Ionospheric plasma irregularities at high latitudes as observed by CHAMP

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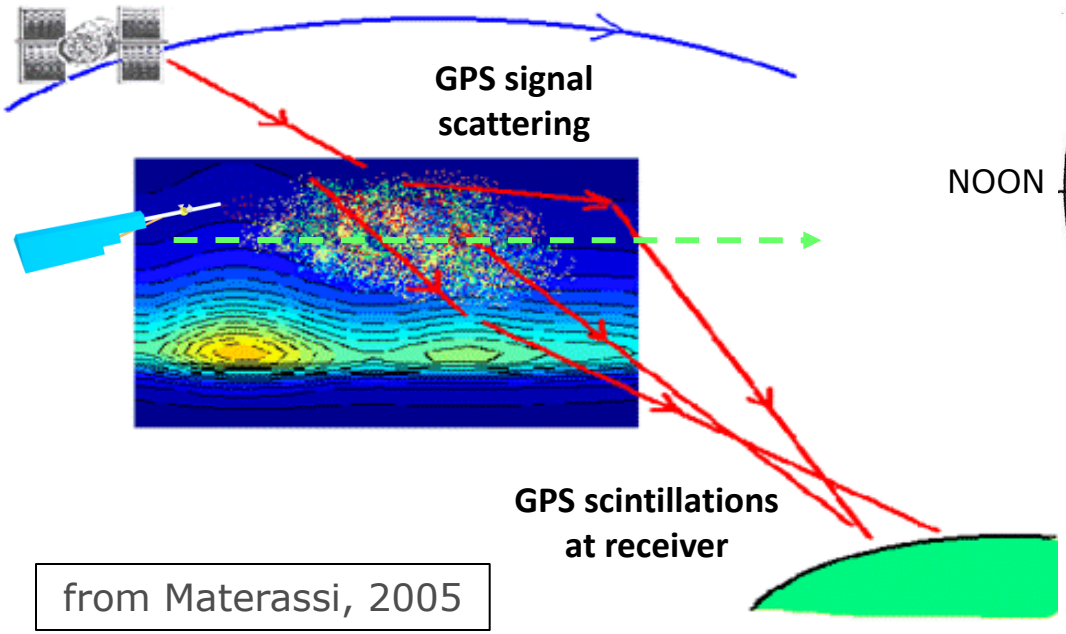
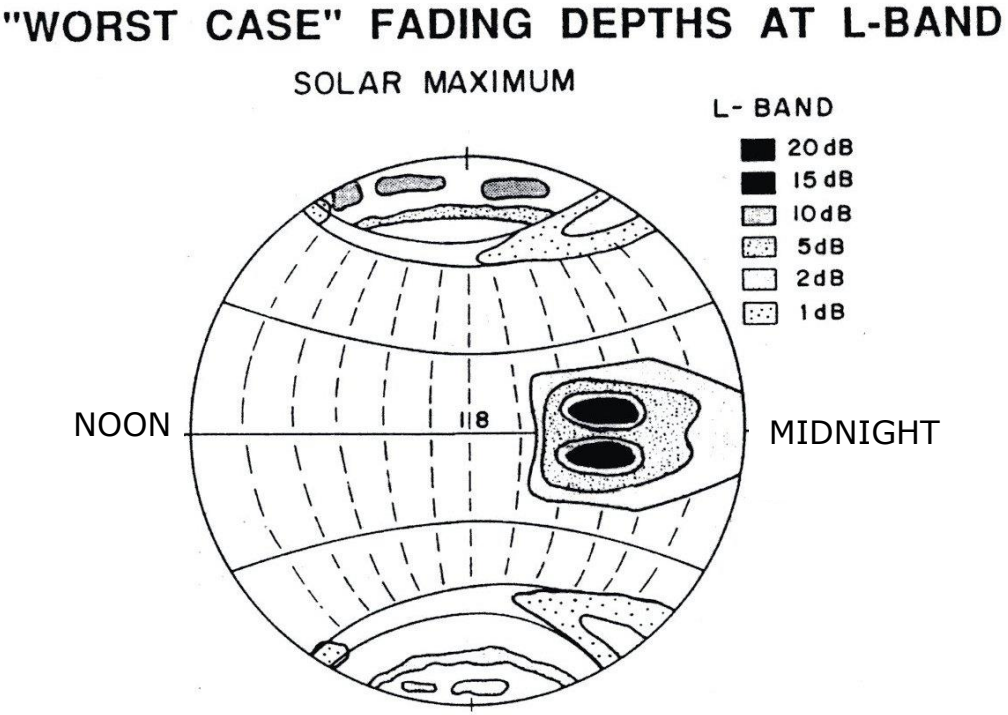
Disturbance of GPS signal by ionospheric irregularities

Steep electron density gradients scatter RF signals and affect systems like GPS.

