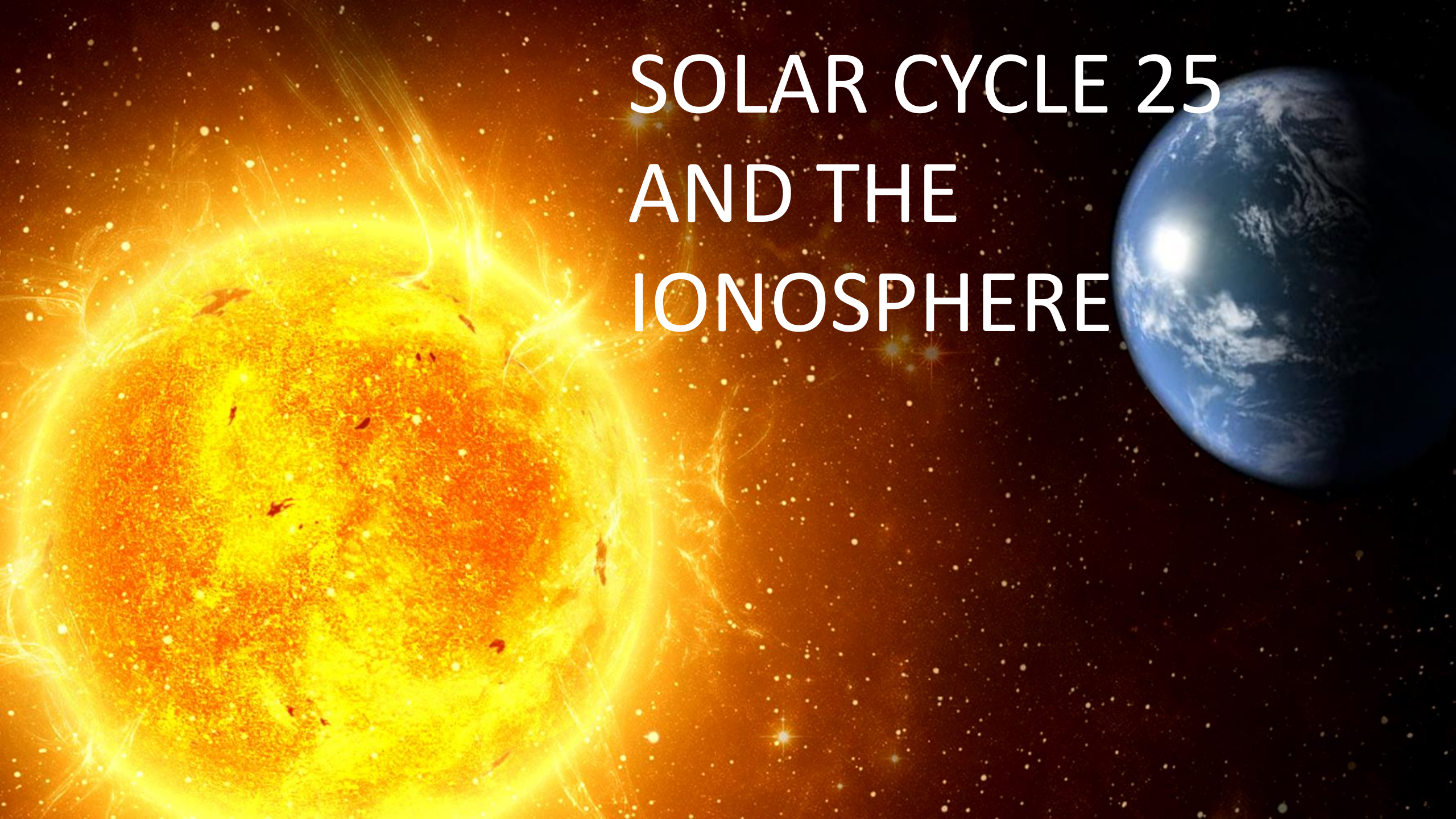
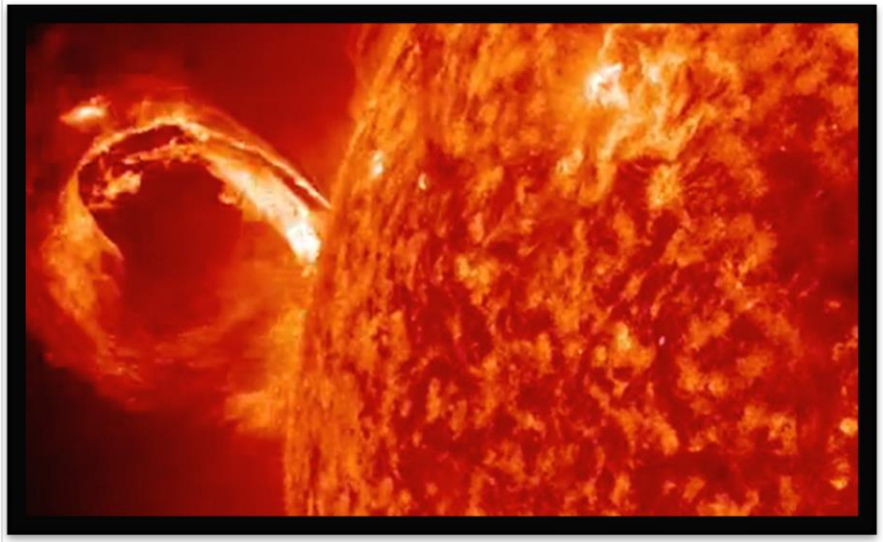
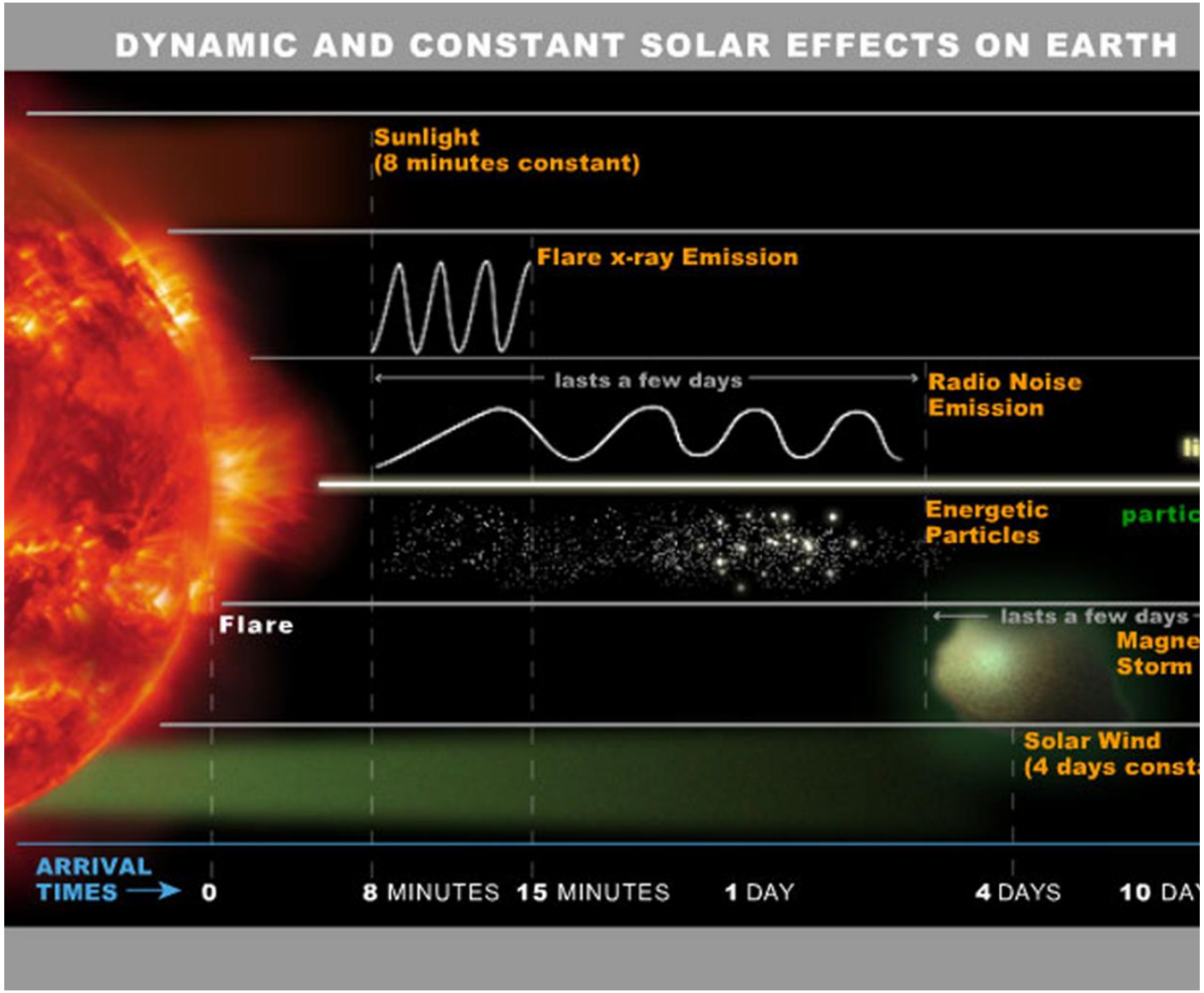
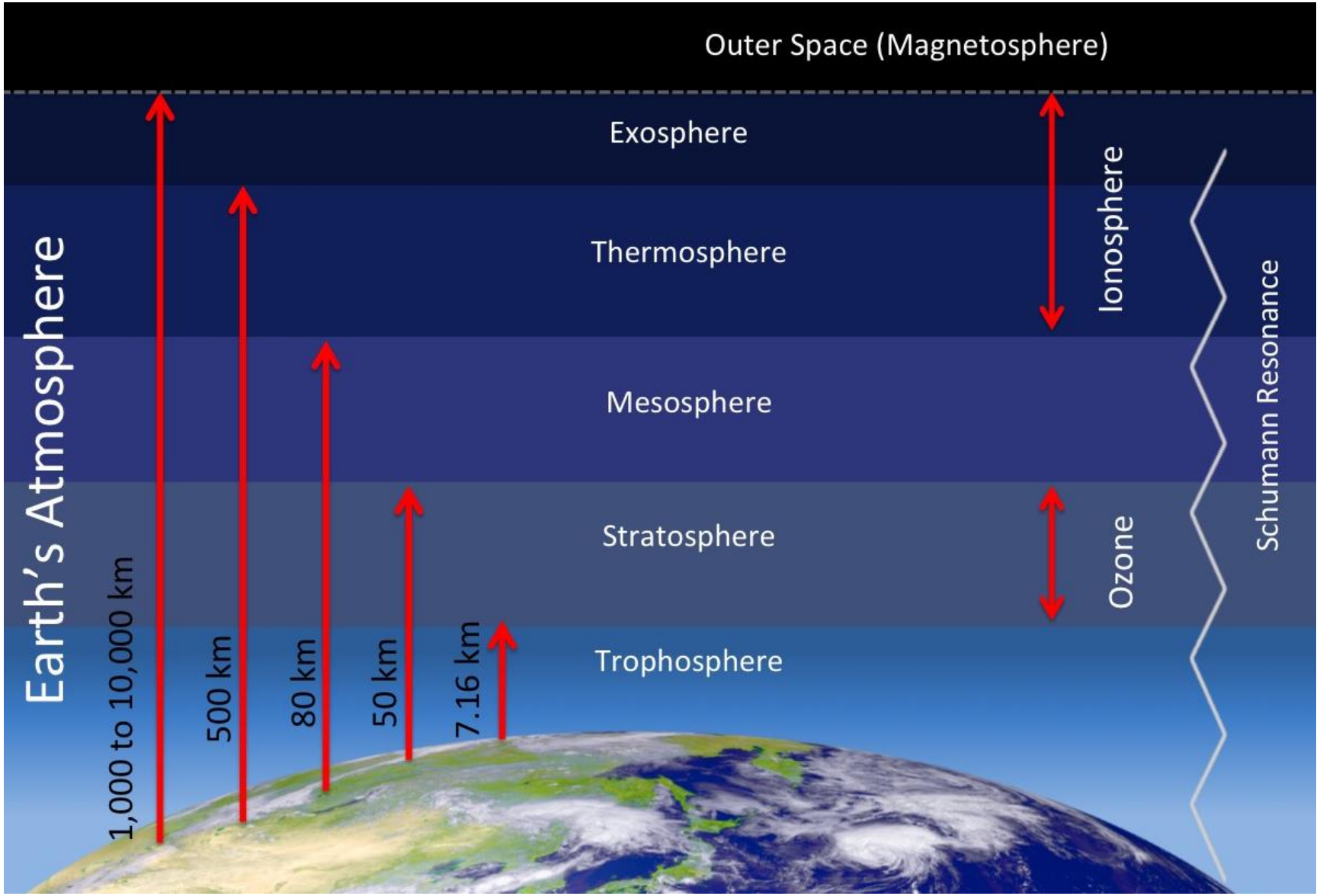
SOLAR CYCLE 25 AND THE IONOSPHERE

