Comparison of electric field between THEMIS satellites and their ionospheric conjugate points

Guiping Liu, Scott England, Stephen Mende,

Thomas Immel, Harald Frey, John Bonnell,

Vassilis Angelopoulos

Sep, 2011

THEMIS & ISR E-field comparison

- Compare **E-fields** between the **magnetosphere** and the **ionosphere** (in two regions).

- Compare **simultaneous observations** between **THEMIS** satellites

  - ~10RE distance in the magnetosphere

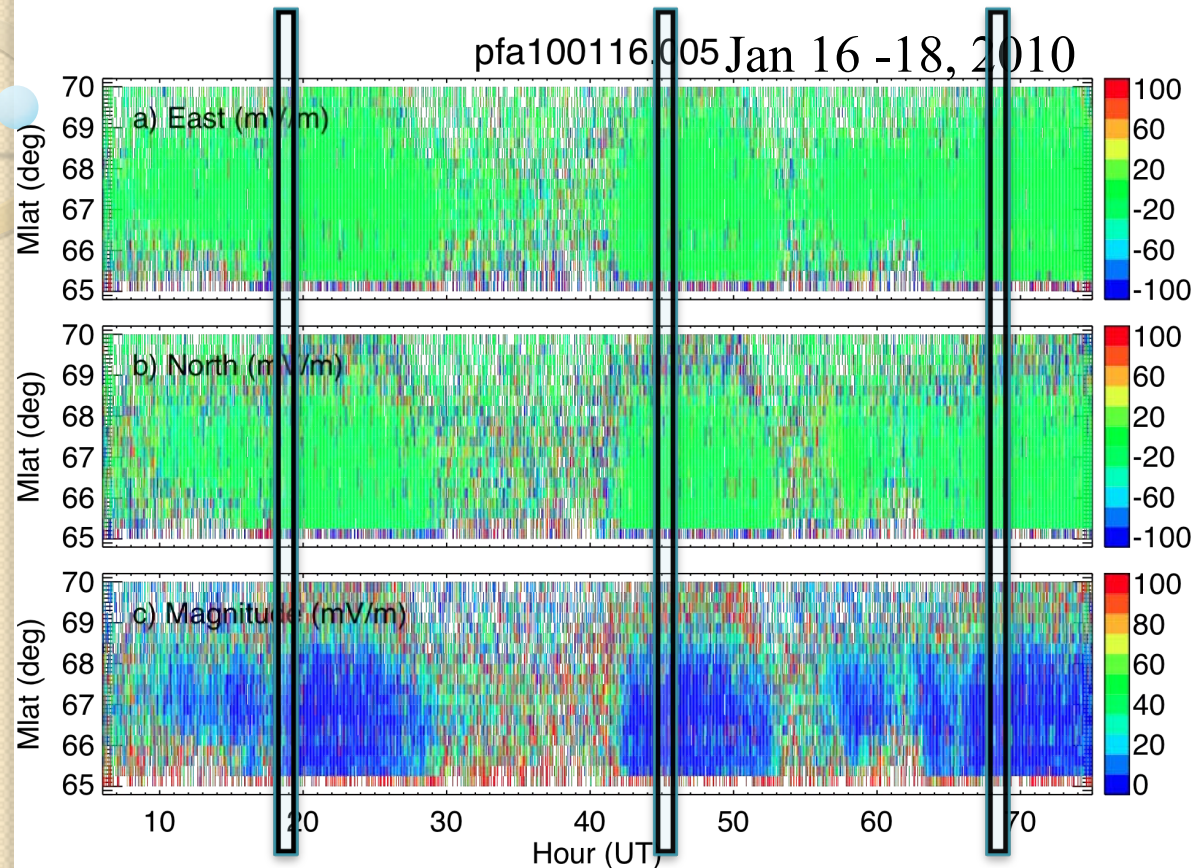 and **conjugate points observed by the ISR**

  - at Poker Flat (65°N, 147°W).

THEMIS satellite footpoint

2010-04-26

pfa ◄
(65°N, 147°W)

2011-03-01
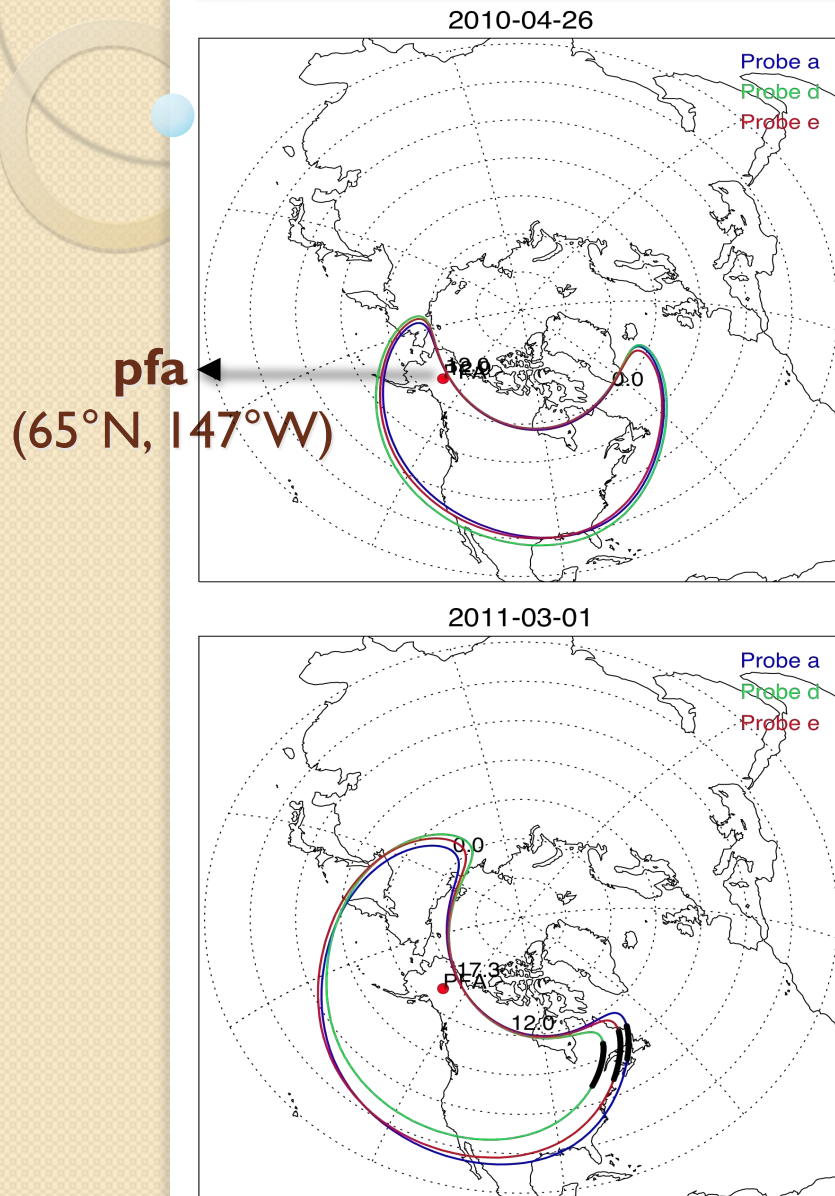
Footpoints of the THEMIS satellites (a, d, e) for one day. The top plot is for Apr 26, 2010. The bottom one is for a different day. The red dot gives the location of the ISR at Poker Flat (65°N, 147°W).

- For the day of Apr 26, 2010, the THEMIS satellites have observations falling within the range of the ISR measurements at same times.

- We have looked at year 2010, and looked for overlapped observations between THEMIS satellites and the ISR at Poker Flat.

