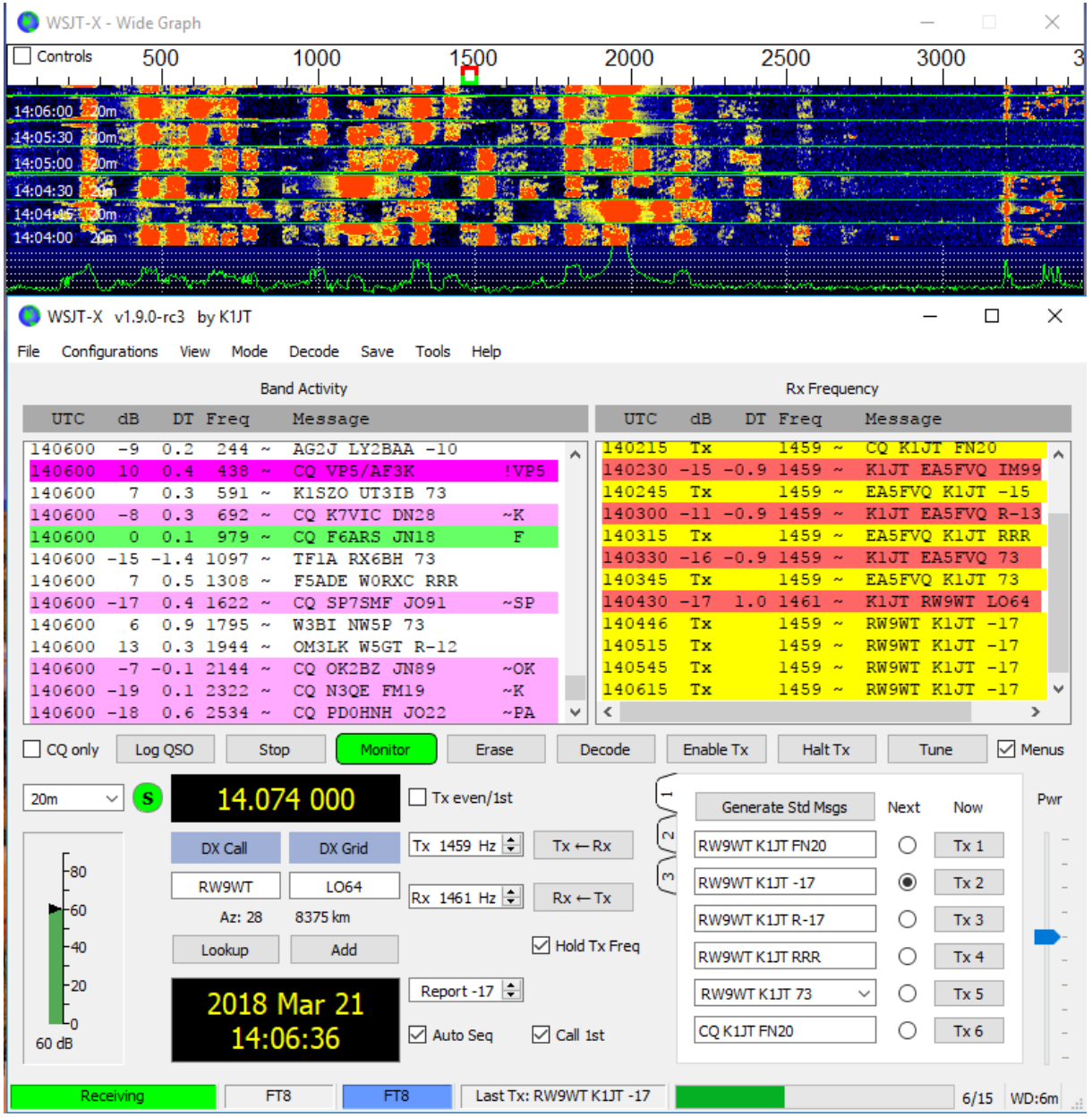
Work the World with *WSJT-X*



Joe Taylor
K1JT

MicroHAMS Digital Conference

March 24, 2018

Weak-Signal Communication Software

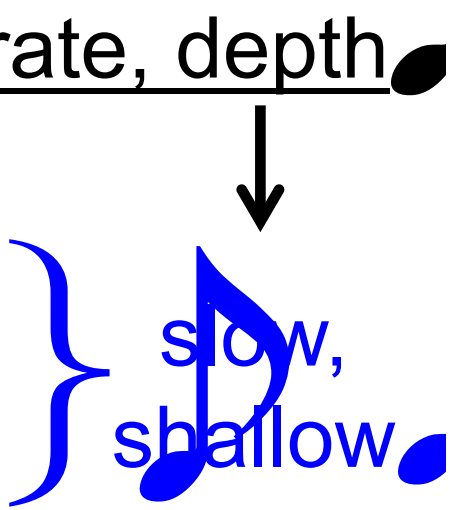
- ***WSJT*** – 2001 – VHF+: meteor scatter, EME; HF: QRP DXing
- ***MAP65*** – 2006 – Wideband EME: multi-decode, adaptive polarization
- ***WSPR*** – 2008 – QRP propagation probe
- ***WSJT-X*** – 2012 – All bands, many modes
  LF MF HF VHF UHF SHF
  2018: >15,000 active users, world-wide

Modes ? Codes ??

- "Mode" – signaling method and protocol
  - CW, PSK31, JT65, WSPR, JT9, JT4, QRA64, MSK144, FT8, …
  - coding, modulation, symbol rate, block size, …

- "Code" – how symbols represent information
  - Character-by-character: Morse, baudot, ASCII, PSK31, FSK441, …
  - Block structured: Reed-Solomon, Convolutional, Turbo, LDPC, QRA, …

Relevant Propagation Types



- MF, HF – groundwave, skywave
- Tropospheric scatter
- Multi-hop (weak) sporadic-E
- EME (VHF, UHF, microwave …)
- Meteor scatter
- Aircraft scatter
- Ionospheric scatter

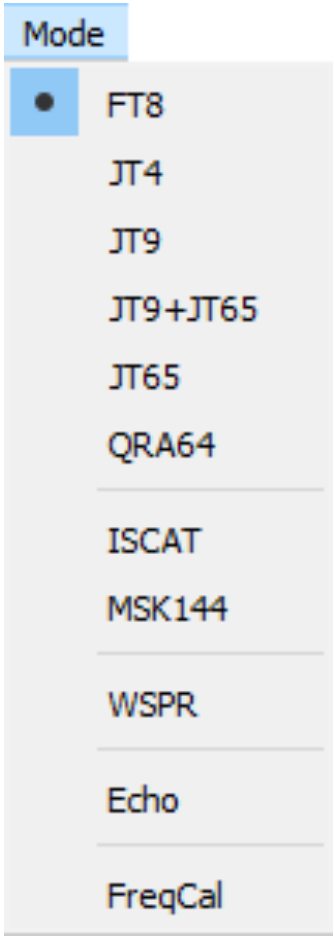
Modes in *WSJT-X*

Scatter ➔ "Fast"

- **MSK144**
- **JT9 E-H**
- **ISCAT**

QRP, EME, … ➔ "Slow"

- **FT8**
- **JT4**
- **JT9**
- **JT65**
- **QRA64**
- **WSPR**



Echo

Why so many modes?

- Different propagation types
- Code design and parameter optimization for each purpose
  - Fading depth
  - Fading rate (Doppler spread)
  - Sync requirements: Frequency stability
- Also important: learning as we go …

Mode design: Tunable parameters

- Block message structure
- Compression → "Source encoding"
- Error control (code type, rate, …)
- Information throughput
- Modulation type
- Symbol rate

} bandwidth

- Synchronization method

Weak-signal minimal QSO, with structured messages

CQ K1ABC FN42

K1ABC W9XYZ EN37

W9XYZ K1ABC -22

K1ABC W9XYZ R-19

W9XYZ K1ABC RRR

K1ABC W9XYZ 73

Structured Messages: Design choice for ECC Modes

Information block size: 72 bits

Calls and locator:

KA1ABC WB9XYZ EN37

28 + 28 + 15 + 1 = 72

Free text:

TNX BOB 73 GL

71 + 1 = 72

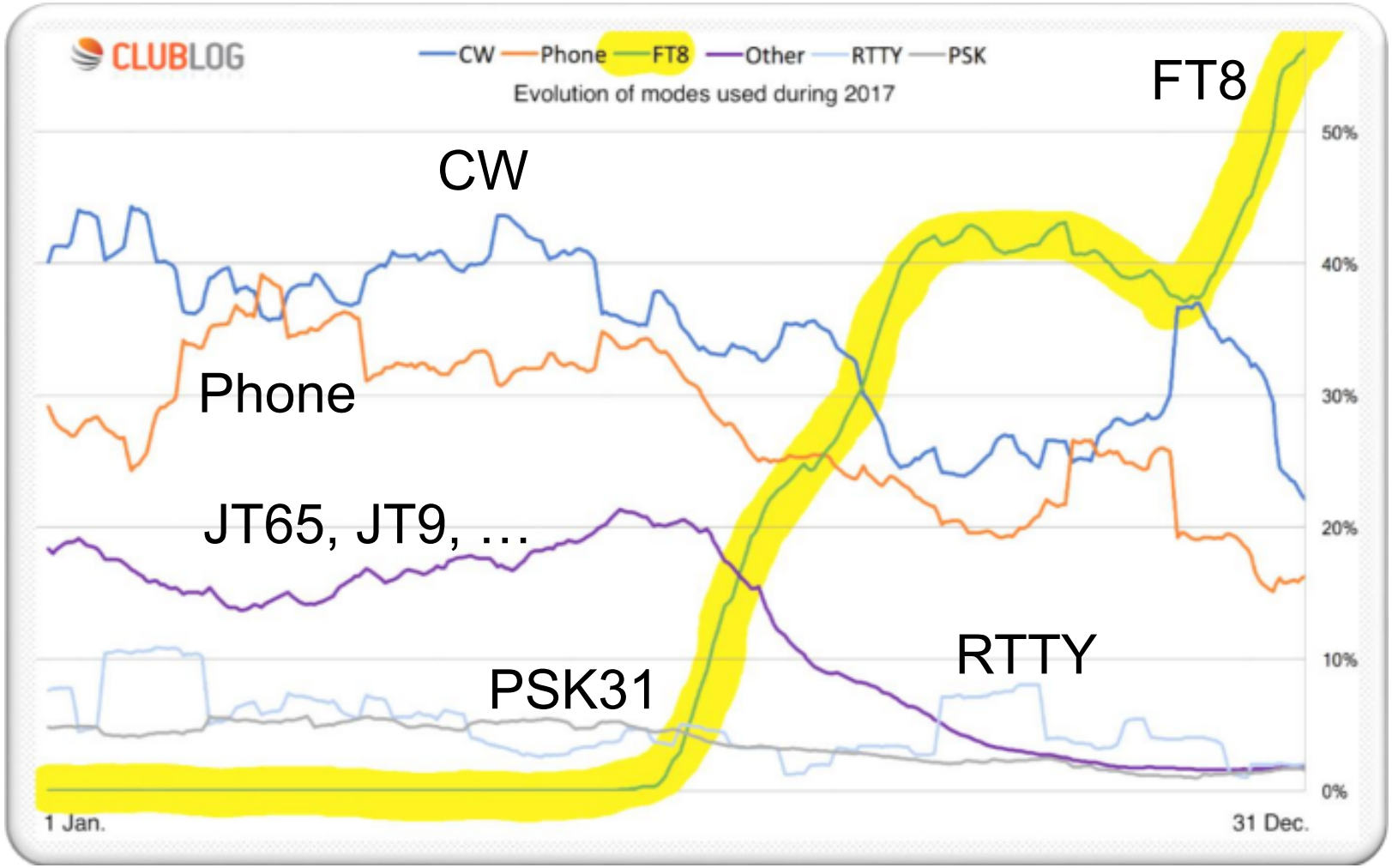
WSJT-X Features

- All platforms: Windows, Linux, OS X, …
- Rig control for nearly all modern radios
- Error-free communication (minimal QSOs)
- State-of-the-art decoders
- Decoding at S/N = −20 dB and below…
- Accurate frequency calibration

