UNDERSTANDING SPORADIC-E PROPAGATION ON 6 METERS

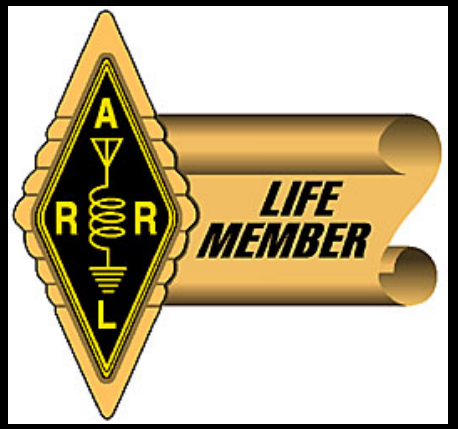
(or at least pretending you do)

Eric Gruff, NC6K

Palomar ARC Meeting - February 2019

NC6K

- January 1977 - Licensed as WB2KIH: Huntington, NY [**FN30**]
  - Typical teenaged boy radio operator/nerd
  - Best ham friend was Steve Bloom, WB2IDP (now KL7SB, owner of KL7RA contest station)
- May 1990 - Moved to San Diego [**DM12**], operated as WB2KIH/6
- July 2002 – Bye-bye WB2KIH, hello NC6K
- July 2006 – Moved to Poway [**DM13**]
- March 2016 – Installed HDX-555 Tower & SteppIR DB36 w/ passive 6 M elements
- October 2016 – Installed OP-DES 7-element yagi w 24' boom



- Married to Beth since 1996
- 3 children, including 16 year-old twins & 1 granddaughter (5 yrs)
- BS, Chemistry, Rensselaer Polytechnic Institute
- PhD, Chemistry, SUNY Stony Brook
- MBA, SDSU Executive Program
- Pharmaceutical & Biotech Consultant
- Other hobbies – bicycling (road & mountain), woodworking, guitar

NC6K – 6 METER GEAR 1999

- Icom IC-736 (≤100 W on 6 M)

- Horizontal loop at 25’
- Cushcraft R-7 vertical (0 dBd gain in all directions)

- ***Effective Radiated Power = 100 W***

- ***Modes used: CW, SSB, FM***

NC6K – 6 METER GEAR 2019

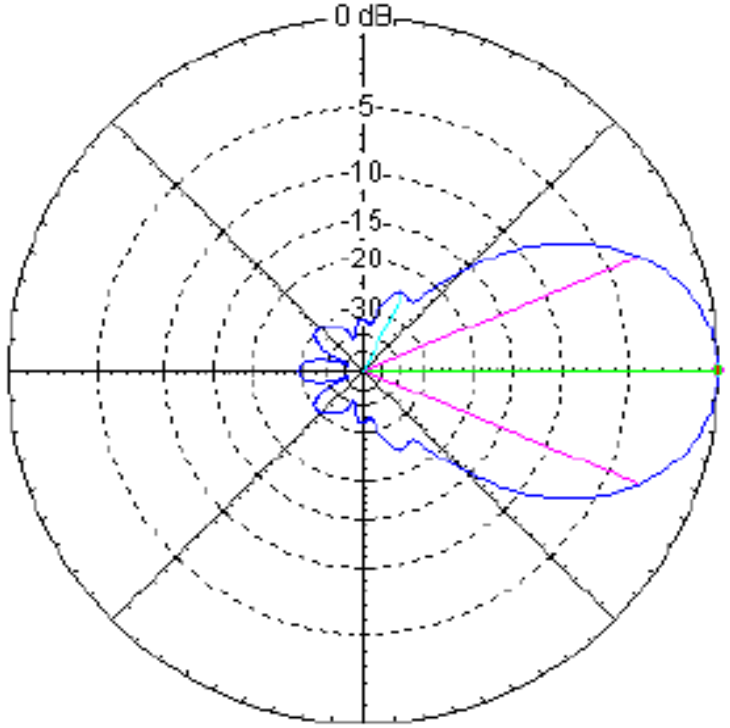
- FlexRadio 6700
  - Apache ANAN-7000
  - Yaesu FT-dx5000MP (200 W)
- Acom 2100 – max. 1500 W output on 160-6 M
  - 4CX1000A tetrode
- SSB Electronic MHP-600 Ultra Low Noise 20 dB Preamp (base of tower) & Sequencer
- InnoVAntennas OP-DES* 7-EL Yagi (24' boom) at 62' (+)
  - Gain = 12.33 dBi
  - F/B = 29.0 dB
  - LMR400 coax 150' to shack (1.3 dB total loss at 50 MHz) & Messi and Paoloni ZMP-UF13-50U UltraFlex 13 (<0.5 dB loss) from yagi to preamp
  - **ERP at 1500 W feed = 18,942 Watts!**

*OP-DES = Opposing-Phase Driven Element System

7 el 6m InnovAntennas OP-DES

File Edit View Options Reset

Total Field EZNEC Pro/4



50.15 MHz

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	12.33 dBi
Outer Ring	12.33 dBi		0.0 dBmax
Slice Max Gain	12.33 dBi @ Az Angle = 0.0 deg.		
Front/Back	29.01 dB		
Beamwidth	45.2 deg.; -3dB @ 337.4, 22.6 deg.		
Sidelobe Gain	-11.57 dBi @ Az Angle = 63.0 deg.		
Front/Sidelobe	23.9 dB		

2D Plot: 7 el 6m InnovAntennas OP-DES

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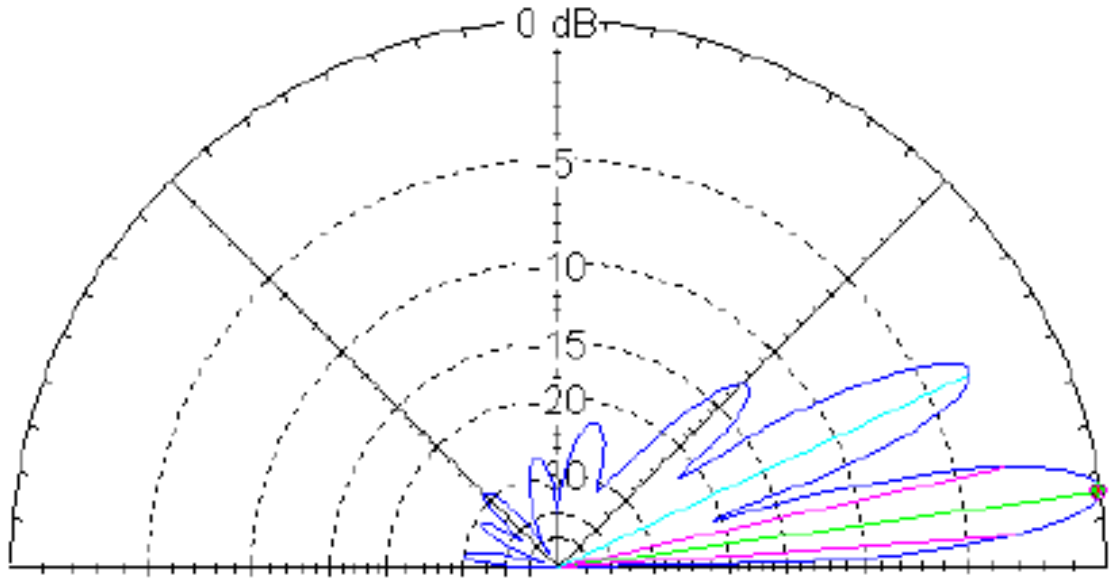
Total Field EZNEC Pro/4



50.15 MHz

Elevation Plot		Cursor Elev	8.0 deg.
Azimuth Angle	0.0 deg.	Gain	17.75 dBi
Outer Ring	17.75 dBi		0.0 dBmax
Slice Max Gain	17.75 dBi @ Elev Angle = 8.0 deg.		
Beamwidth	8.5 deg.; -3dB @ 4.1, 12.6 deg.		
Sidelobe Gain	14.57 dBi @ Elev Angle = 25.0 deg.		
Front/Sidelobe	3.18 dB		

