What is *VOACAP* Trying to Tell Me?

A Presentation to
The Yankee Clipper Contest Club

Feb. 1, 2003
Milford, CT

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VOACAP

- *VOACAP* has been under development by the US government for more than three solar cycles.
- *VOACAP* is recognized as being an accurate propagation-prediction program.
- *VOACAP* produces *reams* of output data and forces the user to make information from it!

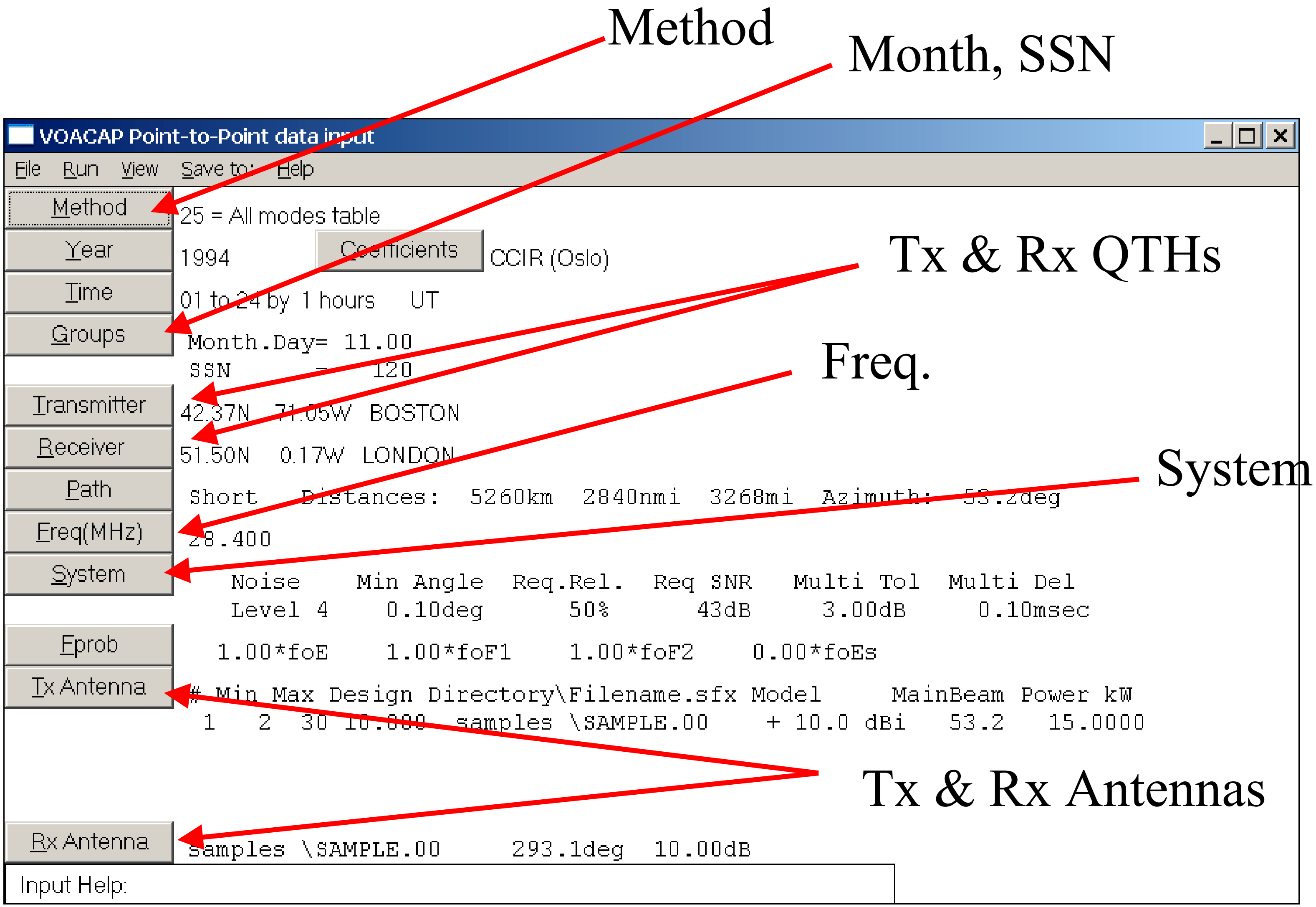
There is a big difference between *data* and *information*.

VOACAP

You must give *VOACAP* a number of parameters before it can do a propagation prediction.

The most important selections are the Method and the Antennas used.

VOACAP Inputs



VOACAP Methods

- There are 30 “Methods” in *VOACAP*.
- Most are not useful to the contester.
- I use Method 25 (All Modes) and Method 30 (short-long path smoothing) most often.
- Method 30 gets rid of anomalies between 7,000 to 10,000 km (what *IONCAP* calls “short” and “long” paths).

VOACAP Methods

Change propagation METHOD

Accept | Cancel

Select the Propagation METHOD to use:

1 = Ionospheric parameters
2 = Ionograms
3 = MUF-FOT lines (nomogram)
4 = MUF-FOT graph (use 11 or 28)
5 = HPF-MUF-FOT graph
6 = MUF-FOT-Es graph (use 11)
7 = FOT-MUF table (full ionosphere)
8 = MUF-FOT graph (use 11 or 28)
9 = HPF-MUF-FOT graph
10 = MUF-FOT-ANG graph
11 = MUF-FOT-Es graph - real graph, not line printer
12 = MUF by magnetic indices, K(not implemented)
13 = Transmitter antenna pattern
14 = Receiver antenna pattern
15 = Both transmitter & receiver antenna patterns
16 = System performance (S.P.)
17 = Condensed system performance, reliability
18 = Condensed system performance, service probability
19 = Propagation path geometry
20 = Complete system performance (C.S.P.)
21 = Forced long path model (C.S.P.)
22 = Forced short path model (C.S.P.)
23 = User selected output (set by TOPLINES & BOTLINES)
24 = MUF-REL table
25 = All modes table
26 = MUF-LUF-FOT table (nomogram)
27 = FOT-LUF graph (use 28)
28 = MUF-FOT-LUF graph - real graph, not line printer
29 = MUF-LUF graph (use 28)
30 = For VOACAP only - S/L path smoothing (7-10000 km)

All modes table

S/L path smoothing

VOACAP Method 25 Output

```
   CCIR Coefficients        ~METHOD 25   VOACAP 02.1106W  PAGE   2

 Feb     2003          SSN =   90.              Minimum Angle= 0.100 degrees
 BOSTON               LONDON               AZIMUTHS          N. MI.      KM
 42.37 N   71.05 W - 51.50 N    0.17 W     53.15  288.25    2840.2    5259.6
 XMTR  2-30 + 10.0 dBi[samples\SAMPLE.00    ] Az= 53.2 OFFaz=360.0  15.000kW
 RCVR  2-30 + 10.0 dBi[samples\SAMPLE.00    ] Az=293.1 OFFaz=355.1
 3 MHz NOISE = -163.6 dBW     REQ. REL = 50%     REQ. SNR = 43.0 dB


SUMMARY    3 MODES    FREQ =    7.2 MHZ  UT =    1.0
                                                Most REL
                  2.F2       3.F2       3. E       2.F2
 TIME DEL.       18.41      19.17      17.88      18.41
 ANGLE            7.06      16.30       4.10       7.06
 VIR. HITE      311.51     332.19     125.30     311.51
 TRAN.LOSS      123.63     125.75     947.56     123.63
 T. GAIN         10.00      10.00      10.00      10.00
 R. GAIN         10.00      10.00      10.00      10.00
 ABSORB           4.09       2.66       4.62
 FS. LOSS       124.43     124.79     124.18
 FIELD ST.       32.48      30.36    -791.46      34.56
 SIG. POW.      -81.86     -83.99    -905.80     -79.79
 SNR             76.25      74.13    -747.69      78.33
 MODE PROB        0.99       0.83       0.00       0.99
 R. PWRG       1000.00    1000.00    1000.00     -35.33
 RELIABIL         1.00       0.99       0.00       1.00
 SERV PROB        1.00       1.00       0.00       1.00
 SIG LOW          9.09      15.16       8.61      10.55
 SIG  UP          4.88       5.39       4.86       5.08
 NOISE =    -158       S. POWER =   -79.8
 SIGNAL =     8.6    10.1      4.9   /     1.8       5.7      1.0
 NOISE =      6.2 -158.1      5.1   /     2.2       3.3      2.0
 RELIAB =     7.2    78.3     12.2
 SPROB =      6.8    76.2      6.8
```

Mode

Elev. angle

Signal power, dBW

SNR, in 1 Hz BW

Mode probability

All modes for one frequency, for each hour -- the output file is huge!

