

# INTRODUCTION TO SOLAR WEATHER & HF PROPAGATION

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17 AUG 2023

# Outline

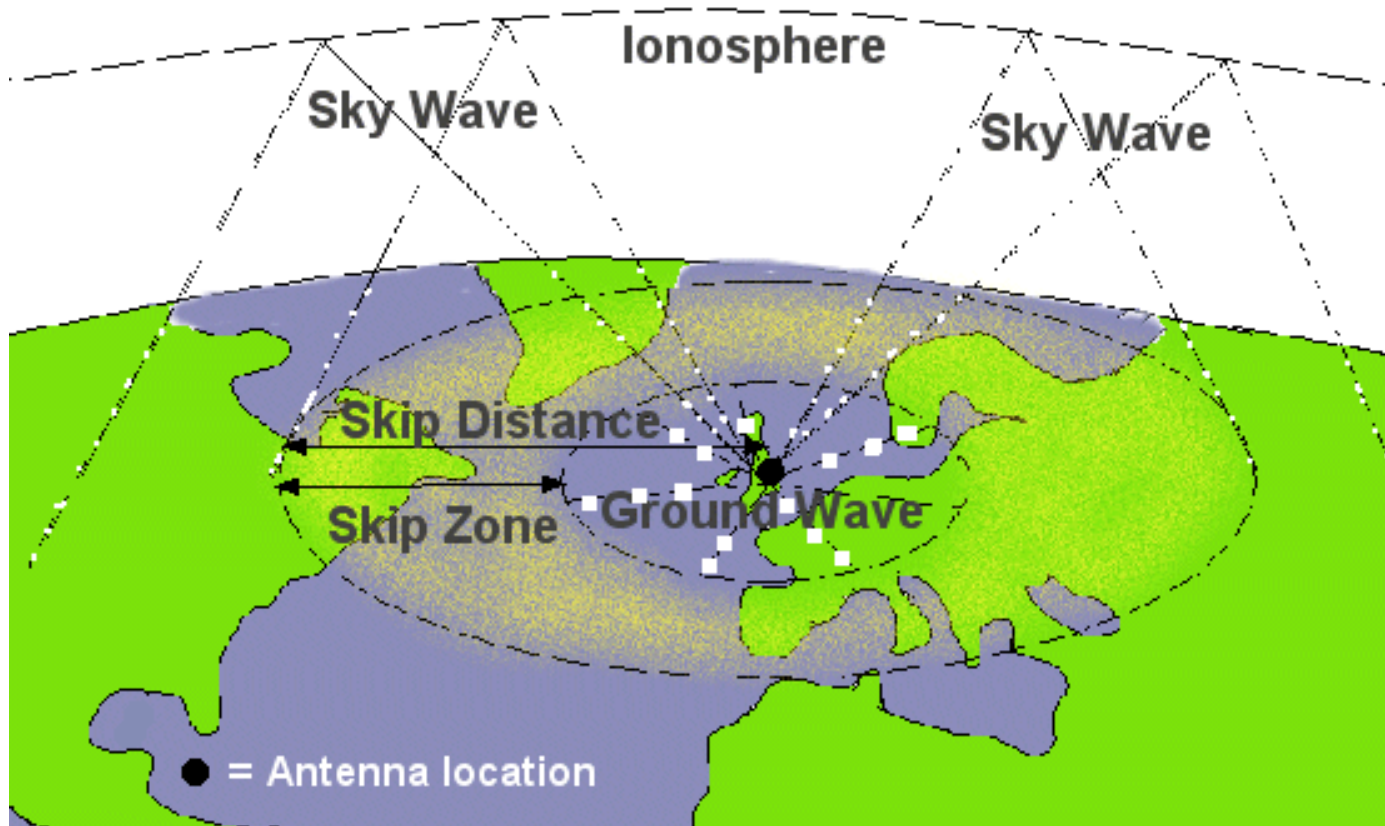
- Ionospheric propagation
  - NVIS
  - Long-Range
  - Frequency Selection (Critical Frequency & MUF)
  - Propagation modeling
- Solar Weather
  - Ionosphere (Solar Flux, Sun Spot Number)
  - Earth's Geomagnetic Field
  - Solar Flares
  - CME
  - Proton Event

# HF Propagation Modes

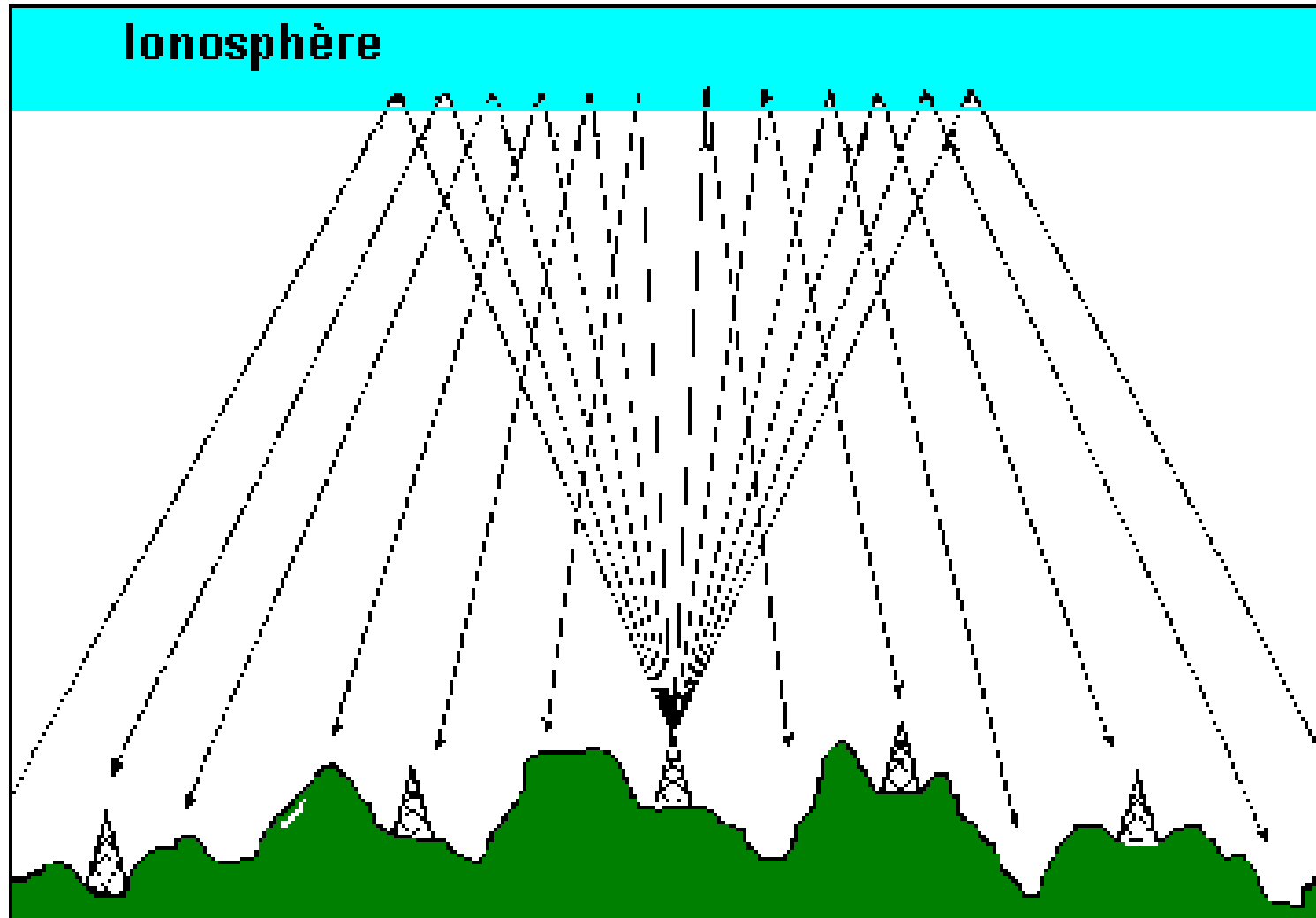
(3 – 30 MHz)

- Free Space – Line of sight
- Ground Wave – Follows Earth's curvature
- Ionospheric Skip (Affected by Solar Wx)
  - Long Distance with a “skip-zone”
  - NVIS (Near Vertical Incidence Sky Wave)

# Long Distance Sky Wave



# NVIS Propagation



# IONOSPHERE

**F2 layer**

**F1 Layer (daytime only)**

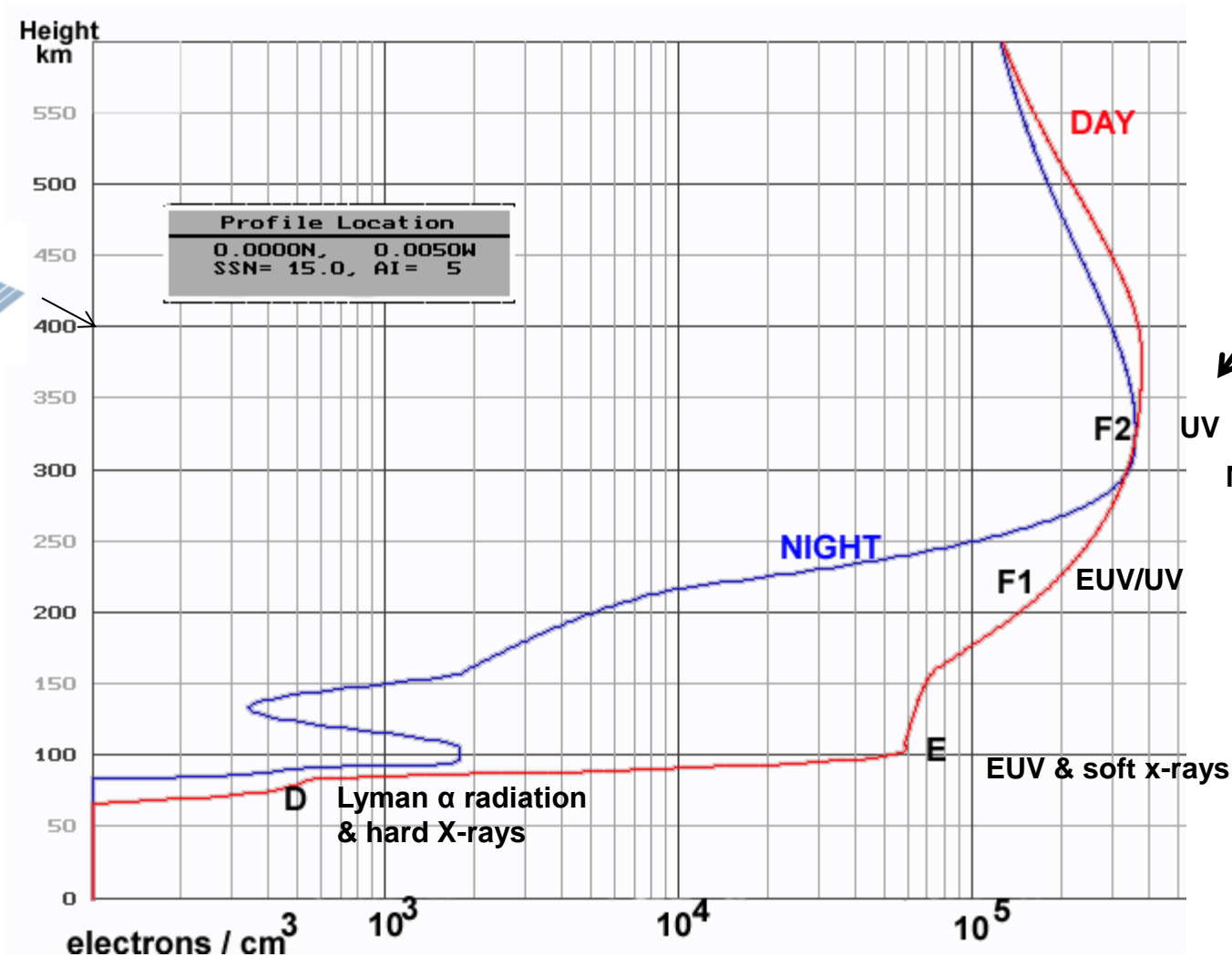
**E Layer**

**D Layer**

# Ionosphere Structure

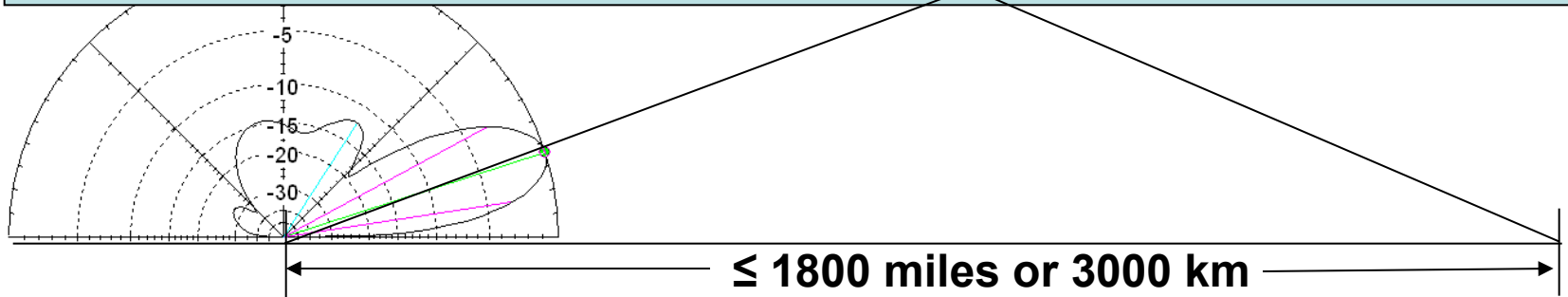


**Gravity**  
↓



# TYPICAL LONG-RANGE PROPAGATION

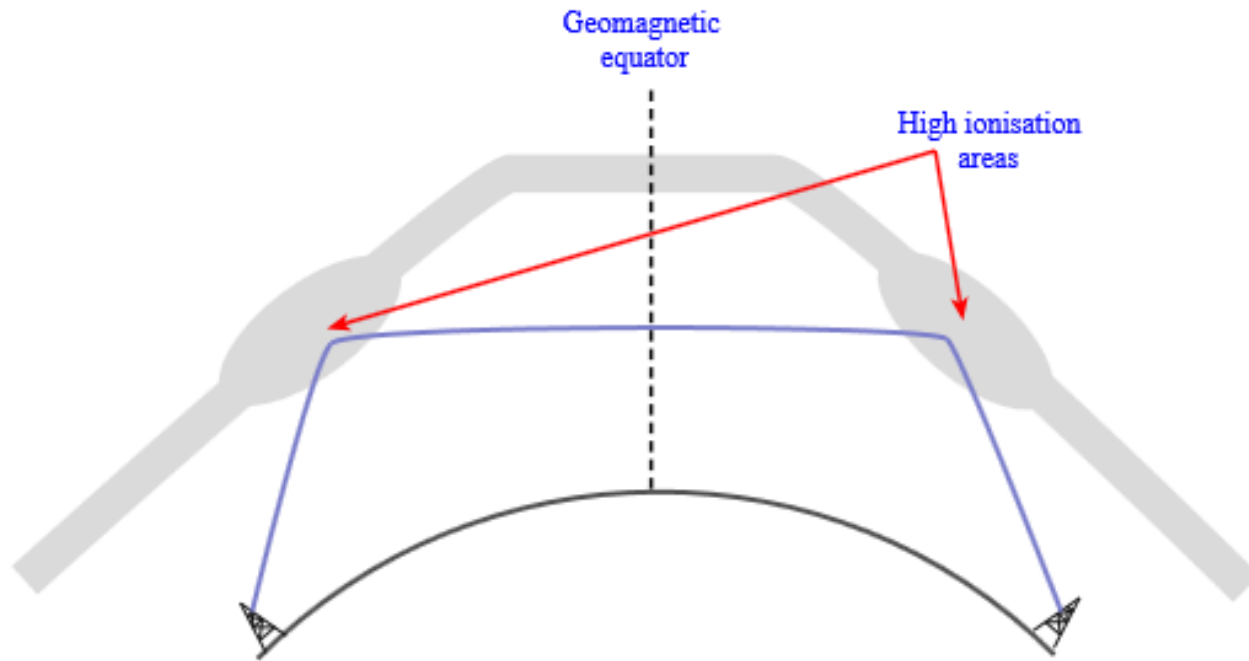
**Ionosphere F2 Layer – 200 miles or 320 Km**



**Both F2 & E layers propagation can be involved in multiple reflection circuits.**



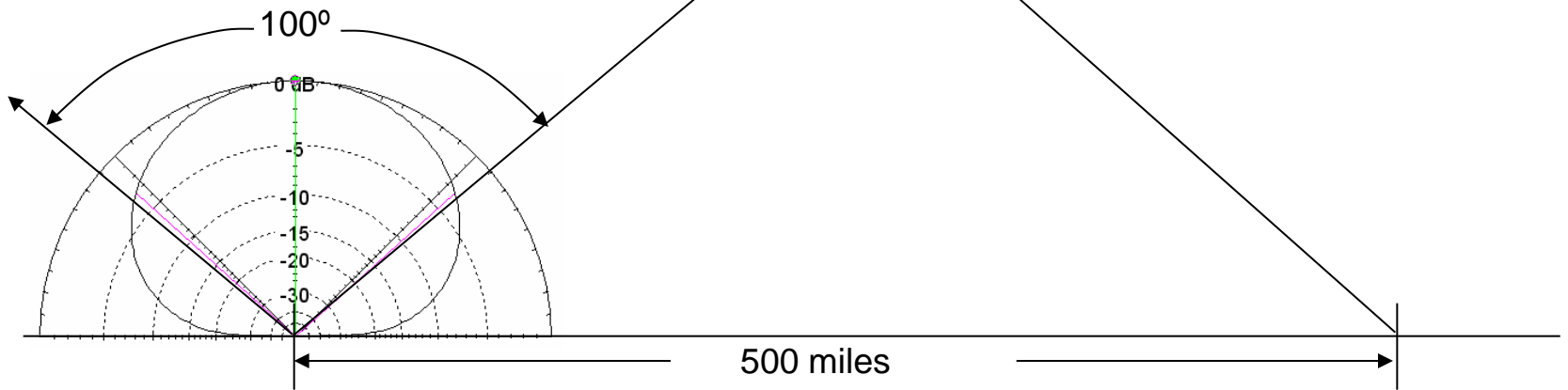
# Transequatorial Propagation (TEP)



Mode of operation of transequatorial propagation, TEP

# NVIS PROPAGATION

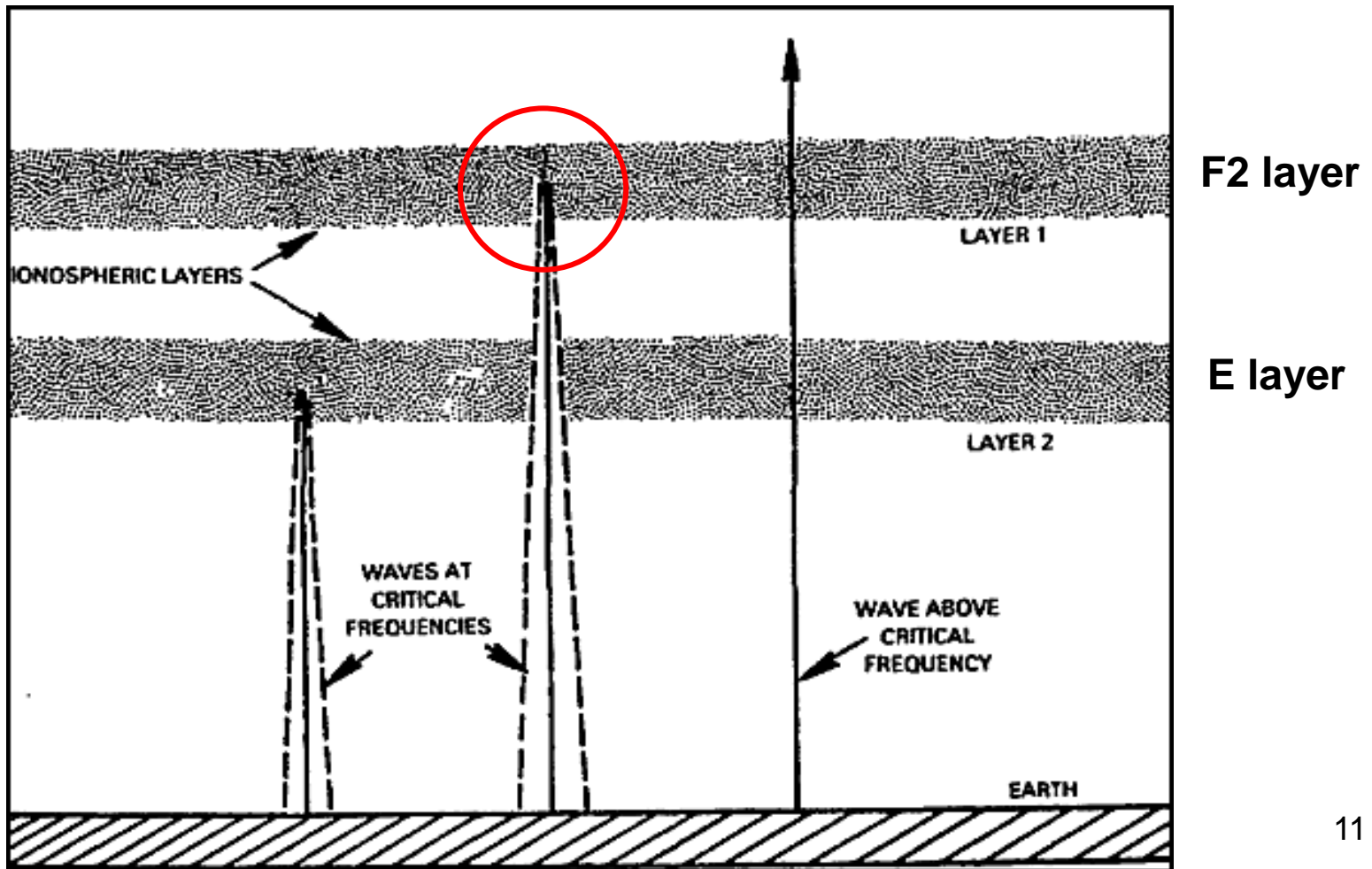
**Ionosphere F2 Layer – 200 miles**



**Only F2 layer propagation can provide necessary range**

# NVIS Frequency Selection

- Must operate at or below the local Critical Frequency (CF)

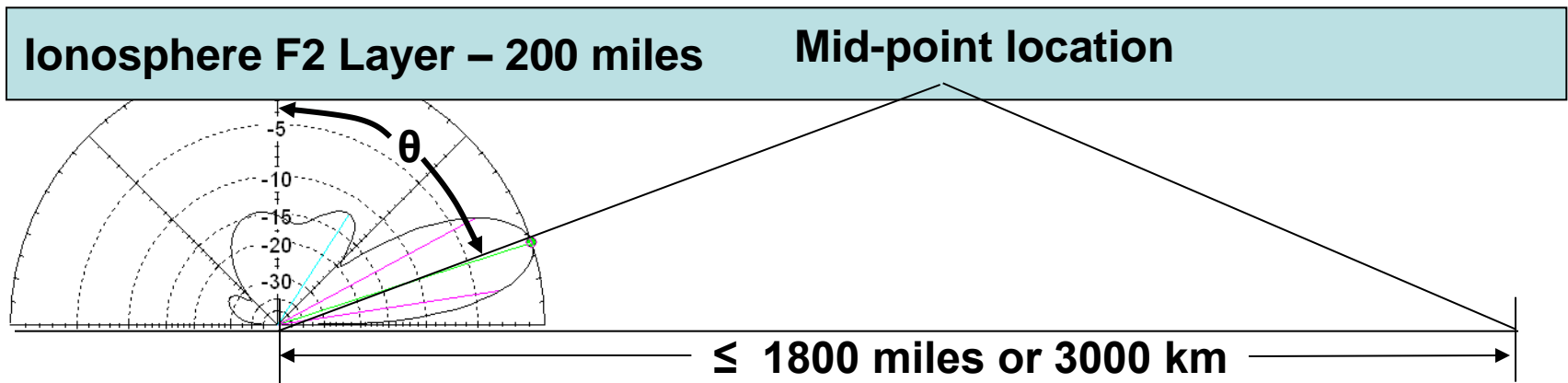


# Critical Frequency

- Critical Frequency increases with increased ionization of F-layer
  - Time of day
  - Time of year
  - Time of the 11-year sun spot cycle

# Maximum Useable Frequency (MUF)

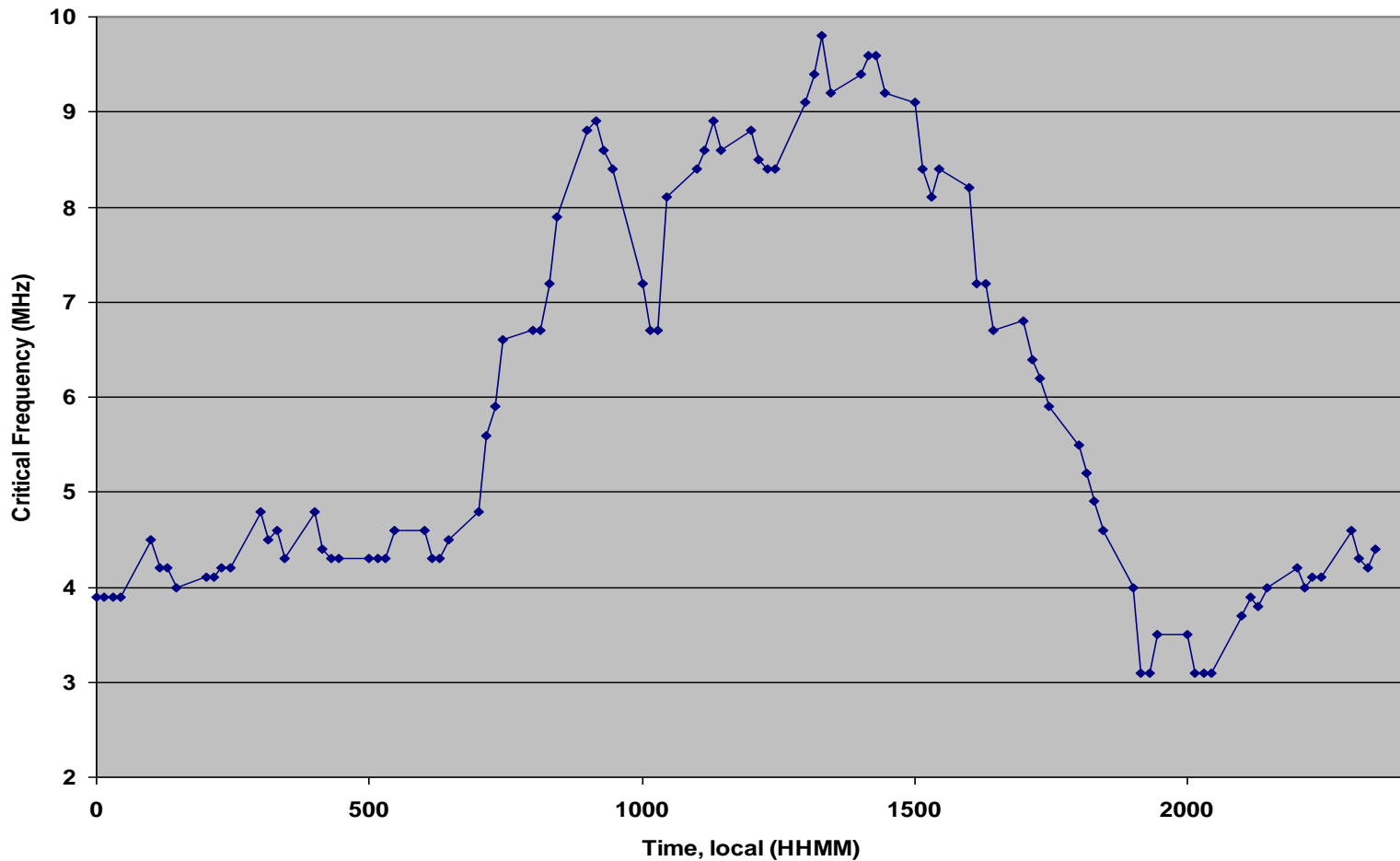
- MUF (Maximum Useable Frequency) is  $CF/\cos\theta$ , where  $\theta$  is the angle from the take-off beam to vertical.



