

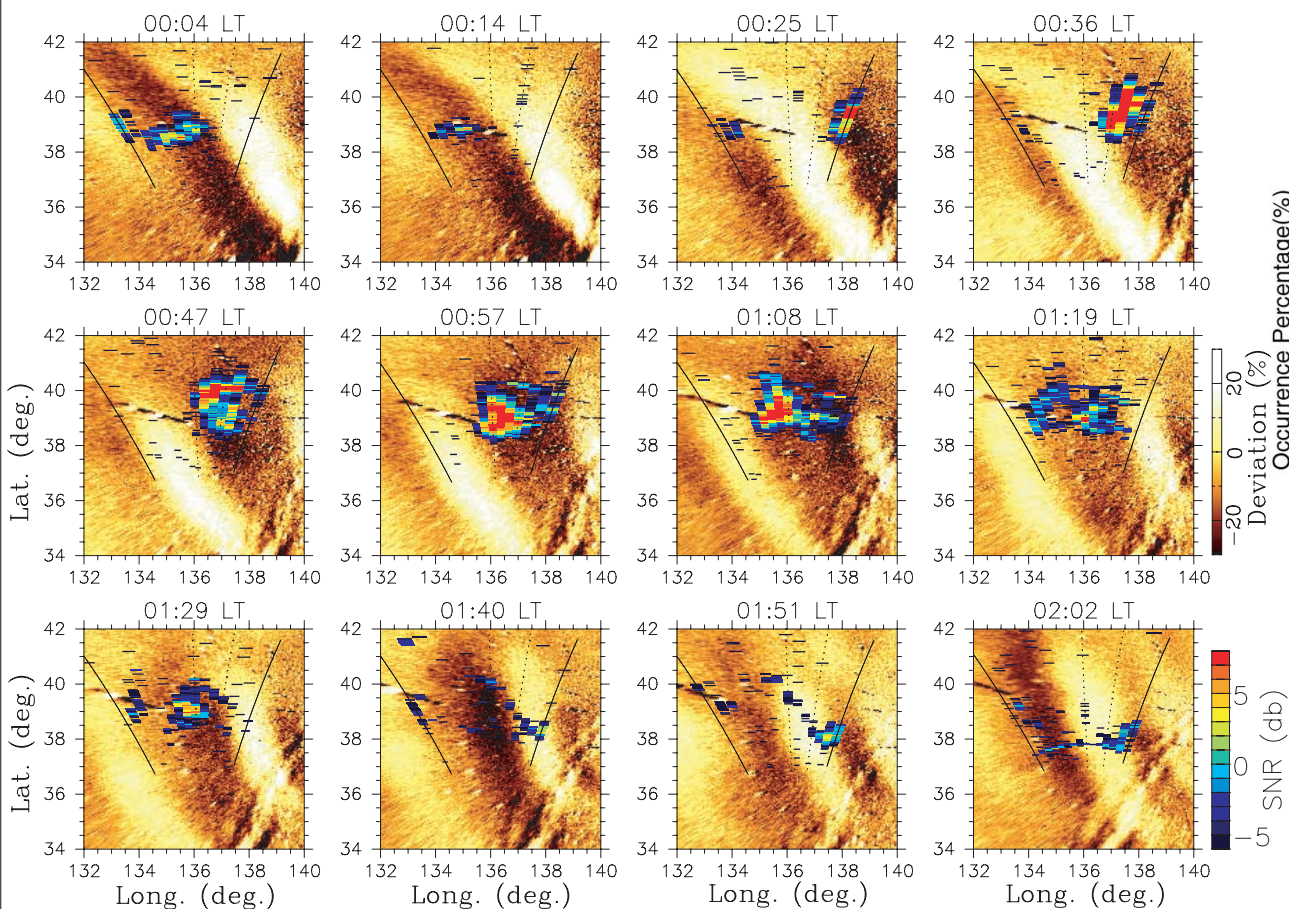
# The Variability in the Morning-Time Plasma Density Irregularities Occurrence Pattern in Mid-to-Low Latitude during the solar minimum period

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and Tae-Yong Yang<sup>3</sup>

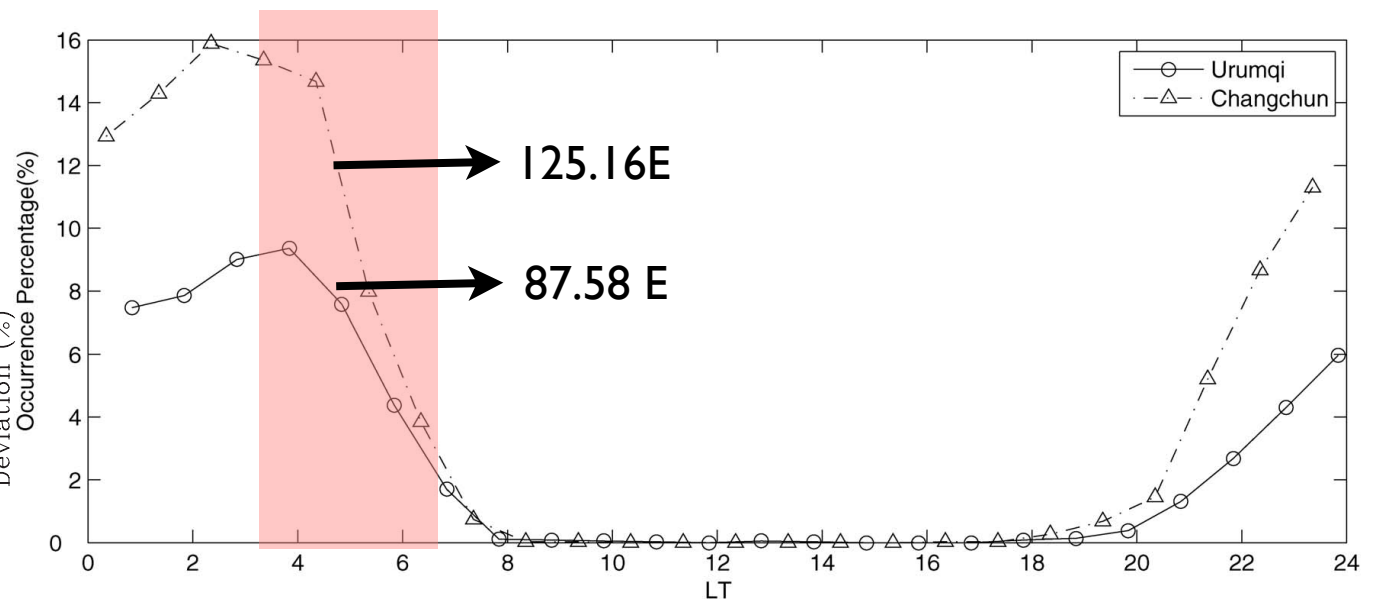
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[oh@spweather.com](mailto:oh@spweather.com)



# Motivation



[Otsuka et al., 2009]



| Stations  | Geographic Longitude | Geographic Latitude | Geomagnetic Longitude | Geomagnetic Latitude |
|-----------|----------------------|---------------------|-----------------------|----------------------|
| Changchun | 125°16'E             | 43°50'N             | 192°53'E              | 36°46'N              |
| Urumqi    | 87°38'E              | 43°45'N             | 160°41'E              | 33°05'N              |

[Huang et al., 2011]

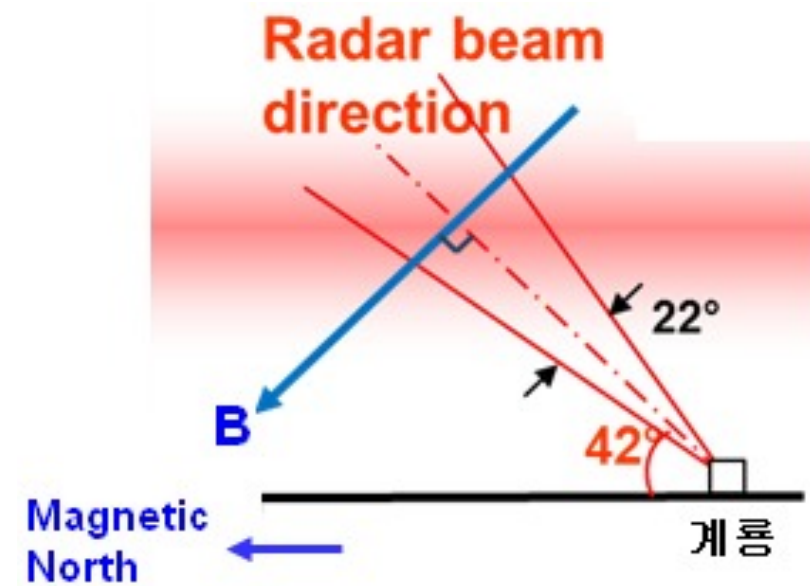
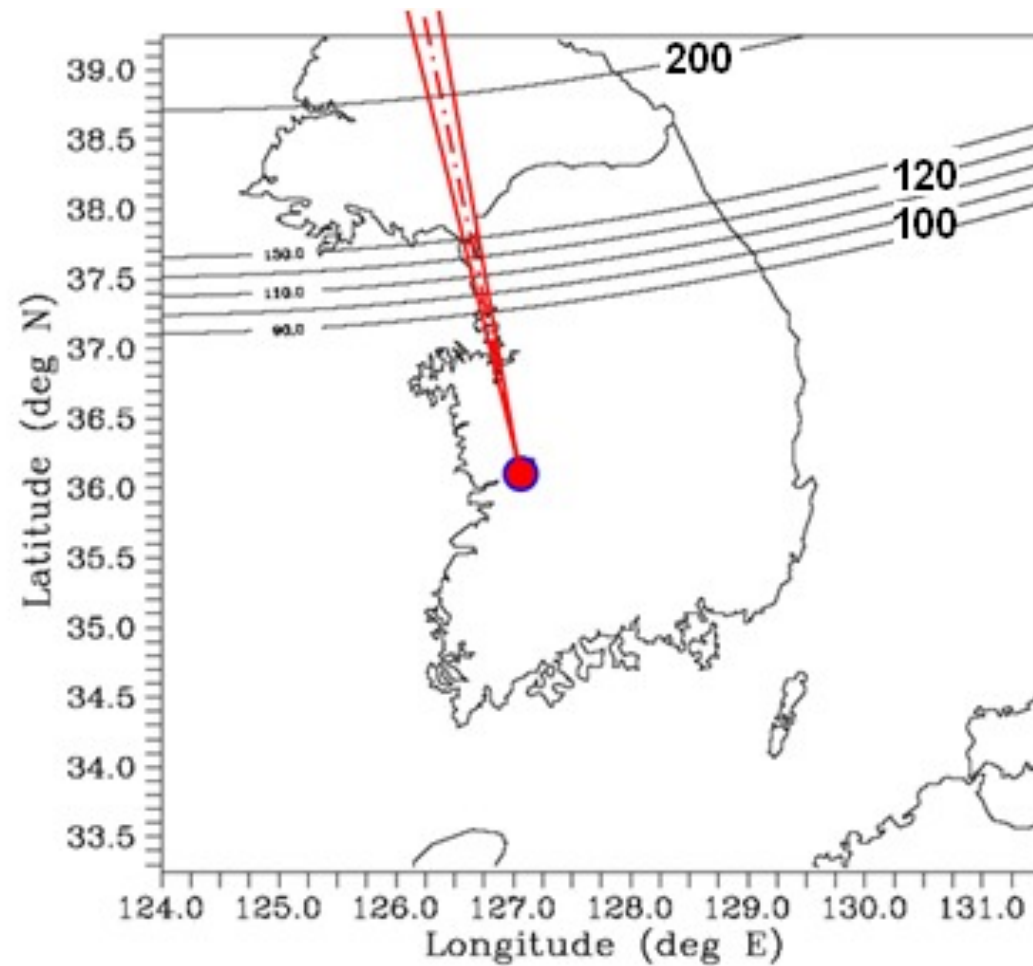
- The plasma density irregularities appear in the nighttime midlatitude ionosphere, and it is suggested that it is relevant to the MSTIDs' depletion region
- The plasma irregularities occurs in the midlatitude during the morning time as well and its occurrence probabilities are different with respect to the longitude.