Sample *VOACAP* Method 25 Output

```
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 BOSTON                   LONDON                 AZIMUTHS           N. MI.      KM
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SUMMARY    3 MODES   FREQ =   7.2 MHZ  UT =   1.0
                                                  Most REL
                2.F2        3.F2        3. E        2.F2
 TIME DEL.     18.41       19.17       17.88       18.41
 ANGLE          7.06       16.30        4.10        7.06
 VIR. HITE    311.51      332.19      125.30      311.51
 TRAN.LOSS    123.63      125.75      947.56      123.63
 T. GAIN       10.00       10.00       10.00       10.00
 R. GAIN       10.00       10.00       10.00       10.00
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 FS. LOSS     124.43      124.79      124.18
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 SERV PROB      1.00        1.00        0.00        1.00
 SIG LOW        9.09       15.16        8.61       10.55
 SIG  UP        4.88        5.39        4.86        5.08
 NOISE =    -158       S. POWER =  -79.8
 SIGNAL =     8.6    10.1     4.9  /     1.8      5.7      1.0
 NOISE =      6.2  -158.1     5.1  /     2.2      3.3      2.0
 RELIAB =     7.2    78.3    12.2
 SPROB =      6.8    76.2     6.8
```

Two 7.2-MHz modes: 2.F2 at 7.06° and 3.F2 at 16.30° takeoff angles.

The signal power at the receiver is -81.86 dBW and -83.99 dBW -- very close, so fading can easily occur.

Sample *VOACAP* Method 25 Output

Let's drill down and look more closely at the information around 1200 UTC, East-Coast sunrise on 15 meters.

Here's how to convert from dBW to dBμV:

dBμV = 137 + dBW
Now, 34 dBμV = S9
So, -103 dBW = S9, and -93 dBW = S9+10.

Edited *VOACAP* Method 25 Output

Elevation Angle

UT = 12.0	2.F2	2.F2	2.F2
ANGLE	7.04	10.25	7.04
SIG. POW.	-98.66	-112.02	-98.46
SNR	82.59	69.22	82.78
MODE PROB	0.56	0.56	0.56

S9+4

S7, Pedersen wave

VOACAP's choice of Most Reliable Mode (MRM) = 56% of days in the month

Edited *VOACAP* Method 25 Output

UT = 12.0	2.F2	2.F2	2.F2		
ANGLE	7.04	10.25	7.04		
SIG. POW.	-98.66	-112.02	-98.46		
SNR	82.59	69.22	82.78		
MODE PROB	0.56	0.56	0.56		
UT = 13.0	2.F2	2.F2			
ANGLE	4.64	4.64			
SIG. POW.	-92.39	-92.39			
SNR	87.95	87.95			
MODE PROB	0.89	0.89			
UT = 14.0	2.F2	3.F2	3.F2	3. E	2.F2
ANGLE	4.40	13.89	17.01	4.10	4.40
SIG. POW.	-93.26	-102.87	-113.59	-686.02	-92.77
SNR	85.94	76.33	65.60	-506.82	86.42
MODE PROB	0.92	0.41	0.41	0.00	0.92
UT = 15.0	2.F2	3.F2	3.F2	3. E	2.F2
ANGLE	4.78	14.03	18.30	4.10	4.78
SIG. POW.	-93.70	-101.82	-118.36	-857.80	-93.07
SNR	85.58	77.46	60.92	-678.52	86.21
MODE PROB	0.93	0.47	0.47	0.00	0.93
UT = 16.0	2.F2	3.F2	3.F2	3. E	2.F2
ANGLE	4.86	14.68	18.16	4.10	4.86
SIG. POW.	-92.68	-102.42	-116.01	-919.18	-92.22
SNR	86.71	76.96	63.37	-739.80	87.17
MODE PROB	0.93	0.44	0.44	0.00	0.93
UT = 17.0	2.F2	2.F2			
ANGLE	5.02	5.02			
SIG. POW.	-90.60	-90.60			
SNR	88.90	88.90			
MODE PROB	0.94	0.94			

12 UTC: Pedersen wave on 2.F2 is weaker

13 UTC: 1 mode only, no Pedersen

14 UTC: 3 modes; Pedersen on 3.F2

15 UTC: 3 modes; Pedersen on 3.F2

16 UTC: 3 modes; Pedersen on 3.F2

17 UTC: 1 mode only, no Pedersen

VOACAP Antenna Selection

- To see a propagation prediction without bias due to antenna type or height, I usually choose “isotropic” Tx and Rx antennas, but with +10 dBi gain to simulate real-world gains.

- The resulting gain shows in the TGAIN and RGAIN lines in the output printout.

VOACAP Method 30 Output

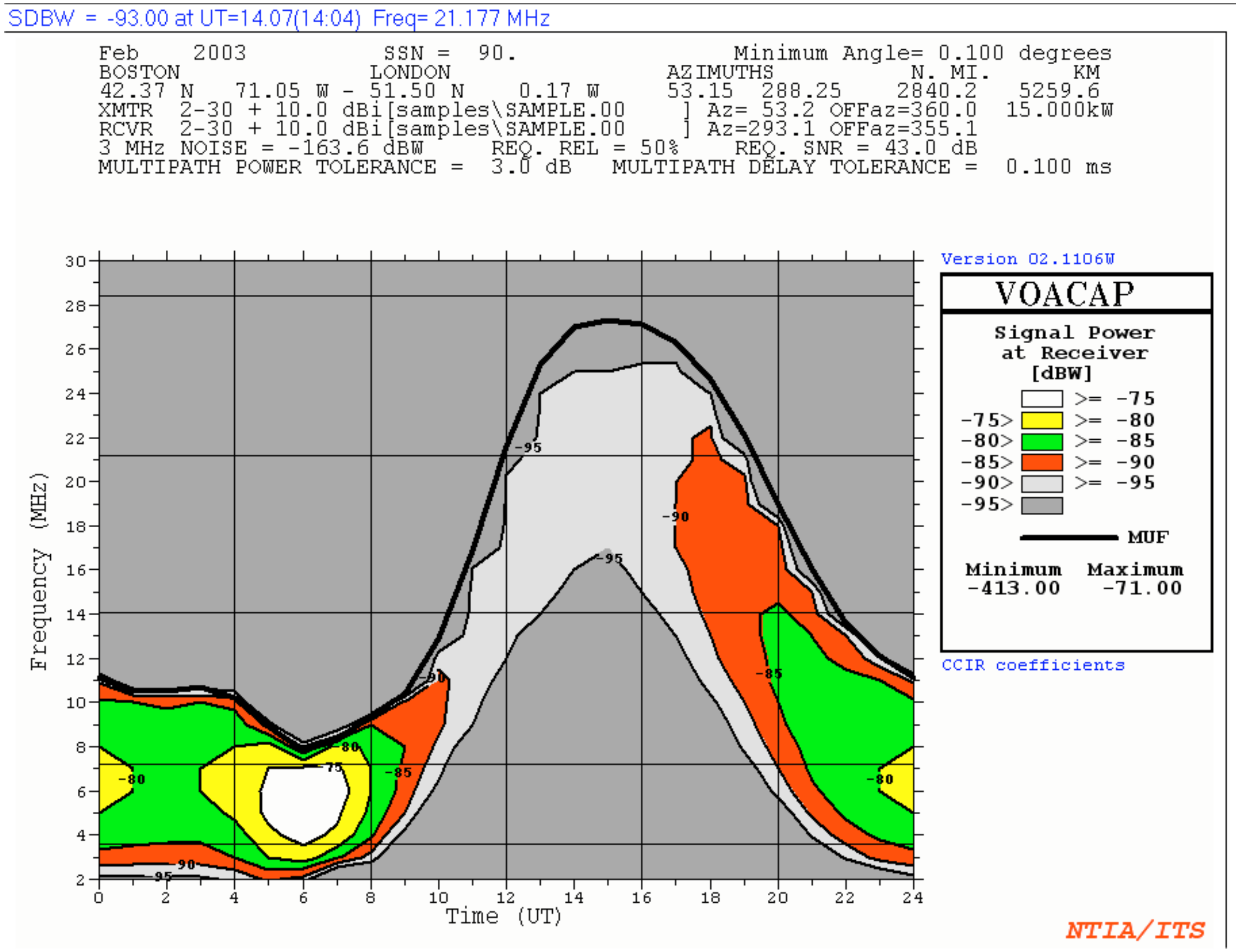
```
Feb     2003            SSN =   90.             Minimum Angle= 0.100 degrees
BOSTON                 LONDON                 AZIMUTHS          N. MI.       KM
42.37 N   71.05 W - 51.50 N    0.17 W       53.15  288.25     2840.2     5259.6
XMTR  2-30 + 10.0 dBi[samples\SAMPLE.00     ] Az= 53.2 OFFaz=360.0  15.000kW
RCVR  2-30 + 10.0 dBi[samples\SAMPLE.00     ] Az=293.1 OFFaz=355.1
3 MHz NOISE = -163.6 dBW     REQ. REL = 50%     REQ. SNR = 43.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms

 1.0 10.5  3.6  7.2 14.1 21.2 28.4  0.0  0.0  0.0  0.0  0.0  0.0 FREQ
      2F2  2F2  2F2  2F2  2F2  2F2    -    -    -    -    -    - MODE
     12.4  6.8  7.1 12.4 12.4 12.4    -    -    -    -    -    - TANGLE
     19.1 18.4 18.4 19.1 19.1 19.1    -    -    -    -    -    - DELAY
      453  305  312  453  453  453    -    -    -    -    -    - V HITE
     0.50 1.00 0.99 0.07 0.00 0.00    -    -    -    -    -    - MUFday
      139  129  124  184  364  409    -    -    -    -    -    - LOSS
       20   24   35  -22 -199 -241    -    -    -    -    -    - DBU
      -97  -84  -80 -143 -322 -368    -    -    -    -    -    - S DBW
     -167 -148 -158 -176 -183 -186    -    -    -    -    -    - N DBW
       70   63   78   34 -139 -182    -    -    -    -    -    - SNR
      -27  -20  -35    9  182  225    -    -    -    -    -    - RPWRG
     0.91 0.99 1.00 0.32 0.00 0.00    -    -    -    -    -    - REL
     0.00 0.95 0.99 0.00 0.00 0.00    -    -    -    -    -    - MPROB
     1.00 0.99 1.00 0.07 0.00 0.00    -    -    -    -    -    - S PRB
     25.0  8.6 10.6 25.0 25.0  8.6    -    -    -    -    -    - SIG LW
     20.8  4.9  5.1 25.0 25.0  4.9    -    -    -    -    -    - SIG UP
     25.5 11.9 12.2 25.9 26.1 11.3    -    -    -    -    -    - SNR LW
     21.1  8.2  7.2 25.1 25.1  5.5    -    -    -    -    -    - SNR UP
     10.0 10.0 10.0 10.0 10.0 10.0    -    -    -    -    -    - TGAIN
     10.0 10.0 10.0 10.0 10.0 10.0    -    -    -    -    -    - RGAIN
       70   63   78   34 -139 -182    -    -    -    -    -    - SNRxx
```