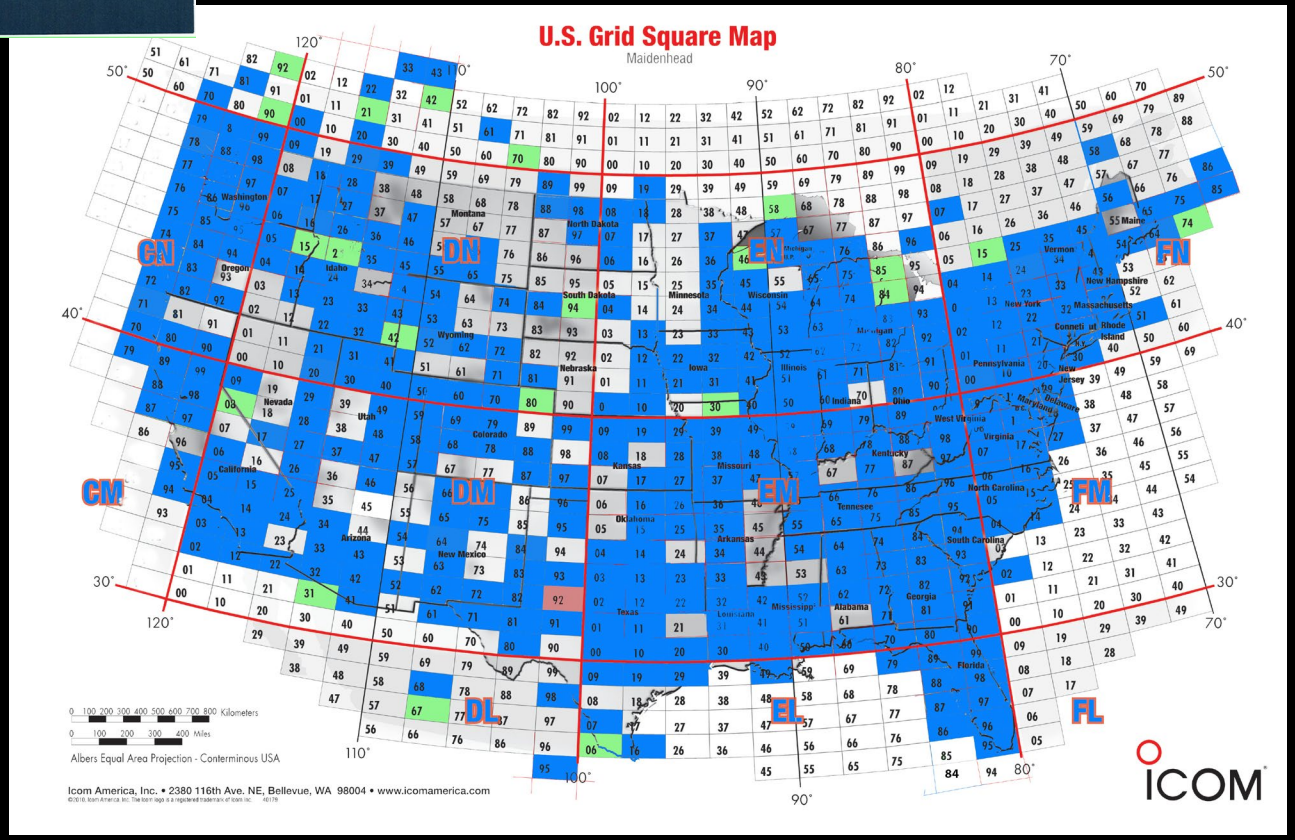
NC6K – 6 METERS
(JUNE 2012-FEBRUARY 2019)

- 3232 QSOs on CW, SSB and digital (MSK144, PSK31 (2), RTTY (2), JT65 and FT8)
- **First QSO – W5WM [DM64] – CW: 606 miles (New Mexico) on 6/2/2012**
- **First JT65 QSO – W7KRS [CN97]: 1044 miles on 5/11/2013 <RSTs -23/RSTr -19>**
- **First Non-US/Canada/Mexico QSO – G8BCG [IO70] via JT65 on 6/14/2016**
  - **Same day - worked G, GU, GM and almost EI (opening died in the middle of the QSO)**
  - **Early June 2017 had several EU openings, but many busted JT65 QSOs – this led to NC6K and NA6L (among others) bitching on all the discussion boards about needing a faster mode for Es openings without sacrificing too much sensitivity**
  - **K1JT (Joe Taylor, PhD – Nobel Prize in Physics) offered that he and Steve Franke were working on a new mode called "FT8". The rest is history…**
- **First FT8 QSO – K9AN (Steve Franke, the "F" in FT8) [EN50] on 7/1/2017**
  - **Worked K1JT (Joe Taylor, a.k.a. The Creator) on 6/17/2018 for 6 M WAFT**

- **Longest Distance QSO – BG6CJR [OM90] – 6724 miles on 7/10/2018 FT8 <RSTs -2/RSTr -11>**
- **Shortest Distance QSO – NN3V [DM13] – 1.1 miles on 7/21/2018 FT8**

NC6K – 6 METERS (JUNE 2012-PRESENT)

- **Worked All States** (July 2018)
  - 10th Band: 500/500 via LoTW
- **VUCC**: 462 Grids worked/436 confirmed
- FFMA: 356 worked/344 confirmed
  (*488 total needed for award*)
- DXCC: 36 worked/31 confirmed



- Puerto Rico
- Cuba
- US Virgin Is.
- Anguilla
- Bermuda
- Cayman Is.
- Guadeloupe
- Haiti
- Costa Rica
- Dominican Rep.

- China
- Japan
- S. Korea

- USA
- Canada
- Mexico
- Alaska
- Hawaii

- Azores
- Canary Is.
- Portugal
- Spain
- England
- Scotland
- Guernsey
- Italy
- Norway
- Czech Rep.
- Belgium
- Denmark
- Netherlands
- Sweden

- Belize
- Brazil
- Suriname
- Venezuela

TOPICS

- What causes Sporadic E (Es) openings
- When to look for Es
- Factors affecting paths – Vorticity Theory
- Predicting Es openings
- Maximizing your chances of finding an Es opening

HF vs 6 M Es PROPAGATION

HF (20 M and up)

- Strong correlation with SSN and solar flux
- Solar storms and CMEs have negative impact on propagation
- Openings typically peak during daylight hours, especially during waning periods of solar cycles
- Fairly strong ability to predict propagation between any two points given the solar flux, time of day, etc.

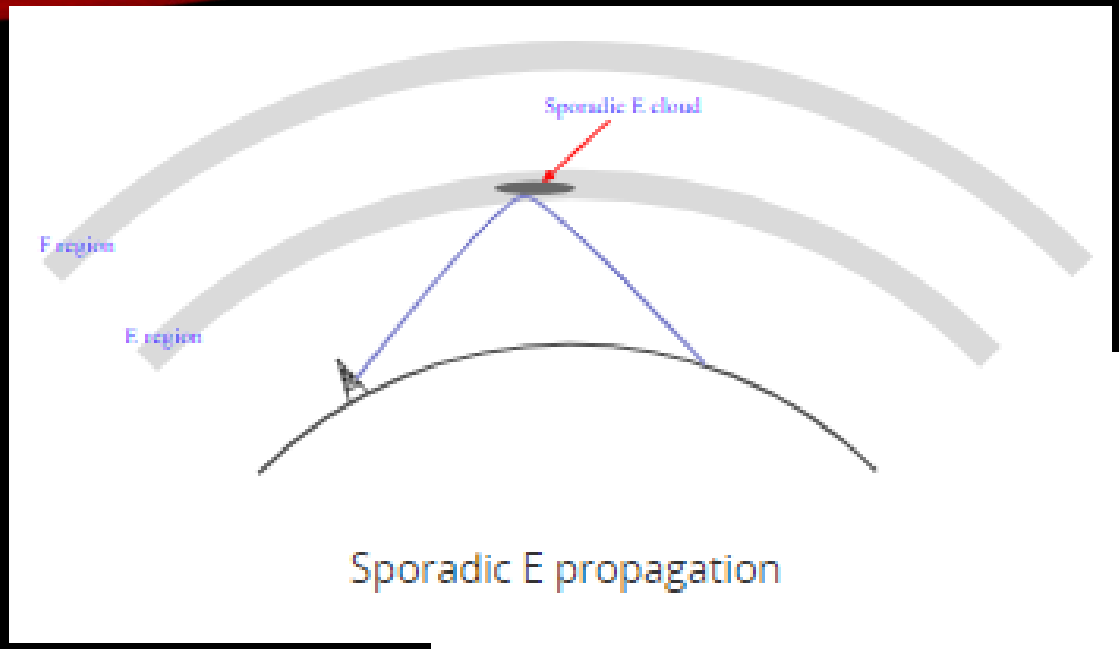
6 Meter Es

- No correlation has been demonstrated with SSN/solar flux
- Solar storms and CMEs usually have negative impact on propagation – mostly via noise level increases, but can also cause openings
- Openings more likely during daytime, but can be very strong at night
- No apparent ability to predict openings other than by time of year (very general)

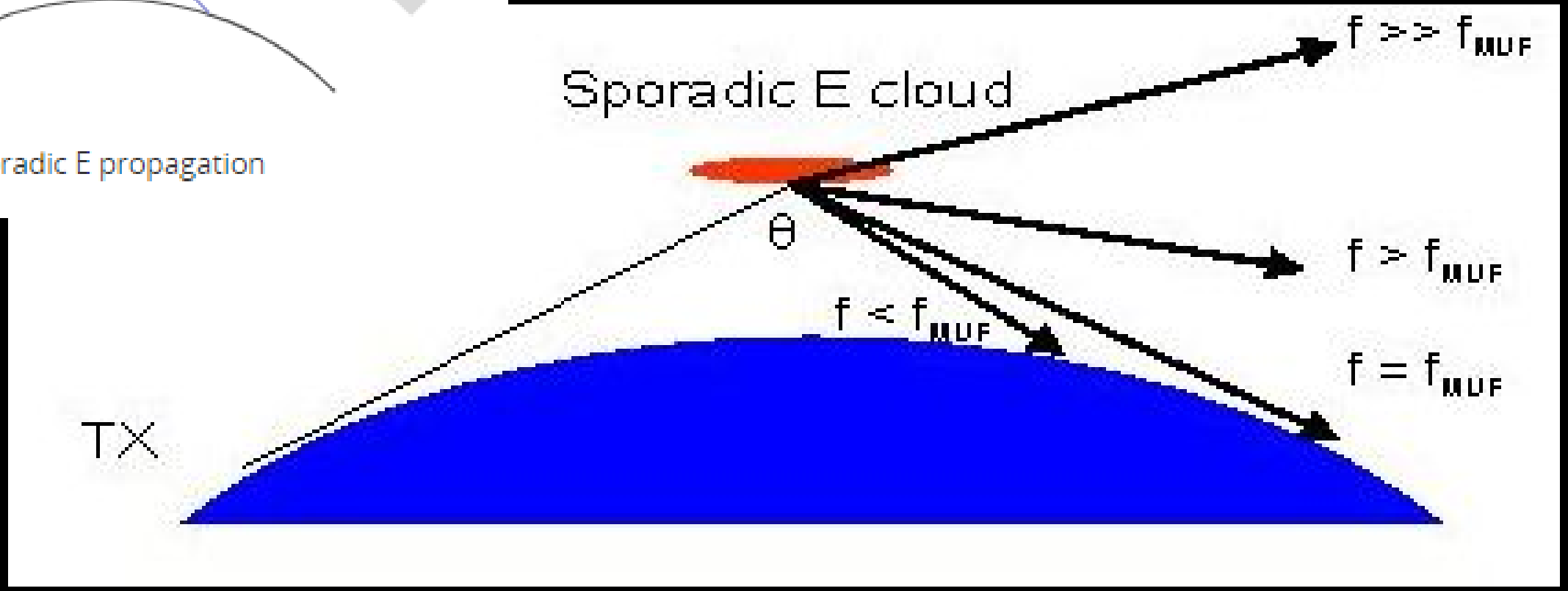
F2 propagation is very different from Es, and is much more like HF

