Ionospheric Sounders

What are they?

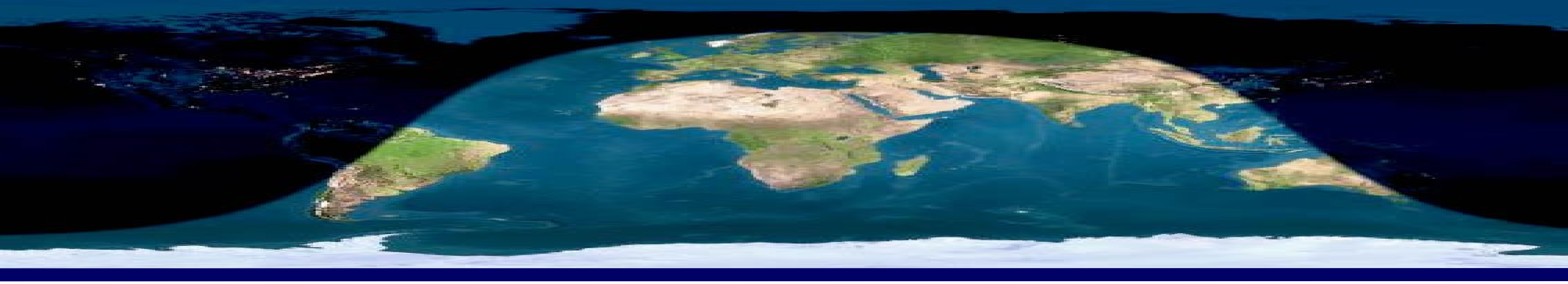
How can you use them?

Steve Nichols G0KYA, RSGB Propagation Studies Committee

History of the ionosphere

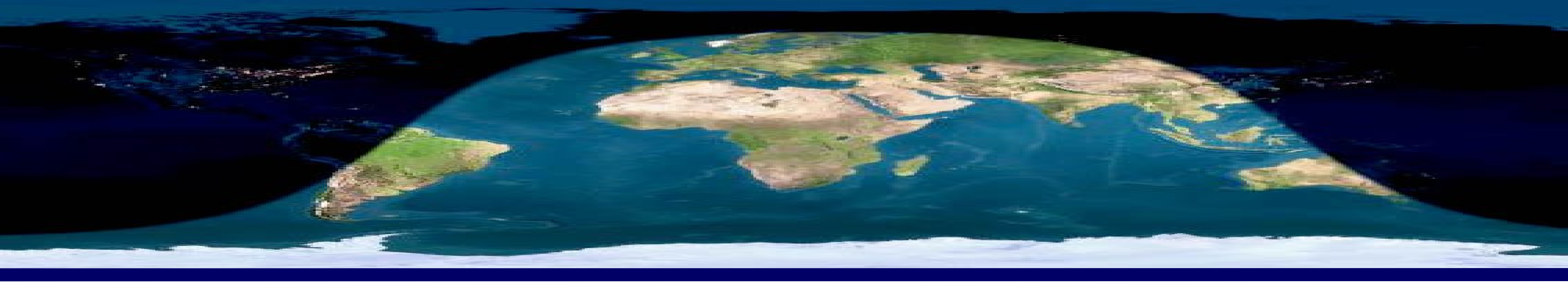
Jan. 1901
Marconi sends signals from Isle of Wight to The Lizard, Cornwall

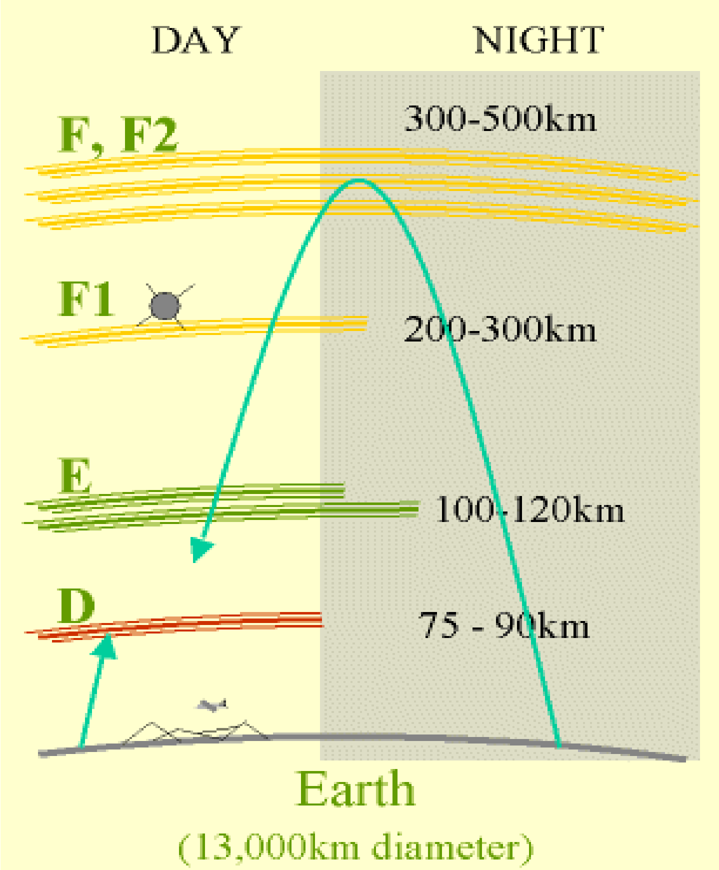
Dec. 1901
Marconi crosses Atlantic, from Poldhu to Newfound -land



History of the ionosphere

- **1899**, Nikola Tesla experiments at Colorado Springs, USA
- **1902**, Oliver Heaviside and Arthur Edwin Kennelly propose the existence of the Kennelly-Heaviside Layer
- **1926**, Scottish physicist Robert Watson-Watt introduces the term “ionosphere”
- **1947,** Edward V. Appleton awarded a Nobel Prize for his confirmation in 1927 of the existence of the ionosphere




DAY
NIGHT
F, F2
300-500km
F1
200-300km
E
100-120km
D
75 - 90km
Earth
(13,000km diameter)

History of ionospheric sounding

- Ionospheric sounding uses high frequency (HF) radio waves for the vertical-incidence remote sounding of the ionosphere
- The basic technology was introduced by Sir Edward Appleton in the 1920s

History of ionospheric sounding

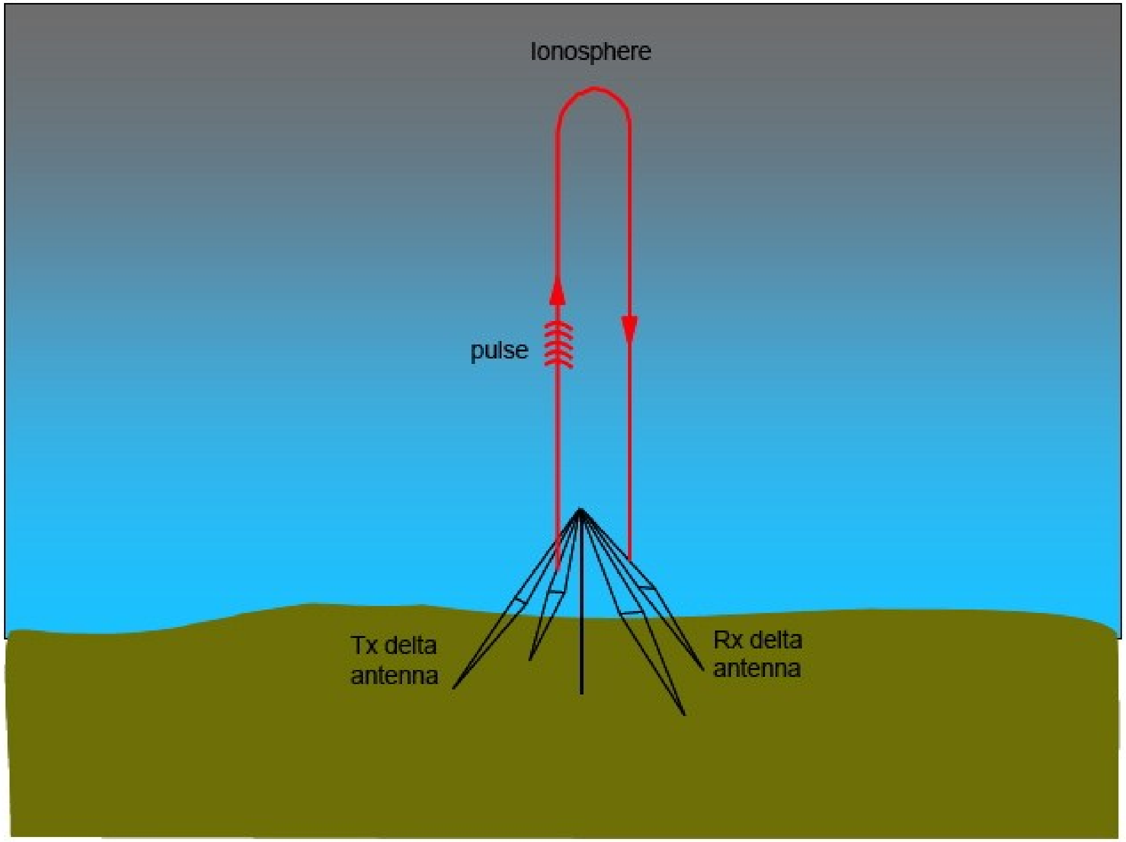
- Appleton's Oxford-Bournemouth experiment
- Used the BBC broadcasting station in Bournemouth in 1924 to vary the wavelength of its emissions after the evening programs had finished.
- Installed a receiving station in Oxford to monitor the interference effects of a ground and sky wave - fading.

Modern ionospheric sounding

• The modern equipment is called a **Digisonde** - an acronym for **Digital Ionospheric Goniometric Ionosonde**

• Also travel time or “time of flight” is used to determine range to the reflection point

• Can also evaluate angle of arrival, polarisation, and Doppler frequency shift of skywave signals reflected from the ionosphere.


