IONSOUND HDX TURBO: SKYWAVE PROPAGATION PREDICTION SOFTWARE FOR AMATEUR, PROFESSIONAL AND MILITARY APPLICATIONS

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AMERICAN RADIO RELAY LEAGUE (ARRL); YANKEE CLIPPER CONTEST CLUB (YCCC); SKYWAVE TECHNOLOGIES

PRESENTED AT:

1. BACKGROUND

IONSOUND HDX Software for Contesting & DXing

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President / CEO,
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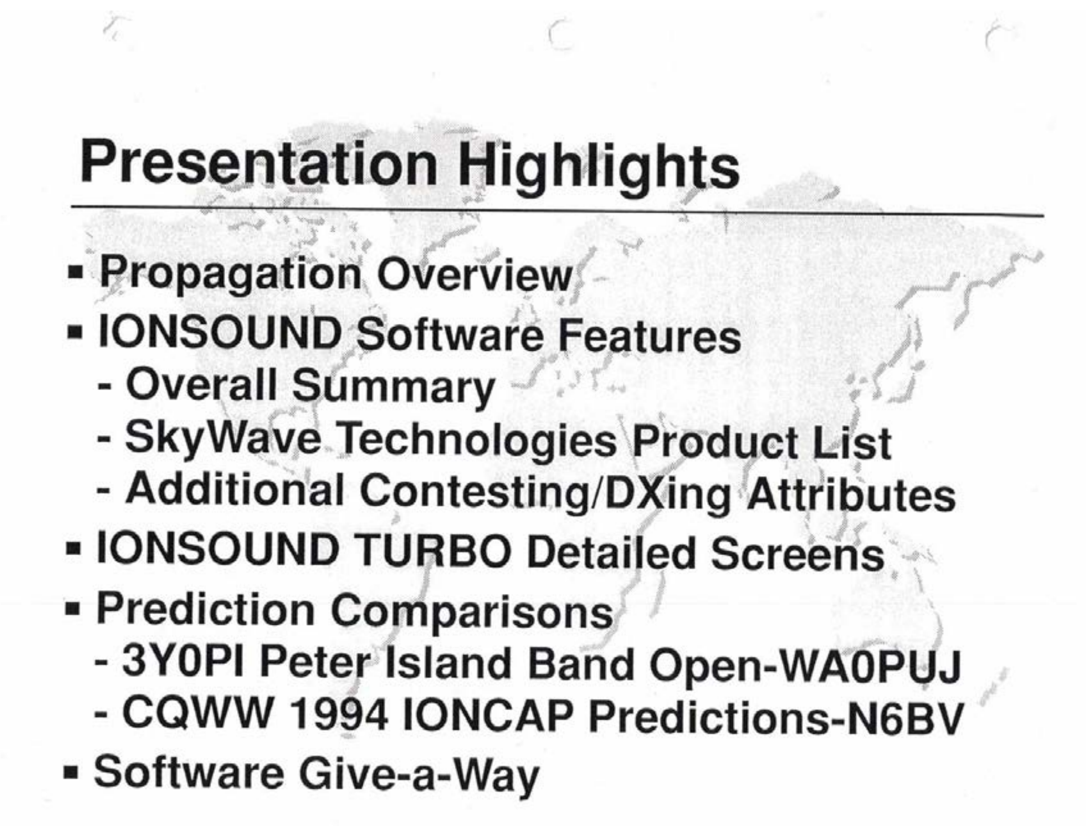
BACKGROUND

- IONSOUND HDX TURBO is a software propagation prediction program for use in the 1.8-30 MHz MF/HF range that evolved over a number of years and was primarily marketed in the 1990's by its author, W1FM, for use with IBM or IBM-compatible personal computers using DOS. It was intended to produce easy-to-interpret tabular predictions of radio frequency link performance between any two locations on the earth's surface.
- Menu selections within IONSOUND made it possible to compute predictions for comparison with Highest Possible Frequency (HPF), Maximum Possible Frequency (MUF) and Frequency of Optimum Transmission (FOT) predictions derived from U.S. Department of Commerce, National Telecommunications and Information Administration (NTIA) IONCAP program as found in ARRL's monthly QST Magazine "How's DX" Column.
- Parameters used in predictions included: Transmit and Receive Location, Short or Long Path, Local Receiver Noise Condition, Transmit and Receive Antenna/Gain, Receiver Bandwidth, Required Signal-to-Noise Ratio, Transmitter Power, Sunspot Number (SSN) or Solar Flux Number (SFN) Minimum Elevation Angle from the horizon, Prediction Frequencies, Prediction Months, Prediction Times, and Prediction Modes involving E and F Layer Propagation.

BACKGROUND (CONTINUED)

- The receive reliability prediction estimates include Total Receive Reliability which is composed of the product of Path Reliability and Signal-to-Noise (S/N) Availability.
- Path Reliability deals with the physics of the communication path specified by user-supplied transmitter/receiver latitude/longitude or location choices whereas the S/N Availability deals with the effects of absorption on the actual signal levels and local noise conditions relative to the minimum required S/N specified by the user.
- Takeoff radiation angle dependency on E, F, or multimode E/F hops along with antenna elevation angle gain, E and F layer ionospheric absorption, polarization loss, and ground reflection losses are also taken into account.
- The IONSOUND HDX TURBO program operates with or without a math coprocessor but will automatically take advantage of the 8087, 80287, or 80387 coprocessor if it finds it. A coprocessor is recommended due to the mathematically intensive nature of the calculations performed.
- A personal computer with 640 kilobytes of Random Access Memory (RAM) is desirable, along with DOS 2.11 or greater. For hard copy printout, a printer supporting IBM Graphics is recommended.



Presentation Highlights

- Propagation Overview
- IONSOUND Software Features
  - Overall Summary
  - SkyWave Technologies Product List
  - Additional Contesting/DXing Attributes
- IONSOUND TURBO Detailed Screens
- Prediction Comparisons
  - 3Y0PI Peter Island Band Open-WA0PUJ
  - CQWW 1994 IONCAP Predictions-N6BV
- Software Give-a-Way

IONSOUND Software by W1FM

Propagation Prediction Software for Amateur, Professional, Marine and Military Applications

SkyWave Technologies, 17 Pine Knoll Road
Lexington, MA 02173 U.S.A.
Tel: 617-862-6742

The **IONSOUND** family of copyrighted programs (**HDX**, **HDX TURBO**, **STD**, and **PRO**) represent state-of-the-art software tools for predicting MF/HF/VHF ionospheric (skywave) propagation to any part of the world. They are ready-to-run programs designed to be fast and user-friendly through its menu-driven screens. As a minimum, all versions are supplied with an on-disk printable manual. Support is provided for color and graphics for PCs or compatibles for DOS. Use of a coprocessor is recommended but not required. **IONSOUND** programs can be stored on a hard drive and require up to approximately 520 Kbytes of RAM memory for execution.

IONSOUND provides prediction of skywave propagation by using sunspot number or solar flux number solar indicies, along with a host of other variables. Calculations take into account actual operating conditions which can affect performance, such as antenna types or antenna gain, minimum elevation angle, transmitter power, receiver bandwidth, minimum required signal-to-noise (S/N) ratio, and local receive noise conditions. The programs provide automatic propagation mode searching and predict E-layer, F-layer, and mixed E/F layer propagating modes and path delays, received signal (dBuV) level, receiver S/N level, total antenna gain at each radiated takeoff angle, and receive reliability estimates. Calculated distances and bearings from transmitter to receiver are also provided. The receive reliability estimates include the Total Receive Reliability which is composed of the product of Path Reliability and S/N Availability. The Path Reliability deals with the physics of the path specified by user-supplied transmitter/receiver latitude/longitude or location choices whereas the S/N Availability deals with the effects of absorption on the actual signal levels and local noise conditions relative to the minimum required S/N specified by the user. Takeoff radiation angle dependency on E, F, or multimode E/F hops along with antenna elevation angle gain, E and F layer ionospheric absorption, polarization loss, and ground reflection losses are also taken into account. Seasonal, monthly, and diurnal (daily) hourly affects are also considered on a global basis.

All of the **IONSOUND** programs provide comprehensive tabular hourly output display containing the quantitative predicted results at each time of interest. The **HDX** and **HDX TURBO** versions accommodate up to 9 simultaneous frequencies in the range 1.8-30 MHz and provide a single-screen 24 hour tabular summary for up to eight parameters of interest. Pre-stored station variables make the **HDX** and **HDX TURBO** versions easy-to-use for first-time users. The **PRO** version also offers a more comprehensive 24 hour tabular summary which can be readily displayed, printed or stored to an ASCII file. The **STD** and **PRO** versions can accommodate up to 128 frequencies over an extended range from 1.8-54 MHz and also provide three unique simulated ionospheric chirpsounder graphic outputs depicting an ionogram display which conveys a great deal of information to the user. These plots show the predicted propagation modes, their relative delays, their bandwidth extents (frequency ranges of each propagating mode) and the mode propagation reliability/availability as indicated by display dot density and plot color code. Ionograms with selectable 0-30 MHz and 0-60 MHz display viewport windows are provided for Total Link Reliability, S/N Availability, and Path Availability, with each plot depicting the possibilities for multipath as well as the predicted reliability or availability for each propagating mode and frequency. The ionogram chirp plot, in conjunction with the more traditional tabular summary, provides a user with a more detailed and intelligent assessment of propagation with respect to actual operating conditions by providing visualization of the Maximum Usable Frequency (**MUF**) and Lowest Usable Frequency (**LUF**) for each propagating mode and is widely recognized by military and commercial users. Finally, all **IONSOUND** versions provide the capability for printing a distance and bearing table from its on-disk, user-modifiable, ASCII data base containing DXCC country/call-sign prefix location listing and analyzing antenna height above ground versus E and F-Layer hop distances as a function of solar indicies.

SKYWAVE PROPAGATION PREDICTION

Shown below, from data provided by the National Geophysical Data Center in Boulder, Colorado, is a table of smoothed running sunspot numbers for the present solar cycle along with predicted values of activity expected for 1995-1996.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Jan		18	58	142	151	148	124	71	37	24	14*
Feb		20	65	145	151	148	116	69	35	23	13*
Mar		22	71	150	152	147	108	67	34	22	13*
Apr		24	78	154	149	146	103	64	34	21*	12*
May		26	84	157	147	146	100	60	33	20*	12*
June		28	94	158	144	145	97	56	31	19*	11*
July		31	104	159	141	146	91	55	29	19*	11*
Aug		35	114	158	141	147	84	52	27	18*	10*
Sept	12	39	121	157	142	145	80	49	27	18*	9*
Oct	13	44	125	157	142	142	76	45	27	17*	9*
Nov	15	47	130	158	142	138	74	41	26	16*	8*
Dec	16	51	138	154	144	132	73	39	26	15*	8*

Smoothed Sunspot Numbers for Cycle 22 and Forecasts for 1995-96
(Predicted Values shown with an *)

IONSOUND™ Software from SkyWave Technologies

Skywave Propagation Prediction PC Software by W1FM

State-of-the-Art Forcasting for Amateur, Marine, Professional & Military users

IONSOUND HDX: $5.00 (A great value for the beginner)
- For use with *QST* "How's DX?" column + additional locations
- Same propagation software bundled with the recently published 17th edition of the ARRL Antenna Book—Sept. 1994 *QST* article describing the Antenna Book software
- Utilizes pre-stored parameters; provides 24 hr predictions

IONSOUND HDX TURBO: $20.00 ($15.00 for registered IONSOUND users)
- Low-cost upgrade to the HDX version found in The Antenna Book
- Provides world-wide latitude/longitude or DXCC database entry

IONSOUND STD: $35.00 ($25.00 for registered IONSOUND users)
- Provides unique color-coded IONOGRAM LUF/MUF graphics

IONSOUND PRO: $75.00 ($60.00 for registered IONSOUND users)
- Includes STD capabilities + comprehensive 24 hr summary table
- See April 1992 IEEE Antenna & Propagation Magazine Product Review

SPECIFY DISK SIZE. MA residents add 5% sales tax. Overseas add $5 shipping.
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SkyWave Technologies, 17 Pine Knoll Rd., Lexington, MA 02173, USA

IONSOUND SOFTWARE by W1FM

3. DIURNAL VARIATION

INDEPENDENT SCIENCE PROJECT

DIURNAL VARIATION OF IONOSPHERIC RADIO-WAVE PROPAGATION

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MARCH 17, 1992

ABSTRACT

Ionized particles found in the earth's ionosphere are capable of providing support for long-distance communications in the High Frequency (HF) broadcast frequency range of 2-30 MHz. Values of signal-to-noise ratio are predicted and measured for two skywave communication paths from radio stations WWV (Fort Collins, CO) and CHU (Ottawa, Canada) to Lexington, MA. These paths are supported by refraction effects from the E and F ionized layer regions within the ionosphere. The Ionospheric Communications Analysis and Prediction (IONCAP) Program is used on an IBM-PC compatible computer to provide an assessment of the predicted receive performance levels. Shortwave receiving equipment, in conjunction with the predicted assessments, are used to monitor and track the diurnal (daily) variation of the received signal and noise levels on the five frequencies transmitted by WWV and the three frequencies transmitted by CHU. Analysis of the measurement results obtained indicate close correlation with performance predictions such that diurnal variations caused by daily ionospheric changes exhibit predictable patterns. These changes are shown to be closely related to the daily solar cycle. It is concluded that diurnal variation effects need to be considered for a wide range of frequencies when reliable HF reception is desired.

2.0 METHODOLOGY

2.1 Primary Objective

It is the object of this investigation to focus on the diurnal (or daily) variations of shortwave reception from two particular radio stations, over a range of frequencies, in order to gain insight regarding this phenomena. For this purpose, I have chosen to monitor two radio stations. WWV in Ft. Collins, CO broadcasts continuously on 2.5, 5, 10, 15, and 20 MHz. CHU in Ottawa, Canada broadcasts continuously on 3.330, 7.335, and 14.670 MHz.

WWV is a standard time and frequency radio station operated by the U.S. National Institute of Standards and Technology (NIST). Part of it's broadcast service involves dissemination of solar information and propagation at 18 minutes after each hour. It is intended that periodic monitoring of propagation information broadcast by WWV could conceivably result in additional insight into the observed propagation monitoring.

CHU is operated by the government of Canada in order to disseminate standard time information. By comparing observed reception of these ionospherically propagated frequencies with theoretical predictions for their reception, it is hoped that an understanding of this diurnal variation will be obtained.

On an hourly basis, a shortwave receiver will be tuned to each of the WWV and CHU transmitted frequencies. Indications of the received signal and noise levels (in signal strength or S-units) will be manually recorded in a table for subsequent conversion to standard power levels measured in decibels below one watt (dBW). In addition, a computation for signal-to-noise ratio will also be performed and recorded. At selected times, solar activity levels will also be recorded from the WWV geomagnetic alert transmissions at 18 minutes past the hour. The tabular data will then be plotted in a graphical form along with predicted signal and noise levels for subsequent comparison and evaluation.

2.2 Procedures and Materials

To accommodate this procedure, the following major components have been identified. These components are:

Major Project Components

1. Yaesu model FT-757GX-II Transceiver
2. Yaesu model FP-757HD Power Supply
3. Wm.M. Nye Directional Coupler
4. E.F. Johnson Directional Coupler VSWR Indicator
5. Drake TV-1000-LP Low Pass Filter
6. Radio Shack Coaxial Lightning Arrestor
7. Heathkit 5-position Coaxial Switch
8. Cushcraft model AP-8 Vertical Groundplane Antenna
9. ITT RG-214/U 50 Ohm Coaxial Cable, part no. 90484
10. Flat Braided Wire for grounding purposes
11. Amdek model System/286A Personal Computer
12. Ionospheric Communications Analysis and Prediction (IONCAP) computer software program.

Components 1-10 are utilized for radio frequency (RF) measurements and are physically part of an amateur radio station; components 11-12 are utilized for propagation prediction and analysis of data.

2.3 Safety Features

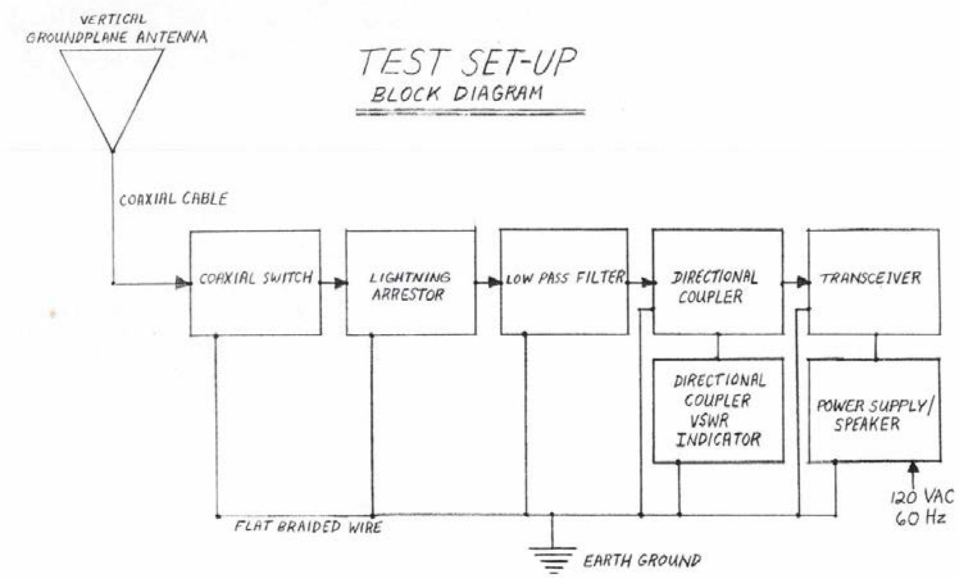
Incorporated into the materials, set-up, and procedure are several safety features in order to insure my protection and the protection of the equipment. These features are as follows:

a. To protect against electrical static build-up on the antenna when not in use, a shorting coaxial switch is used to ground the antenna.

b. A coaxial lightning arrestor with a built-in spark gap is used against high voltage induced by potential lightning hits on the antenna.

c. A braided wire ground strap is connected to all chassis grounds of all the equipment used in the test set-up. The ground strap is then connected to a cold water pipe which runs to an outside Earth ground.

d. All measurements were conducted in fair weather to minimize the possibility of lightning strikes.


TEST SET-UP
BLOCK DIAGRAM
VERTICAL GROUNDPLANE ANTENNA
COAXIAL CABLE
COAXIAL SWITCH
LIGHTNING ARRESTOR
LOW PASS FILTER
DIRECTIONAL COUPLER
TRANSCEIVER
DIRECTIONAL COUPLER VSWR INDICATOR
POWER SUPPLY/ SPEAKER
120 VAC 60 Hz
FLAT BRAIDED WIRE
EARTH GROUND

3.0 DATA

Data was manually recorded from S-meter readings taken on the Yaesu FT-757 transceiver for February 22, 1992 and February 29, 1992. The data consisted of various signal and noise readings from WWV (transmitting at 2.5, 5.0, 10, 15 and 20 MHz) and CHU (transmitting at 3.330, 7.335 and 14.670 MHz) taken at one hour intervals for a 24-hour period for each day. The data collected was then inputted to a spreadsheet program on the computer where it was later tabulated and graphed. See Appendix I for additional tables and graphs.

[Note: WWV and CHU are standard frequency and time stations which are broadcast 24 hours a day, continuously, by the governments of the United States and Canada, respectively.]

WWV Solar Activity Reports monitored during the days that data was taken is summarized below:

WWV Solar Activity Reports for February 22 and 29, 1992

Local Time	Solar Flux Number	A Index	K Index	Conditions
0018 (2/22)	217	62	4	Last 24 Hours Solar: Moderate Geomagnetic: Quiet-to-Storm Next 24 Hours Solar: Moderate Geomag: Unsettled-to-Storm
1318 (2/22)	217	62	3	Last 24 Hours Solar: Moderate Geomag: Quiet-to-Minor Storm Next 24 Hours: Moderate Geomag: Unsettled-to-Active
2218 (2/22)	235	20	3	Last 24 Hours: Low Geomagnetic: Flat Next 24: Quiet-to-Minor Storm Geomag: Unsettled-to-Active
0118 (2/29)	233	3	2	Last 24 Hours: Low Geomagnetic: Quiet Next 24 Hours: Mid-to-High Geomag: Minor-to-Major Storm
0818 (2/29)	233	3	4	Last 24 Hours Solar: Low Geomagnetic: Quiet Next 24 Hours: Moderate Geomag: Quiet-to-Minor Storm
1718 (2/29)	218	28	4	Last 24 Hours Solar: Moderate Geomag: Quiet-to-Minor Storm Next 24 Hours Solar: Moderate Geomag: Moderately Active
2318 (2/29)	218	26	3	Last 24 Hours Solar: Moderate Geomag: Quiet-to-Minor Storm Next 24 Hours Solar: Moderate Geomag: Mostly Active

a

4.0 CALCULATIONS

4.1 Calculation of Predicted Values using IONCAP

Computer generated calculations have been made using the IONCAP program in order to obtain predictions of radio wave propagation from WWV to Lexington, MA and from CHU to Lexington, MA. These calculations involved the current solar activity level (sunspot number) and have been printed out for comparison with experimental data that I have collected. The IONCAP calculations are carried out as follows:

1. An input data file describing IONCAP parameters is created using a word processor. Each line of this data file corresponds to the system requirements of IONCAP.

2. A blank output data file is created for use by the IONCAP program to store prediction results.

3. A typical set of input and output files, along with all prediction results, are shown in Appendix II.

4.2 Calculation of Power (DBW) from S-Meter Readings

In order to obtain receive power measurements from S-Meter readings, the following procedures and calculations are used:

1. S-Meter readings range from S1 to S9+60 on the FT-757 receiver. The lower S-Meter readings are from calibrated from S1 to S9 in steps of 1 S unit. Above S9 the meter is calibrated in DB above S9 (i.e. S9+10 DB). Due to received signal and noise fluctuations, the S-meter reading was read to the nearest whole S-unit and to the nearest multiple of 5 DB for readings above S9.

2. Since the input impedance of most receivers is R=50 Ohms, the power received at the receiver can be calculated from the received voltage level using:

Power = Voltage * Current

Current = Voltage/Resistance

Power = Voltage^2/Resistance

Power for 1 uV = (1E-6)^2/50 watts

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4.4 Conversion of Predicted-to-Actual Transmit Power Levels

All IONCAP predictions used a constant power level for the transmitter power at WWV or CHU. Not all transmit frequencies, however, employed the same transmit power level. Therefore, a correction factor has to be applied for each individual frequency which differs from that level used in the prediction.

1. IONCAP predictions for WWV utilized 10 kW for all frequencies. However, 2.5 and 20 MHz transmit at 2.5 kW.

2. IONCAP predictions for CHU utilized 3 kW for all frequencies. However, 3.330 and 14.670 transmit at 0.3 and 5.0 kW, respectively.

3. Therefore IONCAP signal-to-noise ratios need to be modified according to the following conversion:

DB = 10*log(Actual Power/Predicted Power)

4.5 Relationship between DB S/N and DB (S+N)/N vs. S/N

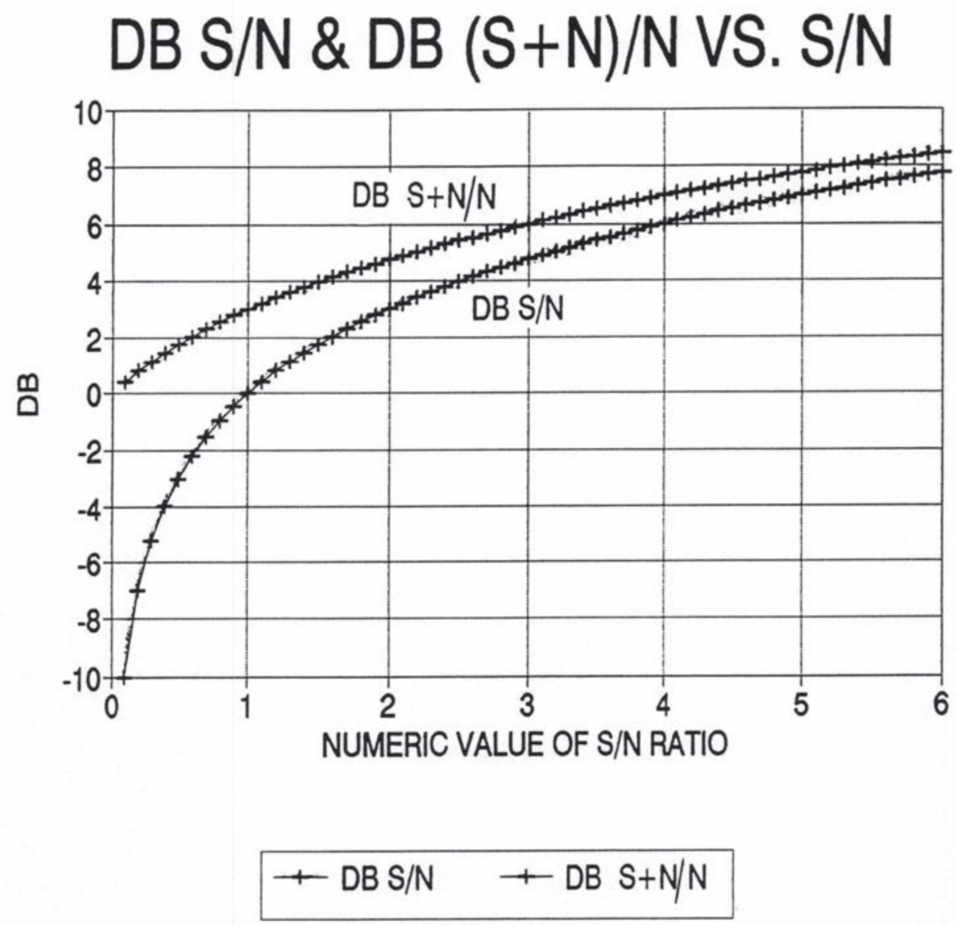
Measurements of received signals over an RF link result in readings of the receiver's S-Meter which yield an estimate of the combined received signal and noise power and the received noise power (in the absence of any signals). The figure showing Signal Power (measured in DBW) vs. S-Meter Reading provides an easy-to-use mechanism for converting the measured signal and noise reading into a power reading.

Since readings on the S-Meter can only be read down to the point where signal and noise levels are approximately equal (for any bandwidth selected), a potential problem arises when trying to estimate the signal-to-noise ratio from a reading which is in actuality a signal-plus-noise-to-noise ratio. The governing equation for measuring a received signal along with noise is given by:

(Signal+Noise)/Noise = (S+N)/N = S/N + N/N = S/N + 1

It can therefore be seen for very large values of signal level relative to noise, the (S+N)/N ratio is going to be approximately equal to the signal-to-noise ratio. For very small signal levels relative to noise, the (S+N)/N ratio will be equal to 1 (or 0 DB). Thus, the best that can be measured for very negative signal-to-noise ratios is a (S+N)/N ratio of 0 DB since the measurement is limited by the actual noise power being observed.

It can also be seen from the chart that when the measured value of (S+N)/N is approximately 6 DB, the actual value of S/N is approximately 5 DB and is only a small fraction of an S-Meter unit difference. Below the 6 DB (S+N)N reading, corresponding to a numeric S/N value of less than 3, the difference between (S+N)/N and S/N diverges very rapidly; above the value of 6 DB (S+N)/N, the difference converges very rapidly and can be neglected. Therefore, for (S+N)/N above 6 DB, there is negligible difference between the actual reading and a true measurement of S/N in DB.


DB S/N & DB (S+N)/N VS. S/N
10
8
6
4
2
0
-2
-4
-6
-8
-10
DB
DB S+N/N
DB S/N
0
1
2
3
4
5
6
NUMERIC VALUE OF S/N RATIO
DB S/N
DB S+N/N

31

Since DB is defined as:

$$DB = 10*\log(Power2/Power1) = 20*\log(Voltage2/Voltage1)$$

The DBW power of 1 microvolt (across 50 Ohms) is given by:

$$DBW \text{ (due to 1 uV)} = 10*\log[(1E-6)^2/(50/1)]$$

$$= 10*\log[(1E-12)/50]$$

$$= -137 \text{ DBW}$$

3. The calibration level of the FT-757 receiver is such that an S-Meter reading of S9 is approximately 50 microvolts (uV). This can be converted to a DB value with respect to a reference of 1uV by taking the ratio of 50uV to 1uV. This is given by:

$$DBuV \text{ value of 50 uV (S9 Reading)} = 20*\log(50/1) = 34 \text{ DBuV}$$

4. Since the power for 1 uv is calculated above to be -137 DBW, the power level for 50 uV is obtained by simply adding the DB ratio of 50 uV to 1 uV (i.e., 34 DBuV) and the DBW power due to 1 uV (i.e., -137 DBW). This S9 (50 uV) power is therefore given by:

$$S9 \text{ DBW Power (due to 50 uV)} = -137 + 34 = -103 \text{ DBW}$$

5. Knowing that each S-unit step is 6 DB for each S-unit and above S9 the steps are just DB values, all of the values of DBW can be calculated from the S9 S-Meter reading. (See table for S-meter Reading Conversions to DBW and DBuv. Also see chart for DBW vs. S-meter Reading.)

4.3 Conversion of 1 Hz Noise Bandwidth to 6000 Hz Noise Bandwidth

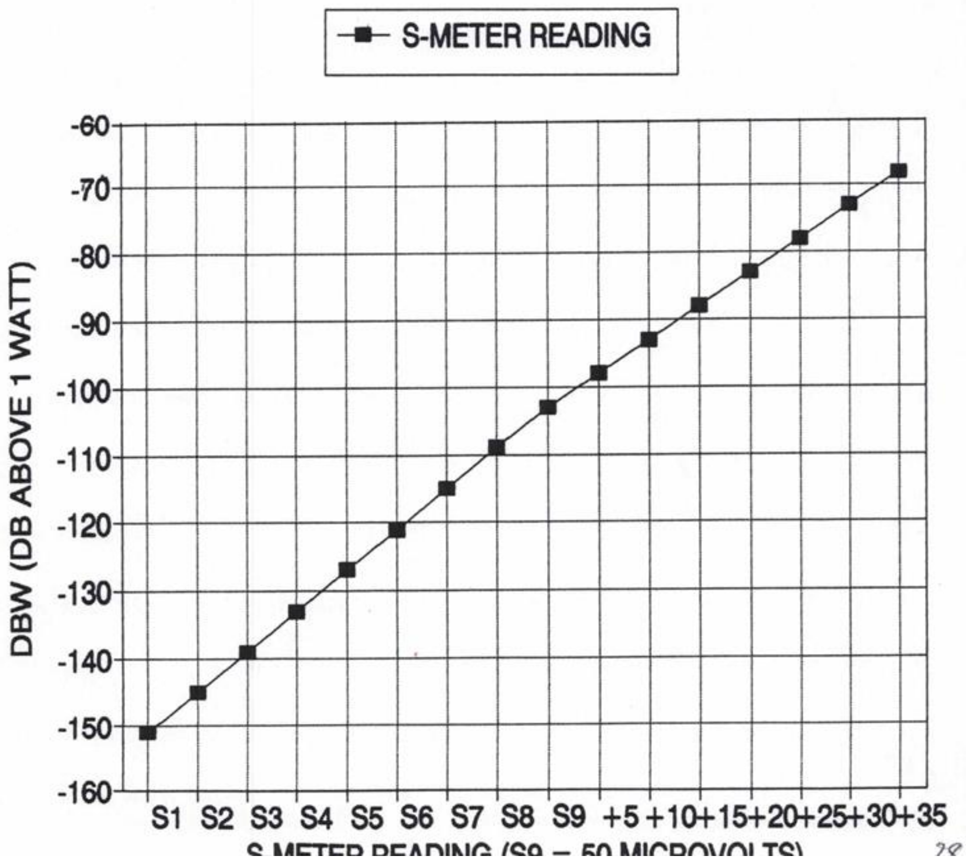
IONCAP computes signal-to-noise ratios in a normalized 1 Hz noise bandwidth. Since the FT-757 measurement receiver has a 6000 Hz (6 KHz) bandwidth for receiving Amplitude Modulation (AM) signals such as WWV and CHU, a conversion calculation is necessary. This DB ratio conversion adjusts the amount of noise from the 1 Hz prediction to the 6 KHz noise prediction and is given by:

$$DB \text{ Ratio of 1 Hz to 6000 Hz} = 10*\log(1/6000) = -38 \text{ DB}$$

Therefore IONCAP signal-to-noise ratios need to be reduced by 38 DB in order compare them to the measurement bandwidth of 6 KHz used in the FT-757 receiver for AM reception.

S-METER READING CONVERSIONS TO DBW AND DBUV

S-METER READING	DBW (DB ABOVE 1 WATT)	DBUV (DB ABOVE 1UV)
S1	-151	-14
S2	-145	-8
S3	-139	-2
S4	-133	4
S5	-127	10
S6	-121	16
S7	-115	22
S8	-109	28
S9	-103	34
S9+5	-98	39
S9+10	-93	44
S9+15	-88	49
S9+20	-83	54
S9+25	-78	59
S9+30	-73	64



```
LABEL      CHU - OTTAWA, CANADA TO LEXINGTON, MA
CIRCUIT    45.30N    75.75W    41.40N    72.25W         0
SYSTEM       3.0  -4.  .001   90 5500 1000   85
MONTH       1992    2
SUNSPOT     157.
COMMENT    TIME            0   24    2

COMMENT    FPROB      1.0  1.0  1.0  1.0

COMMENT    METHOD          1

COMMENT    EXECUTE

COMMENT    CHANGE CRITICAL FREQUENCY MULTIPLIER FOR ES BACK TO PROGRAM DEFAULT
FPROB      OFF
COMMENT    ES CRITICAL FREQUENCY NOW IS MULTIPLIED BY .7 TO ALLOW FOR MEDIAN LOSS
COMMENT    METHOD          2

COMMENT    TIME           12   12    1   -1

COMMENT    EXECUTE

COMMENT    ***********************************************************************
COMMENT    METHODS 3 THROUGH 11 ARE MUF CALCULATIONS (METHOD 12 NOT IMPLEMENTED)
COMMENT    METHODS 3,4,5 AND 6 ARE MUF USING NOMOGRAM AND AREN"T PRESENTED HERE
COMMENT    TIME            1   24    1

COMMENT    METHOD          7

COMMENT    OUTPUT METHODS 8 THROUGH 11 WITHOUT RECOMPUTATION USING "OUTGRAPH"
COMMENT    OUTGRAPH        8    9   10   11

COMMENT    EXECUTE

OUTGRAPH   OFF
COMMENT    ***********************************************************************
COMMENT    METHODS 13 THROUGH 15 ARE ANTENNA PATTERN CALCULATIONS
COMMENT    METHODS 13 AND 14 ARE ANTENNAS ONE AT A TIME AND AREN"T PRESENTED HERE
COMMENT    ANTOUT          ANTFIL.BIN
COMMENT    METHOD         15

COMMENT    ANTENNA         1    2       .001 4.        -0.5

COMMENT    ANTENNA         2    2       .001 4.        -0.25

COMMENT    ANTENNA         1   18 ANTFIL.BIN
COMMENT    ANTENNA         2   18 ANTFIL.BIN
COMMENT    EXECUTE

COMMENT    ANTOUT    OFF
COMMENT    ***********************************************************************
COMMENT    METHODS 16 THROUGH 23 ARE SYSTEM PERFORMANCE PREDICTIONS
FREQUENCY   2.5  3.3 5.0 7.3  10.0 14.7 15.0 20.0
TIME          1   24    1
COMMENT    METHOD         16

COMMENT    EXECUTE

COMMENT    METHOD         17

COMMENT    EXECUTE

COMMENT    METHOD         18
```

```
COMMENT   METHOD       19

COMMENT   EXECUTE

COMMENT   METHOD       20

C  MENT   EXECUTE

COMMENT   METHOD 21 FORCES THE PROGRAM TO EXERCISE THE "LONG" PATH MODEL
COMMENT   METHOD       21

COMMENT   EXECUTE

COMMENT   METHOD 22 FORCES THE PROGRAM TO EXERCISE THE "SHORT" PATH MODEL
METHOD       22
EXECUTE
COMMENT   METHOD 23 ALLOWS THE USER TO SELECT THE DESIRED OUTPUT BY SPECIFYING
COMMENT   PREDEFINED LINE NUMBERS ON THE "TOPLINES" AND "BOTLINES" CARDS
COMMENT   LINES ARE NUMBERED IN ORDER AS IN METHOD 20 (SEE TABLES 8 AND 9)
COMMENT   METHOD       23

COMMENT   TOPLINES      1    2    3    4    5    6    7

COMMENT   BOTLINES      1    2    4   10   11   12

COMMENT   EXECUTE

COMMENT   ************************************************************************
COMMENT   METHOD 24 IS THE MUF-RELIABILITY TABLE
COMMENT   ************************************************************************
METHOD       24
T  E          1   24    1
E  CUTE
COMMENT   ************************************************************************
COMMENT   METHOD 25 IS THE ALL MODES TABLE
COMMENT   METHOD       25

COMMENT   NOTE THAT THE MUF ALL MODES TABLE IS ALSO PRINTED
COMMENT   FREQUENCY   2.5  5.0 10.0 15.0 20.0

COMMENT   TIME          1   24    1

COMMENT   EXECUTE

COMMENT   ************************************************************************
COMMENT   METHODS 26 THROUGH 29 ARE LUF PREDICTIONS
METHOD       26
COMMENT   OUTPUT METHODS 27, 28 AND 29 WITHOUT RECOMPUTATION USING "OUTGRAPH"
COMMENT   OUTGRAPH     27   28   29

COMMENT   TIME          2   24    2

COMMENT   EXECUTE

COMMENT   OUTGRAPH  OFF

COMMENT   ************************************************************************
C  T
```

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METHOD 22 IONCAP PC.20 PAGE 1

FEB 1992 SSN = 157.

