

Aurora and Airglow

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Institute of Space Science
National Central University

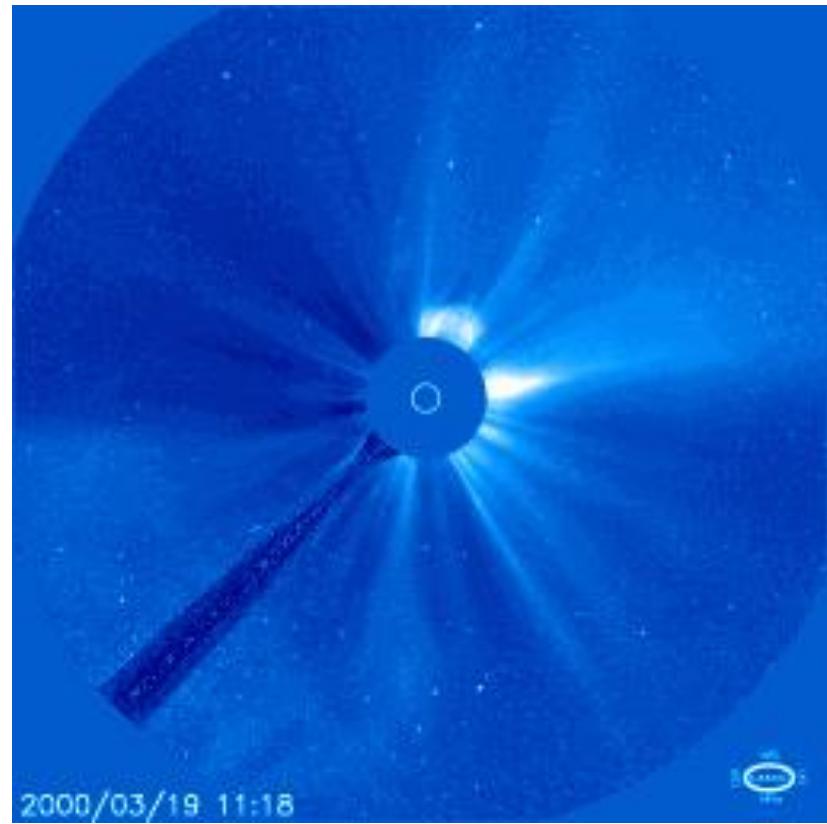
May 10, 2008

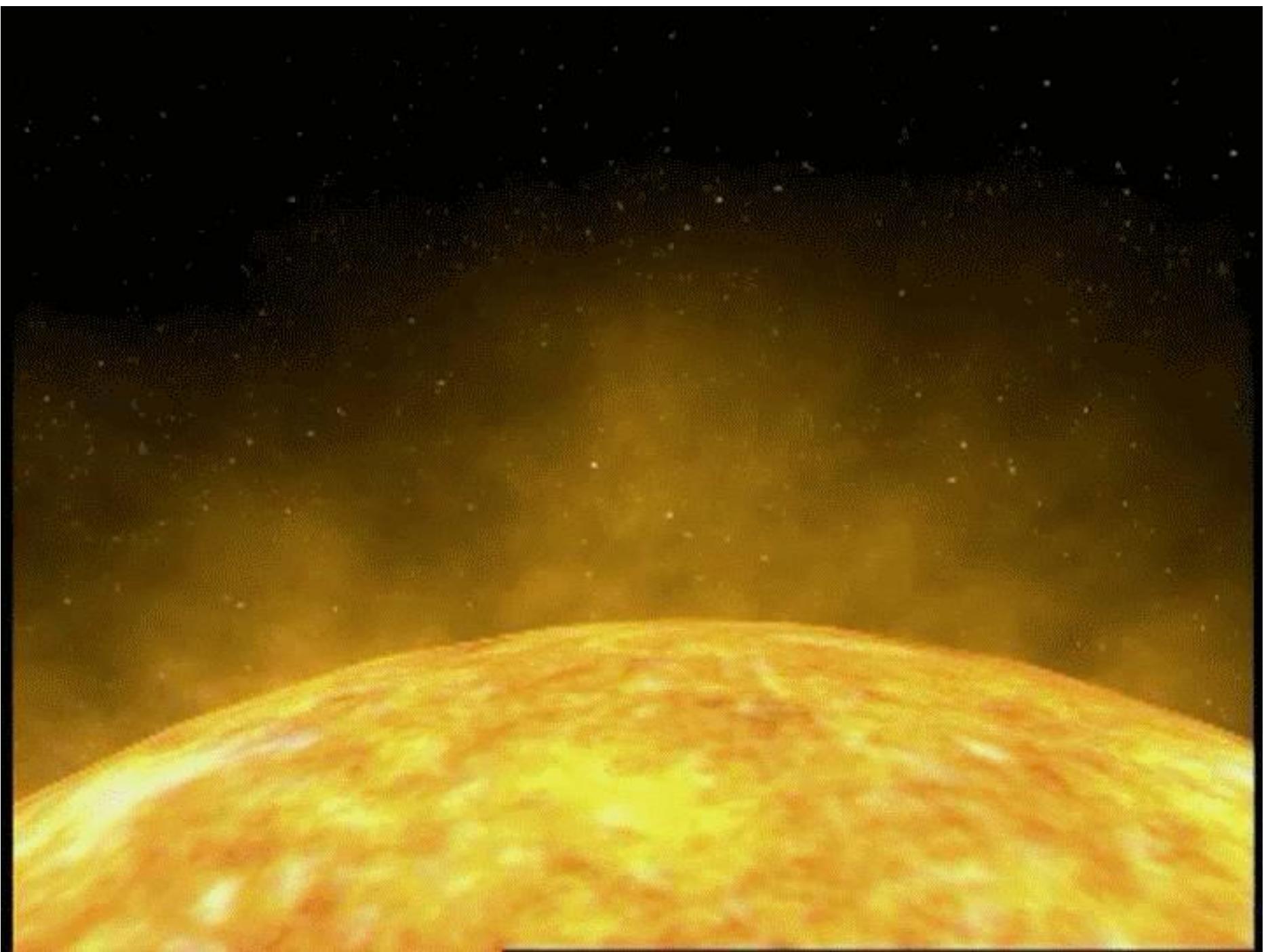
Content

- Goal
- Introduction
- Equatorial Spread-F
- Experiments
- Observation and Discussion
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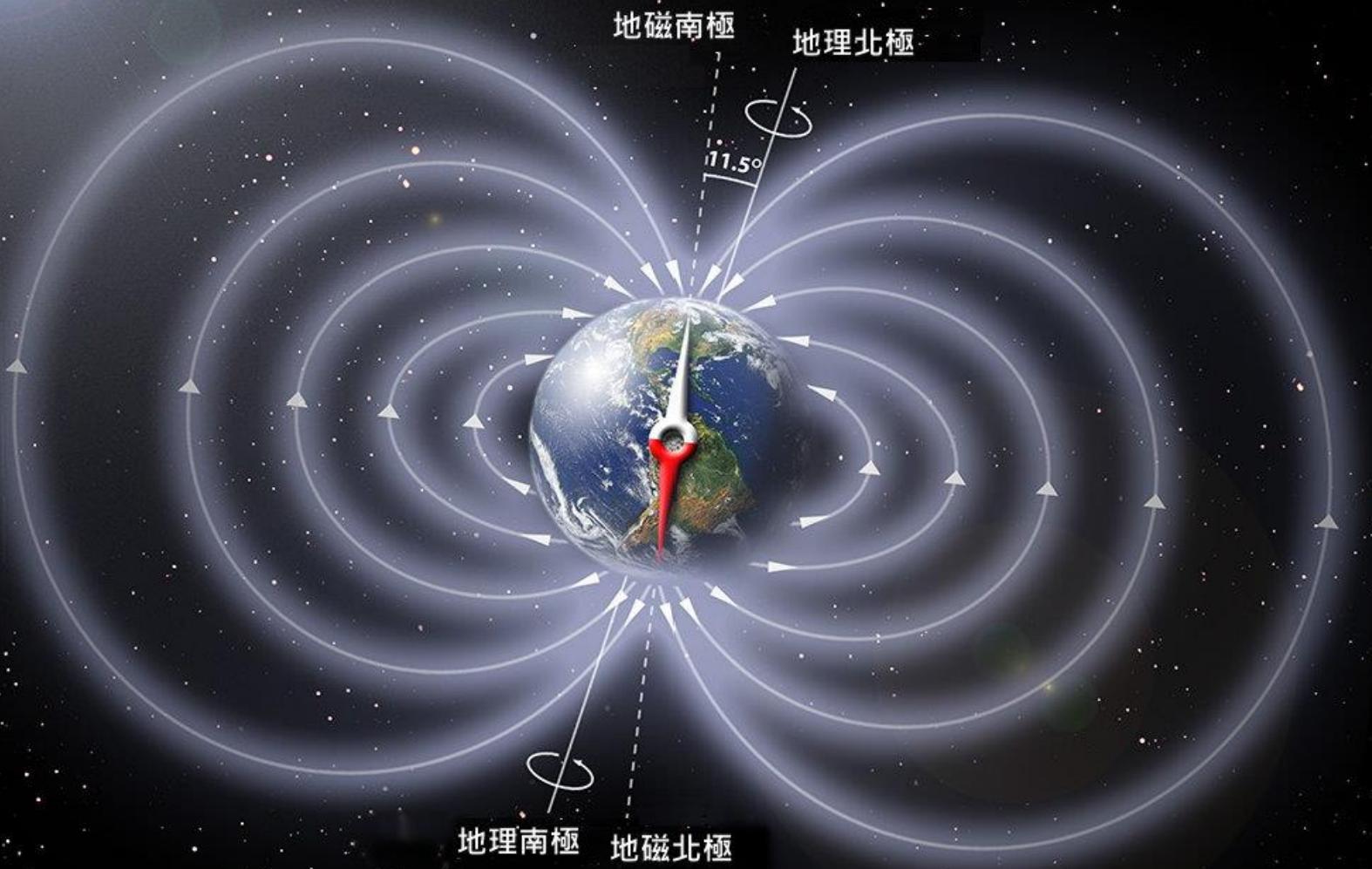
Goal

- To observe and study dynamics and structure of irregularities and plasma depletions in the ionosphere.



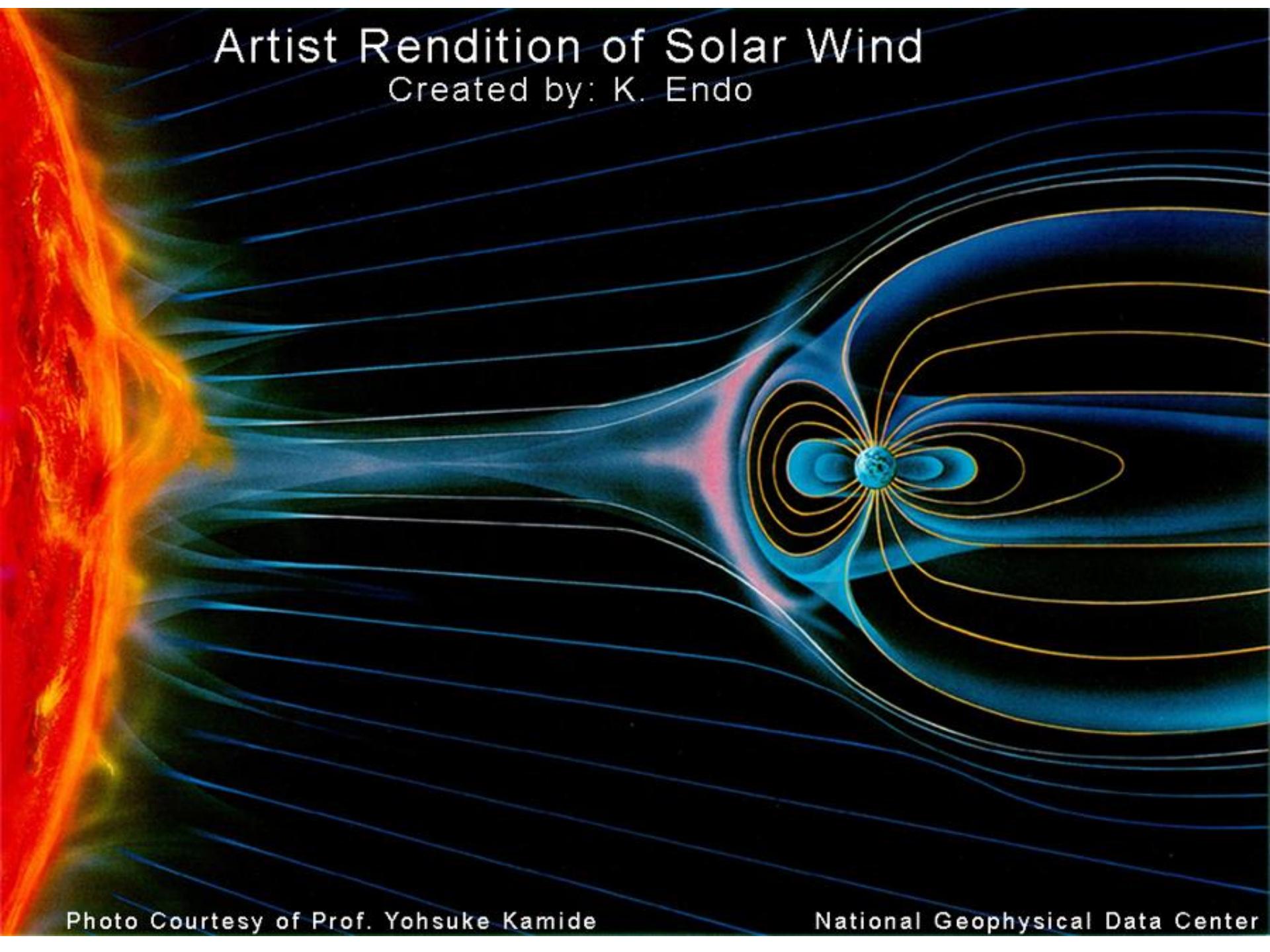


The Earth's Magnetic Field



Artist Rendition of Solar Wind

Created by: K. Endo



磁力線

能





一共有幾種顏色呢？



極光的顏色

- 粉紅色—氫原子 ($H, 1$)



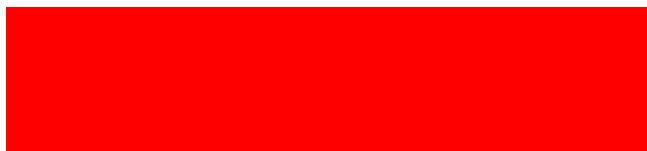
- 白綠色—氧原子 ($O, 16$)



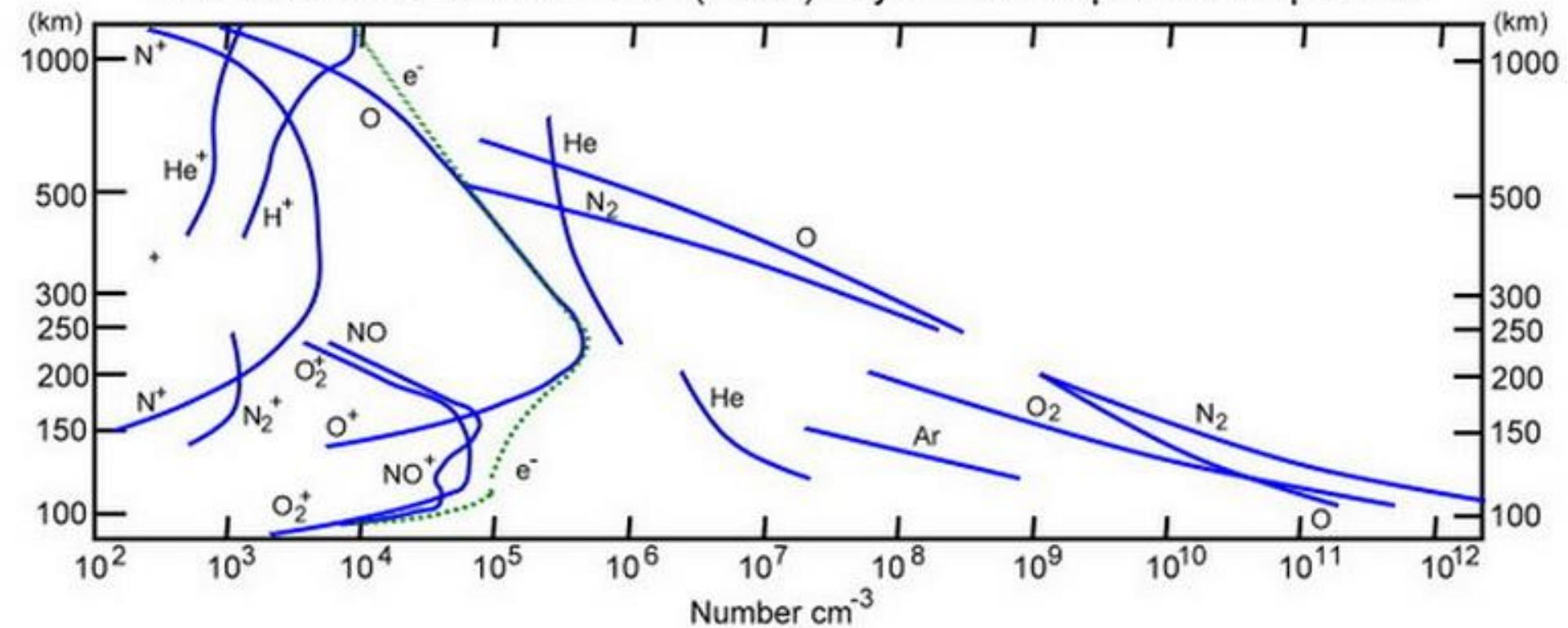
- 青藍色—氮分子 ($N_2, 28$)