Ionosphere
pulse
Tx delta
antenna
Rx delta
antenna

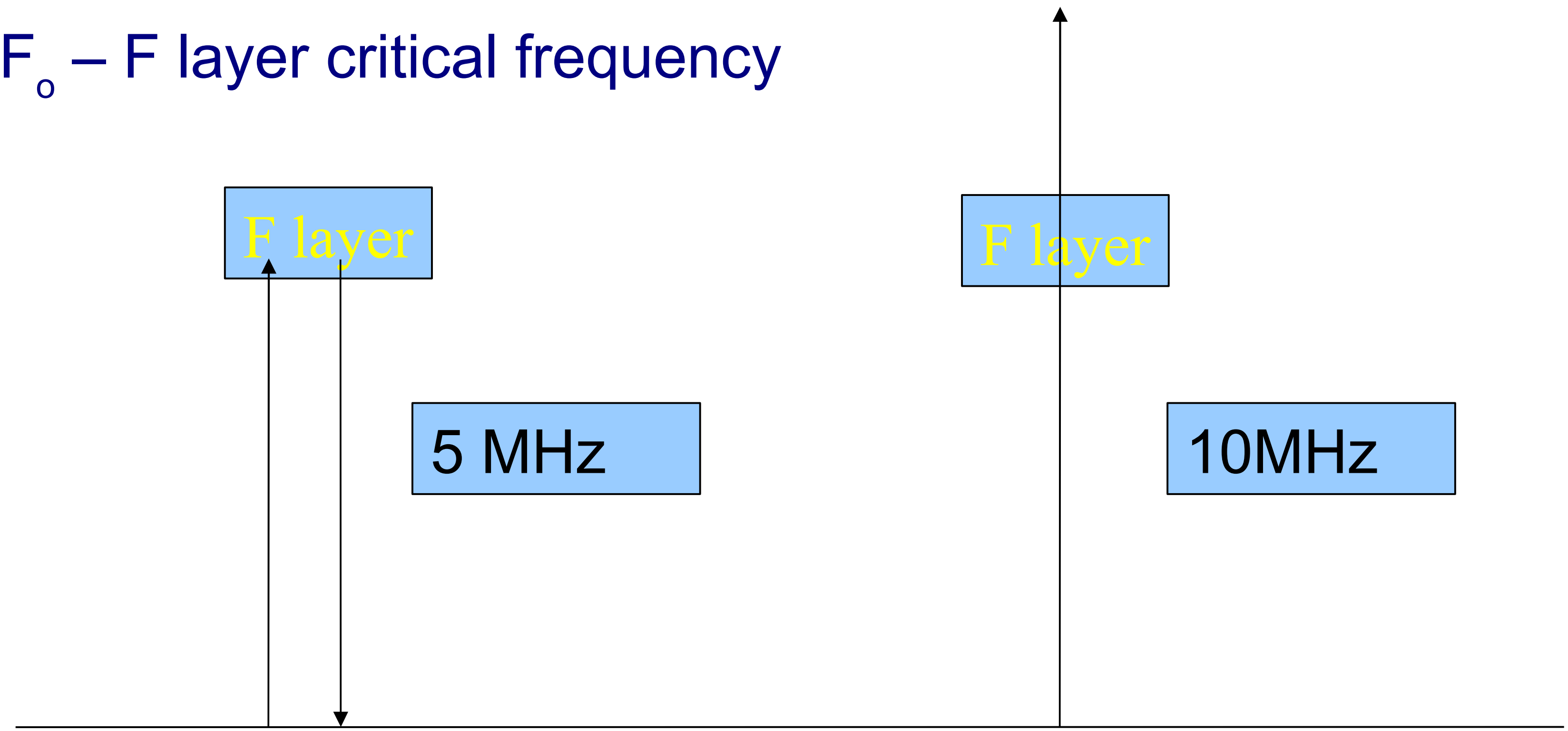
Digisonde 128
(1970)

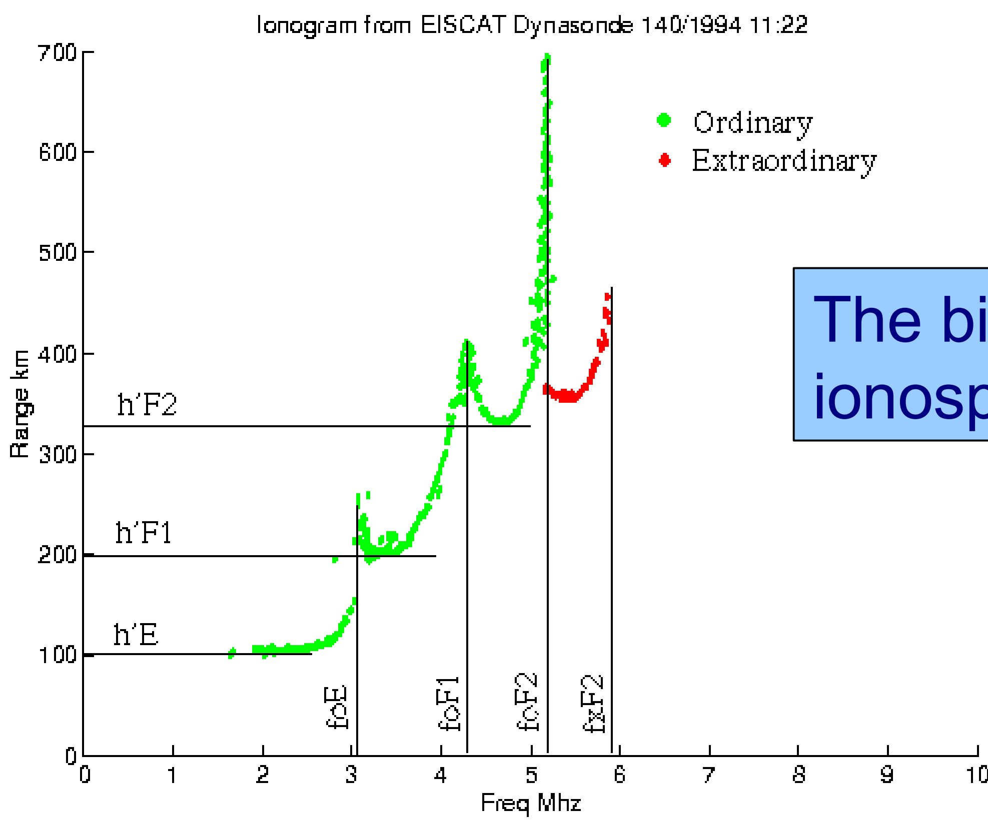
Digisonde 256
(1978)

Digisonde DPS-4
(1993)

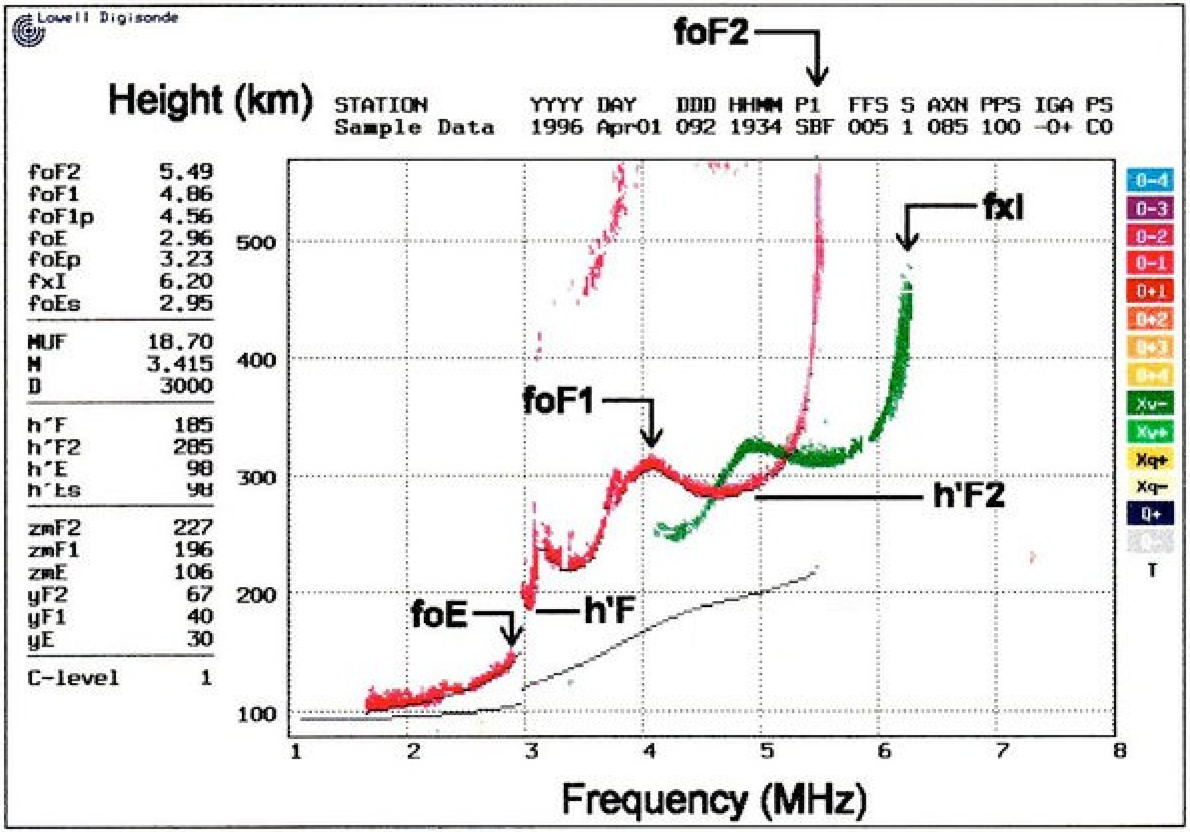
Digisonde 4D
(2008)

