On Seasonal/Longitudinal Distributions of Post-Midnight Quiettime Equatorial Ionospheric Irregularities

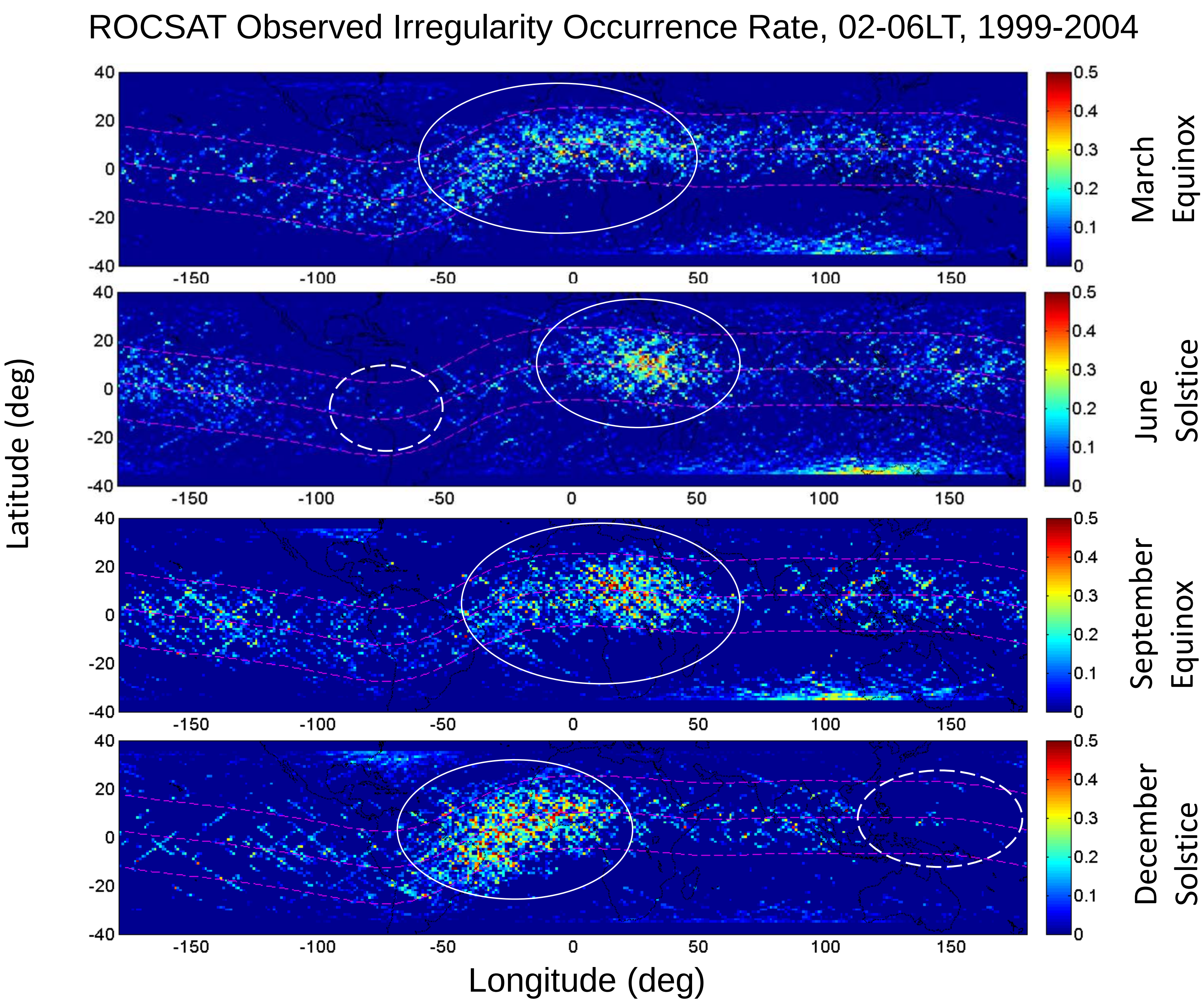
S.-Y. Su[1,2] and C. H. Liu[3]

1. Center for Space and Remote Sensing Research, National Central University, Taiwan.
2. Institute of Space Science, National Central University, Taiwan
3. Academia Sinica, Taipei, Taiwan

