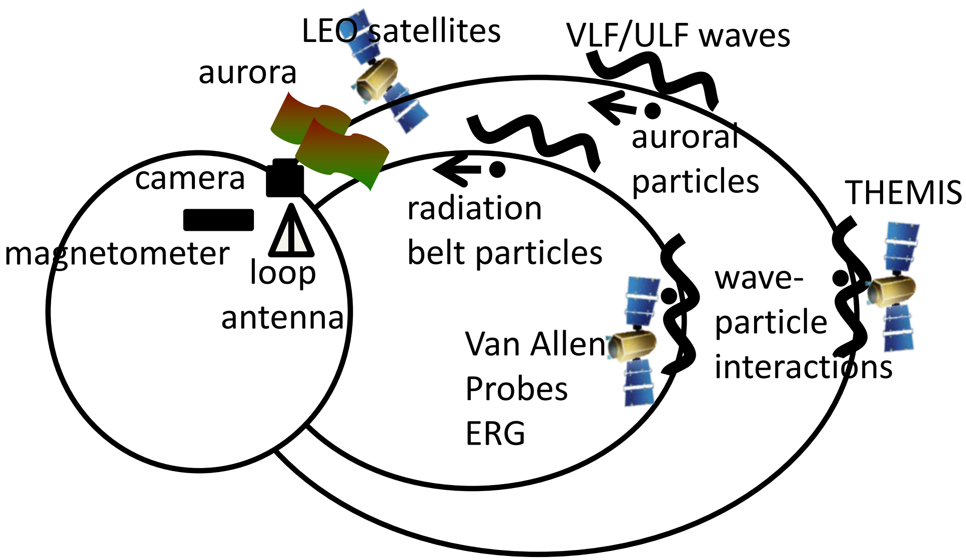
Observable from ground



Reeves (SW, 2007)


Magnetopause
relativistic electron orbits (black arrows)
storm time ring current ions & electrons
plasmasphere
EMIC waves
ULF waves
VLF chorus
Earthward Radial Diffusion
Substorm Injections
Plasmasheet Sources


60°
70°
80°
Paratunka
Magadan
Athabasca
Zhigansk
Resolute
Fredericton
Tjornes
Tromsoe
Blue:exist
Red: new
MLAT/MLON map


LEO satellites
VLF/ULF waves
aurora
auroral particles
camera
radiation belt particles
THEMIS
magnetometer
loop antenna
wave-particle interactions
Van Allen Probes ERG

Summary

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- MSTID motion → monitoring of penetrating electric field
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Induction magnetometers

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