Preliminary results of ionosphere measurement from GNOS on China FY-3C satellite

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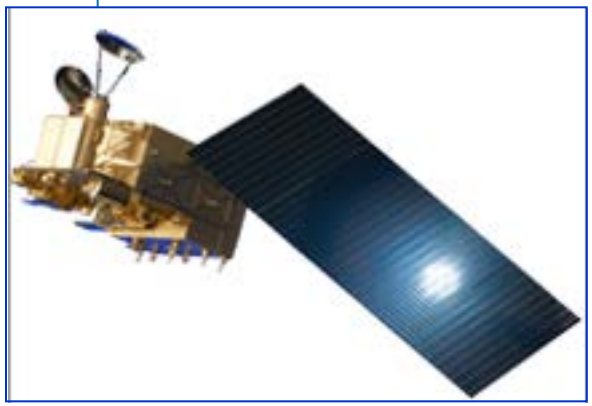
Outline

- Introduction to FY-3C & GNOS
- GNOS ionospheric measurement results
- Summary and outlook

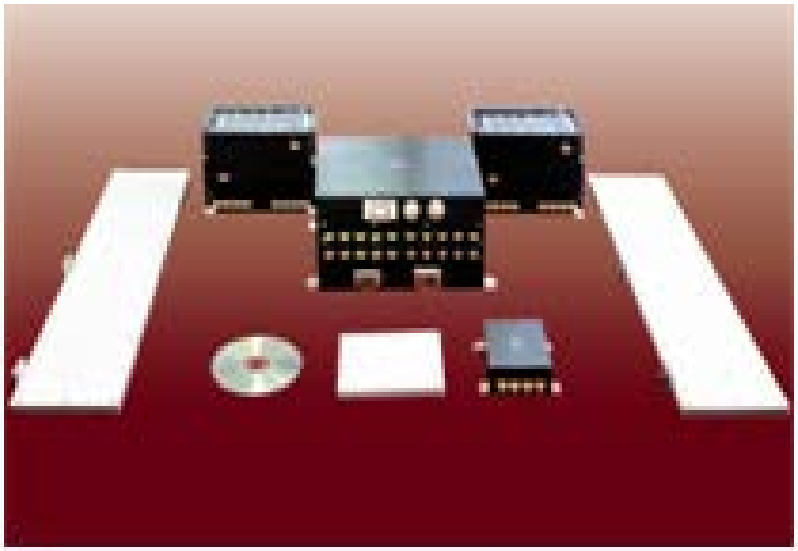
Introduction to FY-3C



- FY (FengYun): Chinese meteorological satellite
- FY-3: second generation polar-orbiting satellite
- FY-3C: 3rd flight unit of the FY-3 series ; First satellite of the FY3 02 batches
- Operational satellite

Orbit	Sun-synchronous orbit
Altitude	836 km
ECT	10:15 desc
Launch	2013-09-23
End of life	≥2018
Status	Operational

Introduction to GNOS ON FY-3C



- GNSS occultation sounder
- GNOS Measures the phase delay due to refraction during occultation between GNSS satellites and FY-3C
- GNOS receives signals from GPS and BDS

Parameter	Content
Constellation	GPS:L1、L2 BDS:B1、B2
Channel number	Positioning: 8 Occultation: GPS 6 BDS 4
Sampling rate	Ionosphere occultation: 1Hz
Designed Precision of F2 peak electron density	20%

Productions about ionosphere

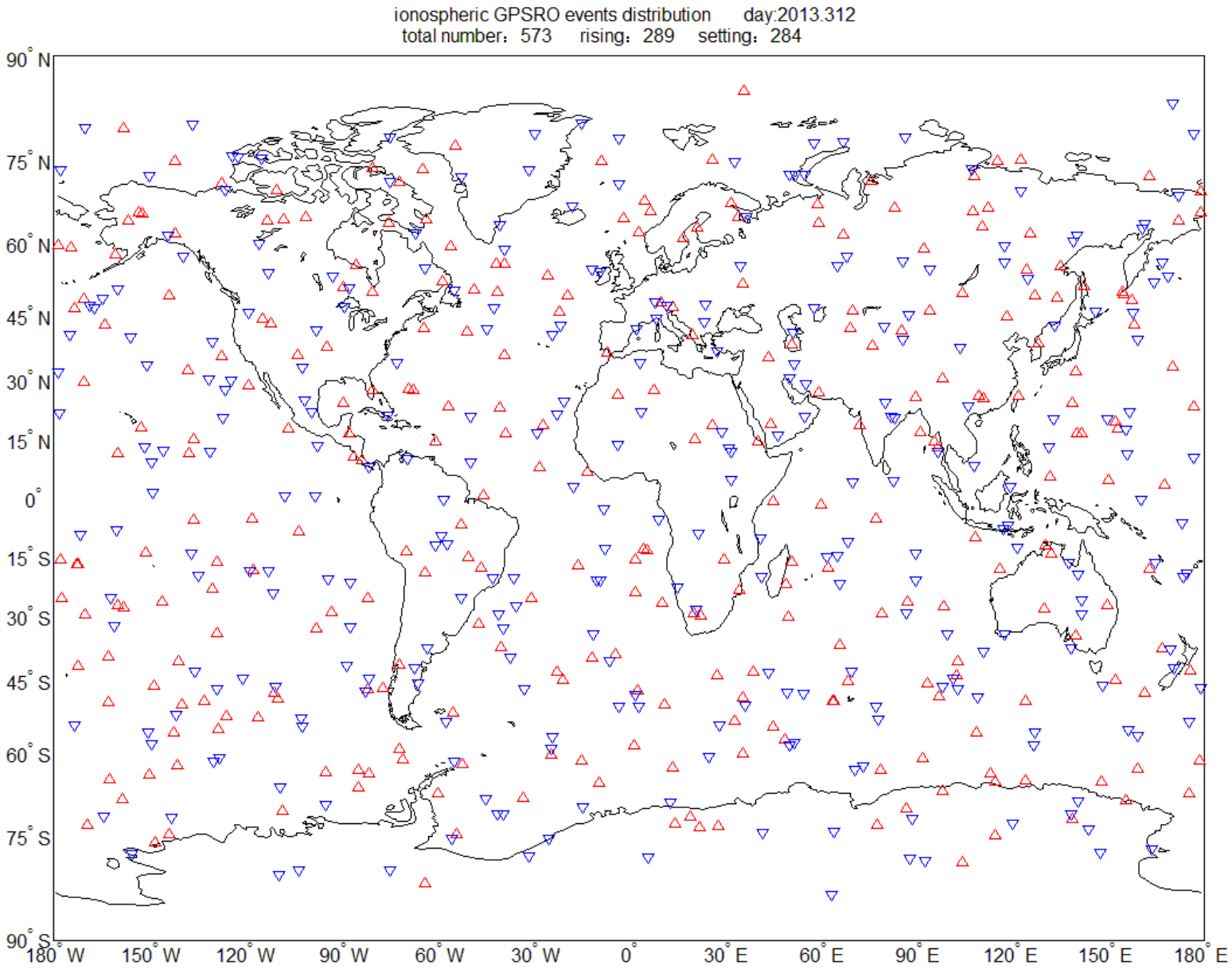
L1

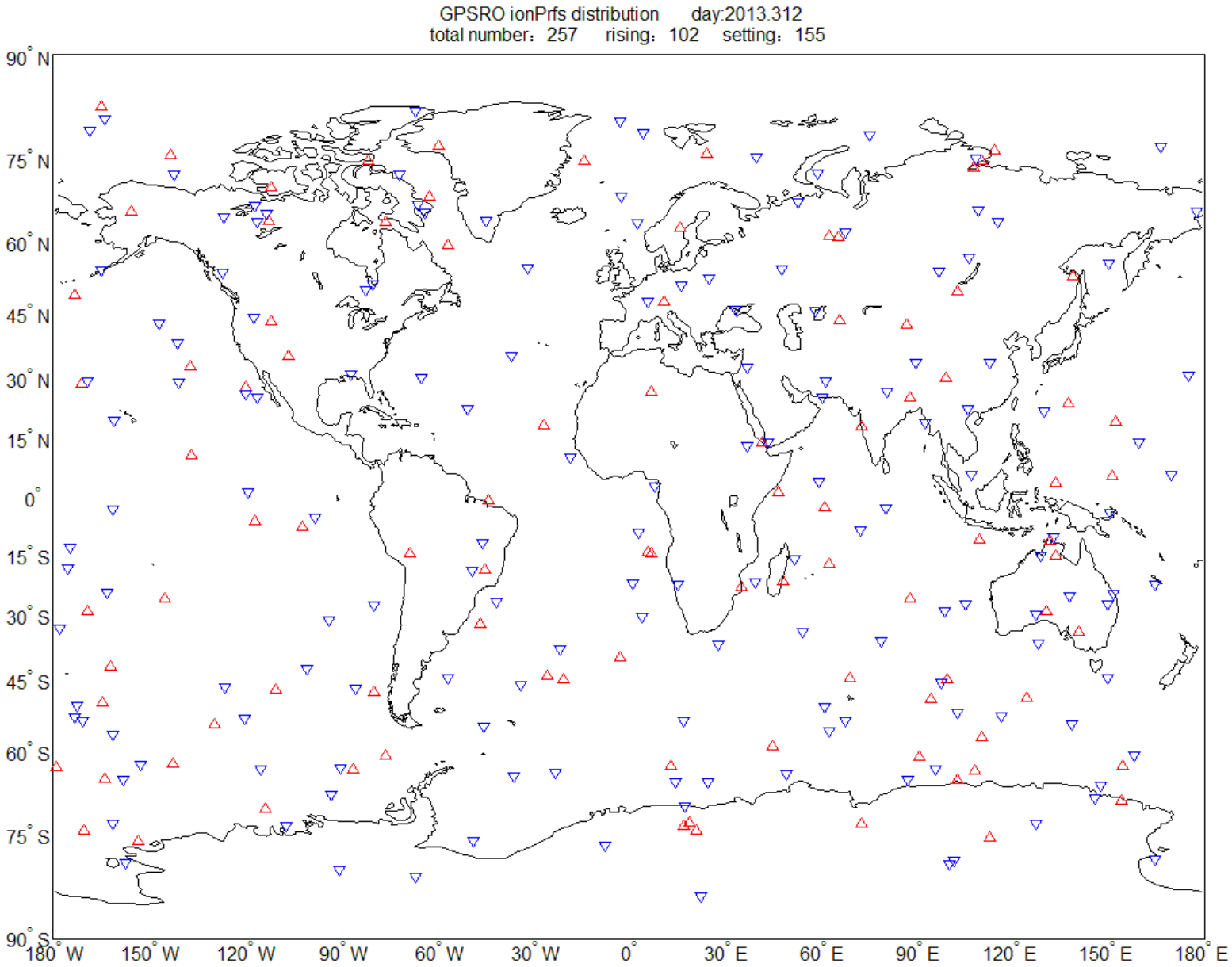
- Ionosphere excess phase (IE)
- nc format