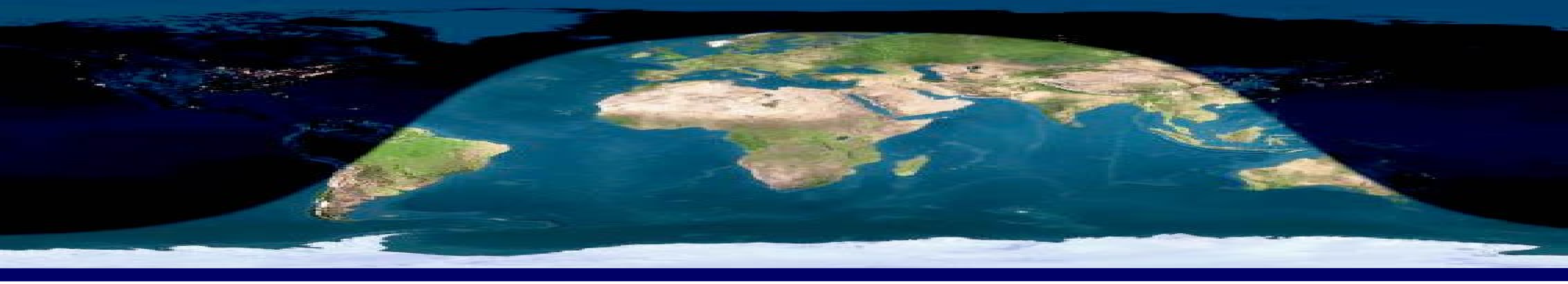
F_o – F layer critical frequency





The bi-refringent ionosphere in action


Lowell Digisonde
Height (km)
STATION
Sample Data
YYYY DAY
1996 Apr01
DDD HHMM P1
092 1934 SBF
FFS S AXN PPS IGA PS
005 1 085 100 -0+ CO
foF2 5.49
foF1 4.86
foF1p 4.56
foE 2.96
foEp 3.23
fxI 6.20
foEs 2.95
MUF 18.70
M 3.415
D 3000
h'F 185
h'F2 285
h'E 98
h'Es 98
zmF2 227
zmF1 196
zmE 106
yF2 67
yF1 40
yE 30
C-level 1
foF2
foF1
fxI
h'F2
h'F
foE
500
400
300
200
100
1 2 3 4 5 6 7 8
Frequency (MHz)
O-4
O-3
O-2
O-1
O+1
O+2
O+3
O+4
Xv-
Xv+
Xq+
Xq-
Q+
T




Nord
Quaanaaq
Sondrestrom
Narassarssuaq
Goose Bay
College
Gakona
King Salmon
Hanscom AFB
Millstone Hill
Boulder
Wallops Is.
Pt. Arguello
Eglin
Dyess AFB
Ramey
Tromso
Fairford
Juliusruh
Chilton
Moscow
Pruhonice
Dourbes
Rome
Roquetes
San Vito
El Arenosillo
Athens
Nicosia
Islamabad
Multan
Karachi
Norilsk
Zhigansk
Yakutsk
Irkutsk
Anyang
Osan
Hokkaido
XinXiang
Kokubunji
Wuhan
Okinawa
Chung Li
Hainan Is.
Kwajalein Is.
Pontianak
Sao Luis
Fortaleza
Ascension Is.
Jicamarca
Tucuman
Cachoiera Paulista
Santa Maria
Madimbo
Louisvale
Grahamstown
Hermanus
Learmonth
Bundoora
Port Stanley
Davis Base
Zhong-Shan
Lowell DIGISONDE
INTERNET/ DIDBase
Secure Net
No Remote Access

UK Solar System Data Centre

Data | Contact Us | Register to Retrieve Data | Site Index | Search [ ] Go | Access keys | News

Home > WDC > Data > Ionospheric > Latest ionogram

View Latest Ionogram

News - Ionosonde at Stanley Back in Action - June 2008
News - UK Ionosonde Service secure funding for 2007/2008

This form allows you to view the latest ionograms available in the WDC databases for the following ionosondes. The times gi
are in UT.

A basic introduction to ionosonde theory and ionogram interpretation is available.

Note that you will need to register to have access to the ionograms.

Chilton (RAL) ⦿
Port Stanley ○
Get latest ionogram

See http://www.ukssdc.ac.uk/ionosondes/view_latest.html

Data | Contact Us | Register to Retrieve Data | Privacy Policy | Site Index | Search [ ] Go | Access keys | News

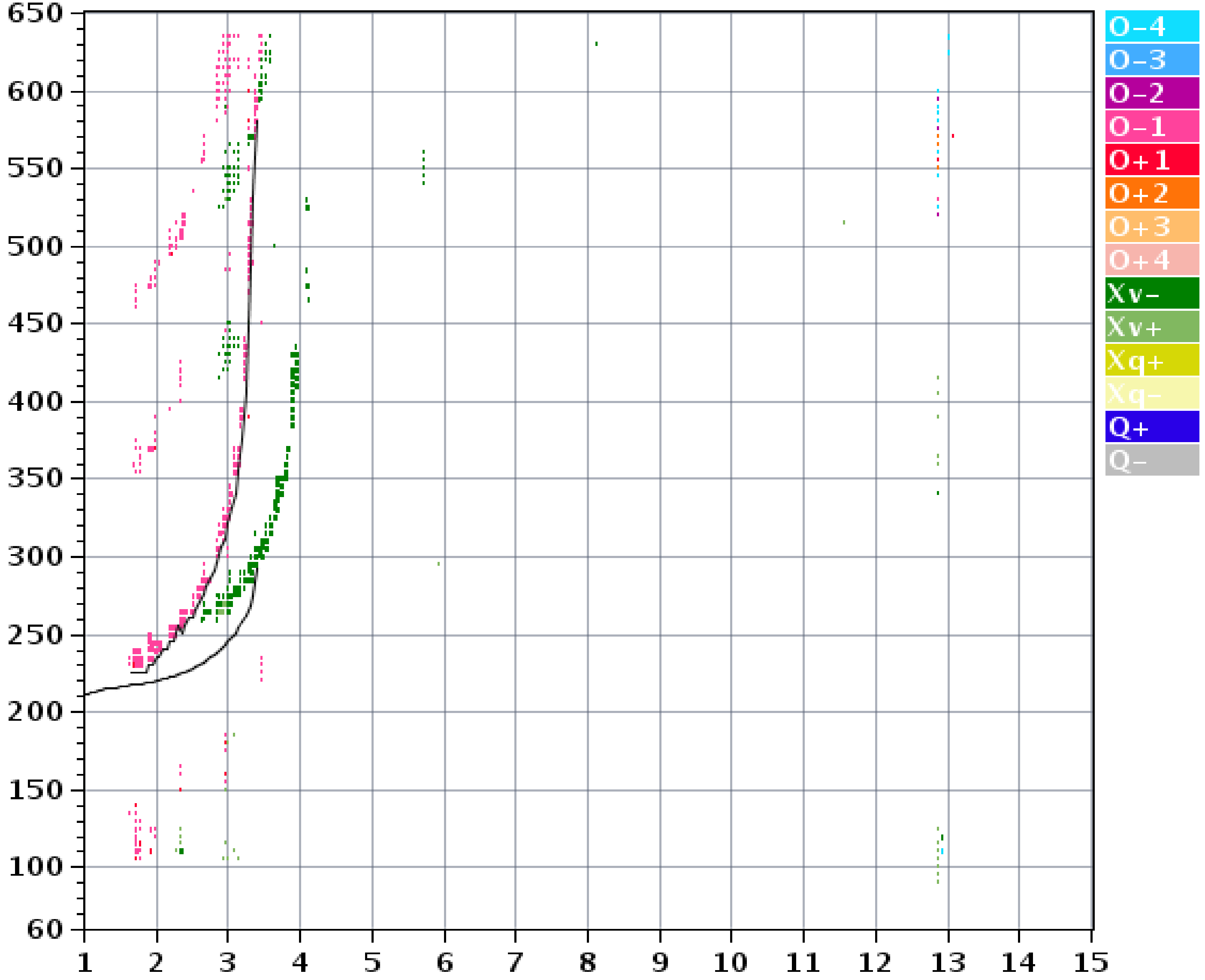
Page last updated by Sarah James on Monday, 02-Feb-2009 16:08:11 GMT

Lowell DIGISONDE

Station	YYYY	DAY	DDD	HHMM	P1	FFS	S	AXN	PPS	IGA	PS
Chilton	2011	Jan19	019	1750	MMM		1	015	200	10+	A1

foF2	3.400
foF1	N/A
foF1p	N/A
foE	N/A
foEp	.47
fxI	4.10
foEs	N/A
fmin	1.65
MUF(D)	10.56
M(D)	3.11
D	3000.0
h\`F	225.0
h\`F2	N/A
h\`E	N/A
h\`Es	N/A
hmF2	293.0
hmF1	N/A
hmE	110.0
yF2	94.4
yF1	N/A
yE	20.0
B0	77.3
B1	6.00
C-level	11

