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Recent Initiatives in Oblique HF at Space Weather Services

Phill Maher

Consultancy and Development

Space Weather Services

17 Nov 2017

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Vertical Incidence Sounder Networks

- Space Weather Services VIS (Vertical Incidence Sounding) ionosondes maintained by Bureau Space Weather Networks.
- Worldwide GIRO network of VIS ionosondes
- Automatically scaled f_oF2 values used for generating real time ionospheric maps.

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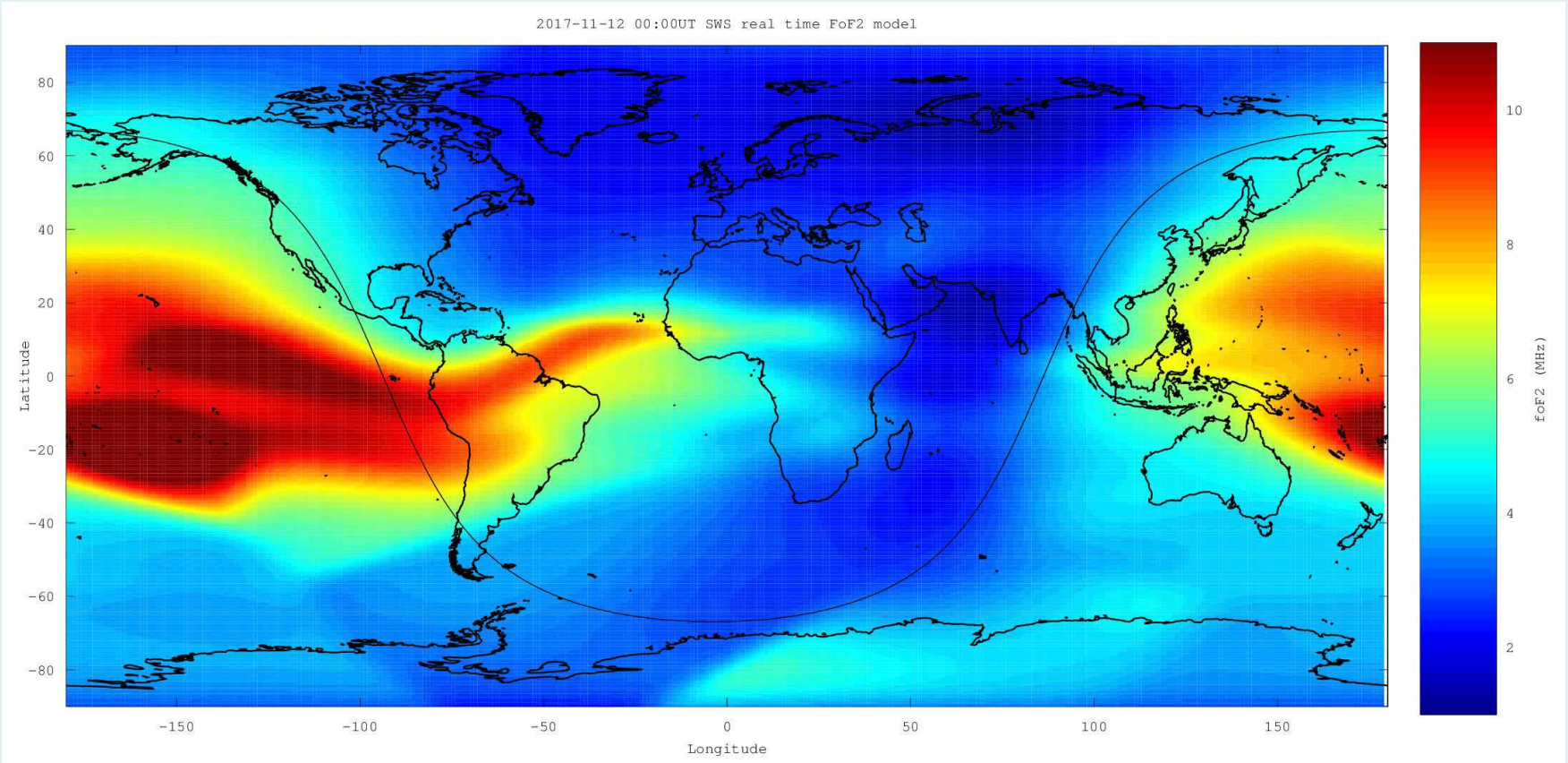
Near Real time f_0F2 maps

- Operational model of f_0F2 maps derived using SWS-VIS, GIRO VIS and IRI model [Dr. Vickal Kumar].
- f_0F2 maps converted to T-index for use in ASAPS