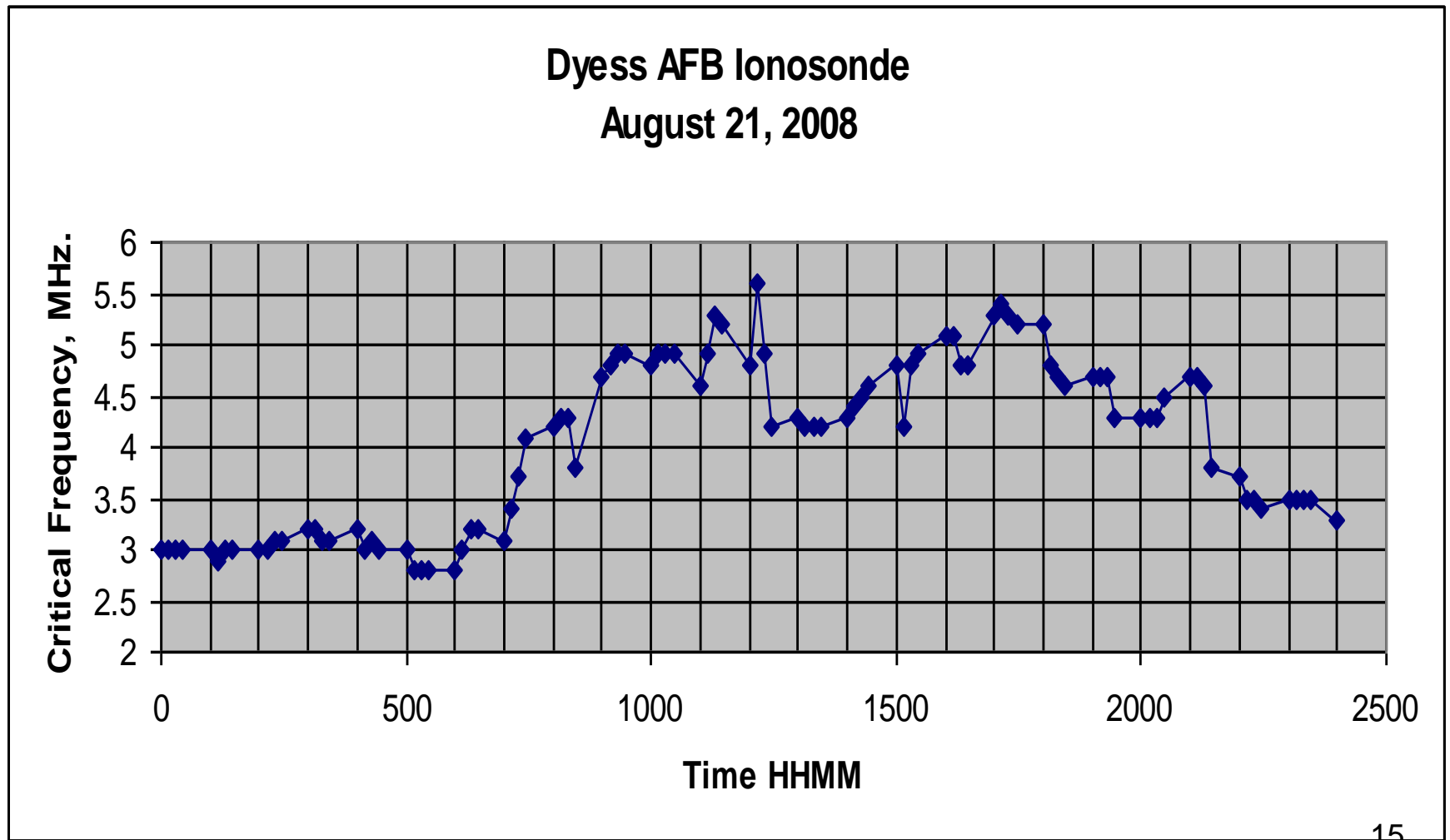
# Critical Frequency

(During Sun Spot Cycle 23)

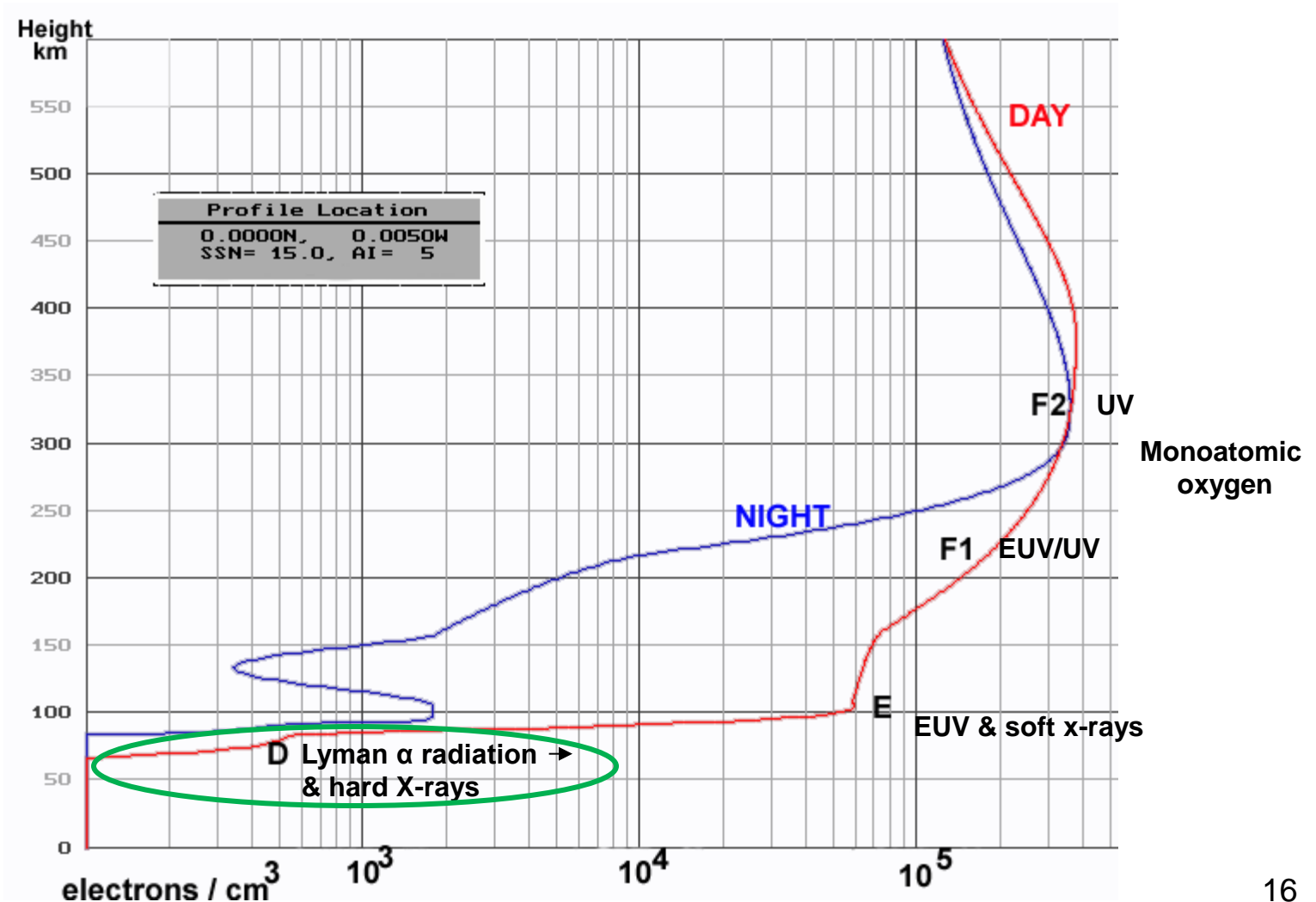
Dyess AFB Ionosonde Data (Nov. 13, 2005)



# Critical Frequency (Between Cycles 23 & 24)



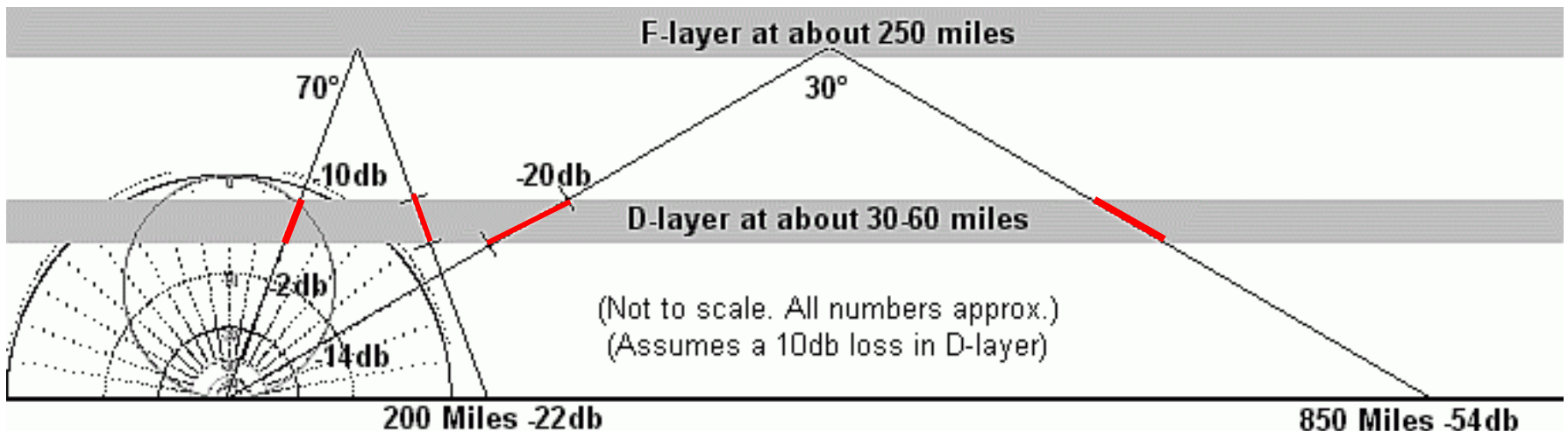
# Lowest Useable Frequency (D-Layer Absorption)





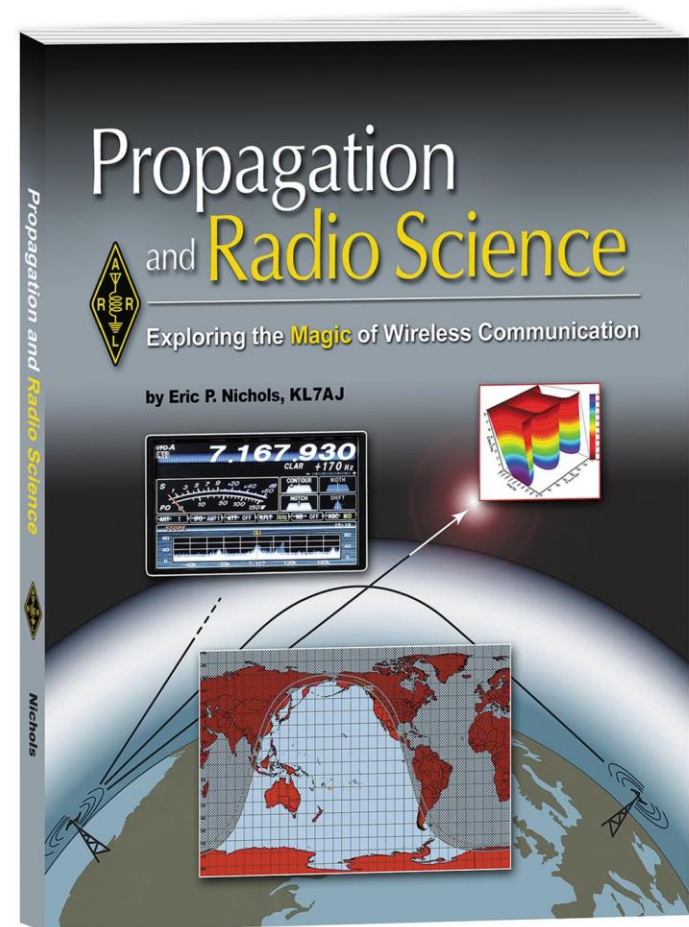
# Lowest Usable Frequency (LUF)

- Controlled by D-Layer absorption
- Day-time effect (Gray-Line)
- Function of transmit power and mode of operation
- Absorption is a function of  $1/f^2$



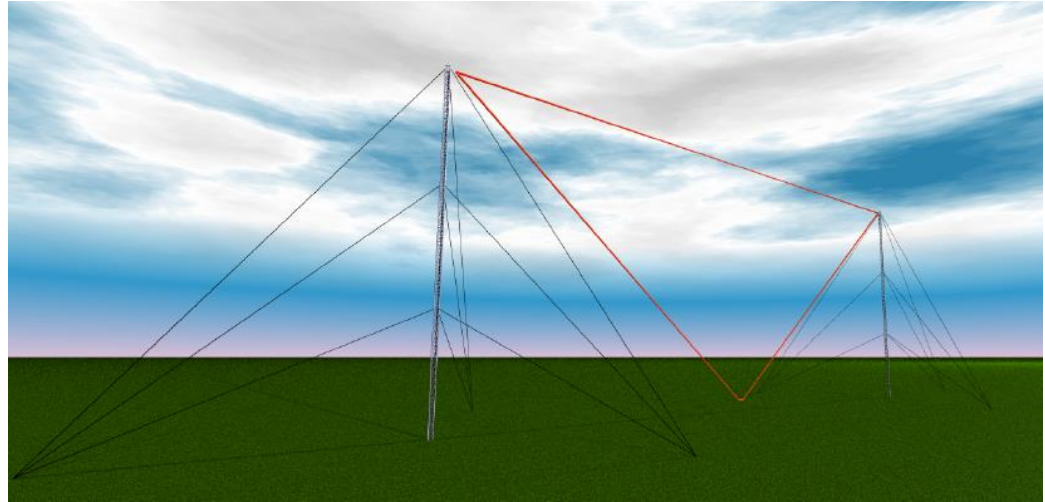
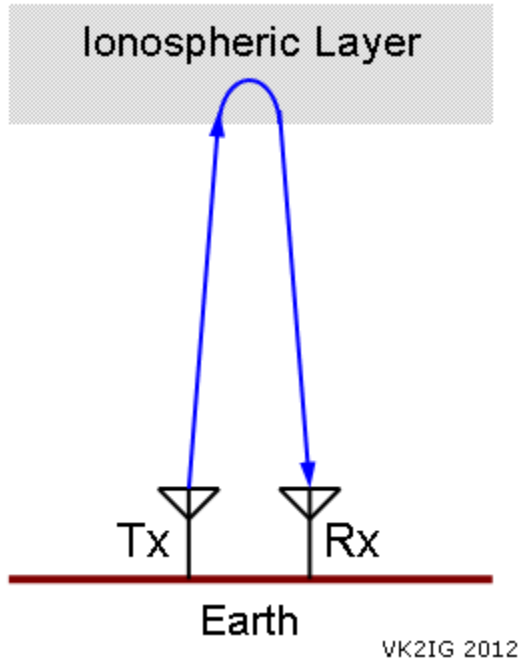
# Ionosonde Use

**“Whether you plan on just using the ionosphere, or wish to make a meaningful contribution to understanding the ionosphere... Every radio amateur should know how to read an ionogram”.**



**By Eric PI Nichols, KL7AJ**

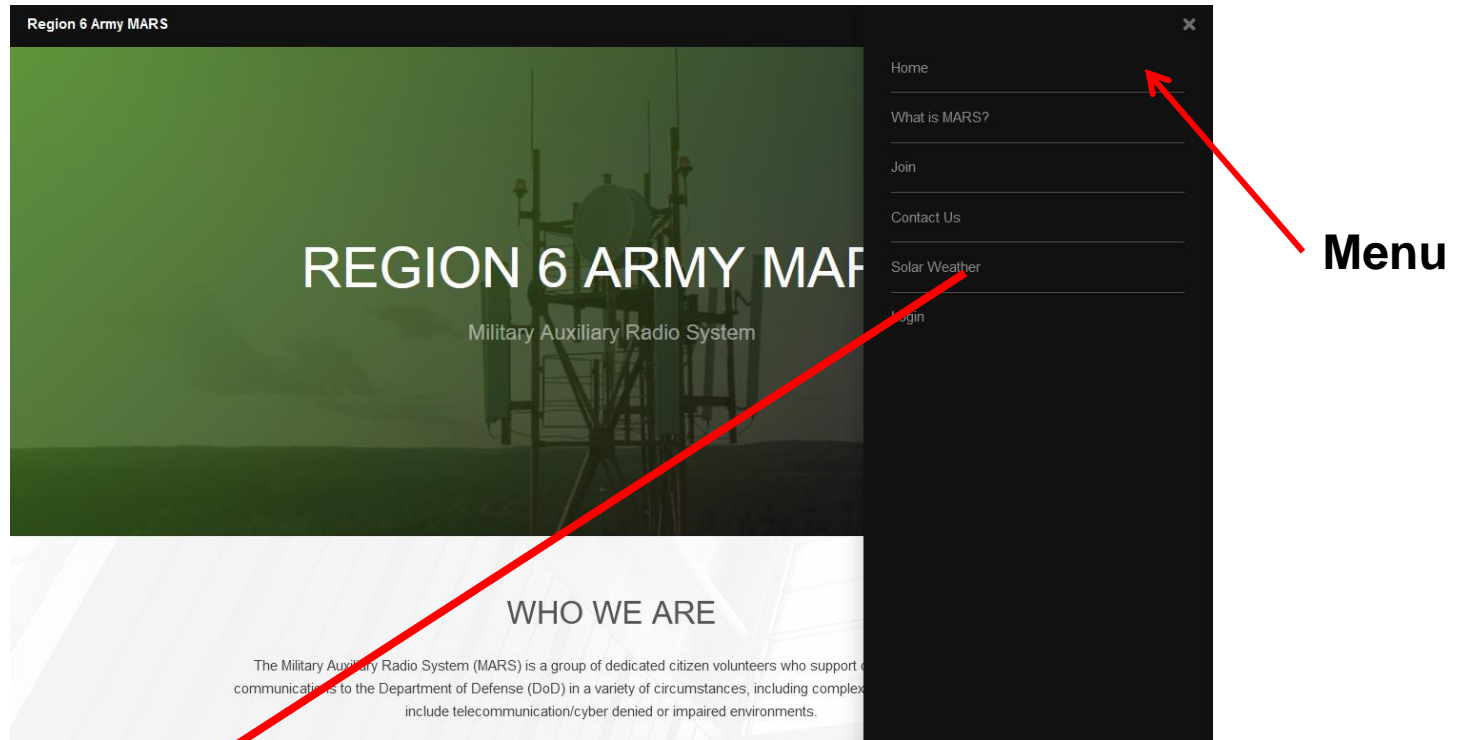
# Austin Ionosonde



# Ionosonde Locations



# Ionosonde Data



**Solar Weather**

## Other Solar Weather Links of Interest

**All Ionosondes**

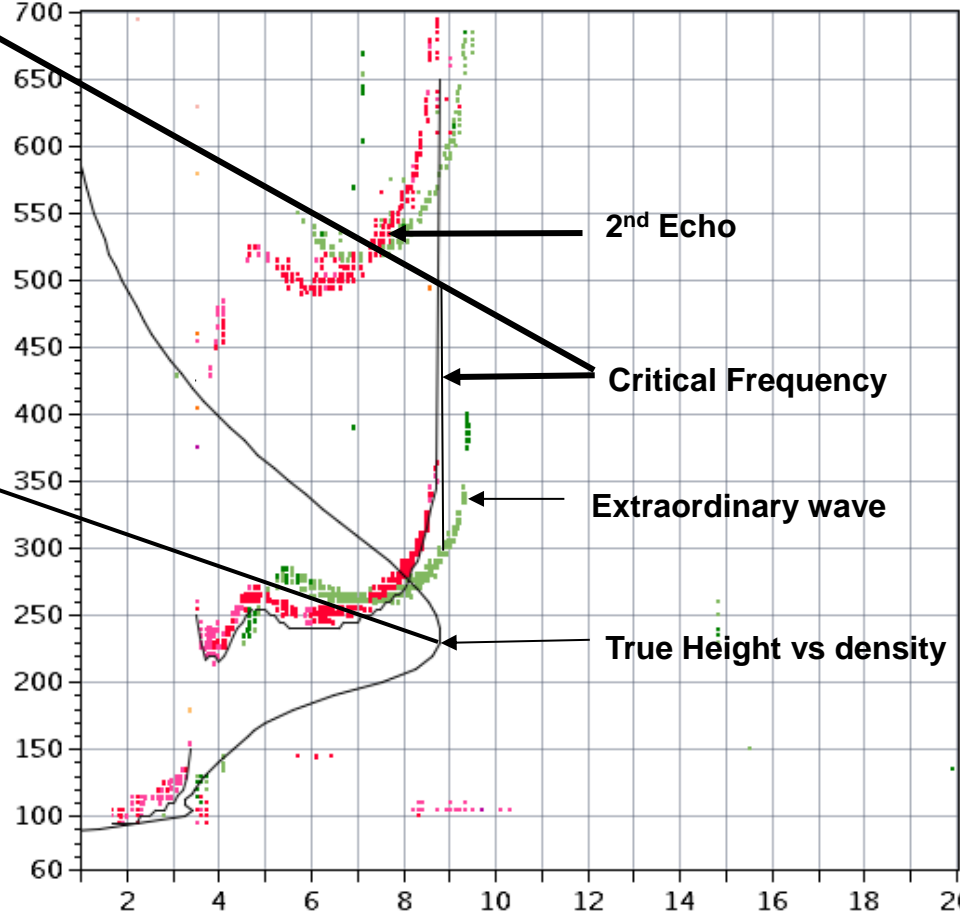
- [DIDBase](#) - Select Station List then EGLIN then year/month/day/time for ionosonde plot.
- [NOAA Solar Weather](#) - Solar Weather plots of Kp and X-Ray and other solar emissions.
- [Solen Solar Weather](#) - Good general solar forecast from an individual.
- [Solar Ham](#) - SolarHam provides real time solar news, as well as consolidated data from various sources.