*Morning time plasma irregularities  
occurrence in low-to-mid latitude during  
solar minimum?*

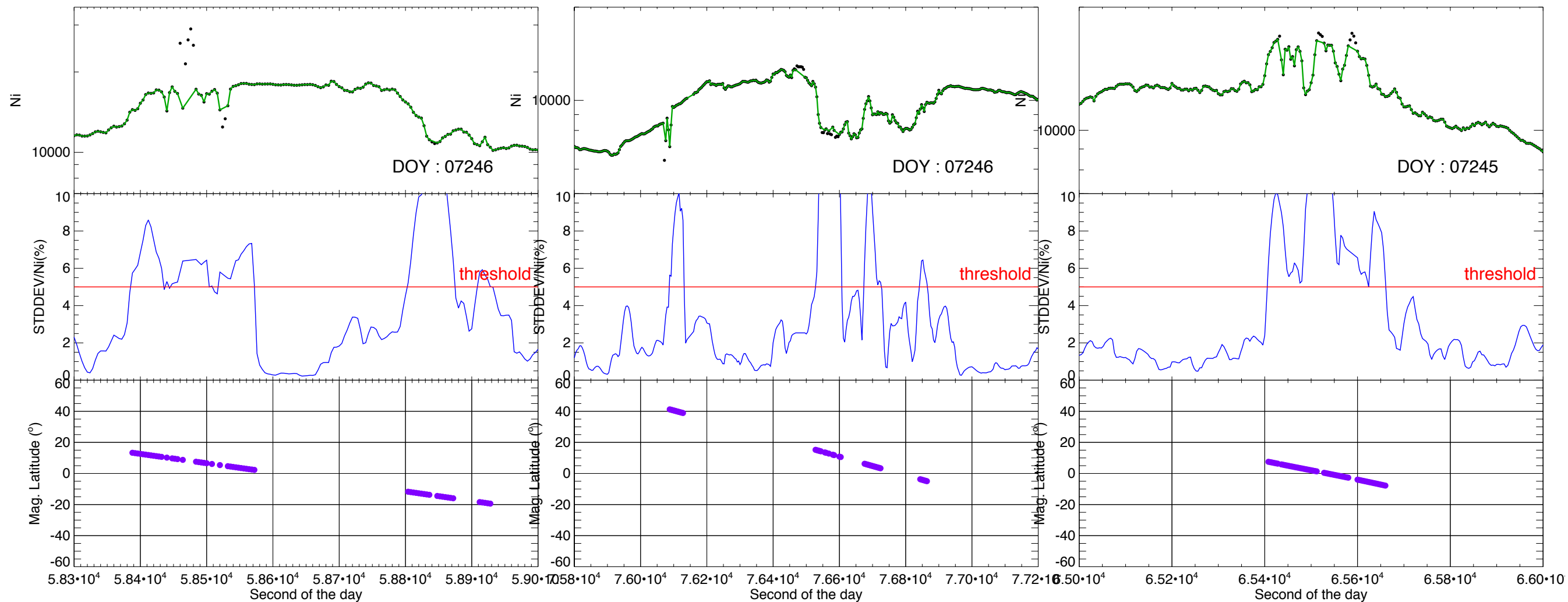
# Analysis

- Observation : *in-situ* measurements by DMSP (Defense Meteorological Satellite Program) F13 with sun-synchronous orbit at 800 km altitude
- Data : 0600 LT (morning sector) data during 2006-2009
- Quality control : The rejection of the sudden peaked data that have 20% larger electron density than the 400 sec average electron density.
- Irregularities detection : The percentage standard deviation of the 40 sec data normalized by the mean plasma density with the threshold of 5% has been used to detect irregularities.

