Sporadic E – on 4m and 6m

Graham Kimbell
G3TCT

Scope of this talk

- History, covering 4m and 6m
- Examples of Es
- Characteristics and types of Es
- Recent developments and dx achievements

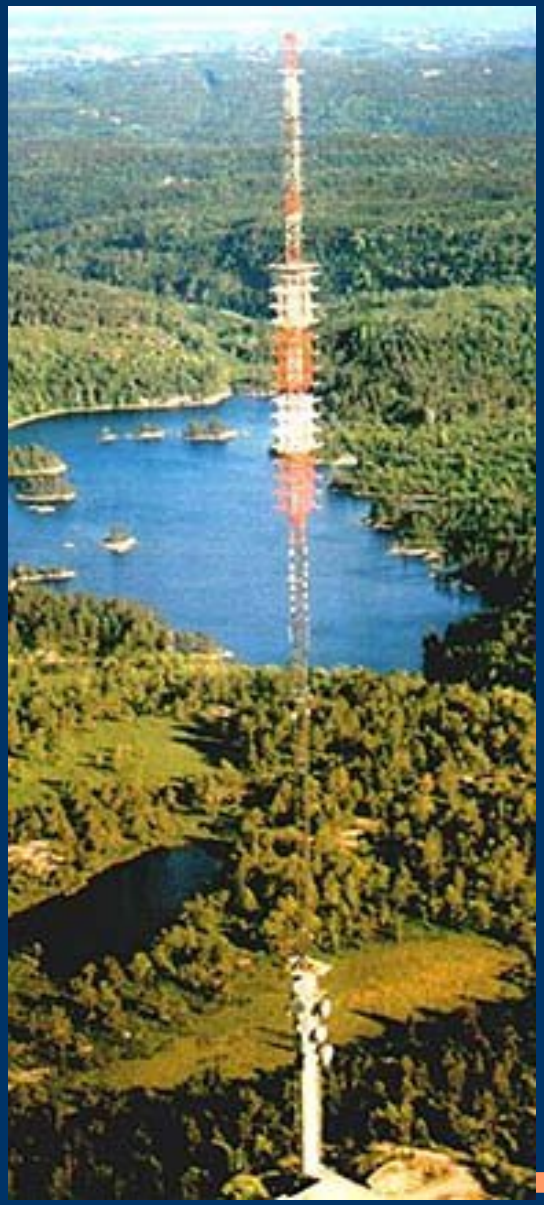
Sporadic E – the most interesting propagation mode?

- very strong signals (for <2000km)
- sometimes brief and somewhat unpredictable
- works over 20-220MHz
- ranges from <500km to >10,000km on 6m
- works in low sunspot periods
- continuing source of discussion and research

History

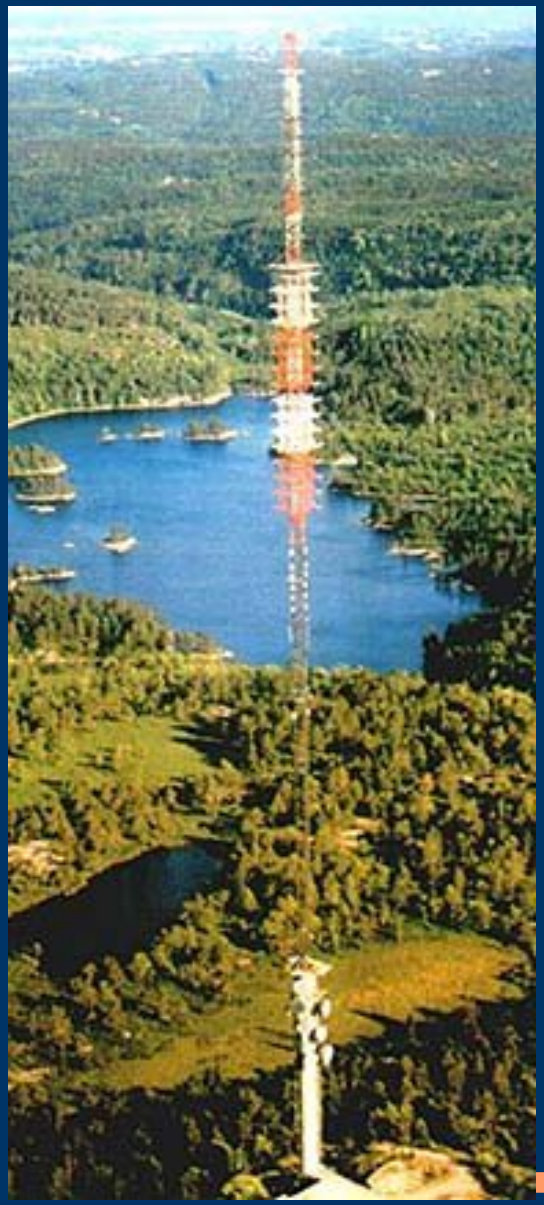
- Pre 1939 – 56MHz
- 1956 – 4m available
- 1979 – 6m x-band to 28.885
- 1983 – 40 special permits for 6m
- 1984 – 100 special permits for 6m
- 1986 – 6m open to class A licensees
- 1987 – 6m open to all

Example – Broadcast reception



- 4m – QRM from -
- 65.8-74MHz OIRT east European FM broadcast band

Example – Broadcast reception



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Amateur Es – 4m pre 1970

- GM, GI
- PX1RI Andorra
- TF3EA Iceland
- ZB2VHF - June 1968

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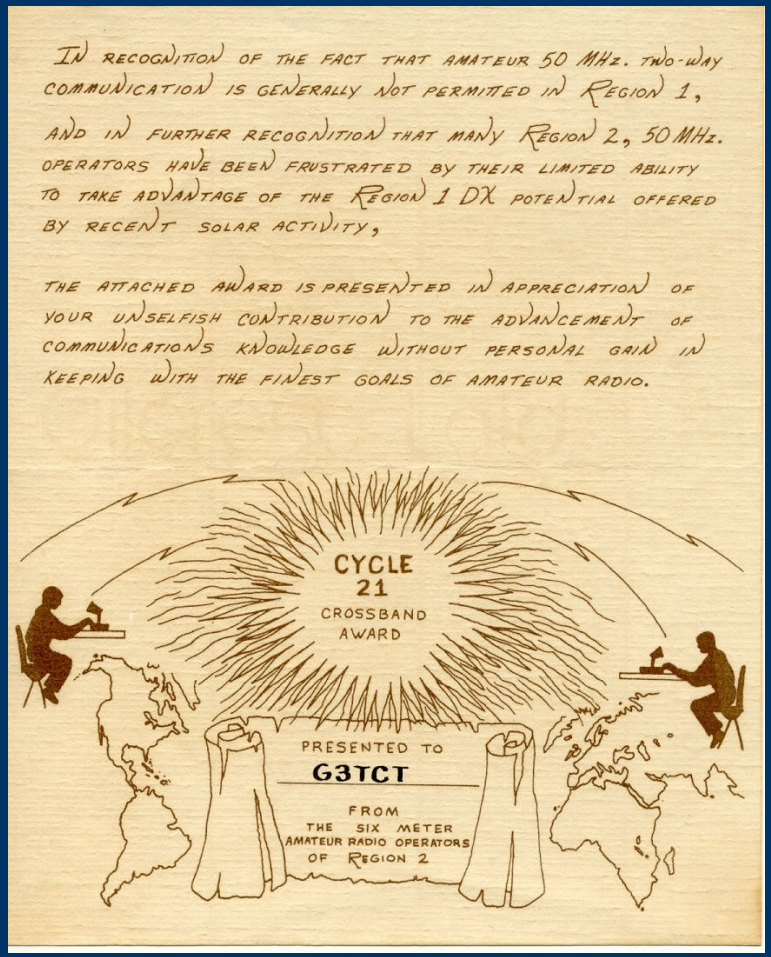
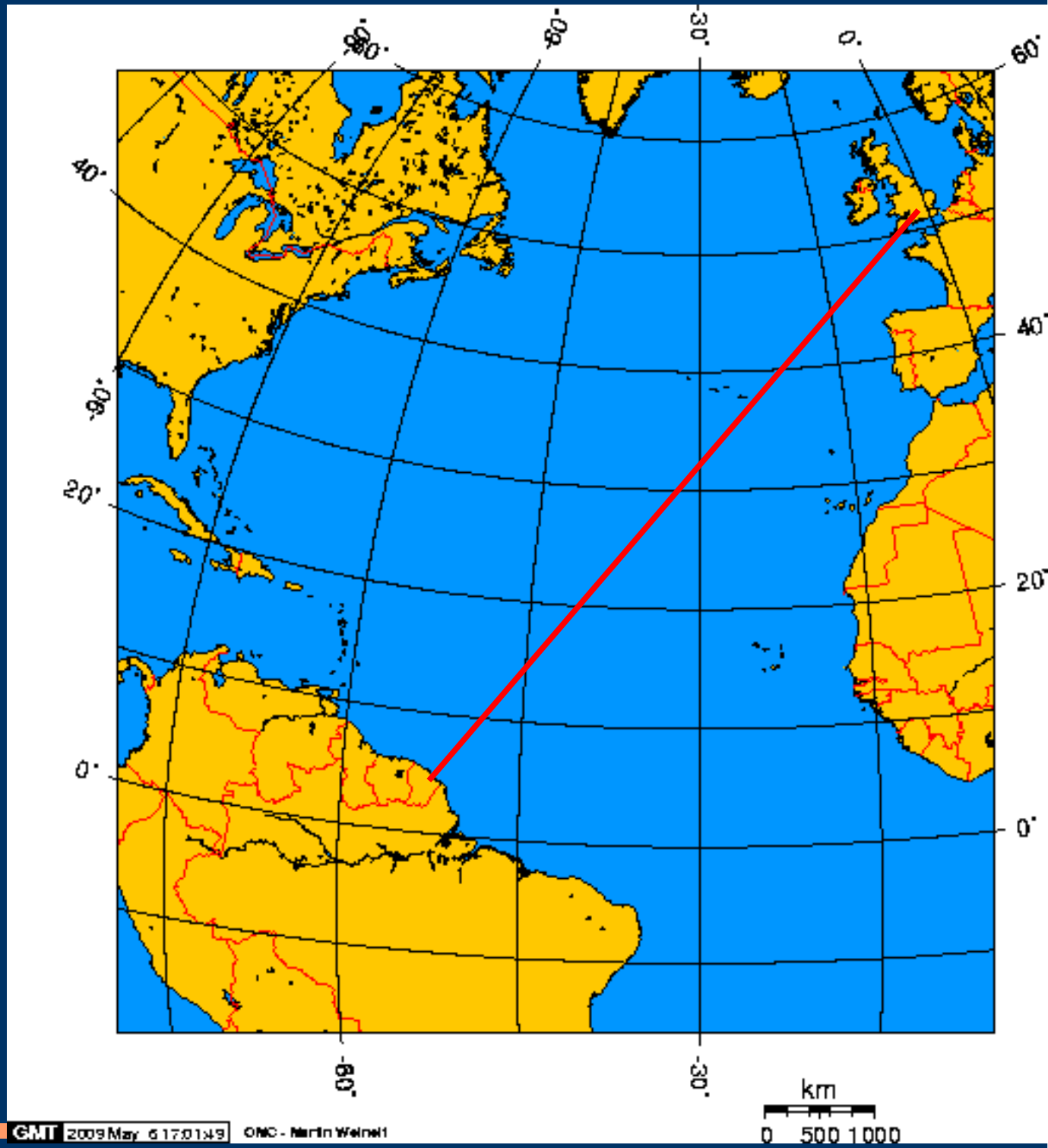
Cycle 21 – 1979 - 1983

- F2 propagation
- Interest grew in working cross band - US stations on 6m, Eu on 10m (28.885)
- Band 1 TV very evident – QRM but a wonderful beacon resource



