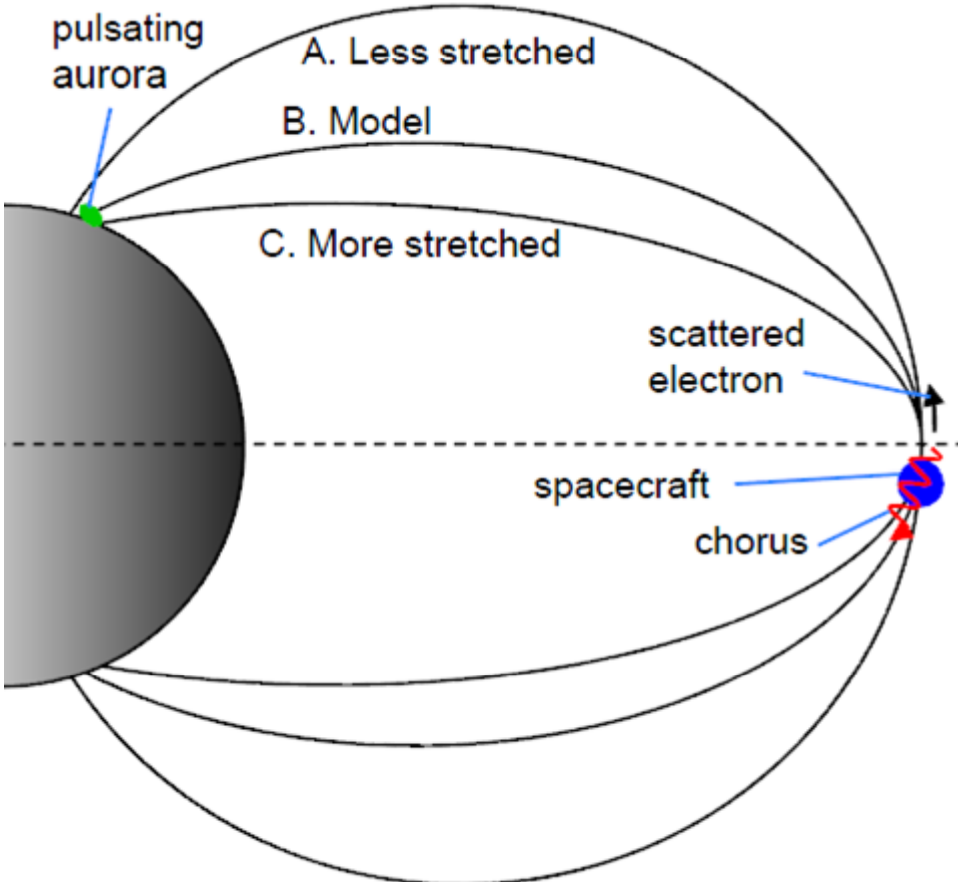
Estimation of magnetic field mapping accuracy using the pulsating aurora-chorus connection

Toshi Nishimura
(Given by Jacob Bortnik)

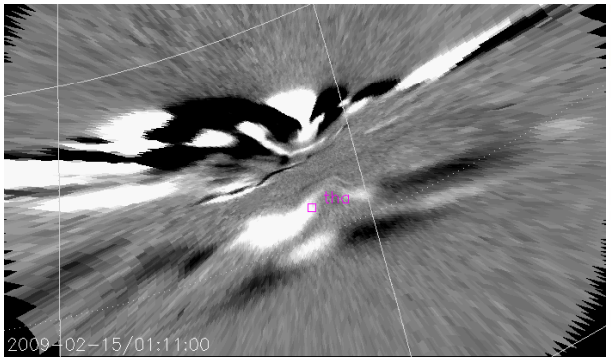
Collaborators
J. Bortnik, W. Li, R. M. Thorne, L. R. Lyons, V. Angelopoulos, S. B. Mende, J. Bonnell, O. Le Contel, C. Cully, R. Ergun and U. Auster

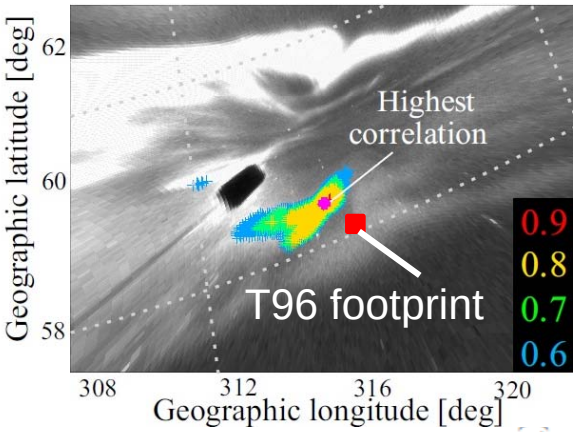


Lower-band chorus as a driver of pulsating aurora

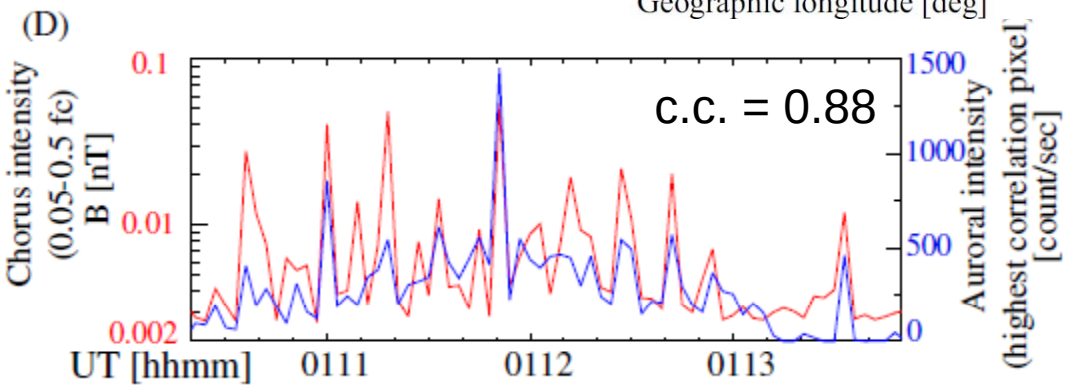
The driver of the pulsating aurora has been extensively discussed:

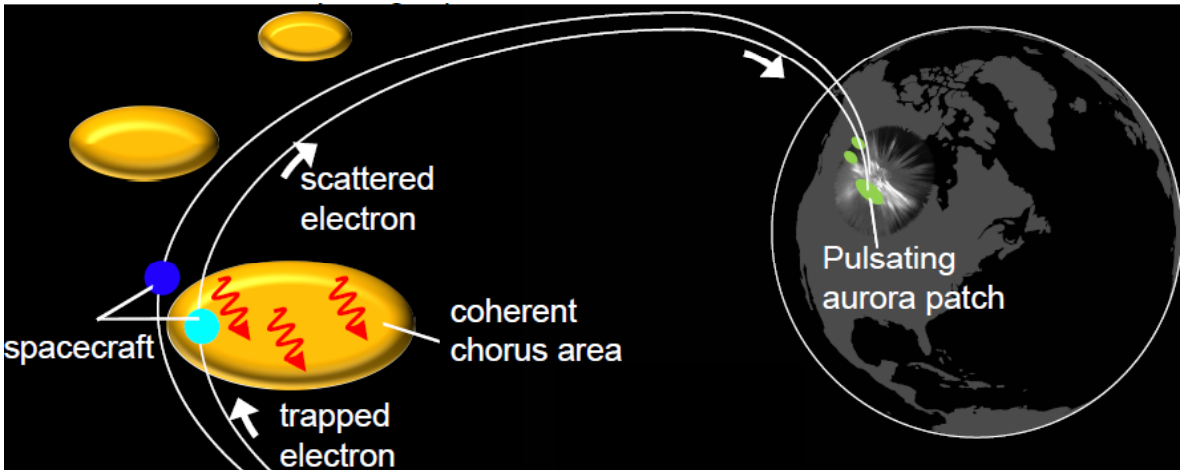
- Chorus [Davidson, 1990]
- ECH [Liang et al., 2010]
- E|| [Sato et al., 2004]





Simultaneous THEMIS spacecraft and imager observations showed almost one-to-one correlation between chorus and aurora intensities over a localized area of the sky.