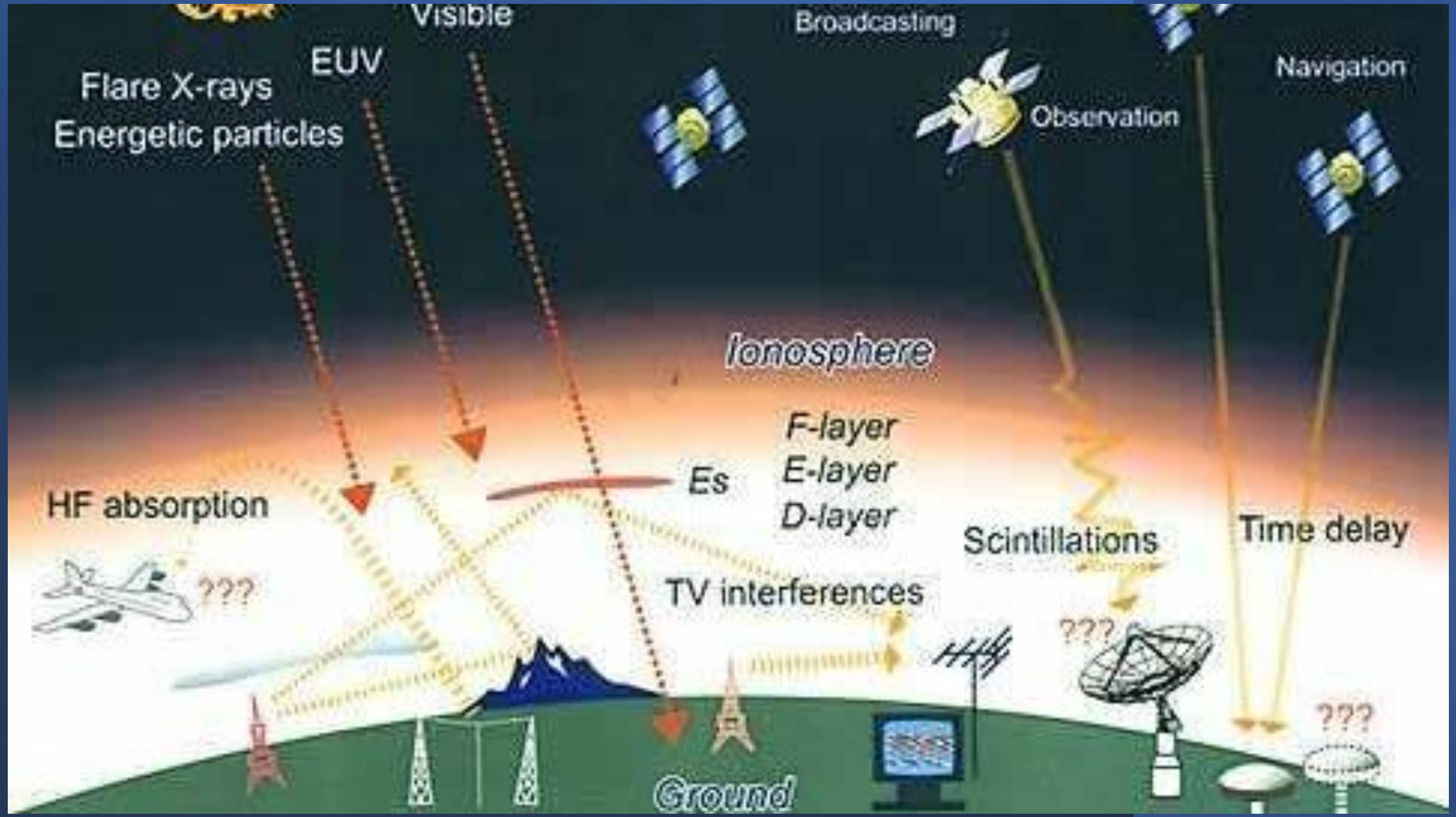


Solar Effects and CME's Impact the Ionosphere

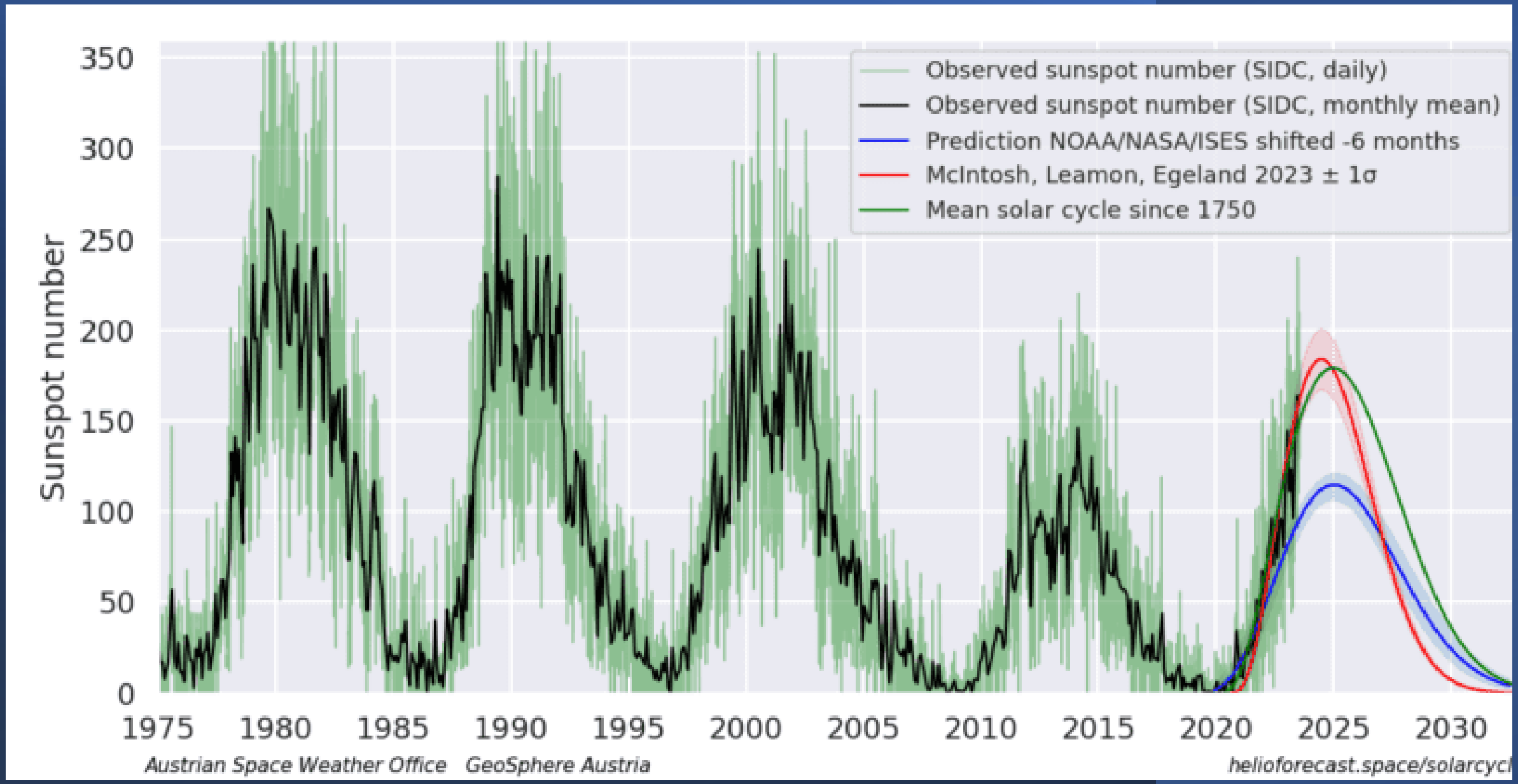




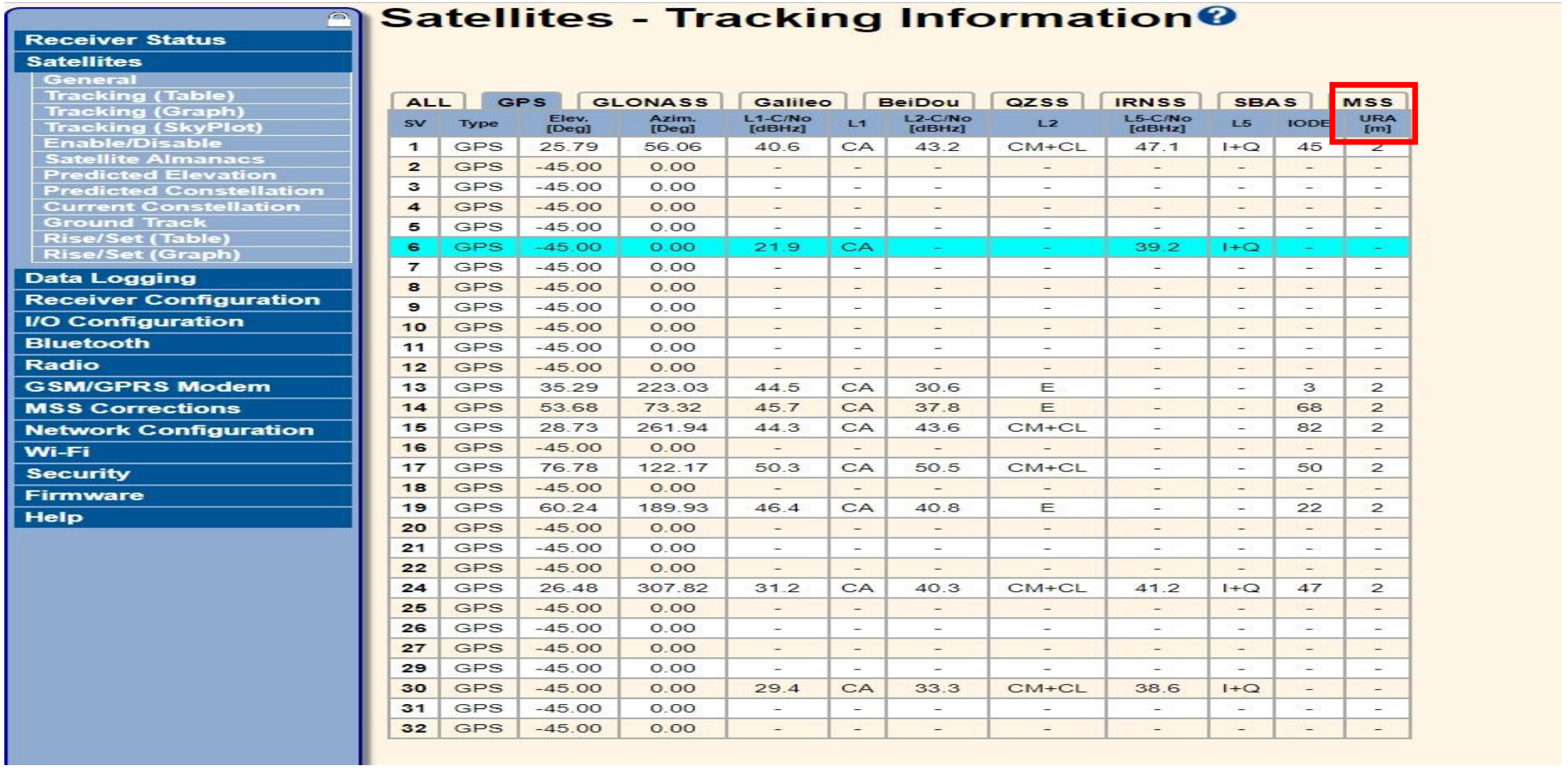

Outer Space (Magnetosphere)
Exosphere
Thermosphere
Mesosphere
Stratosphere
Trophosphere
Earth's Atmosphere
1,000 to 10,000 km
500 km
80 km
50 km
7.16 km
Ionosphere
Ozone
Schumann Resonance


Visible
Broadcasting
EUV
Navigation
Flare X-rays
Energetic particles
Observation
Ionosphere
F-layer
E-layer
D-layer
Es
HF absorption
???
Scintillations
Time delay
TV interferences
???
???
Ground

What are *ionospheric disturbances* and how do they affect GNSS?


Observed sunspot number (SIDC, daily)
Observed sunspot number (SIDC, monthly mean)
Prediction NOAA/NASA/ISES shifted -6 months
McIntosh, Leamon, Egeland 2023 ± 1σ
Mean solar cycle since 1750
Sunspot number
350
300
250
200
150
100
50
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
Austrian Space Weather Office
GeoSphere Austria
helioforecast.space/solarcycl

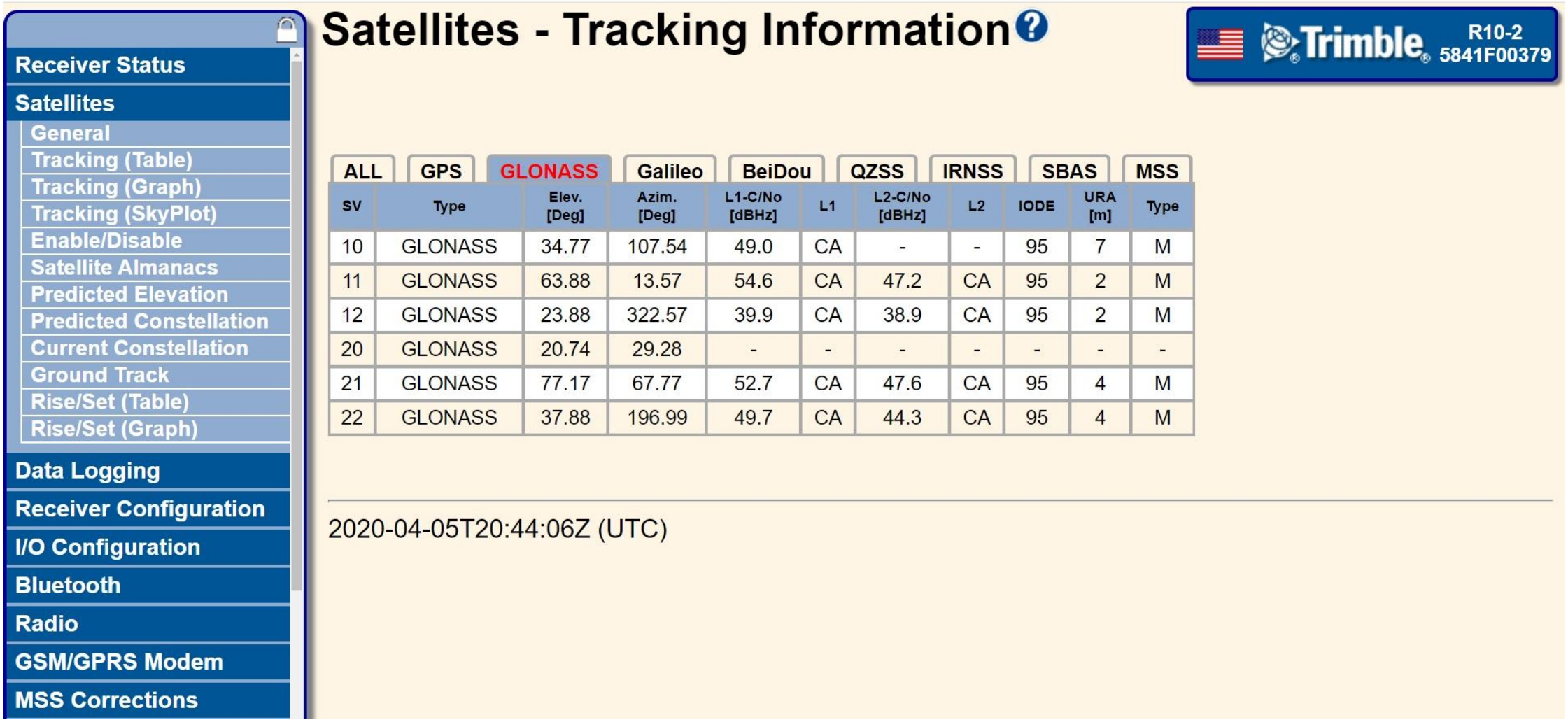
Receiver WebUI GPS Tracking



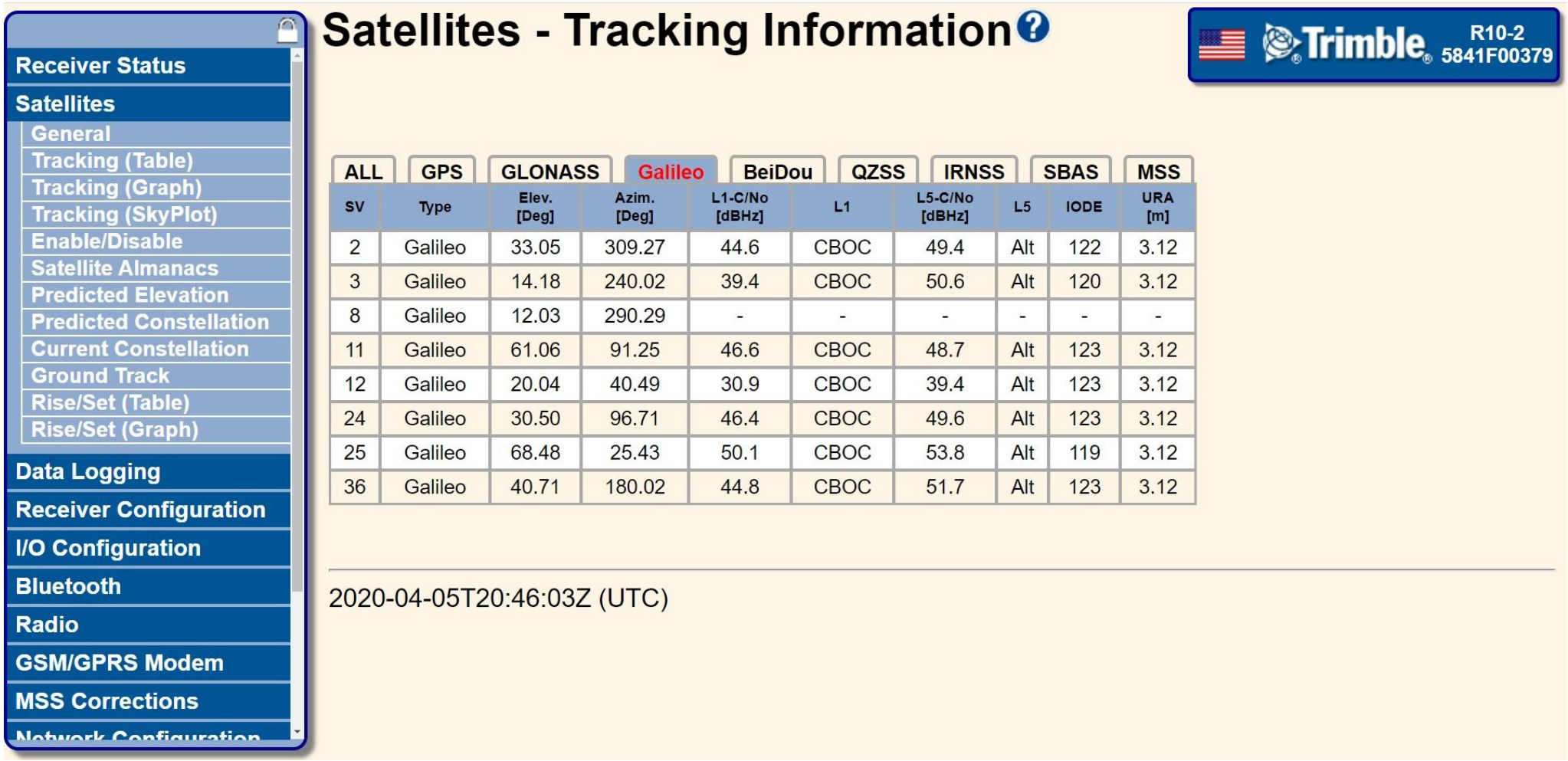
SV	Type	Elev. [Deg]	Azim. [Deg]	L1-C/No [dBHz]	L1	L2-C/No [dBHz]	L2	L5-C/No [dBHz]	L5	IODE	URA [m]
1	GPS	25.79	56.06	40.6	CA	43.2	CM+CL	47.1	I+Q	45	2
2	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
3	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
4	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
5	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
6	GPS	-45.00	0.00	21.9	CA	-	-	39.2	I+Q	-	-
7	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
8	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
9	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
10	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
11	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
12	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
13	GPS	35.29	223.03	44.5	CA	30.6	E	-	-	3	2
14	GPS	53.68	73.32	45.7	CA	37.8	E	-	-	68	2
15	GPS	28.73	261.94	44.3	CA	43.6	CM+CL	-	-	82	2
16	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
17	GPS	76.78	122.17	50.3	CA	50.5	CM+CL	-	-	50	2
18	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
19	GPS	60.24	189.93	46.4	CA	40.8	E	-	-	22	2
20	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
21	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
22	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
24	GPS	26.48	307.82	31.2	CA	40.3	CM+CL	41.2	I+Q	47	2
25	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
26	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
27	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
29	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
30	GPS	-45.00	0.00	29.4	CA	33.3	CM+CL	38.6	I+Q	-	-
31	GPS	-45.00	0.00	-	-	-	-	-	-	-	-
32	GPS	-45.00	0.00	-	-	-	-	-	-	-	-

