MAPÚA UNIVERSITY

DEPARTMENT OF PHYSICS

Effects of major solar flares on ionospheric plasma density over the Southeast Asian Region using GNSS

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Space weather

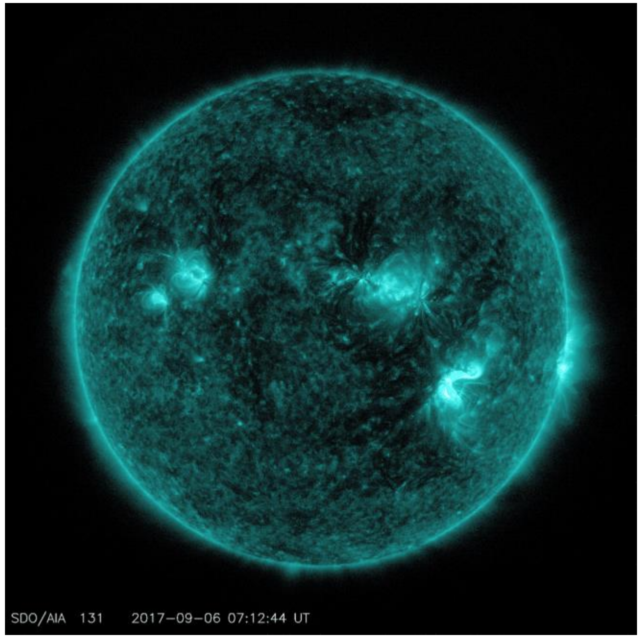
- Concerned with varying conditions in the environment between the Sun and Earth

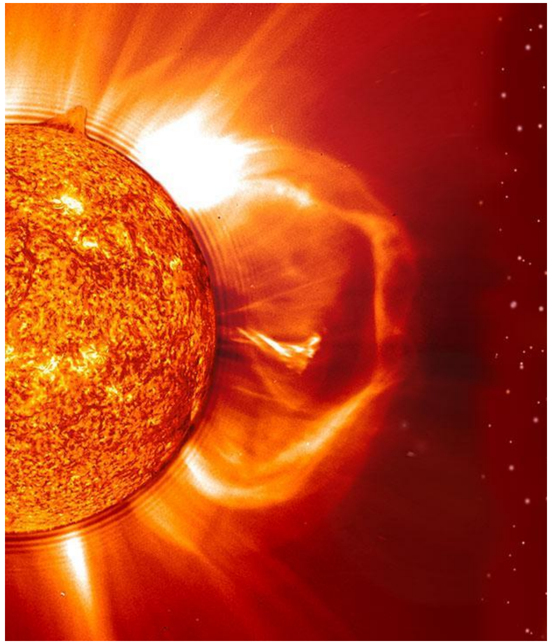
Solar flares

- Electromagnetic (EM) Waves

➔ X-ray
➔ EUV

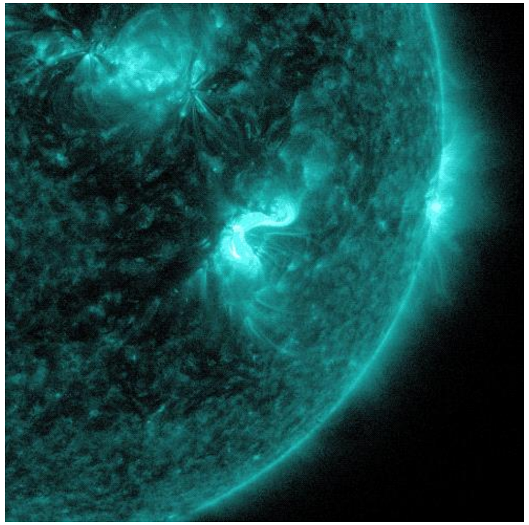
➔ Ionization of atmosphere





(Earth)

Classification	Peak flux range at 1–8 Ångstrom (W/m^2)
A	$< 10^{-7}$
B	$10^{-7} - 10^{-6}$
C	$10^{-6} - 10^{-5}$
M	$10^{-5} - 10^{-4}$
X	$> 10^{-4}$