The localized high correlation can be used to highlight the real magnetic footprint of the spacecraft, independently from magnetic field models.

[Nishimura et al., Science, 2010]

Questions

- How common is the chorus-pulsating aurora correlation?
- What is the typical error of the Tsyganenko magnetic field models?
  - Exciting opportunity to determine the accuracy of the widely-used models, which intrinsically have statistical errors
  - Magnetic activity dependence of the footprint location

Multi-event study of pulsating aurora-chorus correlation

<u>Event selection criteria</u>

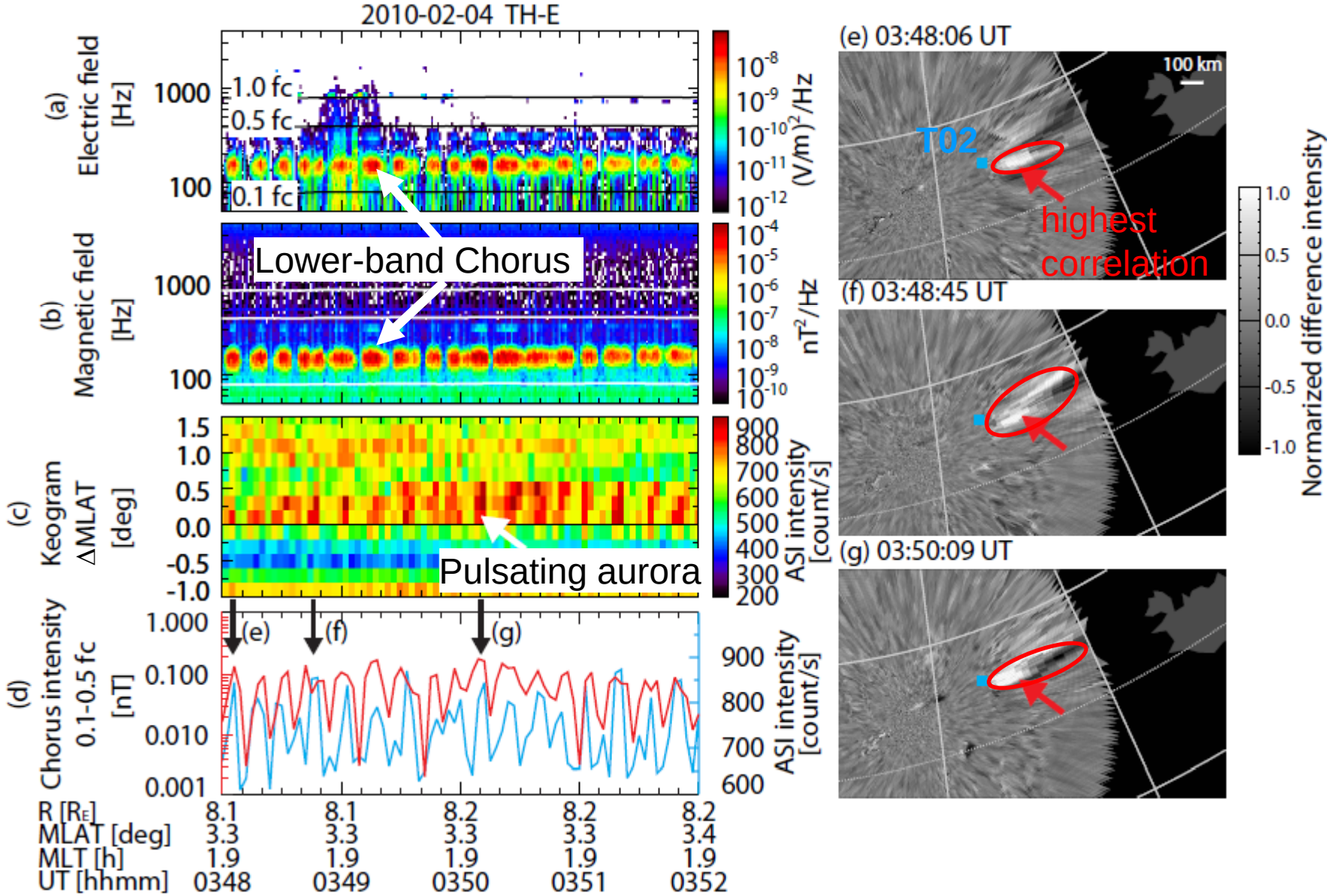
Spacecraft

- Particle burst-mode observations
- Intense (>10 pT) chorus
- no strong ECH (To eliminate strong diffuse aurora events)