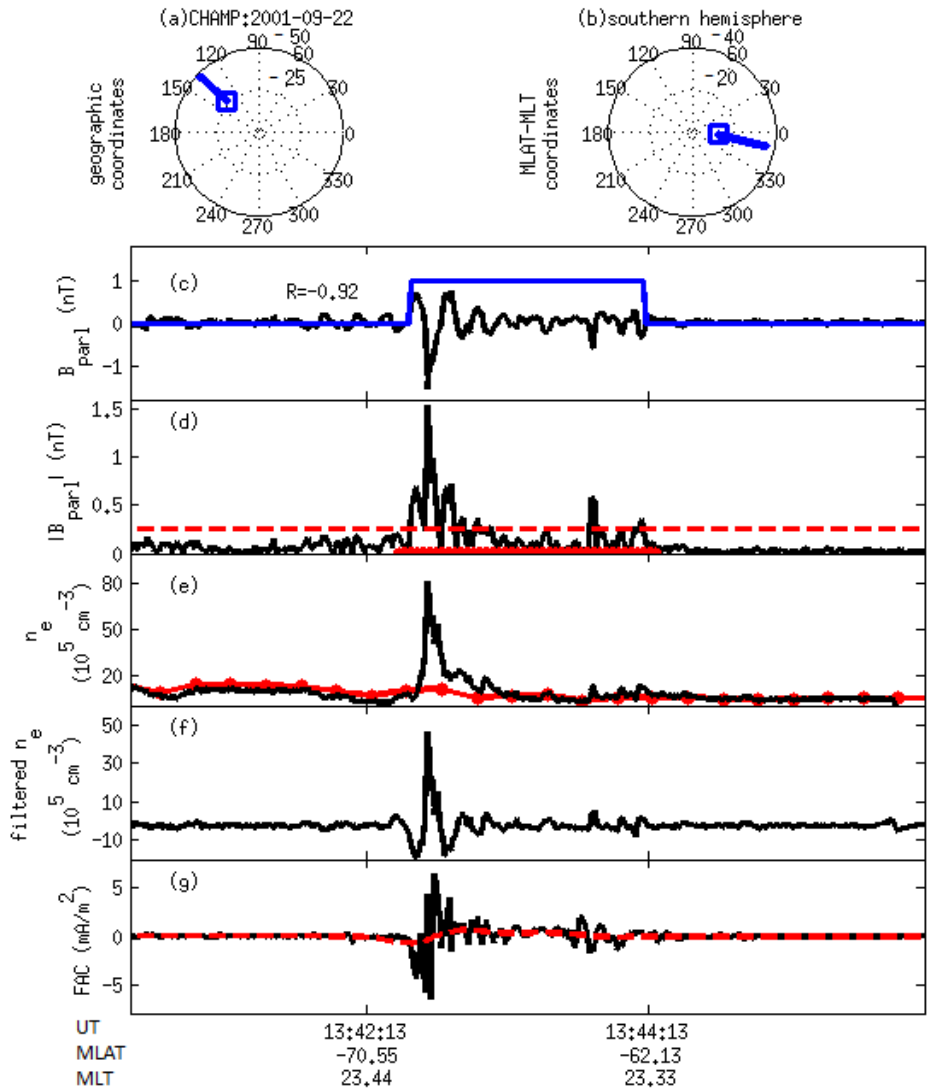


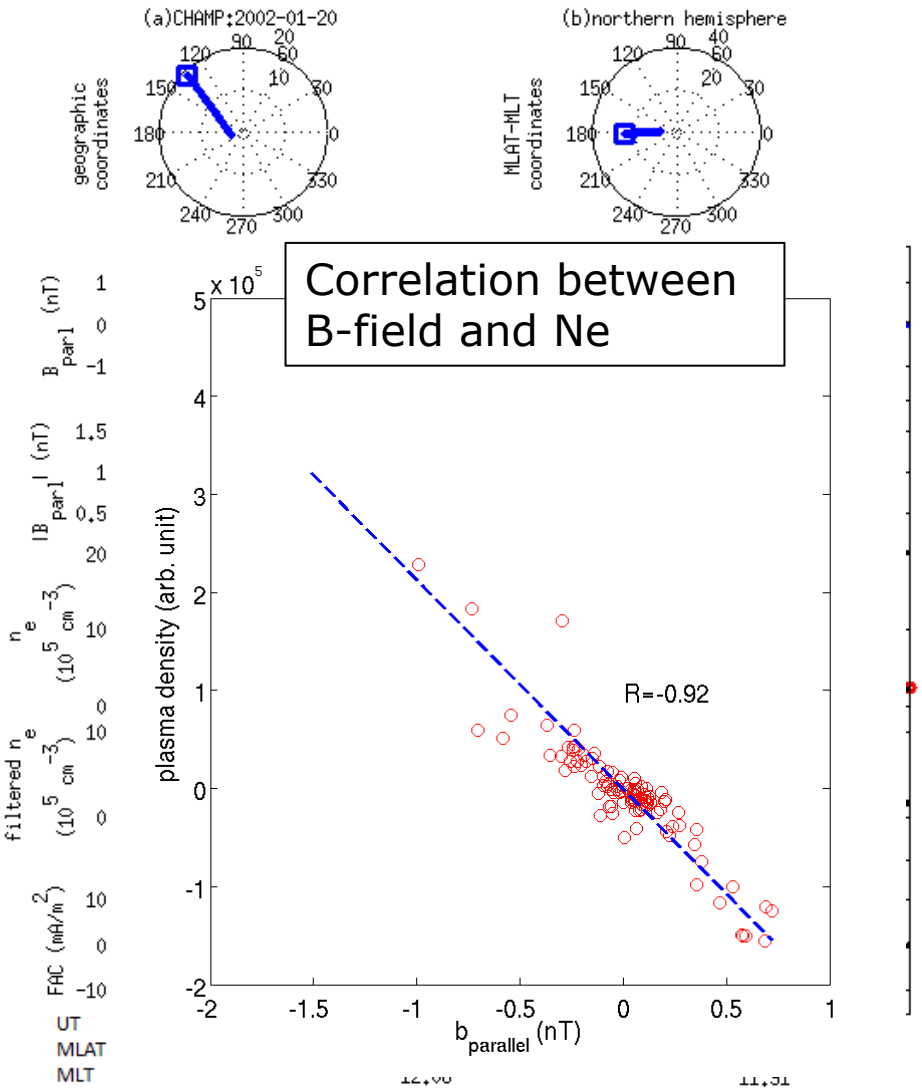
from Materassi, 2005



(Basu et al., 2002)

Two examples of ionospheric irregularities at high latitudes





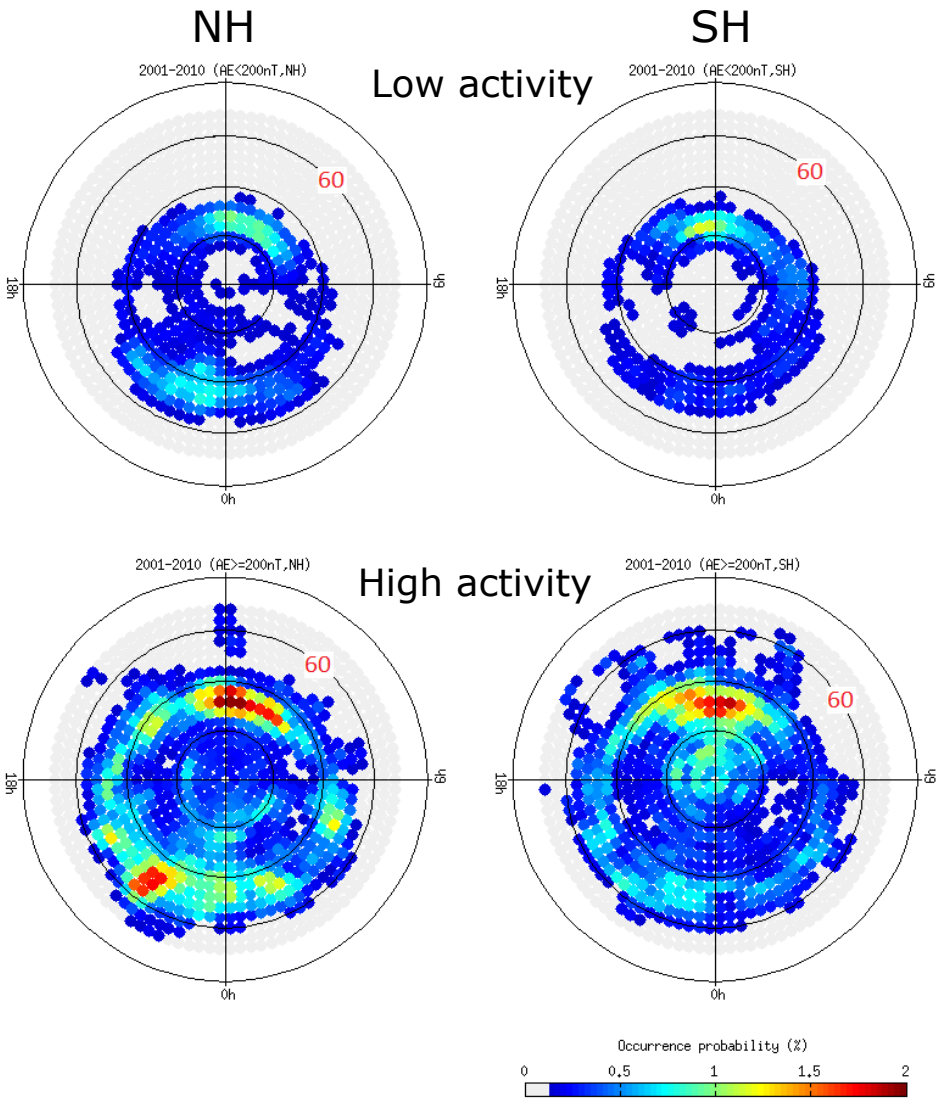
Characteristics of high-latitude irregularities

- The electron density is locally enhanced over scales of ~100km (steep gradients).
- As a response, the magnetic field strength is decreased (diamagnetic effect of dense plasmas).
- Irregularities are always accompanied by bursts of small-scale field-aligned currents.