## VHF (40.8 MHz) radar observations – irregularities ( $\sim 3$ m)



# Detection



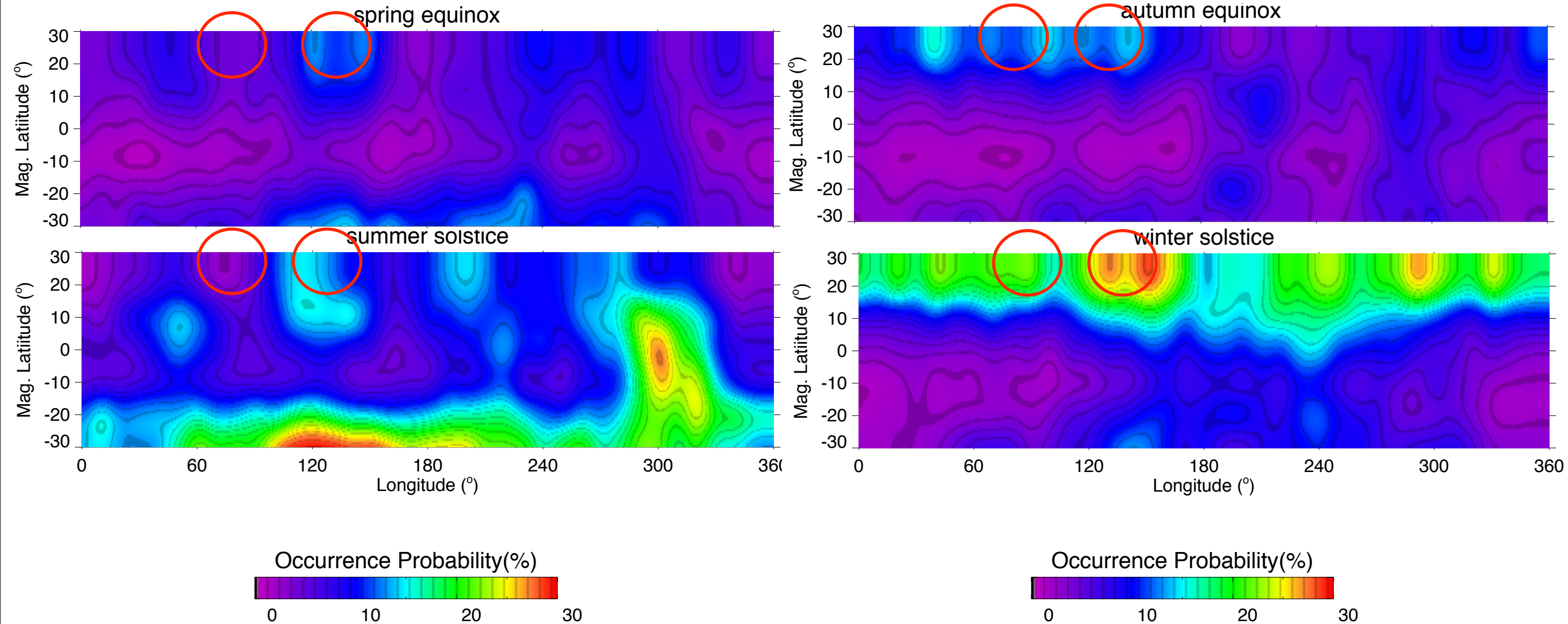
mid-latitude irregularities

density depletions

blobs

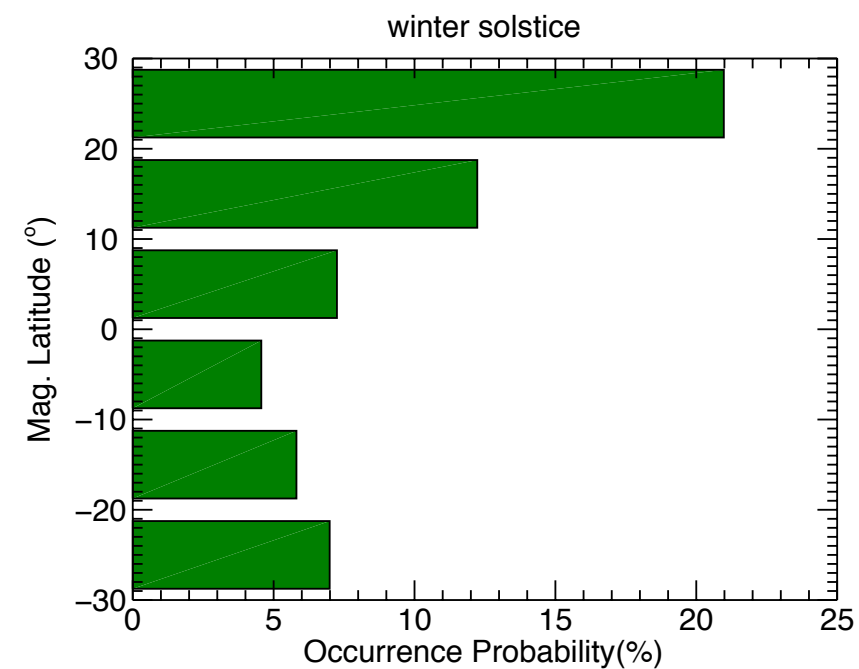
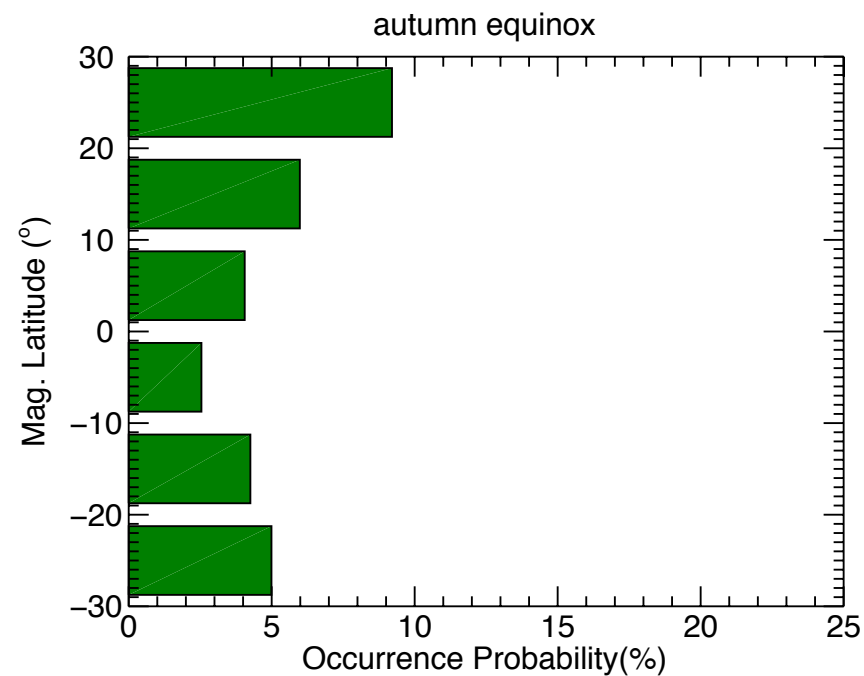
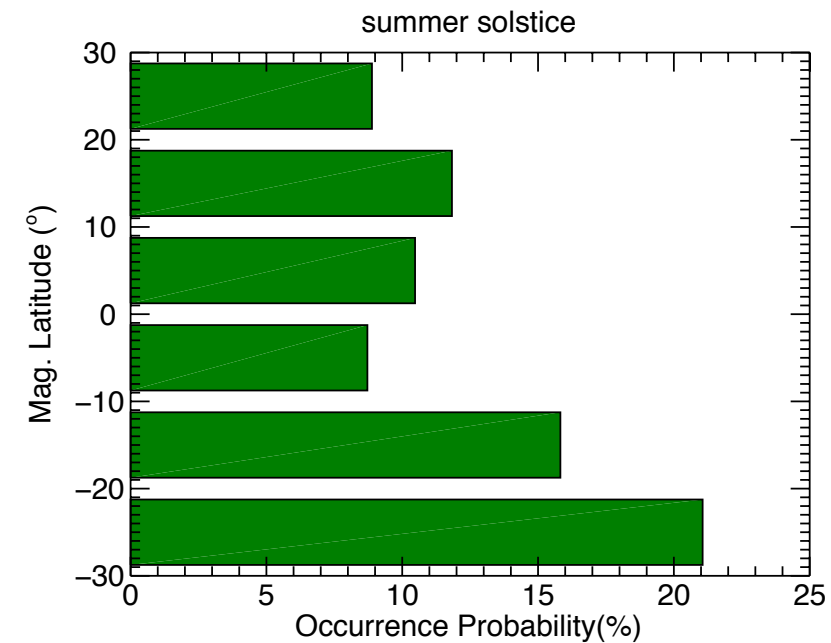
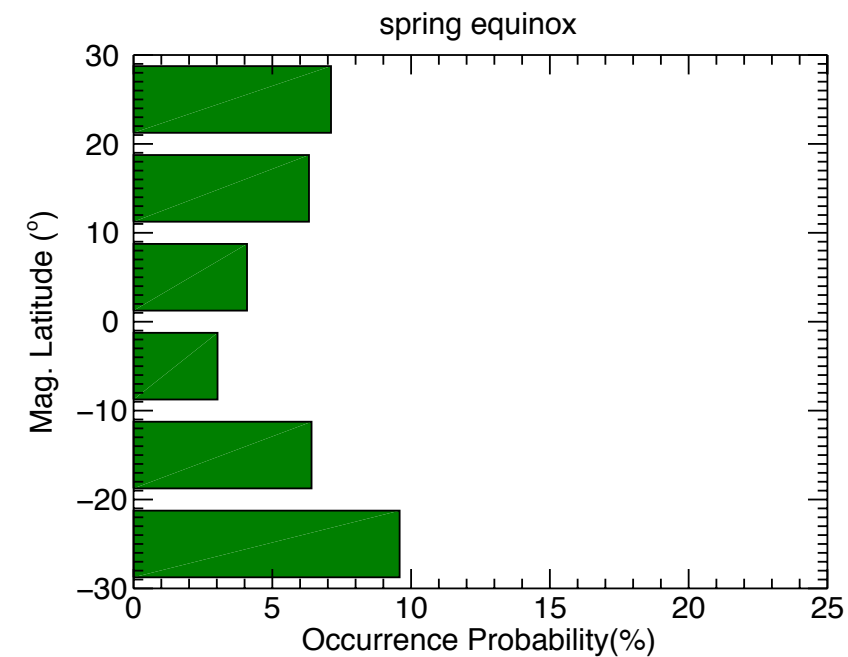
The examples of irregularities detection results during solar minimum

# *s// distribution*



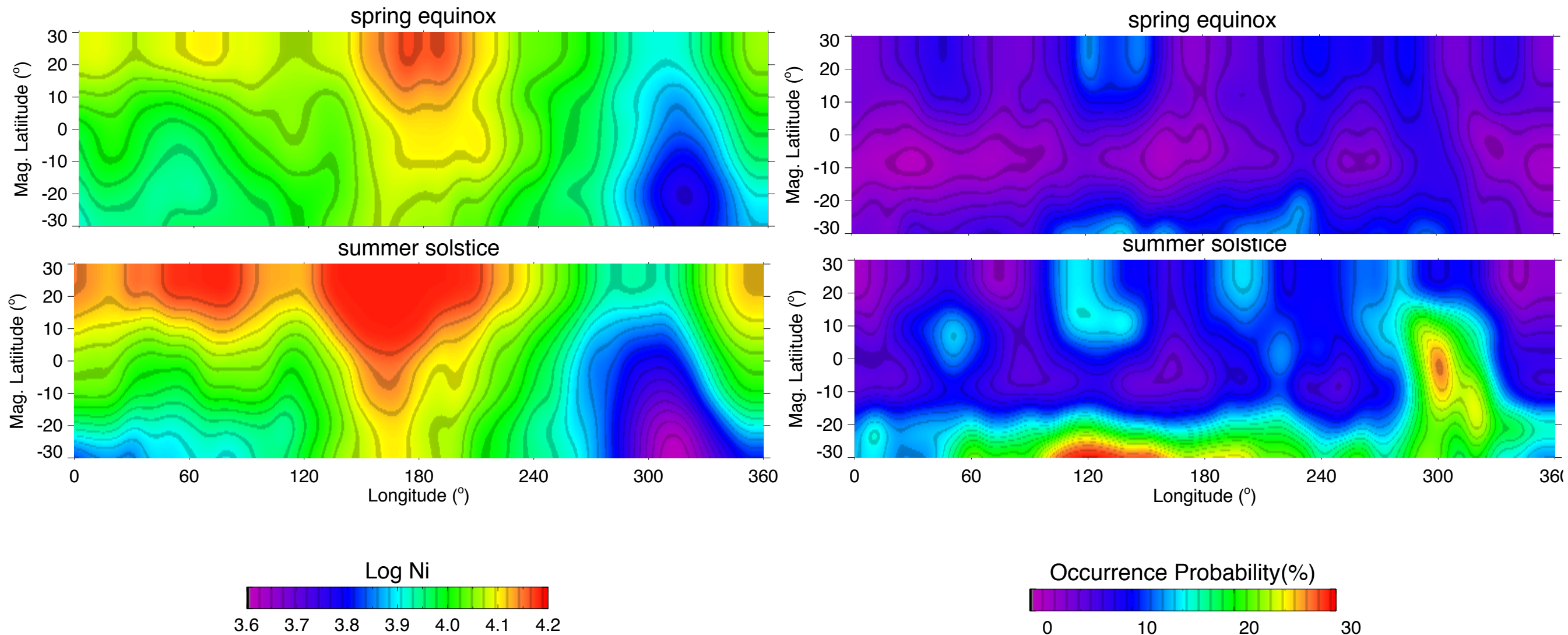
The seasonal-longitudinal distribution of the irregularity occurrence rate during Spring equinox (Mar., Apr. and May), Summer solstice (June, July and Aug.), Autumn equinox (Sep., Oct. and Nov.), and Winter solstice (Dec., Jan., and Feb). The plots show the average occurrence rate obtained from the F13 0600 LT data during 2007-2009.

# *latitudinal distribution*



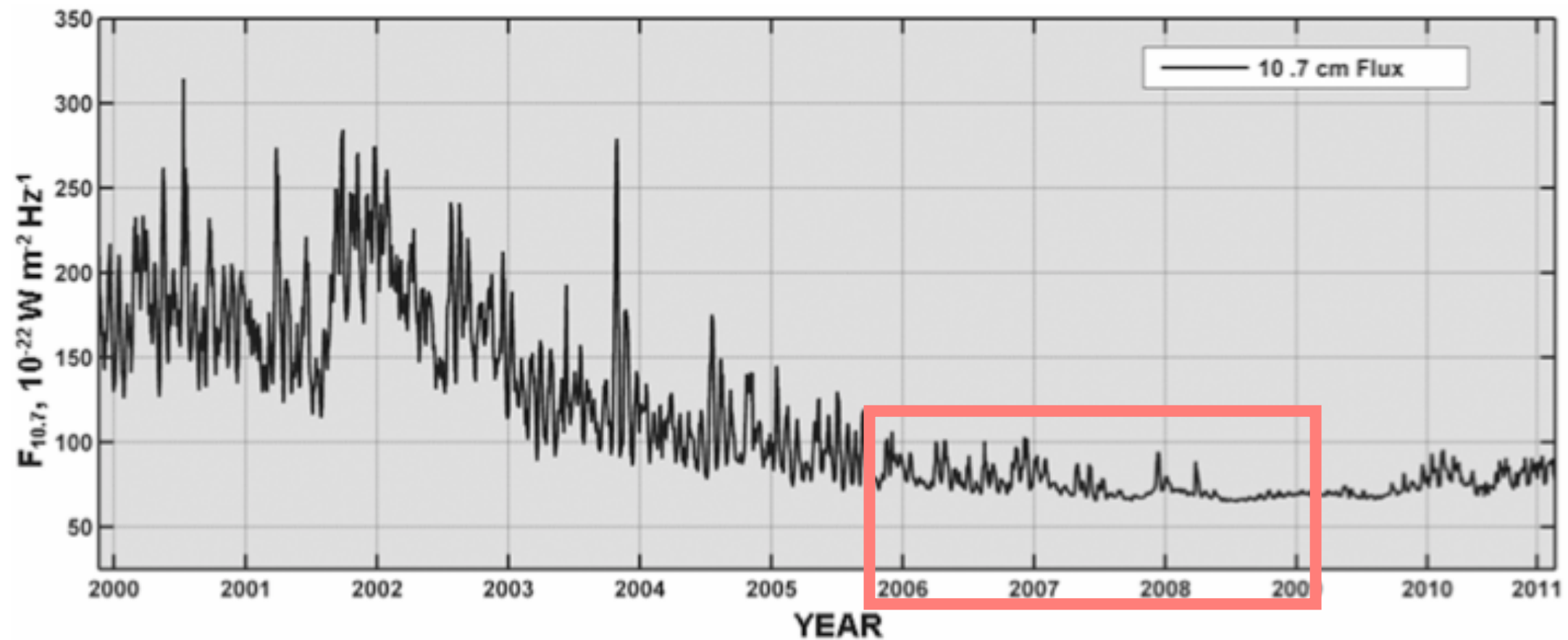
The latitudinal distribution of the longitudinal average irregularity occurrence rate during 2007-2009.