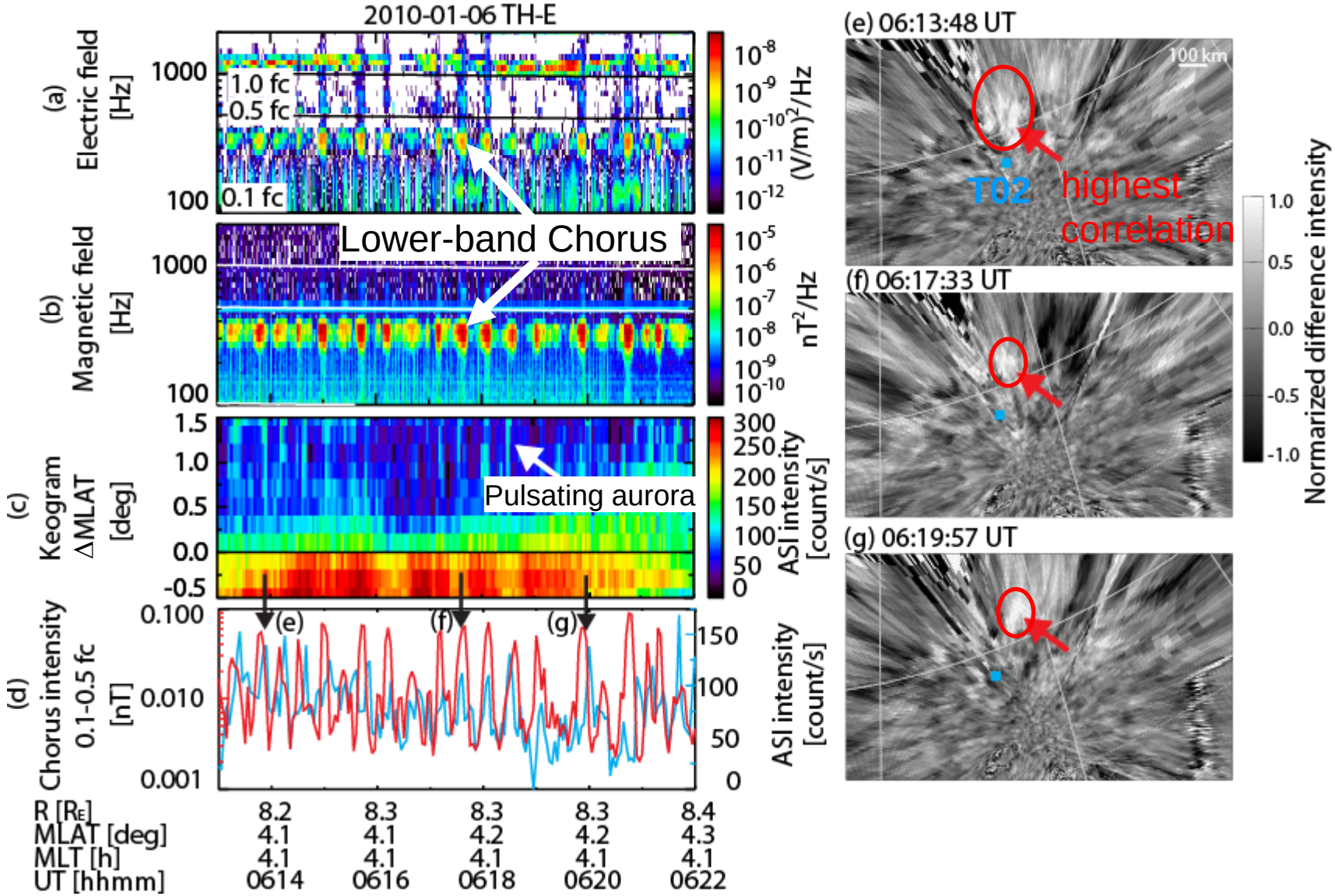
ASI

- T01 footprint within a field-of-view
- Less light contamination or clouds
- If exists, PA should be strong enough to determine the patch size

⇨ **13 events during 2007-2010**



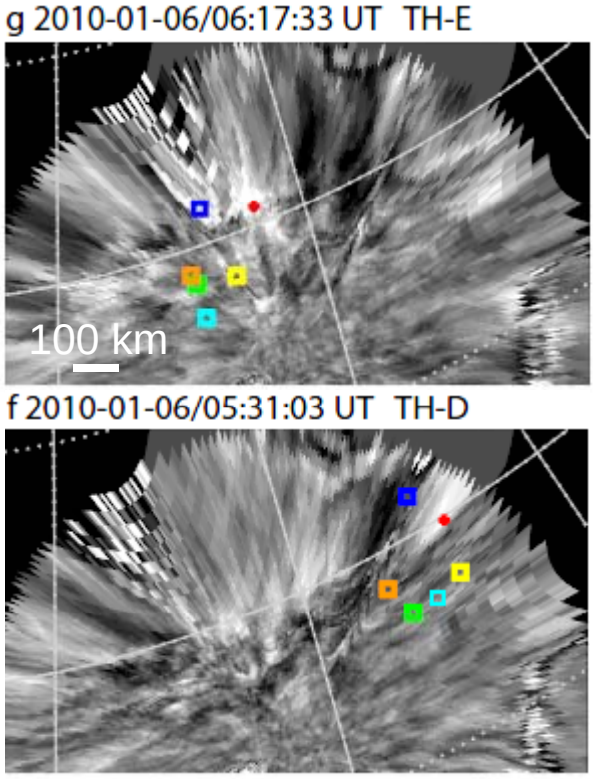
- High correlation between chorus and pulsating aurora
- High correlation region over a single auroral patch, changing its shape
  - Likely to highlight the real spacecraft footprint
  - Located slightly to the east of the model footprint



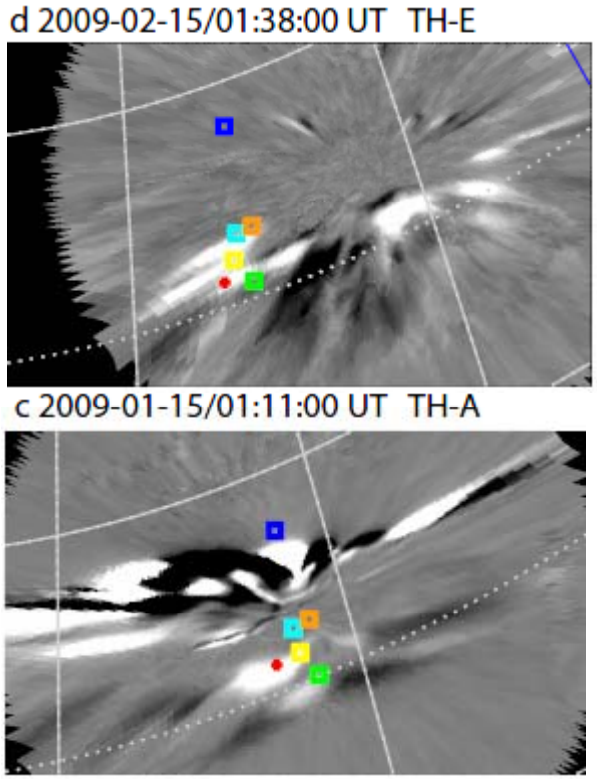
- High correlation between chorus and pulsating aurora
- High correlation region over a single auroral patch, changing its shape
  - Likely to highlight the real spacecraft footprint
  - Located slightly poleward of the model footprint

Footprint location compared to multiple models

Quiet time (ΔH and ΔZ~0)



Disturbed time (|ΔH| or |ΔZ|>~50 nT)



IGRF T89 T96 T02 T05s chorus-PA correlation -1.0 -0.5 0.0 0.5 1.0 Normarized difference intensity

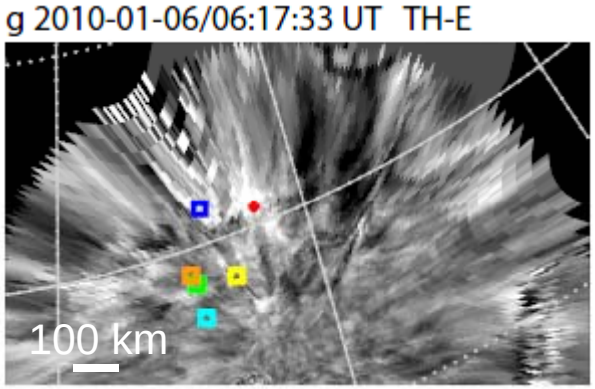
- The T02 magnetic field model (yellow) tends to be closer to the chorus-PA correlation location (error ~ 100 km in the ionosphere).

Magnetic activity dependence

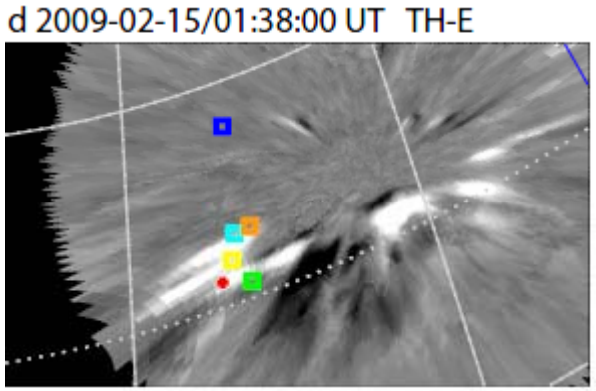
- Quiet time footprint: Closer to IGRF than Tsyganenko
- Disturbed time footprint: Closer to or slightly equatorward of Tsyganenko

Comparison to in-situ magnetic field

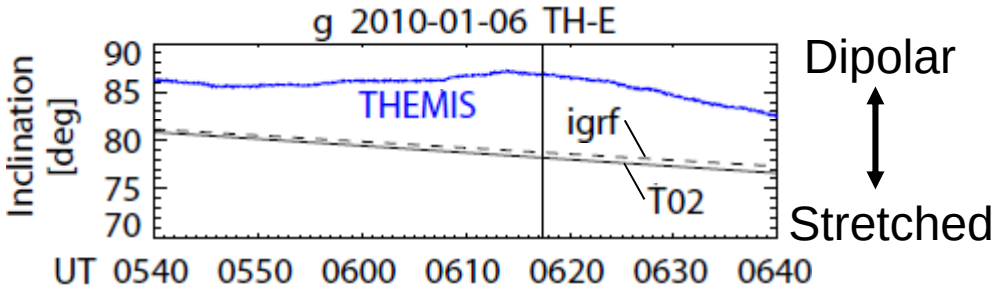
Quiet time (ΔH and ΔZ~0)



