

HF Propagation

Can we work Winter FD?

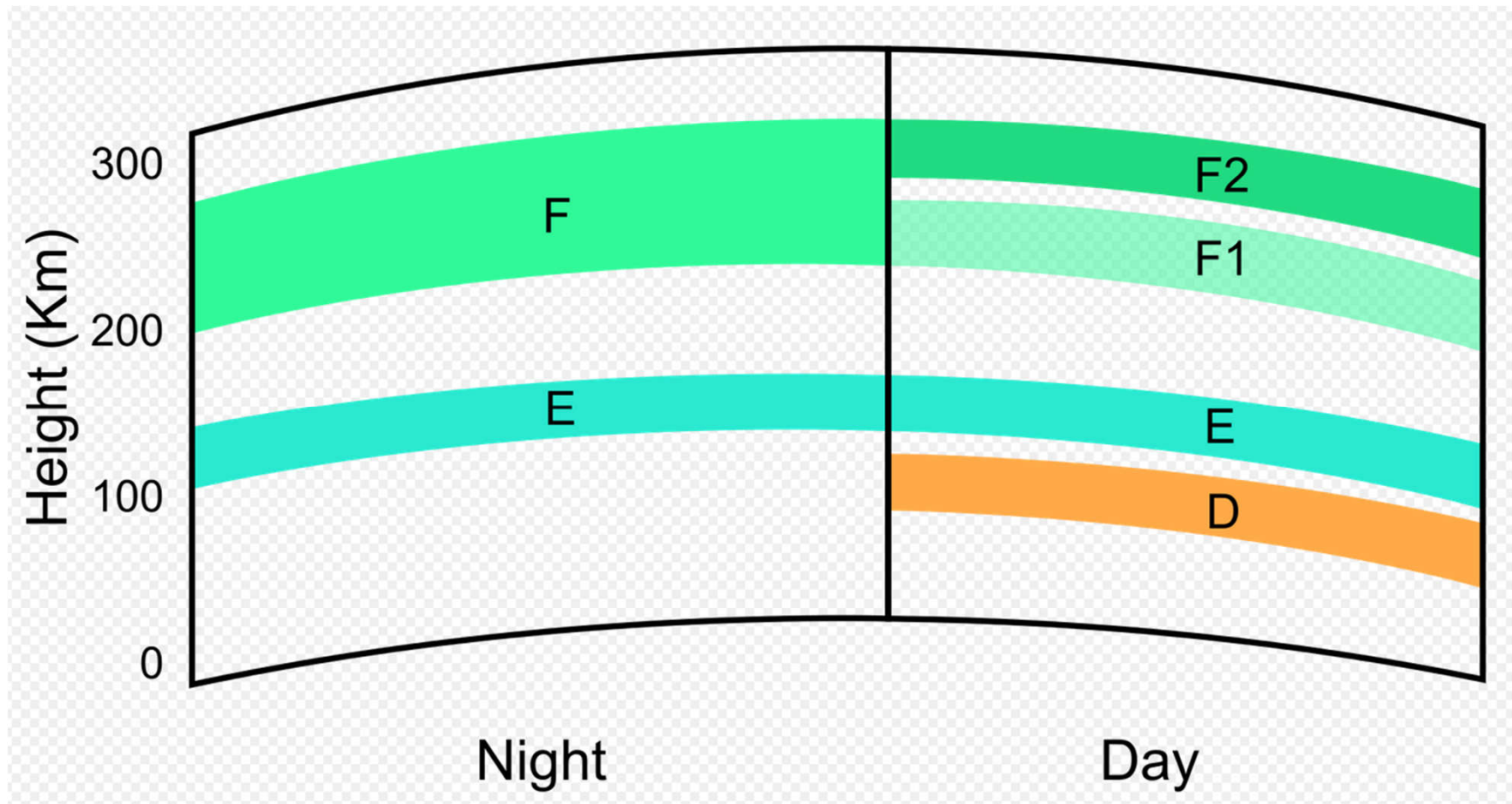
Winter FD 2019

Center: $33^{\circ}17'59''\text{N}$ $87^{\circ}0'0''\text{W}$ Radius: 4000 km

Courtesy of Tom (NS6T)



Ionospheric Layers

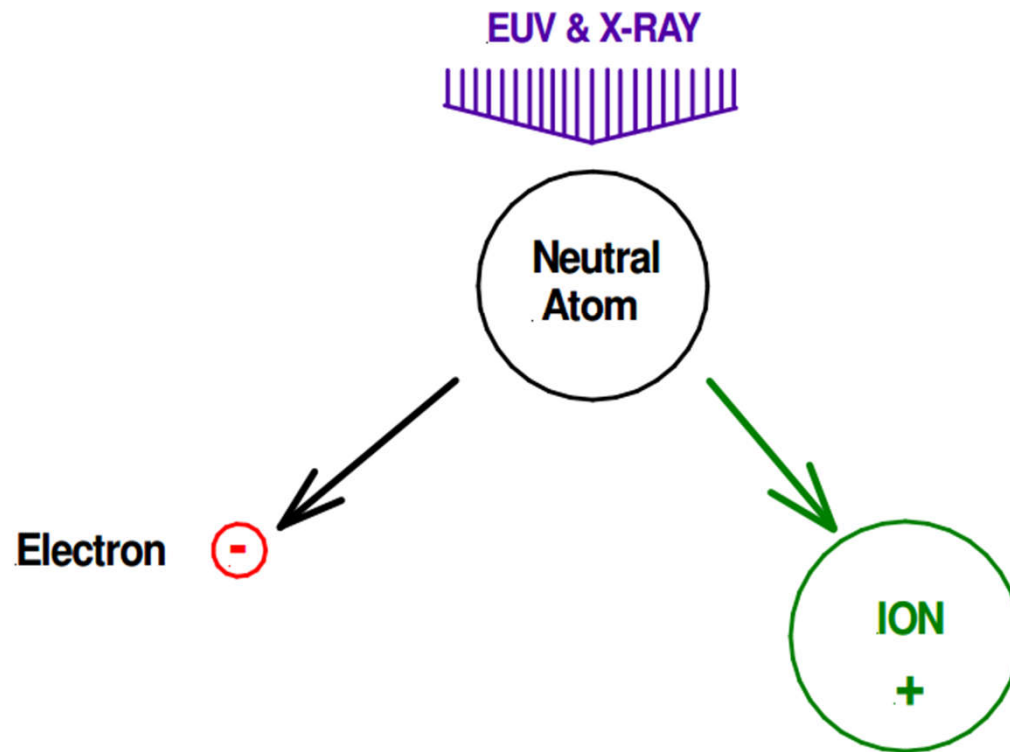


Making Ionosphere

- Sun creates ions
- Form layers above the earth
- Fairly predictable
 - Day
 - Night
 - Seasons
 - Sunspots