MUF

Summary of all frequencies for each hour

VOACAP Graph Output



This looks pretty, but it doesn't really give that much useful information for contest planning!

VOACAP Output Information

I use two types of information from *CAPMAN/VOACAP*:

- Elevation angle statistics
- Signal-strength predictions

Elevation-Angle Statistics

- About ten years ago I started a detailed study at ARRL HQ on the range of elevation angles needed for communication between various QTHs around the world.

- I used the *VOACAP* program, along with some proprietary software, to create some *huge* databases. From these, elevation I generated statistics for 150+ QTHs around the world.

Elevation-Angle Statistics

A tiny portion of the raw database from Boston to the world.

RxQTH	Freq	SSN	Month	Hour	dBuV	Elev	Rel	Mode
London	3.6	5	2	0	38.5	5.6	0.690	2.F2
London	3.6	5	2	0	35.9	13.0	0.580	3.F2
London	3.6	5	2	0	33.6	19.4	0.490	4.F2
London	3.6	5	2	1	38.9	5.6	0.660	2.F2
London	3.6	5	2	1	36.4	13.1	0.570	3.F2
London	3.6	5	2	1	34.3	19.6	0.500	4.F2
London	3.6	5	2	2	38.3	5.5	0.620	2.F2
London	3.6	5	2	2	35.7	13.0	0.530	3.F2
London	3.6	5	2	2	33.7	19.5	0.420	4.F2
London	3.6	5	2	3	37.9	5.5	0.640	2.F2
London	3.6	5	2	3	35.3	13.0	0.550	3.F2
London	3.6	5	2	3	33.3	19.4	0.470	4.F2
London	3.6	5	2	4	39.6	5.6	0.710	2.F2
London	3.6	5	2	4	37.1	13.2	0.630	3.F2

Elevation-Angle Statistics

• The resulting elevation-angle files are on the CD-ROM in *The ARRL Antenna Book*. They contain statistical averages over the entire 11-year solar cycle -- for all months of the year and for all hours of the day.

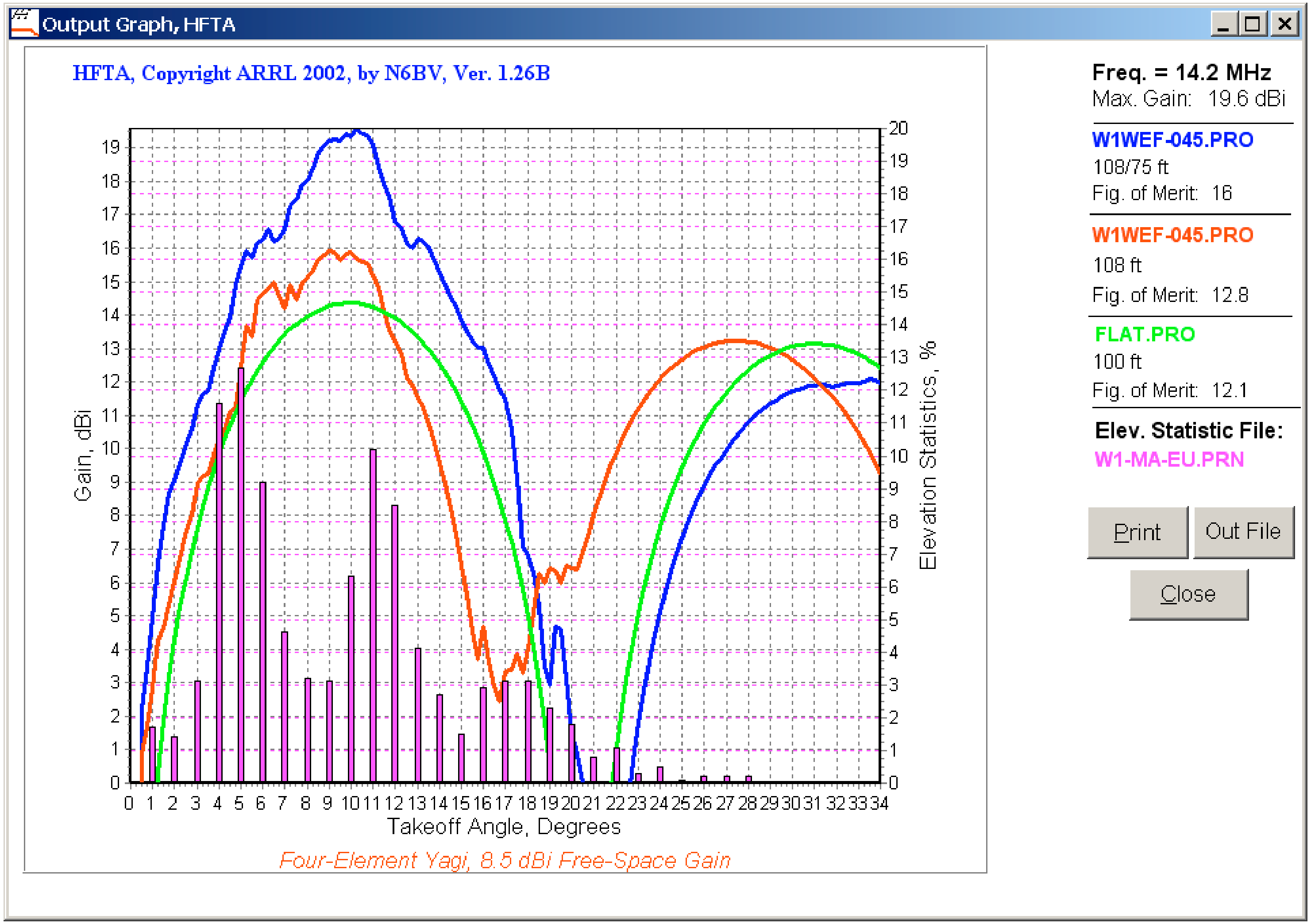
• These statistical files are used by the *YT* and *HFTA* terrain-assessment programs.

Sample Table, Boston to Europe

Boston, Massachusetts to Europe

Elev	80m	40m	30m	20m	17m	15m	12m	10m
1	4.1	9.6	4.6	1.7	2.1	4.4	5.5	7.2
2	0.8	2.3	7.2	1.4	2.8	2.8	3.7	5.3
3	0.3	0.7	4.3	3.1	2.4	2.2	4.4	7.9
4	0.5	4.1	8.7	11.6	12.2	9.4	8.1	3.9
5	4.6	4.8	7.5	12.7	14.3	13.1	9.2	11.2
6	7.1	8.9	5.5	9.2	9.6	12.2	9.2	7.2
7	8.5	6.9	7.2	4.6	7.9	7.4	10.0	5.9
8	5.1	7.0	5.4	3.2	5.9	7.4	4.8	6.6
9	3.3	5.6	3.2	3.1	2.1	3.9	8.1	9.2
10	1.0	4.0	7.9	6.3	5.1	3.7	11.1	6.6
11	1.9	3.8	9.7	10.2	7.2	5.4	3.7	7.9
12	5.6	3.4	4.8	8.5	6.9	7.4	4.8	6.6
13	11.0	3.0	2.4	4.1	5.9	4.6	3.3	2.6
14	7.6	4.8	2.0	2.7	3.8	3.9	6.3	5.9
15	5.3	7.9	2.0	1.5	2.4	1.7	1.5	2.0
16	2.8	6.4	3.8	2.9	1.5	1.3	2.6	2.6
17	5.0	3.4	4.5	3.1	1.0	1.5	0.0	0.0
18	4.2	2.0	3.1	3.1	2.0	2.2	1.8	1.3
19	5.7	1.4	1.4	2.3	1.3	0.7	0.0	0.0
20	6.6	1.4	1.2	1.8	1.1	1.3	0.7	0.0
21	4.4	1.4	0.5	0.8	0.7	0.7	0.4	0.0
22	2.3	2.4	1.0	1.1	0.6	1.3	0.7	0.0
23	1.3	1.8	0.1	0.3	0.1	0.0	0.0	0.0
24	0.6	1.0	0.5	0.5	0.4	0.7	0.0	0.0
25	0.3	0.8	0.3	0.1	0.4	0.0	0.0	0.0
26	0.0	0.5	0.7	0.2	0.1	0.4	0.0	0.0
27	0.1	0.1	0.1	0.2	0.1	0.2	0.0	0.0
28	0.0	0.3	0.1	0.2	0.0	0.2	0.0	0.0
29	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0
30	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

One Picture = 1000 Words



Propagation Predictions

YCCC members are familiar with the predictions I provide for the major DX contests (CQWW Phone, CW and ARRL DX Phone, CW).