Disturbed time (|ΔH| or |ΔZ|>~50 nT)

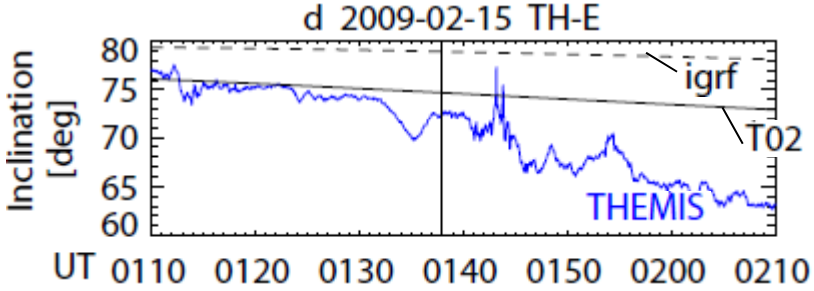


IGRF T89 T96 T02 T05s • chorus-PA correlation -1.0 -0.5 0.0 0.5 1.0 Normarized difference intensity



Dipolar

Stretched



- Quiet-time magnetic field: More dipolar and closer to IGRF
- Disturbed time magnetic field: Closer to or more stretched than T02

⇨ The in-situ magnetic field measurements support the tendency of the chorus-PA mapping result.

The chorus-PA mapping is likely to highlight a real magnetic footprint of the spacecraft.

Summary

Magnetic field mapping using chorus-PA correlation using 13 events during 2007-2010 THEMIS spacecraft-ASI conjunctions.

• A multiple event analysis demonstrated that the high correlation between chorus and PA commonly occurs.

• Taking advantage of this method independent of model fields, a typical error of Tsyganenko model was estimated.

~100 km in the ionosphere → ~2000 km at the equator

•Magnetic activity dependence is found.

- •Quiet time footprint: Closer to IGRF than Tsyganenko
- •Disturbed time footprint: Closer to or slightly equatorward of Tsyganenko

This tendency is consistent with the in-situ magnetic field inclination.

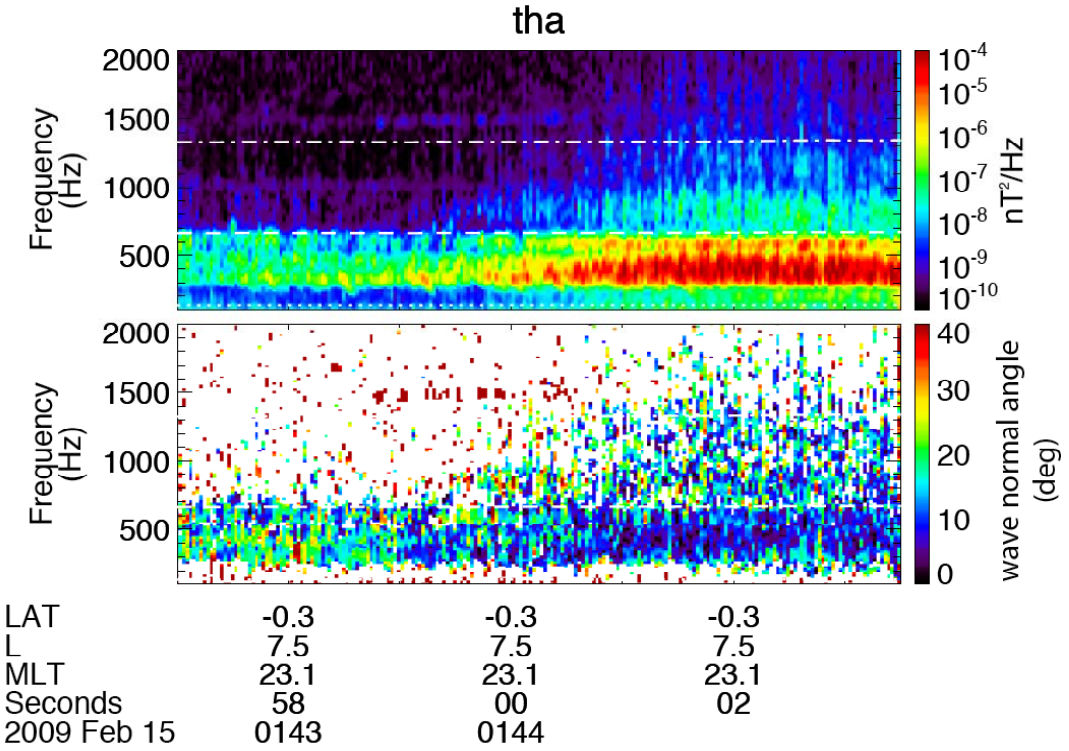
END

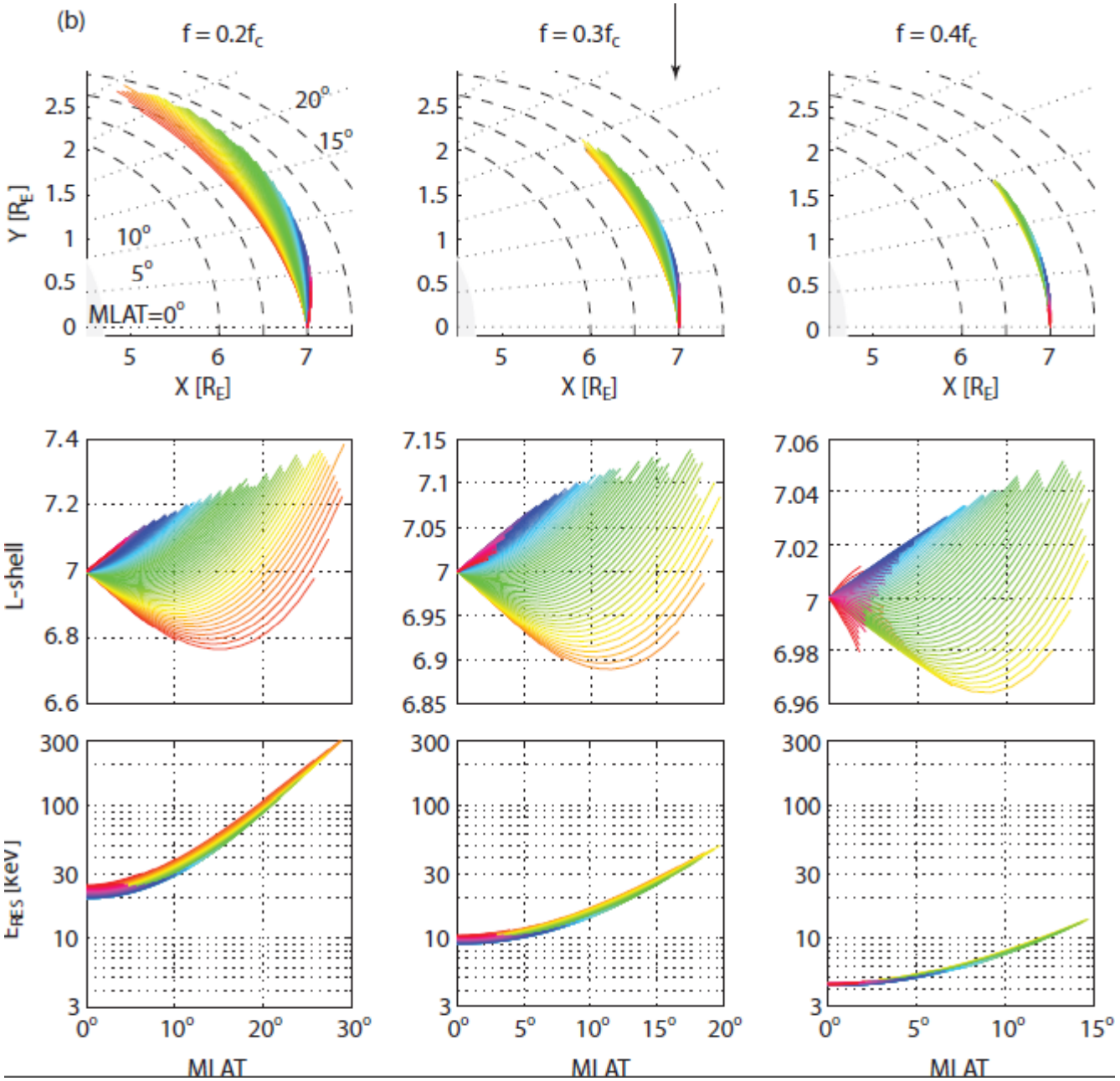
List of lower-band chorus—ASI conjunction events satisfying the selection criteria