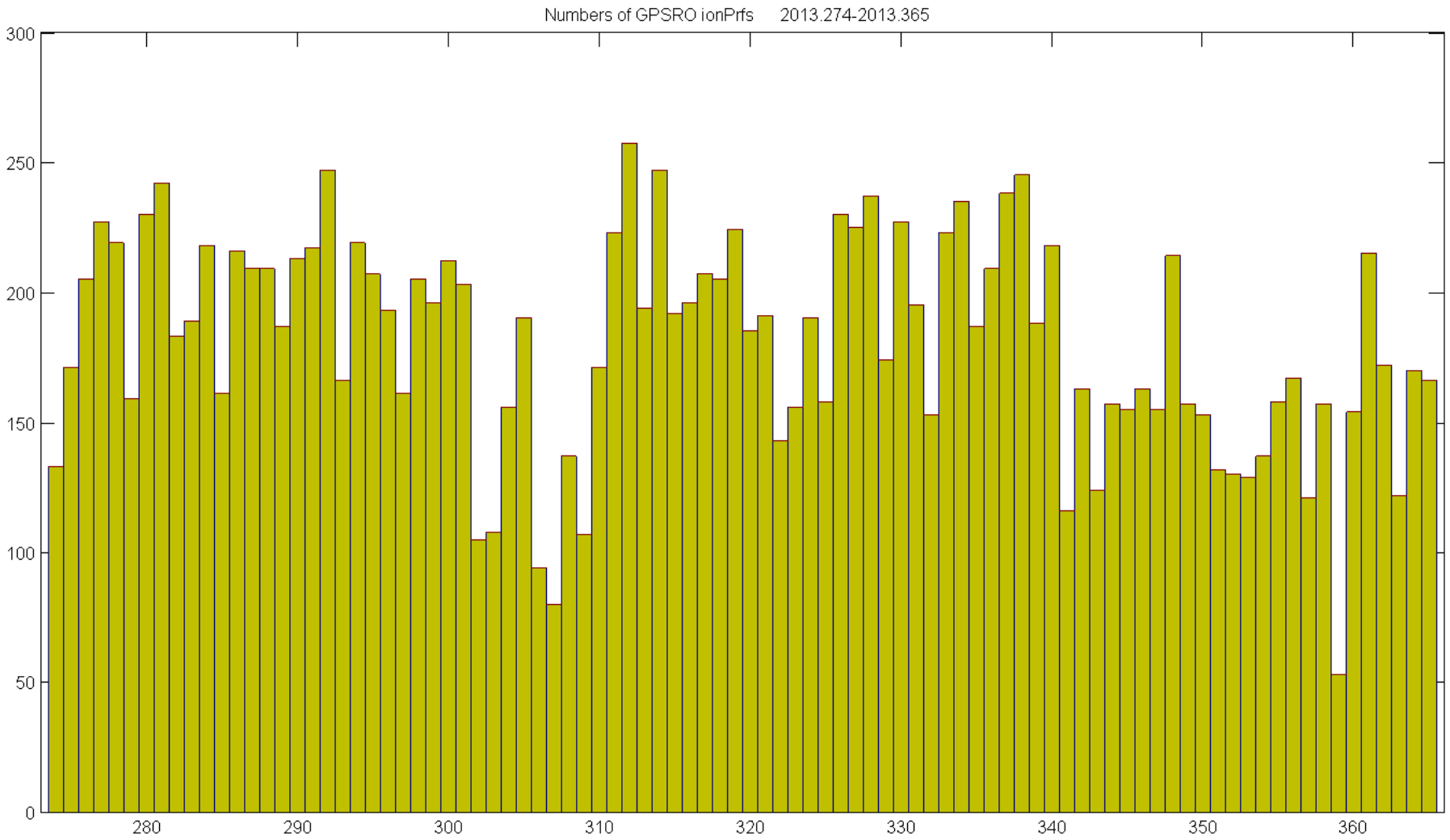
L2

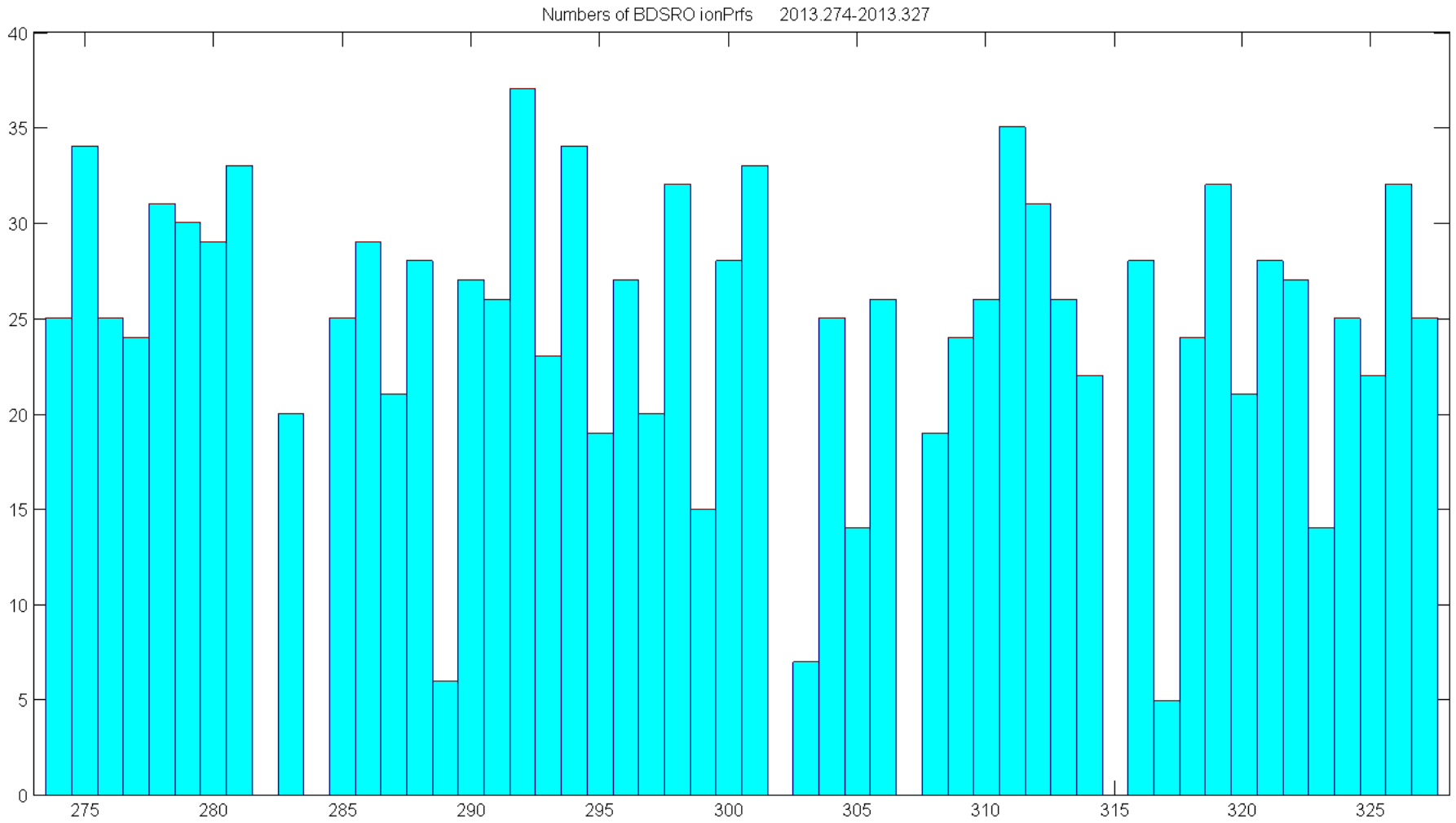
- Electron density profile (EDP)
- nc format

Present status




GPSRO ionPrfs distribution day:2013.312
total number：257 rising：102 setting：155
90° N
75° N
60° N
45° N
30° N
15° N
0°
15° S
30° S
45° S
60° S
75° S
90° S
180° W
150° W
120° W
90° W
60° W
30° W
0°
30° E
60° E
90° E
120° E
150° E
180° E


Numbers of GPSRO ionPrfs 2013.274-2013.365
300
250
200
150
100
50
0
280
290
300
310
320
330
340
350
360


Numbers of BDSRO ionPrfs 2013.274-2013.327
40
35
30
25
20
15
10
5
0
275
280
285
290
295
300
305
310
315
320
325

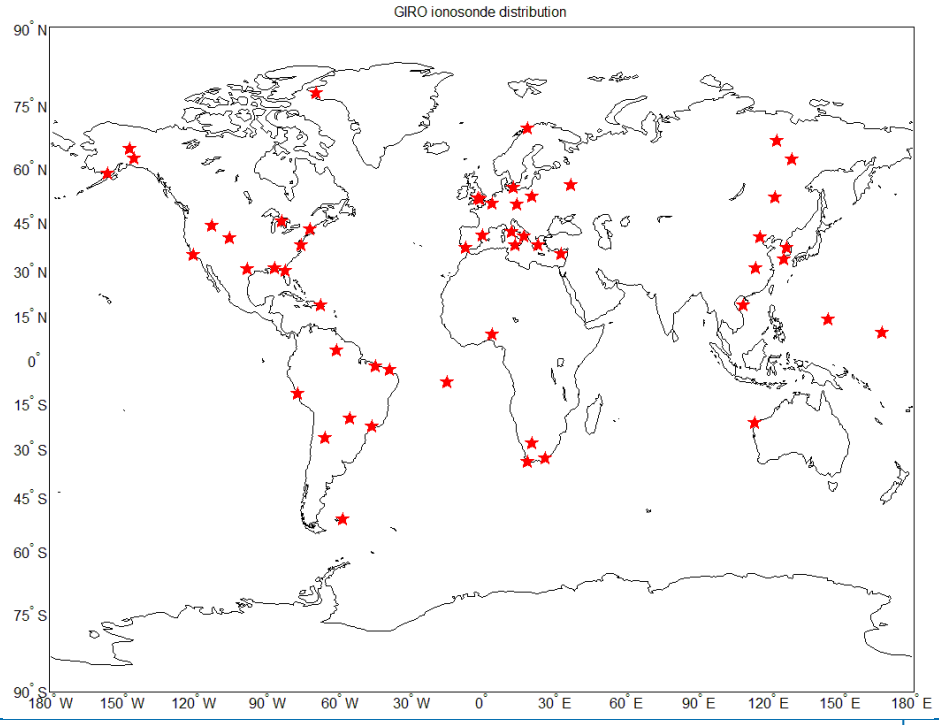
Evaluation1: comparison with ionosonde

Data

- GNOS EDPs
  - GPSRO:2013.272----2014.247
  - BDSRO:2013.274----2014.090
- Ionosonde observation data
  - Source: GIRO(Global Ionospheric Radio Observatory)
  - 54 sites

Compared Parameters

- NmF2 (foF2→NmF2)
- hmF2



Evaluation1 : comparison with ionosonde

▣ Data quality control

- ❖ GNOS EDPs quality control
  - Incomplete profiles were wiped off
  - Profiles that NmF2<0 were wiped off
- ❖ Ionosonde data quality control
  - Record that have both hmF2 and NmF2 simultaneously w as kept;