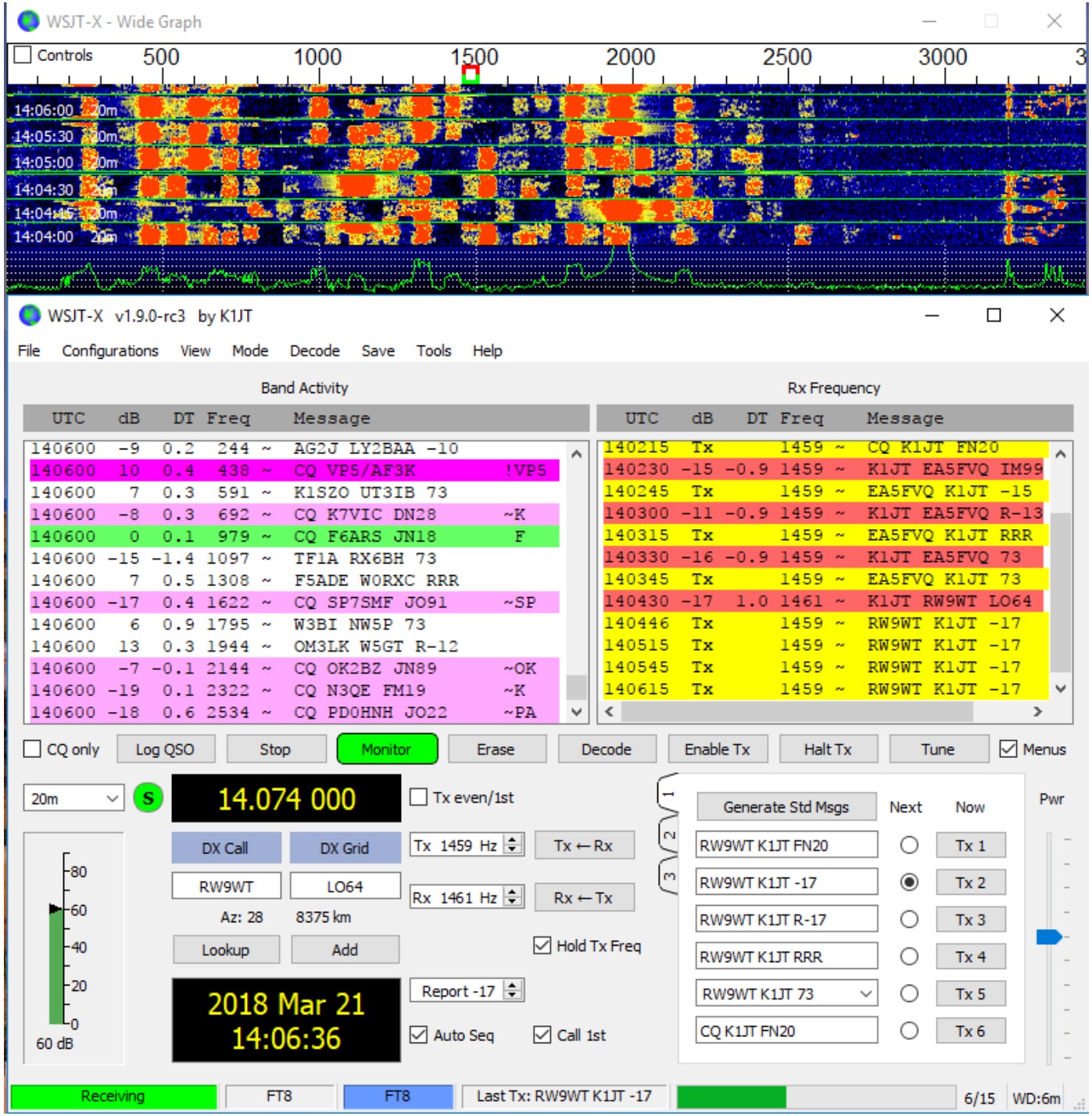
Weak-Signal S/N Limits

Mode	(B = 2500 Hz)
SSB	~+10 dB
MSK144	- 8
CW, “ear-and-brain”	-15
FT8	-21
JT4	-23
JT65	-25
JT9	-27
QRA64	-27
WSPR	-31

Modes used during 2017



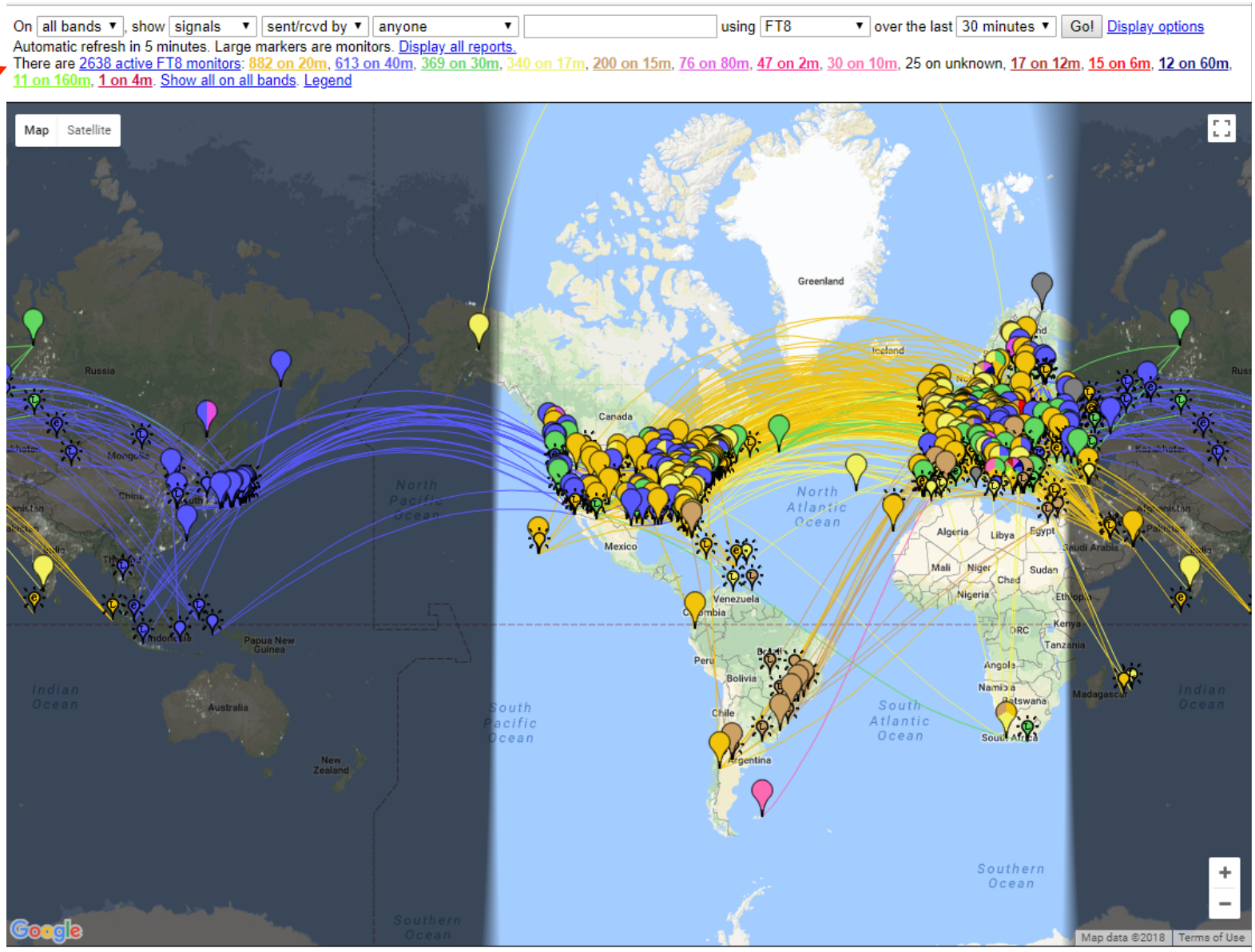
Total QSOs: 32 M FT8 QSOs: 5 M


WSJT-X - Wide Graph
Controls
500
1000
1500
2000
2500
3000
14:06:00 20m
14:05:30 20m
14:05:00 20m
14:04:30 20m
14:04:15 20m
14:04:00 20m
WSJT-X v1.9.0-rc3 by K1JT
File Configurations View Mode Decode Save Tools Help
Band Activity
UTC dB DT Freq Message
140600 -9 0.2 244 ~ AG2J LY2BAA -10
140600 10 0.4 438 ~ CQ VP5/AF3K !VP5
140600 7 0.3 591 ~ K1SZO UT3IB 73
140600 -8 0.3 692 ~ CQ K7VIC DN28 ~K
140600 0 0.1 979 ~ CQ F6ARS JN18 F
140600 -15 -1.4 1097 ~ TF1A RX6BH 73
140600 7 0.5 1308 ~ F5ADE W0RXC RRR
140600 -17 0.4 1622 ~ CQ SP7SMF JO91 ~SP
140600 6 0.9 1795 ~ W3BI NW5P 73
140600 13 0.3 1944 ~ OM3LK W5GT R-12
140600 -7 -0.1 2144 ~ CQ OK2BZ JN89 ~OK
140600 -19 0.1 2322 ~ CQ N3QE FM19 ~K
140600 -18 0.6 2534 ~ CQ PD0HNH JO22 ~PA
Rx Frequency
UTC dB DT Freq Message
140215 Tx 1459 ~ CQ K1JT FN20
140230 -15 -0.9 1459 ~ K1JT EA5FVQ IM99
140245 Tx 1459 ~ EA5FVQ K1JT -15
140300 -11 -0.9 1459 ~ K1JT EA5FVQ R-13
140315 Tx 1459 ~ EA5FVQ K1JT RRR
140330 -16 -0.9 1459 ~ K1JT EA5FVQ 73
140345 Tx 1459 ~ EA5FVQ K1JT 73
140430 -17 1.0 1461 ~ K1JT RW9WT LO64
140446 Tx 1459 ~ RW9WT K1JT -17
140515 Tx 1459 ~ RW9WT K1JT -17
140545 Tx 1459 ~ RW9WT K1JT -17
140615 Tx 1459 ~ RW9WT K1JT -17
CQ only
Log QSO
Stop
Monitor
Erase
Decode
Enable Tx
Halt Tx
Tune
Menus
20m
S
14.074 000
Tx even/1st
DX Call
DX Grid
Tx 1459 Hz
Tx ← Rx
RW9WT
LO64
Rx 1461 Hz
Rx ← Tx
Az: 28
8375 km
Lookup
Add
Hold Tx Freq
Report -17
2018 Mar 21
14:06:36
Auto Seq
Call 1st
80
60
40
20
0
60 dB
Generate Std Msgs
Next
Now
Pwr
RW9WT K1JT FN20
RW9WT K1JT -17
RW9WT K1JT R-17
RW9WT K1JT RRR
RW9WT K1JT 73
CQ K1JT FN20
Tx 1
Tx 2
Tx 3
Tx 4
Tx 5
Tx 6
Receiving
FT8
FT8
Last Tx: RW9WT K1JT -17
6/15
WD:6m