YYYYMMDD	HHMM-HHMM	lower band	upper band	weak ECH	s/c	ASI site	Pulsating aurora
20081109	0624-0632	yes	yes	?	e	nrsq	yes
20081207	0555-0558	yes	yes	yes	e	nrsq	yes
20090215	0133-0142	yes	no	yes	e	nrsq	yes
20100106	0529-0538	yes	yes	yes	d	nrsq	yes
20100106	0635-0645	yes	yes	yes	d	nrsq	yes
20100106	0605-0625	yes	yes	yes	e	nrsq	yes
20100111	0507-0516	yes	yes	no	e	nrsq	yes
20100114	0505-0515	yes	no	yes	d	nrsq	yes
20100204	0317-0346	yes	no	no	e	nrsq	yes
20100306	0105-0155	yes	yes	yes	e	nrsq	yes
20100306	0150-0158	yes	yes	yes	d	nrsq	yes
20100306	0201-0220	yes	no	yes	d	nrsq	yes

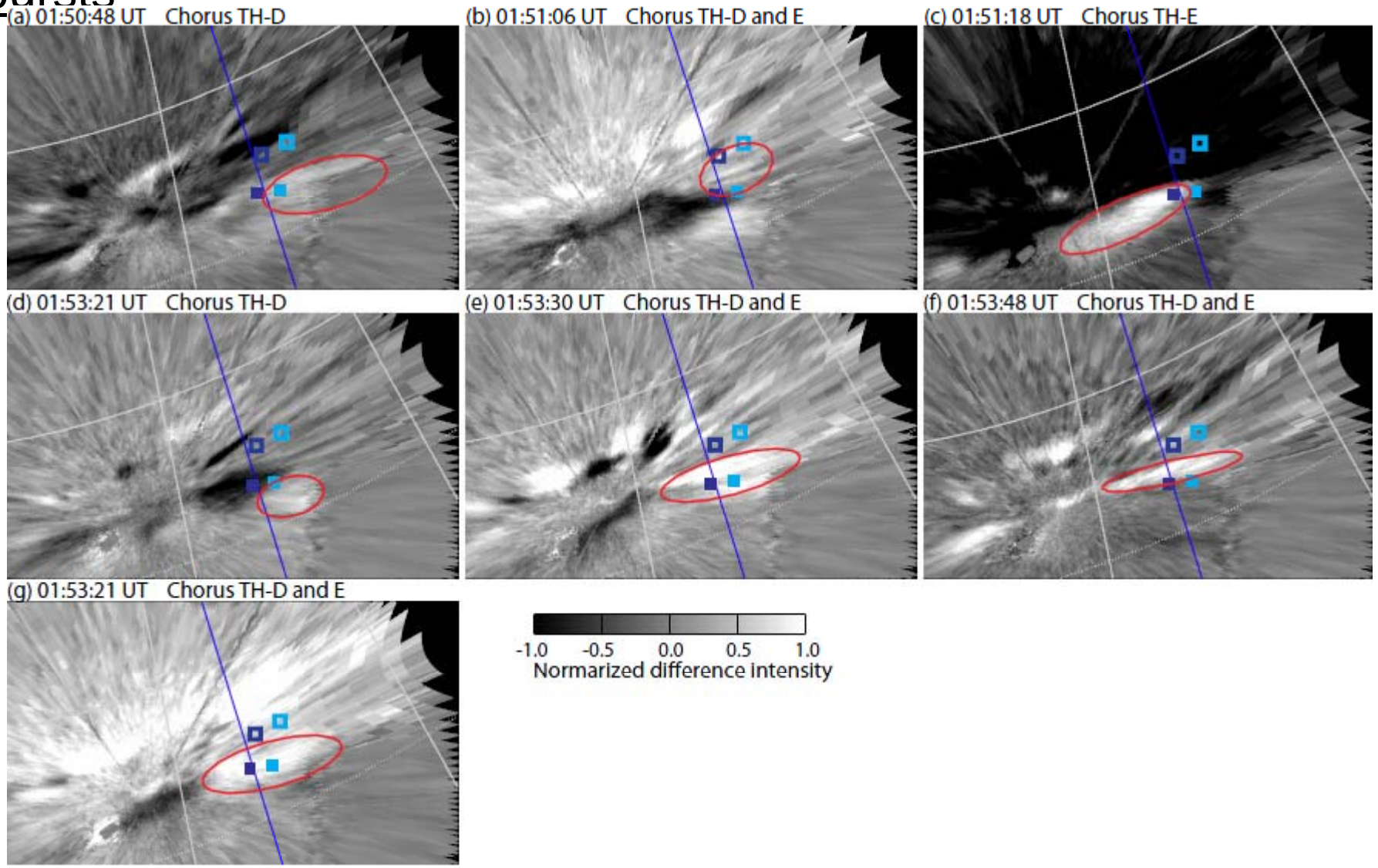
All events are associated with pulsating aurora around the footprints of spacecraft.