Poker Flat ISR E- field

- ISR E-field perp measurement at 3min time intervals.

- Poker Flat ISR measurements cover the range of mlat 65°-72°and the longitude coverage is about 6°.

- We have looked for THEMIS data within this range.

Overlaps

E-perp measurements by the ISR at Poker Flat during Jan 16-18, 2010. a) East component, b) North component, c) Magnitude. (Data are from http://www.openmadrigal.org)

- Overlaps are for ~1hr time period on each day.

4

THEMIS Observations (THA)

11:00-12:30

pos

EFI

B-

-VXB

E
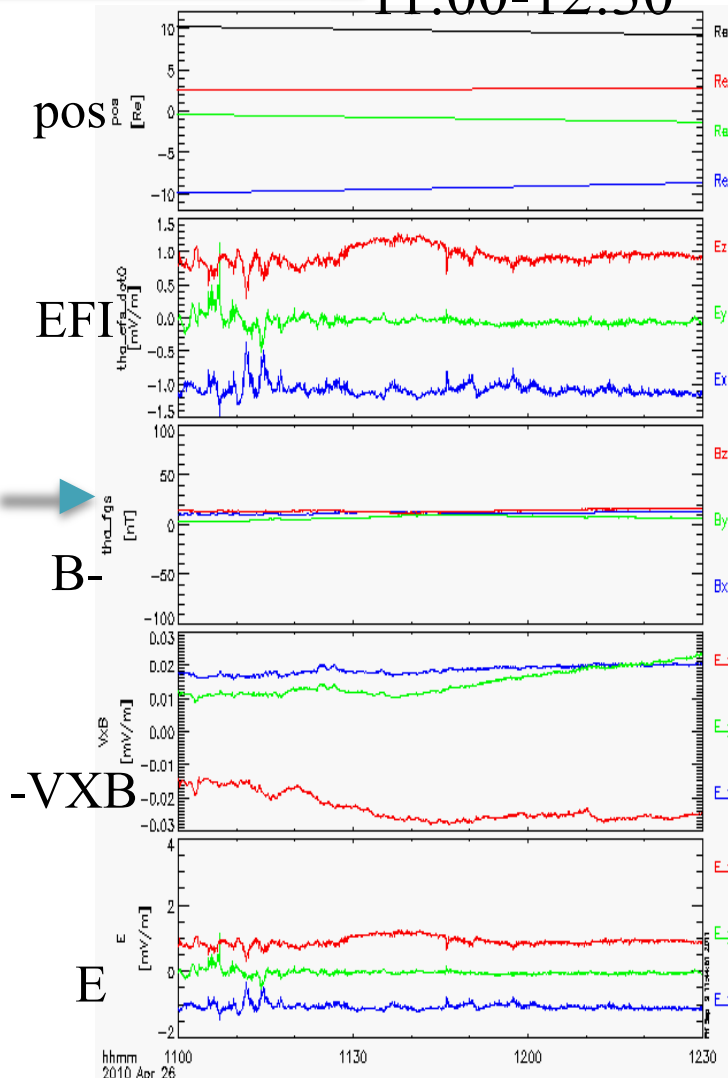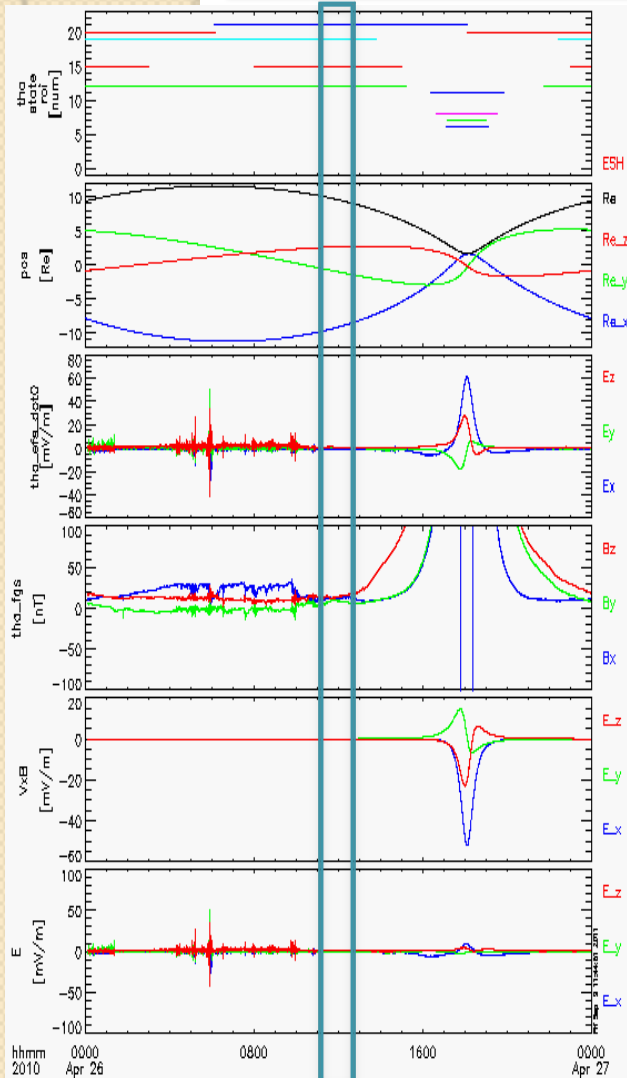
- Satellite distance is ~7-10RE during these overlaps.

- E-field assuming edotb=0 measured by the onboard EFI.

- B- measured by the onboard FGS.

- Remove E=-VXB produced by SC movement.

- Actual E- field has the magnitude of ~a few mV/m.

THEMIS tha satellite observations for one day on Apr 26, 2010.

Overlaps

5

Compare E-field bw THEMIS & ISR

- Overlaps (coincidence in time and space) between THEMIS satellites and the Poker Flat ISR (pfa).

  Year 2010 for each satellite:

  ~27 days of data, in the first half year (Jan to July)

  ~1 hr/day (3min interval) – 20 points (comparison)/day

  ~30X20 (600) data points.