WSJT-X

PSK Reporter: FT8 usage

2638 FT8 monitors



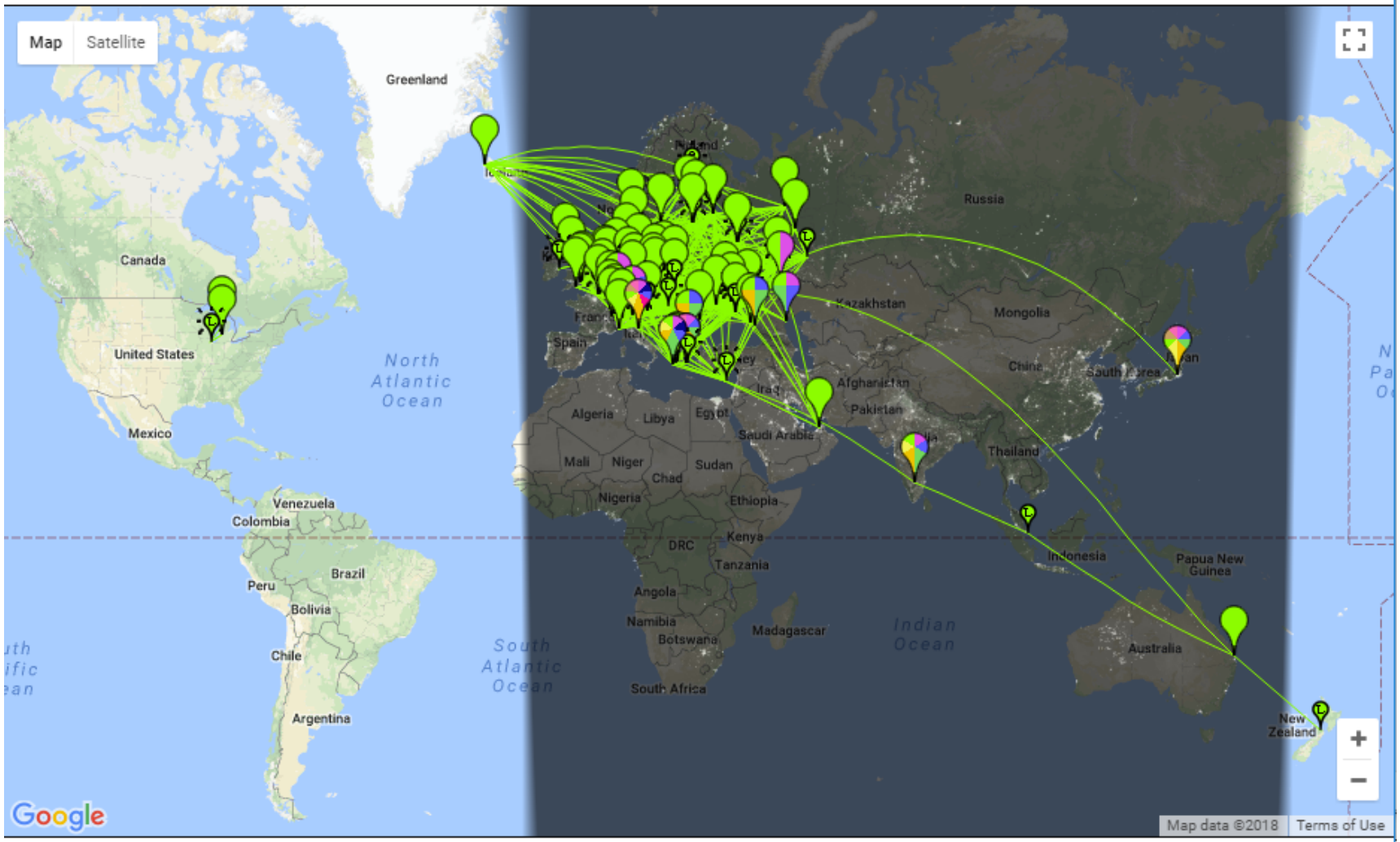
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems/issues. Reception records: 2,981,569,138 PSKREPORTER.INFO

PSK Reporter - FT8 - 160 m

On 160m, show signals, sent/rcvd by anyone, using FT8, over the last 30 minutes, Go! Display options Permalink

Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.

There are 48 active FT8 monitors on 160m. Show all FT8 on all bands. Show all on all bands. Legend



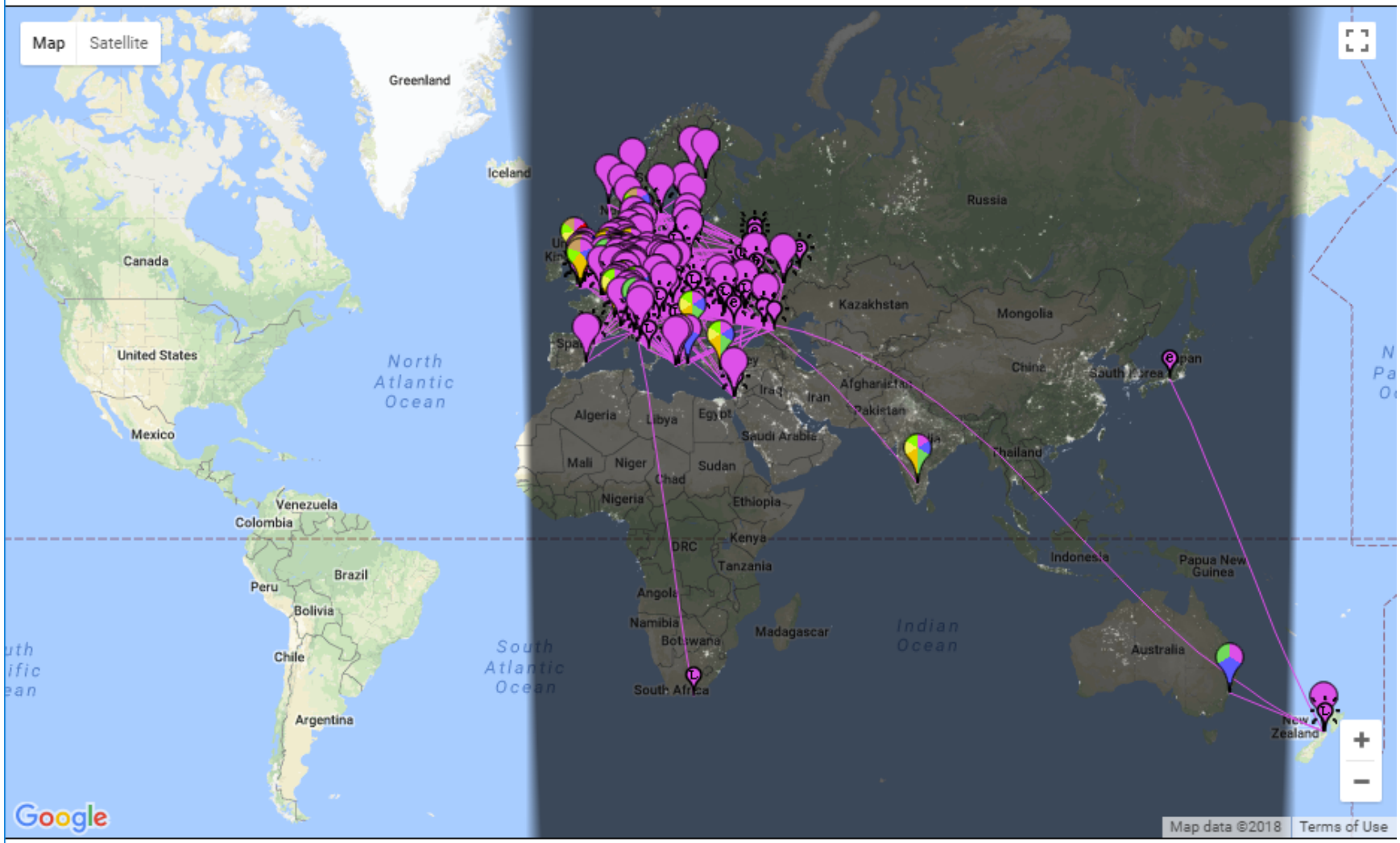
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems/issues. Recept[illegible]

FT8 - 80 m

On 80m, show signals, sent/rcvd by, anyone, using FT8, over the last 30 minutes, Go! Display options Permalink

Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.

There are 159 active FT8 monitors on 80m. Show all FT8 on all bands. Show all on all bands. Legend



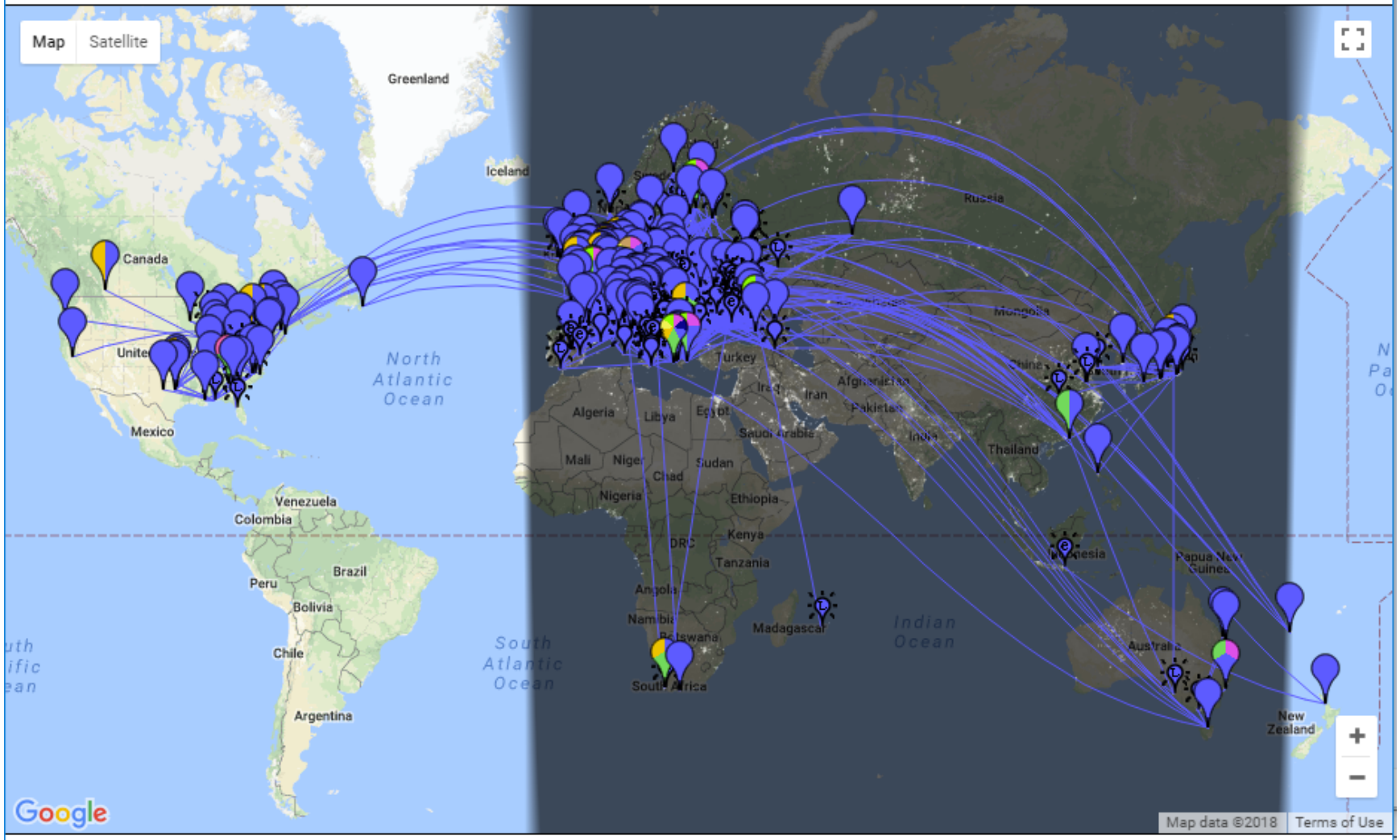
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems/issues. Recept[illegible]

FT8 - 40 m

On 40m, show signals, sent/rcvd by anyone, using FT8 over the last 30 minutes Go! Display options Permalink

Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.