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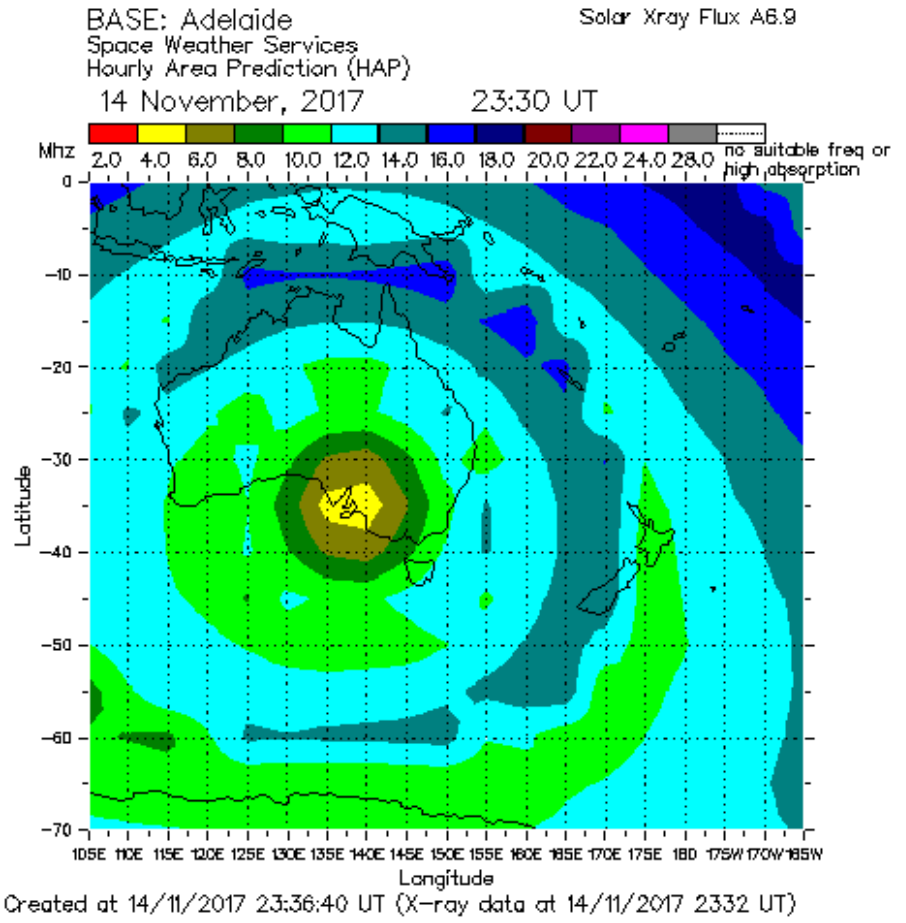
ASAPS – Advanced Stand Alone Prediction System

- ASAPS software available as
  - Stand alone windows program
  - ASAPS kernel (compiled for use in Windows/Linux/BSD)
  - Under the hood of the SWS online tools
- Contains the IPS HF-radio propagation model developed by IPS Radio and Space Services (SWS) and incorporates ITUR / CCIR HF models.
- ASAPS predictions are especially accurate when they are driven by real-time T indices for the circuit or region of interest.
- T-index developed by IPS to provide and indication of ionospheric support.



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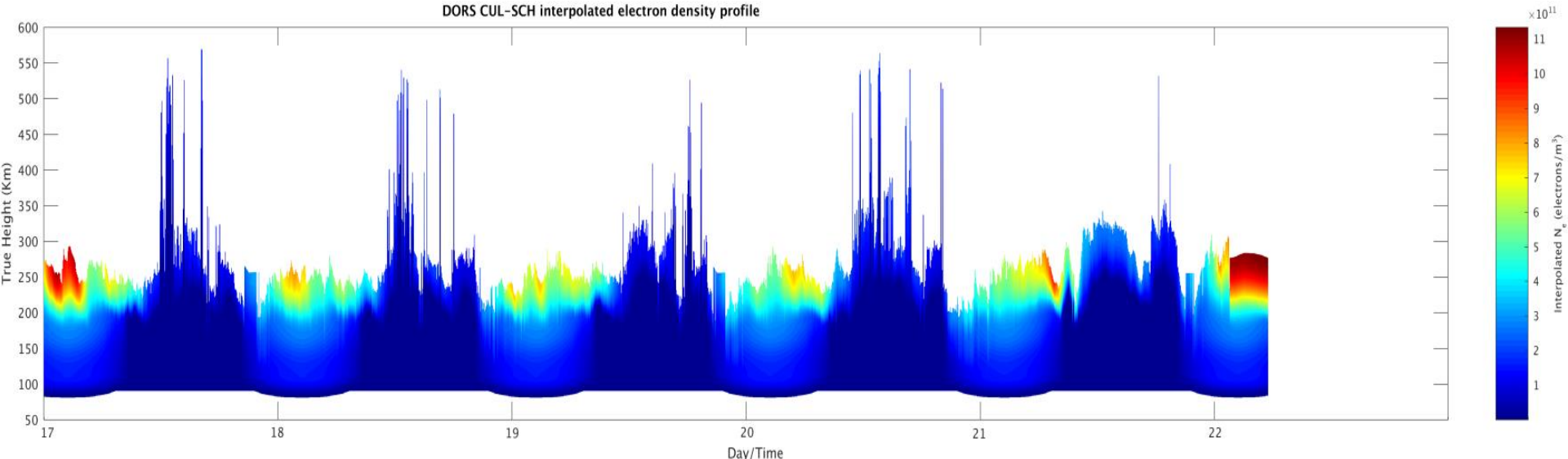
Oblique HF activities @ SWS

- Space Weather Services / IPS activities in this area have been limited to
  - Providing online tools that use the ASAPS HF prediction model for Base-Area, Area-Base and Point-Point circuits.
  - Oblique Path monitoring (AUS/NZ) [discontinued ~2006]
  - WinRadio(SDR) HF circuit monitoring [discontinued ~2009]
  - DORS receiver @ Culgoora - on loan from DSTGroup.
- *Are there any other sources of HF circuit data available?*



