



National Institute of Information and Communications Technology

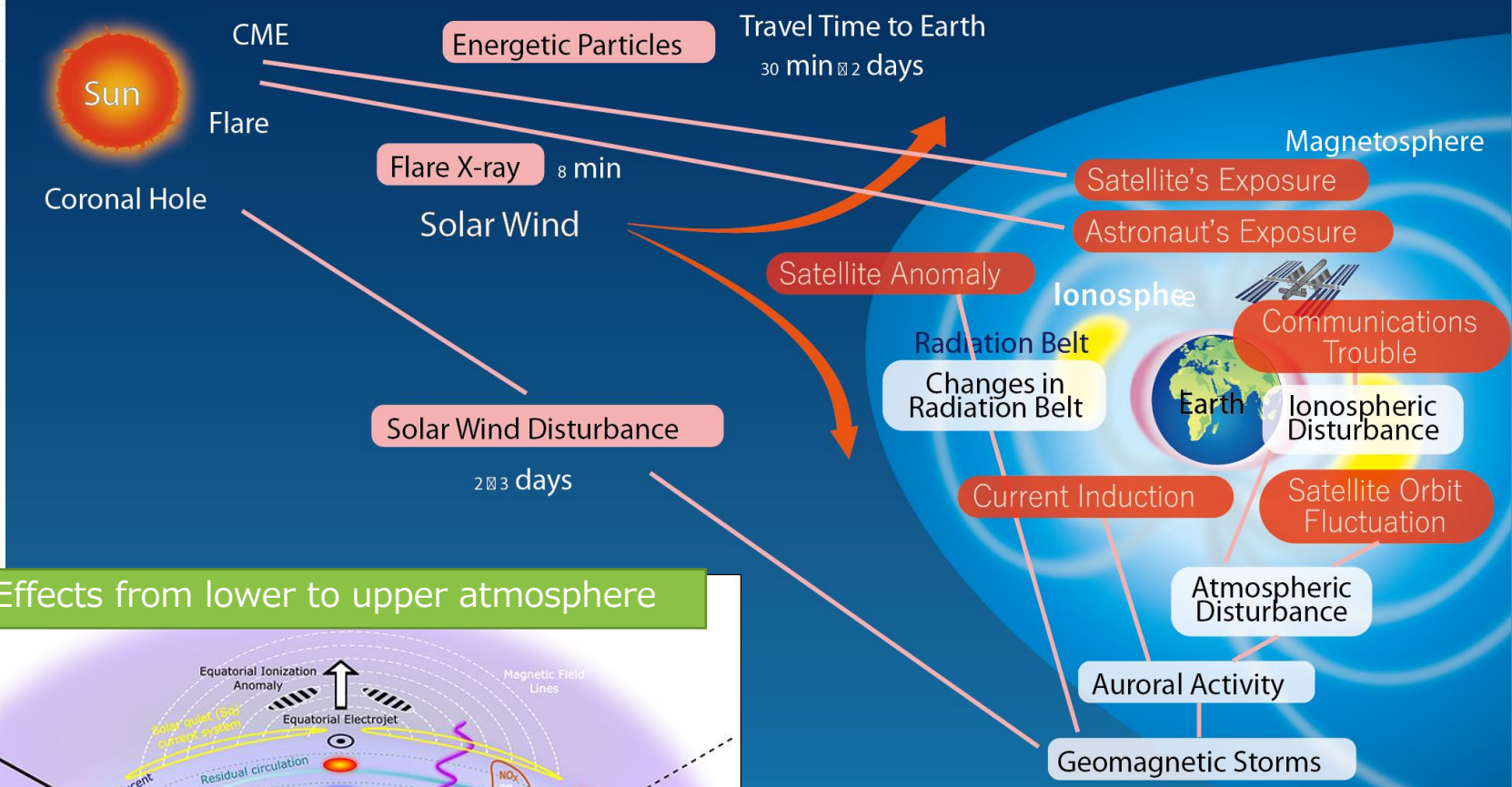
NICT's Space Weather Research & Operation for GNSS

Hidekatsu Jin

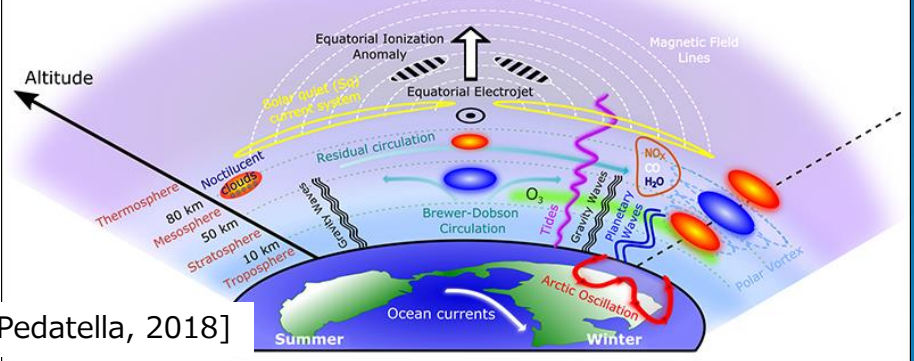
Senior Researcher, Space Environment Laboratory