Dependence of irregularities on auroral activity

The occurrence frequency of irregularities depends significantly on the auroral activity.

Preferred region of occurrence is the auroral oval.
In particular, the cusp around noon and the substorm sector before midnight.



Seasonal dependence of irregularities

The occurrence rate is generally high during equinox months.

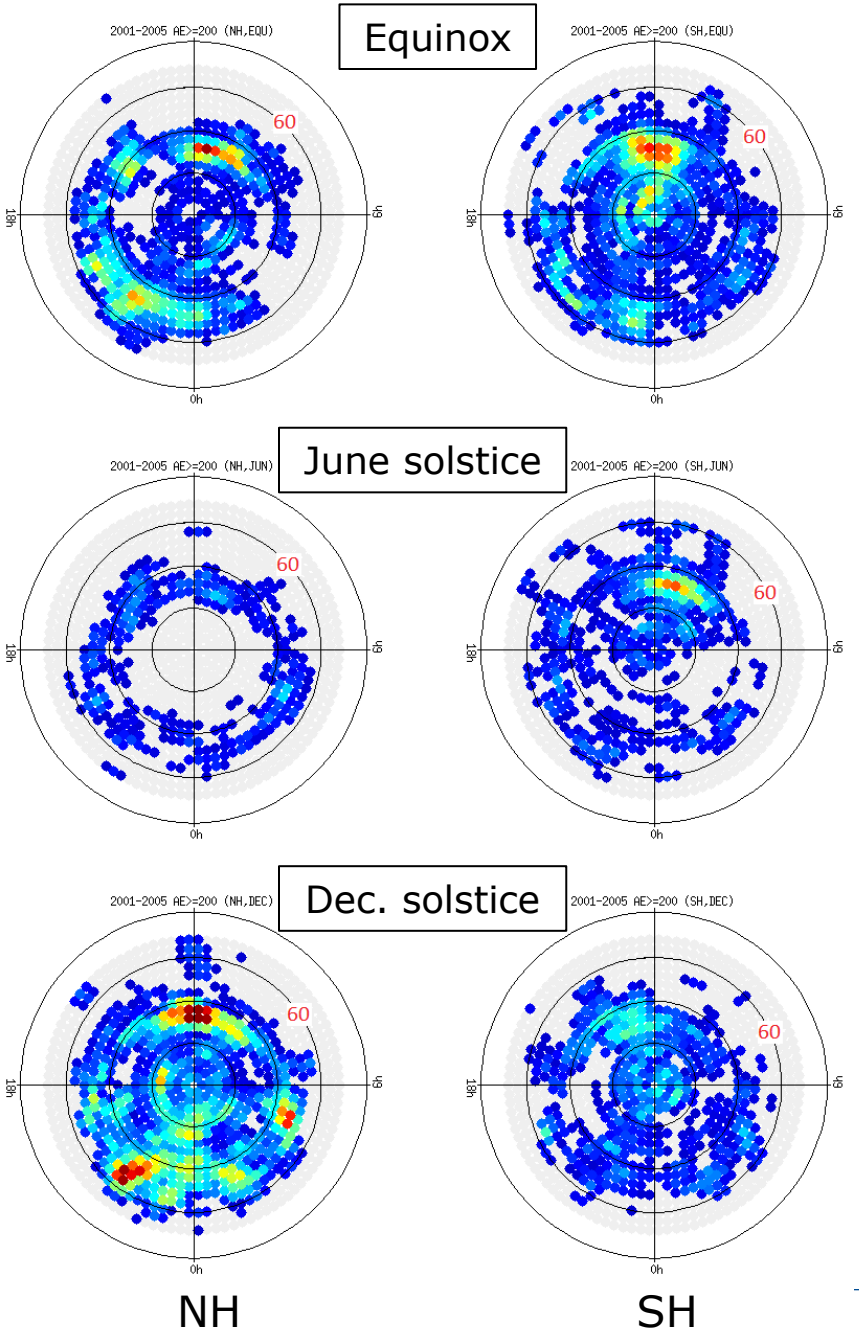
In the northern hemisphere many more events are observed around December solstice than around June.

This seasonal difference is not so pronounced in the southern hemisphere.

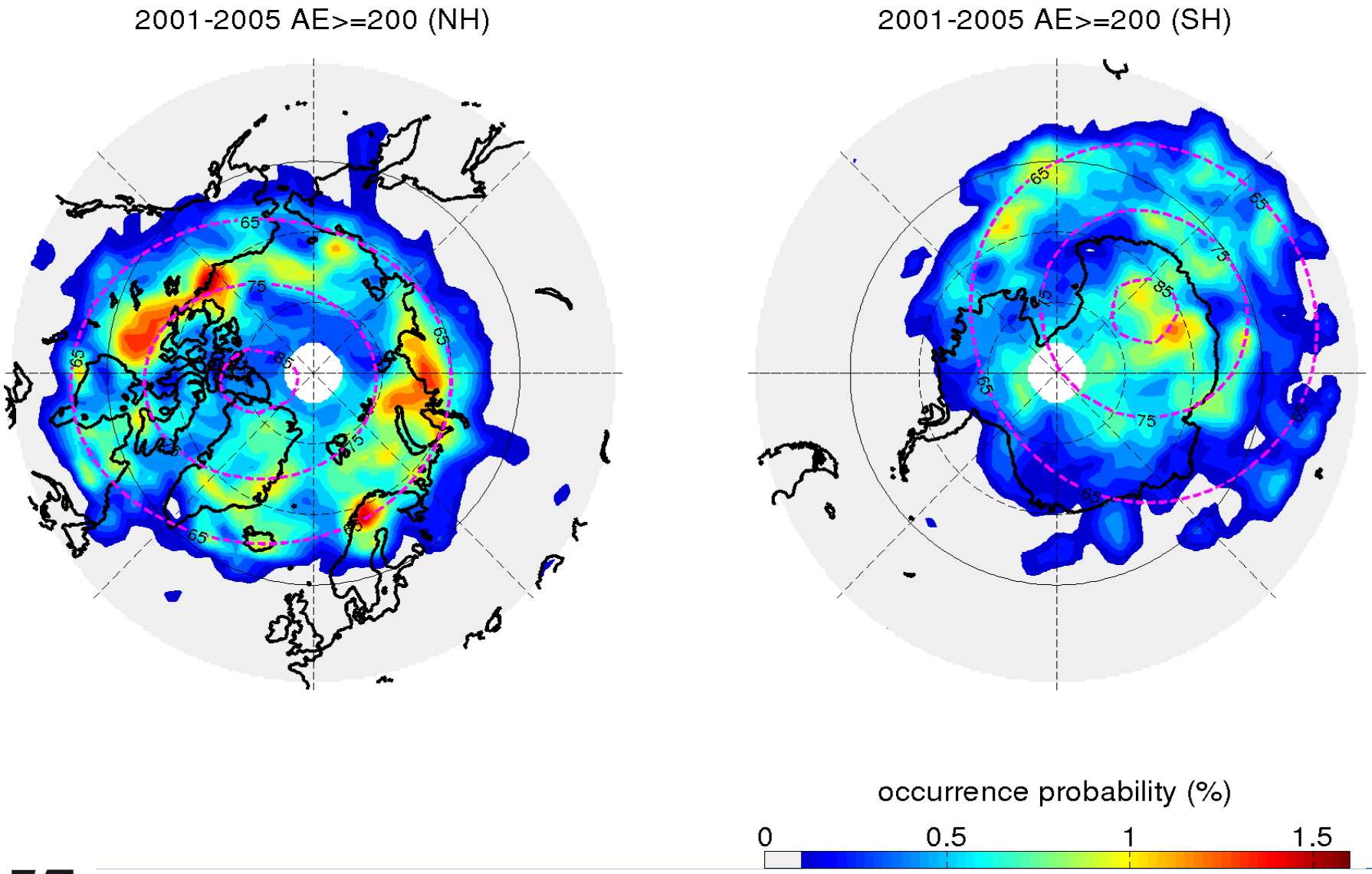
Two effects are playing a role:

- The annual variation with a minimum around June/July,
- The seasonal dependence, preference of dark ionosphere.

In the NH both effects are in phase, in the SH they are in anti-phase.

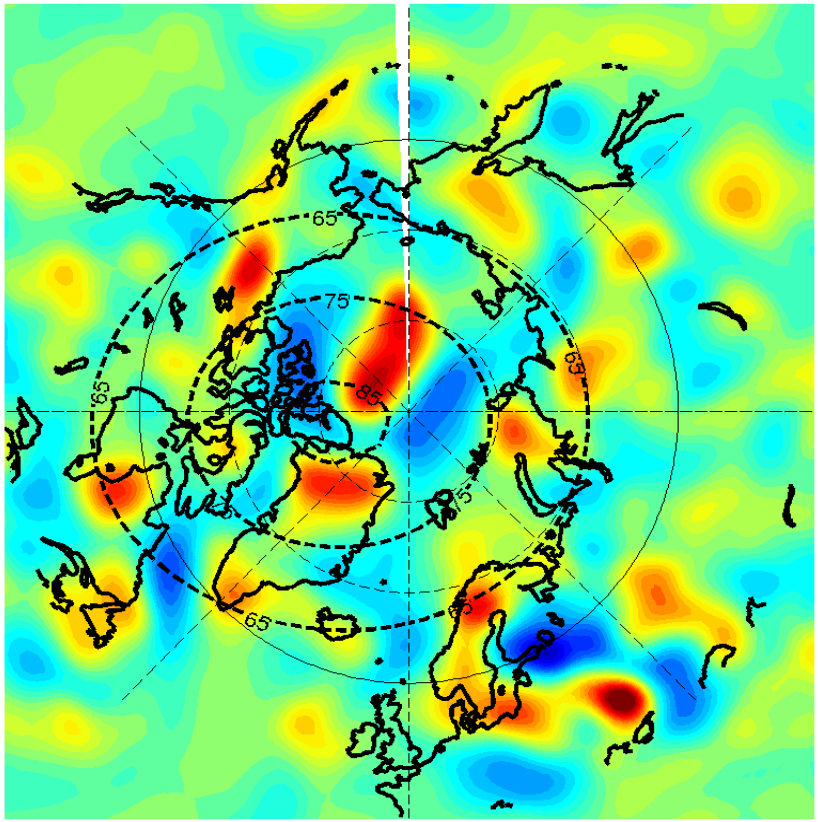


Irregularities appear preferably in certain geographic regions

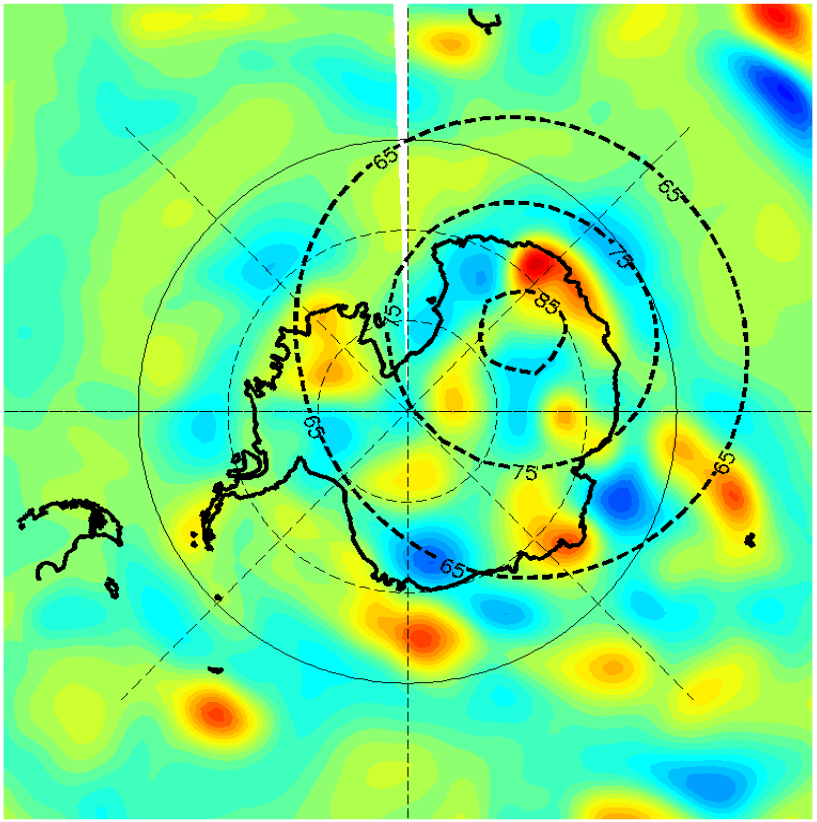


Crustal magnetic fields at CHAMP altitude (~400km)

CRUSTAL FIELD ANOMALY (NH)



CRUSTAL FIELD ANOMALY (SH)



Regions of positive anomalies in the auroral zone correlate well with the event occurrence peaks.