# Ionogram Interpretation



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS  
 Austin 2013 Jan03 003 185505 MMM 1 045 100 32+ A1

foF2	8.804
foF1	4.75
foF1p	4.62
foE	3.42
foEp	3.29
fxI	9.50
foEs	3.40
fmin	1.70
<hr/>	
MUF(D)	31.04
M(D)	3.53
D	3000.0
<hr/>	
h`F	215.0
h`F2	240.0
h`E	95.0
h`Es	95.0
<hr/>	
hmF2	235.5
hmF1	164.4
hmE	105.0
yF2	69.0
yF1	35.4
yE	16.2
B0	70.6
B1	2.28
<hr/>	
C-level	11
<hr/>	
Auto:	
Artist4	
200207	



D 100 200 400 600 800 1000 1500 3000 [km] ← Oblique propagation MUF Chart  
 MUF 9.4 9.5 10.0 10.8 12.0 13.7 18.5 31.0 [MHz] i.e. 31 MHz to 3000 km

# Austin Ionosonde -15 AUG 1335Z

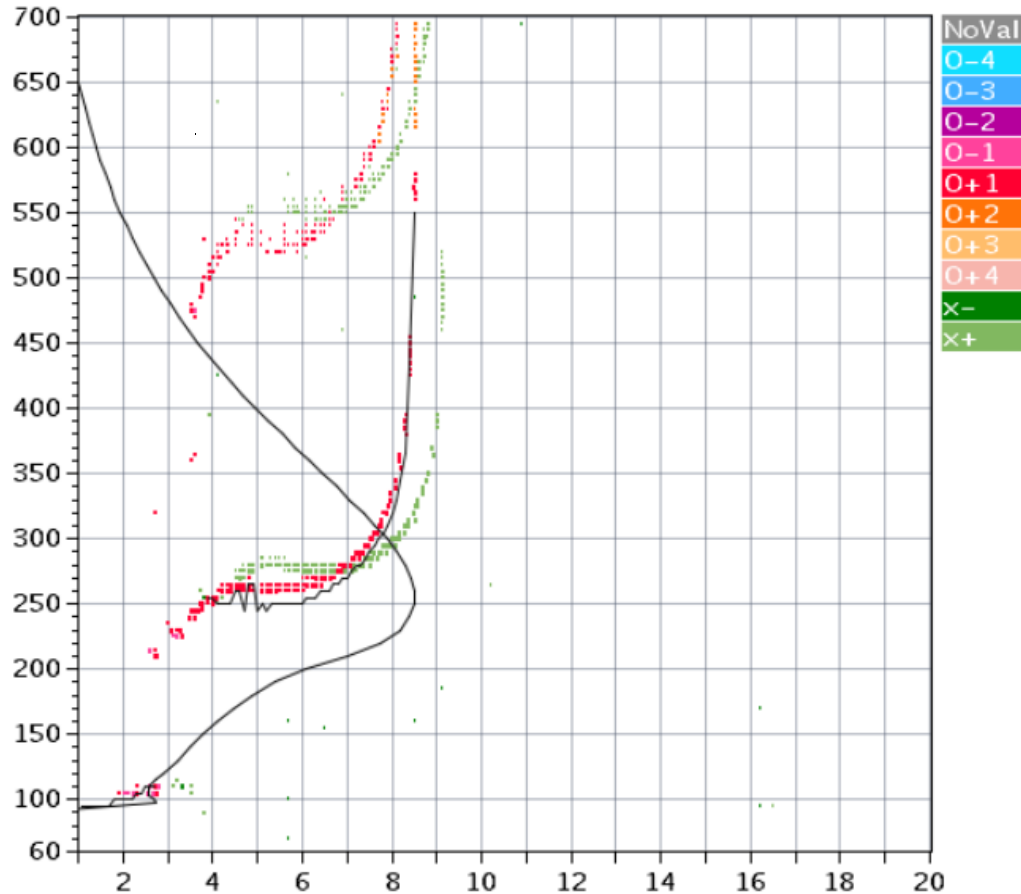
(Available every 5 minutes)



Statio YYYY DAY DDD HHMMSS P1 FFS S AXH PPS IGA PS  
 Austin 2023 Aug15 227 133505 MMM 1 045 100 33+ A1

foF2	8.500
foF1	N/A
foF1p	N/A
foE	2.72
foEp	2.71
fxI	9.30
foEs	2.70
fmin	1.10
MUF(D)	28.28
M(D)	3.33
D	3000.0
h'F	245.0
h'F2	N/A
h'E	95.0
h'Es	95.0
hmF2	254.7
hmF1	N/A
hmE	97.2
yF2	80.0
yF1	N/A
yE	7.0
B0	70.3
B1	3.76
C-level	21

Auto:  
 Artist4.5  
 200311



D	100	200	400	600	800	1000	1500	3000	[km]
MUF	9.1	9.2	9.6	10.4	11.4	12.9	17.2	28.3	[MHz]

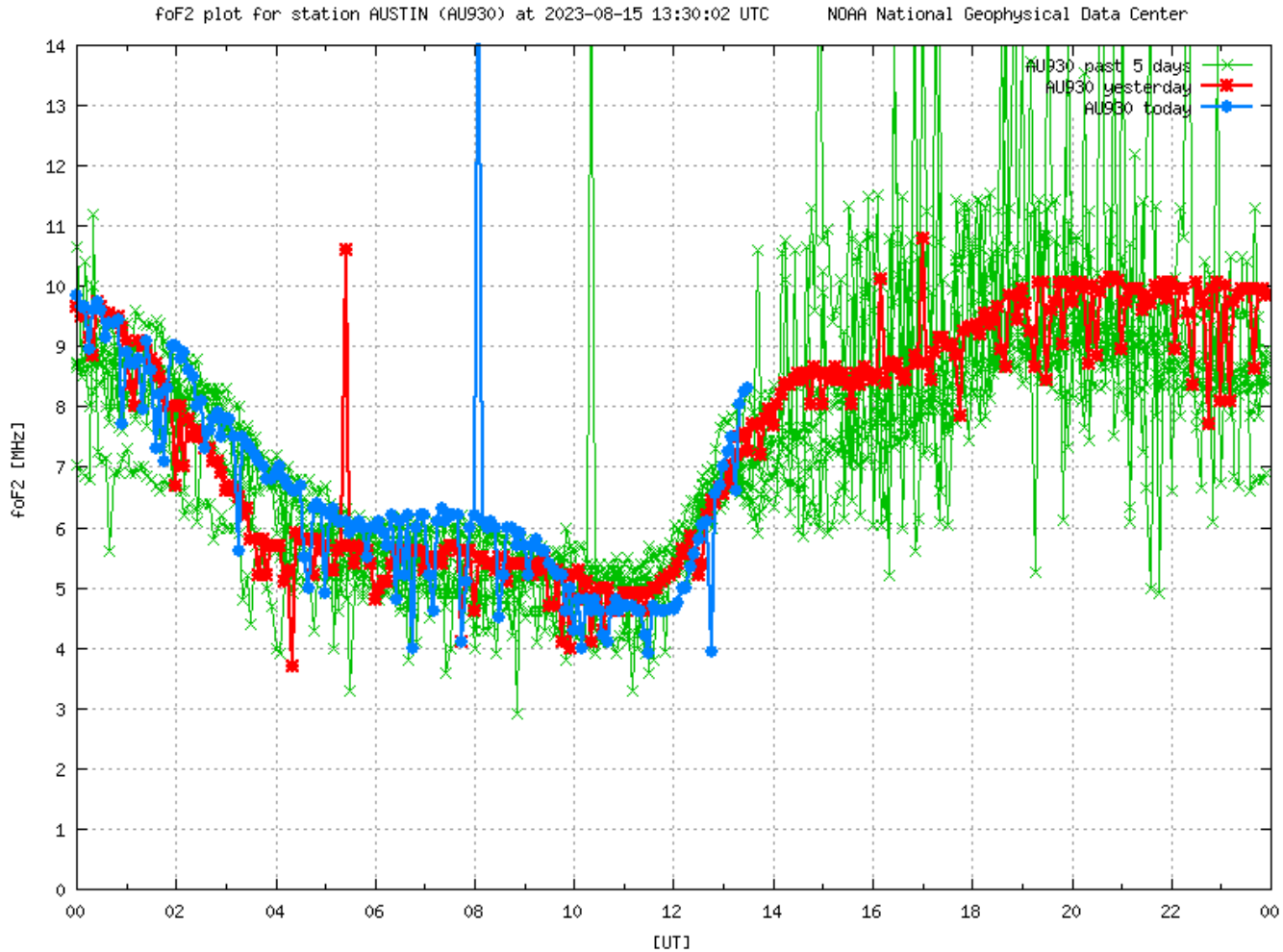
AU930\_2023227133505.MMM / 190fx128h 100 kHz 5.0 km / DGS-236 AU930 130 / 30.4 H 262.3 E

Ion2Png v. 1.3.11

# Austin Ionosonde foF2 Trend

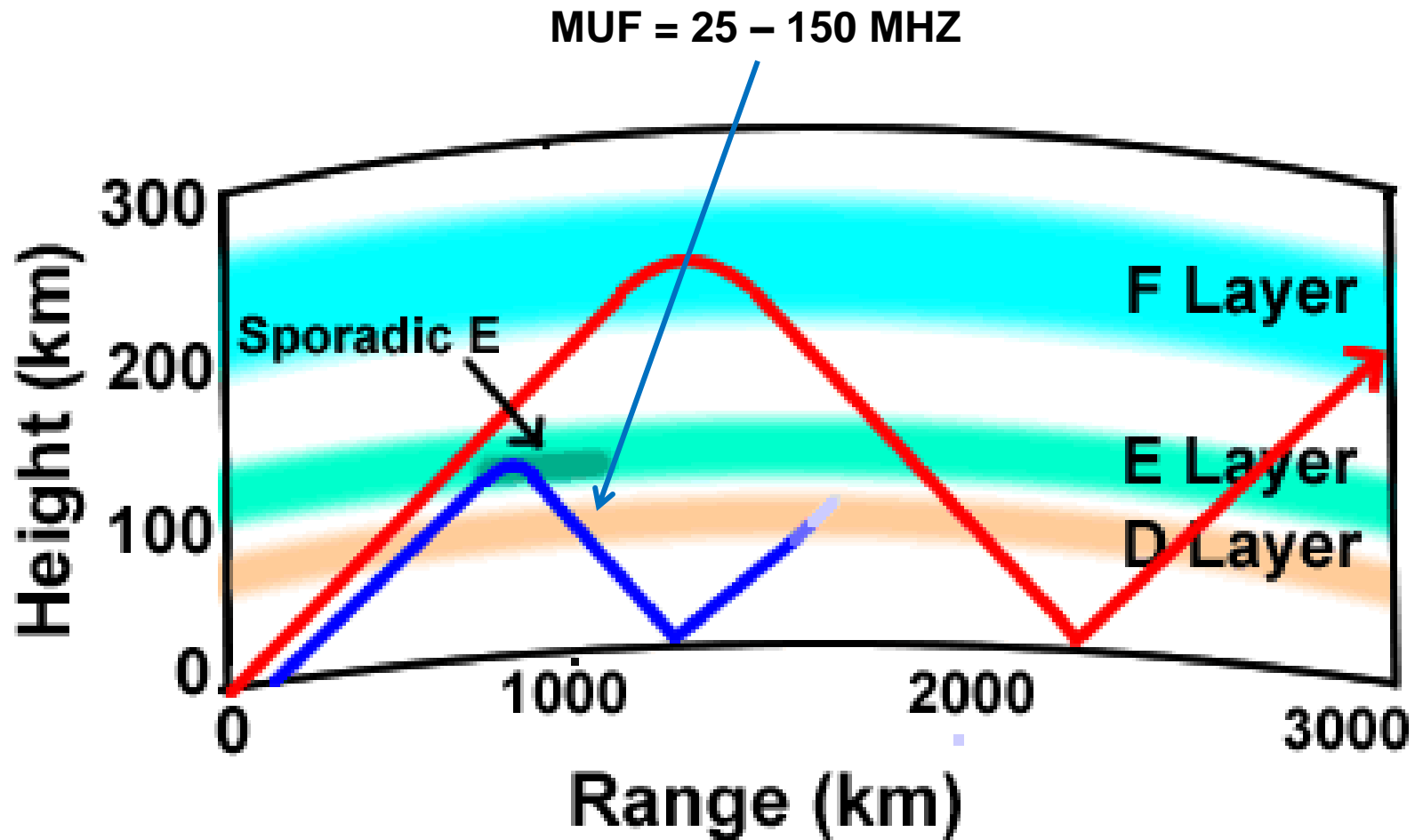
(15 minute update from NOAA)

Critical Freq.





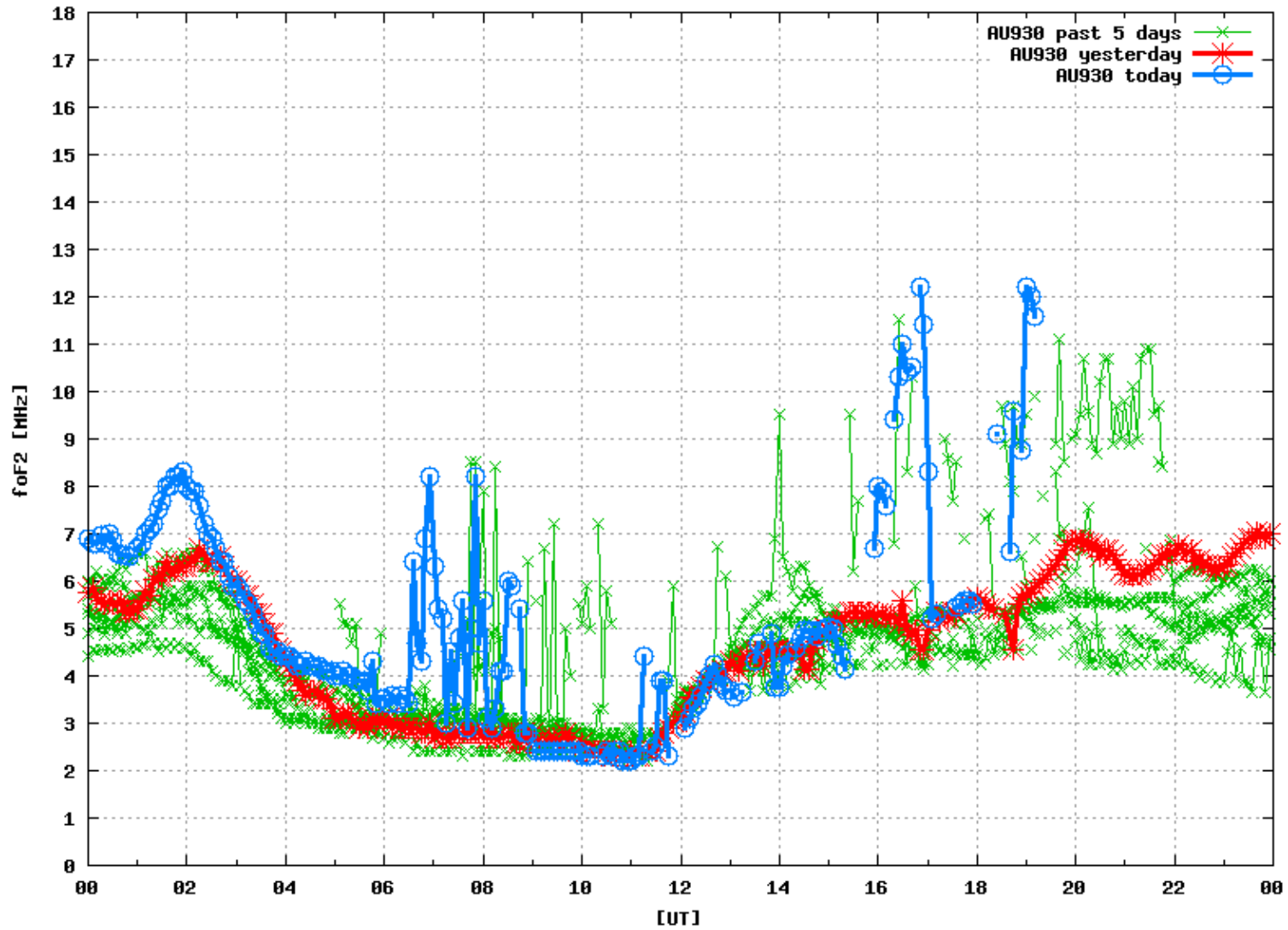
# Sporadic-E Propagation



# Blanketing Sporadic-E

foF2 plot for station AUSTIN (AU930) at 2017-08-04 19:15:02 UTC

NOAA National Geophysical Data Center

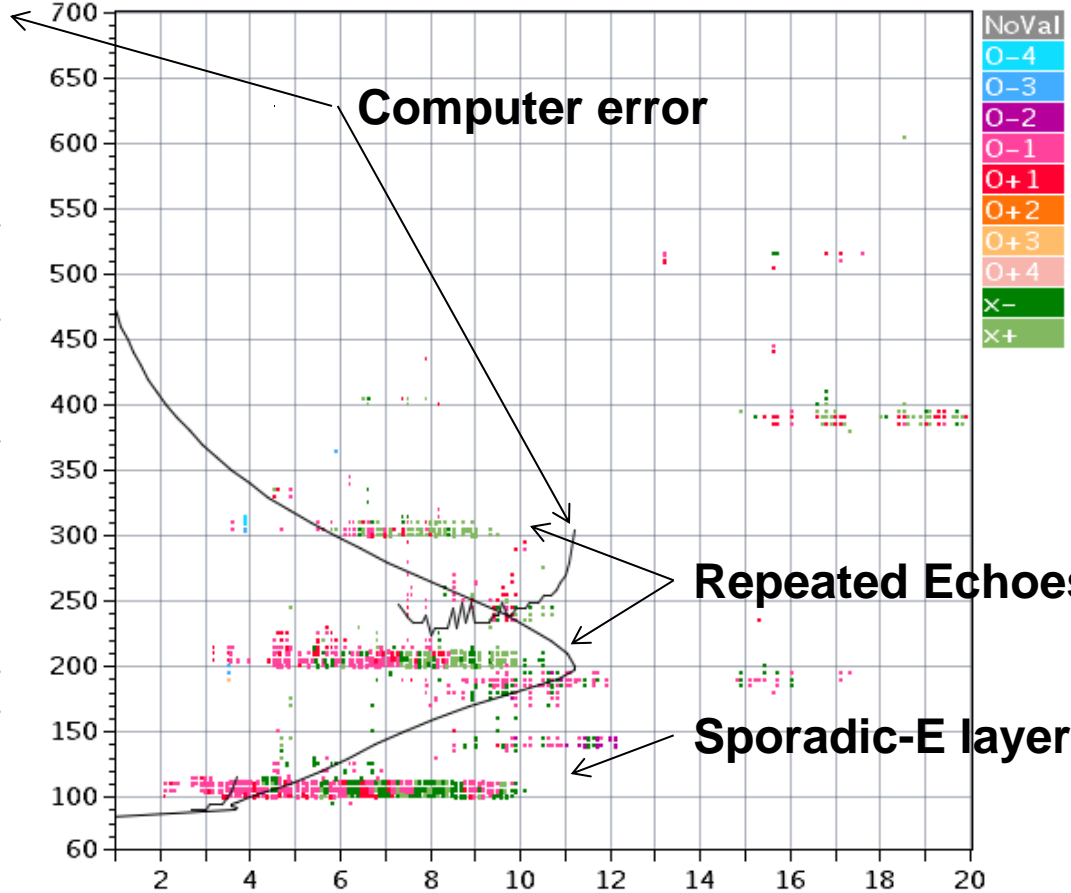


# Ionogram During Sporadic-E



Statio YYYY DAY DDD HMMSS P1 FFS S AXN PPS IGA PS  
 Austin 2017 Aug04 216 193005 MMM 1 045 100 32+ A1

foF2	11.200
foF1	N/A
foFlp	4.58
foE	3.72
foEp	3.40
fxI	11.80
foEs	9.50
fmin	2.70
<hr/>	
MUF(D)	42.79
M(D)	3.82
D	3000.0
<hr/>	
h`F	224.0
h`F2	N/A
h`E	90.0
h`Es	85.0
<hr/>	
hmF2	197.8
hmF1	N/A
hmE	91.6
yF2	48.9
yF1	N/A
yE	8.2
B0	72.3
B1	1.02
<hr/>	
C-level	51
<hr/>	
Auto:	
Artist4.5	
200311	



D 100 200 400 600 800 1000 1500 3000 [km]  
 MUF 11.8 12.0 12.7 13.9 15.5 17.9 24.7 42.8 [MHz]

AU930\_2017216193005.MMM / 190fx128h 100 kHz 5.0 km / DGS-256 AU930 130 / 30.4 N 262.3 E

Ion2Png v. 1.3.11

# Return of F2 Layer Reflection



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS  
 AUSTIN 2013 Aug28 240 120005 MMM 1 045 100 36+ 11

foF2 4.100  
 foF1 N/A  
 foF1p N/A  
 foE N/A  
 foEp 1.19  
 fxI 4.80  
 foEs 7.50  
 fmin 1.70

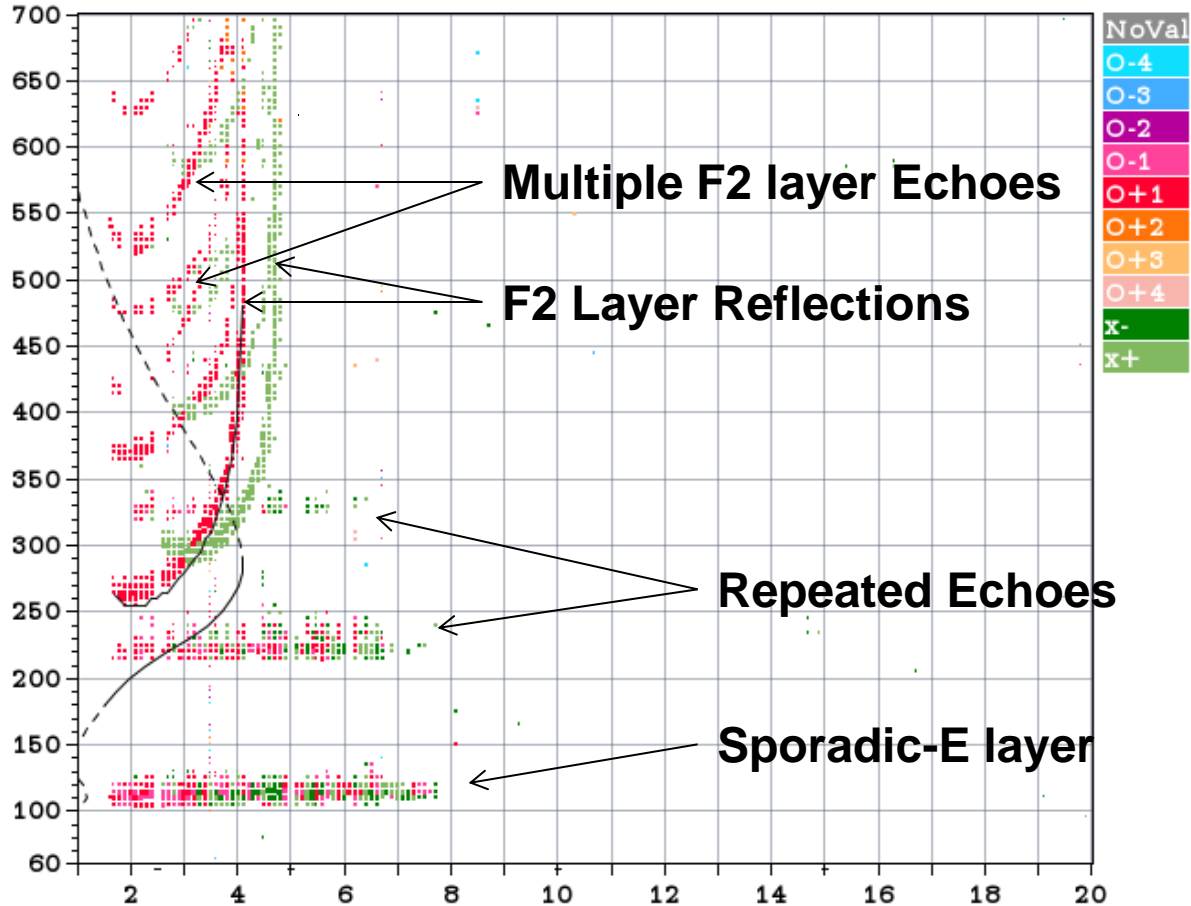
MUF(D) 12.79  
 M(D) 3.12  
 D 3000.0

h`F 255.0  
 h`F2 N/A  
 h`E N/A  
 h`Es 104.0

hmF2 285.3  
 hmF1 N/A  
 hmE 110.0  
 yF2 84.8  
 yF1 N/A  
 yE 20.0  
 B0 82.7  
 B1 2.55

C-level 11

Auto:  
 Artist4.5  
 200311

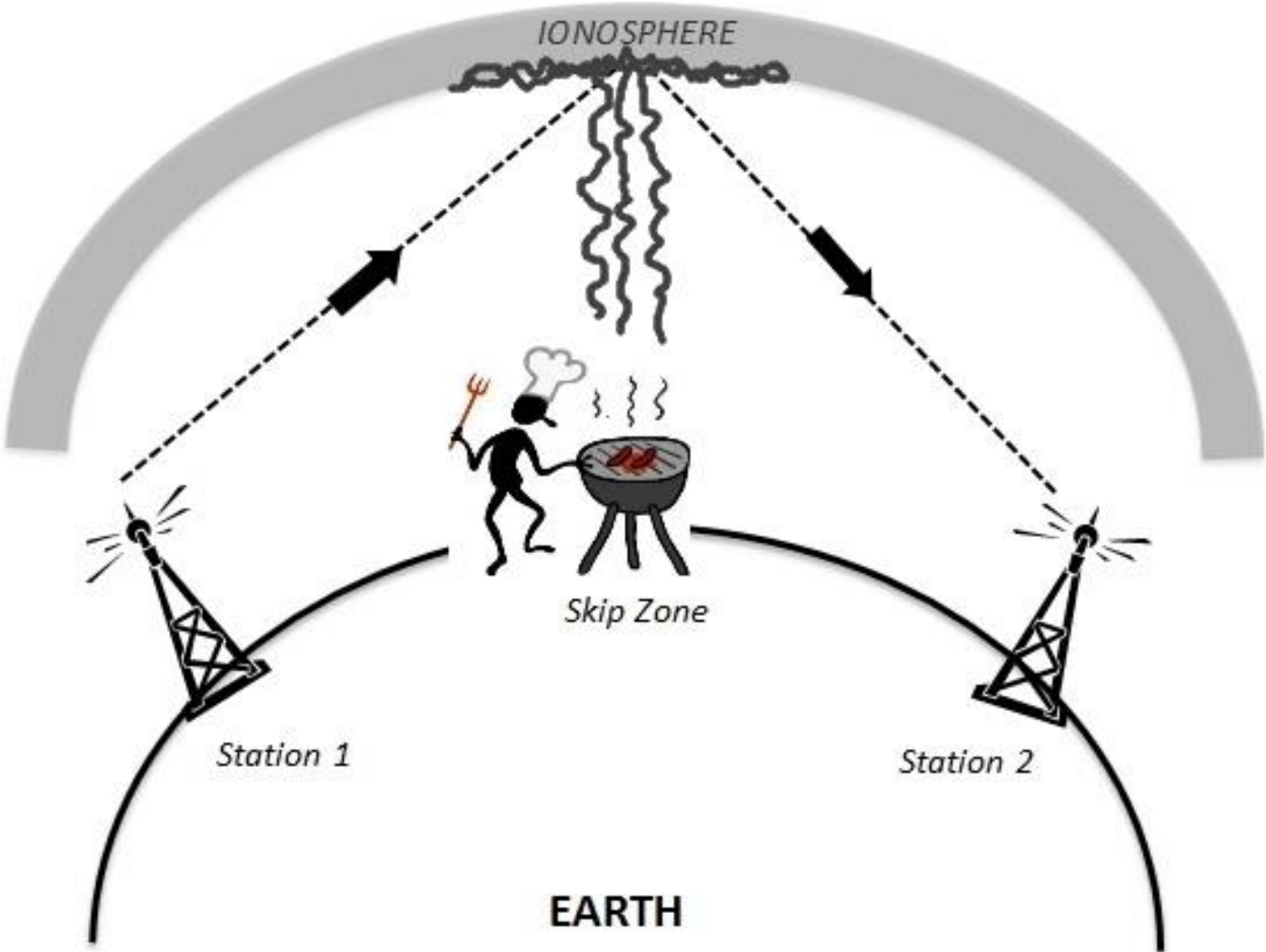


D 100 200 400 600 800 1000 1500 3000 [km]  
 MUF 4.7 4.7 4.9 5.2 5.7 6.3 8.1 12.8 [MHz]