National Institute of Information and
Communications Technology, Japan

space weather from sun to earth



Effects from lower to upper atmosphere

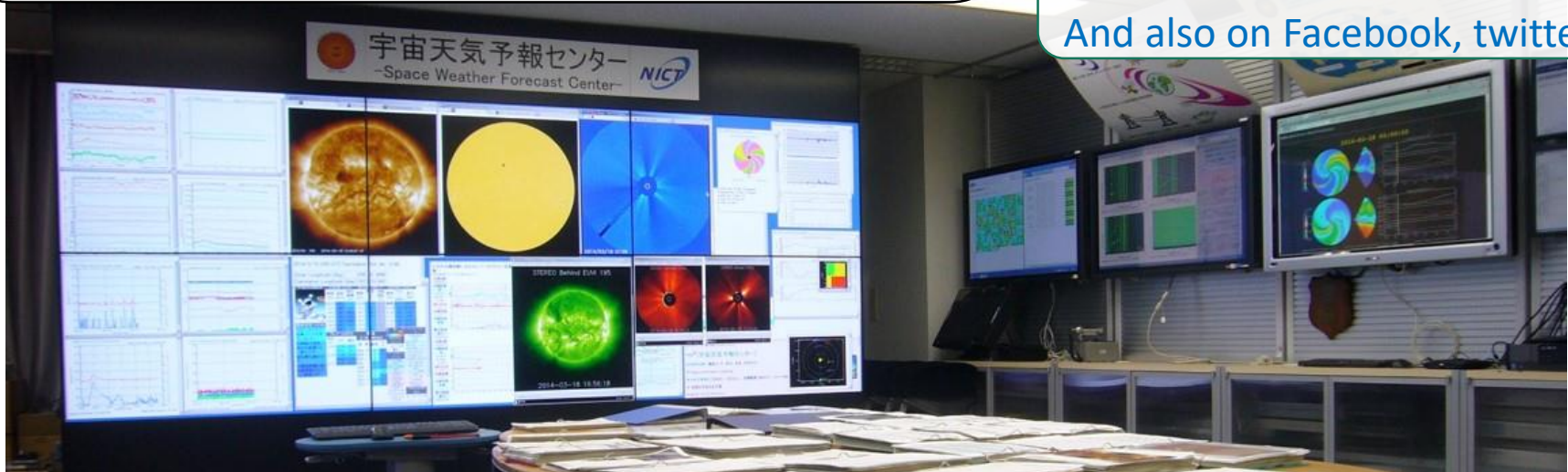


[Pedatella, 2018]

Operational SW nowcast/forecast as an ISES member

- Solar flare occurrence
- High-energy particle condition at geosynchronous orbit
- Geomagnetic field condition over Japan
- Ionospheric condition over Japan

Web access : 160,000/month
No. of e-mail address : 10,000
And also on Facebook, twitter



Domestic Users:

satellite operator, aviation office and companies, power plant companies, HF telecommunicators / broadcasters, resource survey, Univ. and research institutes, amateur radio operators