FY7THF

- GJ35 ~7000km
- 50.038MHz



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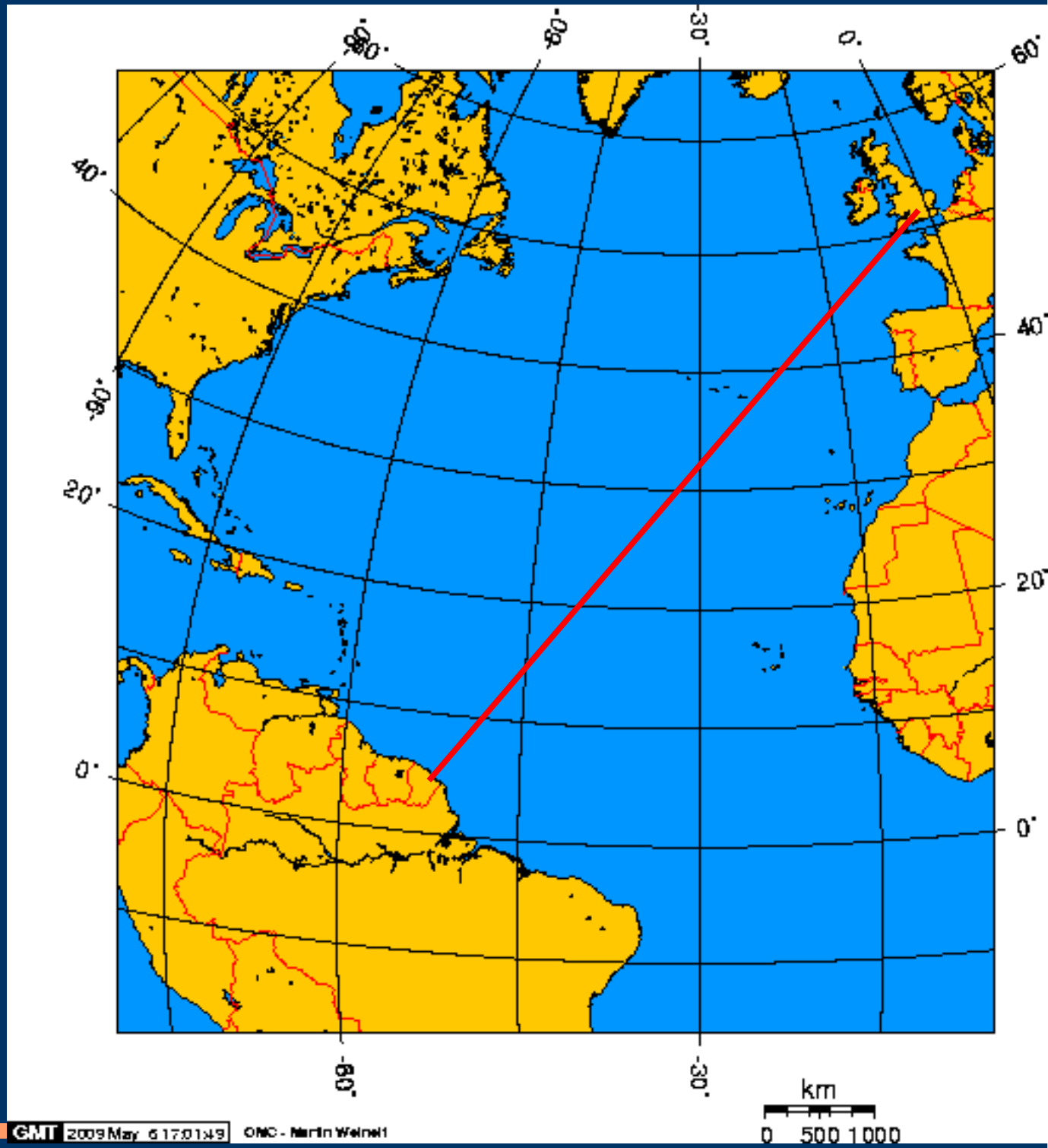
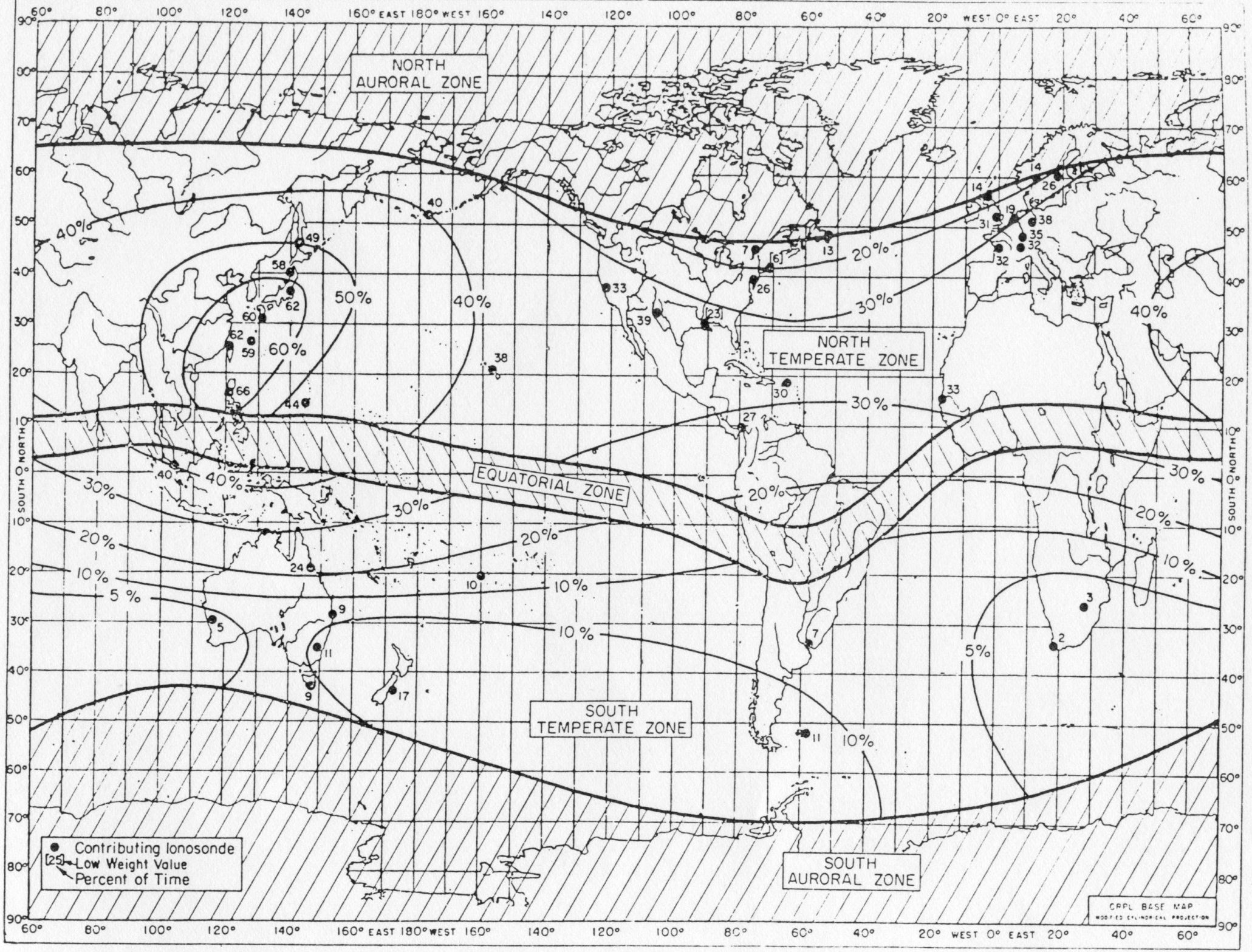


Es characteristics

- an opening on a band 20-220MHz
- usually summer time around solstice
- peaks around midday, but can occur at any time of day or night
- range from 500km up to ~2400km (single hop)
- Rayleigh fading typical
- usually an absence of selective fading
- occasional backscatter evident

What is sporadic E?

- transient, localized patches of relatively high electron density in the E region at ~115km altitude
- varies markedly with latitude
- random time of occurrence
- mechanisms:-
  - Metal ions from meteors and cometary dust
  - ionisation by solar radiation and collisions
  - ionospheric wind shear
  - geomagnetic field
  - thunderstorms and other weather?


NORTH AURORAL ZONE
NORTH TEMPERATE ZONE
EQUATORIAL ZONE
SOUTH TEMPERATE ZONE
SOUTH AURORAL ZONE
40%
50%
60%
30%
20%
10%
5%
Contributing Ionosonde
[25] Low Weight Value
Percent of Time
CRPL BASE MAP
MODIFIED CYLINDRICAL PROJECTION
60° 80° 100° 120° 140° 160° EAST 180° WEST 160° 140° 120° 100° 80° 60° 40° 20° WEST 0° EAST 20° 40° 60°
90° 80° 70° 60° 50° 40° 30° 20° 10° SOUTH 0° NORTH

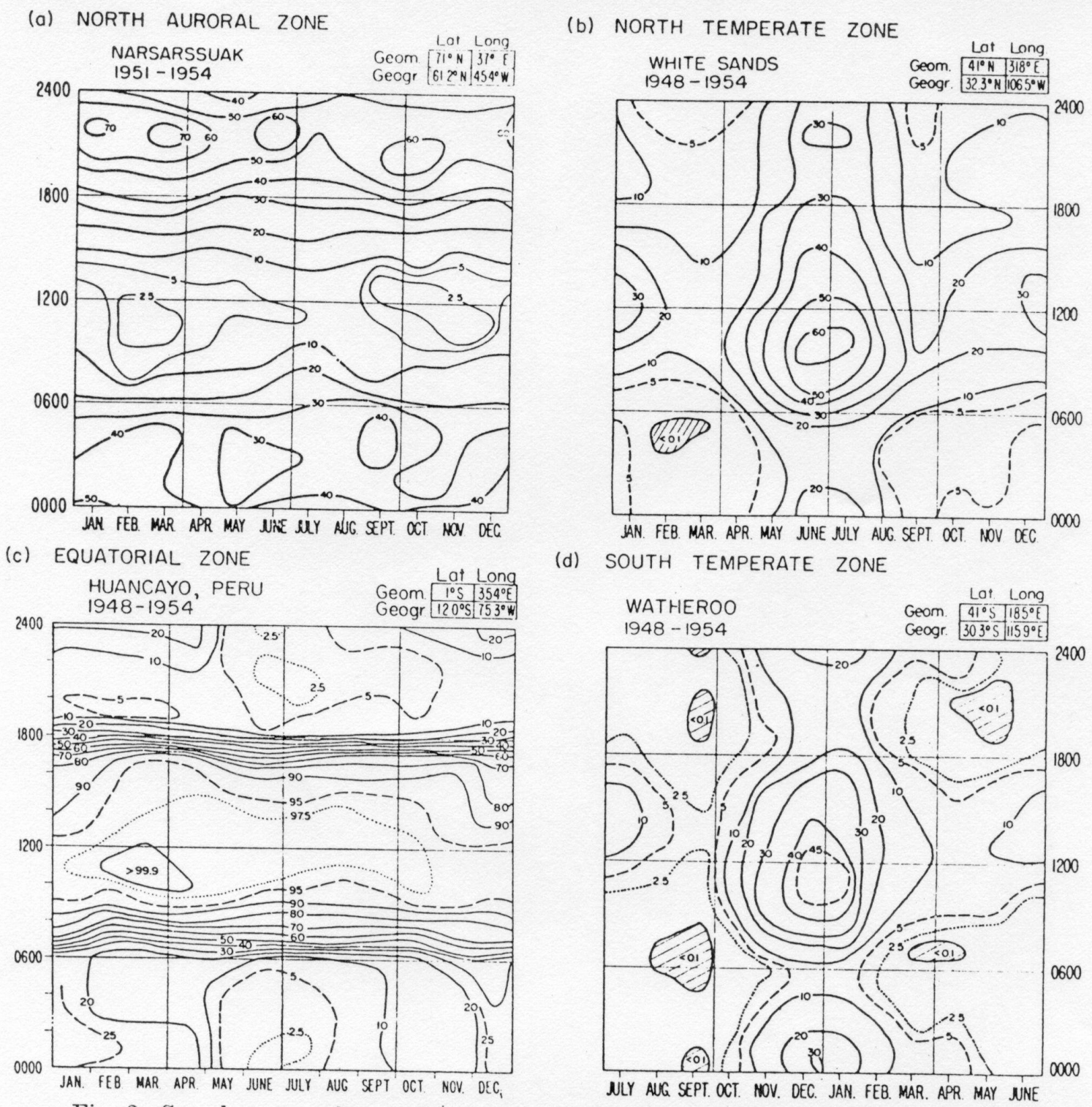
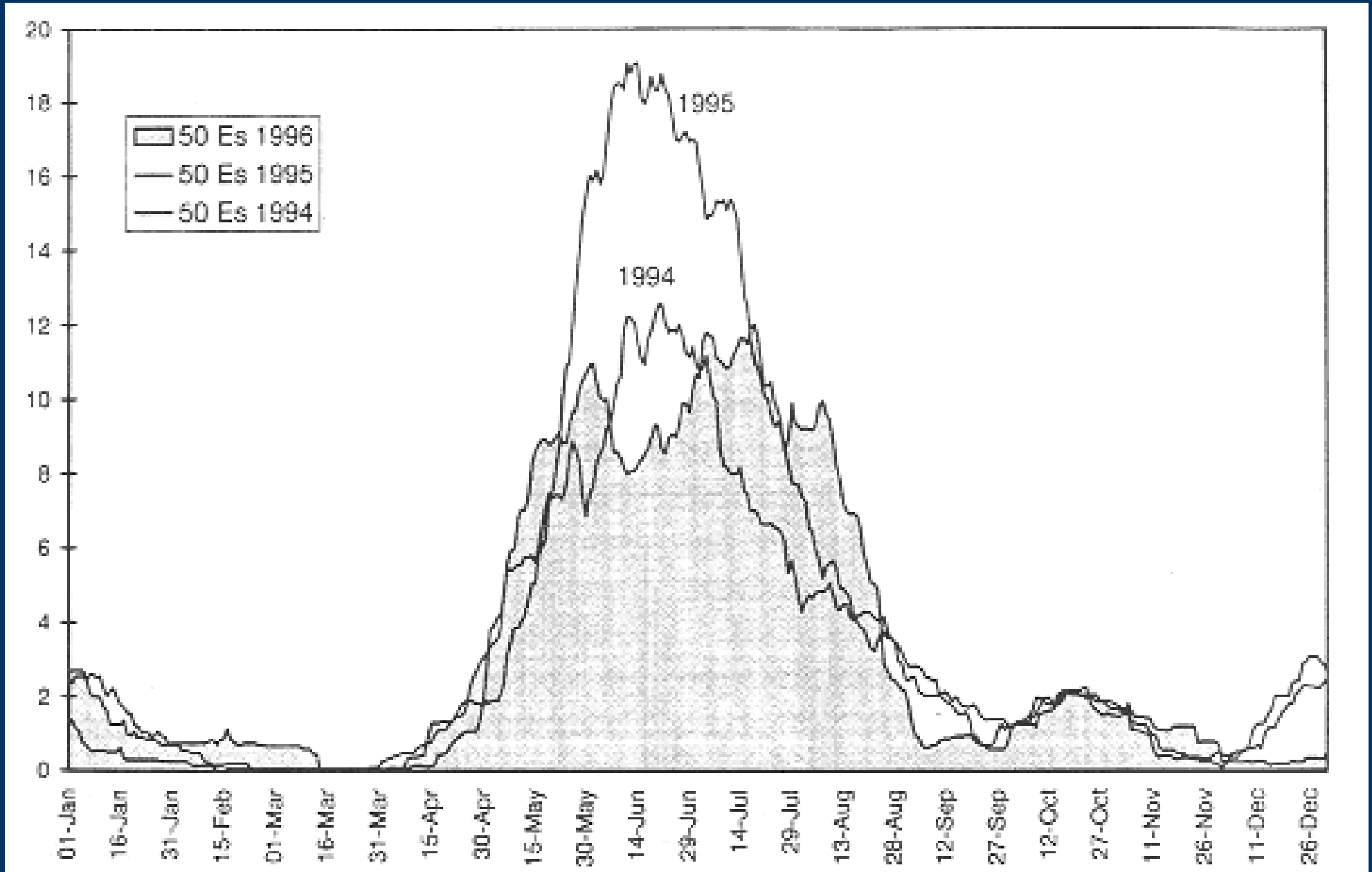