(Investigated) Solar flares

	SC	Start (UT)	Max (UT)	End (UT)	Max (LT)	Region	Class
9 Aug 2011	24	07:48	08:05	08:24	16:05	1263	X6.9
20 Apr 2022	25	03:41	03:57	04:04	11:57	2992	X2.25
21 Apr 2022	25	01:47	01:59	02:05	09:59	2993	M9.7

Objective

- To analyze the ionospheric effects generated by strong SFs on 9 August 2011, 20-21 April 2022

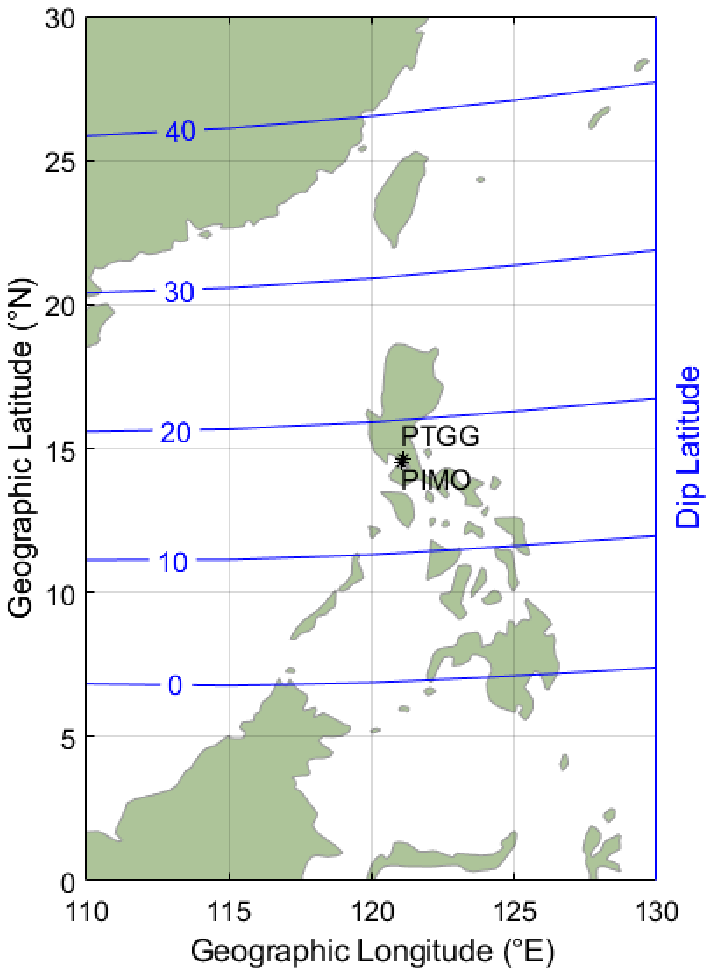
GNSS stations (low-latitude regions)