nT

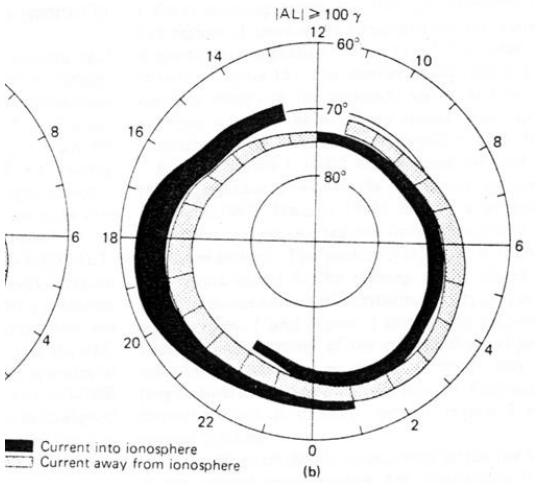
-15 -10 -5 0 5 10 15

Superposed epoch analysis of field-aligned currents co-located with events

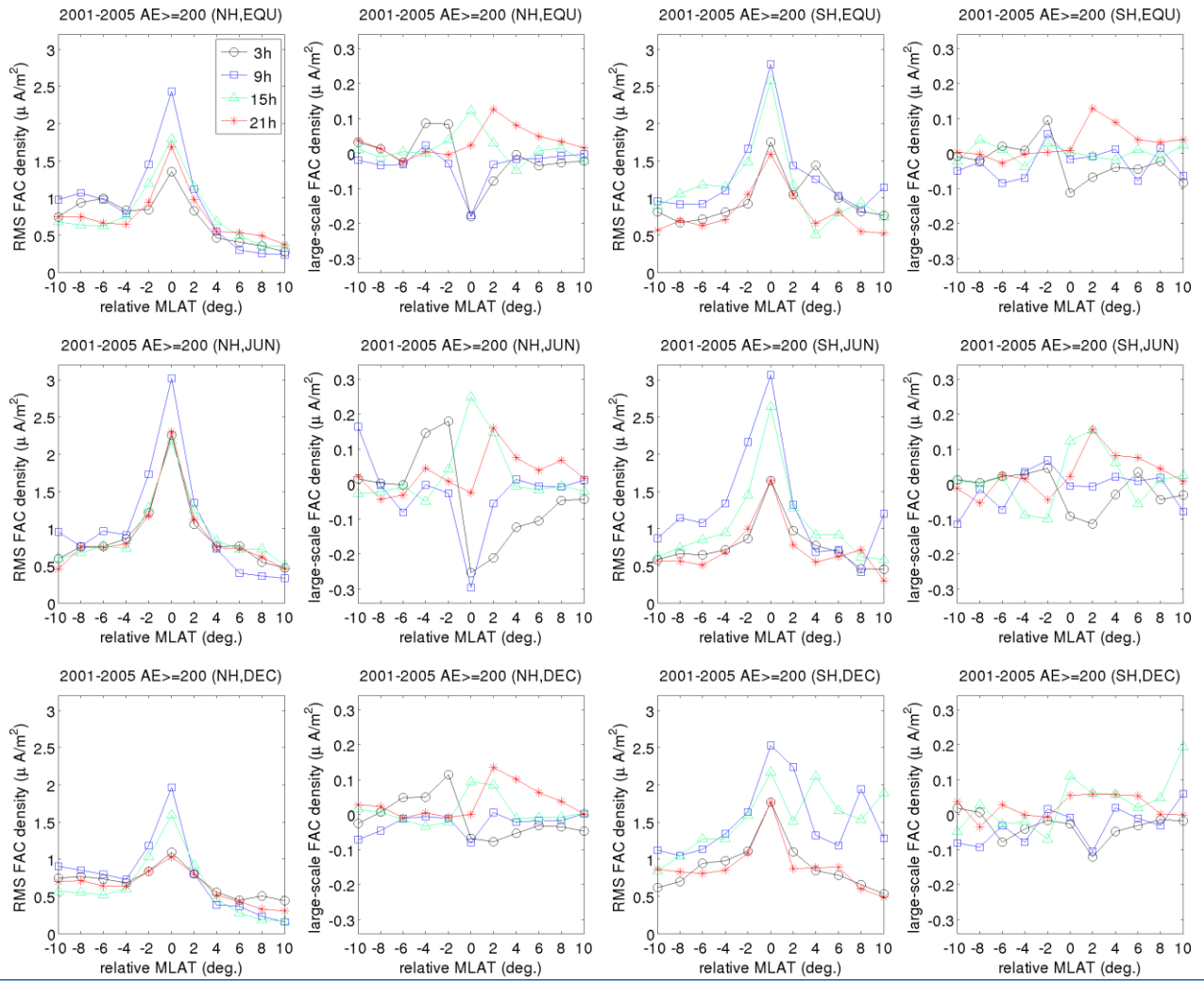
Irregularities are always accompanied by bursts of small-scale FACs.

In the morning and pre-noon sector events are co-located with downward FAC, during afternoon and evening they accompany upward FACs.

This implies a co-location with the R1 FAC region.



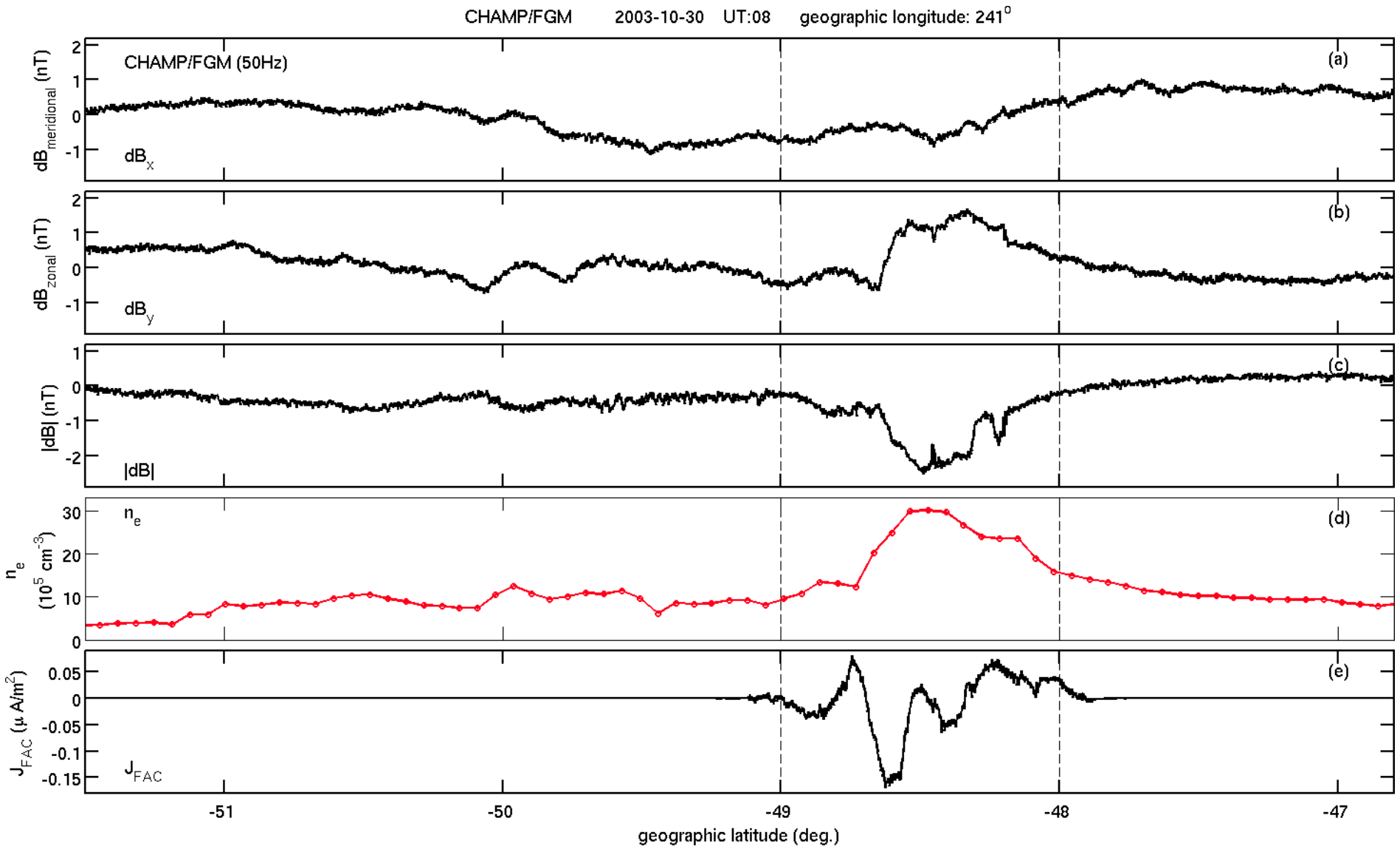
Northern Hemisphere **Southern Hemisphere**