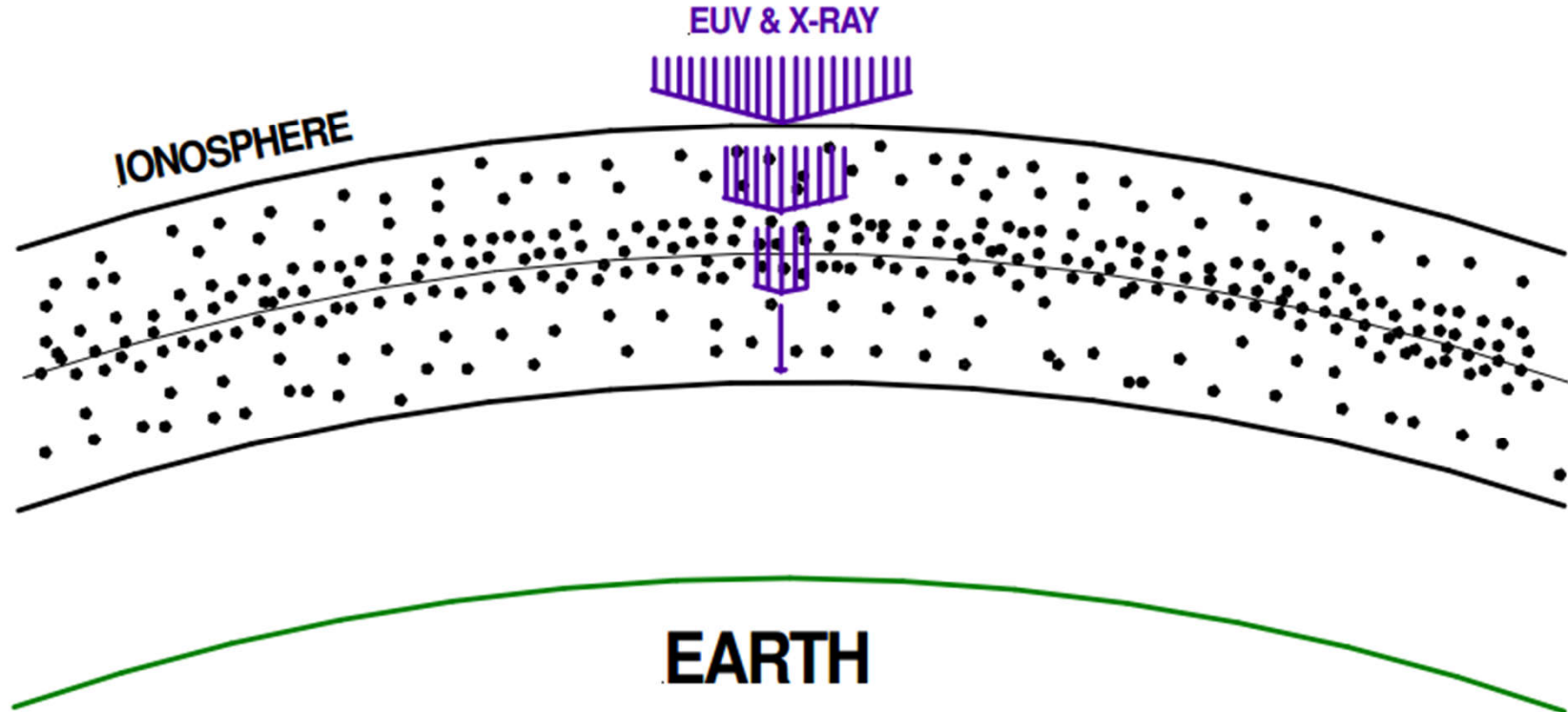
Making Ions

Upper Atmosphere Ionization

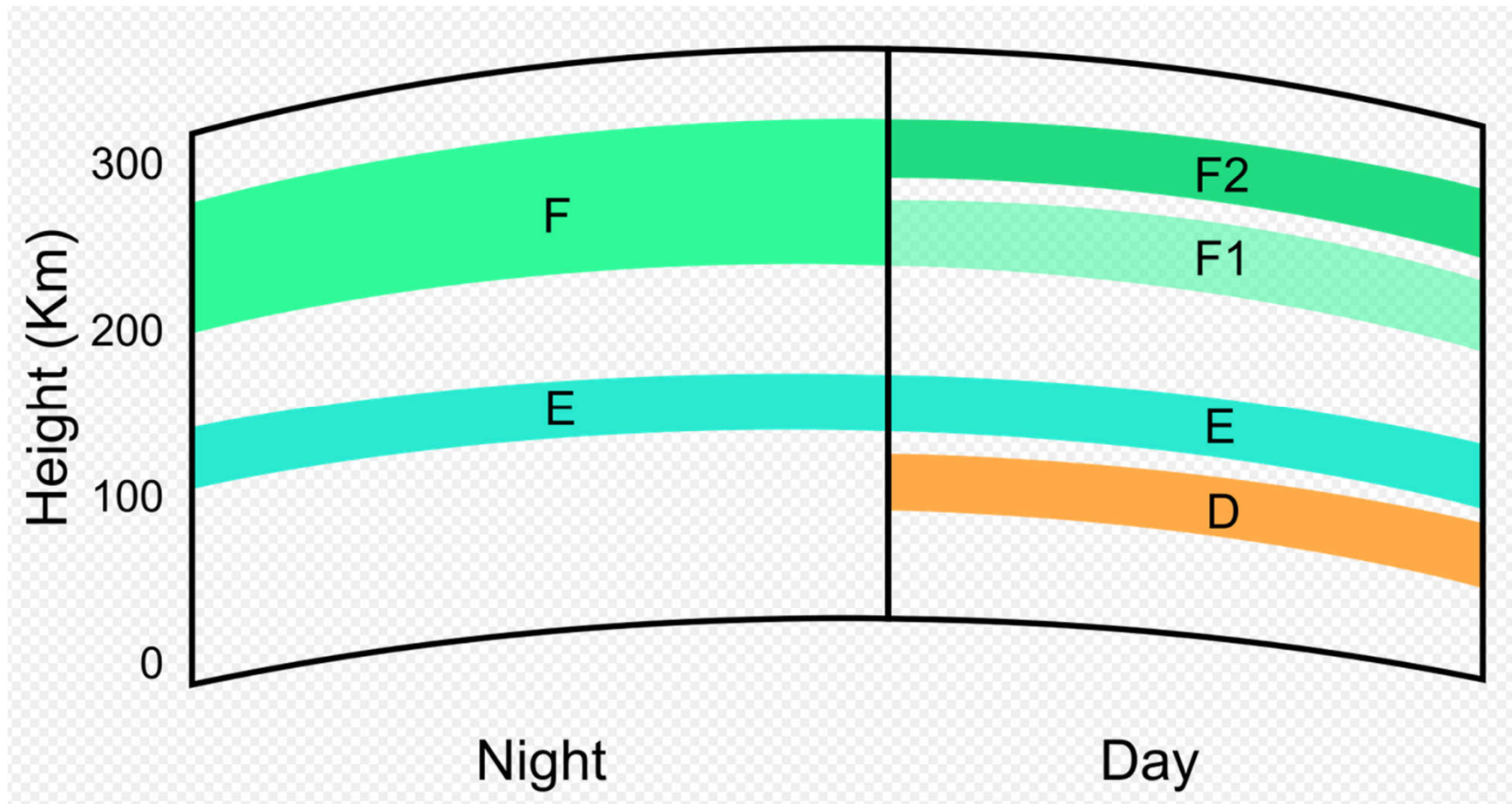


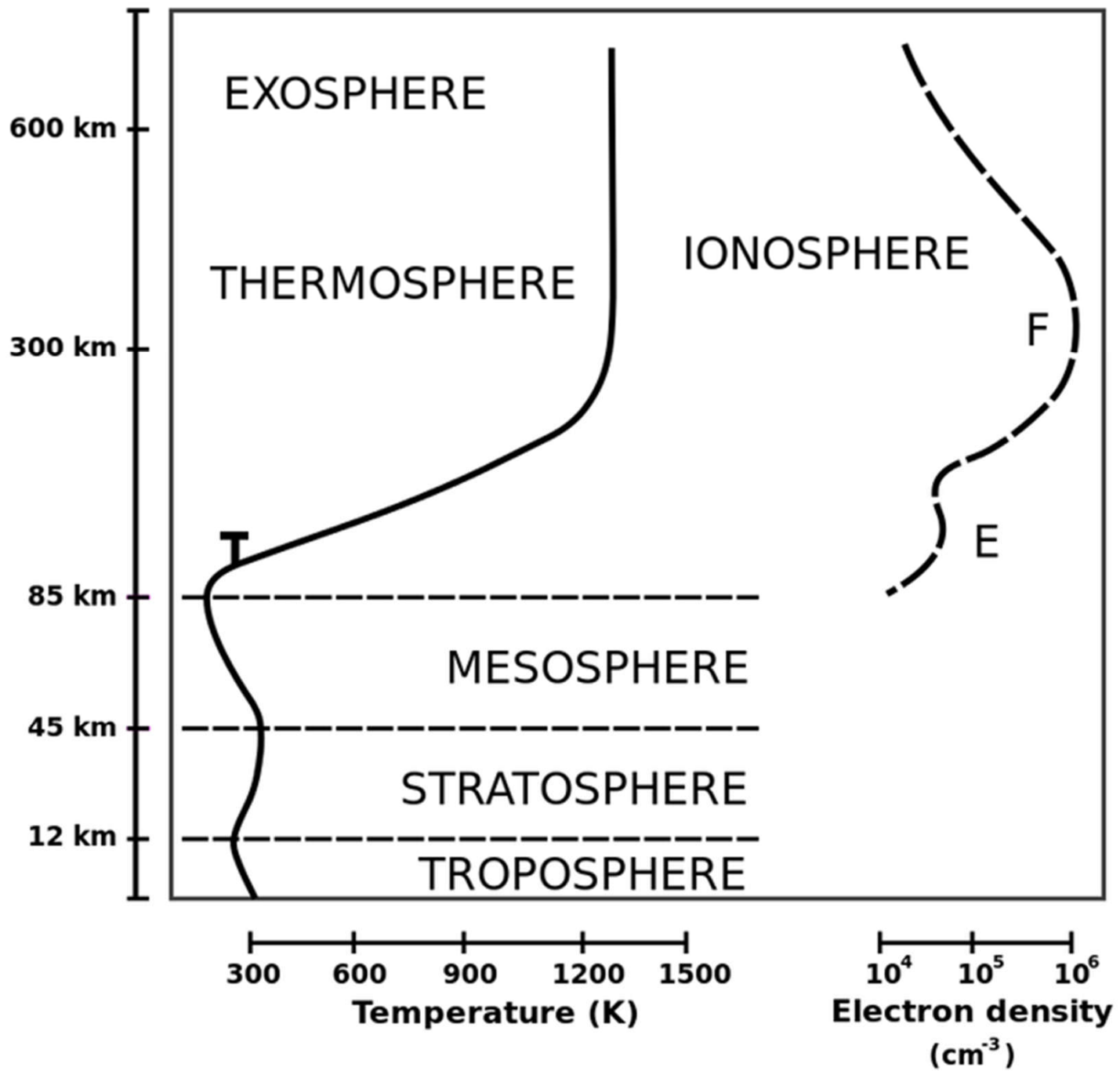
Making Ionosphere Layers

Formation of the Ionosphere

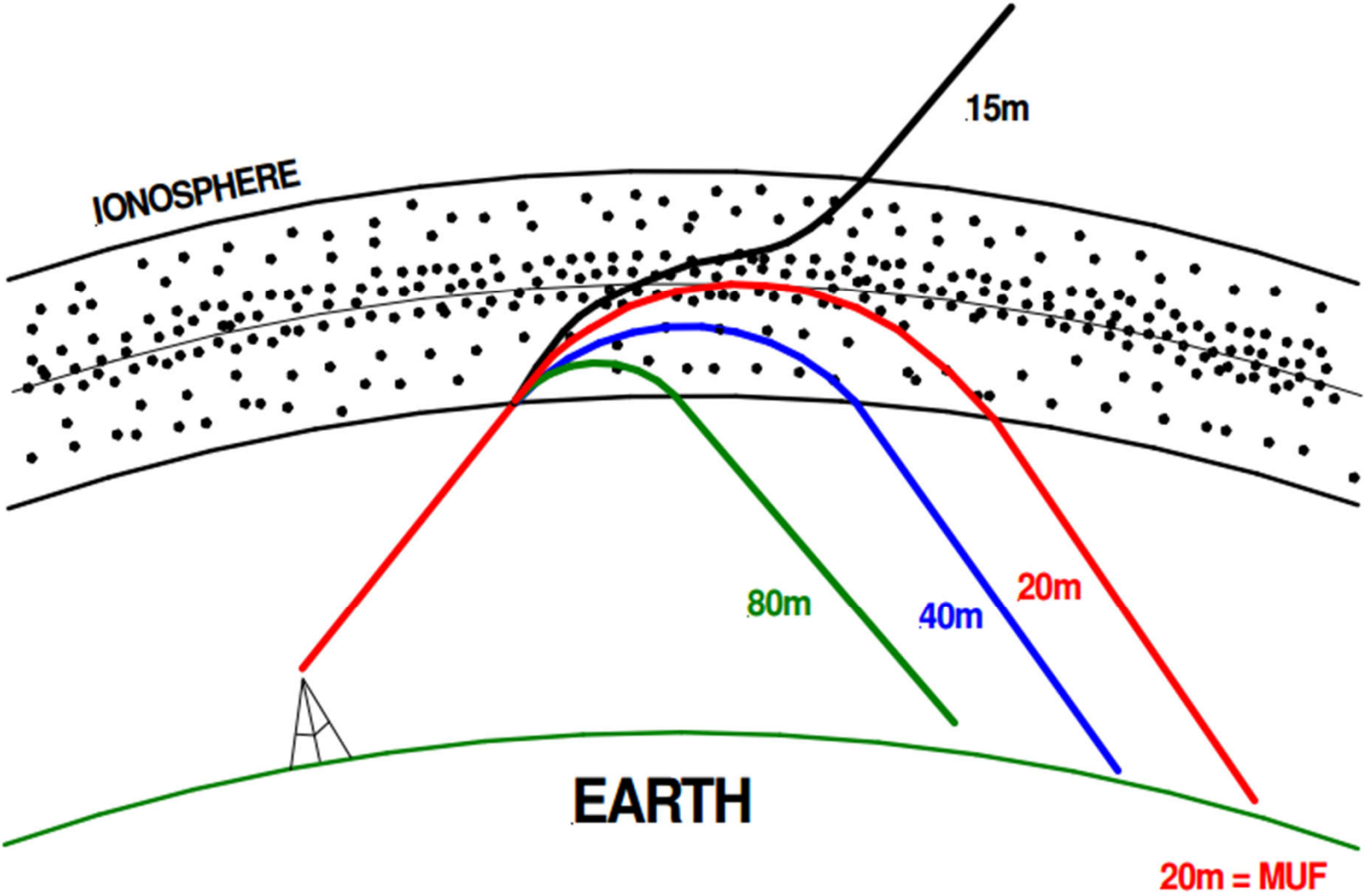


Ionospheric Layers





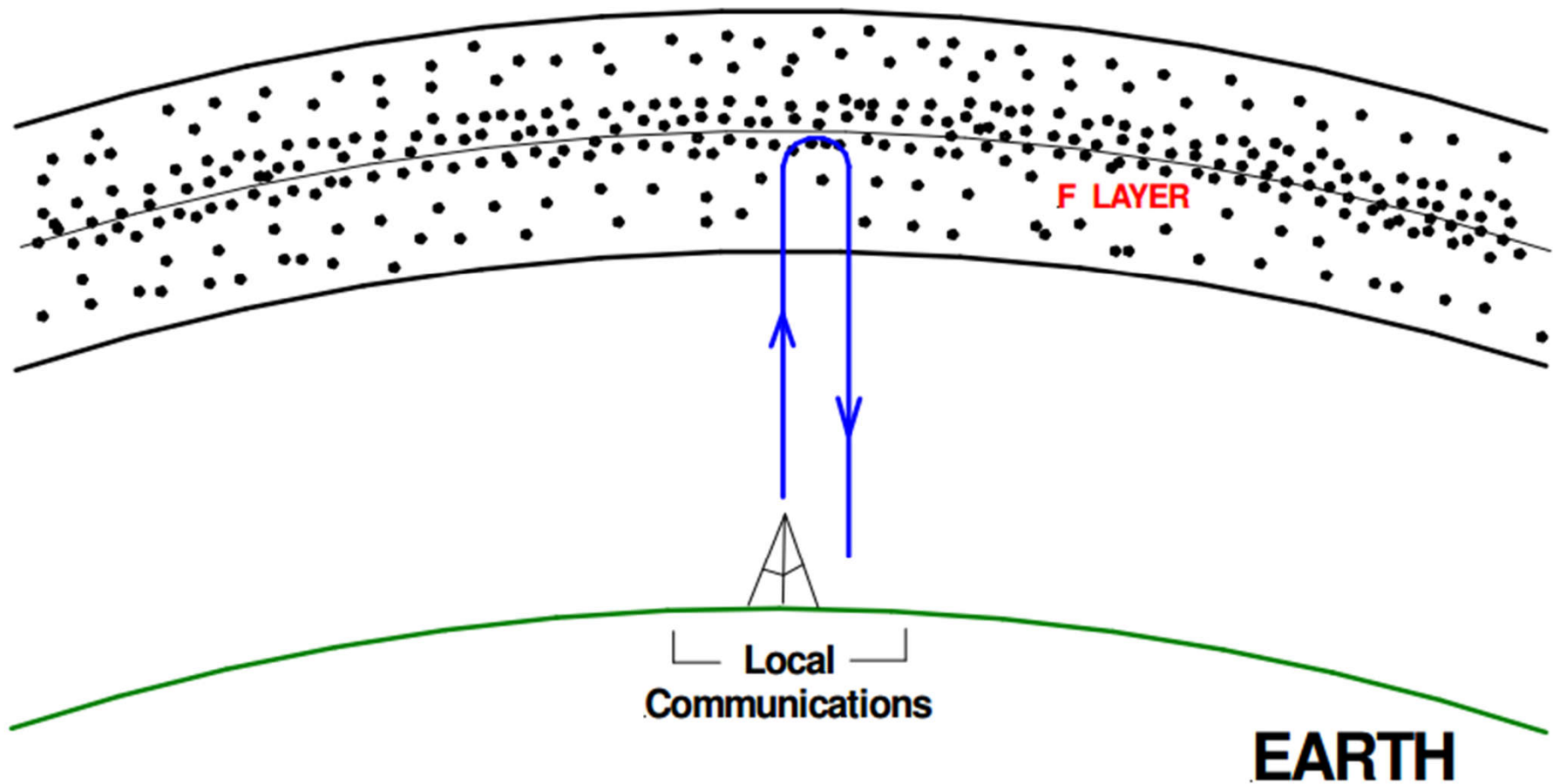
Ionospheric Refraction



What's your Fc?

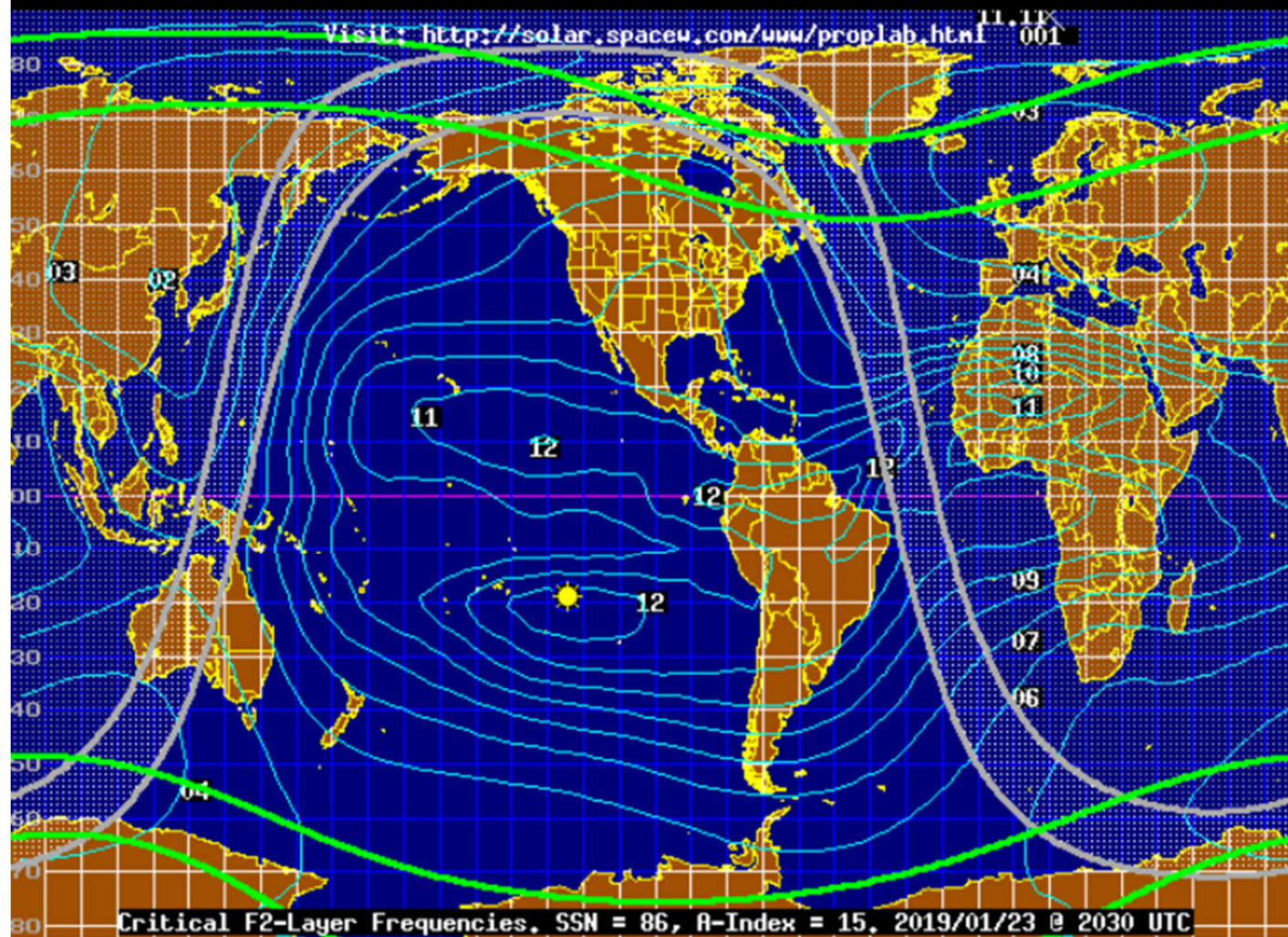
- The highest frequency that bounces is critical
 - Straight up and back down
 - Fc is the nomenclature
- [Realtime Fc map](#)
- <http://www.spacew.com/www/fof2.html>
 - Updated every 5 minutes for free
 - Buy software for >\$200
- Where does it come from?

Critical Frequency



NEW Proplab for Windows 10, Version 3.1

Now available at: <http://shop.spacew.com>



Ionograph

- Profile of Critical Frequency, and MORE
- Digisonde
 - automatically plot a vertical profile
- Project of Umass, Lowell
- Stations all over the world





DIGISONDE-128
1970



DIGISONDE-256
1978



DIGISONDE-DPS
1993

UMass Lowell

- University of Massachusetts – Lowell
- Space Science Lab
 - <http://ulcar.uml.edu/digisonde.html>
- GIRO
 - Global Ionosphere Research Organization
- IRTAM
 - IRI Real-Time Assimilative Mapping

UML-SSL