Quasi field-aligned propagation



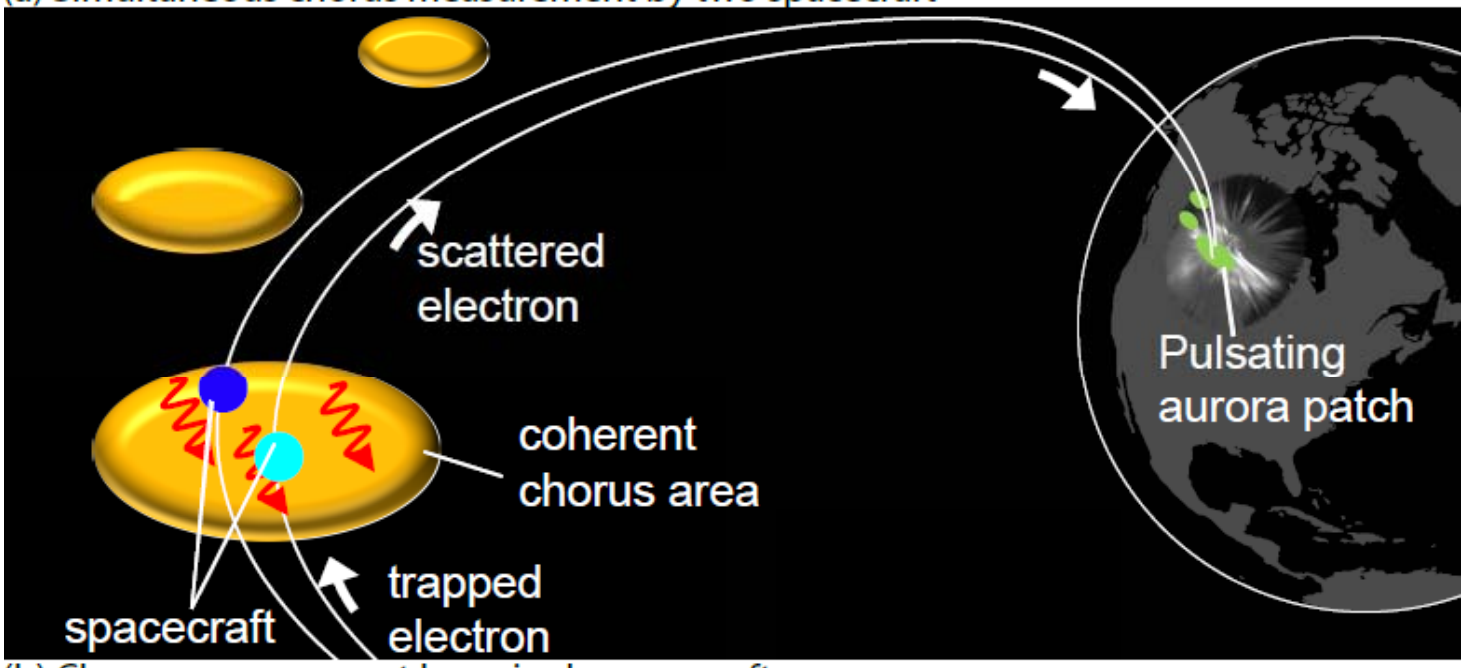

(b)
f = 0.2f_c
f = 0.3f_c
f = 0.4f_c
20°
15°
10°
5°
MLAT=0°
Y [R_E]
X [R_E]
L-shell
E_RES [keV]
MLAT

Correlation with pulsating aurora for 7 most intense chorus bursts

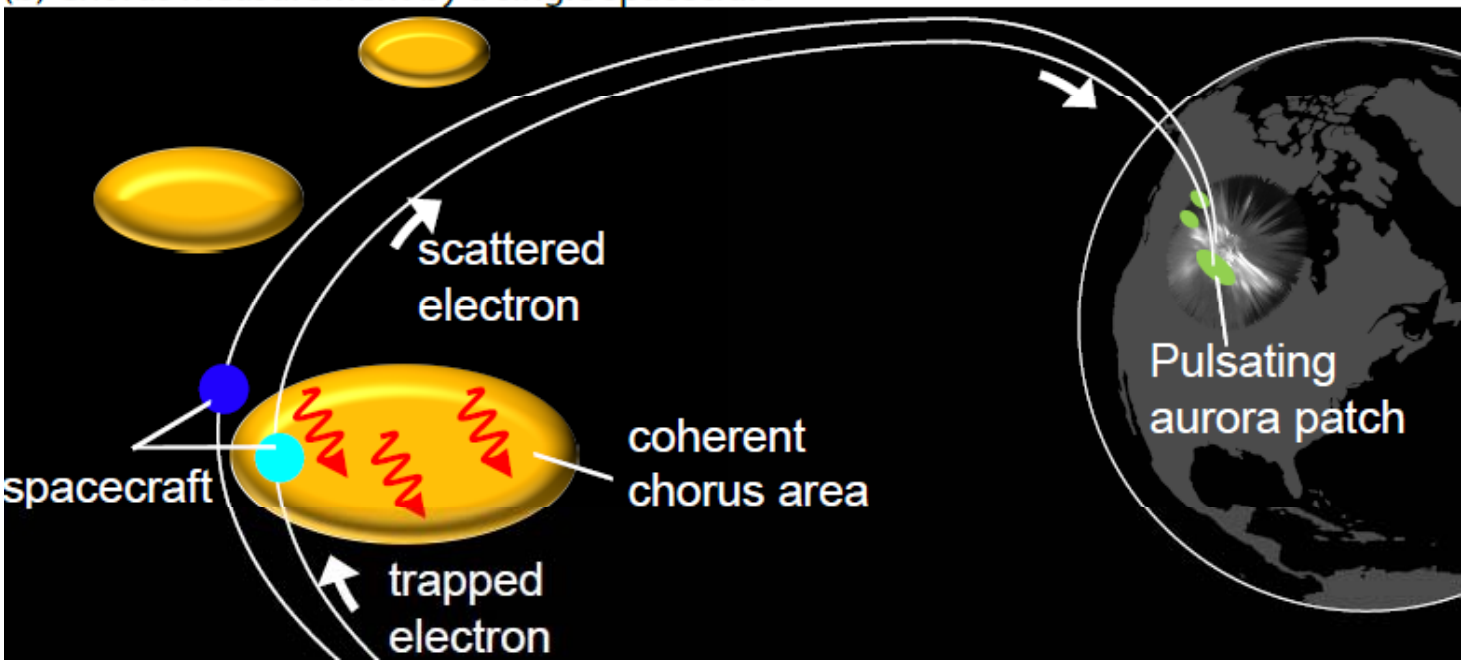


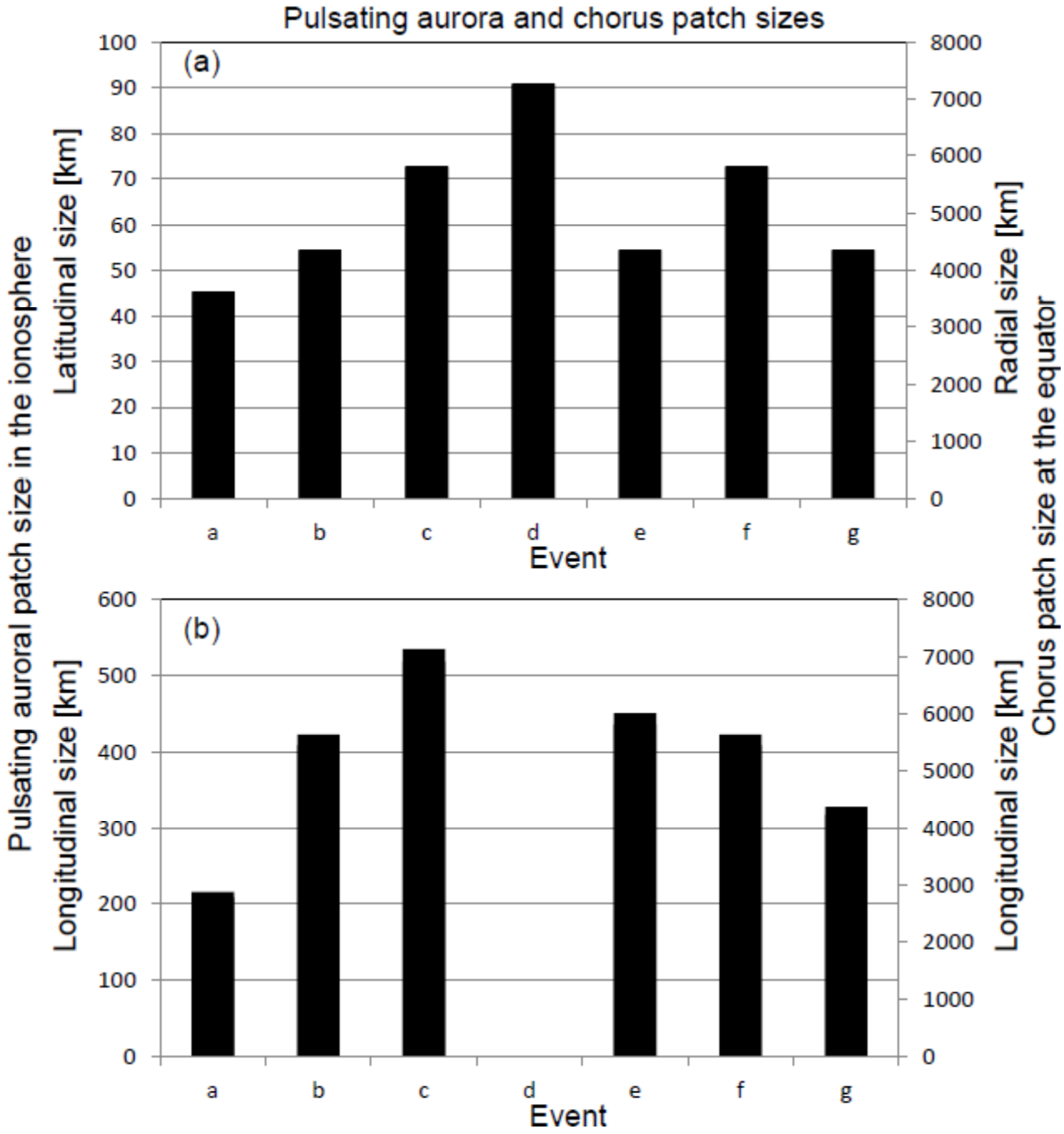
The PA and chorus correlation at two spacecraft suggests that a coherent chorus size corresponds to the size of wave-particle interaction determining the PA size.