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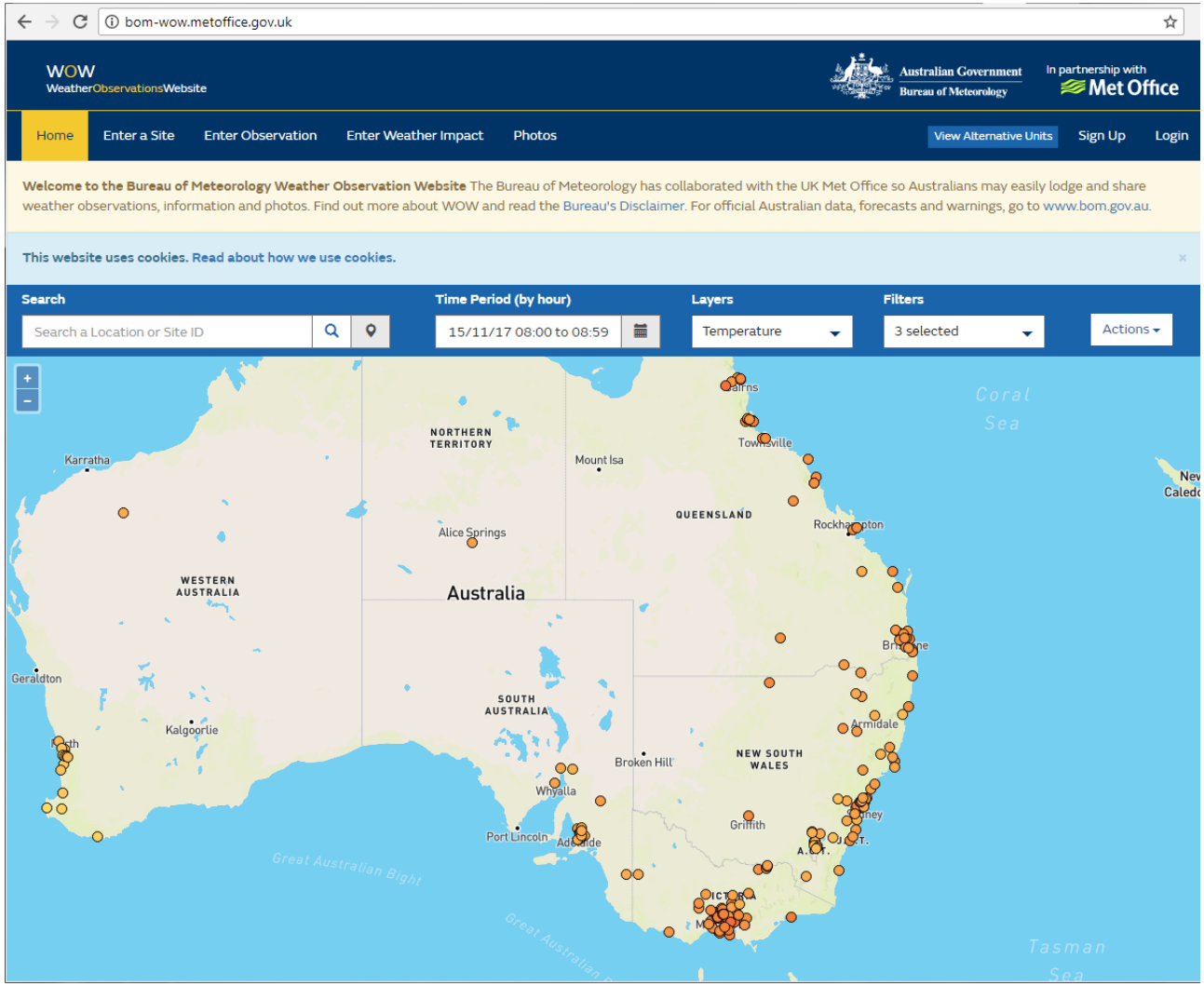
WOW : Crowd sourced weather data



- Weather Observation Wwebsite was launched in the UK in 2011 and in Australia in early 2014.
- Backyard automatic weather stations (if capable) can supply information on temperature etc.
- Data is used to compliment the information obtained from the Bureau's weather stations across the country.