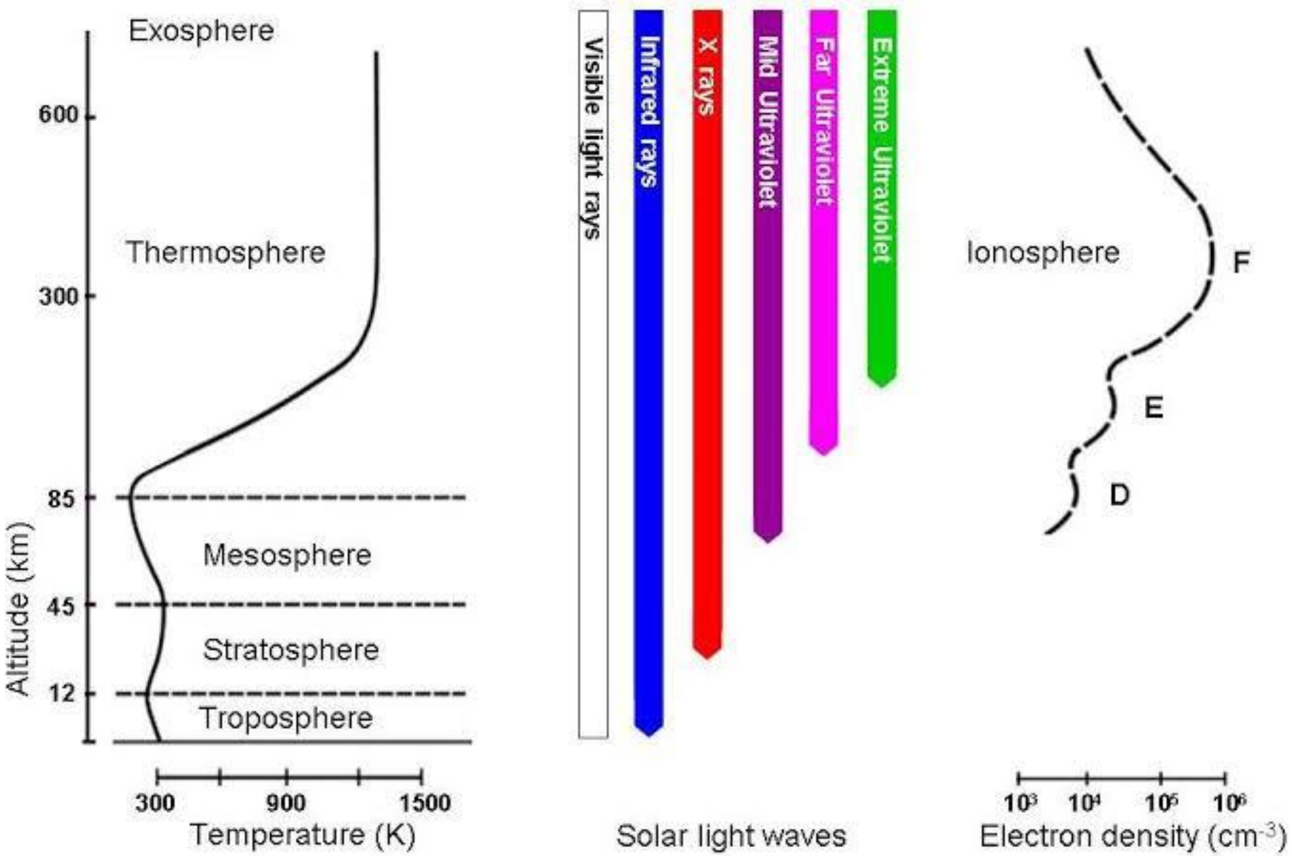
9 August 2011

PIMO: 14.63571966°N, 121.07773220°E (Quezon city)

20-21 April 2022

PTGG: 14.5354022°N, 121.04126541°E (Taguig city)