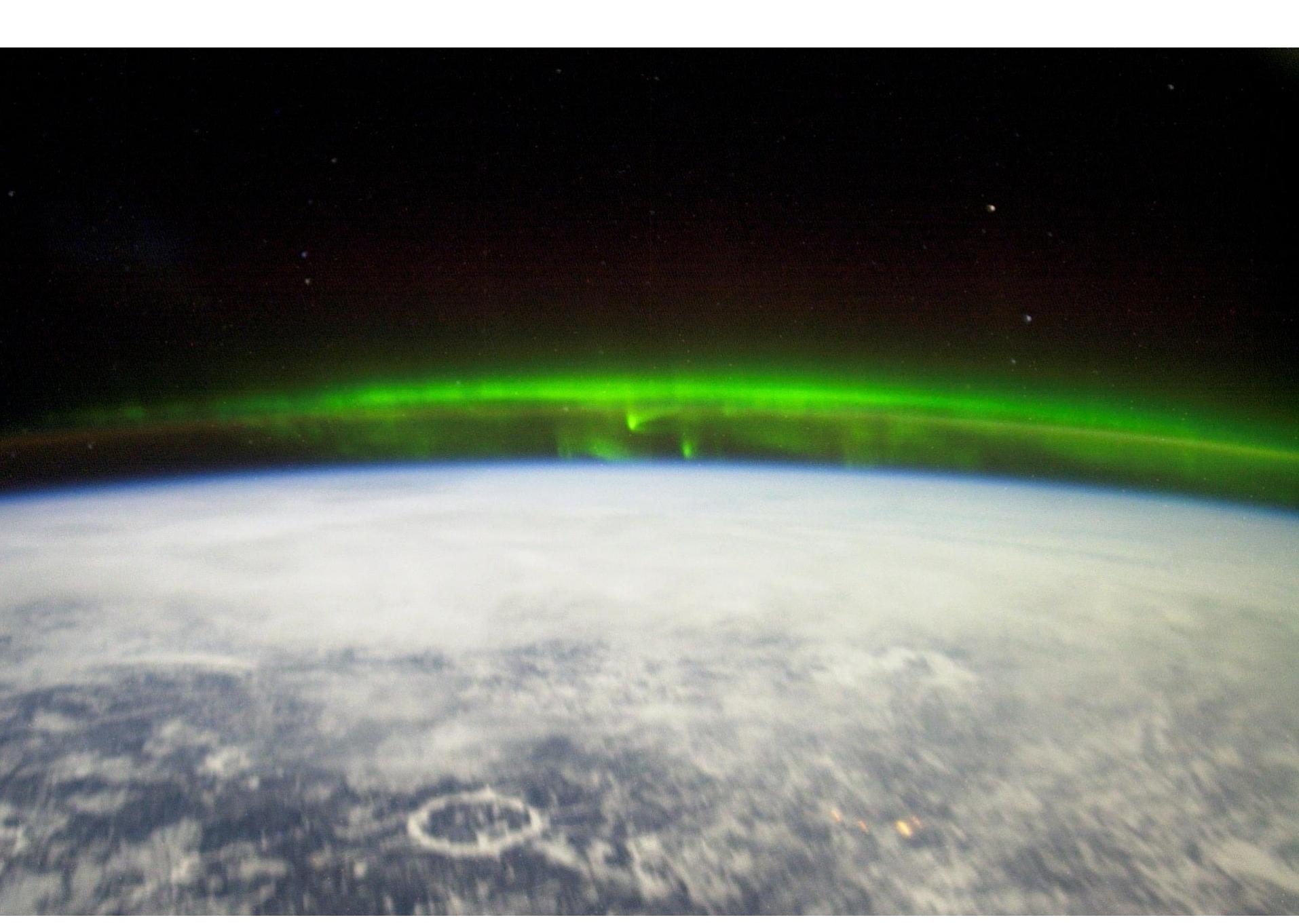


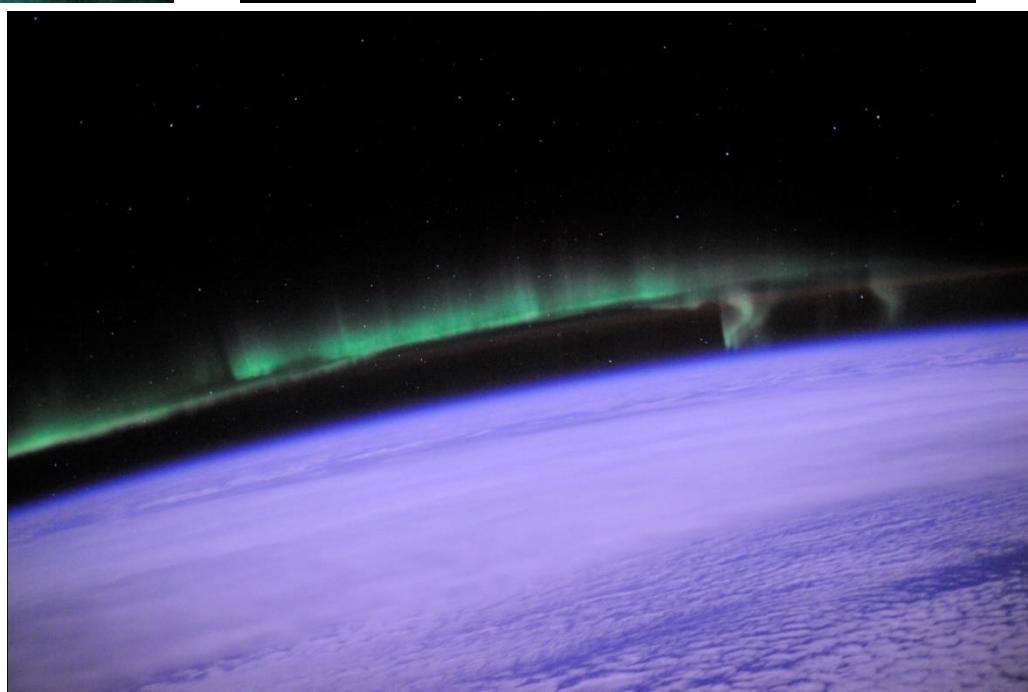
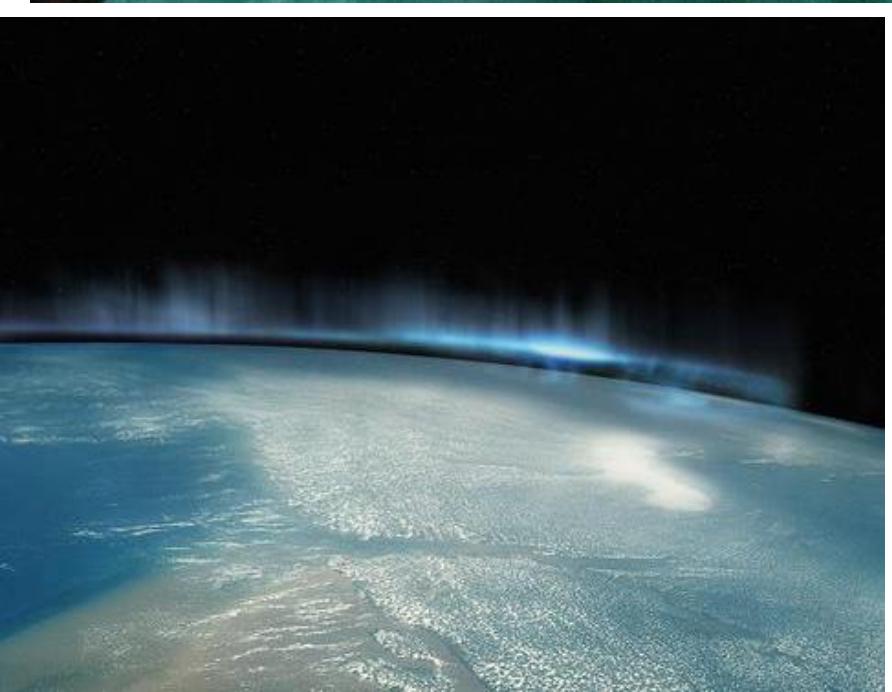
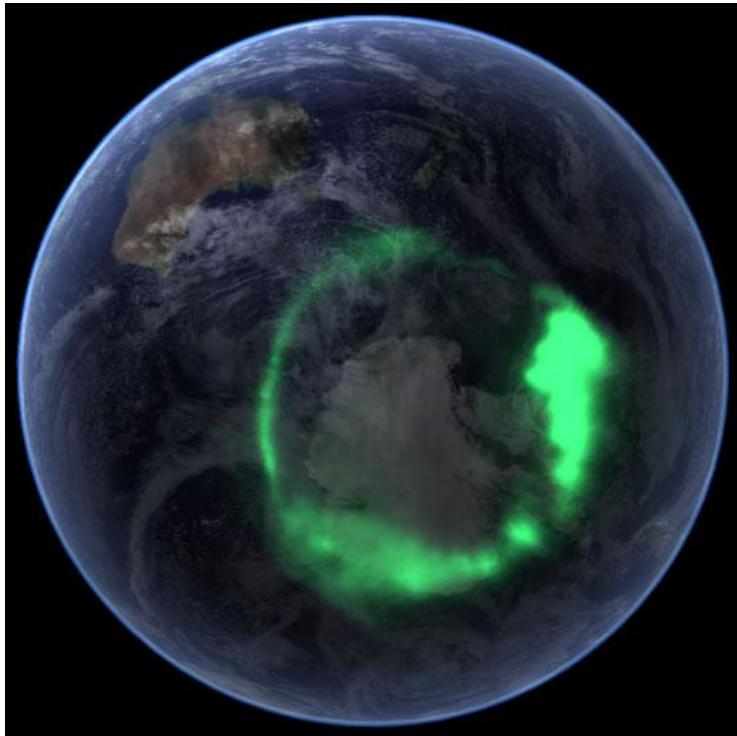
- 血紅色—氧分子 ($O_2, 32$)



International Quiet solar Year (IQSY) daytime atmospheric composition

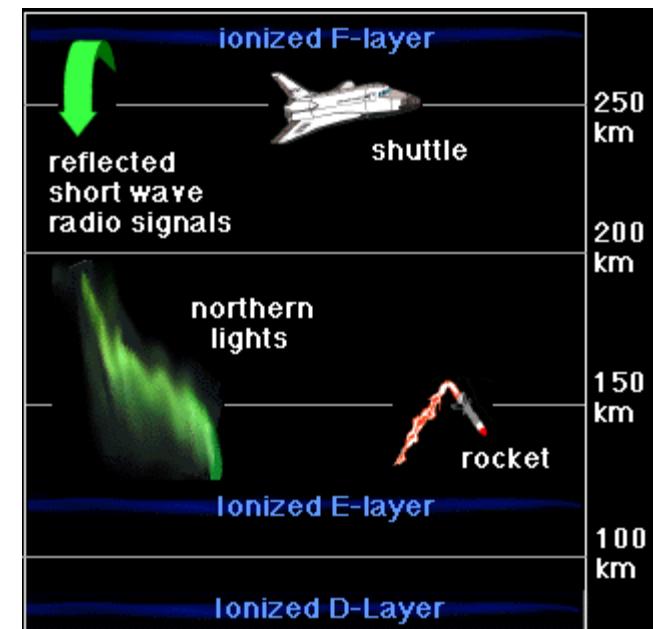
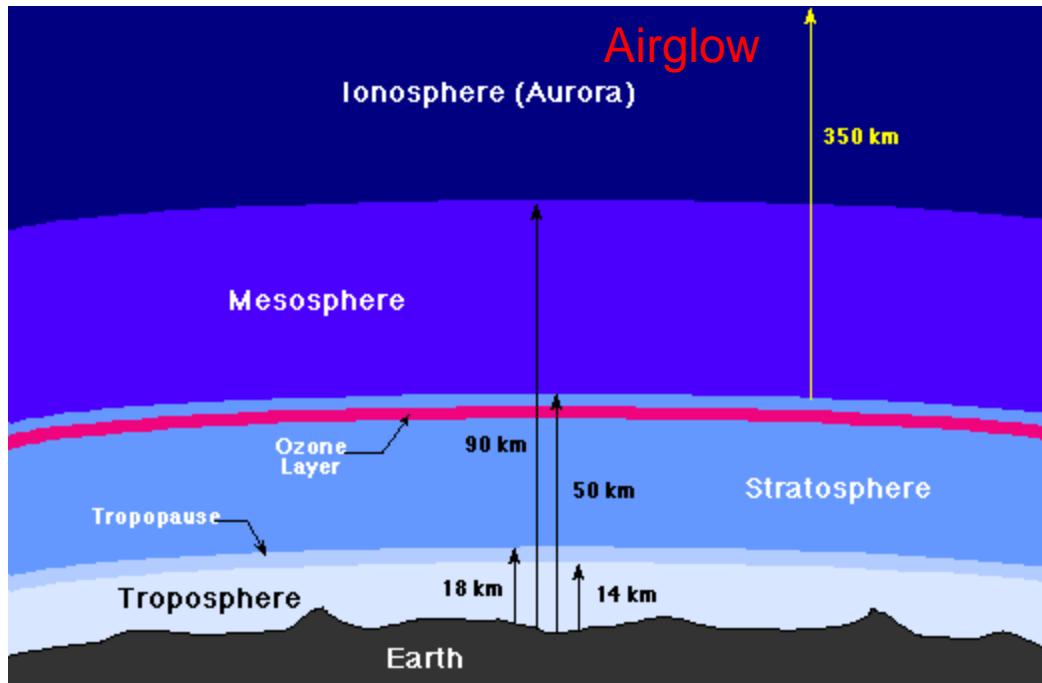




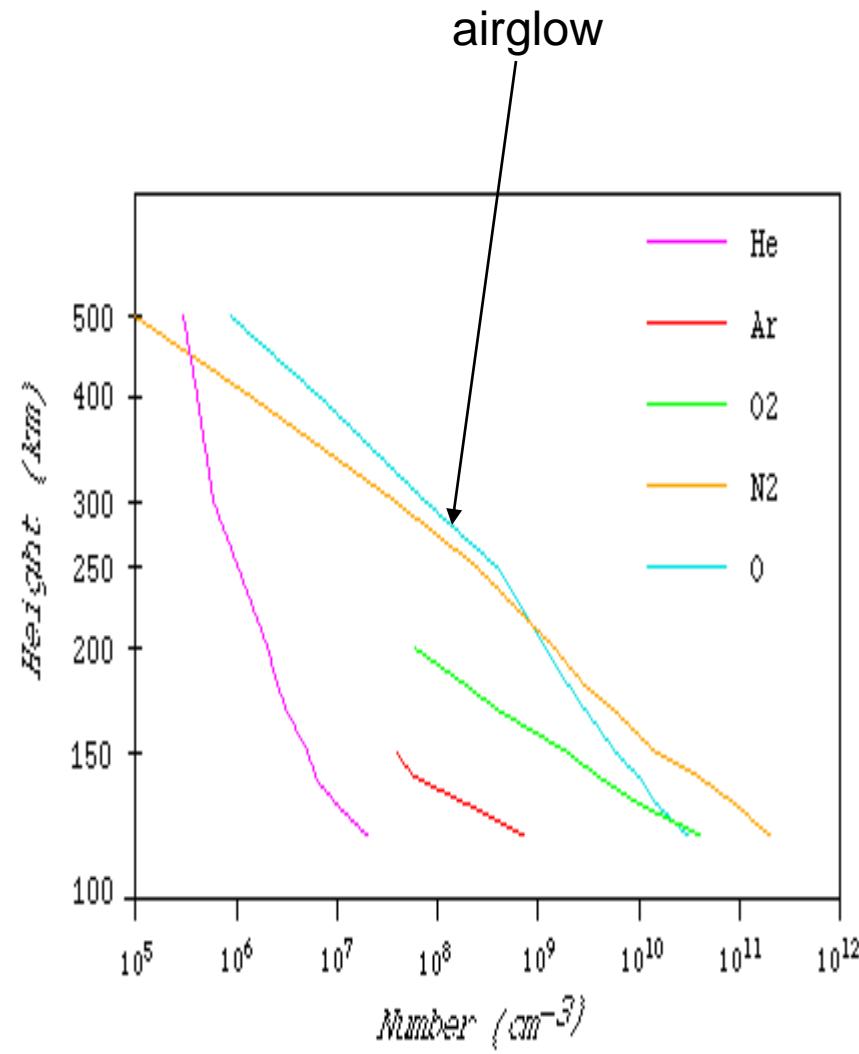
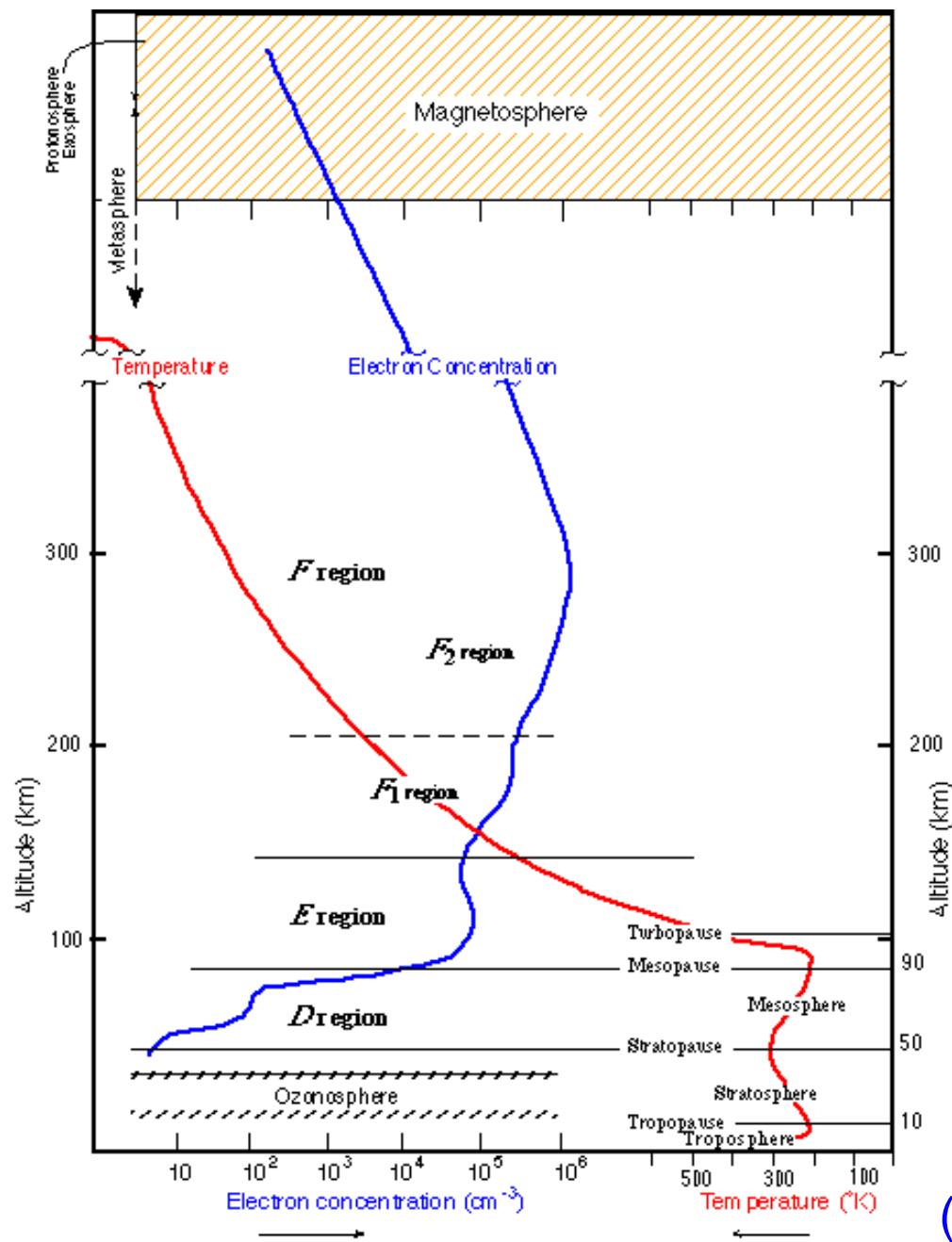


Introduction

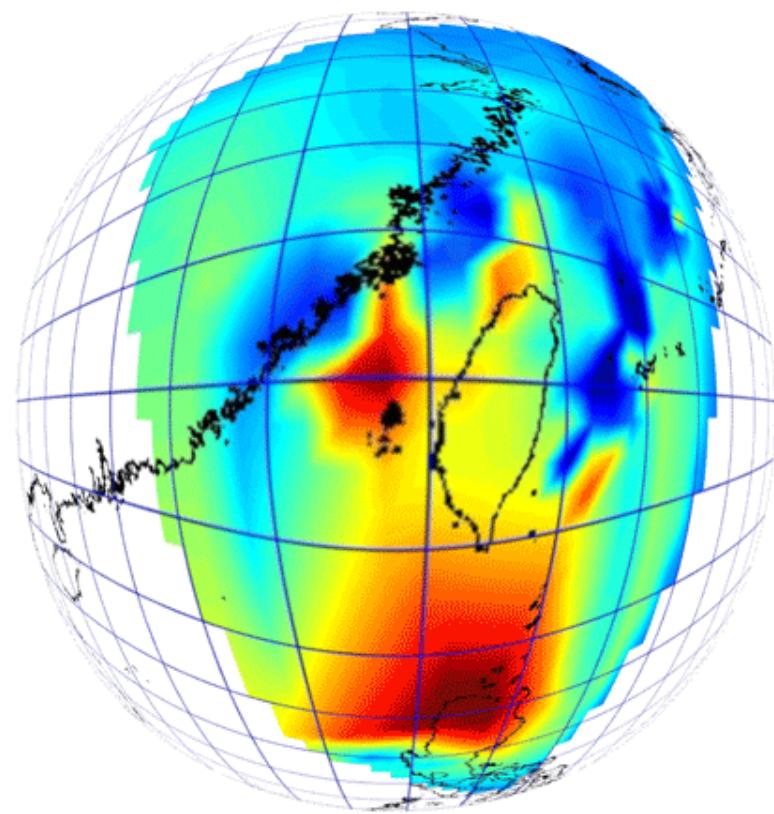
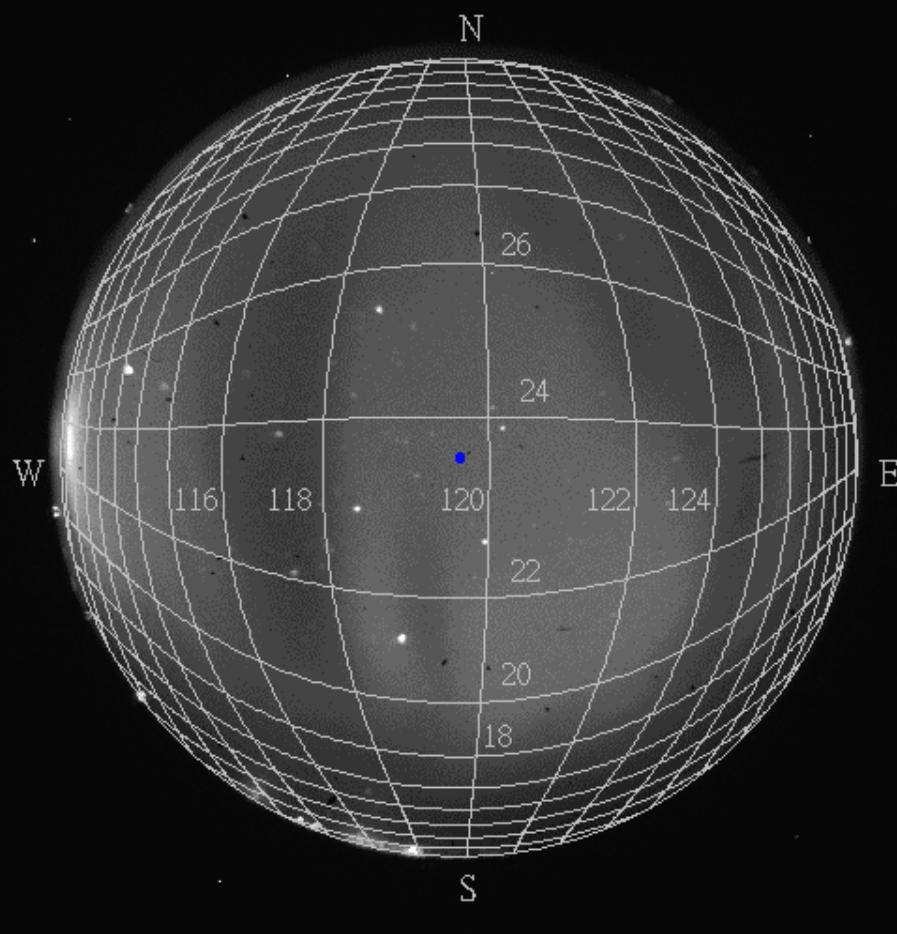
(<http://www.windows.ucar.edu>)



(<http://csep10.phys.utk.edu>)