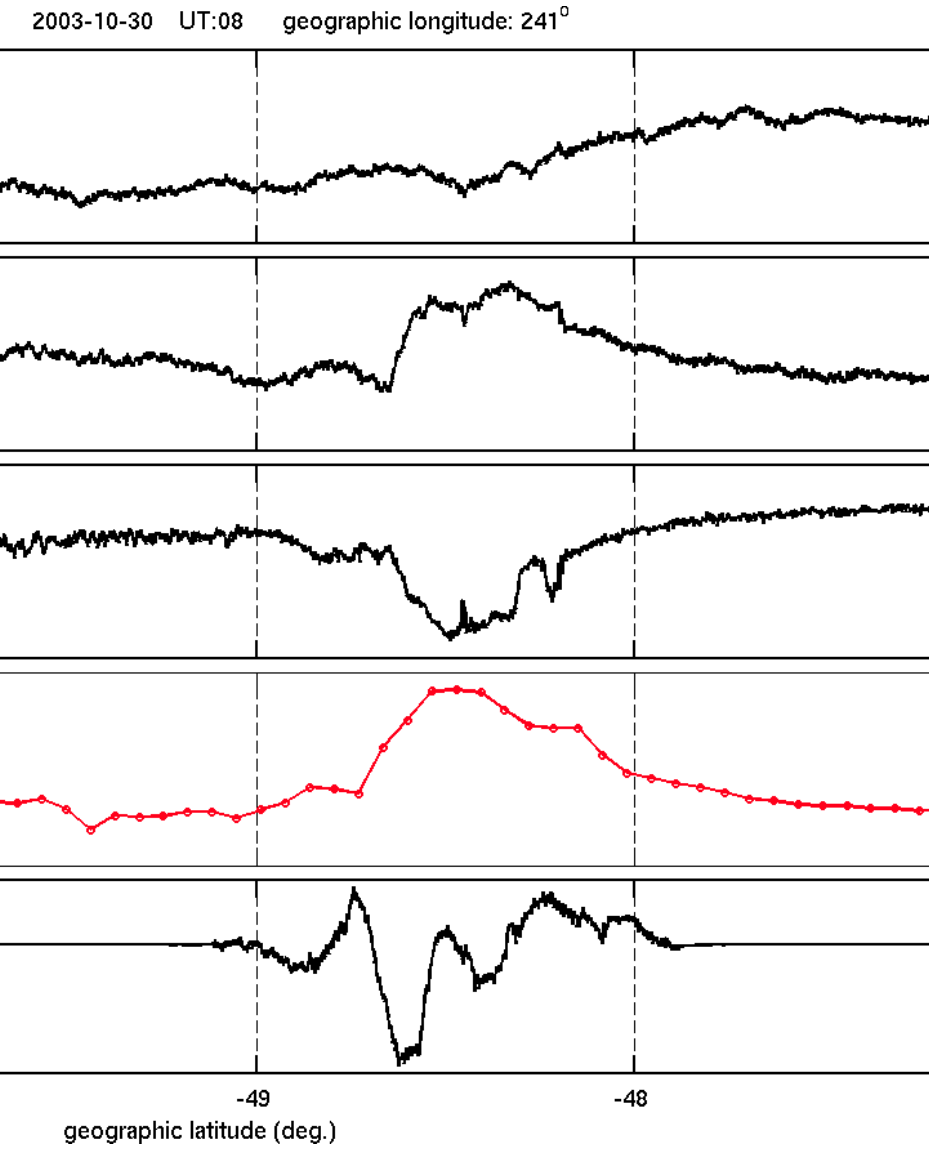
So far the statistical properties of high-lat. irregularities have been presented.

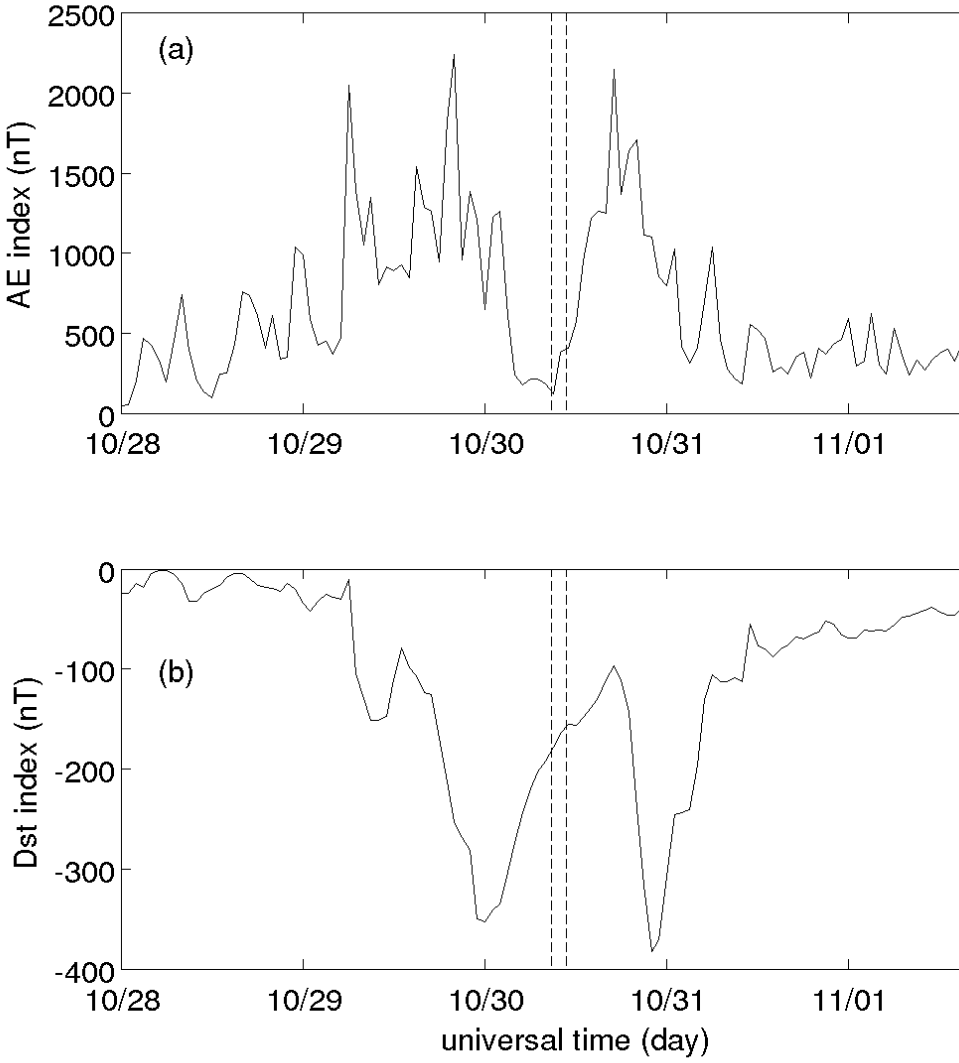
Next we study a long-lasting event occurring during the Halloween storm, Oct. 2003.