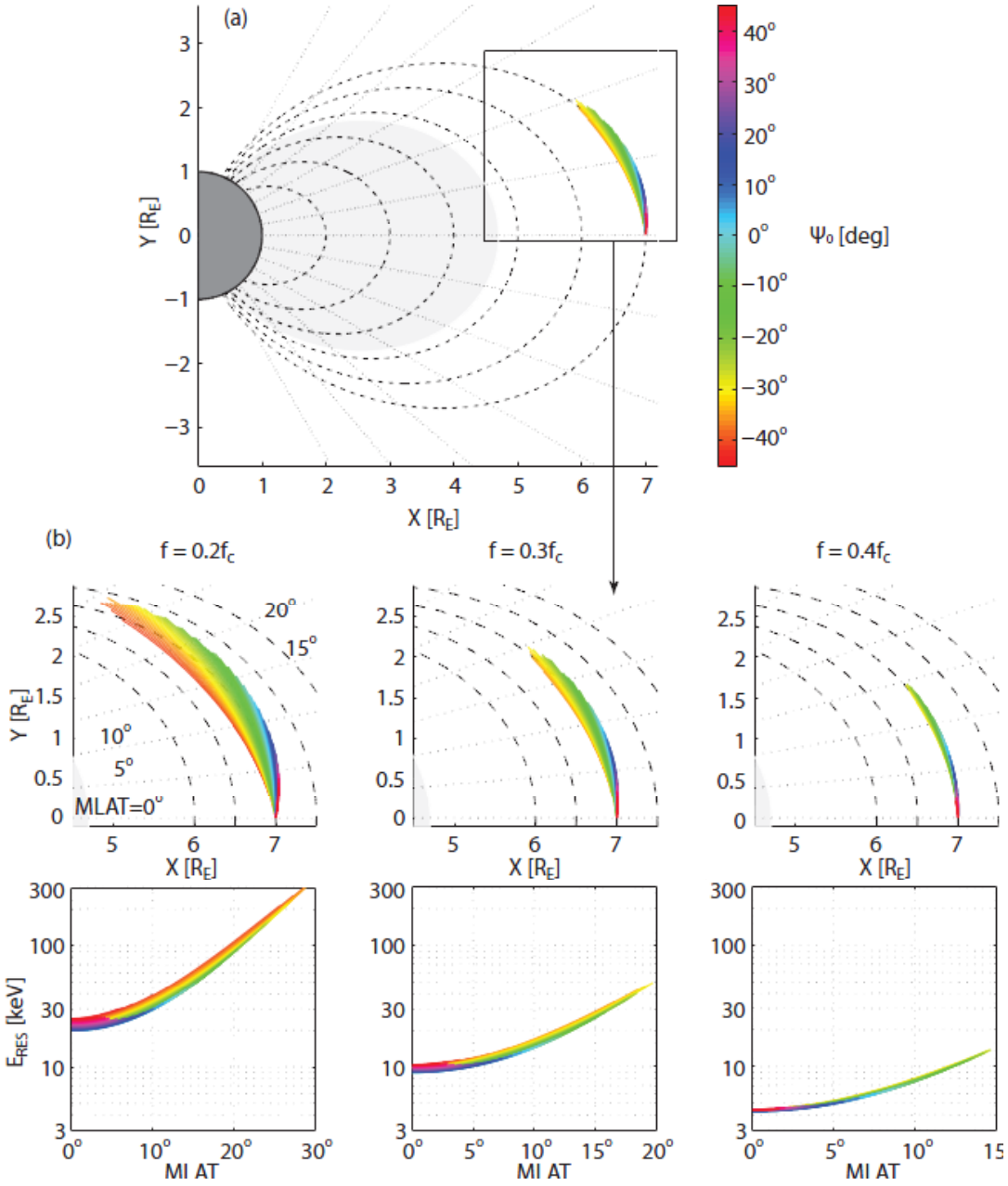
(a) Simultaneous chorus measurement by two spacecraft