CHU - OTTAWA, CANADA TO LEXINGTON, MA AZIMUTHS N. MI. KM

45.30 N 75.75 W - 41.40 N 72.25 W 145.66 328.06 279.5 517.6

MINIMUM ANGLE .0 DEGREES

ITS- 1 ANTENNA PACKAGE

XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

RCVR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0

POWER = 3.000 KW 3 MHZ NOISE = -163.6 DBW REQ. REL = .90 REQ. SNR = 55.0

MULTIPATH POWER TOLERANCE = 10.0 DB MULTIPATH DELAY TOLERANCE = .850 MS

UT	MUF												
1.0	9.4	2.5	3.3	5.0	7.3	10.0	14.7	15.0	20.0	.0	.0	.0	FREQ
	1F2	1F2	1F2	1F2	1F2	1F2	1F2	1F2	1F2	-	-	-	MODE
	55.9	45.4	44.7	45.1	47.8	55.9	55.9	55.9	55.9	-	-	-	ANGLE
	3.3	2.6	2.5	2.6	2.7	3.3	3.3	3.3	3.3	-	-	-	DELAY
	412.	279.	273.	277.	305.	412.	412.	412.	412.	-	-	-	V HITE
	.50	1.00	1.00	1.00	.99	.27	.00	.00	.00	-	-	-	F DAYS
	121.	108.	109.	111.	114.	125.	183.	183.	186.	-	-	-	LOSS
	40.	43.	44.	45.	46.	37.	-18.	-18.	-18.	-	-	-	DBU
	-86	-71	-72	-75	-78	-89	-148	-148	-150	-	-	-	S DBW
	-162	-150	-152	-155	-159	-164	-172	-172	-180	-	-	-	N DBW
	77.	78.	79.	80.	81.	74.	24.	24.	30.	-	-	-	SNR
	-6.	-13.	-13.	-15.	-16.	-1.	40.	39.	33.	-	-	-	RPWRG
	.96	1.00	1.00	1.00	1.00	.91	.02	.01	.00	-	-	-	REL
	.00	.00	.00	.00	.00	.00	.00	.00	.00	-	-	-	MPROB
	.60	.70	.73	.76	.79	.51	.01	.01	.02	-	-	-	S PRB
	14.	6.	6.	7.	7.	17.	7.	7.	7.	-	-	-	SIG LW
	6.	3.	3.	4.	3.	8.	18.	14.	3.	-	-	-	SIG UP
2.0	8.3	2.5	3.3	5.0	7.3	10.0	14.7	15.0	20.0	.0	.0	.0	FREQ
	1F2	1F2	1F2	1F2	1F2	1F2	1F2	1F2	1F2	-	-	-	MODE
	56.5	46.2	46.0	47.0	51.2	56.5	56.5	56.5	56.5	-	-	-	ANGLE
	3.3	2.6	2.6	2.6	2.9	3.3	3.3	3.3	3.3	-	-	-	DELAY
	423.	287.	285.	296.	344.	423.	423.	423.	423.	-	-	-	V HITE
	.50	1.00	1.00	1.00	.87	.03	.00	.00	.00	-	-	-	F DAYS
	116.	103.	104.	106.	110.	132.	178.	178.	181.	-	-	-	LOSS
	45.	48.	49.	50.	49.	30.	-13.	-13.	-13.	-	-	-	DBU
	-80	-66	-68	-70	-74	-97	-143	-143	-146	-	-	-	S DBW
	-160	-147	-150	-154	-158	-163	-173	-173	-181	-	-	-	N DBW
	79.	80.	81.	83.	83.	66.	30.	30.	35.	-	-	-	SNR
	-5.	-13.	-13.	-14.	-13.	14.	37.	37.	31.	-	-	-	RPWRG
	.95	.99	1.00	1.00	.99	.72	.00	.00	.00	-	-	-	REL
	.00	.00	.00	.00	.00	.00	.00	.00	.00	-	-	-	MPROB
	.57	.69	.71	.73	.72	.33	.02	.02	.05	-	-	-	S PRB
	18.	10.	10.	11.	13.	25.	11.	11.	11.	-	-	-	SIG LW
	6.	4.	4.	4.	4.	15.	3.	3.	3.	-	-	-	SIG UP

METHOD 24 IONCAP PC.20 PAGE 13

FEB 1992 SSN = 157.

CHU - OTTAWA, CANADA TO LEXINGTON, MA AZIMUTHS N. MI. KM
45.30 N 75.75 W - 41.40 N 72.25 W 145.66 328.06 279.5 517.6
MINIMUM ANGLE .0 DEGREES

.TS- 1 ANTENNA PACKAGE
XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0
RCVR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0
POWER = 3.000 KW 3 MHZ NOISE = -163.6 DBW REQ. REL = .90 REQ. SNR = 55.0

FREQUENCY / RELIABILITY

UT	MUF	2.5	3.3	5.0	7.3	10.0	14.7	15.0	20.0	-	-	-	MUF
1	9.4	1.00	1.00	1.00	1.00	.91	.02	.01	.00	-	-	-	.96
2	8.3	.99	1.00	1.00	.99	.72	.00	.00	.00	-	-	-	.95
3	7.6	.99	.99	.99	.97	.54	.00	.00	.01	-	-	-	.94
4	7.1	.99	.99	.99	.92	.34	.00	.00	.01	-	-	-	.94
5	6.7	.99	.99	.99	.87	.20	.00	.00	.01	-	-	-	.93
6	6.6	.99	.99	.99	.85	.16	.01	.01	.01	-	-	-	.94
7	6.5	.99	.99	.99	.82	.09	.01	.01	.01	-	-	-	.89
8	6.0	.99	.99	.98	.68	.00	.01	.01	.01	-	-	-	.88
9	5.1	.99	.99	.87	.18	.00	.01	.01	.01	-	-	-	.85
10	4.5	.99	.99	.81	.01	.00	.00	.00	.01	-	-	-	.87
11	5.3	.99	.99	.97	.23	.00	.00	.00	.01	-	-	-	.92
12	7.4	.99	.99	.99	.95	.33	.00	.00	.01	-	-	-	.91
13	10.1	.86	.99	1.00	1.00	.96	.07	.05	.00	-	-	-	.93
14	12.4	.09	.59	.96	.98	.98	.59	.54	.00	-	-	-	.82
15	13.7	.00	.15	.94	.99	.99	.75	.71	.00	-	-	-	.86
16	14.3	.00	.01	.48	.97	.98	.80	.76	.00	-	-	-	.86
17	14.5	.00	.00	.36	.96	.98	.81	.77	.02	-	-	-	.86
18	14.6	.00	.01	.49	.98	.99	.82	.78	.01	-	-	-	.88
19	14.5	.00	.17	.97	1.00	.99	.77	.74	.01	-	-	-	.79
20	14.3	.18	.76	1.00	1.00	1.00	.78	.76	.00	-	-	-	.82
21	14.0	.77	.95	.98	.99	.99	.75	.72	.00	-	-	-	.79
22	13.3	.96	.98	.98	.99	.99	.68	.62	.00	-	-	-	.80
23	12.3	.97	.97	.98	.99	.99	.64	.60	.00	-	-	-	.87
24	10.9	.98	.99	.99	1.00	.99	.28	.23	.00	-	-	-	.92

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METHOD 22 IONCAP PC.20 PAGE 1

FEB 1992 SSN = 157.

WWV - FT. COLLINS, CO TO LEXINGTON, MA AZIMUTHS N. MI. KM
40.67 N 105.00 W - 41.40 N 72.25 W 77.43 279.27 1474.9 2731.2
MINIMUM ANGLE .0 DEGREES

ITS- 1 ANTENNA PACKAGE
XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0
RCVR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0
POWER = 10.000 KW 3 MHZ NOISE = -163.6 DBW REQ. REL = .90 REQ. SNR = 55.0
MULTIPATH POWER TOLERANCE = 10.0 DB MULTIPATH DELAY TOLERANCE = .850 MS

UT	MUF													
1.0	26.4	2.5	5.0	10.0	15.0	20.0	.0	.0	.0	.0	.0	.0	FREQ
	1F2	2 E	1F2	1F2	1F2	1F2	-	-	-	-	-	-	MODE
	9.8	4.9	7.6	4.1	4.3	5.1	-	-	-	-	-	-	ANGLE
	9.8	9.3	9.6	9.4	9.4	9.5	-	-	-	-	-	-	DELAY
	403.	96.	344.	254.	259.	278.	-	-	-	-	-	-	V HITE
	.50	1.00	1.00	1.00	1.00	.99	-	-	-	-	-	-	F DAYS
	147.	146.	142.	135.	136.	138.	-	-	-	-	-	-	LOSS
	33.	10.	22.	33.	35.	35.	-	-	-	-	-	-	DBU
	-102	-104	-98	-93	-95	-98	-	-	-	-	-	-	S DBW
	-185	-150	-155	-164	-172	-180	-	-	-	-	-	-	N DBW
	83.	45.	56.	70.	77.	82.	-	-	-	-	-	-	SNR
	-9.	19.	7.	-9.	-17.	-24.	-	-	-	-	-	-	RPWRG
	.97	.15	.59	1.00	1.00	1.00	-	-	-	-	-	-	REL
	.00	.00	.17	.00	.00	.00	-	-	-	-	-	-	MPROB
	.60	.10	.25	.70	.91	.96	-	-	-	-	-	-	S PRB
	18.	2.	1.	1.	2.	2.	-	-	-	-	-	-	SIG LW
	13.	7.	8.	6.	6.	6.	-	-	-	-	-	-	SIG UP

2.0	22.6	2.5	5.0	10.0	15.0	20.0	.0	.0	.0	.0	.0	.0	FREQ
	1F2	2 E	1F2	1F2	1F2	1F2	-	-	-	-	-	-	MODE
	10.0	5.1	5.2	4.5	5.0	6.5	-	-	-	-	-	-	ANGLE
	9.8	9.3	9.5	9.4	9.5	9.6	-	-	-	-	-	-	DELAY
	409.	99.	282.	264.	277.	316.	-	-	-	-	-	-	V HITE
	.50	1.00	1.00	1.00	1.00	.88	-	-	-	-	-	-	F DAYS
	146.	140.	141.	135.	136.	138.	-	-	-	-	-	-	LOSS
	34.	16.	24.	34.	35.	35.	-	-	-	-	-	-	DBU
	-100	-99	-96	-92	-94	-98	-	-	-	-	-	-	S DBW
	-183	-147	-154	-163	-173	-181	-	-	-	-	-	-	N DBW
	82.	48.	57.	71.	78.	83.	-	-	-	-	-	-	SNR
	-9.	15.	5.	-10.	-18.	-23.	-	-	-	-	-	-	RPWRG
	.97	.24	.63	1.00	1.00	1.00	-	-	-	-	-	-	REL
	.00	.00	.20	.00	.00	.00	-	-	-	-	-	-	MPROB
	.59	.16	.27	.71	.90	.91	-	-	-	-	-	-	S PRB
	18.	2.	1.	1.	2.	4.	-	-	-	-	-	-	SIG LW
	13.	7.	10.	7.	7.	7.	-	-	-	-	-	-	SIG UP

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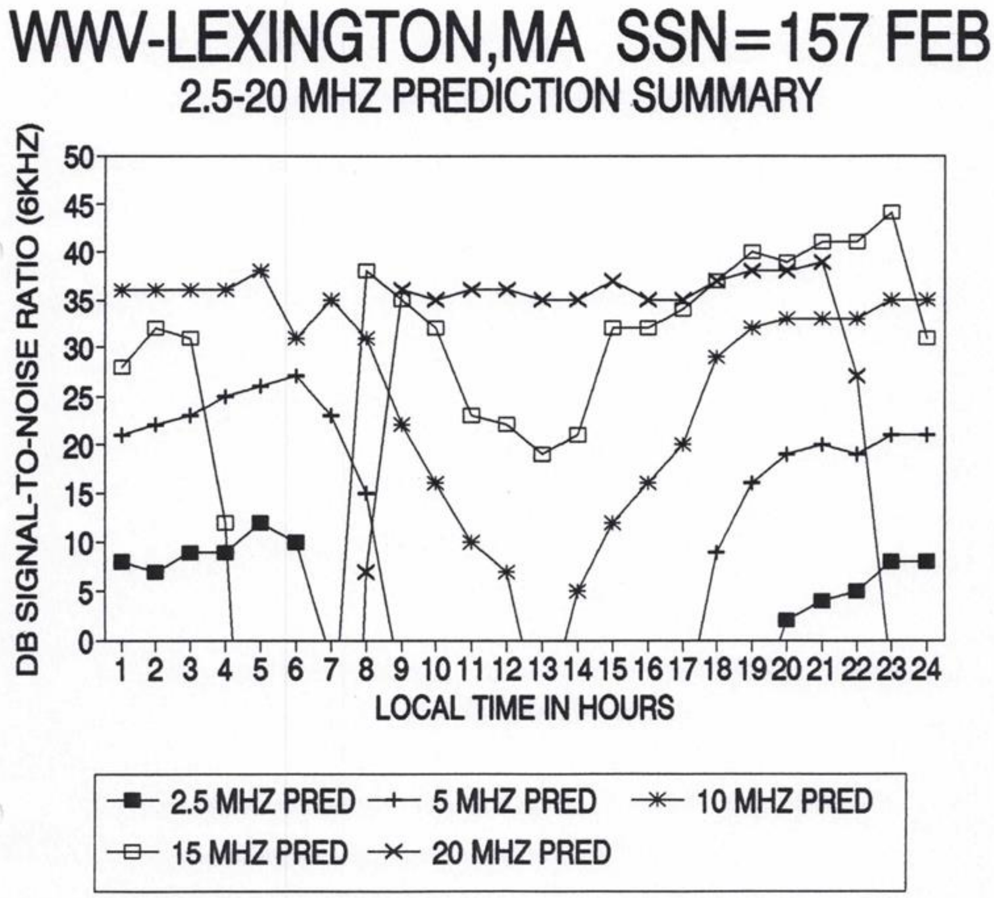
METHOD 24 IONCAP PC.20 PAGE 13

FEB 1992 SSN = 157.
WWV - FT. COLLINS, CO TO LEXINGTON, MA AZIMUTHS N. MI. KM
40.67 N 105.00 W - 41.40 N 72.25 W 77.43 279.27 1474.9 2731.2
MINIMUM ANGLE .0 DEGREES
ITS- 1 ANTENNA PACKAGE
XMTR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0
RCVR 2.0 TO 30.0 CONST. GAIN H .00 L .00 A .0 OFF AZ .0
POWER = 10.000 KW 3 MHZ NOISE = -163.6 DBW REQ. REL = .90 REQ. SNR = 55.0

FREQUENCY / RELIABILITY

UT	MUF	2.5	5.0	10.0	15.0	20.0	-	-	-	-	-	-	MUF
1	26.4	.15	.59	1.00	1.00	1.00	-	-	-	-	-	-	.97
2	22.6	.24	.63	1.00	1.00	1.00	-	-	-	-	-	-	.97
3	19.2	.26	.63	1.00	1.00	.81	-	-	-	-	-	-	.90
4	16.2	.34	.77	1.00	1.00	.22	-	-	-	-	-	-	.89
5	14.2	.36	.79	1.00	.76	.00	-	-	-	-	-	-	.88
6	13.8	.34	.79	1.00	.71	.00	-	-	-	-	-	-	.89
7	14.2	.33	.81	1.00	.78	.00	-	-	-	-	-	-	.90
8	14.1	.38	.85	1.00	.77	.00	-	-	-	-	-	-	.90
9	12.7	.43	.90	1.00	.39	.00	-	-	-	-	-	-	.88
10	10.8	.47	.92	.99	.00	.00	-	-	-	-	-	-	.85
11	9.9	.42	.94	.75	.00	.00	-	-	-	-	-	-	.84
12	11.9	.05	.83	1.00	.07	.00	-	-	-	-	-	-	.75
13	17.5	.00	.39	.99	1.00	.42	-	-	-	-	-	-	.89
14	24.9	.00	.00	.73	1.00	1.00	-	-	-	-	-	-	.90
15	30.9	.00	.00	.42	.98	1.00	-	-	-	-	-	-	.96
16	34.2	.00	.00	.14	.79	1.00	-	-	-	-	-	-	.97
17	35.4	.00	.00	.04	.66	1.00	-	-	-	-	-	-	.99
18	35.6	.00	.00	.00	.58	.99	-	-	-	-	-	-	.93
19	35.5	.00	.00	.03	.62	1.00	-	-	-	-	-	-	.93
20	35.0	.00	.00	.19	.97	1.00	-	-	-	-	-	-	.97
21	35.0	.00	.00	.40	1.00	1.00	-	-	-	-	-	-	.96
22	34.9	.00	.00	.61	.99	1.00	-	-	-	-	-	-	.93
23	33.5	.00	.18	.96	1.00	1.00	-	-	-	-	-	-	.92
24	30.4	.02	.44	.99	1.00	1.00	-	-	-	-	-	-	.96


WWV-LEXINGTON,MA SSN=157 FEB
2.5-20 MHZ PREDICTION SUMMARY
DB SIGNAL-TO-NOISE RATIO (6KHZ)
50
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
LOCAL TIME IN HOURS
2.5 MHZ PRED
5 MHZ PRED
10 MHZ PRED
15 MHZ PRED
20 MHZ PRED

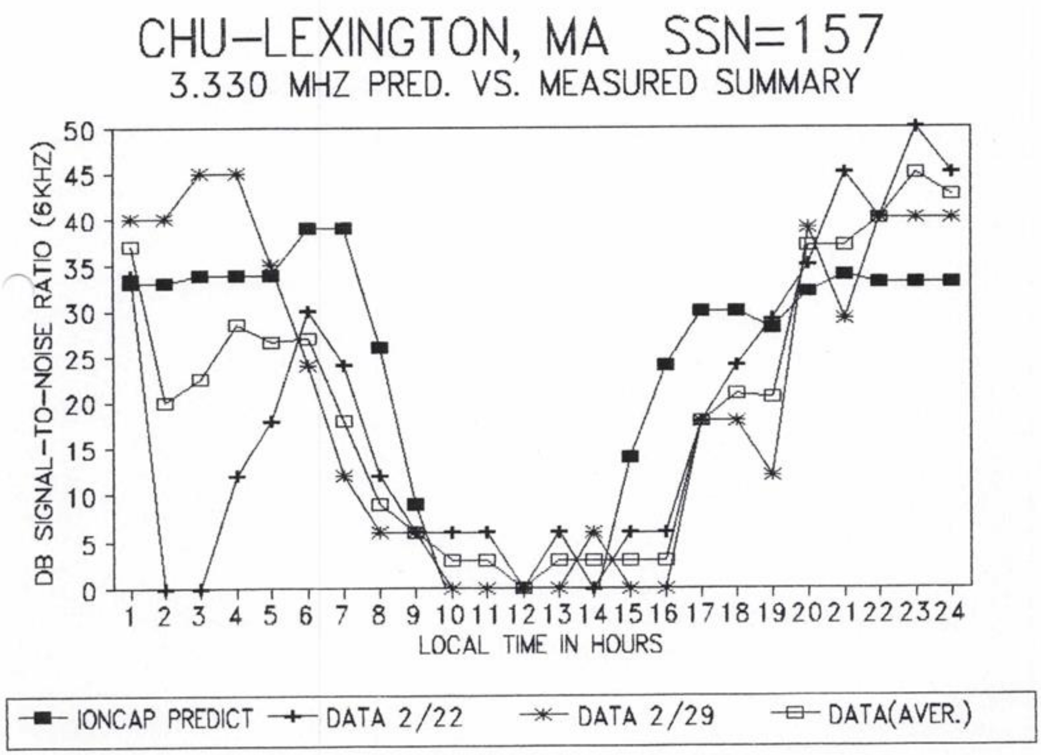
Comparison of Predictions With Measured Data
CHU-Ottawa, Canada to Lexington, MA
22 February 1992 SSN=157 F=3.330 MHz

IONCAP PREDICTED DATA

Loc. Time	3KW Sig(DBW)	0.3KW Sig(DBW)	1HZ N (DBW)	6KHZ N (DBW)	6KHZ S/N(DB)
1	-67	-77	-148	-110	33
2	-67	-77	-148	-110	33
3	-67	-77	-149	-111	34
4	-68	-78	-150	-112	34
5	-69	-79	-151	-113	34
6	-67	-77	-154	-116	39
7	-72	-82	-159	-121	39
8	-88	-98	-162	-124	26
9	-107	-117	-164	-126	9
10	-119	-129	-165	-127	-2
11	-131	-141	-165	-127	-14
12	-136	-146	-165	-127	-19
13	-131	-141	-165	-127	-14
14	-118	-128	-164	-126	-2
15	-102	-112	-164	-126	14
16	-89	-99	-161	-123	24
17	-81	-91	-159	-121	30
18	-78	-88	-156	-118	30
19	-78	-88	-154	-116	28
20	-72	-82	-152	-114	32
21	-68	-78	-150	-112	34
22	-67	-77	-148	-110	33
23	-67	-77	-148	-110	33
24	-67	-77	-148	-110	33

MEASURED DATA

Loc. Time	0.3KW Sig(DBW)	6KHZ N (DBW)	6KHZ S/N(DB)
1	-93	-127	34
2	-133	-133	0
3	-133	-133	0
4	-115	-127	12
5	-109	-127	18
6	-103	-133	30
7	-109	-133	24
8	-127	-139	12
9	-133	-139	6
10	-133	-139	6
11	-127	-133	6
12	-127	-127	0
13	-127	-133	6
14	-133	-133	0
15	-133	-139	6
16	-127	-133	6
17	-115	-133	18
18	-109	-133	24
19	-98	-127	29
20	-98	-133	35
21	-88	-133	45
22	-93	-133	40
23	-83	-133	50
24	-88	-133	45


CHU–LEXINGTON, MA SSN=157
3.330 MHZ PRED. VS. MEASURED SUMMARY
DB SIGNAL–TO–NOISE RATIO (6KHZ)
50
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
LOCAL TIME IN HOURS
IONCAP PREDICT
DATA 2/22
DATA 2/29
DATA(AVER.)

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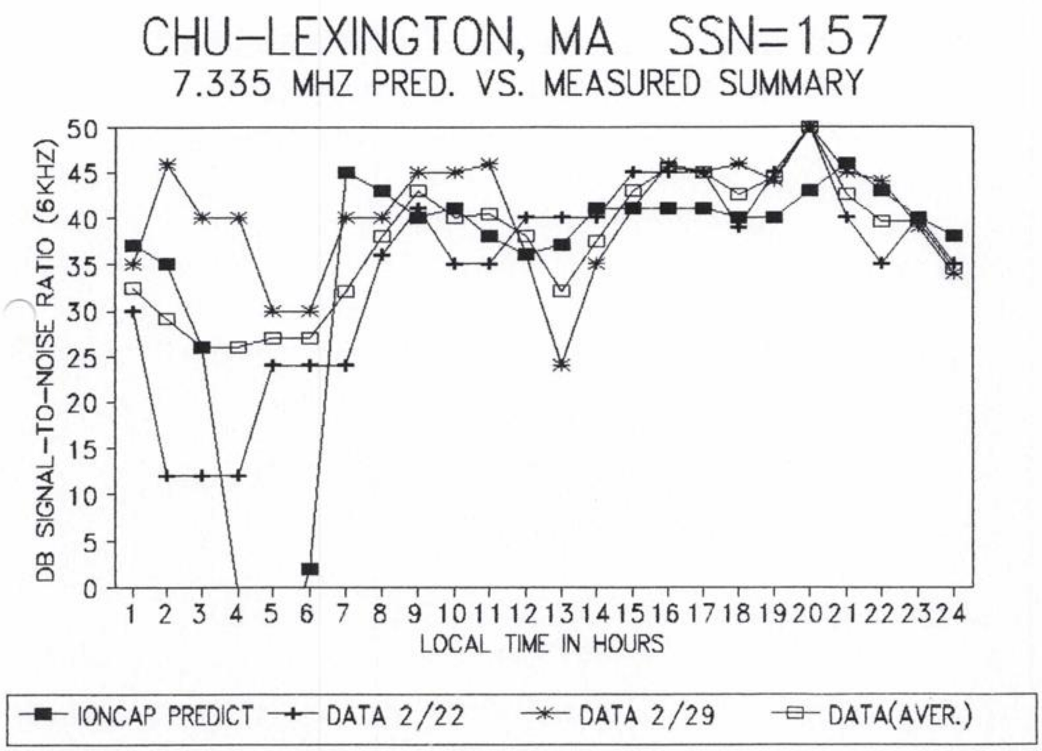
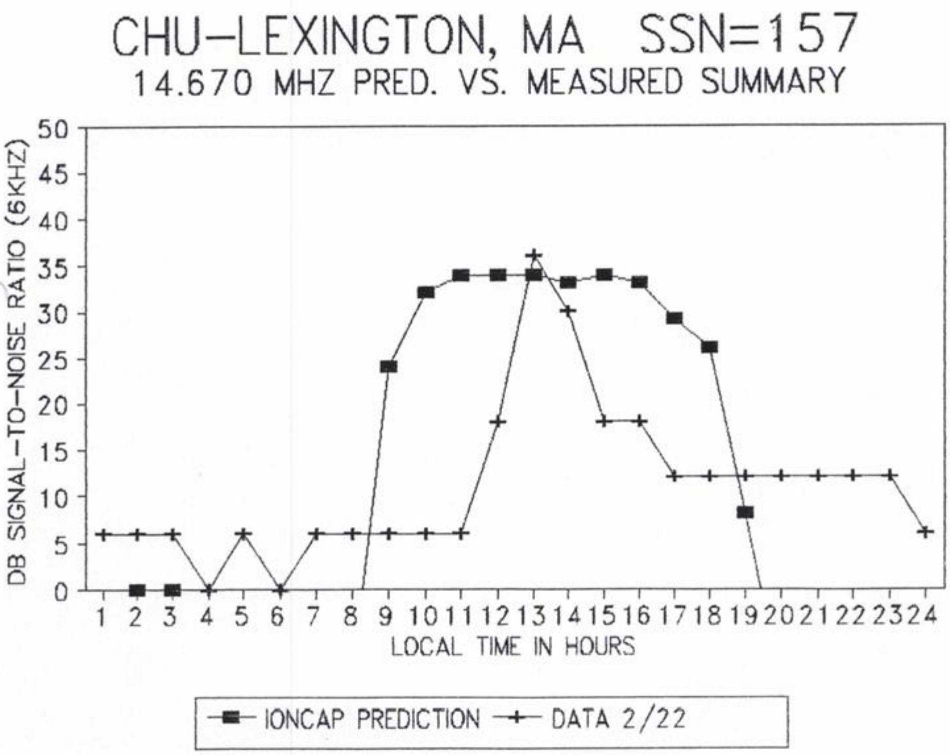
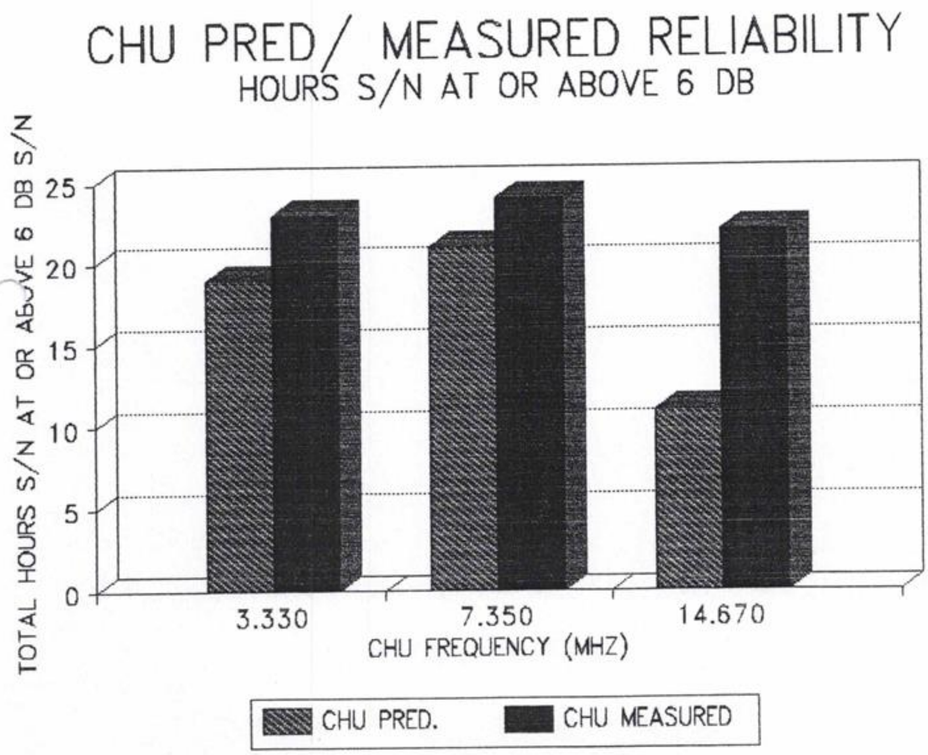

CHU-LEXINGTON, MA SSN=157
7.335 MHZ PRED. VS. MEASURED SUMMARY
DB SIGNAL-TO-NOISE RATIO (6KHZ)
LOCAL TIME IN HOURS
IONCAP PREDICT
DATA 2/22
DATA 2/29
DATA(AVER.)