WHAT IS SPORADIC E?

- E Layer of the Ionosphere – 50 to 150 miles above the earth's surface



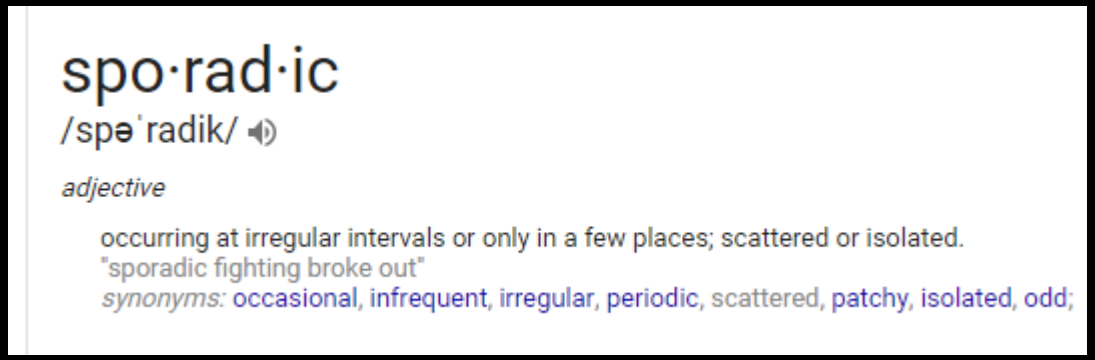
Sporadic E propagation



WHAT IS SPORADIC E?

- "**Cloud**" – Patch of ionized metal ions that follows air currents (a la water clouds)
  - Meteorites are the largest source of metal atoms that can become ionized
- Current prevailing hypothesis is that **wind shear** and **solar radiation** are both responsible for cloud formation by causing ionization
  - Anecdotal evidence that thunderstorms and other severe weather may contribute to Es during the summer season
- Mid-latitude (that's us) Es occurs mainly **between May and August**
  - Small peak in occurrence in December-January
- Each "hop" is typically **500-1100 miles**, but multihop is very common, as are large patches of clouds that provide widespread propagation

IT'S CALLED SPORADIC FOR A REASON


spo·rad·ic
/spəˈradik/

adjective

occurring at irregular intervals or only in a few places; scattered or isolated.
"sporadic fighting broke out"
synonyms: occasional, infrequent, irregular, periodic, scattered, patchy, isolated, odd;

Murphy's Law of Sporadic E: There will be poor or no openings during a VHF contest or DXpedition

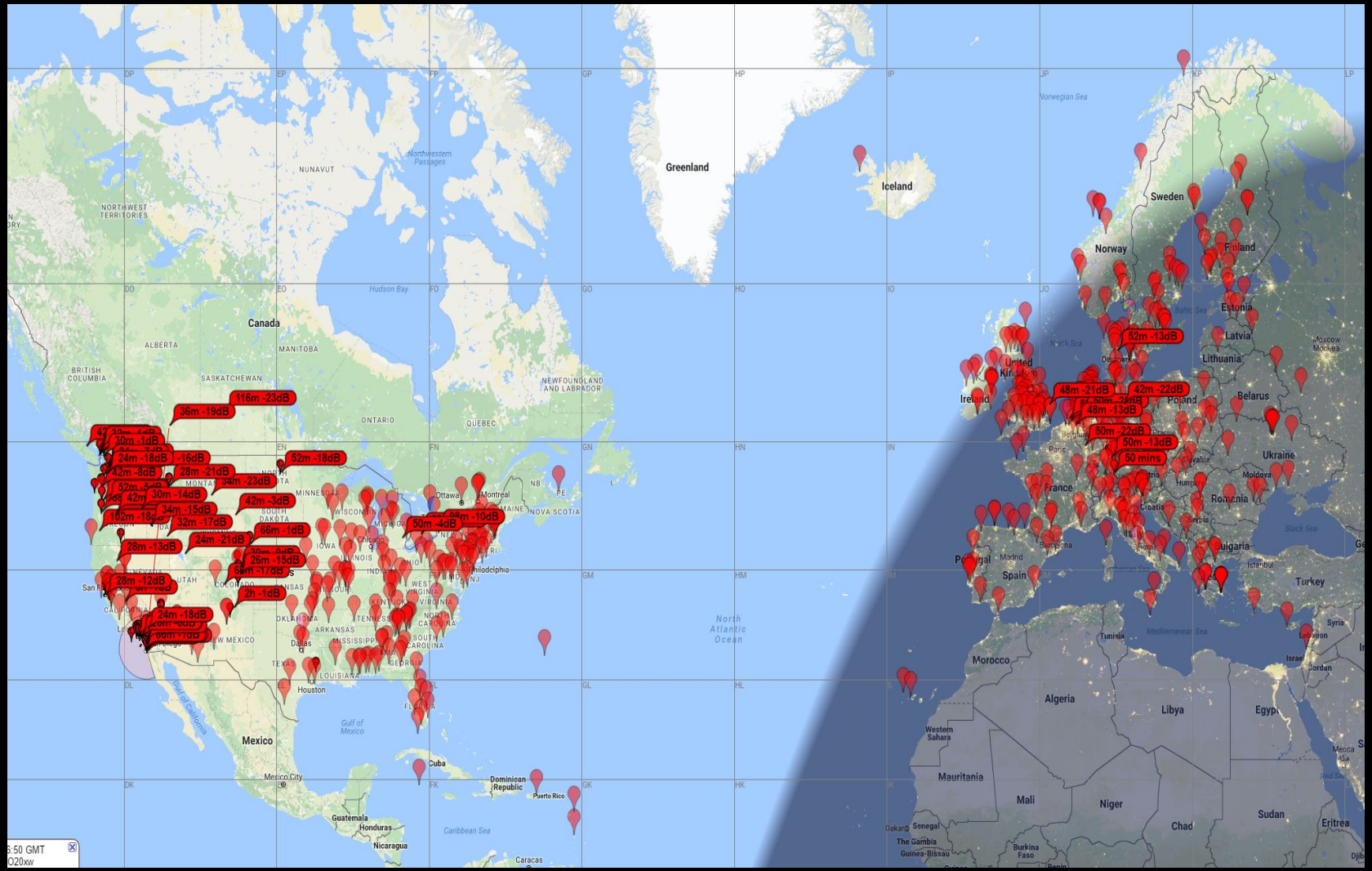
Example: KH1/KH7Z didn't have 6 M antennas up the first few days they were on Baker Island. On their 2nd day, there was a long and strong Es opening to Japan and Hawaii from most of the continental US. They put their antenna up the next day, but then didn't make any 6 M QSOs the entire time they were there due to lack of openings.

NC6K-NA6L Corollary to Murphy's Law: If we leave the house for any reason or are otherwise unable to operate, a tremendous Es opening is highly probable

On Sunday (7/22/18), I tilted my tower over to put on a different HF antenna, and didn't have time to finish the job, so my 6 M Yagi was laying on the ground. The following morning (7/23), 6 M opened to most of Europe. To add insult to injury, I could still receive quite a few EU stations, but no way could they hear me. I was also able to watch a bunch of San Diego stations working them.