Auto:
Artist4.5
200311

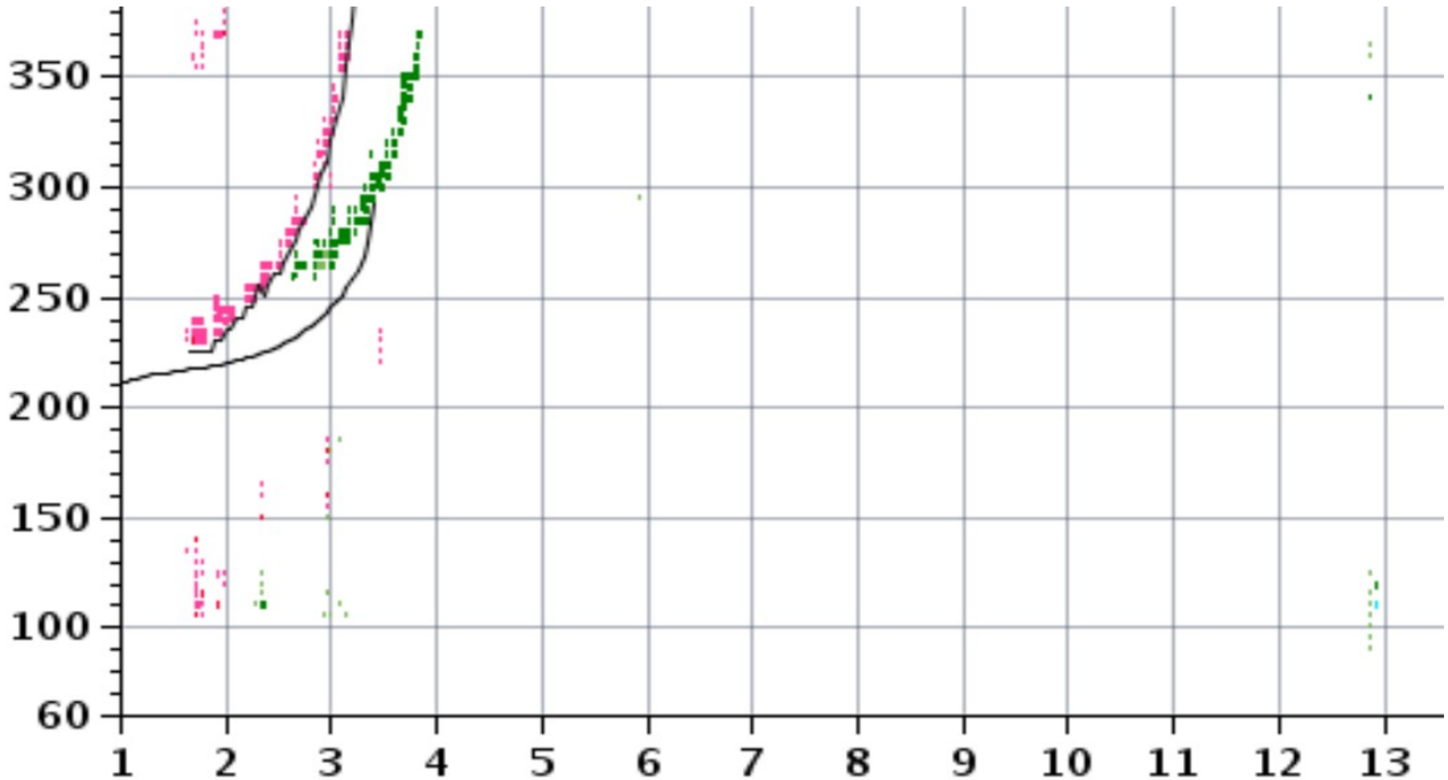


D	100	200	400	600	800	1000	1500	3000	[km]
MUF	4.0	4.0	4.2	4.4	4.8	5.3	6.8	10.6	[MHz]

RL052_2011019175000.MMM / 280fx128h 50 kHz 5.0 km / DPS-1 RL052 052 / 51.6 N 358.7 E Ion2Png v. 1.3.03

h`E	N/A
h`Es	N/A
hmF2	293.0
hmF1	N/A
hmE	110.0
yF2	94.4
yF1	N/A
yE	20.0
B0	77.3
B1	6.00
C-level	11

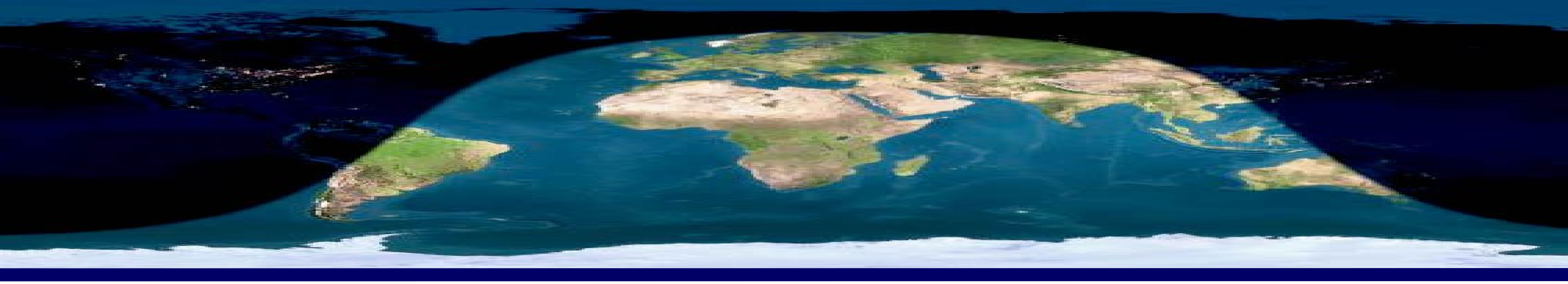
Auto:
Artist4.5
200311



D	100	200	400	600	800	1000	1500	3000	[km]
MUF	4.0	4.0	4.2	4.4	4.8	5.3	6.8	10.6	[MHz]

Predicted max. distance

RL052_2011019175000.MMM / 280fx128h 50 kHz 5.0 km / DPS-1 RL052 052 / 51.6 N 358.7 E



Critical frequency F2 layer

Critical frequency X wave

Minimum frequency of echoes

Maximum usable frequency (3000km - D)

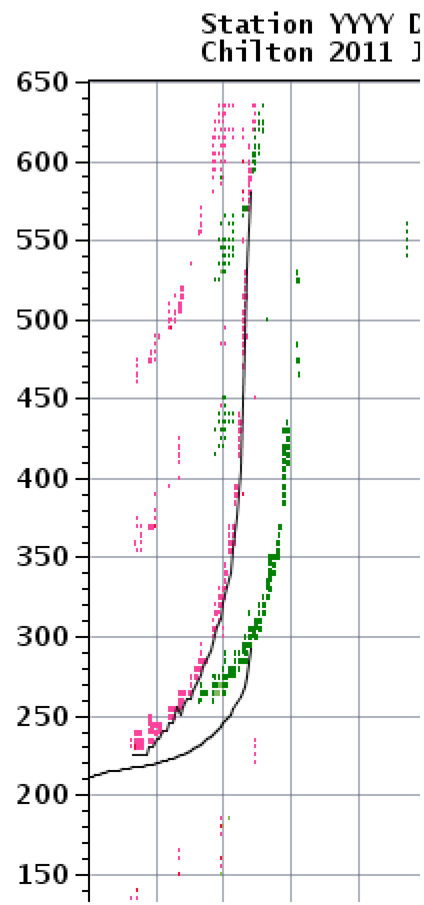
Height F2 layer

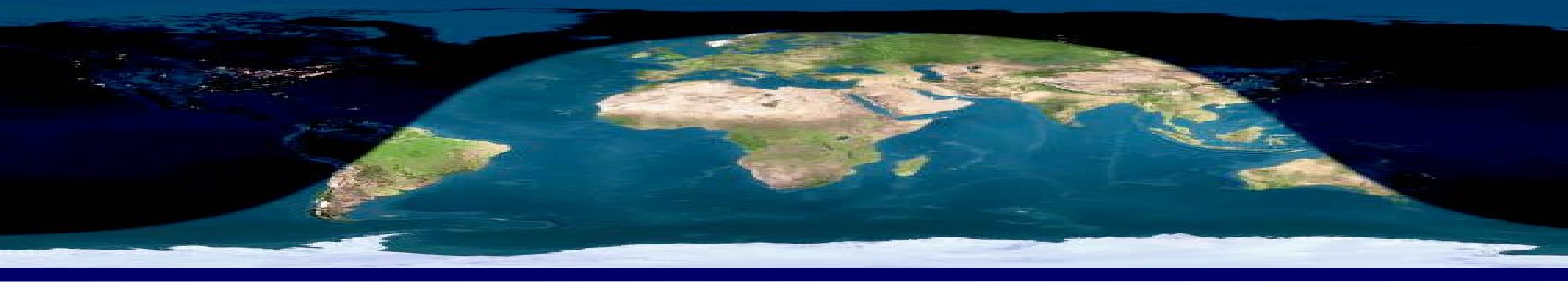
Height E layer

Lowell DIGISONDE

foF2	3.400
foF1	N/A
foF1p	N/A
foE	N/A
foEp	.47
fxI	4.10
foEs	N/A
fmin	1.65
MUF(D)	10.56
M(D)	3.11
D	3000.0
h`F	225.0
h`F2	N/A
h`E	N/A
h`Es	N/A
hmF2	293.0
hmF1	N/A
hmE	110.0
yF2	94.4
yF1	N/A
yE	20.0
B0	77.3
B1	6.00
C-level	11