53449763.tmp / 190fx128h 100 kHz 5.0 km / DGS-256 AU930 130 / 30.4 N 262.3 E

ShowIonogram v 1.0

# Formation of Sporadic E Propagation



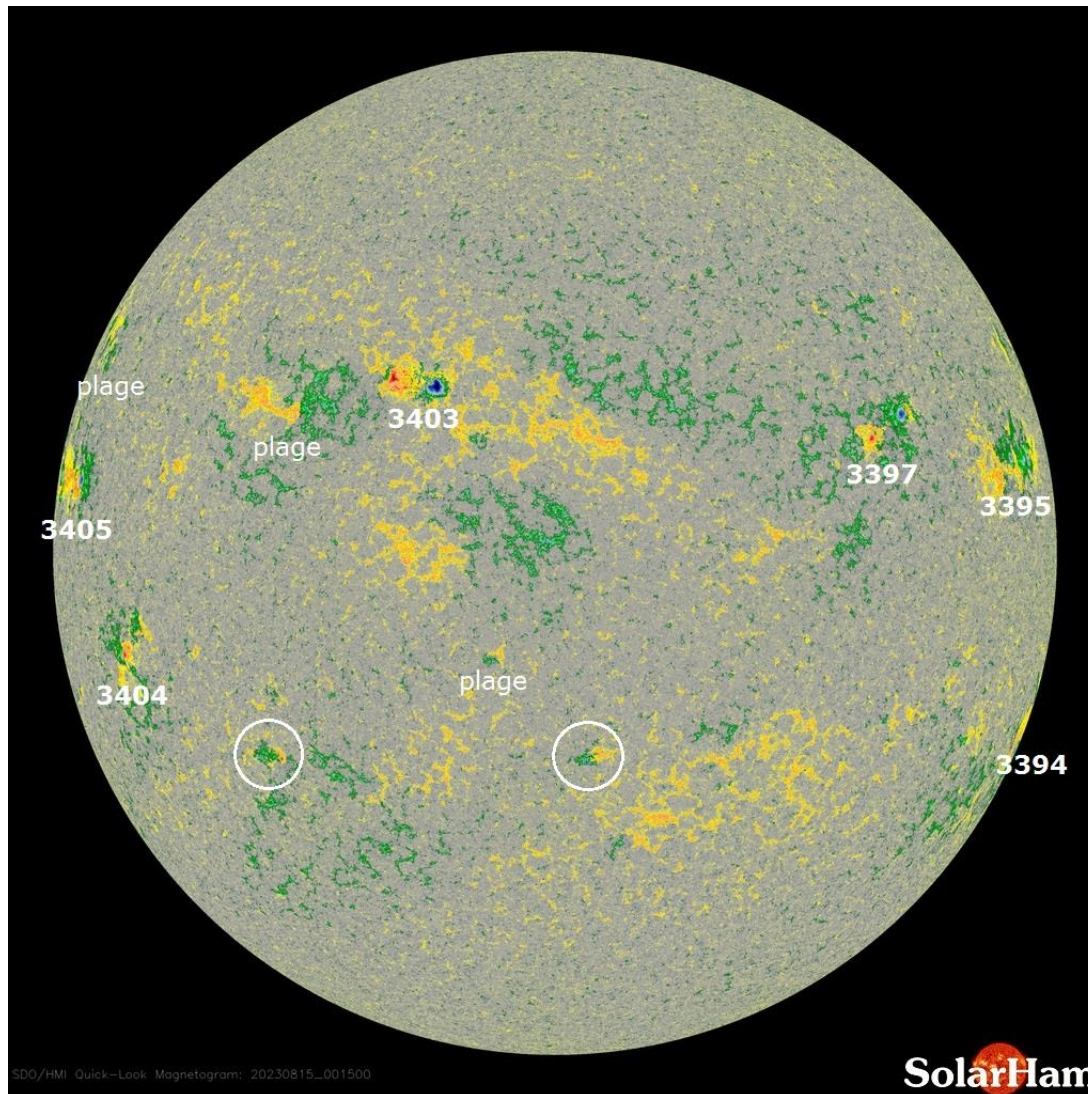
# Propagation Prediction

- Rules of Thumb for Critical Frequency:
  - 2 to 4 MHz at night
  - 4 to 8 MHz in daytime
- Propagation prediction programs (not good for NVIS)
  - **VOACAP** - <http://www.voacap.com/>
  - Web information:
    - <https://www.region6armymars.org/resources/solarweather.php>
    - <http://ulcar.uml.edu/DIDBase/>
  - International Beacons - <http://www.ncdxf.org/pages/beacons.html>
    - Beacon Monitor - <http://www.dxatlas.com/Faros/>

# OUTLINE

- Ionospheric propagation
  - NVIS
  - Long-Range
  - Frequency Selection (Critical Frequency & MUF)
  - Propagation modeling
- Solar Weather
  - Ionosphere (Solar Flux, Sun Spot Number)
  - Earth's Geomagnetic Field
  - Solar Flares
  - Proton Events
  - CME / Coronal Holes

# Sun Spot Activity – 15 AUG 2023



**This Magnetogram uses Zeeman effect to measure polarity of magnetic fields on the Sun.**

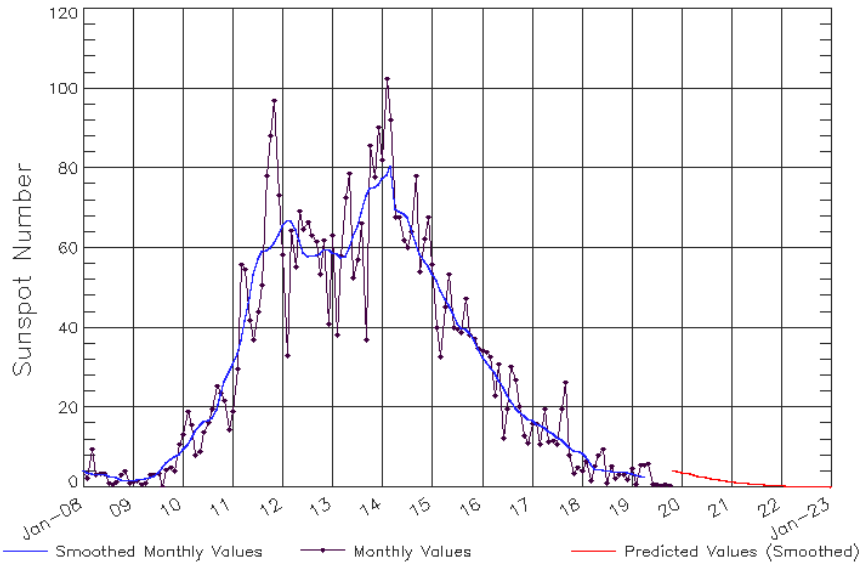


# Solar Ionization Indicators

- **Sun Spot Number (SSN)** (Wolf or Zurich)
  - Special count of # of visible sun spots
  - Varies from 0 to 200+
  - 11-year cycle
  - 12 month running average produces best “fit” with propagation conditions.
  - Increased SSN leads to higher MUF
- **Solar Flux (SF)**
  - Measure of solar radio noise at 2800 MHz (10.7 cm)
  - Varies from 50 to 300
  - Increased SF leads to higher MUF
  - 11-year cycle
  - Does not exactly track propagation conditions

# SSN & Solar Flux

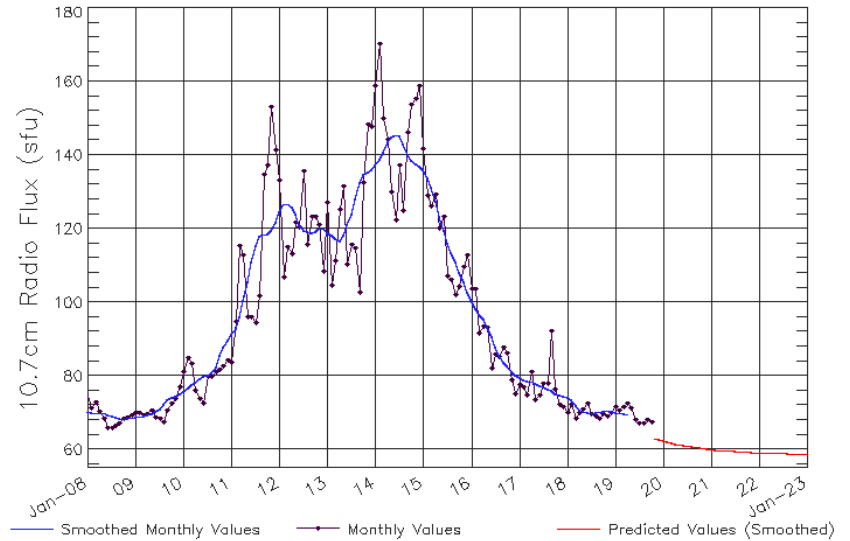
ISES Solar Cycle Sunspot Number Progression  
Observed data through Oct 2019



Updated 2019 Nov 4

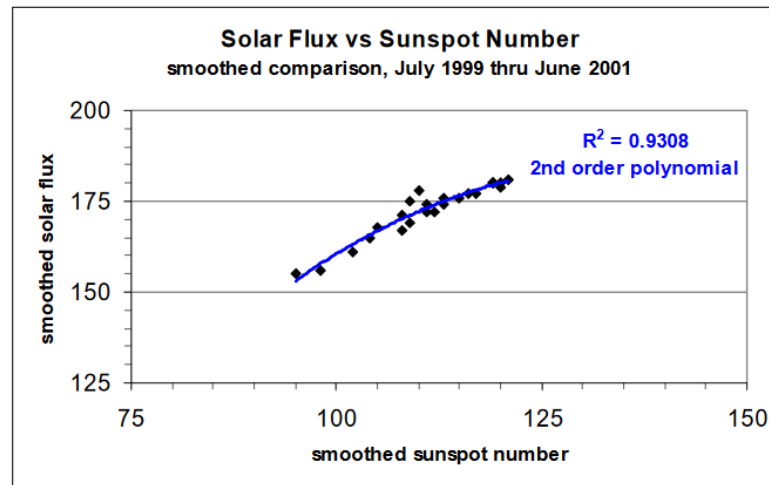
NOAA/SWPC Boulder, CO USA

ISES Solar Cycle F10.7cm Radio Flux Progression  
Observed data through Oct 2019



Updated 2019 Nov 4

NOAA/SWPC Boulder, CO USA



# Sunspot Number

**Visual count of Sunspots by observers:**

$$R = (10 \cdot G + S) \cdot K$$

Where:

R = the sunspot number

G = the number of sunspot groups  
observed

S = the count of all sunspots in all groups

K = a scaling number to compensate for  
variables

Until 1980, traditionally, the sunspot number was essentially the Wolf number provided by the Zürich observatory, with some cross-validation relative to a network of supporting stations.

Since 1981, in Brussels, it was decided to derive the daily sunspot number from an average of all observations from a large worldwide network.

# Sun Spot Analysis – 14 AUG 2023

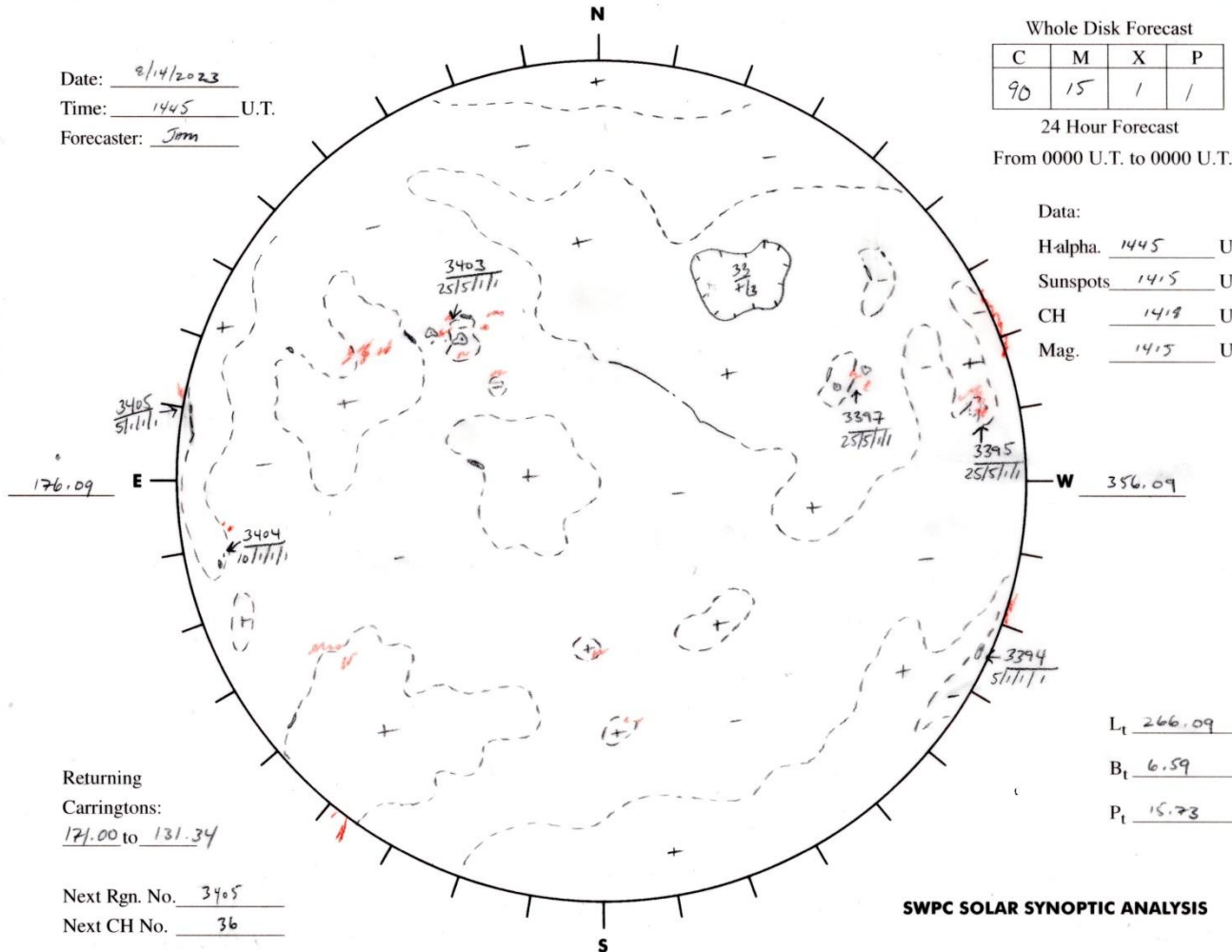
Date: 8/14/2023  
 Time: 1445 U.T.  
 Forecaster: Jimm

Whole Disk Forecast

C	M	X	P
90	15	1	1

24 Hour Forecast  
 From 0000 U.T. to 0000 U.T.

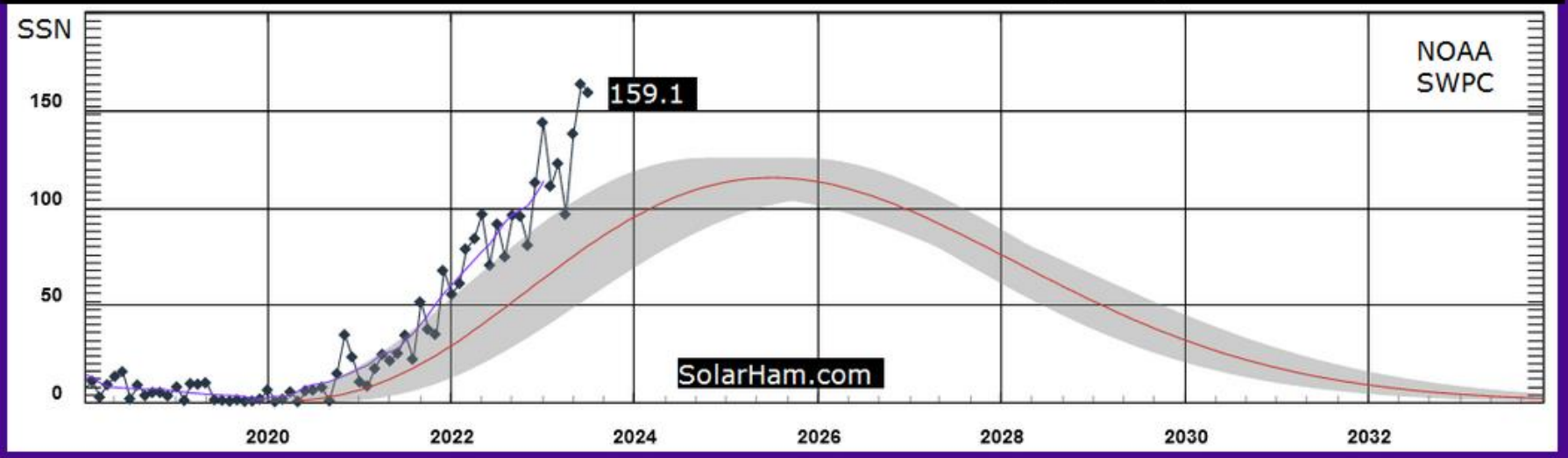
Data:  
 H-alpha. 1445 U.T.  
 Sunspots 1415 U.T.  
 CH 1418 U.T.  
 Mag. 1415 U.T.



# Sun Spot Number Progress

Sunspot Number Progression (July 2023)

Predicted SSN: 80.6    Actual: 159.1    Latest Smoothed Predicted SSN (1/2023): 63.4    Actual: 113.3



# SOLAR FLUX MEASUREMENTS

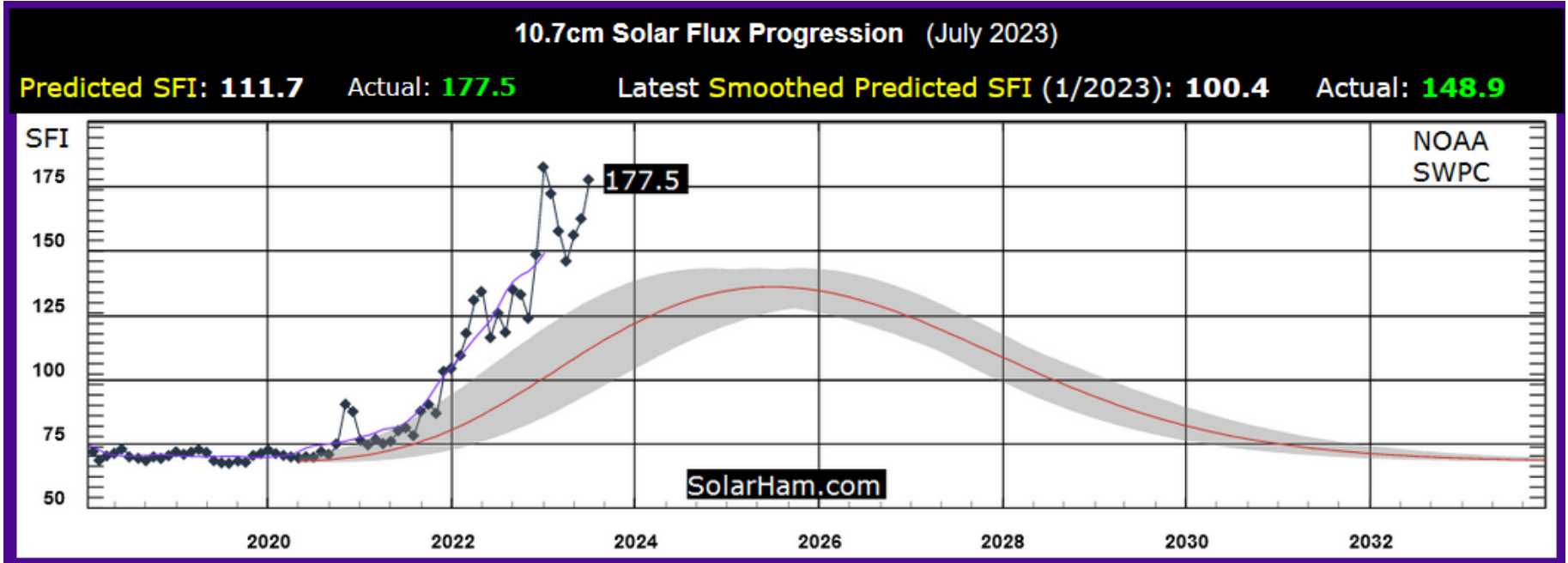
- The various manifestations of solar activity are driven by the total amount of magnetic flux emerging through the photosphere into the chromosphere and corona, and its temporal and spatial distribution. For reasons not clearly understood, solar activity ebbs and flows over a cycle of about 11 years. The 10.7cm Solar Flux is a measurement of the integrated emission at 10.7cm wavelength from all sources present on the disc. It is almost completely thermal in origin, and directly related to the total amount of plasma trapped in the magnetic fields overlying active regions. This in turn is related to the amount of magnetic flux. A comparison made over more than a solar activity cycle show that there is indeed a linear correlation between the 10.7cm Solar Flux and the total photospheric magnetic flux in active regions.
- The 10.7cm Solar Flux, i.e., the solar flux density at 10.7cm wavelength is measured using two fully automated radio telescopes (called *Flux Monitors*), located at the Dominion Radio Astrophysical Observatory.
- The two instruments record the strength of the solar radio emission at 10.7cm wavelength each day for as long as the Sun is above the horizon. In addition, the instruments interrupt the continuous monitoring each day to make three precise measurements of the solar flux density. These measurements constitute the 10.7cm Solar Flux index.

# Solar Flux Monitor at Dominion Radio Astrophysical Observatory

Kaleden, British Columbia, Canada

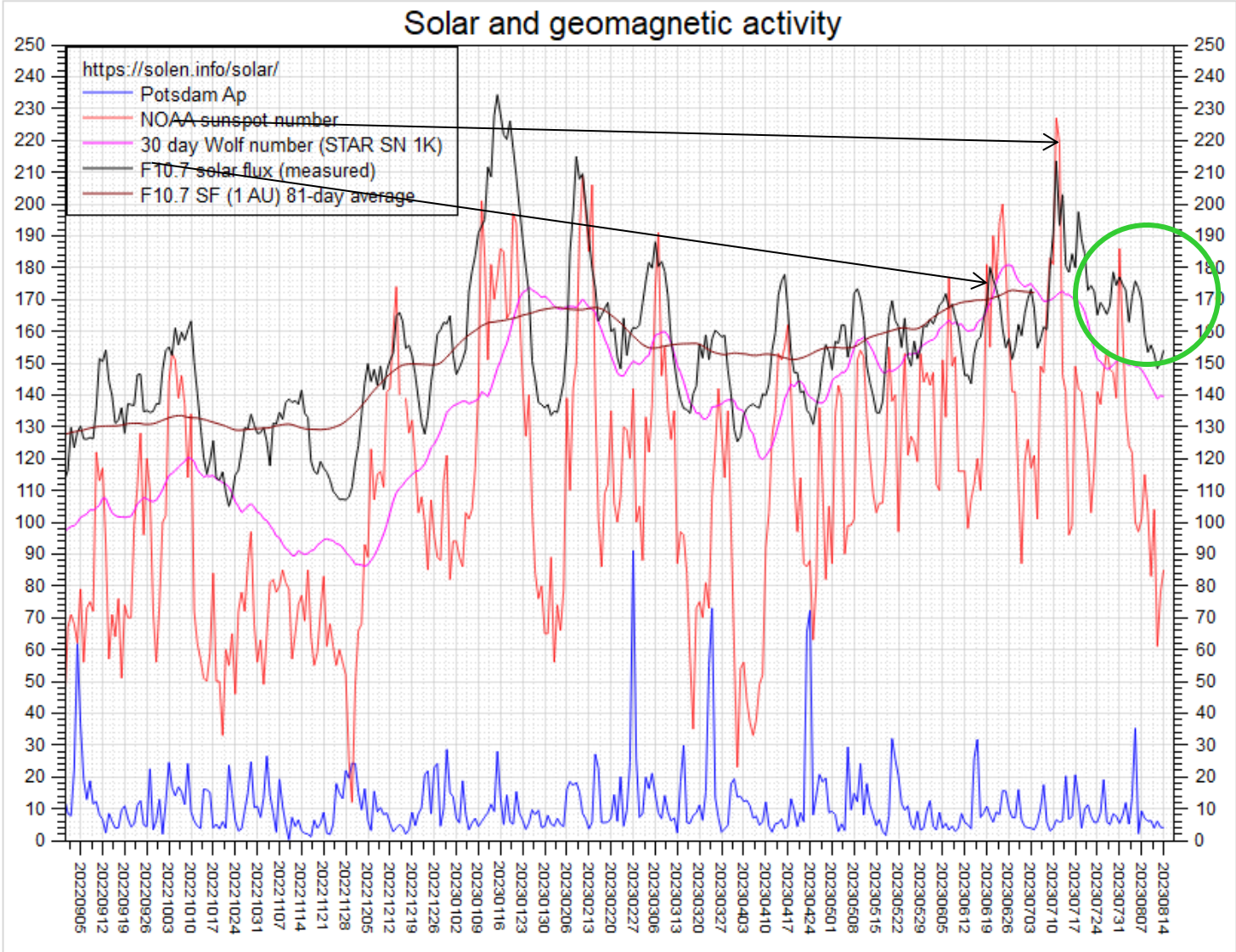


# Solar Flux





# SOLAR FLUX INDEX – 15 AUG 2023



# Geomagnetic Indicators

- Geomagnetic Indices
  - Measure of Earth's geomagnetic activity
  - Increased activity means worse propagation
  - K<sub>p</sub> : Planetary K index varies from 0 to 9 (3-hour average)
    - 0 to 1 – quiet conditions
    - 2 to 4 – some degradation to HF propagation
    - 5 to 6 – minor storm with further degradation to HF propagation
    - 6 to 9 – major storm leading to HF blackouts
  - A<sub>p</sub>: Planetary A index varies 0 to 400 (average of four K<sub>p</sub>)
    - Effectively yesterday's magnetic field variance

# Kp – Index Measurements

## K, Kp, and ap Indices

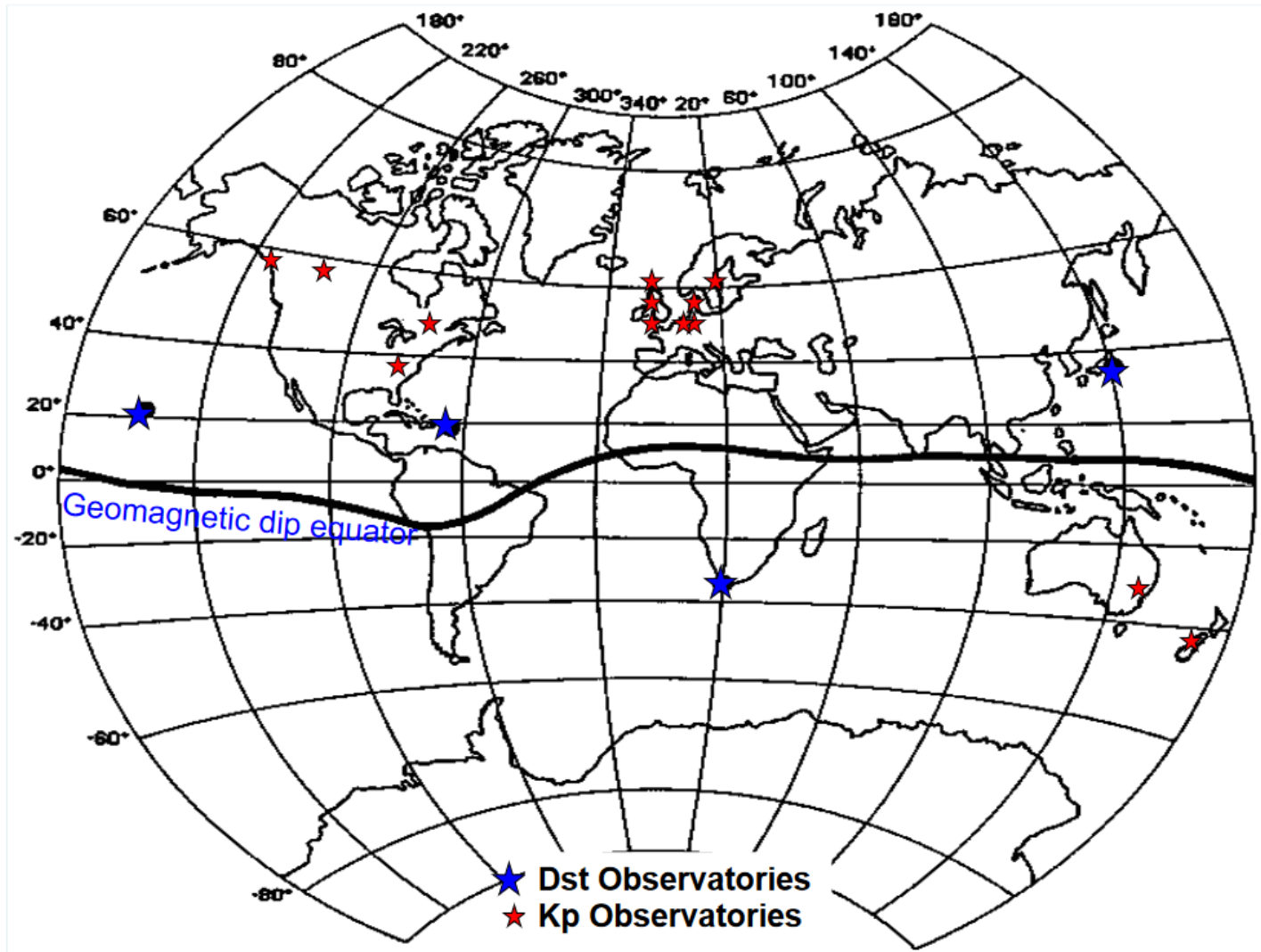
The **K-index** is quasi-logarithmic local index of the 3-hourly range in magnetic activity relative to an assumed quiet-day curve for a single geomagnetic observatory site. First introduced by J. Bartels in 1938, it consists of a single-digit 0 thru 9 for each 3-hour interval of the universal time day (UT).