FRONTIER PRECISION

Receiver WebUI GLONASS Tracking



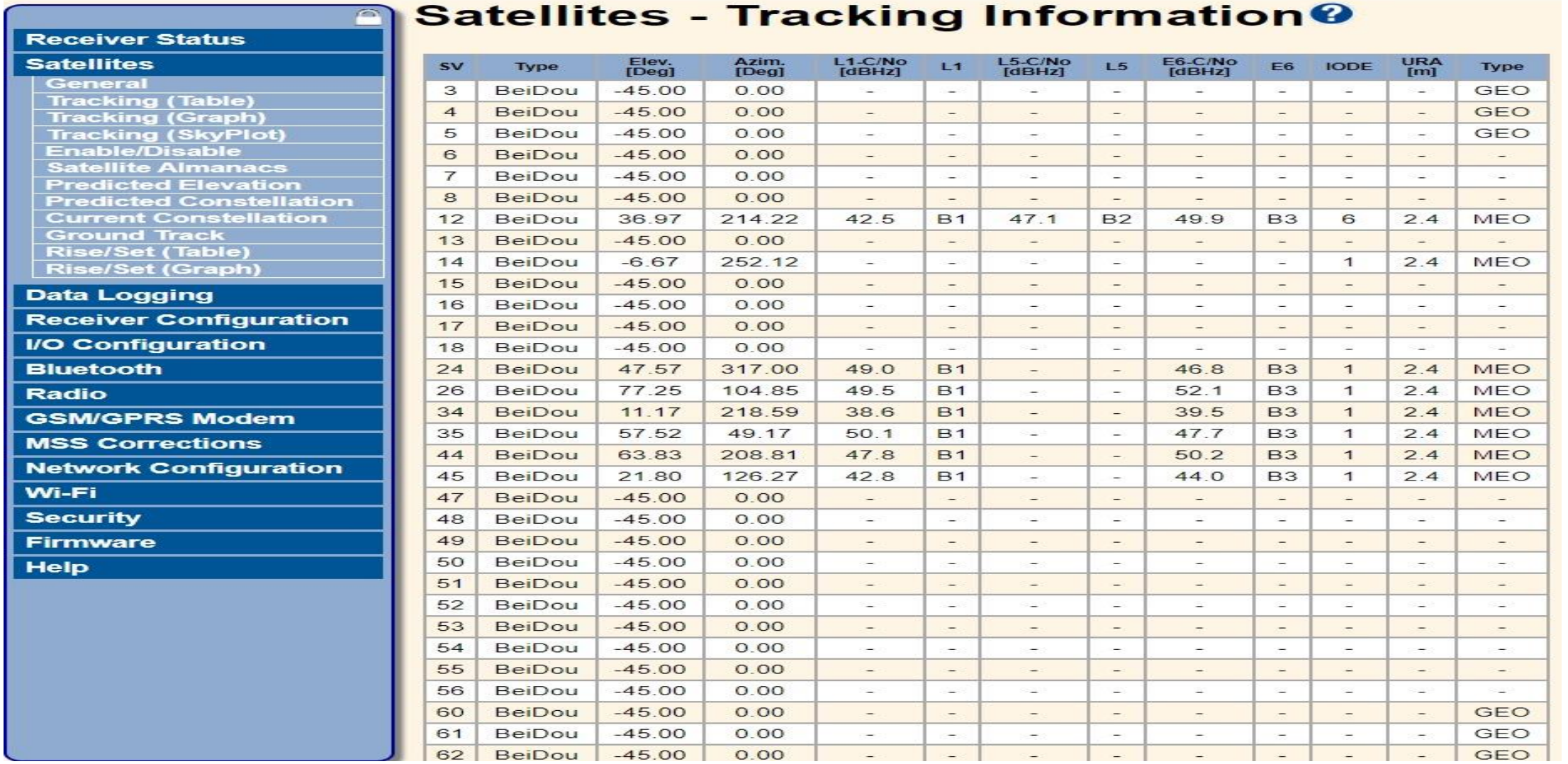
SV	Type	Elev. [Deg]	Azim. [Deg]	L1-C/No [dBHz]	L1	L2-C/No [dBHz]	L2	IODE	URA [m]	Type
10	GLONASS	34.77	107.54	49.0	CA	-	-	95	7	M
11	GLONASS	63.88	13.57	54.6	CA	47.2	CA	95	2	M
12	GLONASS	23.88	322.57	39.9	CA	38.9	CA	95	2	M
20	GLONASS	20.74	29.28	-	-	-	-	-	-	-
21	GLONASS	77.17	67.77	52.7	CA	47.6	CA	95	4	M
22	GLONASS	37.88	196.99	49.7	CA	44.3	CA	95	4	M