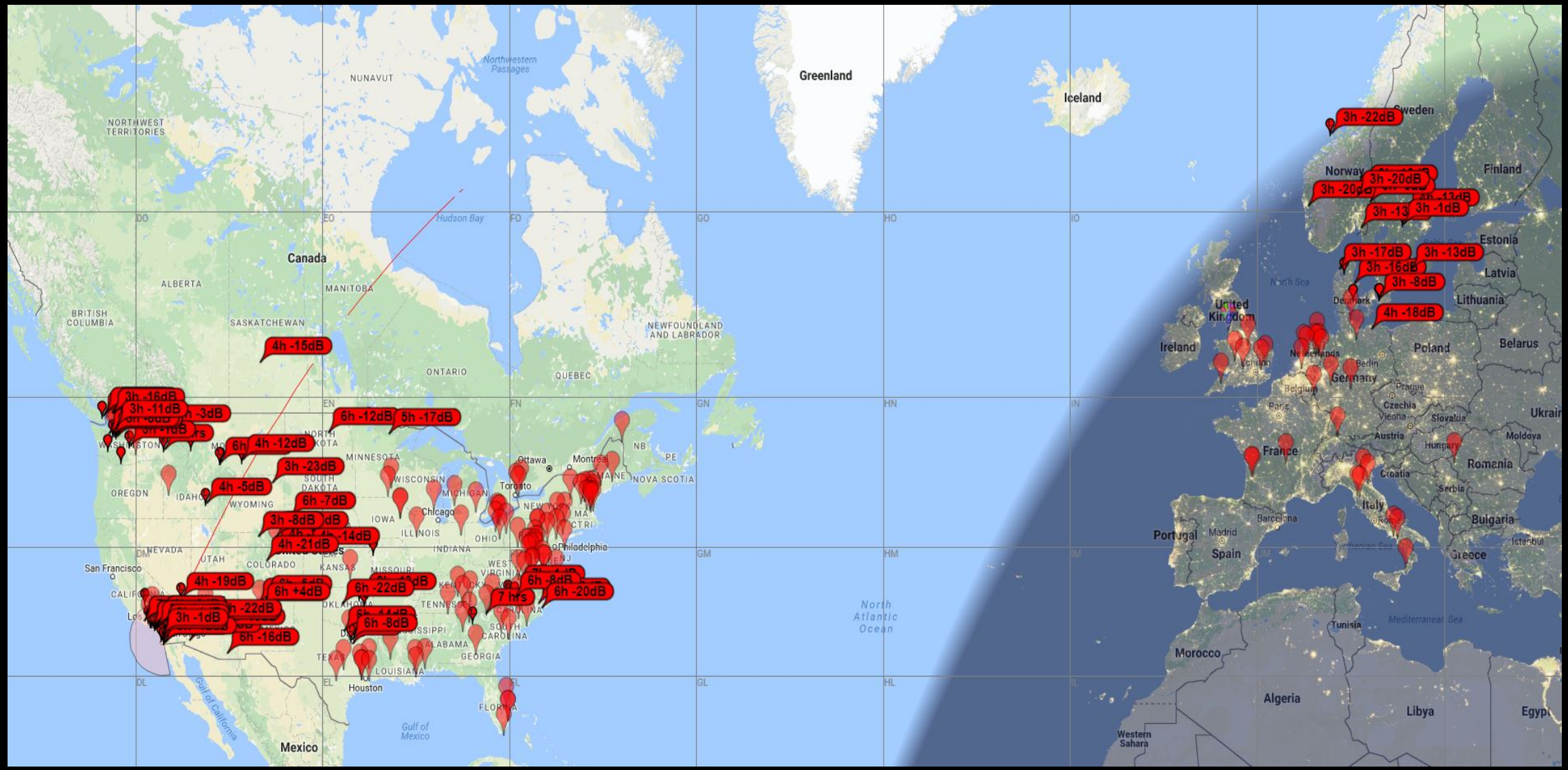
WHAT DOES A GOOD DAY ON 6 METERS LOOK LIKE?

June 5, 2017



WHAT DOES A GOOD DAY ON 6 METERS LOOK LIKE?

July 4, 2017



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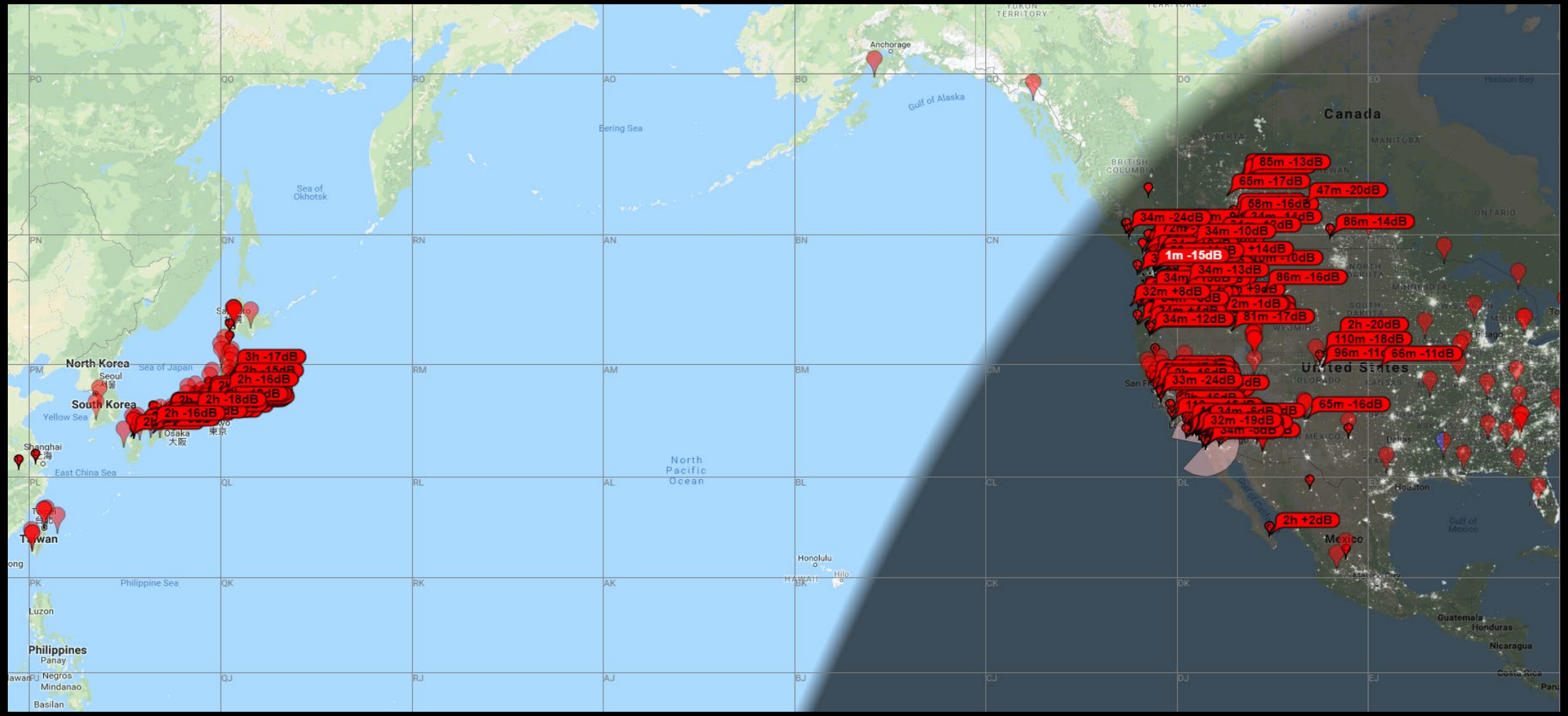