- Comparison

  East direction,

  North direction,

  Magnitude.
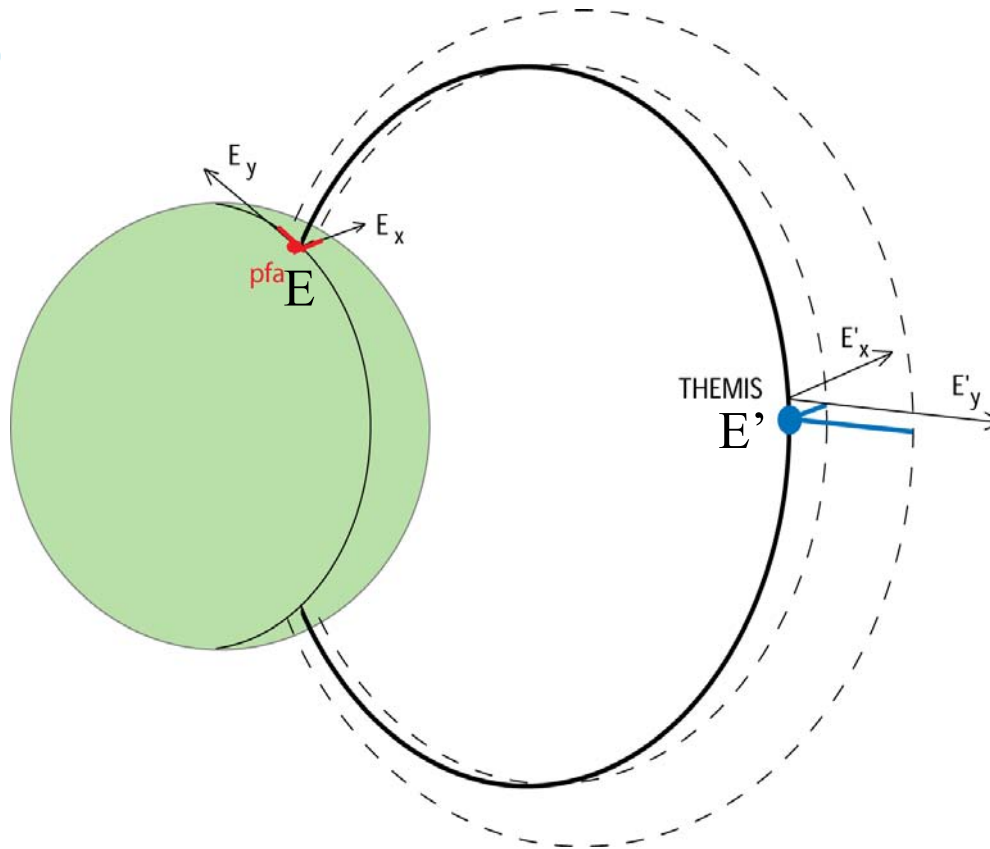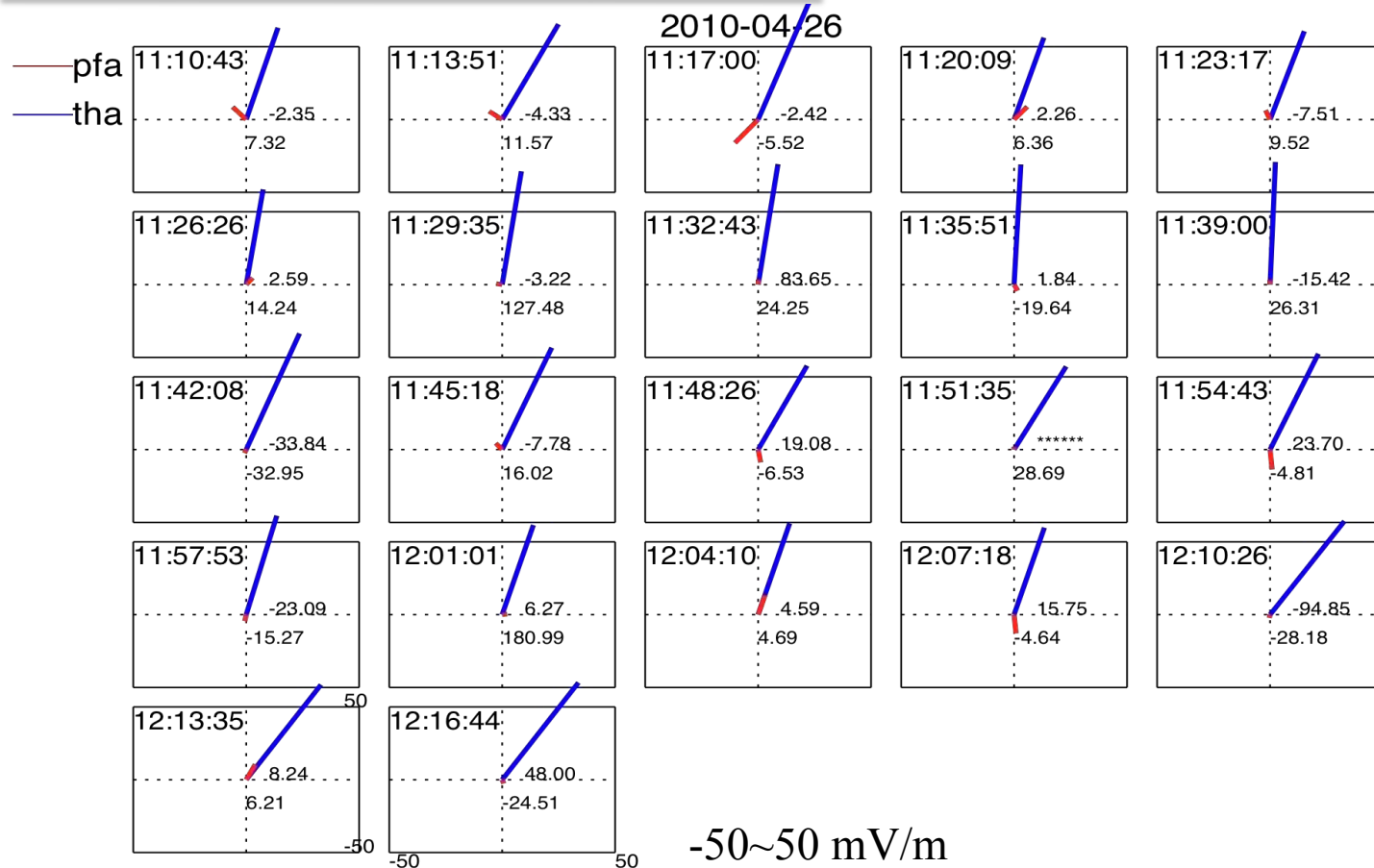
Find east/north directions in space

Illustration of mapping the THEMIS satellite position to the ground and finding the East/North directions of E-field in space.

- We use the Tsyganenko magnetic field model (T89) to map satellite positions to the ground.

- Suppose E is one point on the ground (close to pfa). It maps to E' (at THEMIS position) along the magnetic field line.

- On the ground, we move 1° east of E and 1° north of E. At pfa, these are **~47km** and **111km** distances.

- Find Ex' and Ey' in space, and their distances to E'. Scale THEMIS data by these distances compared to the ground.

## *E-east and E-north comparison*

2010-04-26

pfa
tha

11:10:43 -2.35 7.32	**11:13:51** -4.33 11.57	**11:17:00** -2.42 -5.52	**11:20:09** 2.26 6.36	**11:23:17** -7.51 9.52
11:26:26 2.59 14.24	**11:29:35** -3.22 127.48	**11:32:43** 83.65 24.25	**11:35:51** 1.84 -19.64	**11:39:00** -15.42 26.31
11:42:08 -33.84 -32.95	**11:45:18** -7.78 16.02	**11:48:26** 19.08 -6.53	**11:51:35** ****** 28.69	**11:54:43** 23.70 -4.81
11:57:53 -23.09 -15.27	**12:01:01** 6.27 180.99	**12:04:10** 4.59 4.69	**12:07:18** 15.75 -4.64	**12:10:26** -94.85 -28.18
12:13:35 8.24 6.21	**12:16:44** 48.00 -24.51			

50

-50

-50   50

-50~50 mV/m

E-x (east) and E-y (north) for THEMIS (blue) and ISR (red) for each 3-min overlap on Apr 26, 2010. The plotting range is 50 mV/m for both directions.