These show tables of predictions, one page per band. Each page shows predictions for 40 CQ Zones, for 24 hours.

These are computed for undisturbed ionospheric conditions.

Sample Propagation Prediction

15 Meters: Feb. 2003, YCCC, for SSN = High, Sigs in S-Units. By N6BV, ARRL.

UTC -->

Zone	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
KL7 = 01	9	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	9	9+	9+	9+	9+	9+
VO2 = 02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	7	8	8	8	7	4	1	4
W6 = 03	9+	9	2	-	-	-	-	-	-	-	-	-	-	-	-	5	9+	9+	9+	9+	9+	9+	9+	9+
W0 = 04	9+	9+	6	-	-	-	-	-	-	-	-	-	-	-	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
W3 = 05	1	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	-	-	-	-	-	-	1
XE1 = 06	9	5	9	7	1	1	1	2	5	4	-	-	-	8	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
TI = 07	9	4	9	7	5	3	2	3	4	2	-	2	9	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
VP2 = 08	9+	9	7	4	4	4	4	4	1	-	-	4	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
P4 = 09	9	9+	8	7	6	6	5	6	3	-	1	4	8	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	8
HC = 10	8	7	-	-	-	-	-	-	-	-	-	-	7	5	9+	9+	9+	9	9	9	9	9+	9+	4
PY1 = 11	9	7	4	2	3	4	4	1	-	-	2	9	9+	9	8	7	8	8	9	9+	9+	9+	9+	9+
CE = 12	9+	8	5	4	3	3	2	2	-	-	-	-	9	9	8	8	7	8	8	9	9	9+	9+	9+
LU = 13	9+	7	5	4	2	4	4	3	-	-	-	5	9+	9	8	7	7	8	8	9	9+	9+	9+	9+
G = 14	-	-	-	-	-	-	-	-	-	-	-	-	9+	9+	9+	9+	9+	9+	9+	9+	2	-	-	-
I = 15	-	-	-	-	-	-	-	-	-	-	-	1	6	9+	9+	9+	9+	9+	8	9	2	-	-	-
UA3 = 16	-	-	-	-	-	-	-	-	-	-	-	-	6	9	9	9	8	5	1	-	-	-	-	-
UN = 17	-	-	-	-	-	-	-	-	-	-	-	-	2	9	9	6	1	-	-	-	-	-	-	-
UA9 = 18	-	1	2	-	-	-	-	-	-	-	-	-	-	6	2	1	-	-	-	-	-	1	-	-
UA0 = 19	8	6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	8	9
4X = 20	-	-	-	-	-	-	-	-	-	-	-	1	9	9	9	9	9+	9	6	6	2	-	-	-
HZ = 21	2	-	-	-	-	-	-	-	-	-	-	-	9	9	9	9	9	8	6	4	1	1	1	2
VU = 22	-	-	-	-	-	-	-	-	-	-	-	-	5	9+	9	7	2	1	-	-	1	1	1	-
JT = 23	6	4	1	1	-	-	-	-	-	-	-	-	2*	4	-	-	-	1	-	-	-	-	-	1
VS6 = 24	5	2	-	-	-	-	-	-	-	-	-	-	5*	6	4*	2	2	1	1	1	-	-	1	7
JA1 = 25	8	6	1	-	-	-	-	-	-	-	-	-	4*	2*	1*	-	-	-	-	-	1	7	9+	9+
HS = 26	5	2	-	-	-	-	-	-	-	-	-	-	1*	7	9+	9	8	6	4	4	4	-	-	-
DU = 27	7	4	-	-	-	-	-	-	-	-	-	-	5*	4*	5	7	5	4	2	-	-	-	4	9
YB = 28	5	1	-	-	-	-	-	-	-	-	-	-	3*	2	9	9+	9	9	9	9+	7	-	-	1
VK6 = 29	8	2	1	-	-	-	-	-	-	-	-	-	-	-	1	9	9+	9	9	7	-	-	8	9
VK3 = 30	4	5	3	1	-	-	-	-	-	-	-	-	-	-	9	7	2	-	-	1	7	6	5	5
KH6 = 31	9	9	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9	9	9	9	9	9
KH8 = 32	8	9	8	5	-	-	-	-	-	-	-	-	-	-	6	-	-	4	8	8	8	8	7	8
CN = 33	-	-	-	-	-	-	-	-	-	-	-	8	9	9+	9+	9+	9+	9+	9+	9+	9+	8	2	-
SU = 34	-	-	-	-	-	-	-	-	-	-	-	1	9	9	9	9	9+	9+	9	8	5	2	-	-
6W = 35	1	-	-	-	-	-	-	-	-	-	-	9	9+	9	9	9	9	9+	9+	9+	9+	9+	9+	8
D2 = 36	8	1	-	1	1	5	-	-	-	-	-	8	8	8	7	8	9	9	9+	9+	9+	9+	9+	9
5Z = 37	5	-	-	-	-	-	-	-	-	-	-	8	8	8	8	9	9	9+	9+	9+	9+	9+	9	8
ZS6 = 38	3	-	-	-	-	-	-	-	-	-	-	7	6	5	5	6	8	9	9	9+	9+	9+	9+	9
FR = 39	4	-	-	-	-	-	-	-	-	-	-	6	6	6	7	8	9	9	9+	9+	9+	9+	9	8
FJL = 40	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	4	4	5	4	4	2	-	1	-
Zone	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23

UTC -->

Expected signal levels using 1500 W and 4-element Yagis at 60 feet at each station.

Propagation Predictions

Scaling signal levels for different size stations:

- Subtract 2 S units for a dipole instead of a Yagi
- Subtract 3 S units for a dipole at 50’ instead of a Yagi at 100’
- Subtract 1 S unit for a dipole at 50’ rather than a dipole at 100’
- Subtract 3 S units for 100 W rather than 1500 W