Galileo Satellite Tracking in R10-2 WebUI

FRONTIER PRECISION

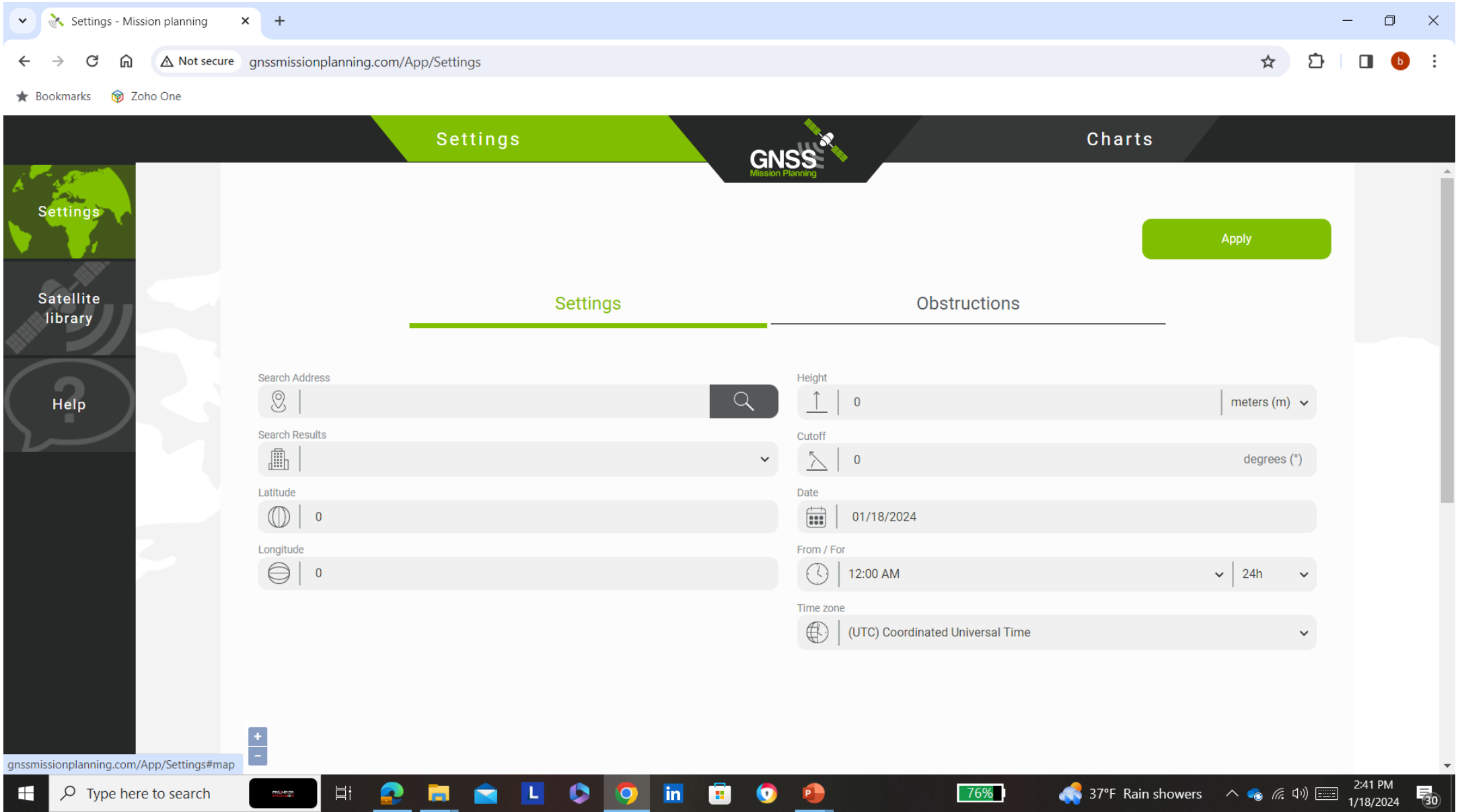
Receiver WebUI BeiDou Tracking



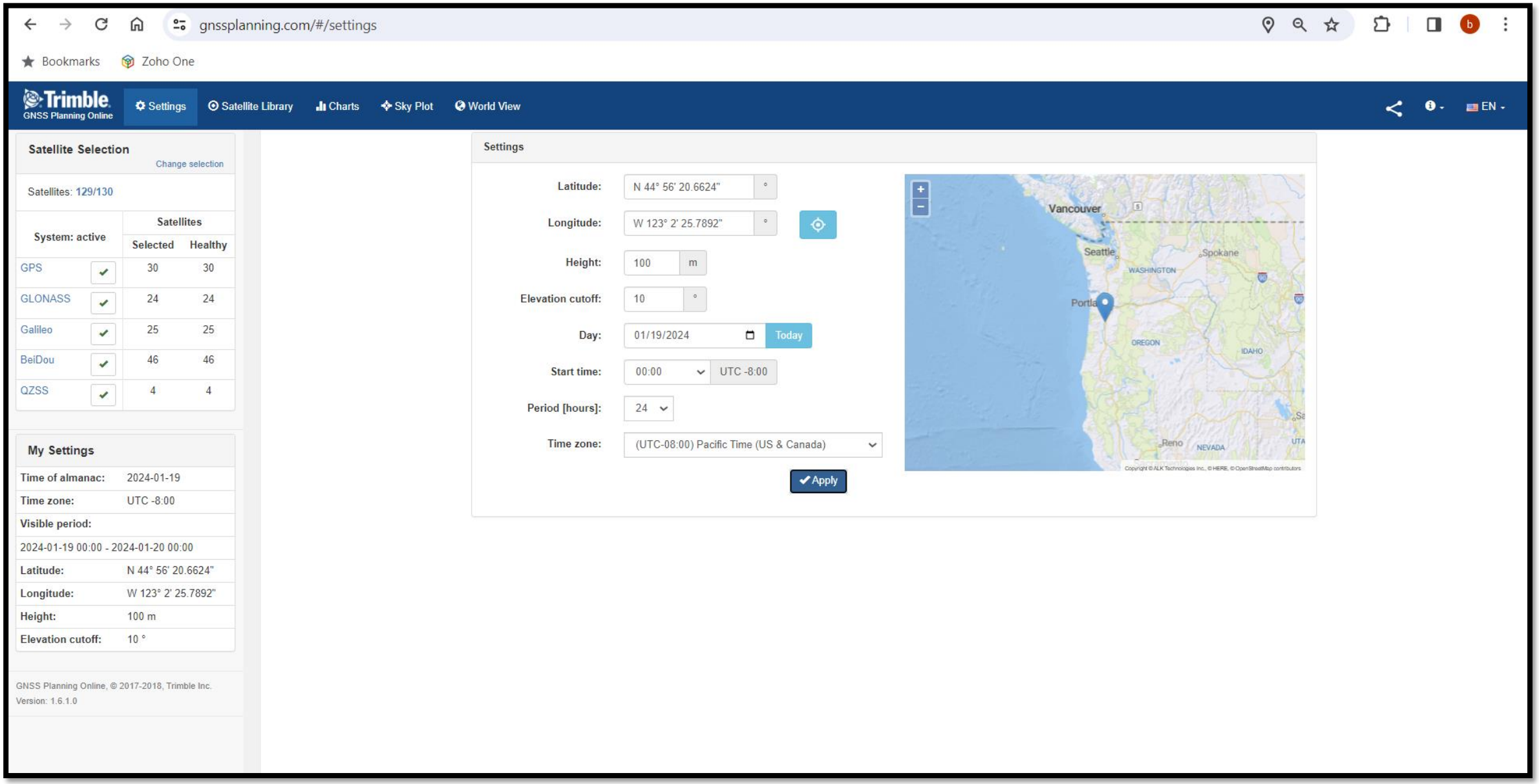
Satellites - Tracking Information

SV	Type	Elev. [Deg]	Azim. [Deg]	L1-C/No [dBHz]	L1	L5-C/No [dBHz]	L5	E6-C/No [dBHz]	E6	IODE	URA [m]	Type
3	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	GEO
4	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	GEO
5	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	GEO
6	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
7	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
8	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
12	BeiDou	36.97	214.22	42.5	B1	47.1	B2	49.9	B3	6	2.4	MEO
13	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
14	BeiDou	-6.67	252.12	-	-	-	-	-	-	1	2.4	MEO
15	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
16	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
17	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
18	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
24	BeiDou	47.57	317.00	49.0	B1	-	-	46.8	B3	1	2.4	MEO
26	BeiDou	77.25	104.85	49.5	B1	-	-	52.1	B3	1	2.4	MEO
34	BeiDou	11.17	218.59	38.6	B1	-	-	39.5	B3	1	2.4	MEO
35	BeiDou	57.52	49.17	50.1	B1	-	-	47.7	B3	1	2.4	MEO
44	BeiDou	63.83	208.81	47.8	B1	-	-	50.2	B3	1	2.4	MEO
45	BeiDou	21.80	126.27	42.8	B1	-	-	44.0	B3	1	2.4	MEO
47	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
48	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
49	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
50	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
51	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
52	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
53	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
54	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
55	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
56	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	-
60	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	GEO
61	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	GEO
62	BeiDou	-45.00	0.00	-	-	-	-	-	-	-	-	GEO

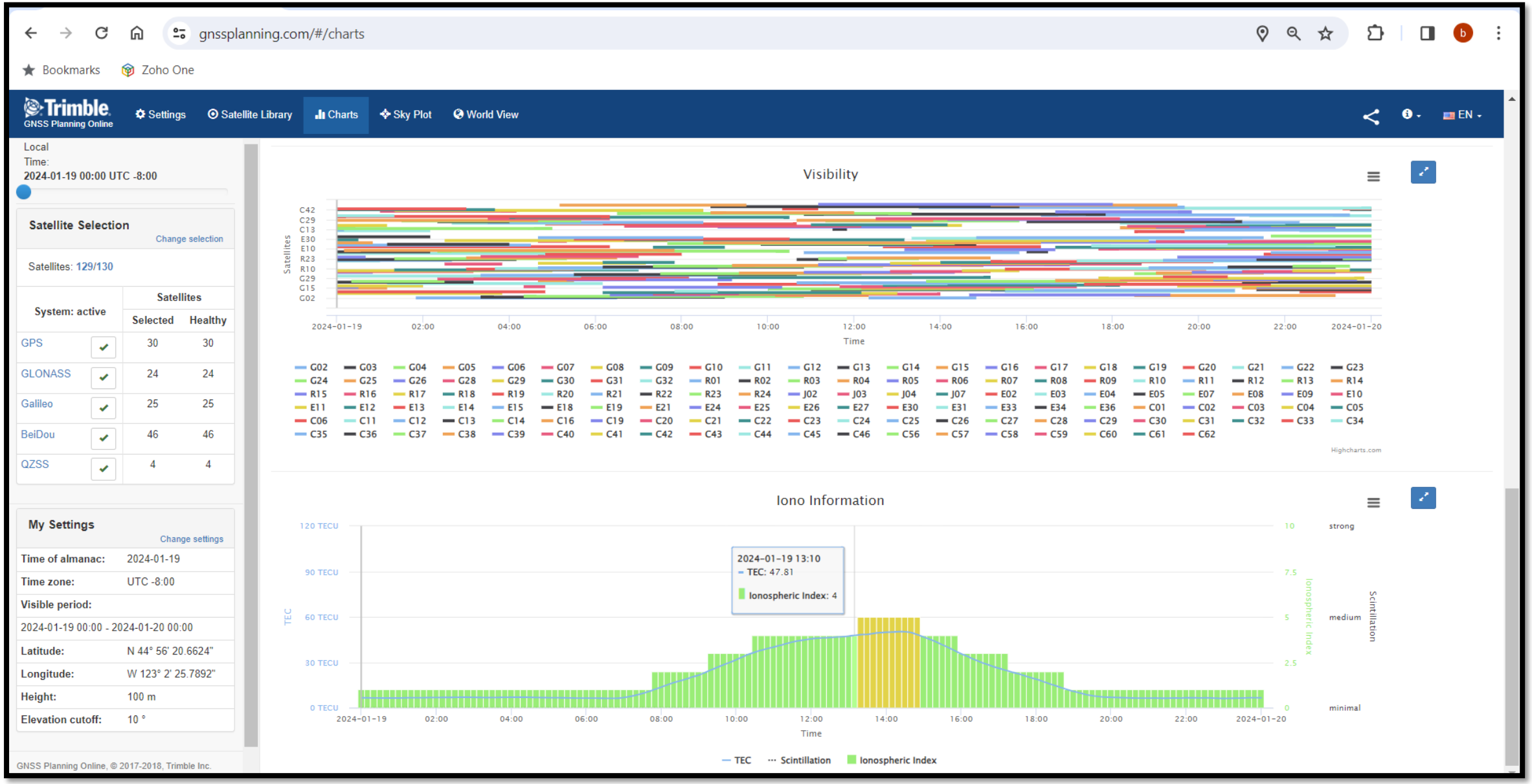
GNSS Mission Planning Tool



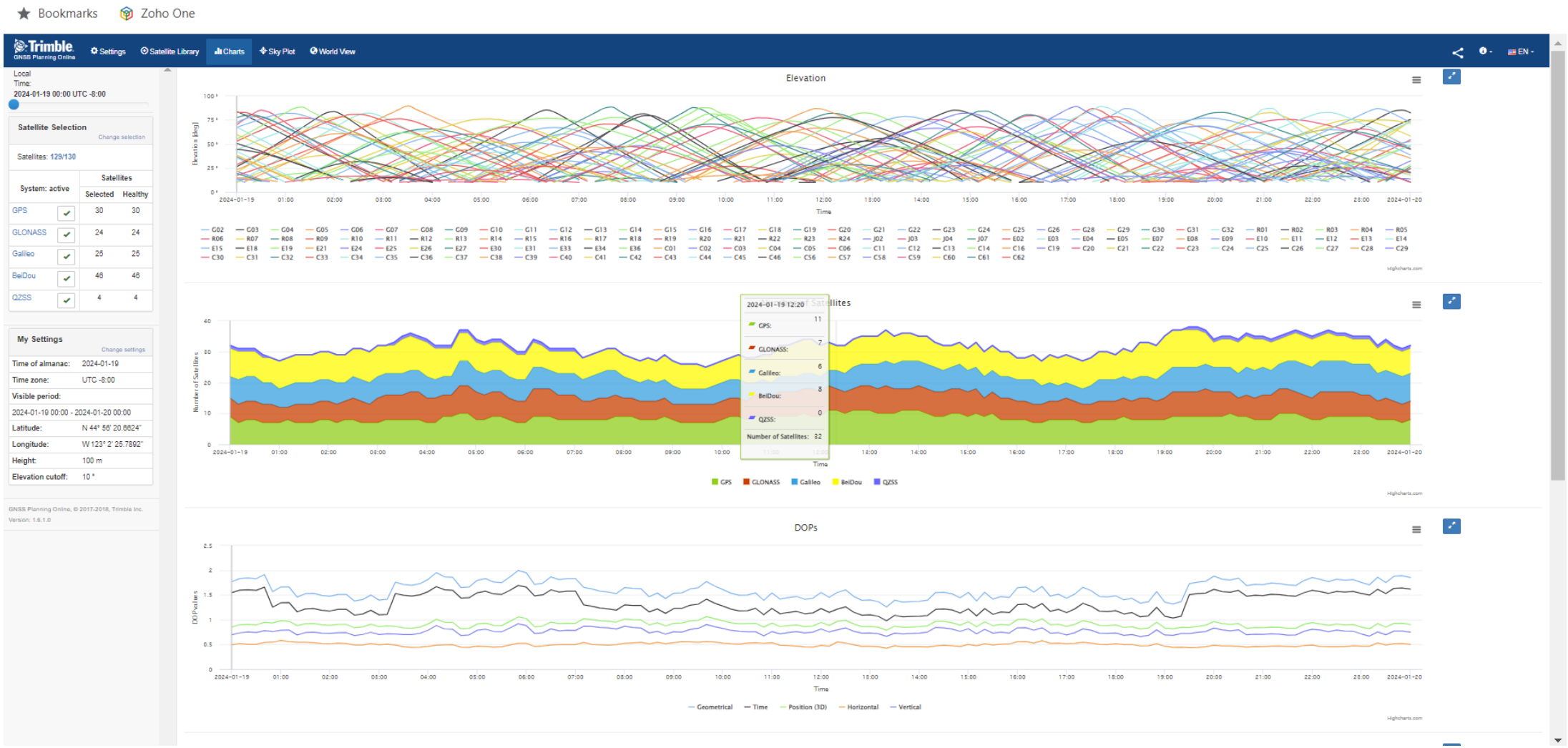
Online Planning Tool for Today/Salem, Oregon