Absorption of increased solar X-ray and EUV

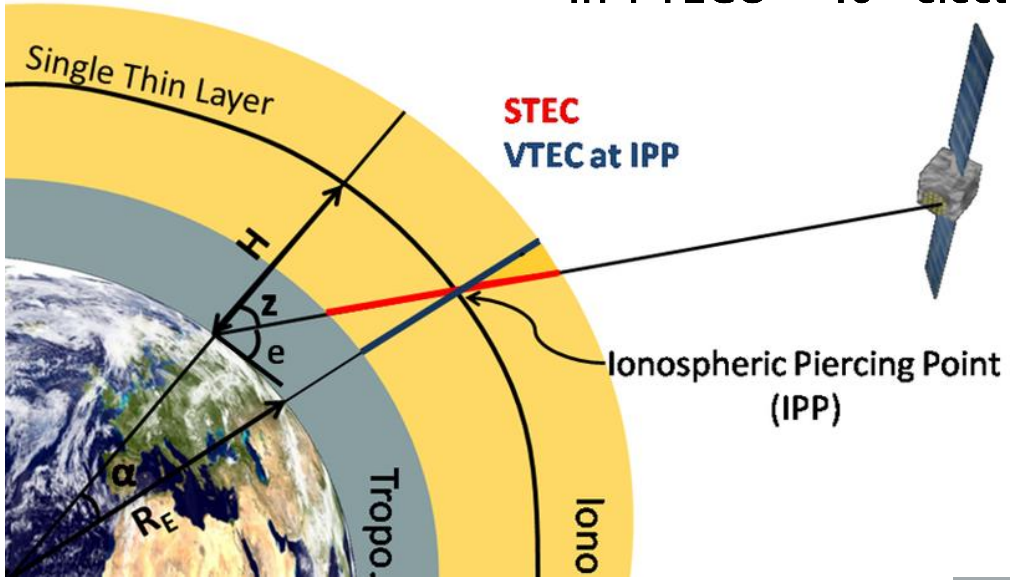
↓

Increased ionization in D & E ionospheric regions

↓

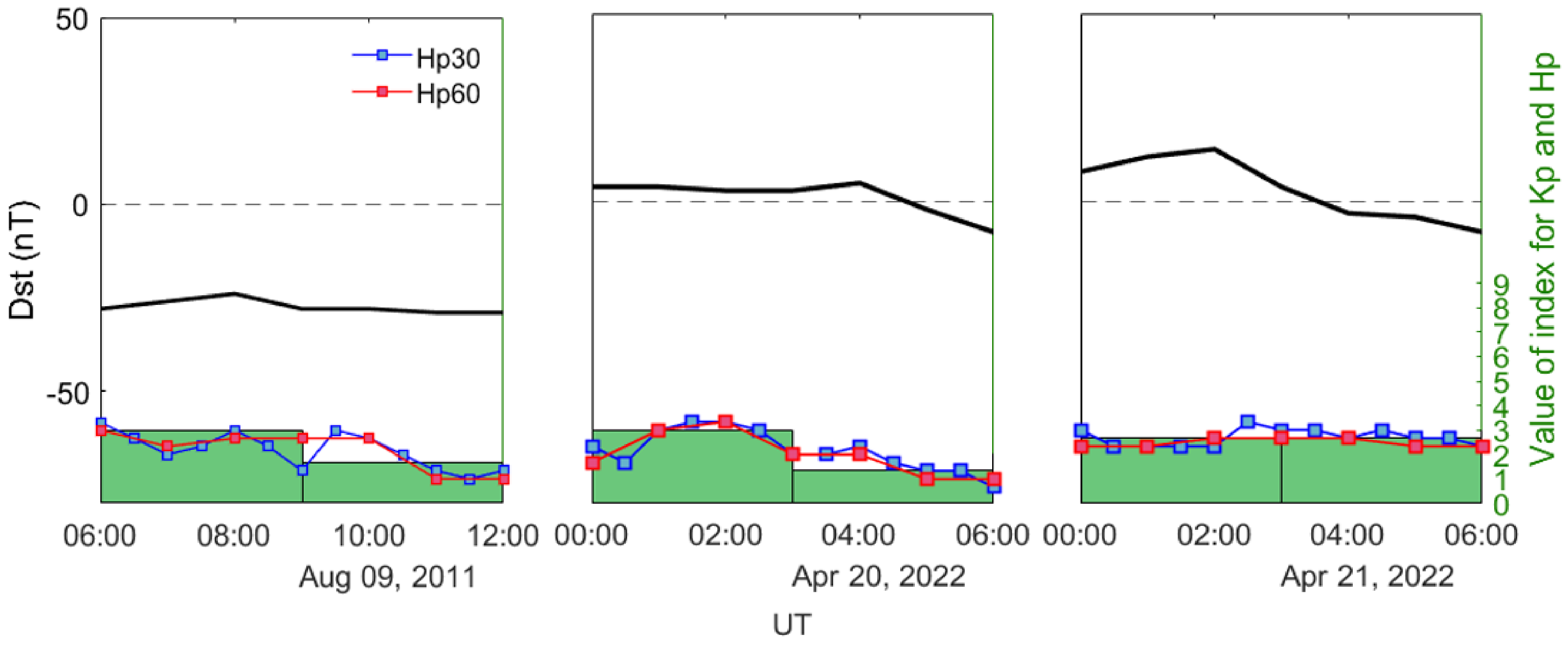
Electron density changes

Total electron content (TEC) in 1 TECU = 10^{16} electrons/m^2

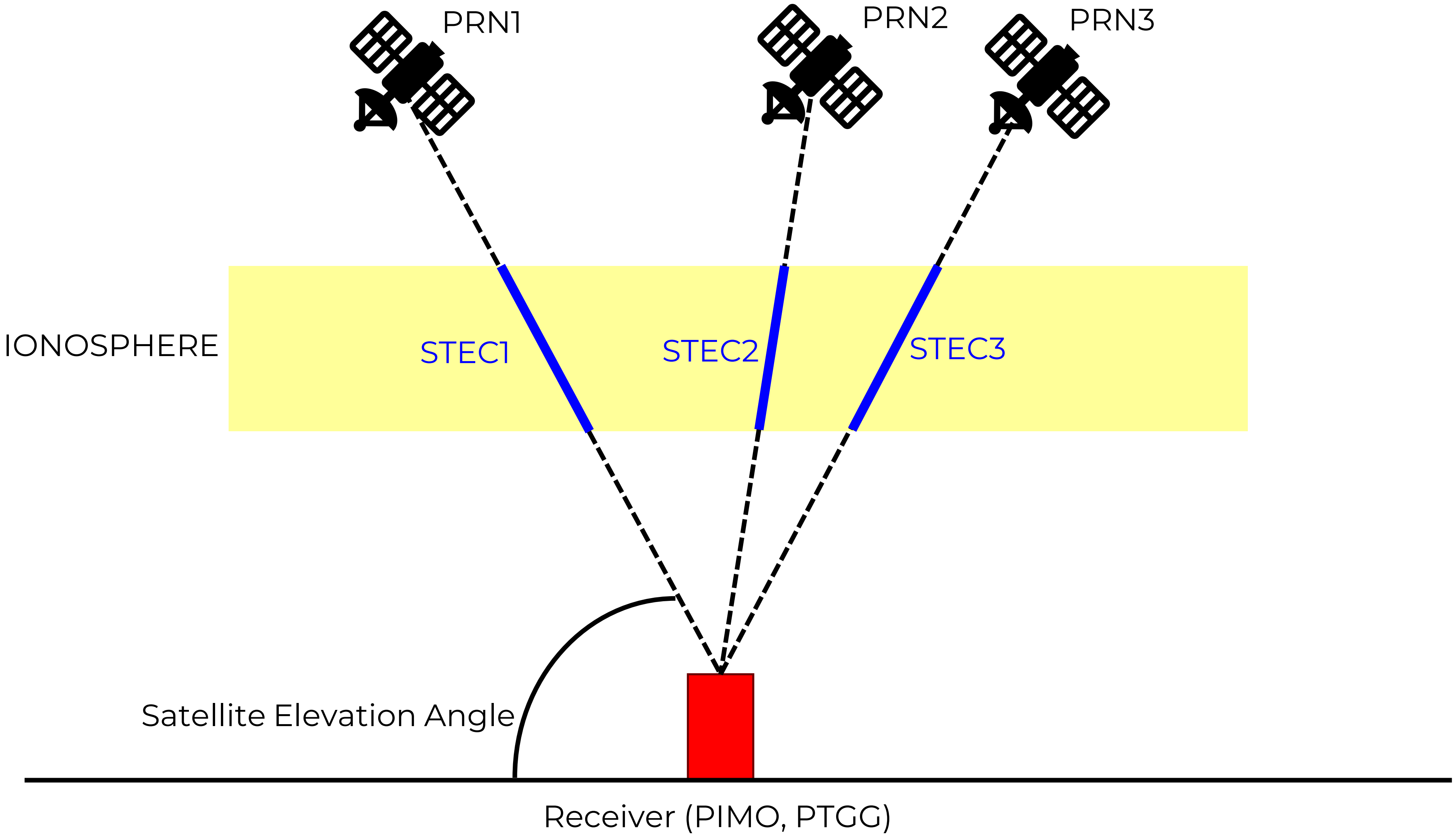


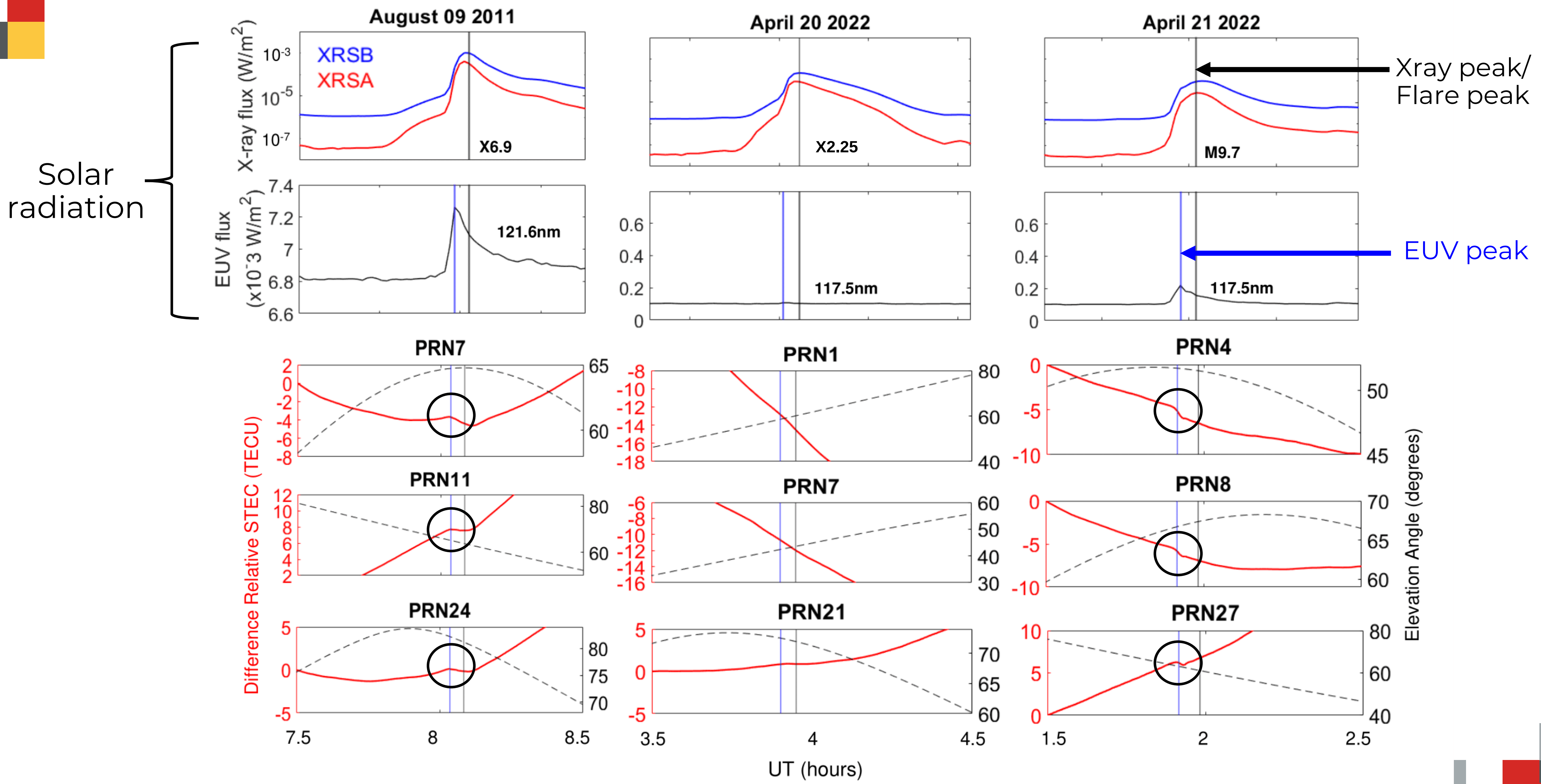
GNSS satellites orbit around 22,000km

Geomagnetic Conditions