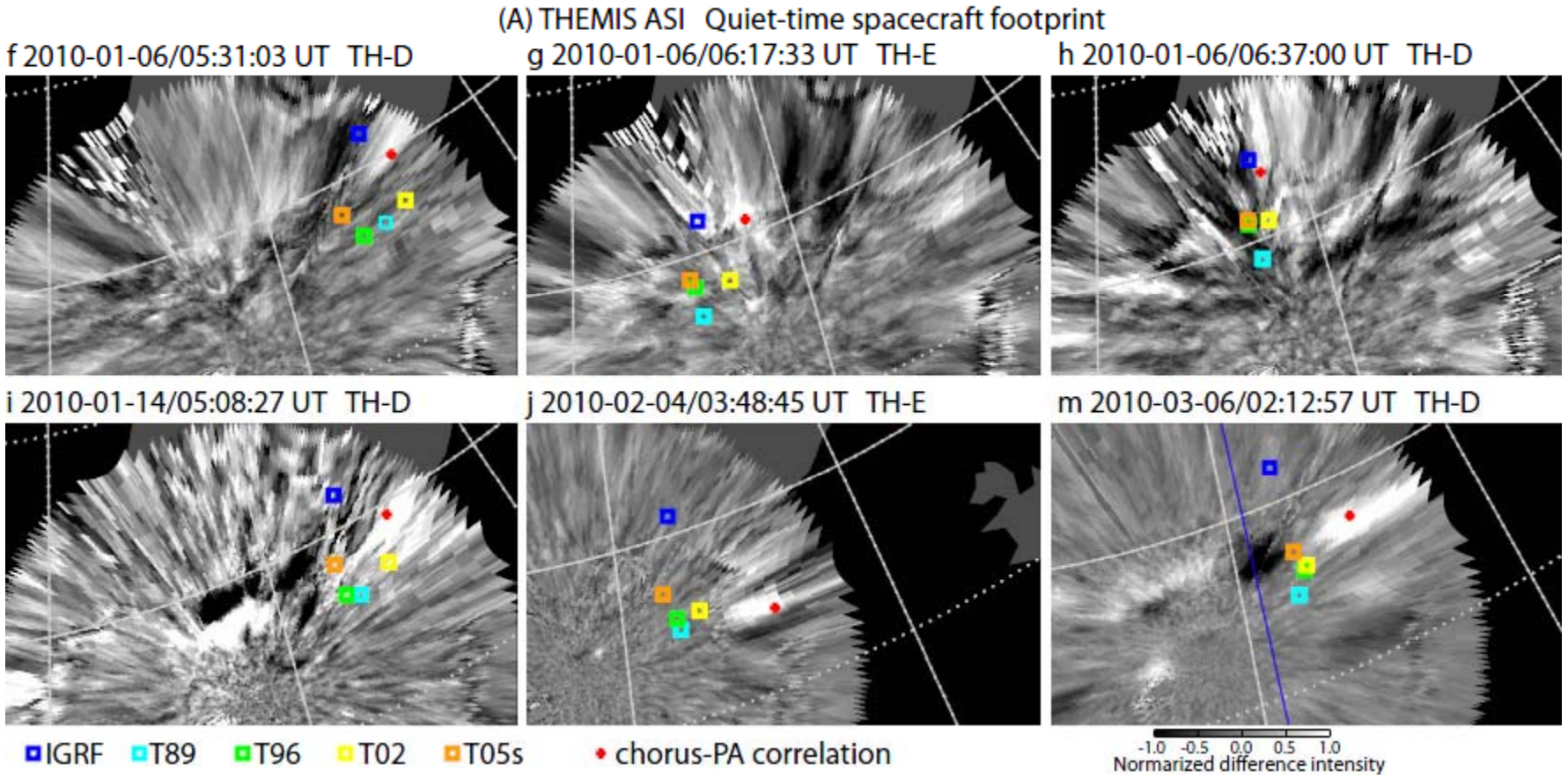


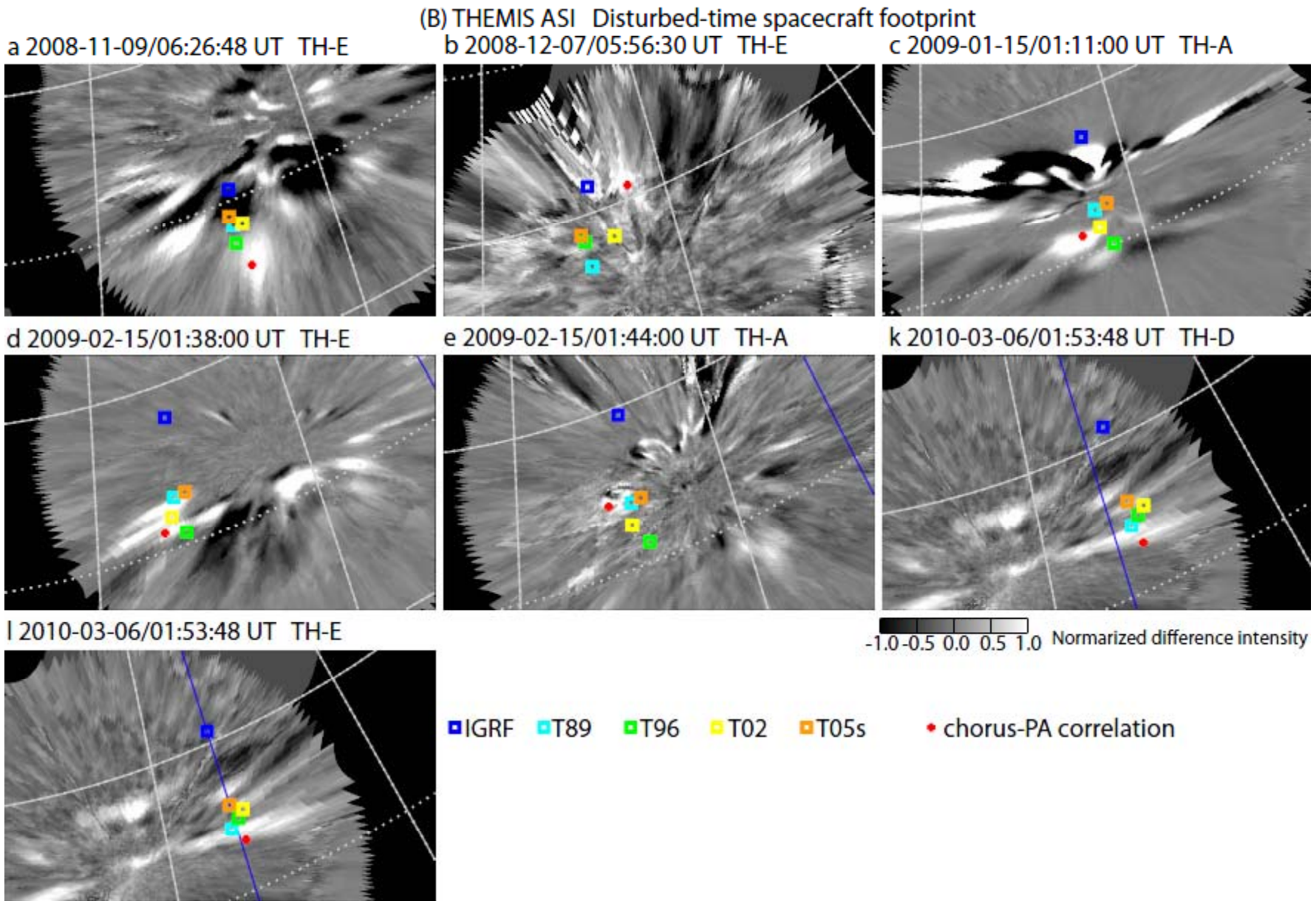
(b) Chorus measurement by a single spacecraft




Pulsating aurora and chorus patch sizes
(a)
Latitudinal size [km]
Radial size [km]
Pulsating auroral patch size in the ionosphere
Chorus patch size at the equator
Event
(b)
Longitudinal size [km]
Longitudinal size [km]
Event


(a)
Y [R_E]
X [R_E]
Ψ₀ [deg]
40°
30°
20°
10°
0°
−10°
−20°
−30°
−40°
(b)
f = 0.2f_c
f = 0.3f_c
f = 0.4f_c
20°
15°
10°
5°
MLAT=0°
E_RES [keV]
MI AT


(A) THEMIS ASI Quiet-time spacecraft footprint
f 2010-01-06/05:31:03 UT TH-D
g 2010-01-06/06:17:33 UT TH-E
h 2010-01-06/06:37:00 UT TH-D
i 2010-01-14/05:08:27 UT TH-D
j 2010-02-04/03:48:45 UT TH-E
m 2010-03-06/02:12:57 UT TH-D
IGRF
T89
T96
T02
T05s
chorus-PA correlation
-1.0 -0.5 0.0 0.5 1.0
Normarized difference intensity


(B) THEMIS ASI Disturbed-time spacecraft footprint
a 2008-11-09/06:26:48 UT TH-E
b 2008-12-07/05:56:30 UT TH-E
c 2009-01-15/01:11:00 UT TH-A
d 2009-02-15/01:38:00 UT TH-E
e 2009-02-15/01:44:00 UT TH-A
k 2010-03-06/01:53:48 UT TH-D
l 2010-03-06/01:53:48 UT TH-E
-1.0 -0.5 0.0 0.5 1.0
Normarized difference intensity
IGRF
T89
T96
T02
T05s
chorus-PA correlation