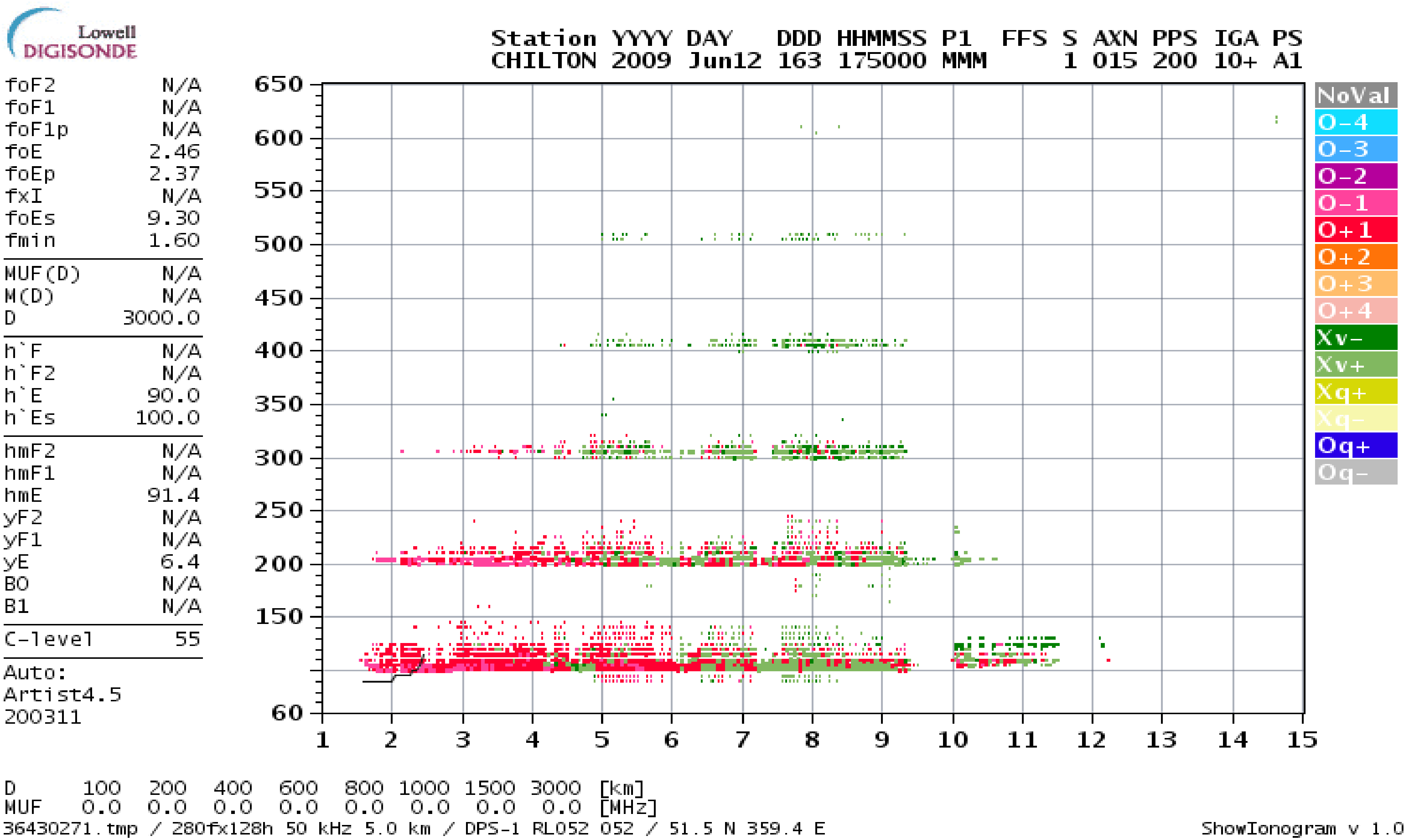
Auto:





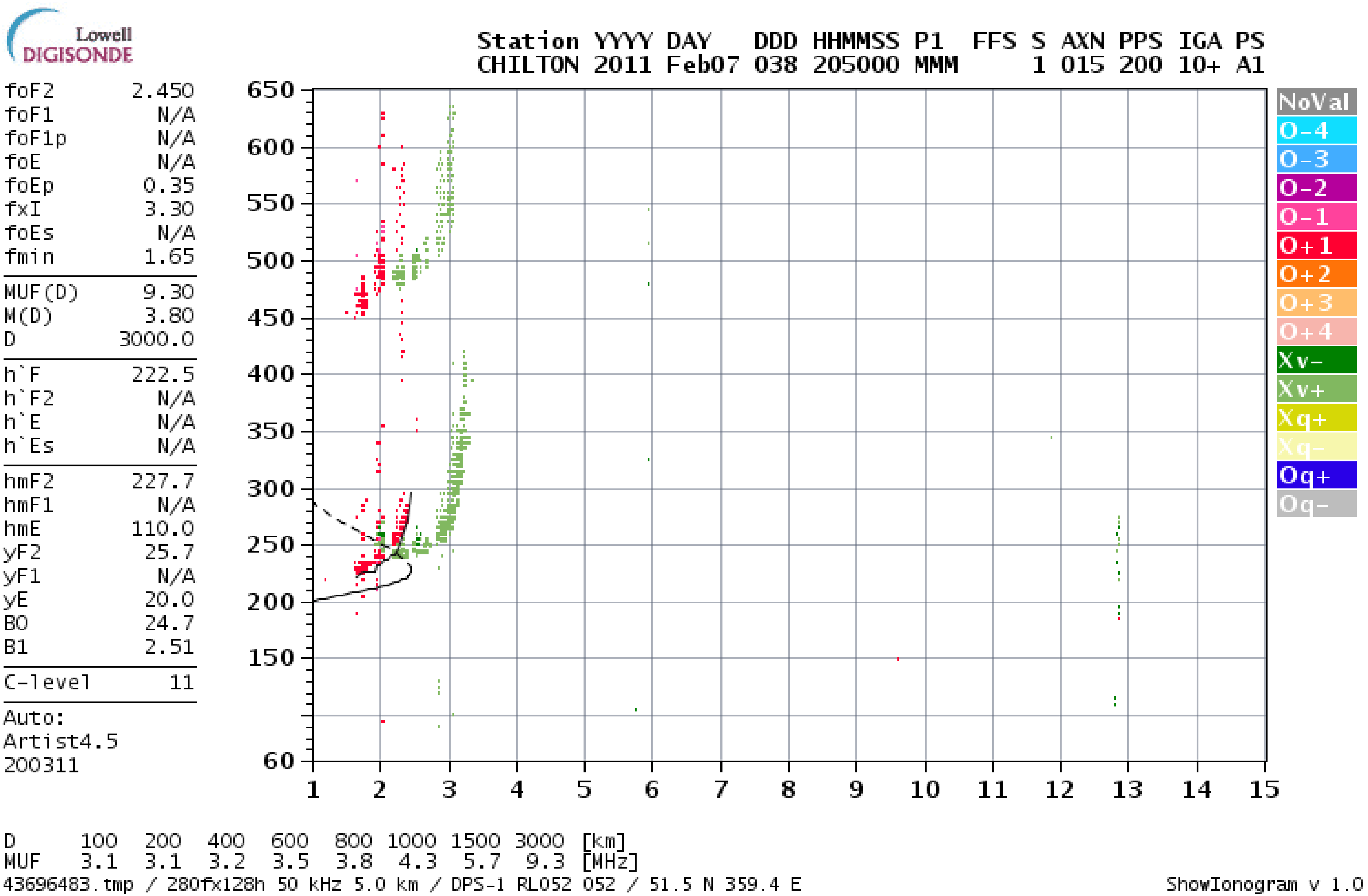
Main points:

- An ionogram is a graph of time-of-flight against transmitted frequency.
- Each ionospheric layer shows up as an approximately smooth curve, separated from each other by an asymptote at the critical frequency of that layer.
- The upwardly curving sections at the beginning of each layer are due to the transmitted wave being slowed by, but not reflected from, underlying ionisation which has a plasma frequency close to, but not equaling the transmitted frequency.
- The critical frequency of each layer is scaled from the asymptote, and the virtual height of each layer is scaled from the lowest point on each curve.

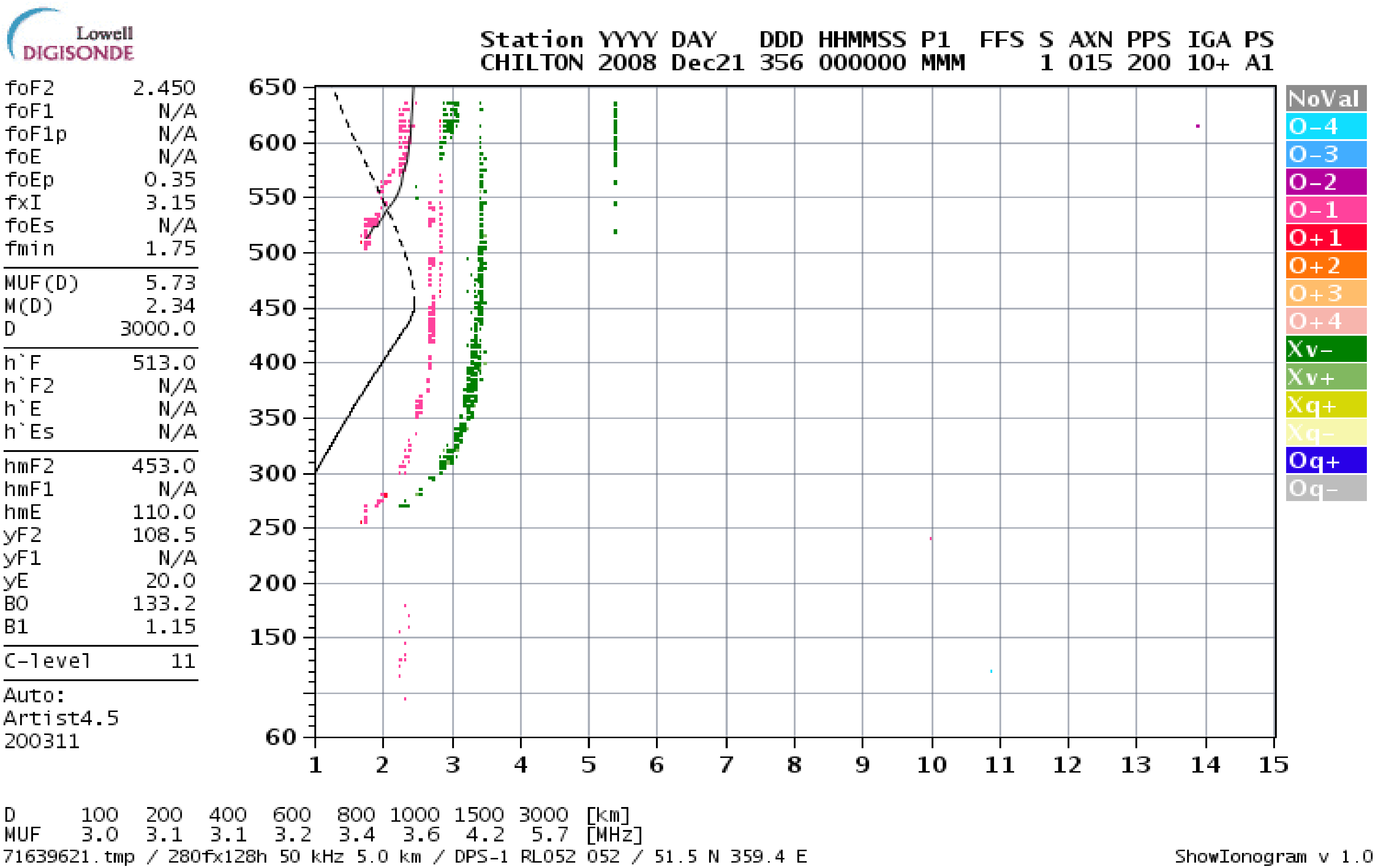


What's happening here – the date is a clue!