Hardware

Instrument Description
[Digisonde Portable Sounder](#)
[Antenna Configuration for UDD](#)
[Antenna Configuration for DDA](#)

DPS-4D Operation Manual
[PDF](#)

DPS-4D System Specifications [PDF](#)
[Digisonde Directograms](#)

Software

SAO Explorer
[SAO-X: Interactive Ionogram Analysis with DIDBase, ARTIST-5, and NHPC](#)

Drift Data Analysis
[DDA Software](#)
[Drift-X Homepage](#)
[User's Guide for TILT software](#)

ARTIST
[Reprocessing ionograms with ARTIST 4](#)
[ARTIST-4 computer description](#)
[Personalizing ARTIST-4 \(station-specific data\)](#)

OTHER SOFTWARE
[IRI-2001 WINDOWS](#)

Data

GIRO
[Global Ionospheric Radio Observatory](#)
[Mirror-GIRO Initiative](#)

Web Access to GIRO Data:
[DIDBase](#) | [DriftBase](#)

[Ionogram Movies](#) | [GIRO-Monitor](#)
[Latest World Ionogram](#)
[Real-Time IRI Animations](#)

IMPORTANT: [Rules of the Road](#)

Data Models/Formats
[SAO.XML 5.0](#)
[IIWG SAO 4.3 Format](#)
[IIWG SAO 4.2 Format](#)
[IIWG "CHARS" Format](#)

Geospace Models
[Latest sunspot numbers from NGDC NOAA](#)



[About Staff News](#)

[Research Publications Presentations](#)

[Digisonde RPI/Image JIMO/PARS](#)

[Downloads StationList StationMap](#)

[Contact Directions Links](#)