Fig. 2. Sample temporal variations in E_s in terms of percentage of time for which fE_s exceeded 5 Mc (after SMITH, 1957).



Graph 2. Comparison of Es in 1994 - 1996. (Areas, 27 day moving averages).

Figure 1 FY7THF reception in Europe 1979-1985

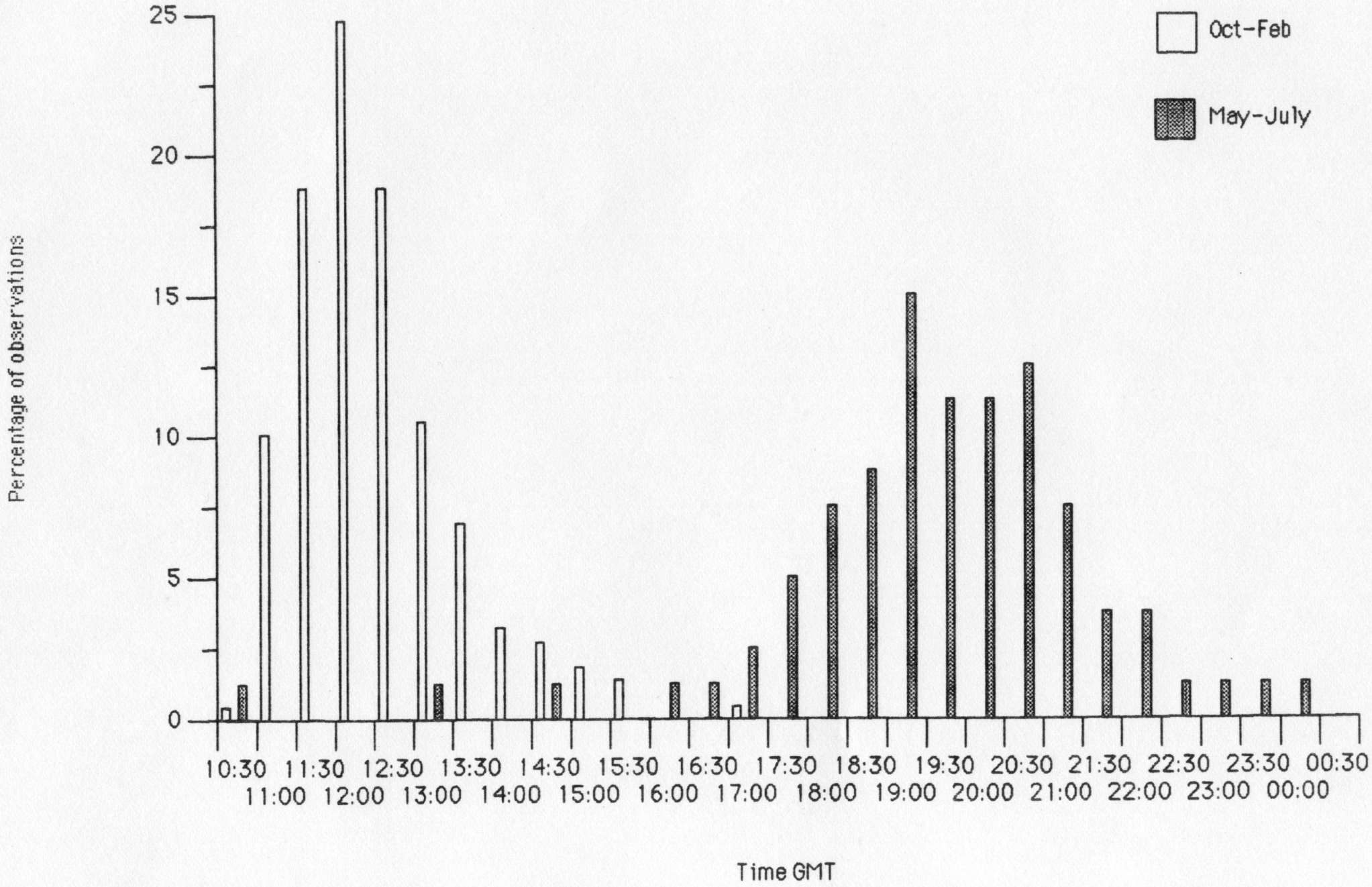
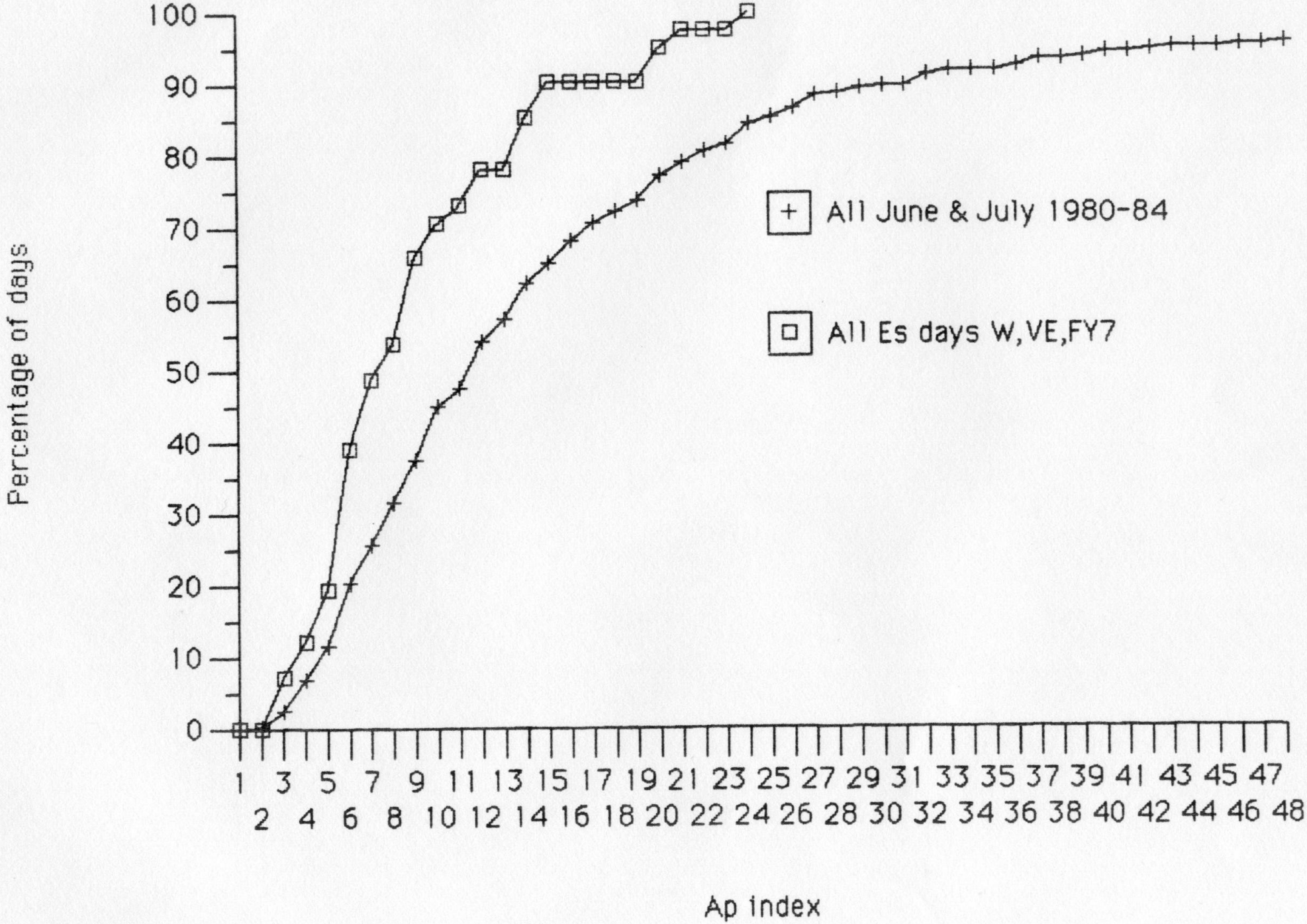