# *plasma density vs. occurrence rate*

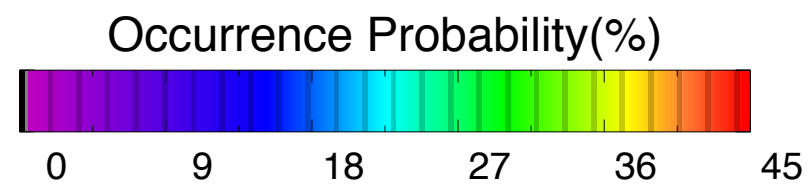
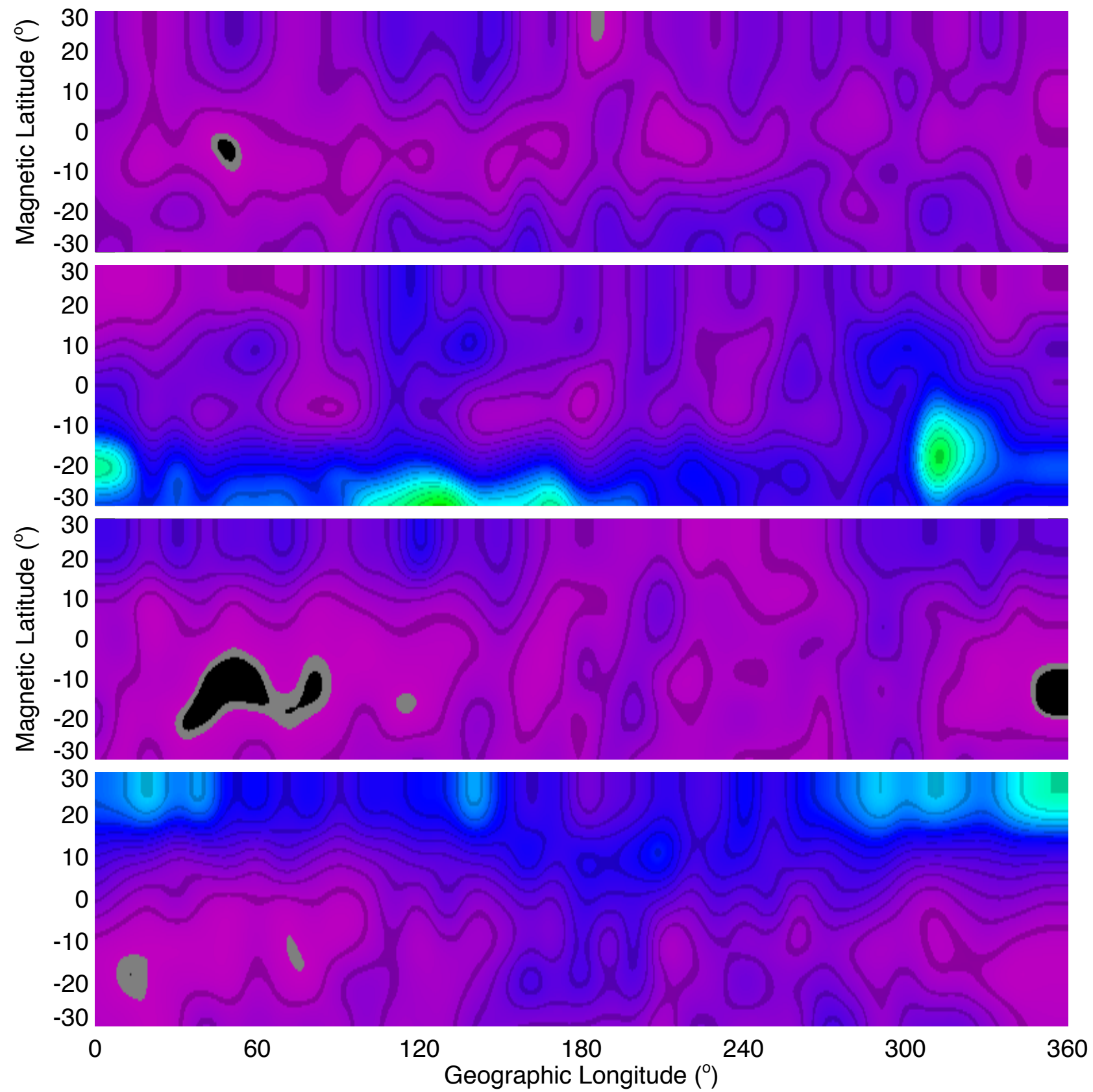


The seasonal-longitudinal distribution of the average plasma density during 2007-2009(Left). The irregularity occurrence rate is likely to be anti-correlated with the background plasma density especially during spring and summer.

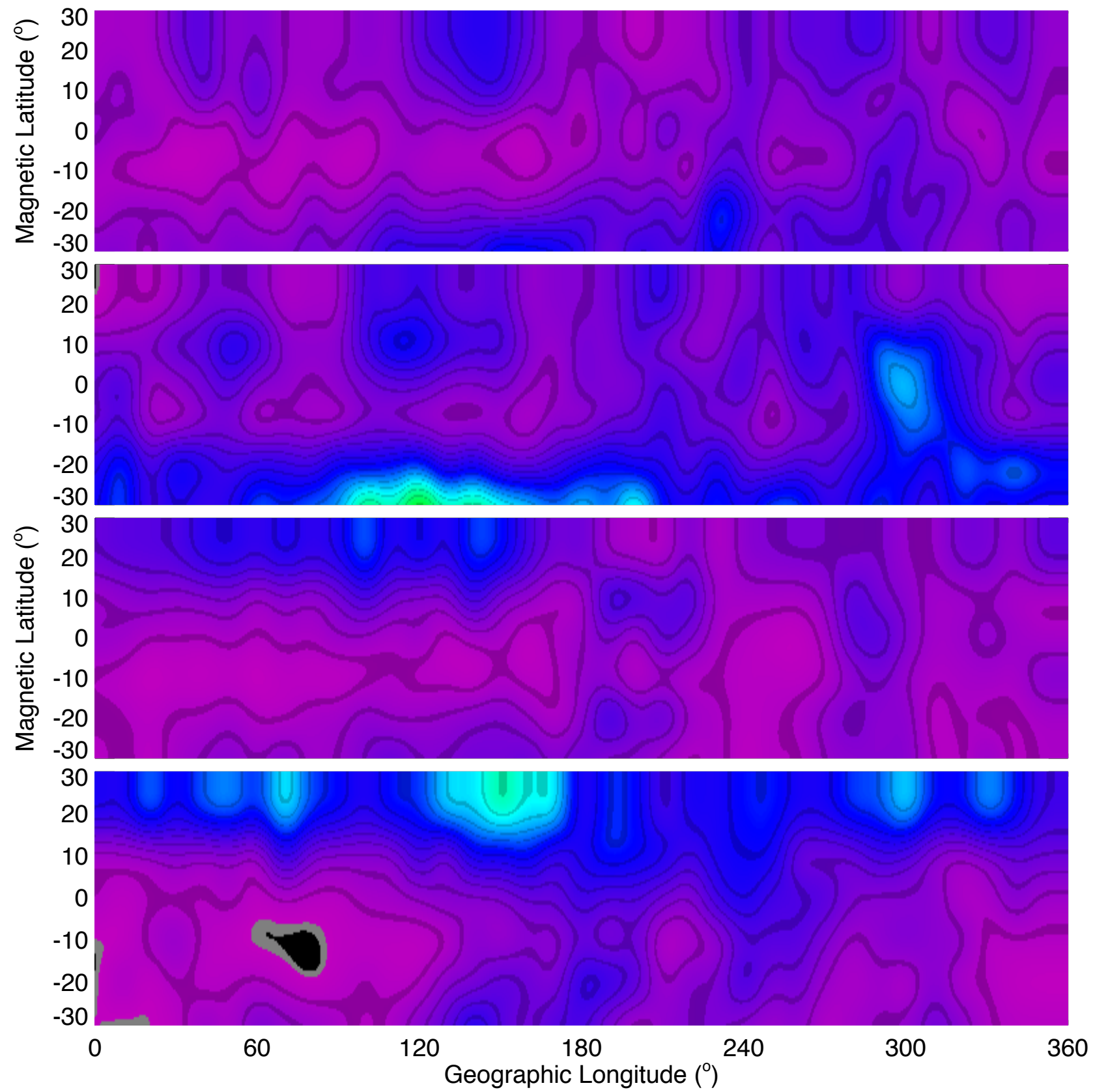
# *The annual variation of the occurrence probabilities from 2006 to 2009*