Propagation Predictions

15 Meters: Feb. 2003, YCCC, for SSN = High, Sigs in S-Units. By N6BV, ARRL.

	UTC -->																							
Zone	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
KL7 = 01	9	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	9	9+	9+	9+	9+	9+
VO2 = 02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	7	8	8	8	7	4	1	4
W6 = 03	9+	9	2	-	-	-	-	-	-	-	-	-	-	-	-	5	9+	9+	9+	9+	9+	9+	9+	9+
W0 = 04	9+	9+	6	-	-	-	-	-	-	-	-	-	-	-	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
W3 = 05	1	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	-	-	-	-	-	-	1
XE1 = 06	9	5	9	7	1	1	1	2	5	4	-	-	-	8	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
TI = 07	9	4	9	7	5	3	2	3	4	2	-	2	9	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
VP2 = 08	9+	9	7	4	4	4	4	4	1	-	-	4	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+
P4 = 09	9	9+	8	7	6	6	5	6	3	-	1	4	8	9+	9+	9+	9+	9+	9+	9+	9+	9+	9+	8
HC = 10	8	7	-	-	-	-	-	-	-	-	-	-	7	5	9+	9+	9+	9	9	9	9	9+	9+	4
PY1 = 11	9	7	4	2	3	4	4	1	-	-	2	9	9+	9	8	7	8	8	9	9+	9+	9+	9+	9+
CE = 12	9+	8	5	4	3	3	2	2	-	-	-	-	9	9	8	8	7	8	8	9	9	9+	9+	9+
LU = 13	9+	7	5	4	2	4	4	3	-	-	-	5	9+	9	8	7	7	8	8	9	9+	9+	9+	9+
G = 14	-	-	-	-	-	-	-	-	-	-	-	-	9+	9+	9+	9+	9+	9+	9+	9+	2	-	-	-
I = 15	-	-	-	-	-	-	-	-	-	-	-	1	6	9+	9+	9+	9+	9+	8	9	2	-	-	-
UA3 = 16	-	-	-	-	-	-	-	-	-	-	-	-	6	9	9	9	8	5	1	-	-	-	-	-
UN = 17	-	-	-	-	-	-	-	-	-	-	-	-	2	9	9	6	1	-	-	-	-	-	-	-
UA9 = 18	-	1	2	-	-	-	-	-	-	-	-	-	-	6	2	1	-	-	-	-	-	1	-	-
UA0 = 19	8	6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	8	9
4X = 20	-	-	-	-	-	-	-	-	-	-	-	1	9	9	9	9	9+	9	6	6	2	-	-	-
HZ = 21	2	-	-	-	-	-	-	-	-	-	-	-	9	9	9	9	9	8	6	4	1	1	1	2
VU = 22	-	-	-	-	-	-	-	-	-	-	-	-	5	9+	9	7	2	1	-	-	1	1	1	-
JT = 23	6	4	1	1	-	-	-	-	-	-	-	-	2*	4	-	-	-	1	-	-	-	-	-	1
VS6 = 24	5	2	-	-	-	-	-	-	-	-	-	-	5*	6	4*	2	2	1	1	1	-	-	1	7
JA1 = 25	8	6	1	-	-	-	-	-	-	-	-	-	4*	2*	1*	-	-	-	-	-	1	7	9+	9+
HS = 26	5	2	-	-	-	-	-	-	-	-	-	-	1*	7	9+	9	8	6	4	4	4	-	-	-
DU = 27	7	4	-	-	-	-	-	-	-	-	-	-	5*	4*	5	7	5	4	2	-	-	-	4	9
YB = 28	5	1	-	-	-	-	-	-	-	-	-	-	3*	2	9	9+	9	9	9	9+	7	-	-	1
VK6 = 29	8	2	1	-	-	-	-	-	-	-	-	-	-	-	1	9	9+	9	9	7	-	-	8	9
VK3 = 30	4	5	3	1	-	-	-	-	-	-	-	-	-	-	9	7	2	-	-	1	7	6	5	5
KH6 = 31	9	9	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9	9	9	9	9	9
KH8 = 32	8	9	8	5	-	-	-	-	-	-	-	-	-	-	6	-	-	4	8	8	8	8	7	8
CN = 33	-	-	-	-	-	-	-	-	-	-	-	8	9	9+	9+	9+	9+	9+	9+	9+	9+	8	2	-
SU = 34	-	-	-	-	-	-	-	-	-	-	-	1	9	9	9	9	9+	9+	9	8	5	2	-	-
6W = 35	1	-	-	-	-	-	-	-	-	-	-	9	9+	9	9	9	9	9+	9+	9+	9+	9+	9+	8
D2 = 36	8	1	-	1	1	5	-	-	-	-	-	8	8	8	7	8	9	9	9+	9+	9+	9+	9+	9
5Z = 37	5	-	-	-	-	-	-	-	-	-	-	8	8	8	8	9	9	9+	9+	9+	9+	9+	9	8
ZS6 = 38	3	-	-	-	-	-	-	-	-	-	-	7	6	5	5	6	8	9	9	9+	9+	9+	9+	9
FR = 39	4	-	-	-	-	-	-	-	-	-	-	6	6	6	7	8	9	9	9+	9+	9+	9+	9	8
FJL = 40	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	4	4	5	4	4	2	-	1	-
Zone	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	UTC -->																							

Expected signal levels using 1500 W and 4-element Yagis at 60 feet at each station.

Propagation Predictions

For example: W1 to Zone 22, VU2

On 15 meters, VU2 uses 100 W to a 50’ high dipole instead of 1500 W to 100’ high 4-ele. Yagi.

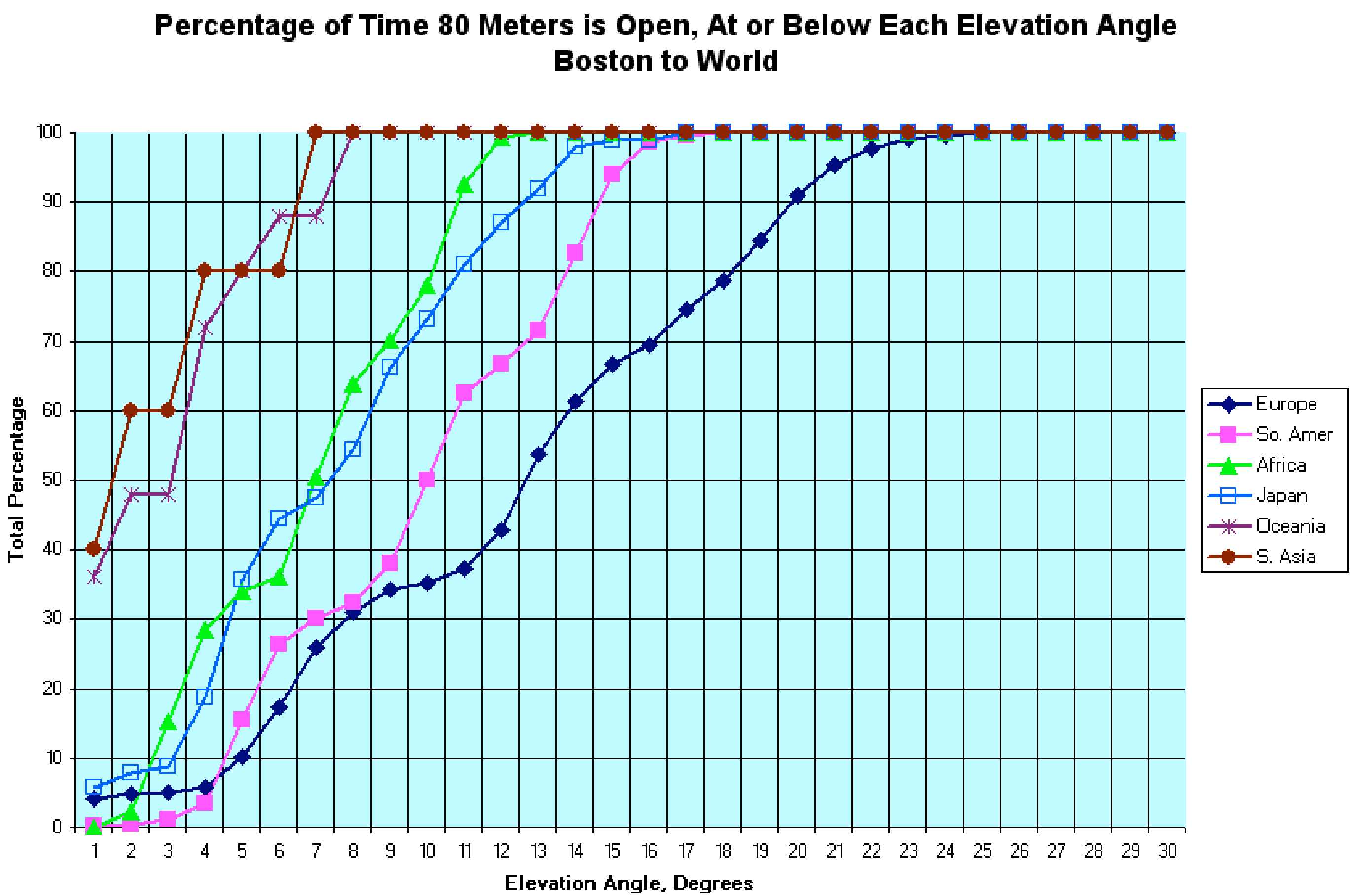
At 14 UTC, base prediction is for S9 signal.
Signal = S9 - 3 (50’ dipole) - 3 (100 W) = S3

At 15 UTC, base prediction is for S7 signal.
Signal = S7 - 3 (50’ dipole) - 3 (100 W) = S1