2000/03/04 20:17:30 LT

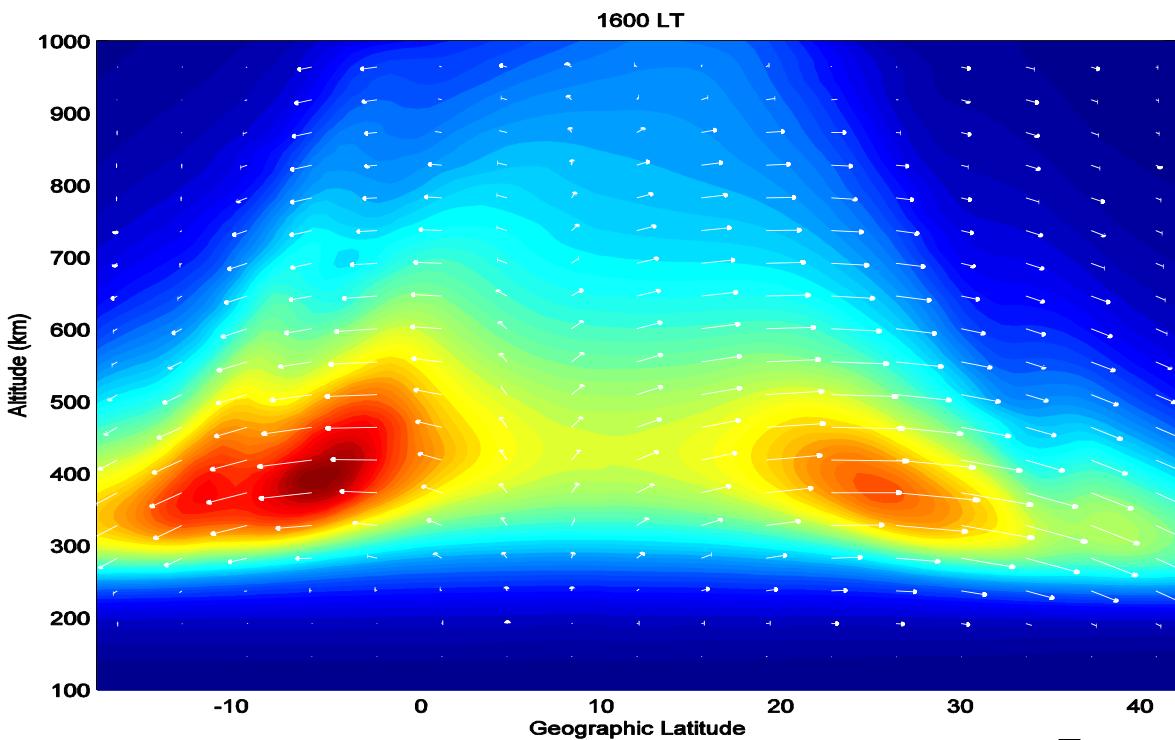


Satellite observation

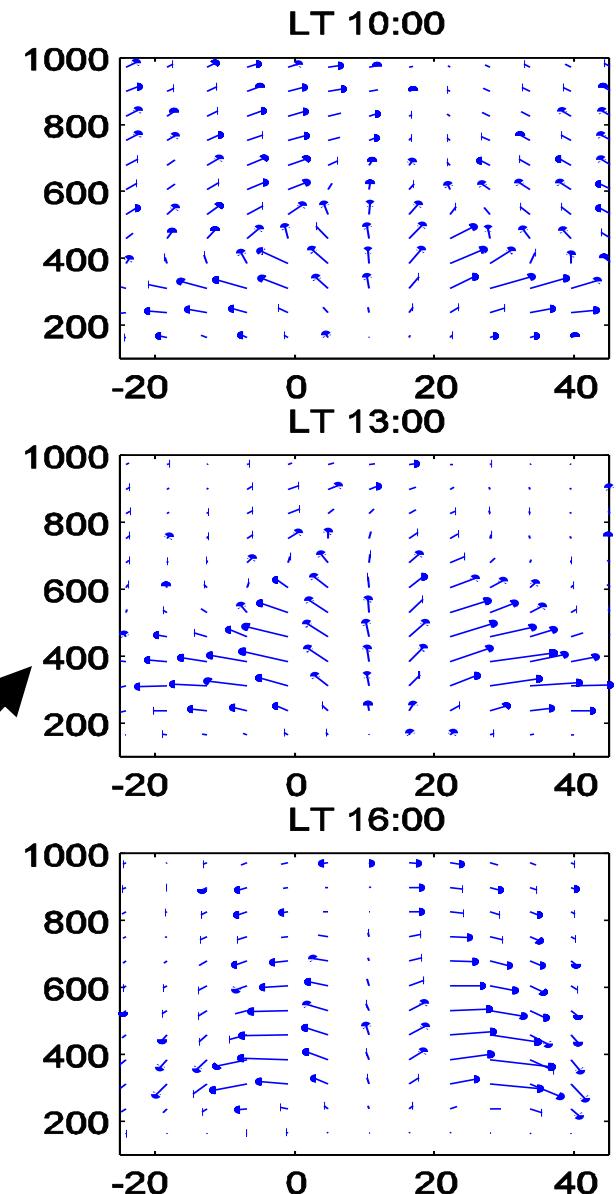
Equatorial Ionization Anomaly (EIA) airglow emission

Equatorial plasma fountain

Low-Latitude Ionosphere is dominated by the electrodynamics



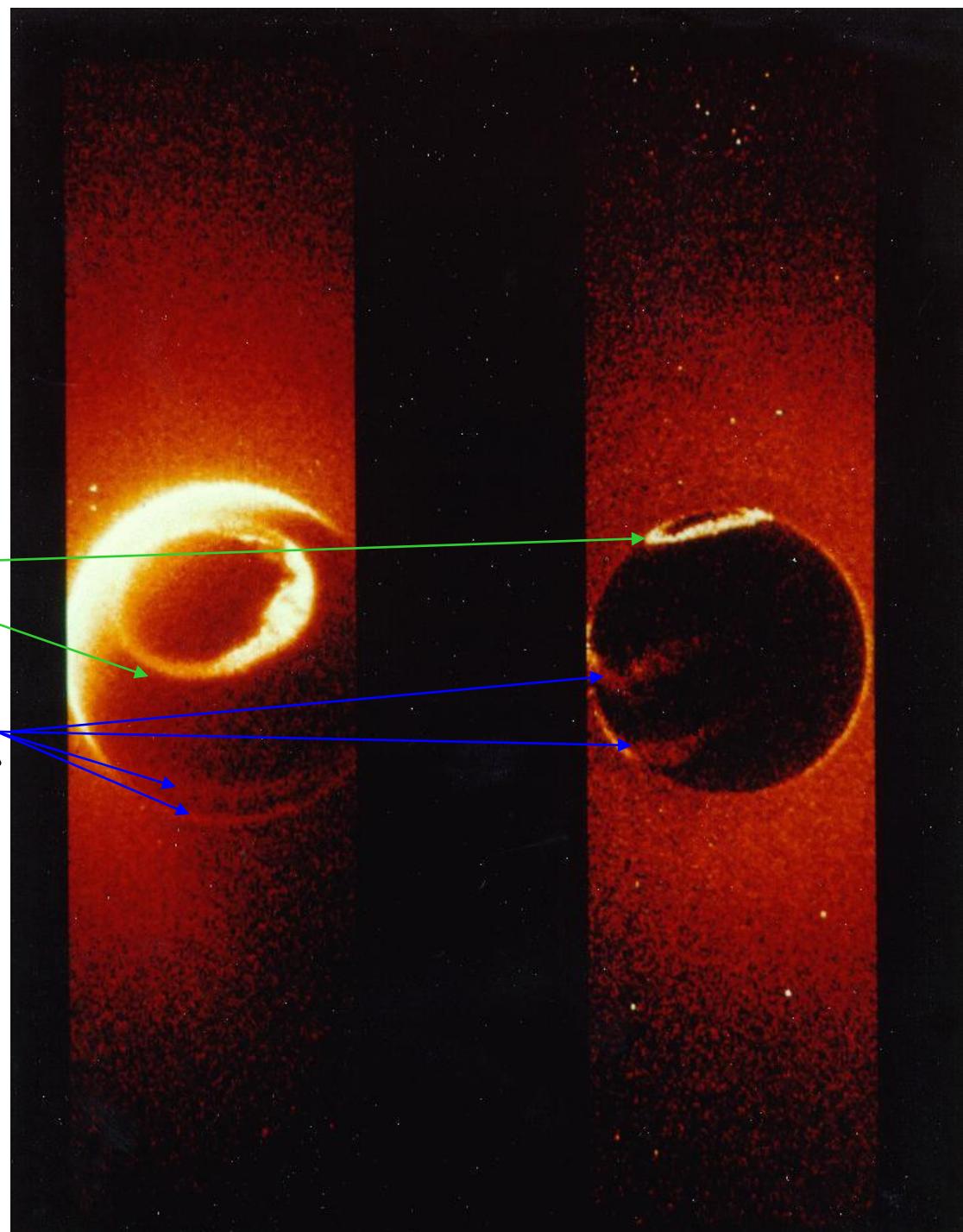
A model simulated plasma fountain effect starting in the morning and enhance to its maximum around noon

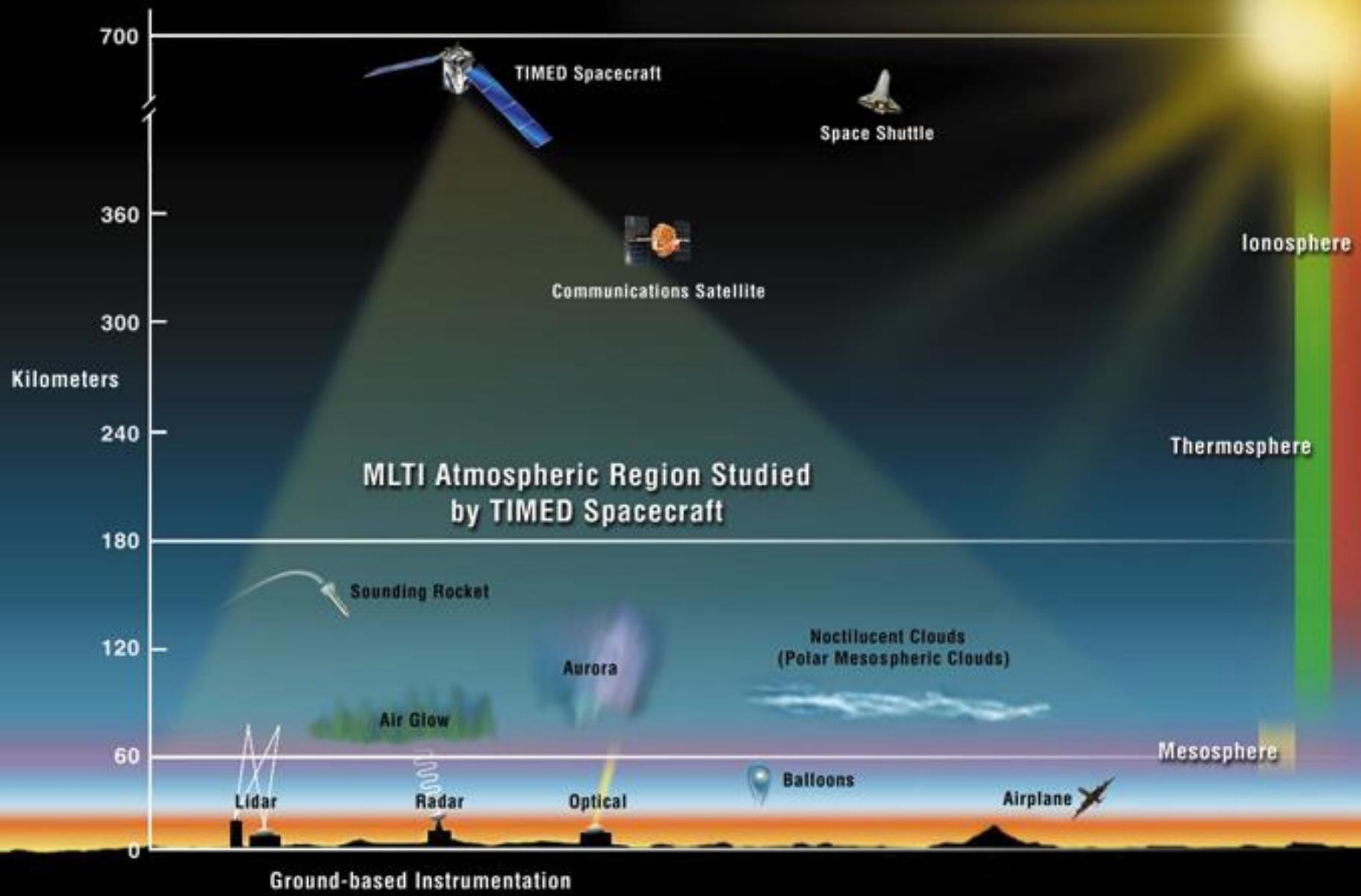


Aurora 極光

Airglow 大氣暉光

DE-1 satellite



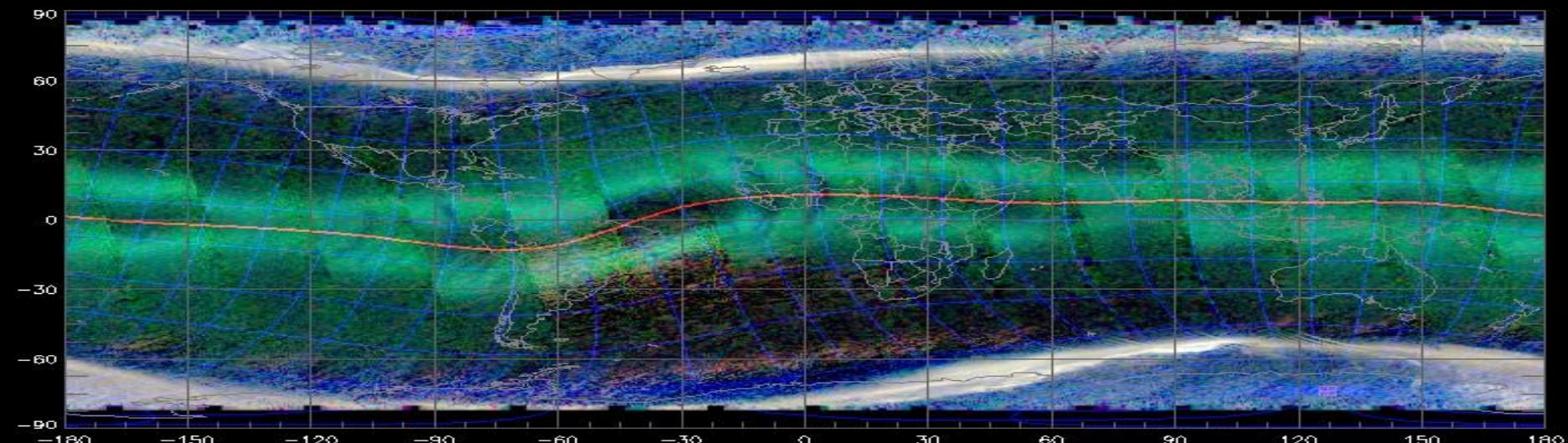


<http://www.timed.jhuapl.edu/WWW/science/objectives.php>

2002.269

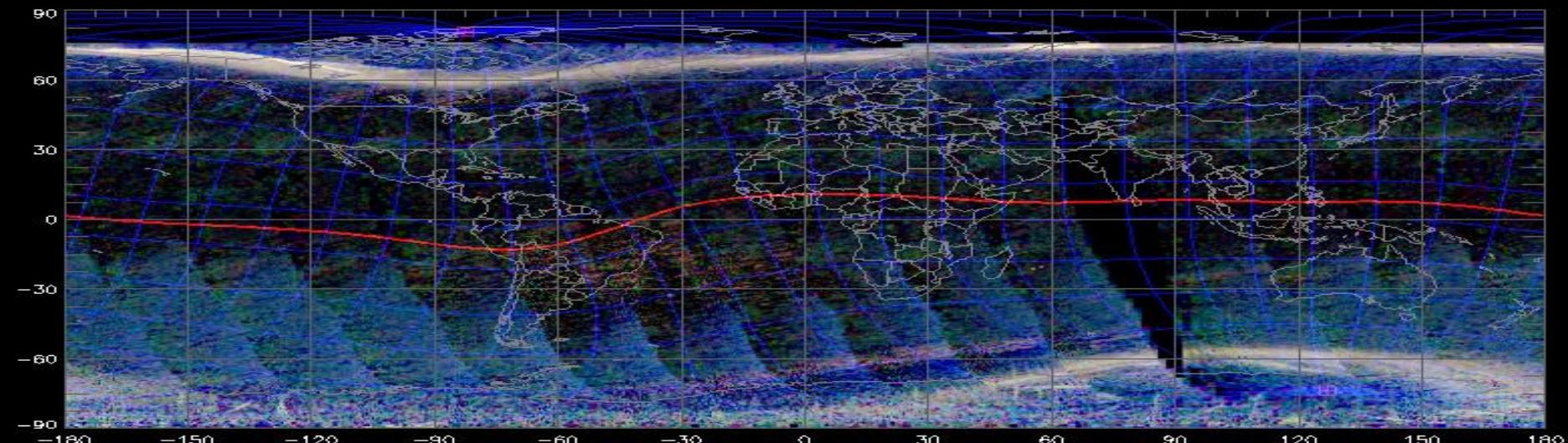
GUVI Composite Image (SZA > 95), 2002 Day 269, Orbits 4328–4342
OI 1304 (blue, 7670.44 R max (data), 10000.0 R max (color scale))
OI 1356 (green, 3422.86 R max (data), 1000.00 R max (color scale))
LBH short (red, 4123.35 R max (data), 1000.00 R max (color scale))

TIMED GUVI 135.6nm

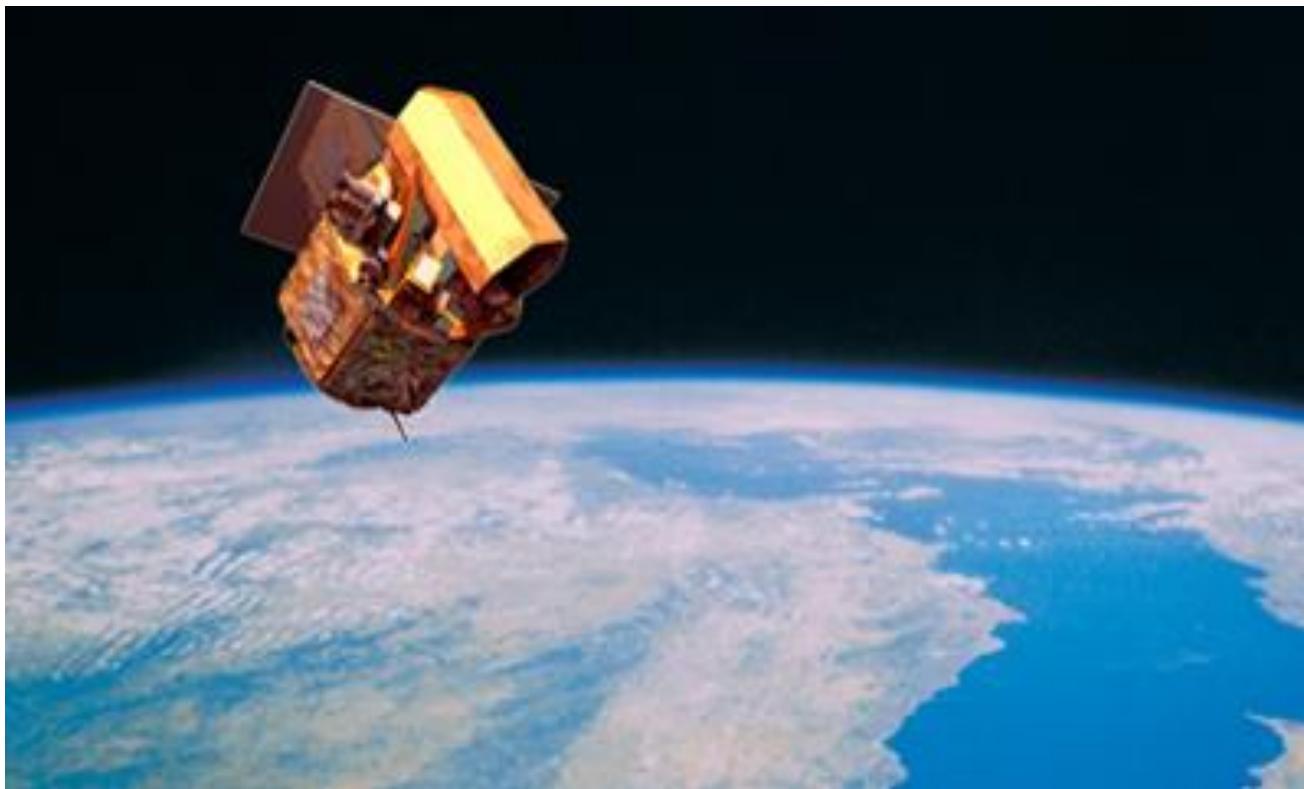


2006. 237

GUVI Composite Image (SZA > 95), 2006 Day 237, Orbits 25516–25529
OI 1304 (blue, 3942.57 R max (data), 10000.0 R max (color scale))
OI 1356 (green, 1438.01 R max (data), 1000.00 R max (color scale))
LBH short (red, 2034.71 R max (data), 1000.00 R max (color scale))