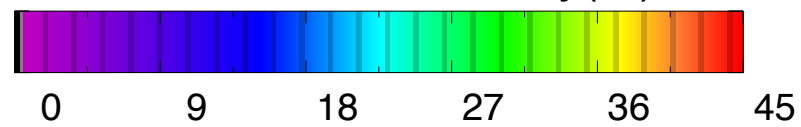
2006



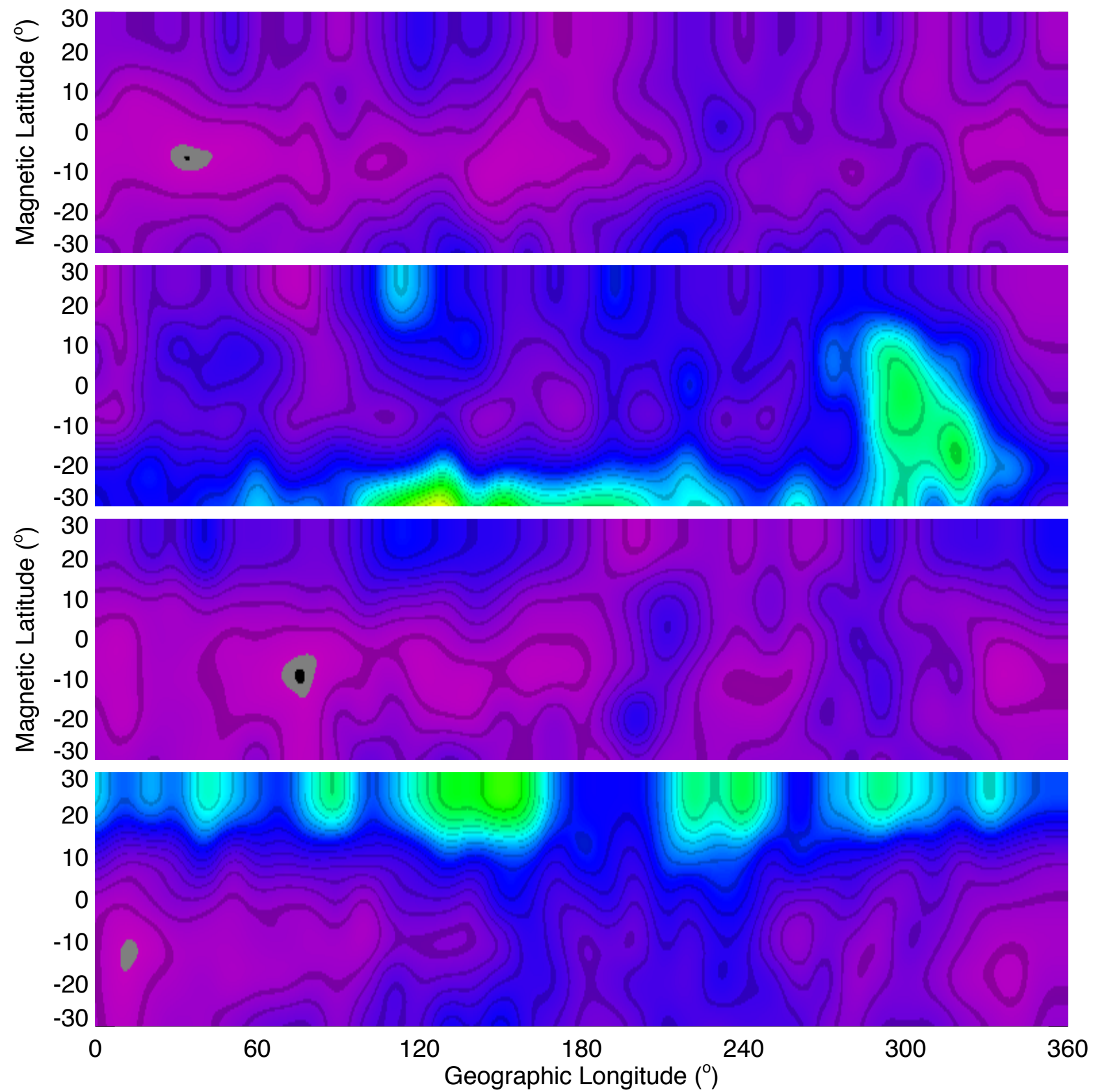
2007



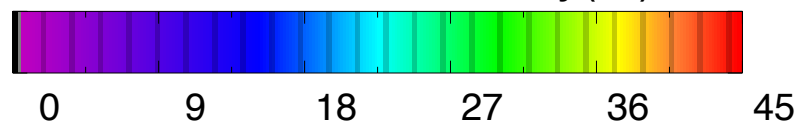
Occurrence Probability(%)



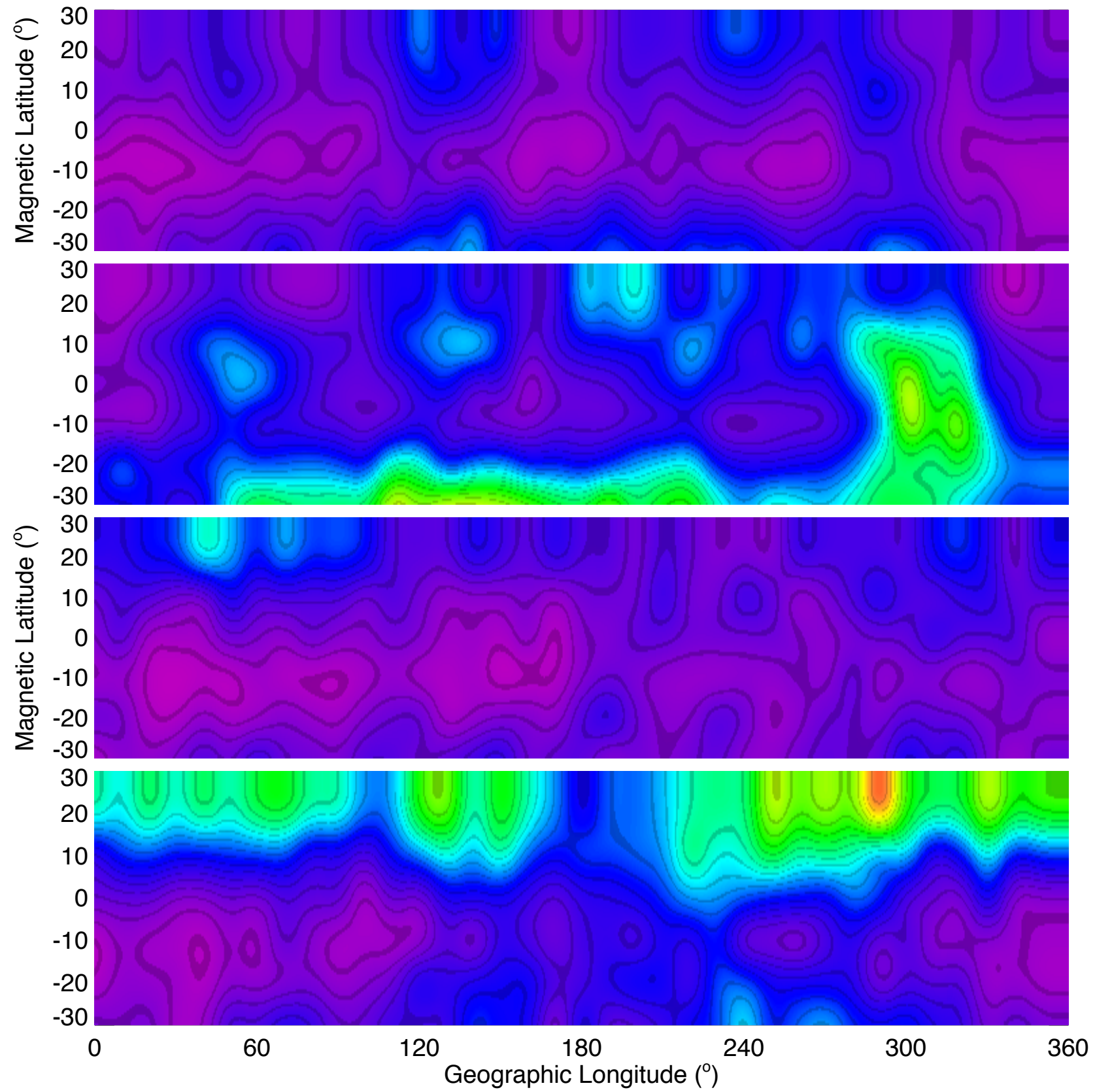
2008



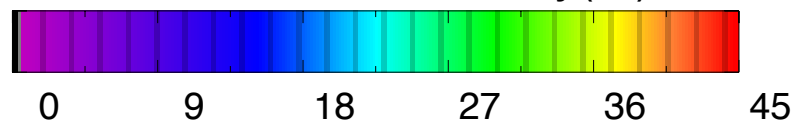
Occurrence Probability(%)