NC6K's spots on June 19, 2018

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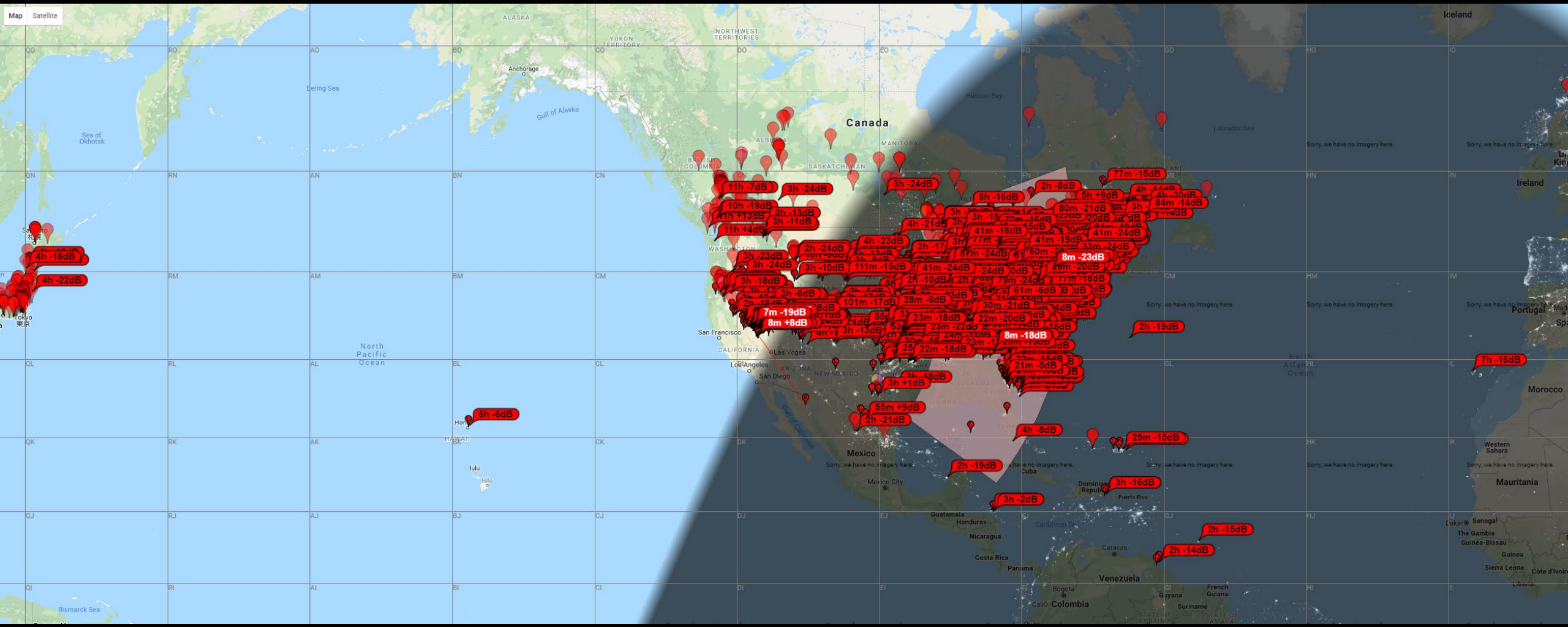
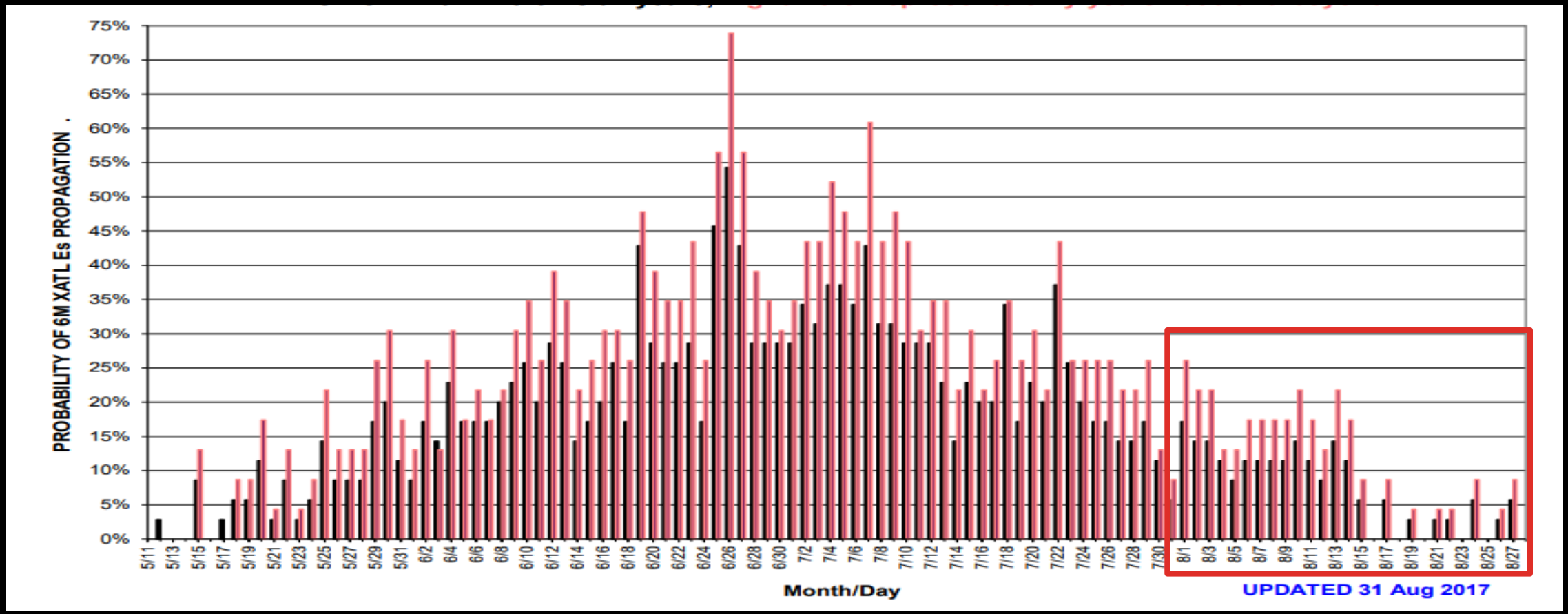


NC6K's spots on June 19, 2018

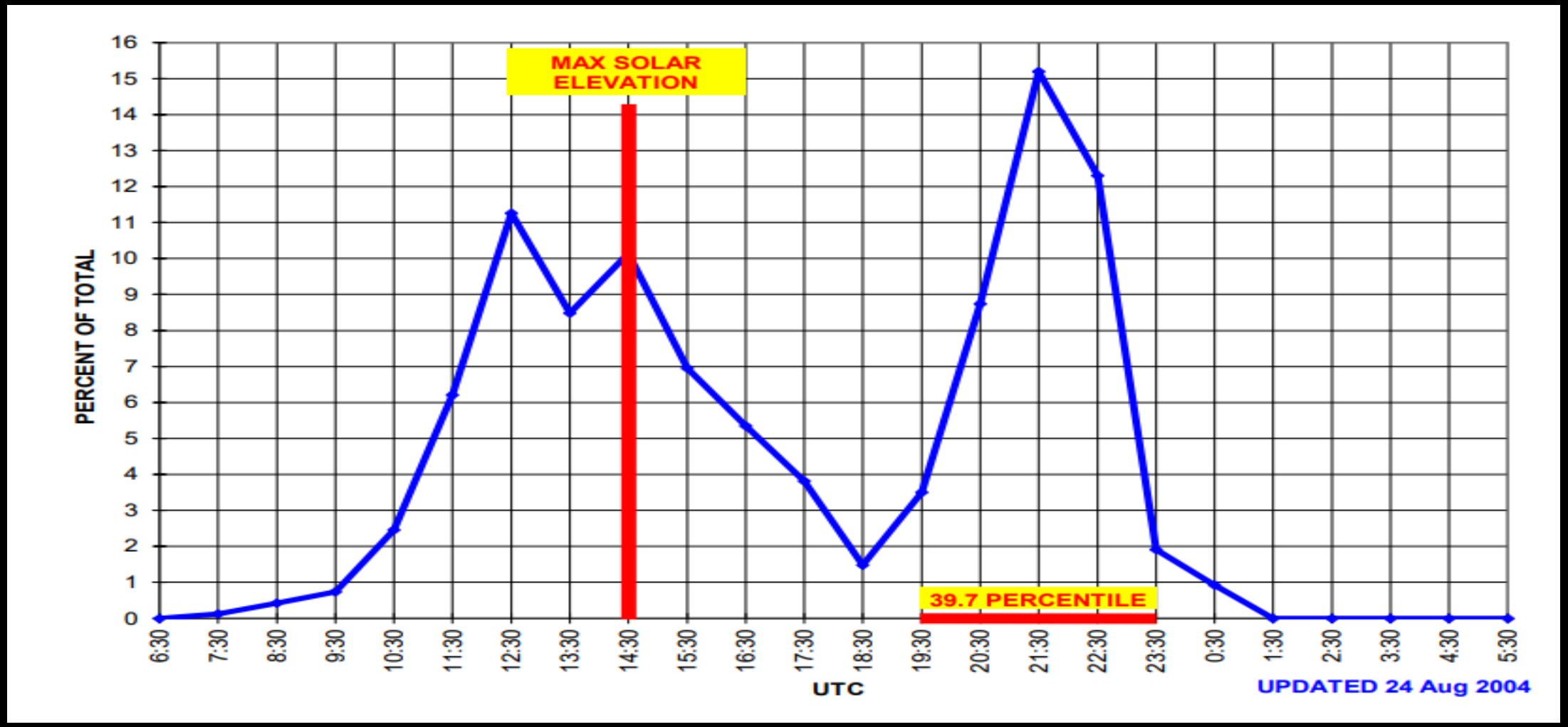
WHEN IS THE BEST TIME OF YEAR FOR Es?