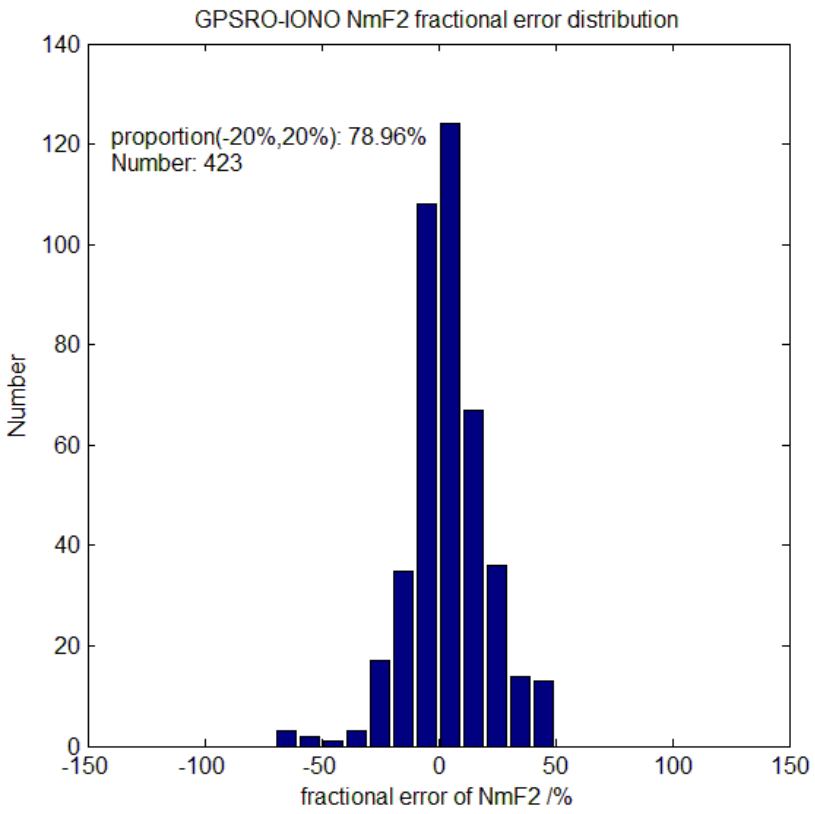
▣ Space weather condition screening

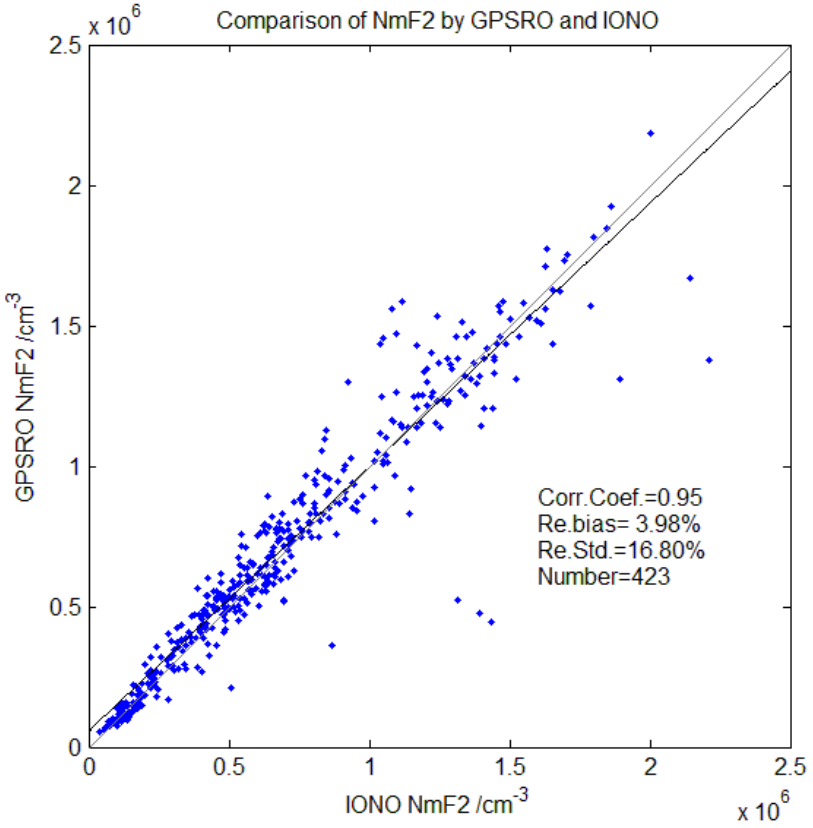
- ❖ Kp < 4

▣ Time-space matching

- ❖ Time interval < 0.5 hrs
- ❖ Spherical distance < 200 kms

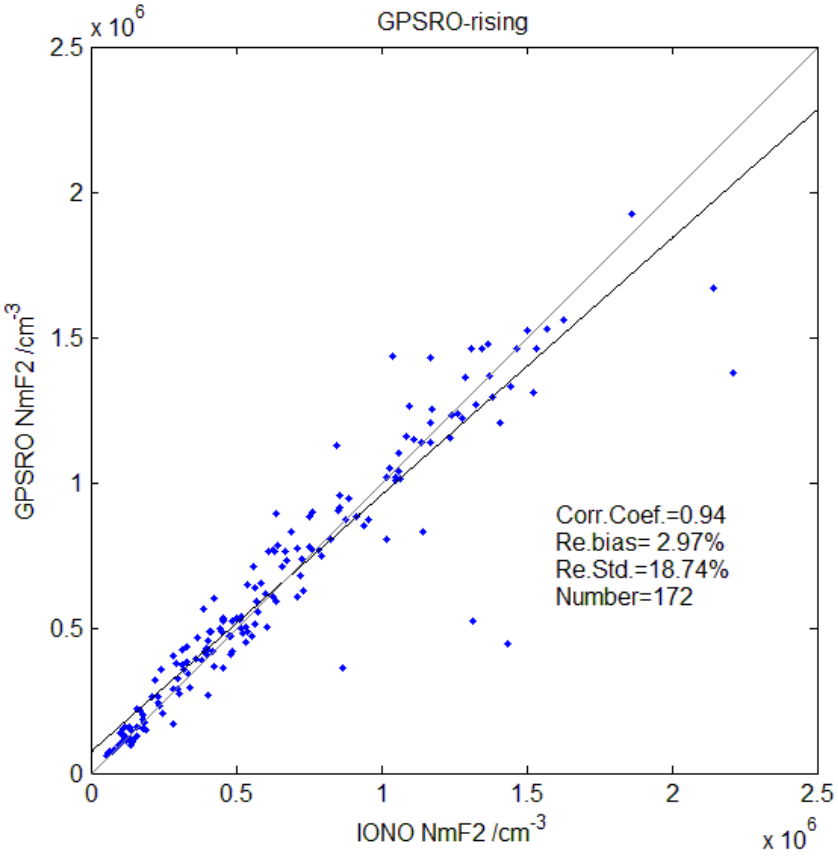
Evaluation1: GPSRO NmF2 ——ensemble

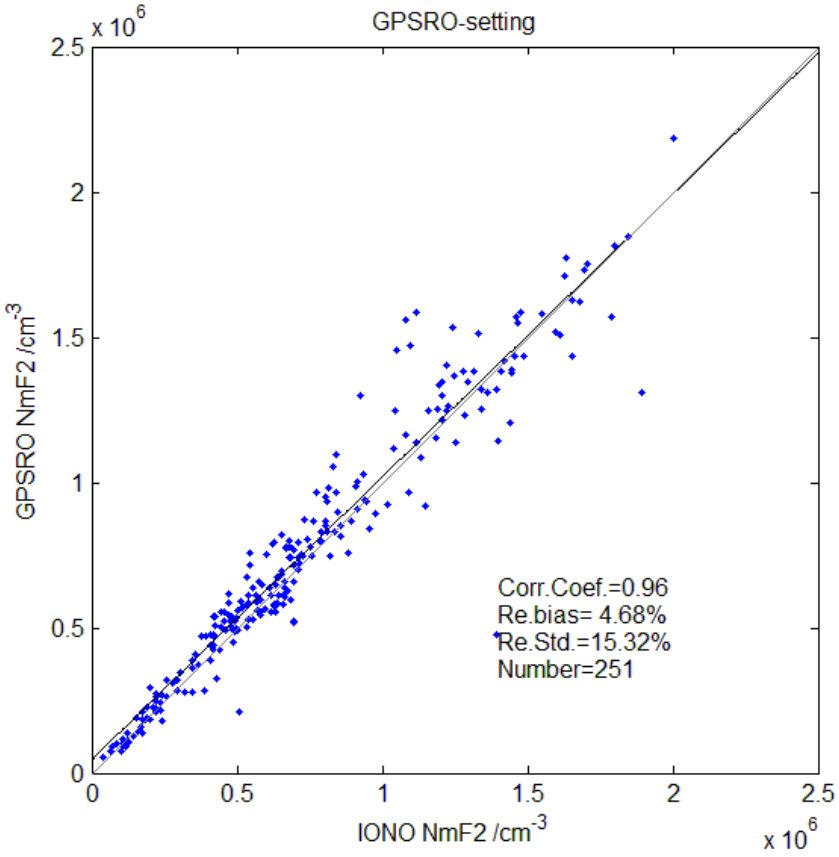




Good agreement between the GNOS GPSRO and the ionosonde measurement

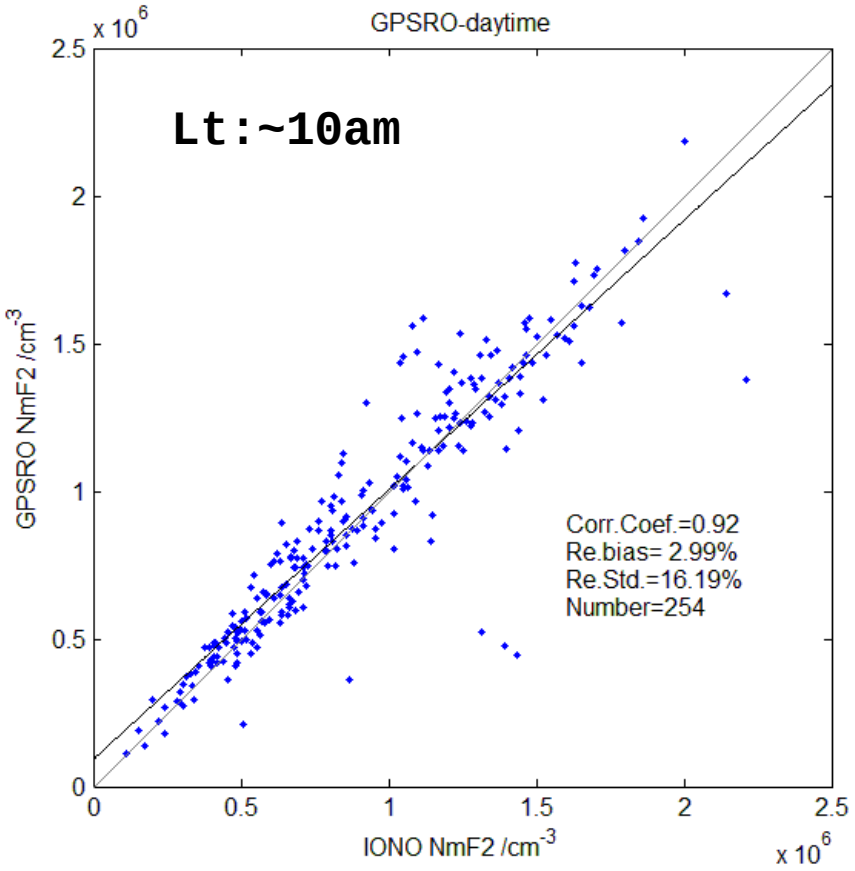
Evaluation1: GPSRO NmF2

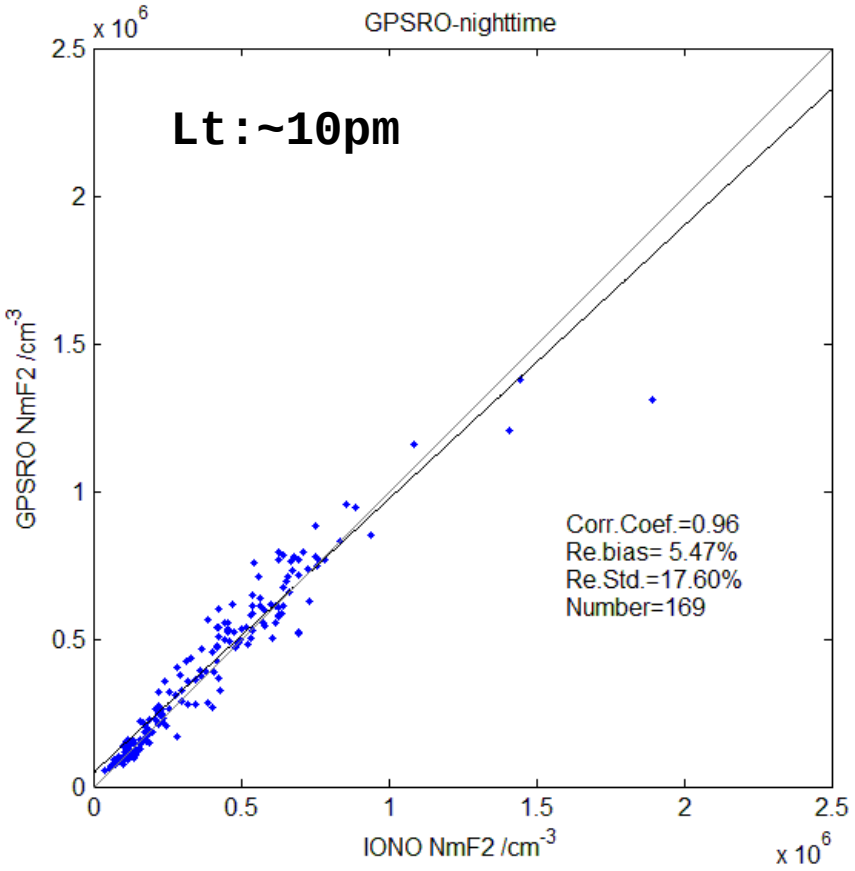




Re.std. : rising > setting

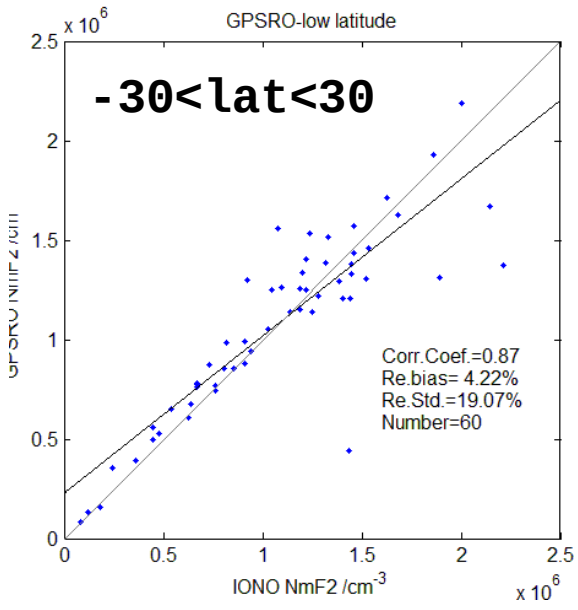