Differences between THA & ISR
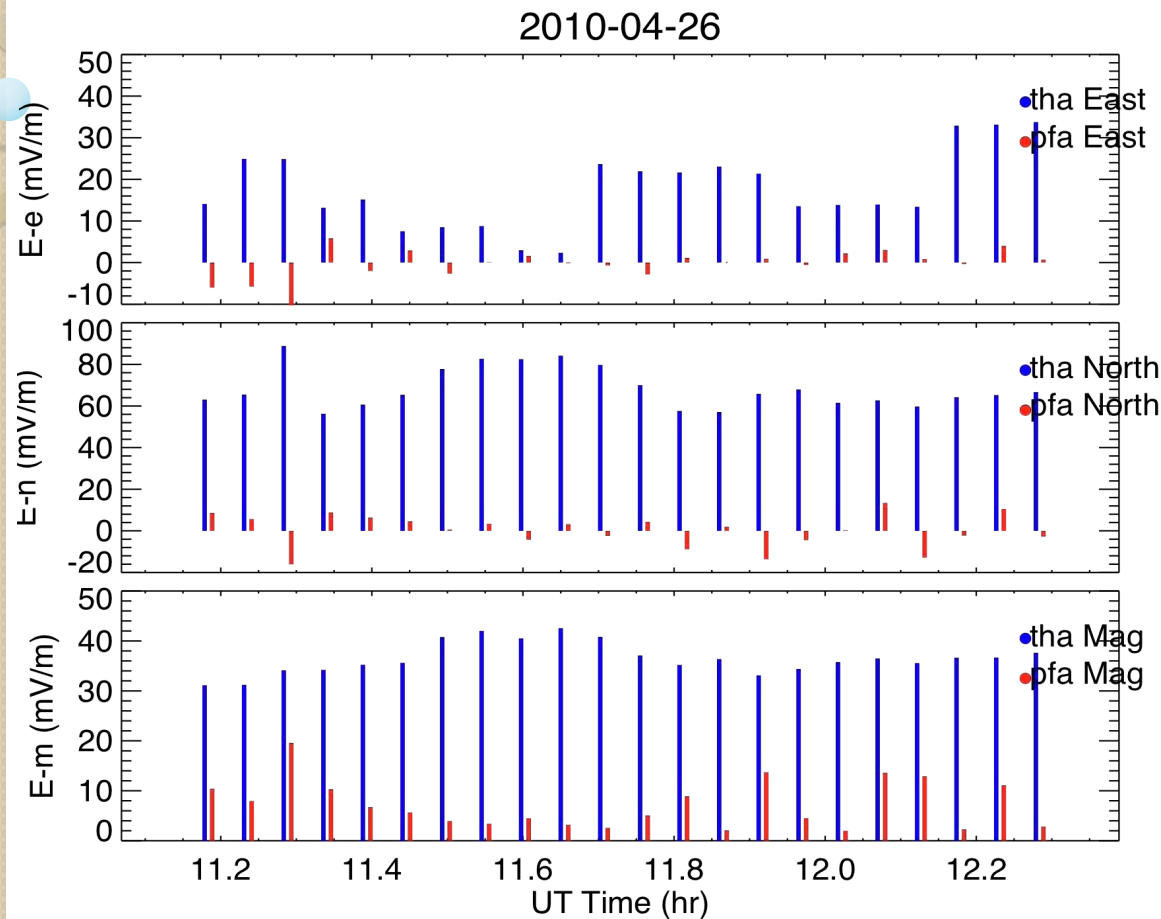
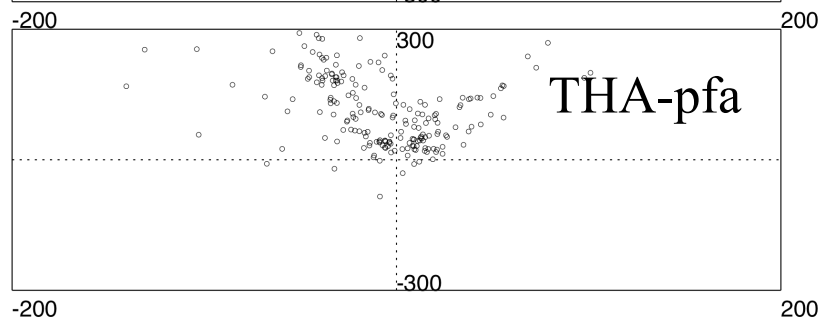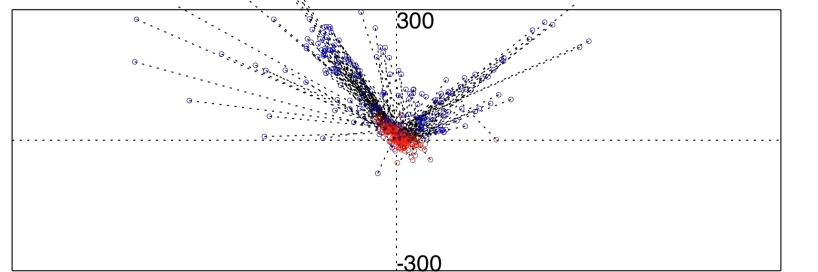E- field by THA (blue) and PFA (red) for east and north directions, and magnitude on Apr 26, 2010.

• blue line is longer than the red line. THEMIS component is larger than the ISR.
• x-direction, the difference could be as large as 50mV/m.
• y-direction, the difference could be ~100mV/m.
• magnitude, the difference is about 50mV/m.

Comparison for 2010

Morning

Evening

THA-pfa

THA-pfa
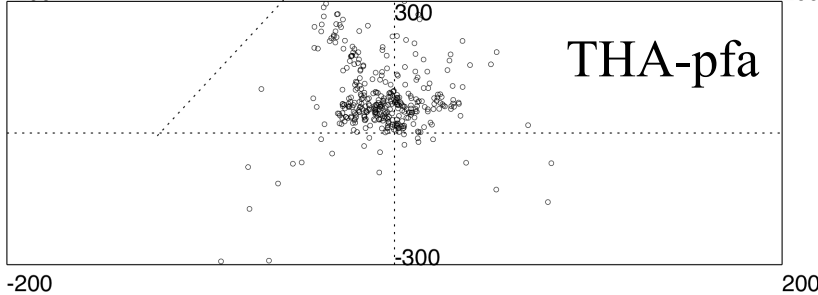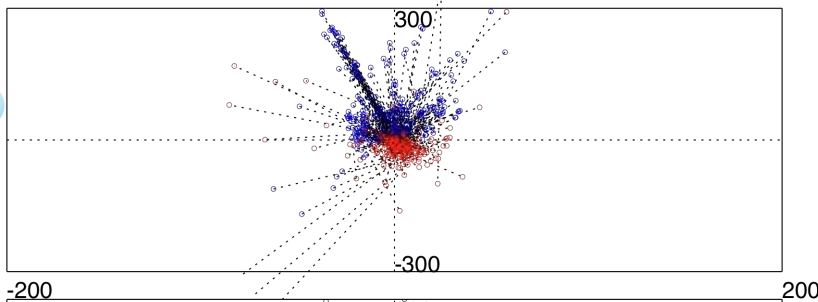
- We group the data by MLT. One group is for the hours after midnight (top plot). Another is for before midnight (bottom plot). They have ~20 days and 10 days of data.

E-x and E-y by THA (blue) and the ISR (red) are plotted for days of overlapped observations during 2010. The differences (tha-pfa) for each overlap are plotted as a black dot at the bottom panels.

- x-direction, differences are both positive and negative. y-direction, they are more positive. THEMIS are mostly greater than ISR for the North component.