Figure 8 Cumulative distribution of Ap



K1GPJ, Maine, FN44

- 17 June 1987, 2208utc
- G3TCT in IO91 running 25W to 3 ele yagi

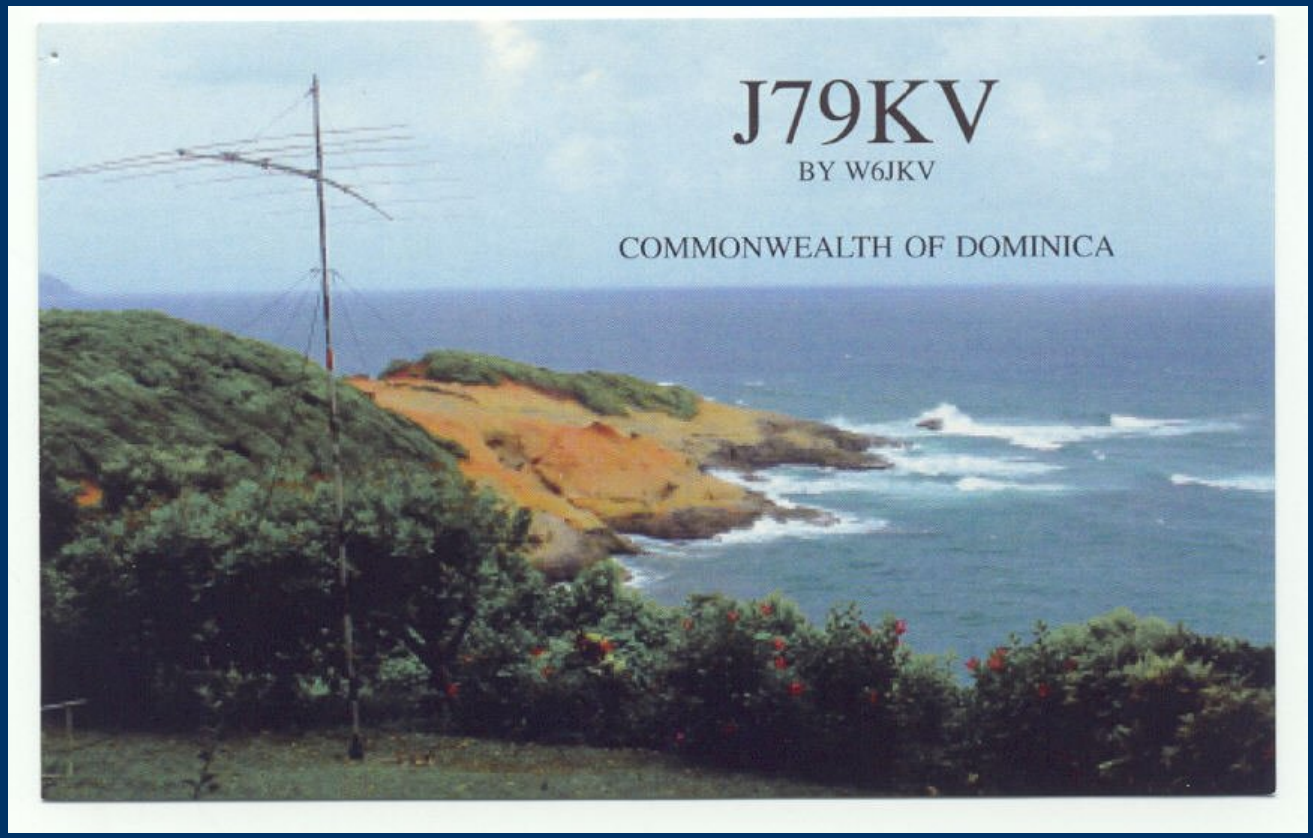
K1GPJ, Maine, FN44

- 17 June 1987, 2208utc
- G3TCT in IO91 running 25W to 3 ele yagi

AF1T, FN43

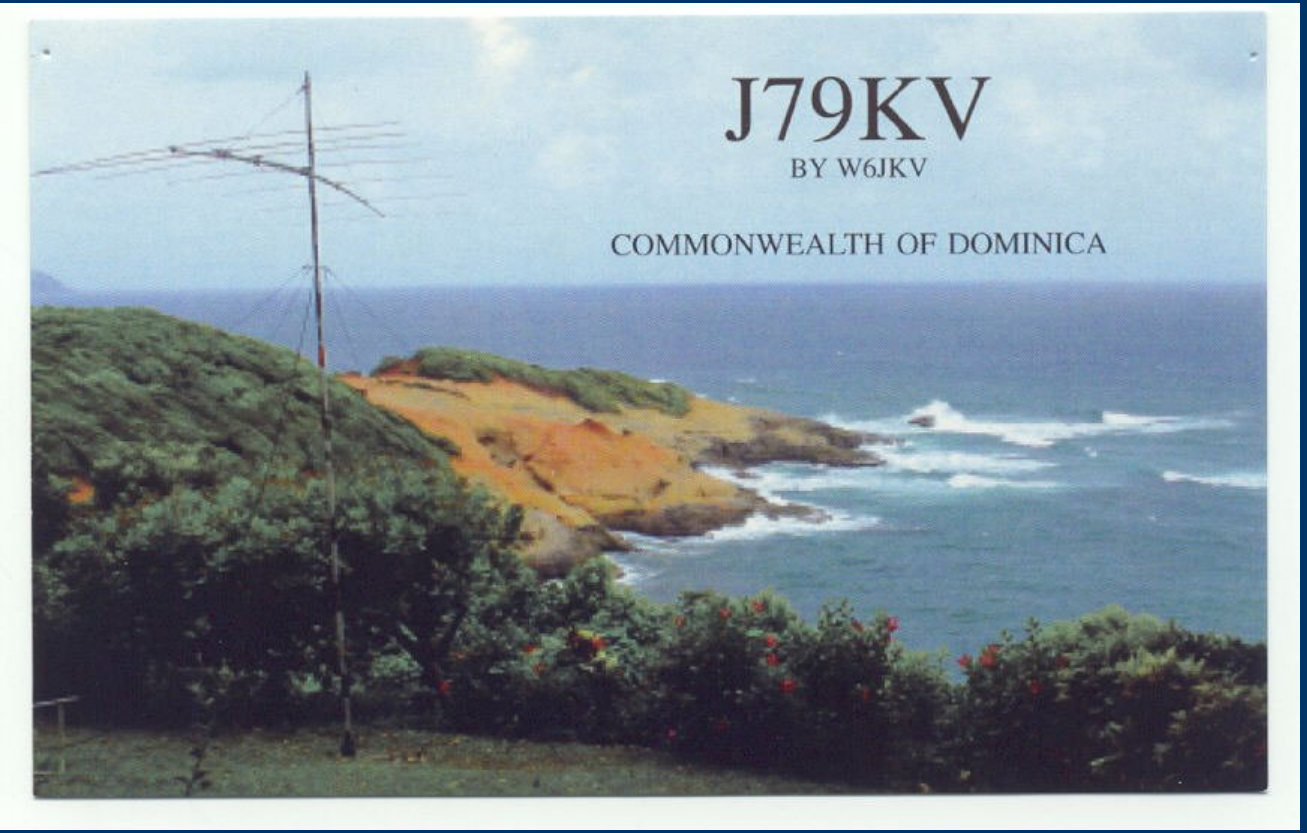
- 19 June 1987 at 1927utc

J79KV – 1 July 2004, 1855utc

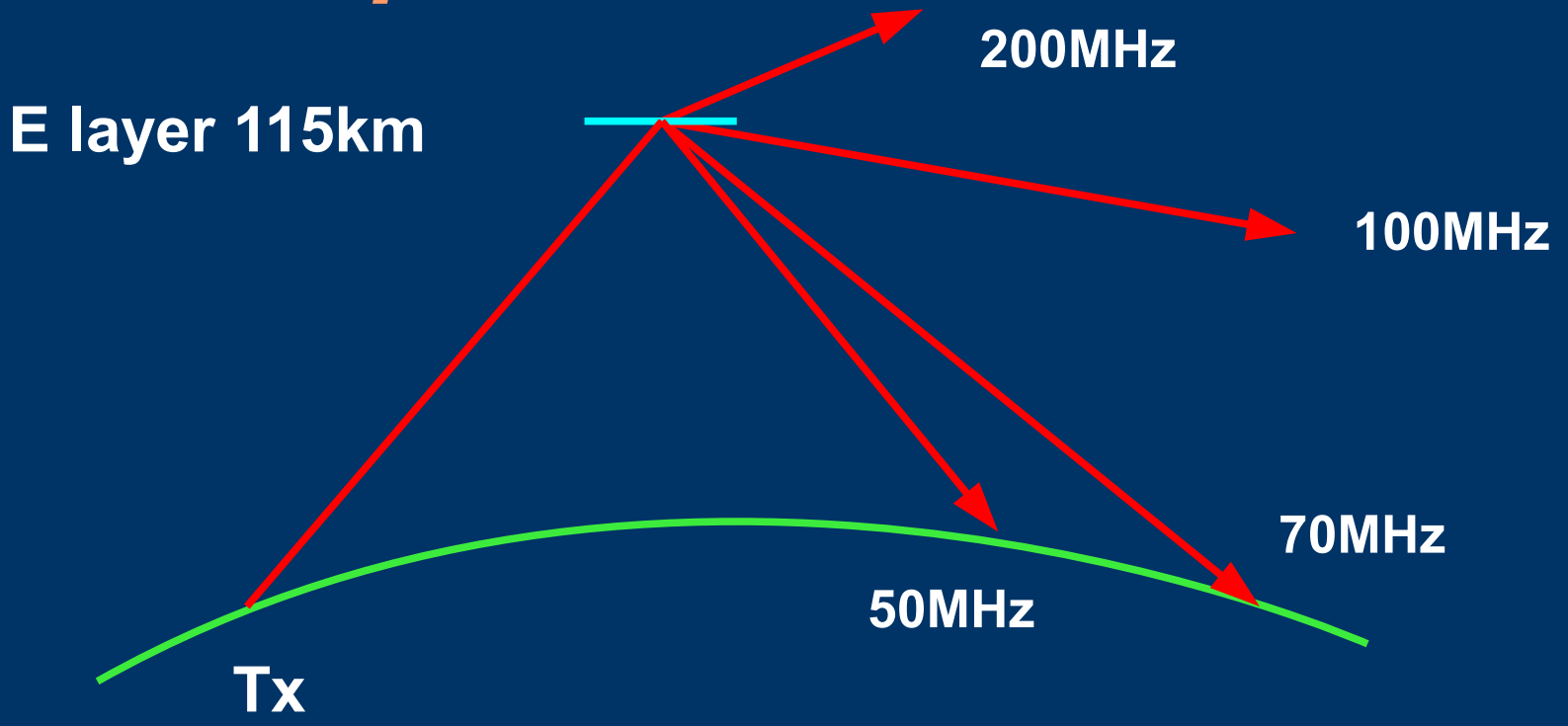


J79KV – 1 July 2004, 1855utc

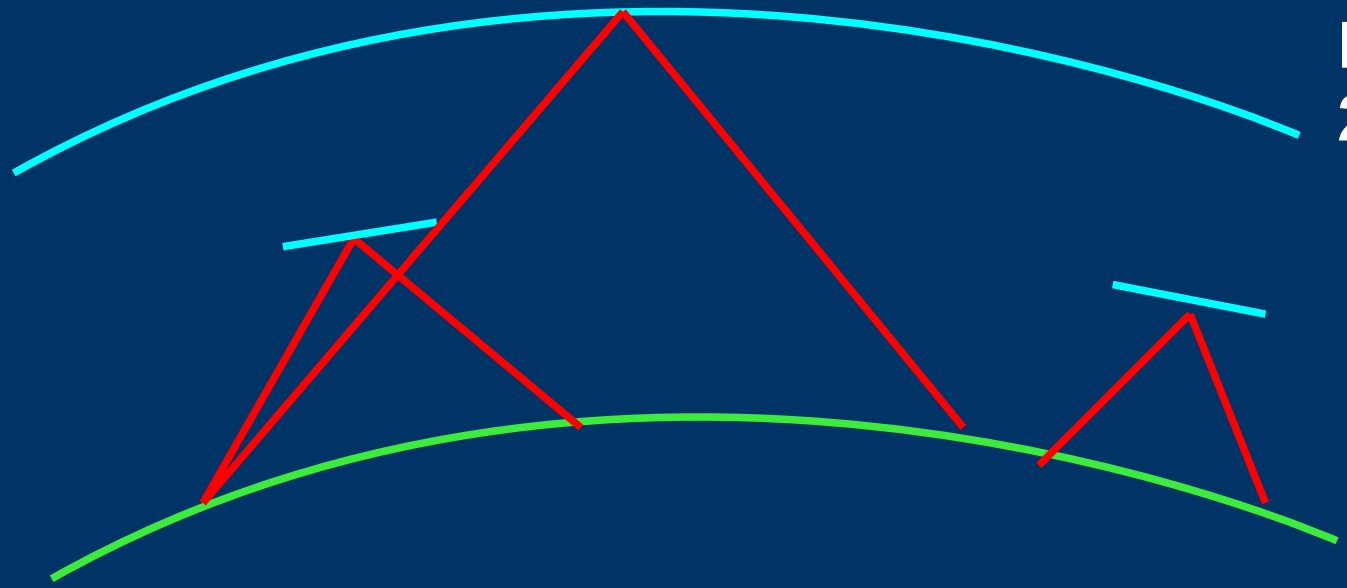
- tks sk de J79KV



Skip distance – frequency relationship

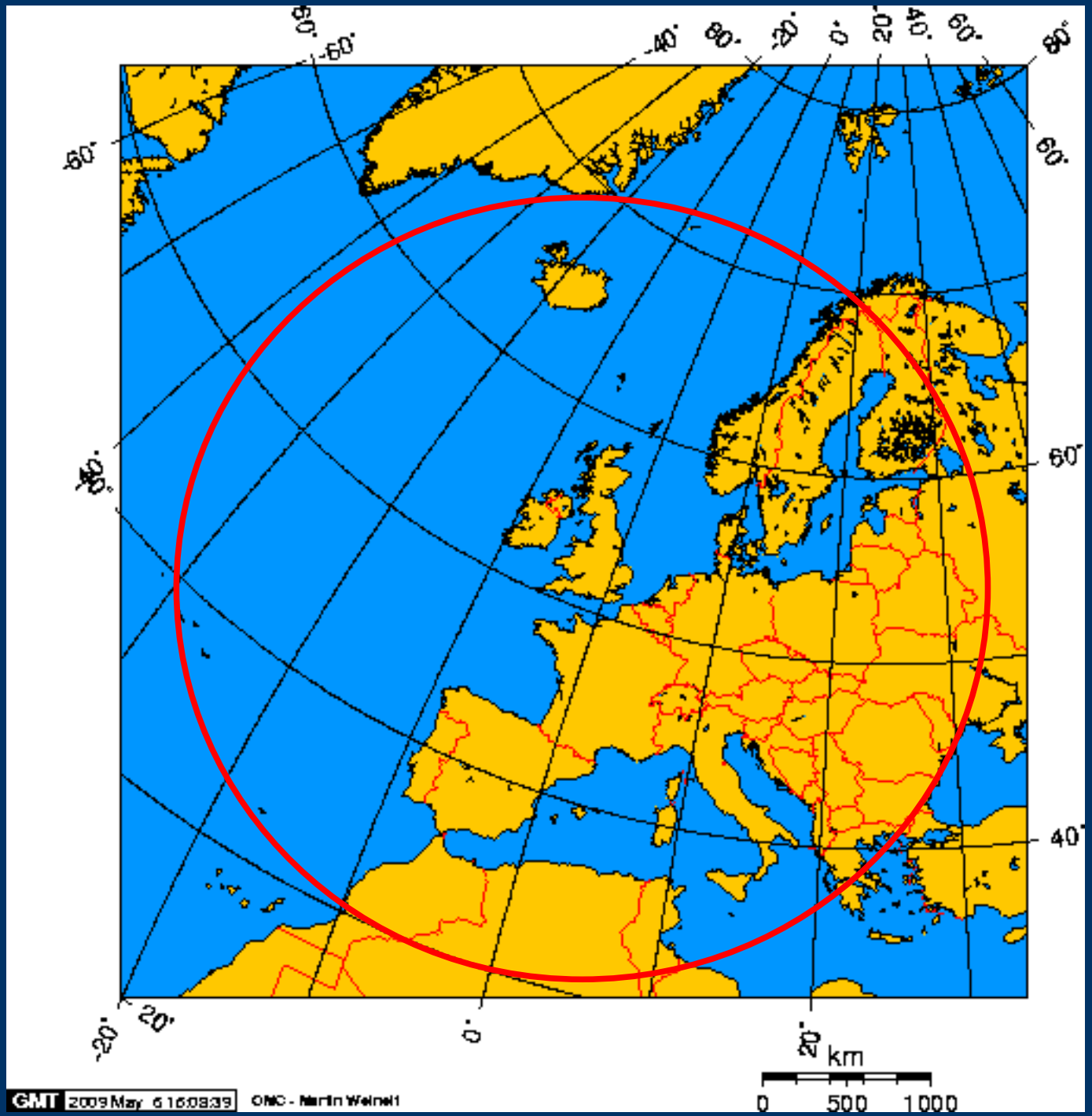


Es and F2 layers



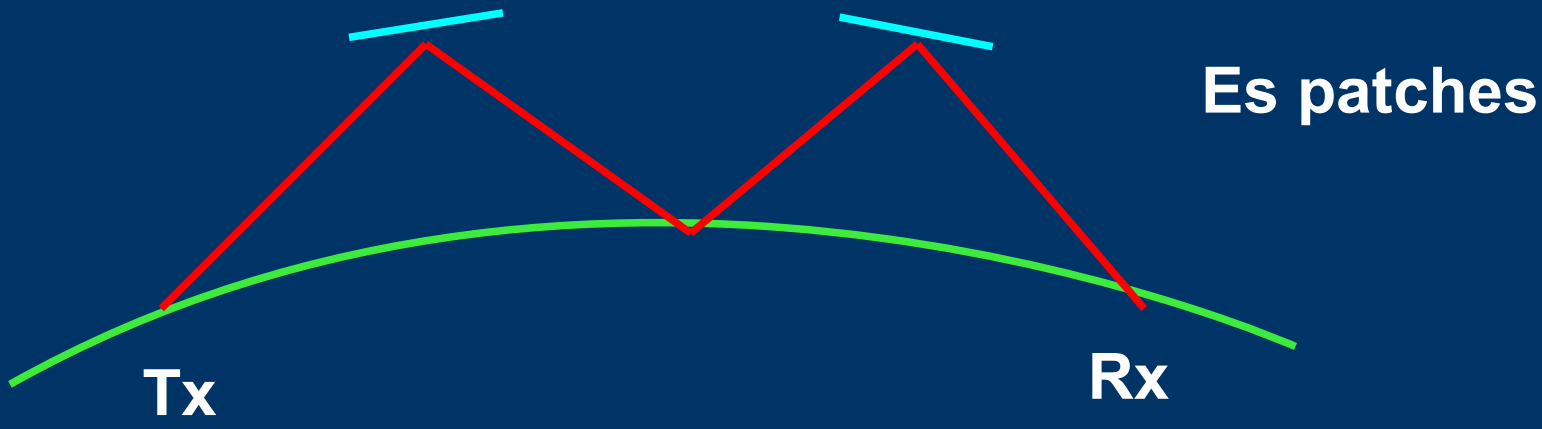