2009



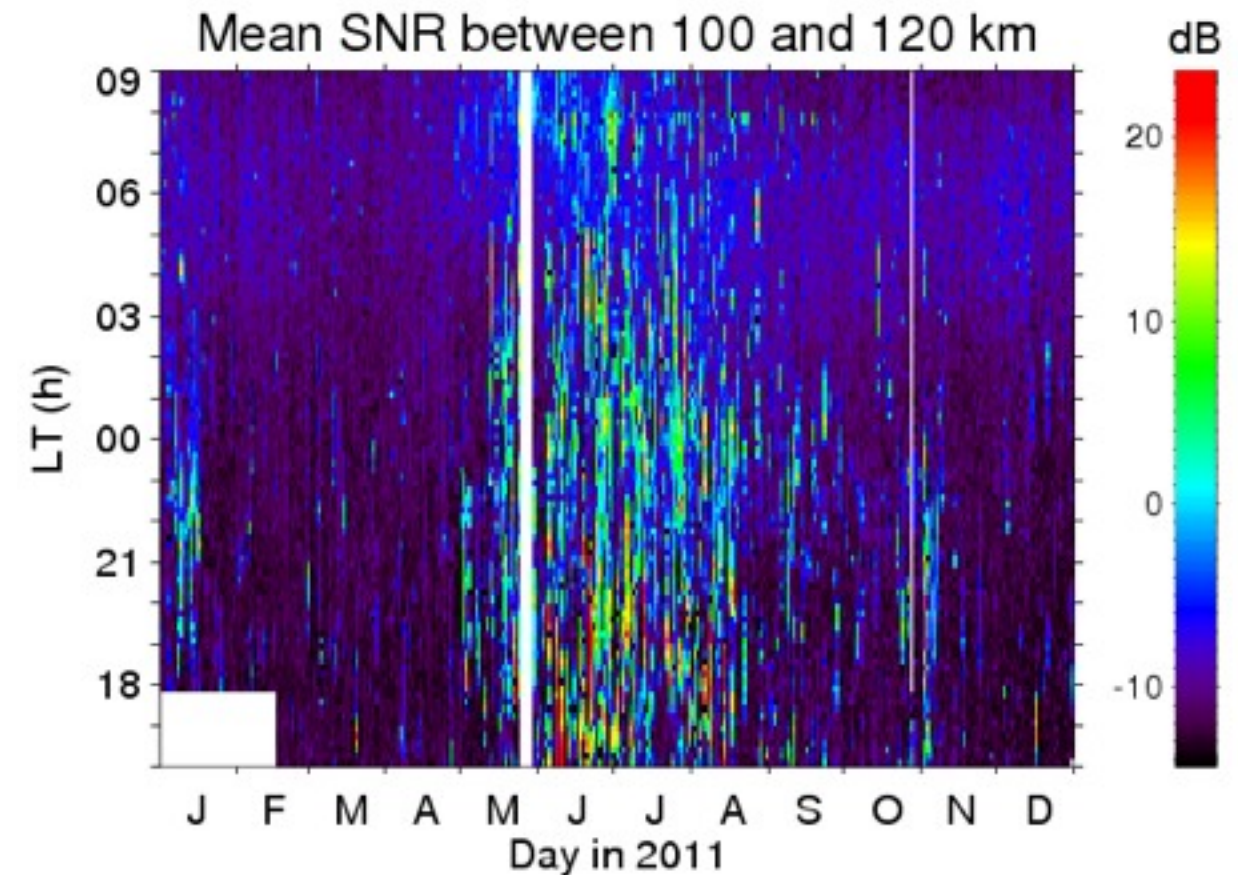
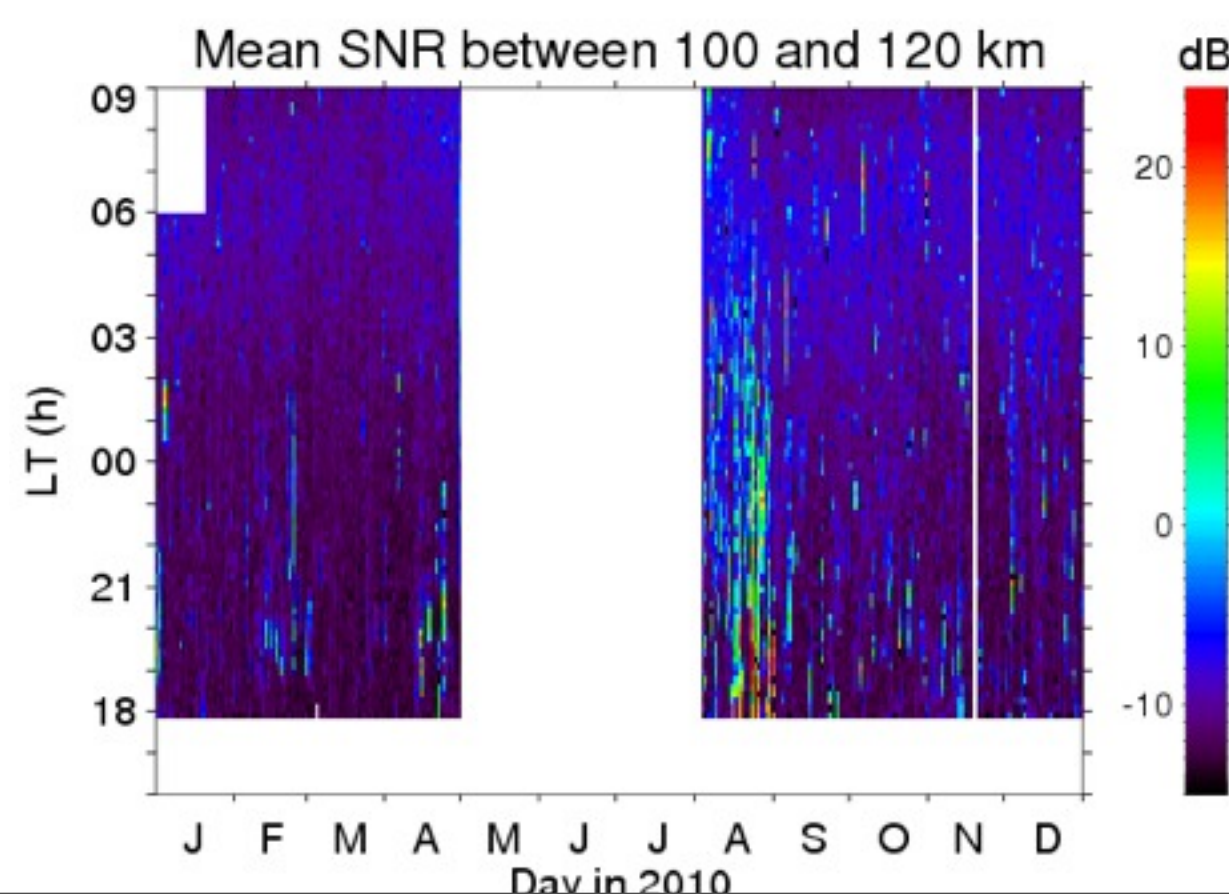
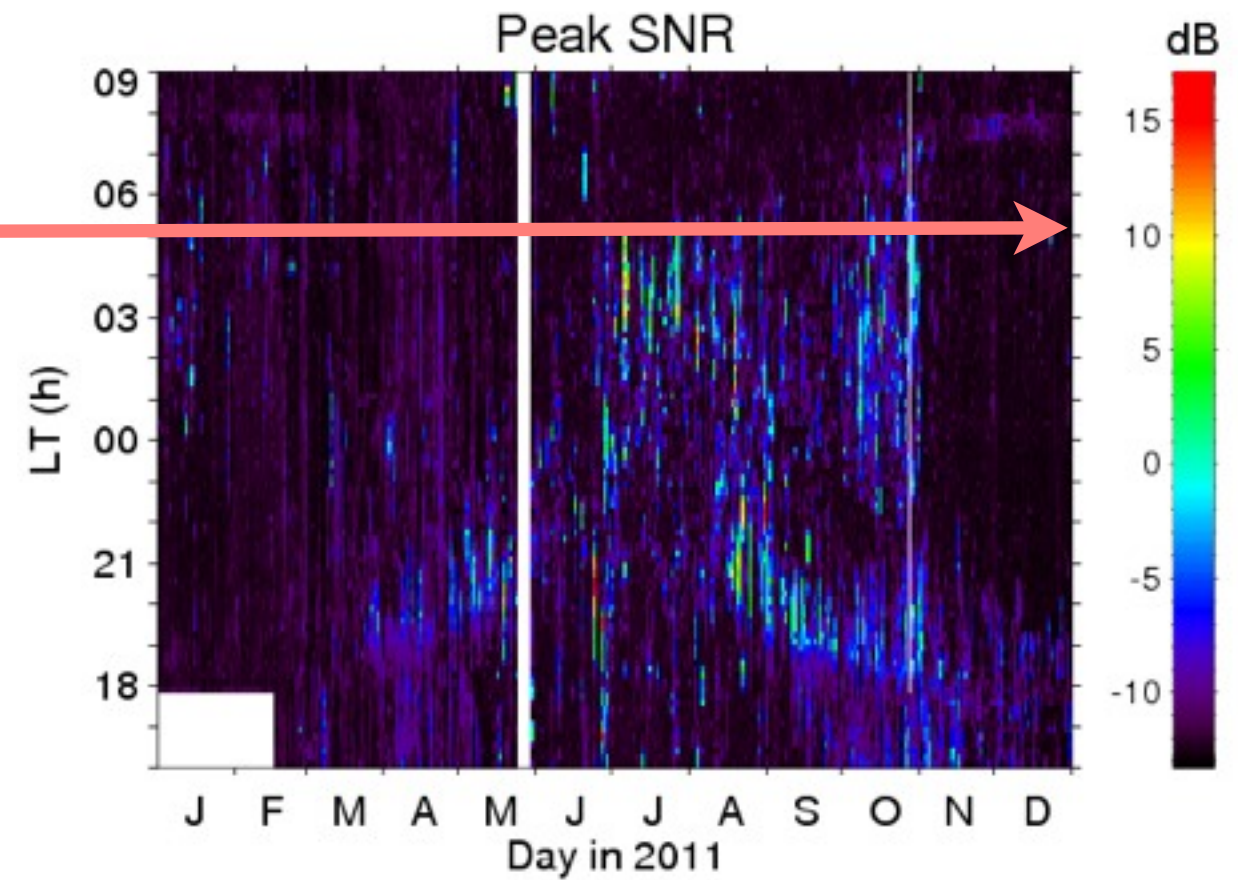
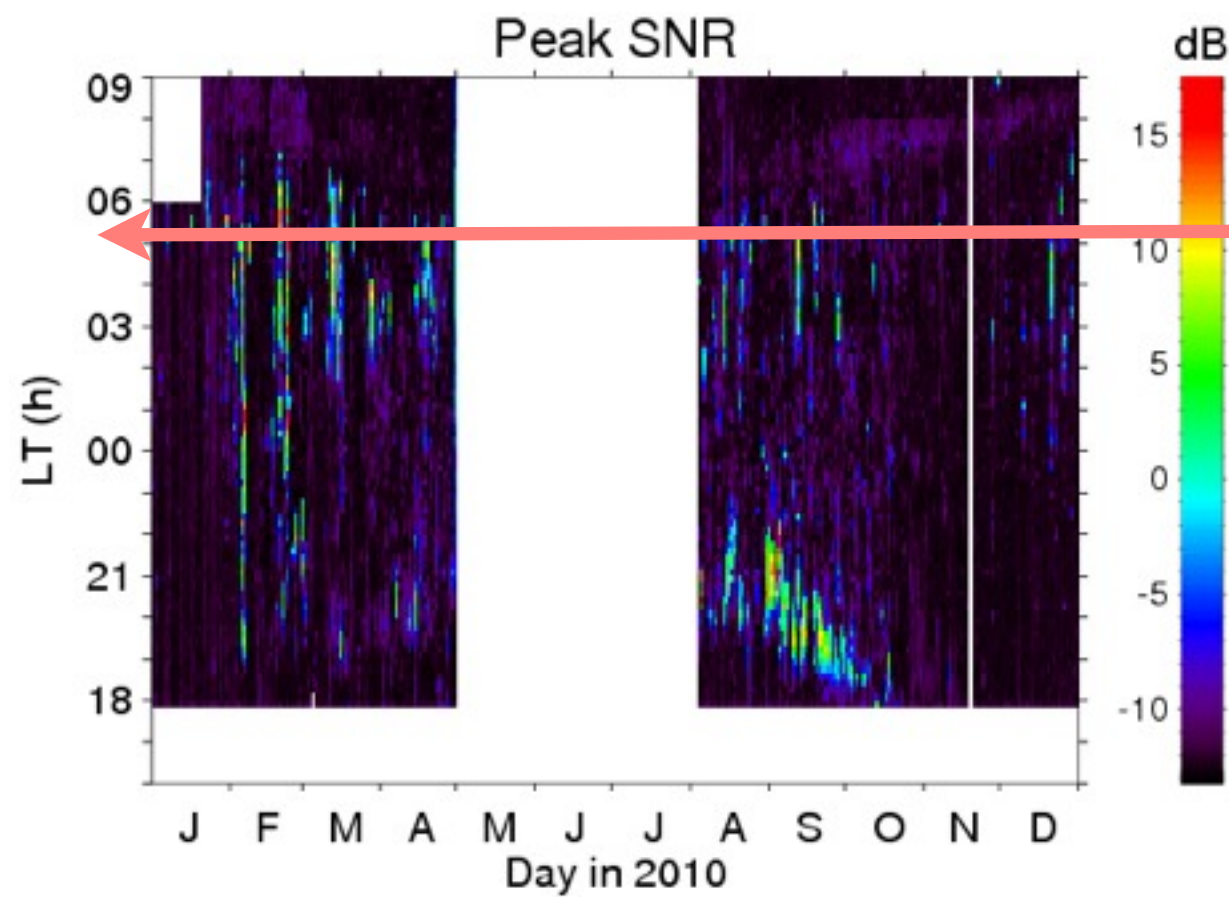
Occurrence Probability(%)