The planetary 3-hour-range index **Kp** is the mean standardized K-index from 13 geomagnetic observatories between 44 degrees and 60 degrees northern or southern geomagnetic latitude. The scale is 0 to 9 expressed in thirds of a unit, e.g. 5- is 4 2/3, 5 is 5 and 5+ is 5 1/3. This planetary index is designed to measure solar particle radiation by its magnetic effects. The 3-hourly **ap** (equivalent range) index is derived from the Kp index as follows:

## The 13 Observatories used to compute official Kp listed in order of geomagnetic latitude

Observatory					Geographic		Geomagnetic		K=9
#	Code	Name	Location	Active	Lat.	Long.	Lat.*	Long.*	
1	LER	Lerwick	Scotland	1932-actual	60°08'	358°49'	62.0°	89.2°	1000 nT
2	MEA	Meanook	Canada	1932-actual	54°37'	246°40'	61.7°	305.7°	1500 nT
3	SIT	Sitka	Alaska (US)	1932-actual	57°03'	224°40'	60.4°	279.8°	1000 nT
4	ESK	Eskdalemuir	Scotland	1932-actual	55°19'	356°48'	57.9°	83.9°	750 nT
5	LOV	Lovö	Sweden	1954-2004	59°21'	17°50'	57.9°	106.5°	600 nT
	UPS	Uppsala	Sweden	2004-actual	59°54'	17°21'	58.5°	106.4°	600 nT
6	AGN	Agincourt	Canada	1932-1969	43°47'	280°44'	54.1°	350.5°	600 nT
	OTT	Ottawa	Canada	1969-actual	45°24'	284°27'	55.8°	355.0°	750 nT
7	RSV	Rude Skov	Denmark	1932-1984	55°51'	12°27'	55.5°	99.4°	600 nT
	BFE	Brorfelde	Denmark	1984-actual	55°37'	11°40'	55.4°	98.6°	600 nT
8	ABN	Abinger	England	1932-1957	51°11'	359°37'	53.4°	84.5°	500 nT
	HAD	Hartland	England	1957-actual	50°58'	355°31'	54.0°	80.2°	500 nT
9	WNG	Wingst	Germany	1938-actual	53°45'	9°04'	54.1°	95.1°	500 nT
10	WIT	Witteveen	Netherland	1932-1988	52°49'	6°40'	53.7°	92.3°	500 nT
	NGK	Niemegk	Germany	1988-actual	52°04'	12°41'	51.9°	97.7°	500 nT
11	CLH	Cheltenham	USA	1932-1957	38°42'	283°12'	49.1°	353.8°	500 nT
	FRD	Fredericksburg	USA	1957-actual	38°12'	282°38'	48.6°	353.1°	500 nT
12	TOO	Toolangi	Australia	1972-1981	-37°32'	145°28'	-45.6°	223.0°	500 nT
	CNB	Canberra	Australia	1981-actual	-35°18'	149°00'	-42.9°	226.8°	450 nT
13	AML	Amberley	New Zealand	1932-1978	-43°09'	172°43'	-46.9°	254.1°	500 nT
	EYR	Eyrewell	New Zealand	1978-actual	-43°25'	172°21'	-47.2°	253.8°	500 nT

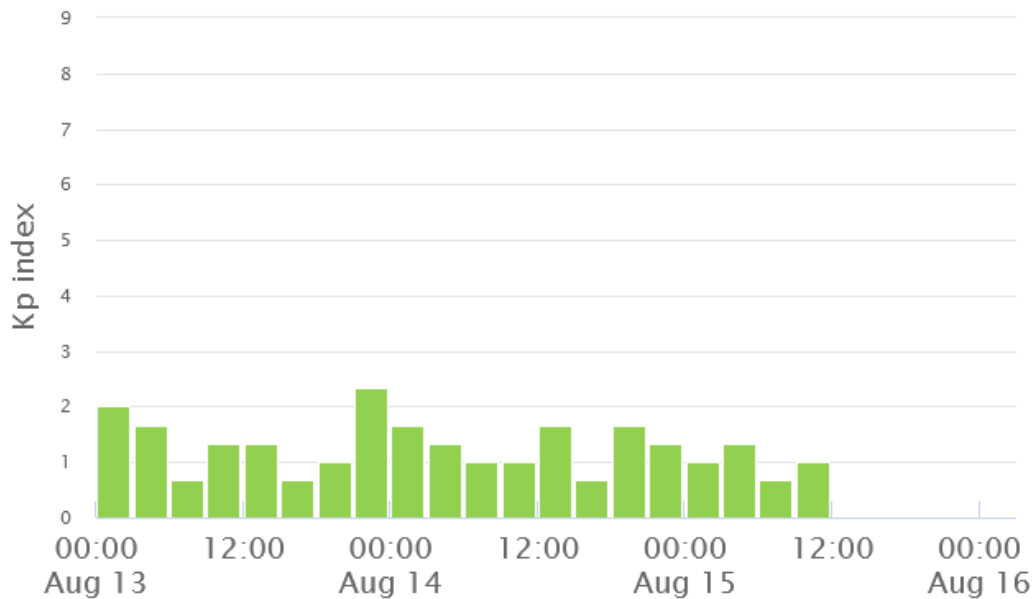
# Kp and Dst Observatories



# Planetary K index – 13-15 AUG 2023

Estimated Planetary K index (3 hour data)

Begin: Sun, 13 Aug 2023 00:00:00 GMT



Universal Time (captured @ 2023-08-15T12:36:16.607Z)

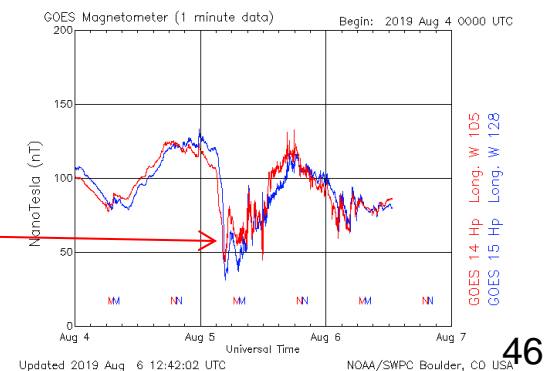
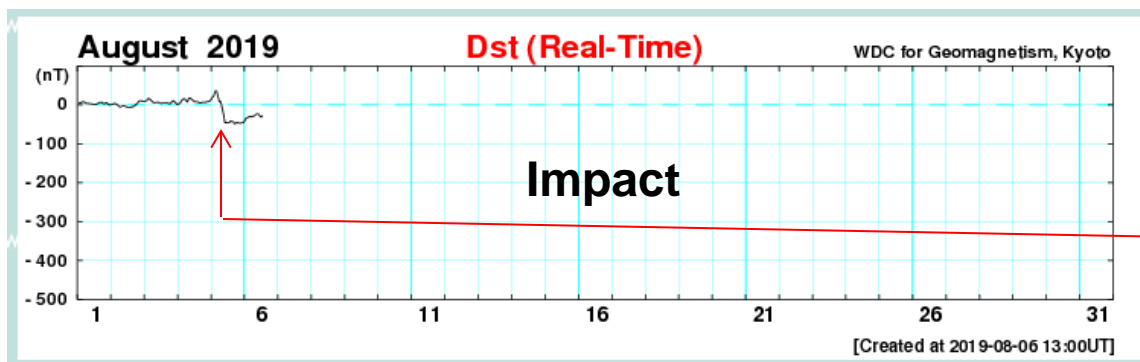
2023-08-15T12:36:16.607Z

Generally, as planetary K-Index rises, critical frequency is suppressed.

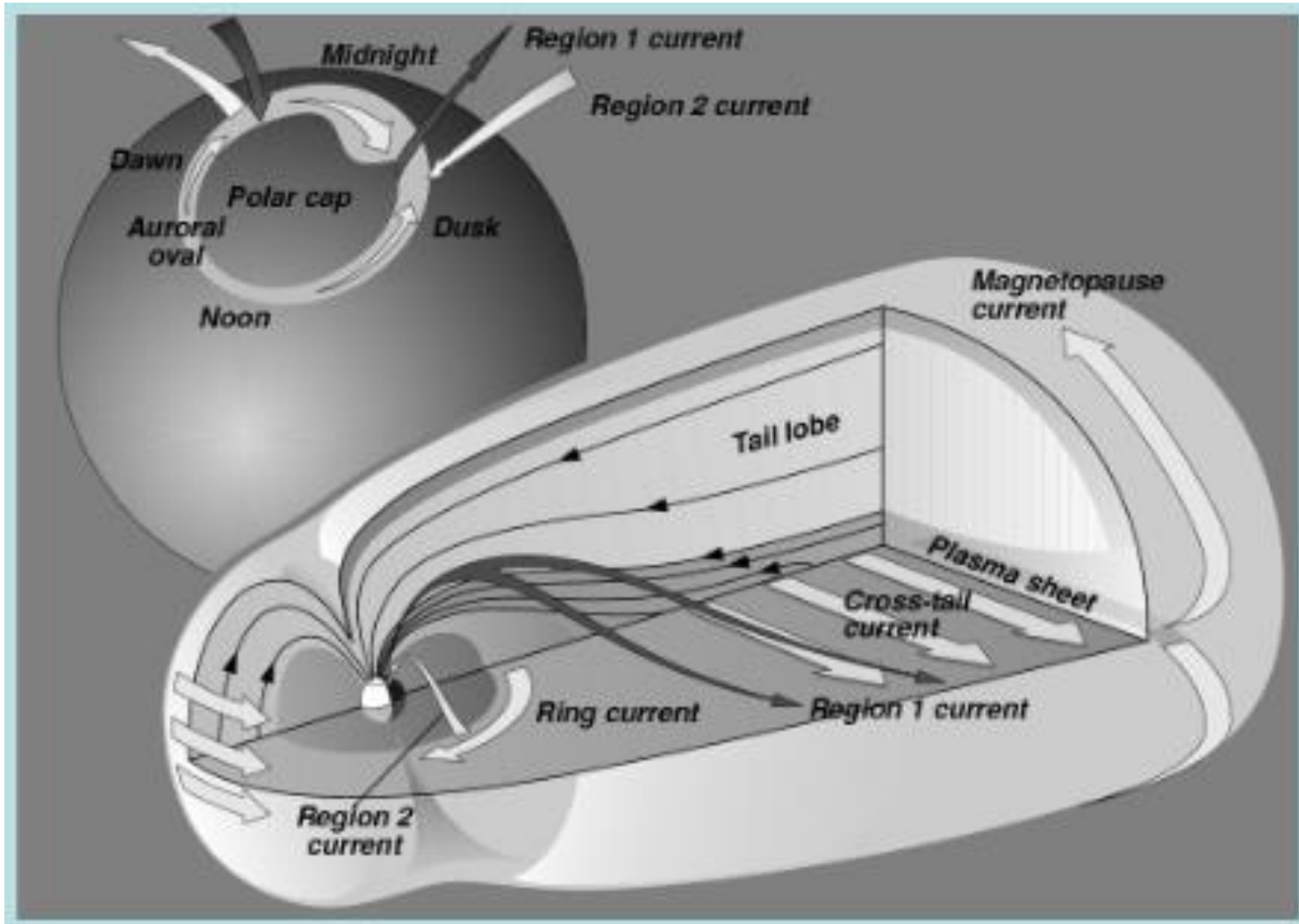
K-Index	Effect
0-2	Inactive/Quiet, no impact on HF
3-4	Unsettled/Active, minor HF fade in higher latitudes
5-6	HF fade at higher latitudes
7-8	HF sporadic
9	HF impossible above 40M

# Dst Definition

- The Dst (disturbance storm time) index provides a measure of the Earth's geomagnetic activity. It can be used to quantify the severity of magnetic storms.
- Dst, expressed in nanoteslas, is based on the average value of the horizontal component of the Earth's magnetic field measured hourly at four near-equatorial geomagnetic observatories.
- During a magnetic storm, the Dst shows a sudden rise, corresponding to the storm sudden commencement, and then decreases sharply as the ring current intensifies.
- Once the IMF turns northward again and the ring current begins to recover, the Dst begins a slow rise back to its quiet time level.



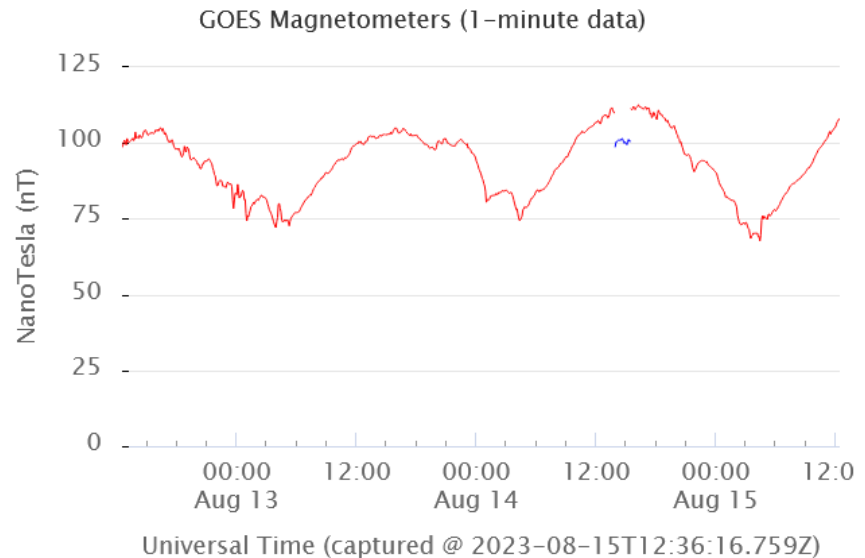
# Ring Current



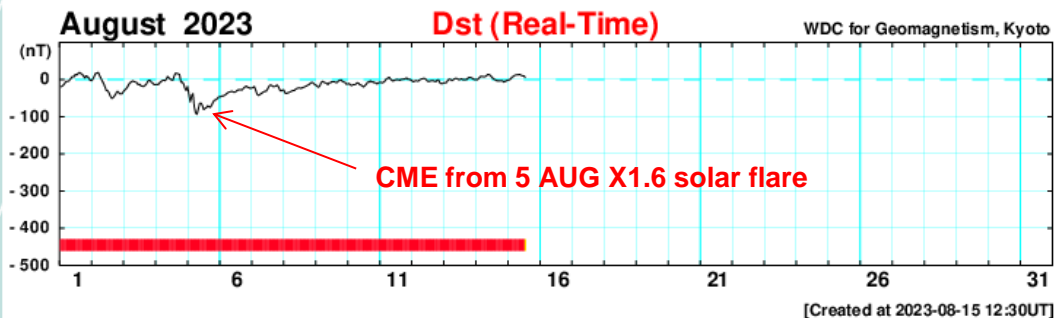
# Geomagnetic Conditions: 15 AUG 2023

**Solar wind:**  
**Bz = 2 nT North**  
**speed = 291 km/sec**  
**density = 2.54 protons/cm<sup>3</sup>**  
**(From – NOAA DSCOVR  
In L1, Lagrange Point)**

**Dst = -12 nT (Ring Field)**  
**(From – Data Analysis Center  
For Geomagnetism and Space  
Magnetism – Kyoto University)**



**From – GOES 16  
In geostationary orbit**





# SolarHam.org Forecast

## Solar Indices (August 15 @ 00:35 UTC)

SFI      SSN      AREA

**154**      **85**      **650**

▲ 4      ▼ 4      ▲ 190

[WWV](#) | [Flux Data](#) | [Last 30 Days](#)

Cycle 25 Progression

## 3 Day Geomagnetic Forecast

Aug 15      Aug 16      Aug 17

**2 (G0)**      **3-4 (G0)**      **3-4 (G0)**

Max Kp

M-Lat	05%	M-Lat	05%	M-Lat	10%
H-Lat	15%	H-Lat	25%	H-Lat	30%

Probabilities

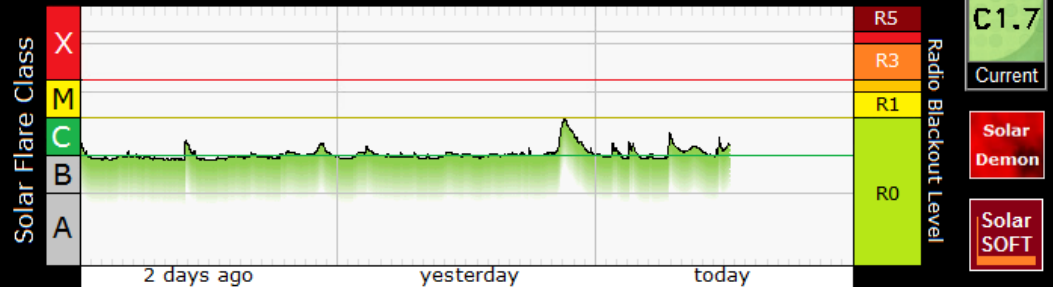
Detailed Forecast

## Solar Flare Detection

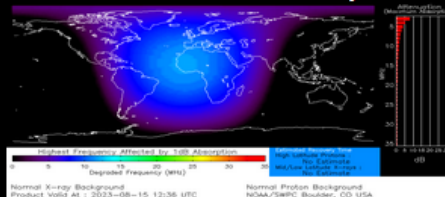
Data provided by NOAA/SWPC

GOES-16 X-Ray Flux

[Click to expand data](#)



## Global D-LAYER Absorption



## Current Solar Flare Threat

C-Flare: 90%      M-Flare: 15%  
X-Flare: 01%      Proton: 01%

[Probability Details](#)

Flare Events (M2+) Past 48 Hours | [Event Report](#) | [Top Solar Flares](#)

No noteworthy solar flares detected.

Visible Sunspot Regions | [Sunspot Summary](#) | [SRS \(txt\)](#)

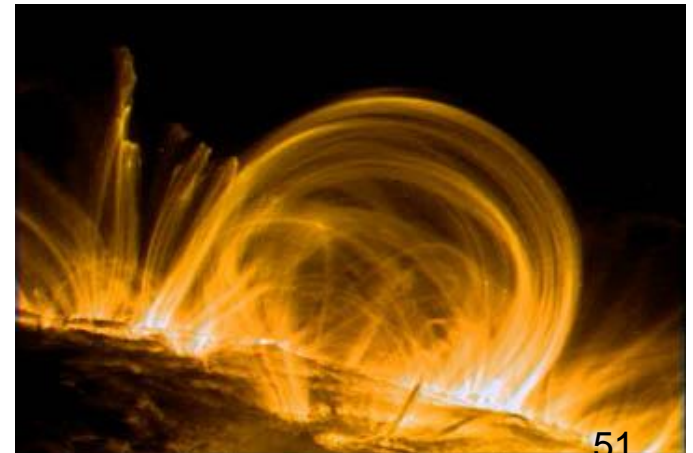
**3394** **3395** **3397** **3403** **3404** **3405**  
A      B      B      B      A      A

# SOLAR EFFECTS ON PROPAGATION

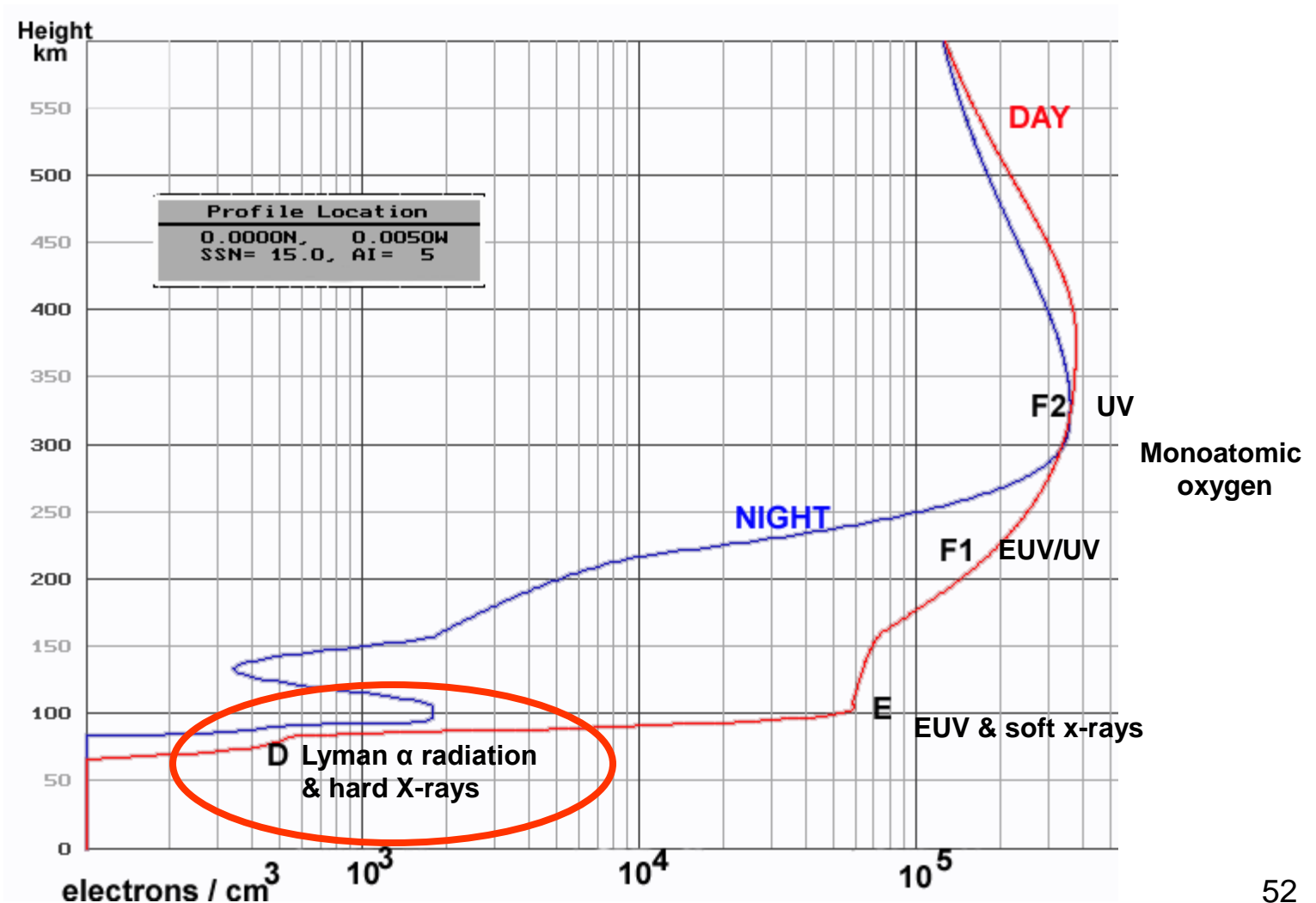
- Ultraviolet Radiation – Good
- X-Ray Radiation from Solar Flares – Bad
- Proton Events - Bad
- Corona Mass Ejections – Bad
- Coronal Holes – Bad

# SOLAR FLARES (X-Rays)

- Radio Blackouts (8 minute arrival)
  - M or X class solar flare releasing X-rays
  - SID (Sudden Ionospheric Disturbance)
  - Caused by Extreme D-layer absorption
  - Day time effect

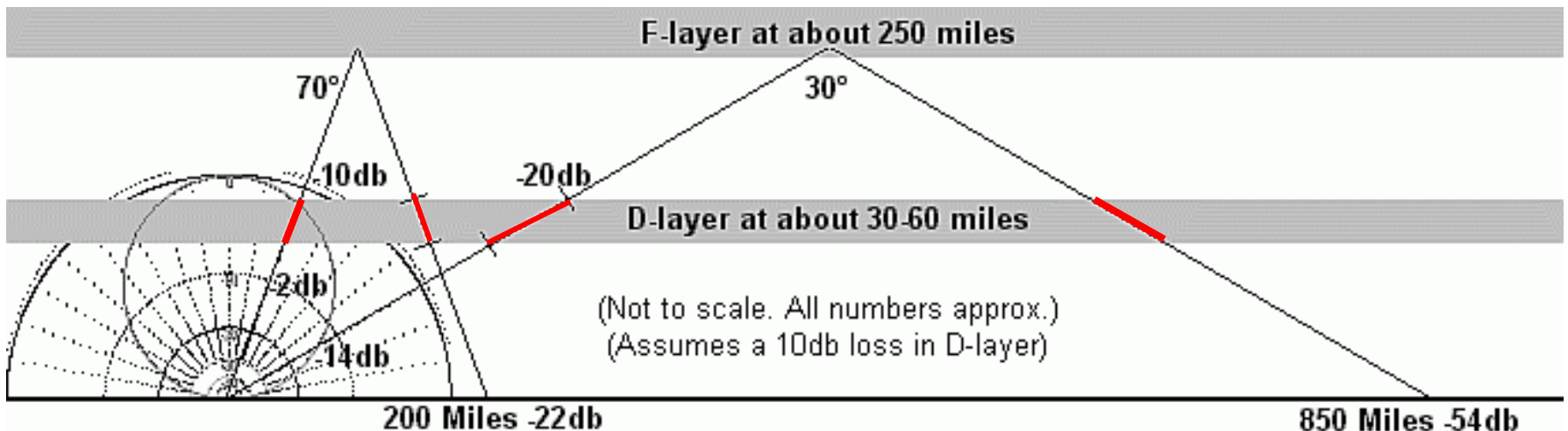


# D-Layer Absorption



# D-Layer Absorption

- Day-time effect
- Absorption is a function of  $1/f^2$
- Can sometimes be compensated by power or bandwidth reduction



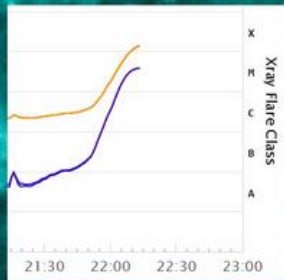
# X1.6 Solar Flare – 5 AUG

## X-Flare!

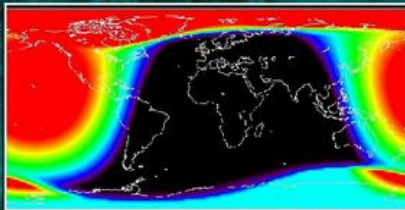
August 5, 2023 @ 22:20 UTC

A strong X1.6 solar flare (R3 Level Radio Blackout) was just observed around AR 3386 approaching the west limb. The flare itself was long in duration with a peak flux at 22:21 UTC. Early indications are that a coronal mass ejection (CME) will be associated with this event. Due to the location towards the west limb, most of the ejected material should be directed away from our planet. Coronagraph imagery will be required to determine if a glancing blow will be possible. This is the fifth strongest solar flare of the current cycle in terms of peak X-Ray flux.