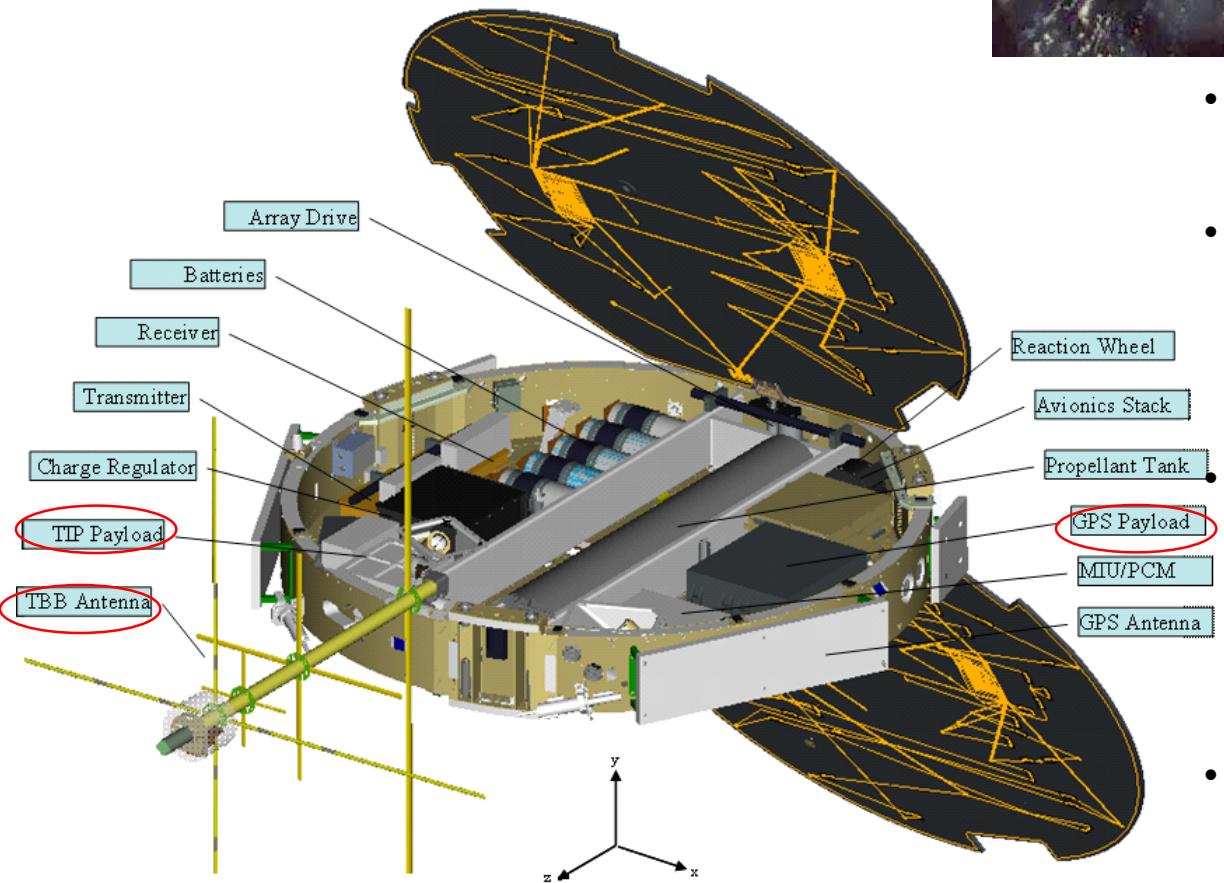
FOMOSAT-2



2006/12/18 14:53:35.385

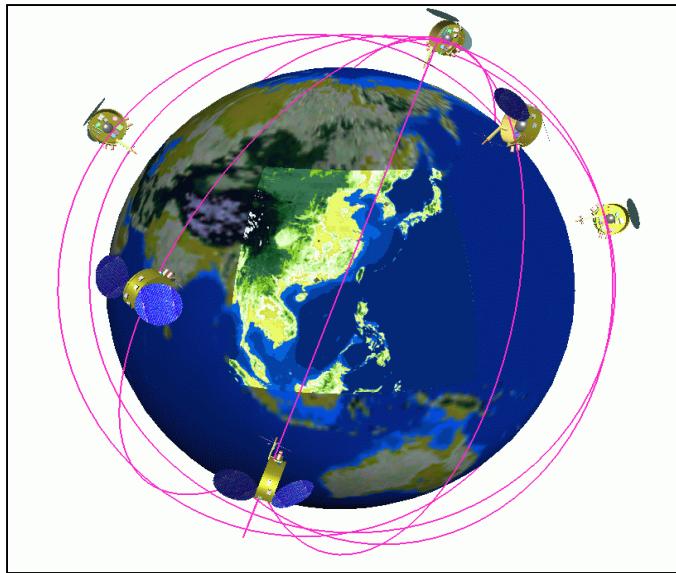


FORMOSAT-3 COSMIC



- The FORMOSAT-3/COSMIC system is a constellation of 6 LEO micro-satellites
- Each satellite carries 3 payloads:
 - **GPS occultation receiver**
 - **Tiny Ionospheric Photometer**
 - **Tri-Band Beacon.**
- Global observation of pressure, temperature, water vapor, refractivity, ionospheric electron density and scintillation for weather and space weather research as well as climate monitoring
- Demonstrate quasi-operational GPS limb sounding with global coverage in near-real time

FORMOSAT-3/COSMIC Program

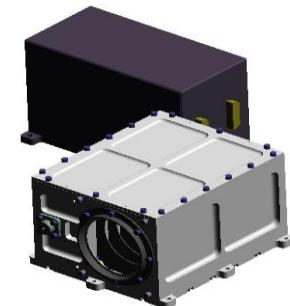
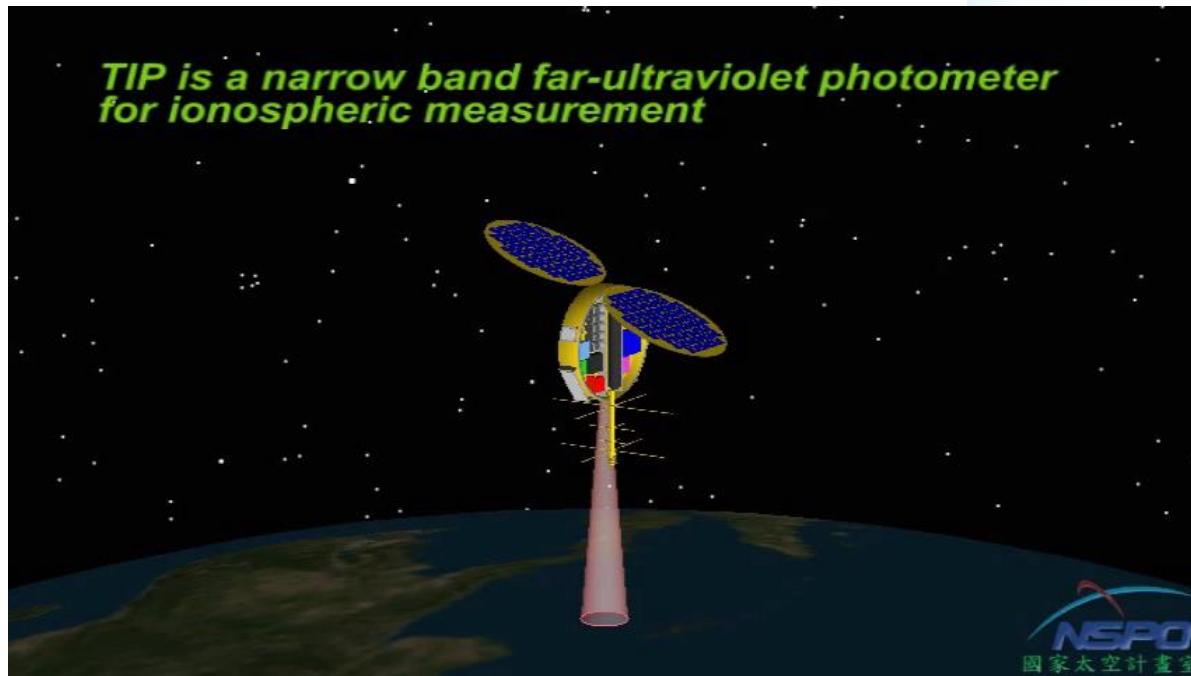


An international cooperation program between NSPO and UCAR, USA

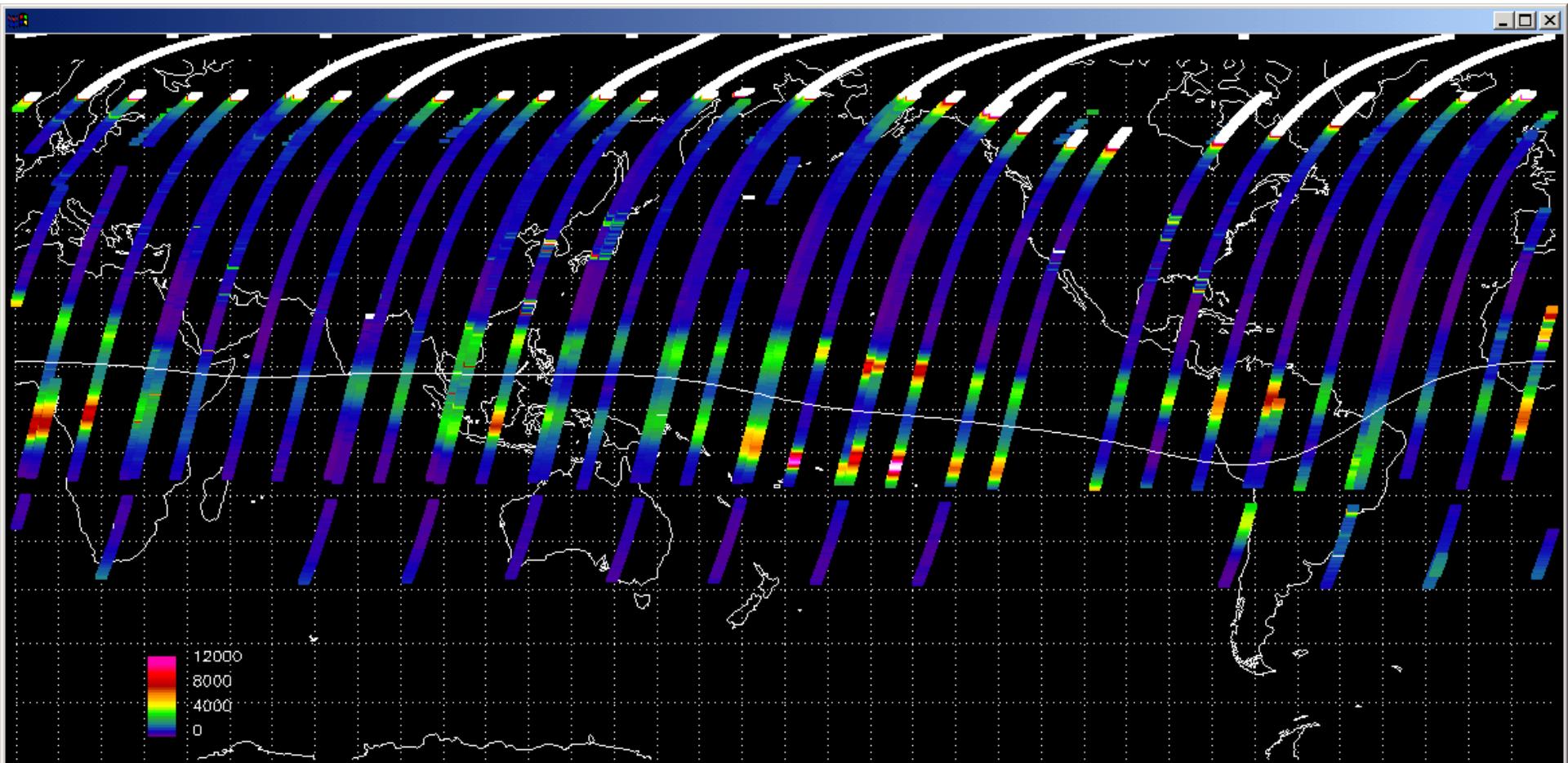
- The FORMOSAT-3/COSMIC system is a constellation of 6 LEO micro-satellites
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Tiny Ionospheric Photometer (TIP)



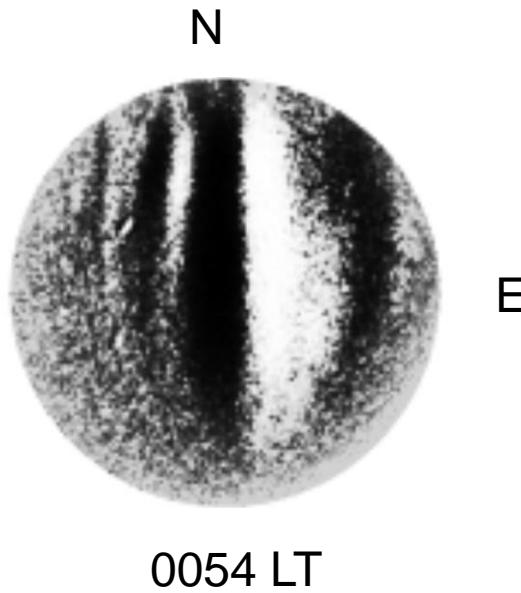
TIP 135.6-nm passes 14 Sep 2006
FM1 FM3 FM6
0-24 UT (2100 LT)



Ground based observation

6300, 5577 and 7774A airglow

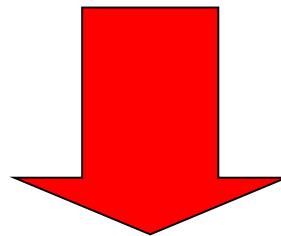
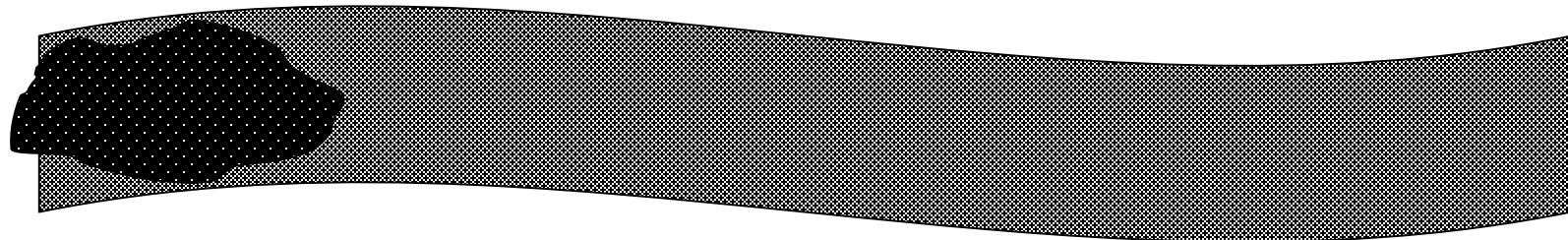
Plasma Depletions



- Large scale irregularities
- N-S extent of more than 1000 km
- Few 100 km E-W extent (width)
- Generated at the equator
- Move in zonal and vertical directions

2002 February 15
630.0nm

Imaging Plasma Depletions



North

West

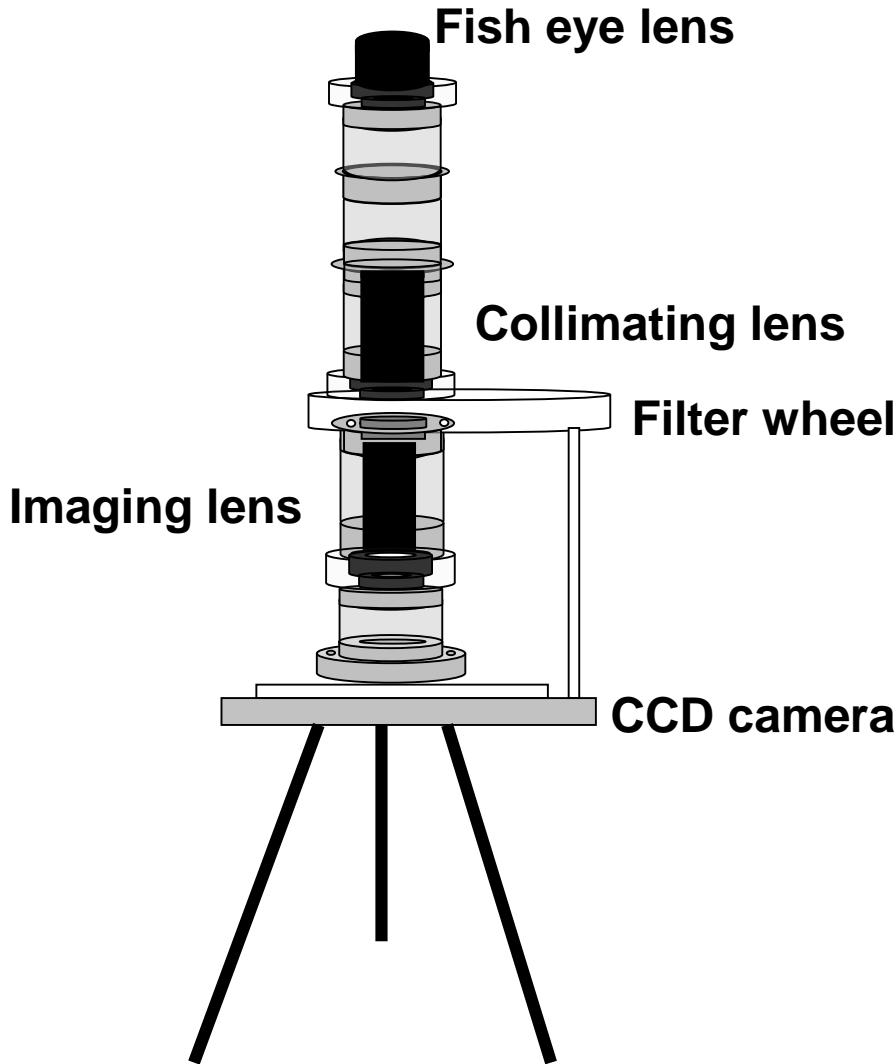
East



South

Experiment

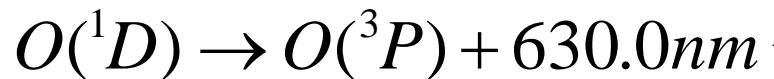
all sky camera (imager)



- 630.0, 557.7 and 777.4 nm airglow emissions

630.0 and 557.7 nm Emissions

Dissociative recombination



FORMOSAT-2

Intensity, $I \propto [O^+]$

777.4 nm Emission

Radiative recombination



Intensity, $I \propto [O^+][e]$

In the F-region, $[O^+] \approx [e]$; and $I \propto [e]^2$

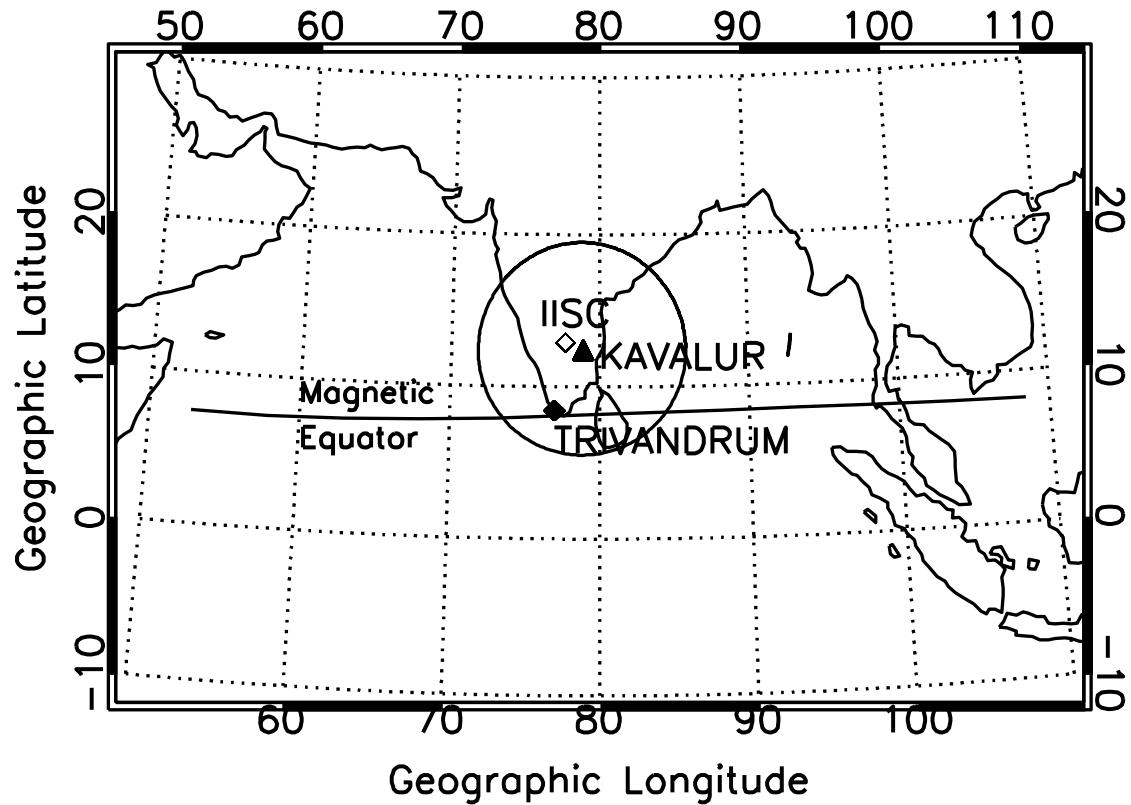
$O(^5S) \rightarrow O(^3P) + 135.6\text{nm} \rightarrow$ used in FORMOSAT 3 (TIP)

Ground-based observation

Characteristics of Plasma Depletions in Solar maximum

IGS station at IISC

Ionosonde data from Trivandrum.