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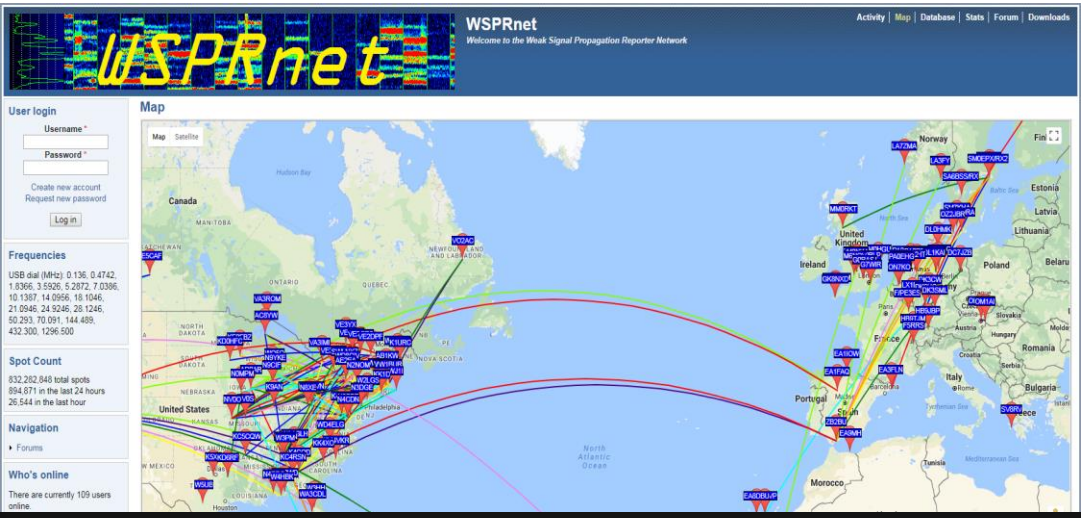
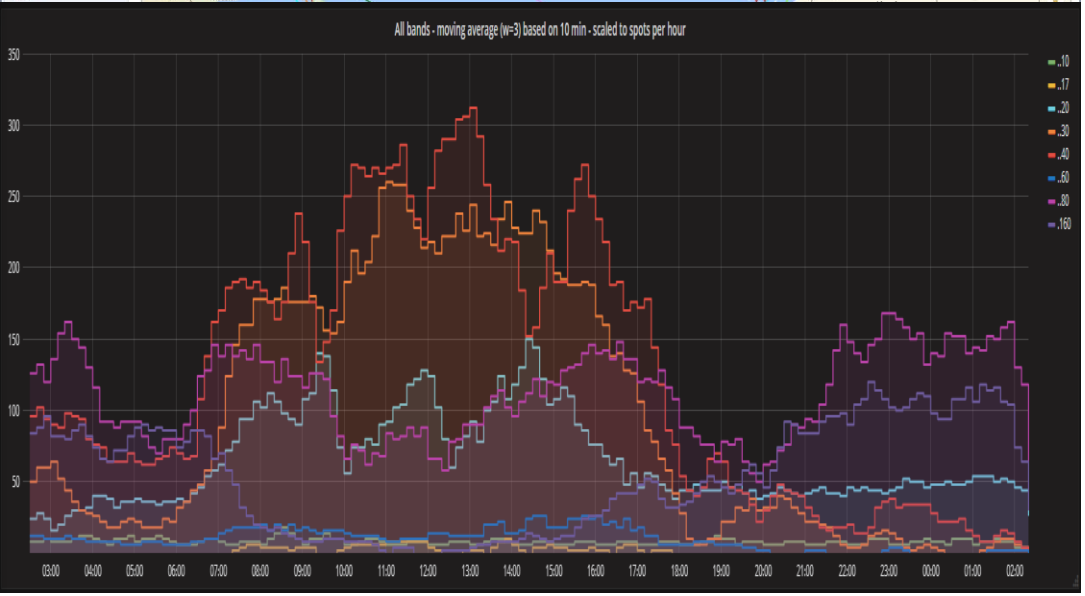
WSPRnet





- **W**eak **S**ignal **P**ropagating **R**eporter (WSPR) protocol developed by Joe Taylor (K1JT).
- HF beacons operating in unlicensed band transmitting Call sign, Location and Tx Power.
- Receiving stations (if connected to the internet) can upload contacts to a database (WSPRnet).
- Provide HF users information on operating frequencies for circuits of interest.
- WSPRnet uploads in the order of 10's of thousands per hour.
- That's a lot of free HF circuit data – what could we do with it?