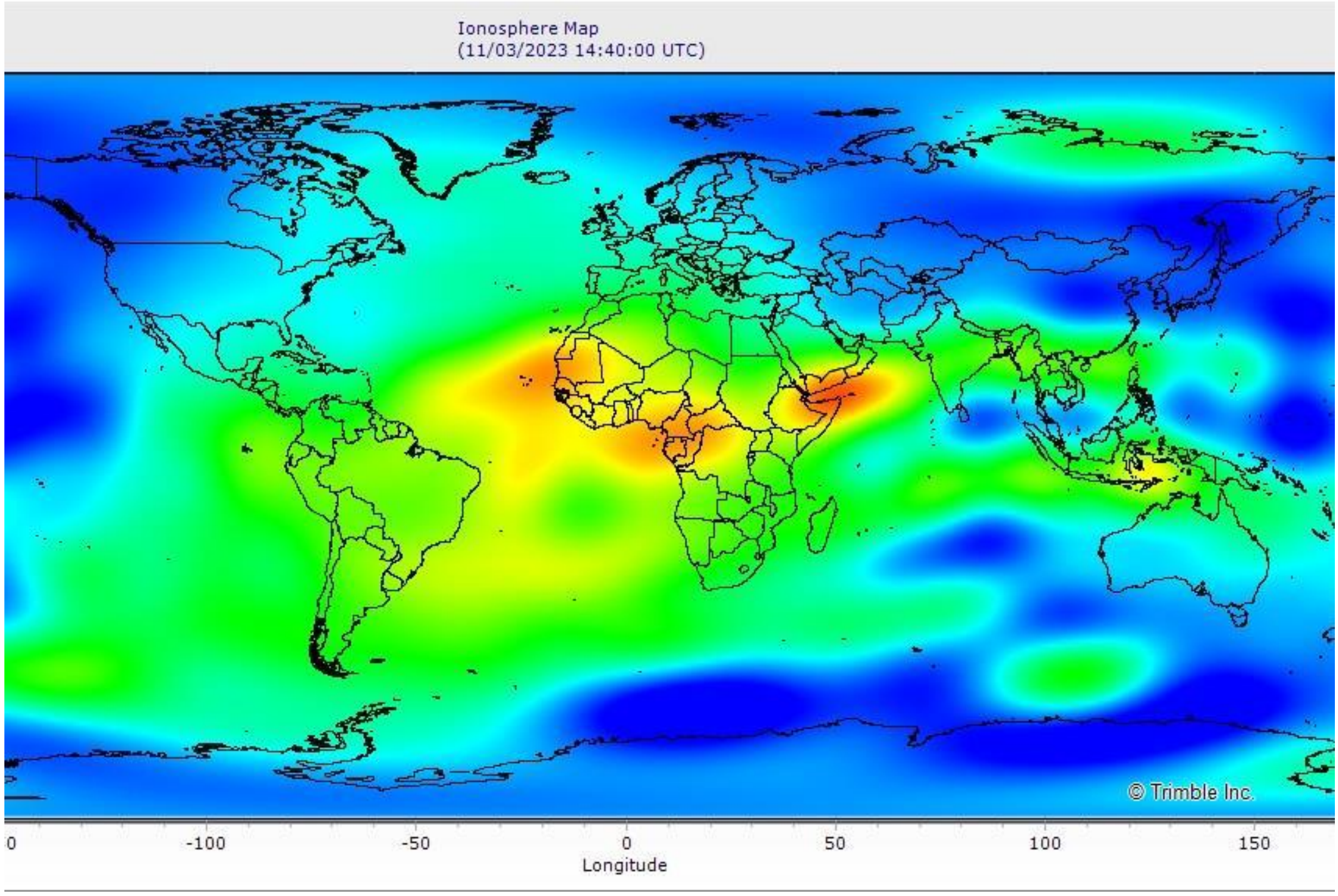


Online Planning Tool Iono Graph



Online Planning Tool Graphs




Ionosphere Map
(11/03/2023 14:40:00 UTC)
© Trimble Inc.
0
-100
-50
0
50
100
150
Longitude

Trimble Online Planning Tool

An ionospheric index value for a given location and time is also provided. This is a value on a scale of zero to 10 indicating ionospheric level derived from measured TEC and scintillation.