There are 652 active FT8 monitors on 40m. Show all FT8 on all bands. Show all on all bands. Legend



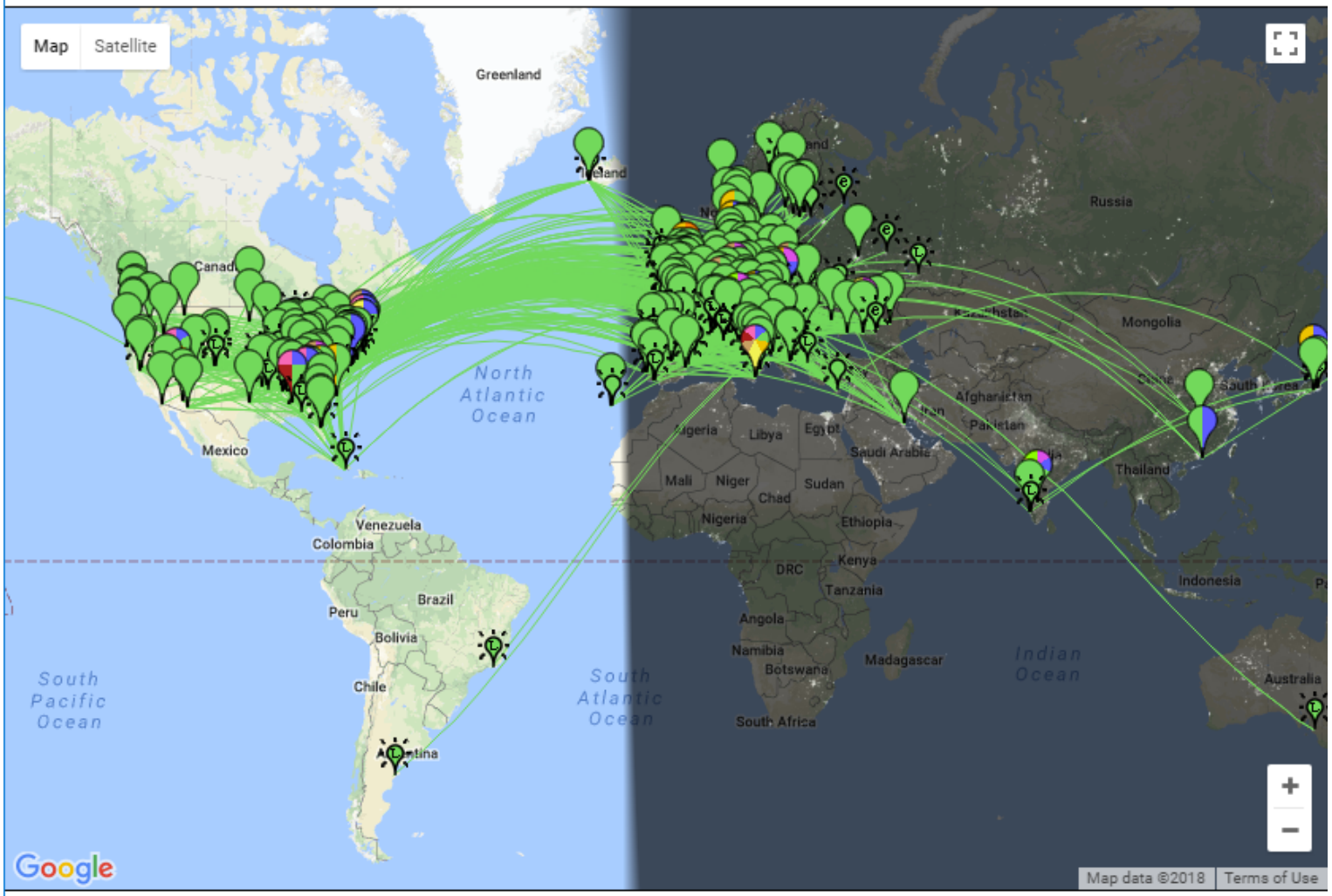
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems/issues. Recept[illegible]

FT8 - 30 m

On 30m ▼, show signals ▼ sent/rcvd by ▼ anyone ▼ using FT8 ▼ over the last 30 minutes ▼ Go! Display options Permalink

Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.

There are 427 active FT8 monitors on 30m. Show all FT8 on all bands. Show all on all bands. Legend



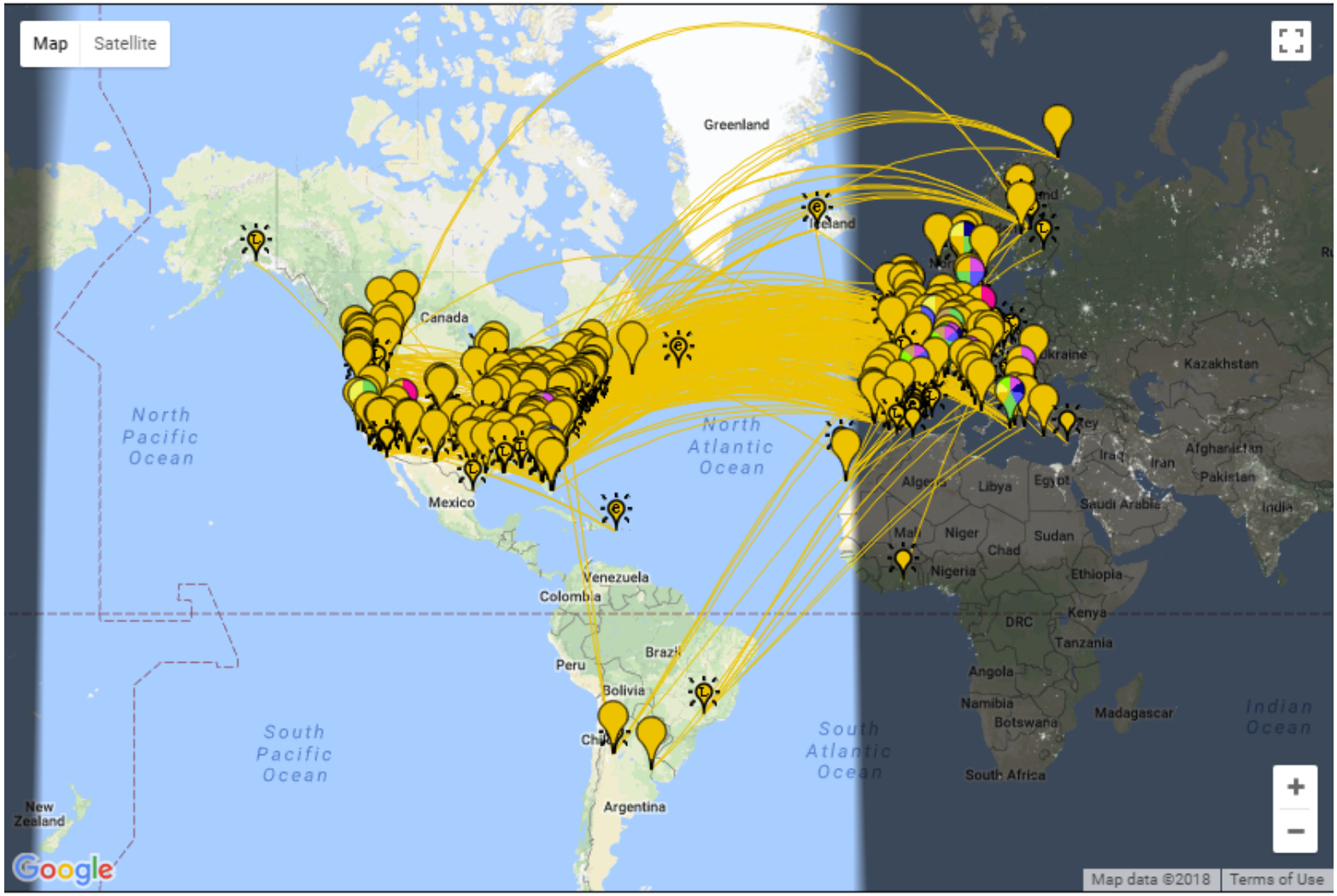
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problem discuss. Reception reports 2,083,939,468

FT8 - 20 m

On 20m ▼, show signals ▼ sent/rcvd by ▼ anyone ▼ using FT8 ▼ over the last 30 minutes ▼ Go! Display options Permalink

Automatic refresh in 4 minutes. Large markers are monitors. Display all reports.

There are 939 active FT8 monitors on 20m. Show all FT8 on all bands. Show all on all bands. Legend



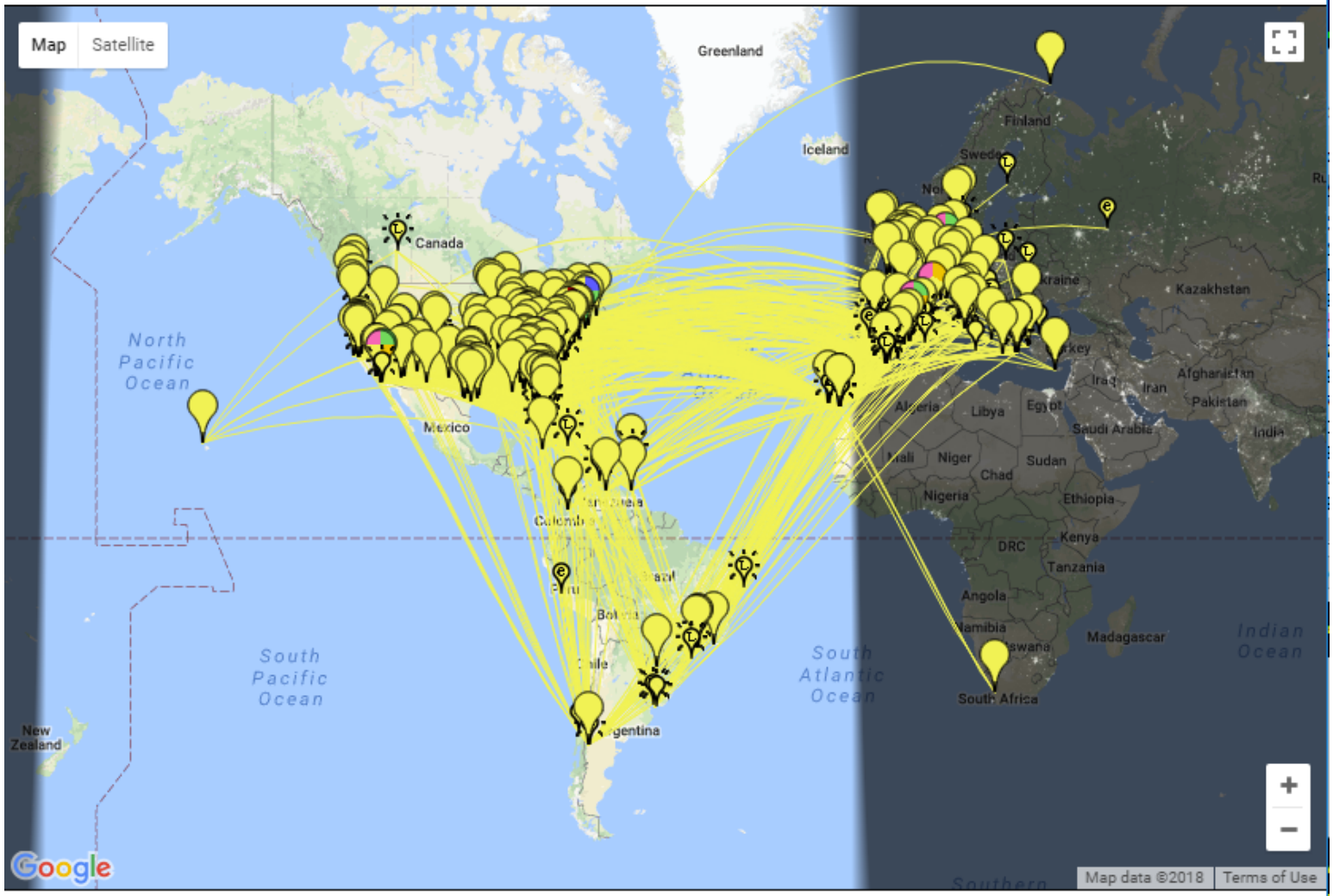
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problem issues. Reception reports 2,282,932 [illegible]

FT8 - 17 m

On 17m, show signals, sent/rcvd by, anyone, using FT8, over the last 30 minutes, Go! Display options Permalink

Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.