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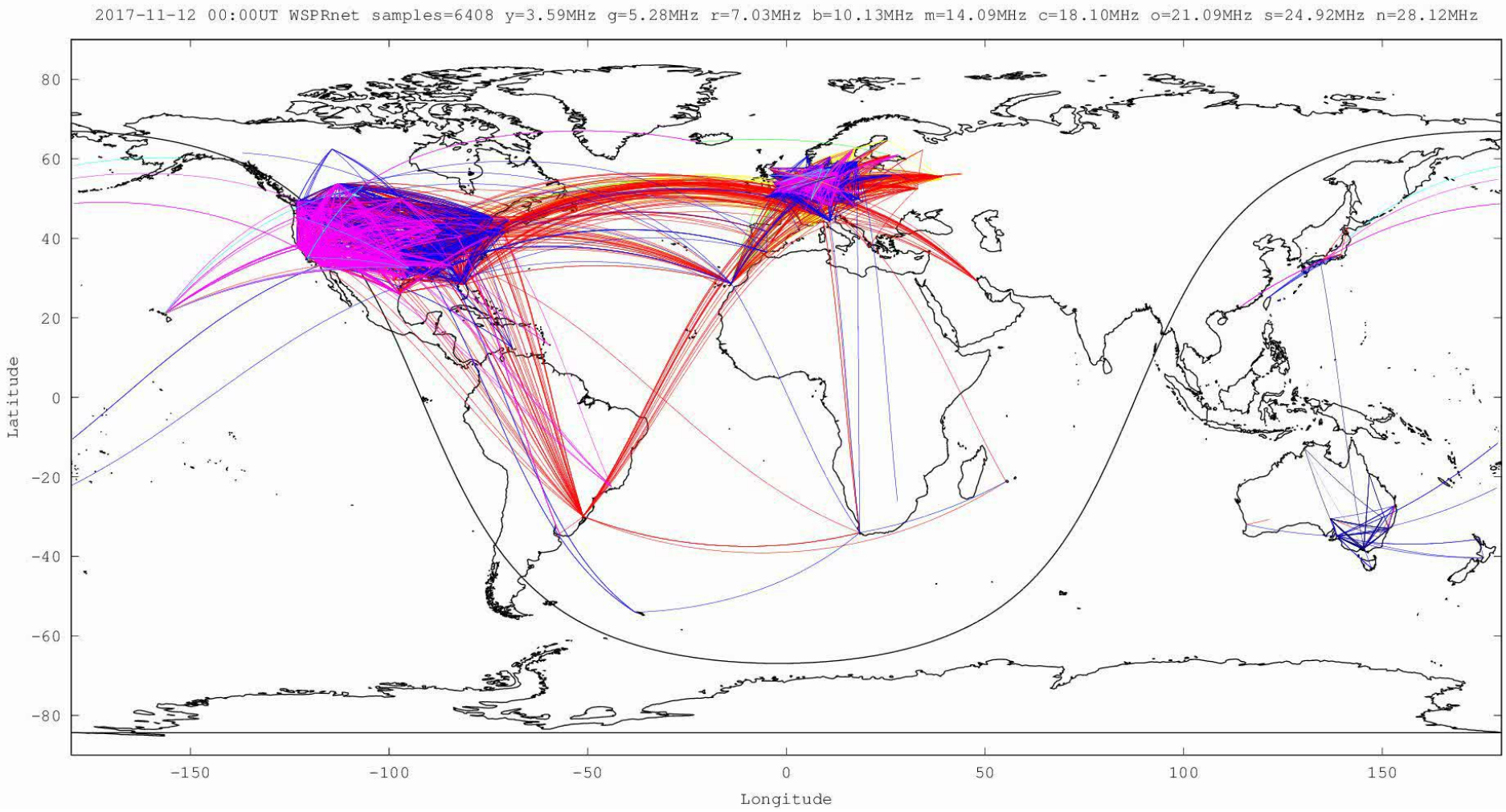
24 hours of WSPRnet



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WSPRnet evaluation

What could we use the data from WSPRnet for?

1. Validate Short Wave Fadeouts…
2. Validate ASAPS HF prediction model (via the SWS Digital HF tool)…

Short Wave Fadeouts

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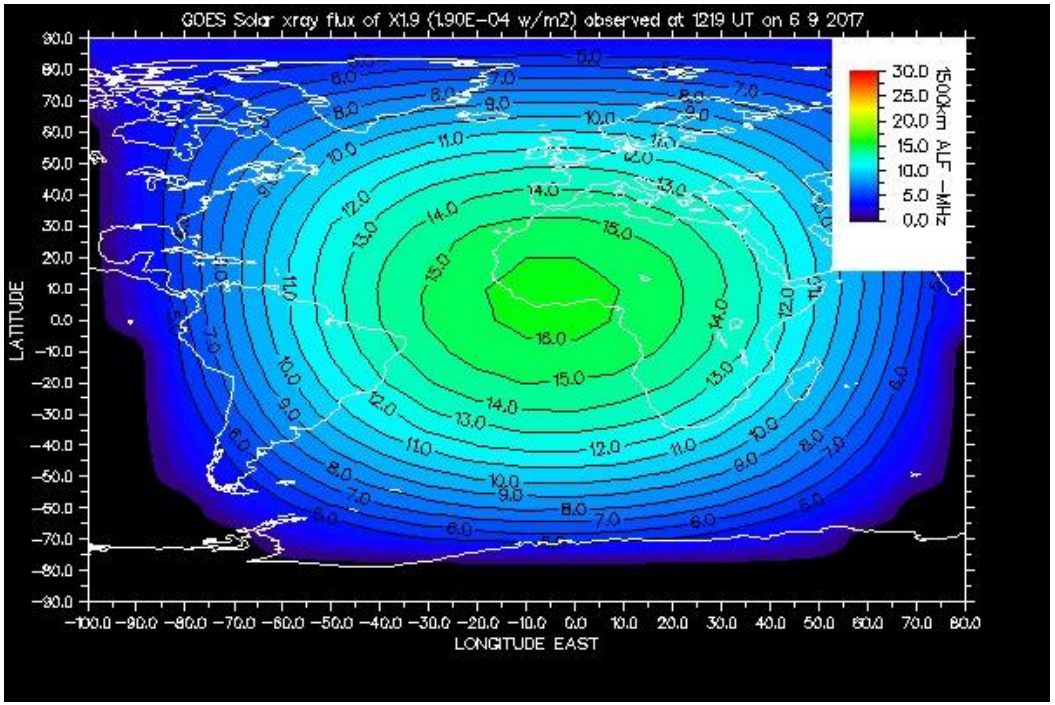
- A flare erupts on the sun sending X-rays rays towards the earth.
- X-rays penetrate further down into the ionosphere (the D-region).
- Increased ionisation in this region, increased HF absorption.
- The Absorption Limited Frequency (ALF) map shows- the lowest frequency able to propagate for circuits ~1500 km in length
- Circuits shorter than 1500 km, communications might be possible for slightly lower frequencies than the ALF.
- For longer circuits, higher frequencies than the ALF can be affected by the fadeout.