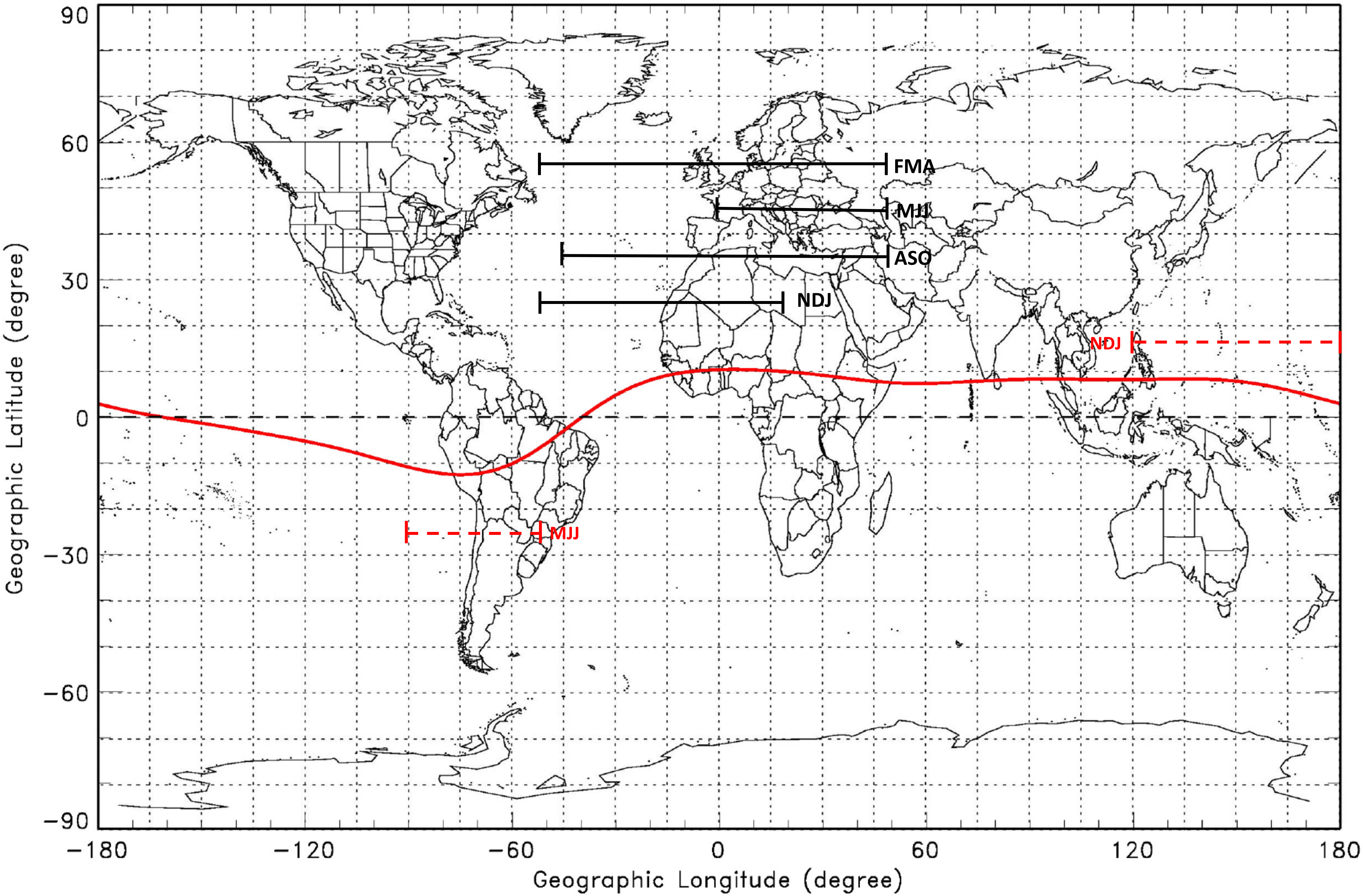
14th International Ionospheric Effects Symposium, Alexandria, VA
May 12-14, 2015

Motivation of Study

- To study the seasonal/longitudinal distributions of post-midnight (02-06 LT) quiettime equatorial irregularity occurrence characteristics for a better understanding of irregularity occurrence mechanism in the sinking nighttime ionosphere.
  - ROCSAT data (at 600 km) from 1999-2004 is used.



ROCSAT Observed Irregularity Occurrence Rate, 02-06LT, 1999-2004
March Equinox
June Solstice
September Equinox
December Solstice
Latitude (deg)
Longitude (deg)
40
20
0
-20
-40
-150
-100
-50
0
50
100
150
0.5
0.4
0.3
0.2
0.1
0