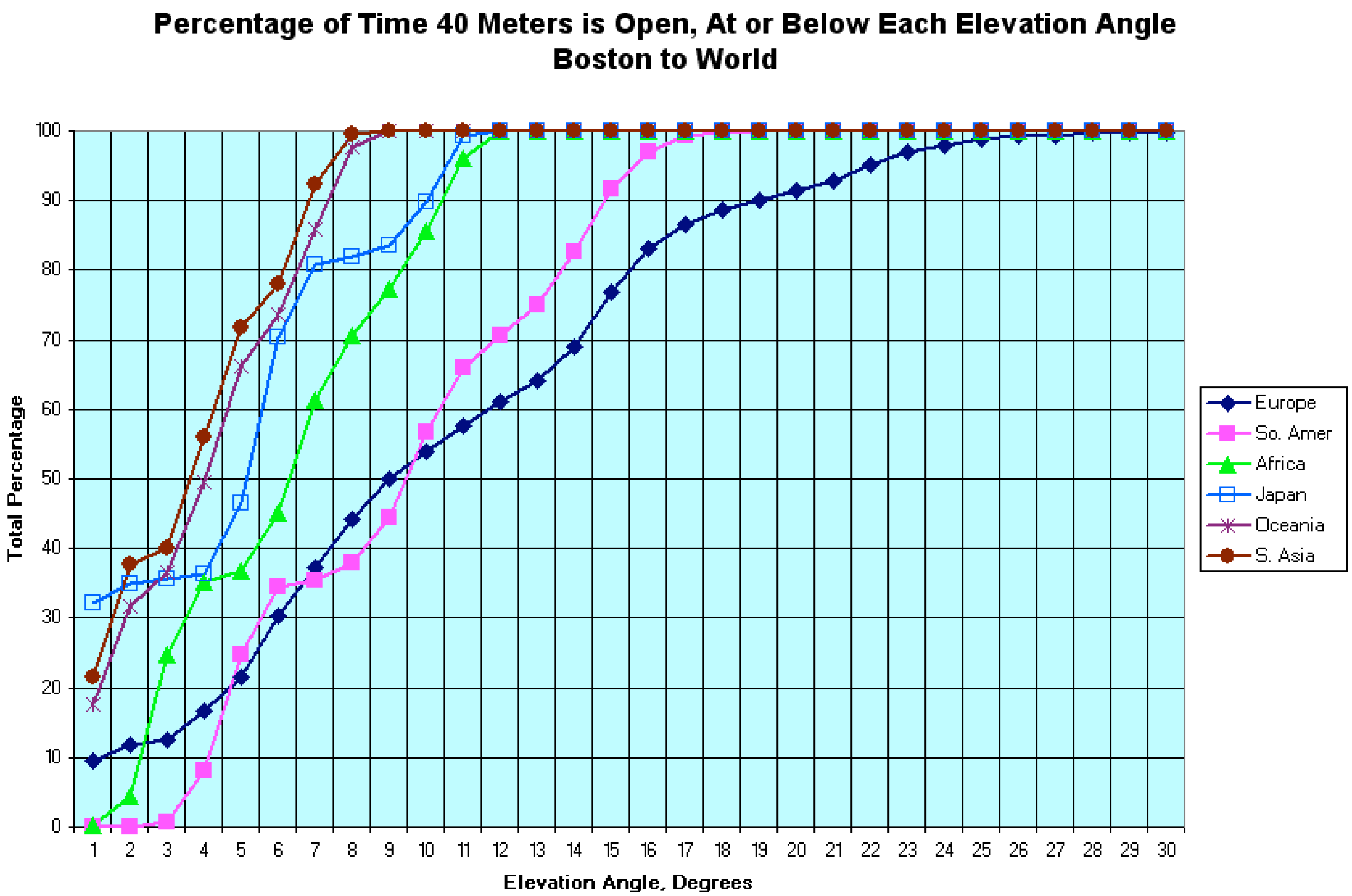
The Importance of Low Angles for DX

- And just in case you didn't know it, low takeoff angles are very important for DX work!
- Even on the low bands.

The Importance of Low Angles for DX, 80 Meters



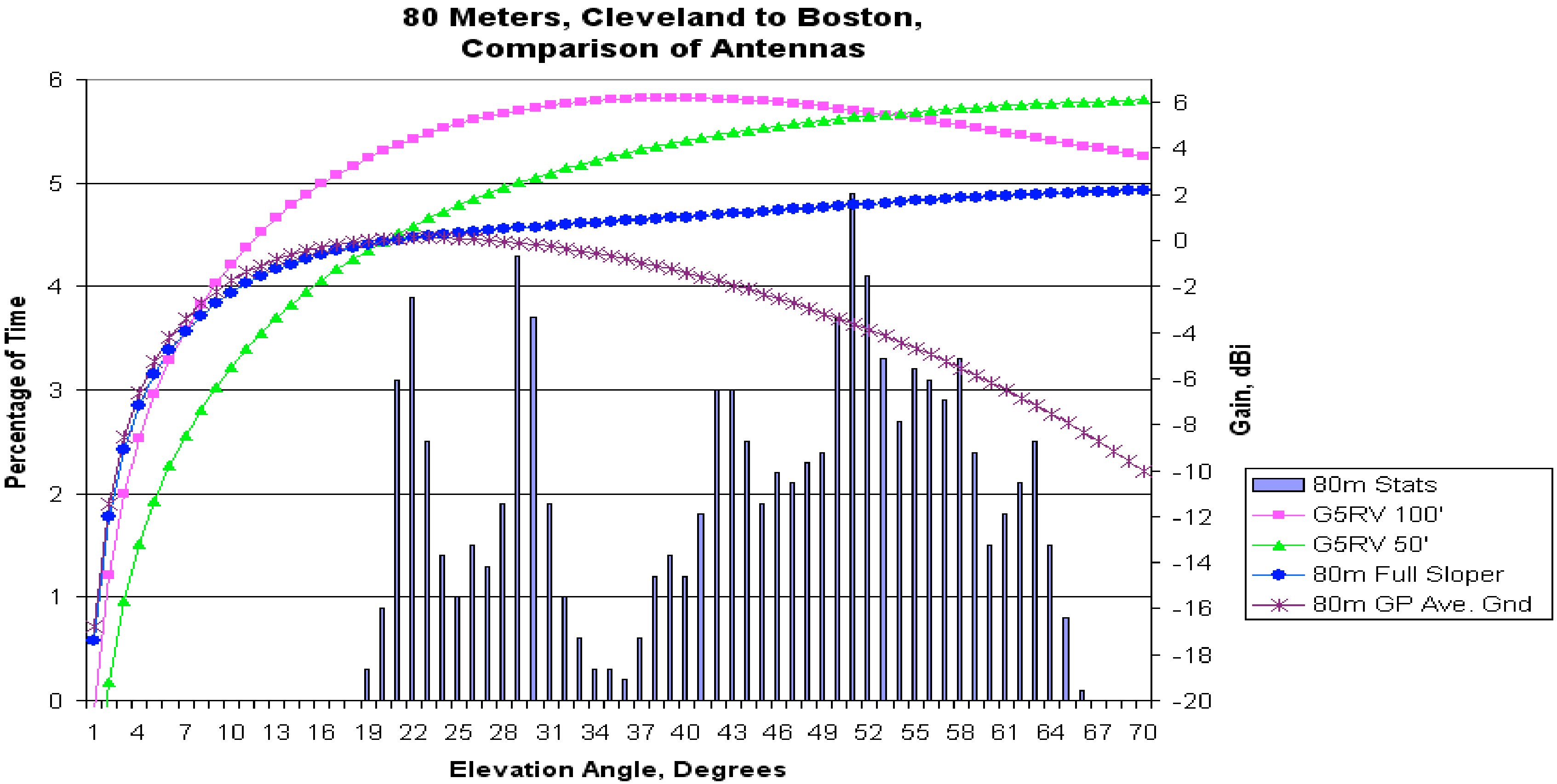
The Importance of Low Angles for DX, 40 Meters



Domestic QSOs

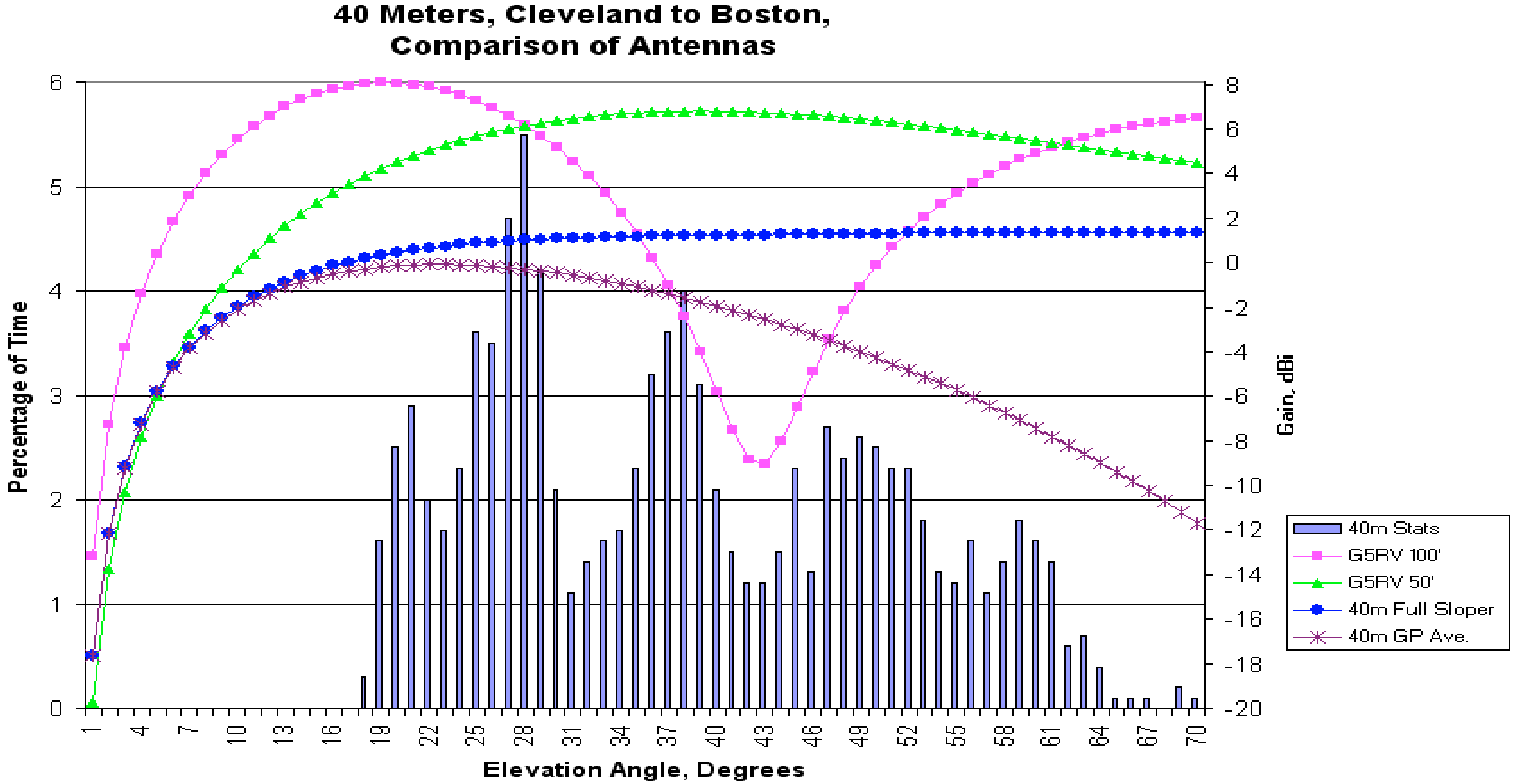
What about short-range communications on 80 and 40 meters -- say, for the ARRL Sweepstakes or for Field Day?