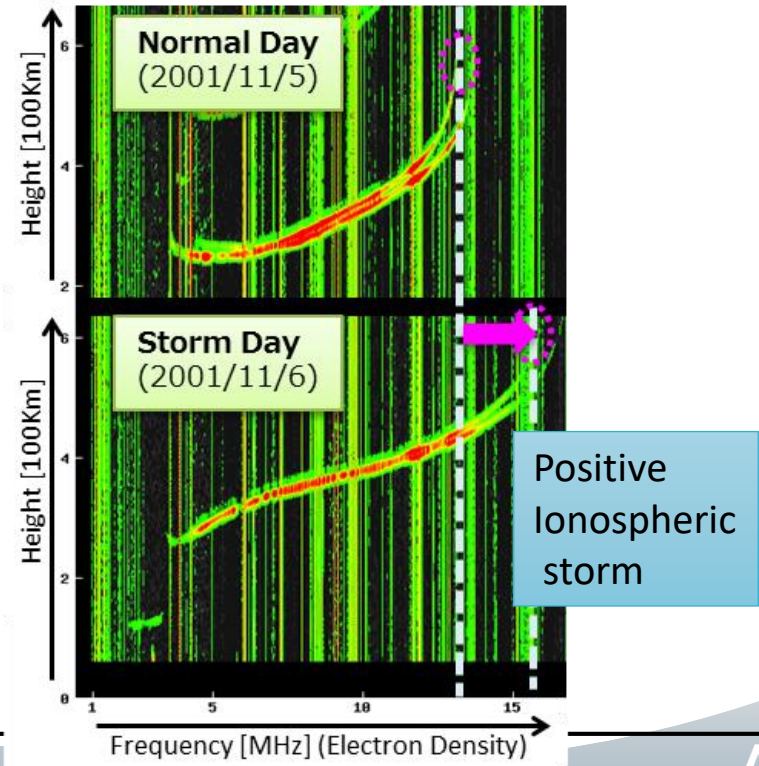
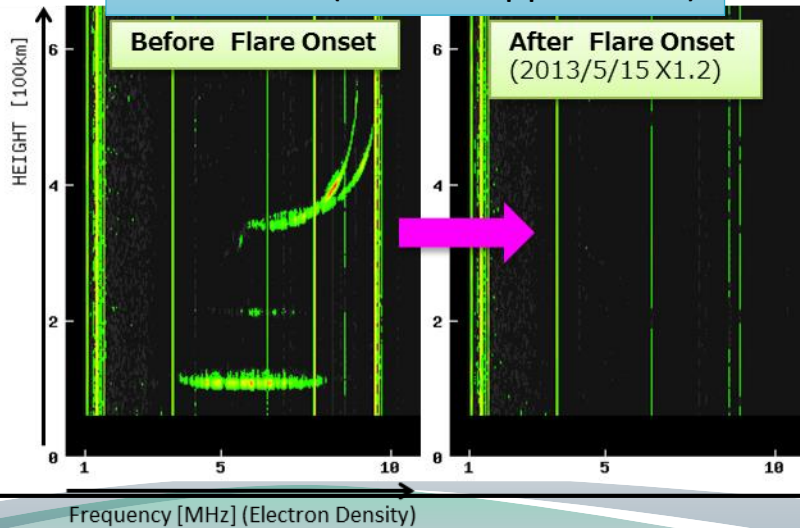
Ionospheric Monitoring by Ionosonde

電離圏観測施設



- Ionospheric sounding from the ground, 4 sites in Japan and 1 in the Antarctica
- First observation in 1937, and regular operation from 1957, normally 15 minutes interval
- Monitoring of Ionospheric storms, Flare effects, and so on.

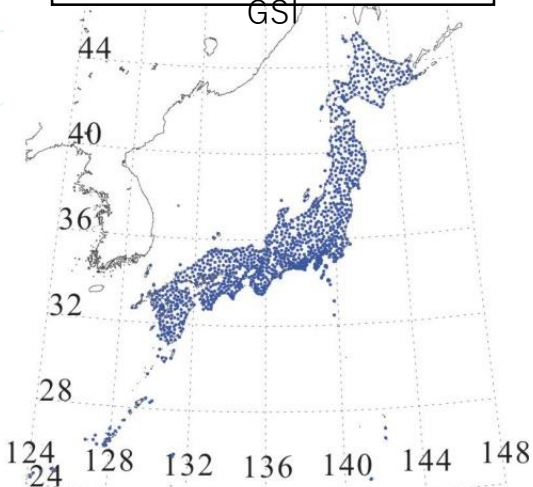
Flare effect (Echo disappearance)



Ionospheric Monitoring by TEC

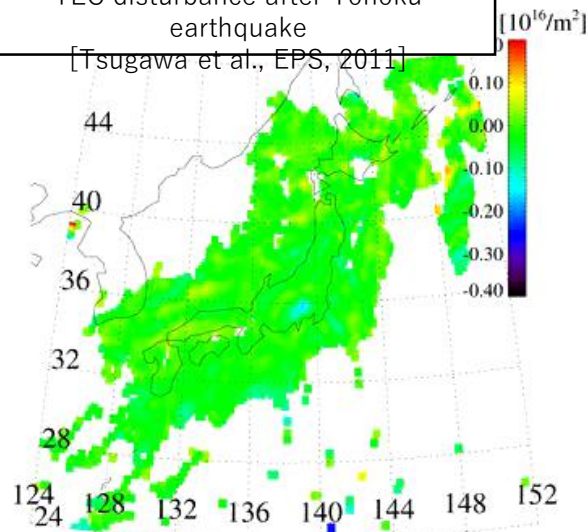
GNSS receiver network
(1,240 points) provided by