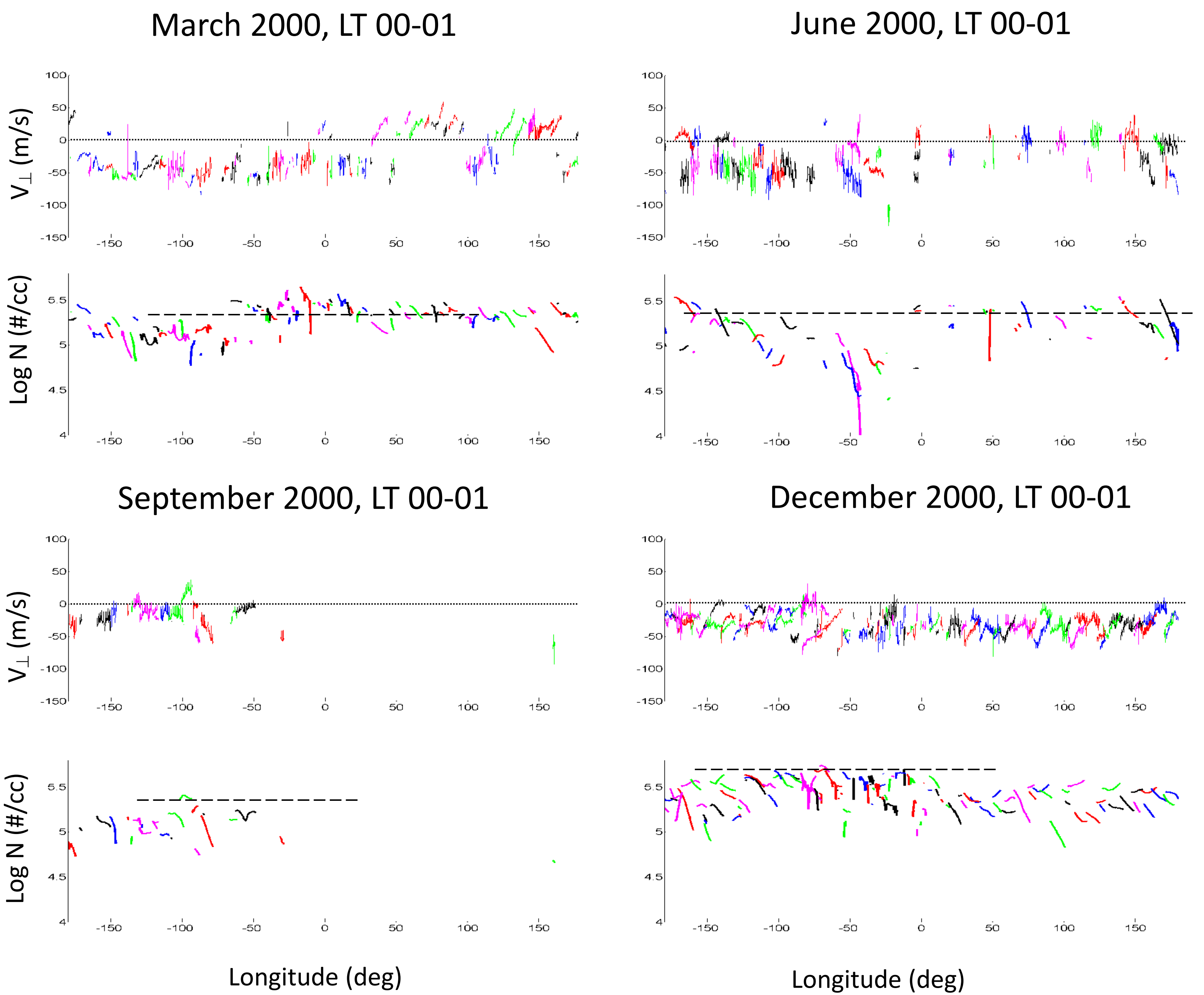
FMA
MJJ
ASO
NDJ
NDJ
MJJ
90
60
30
0
−30
−60
−90
Geographic Latitude (degree)
−180
−120
−60
0
60
120
180
Geographic Longitude (degree)