F2 layer
200- 350km

E layer
115km



Es height 115km : 2400km range

Multihop geometry

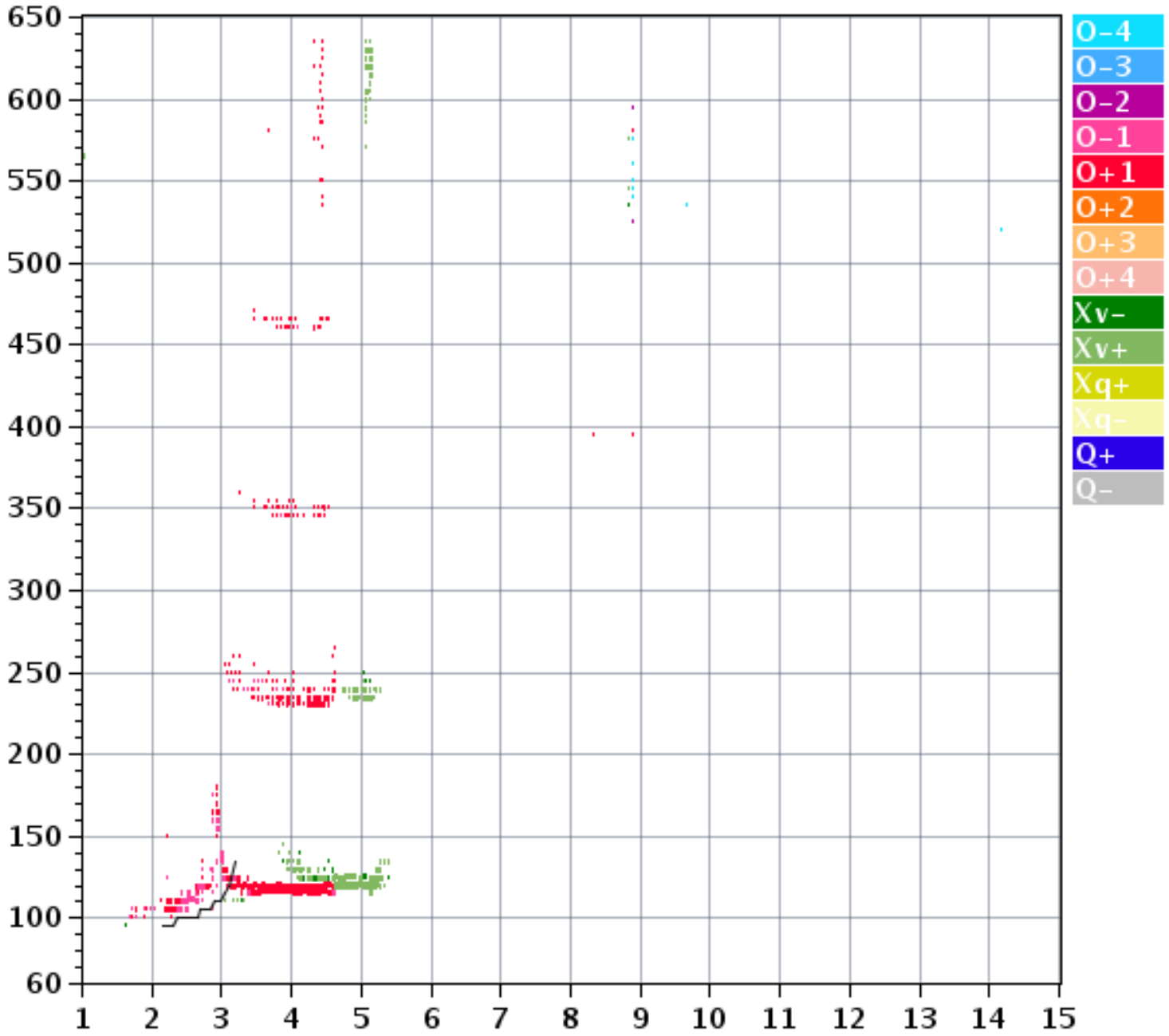


Lowell DIGISONDE

Station YYYY DAY DDD HHMM P1 FFS S AXN PPS IGA PS
Chilton 2008 Jul12 194 0920 MMM 1 015 200 10+ A1

foF2	N/A
foF1	N/A
foF1p	4.07
foE	3.21
foEp	2.95
fxI	N/A
foEs	4.60
fmin	2.15
MUF(D)	N/A
M(D)	N/A
D	3000.0
h`F	N/A
h`F2	N/A
h`E	95.0
h`Es	105.0
hmF2	N/A
hmF1	N/A
hmE	100.5
yF2	N/A
yF1	N/A
yE	10.1
B0	N/A
B1	N/A
C-level	55

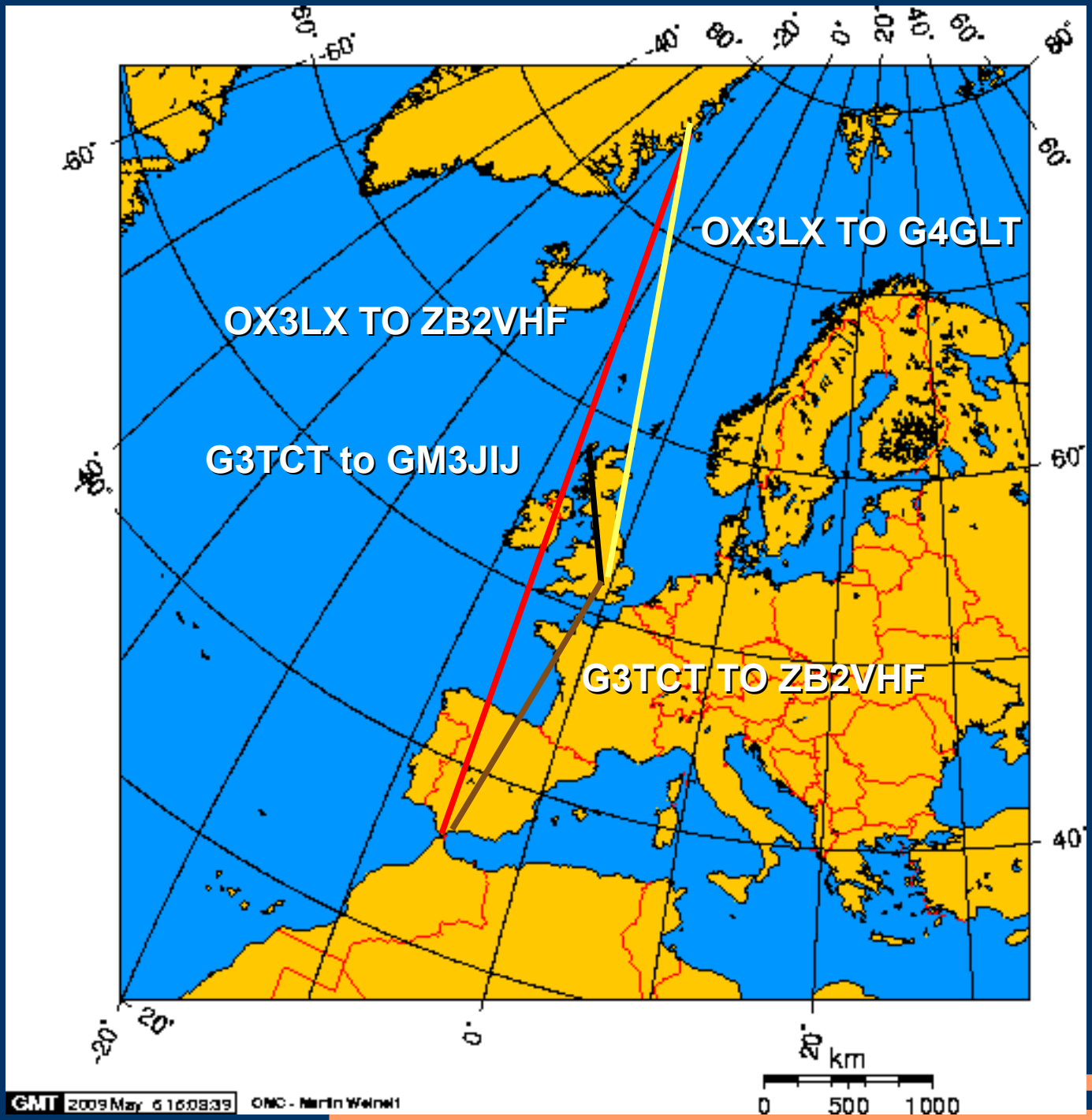
Auto:
Artist4.5
200311



D 100 200 400 600 800 1000 1500 3000 [km]
MUF .0 .0 .0 .0 .0 .0 .0 .0 [MHz]