Comparison for 2010
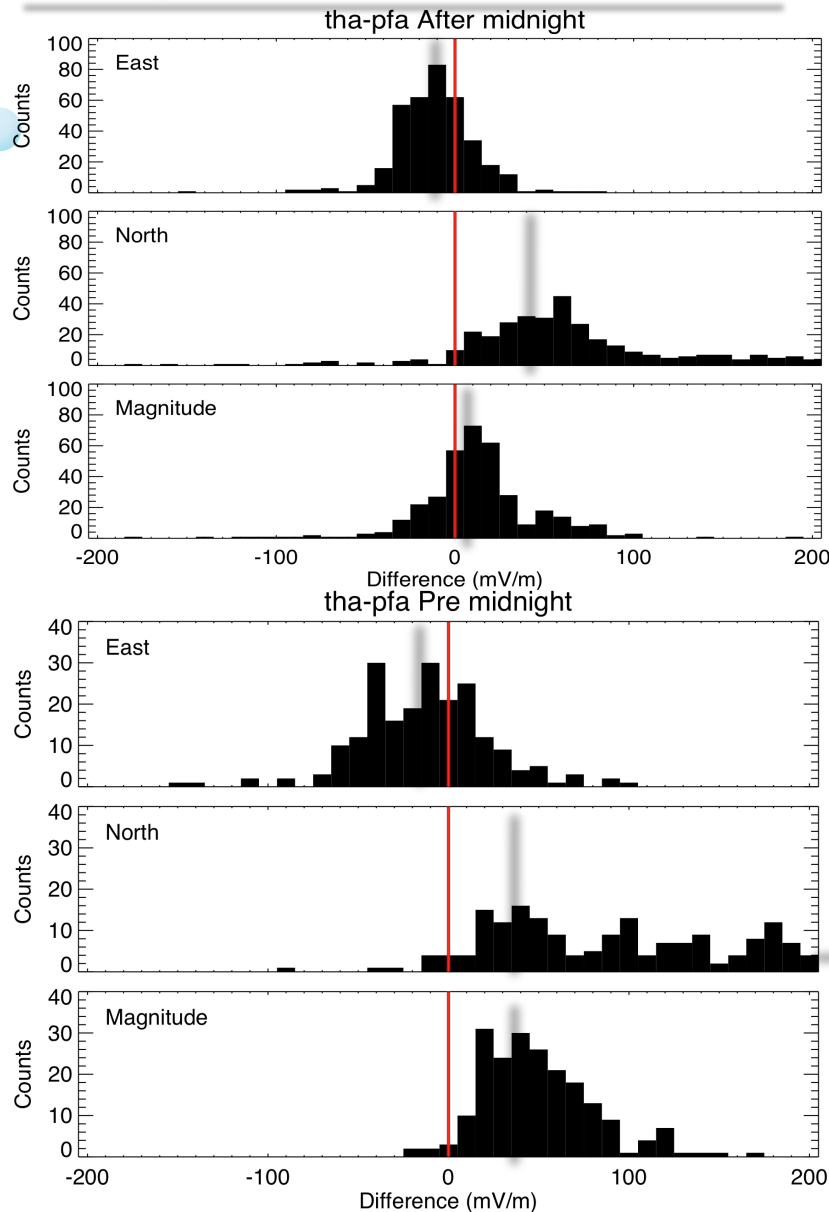
Morning

Evening

Histogram of differences (**THA-pfa**) for two groups of data during 2010. These differences are plotted for the x-(east), y-(north), and the magnitude components.

- For the morning hr group, the difference in x- is ~10mV/m. E-x is smaller in THEMIS. The difference is ~50mV/m in y-. E-y is larger in THEMIS. The magnitude difference is small.
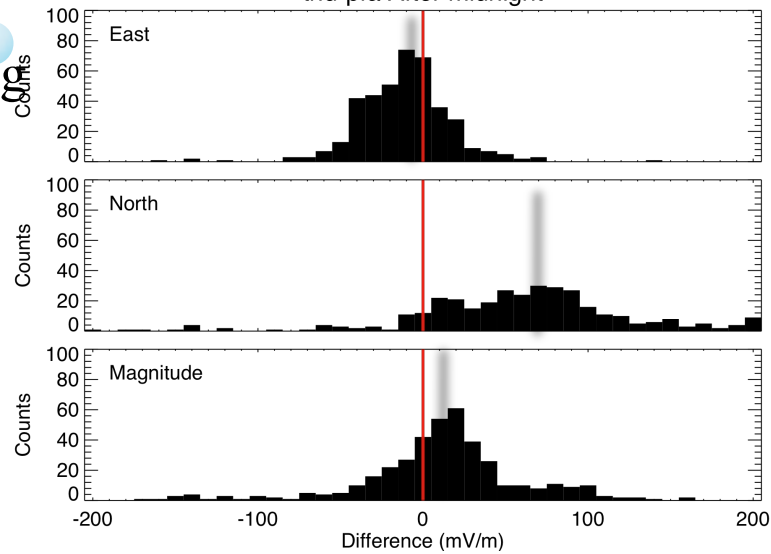- Similar results for the pre-midnight group.
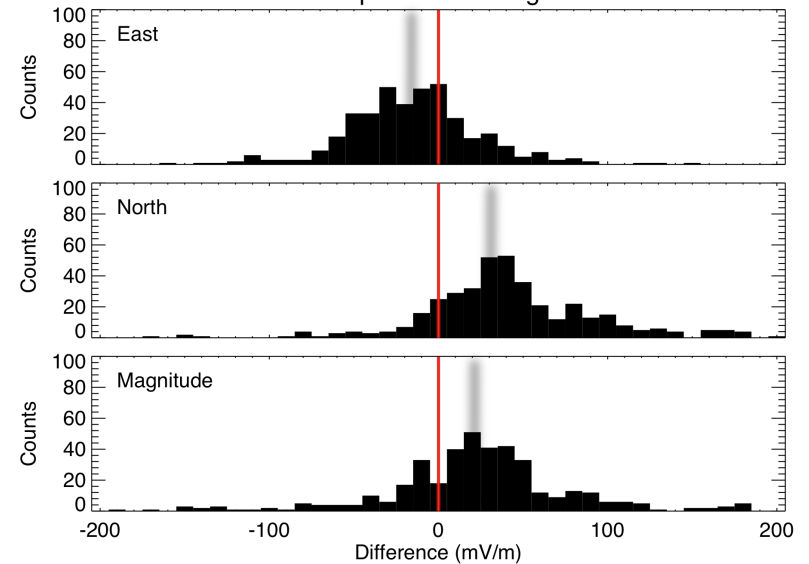
Not enough data points?