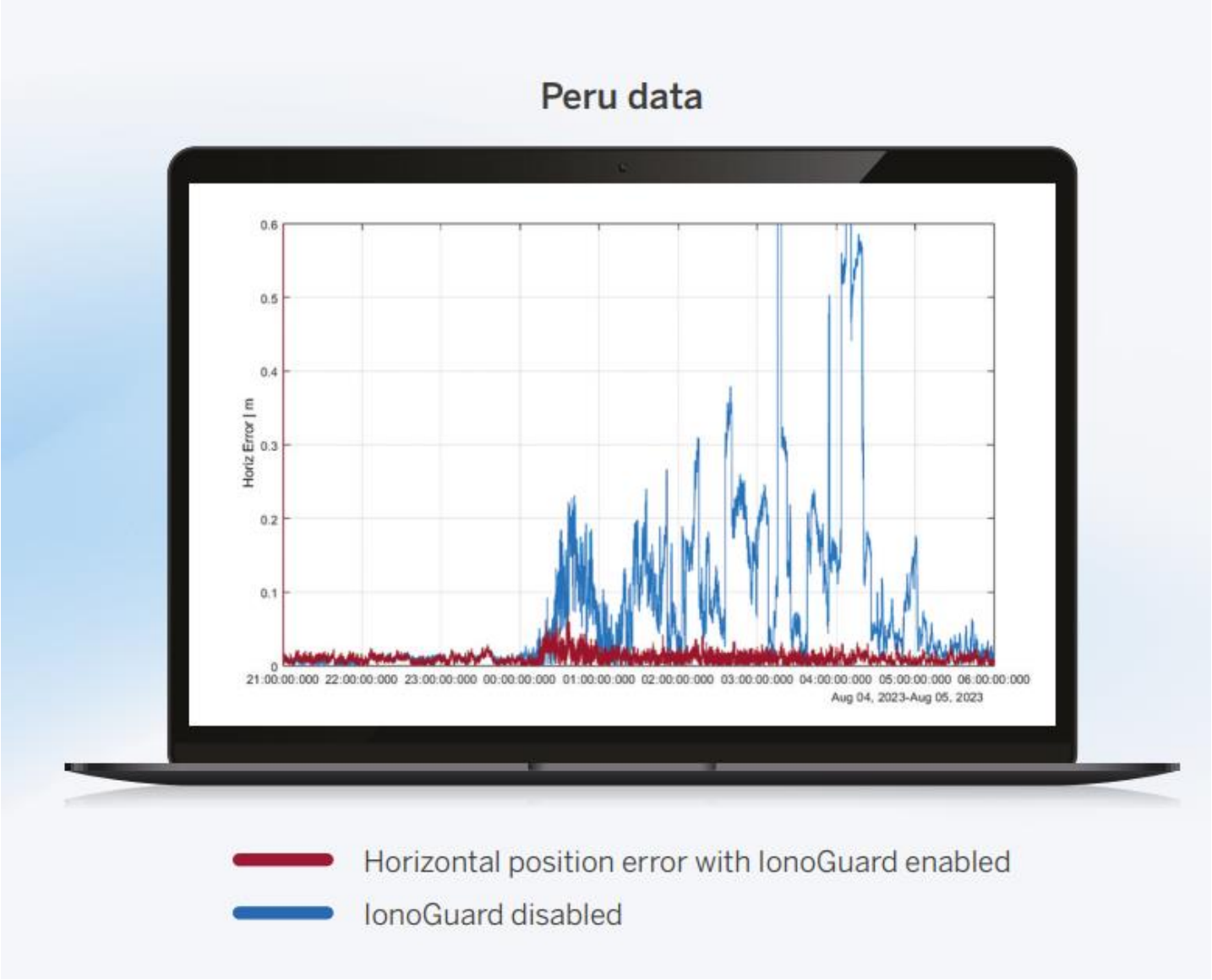
Trimble

Trimble IonoGuard

Protecting RTK GNSS from Ionospheric disturbances

Minimum Receiver Firmware
Version 6.23/ProPoint

IONOGUARD Positional Error

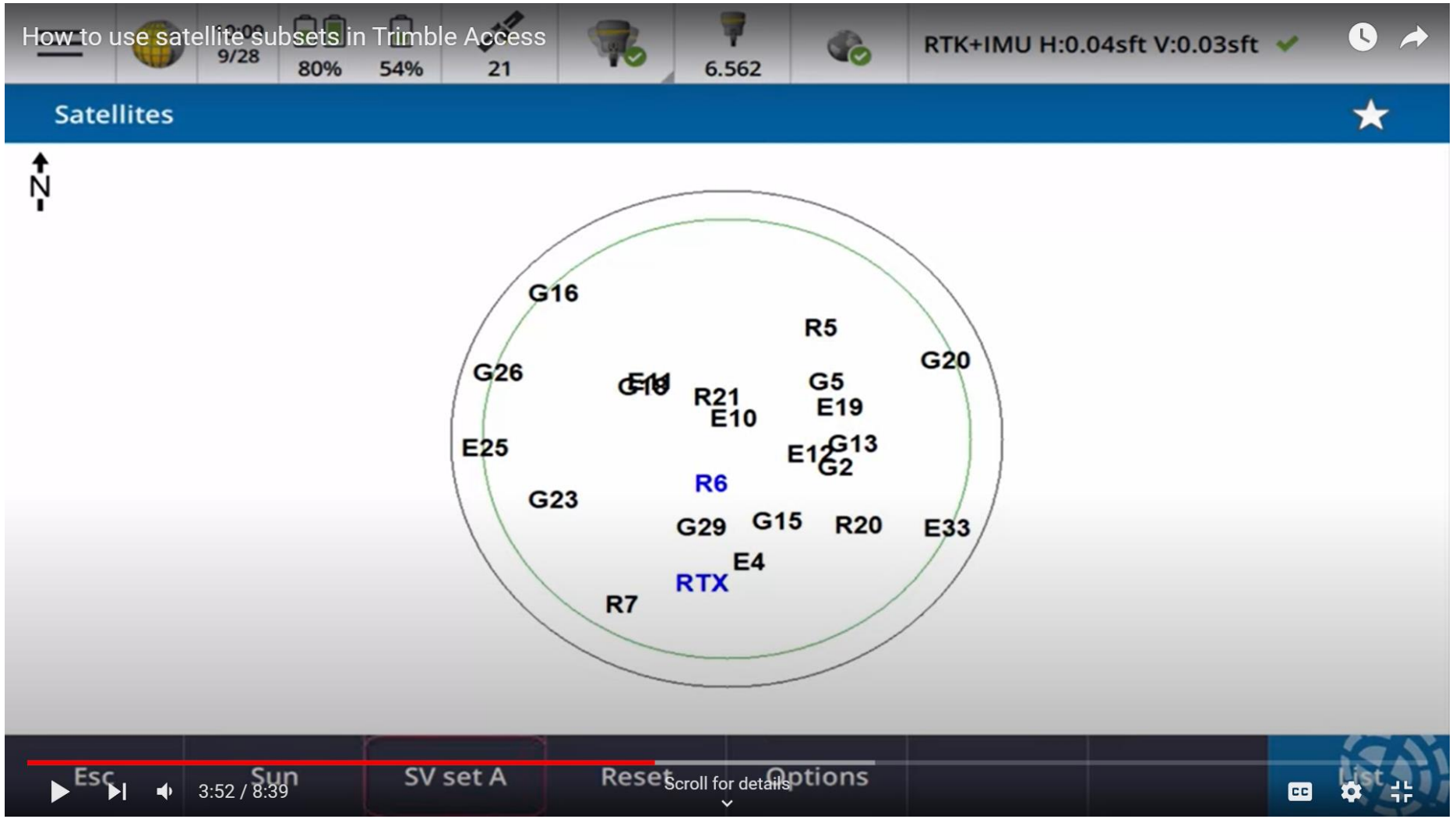


Rover Receiver WebUI
New IONO Tech

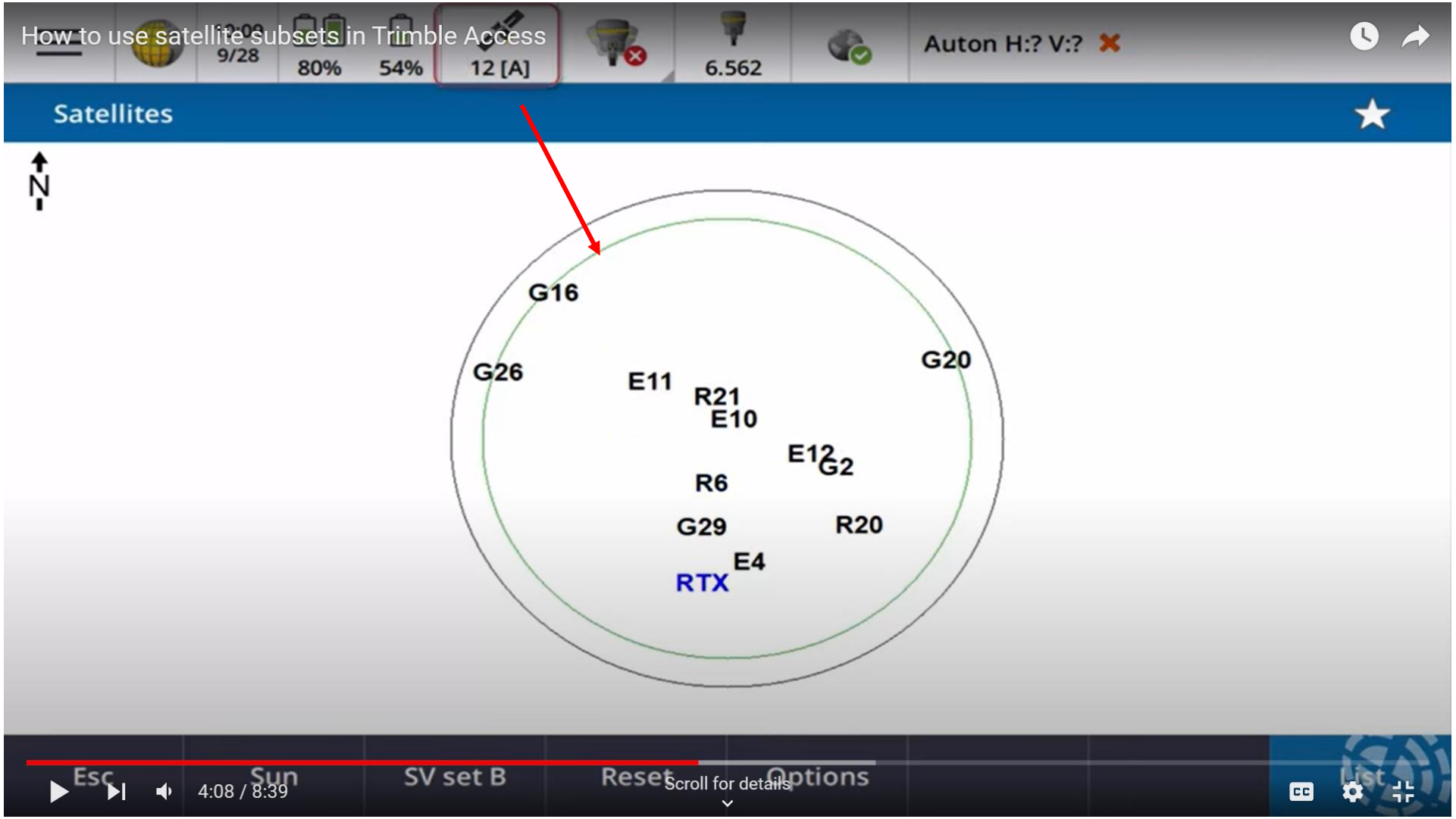
ALL | GPS | GLONASS | Galileo | BeiDou | QZSS | NavIC | SBAS | MSS

SV	Type	Elev. [°]	Azim. [°]	L1-C/No [dBHz]	L1	L2-C/No [dBHz]	L2	L5-C/No [dBHz]	L5	Iono	IODE	URA [m]	Type
3	GPS	86.46	258.86	51.2	CA	51.2	CM+CL	54.3	I+Q	●	34	2	IIF
4	GPS	53.38	307.68	47.2/49.3	CA/BOC	49.3	CM+CL	51.3	I+Q	●	112	2	III
6	GPS	13.12	318.35	39.4	CA	42.4	CM+CL	46.5	I+Q	●	126	2	IIF
9	GPS	26.53	288.58	44.1	CA	44.4	CM+CL	49.1	I+Q	●	107	2	IIF
16	GPS	31.73	130.18	43.5	CA	30.7	E	-	-	●	116	2	IIR
26	GPS	40.05	90.11	44.6	CA	47.2	CM+CL	51.4	I+Q	●	120	2	IIF
31	GPS	42.66	46.71	48.2	CA	43.2	CM+CL	-	-	●	190	2	IIR-M