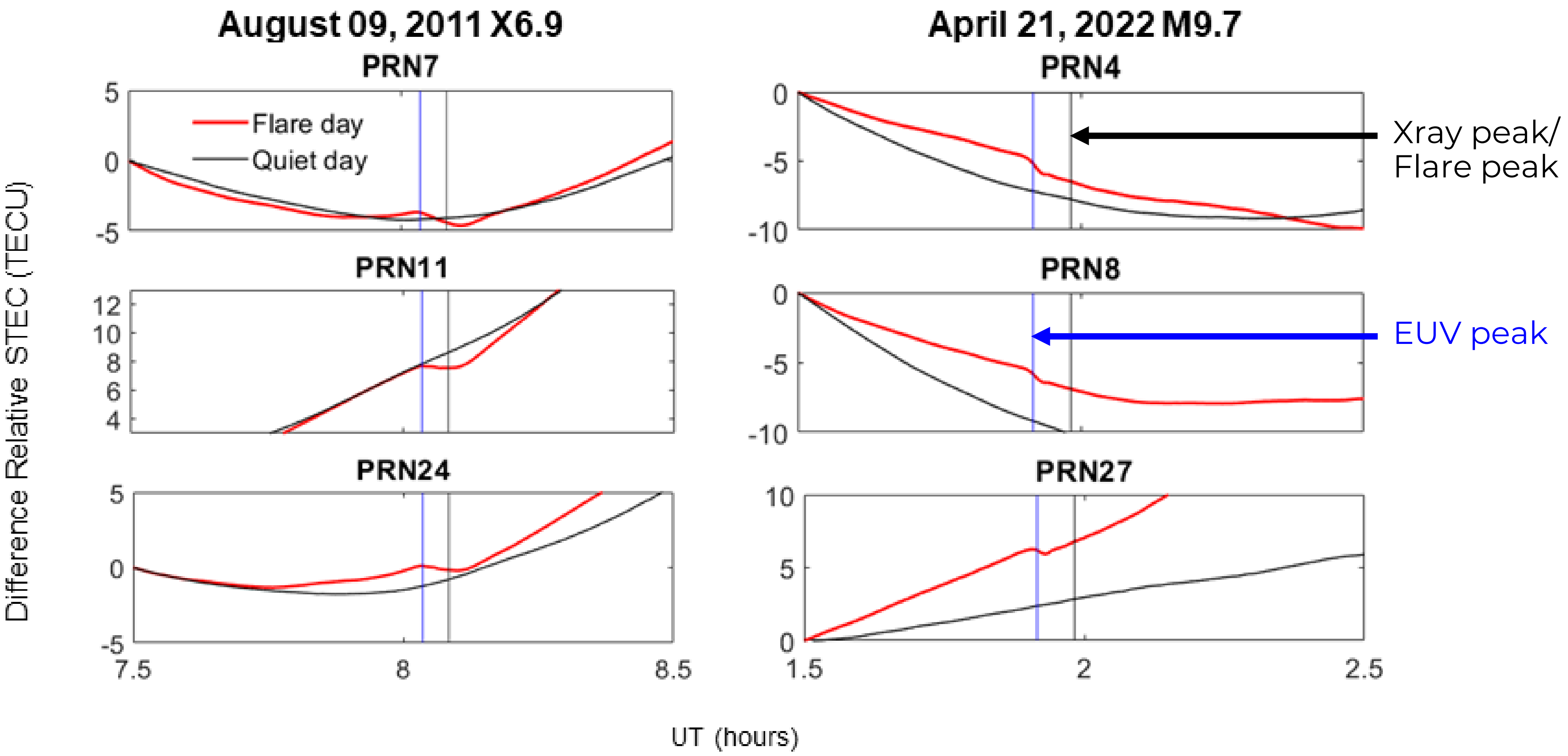


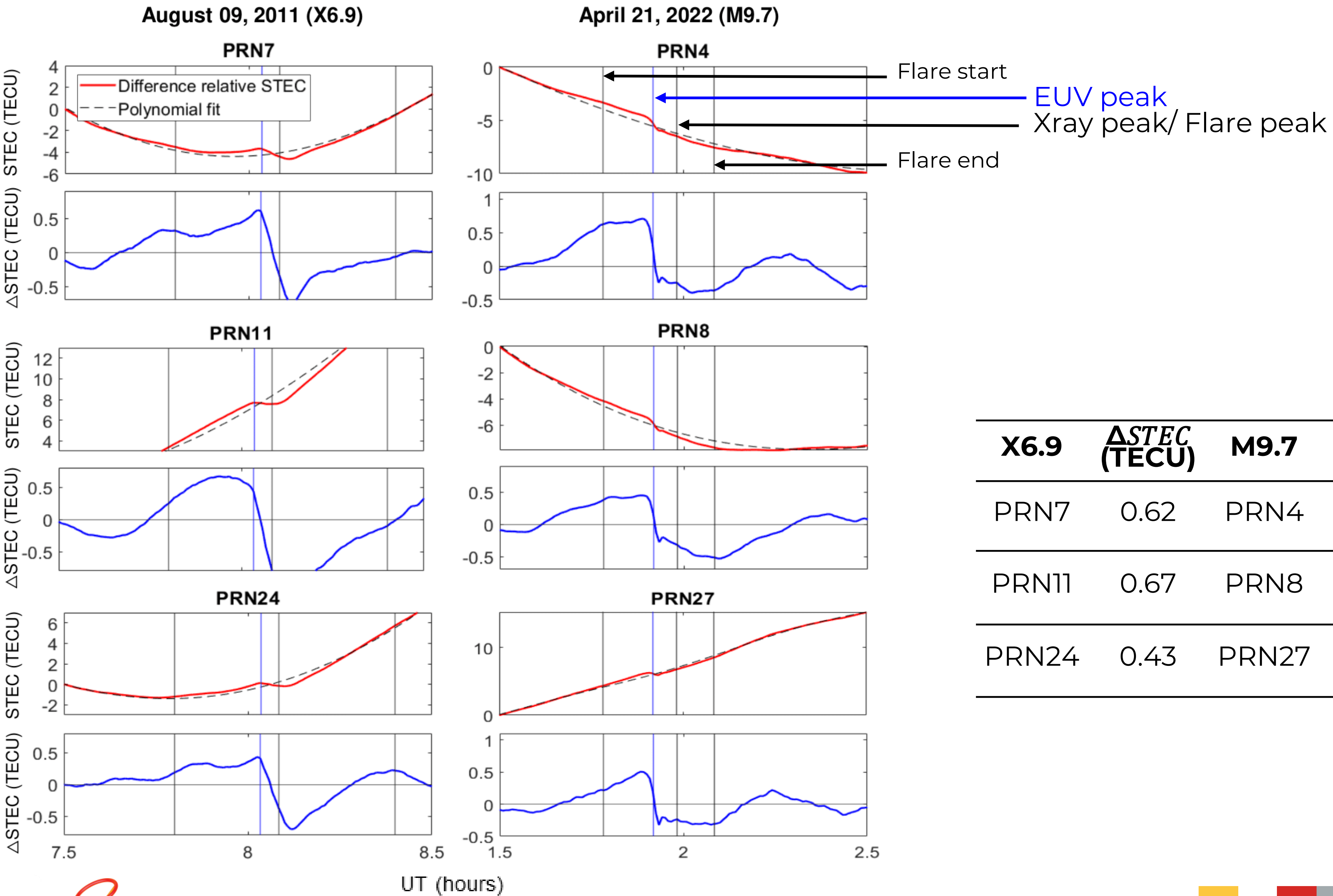
The global geomagnetic field is quiet (no large-scale disturbance)


PRN1
PRN2
PRN3
IONOSPHERE
STEC1
STEC2
STEC3
Satellite Elevation Angle
Receiver (PIMO, PTGG)


Solar radiation
August 09 2011
April 20 2022
April 21 2022
X-ray flux (W/m^2)
XRSB
XRSA
X6.9
X2.25
M9.7
Xray peak/ Flare peak
EUV flux (x10^-3 W/m^2)
121.6nm
117.5nm
117.5nm
EUV peak
PRN7
PRN1
PRN4
PRN11