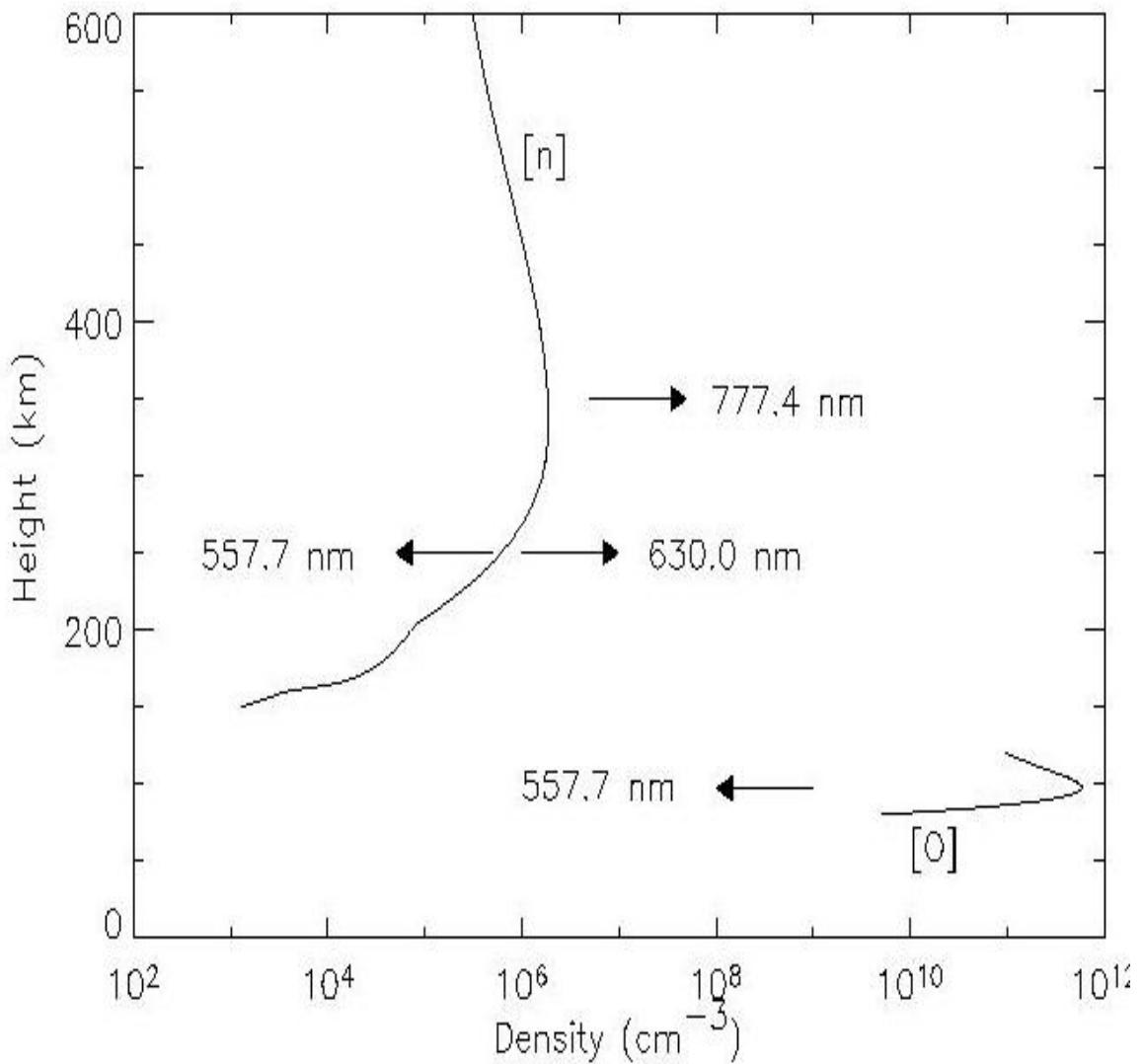
Circle shows the FOV of the imager at 250 km for zenith angle 75°

Observations and Results

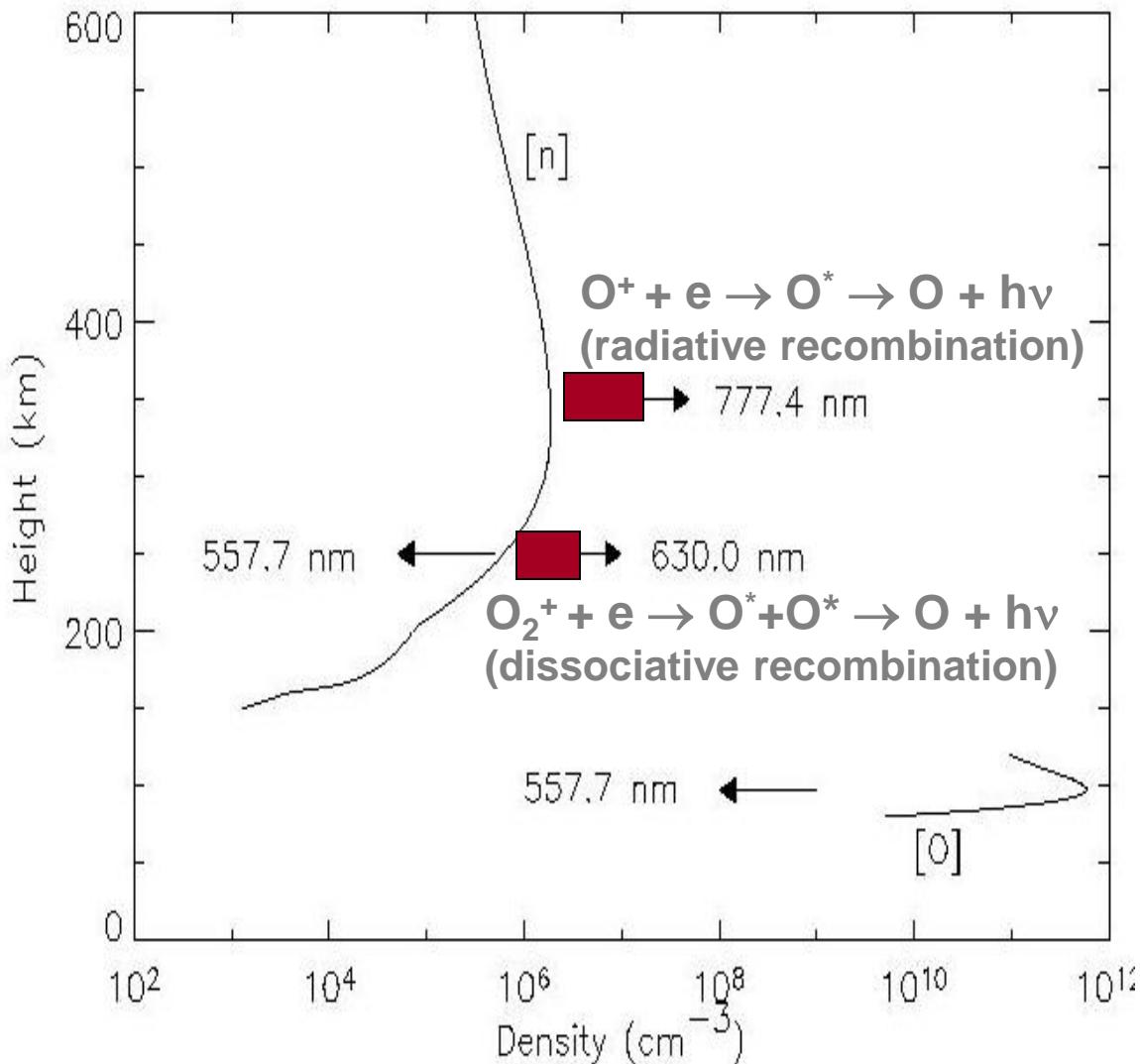
Month	Nights of Observations	630.0 nm	Depletions in	
			777.4 nm	557.7 nm
February	10	4	4	3
March	12	12	10	8
April	11	11	11	8

- Low K_p values; no significant geomagnetic activity.
- Depletions present in 80% of the nights of observations.
- Frequent appearance in 557.7 nm.
- 11 consecutive nights of depletions; March (4-14), and April (5-15).

Depletions in 557.7 nm



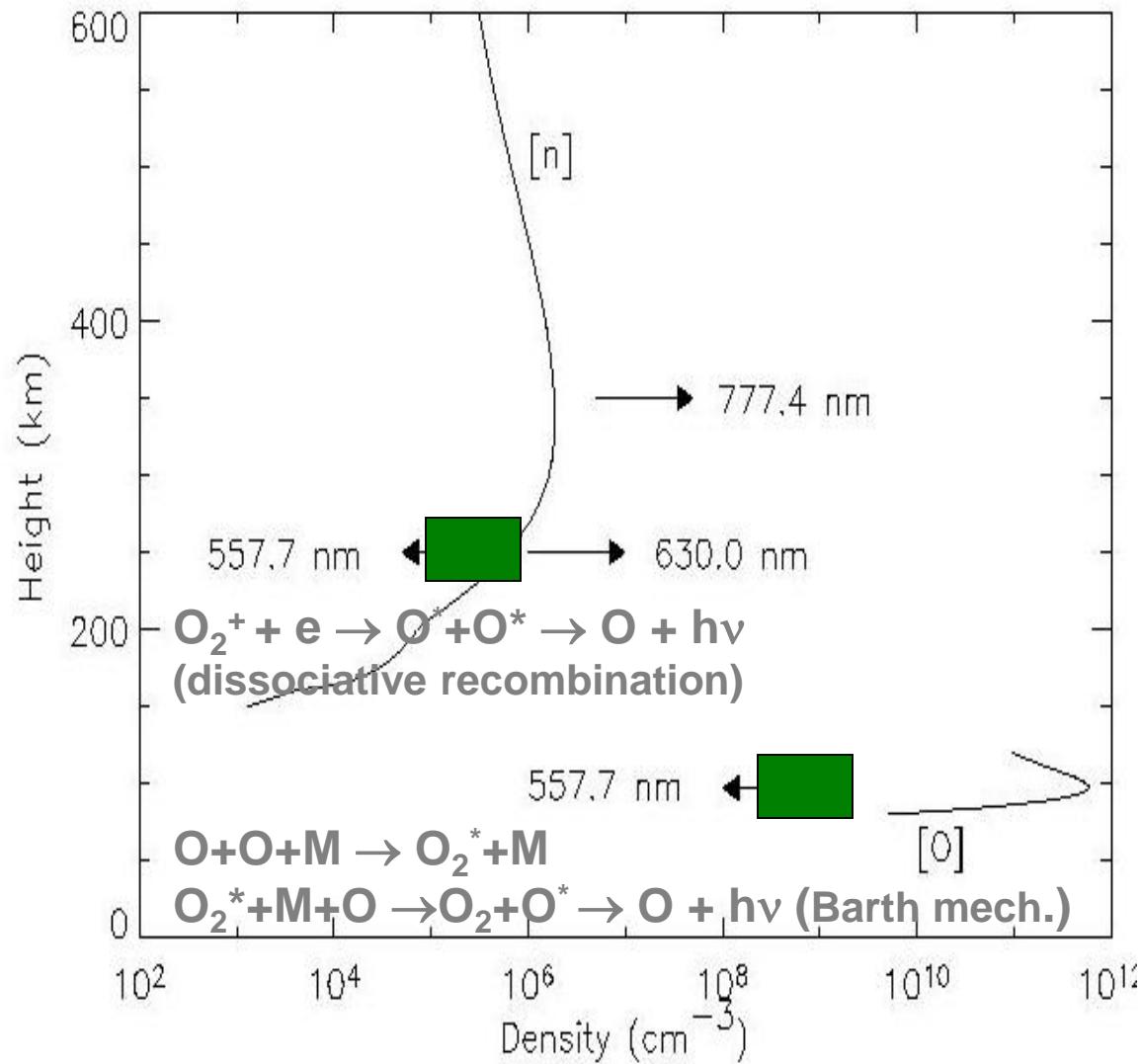
630.0 and 777.4 nm Emissions



The 630.0 and 777.4 nm emissions come from thermospheric region.

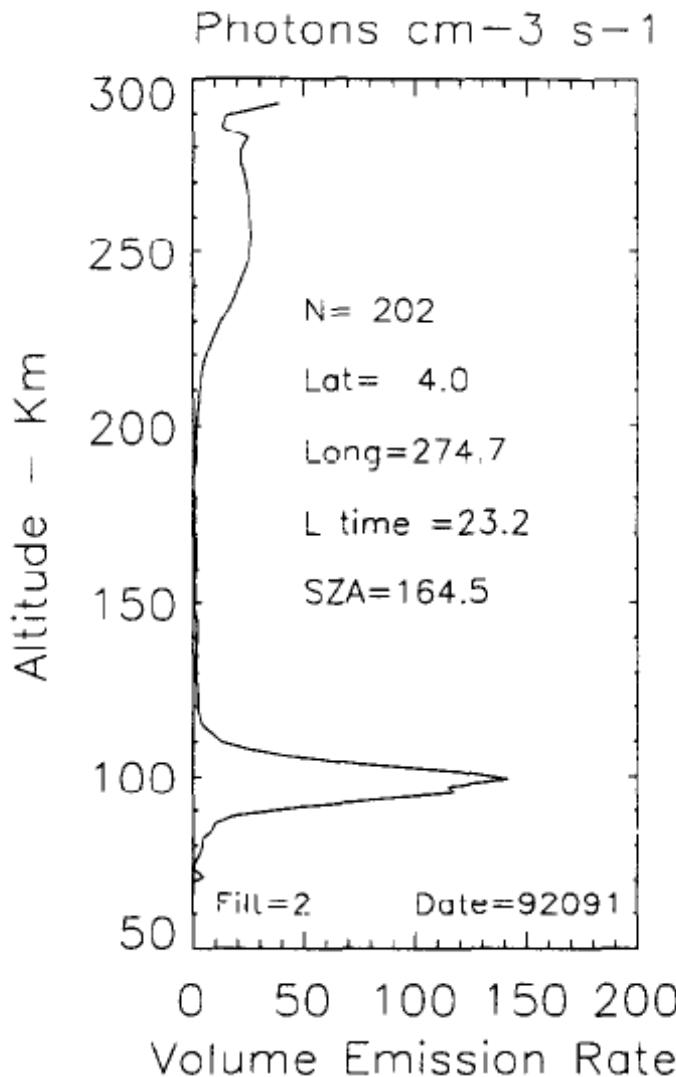
If plasma depletions are present at their altitude of bulk emission they can be readily seen in the images.

The 557.7 nm Emission



The 557.7 nm emission has two source regions; in the thermosphere, and in the mesosphere.

The mesospheric component is much stronger than ionospheric component



(Shepherd *et al.* JASTP, 1997)

Difficult to separate the F-region structures unless thermospheric contribution becomes significant

(Takahashi *et al.* ASR, 2001)

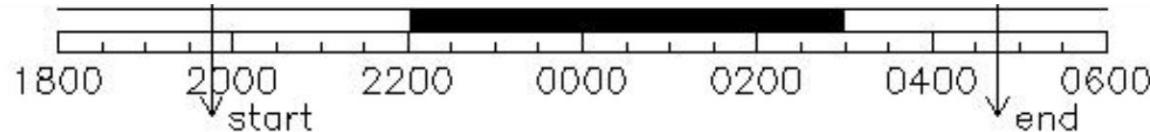
Only on few occasions depletions were seen in 557.7 nm images

Depletions in 557.7 nm

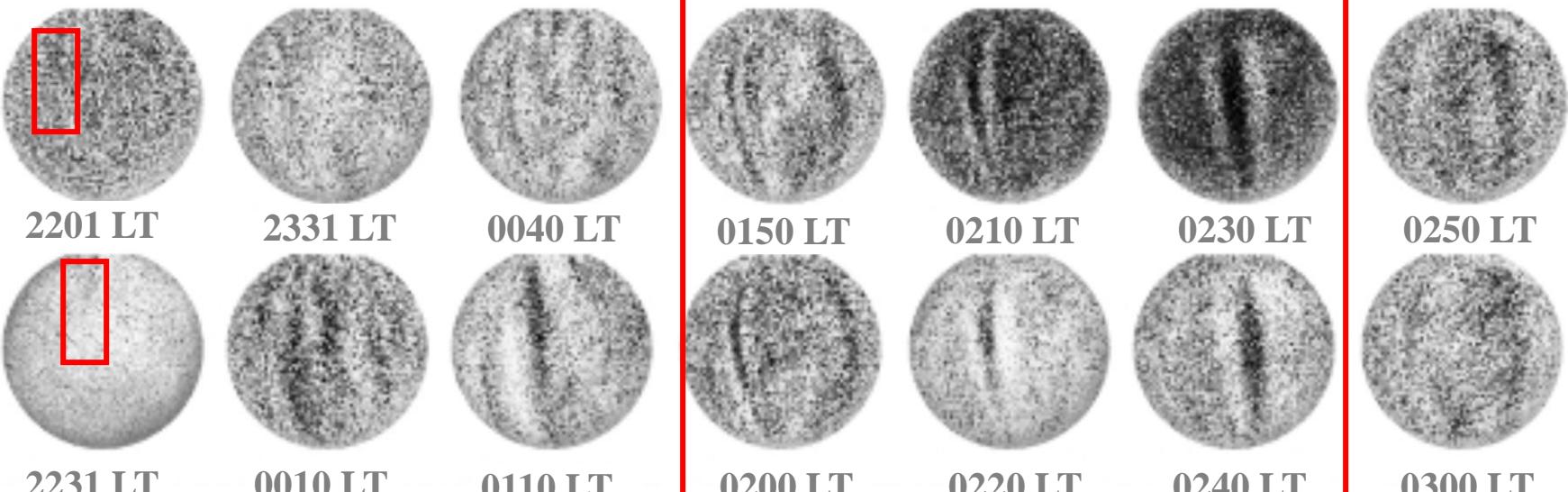
- 70% of the nights with depletions in 630.0 nm showed depletions in 557.7 nm in 2002.

Month	Nights of Depletions	Depletions in 557.7 (630.0) nm
Feb, 02	11	3 (4)
Mar, 02	15	8 (12)
Apr, 02	14	8 (11)

Depletions in 557.7 nm



12 March 2002



Prominent depletions

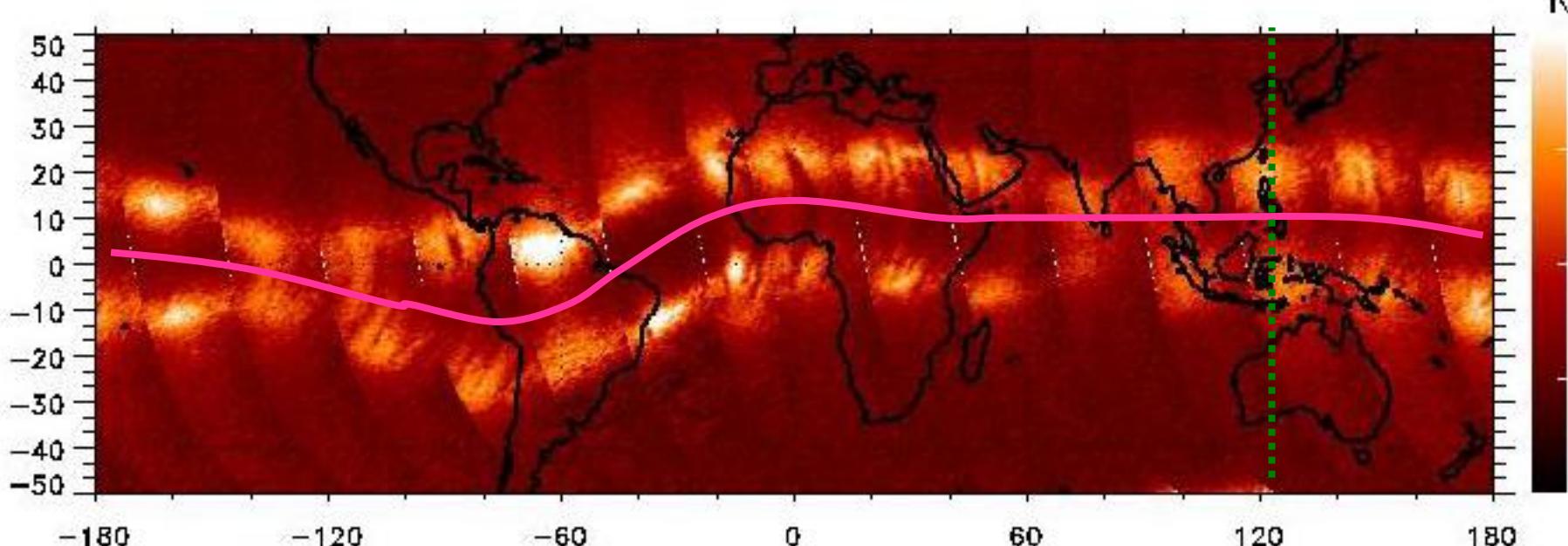
East-west width about 70-85 km

Eastward velocity about 55-60 m/s

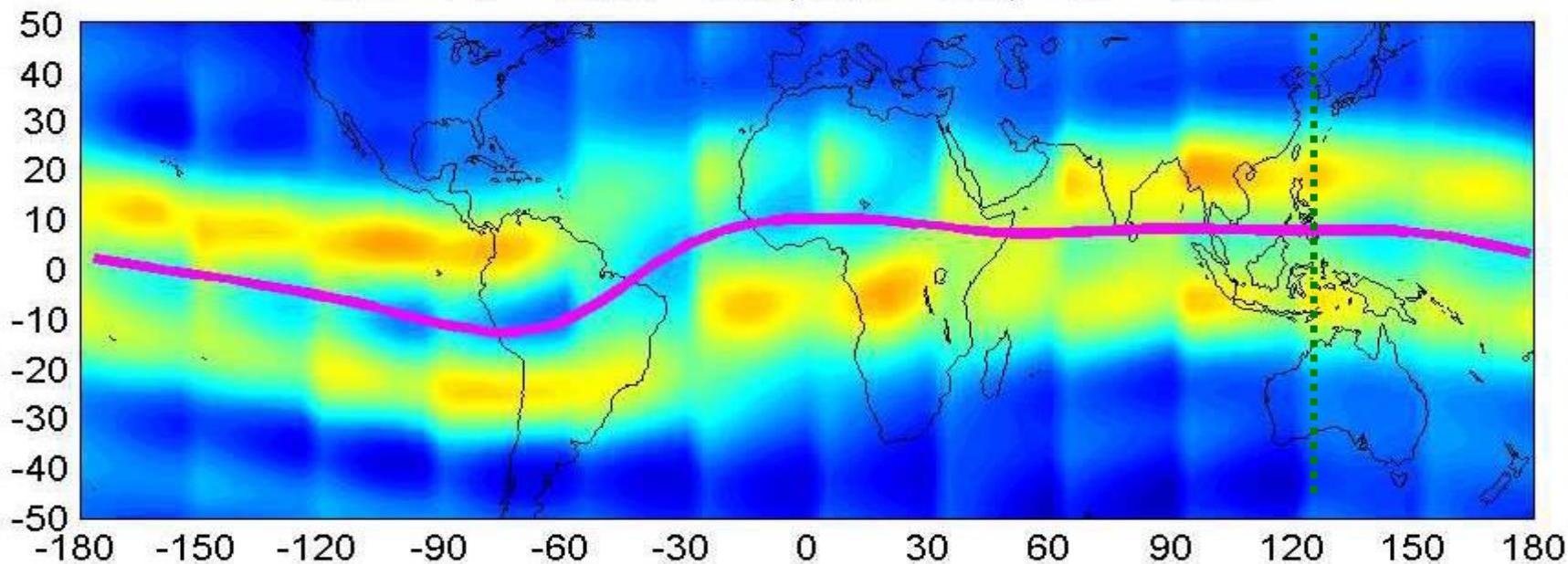
Coordinated observations

- TIMED GUVI 135.6 nm
- FORMOSAT-2 630.0nm
- FORMOSAT-3/COSMIC TIP 135.6nm
- Lulin all sky camera 630.0/557.6/777.4 nm