40


CHU–LEXINGTON, MA SSN=157
14.670 MHZ PRED. VS. MEASURED SUMMARY
DB SIGNAL–TO–NOISE RATIO (6KHZ)
50
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
LOCAL TIME IN HOURS
IONCAP PREDICTION
DATA 2/22

40


CHU PRED/ MEASURED RELIABILITY
HOURS S/N AT OR ABOVE 6 DB
TOTAL HOURS S/N AT OR ABOVE 6 DB S/N
0
5
10
15
20
25
3.330
7.350
14.670
CHU FREQUENCY (MHZ)
CHU PRED.
CHU MEASURED

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Comparison of Predictions With Measured Data
WWV-Ft. Collins, CO to Lexington, MA
22 February 1992 SSN=157 F=10Mhz

IONCAP PREDICTED DATA

Loc. Time	10KW Sig(DBW)	10KW Sig(DBW)	1HZ N (DBW)	6KHZ N (DBW)	6KHZ S/N(DB)
1	-92	-92	-166	-128	36
2	-93	-93	-167	-129	36
3	-93	-93	-167	-129	36
4	-93	-93	-167	-129	36
5	-91	-91	-167	-129	38
6	-98	-98	-167	-129	31
7	-94	-94	-167	-129	35
8	-98	-98	-167	-129	31
9	-108	-108	-168	-130	22
10	-115	-115	-169	-131	16
11	-120	-120	-168	-130	10
12	-123	-123	-168	-130	7
13	-139	-139	-167	-129	-10
14	-124	-124	-167	-129	5
15	-116	-116	-166	-128	12
16	-112	-112	-166	-128	16
17	-107	-107	-165	-127	20
18	-97	-97	-164	-126	29
19	-94	-94	-164	-126	32
20	-93	-93	-164	-126	33
21	-92	-92	-163	-125	33
22	-92	-92	-163	-125	33
23	-91	-91	-164	-126	35
24	-92	-92	-165	-127	35

MEASURED DATA

Loc. Time	10KW Sig(DBW)	6KHZ N (DBW)	6KHZ S/N(DB)
1	-103	-145	42
2	-109	-145	36
3	-109	-145	36
4	-109	-145	36
5	-98	-145	47
6	-93	-145	52
7	-109	-145	36
8	-121	-145	24
9	-121	-145	24
10	-127	-145	18
11	-139	-145	6
12	-139	-139	0
13	-139	-145	6
14	-139	-145	6
15	-139	-145	6
16	-133	-145	12
17	-127	-145	18
18	-127	-145	18
19	-109	-145	36
20	-109	-145	36
21	-103	-145	42
22	-103	-145	42
23	-93	-145	52
24	-98	-145	47

Comparison of Predictions With Measured Data
WWV-Ft. Collins, CO to Lexington, MA
29 February 1992 SSN=157 F=5.0Mhz

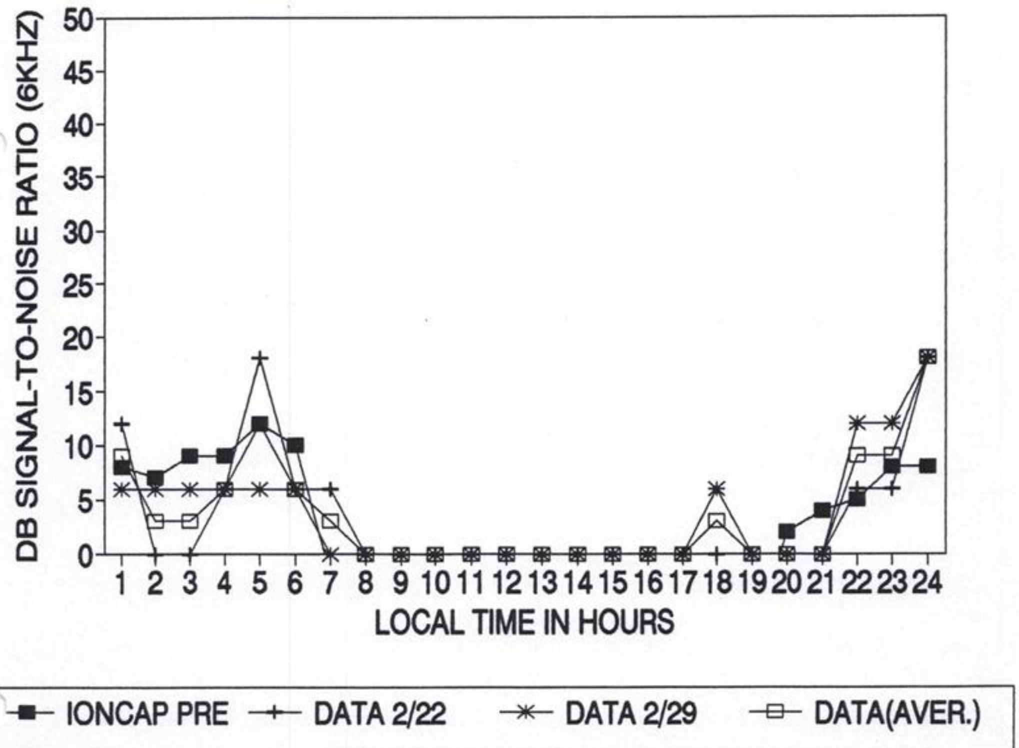
IONCAP PREDICTED DATA

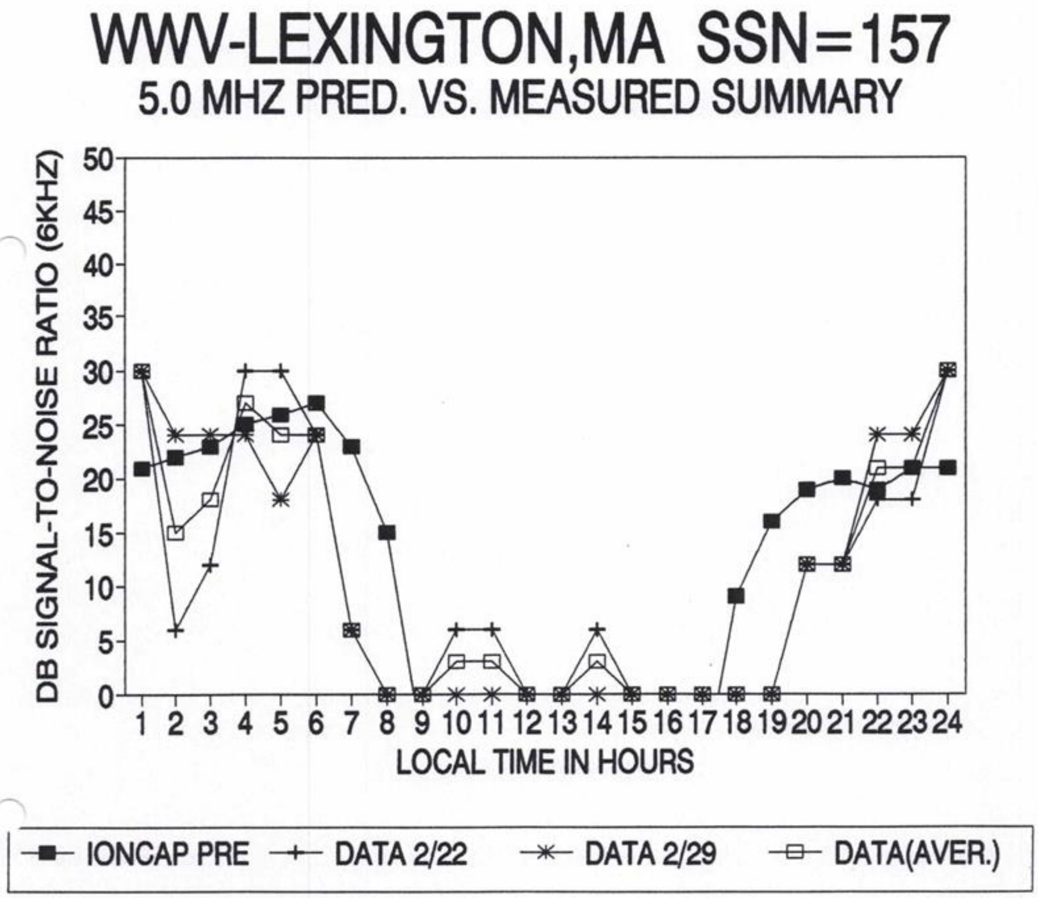
Loc. Time	10KW Sig(DBW)	10KW Sig(DBW)	1HZ N (DBW)	6KHZ N (DBW)	6KHZ S/N(DB
1	-93	-93	-152	-114	21
2	-93	-93	-153	-115	22
3	-92	-92	-153	-115	23
4	-91	-91	-154	-116	25
5	-91	-91	-155	-117	26
6	-91	-91	-156	-118	27
7	-100	-100	-161	-123	23
8	-112	-112	-165	-127	15
9	-135	-135	-168	-130	-5
10	-167	-167	-169	-131	-36
11	-198	-198	-169	-131	-67
12	-226	-226	-169	-131	-95
13	-241	-241	-169	-131	-110
14	-230	-230	-169	-131	-99
15	-193	-193	-167	-129	-64
16	-157	-157	-164	-126	-31
17	-133	-133	-162	-124	-9
18	-112	-112	-159	-121	9
19	-103	-103	-157	-119	16
20	-98	-98	-155	-117	19
21	-96	-96	-154	-116	20
22	-95	-95	-152	-114	19
23	-93	-93	-152	-114	21
24	-93	-93	-152	-114	21

MEASURED DATA

Loc. Time	10KW Sig(DBW)	6KHZ N (DBW)	6KHZ S/N(DB)
1	-115	-145	30
2	-121	-145	24
3	-115	-139	24
4	-115	-139	24
5	-121	-139	18
6	-115	-139	24
7	-133	-139	6
8	-139	-139	0
9	-139	-139	0
10	-139	-139	0
11	-139	-139	0
12	-139	-139	0
13	-139	-139	0
14	-139	-139	0
15	-139	-139	0
16	-139	-139	0
17	-139	-139	0
18	-139	-139	0
19	-139	-139	0
20	-127	-139	12
21	-127	-139	12
22	-115	-139	24
23	-115	-139	24
24	-109	-139	30

WWV-LEXINGTON,MA SSN=157
2.5 MHZ PRED. VS. MEASURED SUMMARY

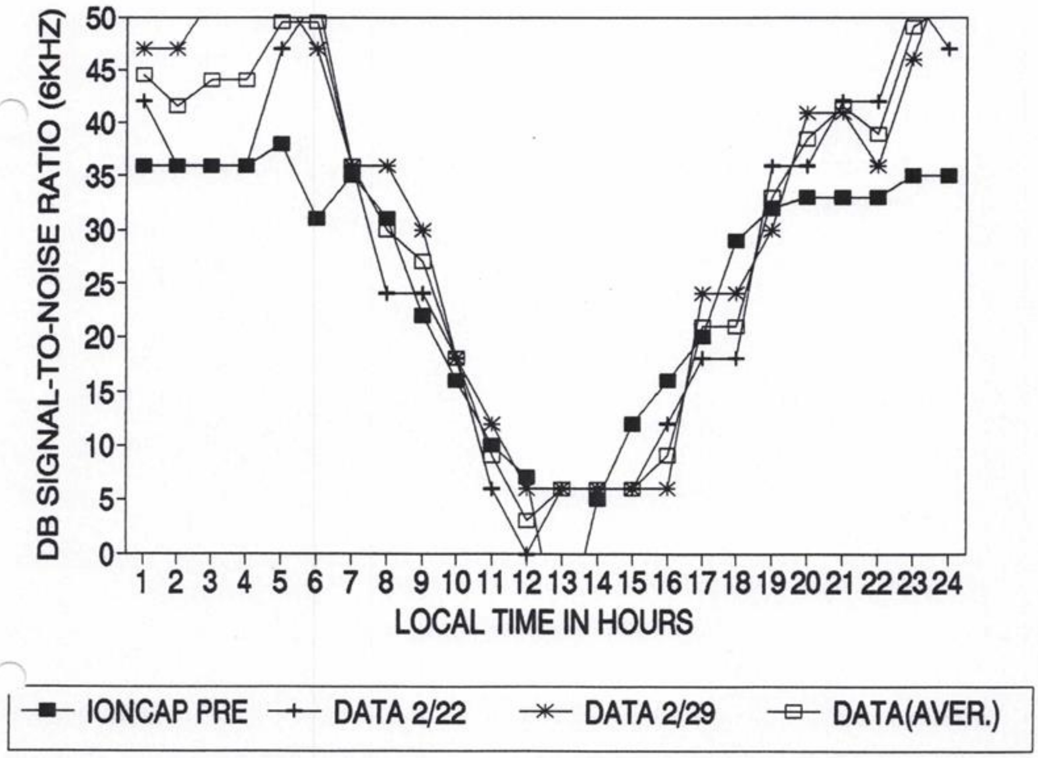



WWV-LEXINGTON,MA SSN=157
5.0 MHZ PRED. VS. MEASURED SUMMARY
DB SIGNAL-TO-NOISE RATIO (6KHZ)
0
5
10
15
20
25
30
35
40
45
50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
LOCAL TIME IN HOURS
IONCAP PRE
DATA 2/22
DATA 2/29
DATA(AVER.)

55

WWV-LEXINGTON,MA SSN=157

10.0 MHZ PRED. VS. MEASURED SUMMARY



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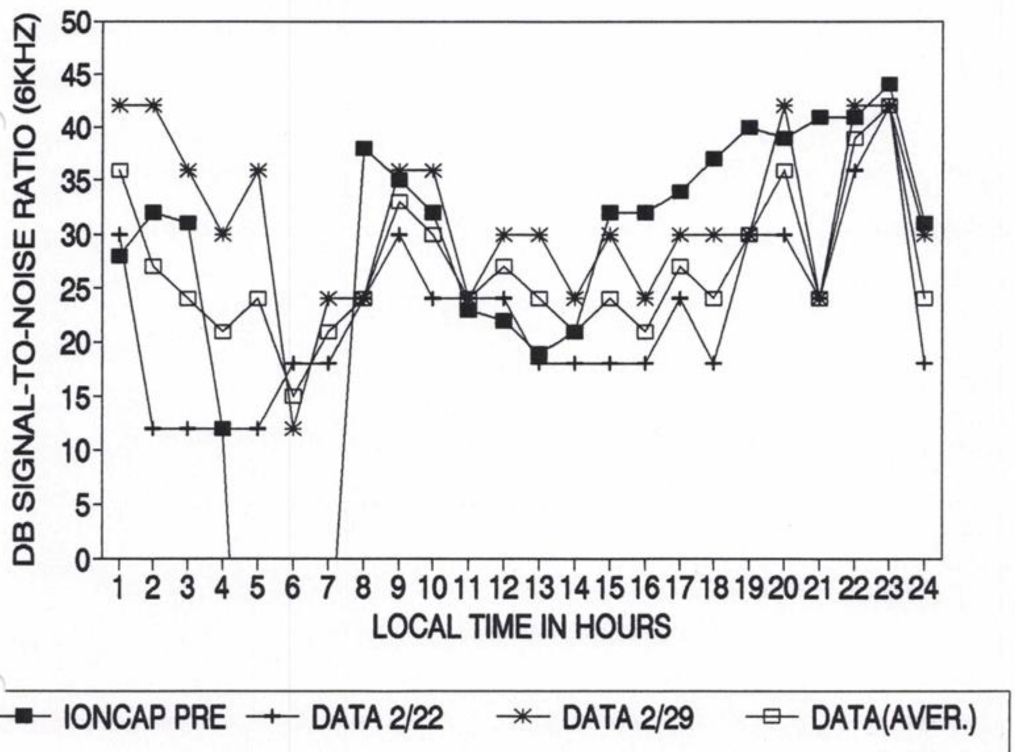
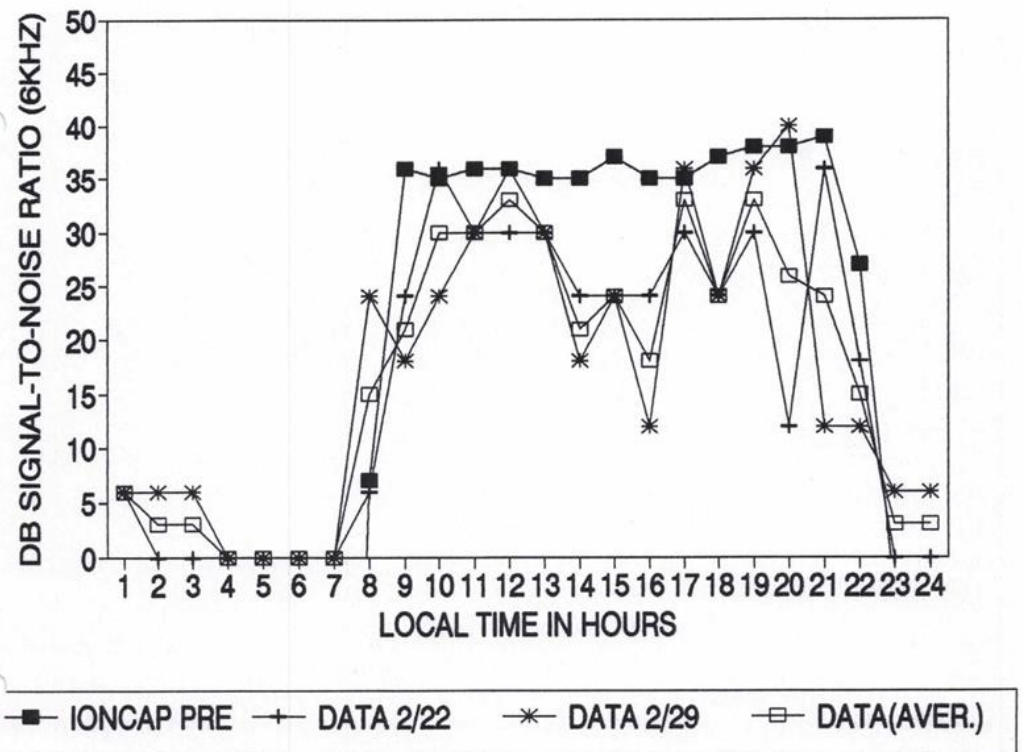
WWV-LEXINGTON,MA SSN=157

15.0 MHZ PRED. VS. MEASURED SUMMARY



WWV-LEXINGTON,MA SSN=157
20.0 MHZ PRED. VS. MEASURED SUMMARY



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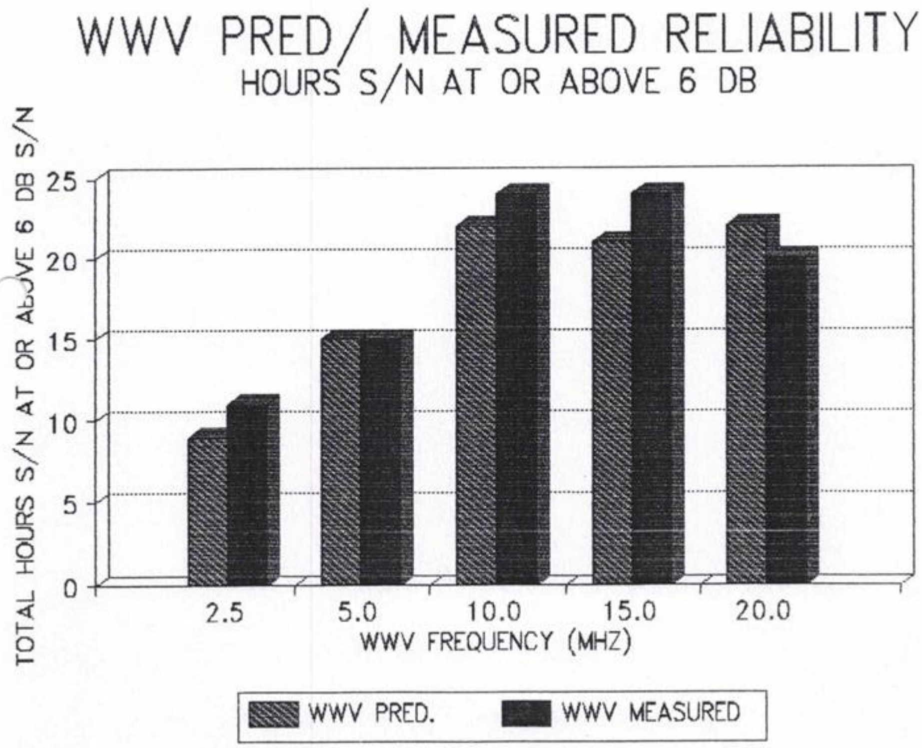
WWV PRED/ MEASURED RELIABILITY
HOURS S/N AT OR ABOVE 6 DB
TOTAL HOURS S/N AT OR ABOVE 6 DB S/N
0
5
10
15
20
25
2.5
5.0
10.0
15.0
20.0
WWV FREQUENCY (MHZ)
WWV PRED.
WWV MEASURED

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SUMMARY OF MEASUREMENT TRENDS

TIME PERIODS VS. FREQUENCIES VS. SIGNAL CHARACTERISTICS

	MIDNIGHT	SUNRISE	NOON	EVENING
GROUP #1 LOWER FREQUENCIES	STRONG	STRONG	WEAK	MEDIUM
WWV 2.5 MHZ CHU 3.33 MHZ WWV 5.0 MHZ WWV 10.0 MHZ	LOW ABSORP- TION	LOW ABORP- TION NO D- LAYER	HIGHEST ION- IZATION STRONG D LAYER	WEAKER ION- IZATION D LAYER WEAKENS LESS ABSORP- TION
GROUP #2 MIDDLE FREQUENCIES	STRONG	WEAK	MEDIUM	STRONG
CHU 7.335 MHZ WWV 15.0 MHZ	LOW ABSORP- TION & ENOUGH ION- IZATION	NOT ENOUGH ION- IZATION	GOOD ION- IZATION LOT OF ABSORP- TION	STILL GOOD ION- LOWER ABSORP- TION
GROUP #3 HIGHER FREQUENCIES	WEAK	WEAK	STRONG	STRONG
CHU 14.67 MHZ WWV 20.00 MHZ	NOT ENOUGH ION- IZATION	LOWEST ION- IZATION BUT ON THE RISE	GOOD ION- IZATION	GOOD ION- IZATION BUT WEAKENING

NOTE: DURING THE MIDNIGHT-TO-EARLY MORNING PERIOD OF 22 FEB 1992 MEASUREMENTS, THERE WAS A PERIOD OF UNUSUALLY HIGH SOLAR AND GEOMAGNETIC ACTIVITY WHICH SEEMED TO HAVE AN EFFECT ON PROPAGATION.

5.0 ANALYSIS OF RESULTS

Certain observations concerning the measured and predicted data, located in Appendix I and II, can be derived from existing ionospheric theory and data analysis. These observations are as follows:

5.1 Analysis of CHU predicted and actual data

a. 3.330 MHz Data

The predicted data indicates that this frequency tends to propagate during nighttime hours. Shortly after sunrise the predicted signal-to-noise ratio drops off sharply such that recovery of the signal does not occur until late afternoon. The minimum signal-to-noise ratio tends to occur at noon local time. This pattern can be attributed to absorption due to the formation of the D-layer during daytime hours. The average measured data indicates somewhat lower signal-to-noise ratios for early morning hours and higher signal-to-noise ratios for late evening hours when compared to IONCAP predictions. In general the propagation tends to follow the pattern which was predicted, with minimum signal-to-noise ratios occurring during daylight hours.

b. 7.335 MHz Data

The predicted data indicates that this frequency tends to propagate best during daylight to late evening hours. Shortly before sunrise this frequency drops off very rapidly, but it recovers quickly with the onset of sunrise. This appears to be a very reliable frequency due to short outage time and high signal-to-noise ratio indicated. This pattern can be attributed to the formation and retention of the F-layer in support of propagation.

The average measured data indicates approximately the same signal-to-noise ratios, as predicted, throughout most of the measurement period. The lowest ratios occurred during the early pre-dawn time interval when IONCAP predicted outages for reception.

c. 14.670 MHz Data

The predicted data indicates that this frequency tends to propagate solely during daylight hours. Shortly after sunset to about an hour after sunrise this frequency suffers an outage. However, with the ionization of the F-Layer to sufficient states, the frequency once again has a favorable signal-to-noise ratio. Peak signal-to-noise ratios occur around noontime. This frequency is less reliable than previously mentioned frequencies.

The average measured data indicates increased signal-to-noise ratios during the nighttime hours and generally lower during daylight hours. However, the pattern established in the prediction is related to actual measurements in that peak performance occurs during daylight hours and minimum performance occurs during nighttime hours. Actual duration of peak performance, however, was small compared to the prediction but this could have been the result of intense geomagnetic activity resulting from solar storm disturbances. Such storms historically tend to affect propagation more severely in higher latitudes.

5.2 Analysis of WWV predicted and actual data

a. 2.5 MHz Data

The pattern established by predicted data indicates that this frequency primarily propagates well during nighttime hours, when the D-Layer has disappeared, resulting in lower absorption. Very shortly after sunrise, however, the signal-to-noise ratio drops off rapidly until it reaches an outage. Not until an hour after sunset does the signal-to-noise ratio-rebound. This frequency appears to have relatively low reliability because of its high overall outage period and its low signal-to-noise ratio when it is being received.

The average measured data closely follows the diurnal pattern established by the predicted data. Data minimum and maximum values occur at approximately the same time as the predicted levels. Furthermore, the frequency tended to only propagate during nighttime hours with the expected low signal-to-noise ratios.

b. 5.0 MHz Data

The pattern established by predicted data indicates that this frequency closely ressembles that of 2.5 MHz. It primarily propagates well during nighttime hours and suffers outages during daylight hours. Also, the signal-to-noise ratio falls in response to sunrise and rises in response to sunset. However, this frequency is more reliable than 2.5 MHz and usually has better performance as exhibited by its higher signal-to-noise ratios. Furthermore, signal-to-noise ratio drops off slower in response to the advent of sunrise and rises more rapidly in response to the arrival of sunset. Its outage time is less than 2.5 MHz.

The average measured data is in general agreement with the pattern established by the predicted data. Both are similar in terms of performance levels, reliability, and response to daytime and nighttime hours although it did drop off slightly earlier than expected at sunrise and recovered slightly following sunset.

c. 10 MHz Data

The predicted data indicates that this frequency tends to propagate almost thoughout the entire 24 hour period. However, peak propagation occurs during nighttime hours when there is minimal absorption. Performance drops during the daylight hours, reaching a minimum at approximately an hour following local noontime. This can be attributed to the effects of D-layer ionization and resulting absorption losses. As the sun starts to set, the signal-to-noise ratio levels return to their high levels. Unlike 2.5 MHz and 5.0 MHz, this frequency has the greatest reliability (i.e., least amount of predicted outage duration), very high signal-to-noise ratio performance, and is affected very gradually by sunrise and sunset.

The average measured data is in excellent agreement with the pattern established by the predicted data. The measured data also reflects similar reliability and performance. It also indicates that best performance occurs at night and that minimum performance occurs around noontime. Signal-to-noise ratios at night, however, were much higher than anticipated from the IONCAP prediction.

d. 15 MHz Data

The predicted data indicates that this frequency tends to propagated best from about an hour after sunrise to late evening hours. However, signal-to-noise ratios sharply drop off resulting in an outage just before sunrise. This can be accounted for by low F-layer ionization at this time period. Following the onset of sunrise, its performance quickly rebounds and is fairly constant throughout the day. This frequency appears to give good reliability and overall performance.

The average measured data is in good agreement with the pattern established by the predicted data. A drop off in signal-to-noise ratio occurs late in the night just before sunrise. It also reflects the same general level of reliability and performance of the predictions with the exception that no observable outage occurred during the measurement period. Additionally, the daytime dropoff in performance appeared following noontime which corresponded closely to the peak in absorption due to E layer ionization.

e. 20 MHz Data

The predicted data indicated that this frequency almost solely propagates during daylight hours, when the F-layer has a sufficient ionization level to support this type of propagation. Performance drops off in the evening and suffers an outage until an hour after sunrise. The frequency lacks some of the reliability and performance levels of 15 MHz since it is supported largely in the daytime hours only.

The average measured data is in very good agreement with the predicted data and follows a similar pattern. Peak performance occurs during daylight hours, and minimum performance occurs during nighttime hours. It also responds to arrival of sunrise and sunset at roughly the identical predicted time and in a similar manner in regard to rate of rise and fall of signal-to-noise ratio. The data recorded for the nighttime was slightly higher than predicted, and it was almost identical or slightly lower for daylight hours.

5.3 WWV and CHU Predicted vs. Measured Reliability

Each of the predictions and measurements for WWV and CHU were analyzed for the total number of hours (out of a 24 hour day) for which the signal-to-noise ratio was at or above 6 DB. In the case of the measured data, occurrences of 6 DB or higher were counted for any given hour, even if it occurred in only one day.

These findings are summarized in the WWV and CHU predicted and measured reliability bar chart showing the respective frequencies. For the CHU case, both the 7.350 MHz predicted and measured frequency had the greatest overall reliability. For the WWV case, 10 MHz had the greatest predicted reliability but 10 MHz and 15 MHz each had the greatest number of hours in which the signal-to-noise ratio was measured at 6 DB or higher.

PREDICTED AND MEASURED
HOURS ABOVE 6 DB S/N RATIO

WWV PREDICTED

2.5	5.0	10.0	15.0	20.0
9	15	22	21	22

WWV MEASURED

2.5	5.0	10.0	15.0	20.0
11	15	24	24	20

CHU PREDICTED

3.330	7.350	14.670
19	21	11

CHU MEASURED

3.330	7.350	14.670
23	24	22

6.0 CONCLUSIONS

1. The diurnal changes for radio frequency propagation from WWV and CHU exhibited very close correspondence to IONCAP predictions. Although a limited amount of data was collected, the resulting averages appeared to be closely correlated with predicted time outage durations and values of predicted signal-to-noise ratio. In general, measurements made on both the WWV and CHU paths to Lexington were very agreeable with IONCAP predictions.

2. Onset of sunrise and sunset, along with the noontime position of the sun, appear to identify the major time-related events affecting increases or decreases in observed signal-to-noise ratio performance. The physical processes in the ionosphere which affect the D, E, and F layers therefore appear to be closely correlated to these events. These processes thus appear to govern the structure of the ionized layers which determine the characteristics of each of the observed frequencies. Therefore, the diurnal variation of the received frequencies appear to be strongly correlated to the daily solar cycle.

3. Geomagnetic disturbances, monitored on WWV solar activity alert broadcasts, did appear to influence ionospheric behavior to some extent so that some measurements did not always achieve their expected values. As an example, this appeared to occur on the highest frequency (14.670 MHz) for the north-south path from CHU to Lexington, MA. This difference in behavior between predicted and measured results could be attributed to geomagnetic storm conditions which have a tendency to depress propagation performance in higher latitudes. As a result, the high levels of signal-to-noise ratio expected for this path did not materialize as often as had been expected.

4. IONCAP predictions can be used with great confidence to predict forecasts of propagation. Using this prediction technique, it is observed that close correlation exists between the propagation predictions and actual measurements when taken on an average basis. I believe that if more data was taken, the overall average measured performance would be even closer to the predictions. It should be noted that the IONCAP predictions correspond to quiet conditions for geomagnetic activity levels although these conditions don't always exist in nature. Additionally, the IONCAP predictions did not appear to be too sensitive to sunspot number variations since the actual equivalent sunspot number at times was much higher than used in the propagation forecasts.

5. When considering diurnal variation, HF signal reception can be improved when 2 or more widely separated frequencies are used.

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NOTE: JASON HANDWERKER IS NOW:

DR. JASON HANDWERKER / N1UEQ

4. IONSOUND HDX TURBO SOFTWARE PREDICTIONS

SkyWave Technologies Products

- IONSOUND HDX
  - -Introductory Software
  - -Bundled with ARRL Antenna Book
  - -Accommodates QST 'How's DX?'
- IONSOUND HDX TURBO
  - -Added features to HDX version
  - -Permits unrestricted Lat/Lon entry
- IONSOUND STD
  - -Simulated IONOGRAM graphics
- IONSOUND PRO
  - -Added features to STD version

IONSOUND Software Features

- Menu Driven MMI
- Prestored Variables
- Default Parameters
- Tabular Summaries
  - 24 Hour Total Rel, Path & Sig Avail, S/N, Ang, dBuV, E/F Hops, S-Meter Sig Level; Indiv. Times
- Color/BW Support
- Prestored Tx/Rx Locations/Freq List
  -User Modifiable
- Auto Co-Processor Support
- Ant Gain Summary
- Antenna Height & Hop Dist. Analysis
- Dist/Bearing Table
- Chirp Plot Graphics

Add'l Contest & DXing Features of IONSOUND HDX TURBO Software

- ASCII Location File Selectable for TX/RX
  - -Contains Prefixes, ITU & CQ Zones
  - -Printable Dist./Bearing from Main Menu
- Utilize Current Solar Flux for Robustness
- Forecast 'Look-Ahead' Predictions Using Projected Solar Flux/Sun Spot Values
- Analyze Antenna Stacking for Pattern Peaks/Nulls vs. E/F Hop Distances vs. SF
- Predict Optimum Band Opening/Closing Times With Different Working Conditions
  - -Maximize QSO Rates; Enhance QRP Ops

Propagation Prediction Variables

- Locations
  - -Lat/Lon entry
  - -DXCC list
- Tx Power Level
- Rx Noise Criteria
  - -Rural/Res/City
- Rx Bandwidth
- Rx SNR Criteria
- E/F Mode Search
- Antenna Choices
  - -Independent Tx/Rx
  - -Gain/Pattern Model
- Min. Elevation Ang.
- Short or Long Path
- SSN or SFN Entry
- Time and Month
- Frequencies
- E/F Layer Height

Opening Screen for IONSOUND HDX TURBO

Welcome to IONSOUND HDX TURBO
Version 3.00 by
Jacob Handwerker / W1FM
SkyWave Technologies
17 Pine Knoll Road
Lexington, MA 02173 USA

This software is intended to complement the IONCAP predictions found in ARRL's QST magazine How's DX? column. Although the HDX software primarily represents a subset of most capabilities found in the more advanced IONSOUND versions, it provides many of the same features. The first 14 locations available for transmitter and receiver selection are identical to those shown in QST; all 21 are usable for a wide variety of geographic predictions. IONSOUND HDX TURBO provides unrestricted latitude/longitude location choices by allowing location selections from a selected file or manual lat/lon entry.

IONSOUND HDX finds today's date is: 09-13-1994
Hit <ENTER> key to continue or a number 1-12 to select a new month:

Solar Flux Number (SFN)= 84 from default parameter file
Hit <ENTER> key to choose SFN from default file or
Input a SFN (equal to or greater than 63.75) <ENTER>

TX and RX Location Screens

***** TRANSMIT LOCATION SELECTION MENU *****

Alaska	1	Central America	15
Australia	2	East Mediterranean	16
Central Asia	3	Indian Ocean	17
East Coast (USA)	4	Northeast (USA)	18
Eastern Europe	5	Northwest (USA)	19
Hawaii	6	Southeast (USA)	20
Japan	7	Southwest (USA)	21
Midwest (USA)	8		
Puerto Rico	9		
South America	10		
South Pacific	11		
Southern Africa	12		
West Coast (USA)	13	LAT/LON entry	22
Western Europe	14	Select from File	23

Enter Transmitter Selection 1-23 < 18 >

***** RX LOCATION SELECTION MENU *****

Alaska	1	Central America	15
Australia	2	East Mediterranean	16
Central Asia	3	Indian Ocean	17
East Coast (USA)	4	Northeast (USA)	18
Eastern Europe	5	Northwest (USA)	19
Hawaii	6	Southeast (USA)	20
Japan	7	Southwest (USA)	21
Midwest (USA)	8		
Puerto Rico	9		
South America	10		
South Pacific	11		
Southern Africa	12		
West Coast (USA)	13	LAT/LON entry	22
Western Europe	14	Select from File	23

Enter Receiver Selection 1-23 < 14 >

Main Menu and Prediction Time

```
Today's Date         ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994          *  Copyright (C) 1994  SkyWave Technologies  *
                     **********************************************
      (CURRENT VARIABLES)          |          (SELECTION CHOICES)
Tx Location:  Northeast (USA)      | Pick Time/Display 24 Hour Summary        0
   Lat= 42.35    Lon=  71.05  deg  | TX/RX Locations & S/L Path               1
   Tx Location Noise: RES          | Sunspot/Solar Flux Number (SSN/SFN)      2
Rx Location:  Western Europe       | Frequency Menu (ALL MF/HF AMATEUR)       3
   Lat= 51.5     Lon= .2  deg      | Month Menu                               4
   Rx Location Noise: RURAL        | Variables (Noise/Ant/BW/SNR/Pwr...)      5
Tx-->Rx Bearing= 53 deg  Path= S   | Propagation Mode Menu                    6
Distance=  3266 mi       5256 km   | TX Power Level                           7
   Tx Power= 1 kw                  | Minimum Elevation Angle Menu             8
   Rx Bandwidth= 3000  Hz          | Swap TX/RX Locations                     9
   Rx min. S/N Ratio= 10  dB       | Color Selection Menu                     10
   Tx Ant: (Y)agi-Uda              | Go to DOS (Type 'EXIT' To Return)        11
   Rx Ant: (Y)agi-Uda              | E/F Layer Height Menu                    12
Sunspot Num= 28  Solar Flux= 85    | Tabulate TX/RX Antenna Gains             13
Layer Ht HF2= 289 km   HE= 115 km  | Calculate Antenna Lobes/Nulls            14
Min Elev Ang= 5    E/F Ht Change= N| Choose New Lat/Lon/Cty File              15
Min F Hops= 2F    F Hop Ang= 6 deg | Print Distance/Bearing Table             16
24 Hr Summary Types=  8 (8 max.)   | Select 24 Hour Summary Types/Order       17
Last Selected Mon= 9  Next Mon= 9  | Store or Load Default Variables/EXIT     18

         Enter Choice: (Default=Pick Time/Display: Type 0 or ENTER)
```

```
Choose Prediction Time (UTC)
         One single time from hour 1-24     (HH) or (HH.MM)
         Every hour (1..24) one at a time    25
         Separate individual times           26
         Time interval using time step       27
         24 Hour Summary Table               28
         Main Menu                           29
Enter Choice  (Default = Return for 24 Hr Summary)
```

24 Hour Summary - Total Reliability Percentage

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	11.9	0	100	100	100	62	7			
1	10.2	0	100	100	91	31				
2	8.6	1	100	100	63					
3	8.6	1	100	100	61					
4	8.6	0	100	100	53					
5	8.6	0	99	100	38					
6	8.7	0	90	100	39					
7	10.5	0	64	70	40					
8	9.1	0	0	31						
9	12.3	0		91						
10	14.6	0	0		44	25				
11	11.5	0	0	0	20					
12	16.4	0	0	0	31	11	5			
13	16.9	0	0	0	29	33	26			
14	17.3	0	0	0	25	51	43			
15	17.5	0	0	0	26	65	55	6		
16	17.5	0	0	0	36	75	64	15		
17	17.3	0	0	0	57	81	69	22		
18	17.0	0	0	0	80	83	70	25		
19	16.5	0	0		93	81	68	25		
20	15.8	0		88	99	100	65	25		
21	15.2	0	0	92	100	100	59	21		
22	14.2	0	62	100	100	94	46	11		
23	13.1	0	98	100	100	80	29			

```
 TOTREL%
==========
Northeast
(USA)->
Western Eu
rope
 (S PATH)
BRNG= 53
 3266 mi
 5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
  RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon=  9
==========
Screen 1/8
  (C/Q)
```

24 Hour Summary - S-Meter Readings

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	11.9	5	9	9+5	9+6	9+6	9+6			
1	10.2	5	9+1	9+5	9+6	9+6				
2	8.6	6	9+2	9+5	9+6					
3	8.6	6	9+2	9+5	9+6					
4	8.6	5	9+1	9+5	9+6					
5	8.6	5	9	9+5	9+6					
6	8.7	4	8	9+4	9+5					
7	10.5	0	6	9	9+4					
8	9.1	0	2	6						
9	12.3	0		6						
10	14.6	0	0		7	9				
11	11.5	0	0	2	6					
12	16.4	0	0	1	5	8	9			
13	16.9	0	0	1	4	8	9			
14	17.3	0	0	1	4	8	9			
15	17.5	0	0	1	4	8	9	9+1		
16	17.5	0	0	1	4	8	9	9+1		
17	17.3	0	0	1	5	8	9	9+2		
18	17.0	0	0	2	5	8	9+1	9+2		
19	16.5	0	0		6	9	9+2	9+3		
20	15.8	0		6	8	9+1	9+4	9+4		
21	15.2	0	1	6	9	9+3	9+5	9+5		
22	14.2	0	6	9	9+4	9+5	9+6	9+6		
23	13.1	4	8	9+4	9+5	9+6	9+6			

S Mtr+dB
==========
Northeast
(USA)->
Western Eu
rope
(S PATH)
BRNG= 53
3266 mi
5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon= 9
==========
Screen 2/8
<C/Q>

24 Hour Summary - Signal-to-Noise (S/N) Ratio

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	11.9	-4	32	43	45	44	44			
1	10.2	-1	34	43	45	44				
2	8.6	2	35	43	45					
3	8.6	1	35	43	45					
4	8.6	-2	34	43	45					
5	8.6	-4	29	43	45					
6	8.7	-9	22	42	45					
7	10.5	-31	12	34	43					
8	9.1	-60	-12	20						
9	12.3	-104		19						
10	14.6	-157	-45		25	36				
11	11.5	-214	-66	-6	16					
12	16.4	-254	-81	-11	12	29	38			
13	16.9	-278	-90	-14	9	28	37			
14	17.3	-291	-94	-15	7	27	37			
15	17.5	-292	-95	-15	7	27	37	38		
16	17.5	-281	-91	-14	8	28	37	39		
17	17.3	-258	-82	-11	11	29	38	39		
18	17.0	-221	-68	-7	15	31	39	40		
19	16.5	-167	-49		20	33	40	41		
20	15.8	-114		17	30	39	42	42		
21	15.2	-67	-15	19	35	42	43	43		
22	14.2	-30	12	34	43	43	44	43		
23	13.1	-8	26	42	45	44	44			