Evaluation1: GPSRO NmF2

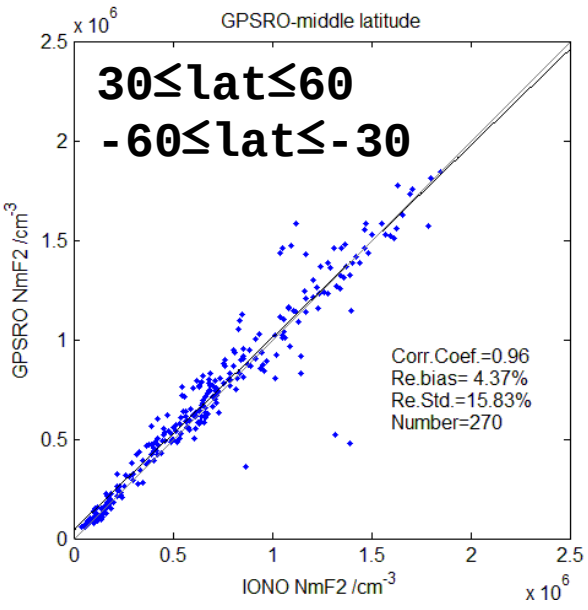


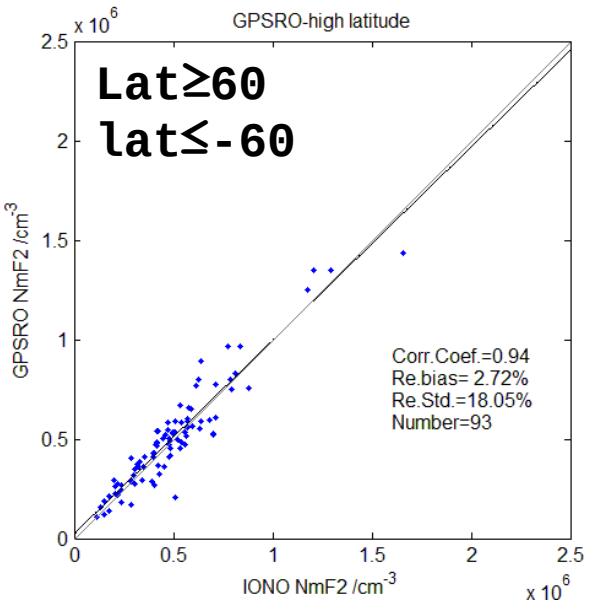


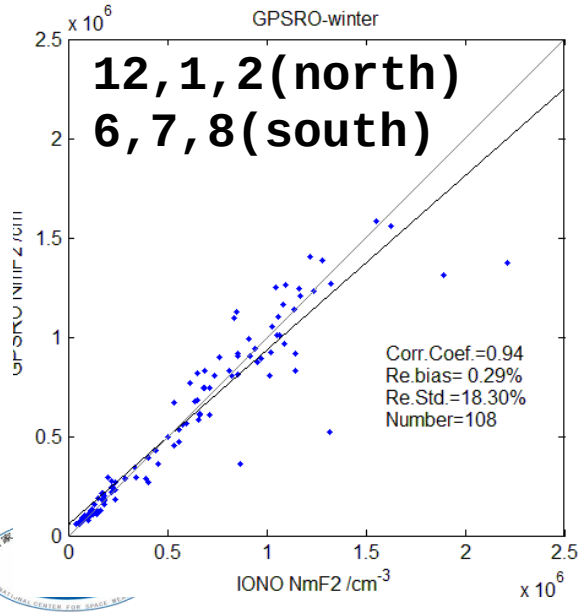
Re.std. : daytime < nighttime

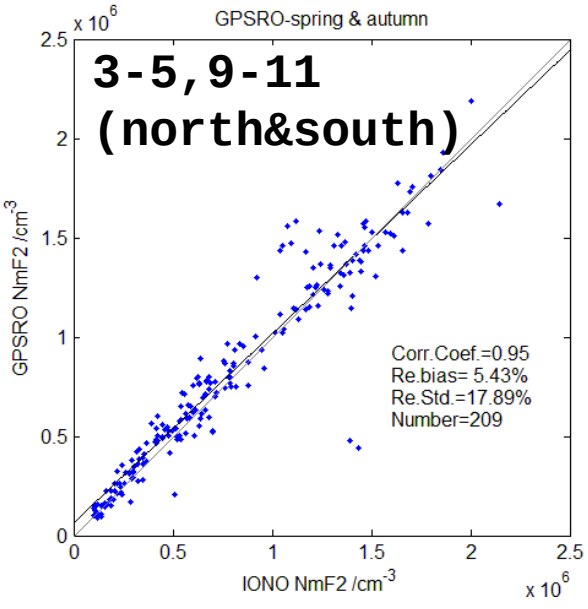
Evaluation1: GPSRO NmF2

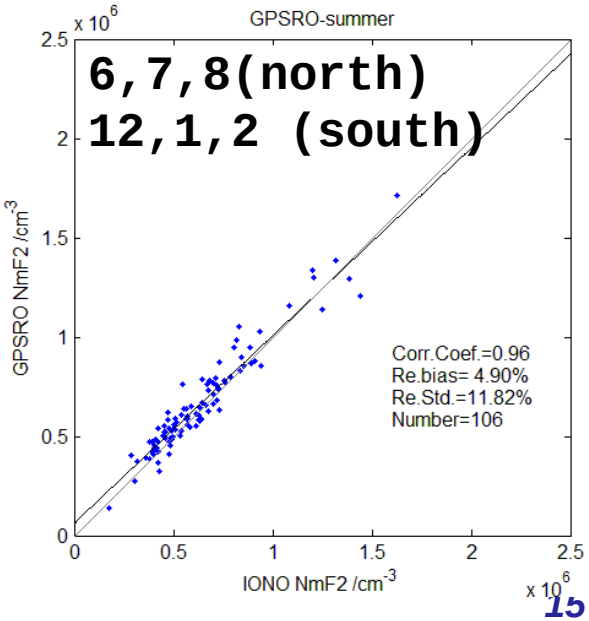




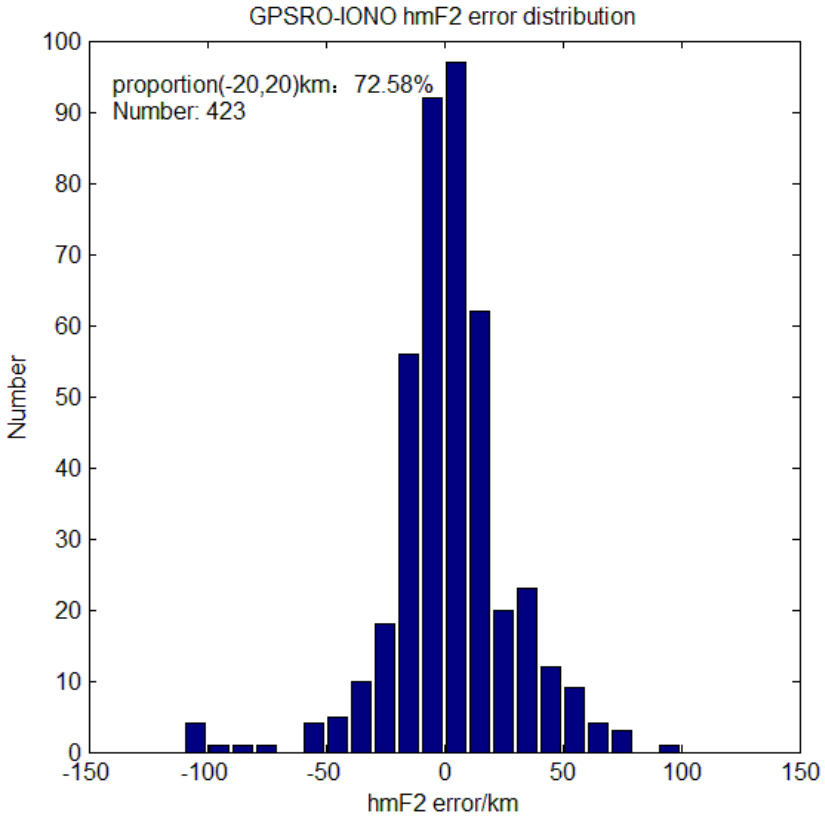


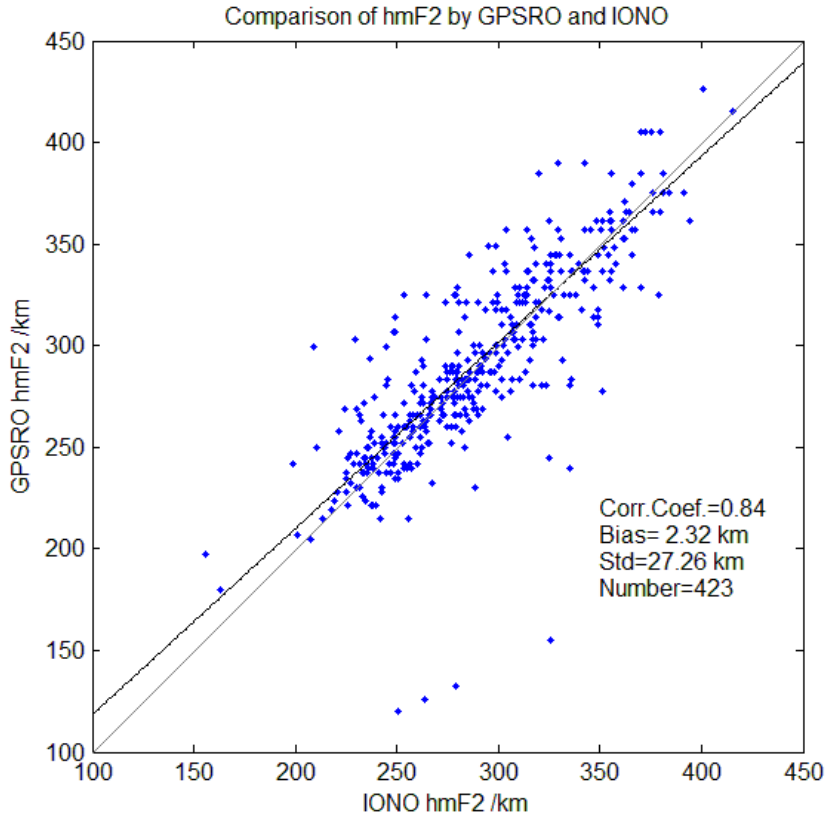






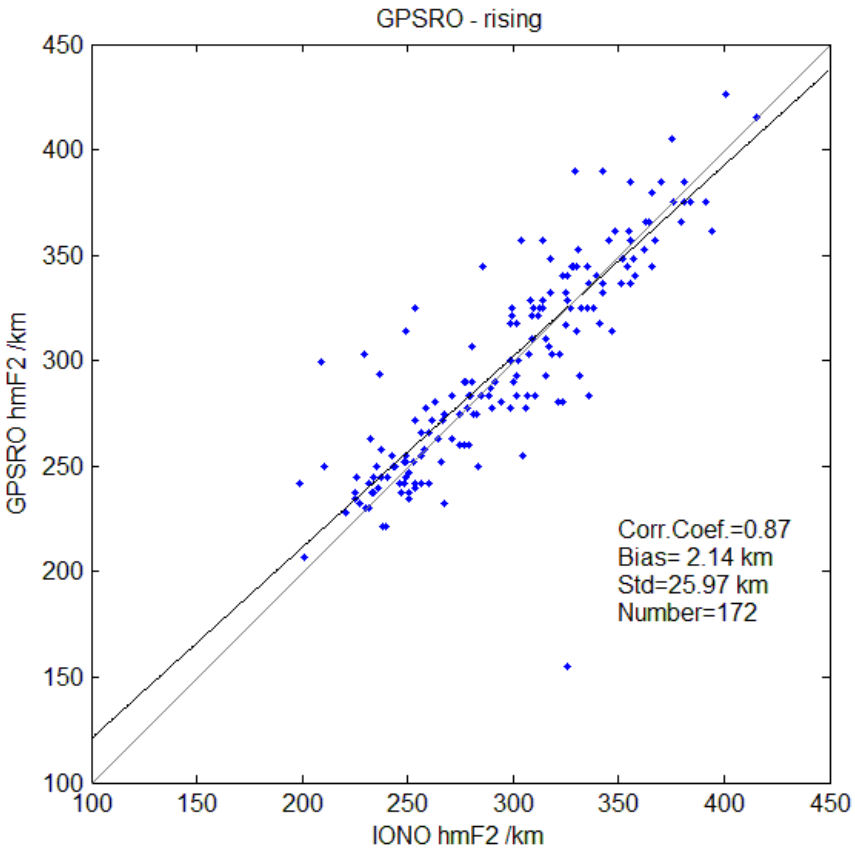
Evaluation1: GPSRO hmF2——ensemble

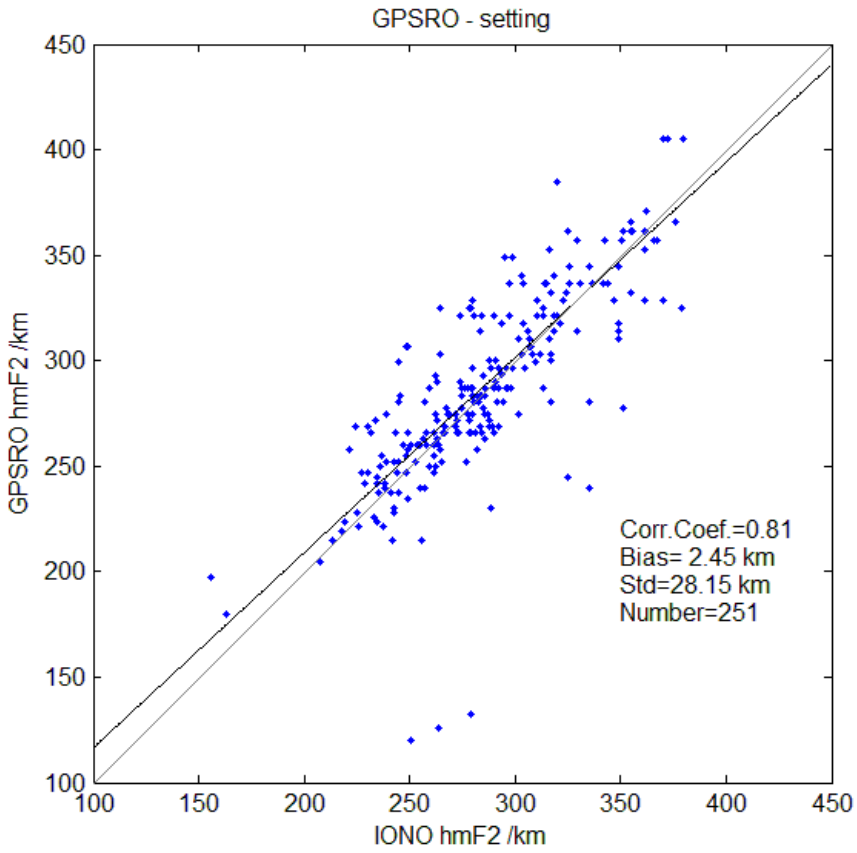




Also agreement

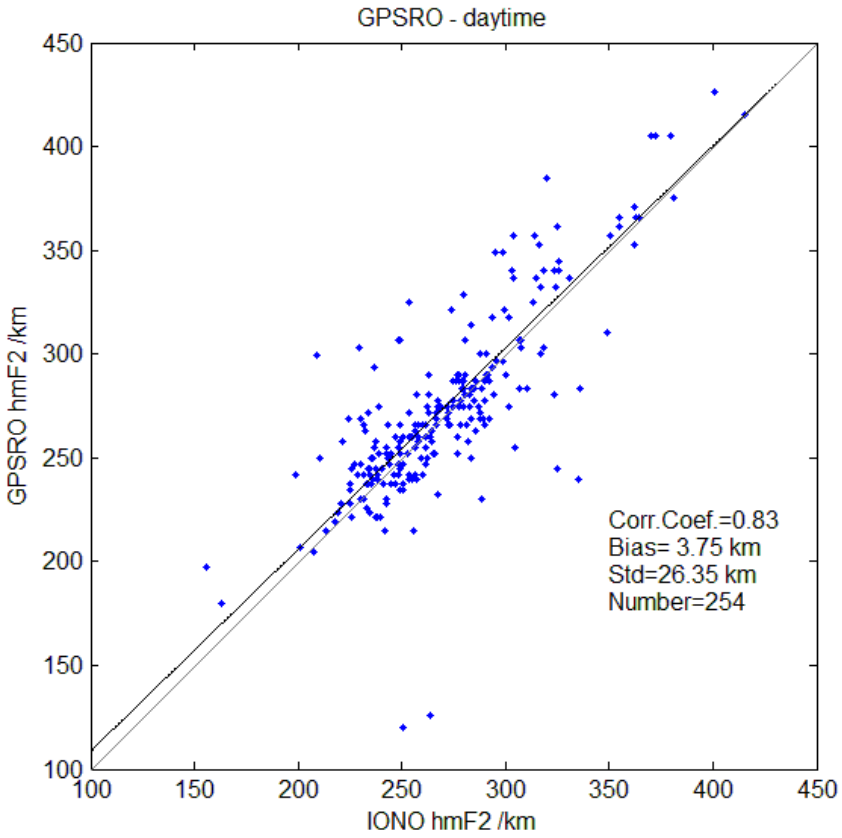