Higher Angles for 80-Meter Domestic Work



A 100' 80-m Dipole is excellent for Field Day

Higher Angles for 40-Meter Domestic Work



A 50’ 40-m Dipole is a Killer for Field Day!

A Takeoff-Angle Quiz

A station in London has a 22-foot high, 15-meter dipole in his garden. (This puts his antenna about a halfwave above ground.) What is the takeoff angle?

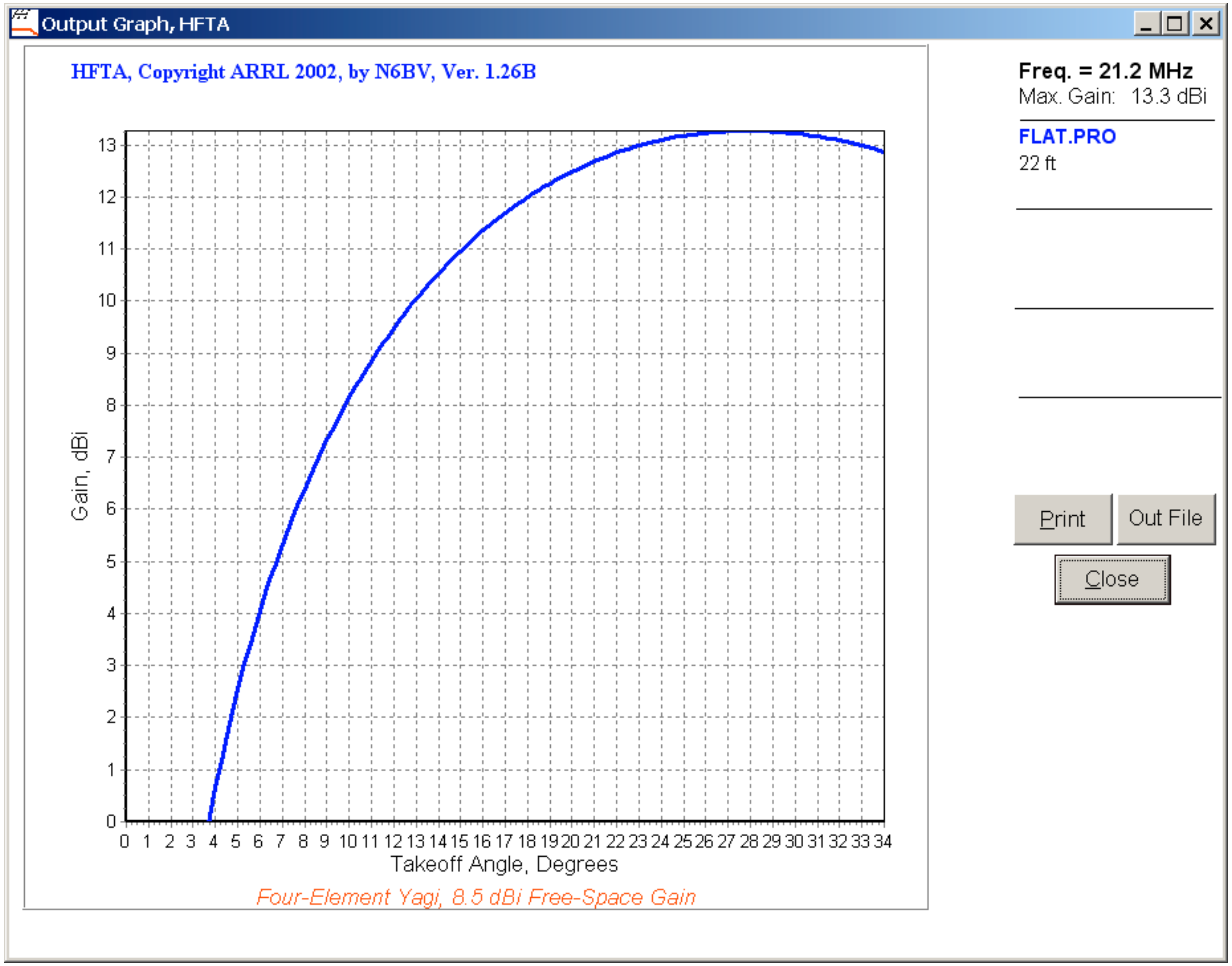
a. 5°

b. 10°

c. 15°

d. 30°

A Takeoff-Angle Quiz



30° = TOA for a halfwave over flat ground

A Propagation Quiz

A station in London is running 100 W to a halfwave high, 15-meter dipole in his garden. What mode & elevation angle to Boston is he using at 16 UTC in February, during a high part of the solar cycle?

a. 2F2 mode at 5°

b. 3F2 mode at 15°

c. 4F2 mode at 28°

The Ionosphere Controls

Scrollw:C:\ITSHFBC\RUN\VOACAPx.out 94015 bytes

File Edit

```
SUMMARY     4 MODES    FREQ =   21.2 MHZ   UT =   16.0
                                                         Most REL
                  2.F2       3.F2       3.F2       3. E       2.F2
 TIME DEL.       18.19      18.94      19.47      17.88      18.19
 ANGLE            4.86      14.68      18.16       4.10       4.86
 VIR. HITE      256.09     302.93     366.86     125.30     256.09
 TRAN.LOSS      142.19     143.34     155.72     970.06     142.19
 T. GAIN          2.24      10.84      12.05       0.88       2.24
 R. GAIN         10.00      10.00      10.00      10.00      10.00
 ABSORB           4.88       3.10       2.68       5.01
 FS. LOSS       133.71     134.06     134.30     133.56
 FIELD ST.        1.53       0.38     -12.00    -826.33       4.11
 SIG. POW.     -122.19    -123.34    -135.72    -950.06    -119.61
 SNR             57.19      56.04      43.66    -770.67      59.77
 MODE PROB        0.93       0.44       0.44       0.00       0.93
 R. PWRG       1000.00    1000.00    1000.00    1000.00     -16.77
 RELIABIL         0.86       0.74       0.51       0.00       0.87
 SERV PROB        1.00       1.00       0.56       0.00       1.00
 SIG LOW         15.70      25.00      25.00      10.74      17.89
 SIG  UP          6.46      13.58      22.24       6.14      12.09
 NOISE =    -179      S. POWER = -119.6
 SIGNAL =    10.7     9.5     6.1  /     4.5     3.6     1.3
 NOISE =      6.1  -179.4     2.3  /     2.1     2.1     1.6
 RELIAB =    12.3    59.8    18.9
 SPROB =      4.6    57.2     4.6
     CCIR Coefficients          METHOD 25   VOACAP 02.1106W   PAGE   32
```

22' Dipole gain

Strongest Mode, weak as it is

The Ionosphere is Boss!

"You should always remember that it is the *ionosphere* that controls the elevation angles, *not* the transmitting antenna. The elevation response of a particular antenna only determines how strong or weak a signal is, at whatever angle (or angles) the ionosphere is supporting at that particular instant, for that propagation path and for that frequency."

This is on page 23-25, in *The ARRL Antenna Book,* 19th Edition.