Characteristics of Post-midnight Irregularity Distributions

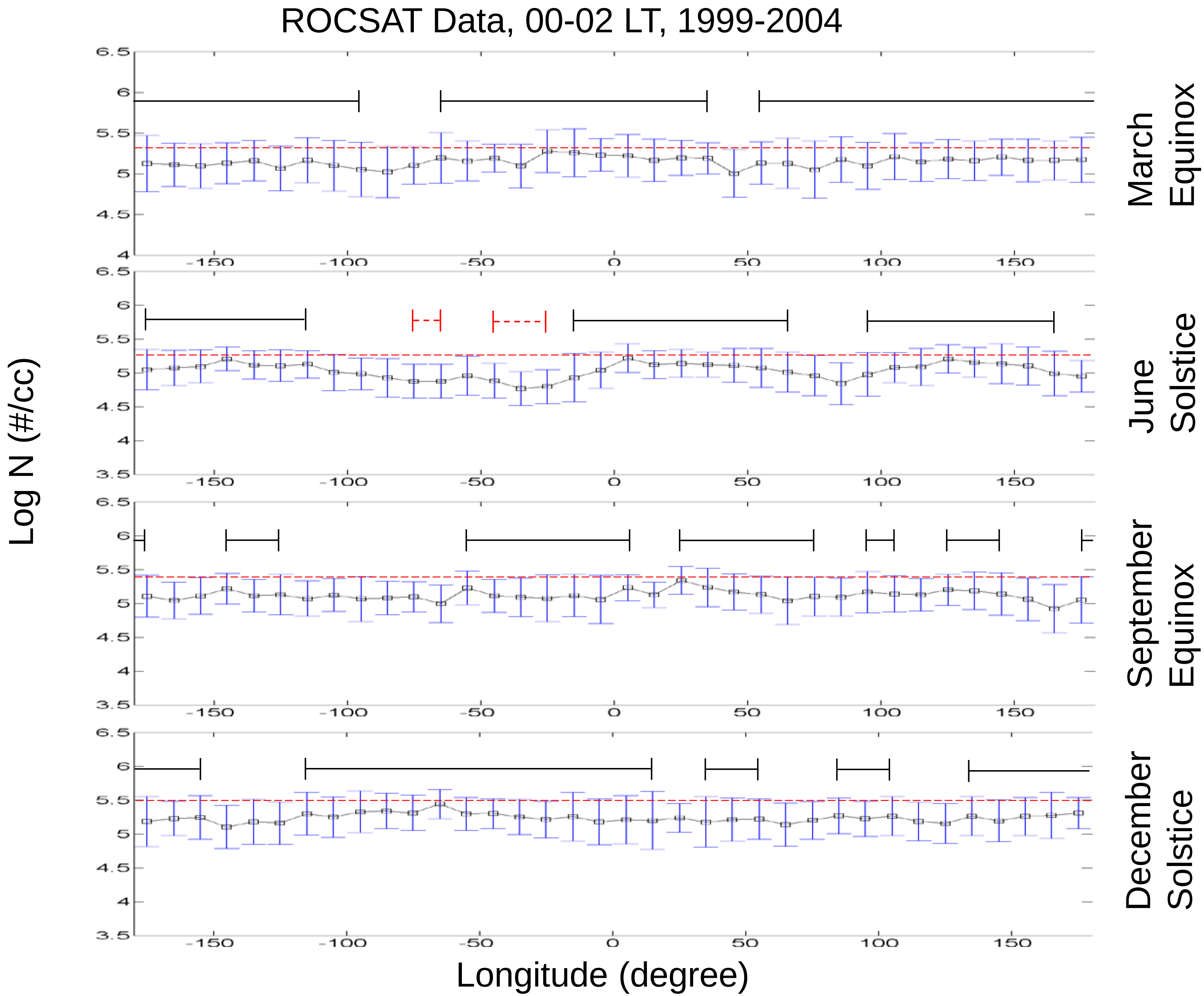
- High irregularity occurrences are clustered in the Atlantic-African sectors (longitudes around -50° to +50°) for the two equinoxes.
  - High occurrence longitude ranges for the two solstices become narrower and are shifted with respect to each other.
- Dip equators of these high occurrence longitudes are almost all located in the northern hemisphere.