SOLAR SUMMARY Activity 06 Sep 2017: High

Flares	Max	Fadeout	Freq.	Sectors
M7.7	**0928UT**	**probable**	**lower**	**Mid East/Indian**
X9.3	**1202UT**	**probable**	**all**	**European**
M1.0	1731UT	possible	lower	Sth American/Atlantic
M1.4	1931UT	possible	lower	E.Pacific/Nth America



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WSPRnet SWF example

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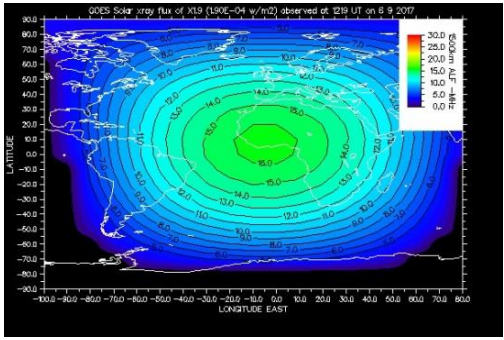

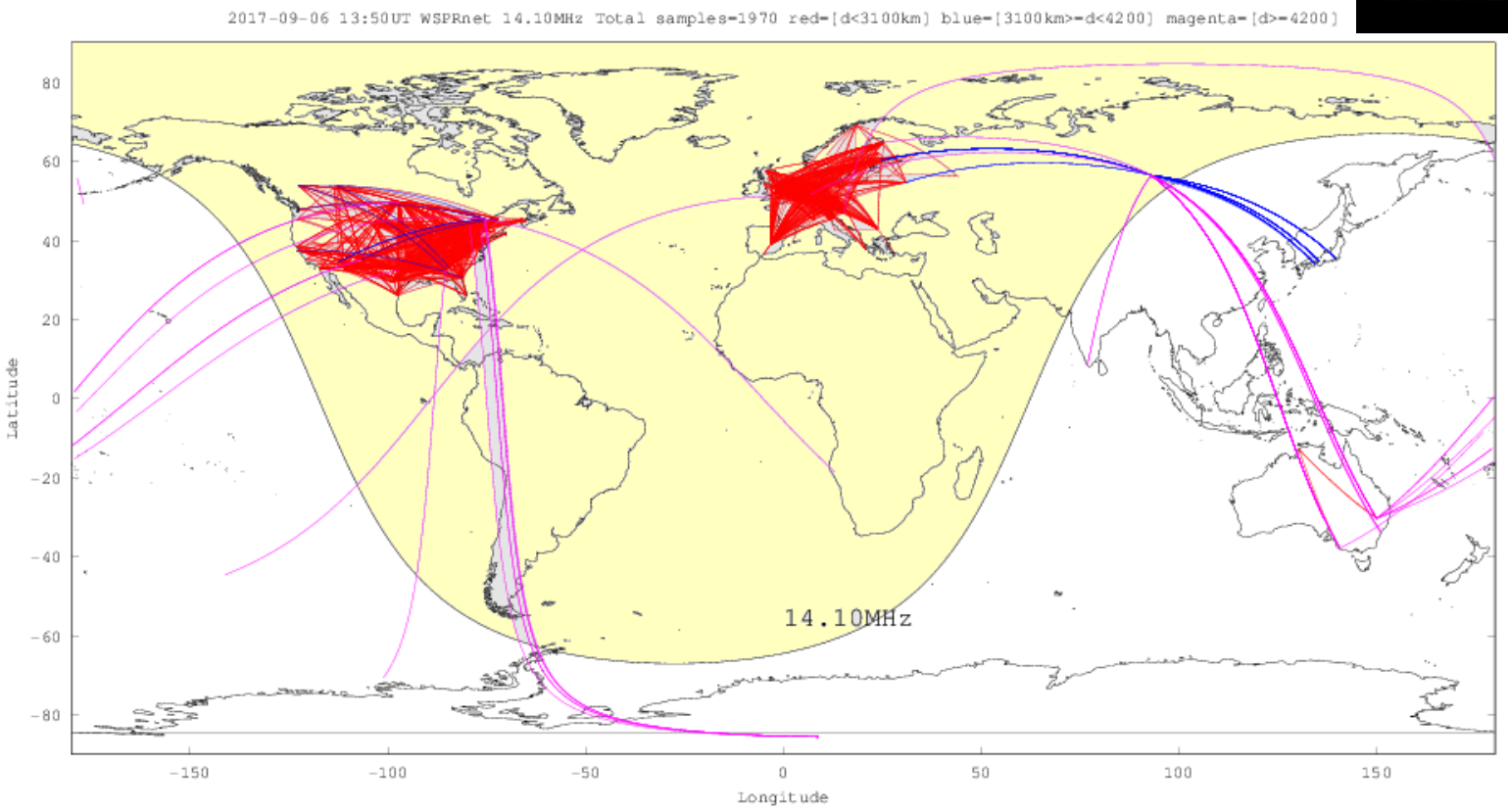

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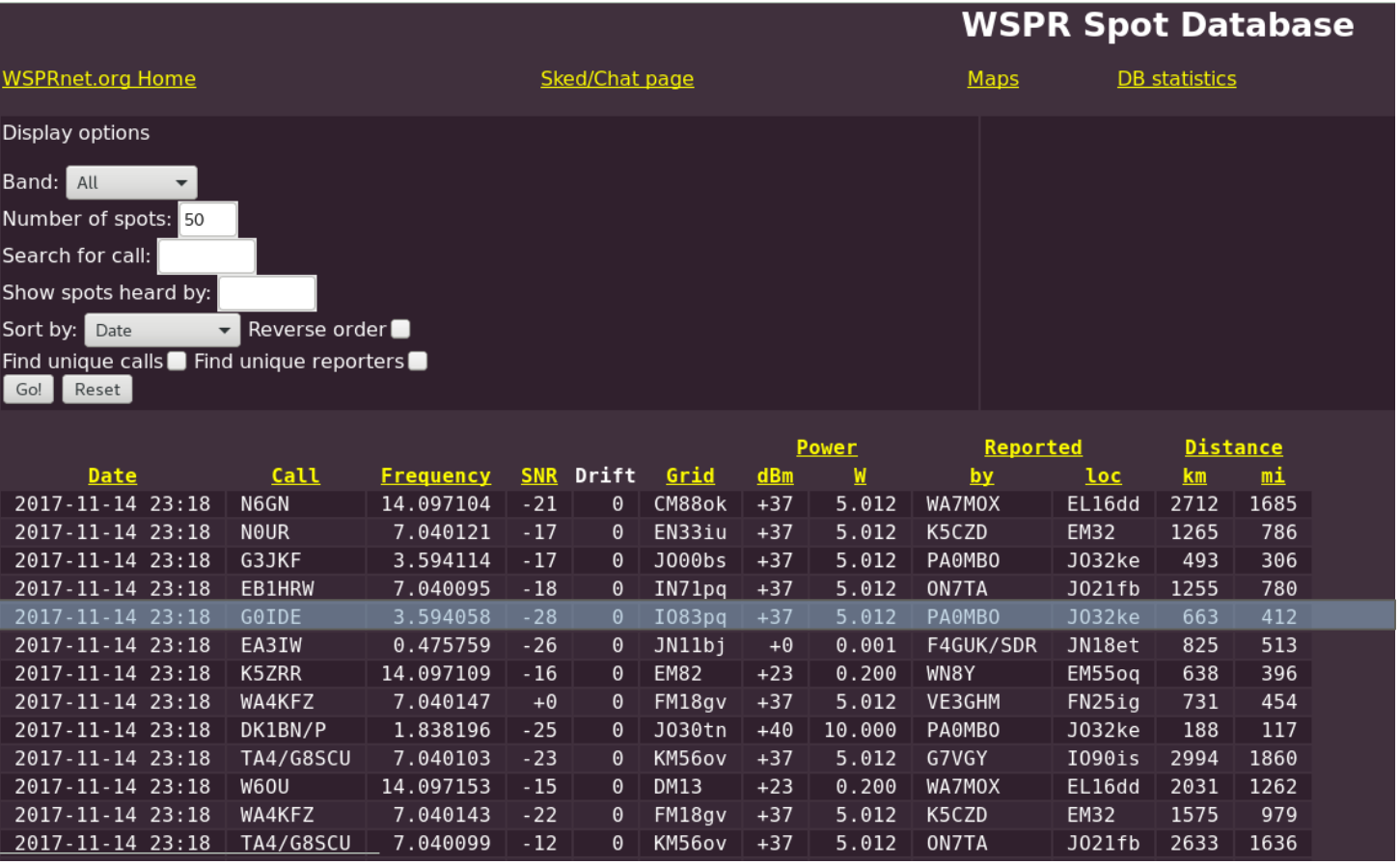
WSPR Spot Database



WSPR Spot Database

WSPRnet.org Home Sked/Chat page Maps DB statistics

Display options

Band: All
Number of spots: 50
Search for call:
Show spots heard by:
Sort by: Date Reverse order
Find unique calls Find unique reporters
Go! Reset

Date	Call	Frequency	SNR	Drift	Grid	Power dBm	Power W	Reported by	Reported loc	Distance km	Distance mi