K1SIX/WA1OUB Transatlantic data
1982-2017

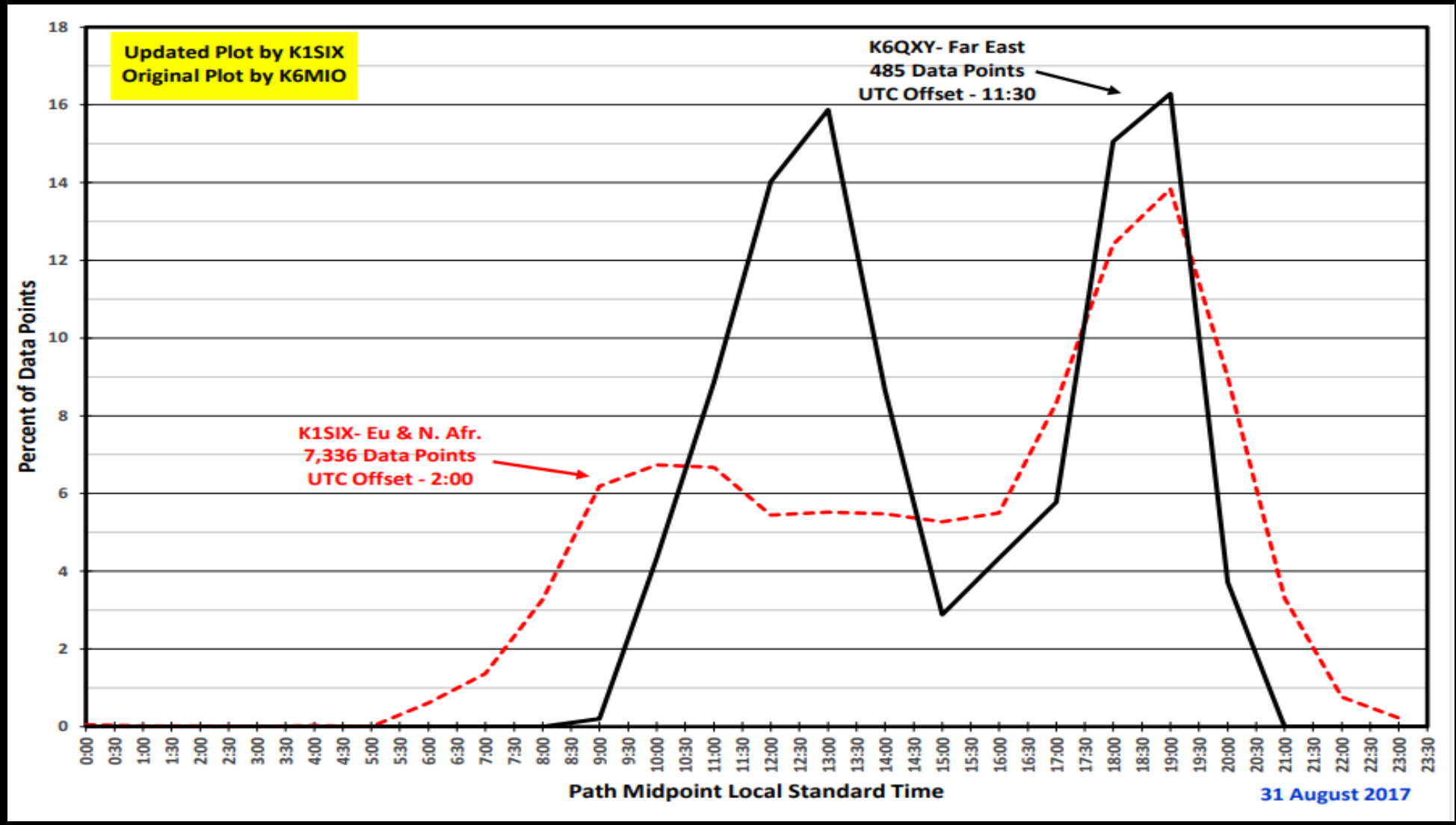


WHEN IS THE BEST TIME OF DAY FOR Es?

EA7KW Transatlantic data
1995-2004



MULTIHOP Es DEPENDS ON THE SOLAR TIME AT THE PATH MIDPOINT

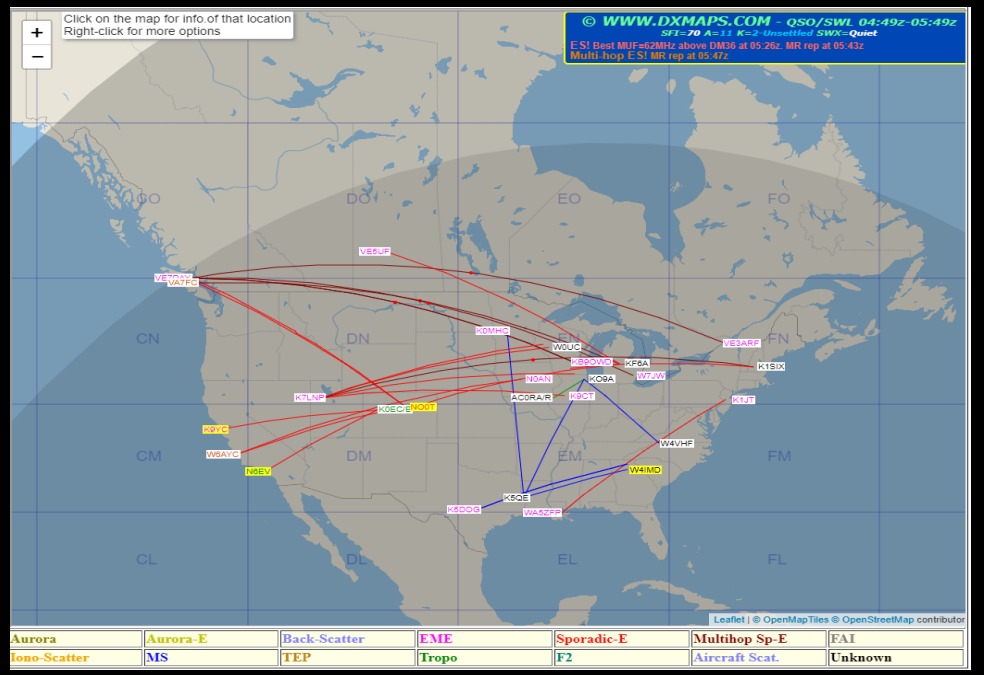


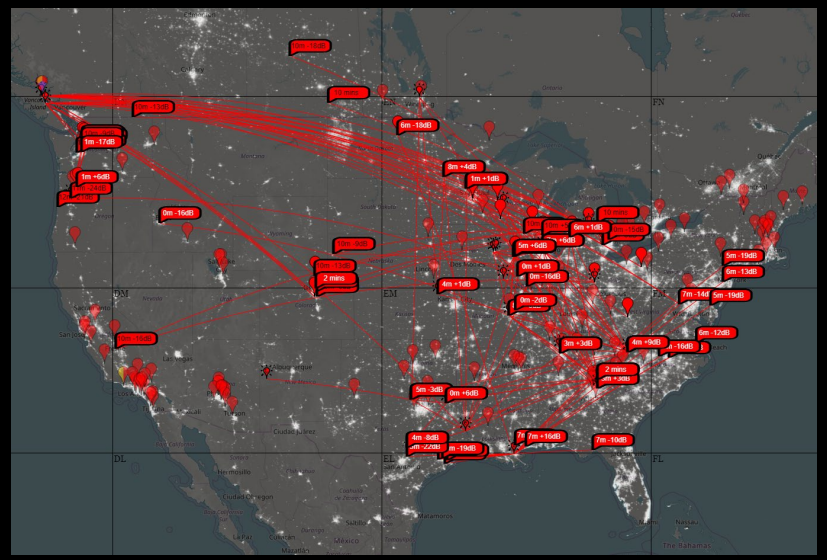
WHAT DOES THIS SOLAR MIDPOINT BUSINESS MEAN FOR HAMS IN SAN DIEGO?

- ***1200 and 1900 Solar Time are the magic numbers***
- East Coast USA (+3 hours)
  - 1030 PT/1330 ET & 1730 PT/2030 ET
- East/Central Europe (+9 hours)
  - 0730 PT/1630 CET & 1430 PT/2330 CET
- Caribbean (+4 hours)
  - 1000 PT/1400 AT & 1700 PT/2100 AT
- Hawaii (-3 hours)
  - 1330 PT/1030 HT & 2030 PT/1730 HT
- Japan (+16 hours)
  - 2000 PT/0400 JT & 0300 PT/1100 JT

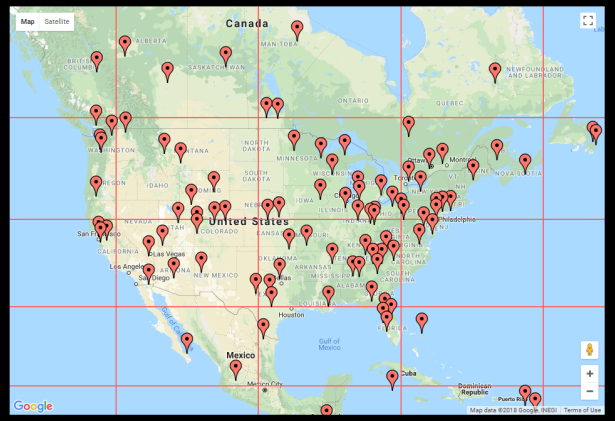
“HOW DO I KNOW IF I HAVE SPORADIC E?”

- CW Beacons - http://www.k9mu.com/map/
  - 50.010 – 50.080 MHz
  - Often heard when no one is on other modes
- PSK Reporter (PSKR) - https://www.pskreporter.info/pskmap.html
- Dxmaps - https://www.dxmaps.com
- WSPRnet – http://wsprnet.org/drupal/wsprnet/map





North American 50 Mhz Beacon Map by K9MU - v2.0



CHAT BOARDS

- Ping Jockeys - http://www.pingjockey.net/cgi-bin/pingtalk/50.010 – 50.080 MHz
  - Supposed to be only for Meteor Scatter, but worth checking
- ON4KST - http://www.on4kst.org/chat/index.php
  - Several boards for different regions
- Cali VHF UHF Page - http://www.n6sjv.org/

- Google is your friend
  - “Search and ye shall receive (many links)”