Nighttime Ionospheric Background Properties

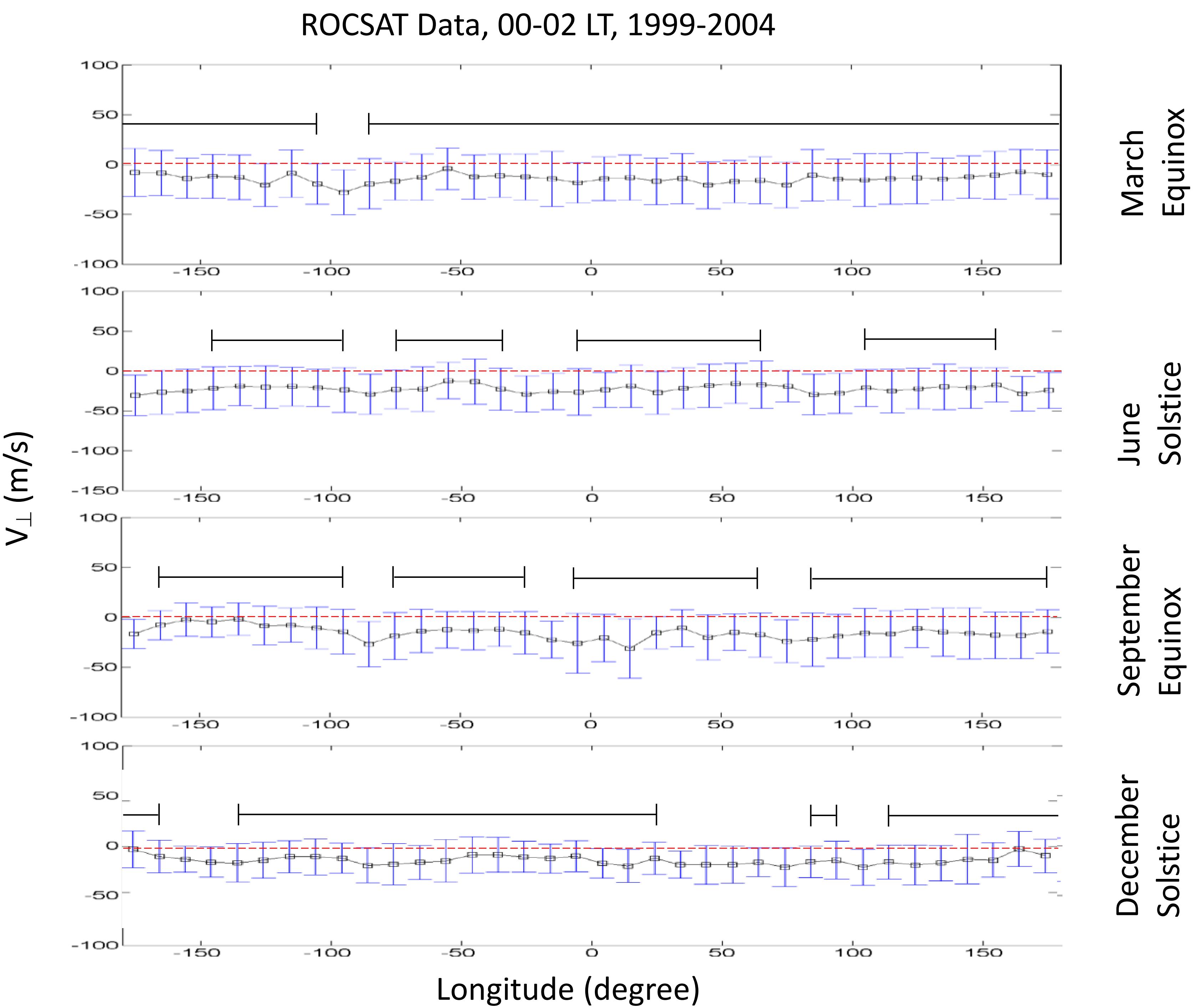
- Longitudinal variation of background density and vertical drift velocity in a month.
  - Local time range: 00 – 01 hr.
  - No density irregularities.
  - Kp < 3.
  - Dip latitudes within ± 5° .



March 2000, LT 00-01
June 2000, LT 00-01
September 2000, LT 00-01
December 2000, LT 00-01
V⊥ (m/s)
Log N (#/cc)
Longitude (deg)



ROCSAT Data, 00-02 LT, 1999-2004
Log N (#/cc)
Longitude (degree)
March Equinox
June Solstice
September Equinox
December Solstice
6.5
6
5.5
5
4.5
4
3.5
-150
-100
-50
0
50
100
150



ROCSAT Data, 00-02 LT, 1999-2004
V⊥ (m/s)
Longitude (degree)
March Equinox
June Solstice
September Equinox
December Solstice
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150

Irregularity Occurrence Probability

The irregularity occurrence probability can be written as (McClure et al., 1998)

$$P_{irr} = P_{iono}\ P_{seed}\ (1 - P_{sup}).$$

Simply set

P_{iono} = 1, if density is over the threshold; otherwise = 0.

P_{seed} = 1, if mean vertical drift > 0; otherwise = 0.

P_{sup} = 0. The effect will be discussed later.

Table 1. Longitudes of High Density and Upward Drift Velocity

	Longitudes of High Density	Longitudes of Positive Upward Drift	Overlap Longitudes: High Probability of Irregularity Occurrences	
			Good comparison with observations	Fail to compare with observations
March Equinox	-180°—-95° -65°—-35° 55°—180°	-180°—-105° -95°—+180°	-65°—+35° (-50°—+50°)[1]	-180°—-105° 55°—180°
June Solstice	-175°—-115° -15°—+65° 95°—165°	-145°—-95° -85°—-35° -5°—+65° 105°—155°	-5°—+65° (0°—50°)[1]	-145°—-115° 105°—155°
September Equinox	-145°—-125° -55°—+5° 25°—75° 95°—105° 125°—145° 175°—185°	-165°—-95° -75°—-25° -5°—+65° 85°—175°	25°—45° (-45°—+50°)[1]	-145°—-125° 95°—105° 125°—145°
December Solstice	-180°—-155° -115°—+15° 35°—15° 85°—105° 135°—180°	-180°—165° -135°—+25° 85°—95° 115°—180°	-115°—+15° (-50°—+25°)[1]	-180°—-165° 85°—95° (135°—165°)[2]

Note: 1. Longitudes of high irregularity occurrences observed by ROCSAT.