Some Useful Propagation URLs

160-meter propagation information:
http://solar.spacew.com/www/160pred.html

Planetary kp indices:
http://www.sel.noaa.gov/ftpmenu/plots/2002_plots/kp.html

General propagation information:
http://dx.qsl.net/propagation/index.html

Solar cycle information:
http://www.sec.noaa.gov/SolarCycle/

Effective sunspot number:
http://www.nwra-az.com/spawx/ssne24.html

Some Useful Propagation URLs

160-meter propagation information:

http://solar.spacew.com/www/160pred.html

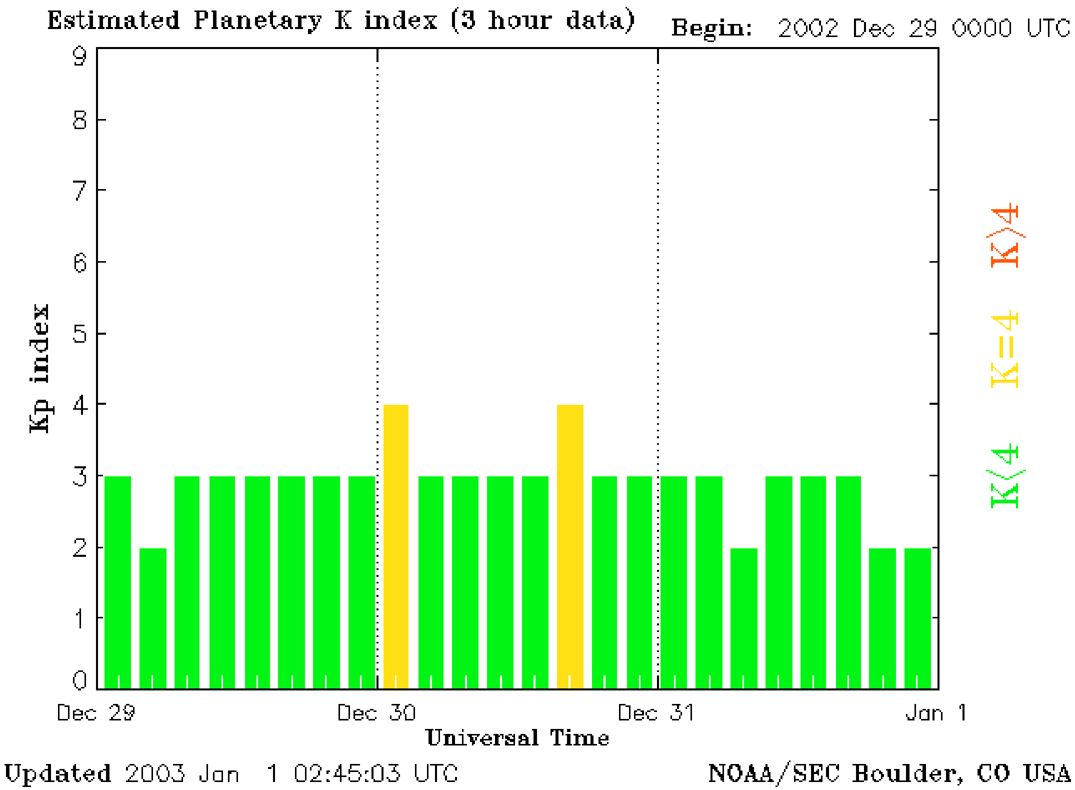
160 Meter Radio Propagation Prediction Table
for
Middle and High Latitude Northern Hemisphere Circuits

	Alska	w.can	c.can	e.can	w.us	c.us	e.us	sw.us	sc.us	se.us	Mex.		U.K.	Spain	Frnce	c.eur	se.eur	Mos.	Israel	Jap.
Alska	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Alska	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
w.can	Poor	Good	Good	Poor	Good	Good	Poor	Good	Good	Good	Good	w.can	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
c.can	Poor	Good	Good	Poor	Good	Good	Good	Good	Good	Good	Good	c.can	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
e.can	Poor	Poor	Poor	Good	Poor	Good	Good	Good	Good	Good	Good	e.can	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
w.us	Poor	Good	Good	Poor	Good	Good	Good	Good	Good	Good	Good	w.us	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good
c.us	Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	c.us	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
e.us	Poor	Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	e.us	Fair	Good	Fair	Fair	Fair	Poor	Fair	Poor
sw.us	Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	sw.us	Poor	Good	Poor	Poor	Poor	Poor	Poor	Good
sc.us	Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	sc.us	Poor	Good	Poor	Poor	Poor	Poor	Poor	Good
se.us	Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	se.us	Fair	Good	Good	Fair	Fair	Poor	Fair	Poor
Mex.	Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Mex.	Fair	Good	Good	Fair	Fair	Poor	Fair	Good
	Alska	w.can	c.can	e.can	w.us	c.us	e.us	sw.us	sc.us	se.us	Mex.		U.K.	Spain	Frnce	c.eur	se.eur	Mos.	Israel	Jap.
U.K.	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Fair	Fair	U.K.	Good	Good	Good	Good	Good	Poor	Good	Poor
Spain	Poor	Poor	Poor	Poor	Poor	Poor	Good	Good	Good	Good	Good	Spain	Good	Good	Good	Good	Good	Good	Good	Good
Frnce	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Good	Good	Frnce	Good	Good	Good	Good	Good	Good	Good	Good
c.eur	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Fair	Fair	c.eur	Good	Good	Good	Good	Good	Good	Good	Good
se.eur	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Fair	Fair	se.eur	Good	Good	Good	Good	Good	Good	Good	Good
Mos.	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Mos.	Poor	Good	Good	Good	Good	Good	Good	Good
Israel	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Fair	Fair	Israel	Good	Good	Good	Good	Good	Good	Good	Good
Jap.	Poor	Poor	Poor	Poor	Good	Poor	Poor	Good	Good	Poor	Good	Jap.	Poor	Good	Good	Good	Good	Good	Good	Good

Some Useful Propagation URLs

Planetary kp indices:

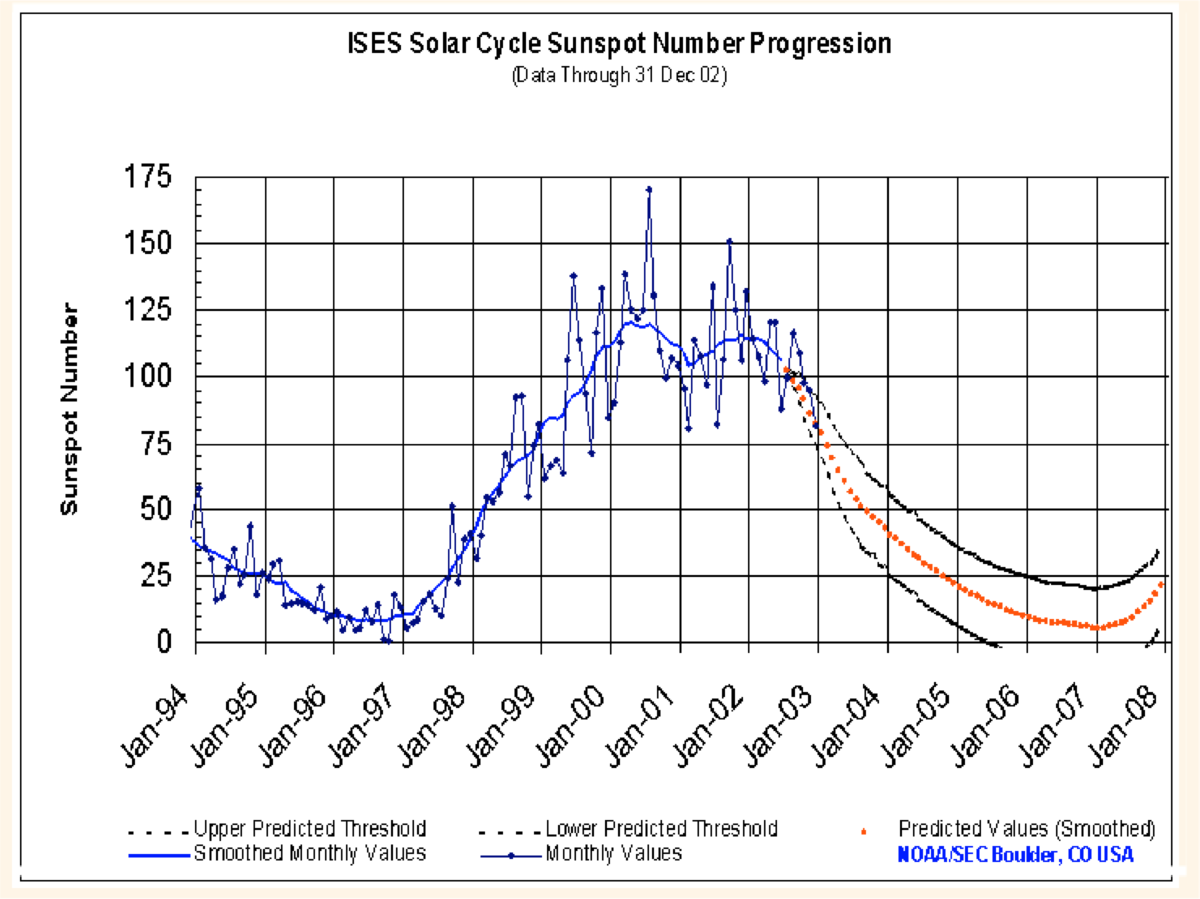
http://www.sel.noaa.gov/ftpmenu/plots/2002_plots/kp.html



Some Useful Propagation URLs

Solar cycle information:

http://www.sec.noaa.gov/SolarCycle/



Some Useful Propagation URLs

Effective sunspot number:

http://www.nwra-az.com/spawx/ssne24.html