Other satellites (thd & the)
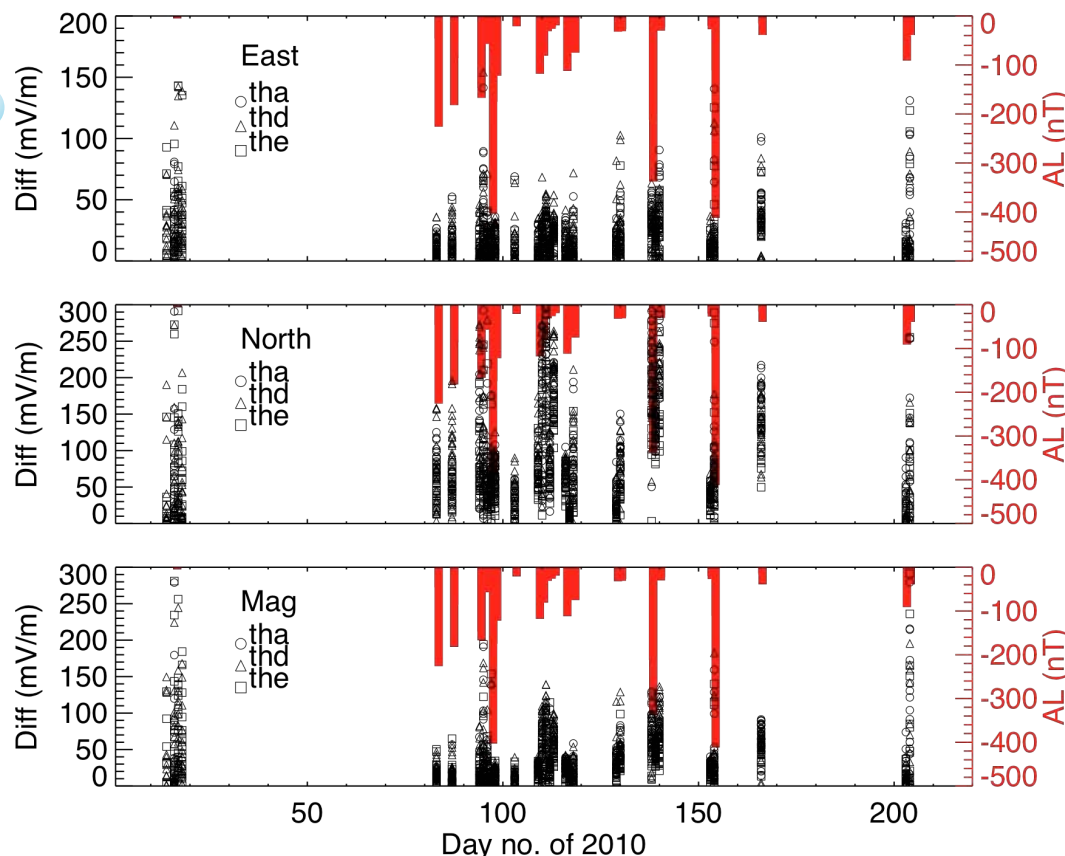
thd

the

morning

evening
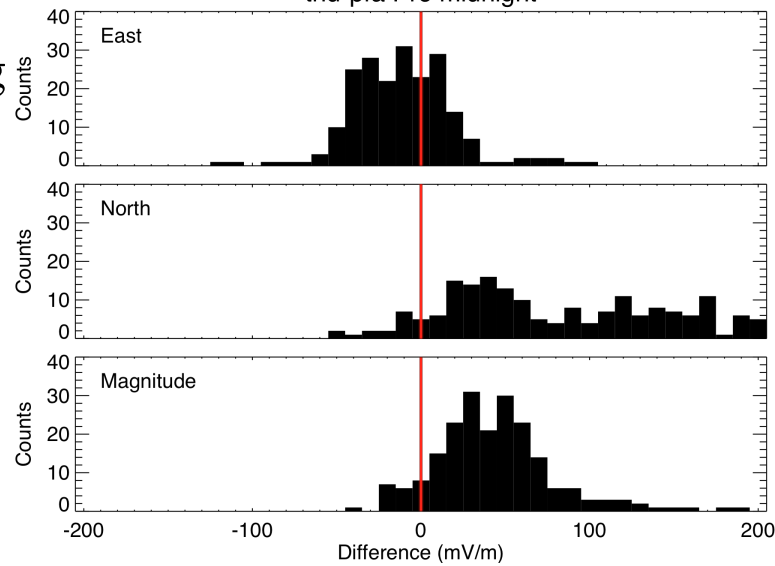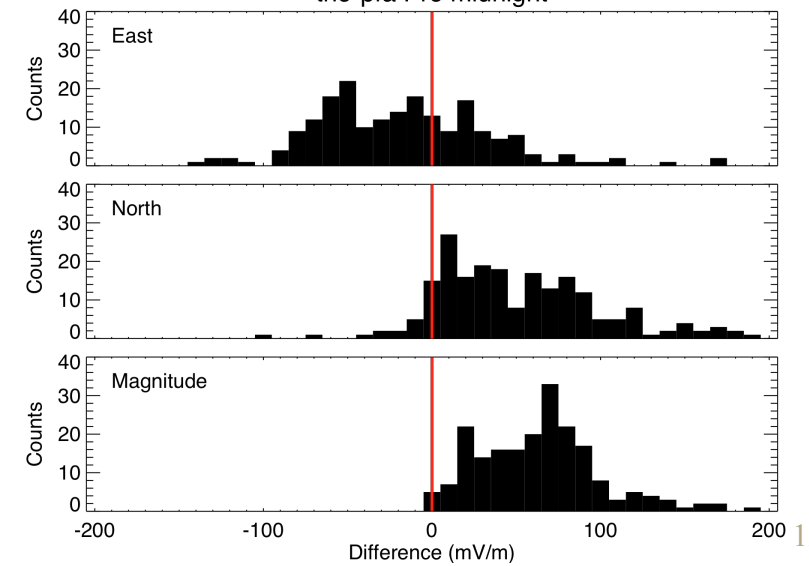
Three satellites & AL

- Differences of the three satellites appear to be consistent.
- The AL indexes are also included. The values are mostly negative during the overlaps between THEMIS and the pfa ISR for year 2010.
- AL doesn't appear to correlate with the difference.

Differences between THEMIS satellites (different symbols) and the pfa ISR during 2010. They are plotted with the hourly AE index (red) on each day.

Let's look at some cases

2010-04-05

2010-04-07
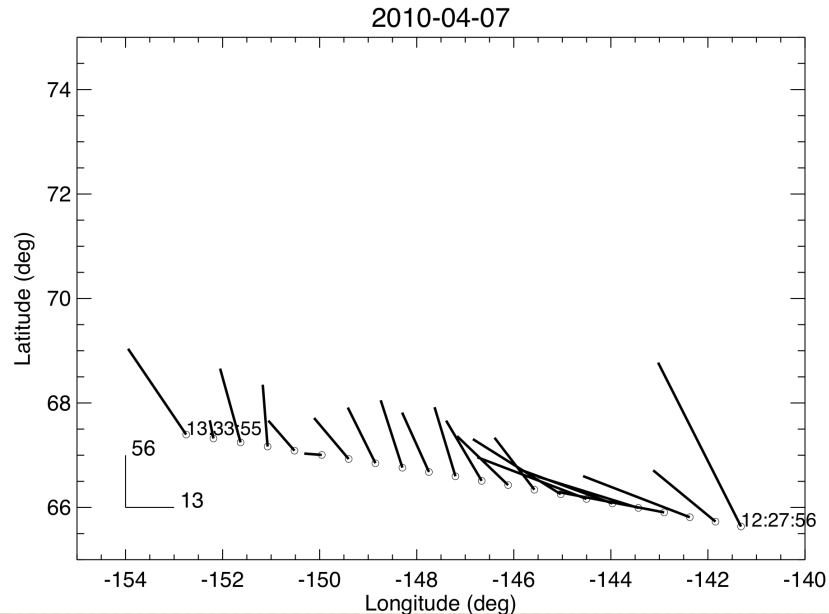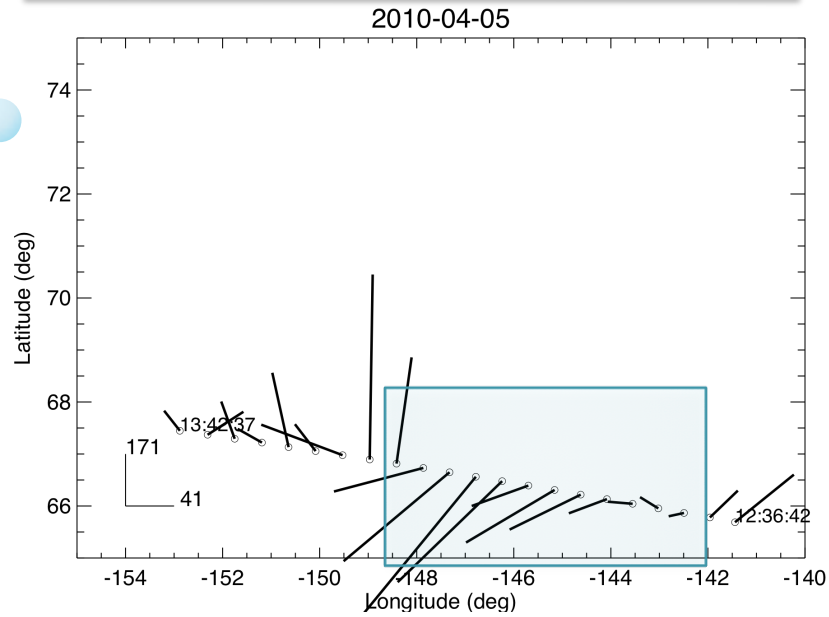
Difference vector between Tha and ISR for each overlap on one day. The vector is scaled in x- and y-directions.