S/N(dB)
==========
Northeast
(USA)->
Western Eu
rope
(S PATH)
BRNG= 53
3266 mi
5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon= 9
==========
Screen 3/8
<C/Q>

24 Hour Summary - Signal Levels (dBuV)

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0	DBuV(dB)
0	11.9	10	36	42	43	43	43				==========
1	10.2	13	38	42	43	43					Northeast
2	8.6	15	39	42	43						(USA)->
3	8.6	15	39	42	43						Western Eu
4	8.6	12	38	42	43						rope
5	8.6	10	33	42	43						(S PATH)
6	8.7	5	26	41	42						BRNG= 53
7	10.5	-17	16	33	41						3266 mi
8	9.1	-46	-8	19							5256 km
9	12.3	-90		17							MinEL= 5
10	14.6	-143	-41		23	35					Min F Hop=
11	11.5	-201	-62	-7	14						2F 6 deg
12	16.4	-240	-77	-12	10	28	37				SSN= 28
13	16.9	-265	-86	-15	7	27	36				SFN= 85
14	17.3	-277	-91	-16	5	26	35				Rx Noise=
15	17.5	-278	-91	-16	5	26	35	38			RURAL
16	17.5	-267	-87	-15	6	27	36	38			Ant= Y/Y
17	17.3	-244	-78	-12	9	28	37	39			BW= 3000
18	17.0	-207	-65	-8	13	30	38	39			Kw= 1
19	16.5	-153	-45		18	32	39	40			SNR= 10
20	15.8	-100		16	28	38	41	41			Mon= 9
21	15.2	-53	-11	18	33	40	42	42			==========
22	14.2	-17	15	33	41	42	43	43			Screen 4/8
23	13.1	5	30	41	42	43	43				(C/Q)

24 Hour Summary - Takeoff Angles

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0	ANG(deg)
0	11.9	6	6	6	6	6	6				==========
1	10.2	20	6	6	6	6					Northeast
2	8.6	20	6	6	6						(USA)->
3	8.6	20	6	6	6						Western Eu
4	8.6	20	6	6	6						rope
5	8.6	6	14	6	6						(S PATH)
6	8.7	6	10	6	6						BRNG= 53
7	10.5	6	6	14	6						3266 mi
8	9.1	6	10	20							5256 km
9	12.3	6		6							MinEL= 5
10	14.6	6	6		14	6					Min F Hop=
11	11.5	6	6	6	20						2F 6 deg
12	16.4	6	6	6	20	14	6				SSN= 28
13	16.9	6	6	6	20	14	6				SFN= 85
14	17.3	6	6	6	20	14	6				Rx Noise=
15	17.5	6	6	6	20	14	6	6			RURAL
16	17.5	6	6	6	20	14	6	6			Ant= Y/Y
17	17.3	6	6	6	20	14	6	6			BW= 3000
18	17.0	6	6	6	20	14	6	6			Kw= 1
19	16.5	6	6		20	14	6	6			SNR= 10
20	15.8	6		6	14	6	6	6			Mon= 9
21	15.2	6	10	20	14	6	6	6			==========
22	14.2	6	6	14	6	6	6	6			Screen 5/8
23	13.1	6	14	6	6	6	6				(C/Q)

24 Hour Summary - Lowest Order E and F Hop Modes

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	11.9	4E	2F	2F	2F	2F	2F			
1	10.2	4F	2F	2F	2F	2F				
2	8.6	4F	2F	2F	2F					
3	8.6	4F	2F	2F	2F					
4	8.6	4F	2F	2F	2F					
5	8.6	4E	3F	2F	2F					
6	8.7	4E	2FE	2F	2F					
7	10.5	4E	F2E	3F	2F					
8	9.1	4E	F3E	4F						
9	12.3	4E		F2E						
10	14.6	4E	4E		3F	2F				
11	11.5	4E	4E	4E	4F					
12	16.4	4E	4E	4E	4F	3F	2F			
13	16.9	4E	4E	4E	4F	3F	2F			
14	17.3	4E	4E	4E	4F	3F	2F			
15	17.5	4E	4E	4E	4F	3F	2F	2F		
16	17.5	4E	4E	4E	4F	3F	2F	2F		
17	17.3	4E	4E	4E	4F	3F	2F	2F		
18	17.0	4E	4E	4E	4F	3F	2F	2F		
19	16.5	4E	4E		4F	3F	2F	2F		
20	15.8	4E		2EF	3F	2F	2F	2F		
21	15.2	4E	3EF	4F	3F	2F	2F	2F		
22	14.2	4E	2EF	3F	2F	2F	2F	2F		
23	13.1	4E	3F	2F	2F	2F	2F			

E/F Hops
==========
Northeast
(USA)->
Western Eu
rope
(S PATH)
BRNG= 53
3266 mi
5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon= 9
==========
Screen 6/8
(C/Q)

24 Hour Summary - Path Reliability Percentage

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	11.9	100	100	100	100	62	7			
1	10.2	100	100	100	91	31				
2	8.6	100	100	100	63					
3	8.6	100	100	100	61					
4	8.6	100	100	100	53					
5	8.6	100	100	100	38					
6	8.7	100	93	100	39					
7	10.5	100	100	70	40					
8	9.1	100	67	33						
9	12.3	100		100						
10	14.6	100	100		45	26				
11	11.5	100	100	100	24					
12	16.4	100	100	100	48	11	5			
13	16.9	100	100	100	71	33	26			
14	17.3	100	100	100	91	52	43			
15	17.5	100	100	100	100	66	55	6		
16	17.5	100	100	100	100	76	64	15		
17	17.3	100	100	100	100	82	69	22		
18	17.0	100	100	100	100	83	70	25		
19	16.5	100	100		100	81	68	25		
20	15.8	100		100	100	100	65	25		
21	15.2	100	100	100	100	100	60	21		
22	14.2	100	100	100	100	94	46	11		
23	13.1	100	100	100	100	80	29			

PATHREL%
==========
Northeast
(USA)->
Western Eu
rope
(S PATH)
BRNG= 53
3266 mi
5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon= 9
==========
Screen 7/8
(C/Q)

24 Hour Summary - Signal Reliability Percentage

UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	11.9	0	100	100	100	100	100			
1	10.2	0	100	100	100	100				
2	8.6	1	100	100	100					
3	8.6	1	100	100	100					
4	8.6	0	100	100	100					
5	8.6	0	99	100	100					
6	8.7	0	96	100	100					
7	10.5	0	64	100	100					
8	9.1	0	0	94						
9	12.3	0		91						
10	14.6	0	0		98	100				
11	11.5	0	0	0	83					
12	16.4	0	0	0	63	99	100			
13	16.9	0	0	0	41	99	100			
14	17.3	0	0	0	28	99	100			
15	17.5	0	0	0	26	99	100	100		
16	17.5	0	0	0	36	99	100	100		
17	17.3	0	0	0	57	99	100	100		
18	17.0	0	0	0	80	99	100	100		
19	16.5	0	0		93	100	100	100		
20	15.8	0		88	99	100	100	100		
21	15.2	0	0	92	100	100	100	100		
22	14.2	0	62	100	100	100	100	100		
23	13.1	0	98	100	100	100	100			

```
SIGREL%
==========
Northeast
(USA)->
Western Eu
rope
 (S PATH)
BRNG= 53
 3266 mi
 5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
 RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon=  9
==========
Screen 8/8
 (C/Q)
```

Main Menu Showing Display of Antenna Gain Selected

```
Today's Date         ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994          *  Copyright (C) 1994  SkyWave Technologies  *
                     **********************************************
      (CURRENT VARIABLES)           ¦        (SELECTION CHOICES)
Tx Location:  Northeast (USA)       ¦ Pick Time/Display 24 Hour Summary     0
   Lat= 42.35     Lon=  71.05  deg  ¦ TX/RX Locations & S/L Path            1
   Tx Location Noise: RES           ¦ Sunspot/Solar Flux Number (SSN/SFN)   2
Rx Location:  Western Europe        ¦ Frequency Menu (ALL MF/HF AMATEUR)    3
   Lat= 51.5     Lon= .2  deg       ¦ Month Menu                            4
   Rx Location Noise: RURAL         ¦ Variables (Noise/Ant/BW/SNR/Pwr...)   5
Tx-->Rx Bearing= 53 deg  Path= S    ¦ Propagation Mode Menu                 6
Distance=  3266 mi       5256 km    ¦ TX Power Level                        7
   Tx Power= 1 kw                   ¦ Minimum Elevation Angle Menu          8
   Rx Bandwidth= 3000  Hz           ¦ Swap TX/RX Locations                  9
   Rx min. S/N Ratio= 10  dB        ¦ Color Selection Menu                  10
   Tx Ant: (Y)agi-Uda               ¦ Go to DOS (Type 'EXIT' To Return)     11
   Rx Ant: (Y)agi-Uda               ¦ E/F Layer Height Menu                 12
Sunspot Num= 28  Solar Flux= 85     ¦ Tabulate TX/RX Antenna Gains          13
Layer Ht HF2= 289 km   HE= 115 km   ¦ Calculate Antenna Lobes/Nulls         14
Min Elev Ang= 5   E/F Ht Change= N  ¦ Choose New Lat/Lon/Cty File           15
Min F Hops= 2F   F Hop Ang= 6 deg   ¦ Print Distance/Bearing Table          16
24 Hr Summary Types=  8 (8 max.)    ¦ Select 24 Hour Summary Types/Order    17
Last Selected Mon= 9  Next Mon= 9   ¦ Store or Load Default Variables/EXIT  18

        Enter Choice: (Default=Pick Time/Display: Type 0 or ENTER) 13
```

TX/RX Antenna Elevation Angle Gain Variation

*** Elevation Angle vs. Transmit and Receive ANT Gain Variation ***

ANG(deg)	Tx+Rx (num)	Tx (dB)	Rx (dB)	Tx+Rx (dB)	ANT Codes
1	9.492241	4.886844	4.886844	9.773687	Tx=Y Rx=Y
5	23.13322	6.821181	6.821181	13.64236	Tx=Y Rx=Y
10	67.31529	9.140569	9.140569	18.28114	Tx=Y Rx=Y
15	104.5586	10.0968	10.0968	20.1936	Tx=Y Rx=Y
20	109.2109	10.19133	10.19133	20.38266	Tx=Y Rx=Y
25	96.96384	9.933049	9.933049	19.8661	Tx=Y Rx=Y
30	80.99794	9.54237	9.54237	19.08474	Tx=Y Rx=Y
35	64.83851	9.059165	9.059165	18.11833	Tx=Y Rx=Y
40	49.59016	8.476977	8.476977	16.95395	Tx=Y Rx=Y
45	36.0019	7.781627	7.781627	15.56325	Tx=Y Rx=Y
50	24.58458	6.953314	6.953314	13.90663	Tx=Y Rx=Y
55	15.58719	5.963839	5.963839	11.92768	Tx=Y Rx=Y
60	9.001506	4.771576	4.771576	9.543152	Tx=Y Rx=Y
65	4.603479	3.315431	3.315431	6.630862	Tx=Y Rx=Y
70	2.025527	1.53269	1.53269	3.065381	Tx=Y Rx=Y
75	.7632784	-.5865852	-.5865852	-1.17317	Tx=Y Rx=Y
80	.2196722	-3.291125	-3.291125	-6.58225	Tx=Y Rx=Y
85	2.118986E-02	-8.369359	-8.369359	-16.73872	Tx=Y Rx=Y
89	4.083621E-05	-21.94477	-21.94477	-43.88955	Tx=Y Rx=Y

Hit Enter to Continue

TX and RX Antenna Selection Menu

```
Enter the number code for the following TRANSMIT Antenna or Gain

1)  10 dBi Gain Yagi-Uda array (over ground):                       1
2)  2.15 dBi gain Vertical Monopole (over ground):                  2
3)  5.2 dBi gain Horizontal or Vertical Dipole:                     3
4)  7 to 12 dBi Var. gain (1.8-30 MHz) Log Periodic & Rhombic:      4
5)  23 to 28 dBi Variable gain (1.8-30 MHz) Curtain array:          5
6)  -40 to +40 dBi: Choose your own Isotropic gain:                 6
ANT= (Y)agi-Uda              Enter Choice (Return= 0 dBi (I)sotropic): 1

Choose RX Antenna identical to TX Antenna: Y/N (Default = Y)          n

Enter the number code for the following RECEIVE Antenna or Gain

1)  10 dBi Gain Yagi-Uda array (over ground):                       1
2)  2.15 dBi gain Vertical Monopole (over ground):                  2
3)  5.2 dBi gain Horizontal or Vertical Dipole:                     3
4)  7 to 12 dBi Var. gain (1.8-30 MHz) Log Periodic & Rhombic:      4
5)  23 to 28 dBi Variable gain (1.8-30 MHz) Curtain array:          5
6)  -40 to +40 dBi: Choose your own Isotropic gain:                 6
ANT= (Y)agi-Uda              Enter Choice:  (Return= 0 dB (I)sotropic) 6
Total RX Gain (-40 to +40 dBi)  (Return= 0 dBi)  0
```

Main Menu Showing Antenna Lobes/Nulls Selected

```
Today's Date        ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994         *  Copyright (C) 1994  SkyWave Technologies  *
                    **********************************************
      (CURRENT VARIABLES)          |          (SELECTION CHOICES)
Tx Location:  Northeast (USA)      | Pick Time/Display 24 Hour Summary        0
   Lat= 42.35    Lon=  71.05  deg  | TX/RX Locations & S/L Path               1
   Tx Location Noise: RES          | Sunspot/Solar Flux Number (SSN/SFN)      2
Rx Location:  Western Europe       | Frequency Menu (ALL MF/HF AMATEUR)       3
   Lat= 51.5     Lon= .2  deg      | Month Menu                               4
   Rx Location Noise: RURAL        | Variables (Noise/Ant/BW/SNR/Pwr...)      5
Tx-->Rx Bearing= 53 deg  Path= S   | Propagation Mode Menu                    6
Distance=  3266 mi       5256 km   | TX Power Level                           7
   Tx Power= 1 kw                  | Minimum Elevation Angle Menu             8
   Rx Bandwidth= 3000  Hz          | Swap TX/RX Locations                     9
   Rx min. S/N Ratio= 10  dB       | Color Selection Menu                     10
   Tx Ant: (Y)agi-Uda              | Go to DOS (Type 'EXIT' To Return)        11
   Rx Ant: (Y)agi-Uda              | E/F Layer Height Menu                    12
Sunspot Num= 28  Solar Flux= 85    | Tabulate TX/RX Antenna Gains             13
Layer Ht HF2= 289 km   HE= 115 km  | Calculate Antenna Lobes/Nulls            14
Min Elev Ang= 5   E/F Ht Change= N | Choose New Lat/Lon/Cty File              15
Min F Hops= 2F   F Hop Ang= 6 deg  | Print Distance/Bearing Table             16
24 Hr Summary Types=  8 (8 max.)   | Select 24 Hour Summary Types/Order       17
Last Selected Mon= 9  Next Mon= 9  | Store or Load Default Variables/EXIT     18

        Enter Choice: (Default=Pick Time/Display: Type 0 or ENTER) 14
```

```
                  ********** ANTENNA LOBES AND NULLS **********

ENTER SELECTION OF ANTENNA HEIGHT UNITS:
        F=Feet or M=Meters   (Default = F)

Height above ground (ft): 65

Enter frequency (1.8-30 MHz) 21

Maximum number of Lobes desired (1-6) (DEFAULT=6)
```

Antenna Lobes/Nulls Calculation Summary

********** ANTENNA LOBES AND NULLS **********
Vertical Angle Calculations
for Antennas over Perfectly Conducting Ground
and One-Hop Distances for E-Layer & F-Layer Propagation
SS/FN= 28 / 84.83176   Frequency= 21 MHz

E-Layer ht= 115 km   F-Layer ht= 289 km   Ht of Antenna= 65 Feet

Segment	HORIZ Ant	VERT Ant	Angle	E Hop(km)	E Hop(mi)	F Hop(km)	F Hop(mi)
1	1ST PEAK	1ST NULL	10.37854	1013.876	629.9932	2091.553	1299.631
2	1ST NULL	1ST PEAK	21.1187	553.6707	344.035	1269.413	788.7764
3	2ND PEAK	2ND NULL	32.71436	344.321	213.9512	819.9174	509.4731
4	2ND NULL	2ND PEAK	46.10406	215.4898	133.8992	521.6332	324.1278
5	3RD PEAK	3RD NULL	64.25641	108.6083	67.48605	265.1528	164.7583

NO MORE LOBES/NULLS

FOR MORE LOBE/NULL CALCULATIONS TYPE Y OR N (DEFAULT=Y)

********** ANTENNA LOBES AND NULLS **********
Vertical Angle Calculations
for Antennas over Perfectly Conducting Ground
and One-Hop Distances for E-Layer & F-Layer Propagation
SS/FN= 28 / 84.83176   Frequency= 21 MHz

E-Layer ht= 115 km   F-Layer ht= 289 km   Ht of Antenna= 120 Feet

Segment	HORIZ Ant	VERT Ant	Angle	E Hop(km)	E Hop(mi)	F Hop(km)	F Hop(mi)
1	1ST PEAK	1ST NULL	5.599928	1457.14	905.425	2715.663	1687.435
2	1ST NULL	1ST PEAK	11.25426	955.6617	593.8207	1998.981	1242.109
3	2ND PEAK	2ND NULL	17.02235	678.844	421.8141	1514.916	941.3254
4	2ND NULL	2ND PEAK	22.9748	508.8018	316.1548	1177.127	731.4328
5	3RD PEAK	3RD NULL	29.20314	393.1849	244.3138	929.0298	577.2724
6	3RD NULL	3RD PEAK	35.83751	307.5285	191.0894	736.2131	457.4616
7	4TH PEAK	4TH NULL	43.08396	239.0222	148.5215	577.1449	358.6212
8	4TH NULL	4TH PEAK	51.32009	179.7239	111.6753	436.534	271.2496
9	5TH PEAK	5TH NULL	61.42944	122.5913	76.17471	299.0409	185.8154
10	5TH NULL	5TH PEAK	77.37072	50.50784	31.38411	123.6472	76.83079

NO MORE LOBES/NULLS

FOR MORE LOBE/NULL CALCULATIONS TYPE Y OR N (DEFAULT=Y) n

Main Menu Showing Frequency Data File Selected

```
Today's Date        ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994         *  Copyright (C) 1994  SkyWave Technologies  *
                    **********************************************
      {CURRENT VARIABLES}          |          {SELECTION CHOICES}
Tx Location:  Northeast (USA)      |  Pick Time/Display 24 Hour Summary     0
   Lat= 42.35    Lon=  71.05  deg  |  TX/RX Locations & S/L Path            1
   Tx Location Noise: RES          |  Sunspot/Solar Flux Number (SSN/SFN)   2
Rx Location:  Western Europe       |  Frequency Menu (ION_FREQ.DAT File)    3
   Lat= 51.5     Lon= .2  deg      |  Month Menu                            4
   Rx Location Noise: RURAL        |  Variables (Noise/Ant/BW/SNR/Pwr...)   5
Tx-->Rx Bearing= 53 deg  Path= S   |  Propagation Mode Menu                 6
Distance=  3266 mi       5256 km   |  TX Power Level                        7
   Tx Power= 1 kw                  |  Minimum Elevation Angle Menu          8
   Rx Bandwidth= 3000  Hz          |  Swap TX/RX Locations                  9
   Rx min. S/N Ratio= 10  dB       |  Color Selection Menu                  10
   Tx Ant: (Y)agi-Uda              |  Go to DOS (Type 'EXIT' To Return)     11
   Rx Ant: (Y)agi-Uda              |  E/F Layer Height Menu                 12
Sunspot Num= 28  Solar Flux= 85    |  Tabulate TX/RX Antenna Gains          13
Layer Ht HF2= 289 km   HE= 115 km  |  Calculate Antenna Lobes/Nulls         14
Min Elev Ang= 5   E/F Ht Change= N |  Choose New Lat/Lon/Cty File           15
Min F Hops= 2F   F Hop Ang= 6 deg  |  Print Distance/Bearing Table          16
24 Hr Summary Types=  8 (8 max.)   |  Select 24 Hour Summary Types/Order    17
Last Selected Mon= 9  Next Mon= 9  |  Store or Load Default Variables/EXIT  18

          Enter Choice: (Default=Pick Time/Display: Type 0 or ENTER)
```

24 Hour Summary Showing Prestored Frequencies

```
Prestored Frequencies from ION_FREQ.DAT are as follows
         Frequency #  1      =     2.5       MHz
         Frequency #  2      =     5         MHz
         Frequency #  3      =     10        MHz
         Frequency #  4      =     15        MHz
         Frequency #  5      =     20        MHz

Type Y (Continue) or N (Return to Freq Menu) (Default=Continue)
```

UTC	MUFo MHz	2.5	5.0	10.0	15.0	20.0
0	11.9	87	100	100	48	
1	10.2	94	100	93	16	
2	8.6	95	100	65		
3	8.6	95	100	63		
4	8.6	93	100	55		
5	8.6	57	100	40		
6	8.7	0	100	41		
7	10.5		98	42		
8	10.8	0	85			
9	10.4	0	0			
10	14.6	0			6	
11	15.7	0	0	22	36	
12	16.4	0	0	30	60	
13	16.9	0	0	26	80	
14	17.3	0	0	20	96	10
15	17.5	0	0	20	44	23
16	17.5	0	0	30	54	32
17	17.3	0	0	53	61	38
18	17.0	0	0	78	63	40
19	16.5	0		92	100	40
20	15.8	0	0	99	100	39
21	15.2	0	80	100	96	34
22	14.2	0	98	100	82	23
23	13.1	1	100	100	68	5

```
TOTREL%
==========
Northeast
(USA)->
Western Eu
rope
 (S PATH)
BRNG= 53
 3266 mi
 5256 km
MinEL= 5
Min F Hop=
2F 6 deg
SSN= 28
SFN= 85
Rx Noise=
  RURAL
Ant= Y/Y
BW= 3000
Kw= 1
SNR= 10
Mon=  9
==========
Screen 1/8
 (C/Q)
```

Main Menu Showing Effect of TX/RX Location Swap

```
Today's Date       ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994        *  Copyright (C) 1994  SkyWave Technologies  *
                   **********************************************
      (CURRENT VARIABLES)          |        (SELECTION CHOICES)
Tx Location:  Western Europe       |  Pick Time/Display 24 Hour Summary       0
   Lat= 51.5    Lon=  .2  deg      |  TX/RX Locations & S/L Path              1
   Tx Location Noise: RURAL        |  Sunspot/Solar Flux Number (SSN/SFN)     2
Rx Location:  Northeast (USA)      |  Frequency Menu (ION_FREQ.DAT File)      3
   Lat= 42.34    Lon= 71.05  deg   |  Month Menu                              4
   Rx Location Noise: RES          |  Variables (Noise/Ant/BW/SNR/Pwr...)     5
Tx-->Rx Bearing= 288 deg  Path= S  |  Propagation Mode Menu                   6
Distance=  3266 mi      5256 km    |  TX Power Level                          7
   Tx Power= 1 kw                  |  Minimum Elevation Angle Menu            8
   Rx Bandwidth= 3000  Hz          |  Swap TX/RX Locations                    9
   Rx min. S/N Ratio= 10  dB       |  Color Selection Menu                    10
   Tx Ant:  0 dBi (G)ain, Iso.     |  Go to DOS (Type 'EXIT' To Return)       11
   Rx Ant: (Y)agi-Uda              |  E/F Layer Height Menu                   12
Sunspot Num= 28  Solar Flux= 85    |  Tabulate TX/RX Antenna Gains            13
Layer Ht HF2= 289 km   HE= 115 km  |  Calculate Antenna Lobes/Nulls           14
Min Elev Ang= 5   E/F Ht Change= N |  Choose New Lat/Lon/Cty File             15
Min F Hops= 2F   F Hop Ang= 6 deg  |  Print Distance/Bearing Table            16
24 Hr Summary Types=  8 (8 max.)   |  Select 24 Hour Summary Types/Order      17
Last Selected Mon= 9  Next Mon= 9  |  Store or Load Default Variables/EXIT    18

         Enter Choice: (Default=Pick Time/Display: Type 0 or ENTER)
```

Main Menu Followed by Color Selections

```
Today's Date       ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994        *  Copyright (C) 1994  SkyWave Technologies  *
                   **********************************************
      (CURRENT VARIABLES)          |        (SELECTION CHOICES)
Tx Location:  Northeast (USA)      |  Pick Time/Display 24 Hour Summary       0
   Lat= 42.35    Lon=  71.05  deg  |  TX/RX Locations & S/L Path              1
   Tx Location Noise: RES          |  Sunspot/Solar Flux Number (SSN/SFN)     2
Rx Location:  Western Europe       |  Frequency Menu (ION_FREQ.DAT File)      3
   Lat= 51.5    Lon= .2  deg       |  Month Menu                              4
   Rx Location Noise: RURAL        |  Variables (Noise/Ant/BW/SNR/Pwr...)     5
Tx-->Rx Bearing= 53 deg  Path= S   |  Propagation Mode Menu                   6
Distance=  3266 mi      5256 km    |  TX Power Level                          7
   Tx Power= 1 kw                  |  Minimum Elevation Angle Menu            8
   Rx Bandwidth= 3000  Hz          |  Swap TX/RX Locations                    9
   Rx min. S/N Ratio= 10  dB       |  Color Selection Menu                    10
   Tx Ant: (Y)agi-Uda              |  Go to DOS (Type 'EXIT' To Return)       11
   Rx Ant:  0 dBi (G)ain, Iso.     |  E/F Layer Height Menu                   12
Sunspot Num= 28  Solar Flux= 85    |  Tabulate TX/RX Antenna Gains            13
Layer Ht HF2= 289 km   HE= 115 km  |  Calculate Antenna Lobes/Nulls           14
Min Elev Ang= 5   E/F Ht Change= N |  Choose New Lat/Lon/Cty File             15
Min F Hops= 2F   F Hop Ang= 6 deg  |  Print Distance/Bearing Table            16
24 Hr Summary Types=  8 (8 max.)   |  Select 24 Hour Summary Types/Order      17
Last Selected Mon= 9  Next Mon= 9  |  Store or Load Default Variables/EXIT    18

         Enter Choice: (Default=Pick Time/Display: Type 0 or ENTER)
```

```
                    ***** COLOR SELECTION MENU *****

              Color Set 1 (YELLOW Text on BLACK)  Type 1
              Color Set 2 (YELLOW Text on RED)    Type 2
              Color Set 3 (BLUE Text on WHITE)    Type 3
              Color Set 4 (Normal WHITE on BLACK) Type 4
              Color Set 5 (WHITE Text on BLUE)    Type 5
              Color Set 6 (BLACK Text on WHITE)   Type 6
              Color Set 7 (YELLOW Text on BLUE)   Type 7
              Color Set 8 (WHITE Text on GREEN)   Type 8
              Color Set 9 (WHITE Text on BLACK)   Type 9

                  [NOTE: Actual Monitor Colors may vary]

                     Enter Selection  (Default = 5)        4

         For EGA or VGA Color Monitor Type Y; CGA Type N  (Y)
```

TX and RX Location Selections

TX LOC is: Northeast (USA) Lat= 42.35 Lon= 71.05

RX LOC is: Western Europe Lat= 51.5 Lon= .2

Dist= 3266 Miles (S PATH) Front/Back Bearing at TX= 53 / 233 degrees

Previous Transmitter Location? Type Y or N (ENTER=Yes) y

TX LOC is: Northeast (USA) LAT= 42.35 LON= 71.05

RX LOC is: Western Europe LAT= 51.5 LON= .2

DIST= 3266 Miles (S PATH) Front/Back Bearing at Tx= 53 / 233 DEGREES

Previous Receiver Location? Type Y or N (ENTER=No) n

***** RX LOCATION SELECTION MENU *****

Alaska	1	Central America	15
Australia	2	East Mediterranean	16
Central Asia	3	Indian Ocean	17
East Coast (USA)	4	Northeast (USA)	18
Eastern Europe	5	Northwest (USA)	19
Hawaii	6	Southeast (USA)	20
Japan	7	Southwest (USA)	21
Midwest (USA)	8		
Puerto Rico	9		
South America	10		
South Pacific	11		
Southern Africa	12		
West Coast (USA)	13	LAT/LON entry	22
Western Europe	14	Select from File	23

Enter Receiver Selection 1-23 (14) 23

Location Selection Screen

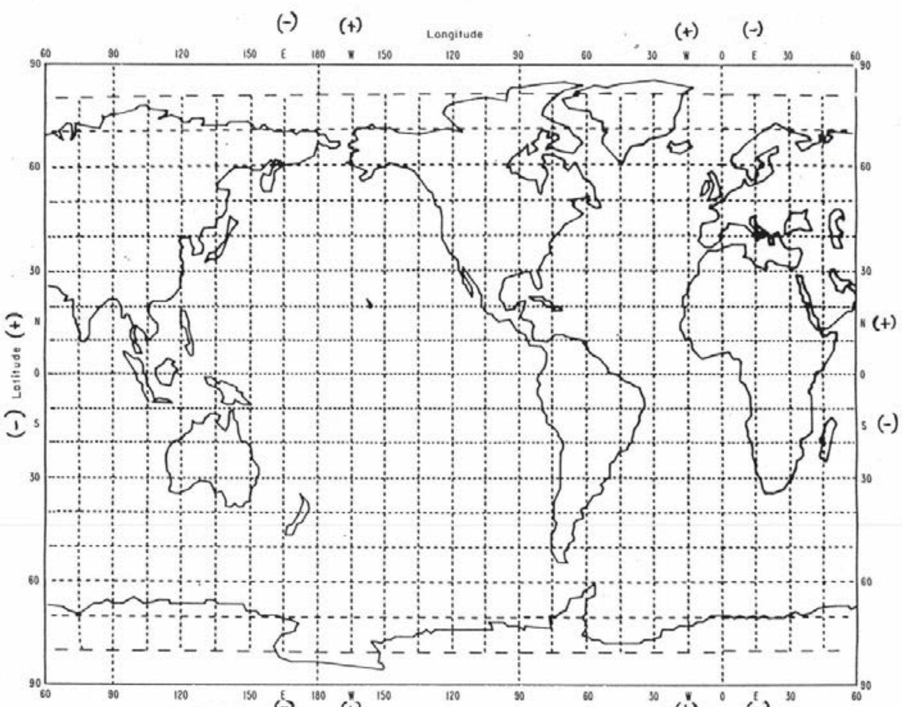
NUM	PREFIX	COUNTRY	CONTINENT	ITU ZONE	CQ ZONE
1	1A0	S.M.O. of Malta	EU	28	15
2	1S	Spratly Island	AS	50	26
3	3A	Monaco	EU	27	14
4	3B6	Agalega	AF	53	39
5	3B7	St. Brandon	AF	53	39
6	3B8	Mauritius	AF	53	39
7	3B9	Rodriguez Is.	AF	53	39
8	3C	Equatorial Guinea	AF	47	36
9	3C0	Pagalu Island	AF	52	36
10	3D2	Fiji	OC	56	32
11	3D2/R	Rotuma Island	OC	56	32
12	3D6	Swaziland	AF	57	38
13	3V	Tunisia	AF	37	33
14	3W	Vietnam	AS	49	26
15	3X	Rep. of Guinea	AF	46	35
16	3Y/B	Bouvet Island	AF	67	38
17	3Y/P	Peter Island	AN	72	12
18	4K2	Franz Josef Land	EU	75	40
19	4S	Sri Lanka	AS	41	22
20	4U/ITU	ITU Geneva	EU	28	14

Choose Number 1 - 20 or Hit ENTER for More Choices (ENTER=More)

Latitude/Longitude Entry Screen

```
***** RX LOCATION SELECTION MENU *****

Alaska              1          Central America       15
Australia           2          East Mediterranean    16
Central Asia        3          Indian Ocean          17
East Coast (USA)    4          Northeast (USA)       18
Eastern Europe      5          Northwest (USA)       19
Hawaii              6          Southeast (USA)       20
Japan               7          Southwest (USA)       21
Midwest (USA)       8
Puerto Rico         9
South America       10
South Pacific       11
Southern Africa     12
West Coast (USA)    13         LAT/LON entry         22
Western Europe      14         Select from File      23


Enter Receiver Selection 1-23  ( 23 )   22



Enter Receiver Location (18 Char Max.)          Your Qth
   Decimal Degrees?  Enter Y/N (Y)

Enter RX LAT:  DEC DEG or DEG.MIN (N +,S -)  (0) 38.45
Enter RX LONG: DEC DEG or DEG.MIN (W +,E -)  (0) 111.25

For Short or Long Path enter S or L   (S)
```

World Map Showing Lat/Lon Entry Criteria



WORLD MAP, MODIFIED CYLINDRICAL PROJECTION.