There are 208 active FT8 monitors on 17m. Show all FT8 on all bands. Show all on all bands. Legend

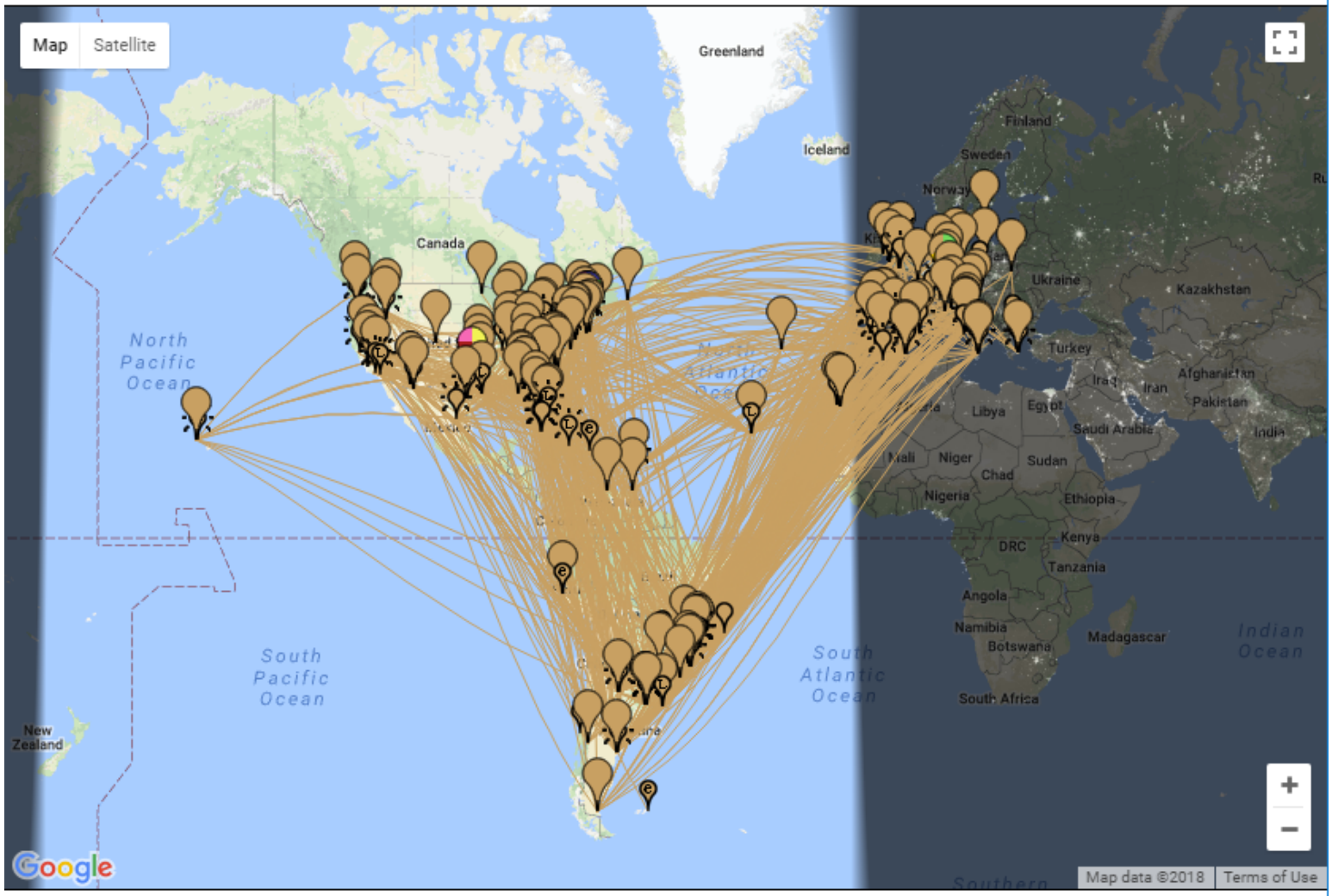


System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems. Reception reports 2,382,396,788

PSKREPORTER.INFO

FT8 - 15 m

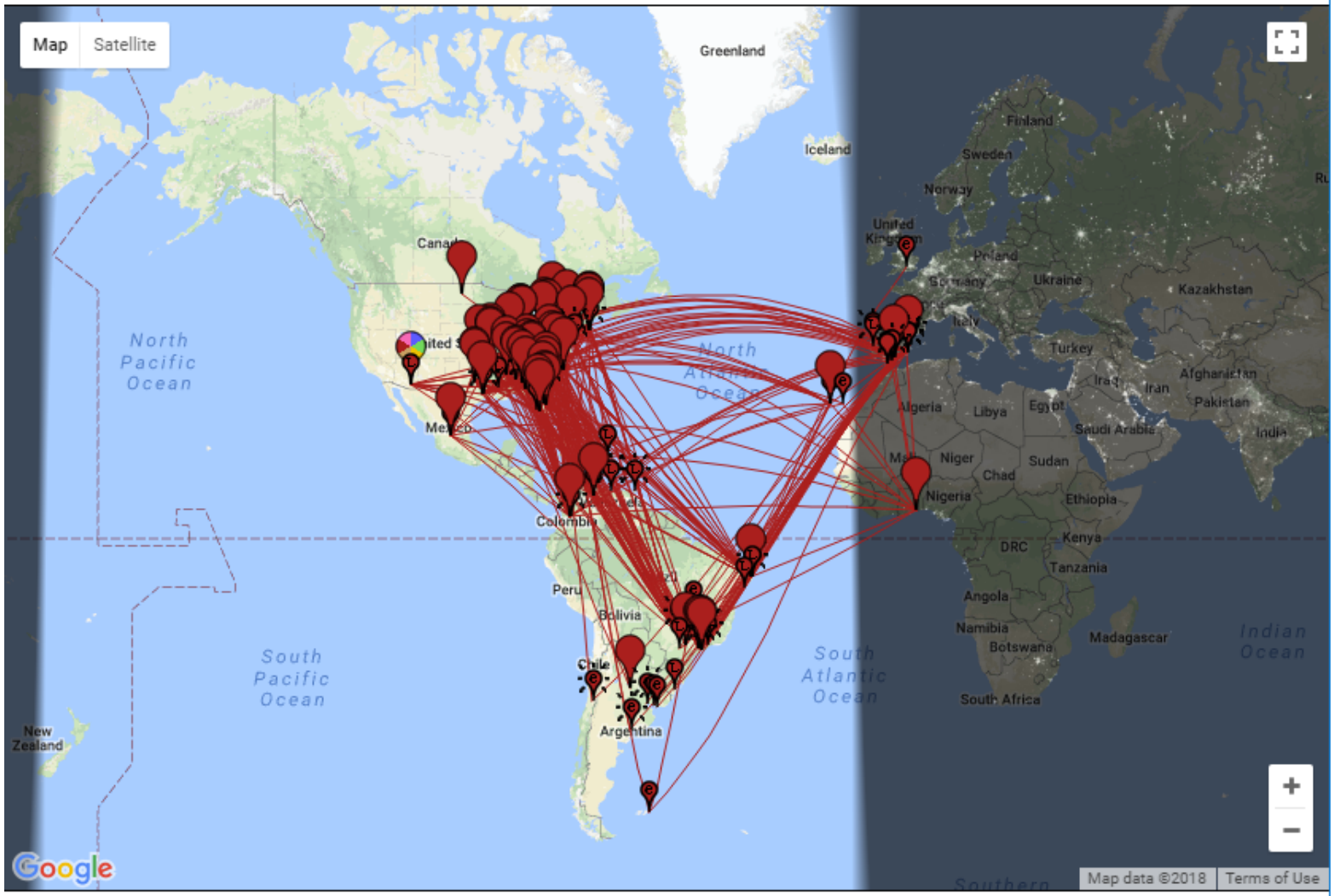
On 15m ▼, show signals ▼ sent/rcvd by ▼ anyone ▼ using FT8 ▼ over the last 30 minutes ▼ Go! Display options Permalink
Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.
There are 154 active FT8 monitors on 15m. Show all FT8 on all bands. Show all on all bands. Legend



System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problem discuss. Reception records 2,380,306,774

FT8 - 12 m

On 12m, show signals, sent/rcvd by anyone, using FT8 over the last 30 minutes Go! Display options Permalink
Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.
There are 49 active FT8 monitors on 12m. Show all FT8 on all bands. Show all on all bands. Legend



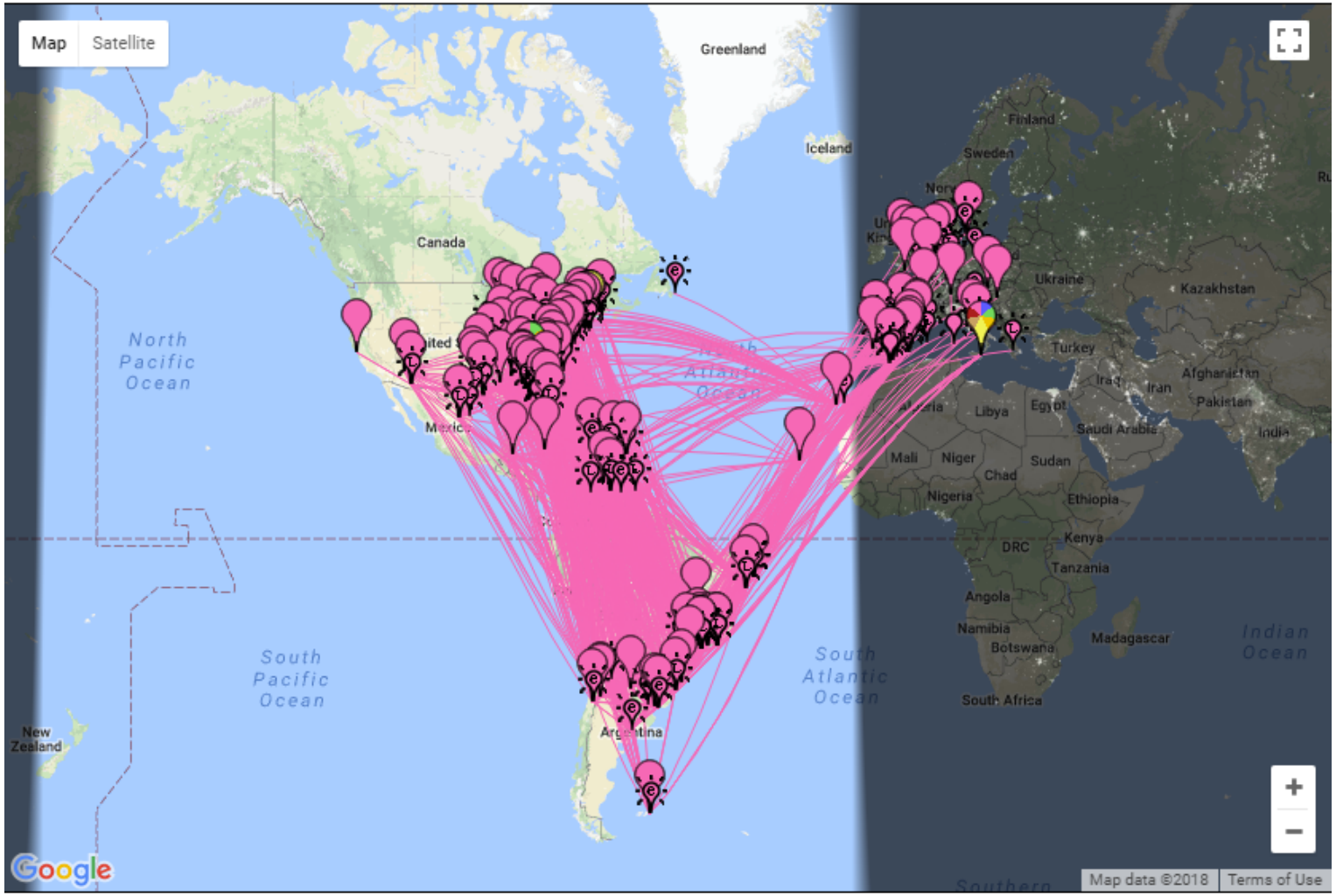
System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problem

FT8 - 10 m

On 10m ▼, show signals ▼ sent/rcvd by ▼ anyone ▼ using FT8 ▼ over the last 30 minutes ▼ Go! Display options Permalink

Automatic refresh in 5 minutes. Large markers are monitors. Display all reports.