Long-lasting event during "Halloween storm"



Long-lasting event during "Halloween storm"

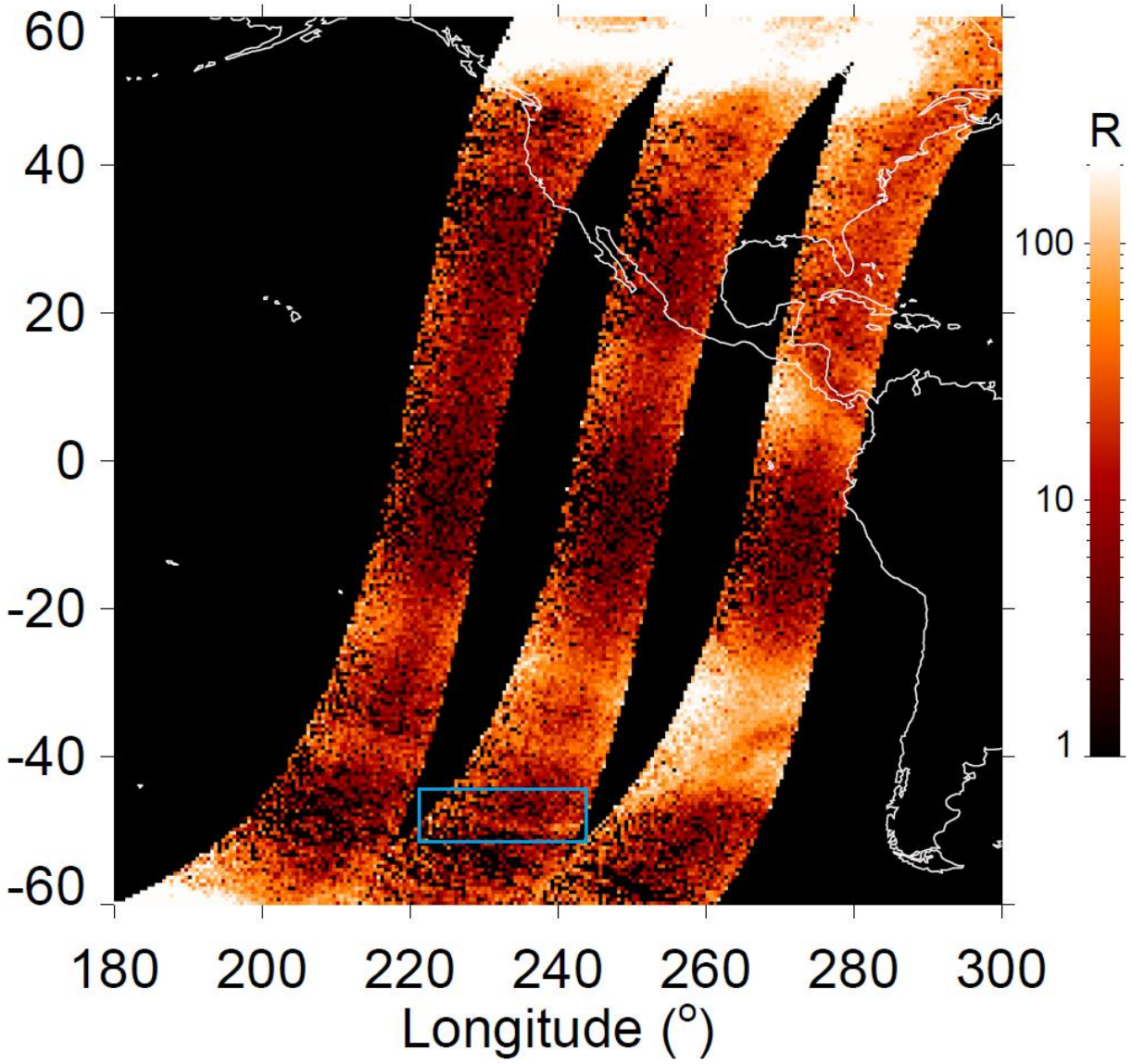


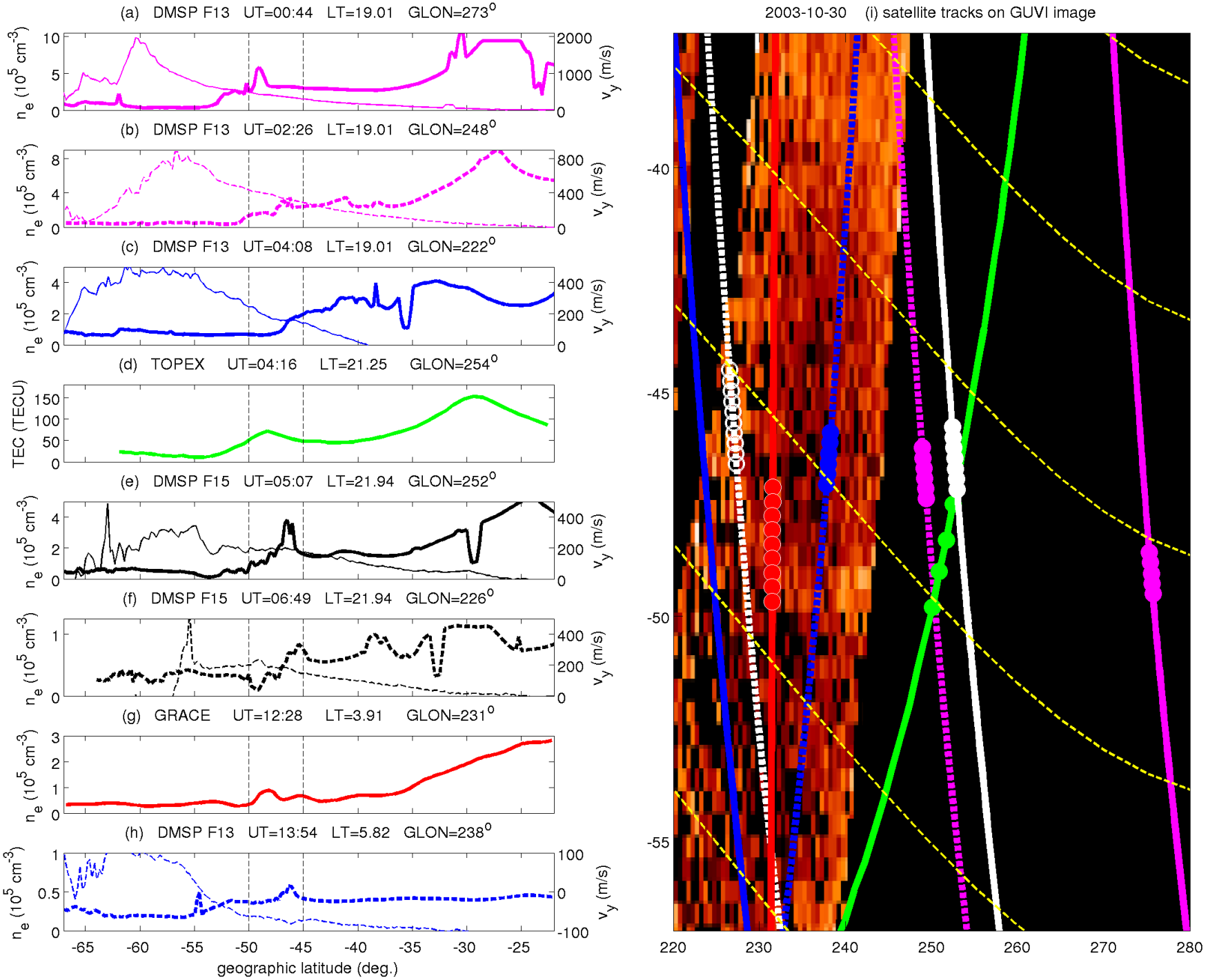


Irregularity signature in airglow images

The irregularity is visible in airglow images of IMAGE.