600 Suffolk Street, Suite 315
Lowell, MA 01854
Tel: 978-934-4900
Fax: 978-459-7915

GIRO worldwide sites





Ionosonde Data DIDBase

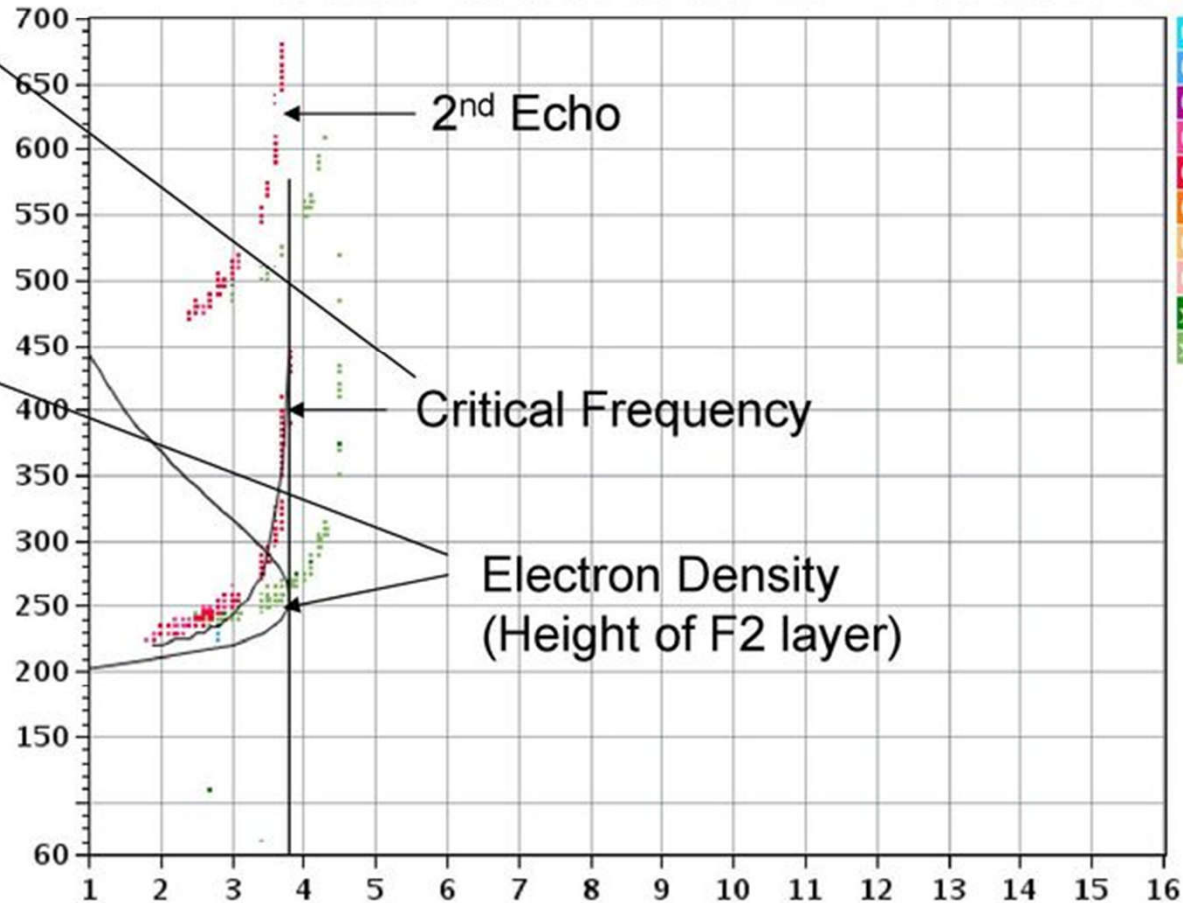
Dyess AFB



Lowell
DIGISONDE

Station YYYY DAY DDD HHMM P1 FFS S AXN PPS IGA PS
DYESS AFB 2008 Jan16 016 0145 MMM 1 045 200 34+ A1

foF2	3.800
foF1	N/A
foF1p	N/A
foE	N/A
foEp	0.35
fxI	4.60
foEs	N/A
fmin	1.90
MUF(D)	13.03
M(D)	3.43
D	3000.0
h'F	220.0
h'F2	N/A
h'E	N/A
h'Es	N/A
hmF2	257.3
hmF1	N/A
hmE	110.0
yF2	58.4
yF1	N/A
yE	20.0
B0	48.2
B1	5.95
C-level	11
Auto:	
Artist4	
200207	



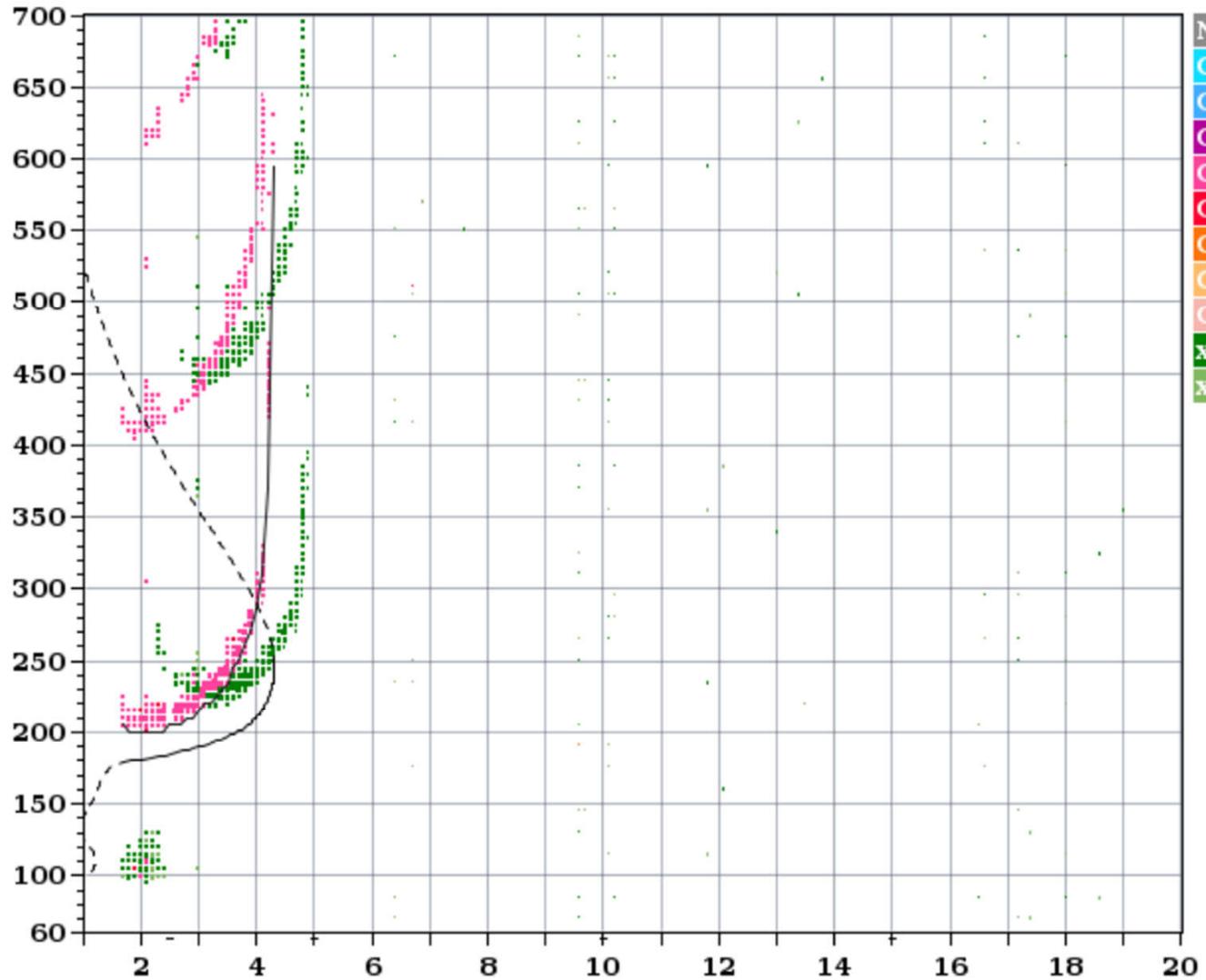
MUF Chart

D	100	200	400	600	800	1000	1500	3000	[km]
MUF	4.4	4.5	4.7	5.0	5.4	6.1	8.1	13.0	[MHz]
150fx128h 100 kHz 5.0 km / DGS-256 DS932 098 / 32.4 N 260.2 E									



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
 AUSTIN 2019 Jan24 024 000005 MMM 1 045 100 34+ 11

foF2	4.313
foF1	N/A
foF1p	N/A
foE	N/A
foEp	1.22
fxI	5.00
foEs	N/A
fmin	1.70
<hr/>	
MUF(D)	15.10
M(D)	3.51
D	3000.0
<hr/>	
h`F	200.0
h`F2	N/A
h`E	N/A
h`Es	N/A
<hr/>	
hmF2	246.6
hmF1	N/A
hmE	110.0
yF2	82.6
yF1	N/A
yE	20.0
B0	66.1
B1	6.00
<hr/>	
C-level	11
<hr/>	
Auto:	
Artist4.5	
200311	



D	100	200	400	600	800	1000	1500	3000	[km]
MUF	4.9	5.0	5.2	5.6	6.1	6.9	9.2	15.1	[MHz]

33326355.tmp / 190fx128h 100 kHz 5.0 km / DGS-256 AU930 130 / 30.4 N 262.3 E

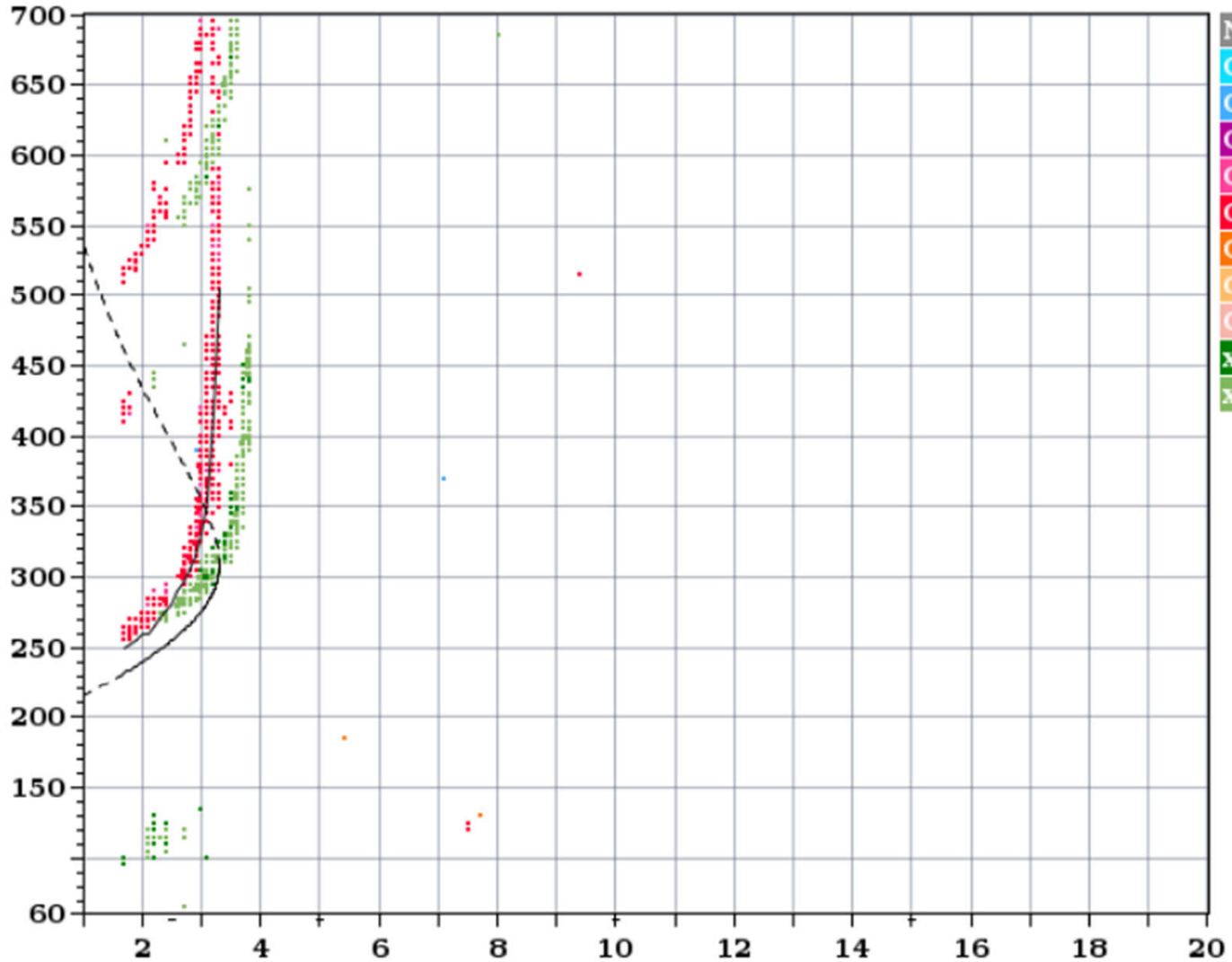
ShowIonogram v 1.0



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
 AUSTIN 2019 Jan24 024 072005 MMM 1 045 100 34+ 11

foF2	3.300
foF1	N/A
foF1p	N/A
foE	N/A
foEp	0.37
fxI	3.90
foEs	N/A
fmin	1.70
MUF(D)	10.36
M(D)	3.14
D	3000.0
h`F	250.0
h`F2	N/A
h`E	N/A
h`Es	N/A
hmF2	307.3
hmF1	N/A
hmE	110.0
yF2	87.6
yF1	N/A
yE	20.0
B0	79.2
B1	2.42
C-level	11