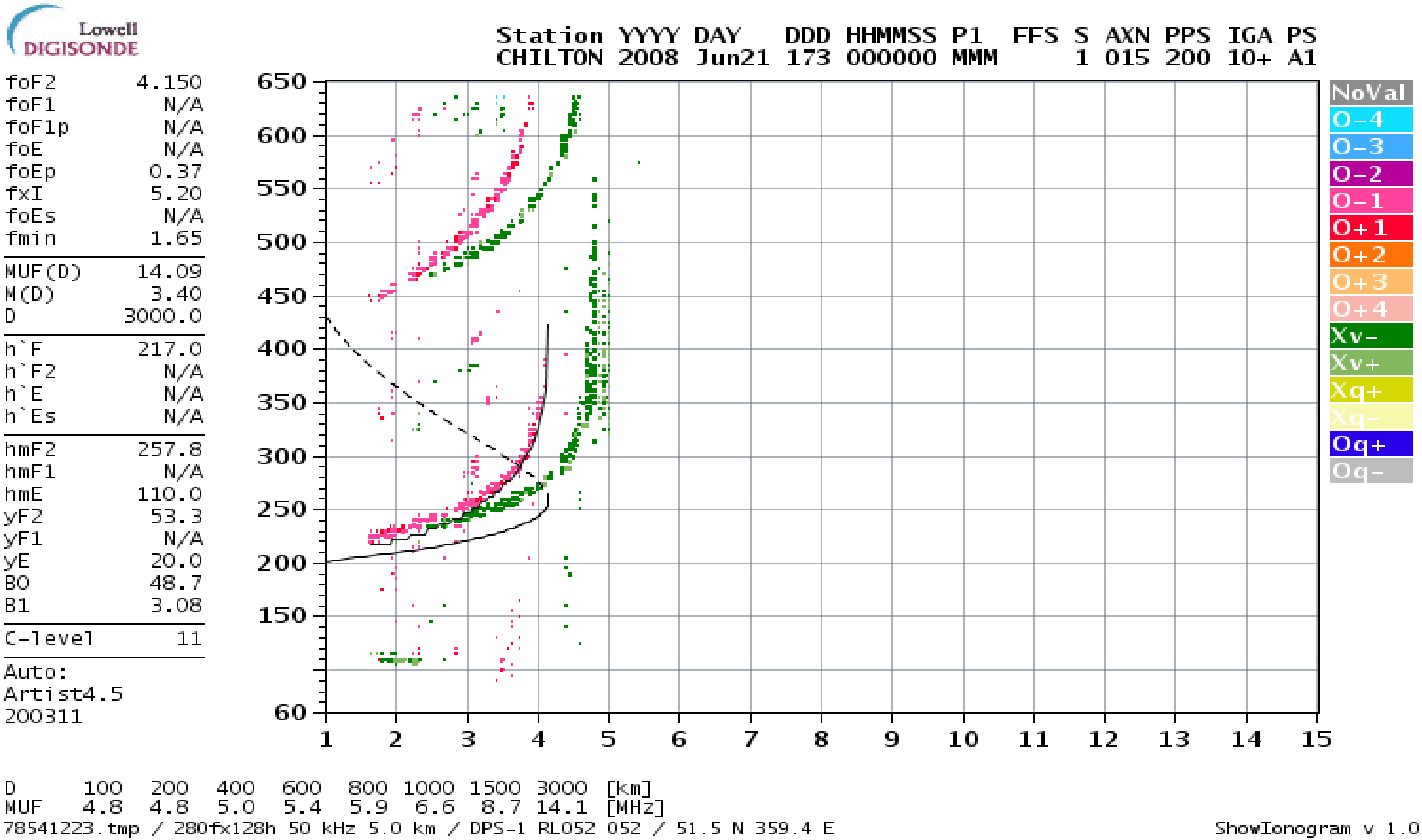
Sunspot maximum or minimum?



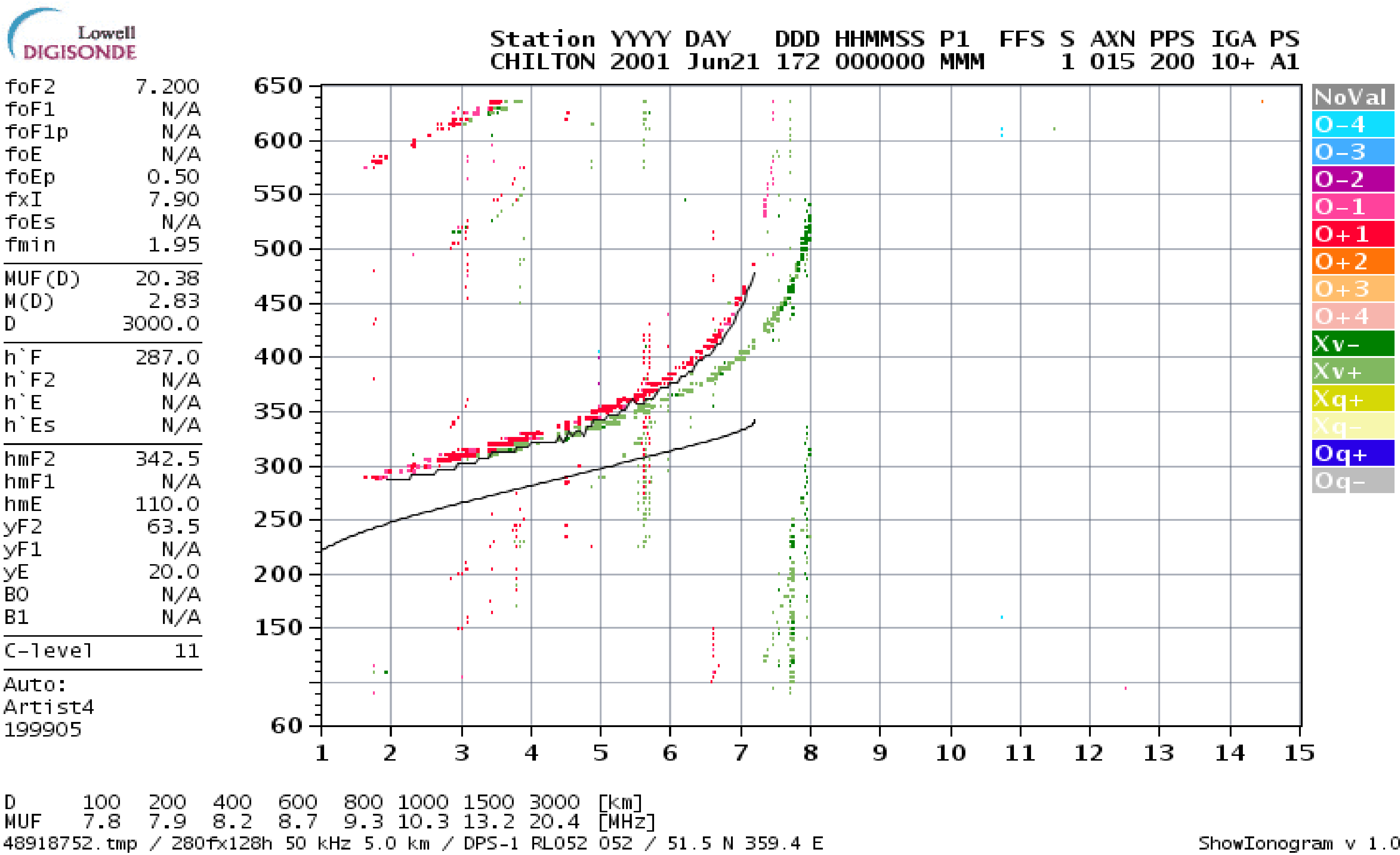
80m Club Championship night – good or bad?



Midnight, Dec. 21, Sunspot minimum – not a good time for HF



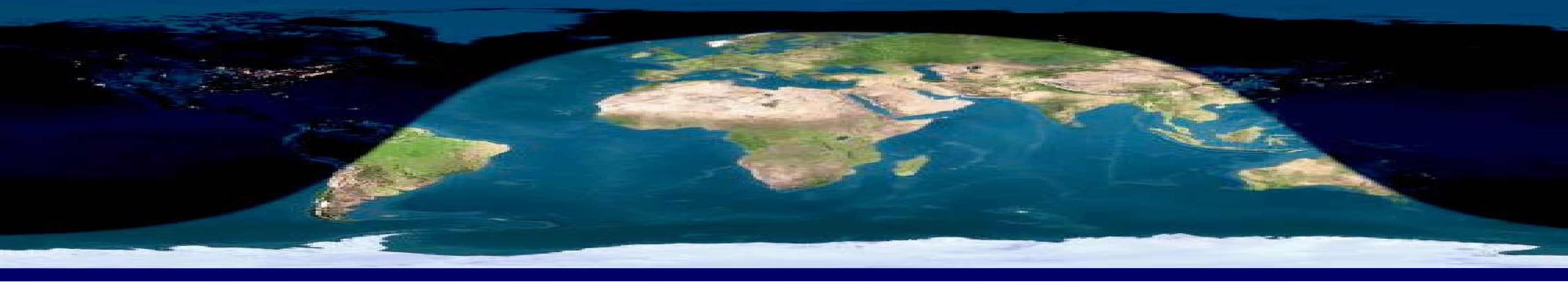
Midnight, June. 21, Sunspot minimum – 20m still open



Midnight, June. 21, Sunspot maximum – 17m still open

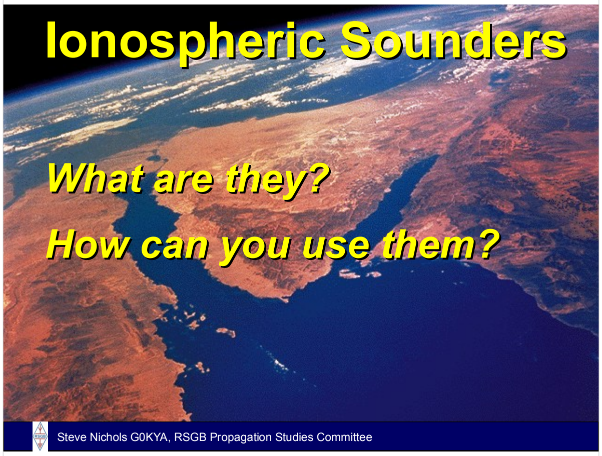
You can get historical data for all of the 64 Digisonde stations at:

http://car.uml.edu/common/DIDBFastStationList



You can read more at:

www.qsl.net/g0kya



This was a talk given to the Norfolk Amateur Radio Club on 23rd February 2011. Use the Acrobat zoom facility if need be.