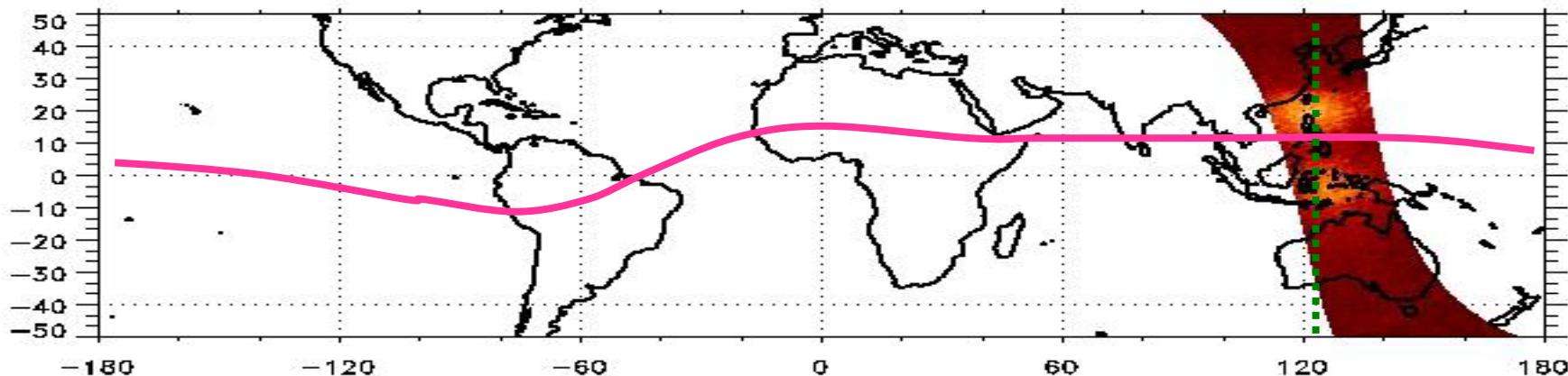
TIMED-GUVI OI135.6nm disk scan 2002 269



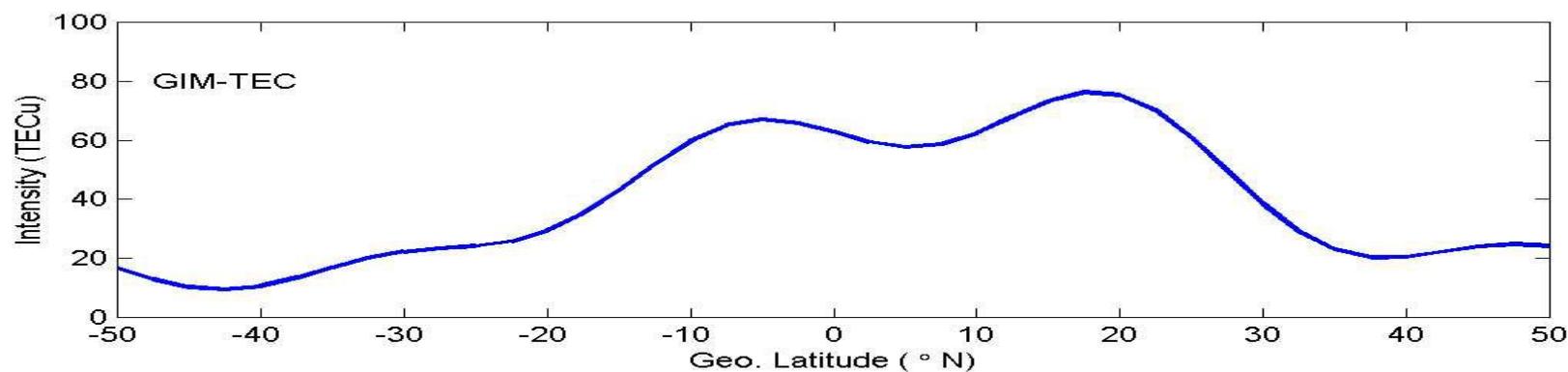
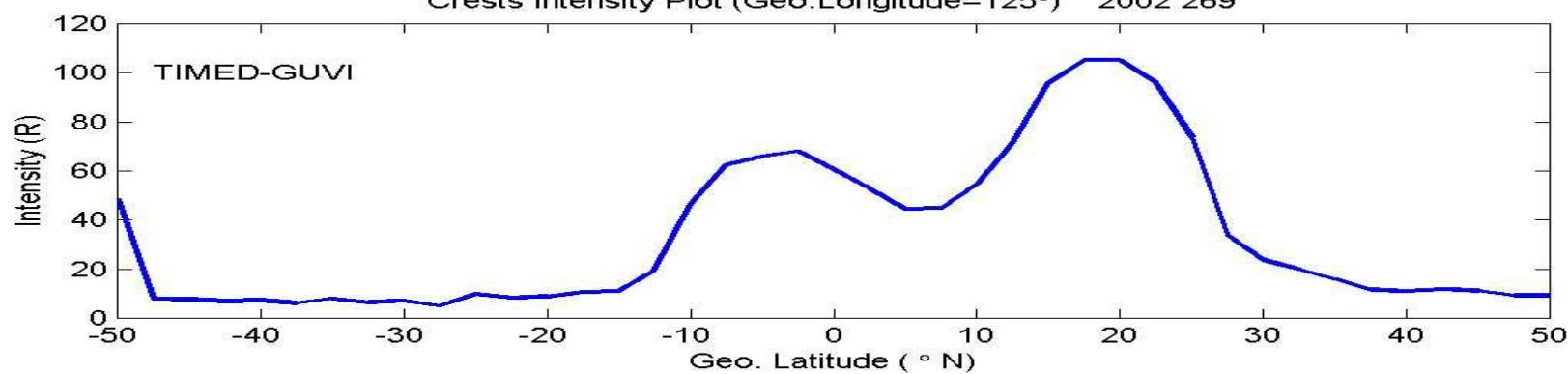
GIM TEC YEAR = 2002; DOY = 269; TIME = 22 LT



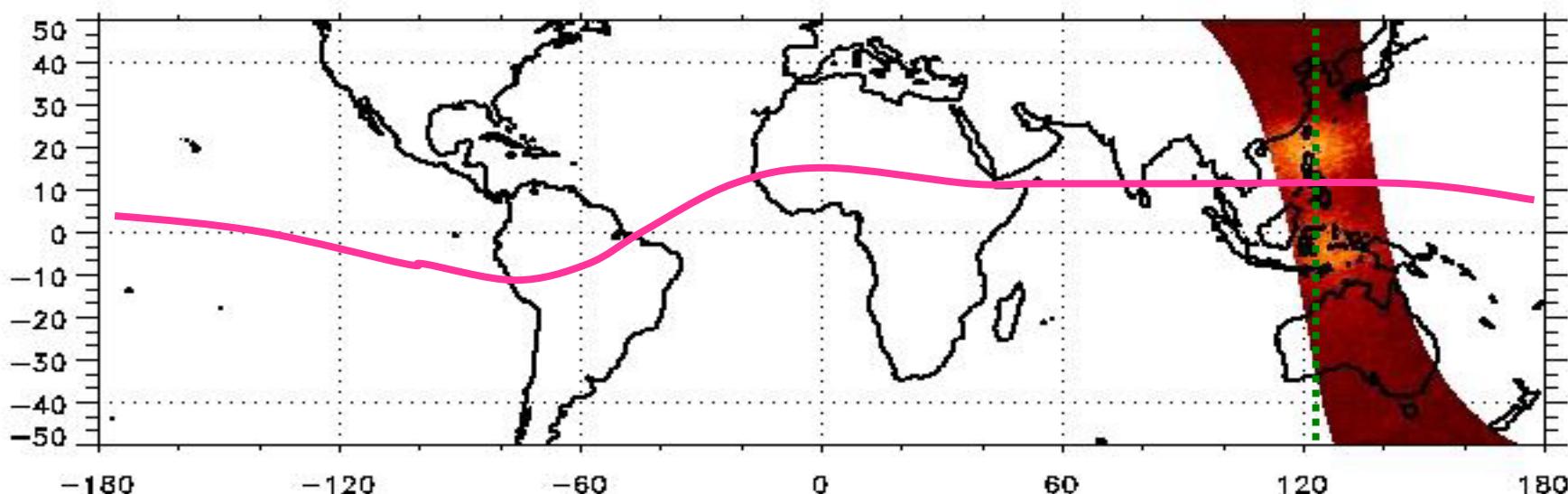
TIMED-GUVI OI135.6nm disk scan 2002 269



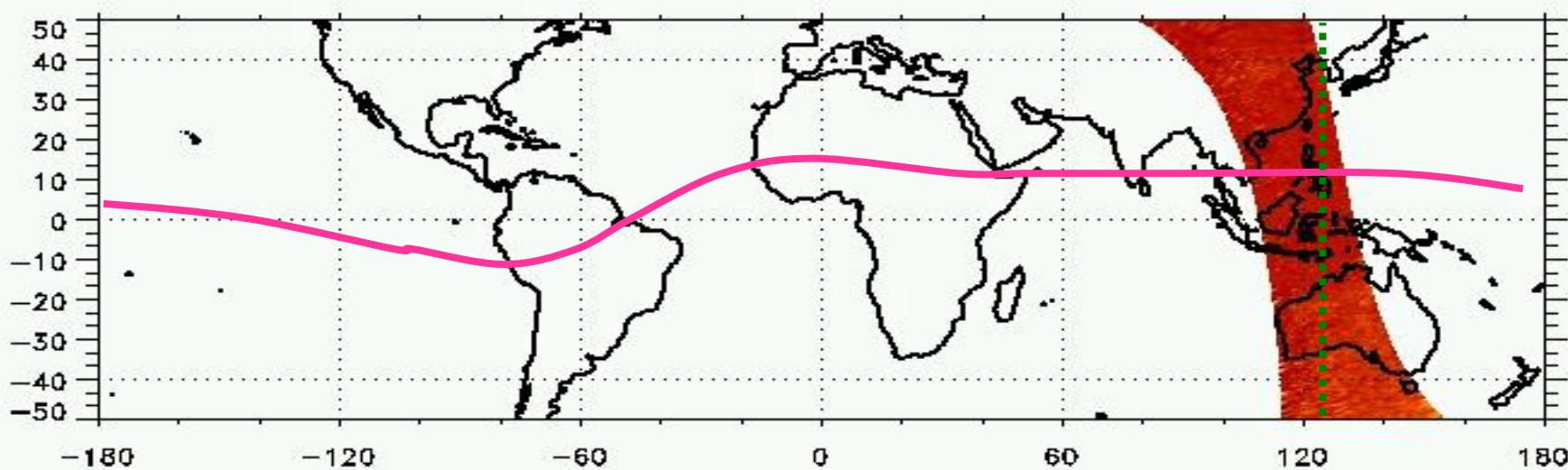
Crests Intensity Plot (Geo.Longitude=125°) 2002 269