Typical Distance/Bearing Table

IONSOUND DIST/BRNG TABLE FROM: EAST COAST (USA) LAT: 39 LON: 77

PREFIX	COUNTRY	LATITUDE	LONGITUDE	BRNG	LBRNG	DIST(MI)	DIST(KM)
1A0	S.M.O. of Malta	41.9	-12.48	55	235	4475	7202
1S	Spratly Island	8.75	-111.9	348	168	9082	14615
3A	Monaco	43.7	-7.4	56	236	4190	6743
3B6	Agalega	-10.42	-56.65	68	248	8968	14433
3B7	St. Brandon	-16.6	-59.6	72	252	9398	15125
3B8	Mauritius	-20.2	-57.5	78	258	9442	15195
3B9	Rodriguez Is.	-19.72	-63.43	72	252	9729	15657
3C	Equatorial Guinea	3.1	-9.4	90	270	5886	9472
3C0	Pagalu Island	-1.4	-5.62	96	276	5879	9462
3D2	Fiji	-17.9	-178.6	264	84	7744	12463
3D2/R	Rotuma Island	-12	-176	271	91	7641	12298
3D6	Swaziland	-26.9	-31.3	102	282	8295	13350
3V	Tunisia	35	-10	63	243	4610	7420
3W	Vietnam	16	-106	356	176	8625	13881
3X	Rep. of Guinea	9.7	11.9	98	278	4462	7180
3Y/B	Bouvet Island	-54.4	-3.28	140	320	7995	12867
3Y/P	Peter Island	-68.83	90.58	185	5	7477	12033
4K2	Franz Josef Land	81	-55	8	188	3956	6367
4S	Sri Lanka	7.4	-80.4	29	209	8912	14342
4U/ITU	ITU Geneva	46.2	-6.15	53	233	4058	6531
4U/UN	United Nations Hq.	40.75	73.97	52	232	201	323
4W	Yemen	15	-45	57	237	7152	11509
4X	Israel	31.7	-35.1	52	232	5889	9478
5A	Libya	30	-15	65	245	5045	8119
5B	Cyprus	35.1	-33.5	51	231	5661	9111
5H	Tanzania	-7	-37	80	260	7800	12553

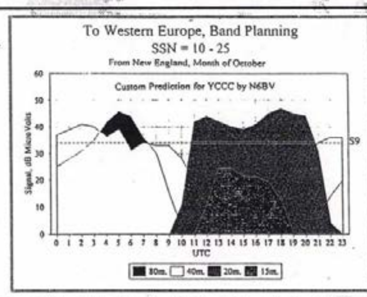
Main Menu Followed by [illegible]ore/Retrieve/Exit Screen

```
Today's Date      ********* IONSOUND HDX TURBO by W1FM *********
 09-13-1994       *  Copyright (C) 1994  SkyWave Technologies  *
                  **********************************************
      (CURRENT VARIABLES)          |        (SELECTION CHOICES)
Tx Location:  Northeast (USA)      | Pick Time/Display 24 Hour Summary      0
   Lat= 42.35     Lon=  71.05  deg | TX/RX Locations & S/L Path            1
   Tx Location Noise: RES          | Sunspot/Solar Flux Number (SSN/SFN)    2
Rx Location:  Your Qth             | Frequency Menu (ION_FREQ.DAT File)     3
   Lat= 38.45     Lon= 111.25  deg | Month Menu                             4
   Rx Location Noise: RURAL        | Variables (Noise/Ant/BW/SNR/Pwr...)    5
Tx-->Rx Bearing= 276 deg  Path= S  | Propagation Mode Menu                  6
Distance=  2111 mi       3397 km   | TX Power Level                         7
   Tx Power= 1 kw                  | Minimum Elevation Angle Menu           8
   Rx Bandwidth= 3000  Hz          | Swap TX/RX Locations                   9
   Rx min. S/N Ratio= 10  dB       | Color Selection Menu                   10
   Tx Ant: (Y)agi-Uda              | Go to DOS (Type 'EXIT' To Return)      11
   Rx Ant:  0 dBi (G)ain, Iso.     | E/F Layer Height Menu                  12
Sunspot Num= 28  Solar Flux= 85    | Tabulate TX/RX Antenna Gains           13
Layer Ht HF2= 289 km    HE= 115 km | Calculate Antenna Lobes/Nulls          14
Min Elev Ang= 5    E/F Ht Change= N| Choose New Lat/Lon/Cty File            15
Min F Hops= 2F    F Hop Ang= 15 deg| Print Distance/Bearing Table           16
24 Hr Summary Types=  8 (8 max.)   | Select 24 Hour Summary Types/Order     17
Last Selected Mon= 9  Next Mon= 9  | Store or Load Default Variables/EXIT   18

        Enter Choice: <Default=Pick Time/Display: Type 0 or ENTER>
```

```
Store current variables, load variables, EXIT to DOS, or return to Main Menu

  Type <S> to Store variables to Default File:                          <S>

  Type <R> to Retrieve (Load) Default File Variables (Restart Program): <R>

  Type <E> for EXIT to DOS (Quit Program):                              <E>

  Hit <ENTER> to Return to Main Menu:                               <ENTER>

                 Enter Choice: <Default = Main Menu>
```

CQWW Predictions for Oct 1994

YCCC Scuttlebutt
October 1994

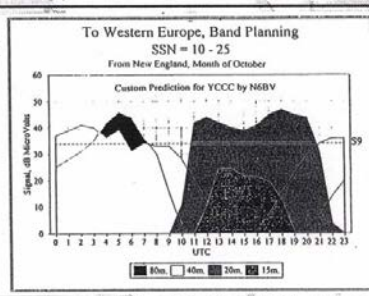


UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	8.7	44	100	100	64					
1	8.6	53	100	100	40					
2	8.5	68	100	100	41					
3	8.4	66	100	100	41					
4	8.3	53	100	98	39					
5	8.3	44	100	96	35					
6	8.3	28	55	95	32					
7	8.6	4	99	96	29					
8	10.5	0	85	58	23					
9	11.2	0	0	100	43					
10	13.0	0	0	95	80					
11	16.2	0	0		32	11				
12	17.5	0	0	46	68	46				
13	18.4	0	0	22	92	77	6			
14	18.9	0	0	12	85	100	36			
15	19.0	0	0	12	87	71	56	10		
16	18.7	0	0	20	89	84	67	24		
17	18.0	0	0	43	92	91	73	30		
18	16.7	0	0		99	100	71	30		
19	15.2	0	0	93	100	100	60	25		
20	13.1	0	0	100	100	81	27			
21	11.3	0	68	100	100	51				
22	9.4	2	85	100	78	12				
23	8.5	26	100	100	60					

TOTREL%
==========
Northeast
(USA)->
Western Eu
rope
(S PATH)
BRNG= 53
3266 mi
5256 km
MinEL= 0
Min F Hop=
2F 6 deg
SSN= 25
SFN= 83
Rx Noise=
RURAL
Ant= Y/Y
BW= 3000
Kw= 1.5
SNR= 10
Mon= 10
==========
Screen 2/2
(C/Q)

CQWW Predictions for Oct 1994

YCCC Scuttlebutt
October 1994



UTC	MUFo MHz	1.8	3.5	7.0	10.1	14.0	18.1	21.0	24.9	28.0
0	8.7	23	41	44	45					
1	8.6	24	41	44	45					
2	8.5	26	42	44	45					
3	8.4	26	42	44	45					
4	8.3	24	41	44	45					
5	8.3	23	41	44	45					
6	8.3	21	34	44	44					
7	8.6	17	33	43	44					
8	10.5	6	20	35	43					
9	11.2	-25	-4	32	35					
10	13.0	-60	-4	20	32					
11	16.2	-97	-18		27	38				
12	17.5	-142	-35	8	22	35				
13	18.4	-167	-44	5	17	33	40			
14	18.9	-179	-48	4	14	31	39			
15	19.0	-180	-48	4	15	31	39	41		
16	18.7	-169	-44	5	15	31	39	41		
17	18.0	-145	-36	8	17	33	40	42		
18	16.7	-104	-20		25	37	41	42		
19	15.2	-72	-9	19	31	40	43	43		
20	13.1	-33	-9	31	35	42	44			
21	11.3	-1	16	35	42	44				
22	9.4	16	28	43	44	45				
23	8.5	21	38	44	44					

DBuV(dB)
==========
Northeast
(USA)->
Western Eu
rope
(S PATH)
BRNG= 53
3266 mi
5256 km
MinEL= 0
Min F Hop=
2F 6 deg
SSN= 25
SFN= 83
Rx Noise=
RURAL
Ant= Y/Y
BW= 3000
Kw= 1.5
SNR= 10
Mon= 10
==========
Screen 1/2
(C/Q)

SKYWAVE PROPAGATION PREDICTION SMOOTHED SUNSPOT NUMBERS EXPECTED FOR 1995-1996

Shown below, from data provided by the National Geophysical Data Center in Boulder, Colorado, is a table of smoothed running sunspot numbers for the present solar cycle along with predicted values of activity expected for 1995-1996.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Jan		18	58	142	151	148	124	71	37	24	14*
Feb		20	65	145	151	148	116	69	35	23	13*
Mar		22	71	150	152	147	108	67	34	22	13*
Apr		24	78	154	149	146	103	64	34	21*	12*
May		26	84	157	147	146	100	60	33	20*	12*
June		28	94	158	144	145	97	56	31	19*	11*
July		31	104	159	141	146	91	55	29	19*	11*
Aug		35	114	158	141	147	84	52	27	18*	10*
Sept	12	39	121	157	142	145	80	49	27	18*	9*
Oct	13	44	125	157	142	142	76	45	27	17*	9*
Nov	15	47	130	158	142	138	74	41	26	16*	8*
Dec	16	51	138	154	144	132	73	39	26	15*	8*

Smoothed Sunspot Numbers for Cycle 22 and Forecasts for 1995-96
(Predicted Values shown with an *)

geomagnetic activity

Category	Range of A index	Typical K indices
Quiet	0-7	Usually no Ks greater than 2
Unsettled	8-15	Usually no Ks greater than 3
Active	16-29	A few Ks of 4
Minor storm	30-49	Ks mostly 4 and 5
Major storm	50-99	Some Ks of 6 or greater
Severe storm	100-400	Some Ks of 7 or greater

Propagation Indices During 3Y0PI Peter Island DXpedition to Antarctica

Date(All 1994)	Solar Flux	A-Index	K-Index
Feb 1	98	5	1-2
Feb 2	94	6	3-4
Feb 3	96	12	1-3
Feb 4	98	8	2-3
Feb 5	95	8	2-4
Feb 6	93	20	4-6
Feb 7	95	46	4-5
Feb 8	96	49	5-6
Feb 9	95	50	5
Feb 10	101	34	4-5
Feb 11	94	29	4-5
Feb 12	93	36	4-5
Feb 13	98	29	3-5
Feb 14	98	24	3-5
Feb 15	101	23	3-4
Feb 16	104	19	3-4
Feb 17	105	14	2-3
Feb 18	106	8	1-3

Source: Robert W. Schmieder, KK6EK, "3Y0PI Peter I Island Antarctica", 1994

3Y0PI BAND OPENING TIMES OBSERVED BY WA0PUJ (MINN.)

Band m / UTC	MUFo MHz	160 / 1.8	80 / 3.5	40 / 7.0	30 / 10.1	20 / 14.0	17 / 18.1	15 / 21.0	12 / 24.9	10 m / 28.0	TOTREL%
0	18.4				7	98	49	12			==========
1	18.2			92	99	45					Minnesota
2	19.1		0	99	77	11					->
3	18.4		0	99	71	6					Peter Isla
4	17.2		77	99	72	12					nd
5	16.1		76	100	77	22					(S PATH)
6	14.8		64	100	75	21					BRNG= 179
7	13.7		74	100	80	28					7860 mi
8	12.6		80	99	81	26					12649 km
9	11.7		1	99	81	22					MinEL= 0
10	10.8		0	99	71	3					Min F Hop=
11	10.1			95	52						4F 3 deg
12	14.6			0	28	17					SSN= 45
13	14.9					46					SFN= 98
14	16.0					0	58	23			Rx Noise=
15	16.9					0	67	49			RURAL
16	17.7					0	23	59	10		Ant= Y/Y
17	18.0						8	60	14		BW= 3000
18	18.1						4	61	17		Kw= 1.5
19	18.2						6	63	19		SNR= 10
20	18.3					0	19	66	21		Mon= 2
21	18.3					0	62	69	23		==========
22	18.3					0	89	71	25		Screen 2/2
23	18.4					46	97	68	26		(C/Q)

Band	Open Times
10 m	1930-2100Z
12 m	1930Z
15 m	2000Z
17 m	2000Z
20 m	2230Z
30 m	2300Z
40 m	0100Z
80 m	0300Z
160 m	0400-0430Z

WA0PUJ

3Y0PI BAND OPENING TIMES OBSERVED BY WA0PUJ (MINN.)

Band	Open Times
160 m	0400-0430Z

SS/FN= 45 / 98 HF2(KM)= 297 UFS(DBWM,DBUVM)= -122 , 23 Noise=RURAL VER=HDX3.2
TX LAT= 45 TX Long= 93 RX LAT=-68.84 RX Long= 90.58 Dist(mi)= 7860
Minnesota to Peter Island (S PATH) Min F Mode= 4 Elev Ang 3
T= 4.15 UT Mon= 2 FB BRNG= 179 / 359 Dist(km)= 12649 Mode= 5 HE(km)= 115
BW(Hz)= 3000 SNR Req= 10 TX PWR(KW)= 1.5 MinEle= 0 Date: 09-23-1994

FREQ	HOP	NPW	SVM	SPW	S/N	%S	%P	%T	ELE	MSDEL	MUFo	MUFv	GAIN
1.80	7E	-123	-17	-154	-31	0	100	0	1	42.79	4.07	0.77	9.75YY
	8E	-123	-27	-164	-40	0	100	0	3	42.88	4.00	0.78	11.63YY
	9E	-123	-37	-174	-51	0	100	0	5	43.02	3.82	0.80	14.00YY
3.50	3FE	-133	19	-118	15	80	100	80	1	43.44	4.07	0.77	9.75YY
	4FE	-133	15	-122	11	56	76	43	5	43.86	3.82	0.80	14.00YY
	6F	-133	12	-125	8	33	100	33	11	44.70	14.22	5.34	18.66YY
	7F	-133	6	-131	2	2	100	2	14	45.28	12.92	5.30	19.92YY
	8F	-133	0	-137	-4	0	100	0	17	45.93	11.78	5.27	20.38YY
7.00	4F	-138	30	-107	31	99	100	99	3	43.75	16.94	5.45	11.63YY
	5F	-138	26	-111	27	99	100	99	7	44.19	15.64	5.39	16.02YY
	6F	-138	21	-116	22	96	92	88	11	44.70	14.22	5.34	18.66YY
	7F	-138	15	-122	16	83	77	64	14	45.28	12.92	5.30	19.92YY
	8F	-138	8	-129	9	40	61	24	17	45.93	11.78	5.27	20.38YY
10.10	4F	-139	31	-106	34	100	73	73	3	43.75	16.94	5.45	11.63YY
	5F	-139	27	-110	30	99	54	54	7	44.19	15.64	5.39	16.02YY
	6F	-139	22	-115	24	98	32	32	11	44.70	14.22	5.34	18.66YY
	7F	-139	16	-121	18	90	10	9	14	45.28	12.92	5.30	19.92YY
14.00	4F	-138	32	-105	33	100	14	14	3	43.75	16.94	5.45	11.63YY

5. IONSOUND HDX TURBO S/W MANUAL

IONSOUND HDX TURBO (TM) by W1FM

VERSION 3.50

SKYWAVE PROPAGATION PREDICTION SOFTWARE

FOR AMATEUR, PROFESSIONAL, AND MILITARY APPLICATIONS

USER'S MANUAL

SkyWave Technologies

***** Acknowledgments *****

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INTRODUCTION

1. Ionospheric Propagation Background

Radio waves can be classified according to various types of propagation. These propagation types are ionospheric, tropospheric, or ground waves. Ionospheric, also known as skywave, propagation provides the major portion of the overall radiation that leaves an antenna at some elevation angle above the horizontal plane. Much of the short and long-distance communications below 30 MHz depends on the bending or refraction of the transmitted wave in the earth's ionosphere which are regions of ionization caused by the sun's ultraviolet radiation and lying about 60 to 200 miles above the earth's surface.

The useful regions of ionization are the E layer (at about 70 miles in height for maximum ionization) and the F layer (lying at about 175 miles in height at night). During the daylight hours, the F layer splits into two distinguishable parts: F1 (lying at a height of about 140 miles) and F2 (lying at a height of about 200 miles). After sunset the F1 and F2 layers recombine again into a single F layer. During daylight, a lower layer of ionization known as the D layer exists in proportion to the sun's height, peaking at local noon and largely dissipating after sunset. This lower layer primarily acts to absorb energy in the low end of the High Frequency (HF) band. The F layer ionization regions are primarily responsible for long distance communications, sometimes in conjunction with the E layer in a variety of mixed propagation modes.

Vertical incidence ionospheric sounding devices are used to determine the virtual height of an ionospheric layer at various frequencies by beaming energy upward and measuring the time delay required for the round trip. The critical frequency for a vertical incidence sounder is the maximum frequency above which no energy is returned to earth for a given layer. An ionogram is a graphic representation of such sounding and usually depicts the height of the layer (or the time delay) as a function of the sounding frequency, along with the intensity of the return signal. An oblique sounding device may require the cooperation of a corresponding receiving device at a distant point in order to depict received energy which has been transmitted at incidence angles less than 90 degrees in elevation; it may also make use of backscatter techniques to assess the propagation path. Devices such as these can then be used to assess (in real time) the propagation path frequencies which can be supported, up to and including the Maximum Usable Frequency (MUF).

As an adjunct to this Users Manual, it is recommended that other sources of information concerning HF propagation prediction and related antenna theory be consulted since this operating manual is not meant to be a comprehensive tutorial on the theoretical aspects of these subjects. A bibliography of several of these source materials is shown at the end of this manual.

2. IONSOUND HDX TURBO Overview

IONSOUND HDX TURBO is a very sophisticated ionospheric propagation prediction program for frequencies between 1.8 MHz and 30 MHz. IONSOUND HDX

TURBO is a member of the IONSOUND family of programs which have been evolving for a number of years. Geographical regions corresponding to those shown in ARRL's QST magazine "How's DX?" column can primarily be chosen from the TX and RX location menus along with several others not found in QST.

IONSOUND HDX TURBO has been designed with user friendliness in mind and is entirely menu-driven, with prompting for various user inputs to the program. It should be emphasized that a comprehensive understanding of propagation phenomena and the technical terms associated with the scientific forecasting of propagation is helpful, but not necessary, to become skilled in the use of IONSOUND HDX TURBO. The goal of the program is to produce an easy-to-interpret tabular prediction of radio frequency (RF) link performance between two locations on the earth's surface.

Technical jargon and output detail has been minimized to essential elements in the interest of simplicity, without a sacrifice in overall performance of the program or its presentation display capabilities. To simplify matters, default inputs have been provided. An explanation of the use of these menus and screens will be provided in this manual, but the program should be largely self explanatory. Once the operator has customized IONSOUND HDX TURBO to suit his/her particular needs, the information is saved to disk as a set of defaults. When the program is started, the operator need only hit the <Enter> key several times to accept the custom defaults and then make a propagation prediction.

3. General Requirements

IONSOUND HDX TURBO is designed for use with IBM or IBM-compatible personal computers. The program operates with or without an 8087, 80287, or 80387 math coprocessor. It will automatically take advantage of the coprocessor if it finds it. However, if at all possible, a coprocessor should be utilized, due to the mathematically intensive nature of the calculations performed in the propagation prediction process. Processing times can become lengthy without a coprocessor; in fact, a coprocessor will usually speed up operation by a factor of 15 or even more. Note that the 80486DX and the Pentium processors have the coprocessor built-in, while 80486SX versions do not. If you intend to do antenna modeling and propagation predictions, an investment in a numeric coprocessor is worthwhile.

A personal computer with 640 kilobytes of RAM is desirable, along with DOS version 2.11 or greater. For hard copy printout, a printer supporting IBM Graphics is recommended.

4. Printing IONSOUND HDX TURBO Operator Manual

You may print out this Operators Manual. First, make sure your printer is on-line, then type the following:

TYPE ION_HDXT.DOC > PRN <Enter> or PRINTDOC <Enter>

5. Starting IONSOUND HDX TURBO

To start IONSOUND HDX TURBO type the following:

ION_HDXT <Enter>

For convenience use the batch file:

ION <Enter>

Following the start-up of IONSOUND HDX TURBO, the program will prompt the user, in a step-by-step fashion, with several screens prompting user responses.

6. General, Menus and Screens

All entries, such as for YES/NO (Y/N) selections, can be made in either lower case or upper case. Default conditions for most of the menus and screens are shown by a notation such as:

<DEFAULT= #> or <Y> or <N> or <C/Q>.

Default= # is the option number which will result if the enter key is pressed instead of actually inputting a number value. Likewise, Y or N defaults indicate YES or NO, respectively.

When a <C/Q> option is encountered, the default is C (continue); typing Q indicates "Quit" back to the Main Menu.

7. Display Color Selection

There are eight possible color combinations for the display text and background. The program comes up in black and white unless you choose another combination. Caution: a background color other than black will cause a black/white monitor to be unreadable!

8. Transmit and Receive Location

The selection menu for transmit (TX) and receive (RX) locations each consist of up to 24 choices. Choices 1-14 allow selection of predefined locations corresponding to those shown in QST magazine's "How's DX?" column, published monthly by the American Radio Relay League (ARRL). Choices 15 through 21 are for additional predefined locations not covered in "How's DX?" Choice 22 allows for input of latitude and longitude for any user-specified location on Earth. Choice 23 allows selection of predefined locations found in the file 'ION_CTY.DAT' or a file of your own choosing. Choice 24 allows the selection of the prior location in choice 22 or 23.

[Note: When inputting a user-specified location in Choice 22, the Degree.Decimal format allows decimal fraction degrees (i.e., 39.25 represents 39 + 25/100 degrees); the Degrees.Minutes format allows degrees and minutes (i.e., 39.25 represents 39 degrees + 25 minutes) as an entry.]

These selections make it easy to compute IONSOUND HDX TURBO predictions for comparison with the Highest Possible Frequency (HPF), Maximum Usable Frequency (MUF), and the Frequency of Optimum Transmission (FOT) predictions derived from U.S. Department of Commerce, National Telecommunications and Information Administration (NTIA) IONCAP program as found in QST.

[Note: Although the "How's DX?" list in QST is limited, it can be successfully used to predict propagation performance between many other locations which are near those shown in Table 1.]

Table 1

Expanded List of QST "How's DX?" TX/RX Locations

Choice	Location	Latitude	Longitude	Nearest City
1	Alaska	61.00	150.00	Anchorage
2	Australia	-33.87	-151.22	Sydney
3	Central Asia	28.50	-77.50	New Delhi, India
4	U.S. East Coast	39.00	77.00	Washington, DC
5	Eastern Europe	50.50	-30.50	Kiev, Ukraine
6	Hawaii	21.33	157.80	Honolulu
7	Japan	35.75	-139.80	Tokyo
8	U.S. Midwest	39.00	95.00	Kansas City, KS
9	Caribbean	18.50	66.00	San Juan, Puerto Rico
10	South America	-25.00	57.50	Asuncion, Paraguay
11	South Pacific	-14.33	170.70	Pago Pago, Am. Samoa
12	Southern Africa	-15.50	-28.00	Lusaka, Zambia
13	U.S. West Coast	38.00	122.00	San Francisco, CA
14	Western Europe	51.50	0.20	London, England
15	Central America	15.00	90.00	Guatemala City
16	East Mediterranean	31.50	-35.00	Jerusalem, Israel
17	Indian Ocean	-6.50	-107.00	Djakarta, Indonesia
18	U.S. Northeast	42.35	71.05	Boston, MA
19	U.S. Northwest	47.50	122.50	Seattle, WA
20	U.S. Southeast	30.25	81.50	Jacksonville, FL
21	U.S. Southwest	33.50	112.00	Phoenix, AZ

Latitude and longitude values are given in decimal degree format. Positive values of latitude (+) are north of the Equator; negative values (-) of latitude are south of the Equator. Positive values of longitude (+) are west of Greenwich, UK; negative values of longitude (-) are east of Greenwich.

See QST Magazine, December 1990, Technical Correspondence, Pages 58-59, "Propagation Predictions and Personal Computers" for a discussion of how these locations are used in conjunction with sunspot numbers and minimum elevation angle requirements to derive IONCAP predictions for QST Magazine's "How's DX?" column.

9. Short/Long Path Selection

Selection of Short <S> or Long <L> path gives an opportunity to choose either the shortest or the longest great circle path from the transmitting to the receiving location. The default for this selection is the short or S path. IONSOUND HDX TURBO is designed to support only direct paths; skew paths that are not on great circles are not supported. Following the selection of either short or long path, the distance in kilometers, statute miles, and nautical miles from the transmitter to the receiver is provided by the program.

Also shown is the front/back (F/B) bearing in degrees (eg, 315 / 135). The front value is the bearing (or heading) direction from the transmitter toward the receiver. The positive value of bearing indicates the clockwise number of degrees offset heading from True North (0 degrees) which a radiated signal will follow on a great circle path from transmitter location to receiver location. The back value is the direction opposite (or 180 degrees away) from the transmitter-to-receiver direction.

10. Receiver Noise

Receiver noise code can be independently selected for the transmitter (TX) location and the receiver (RX) location. Since link predictions are always made for the path from the transmitter to the receiver, it makes a difference in predicted performance when the two locations are 'swapped' and the TX receiver noise code is not the same as the RX receiver noise code. Swapping of the TX and RX locations can easily be done from the Main Menu. When this 'SWAP' function is exercised, the respective noise codes are interchanged for prediction purposes, along with the latitudes, longitudes and location descriptions. A choice of three receiver noise codes can be inputted by the user. These choices are CITY, RESIDENTIAL, or RURAL noise. This selection is used in determining the received signal-to-noise ratio.

The selection of receiver noise code should be made by considering the geographic location of the TX location receiver and the RX location receiver in relation to city, residential or rural surroundings. Choosing city noise results in more noise at the receiver than residential noise. Likewise, residential noise is less than city noise but more than rural noise. The received noise power density, also varies as a function of frequency at the receive end of the RF link. Lower frequencies have greater ambient noise background levels than higher frequencies. The actual receive noise power (expressed in Watts) depends upon the receiver bandwidth. The default for choosing a TX or RX location receiver noise code is residential noise.

11. Antenna/Gain Selection

The Transmit and Receive Antenna Selection Menu allows the operator to choose the antenna for both the transmitter and receiver locations. The selections offered for transmit/receive antennas represent typical candidate configurations for predicting propagation performance. Each is represented by a mathematical model whose gain varies as a function of the elevation angle. Please note that the overall response of each antenna selection is a generic, theoretical response, since real-world effects for an individual location (such as local terrain, other antennas, or nearby power lines) cannot be included.

Table 2

TX/RX Antenna Gains vs. Elevation Angle

Takeoff Angle (deg)	Dipole Ant D (dB)	Vertical Ant V (dB)	Yagi Ant Y (dB)	Log/Rhom Ant L (dB)	Curtain Ant C (dB)	Isotropic Antennas G (dB)	I (dB)
1	-9.37	-3.15	4.89	-4.28	11.72	-40 to +40	0
5	-2.40	-1.21	6.82	2.68	18.68	-40 to +40	0
10	0.54	1.11	9.14	5.57	21.57	-40 to +40	0
15	2.19	2.06	10.10	7.13	23.13	-40 to +40	0
20	3.28	2.16	10.19	8.11	24.11	-40 to +40	0
25	4.04	1.90	9.93	8.71	24.71	-40 to +40	0
30	4.58	1.51	9.54	9.05	25.05	-40 to +40	0
35	4.93	1.02	9.06	9.16	25.16	-40 to +40	0
40	5.13	0.44	8.48	9.07	25.07	-40 to +40	0
45	5.20	-0.25	7.78	8.79	24.79	-40 to +40	0
50	5.13	-1.08	6.95	8.31	24.31	-40 to +40	0
55	4.93	-2.07	5.96	7.62	23.61	-40 to +40	0
60	4.58	-3.26	4.77	6.66	22.66	-40 to +40	0
65	4.04	-4.72	3.32	5.40	21.40	-40 to +40	0
70	3.28	-6.50	1.53	3.72	19.72	-40 to +40	0
75	2.19	-8.62	-0.59	1.41	17.41	-40 to +40	0
80	0.54	-11.33	-3.29	-1.97	14.03	-40 to +40	0
85	-2.40	-16.41	-8.37	-7.91	8.09	-40 to +40	0
89	-9.37	-29.99	-21.96	-21.86	-5.86	-40 to +40	0

Notes on IONSOUND HDX TURBO Antennas:

D=Dipole	Horizontal or Vertical Dipole, approx. 3/8 wave high
V=Vertical	Vertical Monopole, ground-mounted
Y=Yagi-Uda	Yagi-Uda Array, approximately 3/4 wave high
L=Log/Rhom	Log Periodic or Rhombic Array, approx. 1/2 wave high
C=Curtain	Curtain Array, wide elevation takeoff angle coverage
G=Isotropic Gain	-40 to +40 dBi, constant gain at all takeoff angles
I=Isotropic	0 dBi, constant gain at all takeoff angles

The Yagi-Uda (Y) in IONSOUND HDX TURBO emulates a Yagi mounted approximately at 3/4 wavelength above ground. It has a peak gain of +10 dBi (that is, referenced to an isotropic radiator in free space) at 15 degrees and has essentially no output at very high elevation angles. Most amateurs select the IONSOUND HDX TURBO Yagi model for predictions in the HF bands above 14 MHz, or even 7 MHz if they have a 40-meter Yagi. [Note: Many use the Yagi even for 3.5 MHz just to see how the predictions come out for those lucky hams who do have 80-meter Yagis!]

The Vertical Monopole (V) selection emulates the behavior of a ground-mounted vertical antenna over real earth ground. It has a peak gain of 2 dBi at an elevation angle of 30 degrees, with essentially no output near 0 degrees or at very high elevation angles. The upward-tilted elevation pattern for the vertical monopole is broad and usable for low/medium launch-angle coverage.

The Horizontal or Vertical Dipole (D) selection emulates a dipole mounted approximately 3/8 wavelengths over ground, with a peak gain of +5 dBi at 45 degrees elevation. The upward-tilted elevation pattern is broad and usable for all-around elevation coverage. Many amateurs use this IONSOUND HDX TURBO dipole selection for the lower HF bands, mostly on 1.8 and 3.5 MHz.

The variable gain Log-Periodic and Rhombic (L) selection has been weighted to provide gain ranging from +7 dBi at 1.8 MHz to +16 dBi gain at 30 MHz. The maximum gain is maintained at an angle of approximately 30 degrees above the horizon, again with essentially no output near 0 degrees or at very high elevation angles. This pattern emulates a very large multi-band horizontal Log-Periodic or a terminated Rhombic antenna. At each frequency the height of the antenna is approximately one-half wavelength above ground.

The variable gain Curtain (C) Array antenna selection has been weighted to provide a variable peak gain over an isotropic radiator ranging from approximately +23 dBi at 1.8 MHz to +28 dBi gain at 30 MHz. The maximum gain is maintained at an angle of approximately 30 degrees above the horizon. Of course, most 160-meter operators have a hard time achieving any gain at 1.8 MHz, so this curtain antenna provides an upper bound on what is imaginable for antenna gain on all frequencies. In other words, if the band doesn't open up for this antenna, nothing will make HF communication possible!

Selection of 'Choose Your Own Gain' (G) provides an opportunity to pick an Isotropic Gain antenna between -40 to +40 dBi. An isotropic radiator is an ideal antenna that radiates uniformly in all directions. The weighting function for this choice provides the same gain at all elevation angles, allowing the program to pick out all possible propagation modes on a theoretical basis, with virtually no limitations due to the use of real antennas over real ground. Most of the time the lowest possible elevation angles are predicted when a high-gain isotropic antenna is used, even on the low frequencies.

The selection of any particular antenna or isotropic gain value will cause the program to utilize this gain value for all frequencies. If a particular antenna is suitable at some frequencies but not at others, the program should be rerun with the correct antenna selection if more accurate or realistic results are desired.

[Note: The user can use selection 14 from the Main Menu to show the influence of electrical height on an antenna's major lobe and null characteristics and the resulting single hop E and F layer distances.]

12. Receiver Bandwidth

The selection of a receiver bandwidth is used to determine the noise power used into the calculation of signal-to-noise (S/N) ratio. This entry must be greater than 0 Hz and should be consistent with the type of communications activity being predicted. A typical value for single sideband (SSB) voice communication is 3000 Hz. For Morse code (CW) operation, a value of 500 Hz is typical. For AM, a value of 6000 Hz is adequate. A default value of 3000 Hz is selected if the <Enter> key is hit without a numeric value entered.

For direct comparison with IONCAP S/N predictions, a normalized 1 Hz bandwidth can be used, since that is what IONCAP uses internally.

13. Required S/N Ratio

The selection of a required Signal-to-Noise (S/N) ratio determines the threshold level of signal quality on which the propagation prediction is based. Typically, 10 dB or more S/N ratio is required for minimum voice communications capabilities in a 3 KHz (typical) bandwidth. In case of severe interference, or fading conditions due to multipath ionospheric effects, this value should be made higher. The required S/N ratio input by the operator is used to determine the %S availability of the link (i.e., S/N Availability). As the required minimum S/N value is raised, the RF link is less likely to support the requirement.

Therefore, you should usually choose the absolute minimum S/N that is needed in order to assess the %S (S/N Availability percentage) and the %T (Total Reliability percentage) of the link. The %P (Path Availability percentage) of the link is independent of the minimum required S/N ratio, indicating instead that the path is open for some level of communication.

14. Transmitter Power

The selection of transmitter power represents the amount of power (in kilowatts) delivered to the selected antenna. For example, to designate 100 watts delivered to the antenna, the entry would be made as 0.1 (i.e., 1/10 kilowatt). Transmitter power must be entered as a value greater than 0. Increasing or decreasing the amount of power has a direct bearing on the received S/N ratio and thus affects %N S/N Availability and %T Total Link Reliability. Thus, a 10 dB increase in signal power results in a 10 dB increase in received S/N ratio. The default selection value is 1 kW.

[Note: Feedline and other losses to the antenna should be considered in the selection of transmitter power, since this value represents the amount of power actually delivered to a matched antenna.]

15. Sunspot Number (SSN) or Solar Flux Number (SFN)

The level of solar activity influences ionospheric propagation. IONSOUND HDX TURBO accepts either SSN (Smoothed Sunspot Number) or SFN (Solar Flux Number) values. The program uses these values for computation of D, E, and F layer absorption effects on transmitted signals in the ionosphere. The SSN is based upon a statistically smoothed set of observations of sunspots and clusters of sunspots. The SSN can be obtained from publications such as QST (published by the ARRL) or from CQ Magazine. The SFN is based upon a 2800 MHz measurement of solar noise and is broadcast hourly on broadcast services such as WWV. Solar flux data is also available on most packet clusters. If real-time indications of solar activity are utilized, either SSN or SFN, running-averages should be kept and used as input to IONSOUND HDX TURBO. Robust predictions may involve 5, 10, 15 or 30 day running averages, while longer-term averages may be 6 months or longer.

Prior to actual entry of SSN or SFN, a choice is presented for selection of using either SSN or SFN. To pick use of SSN an S should be entered; to pick use of SFN, an F should be entered. The default for this selection is use of the SSN.

For SSN input, a value greater than 0 must be entered. For SFN input, a value greater than or equal to 63.75. If SSN is entered, IONSOUND HDX TURBO computes the equivalent SFN. Likewise, it computes and displays SSN if SFN is used. The default selection value for SSN is 0.

[Note: Sunspot data can also be obtained from the "Solar Indices Bulletin", National Geophysical Data Center, Boulder, Colorado. See Appendix for a discussion of National Bureau of Standards (NBS) forecasts and prediction availability via radio broadcasts and on-line telephone/modem services.]

[CAUTION: Following SSN/SFN entry, any manually entered changes to the F-layer height or the E-layer height should be carefully considered since program derived values will be overridden. In general, knowledge of vertical height from ionospheric soundings is useful and may be used if available.]

16. Minimum Elevation Angle

The operator may enter a minimum elevation angle. This is useful if the horizon towards the desired target location is blocked by hills or other obstructions. Selecting a higher minimum angle precludes unrealistic low-order modes from being used in the computations.

Following the elevation angle selection, the program computes the lowest-order F layer propagation mode (showing the number of hops), the calculated takeoff angle, and the unabsorbed isotropic receiver power density and field strength available at the distant receiver at the oblique critical frequency for this mode. Additional elevation angles may be tried if desired.

With each minimum elevation angle the program finds the corresponding F layer hops, power density and field strength. Finally, after you have decided on a minimum elevation angle (or choose 0 degrees by default), the program will proceed.

17. Choosing Prediction Frequencies

The menu for selection of prediction frequencies presents a variety of choices. In all cases, the entry of any frequency is a MHz value.

Selection 1 allows entry of up to nine separate frequencies in the 1.8 MHz to 30 MHz range. The prediction order will be in the same sequence as the frequencies are entered.

Selection 2 allows entry of a range of frequencies defined by the lowest frequency (greater than or equal to 1.8 MHz), a frequency increment (greater than 0), and a highest frequency (less than or equal to 30 MHz). A number must be entered for each prompt, or the program will simply cycle back to the first prompt. If the frequency increment chosen is too small, resulting in more than nine frequencies, the upper frequency limit will be truncated in order to limit the total number of frequencies to nine.

If selection 2 is chosen and a previously defined range of frequencies already exists, the program will prompt the user whether to keep this previous range of frequencies by typing Y or N. The default for this choice is <Y> so that the program can continue with this previously defined range by simply hitting the <Enter> key.

Selection 3 allows a predefined subset of all 9 HF amateur band frequencies (based on U.S.A. Allocations) currently available in the 1.8-30 MHz range. The frequencies are chosen such that there is one representative frequency from each band. [Note: Technically the 1.80 MHz frequency lies in the Medium Frequency (MF) band which is in the range 0.3 MHz to 3 MHz.] The All HF Amateur Band predefined frequencies are:

1.8, 3.5, 7.0, 10.1, 14.0, 18.1, 21.0, 24.9, 28.0 MHz.

Selection 4 allows a predefined subset of 5 high-band HF amateur band frequencies (based on U.S.A. Allocations) currently available in the 14-30 MHz range. The frequencies are chosen such that there is one representative frequency from each band. The High-Band HF Amateur frequencies are:

14.0, 18.1, 21.0, 24.9, 28.0 MHz.

Selection 5 will automatically load prestored frequencies from the file ION_FREQ.DAT. Up to nine frequencies, covering the range 1.8-30 MHz, can be prestored in the file. This file can be automatically modified by the user from within the program. It can be used to store frequency net lists or other favorite sets of frequency information.

The default selection for the Frequency Menu is <3> which picks the 9 HF amateur band frequencies to be used for prediction purposes. The default selection is also obtained by hitting the <Enter> key.

18. Choosing Prediction Months

The Month Selection Menu for selection of prediction months presents a variety of choices.