RL052_2008194092000.MMM / 280fx128h 50 kHz 5.0 km / DPS-1 RL052 052 / 51.6 N 358.7 E

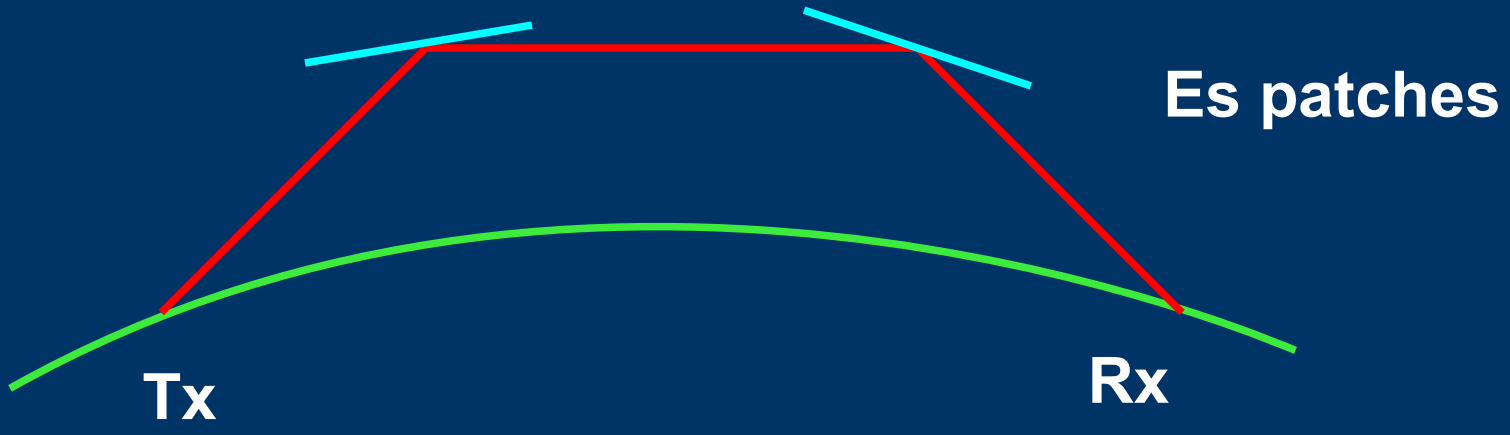
Ion2Png v. 1.3.03



24 June 1986
50MHz - simultaneous paths open

OX-ZB2 4600km
OX-G 2750km
G-ZB2 1700km
G-GM 860km

Reflection geometry – chordal hop



Controversy.....

- Es?
- multi hop?

Path loss

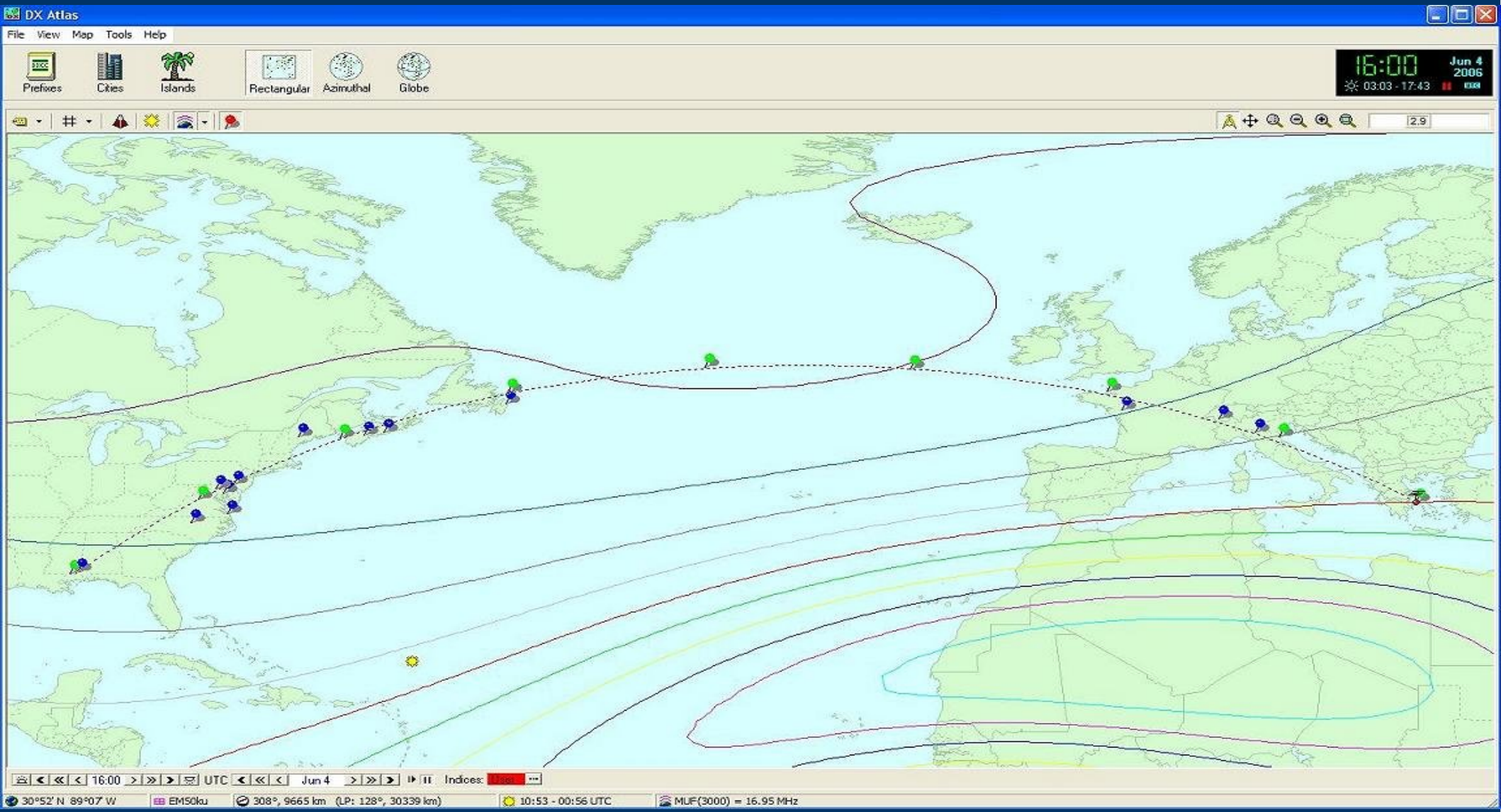
	Measured S/N	loss at iono	hop length
FY7	22 +/- 7dB	6dB	4 x 1750km
W1	32 +/- 7dB	6.5dB	4 x 1200km

- For FY7: 50W, Gt=Gr=6dB, R=7000km and 2.7kHz, F=7dB
- Losses at sea surface ~1dB (hor pol, low grazing angle, even for rough surfaces)
- additional loss for 4 hops: 4*6 + 3 = 27dB
- For W1: 100W, Gt=Gr=9dB, R=4800km

Still can't believe it's multi-hop?

- Costas SV1DH reported on the 6m opening of 4 June 2006:-
- US and VE pile-up from 1530z until 1630z
- Stations who reported hearing him on the dx cluster were then plotted on a map...

SV1DH – reception reports



Path loss SV1DH - W5

- For 500W, Gt=Gr=11dB, R=9600km, 8 hops of 1200km, we get:- S/N = 15dB

Recent developments

- Operating techniques
- Theory
- 4m – more countries
- 4m & 6m – greater distances

Recent developments

- operating
  - ON4KST chat – an invaluable tool

The 50/70 MHz chat (by ON4KST) Web 2.0 version - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.on4kst.info/chat/index.php

Most Visited | Amazon | Six - Coming Home! | Google | My eBay | 50-70 MHz chat | The 4m Forum | Tiscali Webmail | Live storm data IoW | Antenna impedance ...

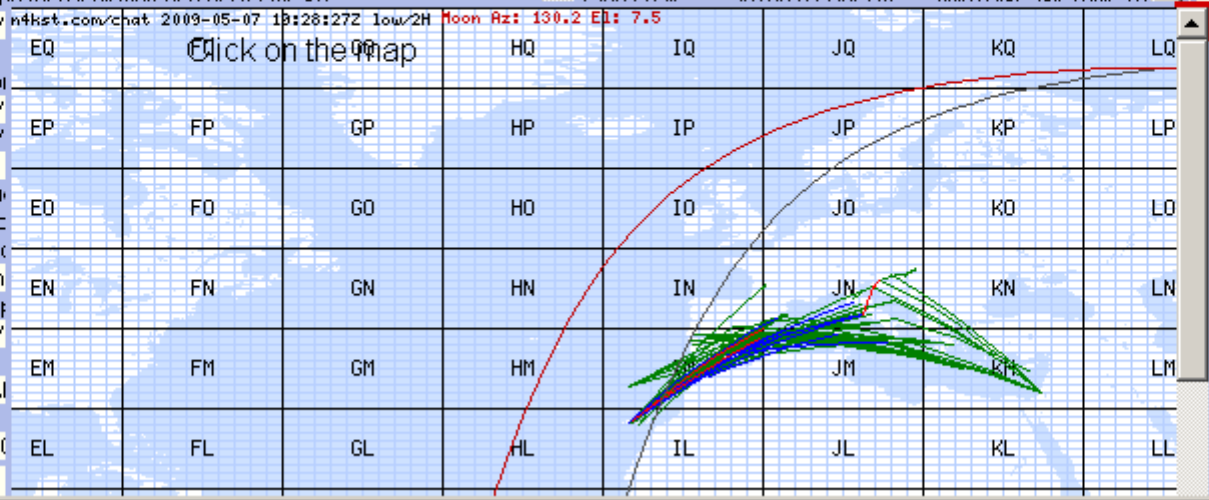
MENU | Send | G3TCT

UTC	CALL/NAME	50/70 MHz MESSAGE **High lat. AU warning**
19:29:26	**9A5CW** Patrik	G8HVY have also 10el yu7ef but never tried - need to put it somewhere
19:28:53	**G8HVY** Graham 4-6M	Patrik RR
19:28:30	**G8HVY** Graham 4-6M	Patrik my element clamps are castings with screws
19:28:03	**9A5CW** Patrik	G8HVY by the way for 4m have 5el 28ohm dk7zb
19:27:39	**G8HVY** Graham 4-6M	Patrik windy hr tonight maybe nead to lower antenna even more B4 dark SUL
19:27:07	**9A5CW** Patrik	G8HVY my elements are grounded with screw true the element and plastic insulator
19:26:36	**9A5CW** Patrik	50200 Arab spelling now
19:25:06	**9A5CW** Patrik	G8HVY rr
19:24:33	**G8HVY** Graham 4-6M	Patrik J Beal + Jaybeam
19:23:47	**9A5CW** Patrik	G8HVY here also element grounded
19:23:44	**G8HVY** Graham 4-6M	Patrik I tried 4ele 12.5 ohm antenna with other antennas on the mast and it would not wrk well 28 ohm more tolerant of other ant
19:22:59	**F4EZJ** Stéphane 10/6/2m	anybody for jt6m test??
19:20:40	**G8HVY** Graham 4-6M	Patrik I had some new original J Beal anrenna clamps elements are dc grounded except for driven element
19:19:49	**9A5CW** Patrik	G8HVY ok, 28ohm type are not so influenced by the close antennas
19:18:13	**G8HVY** Graham 4-6M	Patrik I noticed some de-tune problems untill I used wider spacing then it all matched perfectly :-))
19:16:55	**9A5CW** Patrik	G8HV
19:16:15	**G8HVY** Graham 4-6M	Patrik m/m o
19:12:11	**9A5CW** Patrik	G8HV
19:11:06	**9A5CW** Patrik	G8HV
19:10:41	**G8HVY** Graham 4-6M	Patrik
19:06:14	**SERVER** message	**Requ** Ask tc inline
19:05:15	**2E1IIP** ROBERT	nothin
19:04:41	**9A5CW** Patrik	not a
19:04:15	**9A5CW** Patrik	G8HV
19:03:58	**G8HVY** Graham 4-6M	Patrik
19:03:09	**9A5CW** Patrik	EA3AI
19:02:56	**EA3AKY** Josep	Patrik
18:58:09	**9A5CW** Patrik	50.20