Auto:
 Artist4.5
 200311



NoVal
 O-4
 O-3
 O-2
 O-1
 O+1
 O+2
 O+3
 O+4
 X-
 X+

D	100	200	400	600	800	1000	1500	3000	[km]
MUF	3.9	3.9	4.1	4.3	4.7	5.2	6.6	10.4	[MHz]

35391057.tmp / 190fx128h 100 kHz 5.0 km / DGS-256 AU930 130 / 30.4 N 262.3 E

ShowIonogram v 1.0



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
AUSTIN 2019 Jan24 024 195005 MMM 1 045 100 32+ 11

foF2 5.550
foF1 4.77
foF1p 4.09
foE 3.22
foEp 3.00
fxI 6.10
foEs 3.80
fmin 1.80

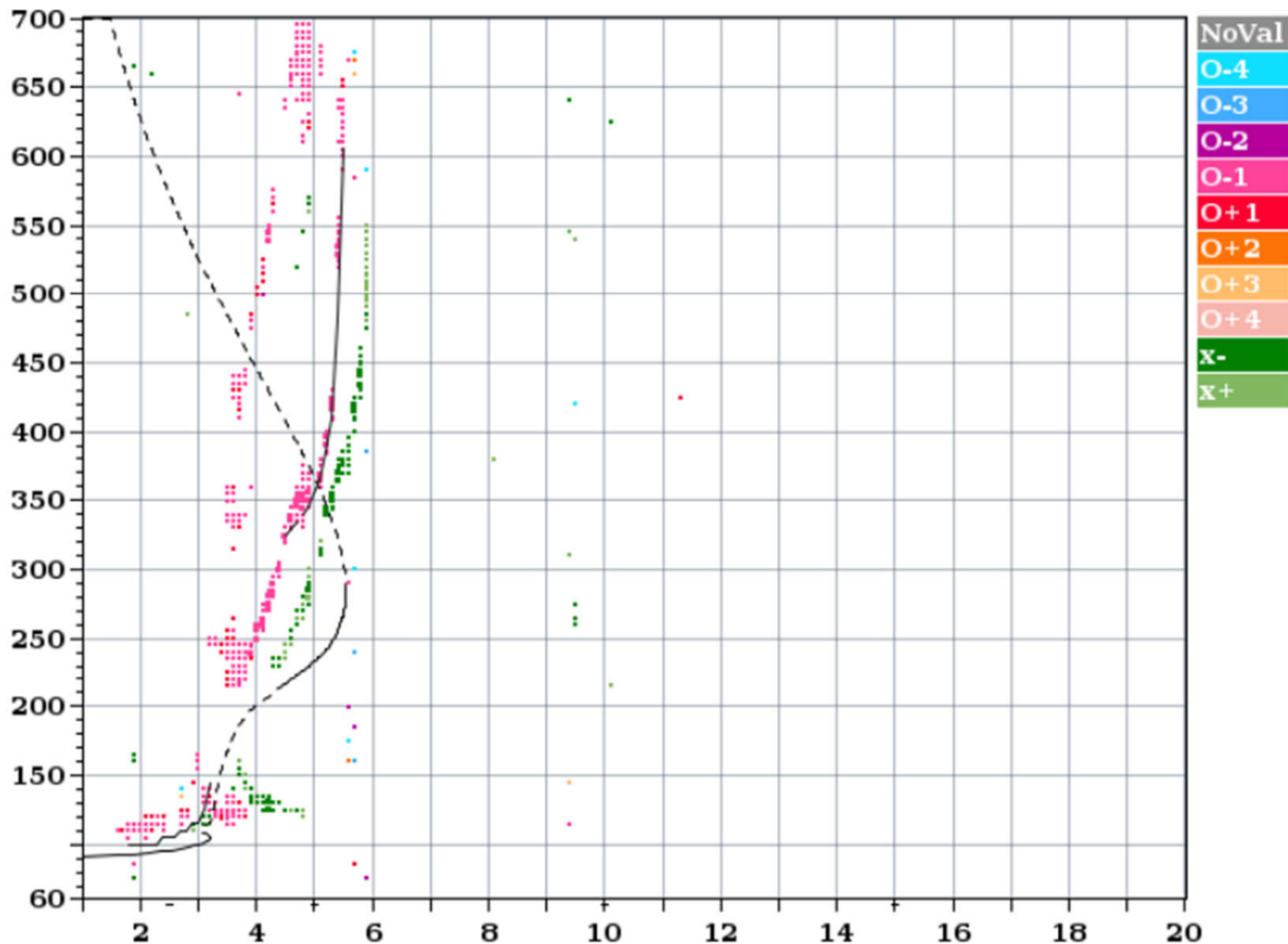
MUF(D) 16.61
M(D) 3.02
D 3000.0

h`F 325.0
h`F2 340.0
h`E 100.0
h`Es 115.0

hmF2 283.2
hmF1 226.4
hmE 105.1
yF2 111.2
yF1 38.3
yE 14.7
BO 84.6
B1 6.00

C-level 11

Auto:
Artist4.5
200311



D 100 200 400 600 800 1000 1500 3000 [km]
MUF 6.1 6.2 6.4 6.8 7.4 8.2 10.6 16.6 [MHz]

26702856.tmp / 190fx128h 100 kHz 5.0 km / DGS-256 AU930 130 / 30.4 N 262.3 E

ShowIonogram v 1.0

GIRO site Reports

- <http://umlcar.uml.edu/WatchIt/latestlonogram.html>
- All sites
 - <http://umlcar.uml.edu/WatchIt/latestlonograms.html>
- Any one site
 - <https://lgdc.uml.edu/common/DIDBFastStationList>

giro.uml.edu/IRTAM/

IRI Real-Time Assimilative Mapping (IRTAM)

Global Near-Real-Time F2-layer Critical Frequency and Peak Height

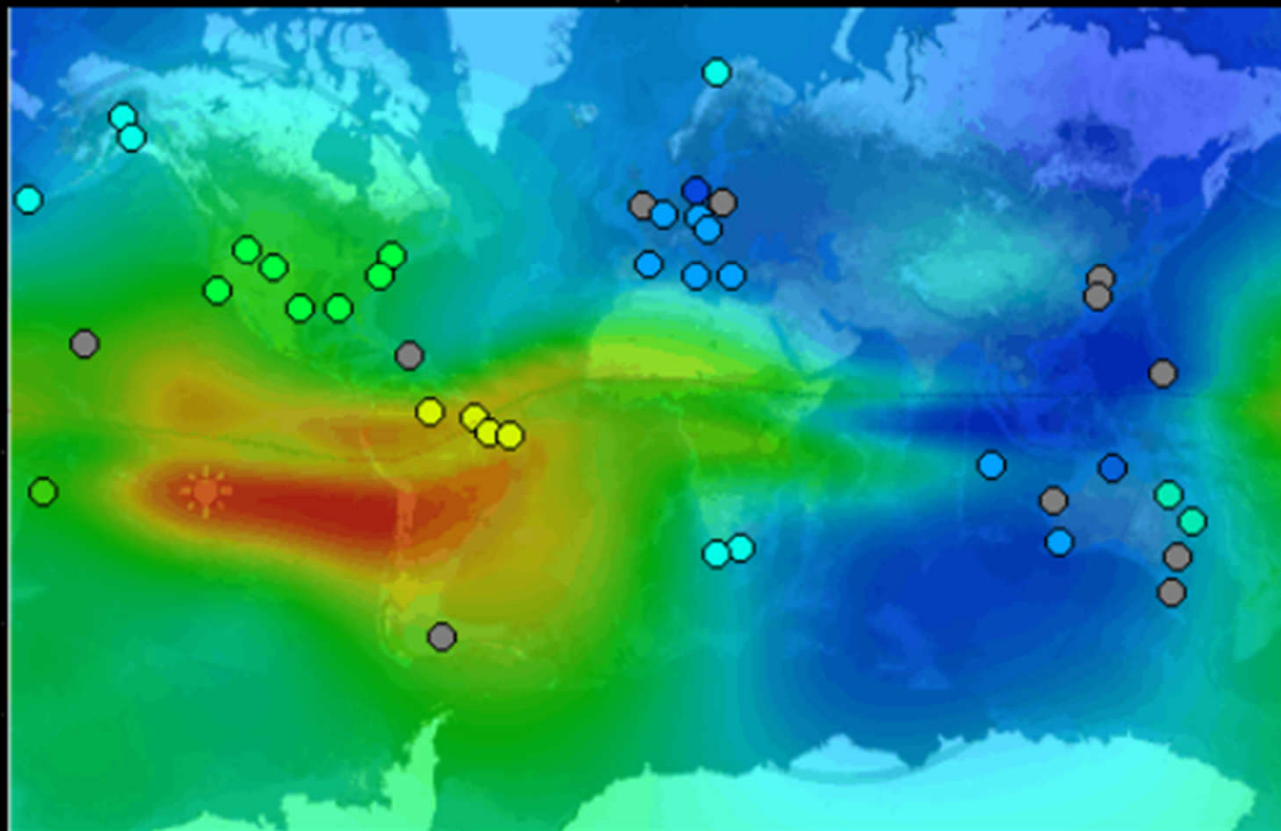
foF2: 24-hour Latest Weather hmF2: 24-hour Latest Weather B0: 24-hour Latest Weather

Map: foF2 (IRTAM) MHz	Sites: foF2 (GIRO) MHz	Map: hmF2 (IRTAM) km	Sites: hmF2 (GIRO) km	Map: B0 (IRTAM) km	Sites: B0 (GIRO) km
0 3 6 9 12	0 3 6 9 12	100 212.5 325 437.5 550	100 212.5 325 437.5 550	-2 98.5 199 299.5 400	-2 98.5 199 299.5 400

These IRTAM maps have been made possible due to real-time data provided by:

<http://giro.uml.edu/IRTAM/>

IRTAM v0.2A 2019.01.23 20:30:00 UT



Map: foF2 (IRTAM) MHz



0 3 6 9 12

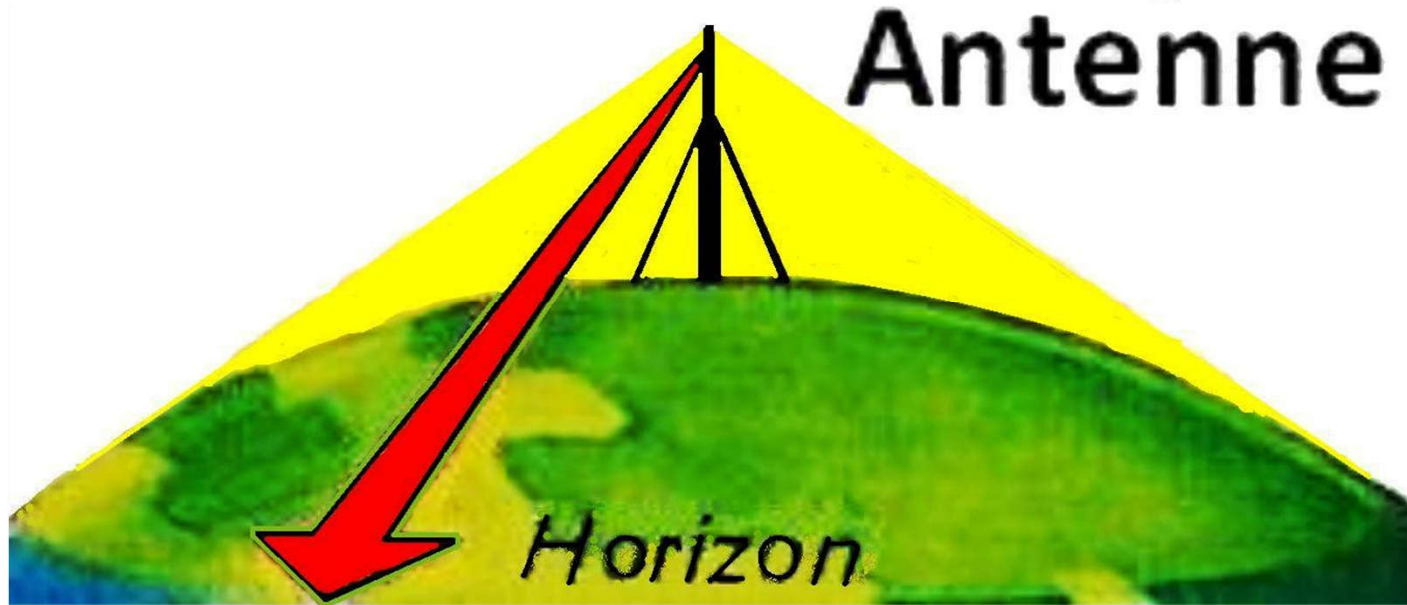
Sites: foF2 (GIRO) MHz



0 3 6 9 12

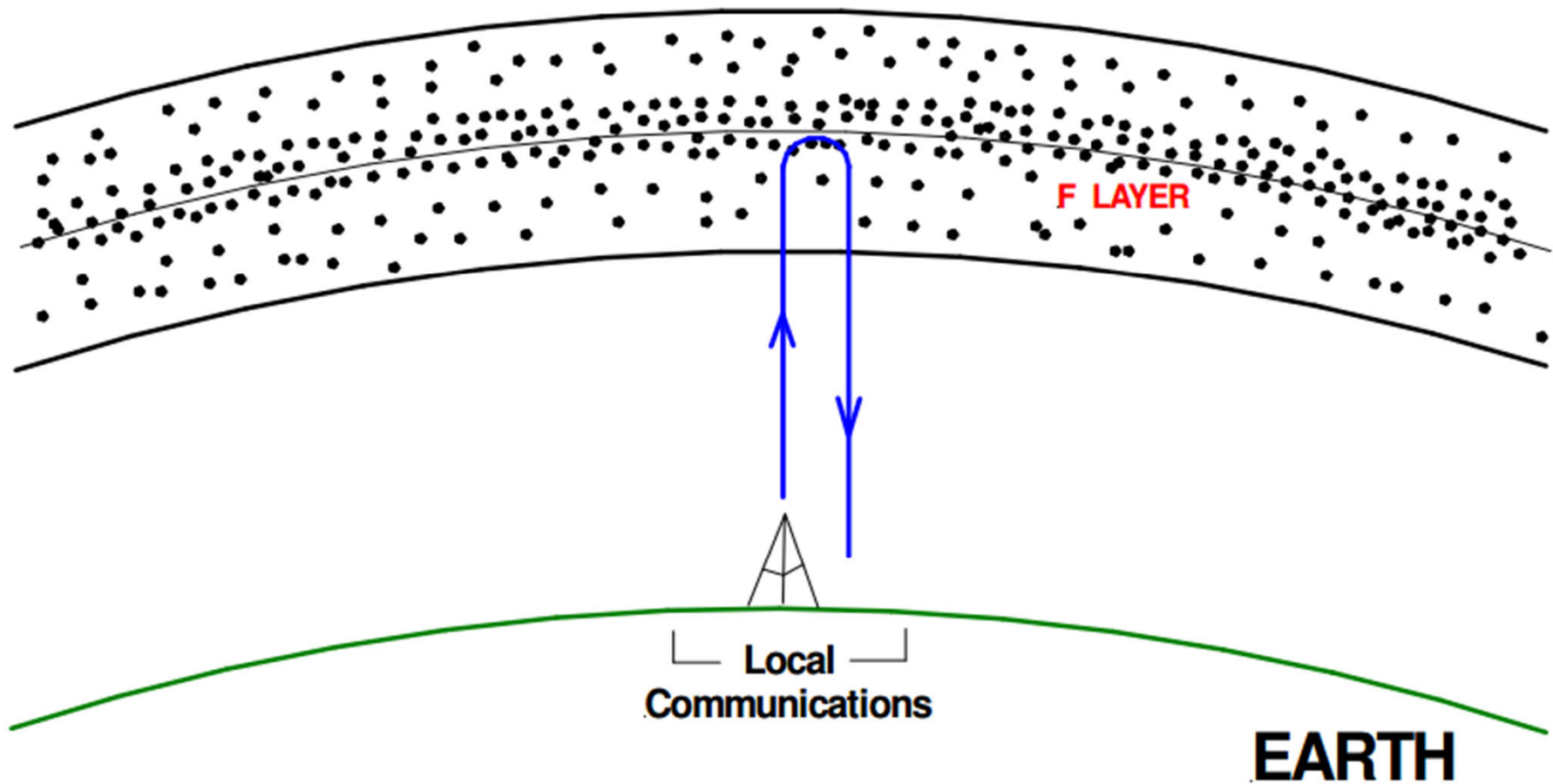
LoS and Skip

- Line of Site
 - Distance based on antenna tower height for VHF

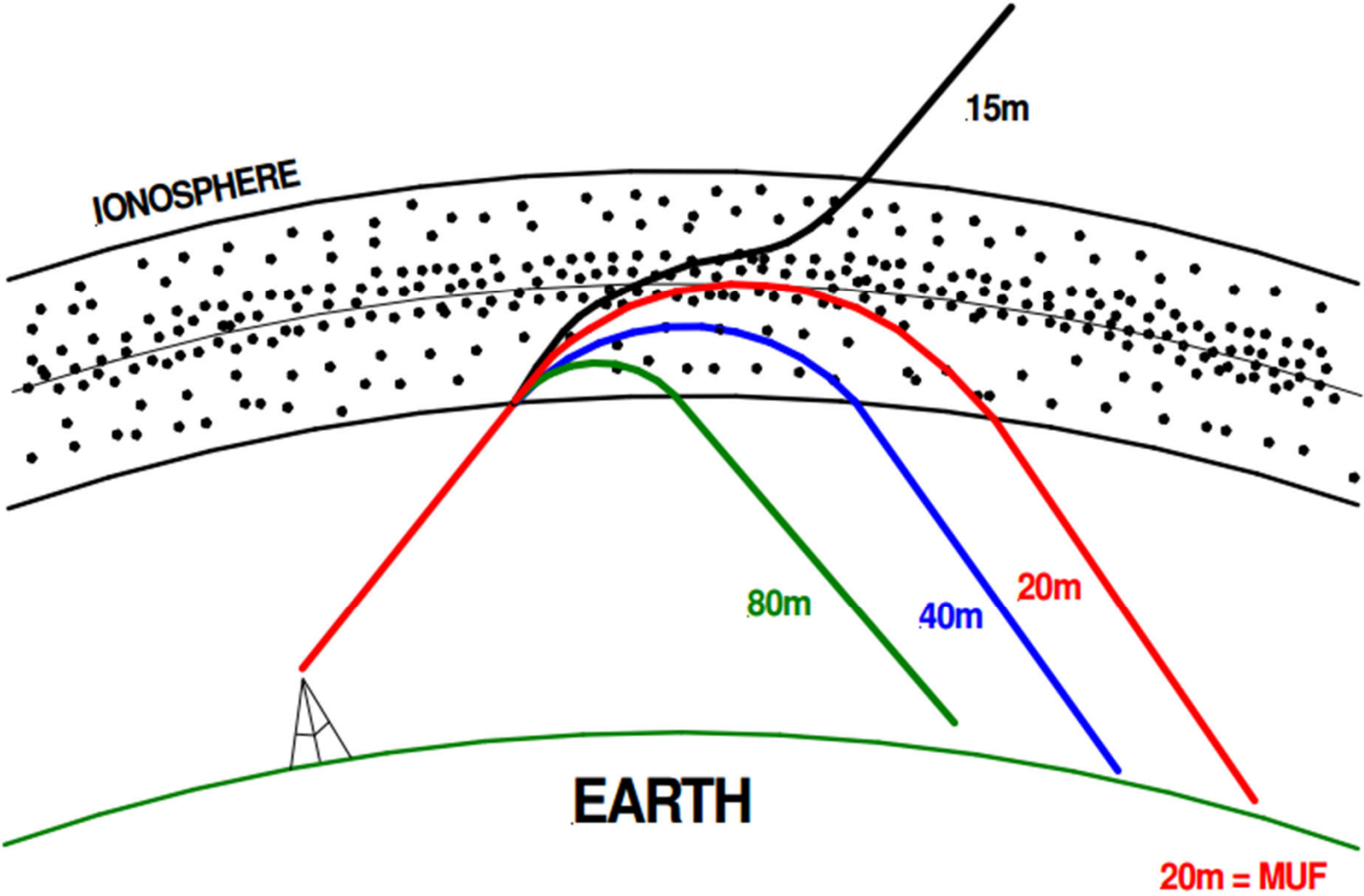


$$\text{horizon}_{\text{km}} \approx 3.57 \cdot \sqrt{\text{height}_{\text{metres}}}$$