PRN7
PRN8
PRN24
PRN21
PRN27
Difference Relative STEC (TECU)
Elevation Angle (degrees)
UT (hours)

For flares with visible changes





X6.9	ΔSTEC (TECU)	M9.7	ΔSTEC (TECU)
PRN7	0.62	PRN4	0.71
PRN11	0.67	PRN8	0.45
PRN24	0.43	PRN27	0.50

Summary & Conclusions

- Solar radiation (Xray, EUV) are observed.
- Using two GNSS stations, STEC increases are found to be coincident with EUV enhancements because the TEC is mostly from the E & F regions, through which the EUV penetrates.
- Conversely, the ionization of the D region due to solar flares (Xray radiation) is insignificant compared to that of the E & F.

The EUV portion of the spectrum is dominantly responsible for the ionization in the E & F regions, which was reflected in more TEC increases for an X17.2 than for an X28.

Tsurutani BT, Judge DL, Guarnieri FL, et al (2005)

- **Strong solar flares don’t necessarily produce the largest TEC enhancements.**

Recommendations

- Include other parameters: solar zenith angle, ionospheric pierce points
- Additional stations

Acknowledgement

We would like to acknowledge the following:

- Geostationary Operational Environmental Satellite
  - X-ray & EUV flux data
- GFZ-Potsdam, NASA/GSFC & Kyoto University
  - global geomagnetic data
- NASA Crustal Dynamics Data Information System
  - TEC calculations