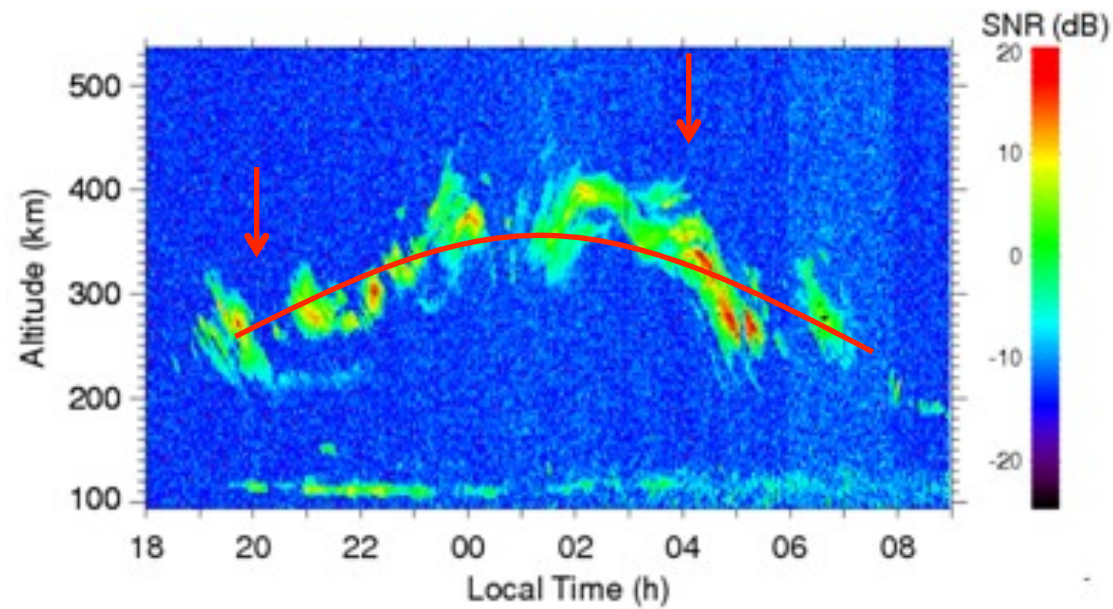
# *The annual variation of the occurrence probabilities from 2006 to 2009*

The seasonal-longitudinal variation of the irregularity occurrence rate between 2006 and 2009. Spring equinox, Summer solstice, Autumn equinox and Winter solstice from top to bottom. Similar distribution repeats year after year. However, the occurrence rate increases with year (with the decrease in solar flux).

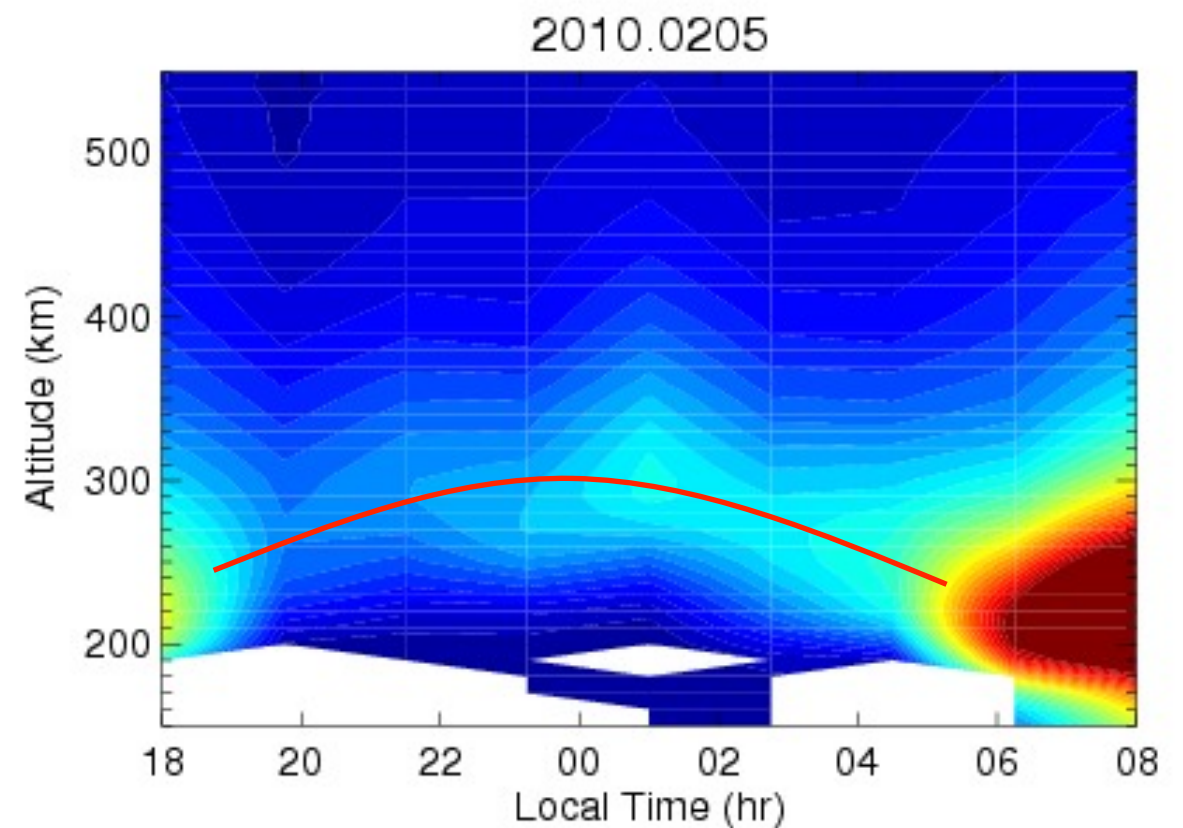
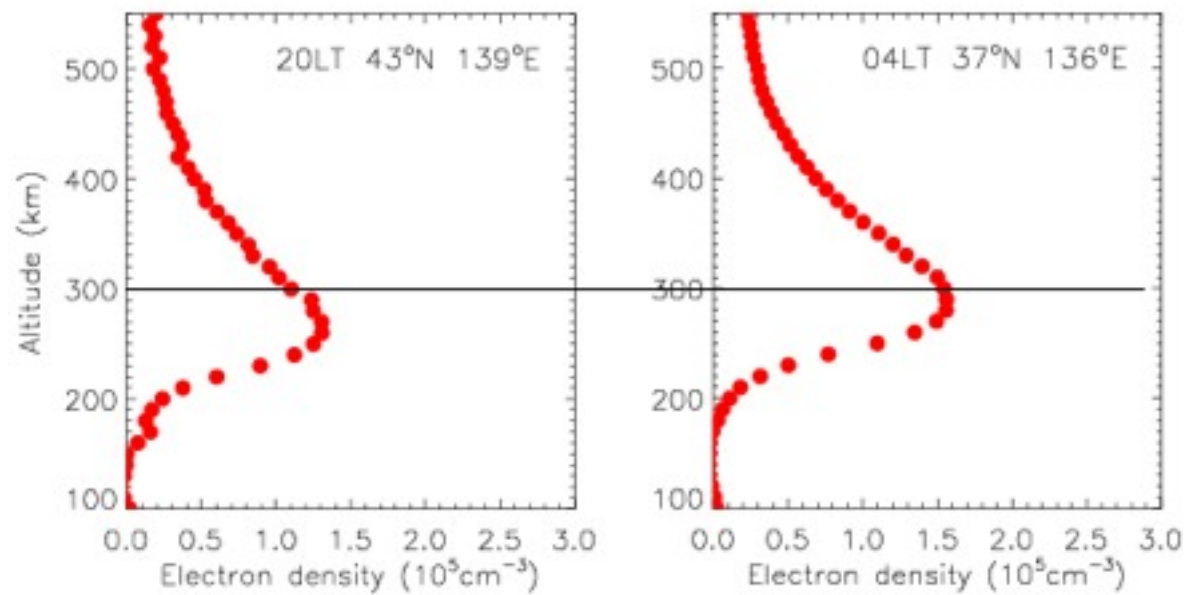
# Comparison of the E-and F-region irregularity distributions



## Comparison with COSMIC data

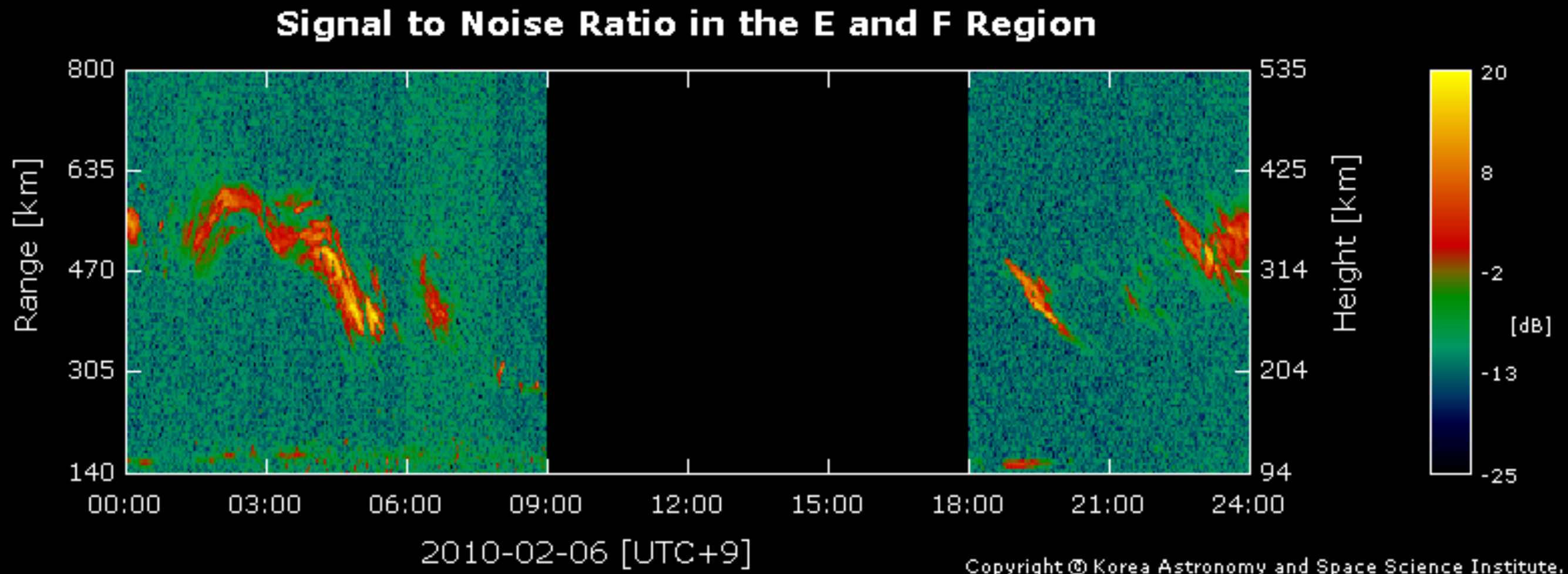


*The echoes or the field-aligned-irregularities are seen to occur near F-peak height*