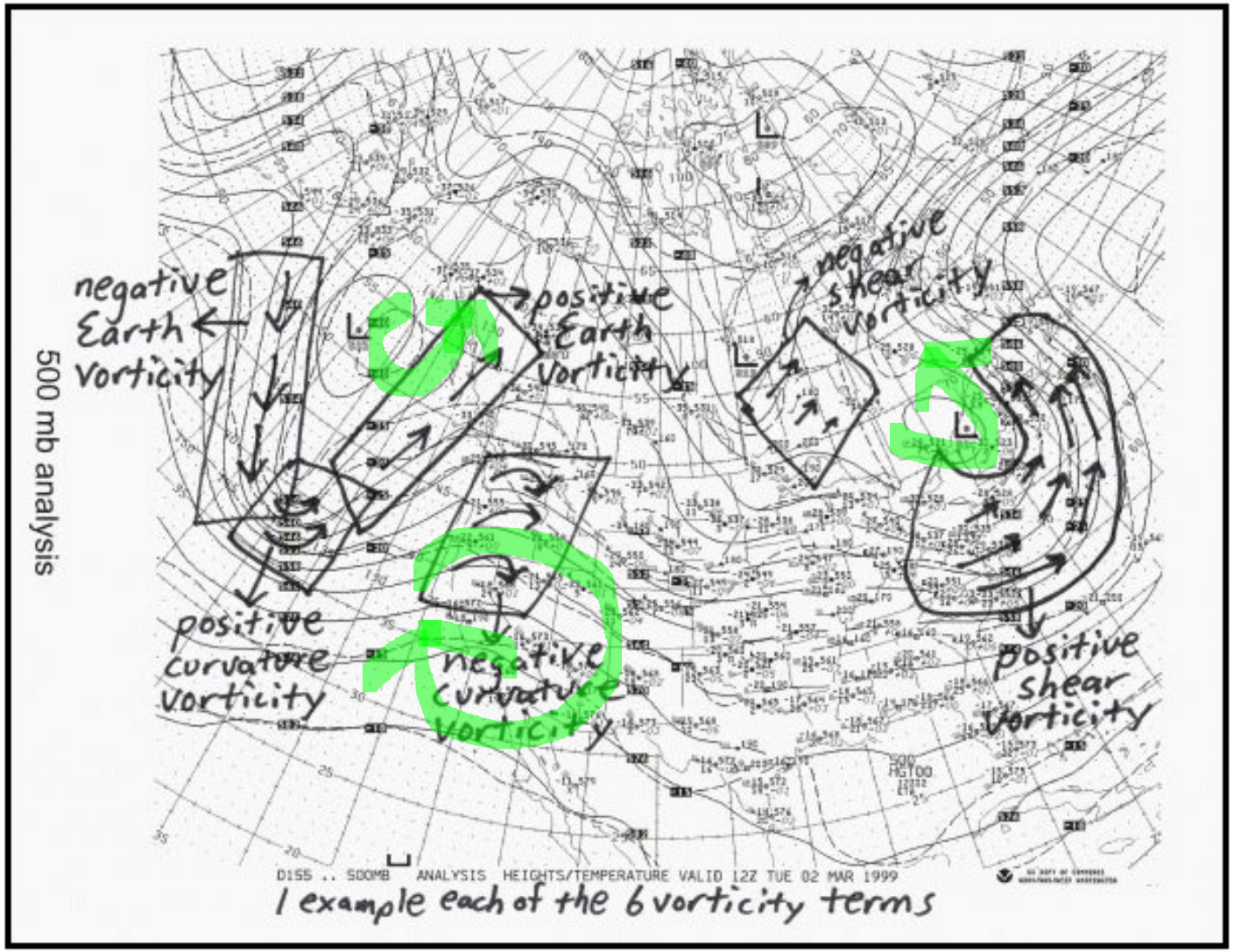
THE VORTICITY THEORY

Maybe we can predict Sporadic E,

or at least where it's likely to be when it occurs

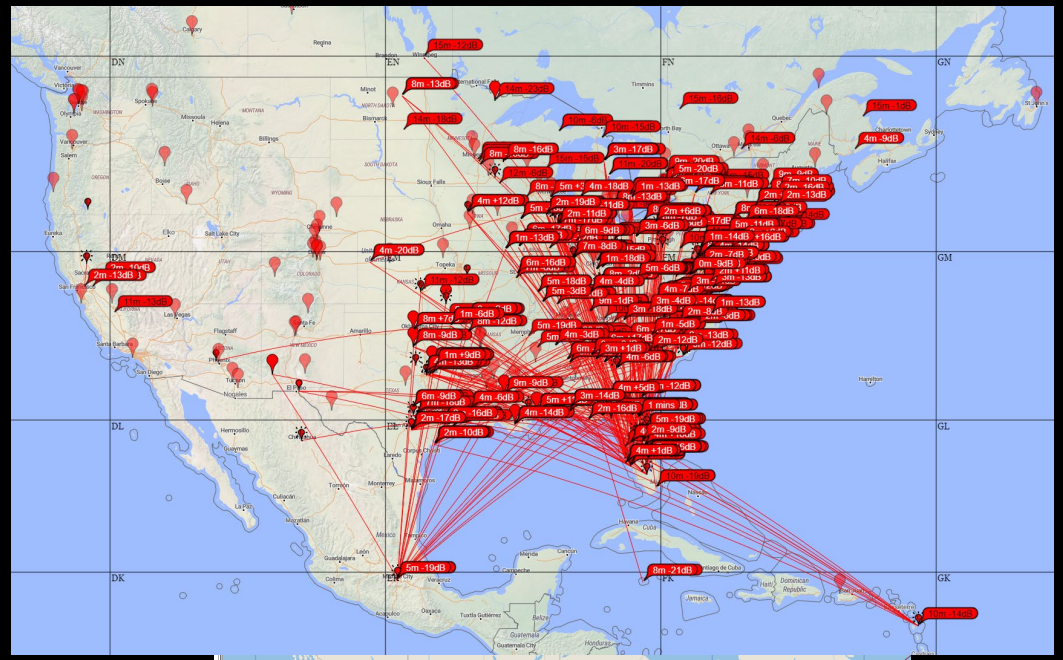
WHAT IS VORTICITY?

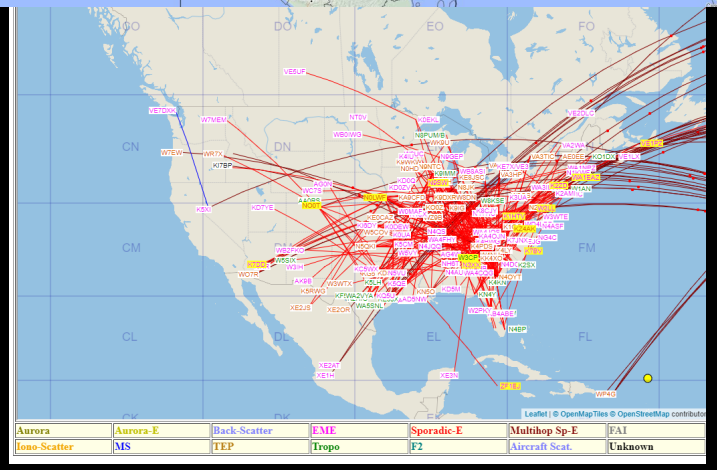
- Simply put, vorticity is a clockwise or counter-clockwise rotation (curvature) or strong planar flow (shear) in the atmosphere – WIND!
- Vorticity caused by a change in wind direction or wind speed with height is termed horizontal vorticity
- Vorticity is commonly determined by examining the contour lines in a 500 mbar pressure map (the jet stream)



WHY SHOULD WE CARE?
OR, WHY DOES THE REST OF THE COUNTRY HAVE OPENINGS AND WE DON'T?

- During summer Es season, high pressure is very typical over the SW USA
- The high pressure blows metal ions away from us, leaving nothing to reflect VHF signals back to earth
- Very often, the Rocky Mtns enhance the Planetary Waves in the jet stream, and creates troughs on the other side where ions accumulate, so we have silence and they have Es