GSI



TEC disturbance after Tohoku
earthquake

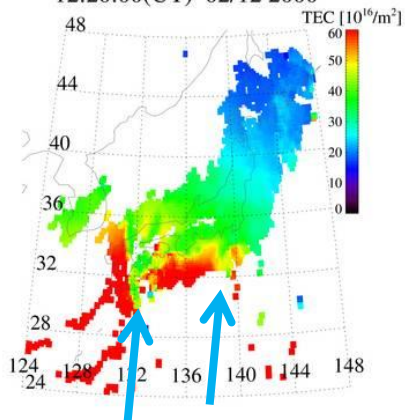
[Tsugawa et al., EPS, 2011]



- Total Electron Content (TEC) map is derived from a dense GNSS receiver network in Japan (GEONET) provided by GSI
- High resolution (30sec, 0.15 by 0.15 deg)
- Monitoring of Ionospheric storms, Traveling Ionospheric disturbances (TIDs), Plasma bubble, and so on.
- Global version -> DRAWING TEC project (see our ICG-12 presentation [Tsugawa et al])

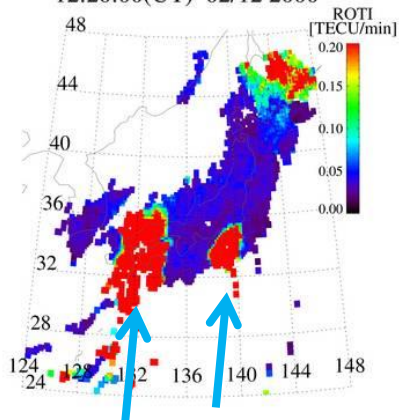
TEC

12:20:00(UT) 02/12 2000



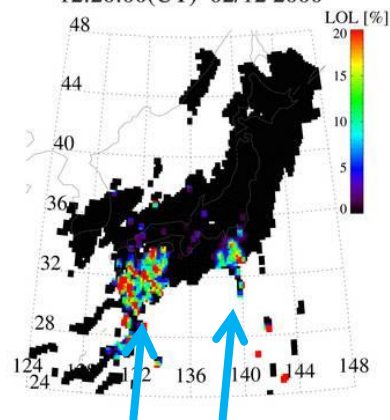
ROTI

12:20:00(UT) 02/12 2000

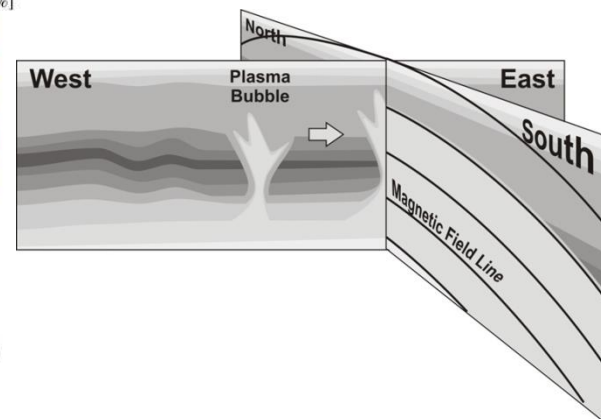


Loss of Lock

12:20:00(UT) 02/12 2000



Plasma bubble observation



```

3.00          GTEX DATA
                                20180525 021508 UTC
16
TEC values in 1016 eI/m2 (1 TEC Unit)
Types of data  = Rd : Raw slant TEC including bias
                  derived from d
                  Ad : Absolute slant TEC
                  derived from d
                  d are combination of carrier
                  phase and pseudorange
ZNI: Satellite zenith angle
AZI: Satellite azimuth angle

Satellite System = G : GPS
                  R : GLONAS
                  E : Galileo
                  S : SBAS
                  J : QZSS
                  C : BeiDou
                  I : IRNSS

OBSERVATION records format is as follow
-Satellite number      A1,I2,2
-m(Observation, TEC status flag) m(F10.4, I1, X1)
  TEC status flag= 0 or blank : Normal data
                  1 : Lack of observables (TEC=99999.9999)
                  2 : Too large TEC (TEC=99999.9999)
                  4 : Cycle slip (TEC discontinuity)
                  5 : Cycle slip (LLI)
                  6 : Beginning of arc
when set ZNI or AZI, TEC status flag is blank.
If ZNI, AZI can not be calculated, set 99999.9999
MTKB1060.18o MTKB1070.18o MTKB1080.18o
MTKB
                                JAVAD Alpha-G3T
                                NOV750.R4  NOVS
-3947739.2646 3364424.9821 3699425.5842
  0.0000      0.0000      0.0000
    
```