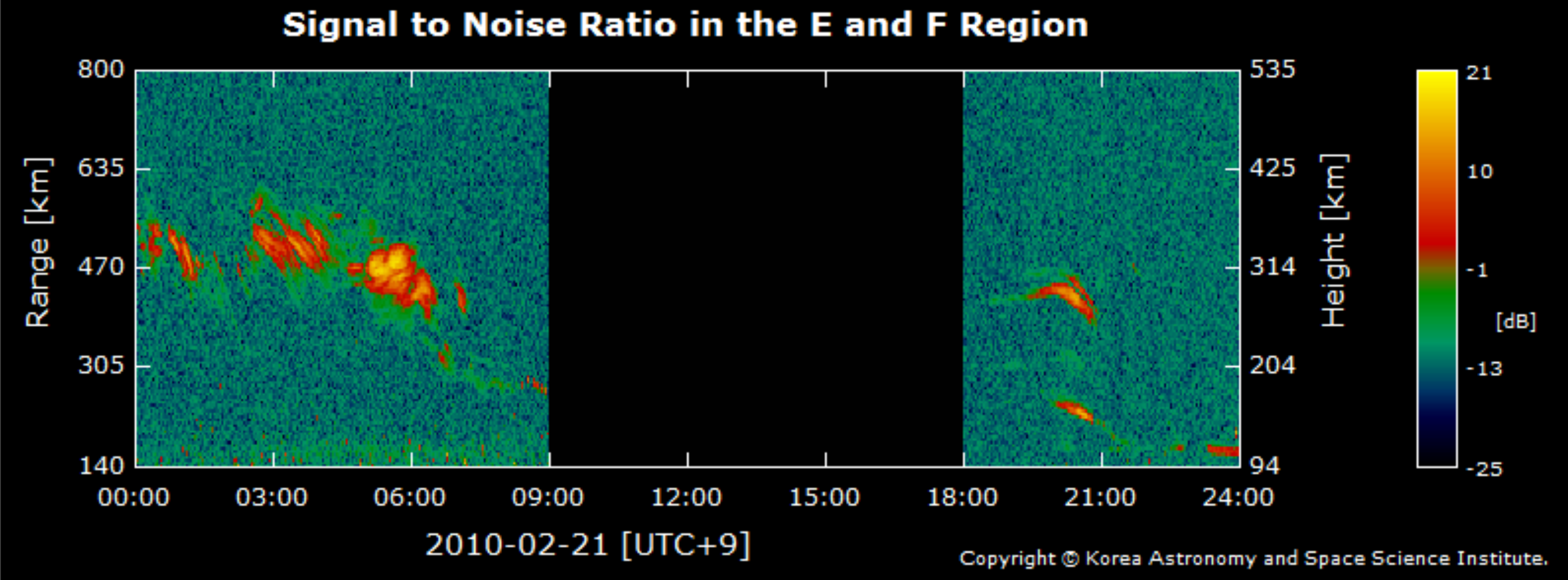


[Courtesy of Wookyoung Lee, UCAR, USA]

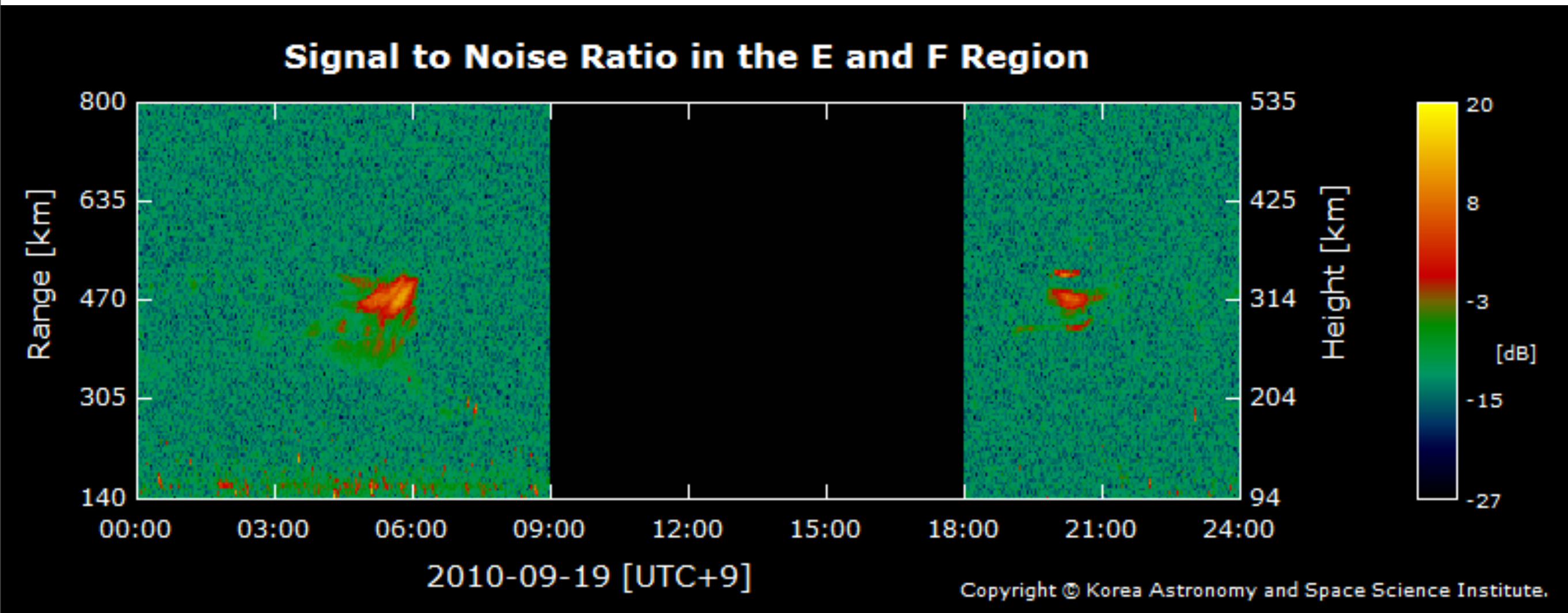
# The Signature of the morning time irregularities observed by VHF radar in Korea



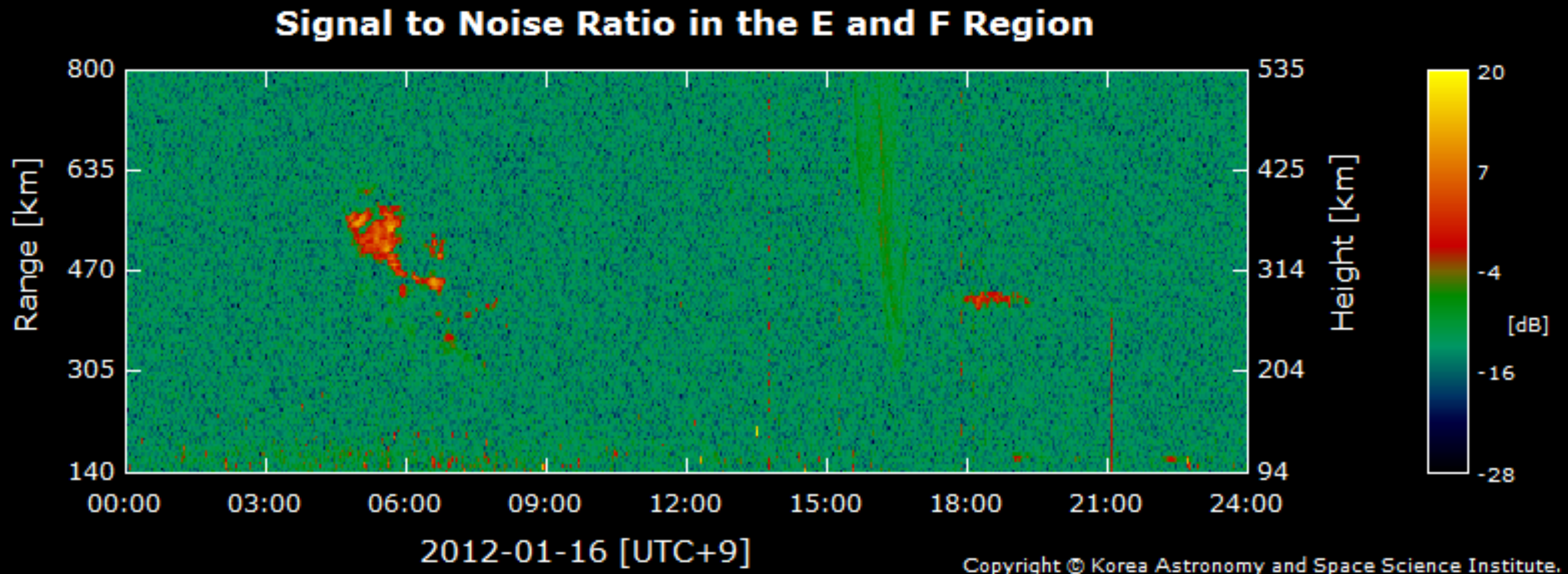
# The Signature of the morning time irregularities observed by VHF radar in Korea



# The Signature of the morning time irregularities observed by VHF radar in Korea



# The Signature of the morning time irregularities observed by VHF radar in Korea



# Summary

We have investigated the plasma density irregularities at 0600 LT by analyzing the DMSP F13 data during 2006-2009 and VHF radar images during 2010-2012

- The irregularity occurrence rate in midlatitudes is greater than that in the equatorial region during the morning time. The VHF radar observation in Korea shows the signature of the morning -time irregularities in mid-latitude.
- The irregularity occurrence rate in the winter hemisphere is greater than that in the summer hemisphere. The irregularity occurrence rate is likely to be **anti-correlated with the background plasma density** whereas the radar echos observed in mid-latitude are seen to occur near F-peak height. These behaviors are **similar to that of the plasma blob distribution**.
- The linkage of Es with the irregularity occurrences was not clearly seen based on the climatological studies of VHF radar data.
- **The onset conditions and growth rate of instabilities in the morning time and the causal link of well-known phenomena such as TID and Es with the mid-latitude irregularities are STILL REMAINING QUESTIONABLE.**

**Thank you**