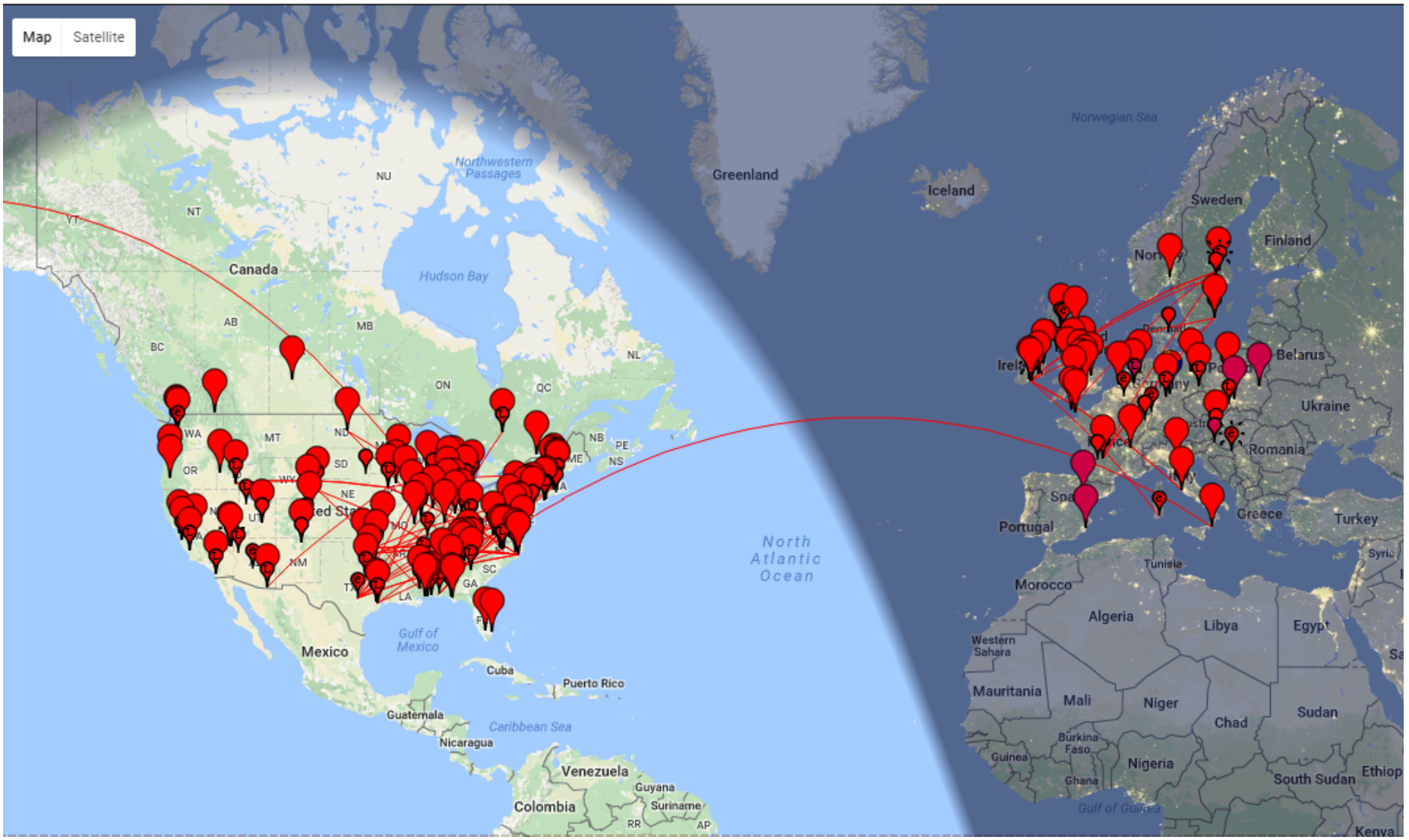
There are 151 active FT8 monitors on 10m. Show all FT8 on all bands. Show all on all bands. Legend



System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problem discuss. Reception reports 2,382,915,483

MSK144 - 6 m

On all bands, show signals, sent/rcvd by, anyone, using MSK144, over the last 12 hours, Go! Display options
Automatic refresh in 3 minutes. Large markers are monitors. Display all reports.
There are 57 active MSK144 monitors: 55 on 6m, 2 on 4m. Show all on all bands. Legend



Recent FT8 Usage Statistics

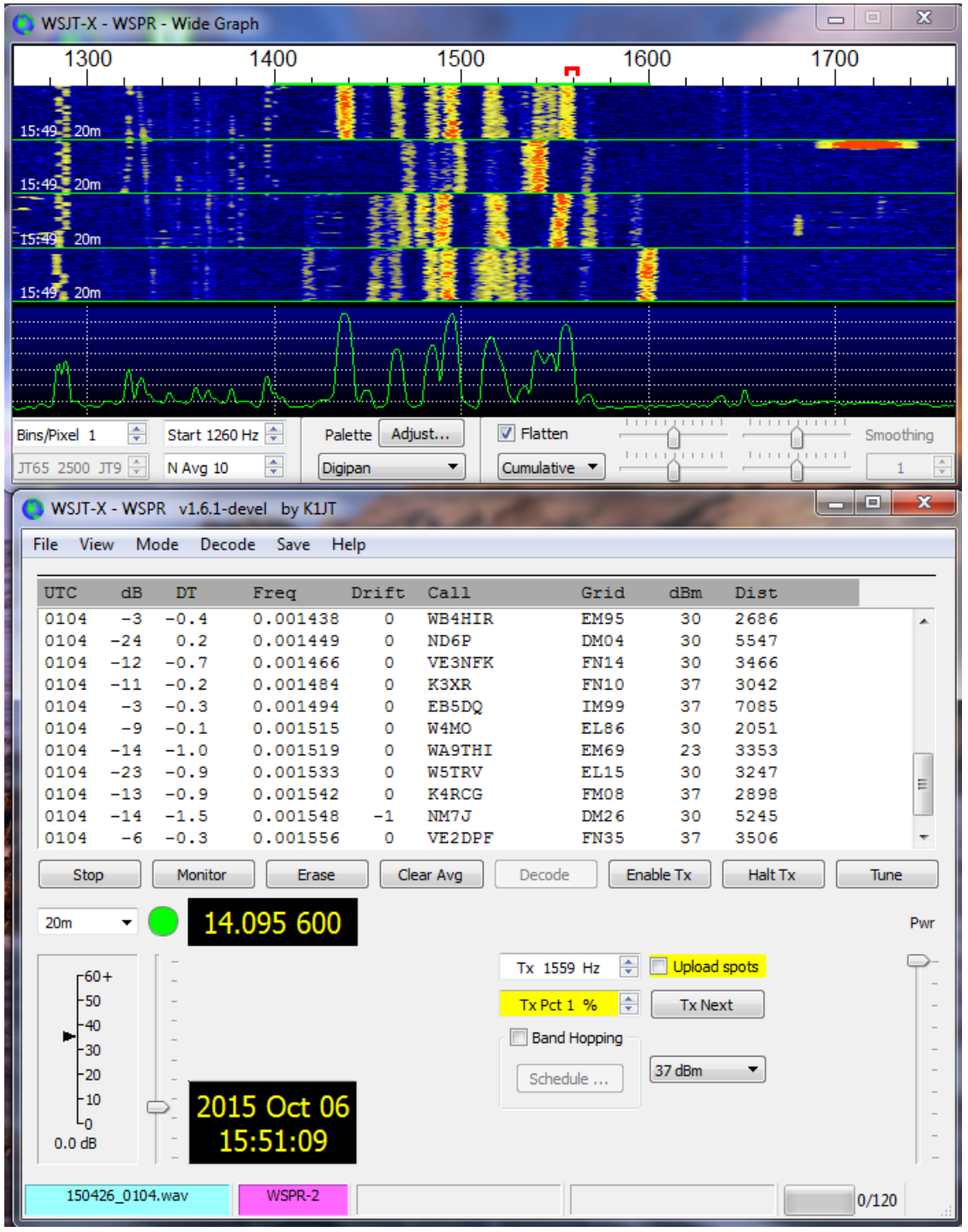
- Spots per hour: 200,000 – 650,000
- Active monitors in any hour
  - Midweek: ~ 2500
  - Weekend: ~ 3700
- Active transmitters in any hour
  - Midweek: 2000 – 5000
  - Weekend: 3500 – 7500
- Top number of DXCCs reported
  - 24 hours: 164
  - 7 days: 221

WSPR

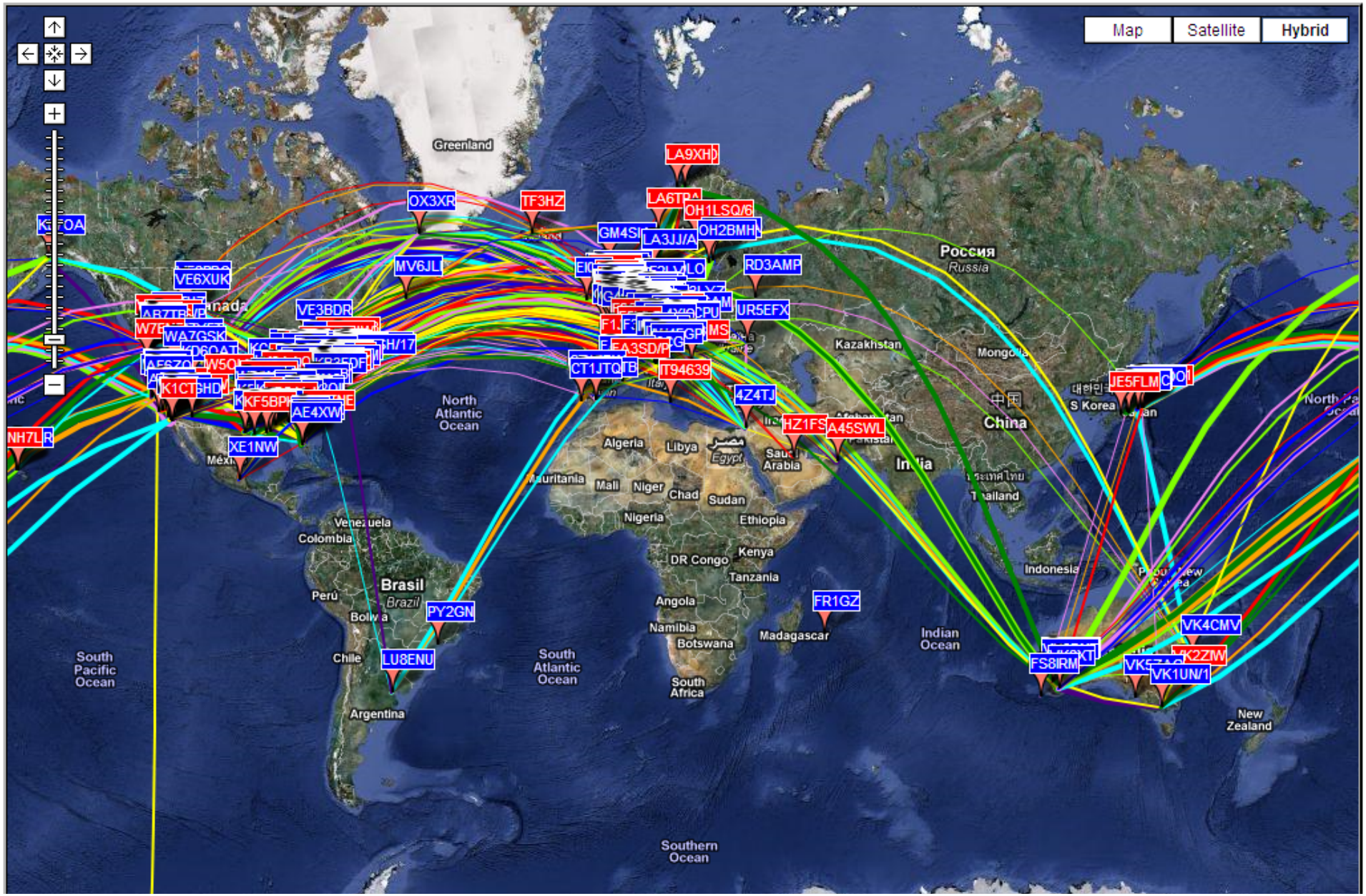
"Weak Signal Propagation Reporter"

- Pronounced "whisper"
- Low-power, one-way mode
- 2-minute Tx, randomized T/R cycle
- Example message: **K1JT FN20 37**
- 4-FSK modulation: BW = 6 Hz
- Spots optionally sent to wsprnet.org
- ~ 1500 stations participating, avg day
- 965 million spots archived, since 2008 !