The difference vector has a large change during this day. The vector changes direction from positive to negative.
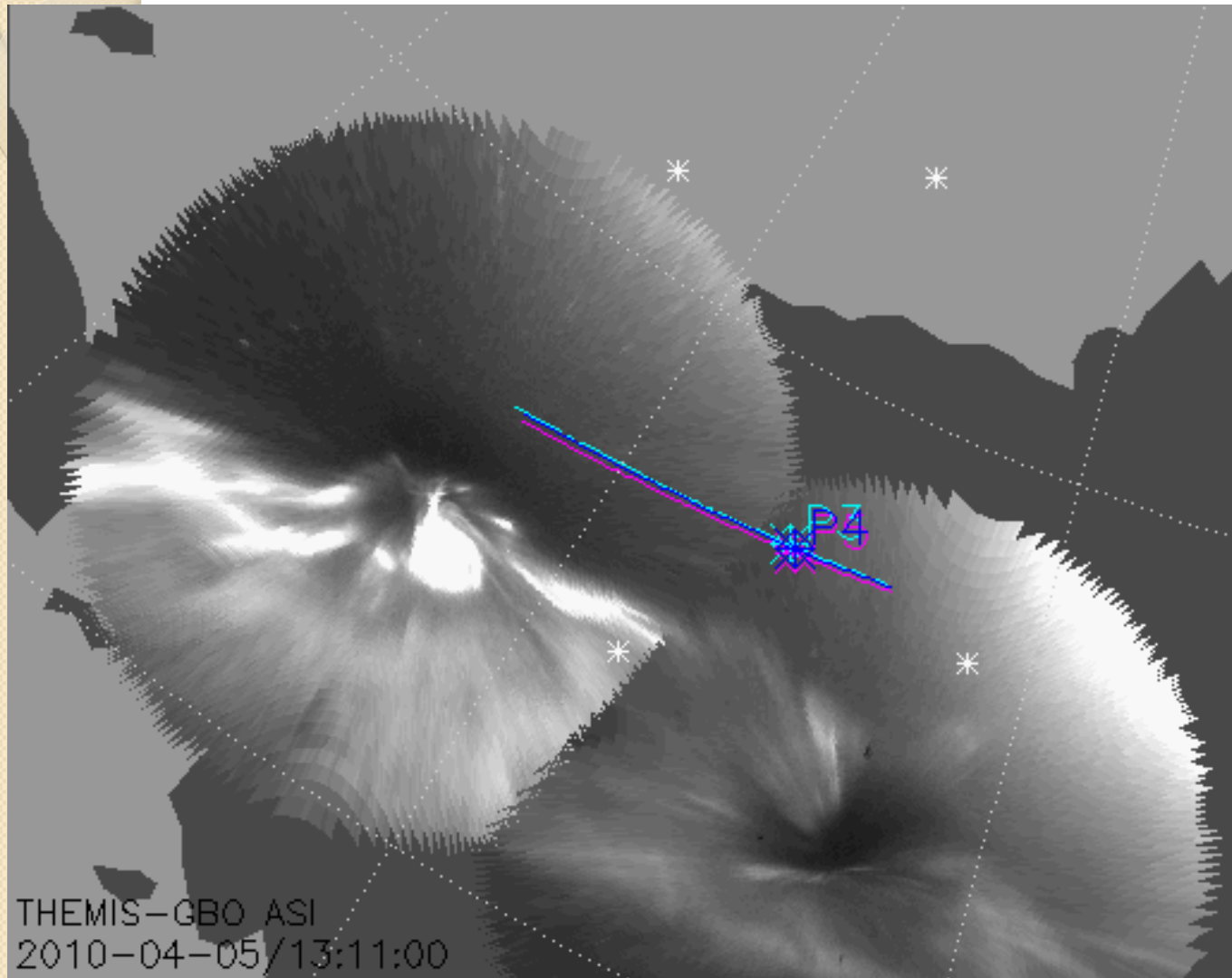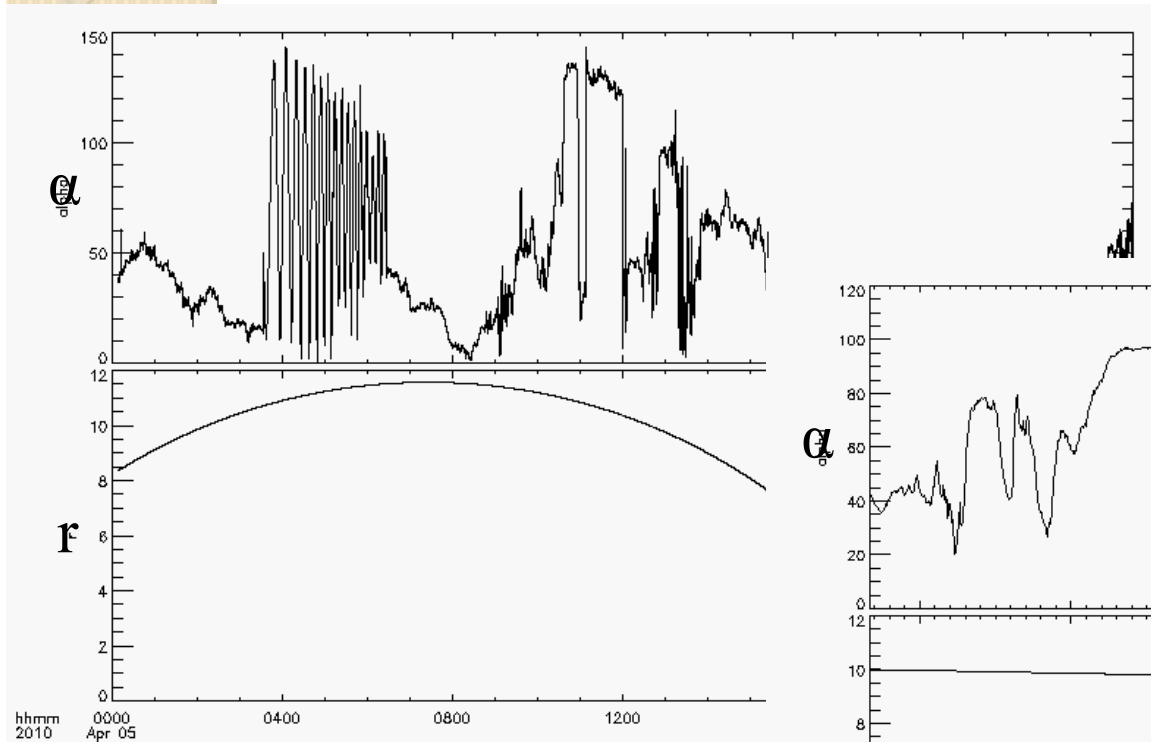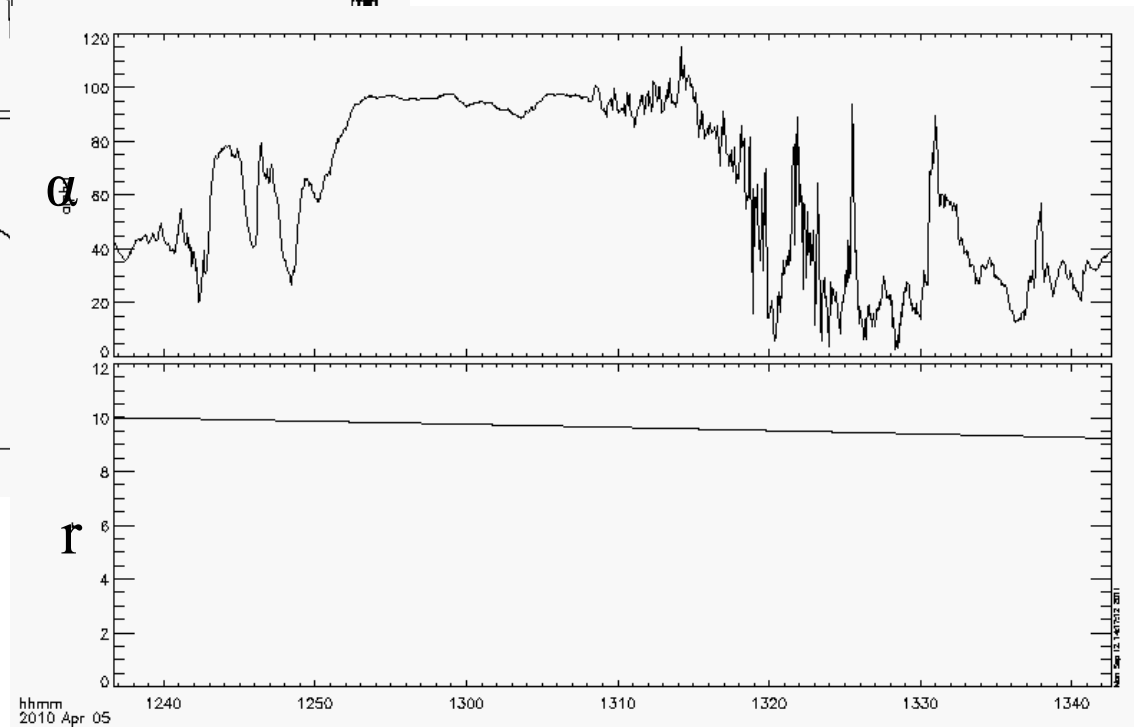
All-sky Imager Data