UTC	SPOTTER	QRG	DX	INFO
1929	ec8amq	50199.0	EA7RZ	IL18UL<ES>IM86SU
1927	9a5cw	50200.0	AR1AB	FM strong
1924	ea4sv	50100.0	EA8/EA4SV	cq Es
1924	9a5cw	50095.0	IW0FFK	cq hrd cw
1923	ec8amq	50199.0	EA5EJG	IL18UL<ES>IM98RP
1921	ea5wp	50150.0	EA8CCG	IM99XX<>IL28TM
1920	iw0ffk	50100.0	EA8/EA4SV	JN61FS<ES>IL18
1919	ea7bj	50110.0	EA8BBL	il38bp
1918	9a5cw	50095.0	S57TW	hrd cq
1914	9a5cw	50150.0	IK5ACO	cq 6
1912	ea7agx	50057.0	IT9X/B	rst 5-5
1911	ik5aco	50195.0	EA8YT	il18sl -jn52sv
1910	iw0ffk	50150.0	EA8CCG	JN61FS<ES>IL18TM s
1910	iw0ffk	50074.5	EA8CCG	JN61FS<ES>IL18TM 5
1909	ea7agx	50150.0	EC8CCG	rst 59
1908	ea6ca	50160.0	EA6CA	cq cq cq to AFRICA
1906	iw0ffk	50074.5	ED7YAD/B	JN61FS<ES>IM76QO 5
1904	ea7ls	50195.0	EA8YT	IL18SL
1903	ik5yjy	50180.0	EB8CDX	
1902	ea6ca	50195.0	EA8YT	tnxqso 73
1901	ec8amq	50199.0	IK5YJY	IL18UL<ES>JN53PG
1900	is0gqx	50027.5	CN8MC	bcn IM63 559 in JM49
1900	eb3#	50180.0	EB8CDX	JN01UL<ES>IL18NLSTF

115 of 6325 registered users

DG0DRF	JO71JJ	Erich
DI2PM	JO30BU	Hans 4m (D
2E1IIP	IO94EW	ROBERT
4X4DK	KM71JV	Ami
9A5CW	JN65UF	Patrik
CT1FFU	IM59KJ	Tony 50/70
CU3EQ	HM68KP	J.Vitor 6/2/
DG2KBC	JN58MI	Ansgar
DK3SML	JN49SF	Michael
DK8NE	JN59FW	Uli
DL2RDT	JN59WK	Heinz
DU1GM	PK04MP	George
(EA3AKY)	JN11AK	Josep
EA3EO	JN01TN	gustavo
EA3LL	JN01NE	Josep
EA4EOZ	IN80CI	Miguel
EI2IP	IO61CX	justin.tv/ei2
EI6CPB	IO63WE	Hugh
F4AZF	JN39GG	Damien
F4EZJ	JN05DK	Stéphane 1
G0CGL	IO80VQ	Eric
(G0CHE)	IO90PS	K€V
G0GMB	IO92NB	Martyn
G0GMS	IO82XT	Tony
G0JHC	IO83PQ	Neil 6&4 cv
G0LFP	IO81XV	Steve g0lfp
G0PQO	IO92UA	Kevin
G0TSM	IO90HX	Darren
G1OAR	IO82SQ	Peter 6/4



	now	+10	+20	+30	+40	+50
	2.0	1.7	1.7	1.0	1.0	0.7
)	1917	1918	1919	1920	19	
	6	6	6	6		
	0	0	0	0		
)	1912	1913	1914	1915	19	
cc)	2	2	2	2		
	431	432	433	426	4	
)	1920	1922	1923	1925	19	
	A1.0	A1.0	A1.0	A1.0	A1.	
)	0606	0901	1206	1506	18	

Done

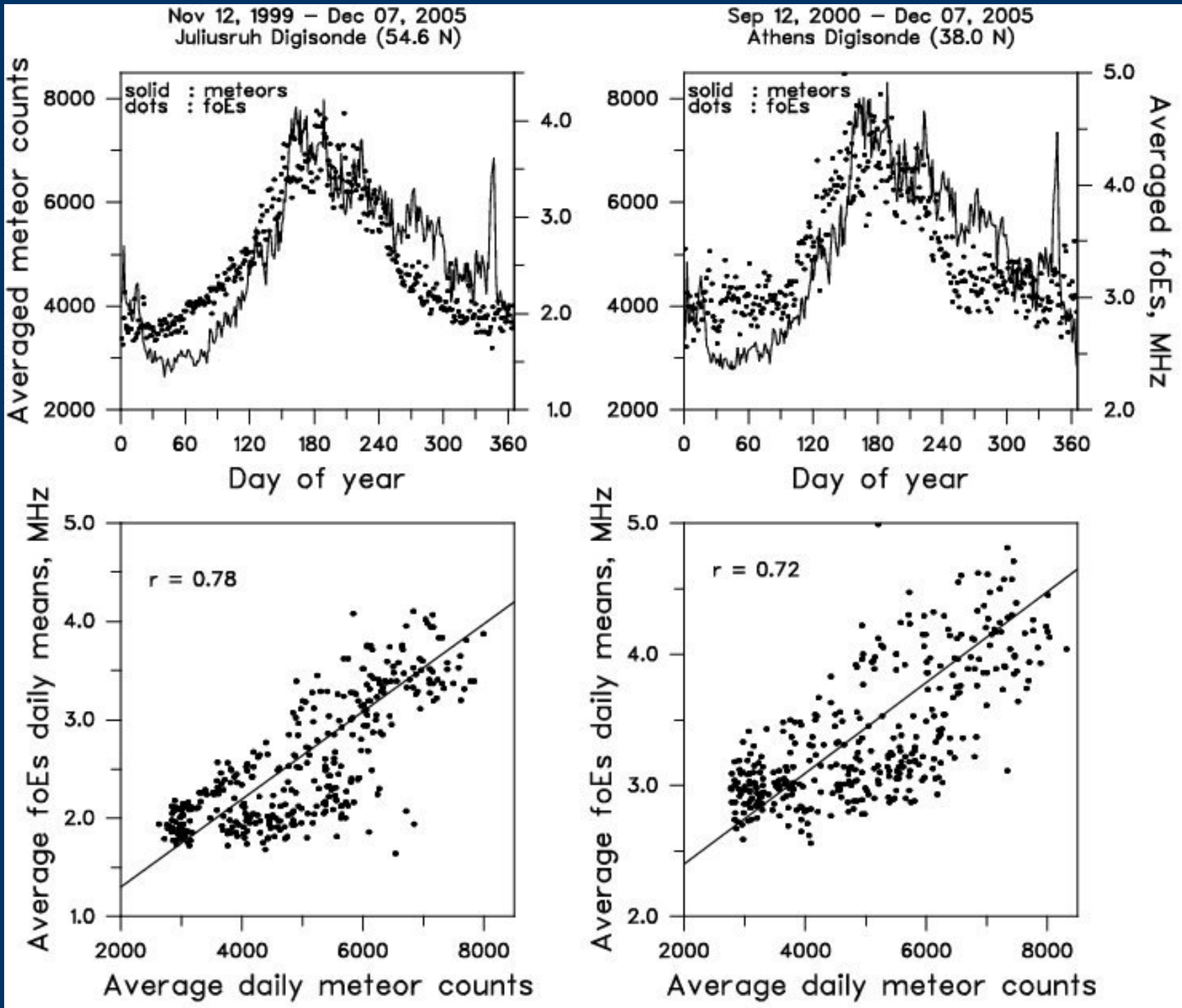
Recent developments - theory

- correlation to the 22 year magnetic cycle of the Sun (CT1HZE, Dubus 1/2008)
- correlation of f0Es with random (non-shower) meteor flux (CT1HZE, Dubus 3/2008)
- long distance propagation in the solar cycle minimum (CT1HZE, Dubus 2/2009)

Correlation with random (non-shower) meteor flux – Dubus 3/2008 from ref 1

- "...marked seasonal dependence of sporadic E correlates well with the annual variation of sporadic meteor deposition in the upper atmosphere."
- "...offers a cause and effect explanation for the long-going mystery of sporadic E layer seasonal dependence."

1 - Haldoupis, C., D. Pancheva, W. Singer, C. Meek, and J. MacDougall (2007), An explanation for the seasonal dependence of midlatitude sporadic E layers, J. Geophys. Res., 112, A06315, doi: 10.1029/2007JA012322


Nov 12, 1999 – Dec 07, 2005
Juliusruh Digisonde (54.6 N)
solid : meteors
dots : foEs
Averaged meteor counts
Day of year
Sep 12, 2000 – Dec 07, 2005
Athens Digisonde (38.0 N)
Averaged foEs, MHz
r = 0.78
r = 0.72
Average foEs daily means, MHz
Average daily meteor counts

Recent developments - theory

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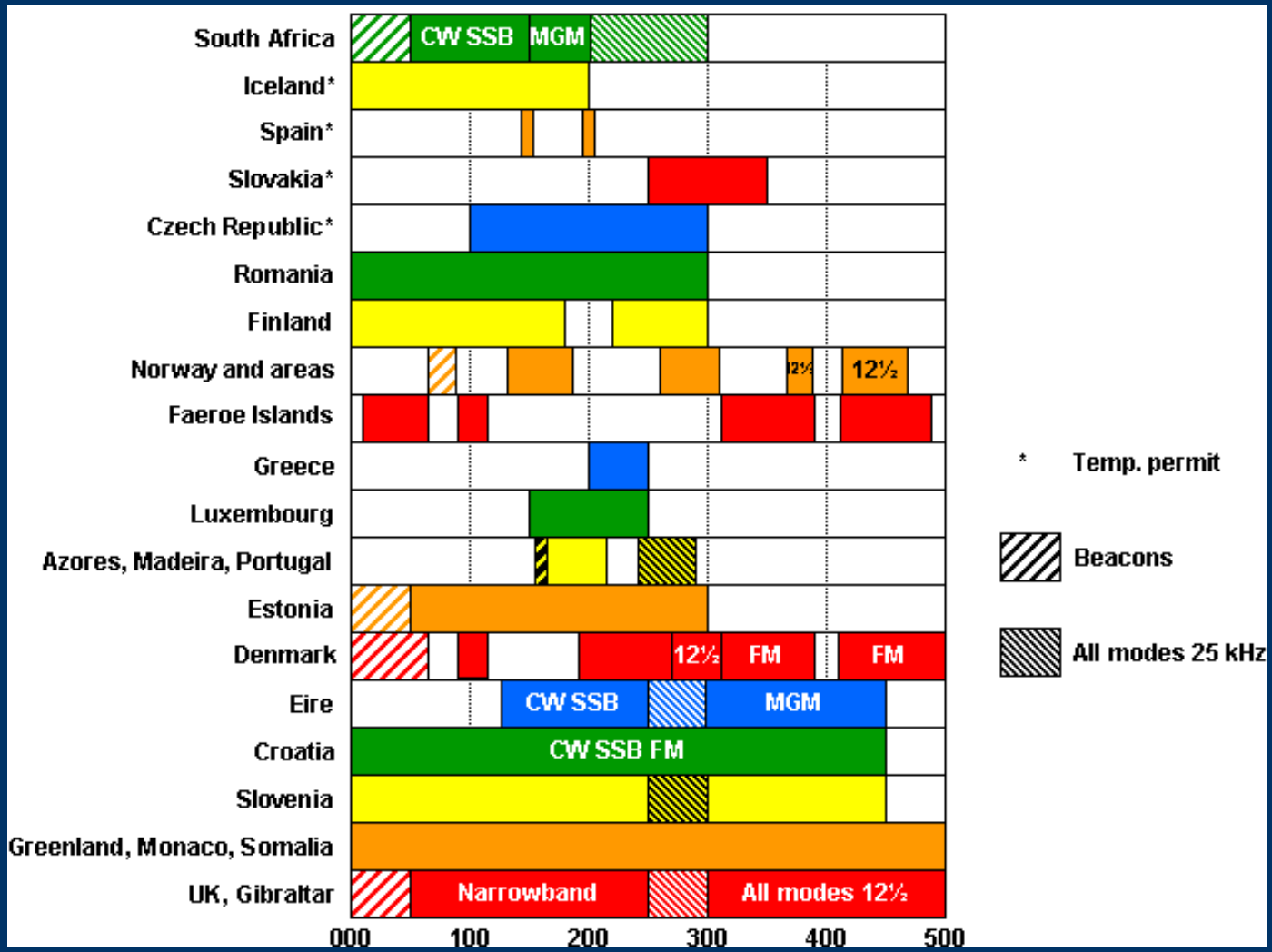
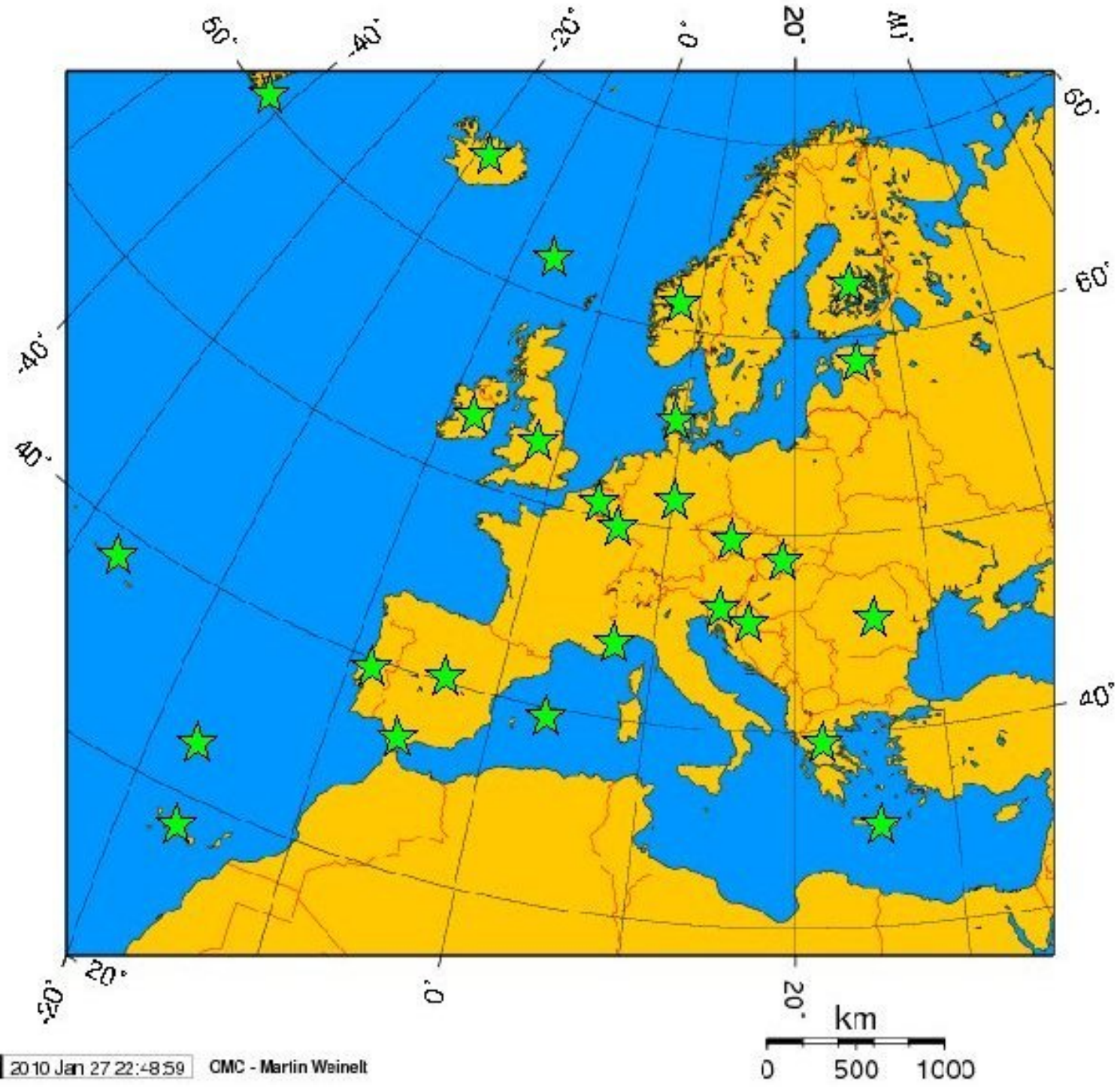
Recent developments – theory of mid-latitude Es