2. Within longitudes of ROCSAT observed extreme low irregularity occurrences (120° - 180°)

Discussions and Conclusions (1/3)

- Many longitudes of high irregularity occurrences seem to coincide with longitudes of high background density and positive vertical drift for every season.
  - Except at Central Pacific sector (longitudes 145° to 175°) in the December solstice where opposite observations of extreme low occurrence exist.
    - For these longitudes, the suppression factors of nighttime transequatorial wind and geomagnetic field strength need included.

Discussions and Conclusions (2/3)

- The lowest density (among the four seasons) at East Pacific-South American sectors (longitudes 270° to 310°) in the June solstice results in the extreme low occurrences of irregularities in the same season.

- Similar to the post-sunset situation, high ionospheric height (inferred from high density) and positive vertical drift velocity in the post-midnight quiettime equatorial ionosphere seem to be the primary driving factors for the irregularity occurrences.

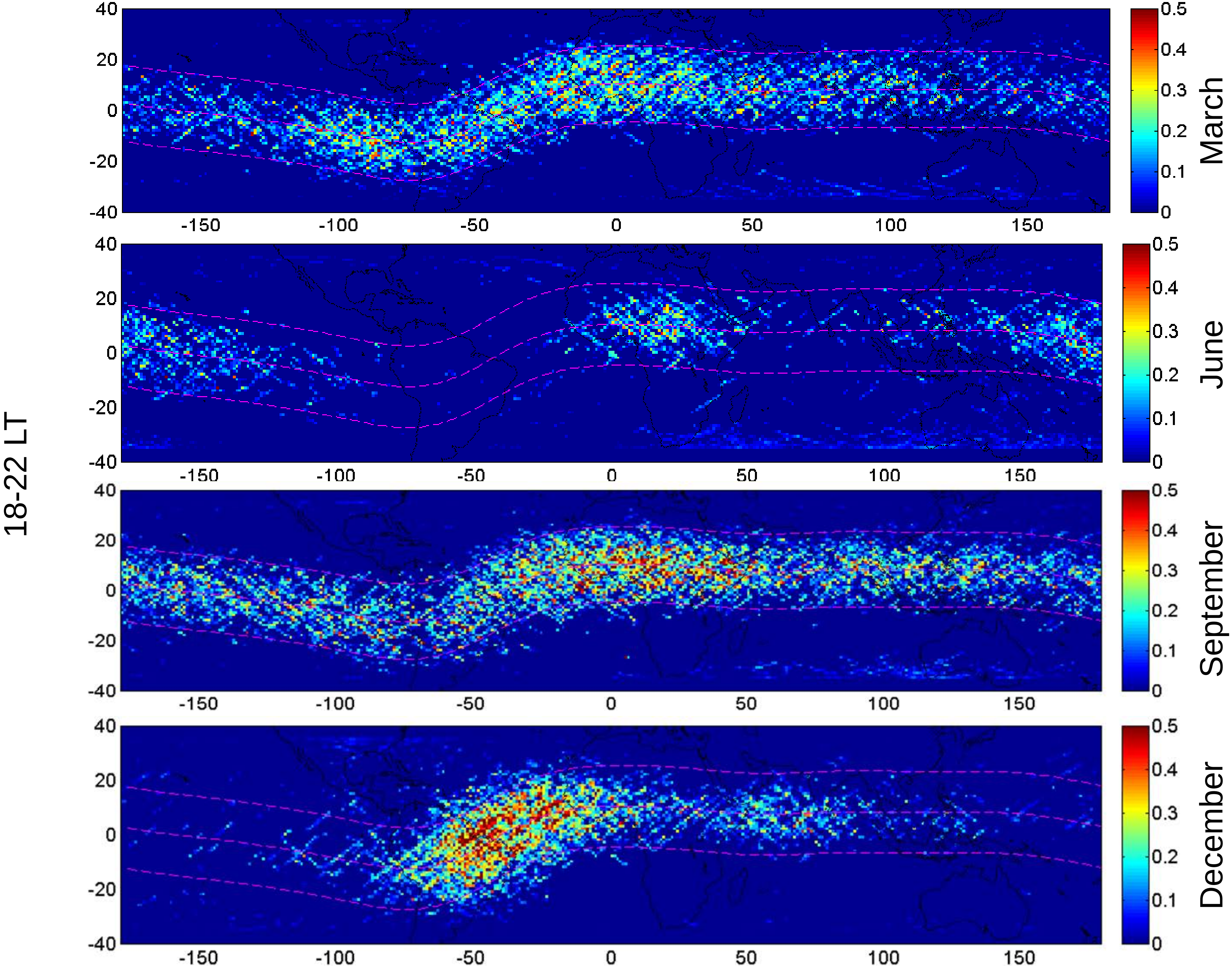
Discussions and Conclusions (3/3)