History of the ionosphere

Jan. 1901
Marconi sends signals from Isle of Wight to The Lizard, Cornwall

Dec. 1901
Marconi crosses Atlantic, from Poldhu to Newfound-land

Steve Nichols G0KYA, RSGB Propagation Studies Committee

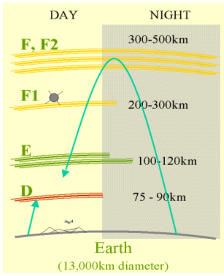
Marconi first postulated that signals were being bent around the Earth after his contacts in 1901. As he said, for signals to get from Poldhu to Newfoundland they would otherwise have to pass through a massive body of water and rock. In this spoof photograph Marconi (centre) is being helped by my club's G3LDI Roger and Mark G0LGJ – well, it got a laugh.

History of the ionosphere

- **1899**, Nikola Tesla experiments at Colorado Springs, USA
- **1902**, Oliver Heaviside and Arthur Edwin Kennelly propose the existence of the Kennelly-Heaviside Layer
- **1926**, Scottish physicist Robert Watson-Watt introduces the term “ionosphere”
- **1947,** Edward V. Appleton awarded a Nobel Prize for his confirmation in 1927 of the existence of the ionosphere

Steve Nichols G0KYA, RSGB Propagation Studies Committee

Nikola Tesla said that he would pass energy through an “electrified” layer in the atmosphere.



Steve Nichols G0KYA, RSGB Propagation Studies Committee

This is the standard model of the ionosphere.

History of ionospheric sounding

- Ionospheric sounding uses high frequency (HF) radio waves for the vertical-incidence remote sounding of the ionosphere
- The basic technology was introduced by Sir Edward Appleton in the 1920s

History of ionospheric sounding

- Appleton's Oxford-Bournemouth experiment

- Used the BBC broadcasting station in Bournemouth in 1924 to vary the wavelength of its emissions after the evening programs had finished.
- Installed a receiving station in Oxford to monitor the interference effects of a ground and sky wave - fading.

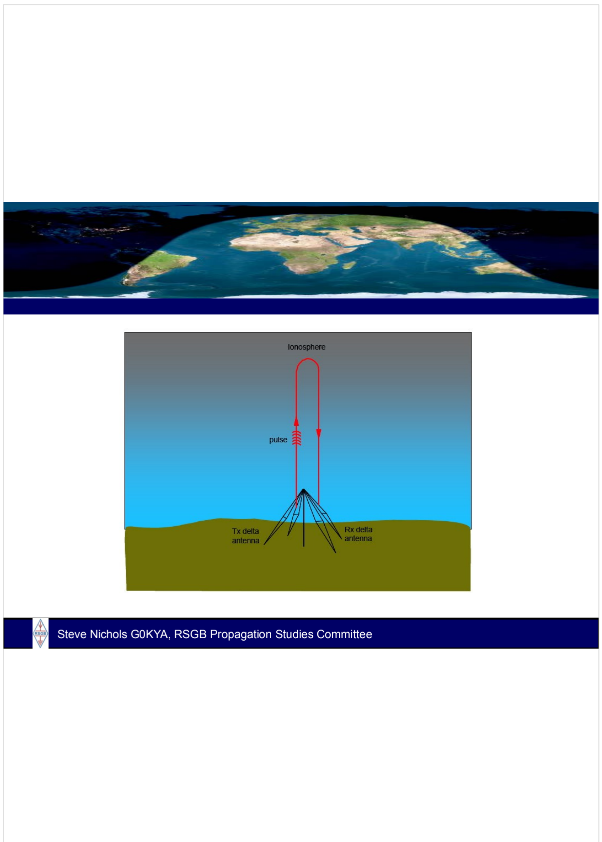
By varying the frequency being transmitted from the BBC in Bournemouth, and seeing how the ground and sky wave interfered in Oxford, Appleton was able to deduce the height of the E layer.

Modern ionospheric sounding

• The modern equipment is called a **Digisonde** - an acronym for **Digital Ionospheric Goniometric Ionosonde**

• Also travel time or “time of flight” is used to determine range to the reflection point

• Can also evaluate angle of arrival, polarisation, and Doppler frequency shift of skywave signals reflected from the ionosphere.



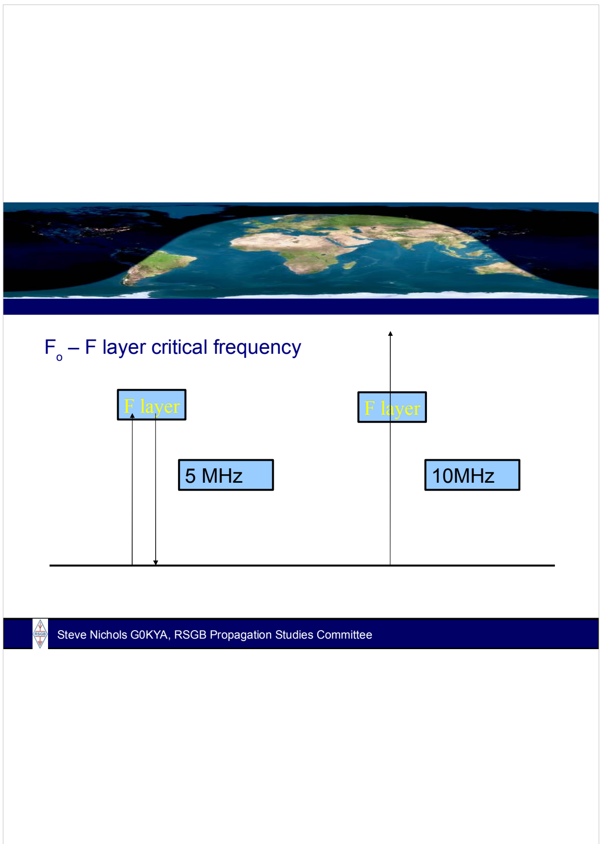
This is how a modern digisonde works.

Digisonde 128
(1970)

Digisonde 256
(1978)

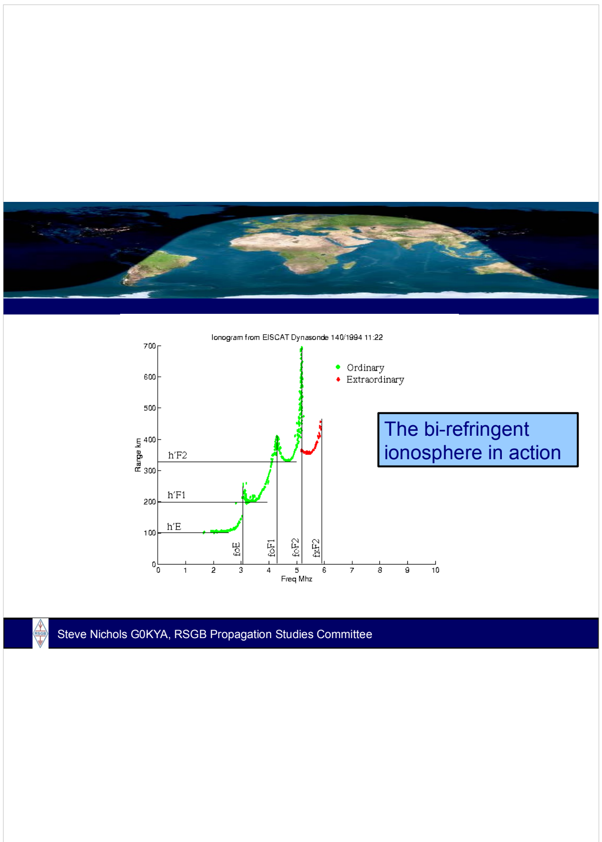
Digisonde DPS-4
(1993)

Modern equipment is small and compact. Note the orange plastic around the antenna designed to stop sheep eating the cabling.



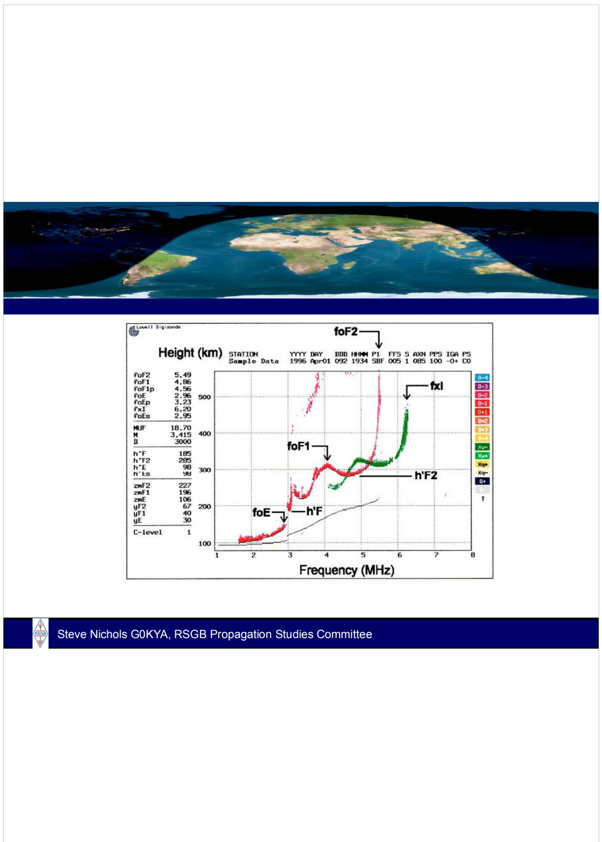
Signals below the critical frequency will be reflected. Signals above will continue into outer space. The Digisonde sweeps from about 0.1MHz to 30MHz, calculates the delay between the emission of the

pulse and its return and therefore
the height of the layer (s). This is then plotted.