If a selection entry between 1 and 12 is made, this entry will then represent a single prediction month. For example, an entry of 3 represents the month of March; 12 represents December.

If selection 13 is made, all 12 months in sequence starting from January and ending with December will be used for prediction purposes.

If selection 14 is made, the program will prompt you for the total number of months (between 1 and 12) for which you want predictions. Following the entry of the number of months, the program then prompts you for each month in the sequence which you care to use for prediction purposes.

If selection 15 is made for entering an interval of months, the program will prompt you for the starting month, an integer increment value, and then the ending month. The program will then list the months corresponding to this selected interval and will ask you if you wish to change the range of months selected. If the month range interval is not acceptable to you, type Y to change the range. If the range is acceptable, then type N, the default, to proceed. Should the increment of months or range be inconsistent or inappropriate, the program will ask you to re-enter the month range.

If selection 16 is made then the user has an opportunity to change the default month to be used in the selection process. When first executing, the default month is set to the present month. Select a new default month by entering a value from 1 to 12. The new default month will then be used for all subsequent propagation predictions. The setting of the default month does not preclude using any other month or months or month intervals when this menu is subsequently accessed.

Selection 17 from the Month Selection Menu allows a return to the Main Menu of the IONSOUND HDX TURBO program.

19. Choosing Prediction Times

The operator uses the Time Selection Menu to choose propagation prediction times.

If 0 or <Enter> is selected, IONSOUND HDX TURBO computes a 24 Hour Summary Table for presentation to the computer screen. A maximum of 8 unique parameters may be chosen, in any order, for these predictions.

Selections from 1 to 24 compute predictions for a single point in time. The hour and the minutes are entered in Universal Coordinated Time (UTC), using a number between 1.00 and 24.00. The digit (or digits) to the left of the decimal point correspond to the hour; the digits to the right of the decimal point correspond to the minutes (i.e., 12.35 corresponds to 12 hours and 35 minutes, UTC).

Selection 25 chooses every full hour from 1 to 24 for the prediction process.

Selection 26 allows entry of particular times of your own choosing. The user is prompted for the number of individual times, up to a maximum of 50. Each individual time is then entered one at a time following prompts.

Selection 27 allows an interval of time values to be selected. The starting time is entered, then the time increment (which must be greater than 0), and finally the ending time. As a simplification, the time moment selected for the interval should be rounded to the nearest 15 minutes. If a very small time increment is selected such that the total number of individual times exceeds 50, a message will appear indicating that the total number of time moments has been truncated to 50.

Following a continuation prompt indicating hit <Enter> to continue, the individual times in the overall time interval selected will appear on the screen. A prompt by the program will then ask whether you wish to change these times. If you want to change these times type Y; if these times are acceptable, type N. The default value for changing these times is <N> so that the program can continue by simply hitting the <Enter> key.

[Note: If selection 27 is chosen by the user and a previously defined interval of time exists, the program will prompt whether you wish to use the previous time interval. The default for keeping the previously defined time interval is <Y> so that the program can continue by simply hitting the <Enter> key.]

Selection 28 of the Time Selection Menu allows the user to return to the Main Menu.

20. Choosing Prediction Modes

The Mode Selection Menu for choosing prediction modes presents a variety of choices, mainly for advanced users of IONSOUND HDX TURBO. These choice can greatly influence the propagation prediction process. At the beginning of the Mode Selection Menu, the lowest-order predicted F layer mode is displayed. Selecting a value of N from 1 to 10 causes the program to automatically seek other propagating modes supported by the ionosphere (for both the E layer and F layer) in addition to the value of the lowest order F layer mode.

Selection of N = 1 (the default value) will cause the mode searching algorithm to consider at least 1 hop for the minimum number of F layer hops. Selecting N = 2 will cause mode searching to consider at least 2 hops. Likewise, further increasing the value of N selected will cause the algorithm to search out an ever-increasing complexity of E layer and F layer hop combinations, up to the maximum value of N = 10. As the value of selected N is increased, the prediction time will also increase accordingly.

[Note: The mode searching algorithm is a complex process, since the program also considers mixed (i.e., combined E and F layer) modes of propagation. If at any time and at any frequency the lowest calculated F layer mode is blocked by the E layer, the program will seek mixed modes having the same number of hops, except that an E layer hop will replace one of the F layer hops. If this mode does not appear to propagate, another try is then made but with one more F layer hop than the original. If this mode in turn does not propagate, then a mixed mode at this increased number of hops is tried, except that one or two E layer hops are substituted in succession. The types of attempts at finding a propagating mode are continued in this fashion until all modes have been exhausted, up to and including two more hops than the starting number determined by the lowest F layer mode.]

Selection 11 allows the user to enumerate which E layer, F layer or combined E and F layer hop modes the program should be forced to consider. Following this selection, the user is asked to input the number of modes to predict, up to a maximum of value of 10. Prompting for the desired number of modes takes place through individual entry of each separate E layer and F layer hop mode combination desired. To input a given mode, the value of the hop corresponding to the F layer mode is entered first, followed by a comma and then the value of the hop corresponding to the E layer mode. For example, to enter a mode corresponding to 3 hops using the F layer and 1 hop using the E layer a value of 3,1 is entered.

Selection 12 allows the user to force the program to consider a single E layer propagation mode between the transmitter and the receiver. This one-hop E layer prediction can be useful when it becomes possible for E layer propagation to result in a higher MUF than the F layer mode.

Selection 13 from the Mode Selection Menu allows the user to return to the Main Menu of the IONSOUND HDX TURBO program.

21. Printing

Make sure that your printer is powered up and on-line before attempting to print anything. The most common usage of IONSOUND HDX TURBO is showing 24-hour prediction screens. These may be captured to the printer by the use of <Shift PrintScreen>. Two screens may be printed on a single sheet of paper. Most printers will require that you take them off-line and force a form feed in order to eject a printed page of paper.

[Note: As an alternative to printing on paper, various file capture utilities may be utilized. An example of such a computer program utility is PRN2FILE.COM and its documentation PRN2FILE.DOC which is available from Ziff-Davis Publishing Co., 1 Park Avenue, New York, NY 10016. Download of PRN2FILE.COM from PC-Magnet, an online service of PC-Magazine is also available. Call 1-800-346-3247 for closest access point.]

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Glossary of Terms

ARRL	American Radio Relay League
BBC	British Broadcasting Corporation
BRNG	bearing
CCIR	International Radio Consultative Committee
CW	continuous wave, Morse code
dB	decibel
dBuV	dB signal level with respect to 1 microvolt
DBUVM	dB field strength with respect to 1 microvolt/meter (dBuV/m)
dBW	dB power with respect to 1 Watt
dBWn	dB noise power with respect to 1 Watt
dBWs	dB signal power with respect to 1 Watt
DBWM	dB power density with respect to 1 Watt/meter squared (dBW/m^2)
DOS	disk operating system
ELE or ANG	elevation or takeoff angle
F/B	front/back
FOE	E Layer critical vertical incidence frequency
FOF	F Layer critical vertical incidence frequency
FOT	optimum working frequency (usually below MUF)
FREQ	frequency
Ham	amateur radio operator
HF	high frequency
HPF	highest possible frequency
Hz	hertz (unit of frequency)
IONCAP	Ionospheric Communications Analysis and Prediction Program
L PATH	long path
LUF	lowest useful frequency (usually limited by absorption and noise)
MCFO	maximum critical oblique frequency
MCFV	maximum critical vertical frequency
MHz	megaHertz
MUF	maximum useable frequency (for a particular layer and distance)
NOAA	National Oceanographic and Atmospheric Administration (U.S.)
NPW	Noise Power in dB-Watts (decibels above or below 1 watt)
NTIA	National Telecommunications and Information Administration (U.S.)
%SIG or %S	signal-to-noise availability N, expressed in percent (%) [percentage of days of the month that the signal-to-noise ratio meets or exceeds the minimum signal-to-noise ratio]
%PATH or %P	propagation path availability P, expressed in percent (%) [percentage of days of the month that the predicted propagation path will be available]
%TOT or %T	total link reliability N x P, expressed in percent (%) [represents the numeric product of signal-to-noise availability, %SIG, and propagation path availability, %PATH, and signifies overall link quality]
RX	receiver
S/N or SNR	signal-to-noise ratio in decibels
S PATH	short path

Glossary of Terms
(continued)

SBRNG	switched bearing (long path bearing, 180 degrees opposite BRNG)
SESC	Space Environmental Services Center, NOAA, Boulder, CO (U.S.)
SSN	smoothed sunspot number
SFN	solar flux number (measured at 2800 MHz)
SM+dB	S Meter + dB [represents S0-S9 plus dB readings above S9]
SVM	signal voltage in dB-Microvolts (dBuV)
SWL	shortwave listener
TX	transmitter
UTC	Universal Coordinated Time
VHF	very high frequency
WWV	A radio station of the National Bureau of Standards (U.S.)

Appendix

NATIONAL BUREAU OF STANDARDS (NBS) SERVICES

The U.S. National Bureau of Standards (NBS) broadcasts the latest geomagnetic Ap and K indices, the 2800 MHz solar flux level number (SFN), and short-term forecasts of expected propagation conditions on radio station WWV, simultaneously at 18 minutes past each hour on 2.5, 5, 10, 15, and 20 MHz. These transmissions originate from Ft. Collins, CO. In addition, radio station WWVH, located in Hawaii, broadcasts Geophysical Alerts at 45 minutes past the hour on 2.5, 5, 10 and 15 MHz. WWV and WWVH information is updated every 3 hours starting at 0000 UTC.

The on-duty forecaster at the National Oceanographic and Atmospheric Administration (NOAA) Space Environmental Services Center (SESC) in Boulder, CO is also able to provide Alert data by calling 303-497-3171. This information is also available, free of charge, by calling NOAA's SESC at 303-497-3235. The SESC also provides a free on-line, menu-driven modem bulletin board service at 303-497-5000, 24 hours a day, for access to propagation data, solar reports, solar and geomagnetic data, and MUF predictions. Modem access is at 300, 1200, or 2400 baud, with a standard protocol of 8-bit data word, 1 stop bit, and no parity.

NOAA publishes a booklet which should be considered required reading for those who would like to more completely understand and utilize WWV and WWVH propagation forecasts. It provides complete and easy-to-understand descriptions of the solar/terrestial indices, a glossary of terms, sources of information, and key details of NOAA's telephone bulletin board service (BBS). This booklet, "A User's Guide to the Space Environment Services Center Geophysical Alert Broadcasts," is available free of charge from the NOAA SESC by requesting a copy o NOAA Technical Memorandum ERL SEL-79. The address for obtaining this free booklet is:

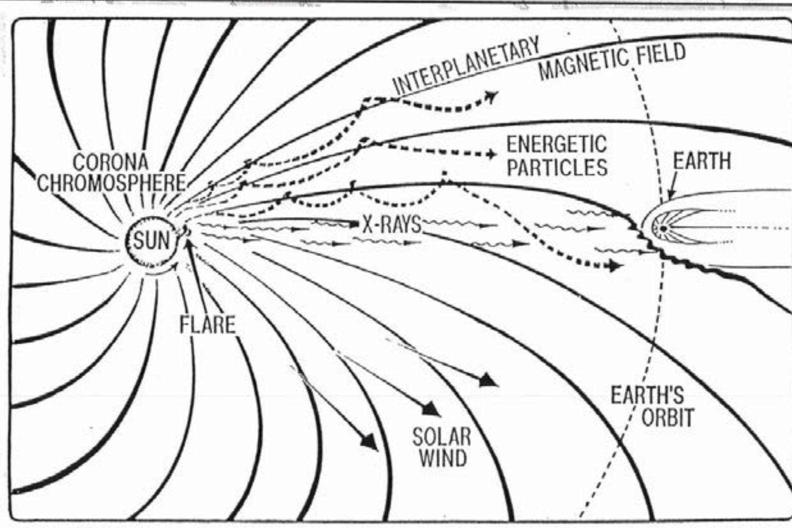
The Space Environment Services Center
NOAA/ERL/SEL - R/E/SE2
325 Broadway
Boulder, CO 80303-3328, USA

2. SOLAR WIND AND SPACE WEATHER

THE EARTH IN THE SOLAR WIND

- This next chart, published in NOAA Technical Memorandum ERL SEL-80 by the Space Environment Laboratory (Boulder, CO), shows the primary influences by the sun on the earth.
- These influences result from the solar wind as the earth orbits the sun and encounters a host of energetic particles, x-rays, flares and other emanations from the corona chromosphere, along with an interplanetary magnetic field.
- All of these influences contribute to a complex interaction that affects ionospheric propagation.

THE EARTH IN THE SOLAR WIND



NOAA Technical Memorandum ERL SEL-80

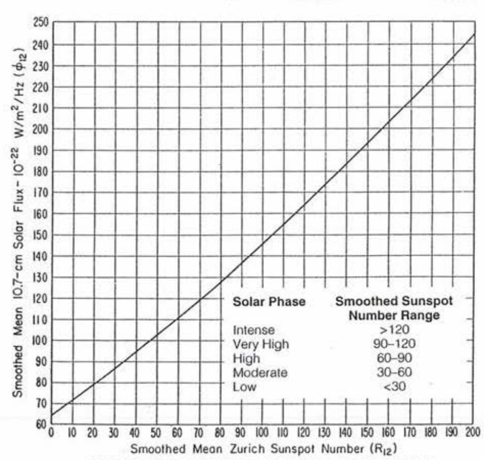
Space Environment Laboratory
Boulder, Colorado
June 1990

A RADIO FREQUENCY USER'S GUIDE TO THE SPACE ENVIRONMENT SERVICES CENTER GEOPHYSICAL ALERT BROADCASTS

SMOOTHED SUNSPOT NUMBERS VS. SMOOTHED SOLAR FLUX

- Shown in this next graphic is the relationship between Smoothed Mean 10.7-cm Solar Flux and Smoothed Mean Zurich Sunspot Number.
- The Smoothed Sunspot Number range is further categorized according to the Solar Phase as Low, Moderate, High, Very High, and Intense.
- Smoothed Sunspot Number or Smoothed 10.7-cm Solar Flux is essential to IONSOUND HDX Turbo propagation prediction and is made available from the Space Environment Services Center Geophysical Alert Broadcasts.

Smoothed Sunspot Numbers vs. Smoothed Solar Flux

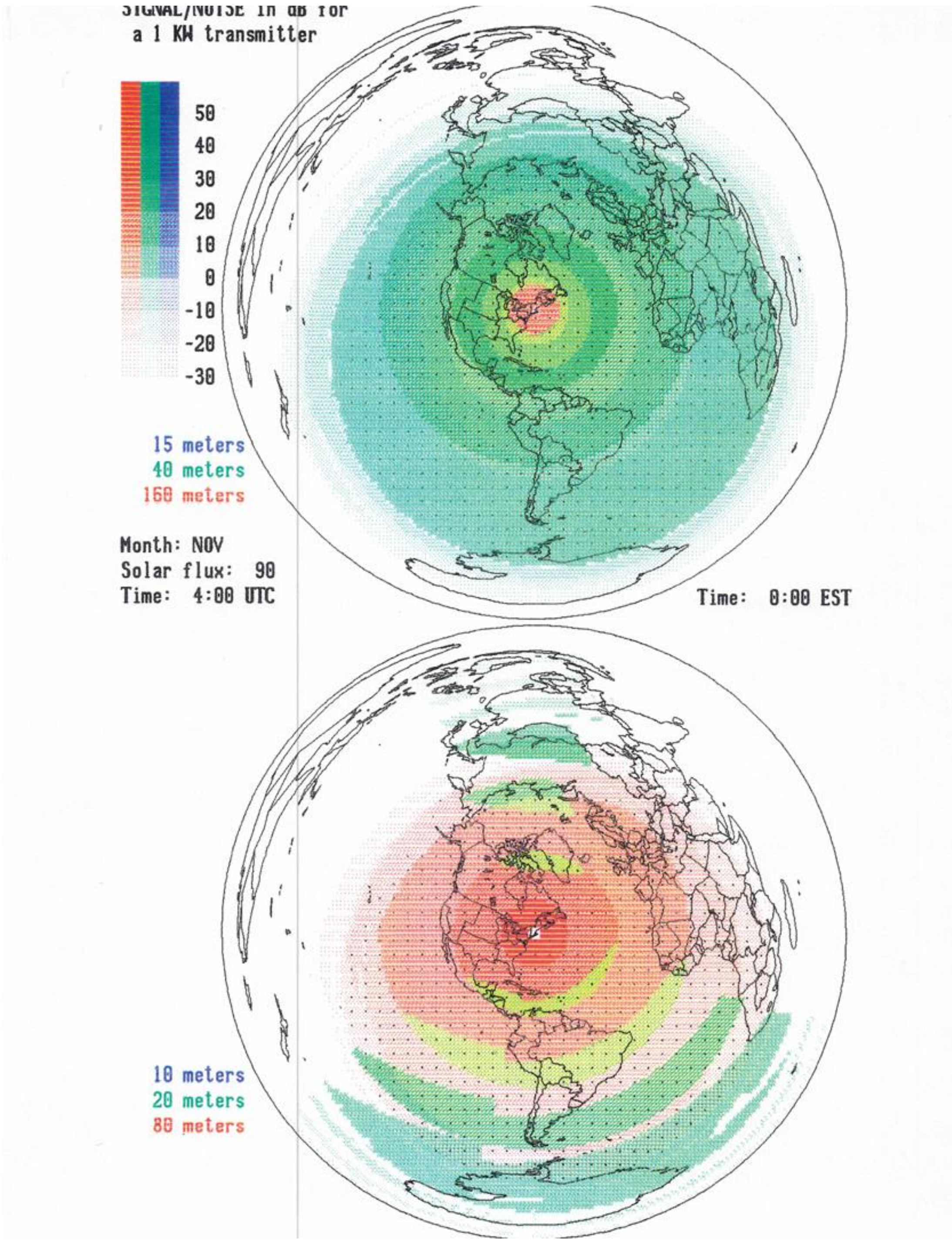


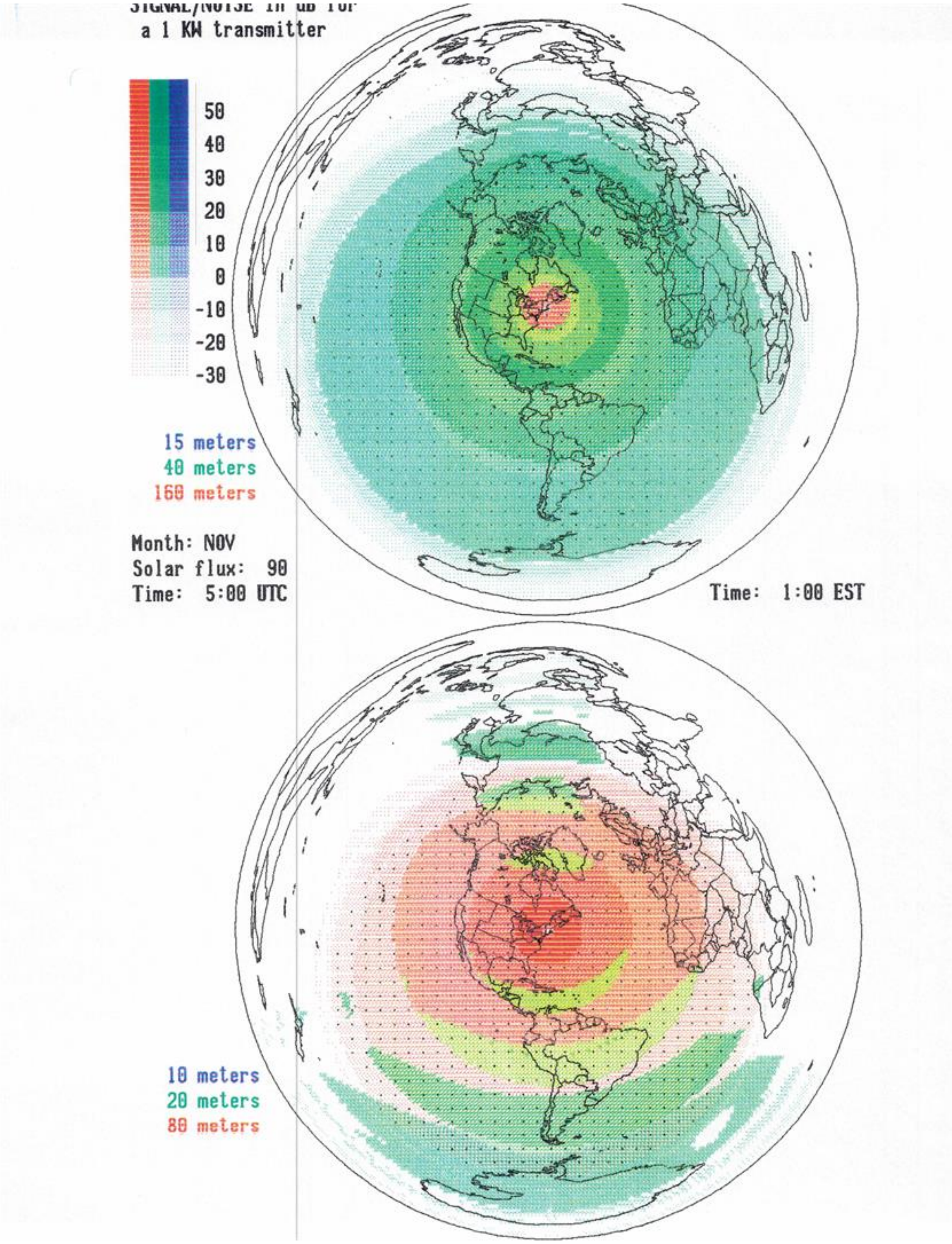
RELATIONSHIP BETWEEN SMOOTHED MEAN ZURICH SUNSPOT NUMBER AND SMOOTHED MEAN 10.7-cm SOLAR FLUX.

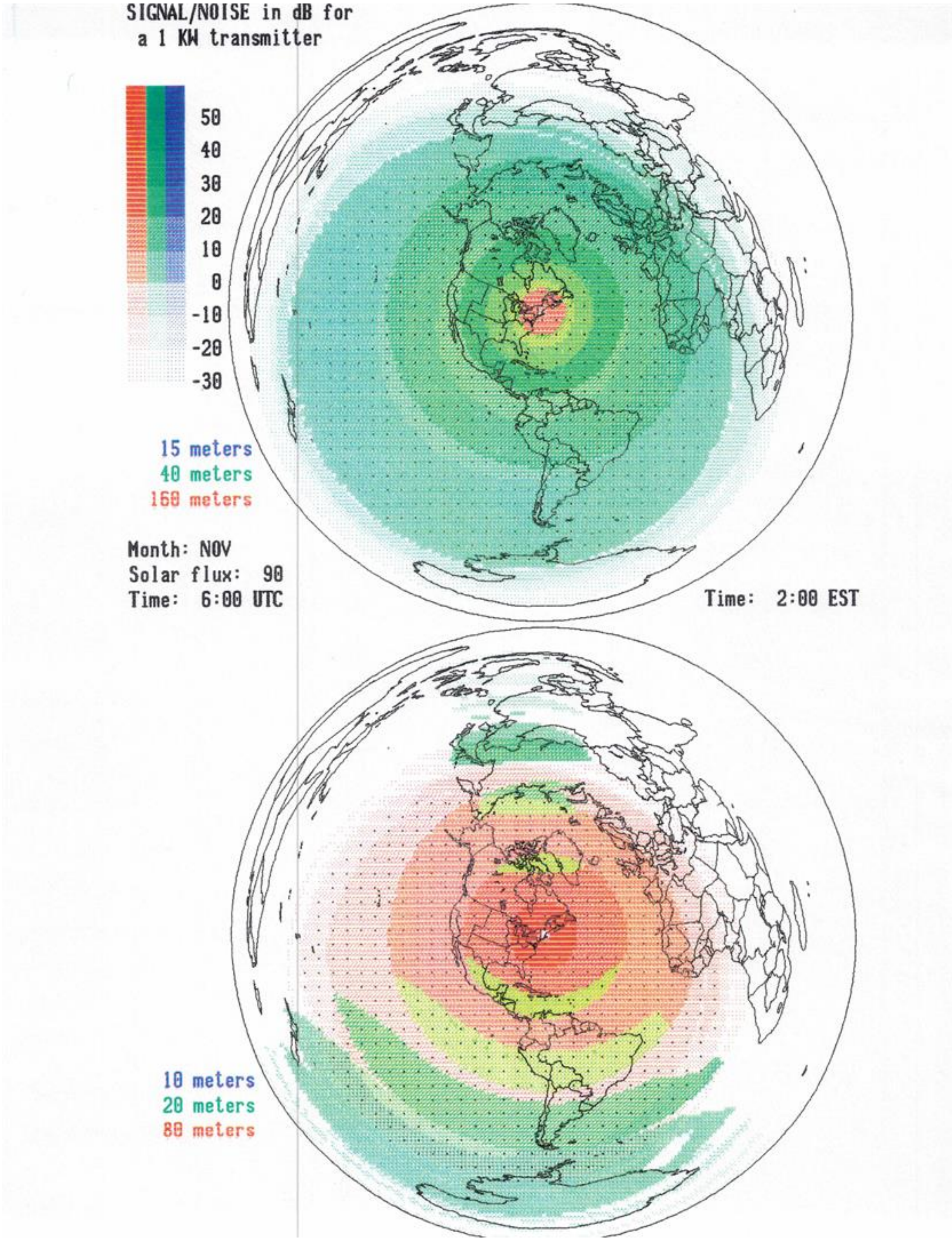
NOAA WWV/WWVH AND CHU BROADCASTS AND SPACE WEATHER GEOPHYSICAL ALERTS

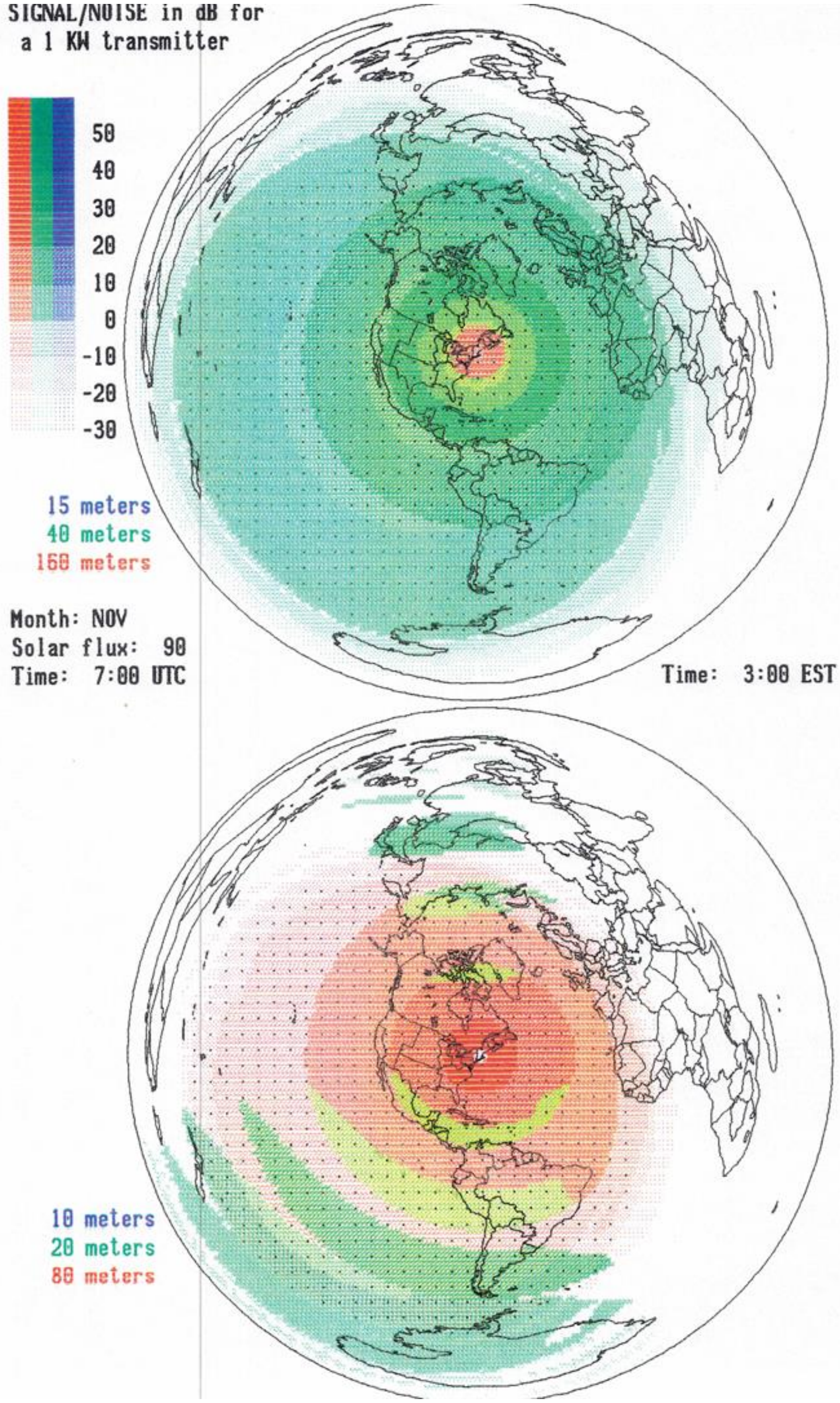
- The National Oceanic and Atmospheric Administration (NOAA) uses WWV and WWVH to broadcast geophysical alert messages that provide information about solar terrestrial conditions. Geophysical alerts are broadcast from WWV at 18 minutes after the hour and from WWVH at 45 minutes after the hour. The messages are less than 45 seconds in length and are updated every 3 hours (typically at 0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 UTC). More frequent updates are made when necessary. WWV broadcasts on 2.5, 5, 10, 15 and 20 MHz from a location near Fort Collins, Colorado. WWVH broadcasts on 2.5, 5, 10 and 15 MHz from Kauai, Hawaii. Both stations broadcast a timing signal 24 hours per day, 7 days per week, to listeners all over the world. CHU transmitted frequencies from Ottawa, at 3.330, 7.335 and 14.670 MHz, are provided by the government of Canada in order to disseminate standard time information.
- All broadcast frequencies used by WWV and WWVH are in the high frequency (HF) radio spectrum which extends from 3 to 30 MHz. This part of the spectrum is commonly referred to as "shortwave". General coverage shortwave receivers typically receive all frequencies from 530 kHz (the beginning of the AM broadcast band) to 30 MHz and are capable of receiving WWV, WWVH and CHU on all of the available frequencies.

EXAMPLES OF HOURLY WORLD-WIDE S/N PREDICTIONS FOR NOVEMBER (SFN=90) DERIVED FROM IONSOUND HDX TURBO SOFTWARE, CENTERED ON BOSTON, MA




SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 5:00 UTC
Time: 1:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 6:00 UTC
Time: 2:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
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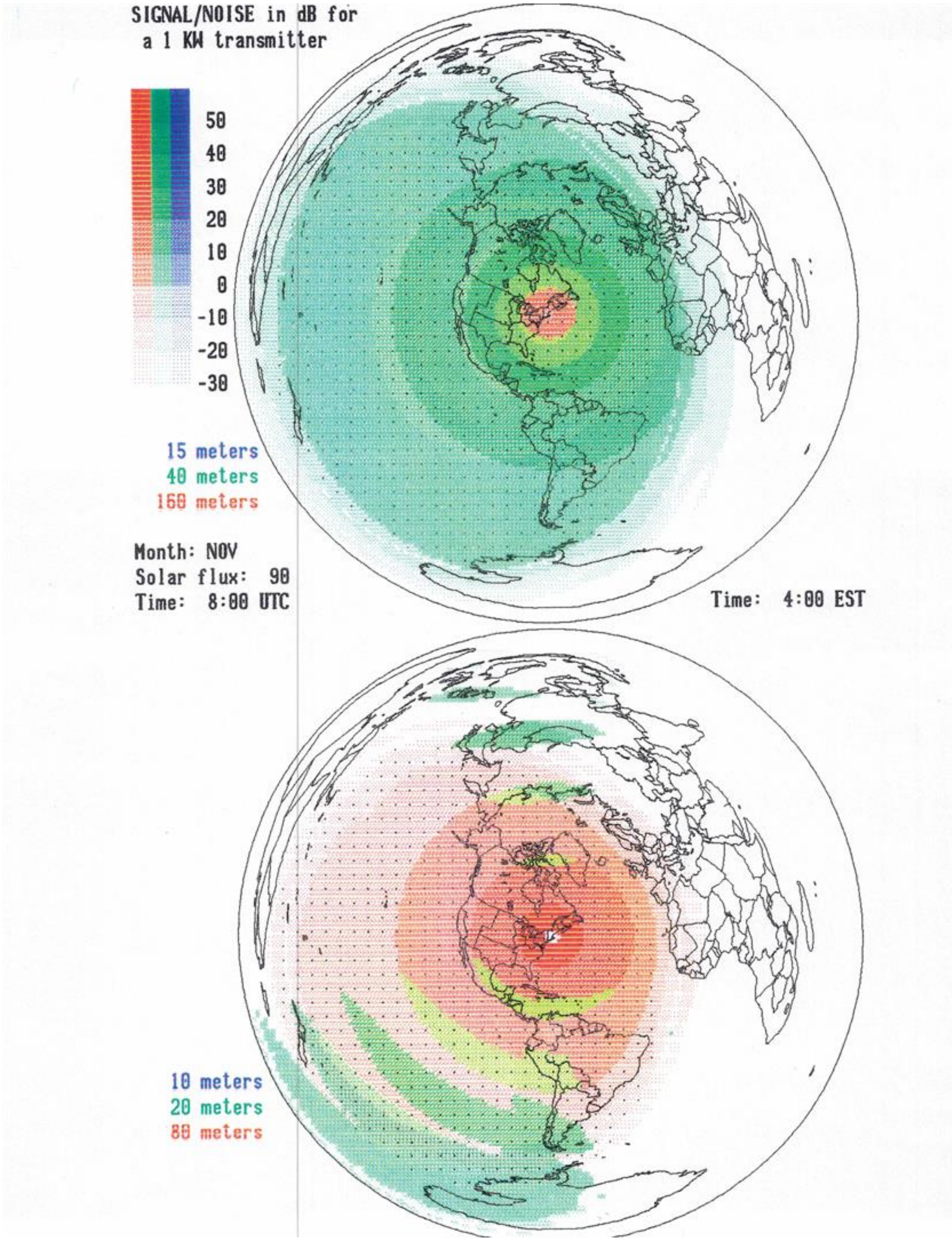
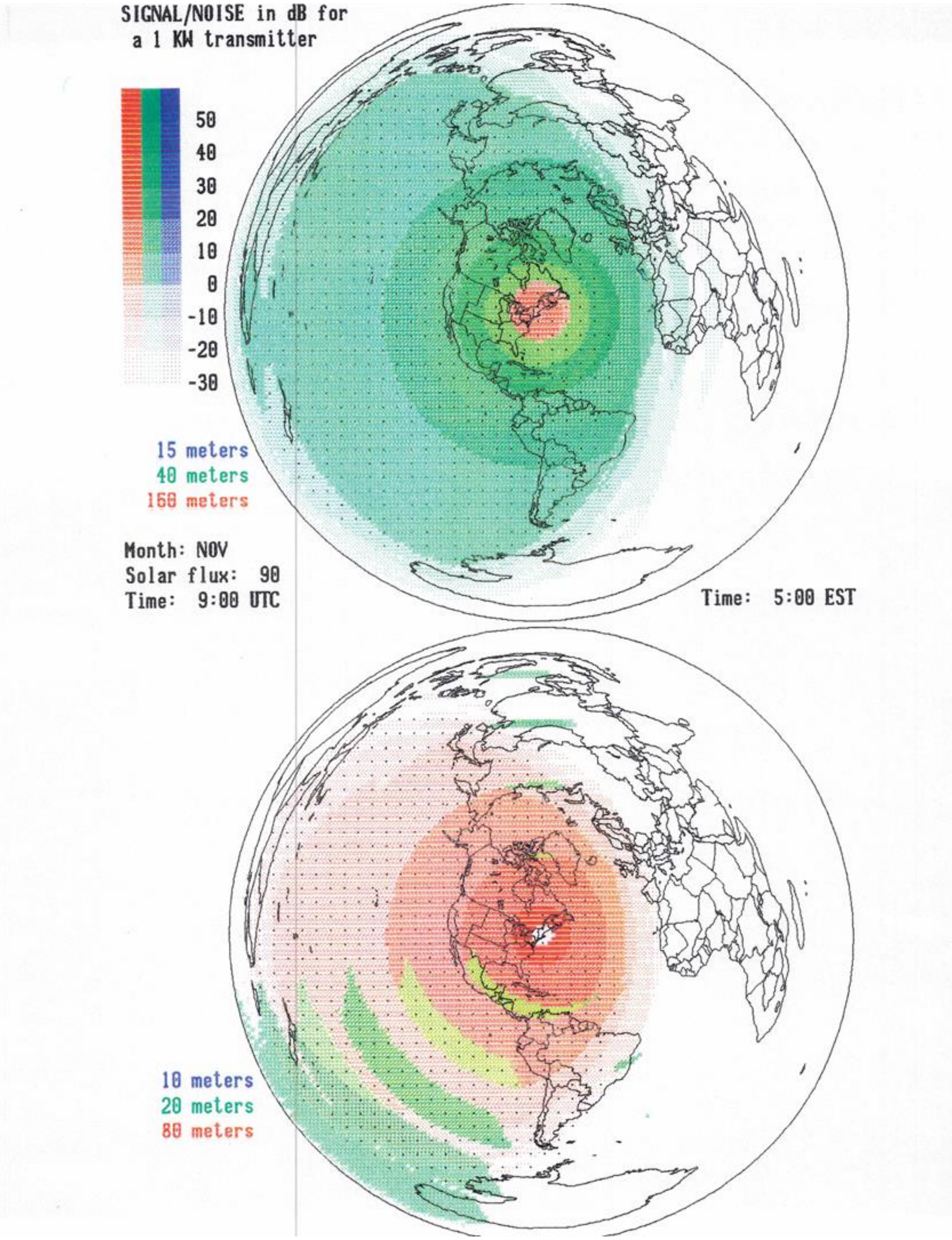
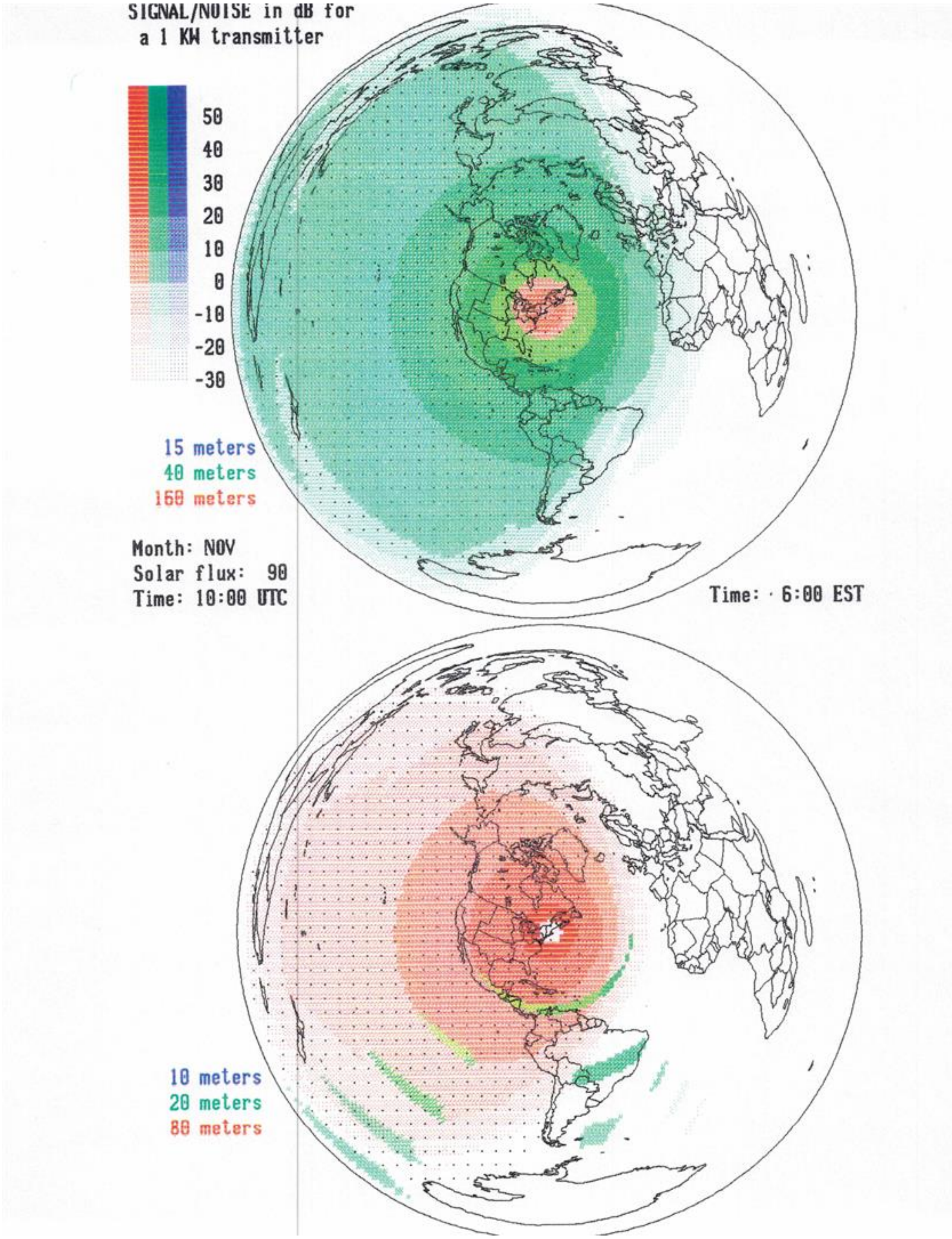
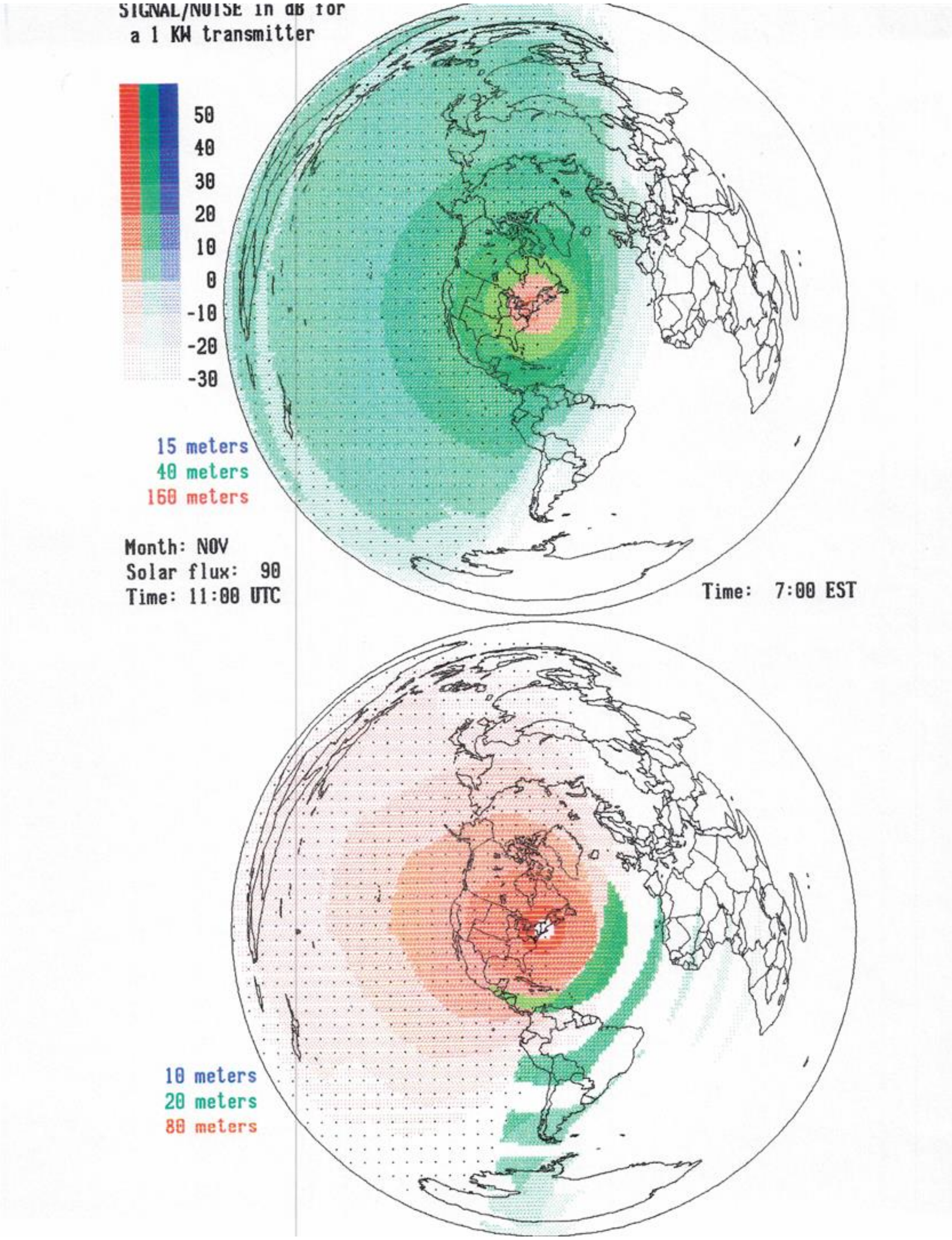
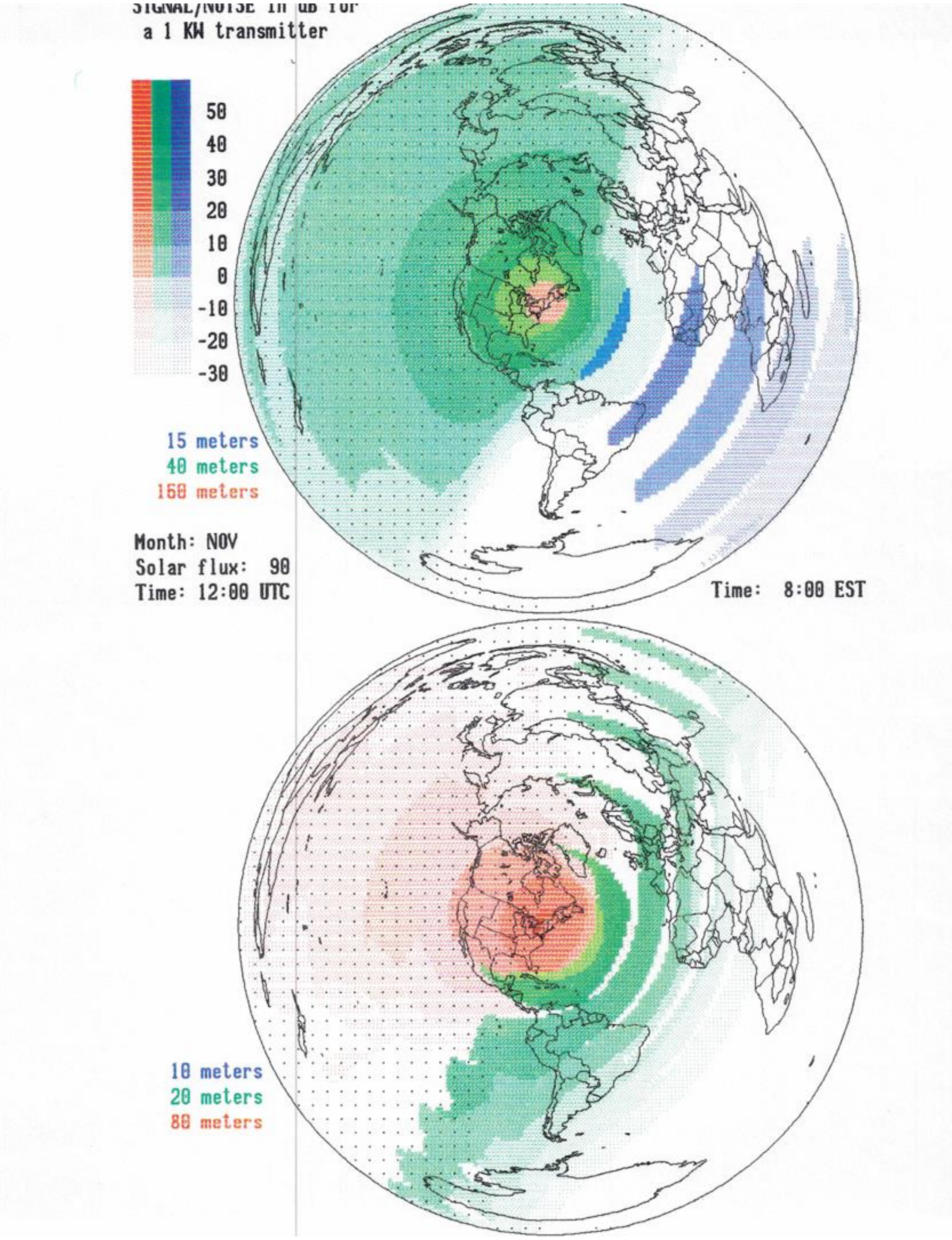
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 7:00 UTC
Time: 3:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 8:00 UTC
Time: 4:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 9:00 UTC
Time: 5:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 10:00 UTC
Time: 6:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 11:00 UTC
Time: 7:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
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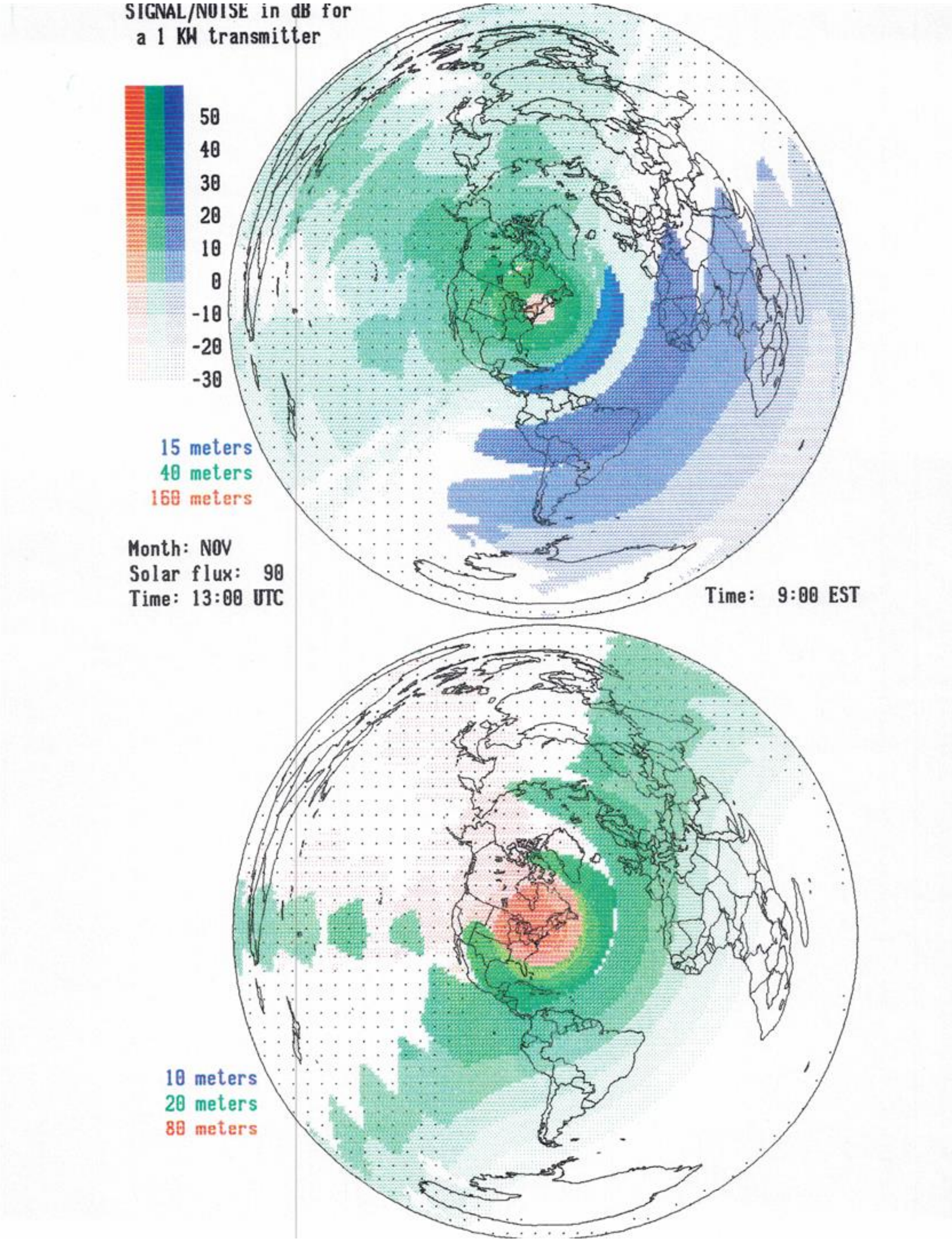
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 12:00 UTC
Time: 8:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
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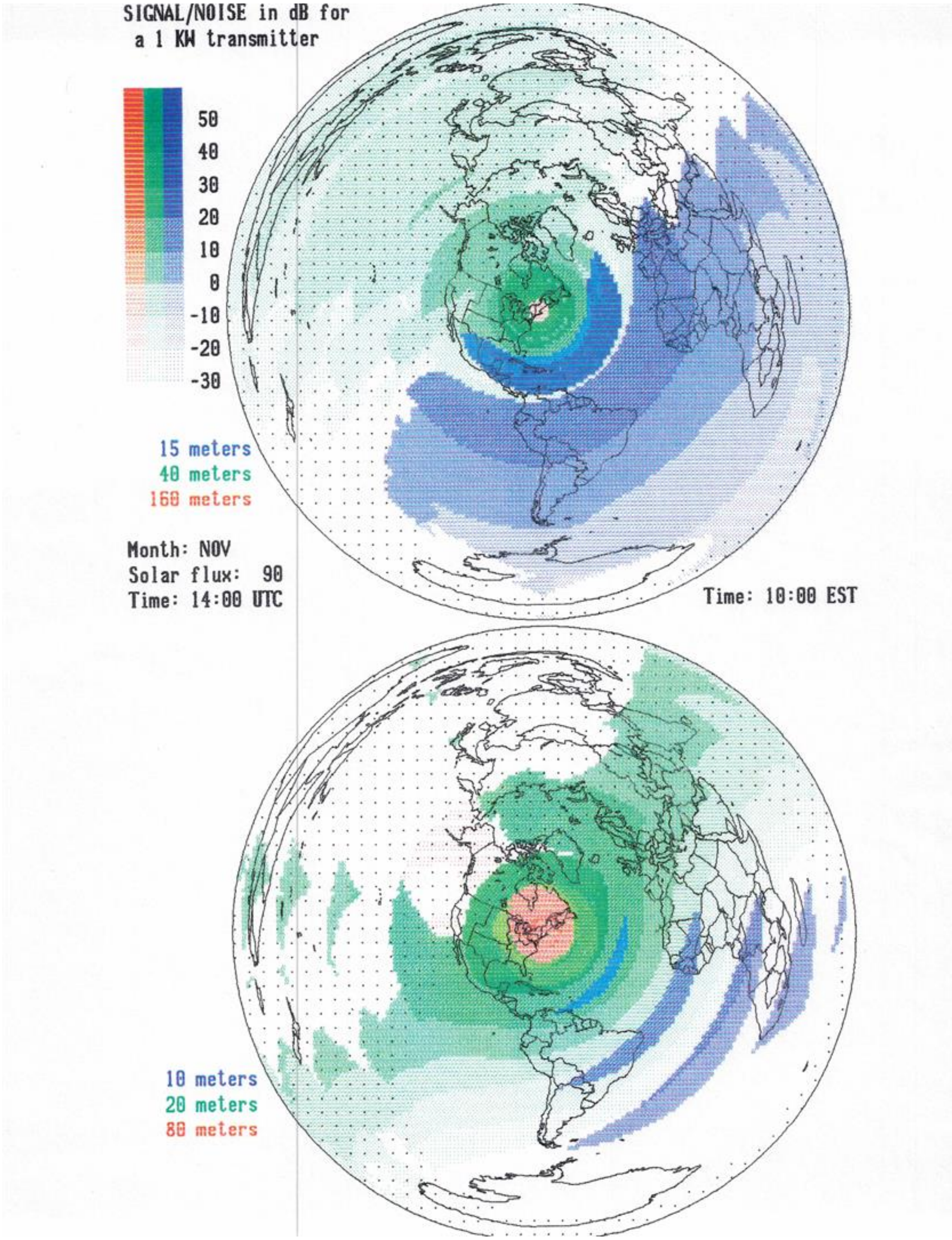
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 13:00 UTC
Time: 9:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
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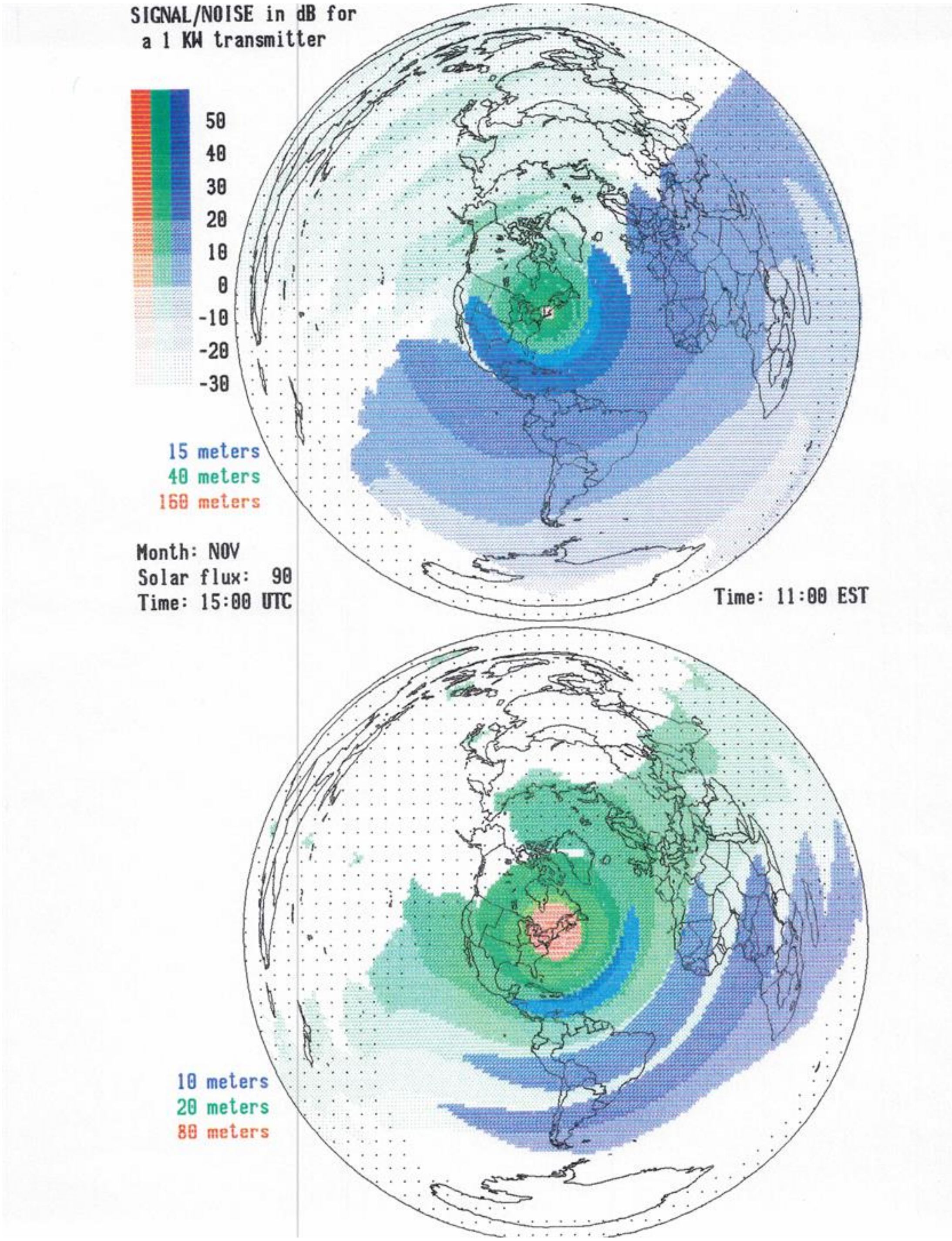
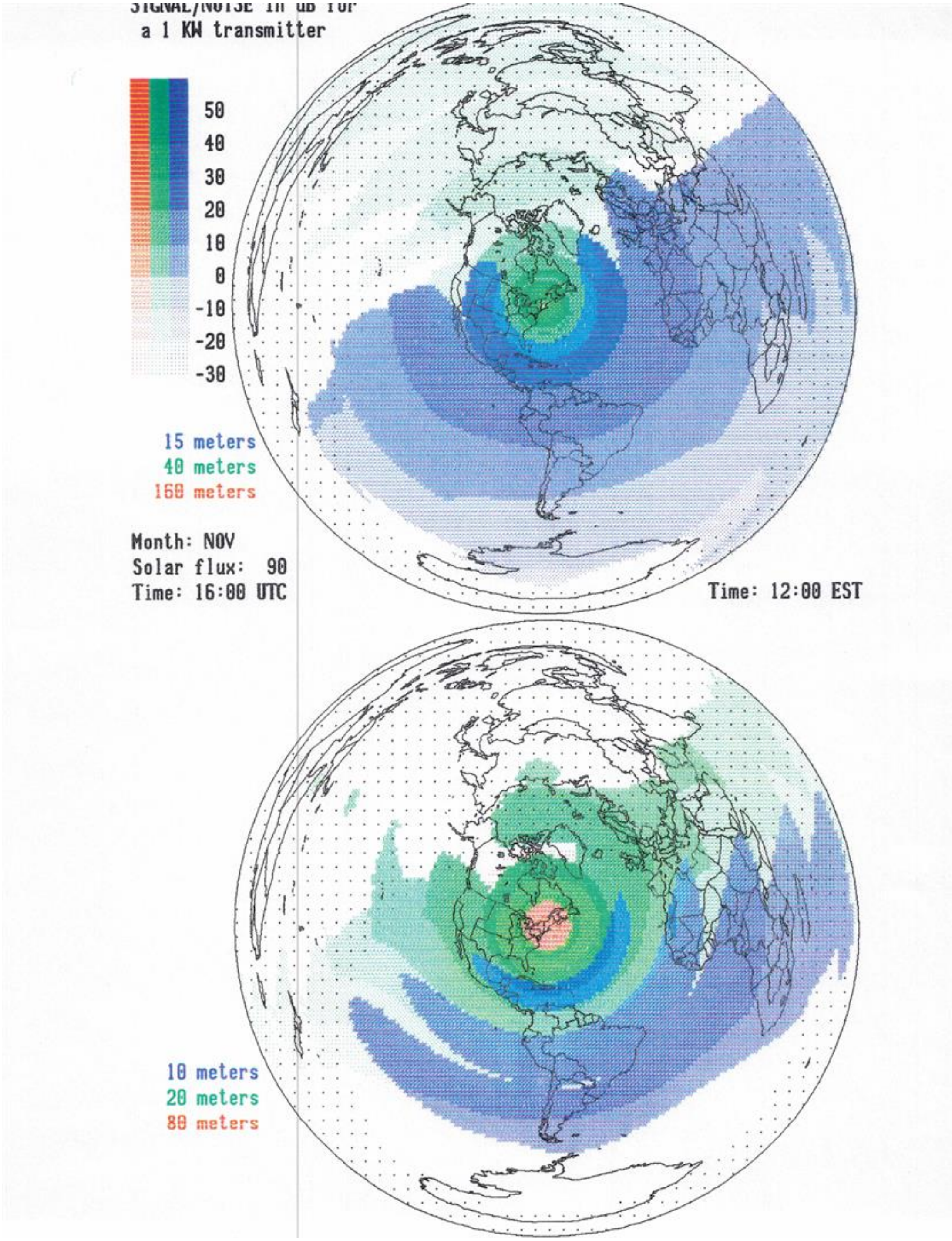
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 14:00 UTC
Time: 10:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 15:00 UTC
Time: 11:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
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40
30
20
10
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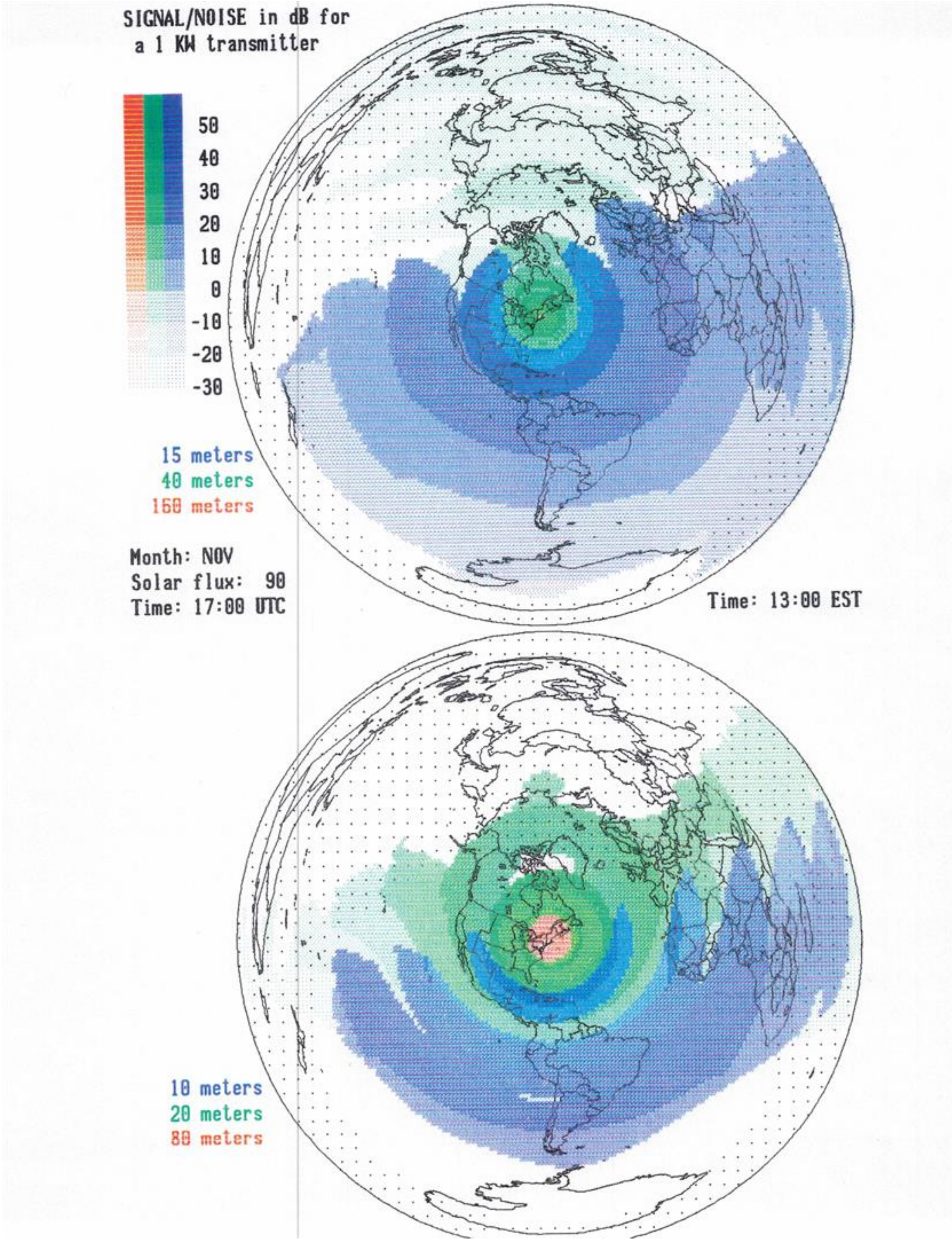
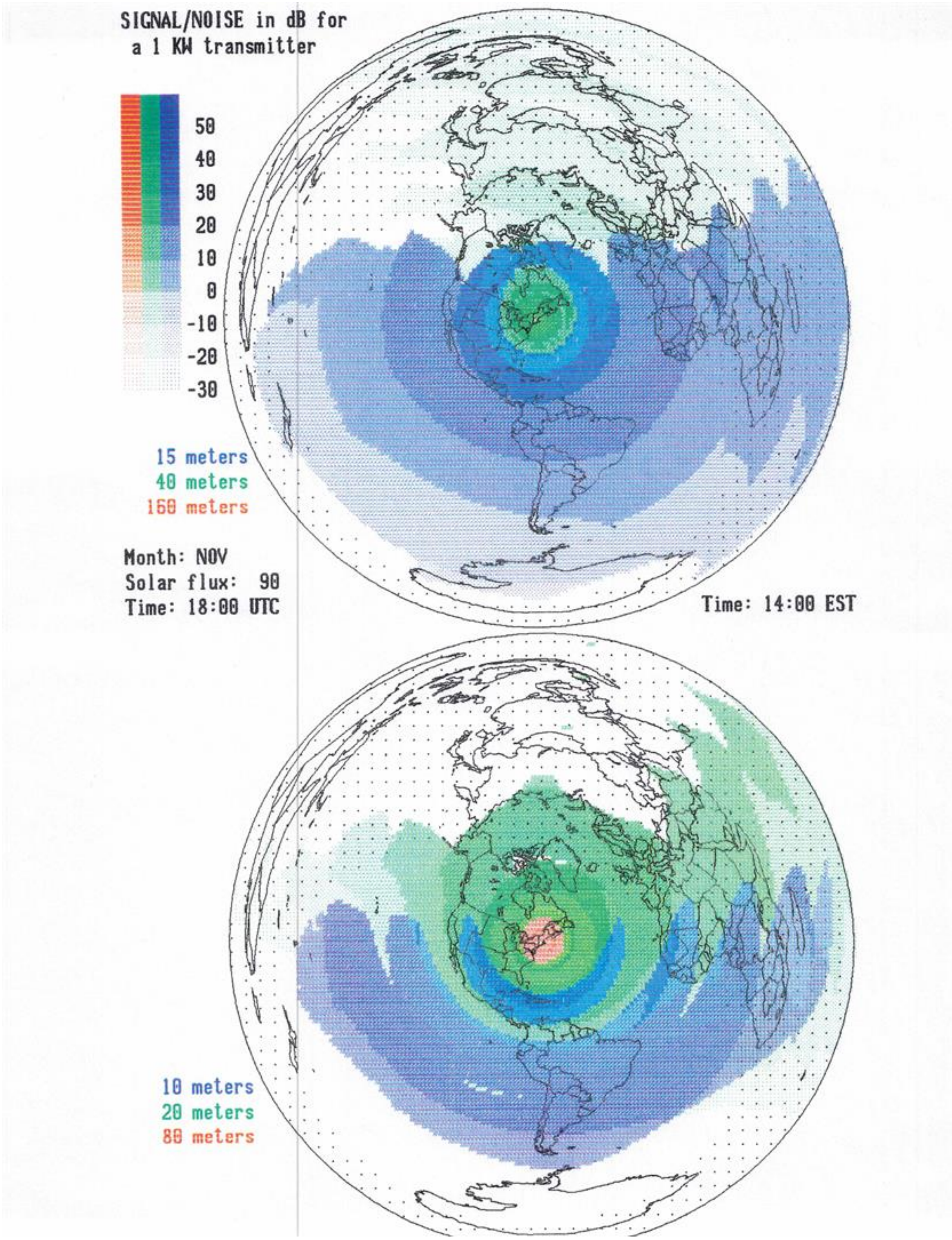
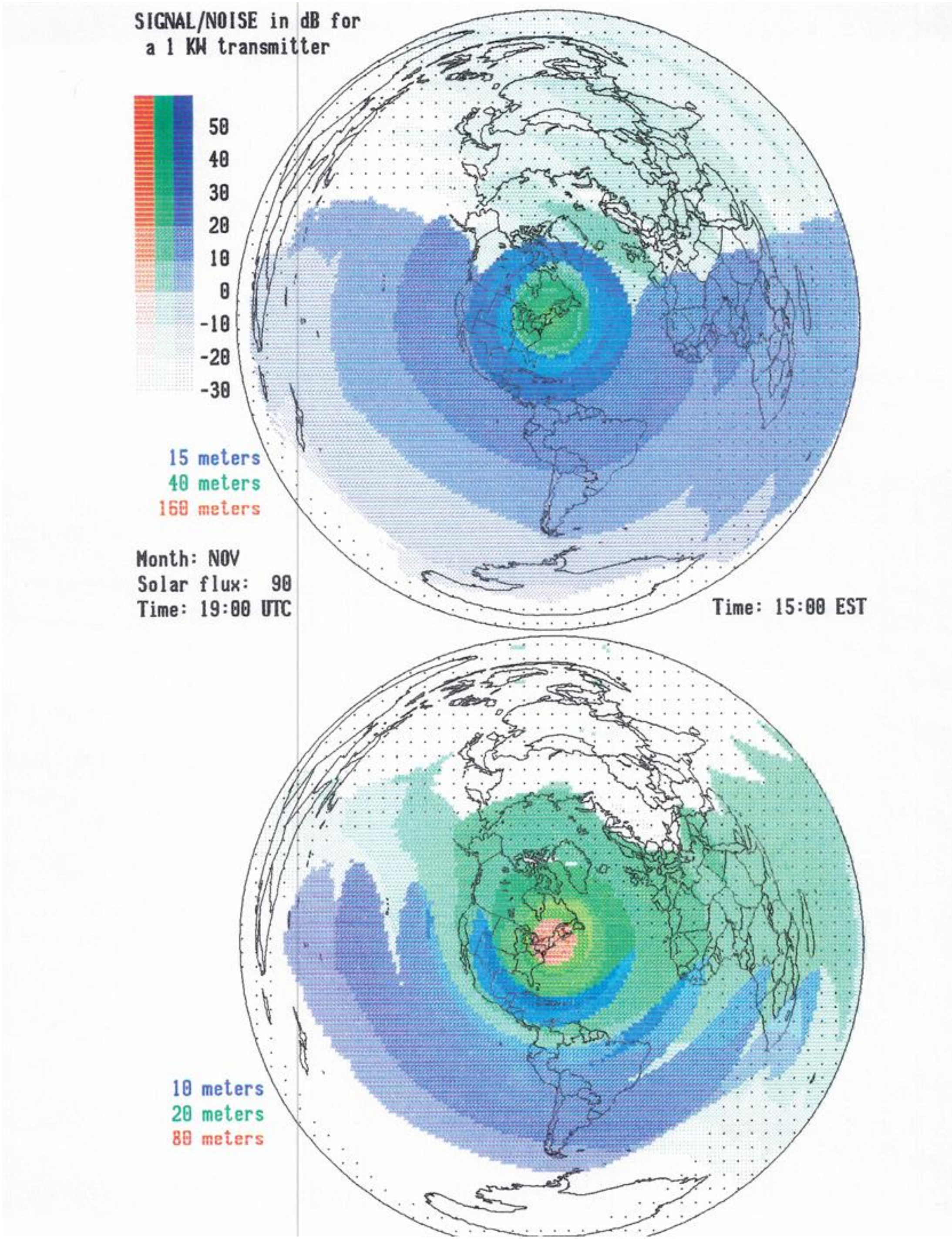
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 16:00 UTC
Time: 12:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 17:00 UTC
Time: 13:00 EST
10 meters
20 meters
80 meters



SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 18:00 UTC
Time: 14:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
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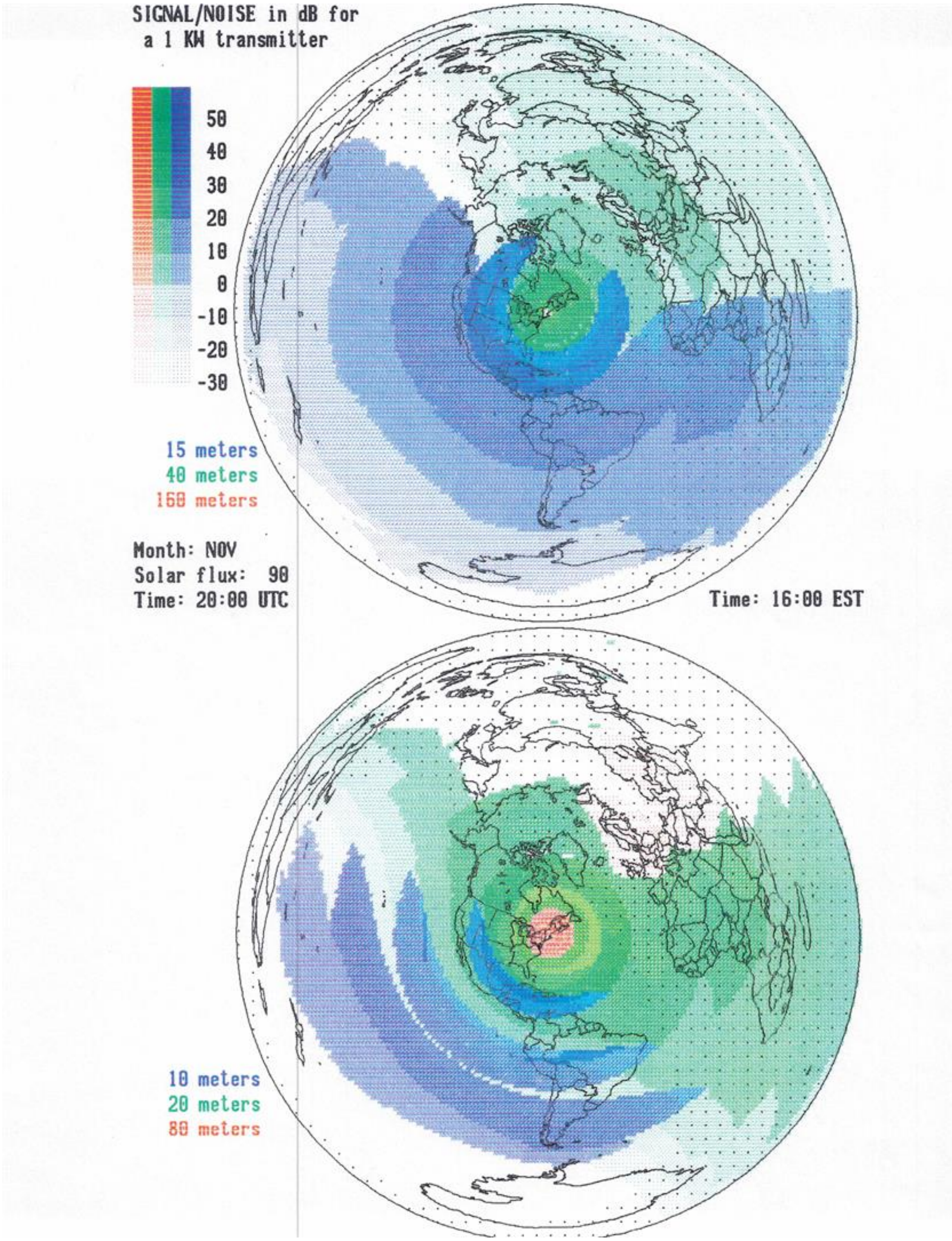
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 19:00 UTC
Time: 15:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
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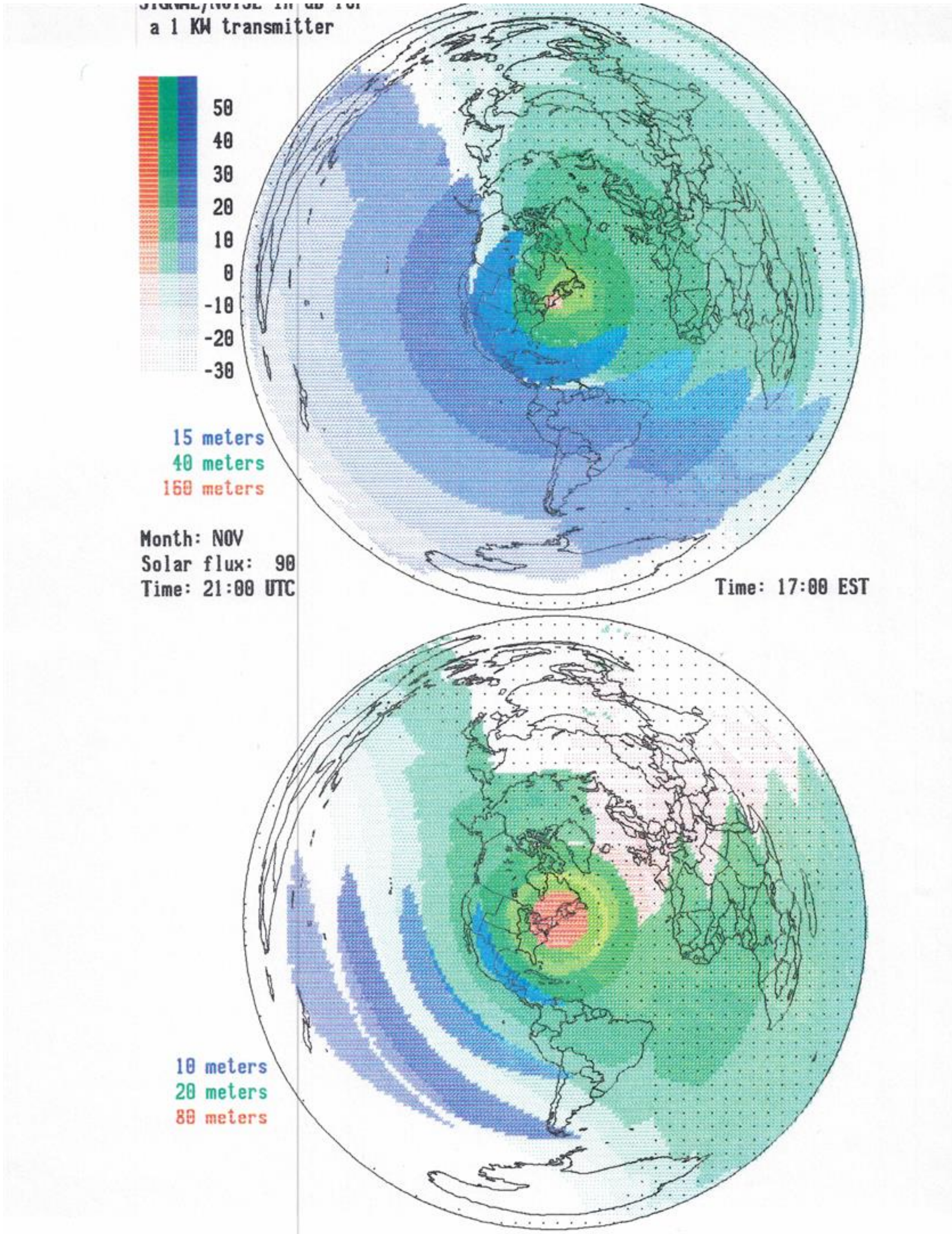
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 20:00 UTC
Time: 16:00 EST
10 meters
20 meters
80 meters


a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
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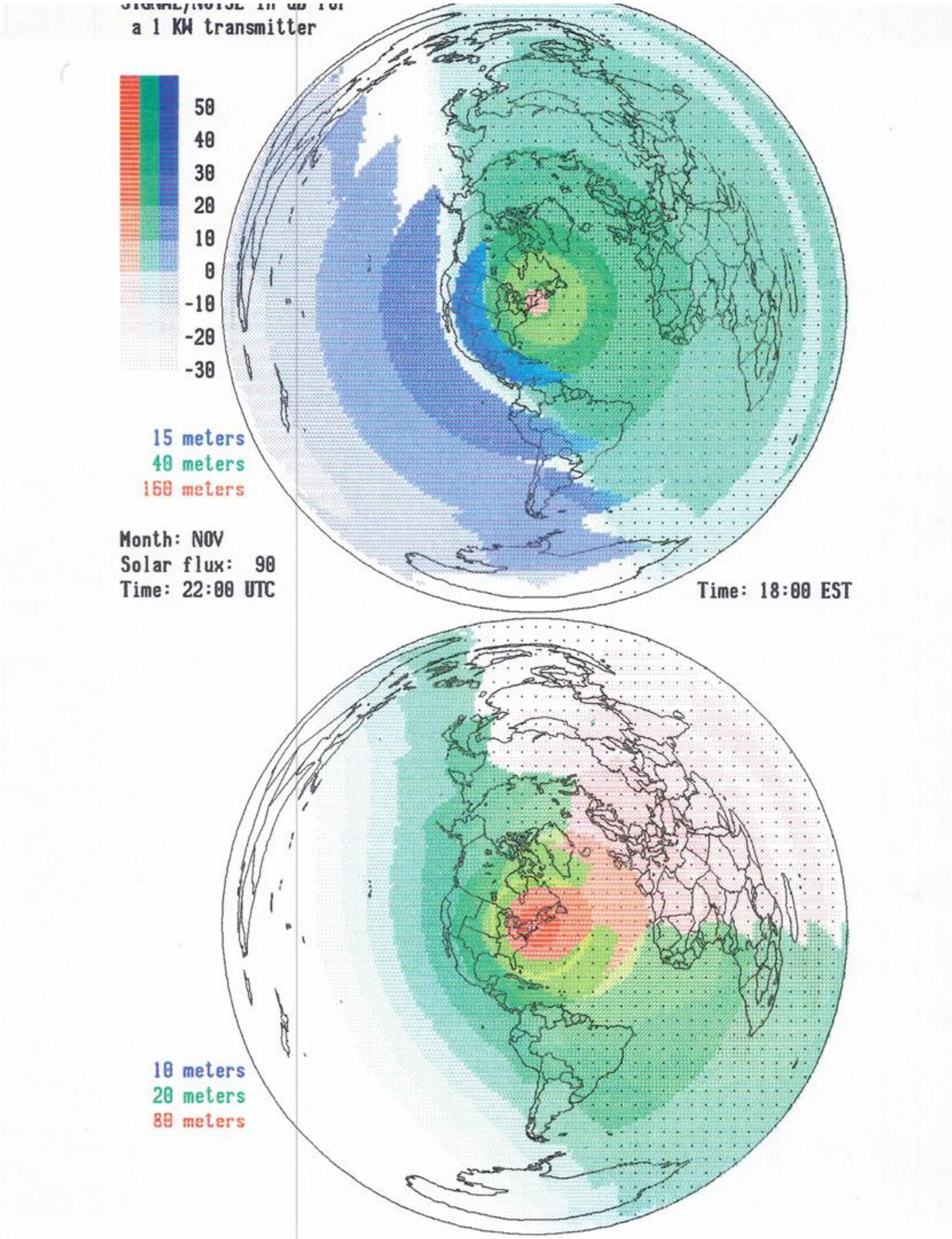
Time: 21:00 UTC
Time: 17:00 EST
10 meters
20 meters
80 meters


a 1 KW transmitter
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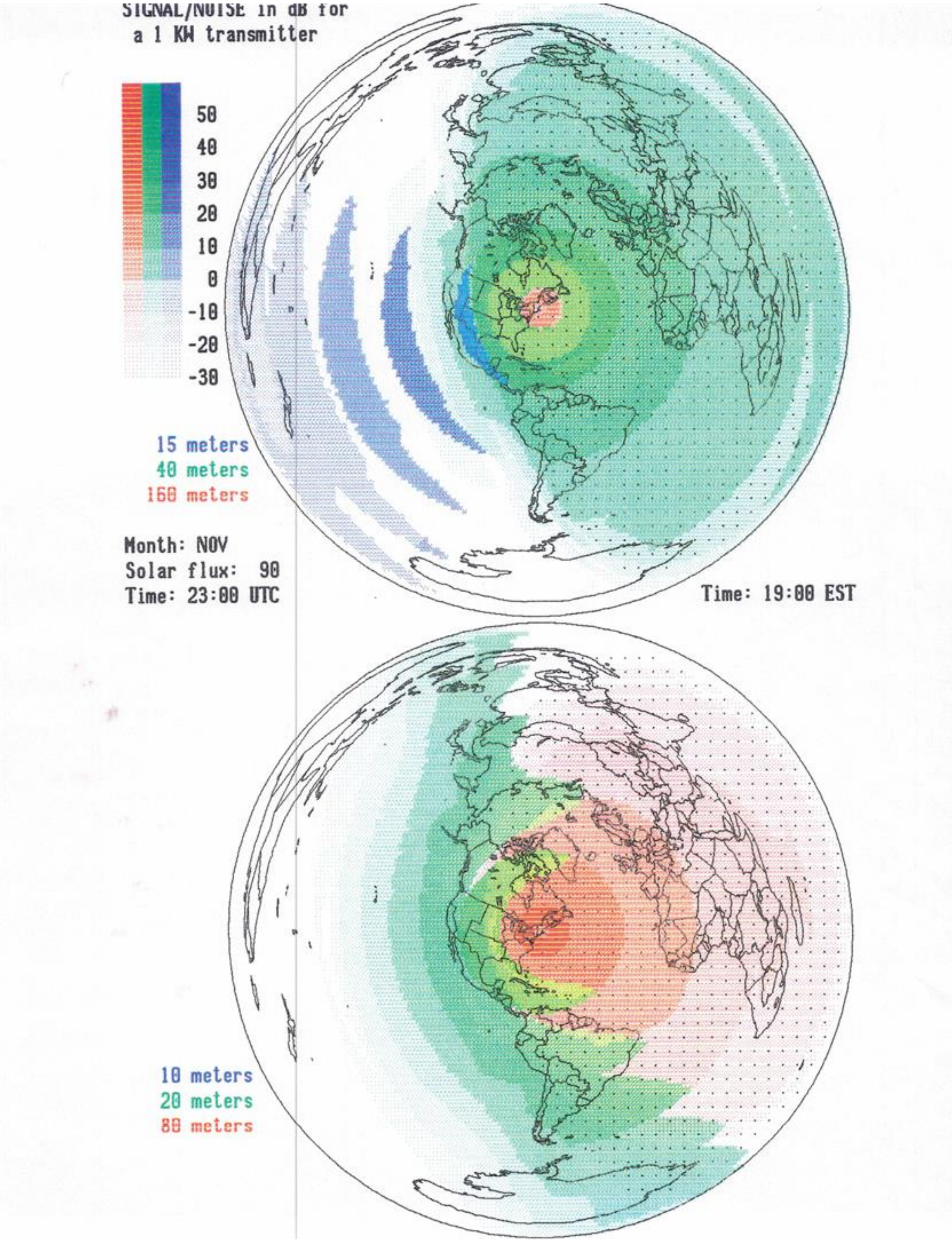
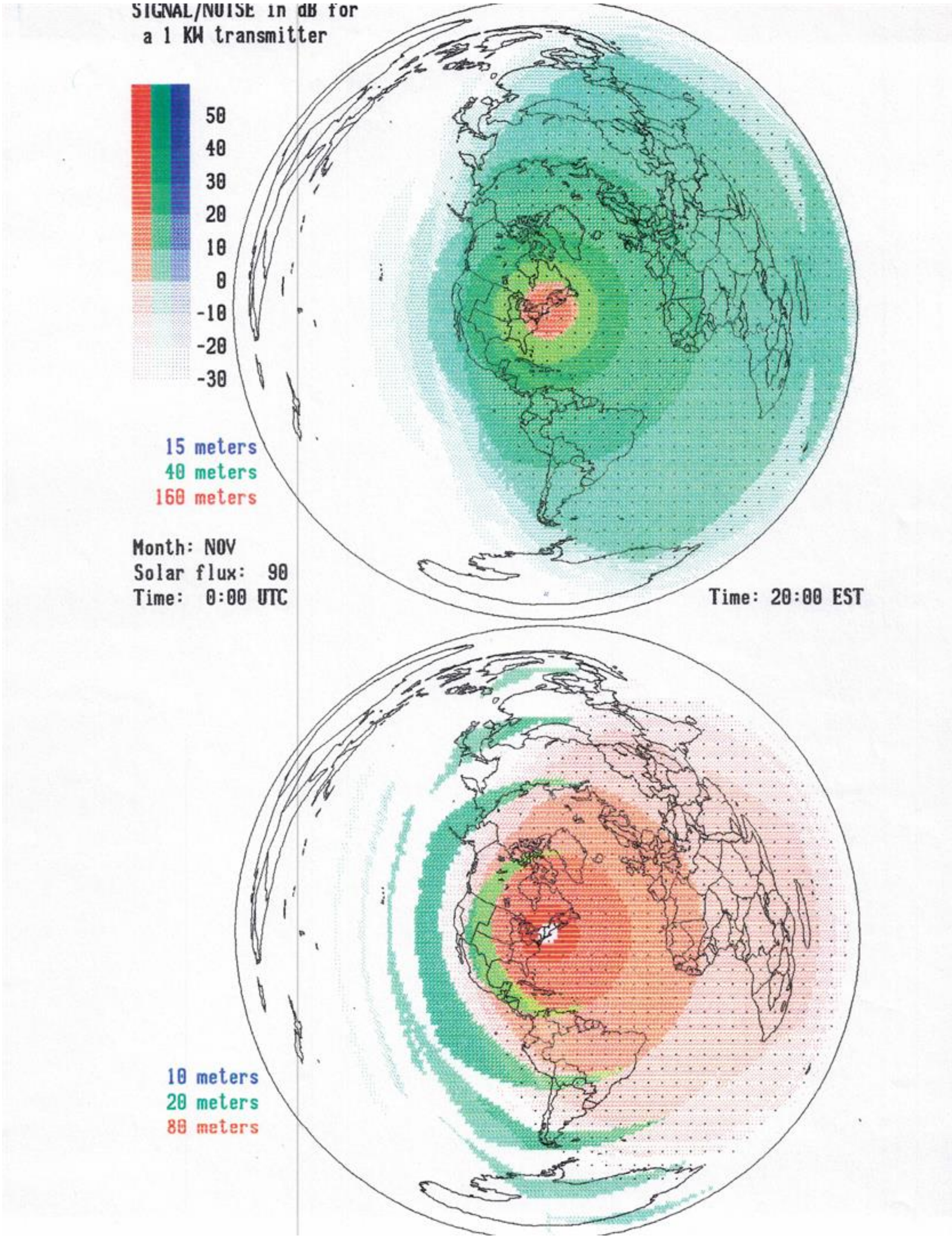
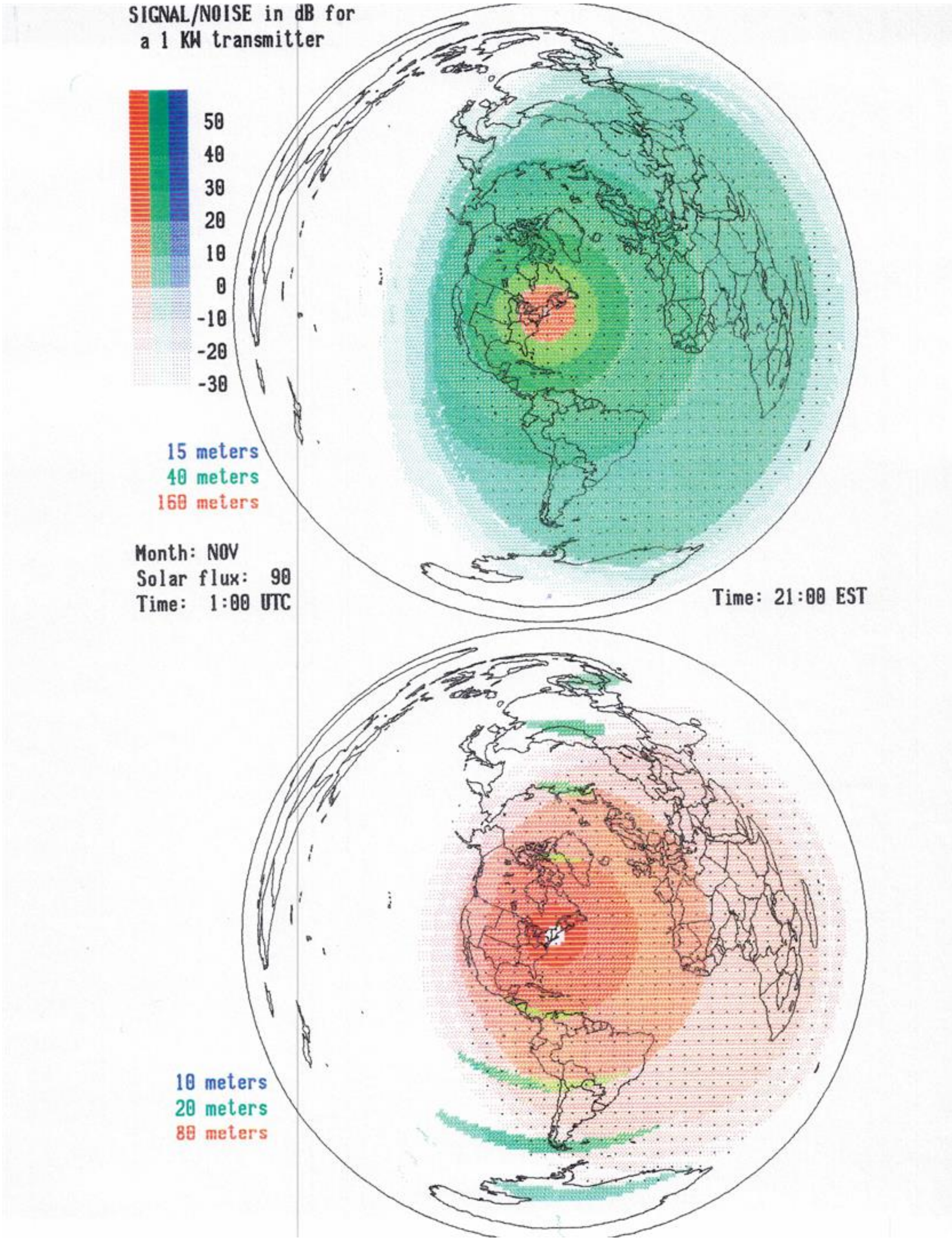
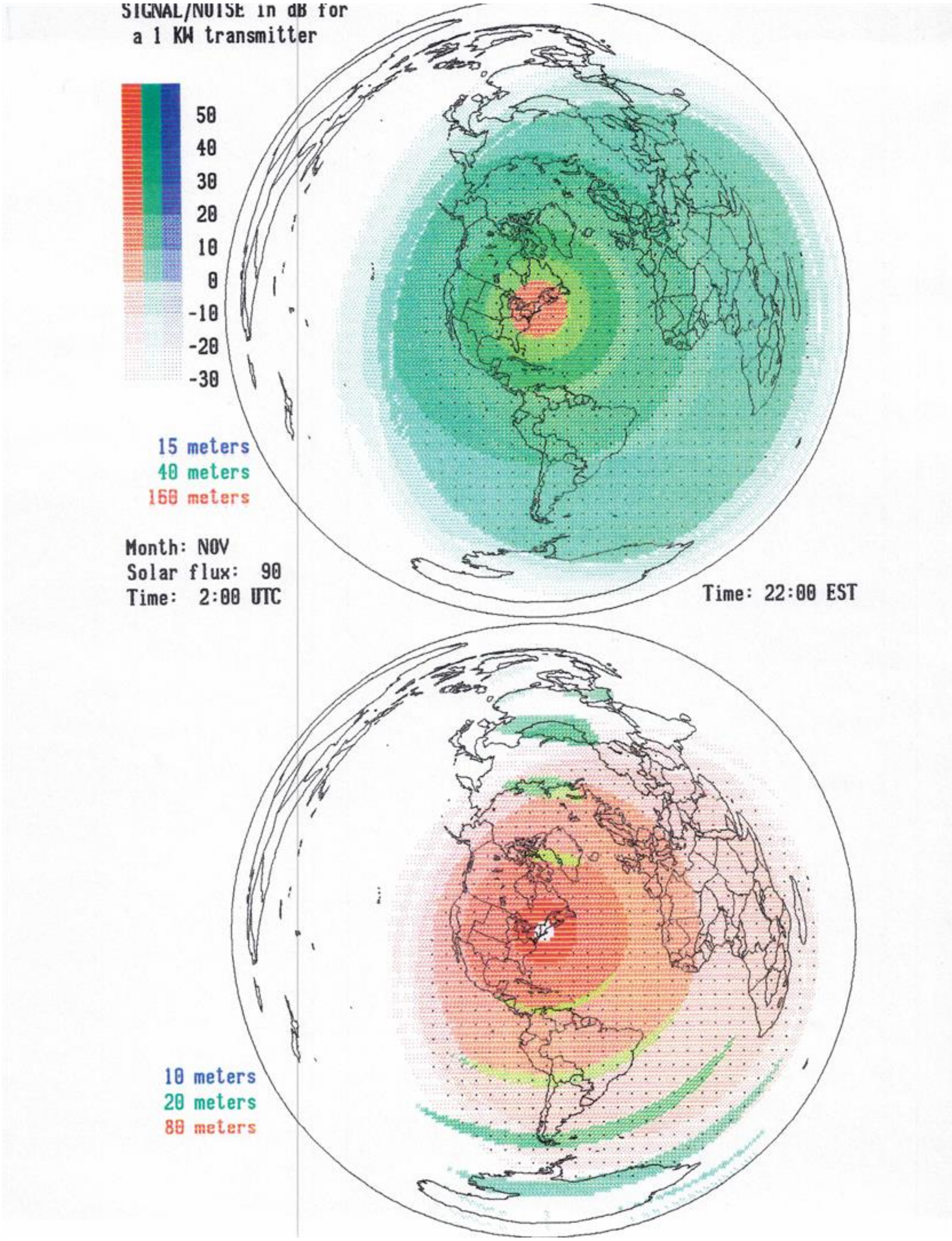
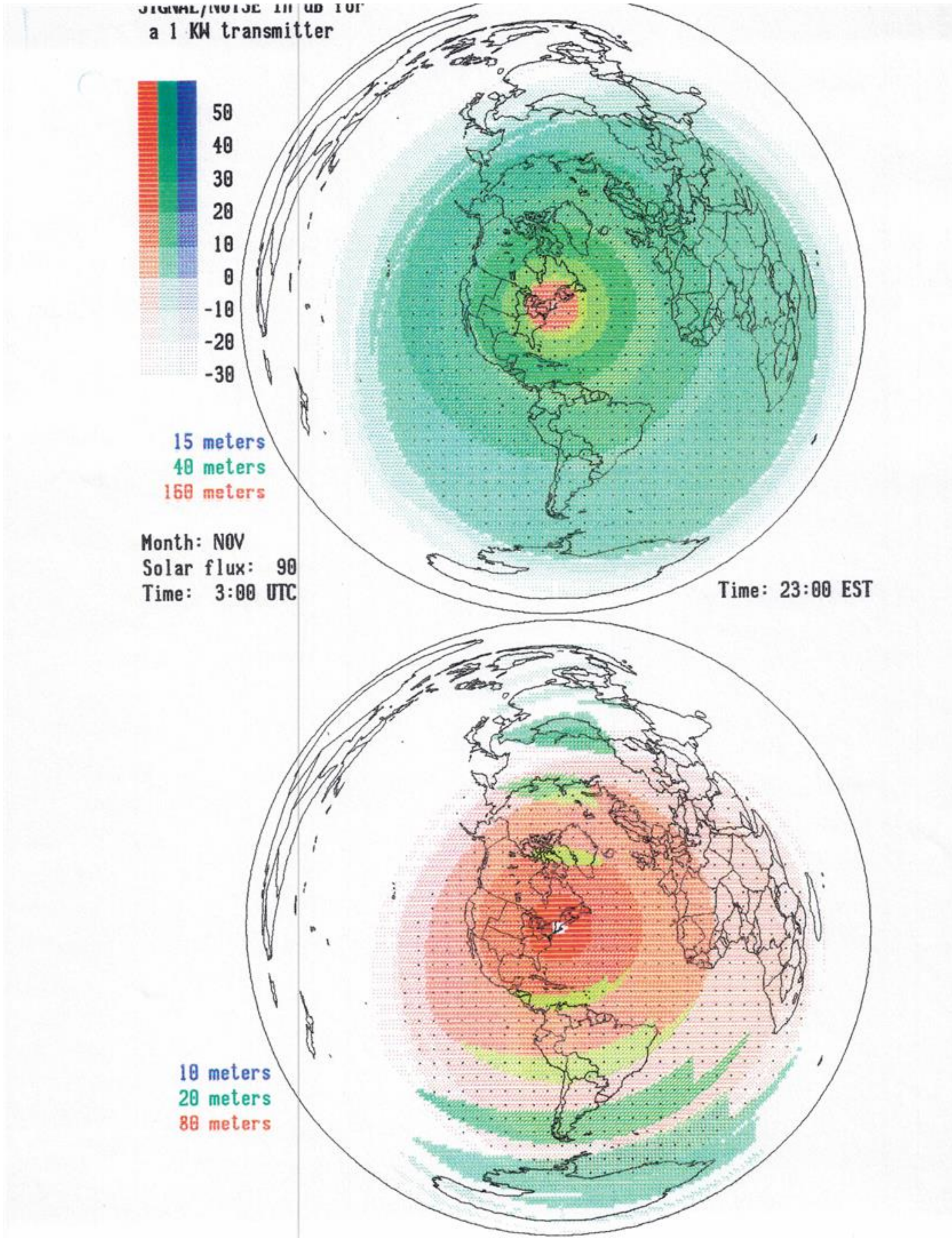
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 22:00 UTC
Time: 18:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 23:00 UTC
Time: 19:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 0:00 UTC
Time: 20:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 1:00 UTC
Time: 21:00 EST
10 meters
20 meters
80 meters


SIGNAL/NOISE in dB for
a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 2:00 UTC
Time: 22:00 EST
10 meters
20 meters
80 meters


a 1 KW transmitter
50
40
30
20
10
0
-10
-20
-30
15 meters
40 meters
160 meters
Month: NOV
Solar flux: 90
Time: 3:00 UTC
Time: 23:00 EST
10 meters
20 meters
80 meters

6. IONSOUND HDX TURBO SOFTWARE AVAILABILITY

A free copy of IONSOUND HDX TURBO software may be obtained electronically (by e-mail) for HAMSCI participants upon request from the author, Jake / W1FM. Send your request with your name, affiliation, amateur call-sign (if applicable), and e-mail address to the following email address of SkyWave Technologies:

SkyWaveTec@AOL.com

As a suggestion, please consider a donation to The American Radio Relay League, Inc. They are located at:

ARRL

225 Main Street

Newington, CT

06111-1400

ARRL Donation Form is found on-line at:

WWW.ARRL.ORG/arrl-donation-form

Note: If you are having trrouble with the on-line donation form, please feel free to call and speak with a ARRL staff person in the ARRL Development office at 860-594-0291.

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Amateur Call Sign: W1FM

ABSTRACT

IONSOUND HDX TURBO is a software propagation prediction program that evolved over a number of years and was primarily marketed in the 1990's by its author, W1FM, for use with IBM or IBM-compatible personal computers using DOS. It was intended to produce easy-to-interpret tabular predictions of radio frequency link performance between any two locations on the earth's surface. Menu selections within IONSOUND made it possible to compute predictions for comparison with Highest Possible Frequency (HPF), Maximum Possible Frequency (MPF) and Frequency of Optimum Transmission (FOT) predictions derived from U.S. Department of Commerce, National Telecommunications and Information Administration (NTIA) IONCAP program as found in ARRL's monthly QST Magazine "How's DX" Column. Parameters used in predictions included: Transmit and Receive Location, Short or Long Path, Local Receiver Noise Condition, Transmit and Receive Antenna/Gain, Receiver Bandwidth, Required Signal-to-Noise Ratio, Transmitter Power, Sunspot Number (SSN) or Solar Flux Number (SFN), Minimum Elevation Angle from the horizon, Prediction Frequencies, Prediction Months, Prediction Times, and Prediction Modes involving E and F layer propagation. The Receive Reliability prediction estimates include Total Receive Reliability which is composed of the product of Path Reliability and Signal-to-Noise (S/N) Availability. Path Reliability deals with the physics of the communication path specified by user-supplied transmitter/receiver latitude/longitude or location choices whereas the S/N Availability deals with the effects of absorption on the actual signal levels and local noise conditions relative to the minimum required S/N specified by the user. Takeoff radiation angle dependency on E, F, or multimode E/F hops along with antenna elevation angle gain, E and F ionospheric absorption, polarization loss, and ground reflection losses are also taken into account.