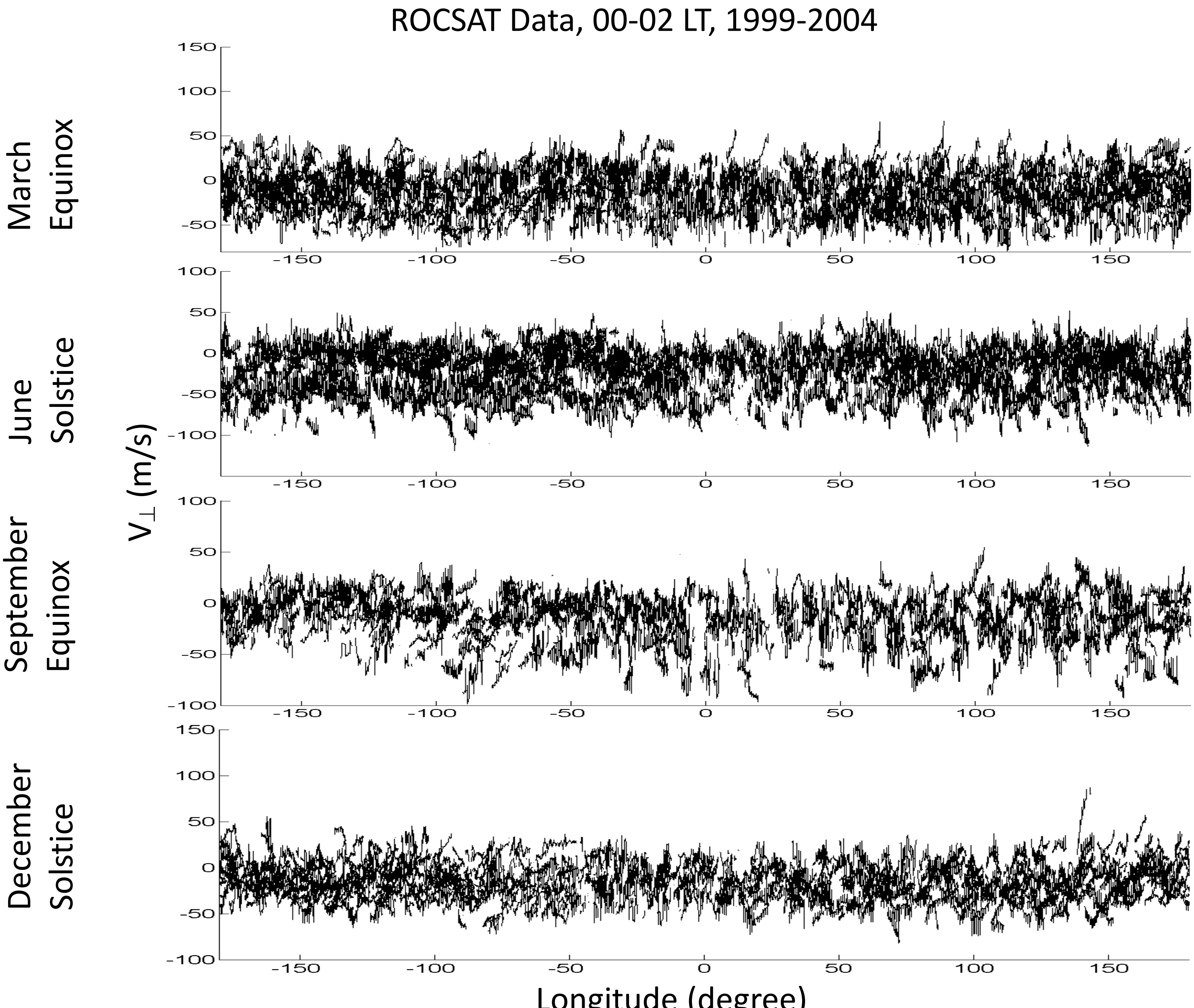
- Cause of high ionospheric height (inferred from high density) in the post-midnight period seems to be inherited from the high ionosphere height in the post-sunset period due to pre-reversal vertical drift enhancement.
- Cause of positive vertical drift velocity seem to be driven by the electric fields that are resulted from interaction of ionosphere-atmosphere coupling at some longitude regions in the bottomside ionosphere.