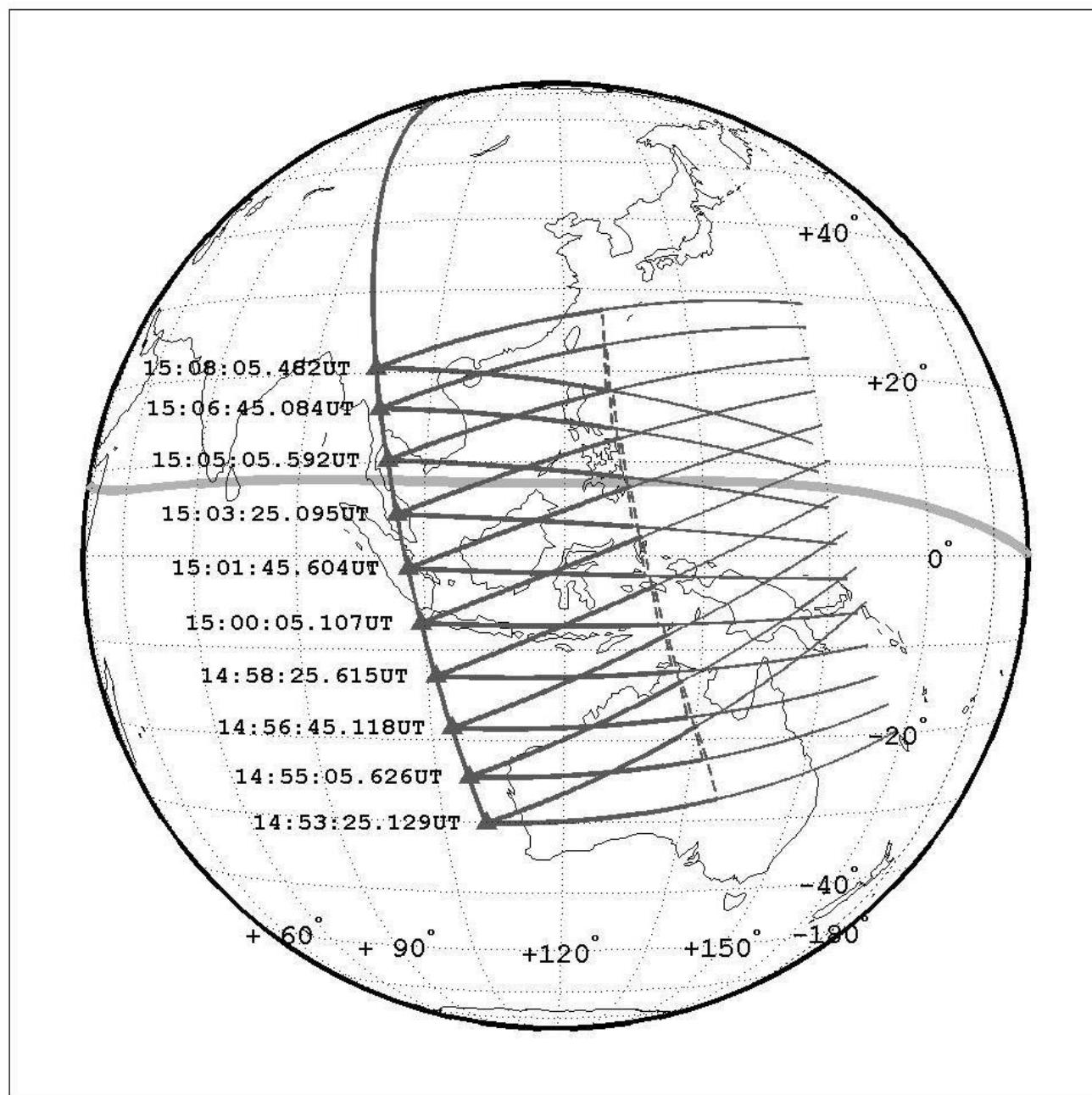
TIMED-GUVI OI135.6nm disk scan 2002 269



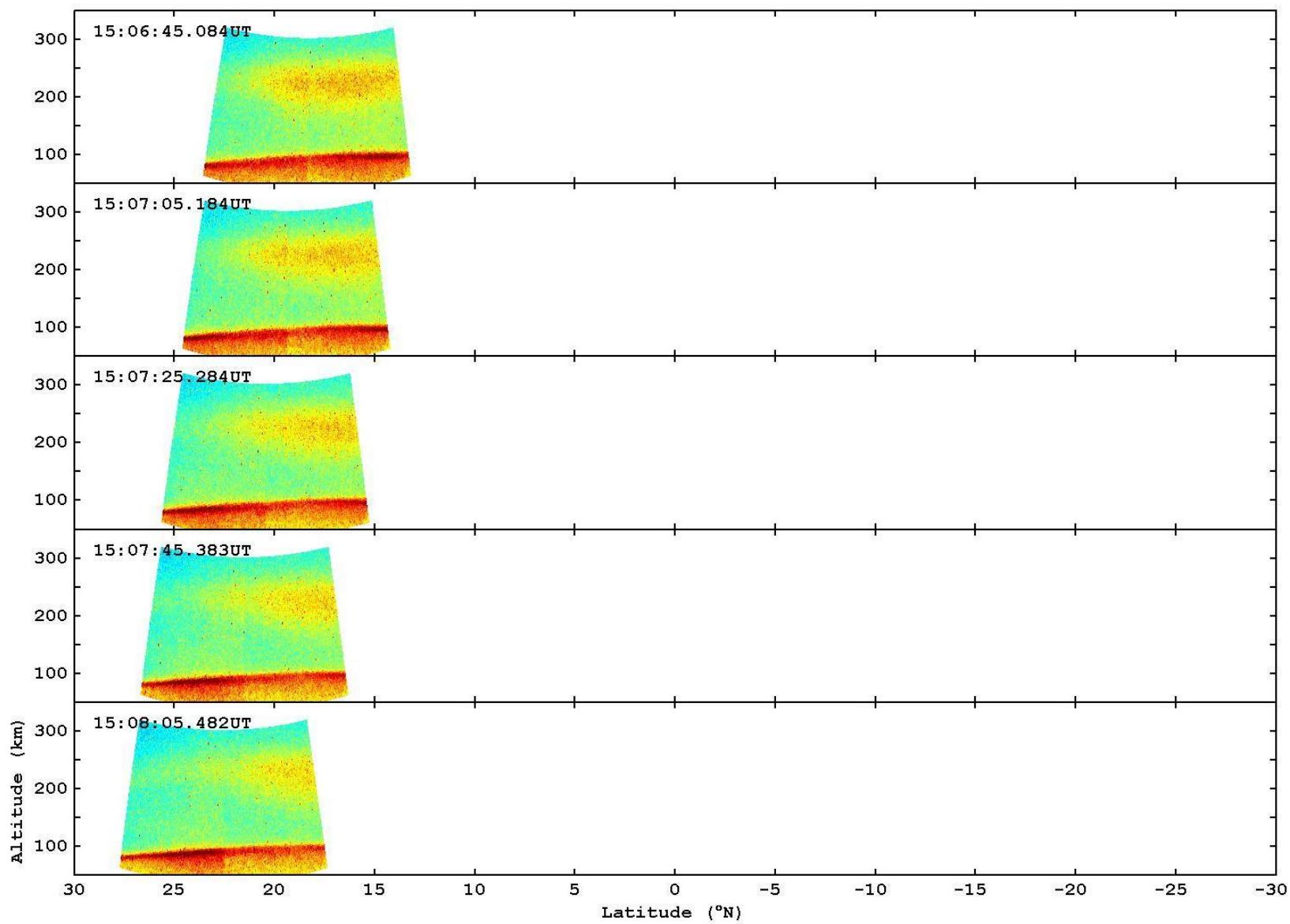
TIMED-GUVI OI135.6nm disk scan 2006 237



2006-12-19

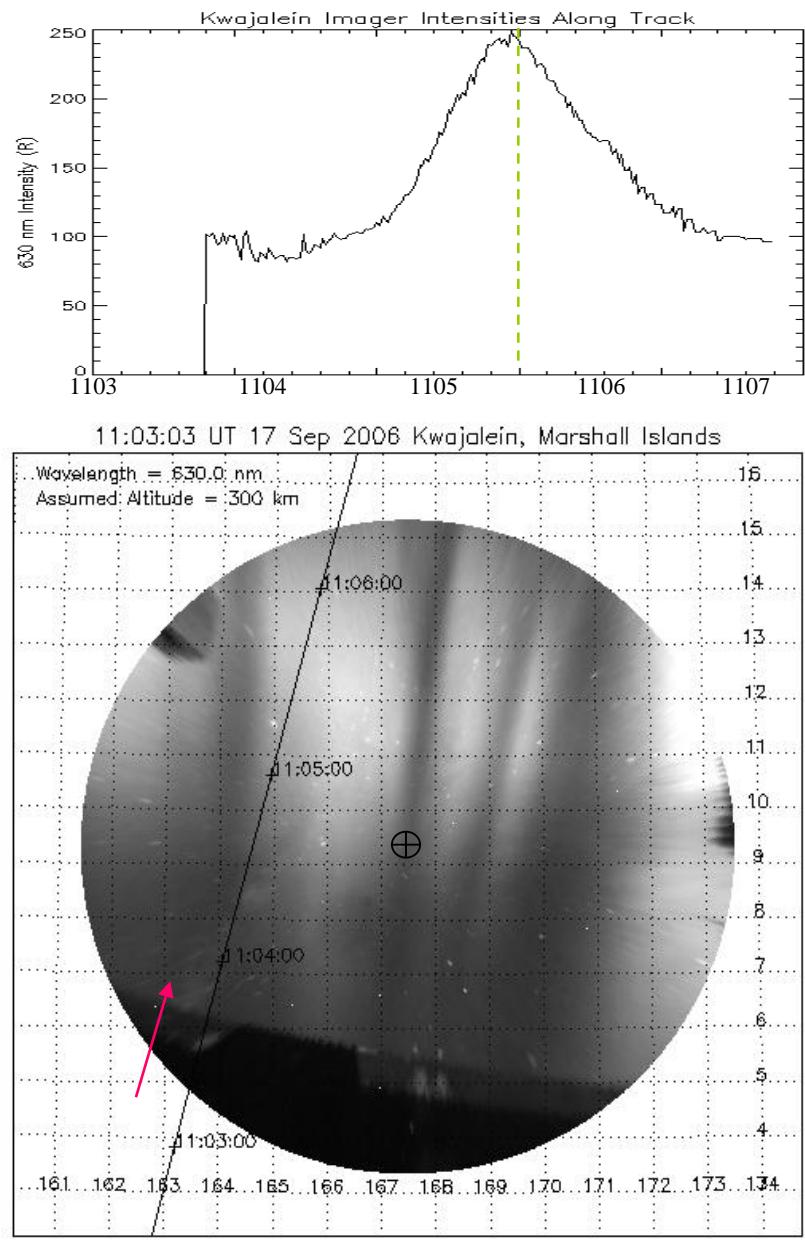
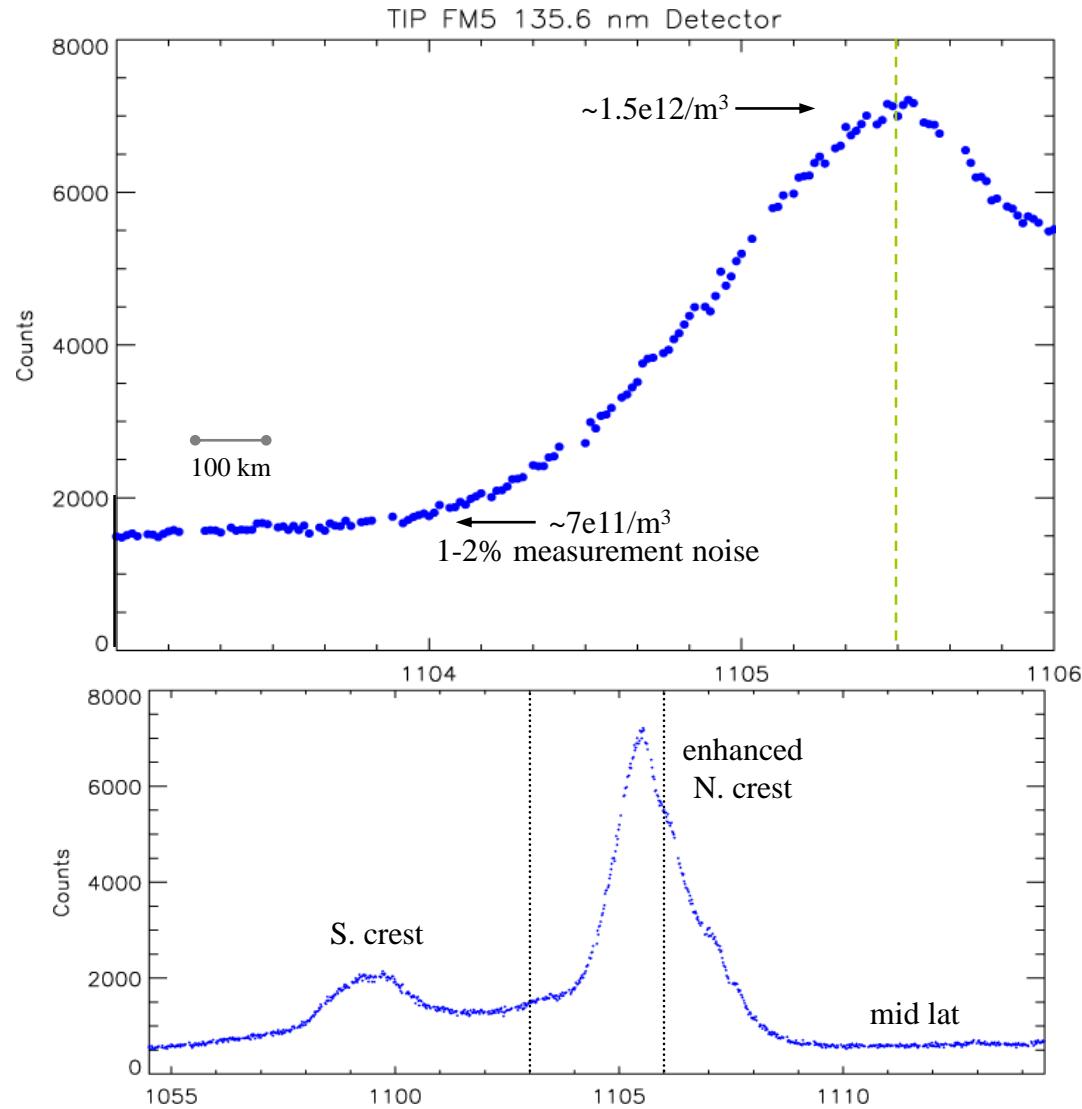


2006-12-19

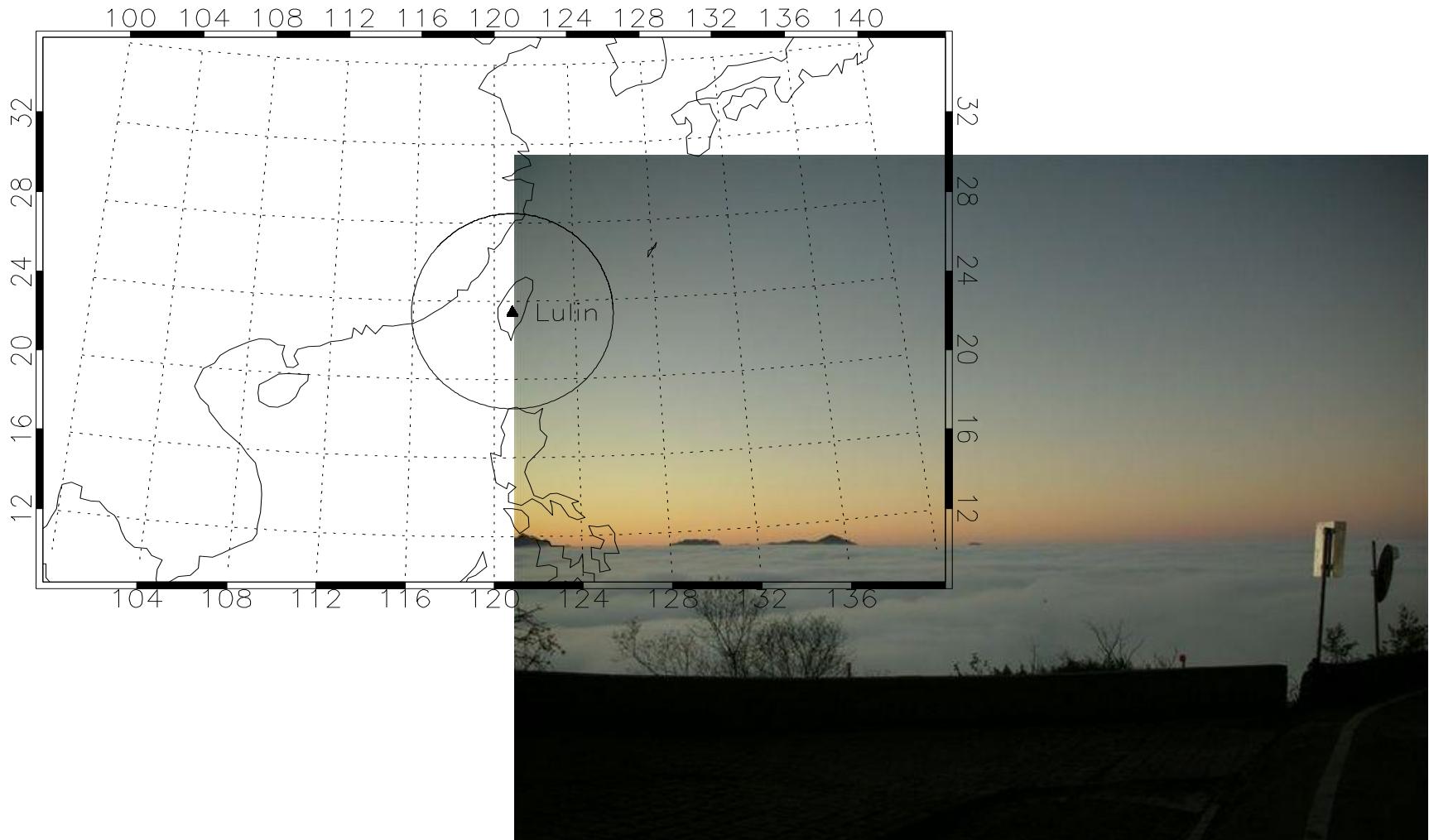


Comparison of TIP and allsky imager

17 Sep 2006



Airglow ground-based Observation at Lulin

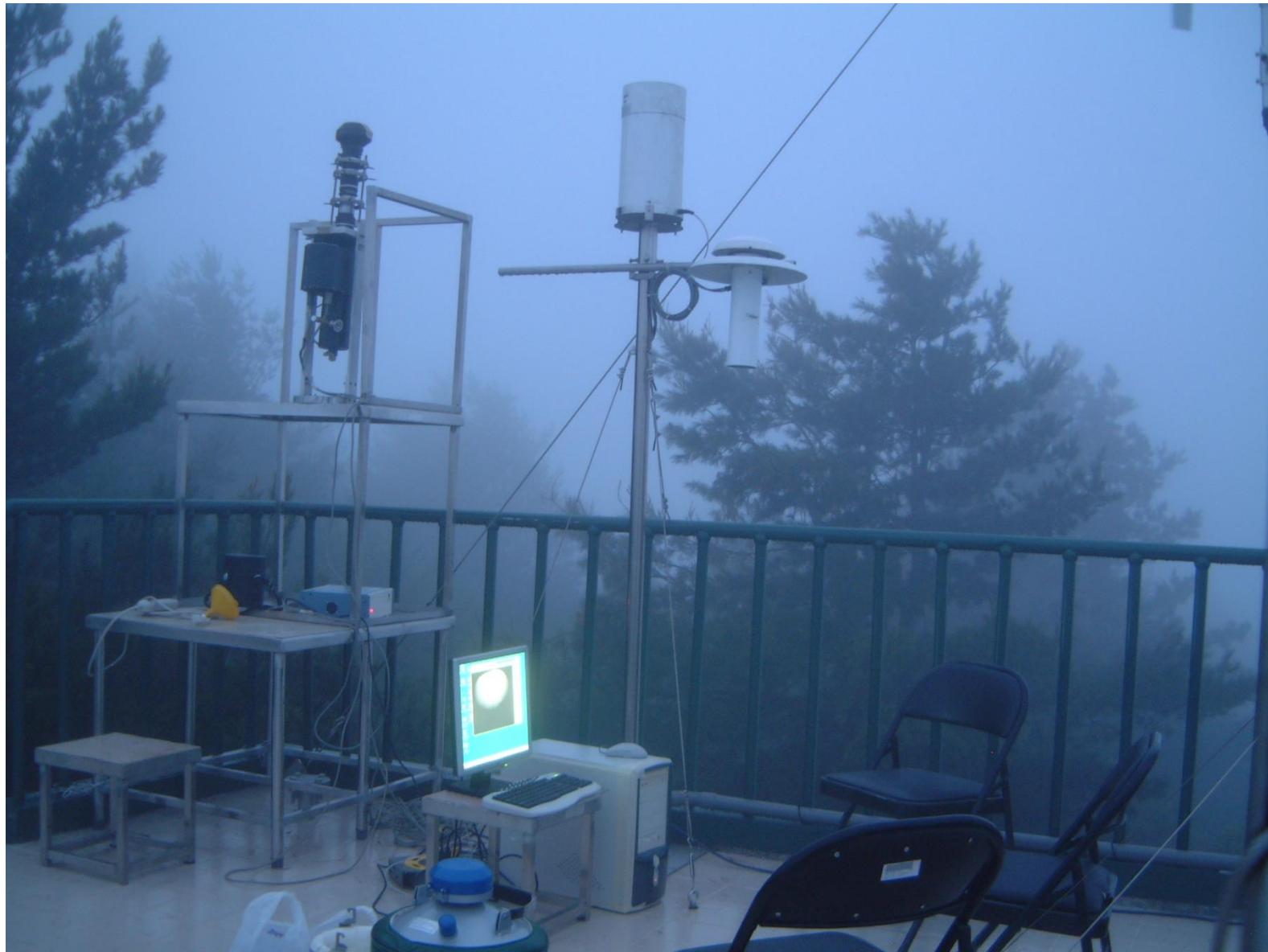


2006-8/12 Airglow Campaign

- Lulin (23.5°N, 120.9°E)



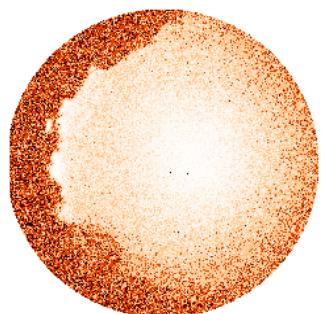
Ground based facility



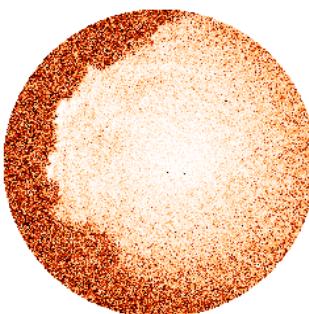
First all sky observations at Lulin using 630.0 nm