Critical Frequency



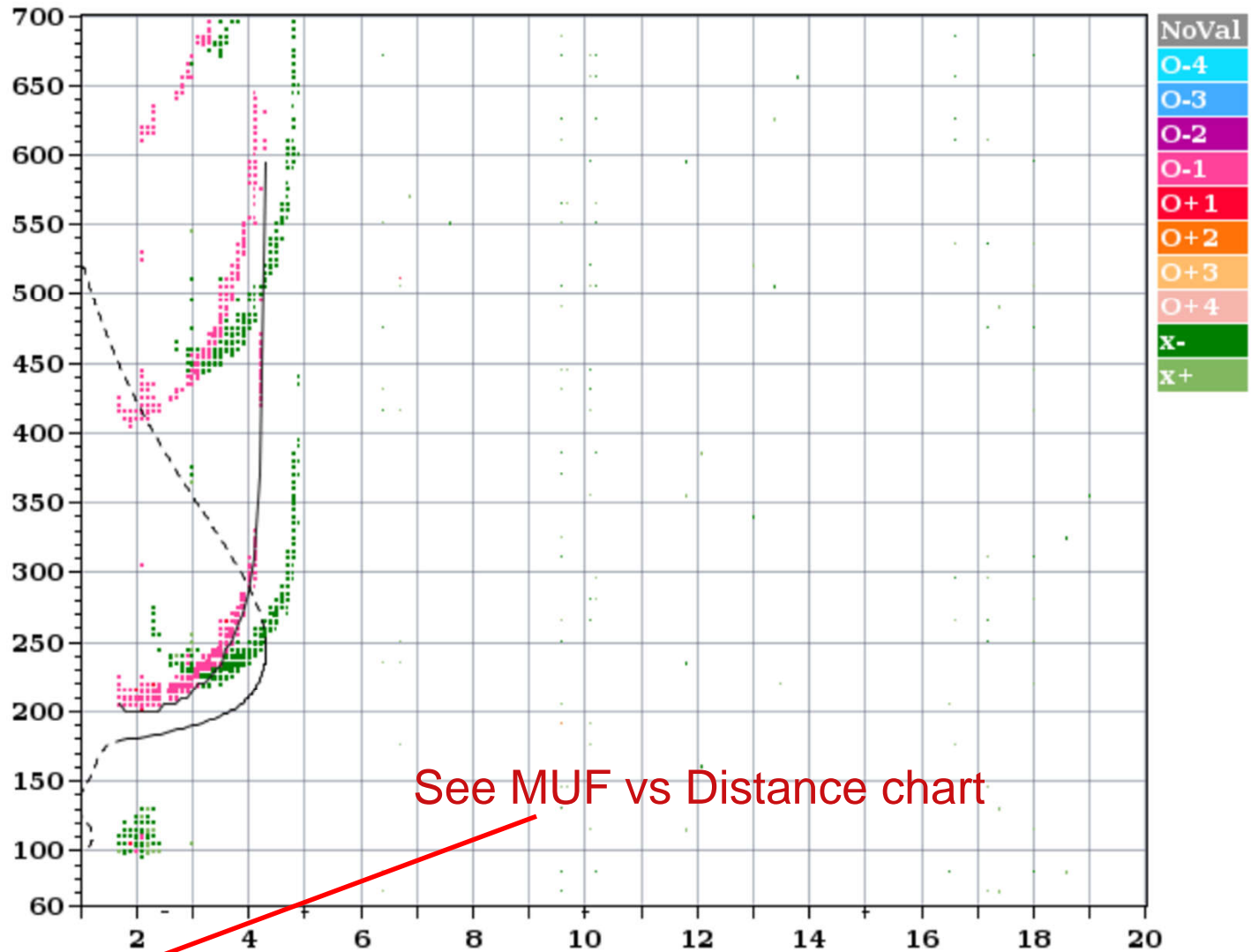
Ionospheric Refraction





Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
AUSTIN 2019 Jan24 024 000005 MMM 1 045 100 34+ 11

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h`E	N/A
h`Es	N/A
<hr/>	
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hmF1	N/A
hmE	110.0
yF2	82.6
yF1	N/A
yE	20.0
B0	66.1
B1	6.00
<hr/>	
C-level	11
<hr/>	
Auto:	
Artist4.5	
200311	



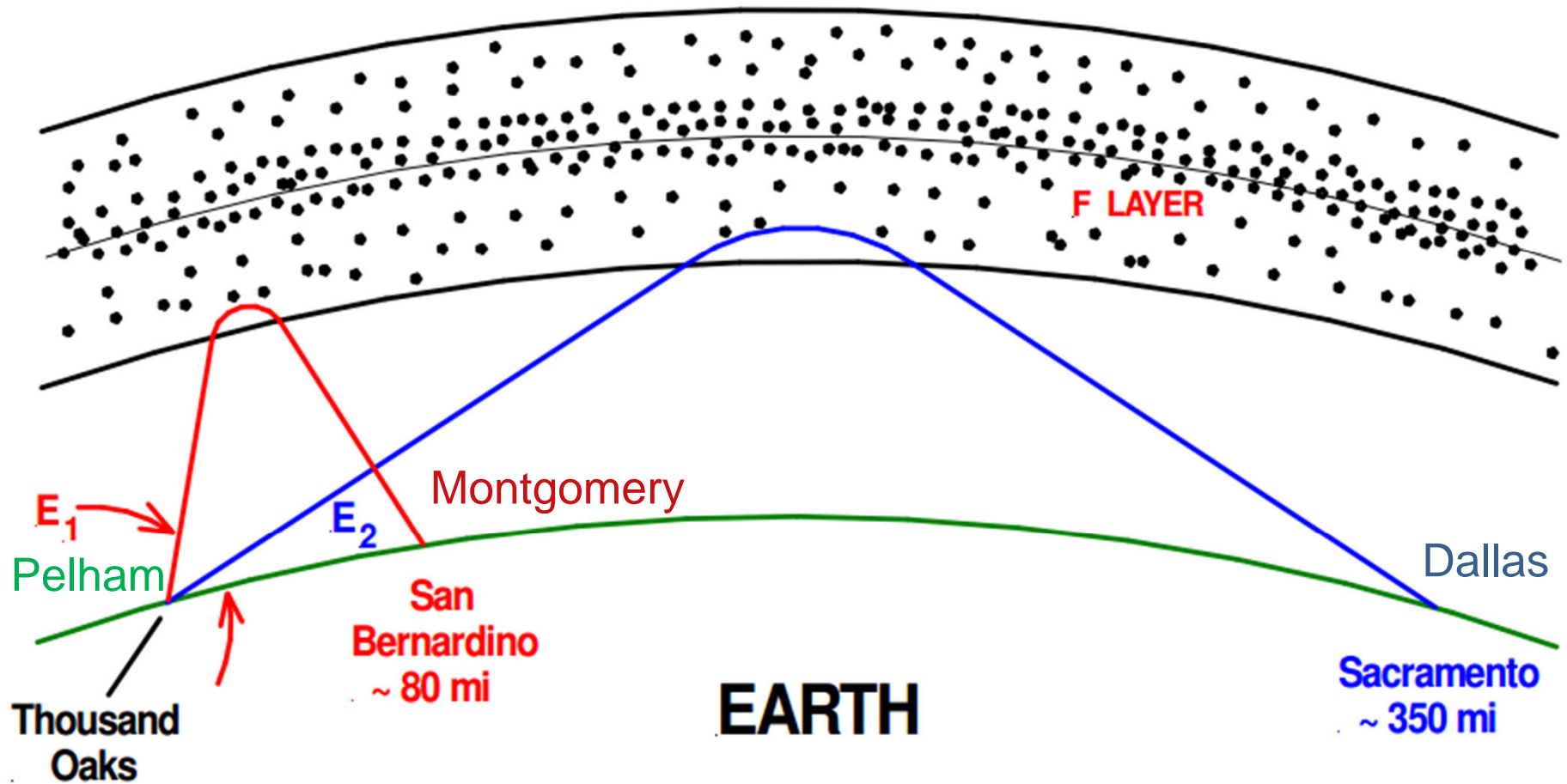
See MUF vs Distance chart

D	100	200	400	600	800	1000	1500	3000	[km]
MUF	4.9	5.0	5.2	5.6	6.1	6.9	9.2	15.1	[MHz]

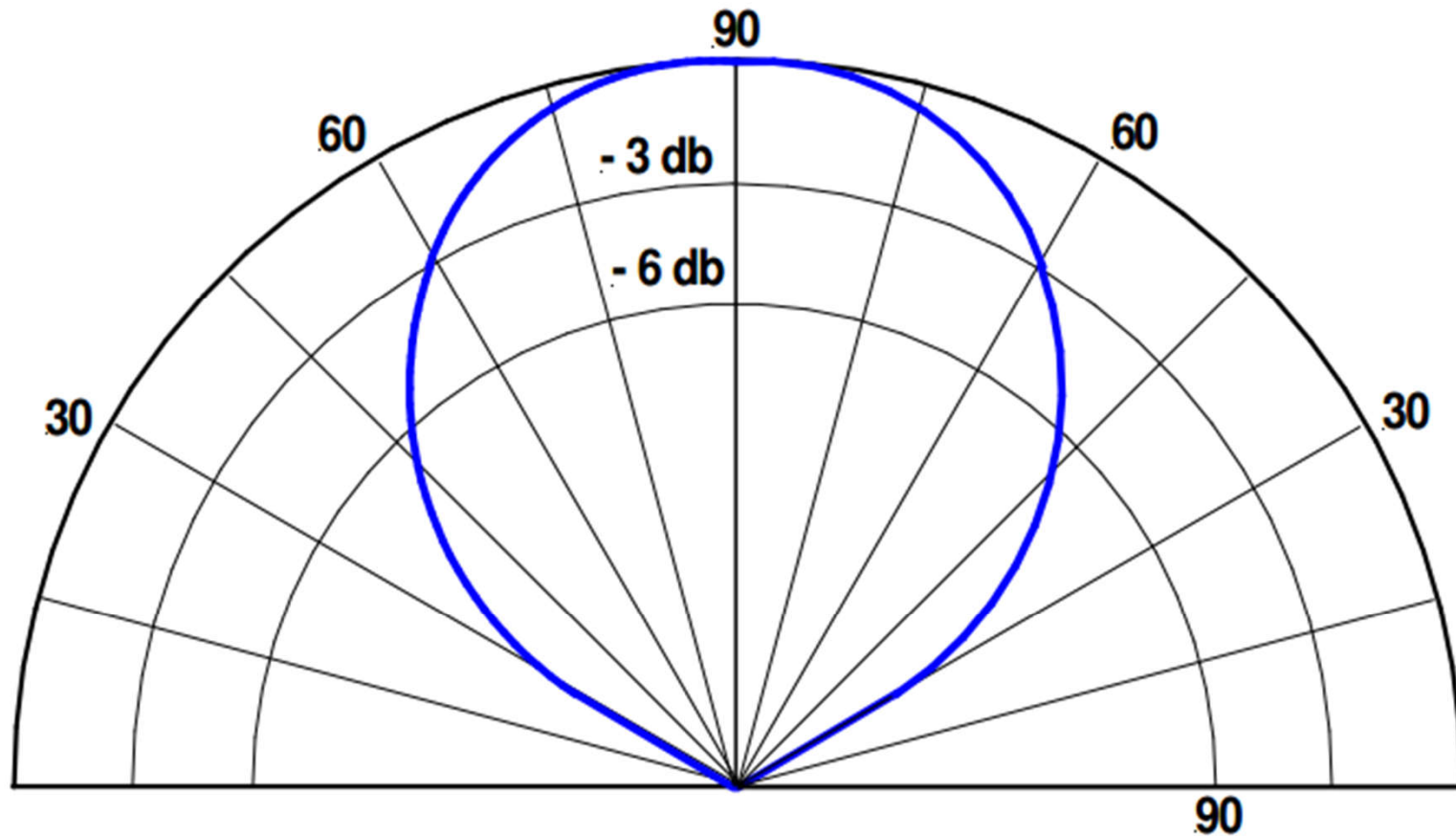
33326355.tmp / 190fx128h 100 kHz 5.0 km / DGS-256 AU930 130 / 30.4 N 262.3 E