Evaluation1: GPSRO hmF2

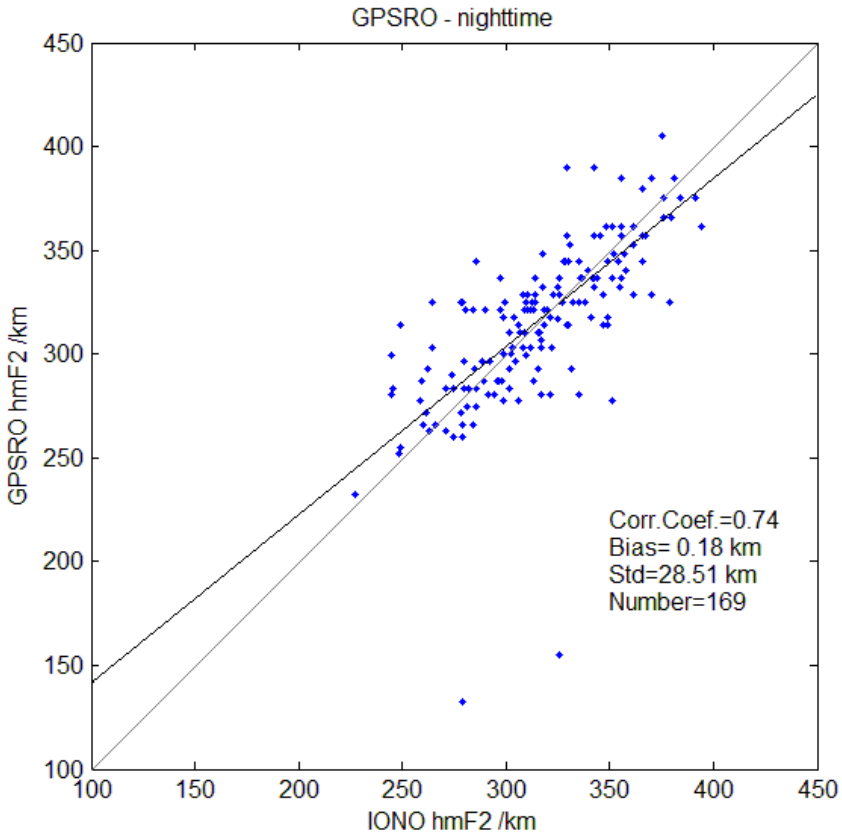




Std. : rising < setting

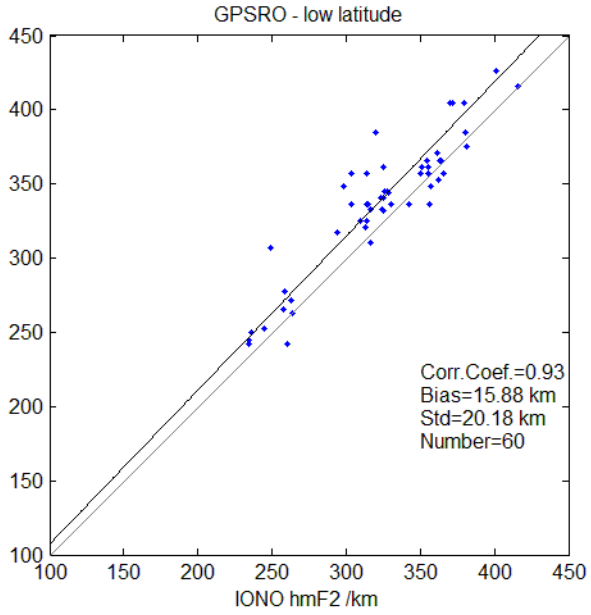
Evaluation1: GPSRO hmF2

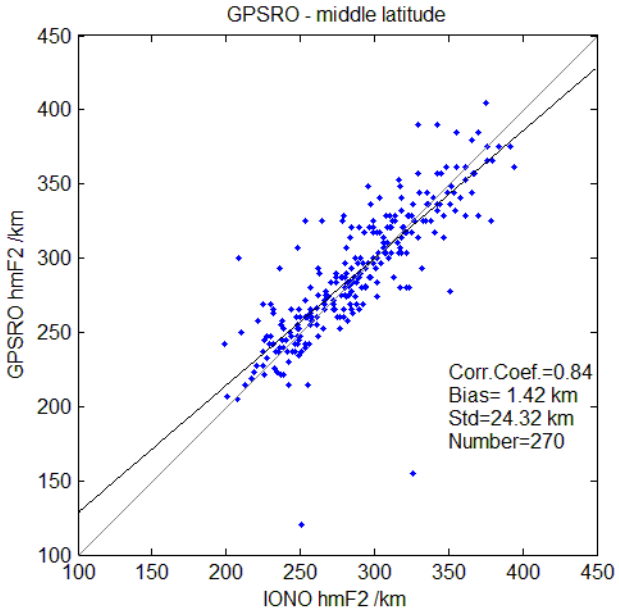


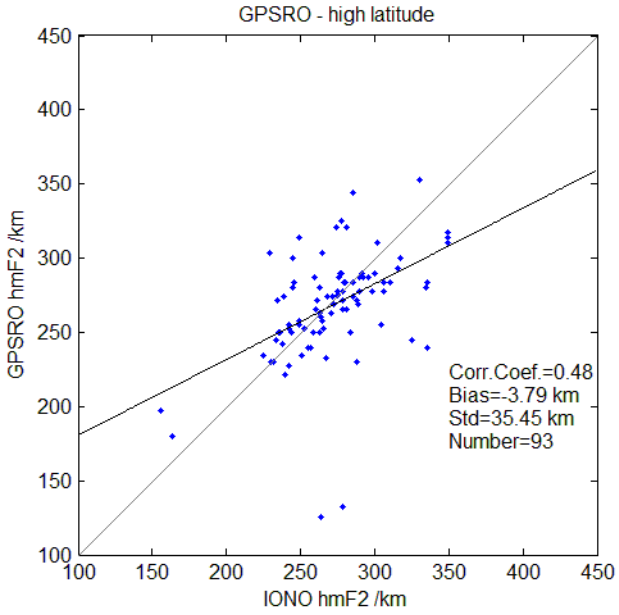


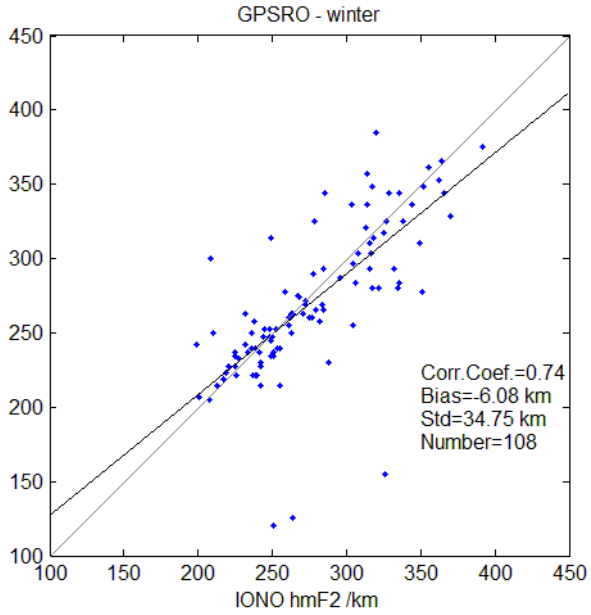
Std. : daytime < nighttime

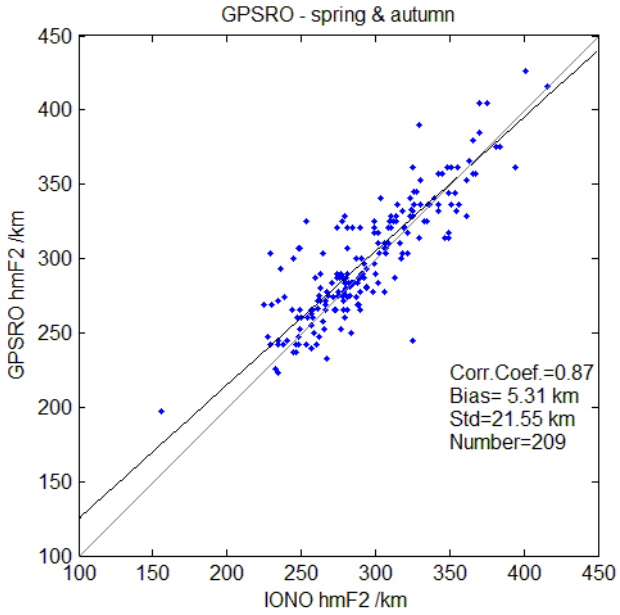
Evaluation1: GPSRO hmF2

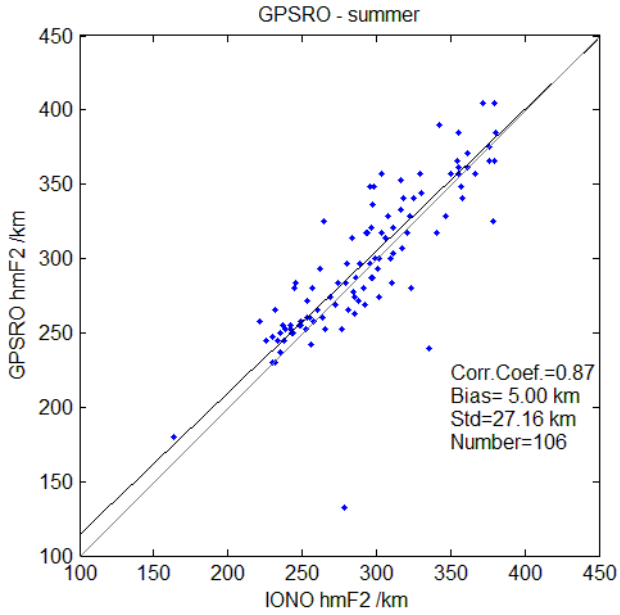




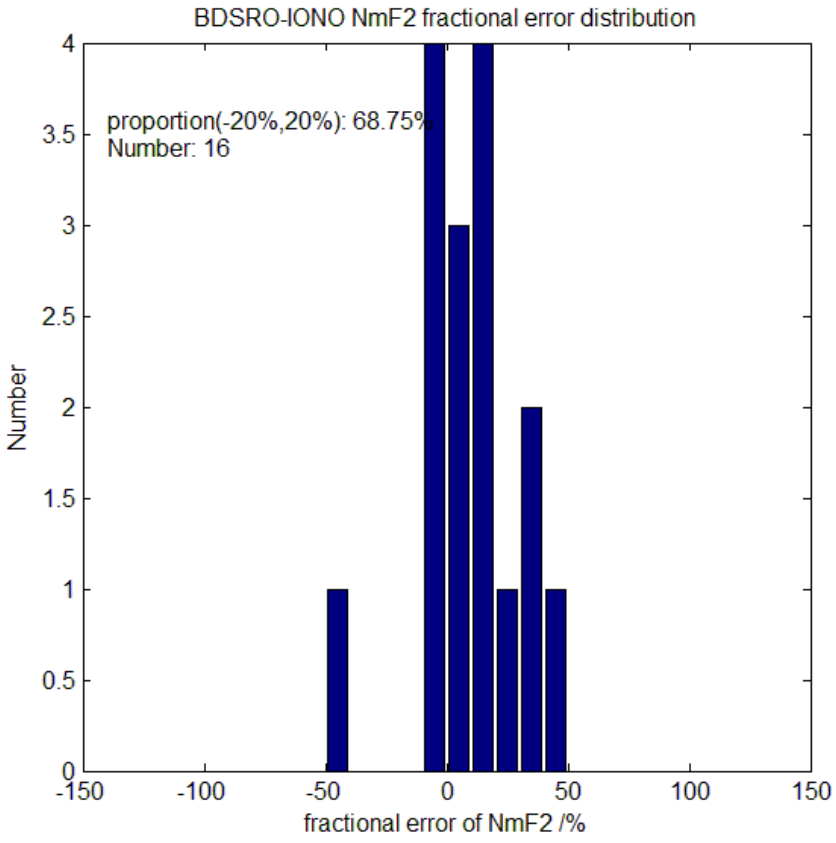


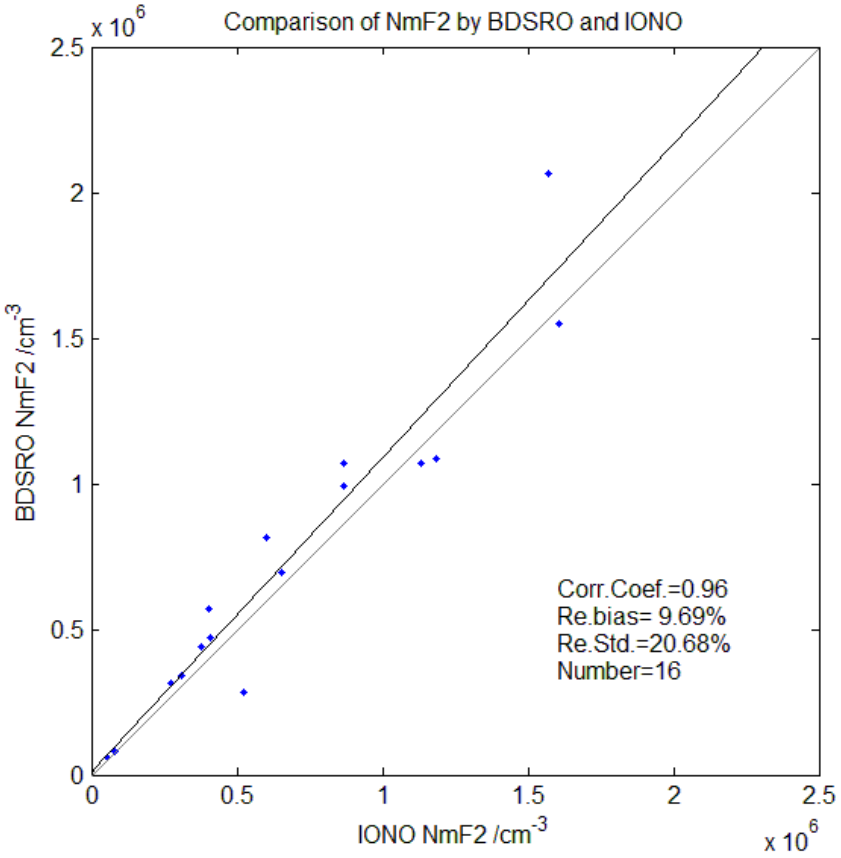






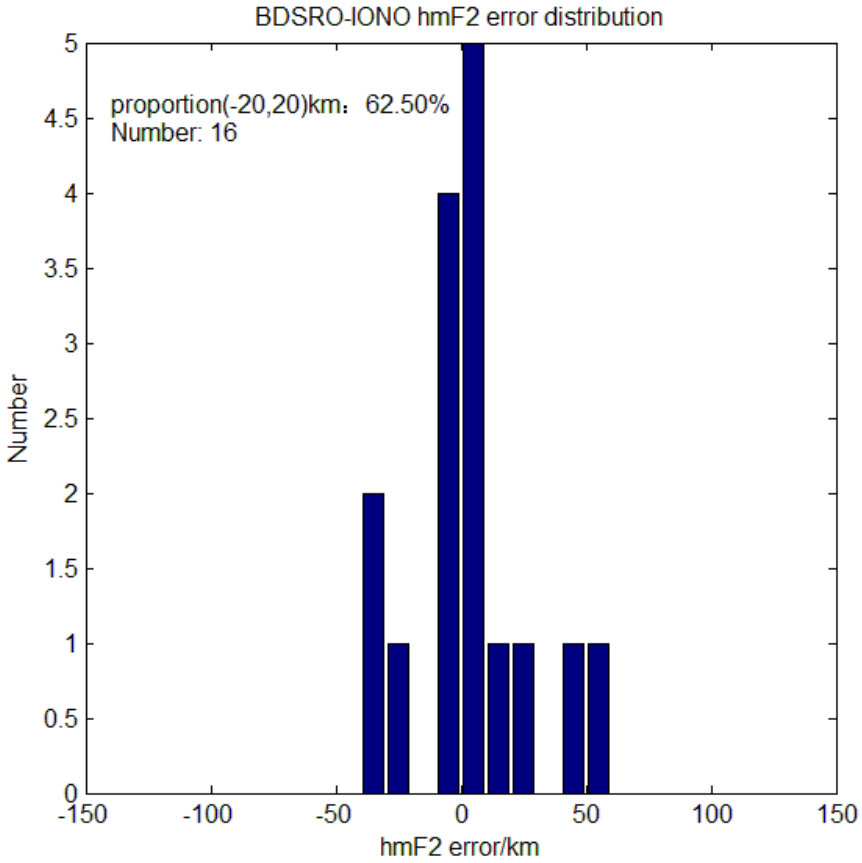