24 August 2006

Exposure: 2 min



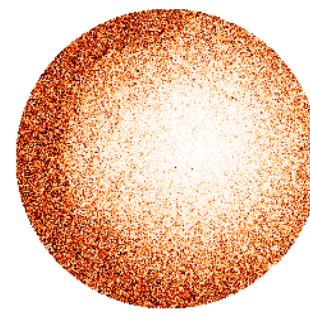
2050 LT



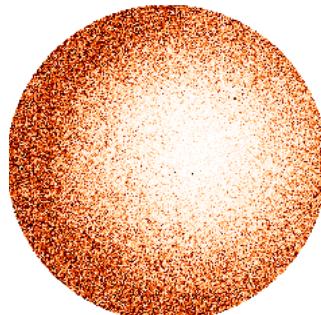
2152 LT



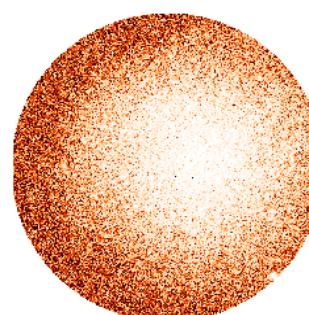
2245 LT



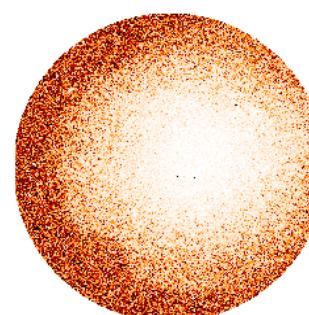
2345



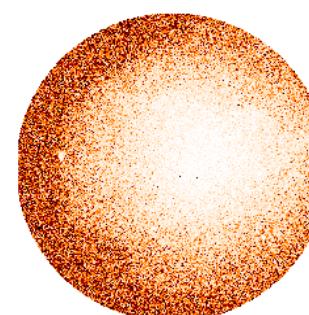
0044 LT



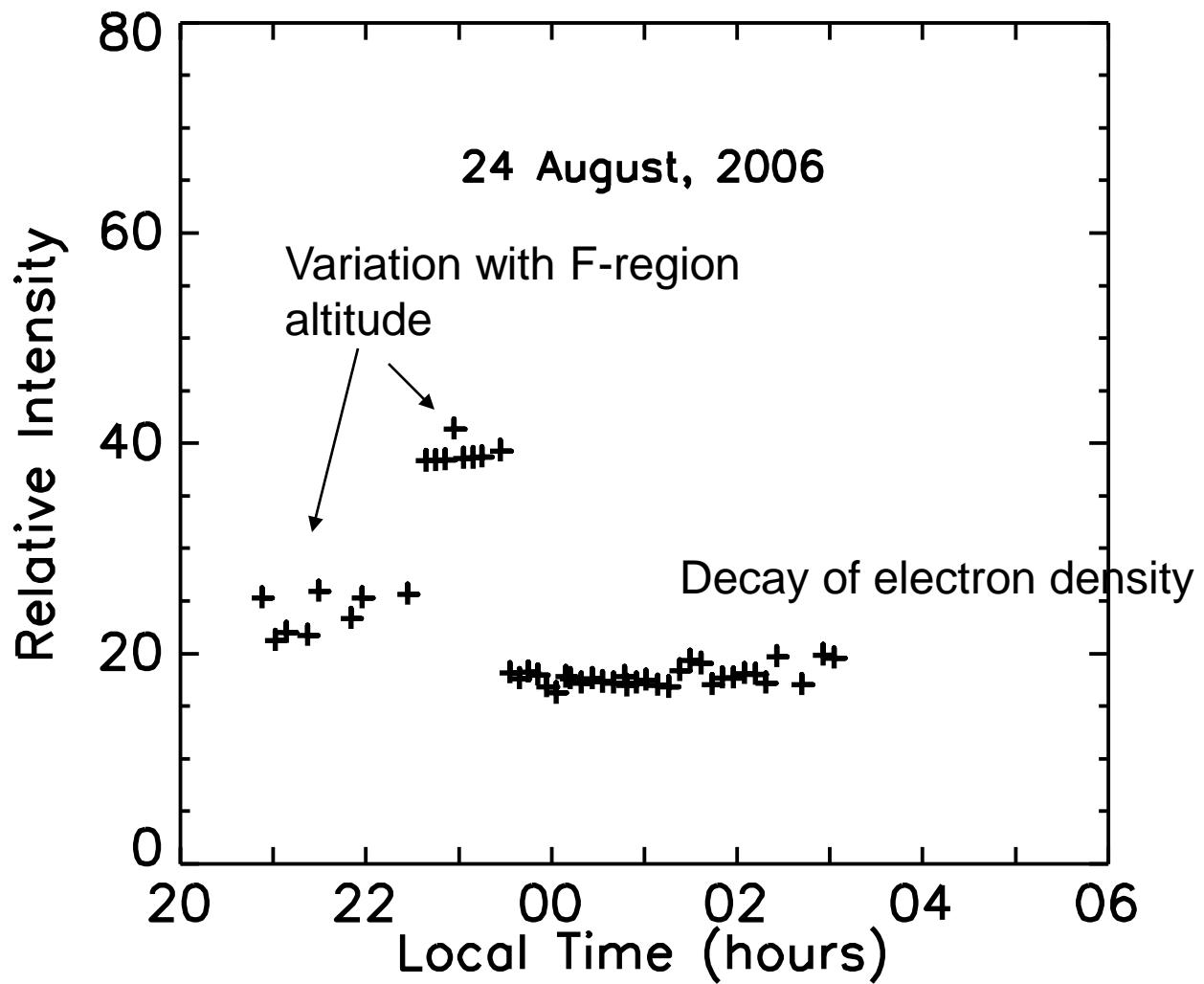
0144 LT



0248 LT



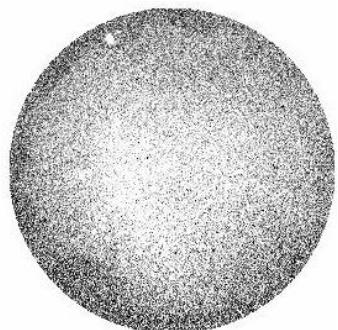
0300 LT



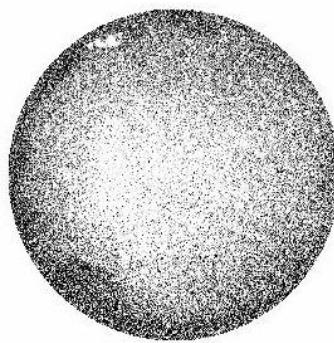
22 December 2006

777.4 nm

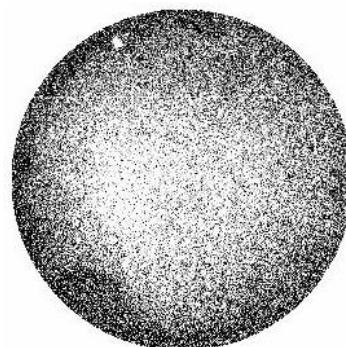
Exposure: 4 min



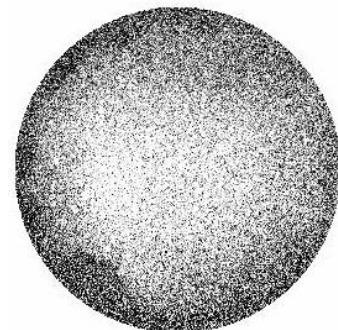
17:51:30 UT



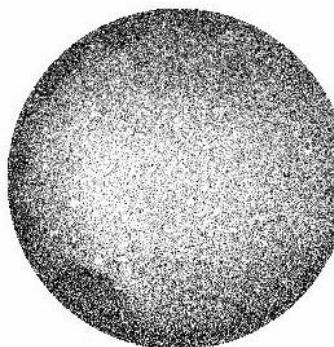
18:21:46 UT



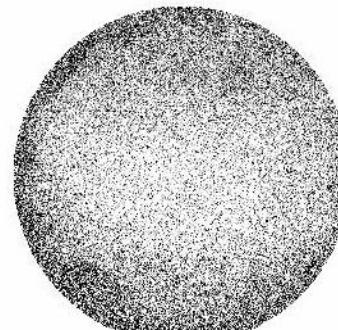
18:36:54 UT



19:07:10 UT



19:22:18 UT

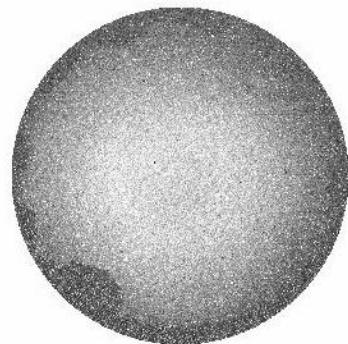


20:37:57 LT

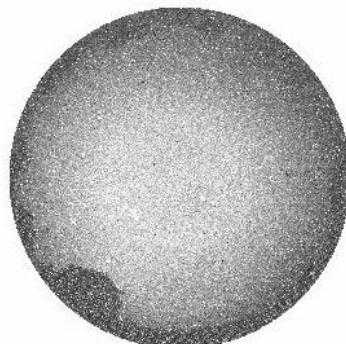
22 December 2006

557.7 nm

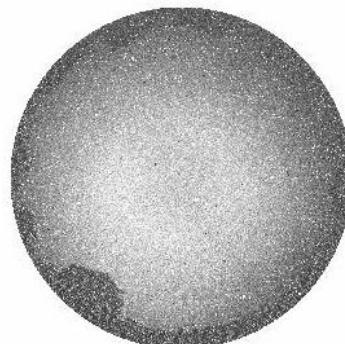
Exposure: 2 min



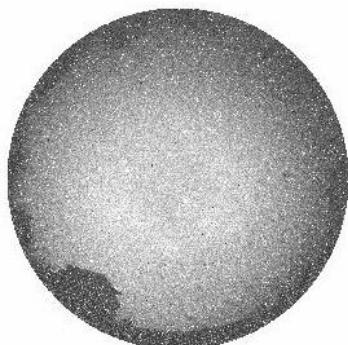
18:28:49 UT



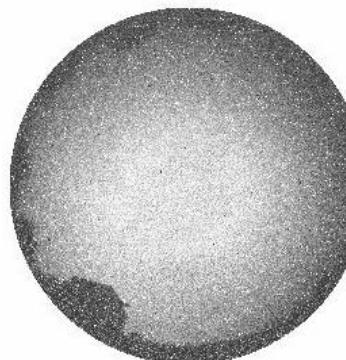
18:59:06 UT



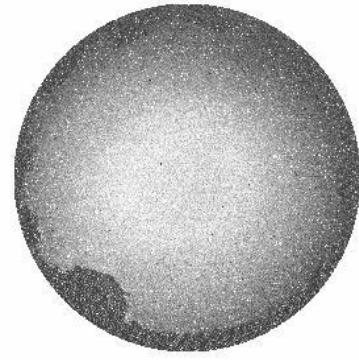
19:14:13 UT



19:29:21 UT

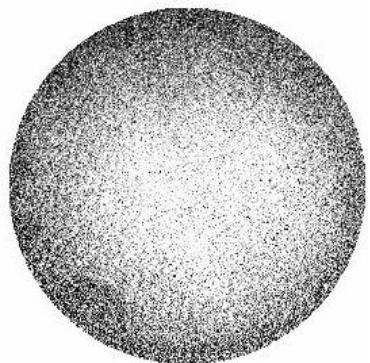


19:44:29 UT

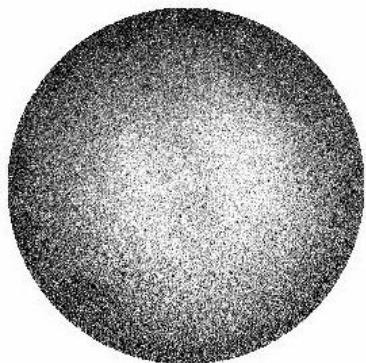


20:29:53 UT

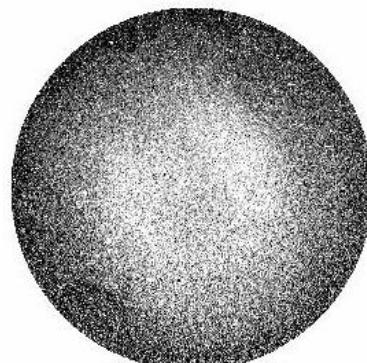
630.0 nm



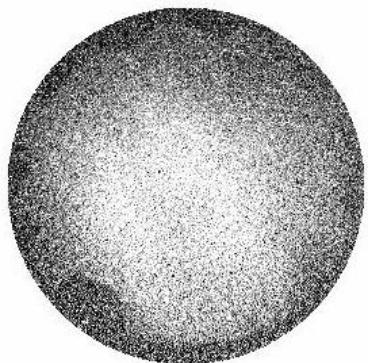
17:01:04 UT



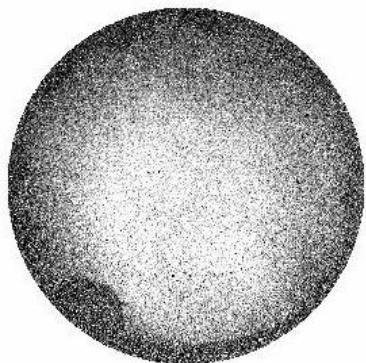
17:31:19 UT



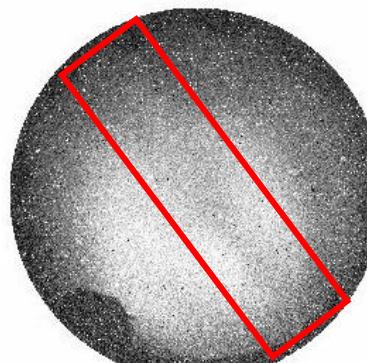
18:01:35 UT



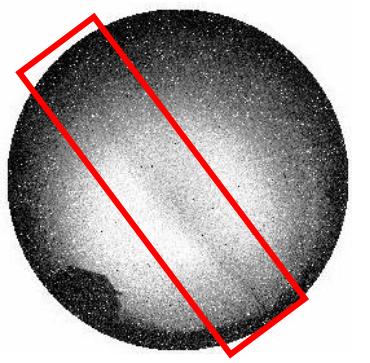
18:31:51 UT



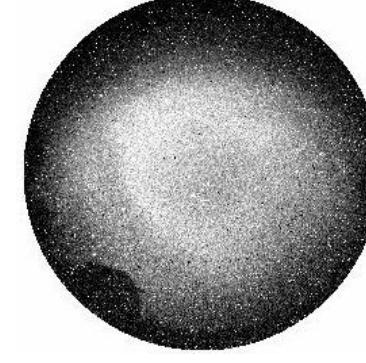
18:46:59 UT



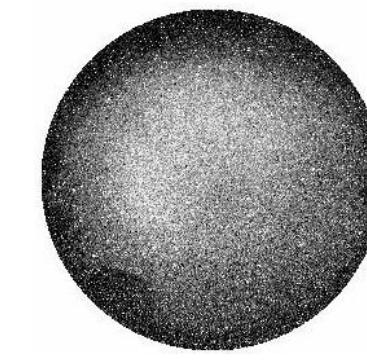
19:02:07 UT



19:17:15 UT



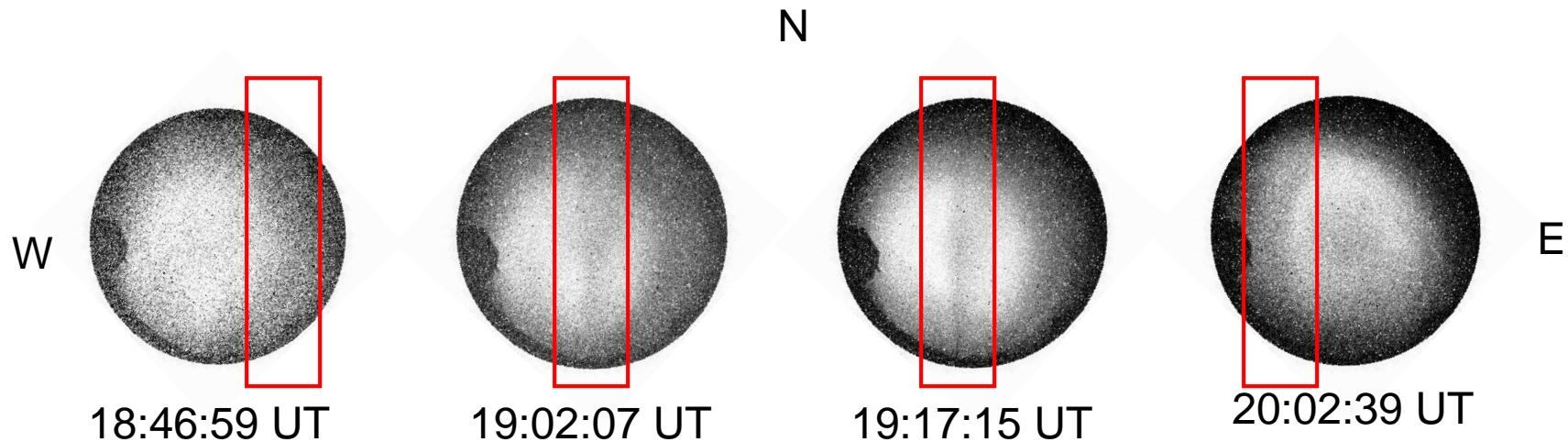
20:02:39 UT



20:32:55 UT

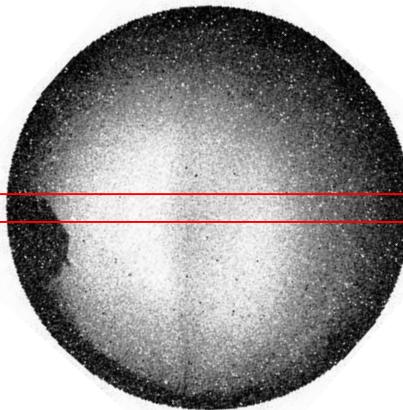
Westward drifting depletions

22 December 2006
630.0 nm
Exposure: 4 min

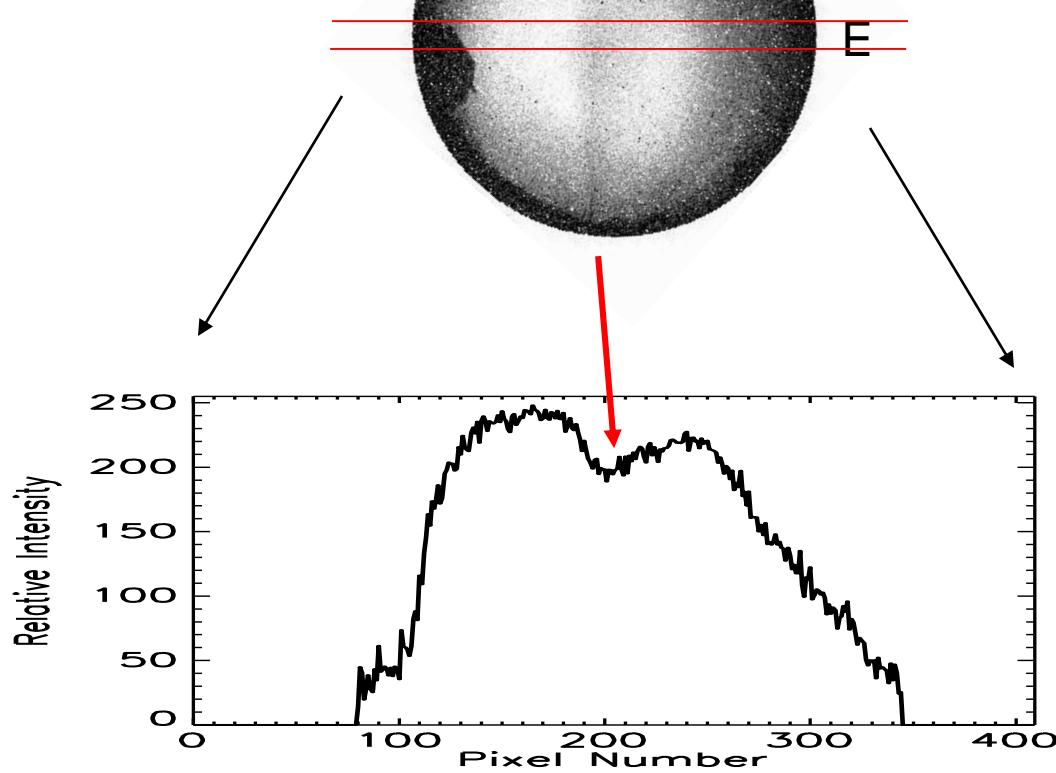


Depletions in general drifts eastwards with ambient plasma drift

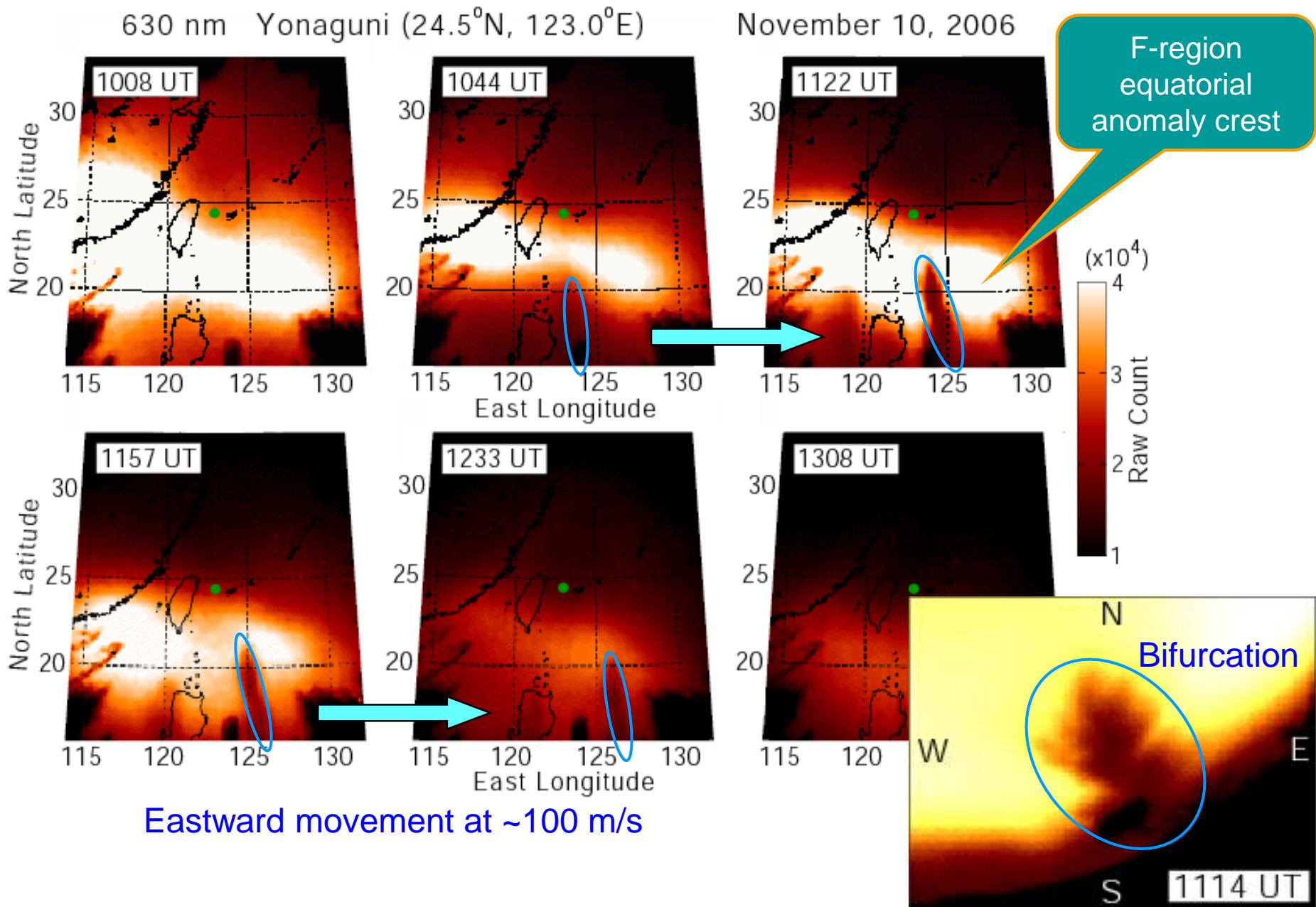
N



22 December 2006
630.0 nm



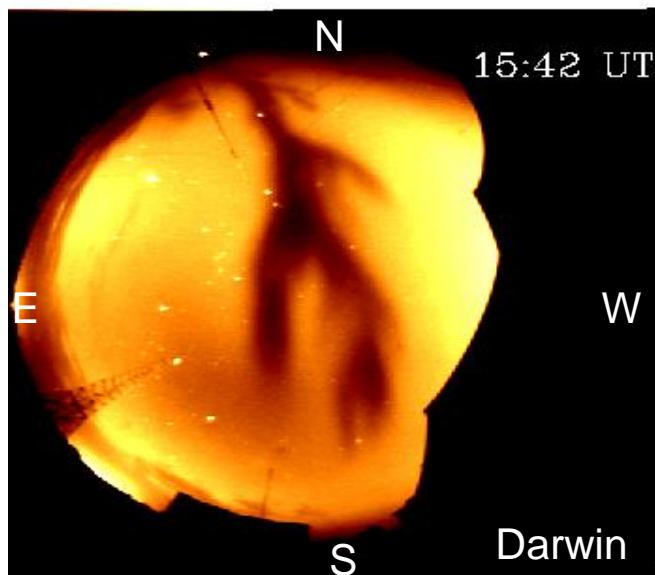
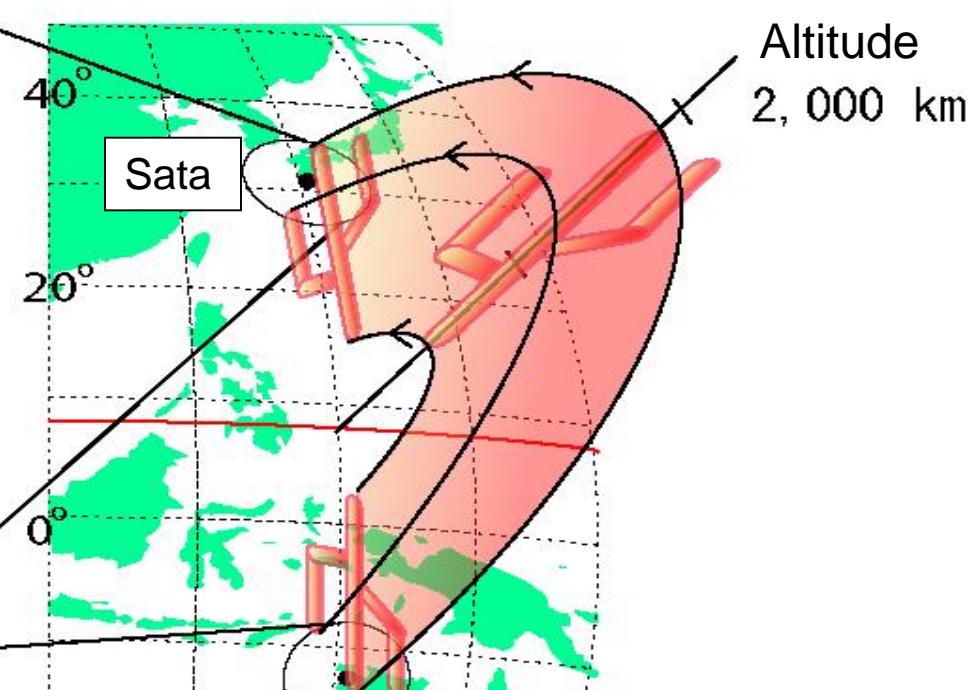
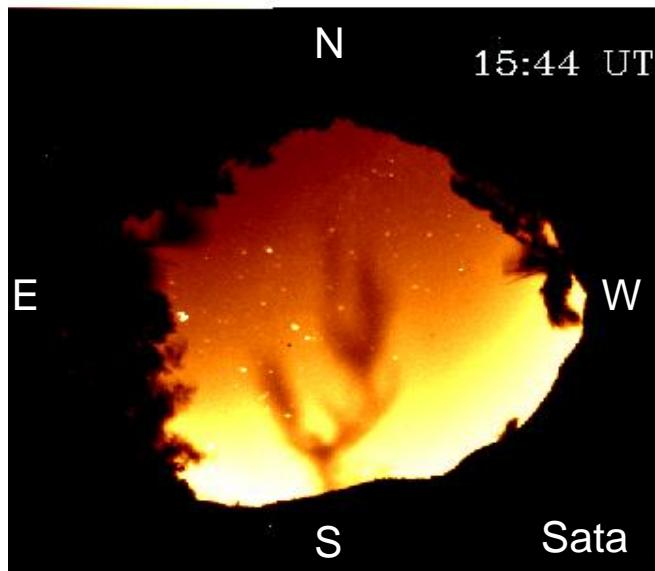
Plasma Bubbles on November 10, 2006



Giant Geomagnetic-Conjugate Plasma Bubbles

630-nm All-Sky Image Nov. 12, 2001

(Otsuka et al., 2002)



Both bubble images are quite similar, indicating that bubble structures are elongated along geomagnetic field.

敬請批評指教 Thank you!!!