ShowIonogram v 1.0

Montgomery vs Dallas

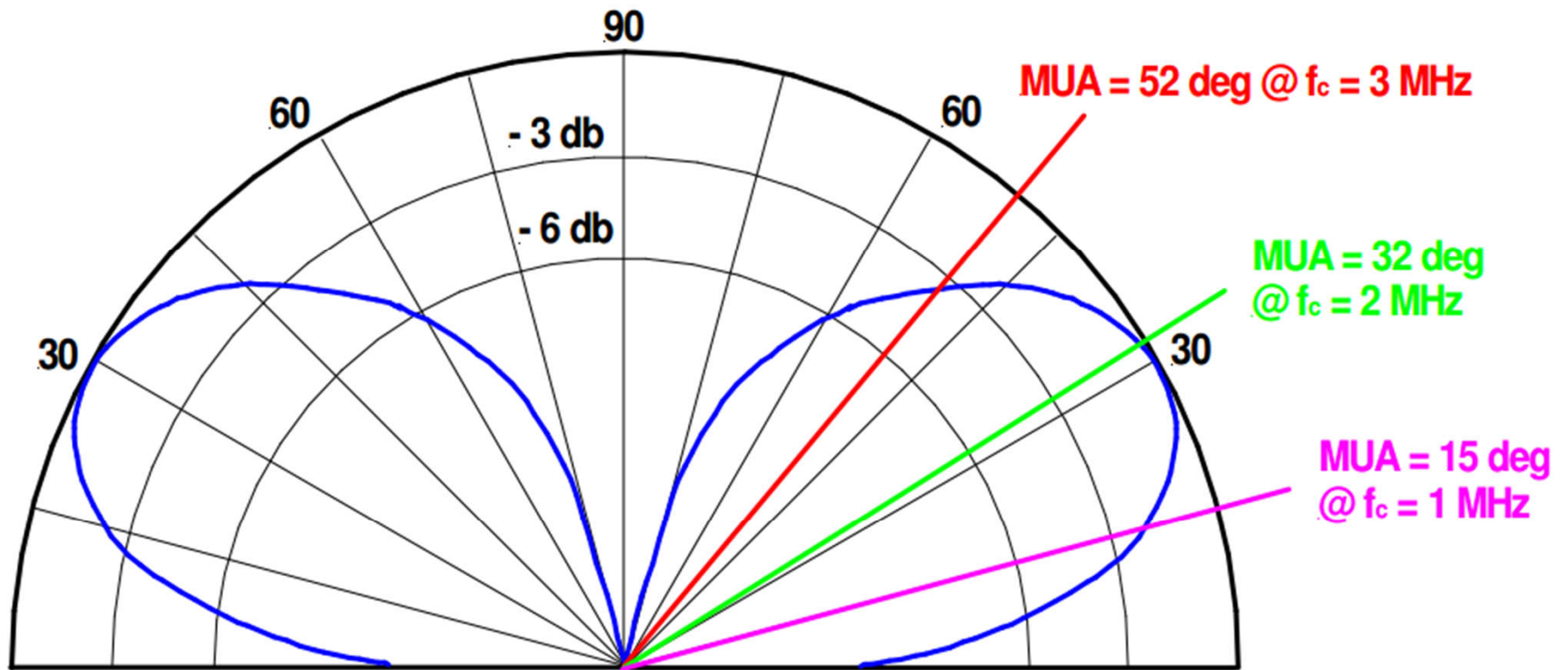


Wire Antenna Pattern



80 meter Inverted V Antenna 1/8 Wavelength Above Ground

Vertical Antenna



1/4 Wave Vertical Antenna

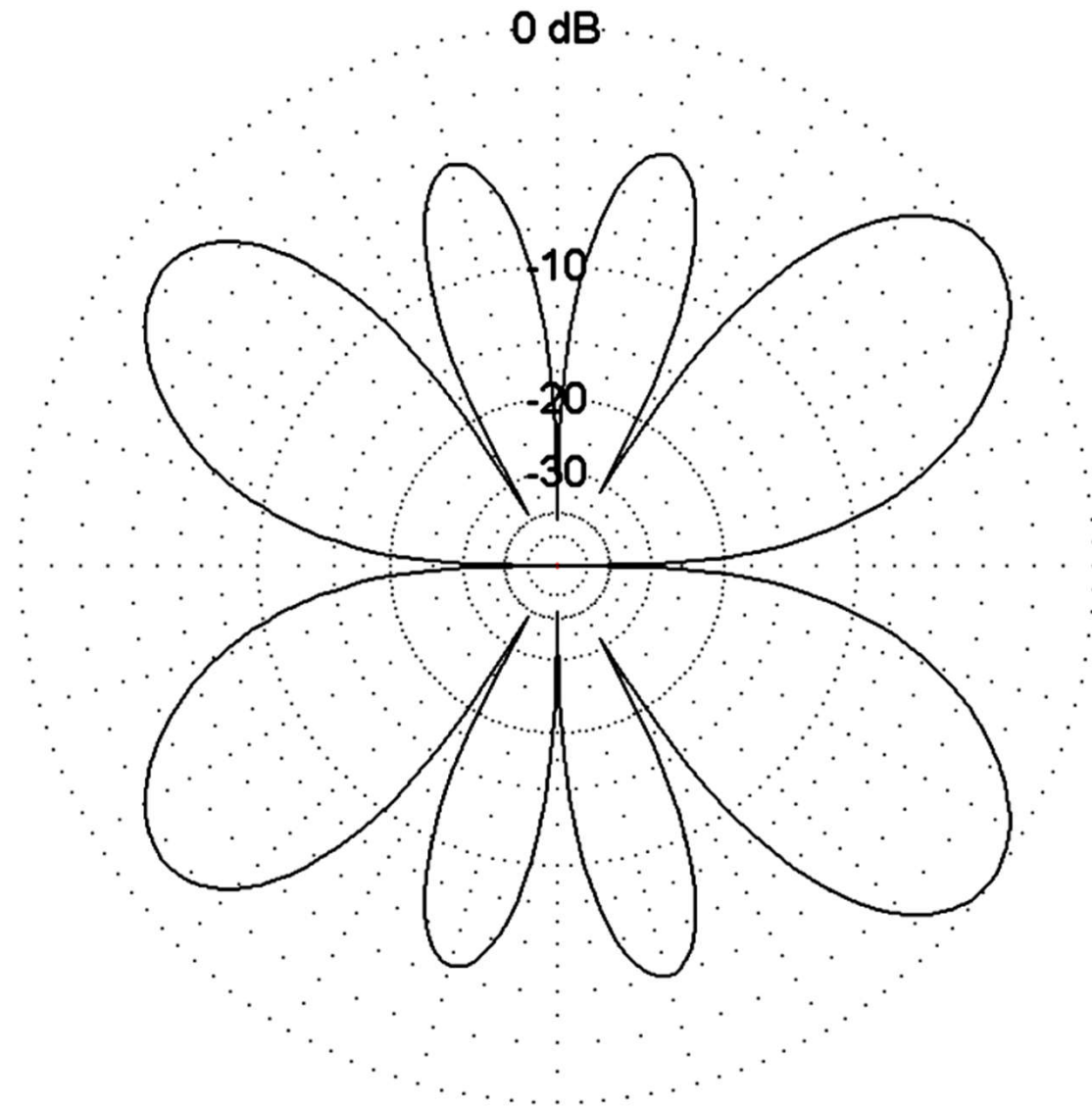
Winter FD 2019

Center: 33°17'59"N 87°0'0"W Radius: 4000 km

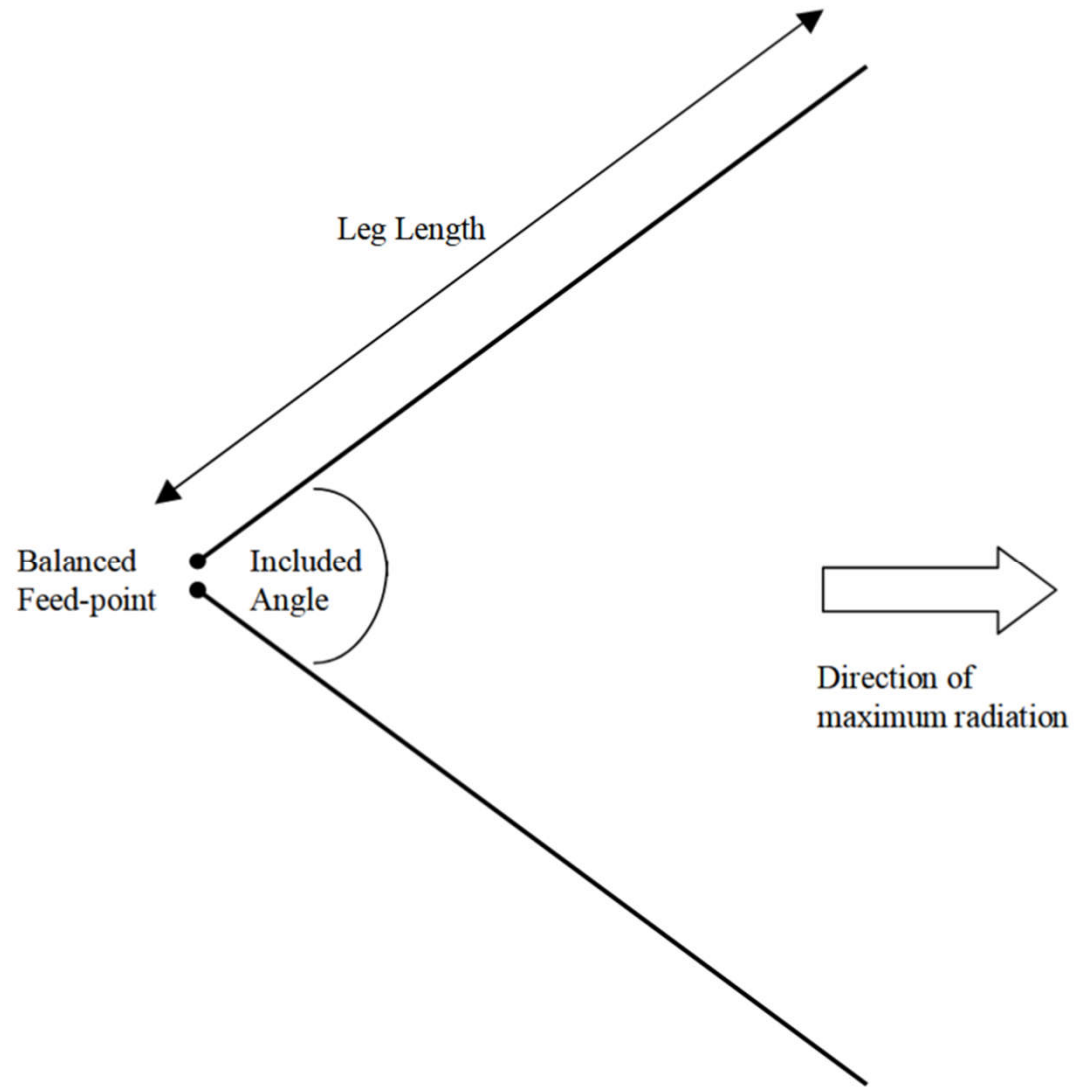
Courtesy of Tom (NS6T)



Two Wavelength Horizontal



V Beam Antenna



MUF vs LUF

- I didn't discuss LUF
 - Lowest Usable Frequency
 - Skywave problem
 - Daytime problem
 - MF problem – 160M
 - Ignore it for night time HF

URLs

- <https://ns6t.net/azimuth/azimuth.html>
- [http://www.cvarc.org/resources/Tech Articles/14-MUF-04-R.pdf](http://www.cvarc.org/resources/Tech_Articles/14-MUF-04-R.pdf)
- <http://www.spacew.com/www/fof2.html>
- <http://ulcar.uml.edu/digisonde.html>
 - <http://umlcar.uml.edu/WatchIt/latestIonograms.html>
 - <http://umlcar.uml.edu/WatchIt/latestIonogram.html>
 - <https://lgdc.uml.edu/common/DIDBFastStationList>
 - <http://giro.uml.edu/IRTAM>