**X1.6 Solar Flare (AR 3386)**  
8/5/2023 @ 22:21 UTC

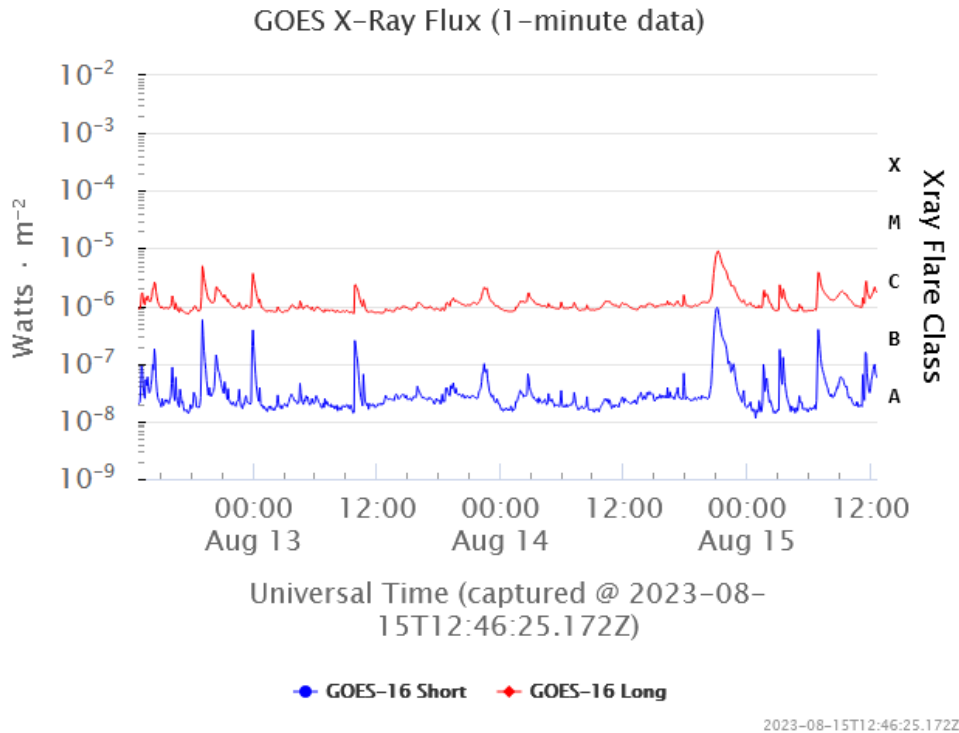


Strong (R3 Level) Radio Blackout



SDO/AIA/SolarHam.com

# Solar X-Ray Flux 13–15 AUG 2023

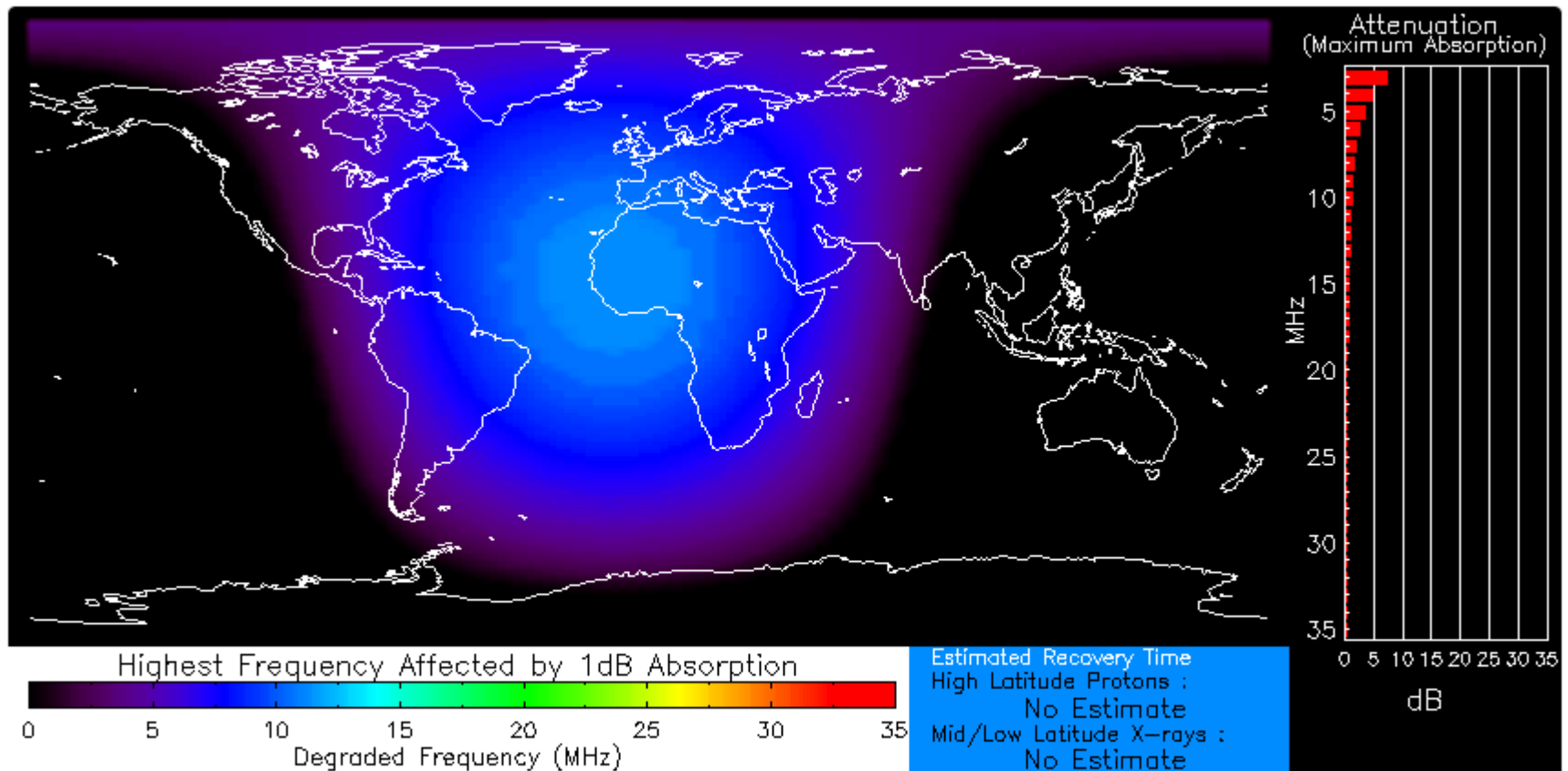


The X-ray radiation that ionizes the D-layer is the 1.0 - 8.0 Å (red) plot. These measurements currently taken from the [GOES 16](#) satellite.

Flare Category	Effect
A1-B9	No or minor impact on HF
C1	Low absorption of HF signals
M1	Occasional loss of radio contact on sun-lit side
M5	Limited HF blackout for several minutes
X1	Wide area HF blackout for approx. 1 hr
X10	HF blackout over most of sun-lit side for 1-2 hrs
X20	Complete HF blackout of all sun-lit areas lasting hours

# D-Region Absorption – 15 AUG

## UNUSUAL D-REGION ABSORPTION PATTERNS

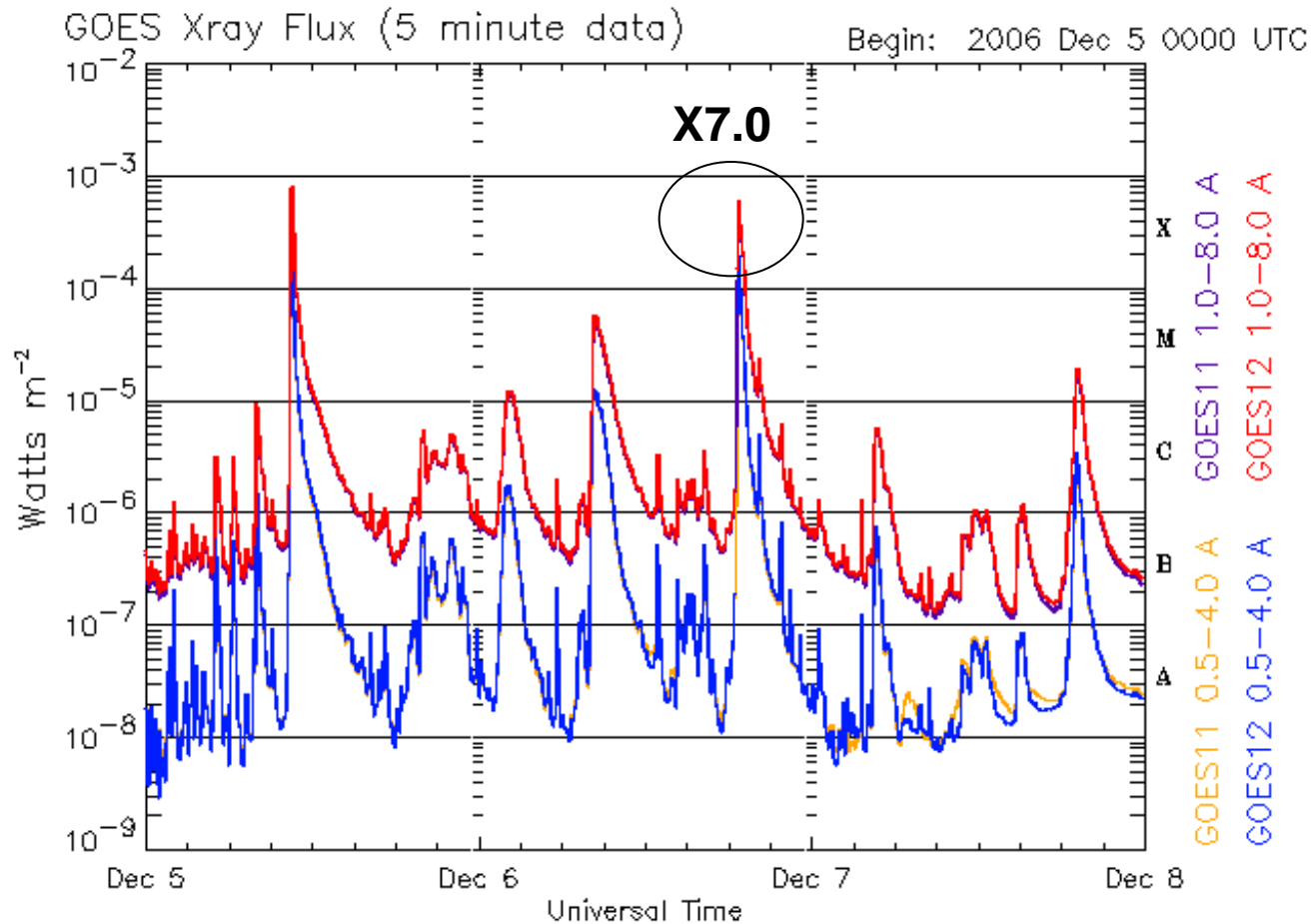


Normal X-ray Background  
Product Valid At : 2023-08-15 12:42 UTC

Normal Proton Background  
NOAA/SWPC Boulder, CO USA



# GOES X-Ray Flux (5-7 DEC 2006)

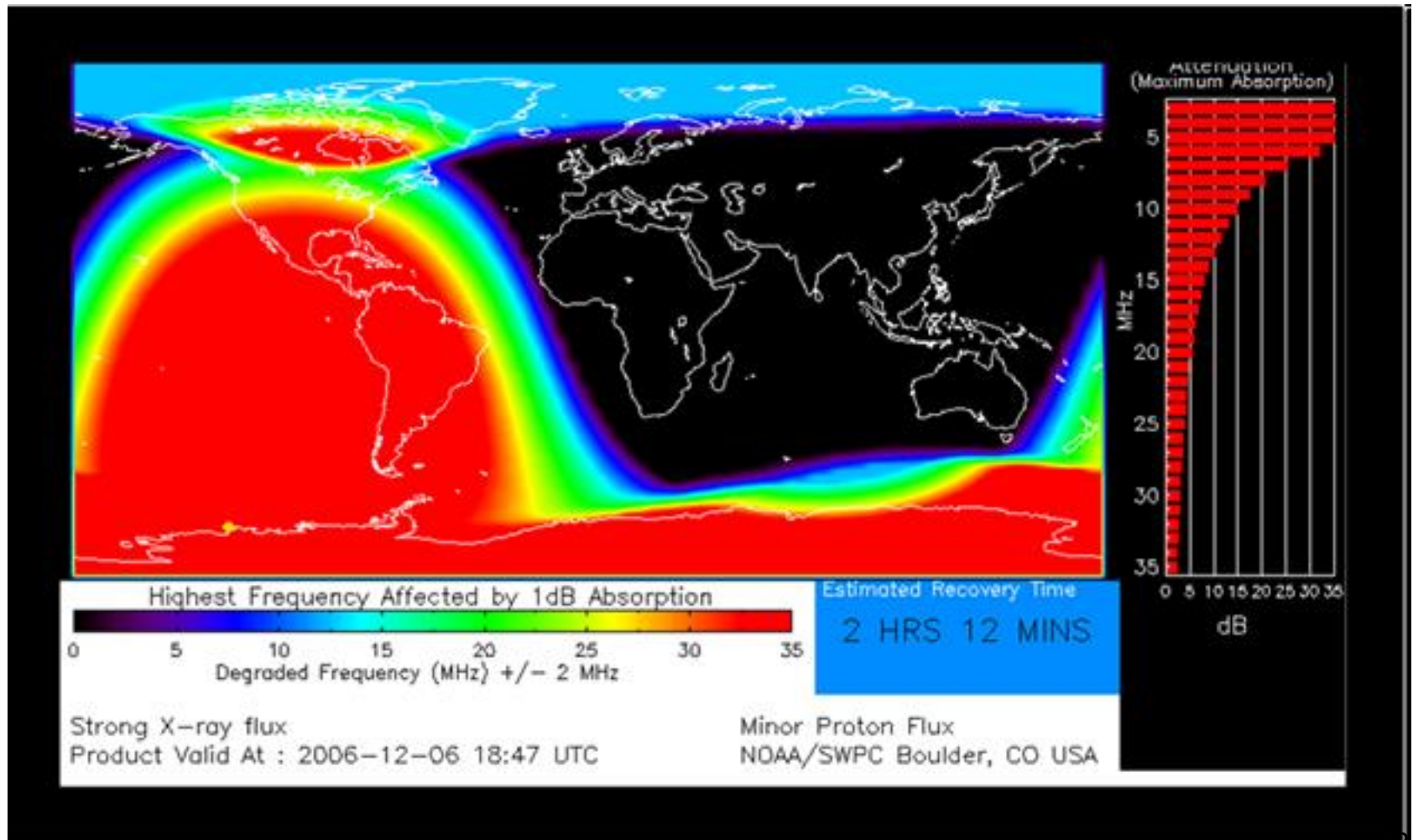


Updated 2008 Dec 7 23:58:08 UTC

NOAA/SEC Boulder, CO USA

# D-Absorption Prediction

(<http://www.ngdc.noaa.gov/stp/drap/index.html>)

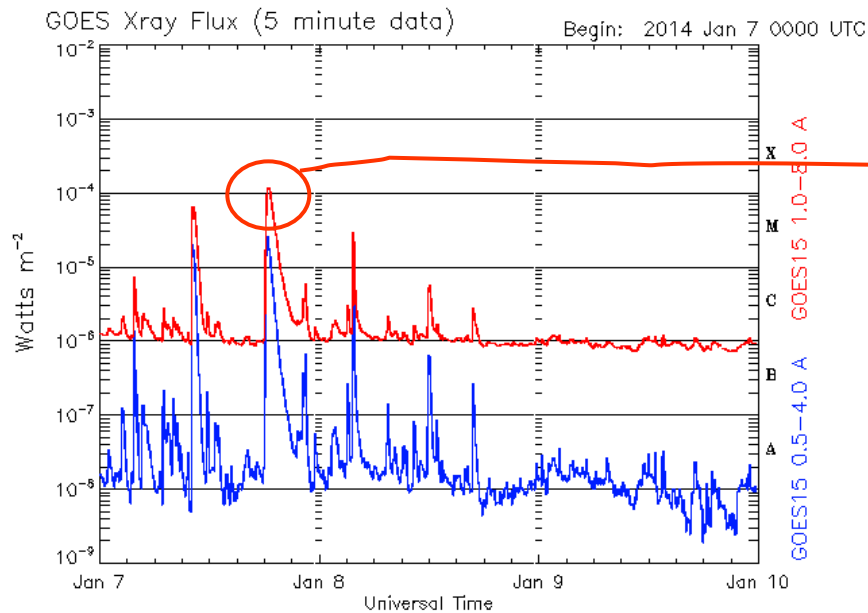


# SOLAR EFFECTS ON PROPAGATION

- Ultraviolet Radiation – Good
- X-Ray Radiation from Solar Flares – Bad
- Proton Events – Bad for high Latitudes
- Corona Mass Ejections – Bad
- Coronal Holes – Bad

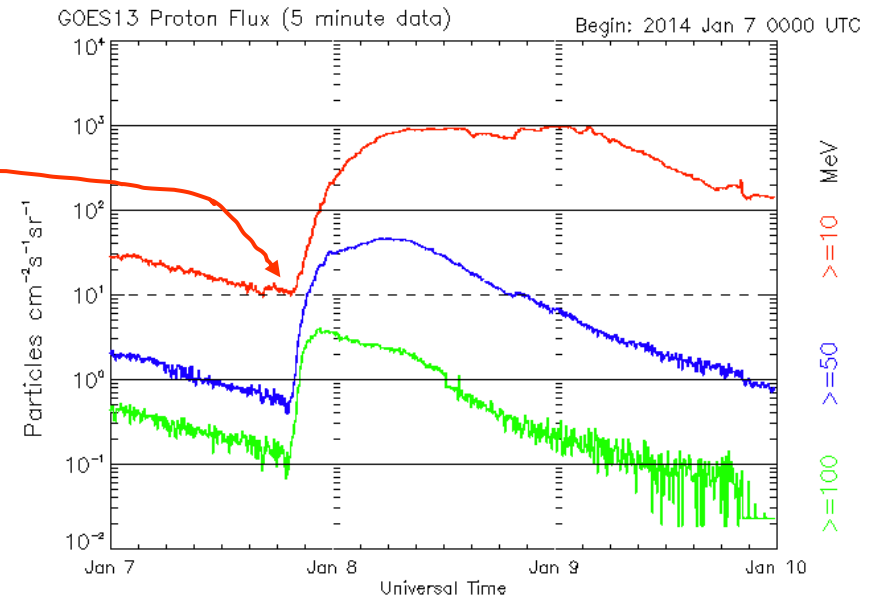
# Proton Events

- Solar Radiation Storms (4 hours arrival after solar flare)
  - Caused by High energy Protons
  - Results in a PCA (Polar Cap Absorption)



Updated 2014 Jan 9 23:55:12 UTC

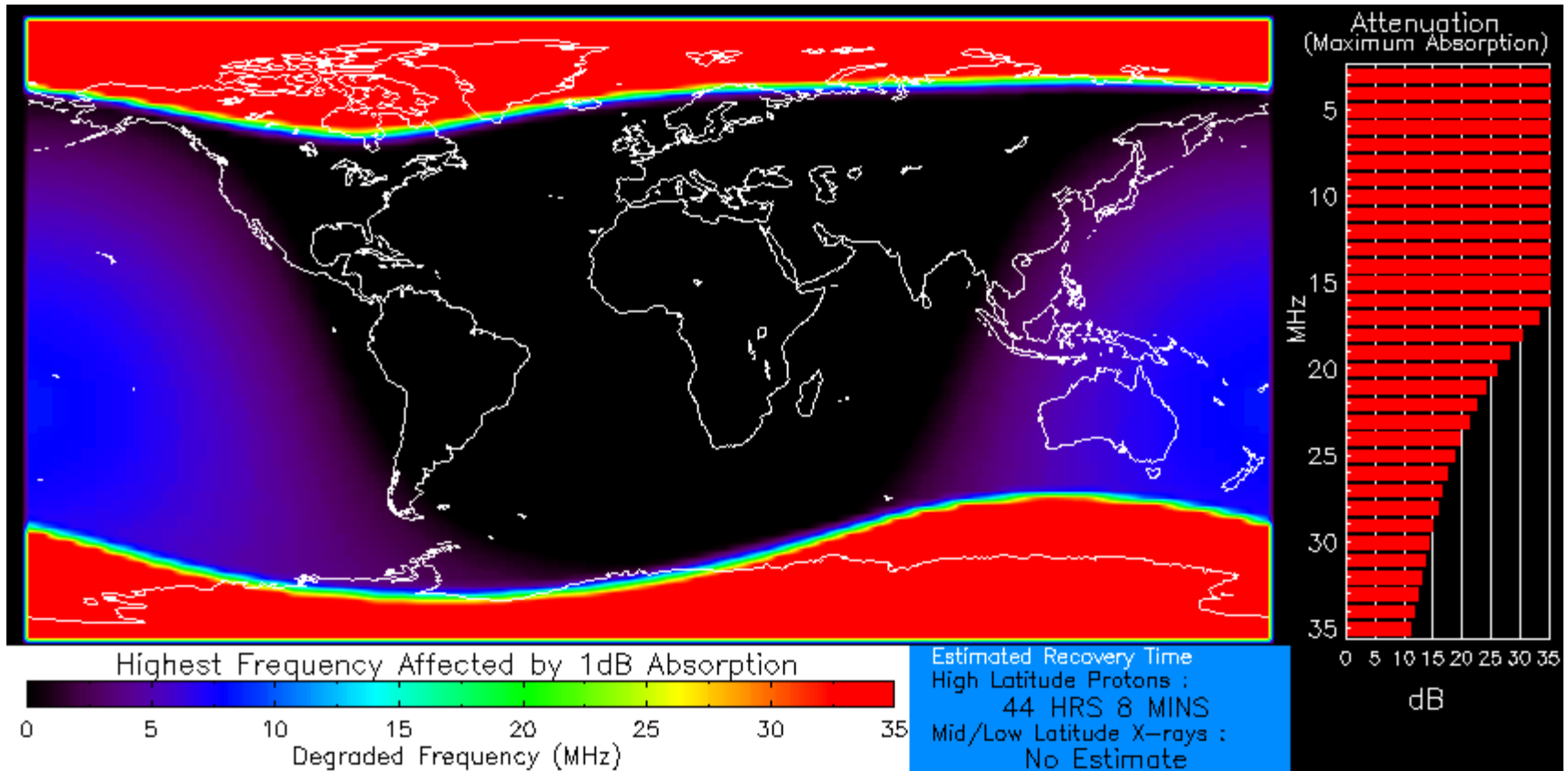
NOAA/SWPC Boulder, CO USA



Updated 2014 Jan 9 23:56:02 UTC

NOAA/SWPC Boulder, CO USA

# Proton Event (D-Layer Absorption)



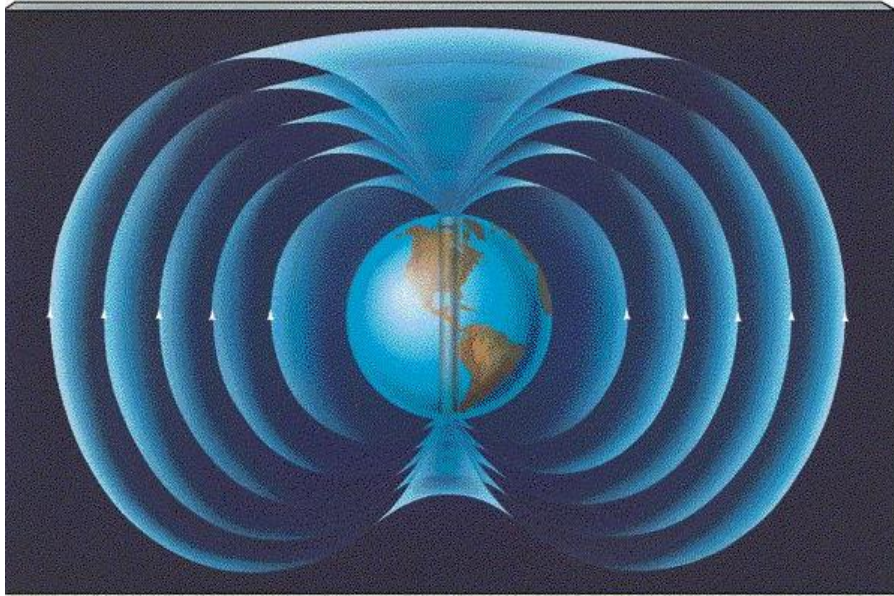
Normal X-ray Background  
 Product Valid At : 2014-01-09 00:00 UTC

Moderate Proton Flux  
 NOAA/SWPC Boulder, CO USA

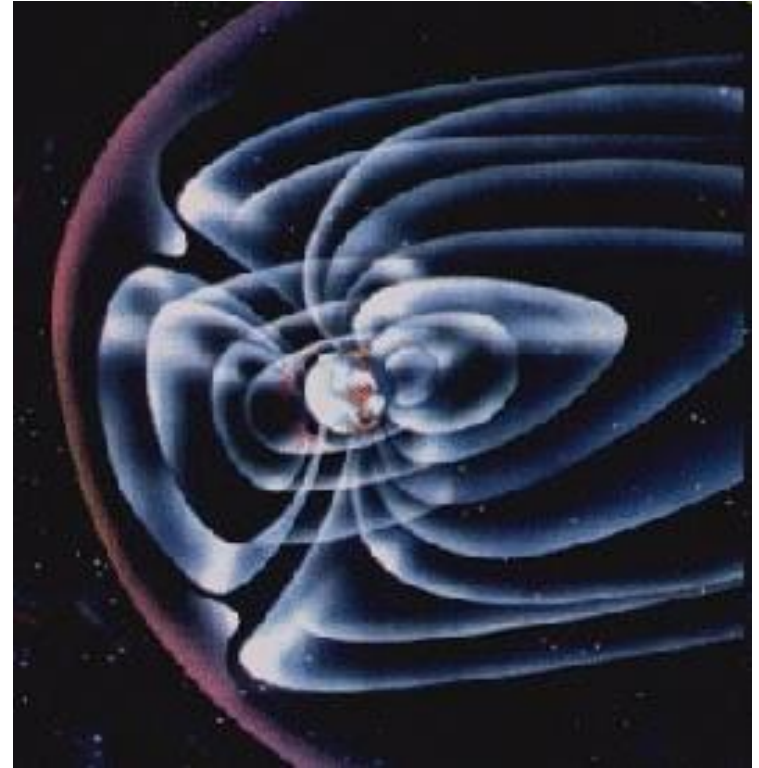
# SOLAR EFFECTS ON PROPAGATION

- Ultraviolet Radiation – Good
- X-Ray Radiation from Solar Flares – Bad
- Proton Events - Bad
- Corona Mass Ejections – Bad
- Coronal Holes – Bad