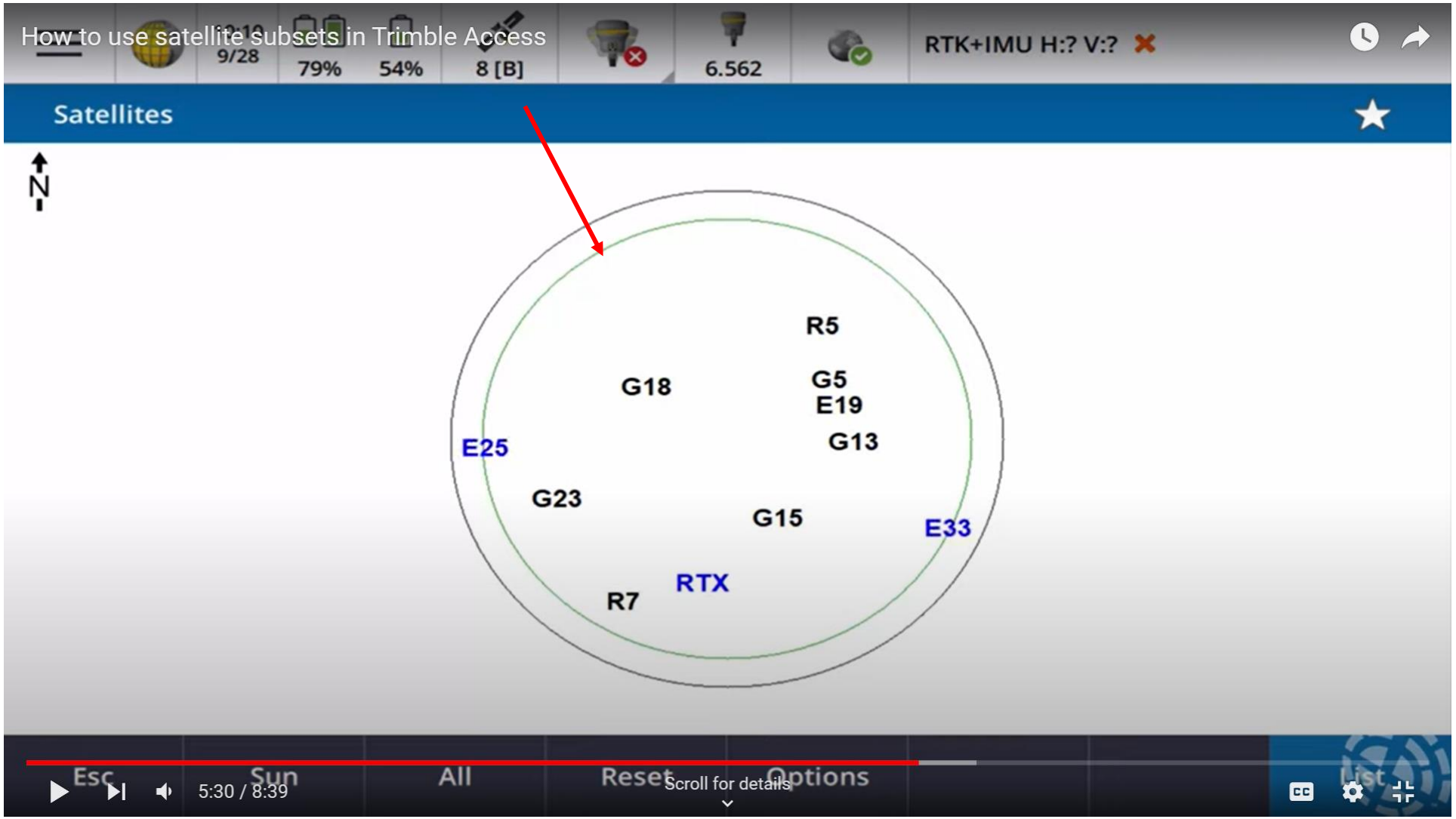
Satellite Subsets



Satellite Subsets

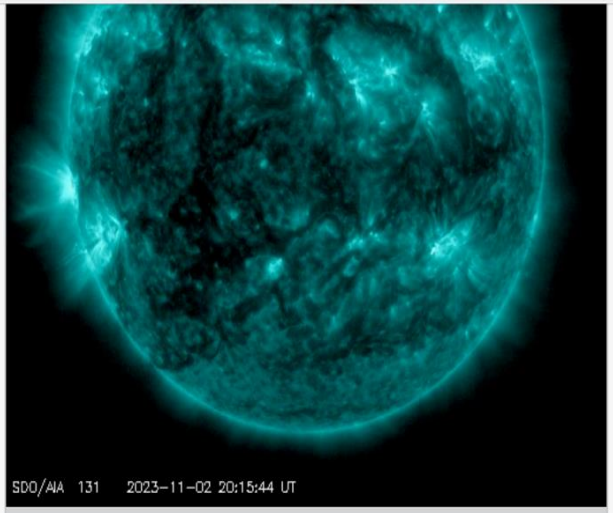


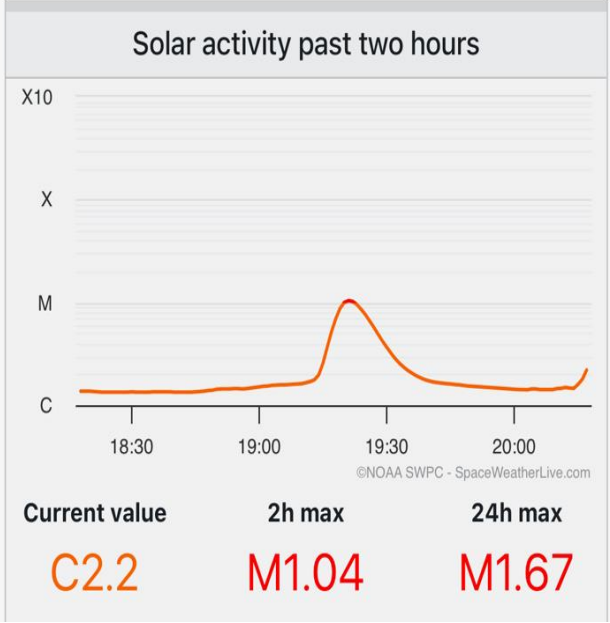
Satellite Subsets



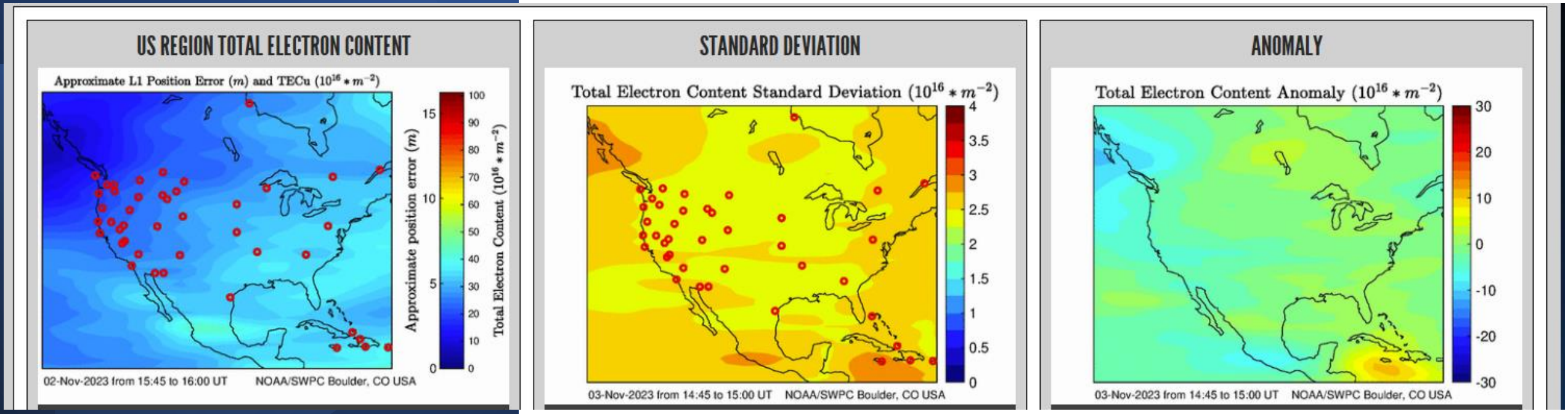
Solar Activity App

CME	Onset time	Duration	Angle	Angular width	Median
33	2023/11/02 11:36	1	72°	6°	308
32	2023/11/02 06:36	2	127°	20°	243
31	2023/11/02 06:36	1	10°	14°	427
30	2023/11/02 05:36	1	248°	14°	280
29	2023/11/02 03:36	8	34°	214°	370
28	2023/11/02 02:24	1	190°	10°	473
27	2023/11/01 21:24	3	91°	20°	385
26	2023/11/01 20:24	3	81°	16°	466

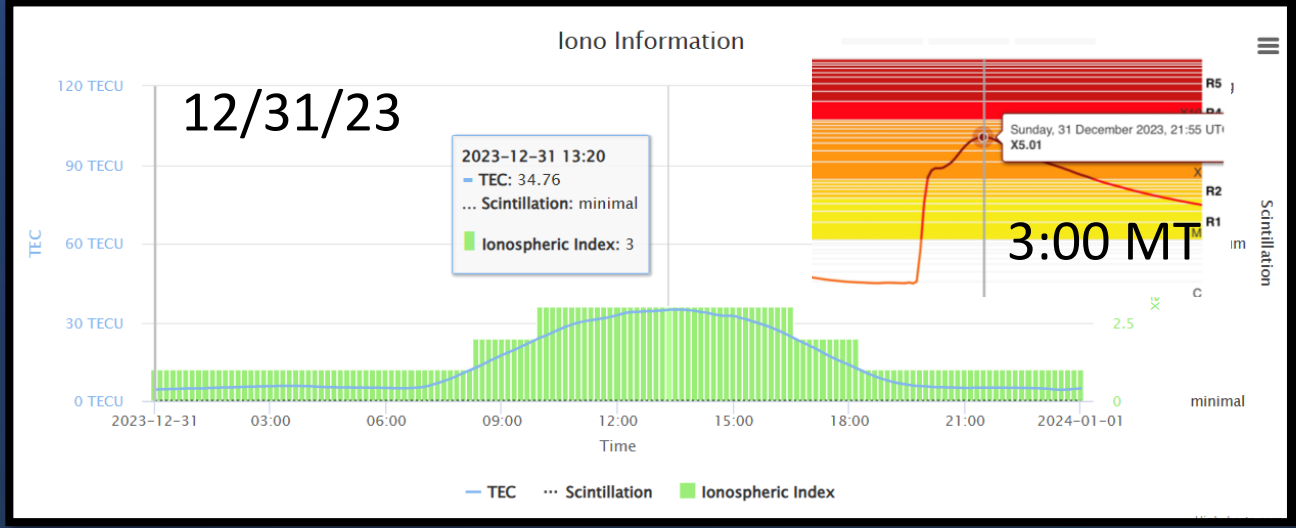


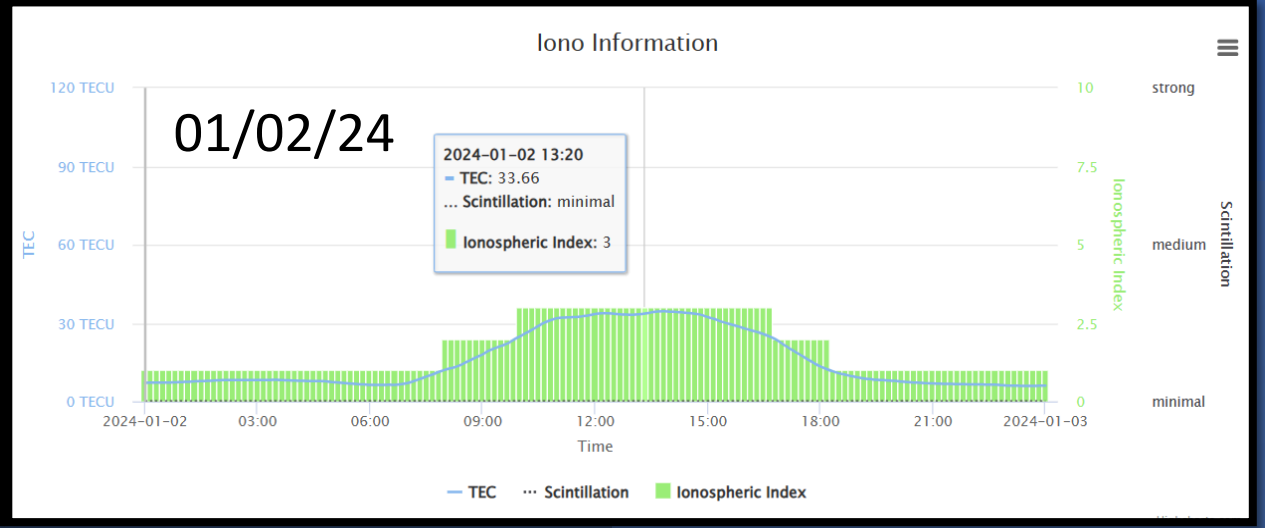


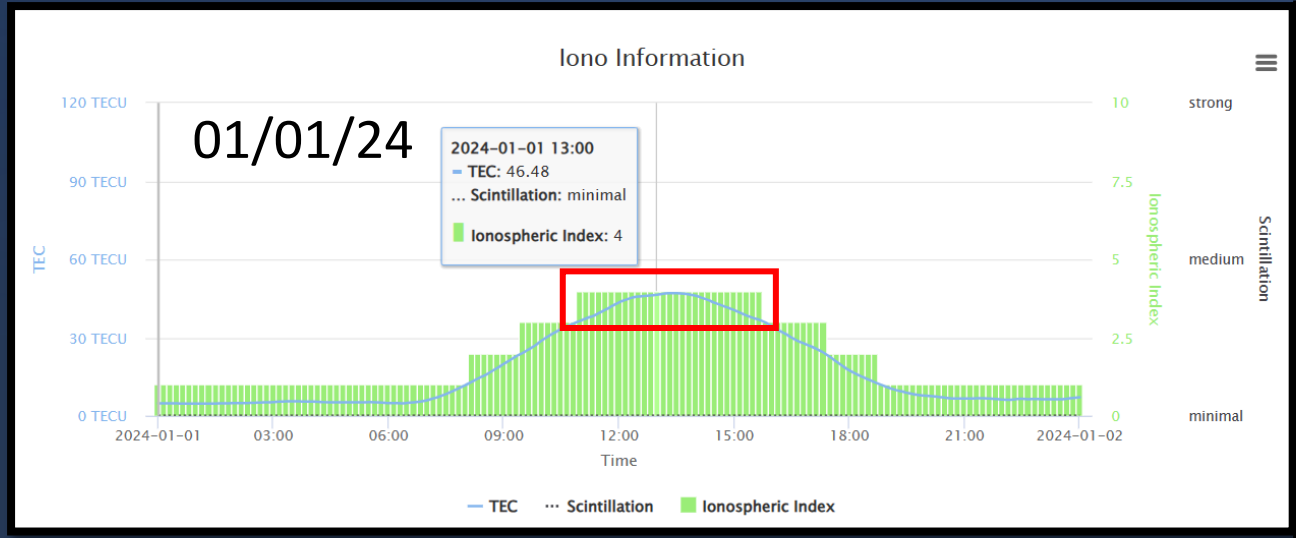
NOAA Space Weather

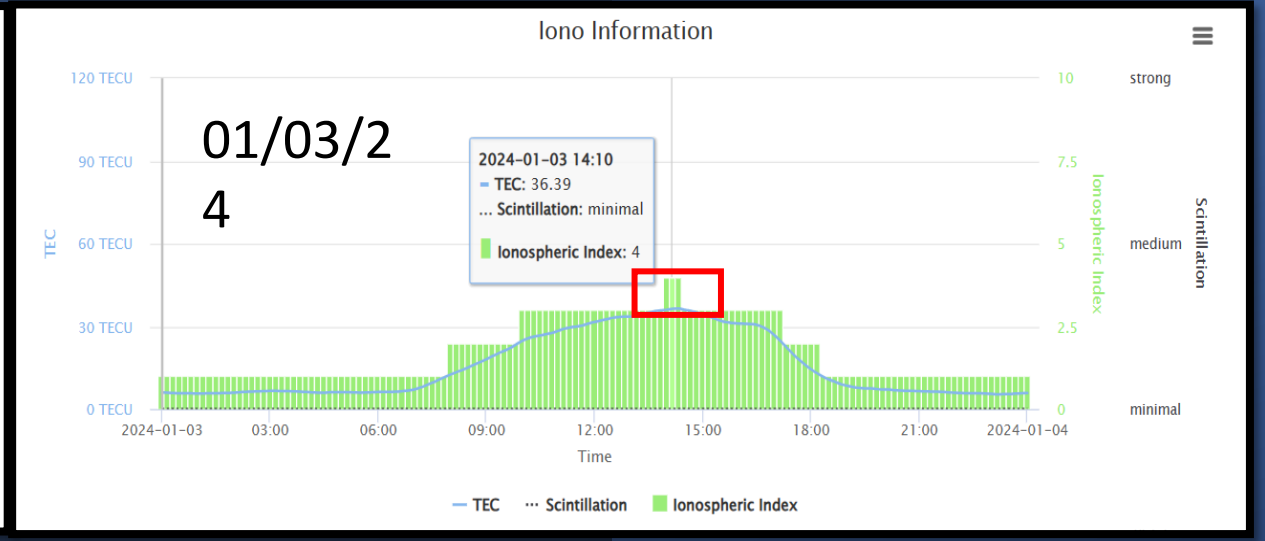


December 31, 2023_X5 Solar Flare









FRONTIER PRECISION