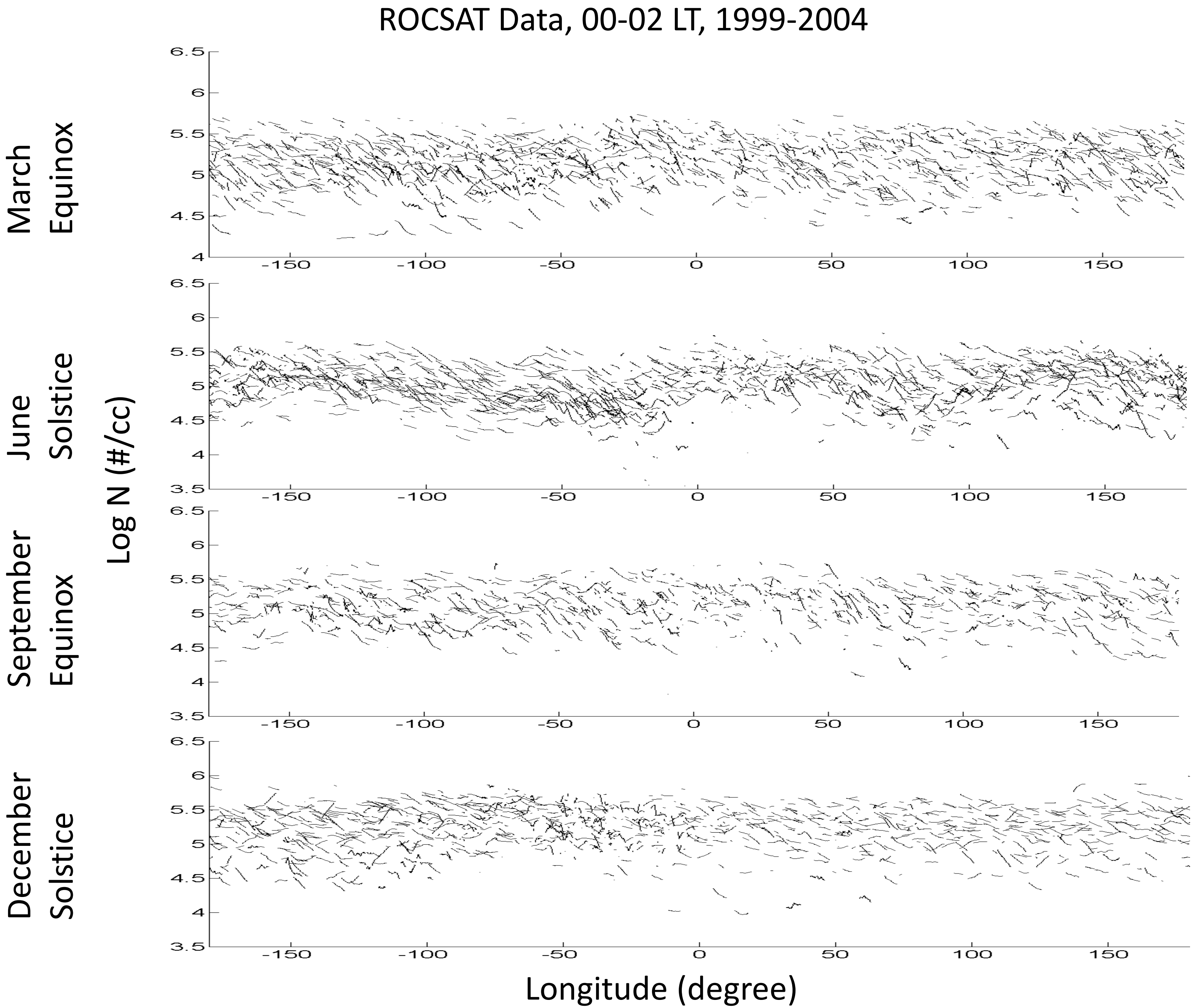
Acknowledgements

- The work is carried out by support, in part, by US AFRL AOARD-134126.
- We thank C.L. Wu for his help in data processing and plotting some of the figures.

Thank You For Your Attention


18-22 LT
March
June
September
December
40
20
0
-20
-40
-150
-100
-50
0
50
100
150
0.5
0.4
0.3
0.2
0.1
0


ROCSAT Data, 00-02 LT, 1999-2004
March Equinox
June Solstice
September Equinox
December Solstice
V⊥ (m/s)
Longitude (degree)
150
100
50
0
-50
-100
-150


ROCSAT Data, 00-02 LT, 1999-2004
March Equinox
June Solstice
September Equinox
December Solstice
Log N (#/cc)
Longitude (degree)
6.5
6
5.5
5
4.5
4
3.5
-150
-100
-50
0
50
100
150