Header

```

G  3 RL1CL2WC1CC2W          ZNI          AZI
R  3 RL1CL2CC1CC2C          ZNI          AZI
E  3 RL1XL5XC1XC5X          ZNI          AZI
J  3 RL1CL2XC1CC2X          ZNI          AZI
30.000
2018  4 17  0  0  0.0000000  GPS
2018  4 17 23 59 30.0000000  GPS

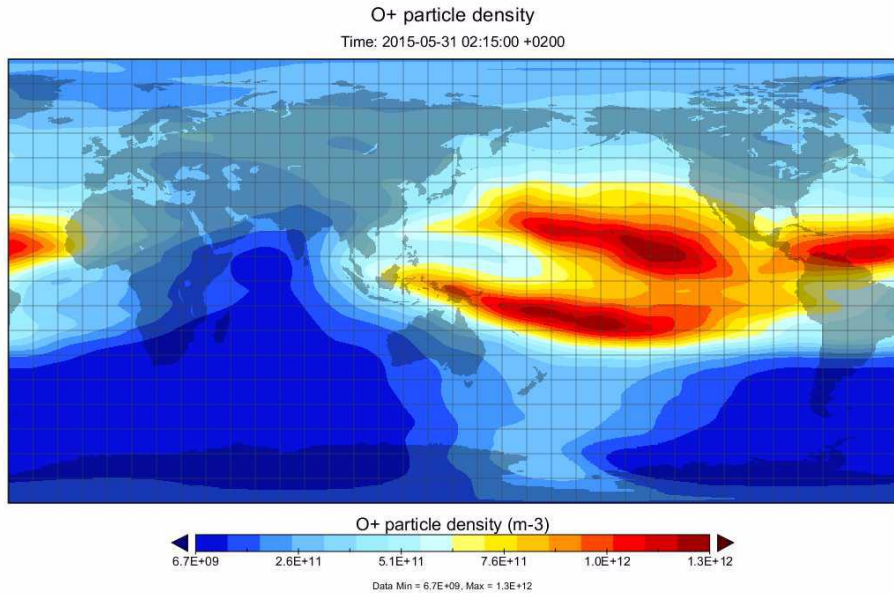
> 2018  4 17  0  0  0.0000000  0 13
G10  21.4241  40.7626  238.3033 ..
G12 -11.7632  34.4779  54.8018 ..
G14  1.5530   64.5740  311.0501 ..
G15  21.6359  78.3918  126.8403 ..
R01  75.1004  49.8949  164.4638 ..
R02  97.7056  19.0021  303.6347 ..
R03  83.8726  71.1253  329.1059 ..
R11  60.6147  59.4903  34.7255 ..
E03  32.4284  38.7892  309.3641 ..
E05  33.5361  20.4626  165.0767 ..
E09  47.5795  71.4971  145.3941 ..
E24 113.5677  37.0608  37.5892 ..
J01  -2.7978  42.1784  197.5812 ..
> 2018  4 17  0  0 30.0000000  0 14
G10  21.4749  40.9104  237.9890 ..
G12 -11.7528  34.6676  54.5400 ..
G14  1.5085   64.3911  311.1354 ..
    
```

Header

TEC data section

- GTEX is a format of slant TEC data
- By sharing slant TEC, various researches would be possible without affected by specific analysis procedures (e.g., bias estimation)
- GTEX v3.0 can treat data from multi-GNSS satellites, and the format similar to RINEX 3

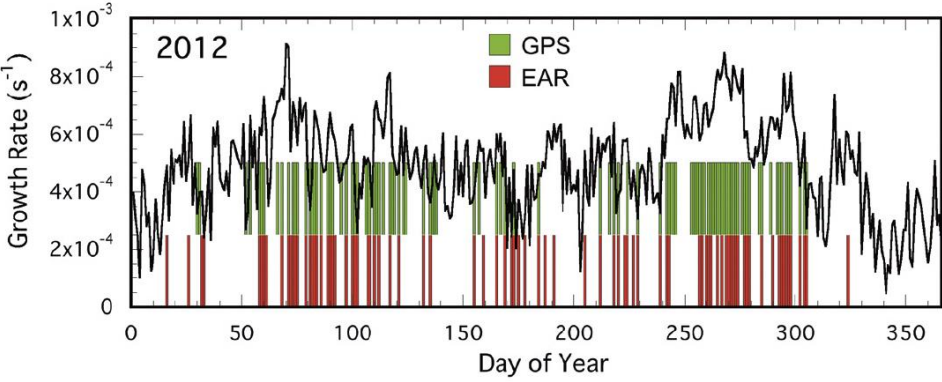
Research for Ionospheric Forecast: Global model of Whole Atmosphere and Ionosphere