Evaluation1: BDSRO NmF2 ——ensemble

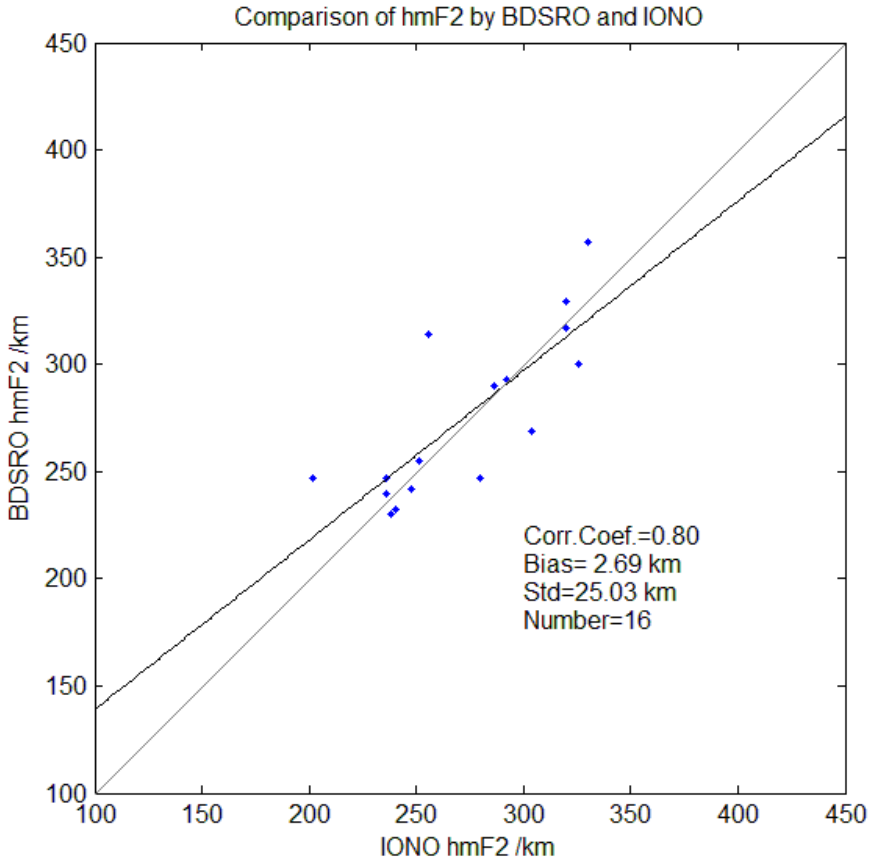




NmF2 Re.Std.: BDSRO > GPSRO, but slightly

Evaluation1: BDSRO hmF2 ——ensemble





hmF2 Std.: BDSRO < GPSRO, but slightly

the precision of EDP production of BDSRO is equivalent to that of GPSRO

GPSRO-IONO NmF2

Dataset	Corr.Coef.	Re.bias	Re.Std.	Number
ensemble	0.95	3.98%	16.80%	423
Rising	0.94	2.97%	18.74%	172
Setting	0.96	4.68%	15.32%	251
Daytime	0.92	2.99%	16.19%	254
nighttime	0.96	5.47%	17.60%	169
winter	0.94	0.29%	18.30%	108
Spring & autumn	0.95	5.43%	17.89%	209
Summer	0.96	4.90%	11.82%	106
Low latitude	0.87	4.22%	19.07%	60
Middle latitude	0.96	4.37%	15.83%	270
High latitude	0.94	2.72%	18.05%	93

GPSRO-IONO hmF2

Dataset	Corr.Coef.	Bias	Std.	Number
ensemble	0.84	2.32 km	27.26 km	423
Rising	0.87	2.14 km	25.97 km	172
Setting	0.81	2.45 km	28.15 km	251
Daytime	0.83	3.75 km	26.35 km	254
nighttime	0.74	0.18 km	28.51 km	169
winter	0.74	-6.08 km	34.75 km	108
Spring & autumn	0.87	5.31 km	21.55 km	209
Summer	0.87	5.00 km	27.16 km	106
Low latitude	0.93	5.88 km	20.18 km	60
Middle latitude	0.84	1.42 km	24.32 km	270
High latitude	0.48	-3.79 km	35.45 km	93