2017-11-14 23:18	N6GN	14.097104	-21	0	CM88ok	+37	5.012	WA7MOX	EL16dd	2712	1685
2017-11-14 23:18	N0UR	7.040121	-17	0	EN33iu	+37	5.012	K5CZD	EM32	1265	786
2017-11-14 23:18	G3JKF	3.594114	-17	0	JO00bs	+37	5.012	PA0MBO	JO32ke	493	306
2017-11-14 23:18	EB1HRW	7.040095	-18	0	IN71pq	+37	5.012	ON7TA	JO21fb	1255	780
2017-11-14 23:18	G0IDE	3.594058	-28	0	IO83pq	+37	5.012	PA0MBO	JO32ke	663	412
2017-11-14 23:18	EA3IW	0.475759	-26	0	JN11bj	+0	0.001	F4GUK/SDR	JN18et	825	513
2017-11-14 23:18	K5ZRR	14.097109	-16	0	EM82	+23	0.200	WN8Y	EM55oq	638	396
2017-11-14 23:18	WA4KFZ	7.040147	+0	0	FM18gv	+37	5.012	VE3GHM	FN25ig	731	454
2017-11-14 23:18	DK1BN/P	1.838196	-25	0	JO30tn	+40	10.000	PA0MBO	JO32ke	188	117
2017-11-14 23:18	TA4/G8SCU	7.040103	-23	0	KM56ov	+37	5.012	G7VGY	IO90is	2994	1860
2017-11-14 23:18	W6OU	14.097153	-15	0	DM13	+23	0.200	WA7MOX	EL16dd	2031	1262
2017-11-14 23:18	WA4KFZ	7.040143	-22	0	FM18gv	+37	5.012	K5CZD	EM32	1575	979
2017-11-14 23:18	TA4/G8SCU	7.040099	-12	0	KM56ov	+37	5.012	ON7TA	JO21fb	2633	1636