Image taken by the all-sky imagers at KIAN at 13:11:00 on 2010-04-05.

Difference bw T89 and fgs
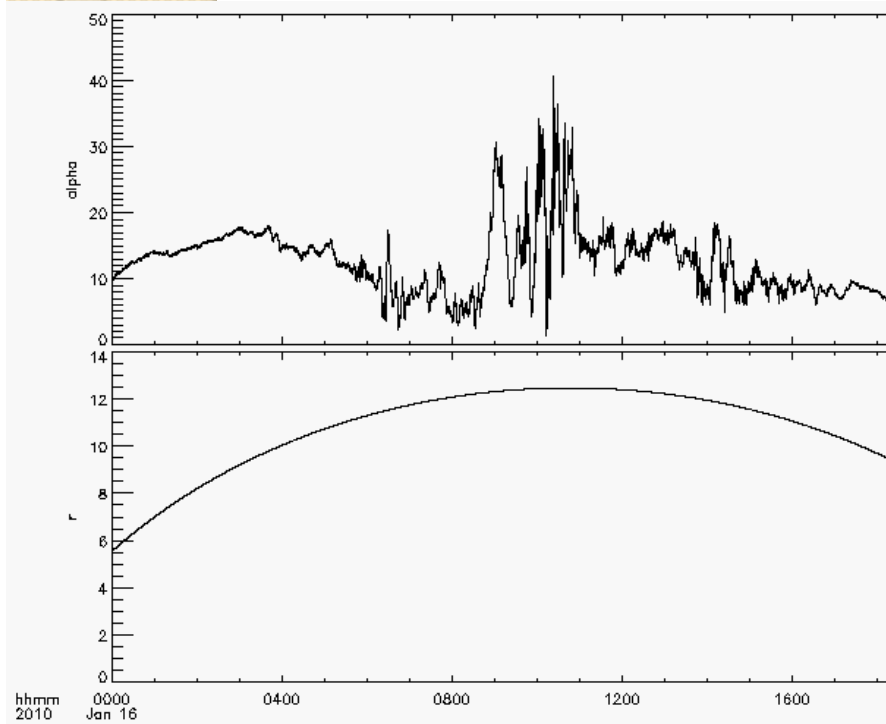
2010-04-05

12:30 – 13:30

Top: Angle between the calculated B- vector and the measured one. Bottom: The distance of the spacecraft to the Earth's center.

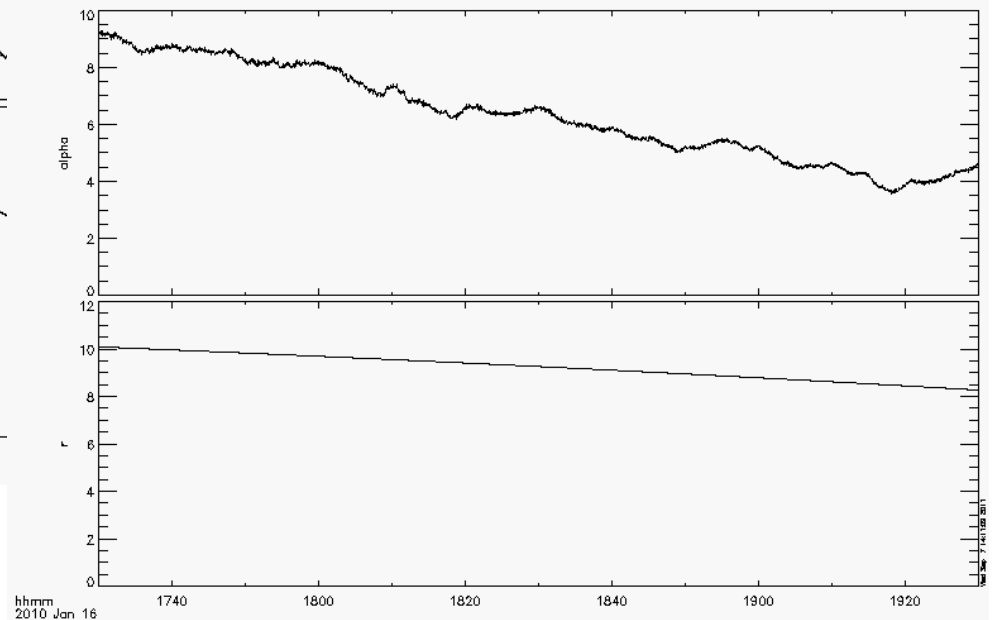modeled B- field largely differs to the measured field.

Difference bw T89 and fgs

2010-01-16

17:30 – 19:30

Angle between the calculated B-vector and the measured one. The distance of the spacecraft to the Earth's center is plotted at the bottom panel.

The angle is small at large RE distance when THEMIS overlaps with the ISR. The modeled B- field is almost on the same direction as the measured one.

Summary

- We compared the simultaneous observations of E-field between the THEMIS satellites in the magnetosphere and their ionospheric conjugate points at Poker Flat (65N, 147W) by the ISR.

- We compared the E-field data for both east (x-) and north (y-) directions, and also the magnitude between the two data sources. The Tsyganenko magnetic field model was used to map the satellite data to the conjugate observations.

- Compared ~20 days of data (600 data points) for 2010. x-direction, THEMIS data are ~10mV/m smaller than the ISR y-direction, THEMIS are larger by ~40mV/m. The magnitude difference is 10-50mV/m between them.

- Large change is seen in the difference vectors between THEMIS and the ISR. This could be related to substorm onset.