It appears as a narrow ribbon extending in east/west direction over 2000 km.



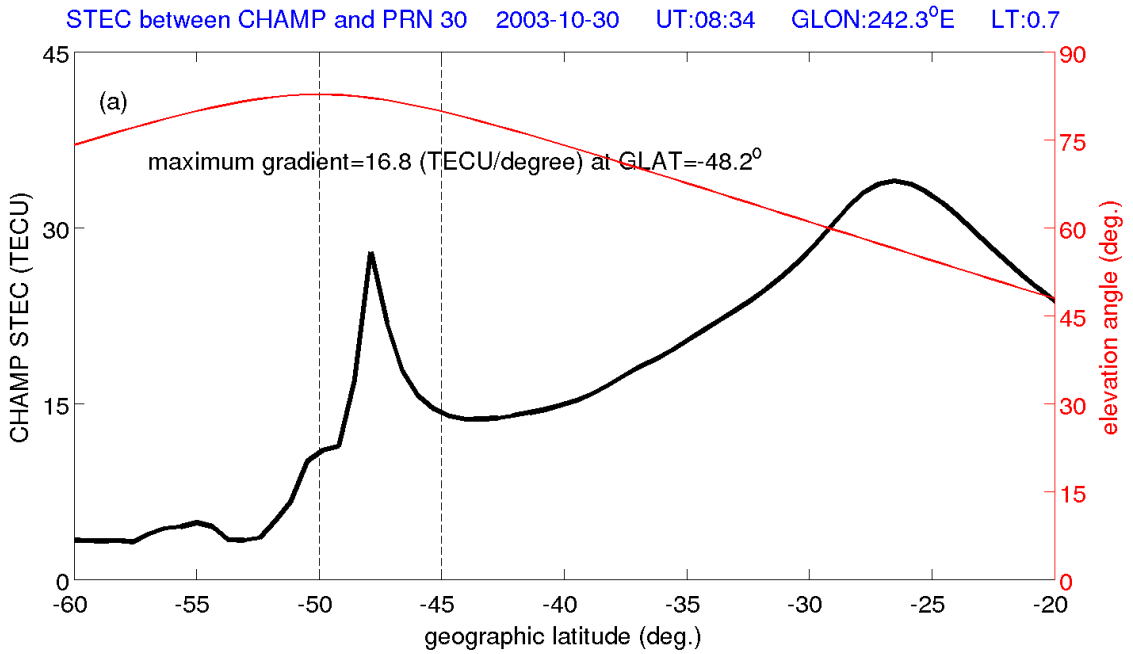

(a) DMSP F13 UT=00:44 LT=19.01 GLON=273°
(b) DMSP F13 UT=02:26 LT=19.01 GLON=248°
(c) DMSP F13 UT=04:08 LT=19.01 GLON=222°
(d) TOPEX UT=04:16 LT=21.25 GLON=254°
(e) DMSP F15 UT=05:07 LT=21.94 GLON=252°
(f) DMSP F15 UT=06:49 LT=21.94 GLON=226°
(g) GRACE UT=12:28 LT=3.91 GLON=231°
(h) DMSP F13 UT=13:54 LT=5.82 GLON=238°
n_e (10^5 cm^-3)
v_y (m/s)
TEC (TECU)
geographic latitude (deg.)
2003-10-30 (i) satellite tracks on GUVI image

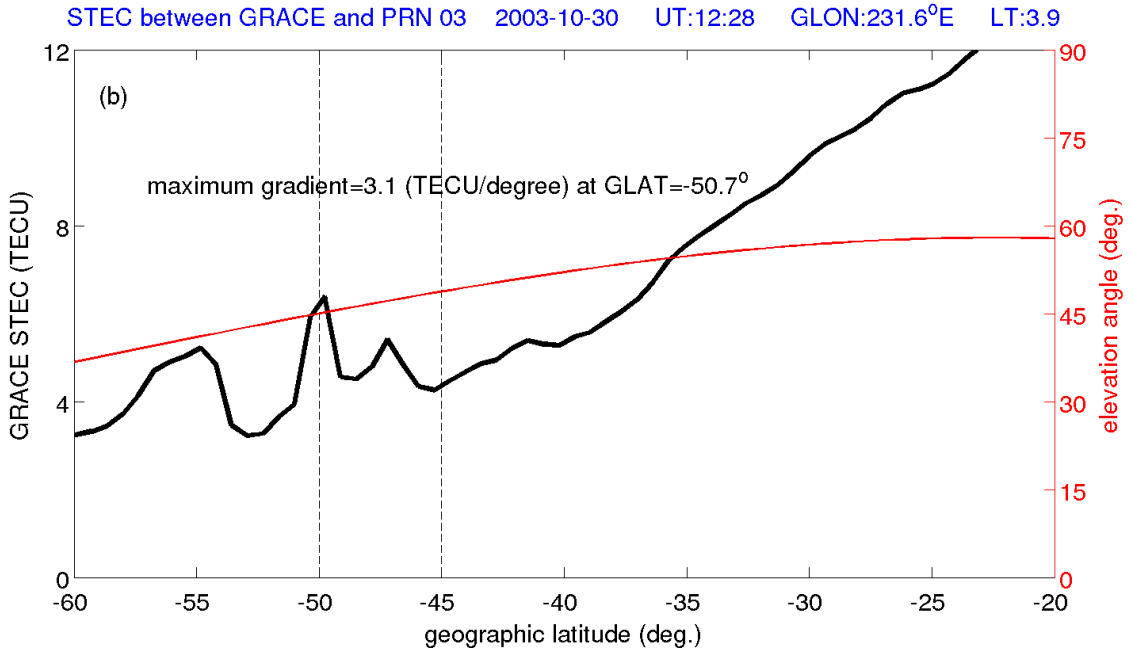
TEC signature of event

Steep TEC gradients are encountered above CHAMP.

They suggest a high reaching field-aligned sheet of enhance electron density.

Even above GRACE (500km) it is still detectable 4 hours later.





Summary

- High-latitude electron density irregularities occur as frequently as plasma bubbles at low latitude.
- Preferred region is the auroral region, in particular polar cusp and substorm region.
- There are geographic regions of high occurrence rates, Scandinavia, Siberia, northern Canada.
- After magnetic storms fossil irregularities can be encountered at middle latitudes that rotate with the Earth and persist for more than 12 hours.

References: Park et al. (2012, JGR); Park et al. (2012, JASTP)

Number of events during solar maximum and solar minimum years

	northern hemisphere		southern hemisphere	
	2001-2005	2006-2010	2001-2005	2006-2010
Equinox	1136	209	1177	196
June solstice	492	244	586	128
December solstice	1666	217	1069	335