Here you can see the elements of a digisonde plot –
the ionosphere splits the radio wave into two parts – the ordinary and extraordinary wave.

It is said to be bi-refringent. This is due to the
influence of the earth's magnetic field. The extraordinary wave normally has a higher critical
frequency, denoted as FxF2.



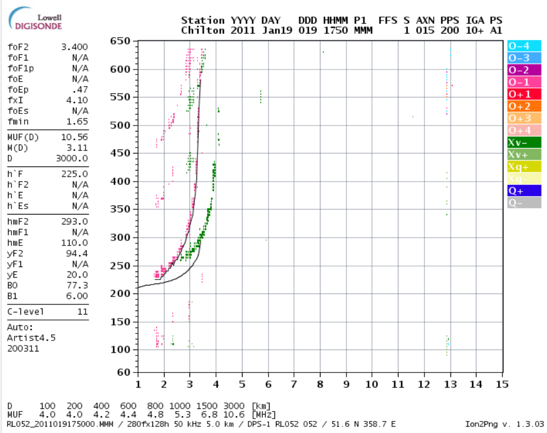
This is a closer look at a typical plot, showing the critical frequency of the E layer (f0E),
height of the F1 layer (h’F) and the corresponding figures for the F2 layer and extraordinary ray.

There are digisondes throughout the world.

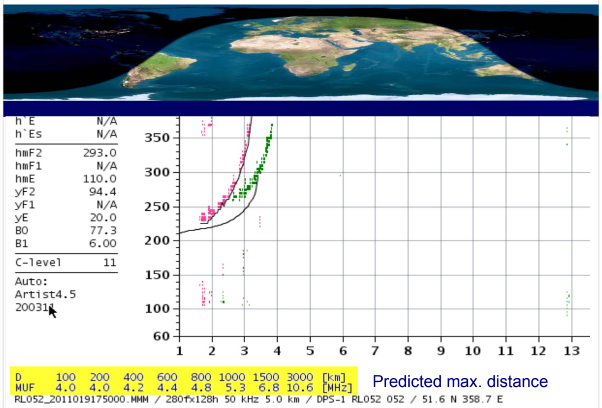
You can register for the Chilton ionograms at:

http://www.ukssdc.ac.uk/ionosondes/view_latest.html

It is free.



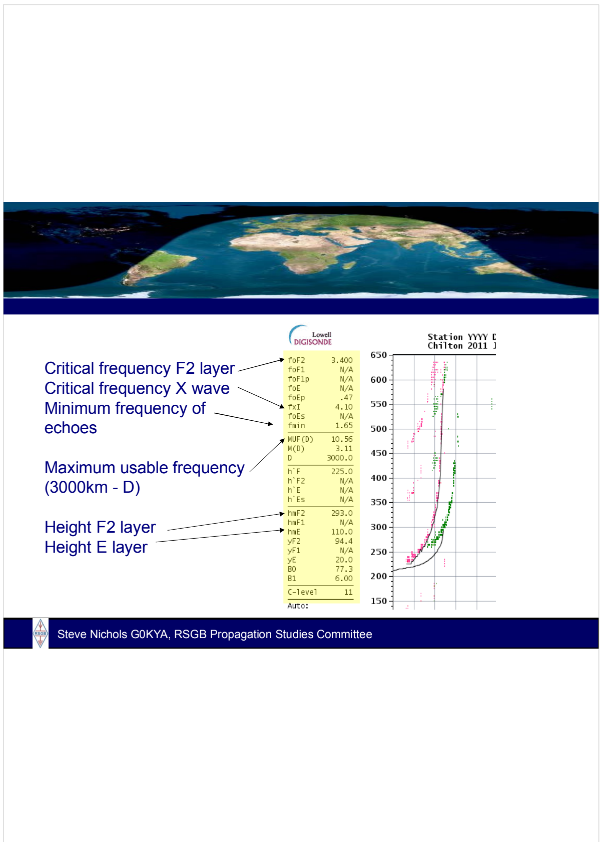
A typical ionogram in all its glory – lets pull it apart in the next few slides.



Steve Nichols G0KYA, RSGB Propagation Studies Committee

Along the bottom the system predicts the maximum usable frequency over different path lengths. Note: the MUF is calculated (roughly) from the critical frequency and is only a guide. It takes the critical frequency at the QTH of the digisonde and then calculates a possible MUF based on this.

In reality I have found that in the optimum direction the calculated MUF over the best 3000km path from that QTH can be pessimistic - you can usually do better. But on a different path it may be less.



The detail on the left and what it means.

Main points:

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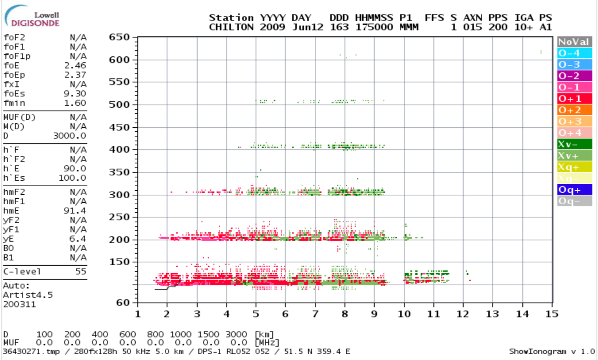
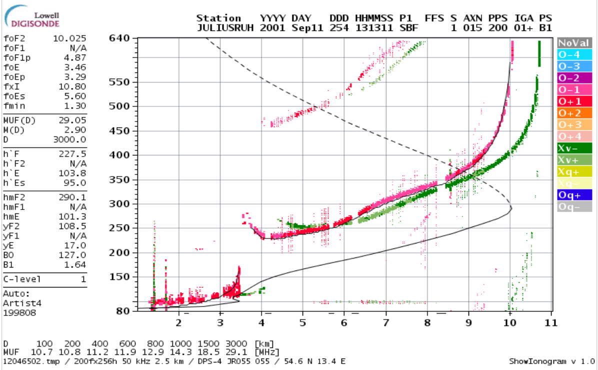


What's happening here – the date is a clue!

This is heavy Sporadic –E – note that no HF signals penetrate to the F layer



Sunspot maximum or minimum?

Steve Nichols G0KYA, RSGB Propagation Studies Committee

This is actually sunspot maximum – look at the date

Sept 11 2001.

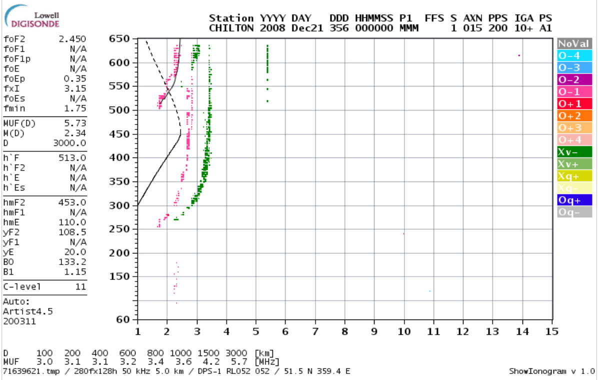
On this day I heard the events of “911” played out on a 10m repeater that was on top of the World Trade Centre. The transmission ended promptly for obvious reasons.

Note the estimated MUF over a 3000km path – 29.1 MHz.

Very bad – that night we couldn’t hear any signals from around the UK.

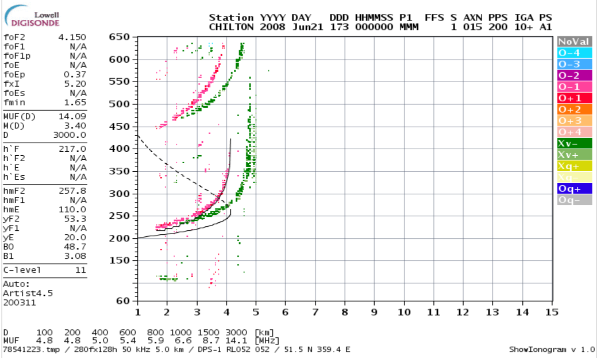
The closest we could hear were Sweden, France etc.

This is what the chart shows – a minimum path length of 800km at 3.8MHz



Midnight, Dec. 21, Sunspot minimum – not a good time for HF

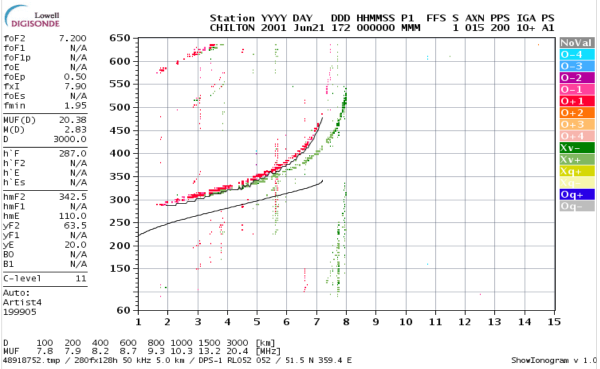
Winter nighttime MUFs are usually very low – here you would only be able to use 3.5 and 1.8MHz – maximum usable frequency over a 3000km path was 5.7MHz.



Midnight, June. 21, Sunspot minimum – 20m still open

Steve Nichols G0KYA, RSGB Propagation Studies Committee

In contrast, midsummer nighttime MUFs are usually higher. Here, even though it is midnight 20m is still open to DX (just).



Midnight, June. 21, Sunspot maximum – 17m still open

Steve Nichols G0KYA, RSGB Propagation Studies Committee

And at sunspot maximum, 17m is still open at midnight in mid summer.

You can get historical data for all of the 64 Digisonde stations at:

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You can read more at:

www.qsl.net/g0kya

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