- meteor flux – source of metallic ions
  - geographical and seasonal distribution
- the 22 year magnetic cycle of the Sun
  - importance of low geomagnetic activity
- vertical wind shears
  - formation of dense plasma layers

4m – more countries



plus Z3, D4, DL, ON....


-60°
-40°
-20°
0°
20°
40°
60°
60°
40°
40°
-20°
20°
0°
20°
km
0
500
1000
GMT 2010 Jan 27 22:48:59
CMC - Marlin Weinelt

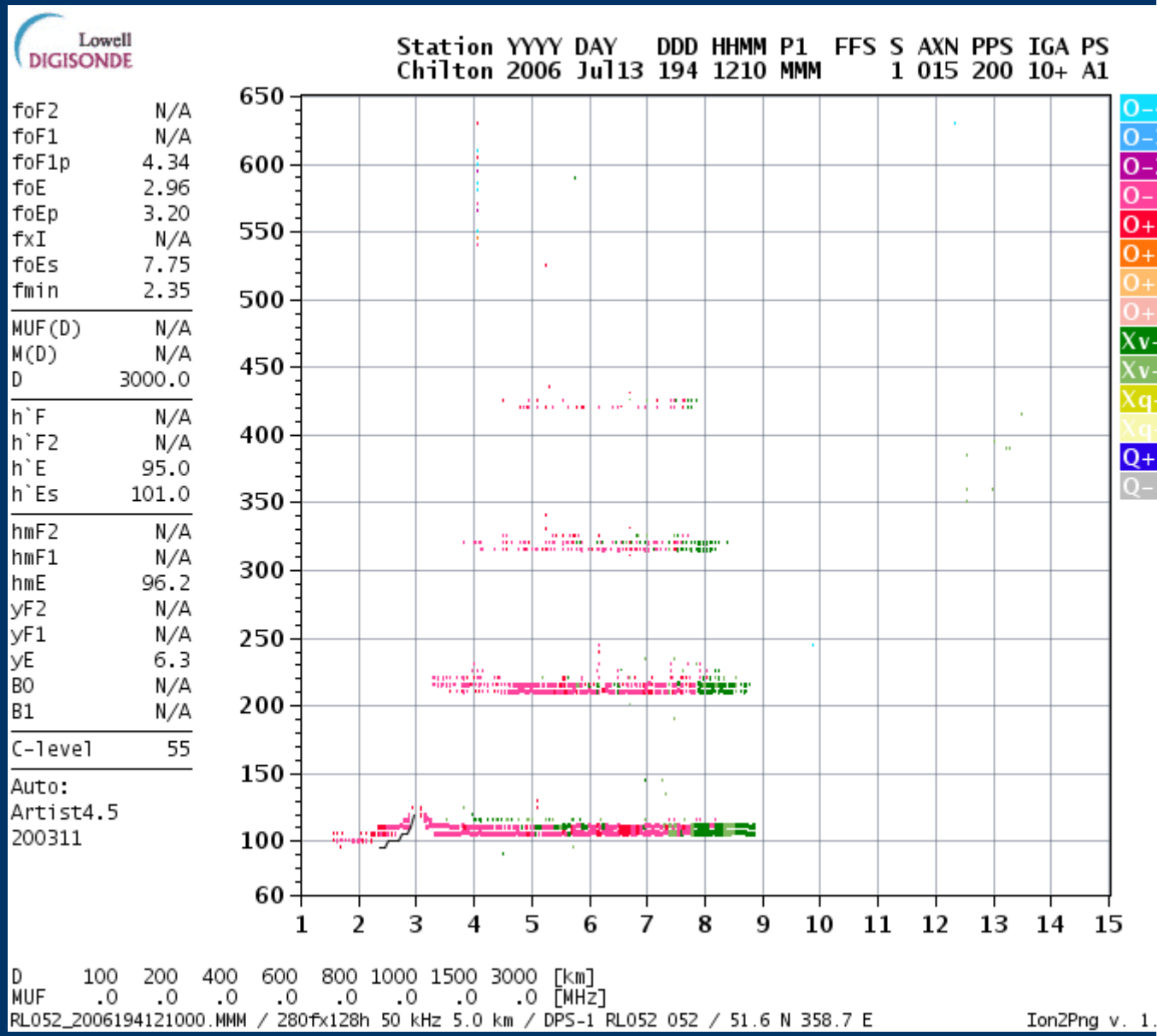
Recent developments

- 4m – greater distances

2513 km

Recent developments

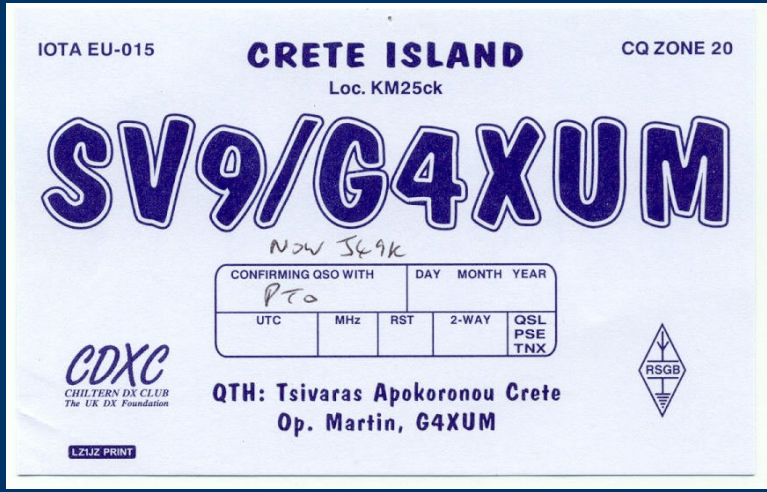
2513 km



Recent developments

- 4m – greater distances

2513 km



2756 km

Recent dx on 4m

12 July 08 – CT1HZE to W3EP 4/6m xband 5334km

12 Jun 09 – SV2DCD to D44TD 4966km
- 4m 2way Es world record

26 Jun 10 – CT1HZE hrd WE9XFT beacon, 6070km at ~1807utc (and again ~2035 on 4 July)

5 July 10 – D44TD to OZ2LD, 5167km
- 4m 2way Es world record

Recent dx on 6m - 2008

Each year, there are new achievements:-
2008 - CT1HZE had 1900 qsos with N America
2008 - JE1BMJ had ~50 qsos with Europe

Recent dx on 6m - 2009

25/05/09 - OA4TT into Europe up to 12000km.

26/05/09 - EA6SA worked 9M6XRO at 11500km. “Many other qsos at >11000km” stated on chat. These are first Es QSOs I've seen into equatorial zone.

08/07/09 - JR2HCB to HI3TEJ – 13288 km Es record

Recent dx – band II FM

- On June 26, 2009 Paul Logan from Lisnaskea, Ireland heard several stations from the United States and Canada including 90.7 WVAS Montgomery, AL
- At 6456 km this constitutes a new world record for Es reception at Band II

Recent dx on 6m - 2010

2010-

BA8AG & BA7IO into Europe & SE England!

Several Gs + G4ASR wkd 9M2TO ~10727km

+ BA, JA, JT, JW, XV, A9, A7, J2, ST, FS, C5.....

Polarisation diversity - 1

- Make use of polarisation twisting in ionosphere
- To help with QSB
- Use cross polarised antennas
- Two receivers locked in frequency, b/w, gain etc
- Record signal in stereo
- LH=horizontal
- RH=vertical

Polarisation diversity - 2

Polarisation diversity - 3

- 1B1AB (N Cyprus) working G0CHE (Bognor)
  note G0CHE via tropo, in LH channel only

Polarisation diversity - 3

- 1B1AB (N Cyprus) working G0CHE (Bognor)
  note G0CHE via tropo, in LH channel only

  Notice the very rapid fading between LH and RH (horizontal and vertical)

Polarisation diversity - 3

- 1B1AB (N Cyprus) working G0CHE (Bognor) note G0CHE via tropo, in LH channel only
- JW9SIX beacon (Bear Island, Svalbard, Arctic)

Polarisation diversity - 3

- 1B1AB (N Cyprus) working G0CHE (Bognor) note G0CHE via tropo, in LH channel only
- JW9SIX beacon (Bear Island, Svalbard, Arctic)

and see my website for others....

Polarisation diversity - 4

- Lissajous figures – a reminder

Polarisation diversity - 5

- Lissajous figures – a reminder

- JW9SIX again
- ST2AR

Sporadic E – the most interesting propagation mode?

- very strong signals (for <2000km)
- sometimes brief and somewhat unpredictable
- works over 20-220MHz
- ranges from <500km to >10,000km on 6m
- works in low sunspot periods
- continuing source of discussion and research

References

Transatlantic propagation by sporadic E – G Kimbell, Radcom July 1986
Sporadic E and 50MHz propagation during 1987 – G Grayer, Six News, Dec 1987
A Review of 50MHz sporadic E in 1996 – S Reed, Six News, May 1997
Interpreting Digital Ionograms – G Williams, RadCom May 2009

RSGB Propagation Studies Committee - http://www.keele.ac.uk/depts/por/psc.htm

UK Six Metre Group – http://www.uksmg.org

Mid-Latitude Sporadic-E (Es) - A Review
http://www.amfmdx.net/propagation/Es.html

Four metre website - http://www.70mhz.org

Online map creation - http://www.aquarius.ifm-geomar.de/omc_intro.html

PC soundscope: http://www.zeitnitz.de/Christian/scope_en

Graham's email: g3tct[at]lineone.net website: www.g3tct.co.uk