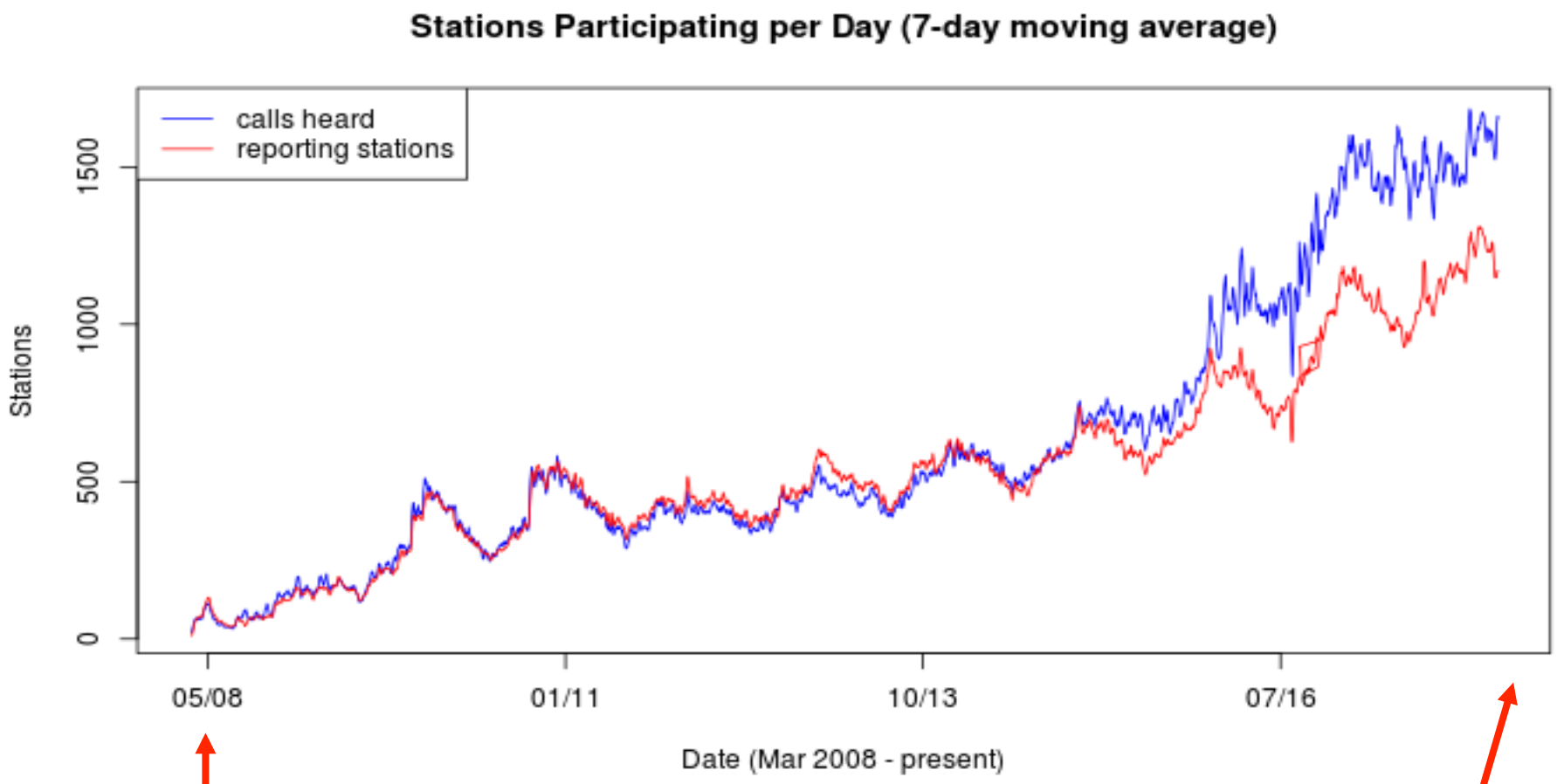
WSPR in *WSJT-X*



WSPRnet.org


Map
Satellite
Hybrid
Greenland
OX3XR
TF3HZ
LA9XHD
OH1LSQ/6
OH2BMH
LA3JJ/A
MV6JL
RD3AMP
VE6XUK
VE3BDR
UR5EFX
T94639
4Z4TJ
HZ1FS
A45SWL
AE4XW
XE1NW
PY2GN
LU8ENU
FR1GZ
FS8IRM
VK4CMV
VK1UN/1
JE5FLM
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Southern Ocean
Brasil
Brazil
Argentina
Chile
Perú
Colombia
Venezuela
Algeria
Libya
Egypt
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
South Africa
Madagascar
Kazakhstan
Mongolia
China
India
Indonesia
Россия
Russia
S Korea
New Zealand