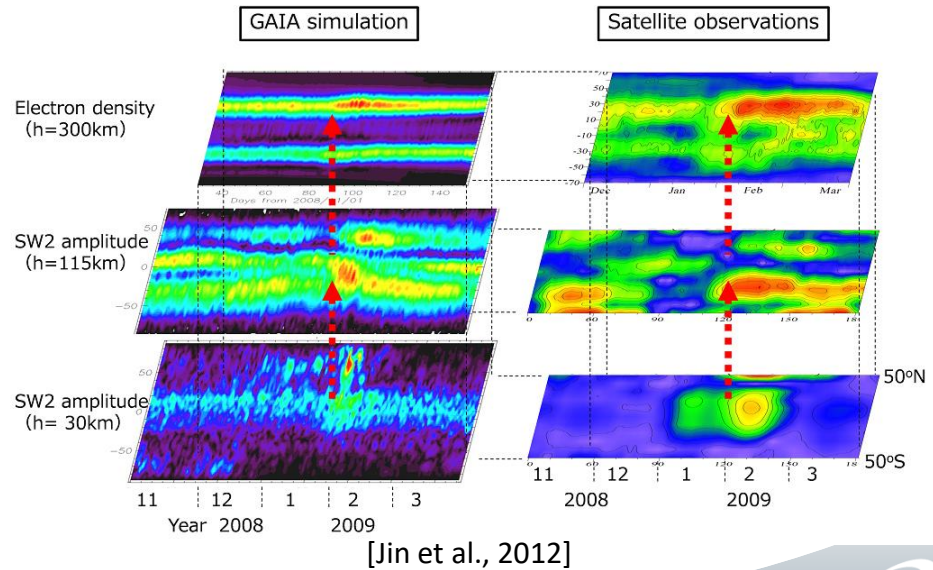
- GAIA is a 3D global model from troposphere to thermosphere and ionosphere
- GAIA reproduces meteorological phenomena, vertical coupling, neutral-plasma interaction, ...
- Meteorological Reanalysis has been assimilated into GAIA. Assimilation of upper atmospheric observations are underway

Effects of Stratospheric sudden warming on Ionosphere

Comparison of plasma bubble occurrence

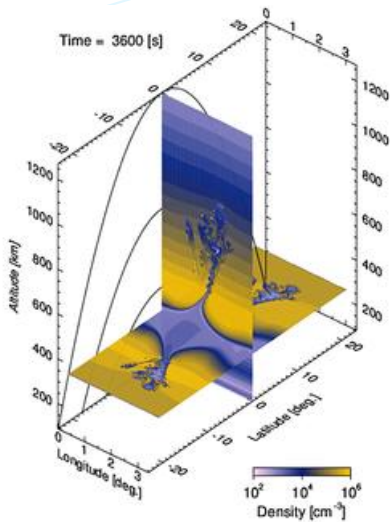


[Shinagawa et al., 2018]

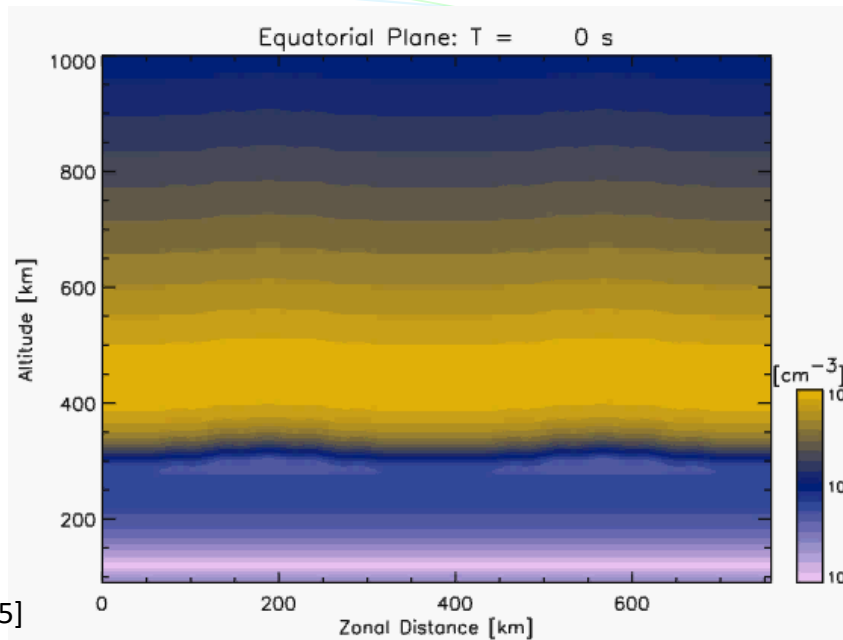


Research for Ionospheric Forecast: Regional model of Equatorial Ionosphere

Simulation of plasma bubbles



[Yokoyama et al., 2014; 2015]