2017-11-14 @ 23:28UT

Tx Call Sign: GOIDE

Tx Frequency: 3.59MHz

Tx Power: 37dBM

Tx Location: I083pq
(Maidenhead Locator System for encoding Lat/Lon)

Rx Call Sign: PA0MB0

Rx SNR: -28dB

Rx Location: J032ke
(Maidenhead Locator System for encoding Lat/Lon)

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Digital HF tool example

```
======================================================================
Input Data:
Date: 14 11 2017      T-index: 0025
Tx Name: K6MCS     Lat:   38.69 deg     Long:  238.62 deg
Tx Antenna:Name= Omni
Rx Name: K5CZD     Lat:   32.56 deg     Long:  267.79 deg
Rx Antenna:Name= Omni
Frequencies: 30.000 28.125 24.925 21.095 18.105 14.096 10.139 7.039 5.287 3.593 MHz
Tx Power:    0.01 kW
Rx Bandwidth: 2500.0 Hz    Rx Noise: -145.0 dBW/Hz at 3 MHz
Required SNR for bandwidth:  -28.0 dB
Minimum Probability of ionospheric support:   90.0 %
Minimum elevation Angle:    5.0 deg
Multipath Limits: Maximum SNR Margin =   30.0 dB
                  Minimum relative Delay =    1.00 ms
                  Minimum Frequency shift =    1.00 Hz

 UT  ----------------- Frequency Set (MHz) -------------------    REL   DOM   BRR   ORR
 22   30.0  28.1  24.9  21.1  18.1  14.1  10.1   7.0   5.3   3.6  14.1  14.1 100.0 100.0
BCR     ..    ..    ..    ..    .. 100.0 100.0 100.0    ..    .. 100.0 100.0
OCR     ..    ..    ..    ..    .. 100.0 100.0 100.0    ..    .. 100.0 100.0
SSM     ..    ..    ..    ..    ..    1F    2E    2E    ..    ..    1F    1F
DLA     ..    ..    ..    ..    ..  9.40  9.23  9.21    ..    ..  9.40  9.40
SIM     ..    ..    ..    ..    ..    ..    ..    ..    ..    ..    ..    ..
PLS     ..    ..    ..    ..    .. 126.5 134.0 133.8                126.5 126.5
LAN     ..    ..    ..    ..    ..  5.10
TAG     ..    ..    ..    ..    ..  0.00
THR1    ..    ..    ..    ..    ..  3709
THR2    ..    ..    ..    ..    ..  1888
THR3    ..    ..    ..    ..    ..   629
BER1    ..    ..    ..    ..    ..     1
BER2    ..    ..    ..    ..    ..  2298
BER3    ..    ..    ..    ..    .. >9999
MOD1    ..    ..    ..    ..    ..   >10     3     1    ..    ..   >10   >10
MOD2    ..    ..    ..    ..    ..   >10     1     1    ..    ..   >10   >10
MOD3    ..    ..    ..    ..    ..     1     1     1    ..    ..     1     1
```

Database

Specify query parameters

50 spots:

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	az
2017-11-14 22:26	K6MCS	14.097104	-14	0	CM98hq	2	K5CZD	EM32vn	2709	96

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WSPR and ASAPS model validation

- Summary of work on WSPRnet
  - Development of an automated WSPR/ASAPS/T-index monitoring system is nearing completion
    - Validation of the ASAPS prediction model
    - Validation of real time T-index maps.
  - Validate effects of SWF (to compliment VIS ionosonde data).

- Issues regarding WSPR data
  - Tx/Rx antenna pattern is ***unknown… cannot determine Tx EIRP.***
    - Assume isotropic Tx/Rx antenna and Tx power in WSPR data.
  - Rx noise environment is ***unknown…. requires a calibrated receiver.***
    - Assumption for Rx noise level.

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Thank you…

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WSPR protocol

- Standard message components after lossless compression: 28 bits for callsign, 15 for locator, 7 for power level, 50 bits total.
- Number of binary channel symbols: N_sym = (50+K-1) * 2 = 162
- Keying rate: 12000/8192 = 1.4648 baud
- Modulation: continuous phase 4-FSK, tone separation 1.4648 Hz (BW: ~ 6Hz)
- Synchronization: 162-bit pseudo-random sync vector.
- Duration of transmission: 162 * 8192/12000 = 110.6 s.
- Minimum S/N for reception: around –28 dB in a 2500Hz bandwidth.

Source:
https://en.wikipedia.org/wiki/WSPR_(amateur_radio_software)