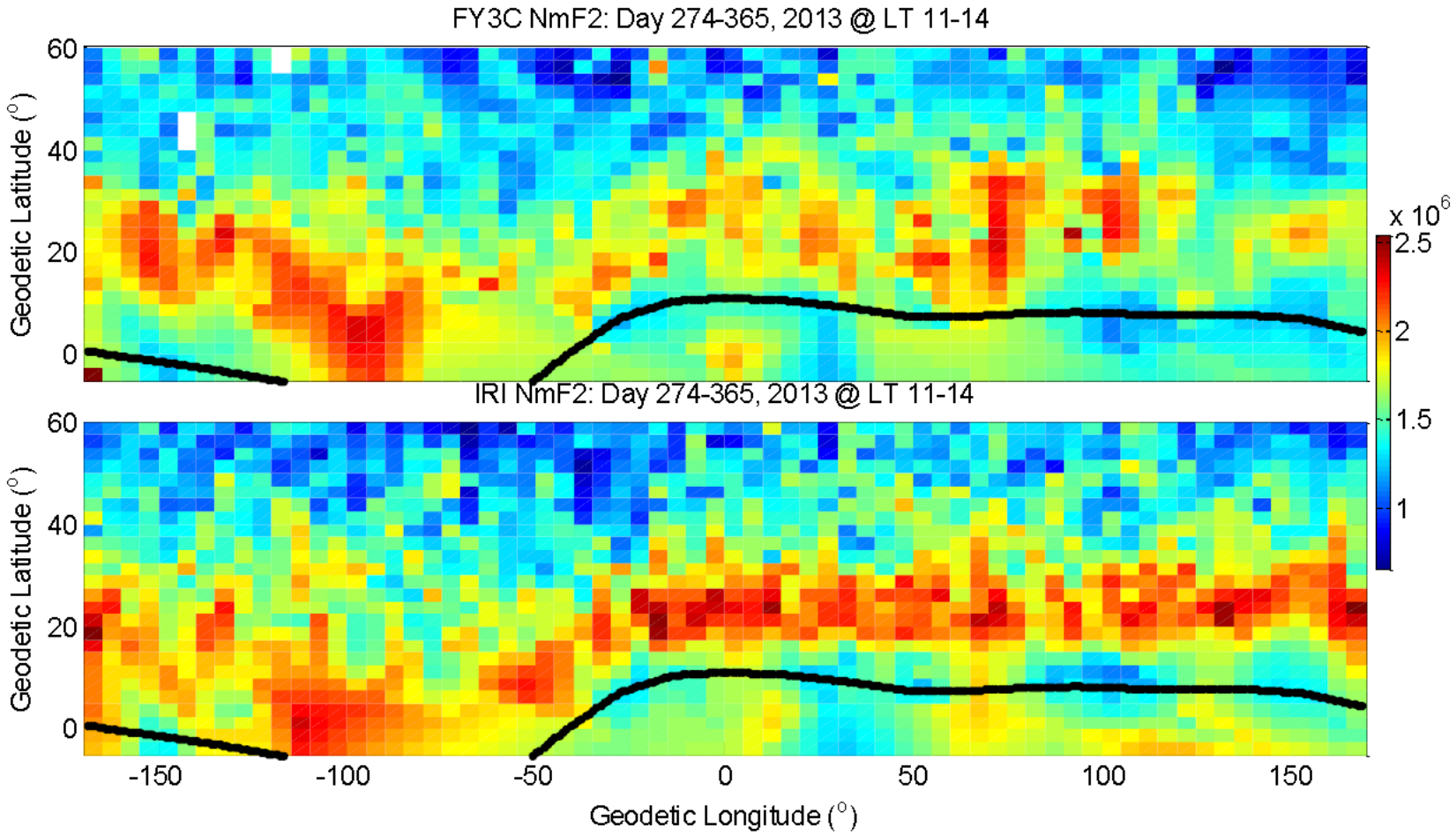
Summary on evaluation 1

▣ FY-3C GNOS comparison with ionosonde

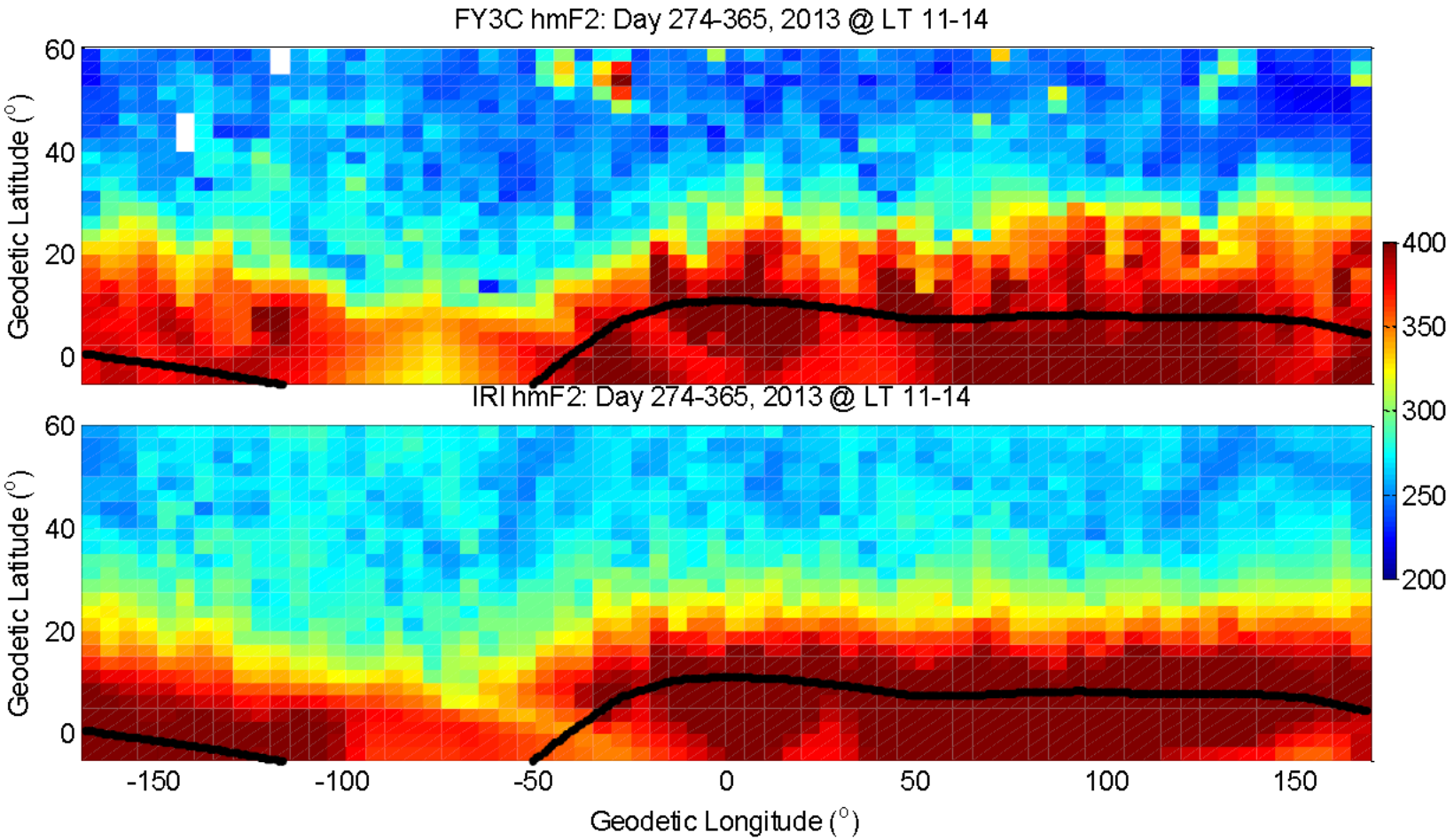
- ❖ For GPS RO:
  - Corr. Coef. For NmF2 >0.9
  - Corr. Coef. For hmF2 >0.7
  - NmF2 Re.Std. <20%
  - hmF2 Std. <30km
- ❖ For BDS RO:
  - NmF2 Corr. Coef.=0.96
  - hmF2 Corr. Coef.=0.8
  - NmF2 Re.Std. =20.58%
  - hmF2 Std. =25 km

The results show good agreement between the GNOS and the ionosonde measurement, and the precision of EDP production of BDSRO is equivalent to that of GPSRO

Evaluation2: comparison with IRI

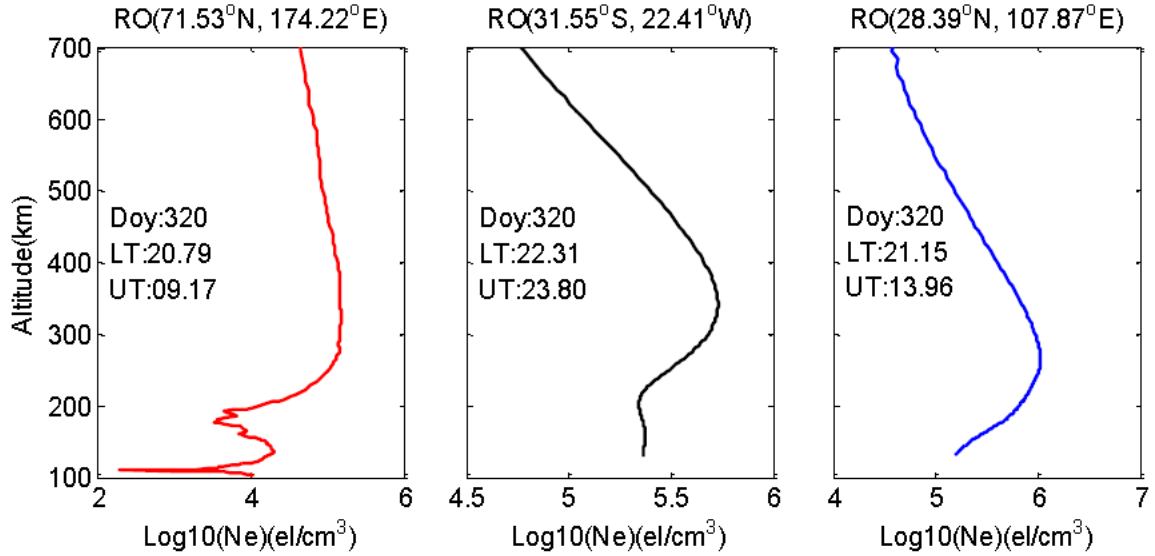


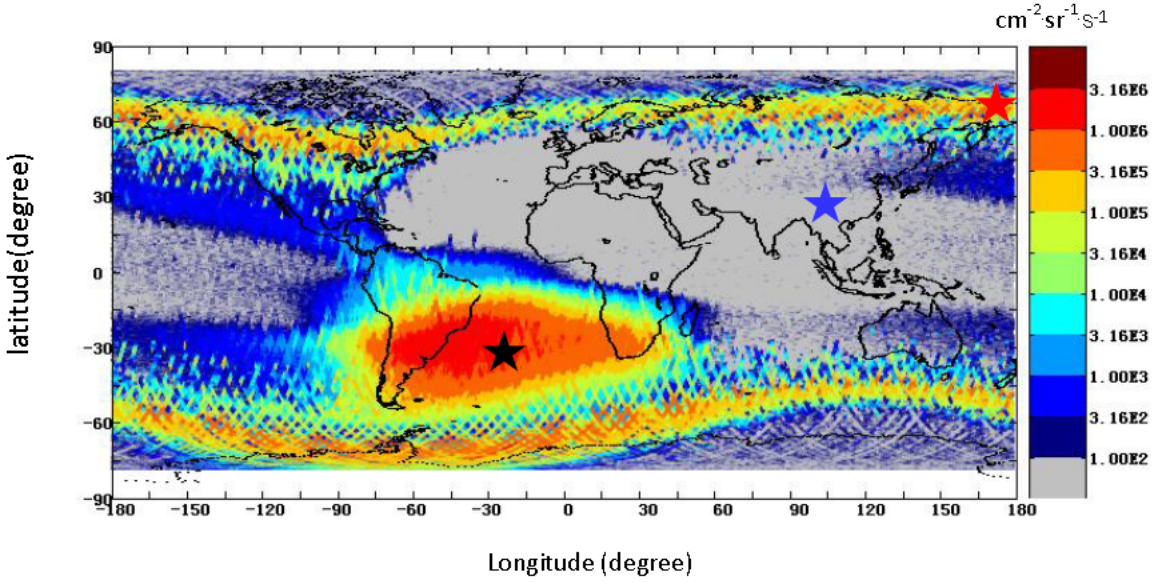
This figure gives the NmF2 maps as functions of geographic latitude and longitude from GNOS measurements (top panel) and IRI model results (bottom panel) in the Northern Hemisphere. The black line describes the location of the magnetic equator.



hmF2 maps of GNOS measurements and IRI results

Observed example: particle precipitation induced ionization enhancement





Summary

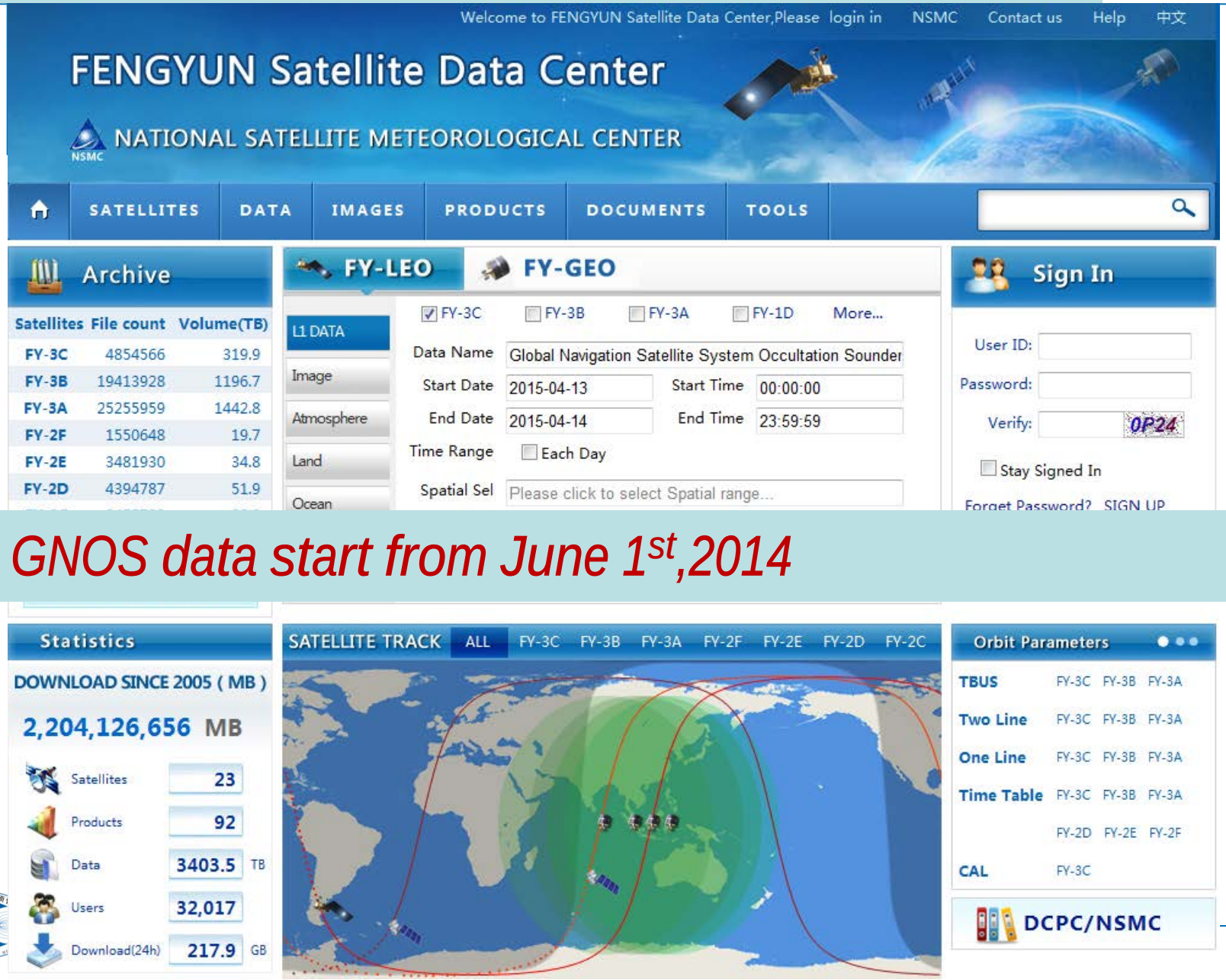
- In addition to GPS, GNOS is capable of tracking the BDS signals from the LEO for the first time.
- Preliminary comparisons show good agreement between the GNOS and the ionosonde measurement, and the precision of EDP production of BDSRO is equivalent to that of GPSRO.
- The comparison between the FY3C/GNOS data and the IRI model is also reasonably good, but the IRI model tends to overestimate NmF2 at the crests of the equatorial anomalies.
- GNOS EDPs show ionization enhancement around E layer during nighttime due to the energetic particle precipitation over the Aurora and SAA regions.

Outlook

- **More satellites to carry the GNOS onboard**
  - FY3D
  - FY3E
  - FY3F
  - FY3G
  - FY3H
- **More RO channels to observe ionosphere RO events**
  - GPS RO channels: 6→8
  - BDS RO channels : 4→8
- **More BDS satellites to track the signals**
  - About 40 BeiDou navigation satellites in total by 2020
  - Global coverage

Promote the quantity and quality of GNOS RO data

http://satellite.cma.gov.cn/portalsite/default.aspx



GNOS data start from June 1st,2014

THANK YOU