Radar observation of plasma bubble

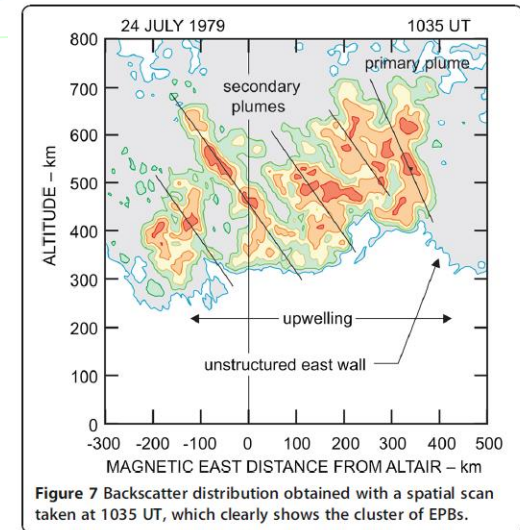


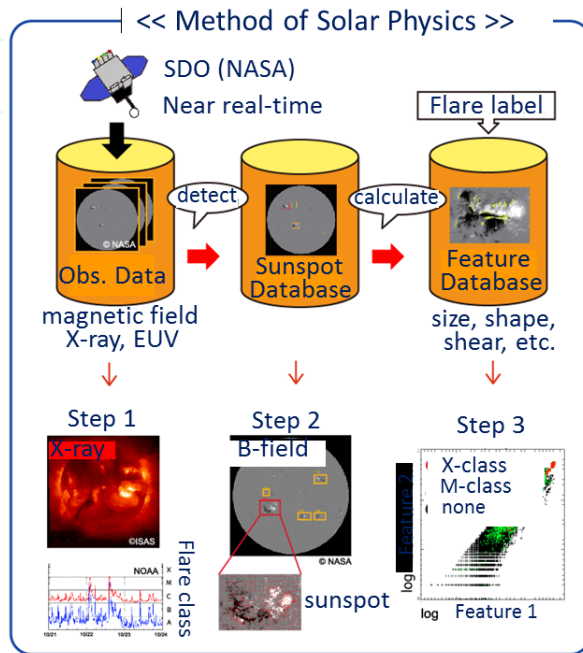
Figure 7 Backscatter distribution obtained with a spatial scan taken at 1035 UT, which clearly shows the cluster of EPBs.

[Tsunoda., 2015]

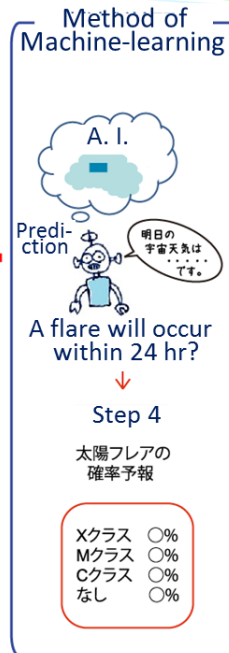
- HIRB is a high-resolution model of equatorial ionosphere, which reproduces detail structures and features of plasma bubbles
- Global-regional model coupling is on-going, and forecast of plasma bubble occurrence and growth will be treated by HIRB

Research for Space Weather Forecast: Prediction using Machine Learning Techniques

Solar Flare Prediction



[Nishizuka et al.]



Accuracy improved
Up to 80 %

Prediction of Ionospheric TEC

Data available on realtime bases

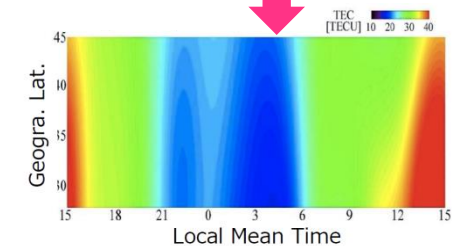
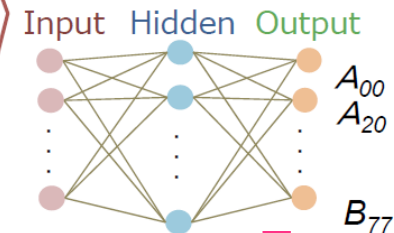
Quiet model