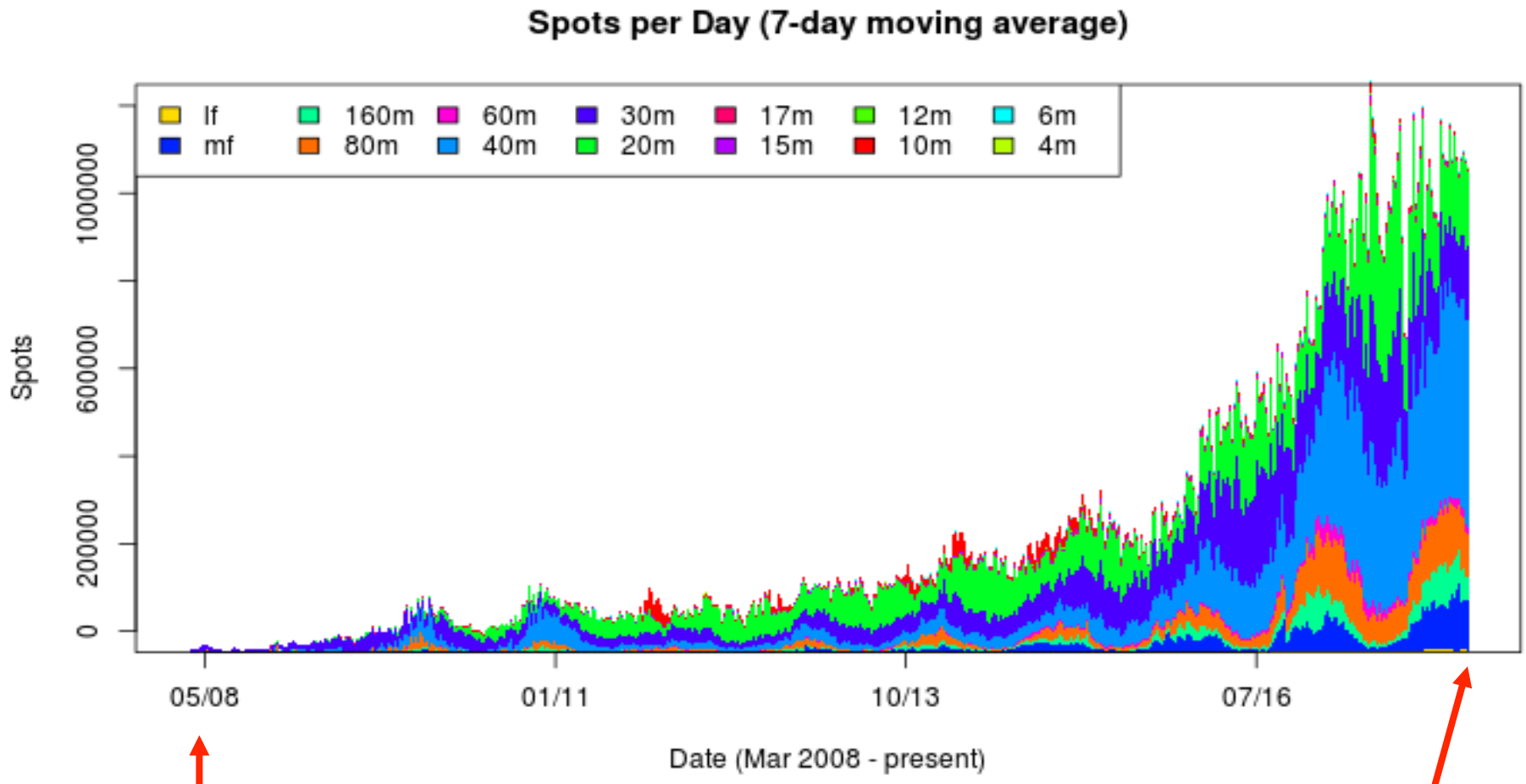
WSPR stations per day



March 2008

Today

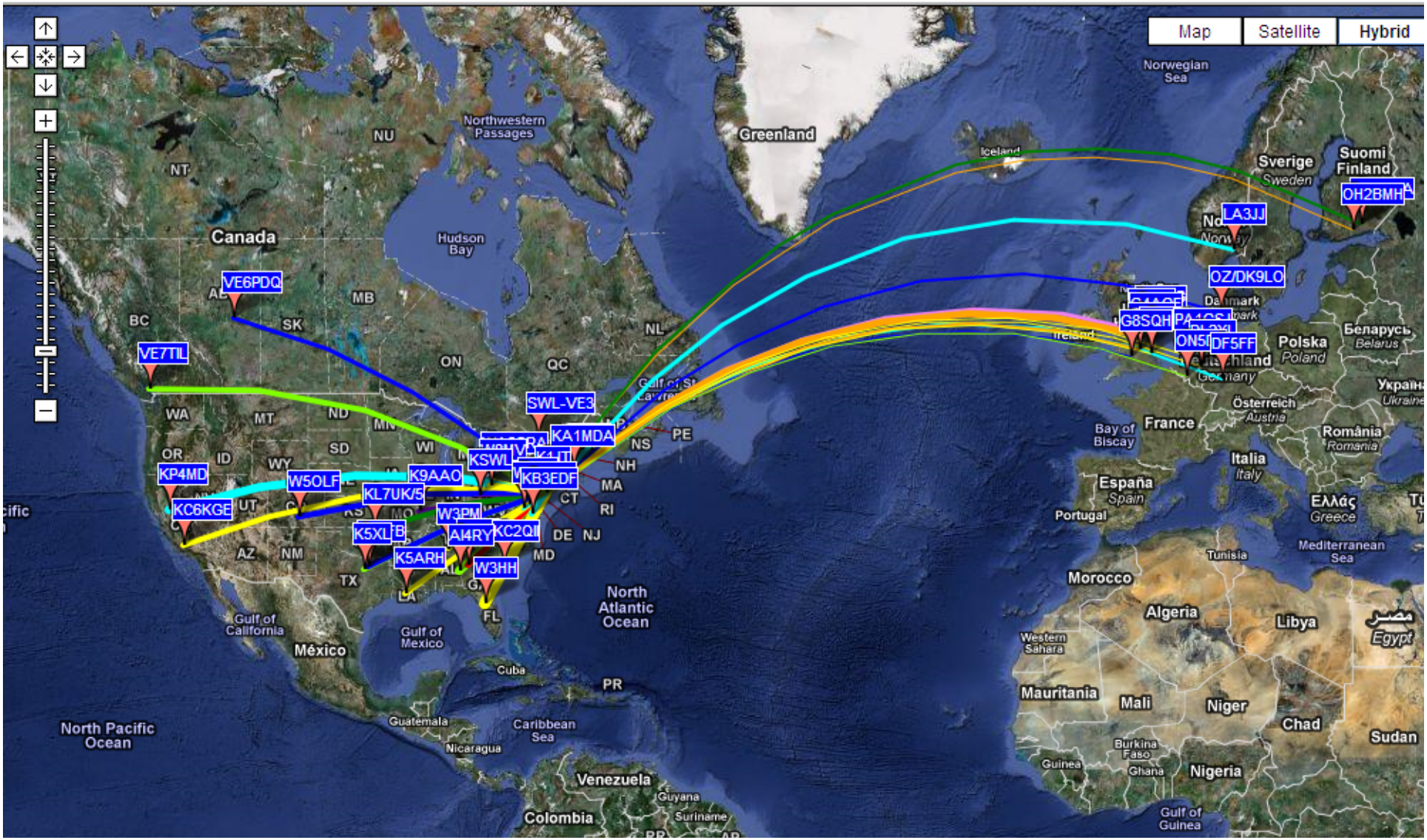
WSPR spots per day



March 2008

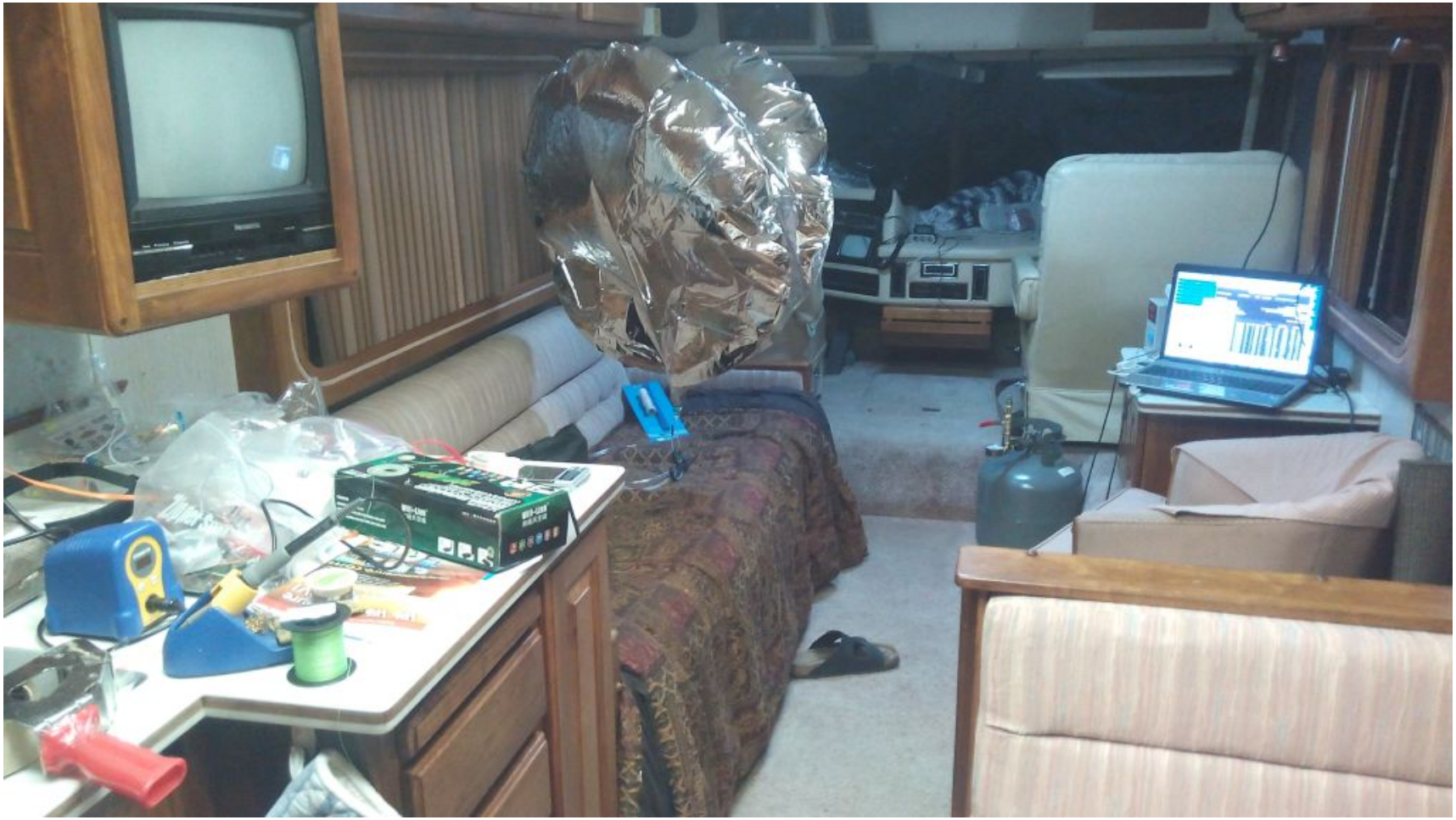
Today

WSPRnet map: selected callsign



VE3KCL: Solar-powered WSPR

- 2 foil party balloons
- 39 g payload, hanging λ/2 vertical dipole
- Rx: GPS Tx: WSPR, JT9; 20 mW



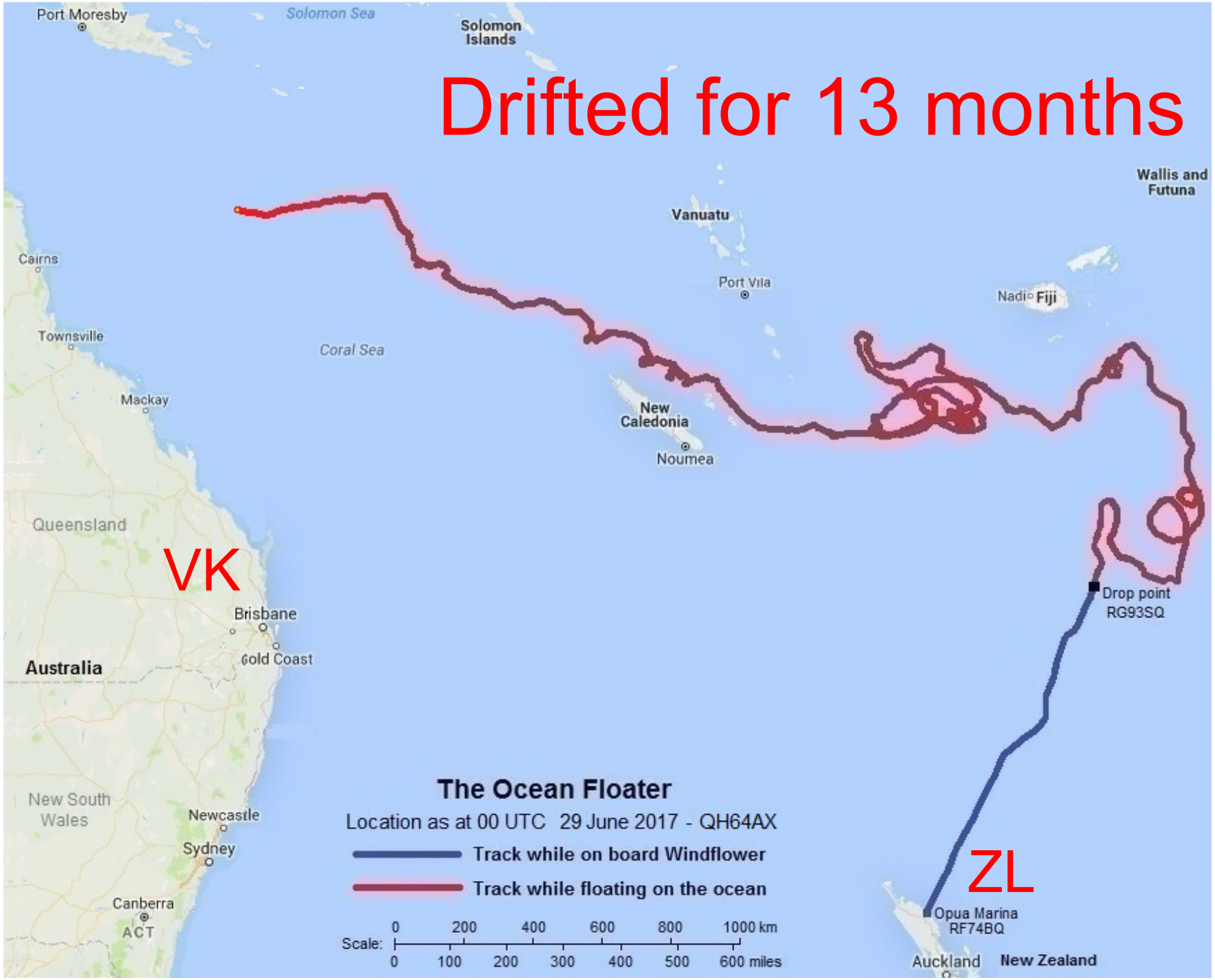
WSPRing around the world 22 days …

Updated 27-Oct-2016 19:54Z; Loc=FM62XE, Duration=20d 08h 54m, Distance=41,086km
Alt=10860m, Speed=48knots, Batt=3.29V, Temp=16.6C, GPS=1, Sat=1

Updated 02-Nov-2016 15:52Z; Loc=, Duration=26d 04h 52m, Distance=46,306km
Alt=m, Speed=knots, Batt=3.44V, Temp=18.5C, GPS=0, Sat=0

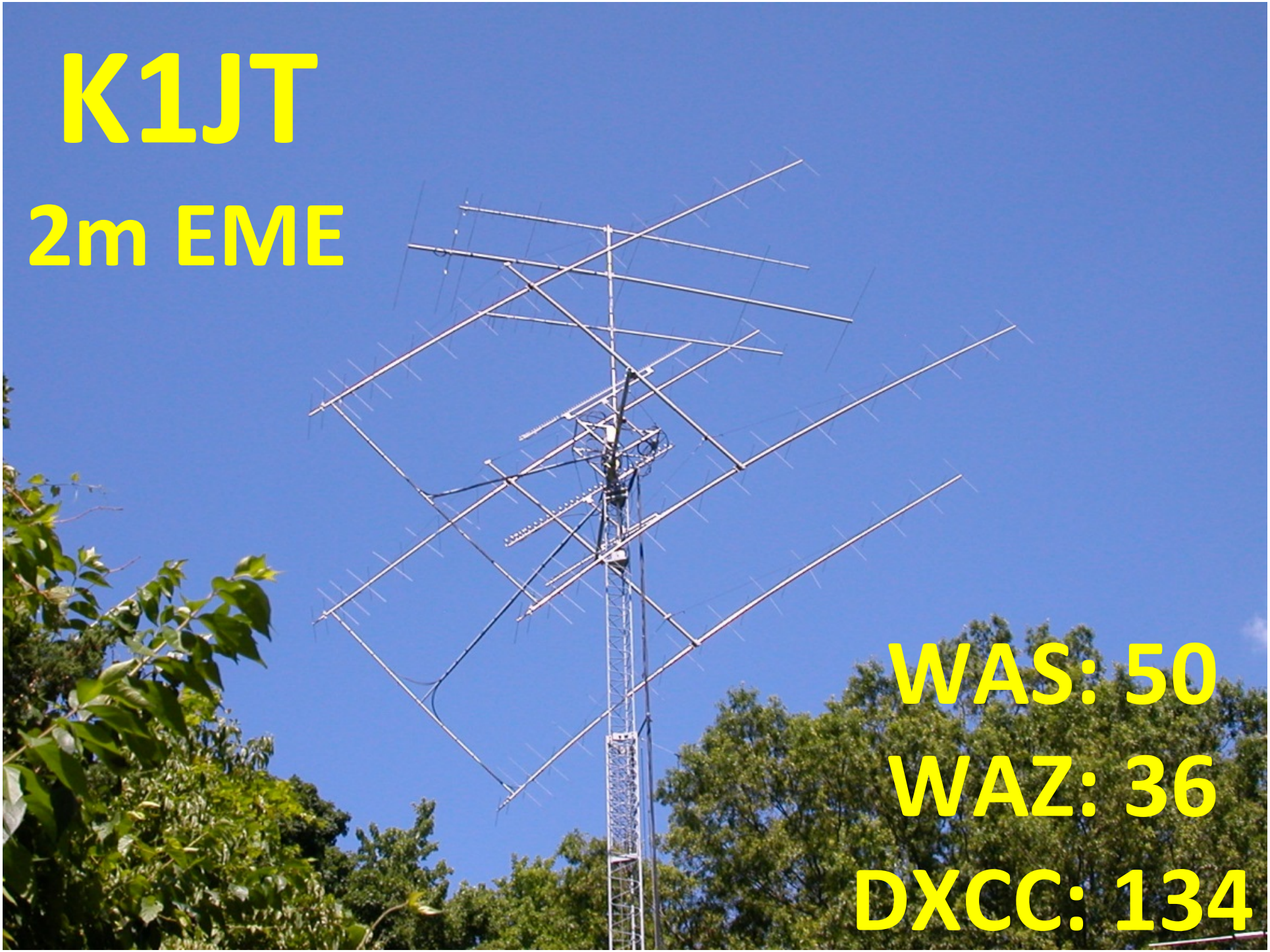
ZL1RS
Ocean Floater

WSPR, JT9
30 m band
200 mW
8 ft whip
18 D-cells


Drifted for 13 months
Port Moresby
Solomon Sea
Solomon Islands
Wallis and Futuna
Vanuatu
Port Vila
Nadi
Fiji
Cairns
Townsville
Coral Sea
Mackay
New Caledonia
Noumea
Queensland
VK
Drop point
RG93SQ
Brisbane
Gold Coast
Australia
New South Wales
Newcastle
Sydney
Canberra
ACT
ZL
Opua Marina
RF74BQ
Auckland
New Zealand
The Ocean Floater
Location as at 00 UTC 29 June 2017 - QH64AX
Track while on board Windflower
Track while floating on the ocean
Scale:
0 200 400 600 800 1000 km
0 100 200 300 400 500 600 miles

Many specialized uses …

- QRP DXing
- Certificate hunting
  - ARRL International Grid Chase, …
- VHF contesting
- Meteor scatter
- EME (“moonbounce”)


K1JT
2m EME
WAS: 50
WAZ: 36
DXCC: 134

10 GHz EME – QRA64 – VK7MO

WSJT Home Page

http://physics.princeton.edu/pulsar/K1JT

Programmer details

- Open source software
- GUI in C++ and Qt
- Number-crunching in Fortran or C
- Version control with Subversion
- Many contributors; new ones are welcome !

See you on the air,
with *WSJT-X* !