# EARTH'S MAGNETIC FIELD



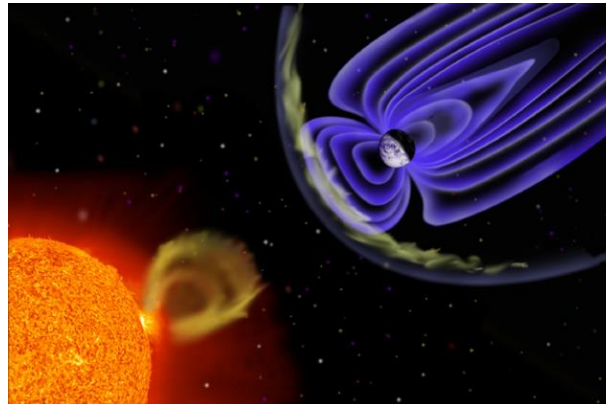
**Without Solar Wind**



**Actual Magnetic Field  
With Solar Wind**

# Coronal Mass Ejections

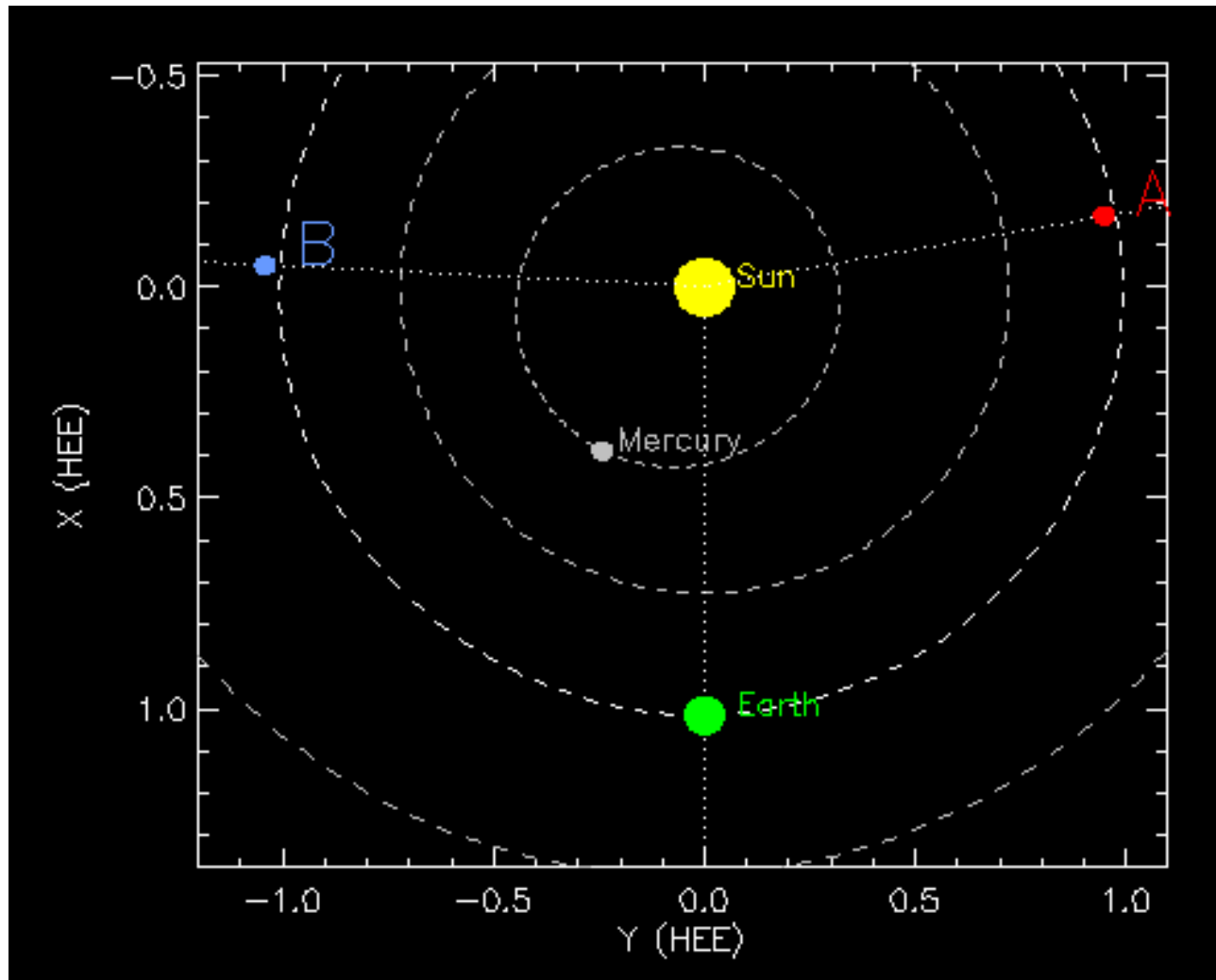
- Geomagnetic Storm causing Ionospheric Storm (1-3 day)  
Caused by CME (Corona Mass Ejection) or Coronal Hole
  - Depressed MUF and increased D absorption
  - Indicated by increased K and A indices
  - Severity of effects function of polarity of Bz
    - Bz South – more severe effects



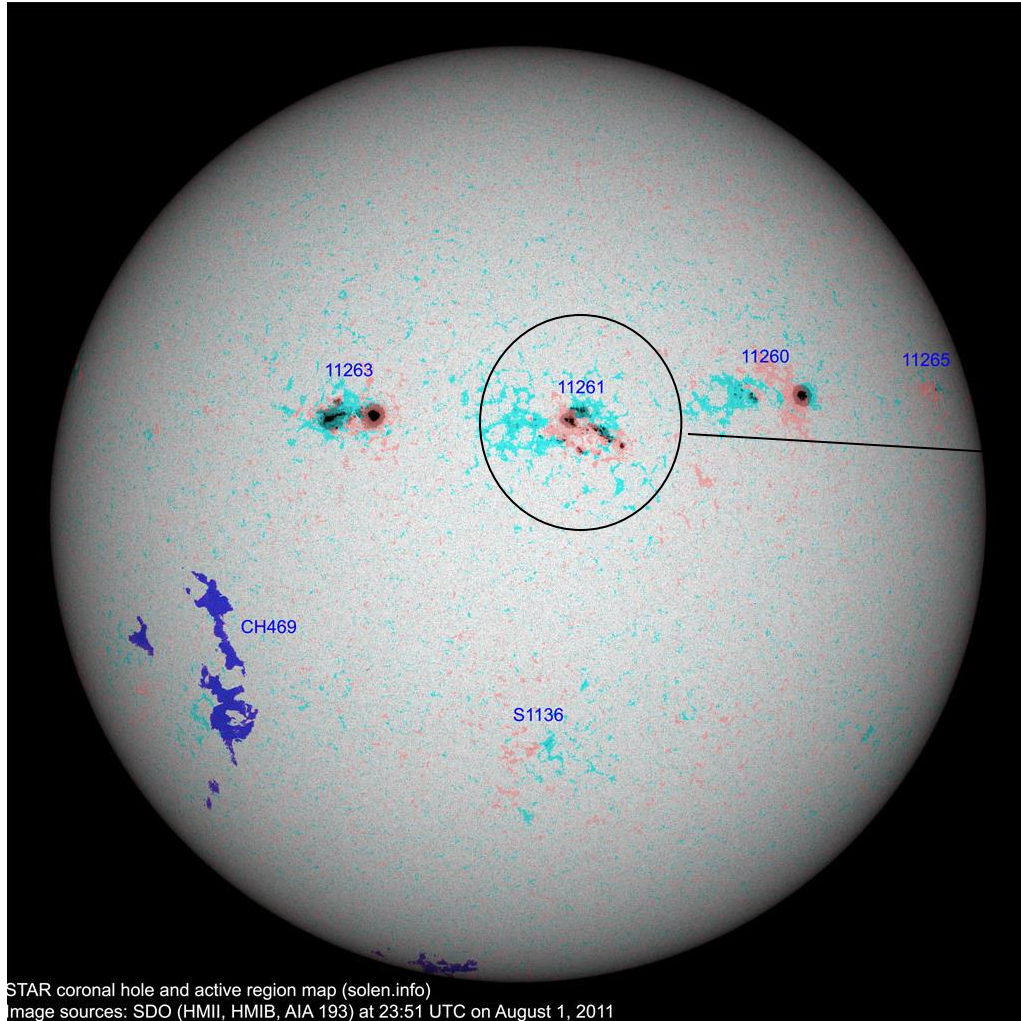


# STEREO Satellite Pair

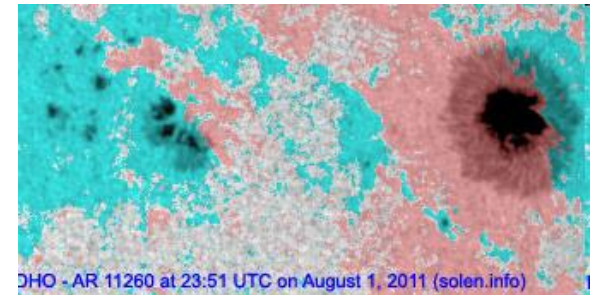
## 2 Aug 2011



# Sun Spots - Aug 2, 2011

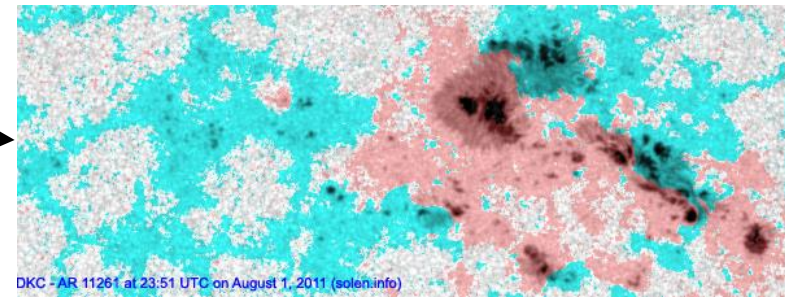


STAR coronal hole and active region map (solen.info)  
Image sources: SDO (HMII, HMIB, AIA 193) at 23:51 UTC on August 1, 2011



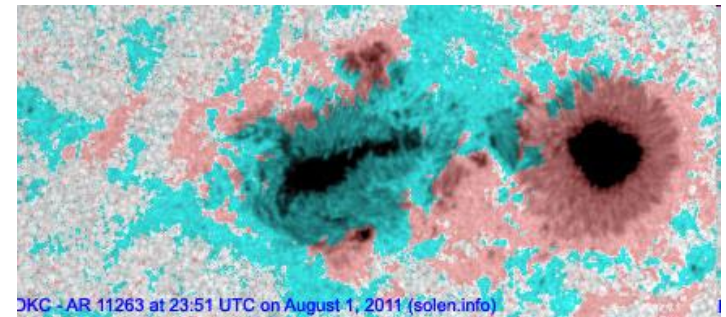
DHO - AR 11260 at 23:51 UTC on August 1, 2011 (solen.info)

**11260 SWPC Classification – EHO  
Beta, Quiet and Stable**



DKC - AR 11261 at 23:51 UTC on August 1, 2011 (solen.info)

**11261 SWPC Classification – FKC  
Beta-Gamma-Delta, C, M, X Flares**

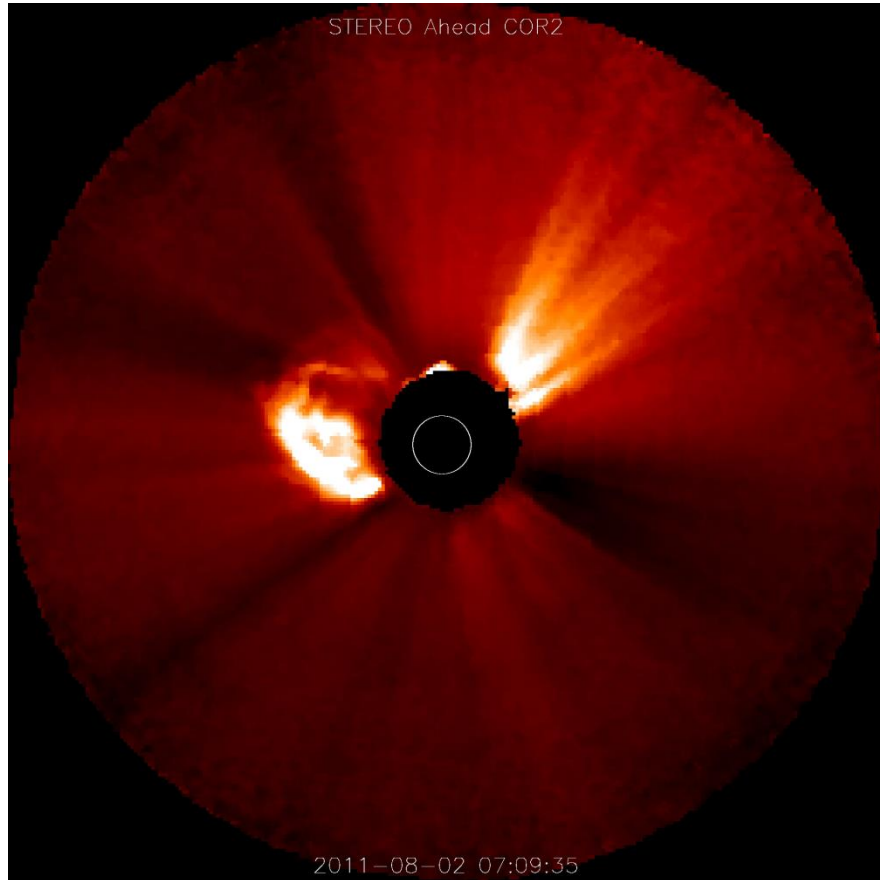


DKC - AR 11263 at 23:51 UTC on August 1, 2011 (solen.info)

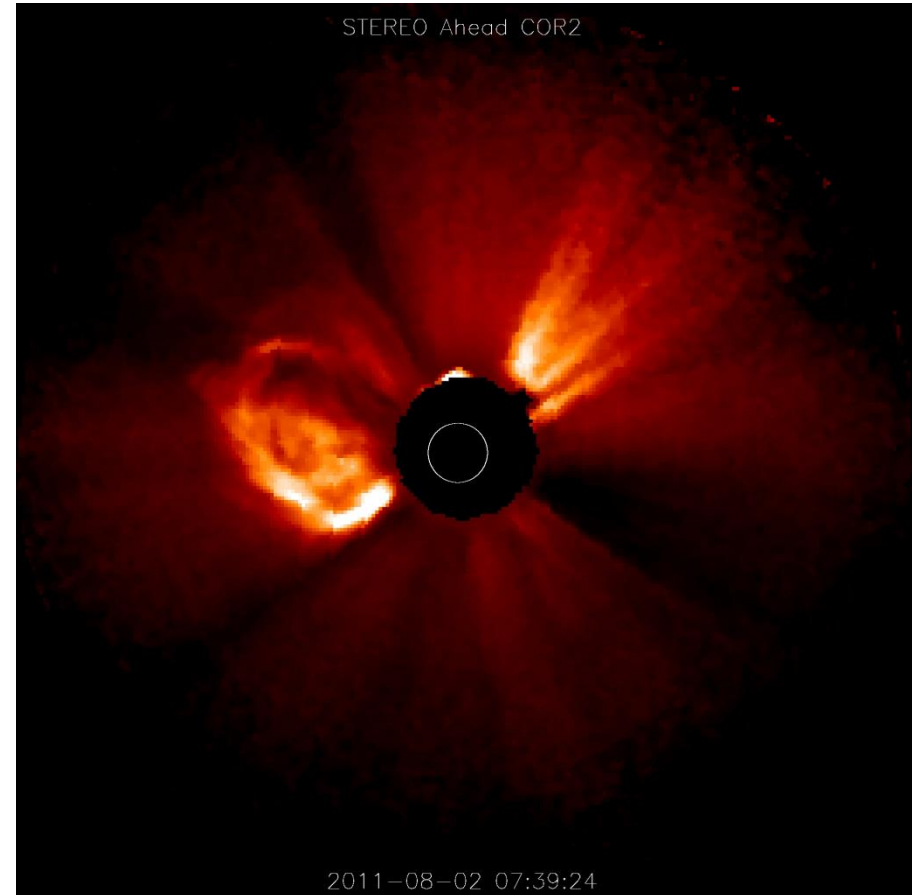
**11263 SWPC Classification – ~~DKC~~  
Beta-Gamma-Delta, C, M, X flares**

# Sunspot 11261 CME

(long duration M1.4 event peaking at 06:19 UTC)

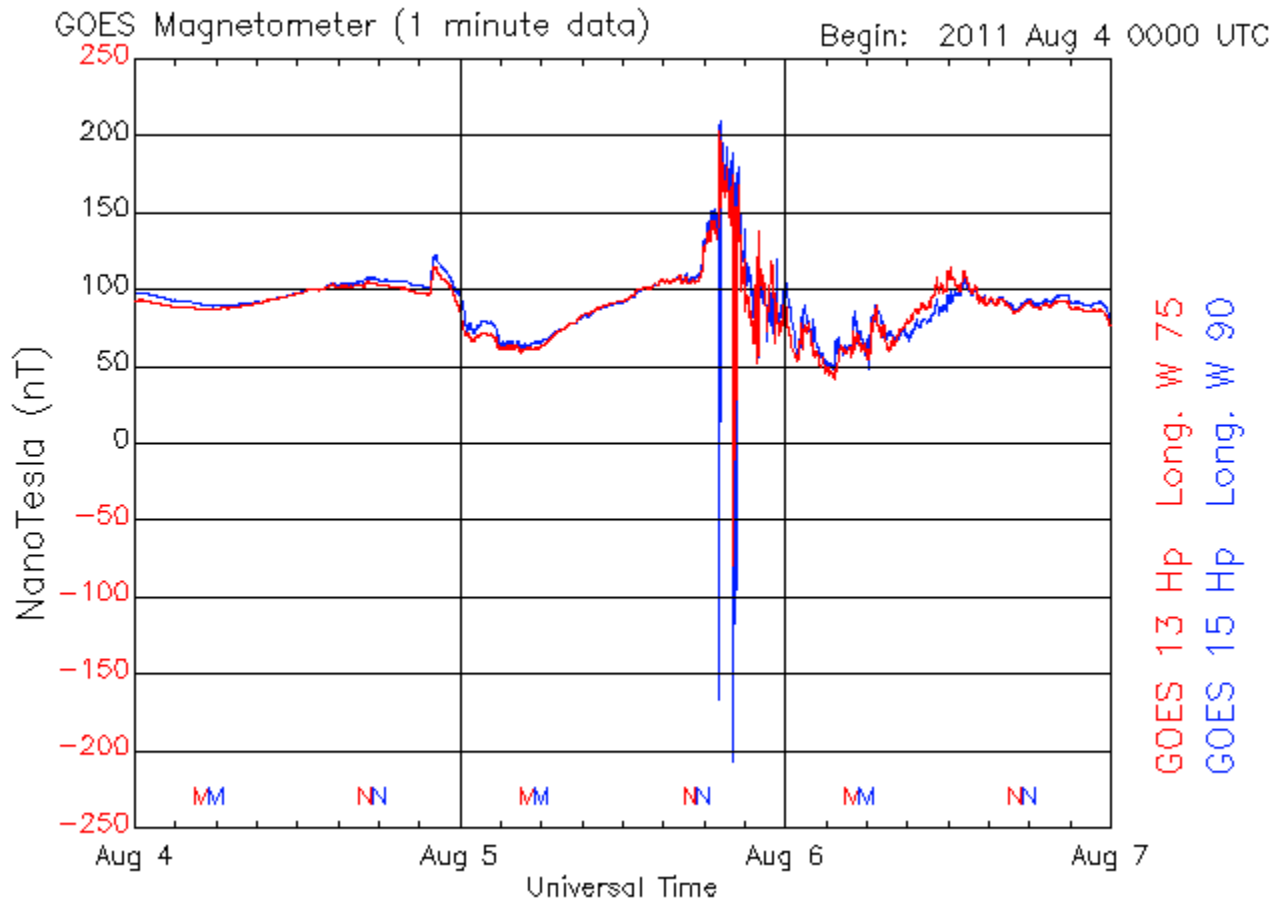


STEREO Ahead – 07:09Z



STEREO Ahead – 08:09Z 67

# GOES Magnetometer (Arrival of 2 Aug. CME)

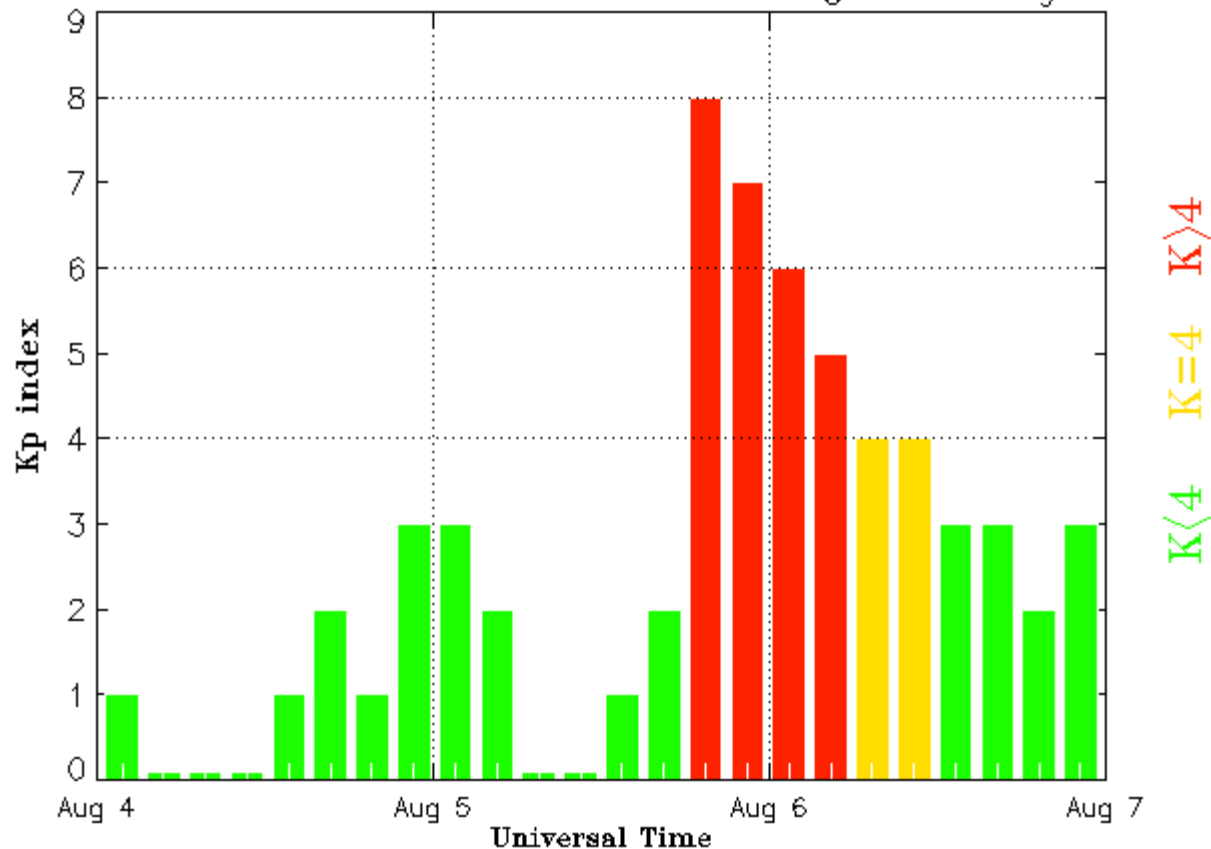


Updated 2011 Aug 6 23:59:02 UTC

NOAA/SWPC Boulder, CO USAI

# Planetary K Index (Arrival of 2 Aug CME)

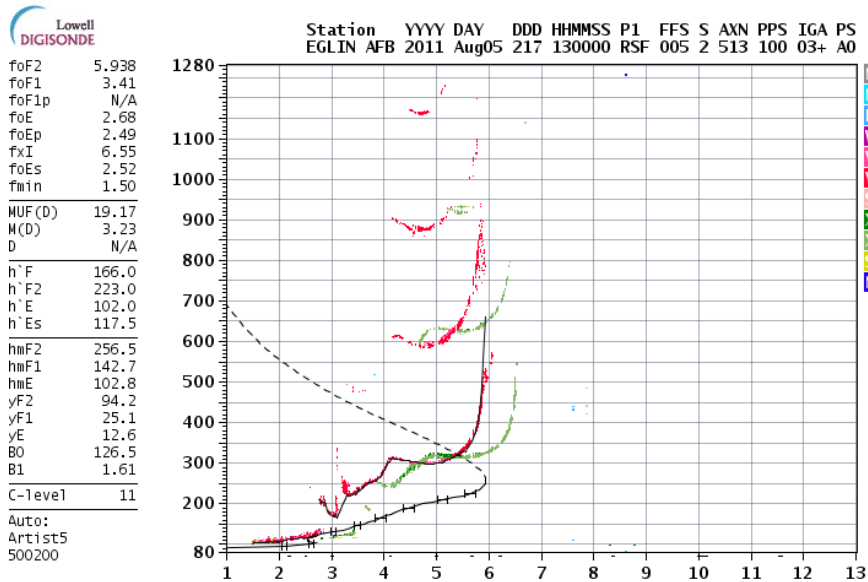
Estimated Planetary K index (3 hour data) Begin: 2011 Aug 04 0000 UTC



Updated 2011 Aug 7 02:55:02 UTC

NOAA/SWPC Boulder, CO USA

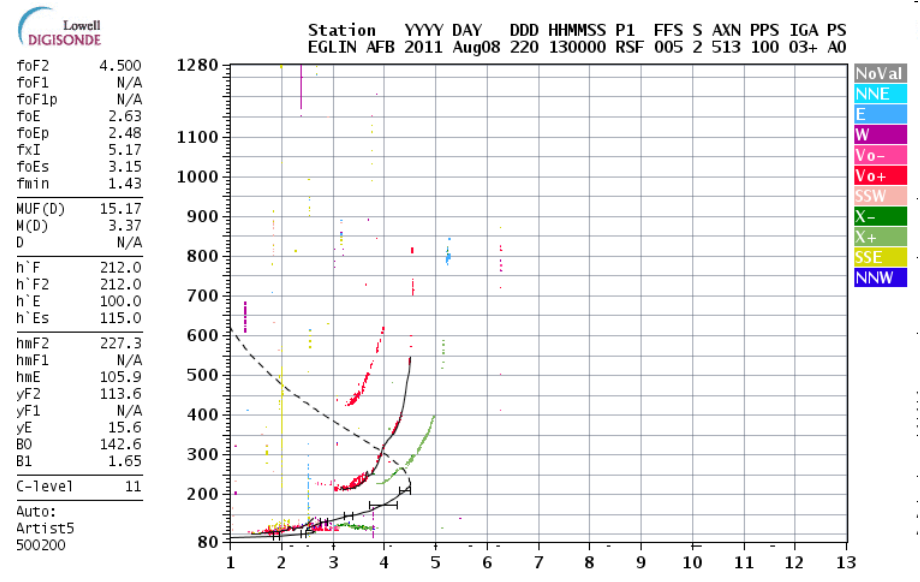
# Ionosonde Data (24% drop in CF)



D 100 200 400 600 800 1000 1500 3000 [km]  
MUF 6.5 6.6 6.9 7.4 8.0 9.0 11.9 19.2 [MHz]  
30420039.tmp / 480fx512h 25 kHz 2.5 km / DPS-4D EG931 084 / 30.5 N 273.5 E