[Sun] F10.7,
SSN, MgII
[Time] DOY
[Iono.]
Previous-day TEC

Disturbed Model

[Iono.] Q-model
output
[SW] IMF-Bt
[Mag.] K-index,
Dst

7000-day data from
1997年 were used

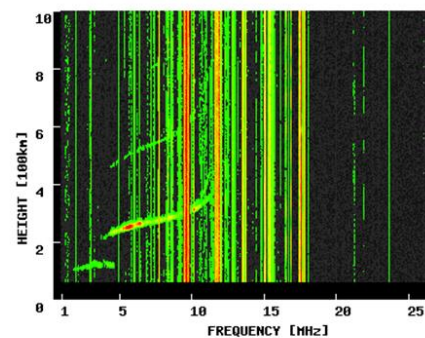
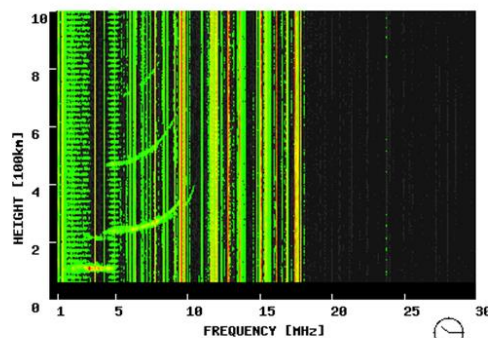
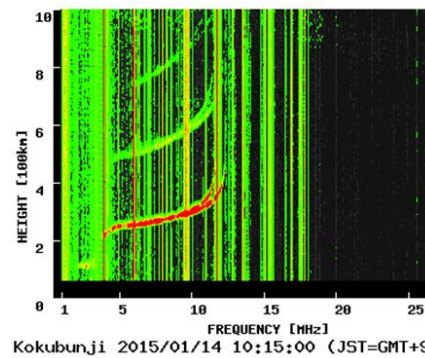
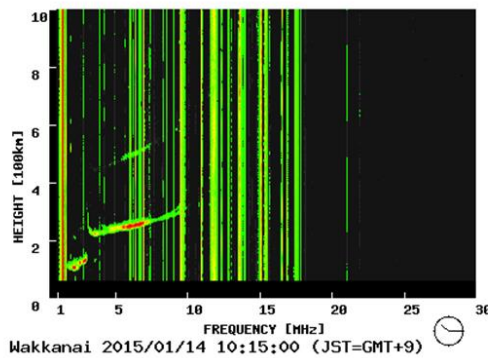


(Based on
Maruyama [2007])

- Solar flare prediction method has been developed using deep learning technique, which gives categorical prediction with occurrence probability at each active region
- The real-time operation using Deep Flare Net (DeFN) will start in FY2018.
- Prediction of 2D TEC map against latitude and LT has been developed using a neural network technique.

Summary

- We are operationally providing space weather nowcast and forecast information as a member of ISES.
- The ionospheric nowcast is based on observations by ionosonde and TEC, which have long history.
- For ionospheric forecast, we are developing physics based models, machine learning models, and data assimilation.



GEONET GPS全電子数マップ (最新24時間、1時間間隔)

Japanese / [English](#)

全電子数(TEC)、TEC変動成分、電離圏電子密度擾乱指数(ROT)データは、国土地理院のGPS受信機網(GEONET)データを利用し、京都大学及び名古屋大学のご意見等は、iono@nirict.go.jpにメールをお願いいたします。

過去の
データ

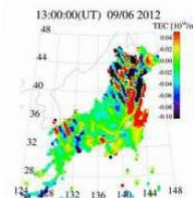
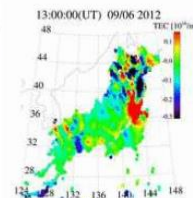
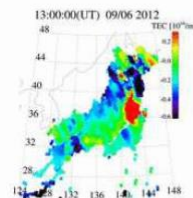
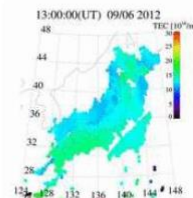
全電子数(TEC)

TEC変動成分
(60分以下)

TEC変動成分
(30分以下)

TEC変動成分
(15分以下)

最新
24時間



日時・時刻

全電子数(TEC)

TEC変動成分
(60分以下)

TEC変動成分
(30分以下)

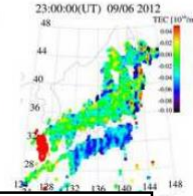
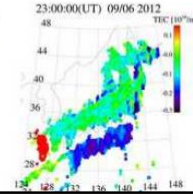
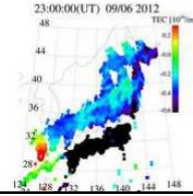
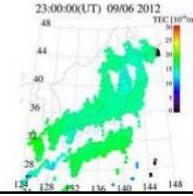
TEC変動成分
(15分以下)

2012/09/06

23:00 UT

2012/09/07

08:00 JST



Observations and other data products available at: <http://wdc.nict.go.jp/IONO/>