ShowIonogram v 1.0.0

**5 August 1300Z**  
**(CF = 5.9 MHz - Normal)**  
**(MUF = 19.2 MHz)**

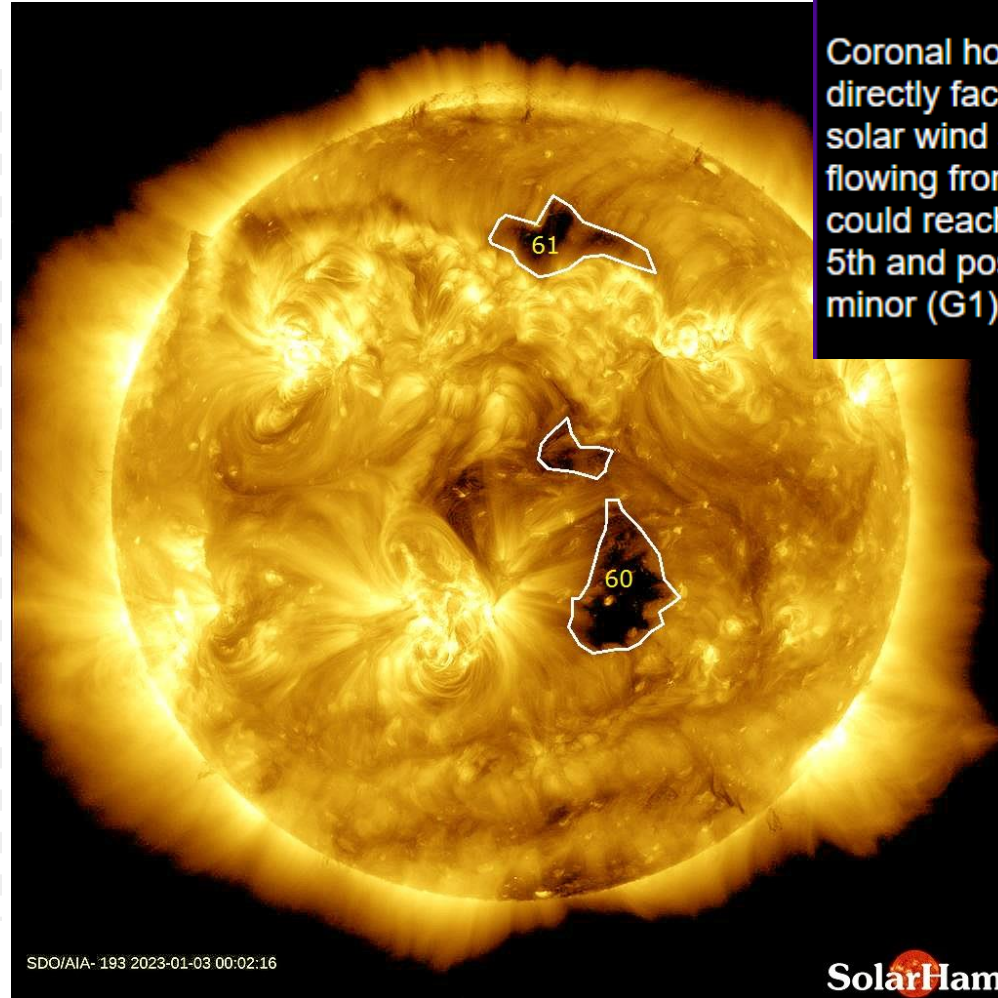
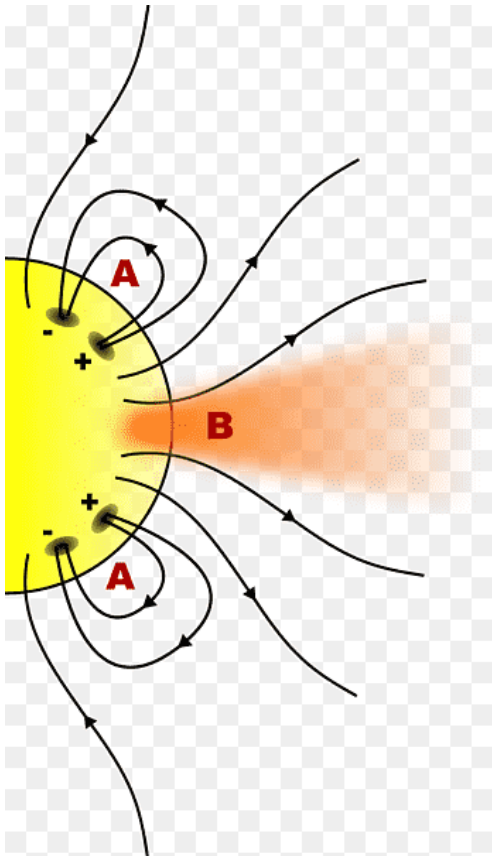


D 100 200 400 600 800 1000 1500 3000 [km]  
MUF 5.1 5.2 5.4 5.8 6.3 7.1 9.3 15.2 [MHz]  
56251370.tmp / 480fx512h 25 kHz 2.5 km / DPS-4D EG931 084 / 30.5 N 273.5 E

ShowIonogram v 1.0.0

**8 August 1300Z**  
**(CF = 4.5 MHz)**  
**(MUF = 15.2 MHz)**

# Coronal Hole Effect



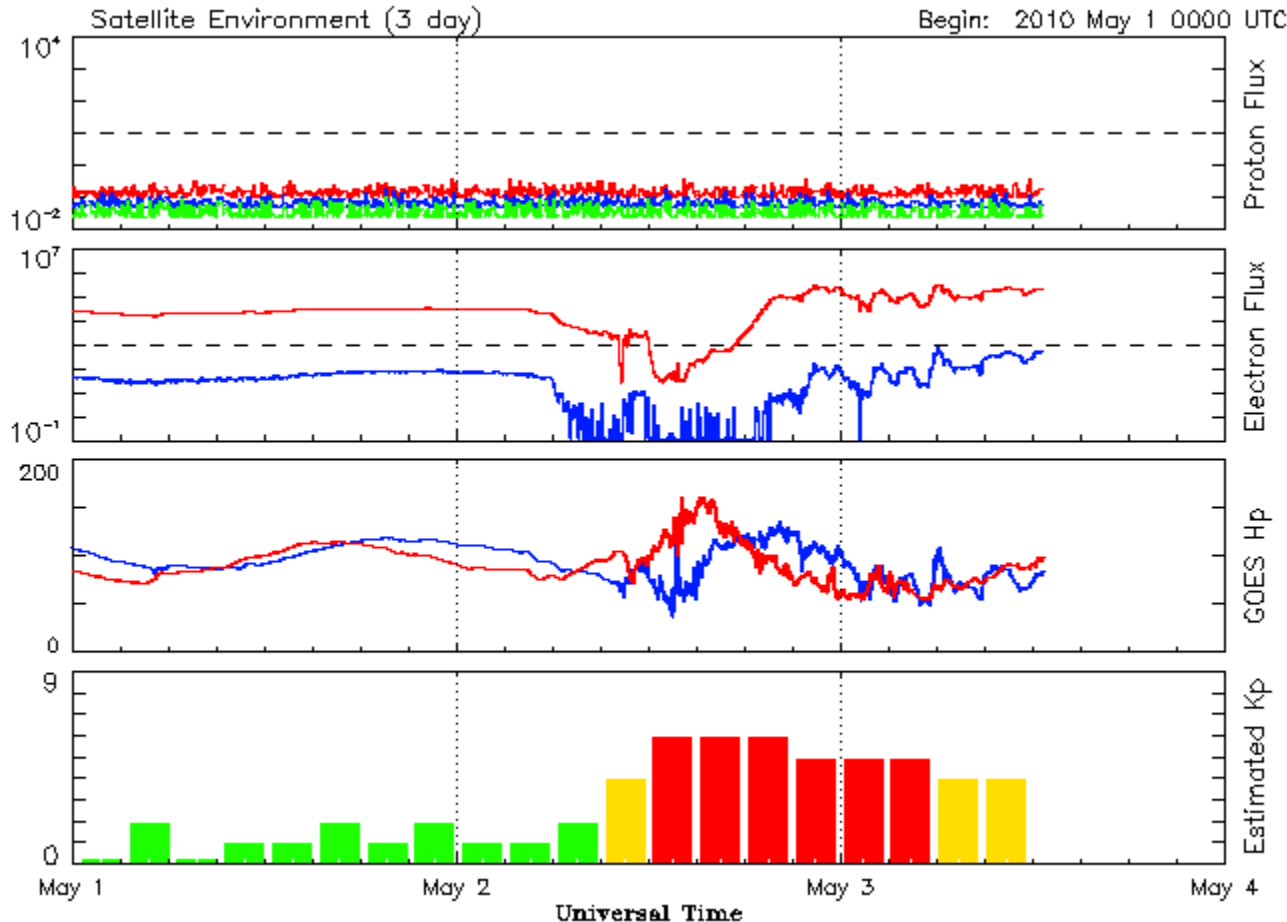
## Analysis

Coronal hole #60 is now directly facing Earth. A solar wind stream flowing from this zone could reach by January 5th and possibly lead to minor (G1) storming.

SDO/AIA- 193 2023-01-03 00:02:16

SolarHam

# Satellite Environment Plot (Coronal Hole Event)

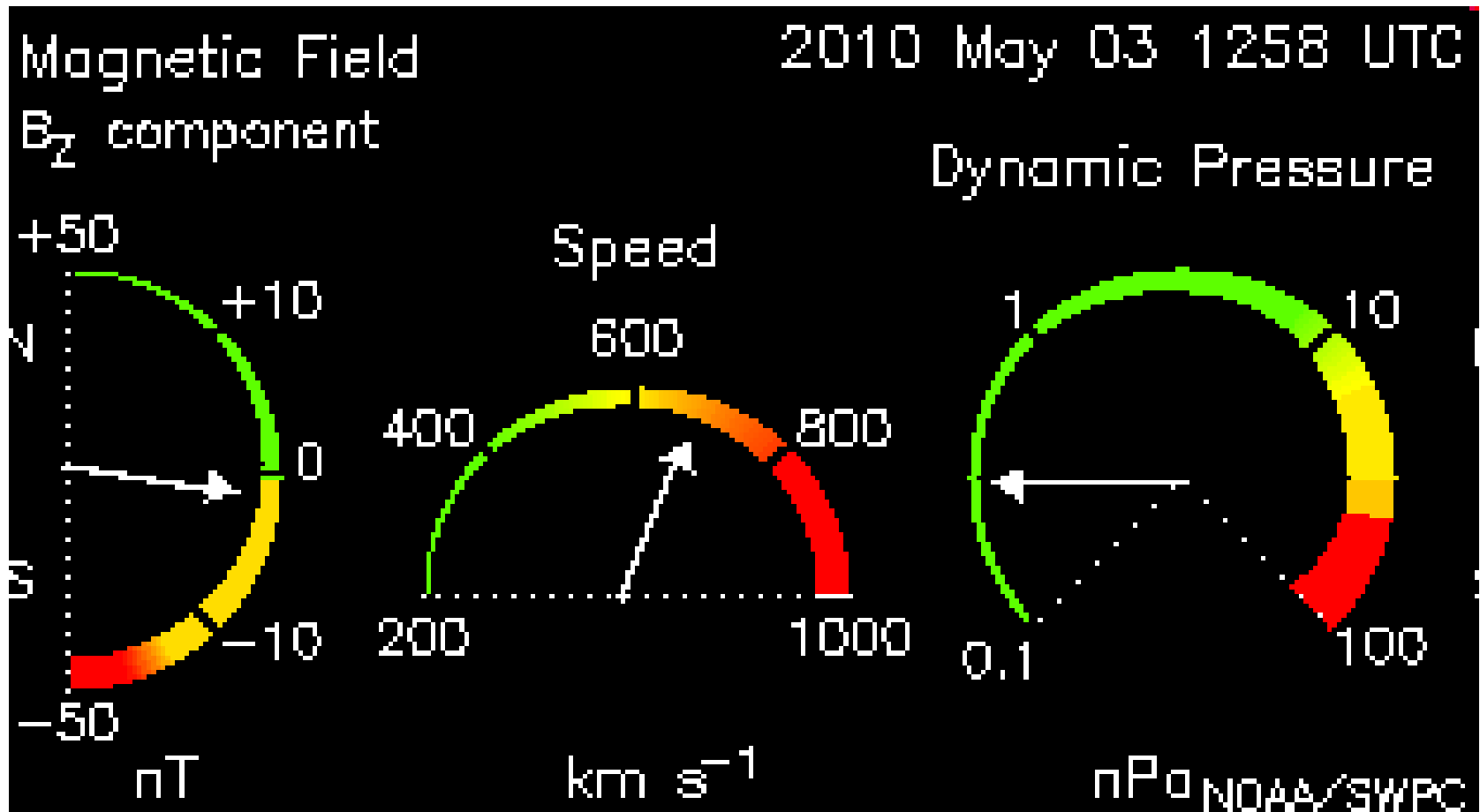


Updated 2010 May 3 12:46:09 UTC

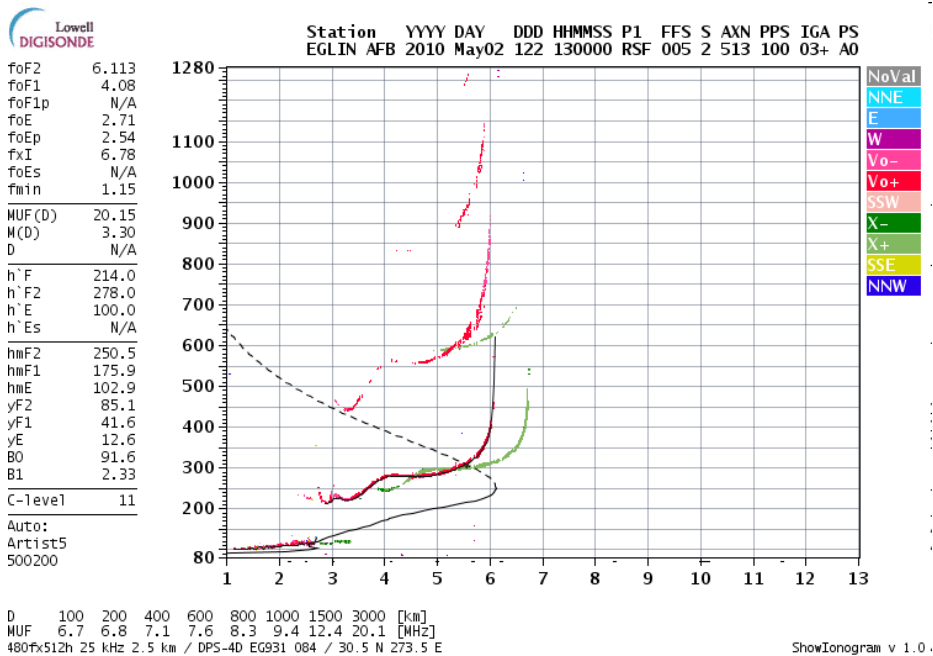
NOAA/SWPC Boulder, CO USA



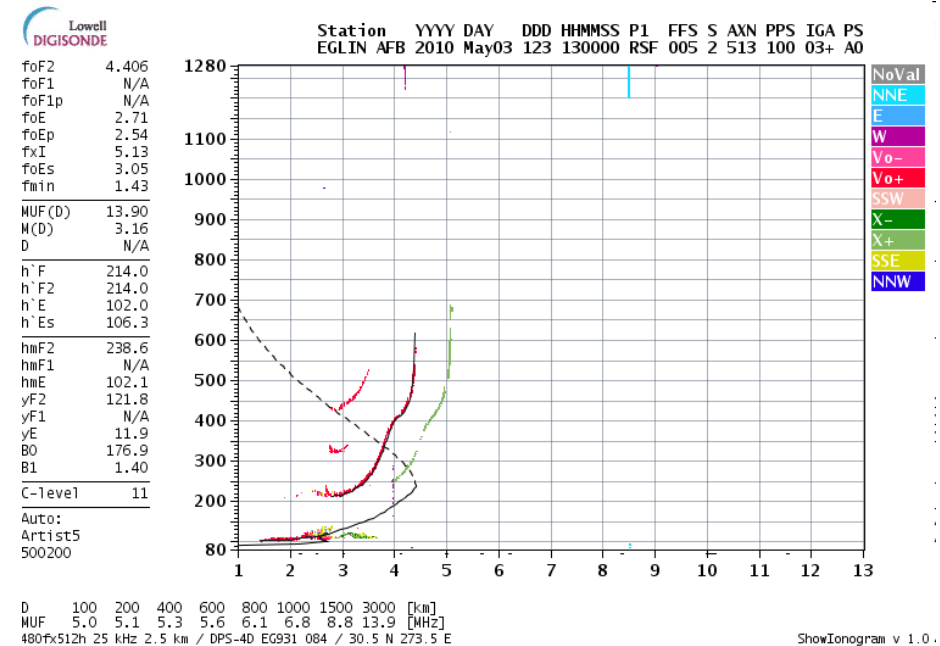
# 3 May Solar Wind (ACE Satellite)



# Ionosonde Data (28% drop in CF)



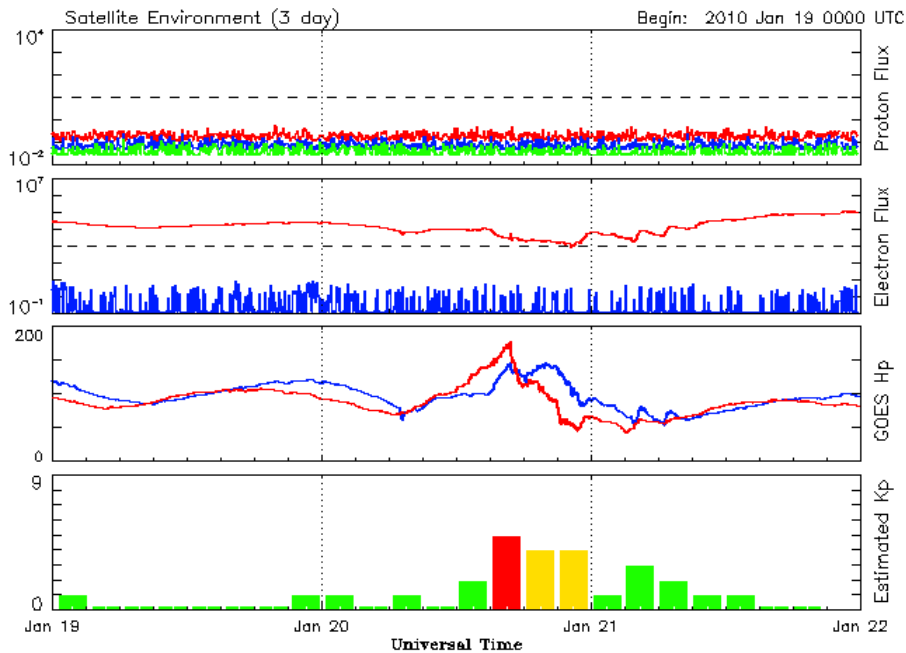
**2 May 1300Z**  
**(CF = 6.1 MHz - Normal)**  
**(MUF = 20.1 MHz)**



**3 May 1300Z**  
**(CF = 4.4 MHz)**  
**(MUF = 13.9 MHz)**

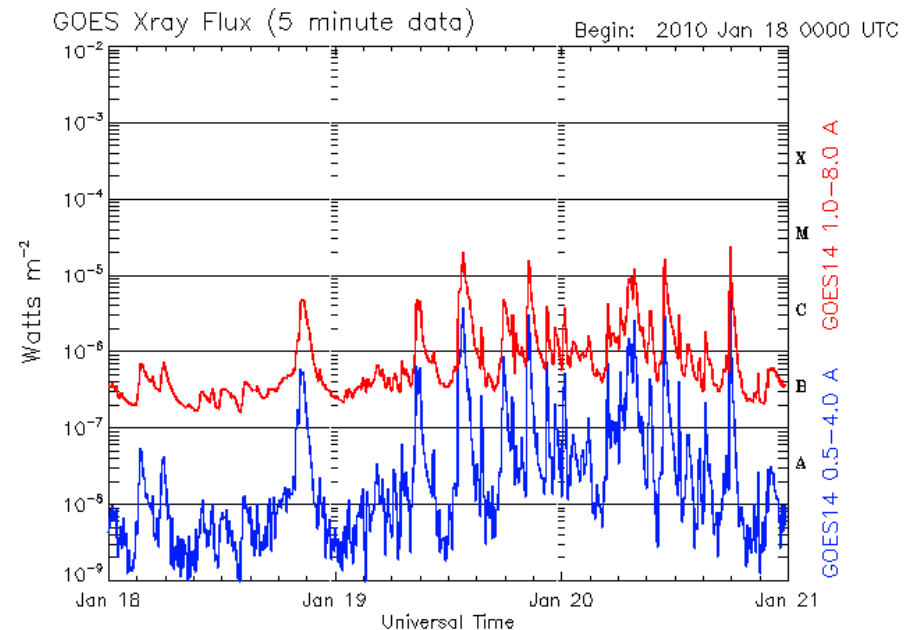
# Solar & Geomagnetic Indicator Sources

- WWV – 2, 5, 10, 15, 20 MHz at 18' pass each hour.
- Web site: <http://www.swpc.noaa.gov/>
- <https://www.region6armymars.org/resources/solarweather.php>



Updated 2010 Jan 21 23:55:03 UTC

NOAA/SWPC Boulder, CO USA



Updated 2010 Jan 20 23:55:12 UTC

NOAA/SWPC Boulder, CO USA

# Solar Weather Sites

The screenshot shows the website for Region 6 Army MARS. The header includes the text "Region 6 Army MARS" and a close button. The main content area features a green background with the text "REGION 6 ARMY MARS" and "Military Auxiliary Radio System". Below this is a section titled "WHO WE ARE" with a paragraph of text. A dark sidebar menu is visible on the right, containing links for "Home", "What is MARS?", "Join", "Contact Us", "Solar Weather", and "Login". Two red arrows point from external text labels to the "Solar Weather" link in the menu and the "WHO WE ARE" section.

**Solar Weather**

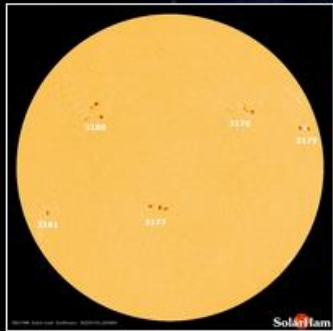
## Other Solar Weather Links of Interest

**All Ionosondes**

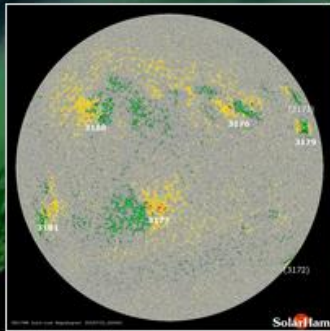
- [DIDBase](#) - Select Station List then EGLIN then year/month/day/time for Ionosonde plot.
- [NOAA Solar Weather](#) - Solar Weather plots of Kp and X-Ray and other solar emissions.
- [Solen Solar Weather](#) - Good general solar forecast from an individual.
- [Solar Ham](#) - SolarHam provides real time solar news, as well as consolidated data from various sources.

## Space Weather for January 3, 2023

UTC Time 13:40:35 Tuesday



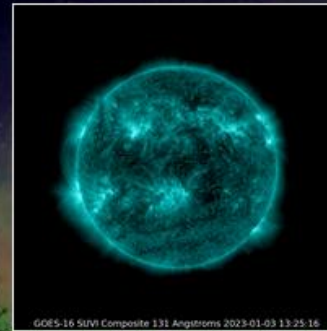
**HMI Intensity**  
Latest | Movie | HARP



**HMI Magnetogram**  
Latest | Movie



**Coronal Holes**  
Analysis | Movie



**AIA 131 (Latest)**  
Movie



**SUVI 304 (Latest)**  
Movies

Latest Imagery: [SDO](#) | [AIA](#) | [GOES-16](#) | [GONG](#) | [STEREO](#) | [LASCO](#)

Video: [SDO](#) | [SOHO](#) | [STEREO](#) | [Helioviewer](#) | [YouTube](#)

### Solar Indices (Jan. 3 @ 00:35 UTC)

SFI	SSN	AREA
146	94	1100
▼ 7	—	▼ 120

[WWV](#) | [Flux Data](#) | [Last 30 Days](#)

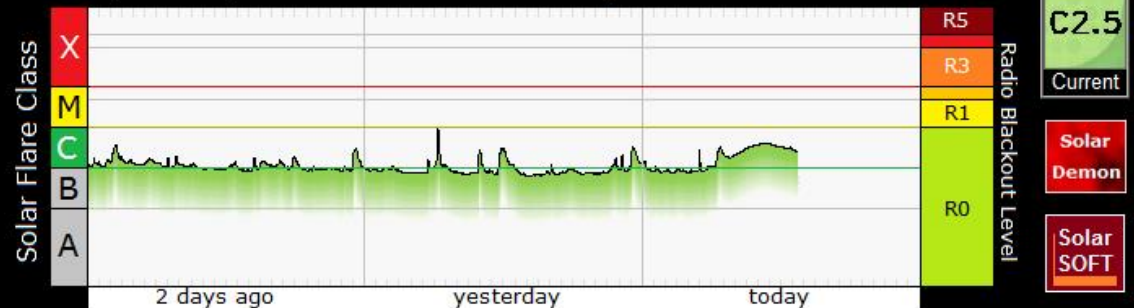
Cycle 25 Progression

### Solar Flare Detection

Data provided by NOAA/SWPC

GOES-16 X-Ray Flux

Click to expand data



<https://www.spaceweather.com/>

## Current Conditions

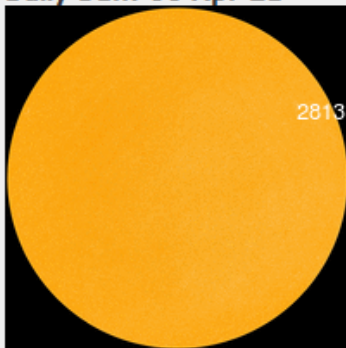
### Solar wind

speed: **314.8** km/sec  
density: **9.9** protons/cm<sup>3</sup>  
more data: [ACE](#), [DSCOVR](#)  
Updated: Today at 1225 UT

### X-ray Solar Flares

6-hr max: **A1** 1027 UT Apr06  
24-hr: **A1** 1515 UT Apr05  
[explanation](#) | [more data](#)  
Updated: Today at: 1230 UT

### Daily Sun: 06 Apr 21



Sunspot AR2813 is decaying, and poses no threat for strong flares.  
Credit: SDO/HMI

**FLYING TO THE VOLCANO:** Iceland's Geldingadalur volcano has turned into an popular tourist attraction—especially since auroras were sighted [above the glowing lava](#). Early this morning, Tuesday, April 6th, Brian Emfinger saw auroras before he even reached the Reykjanes peninsula:



# QUESTIONS?

**Lewis Thompson, P.E.  
W5IFQ**

**[W5IFQ@att.net](mailto:W5IFQ@att.net)**

**Cell (512) 587-9944**