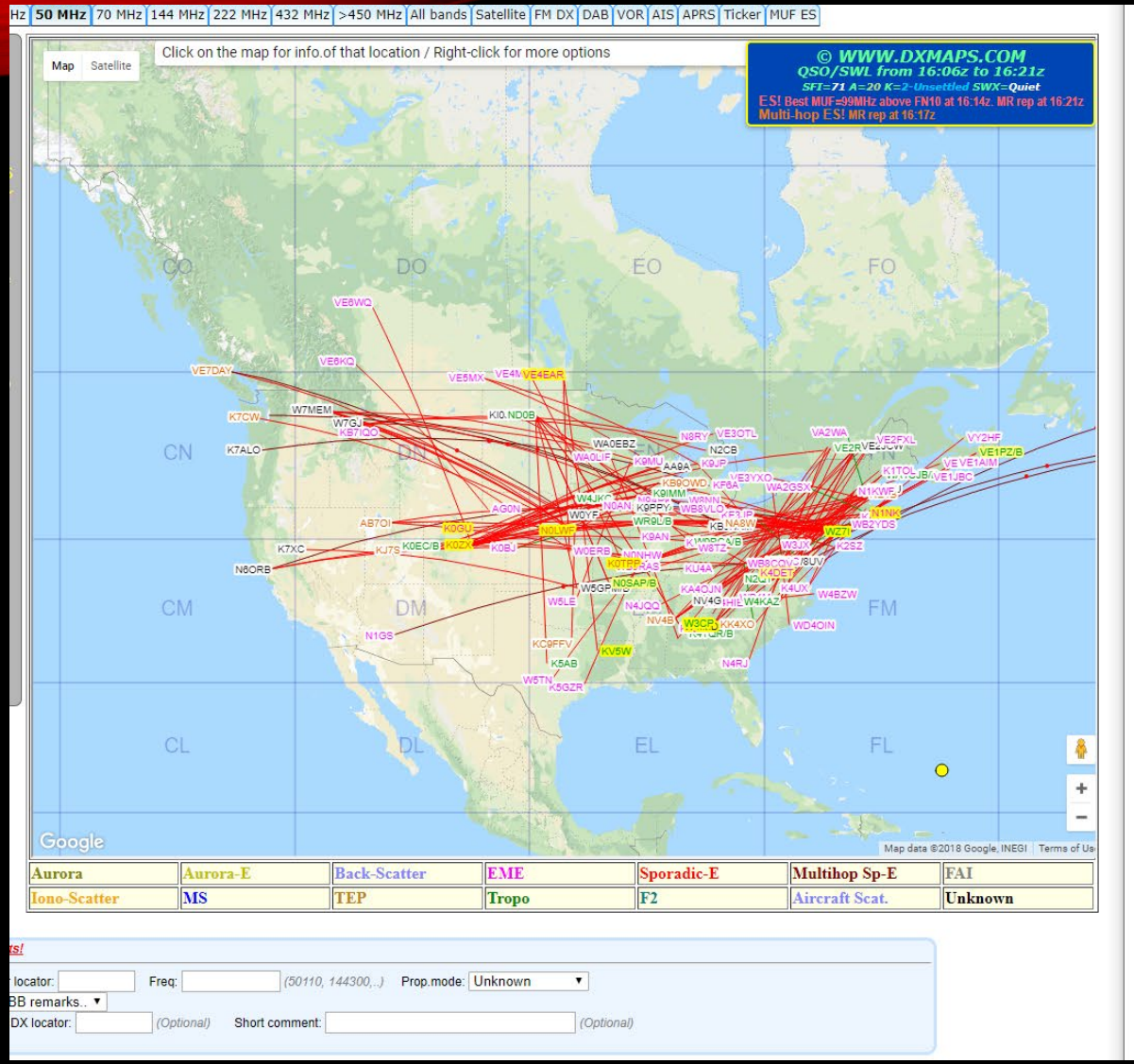


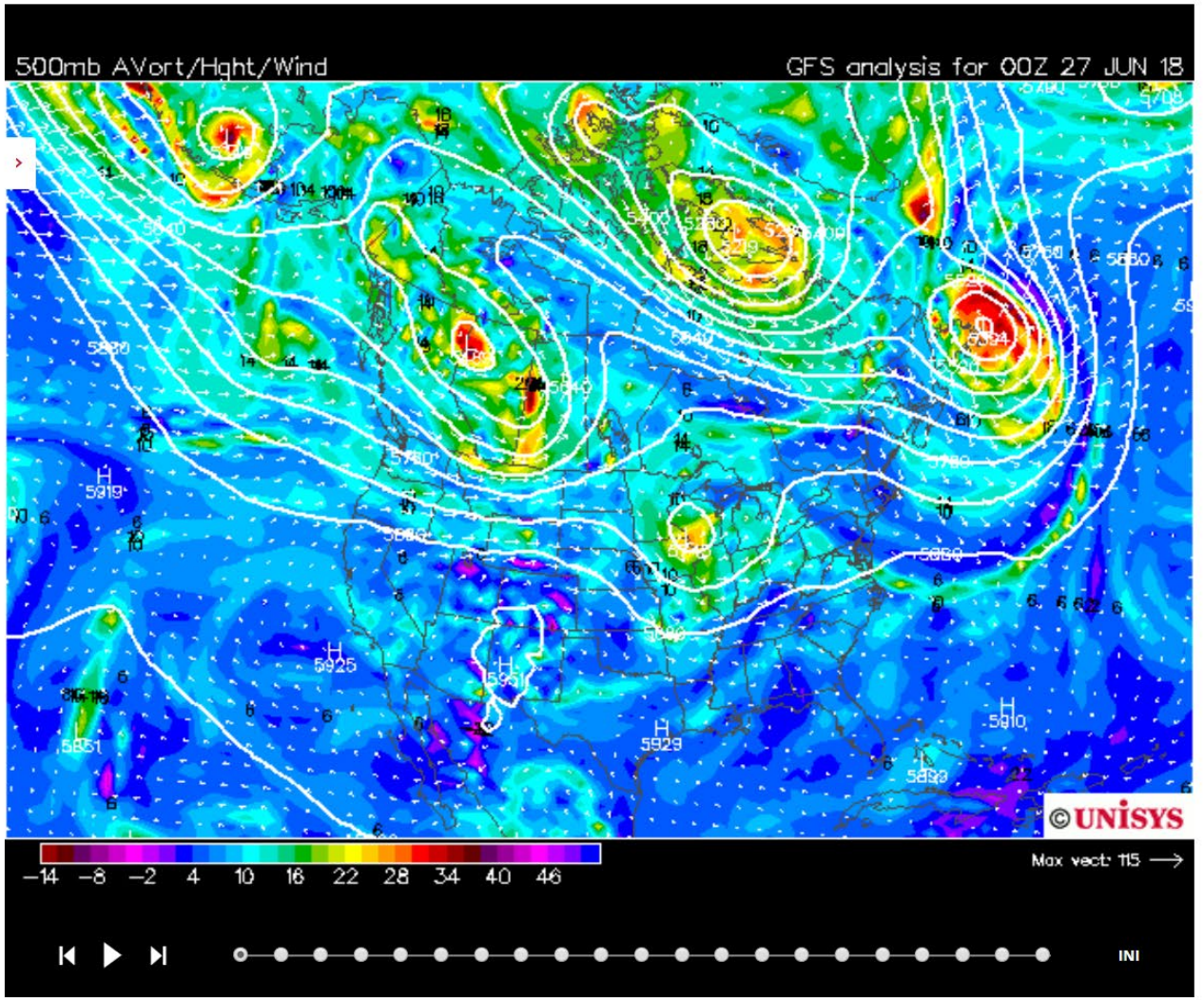
Planetary waves and midlatitude sporadic E layers: Strong experimental evidence for a close relationship

http://onlinelibrary.wiley.com/doi/10.1029/2001JA000212/full

Thanks to Jim, K6OK for this link

VORTICITY VS Es PATHS





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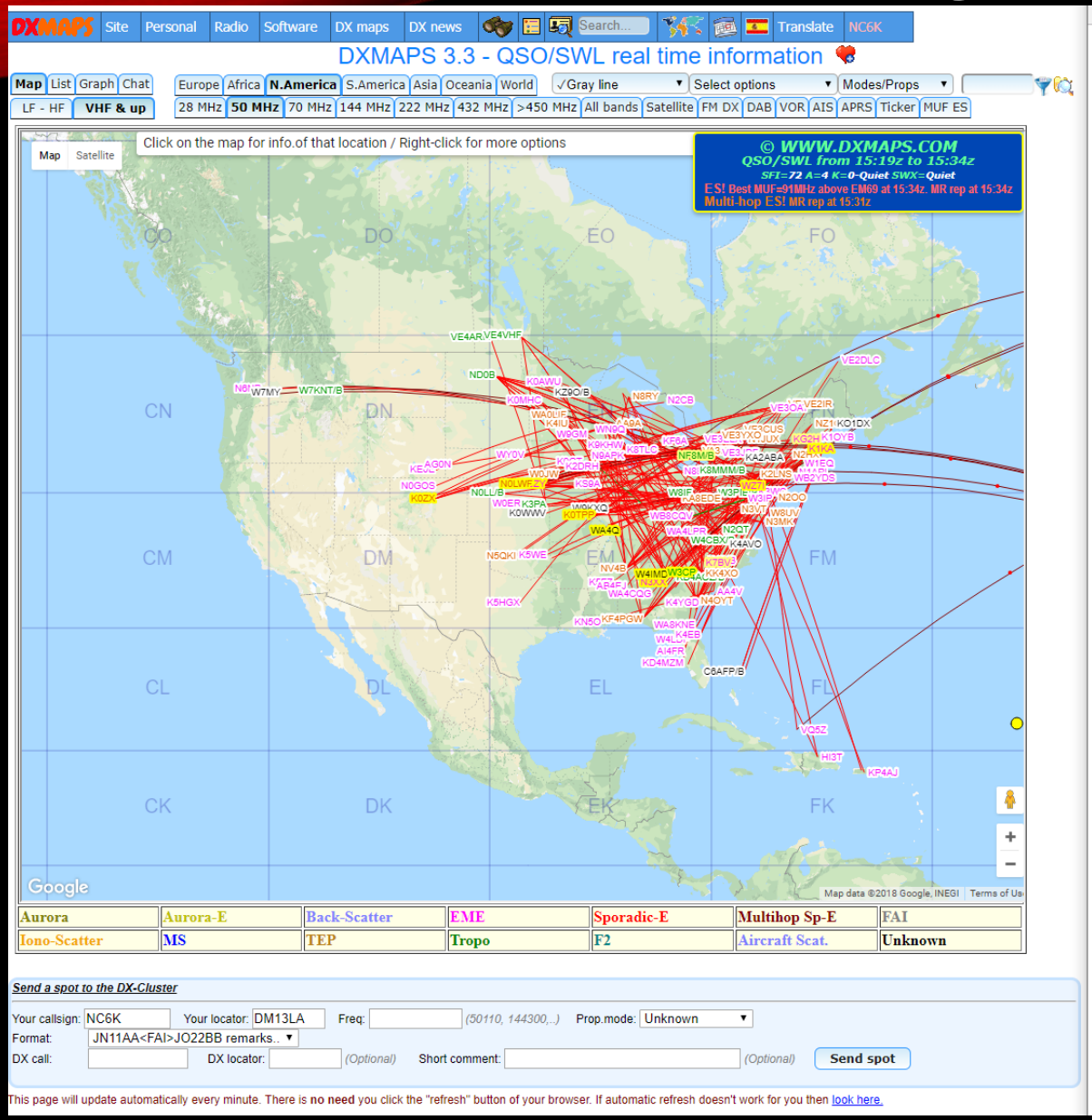

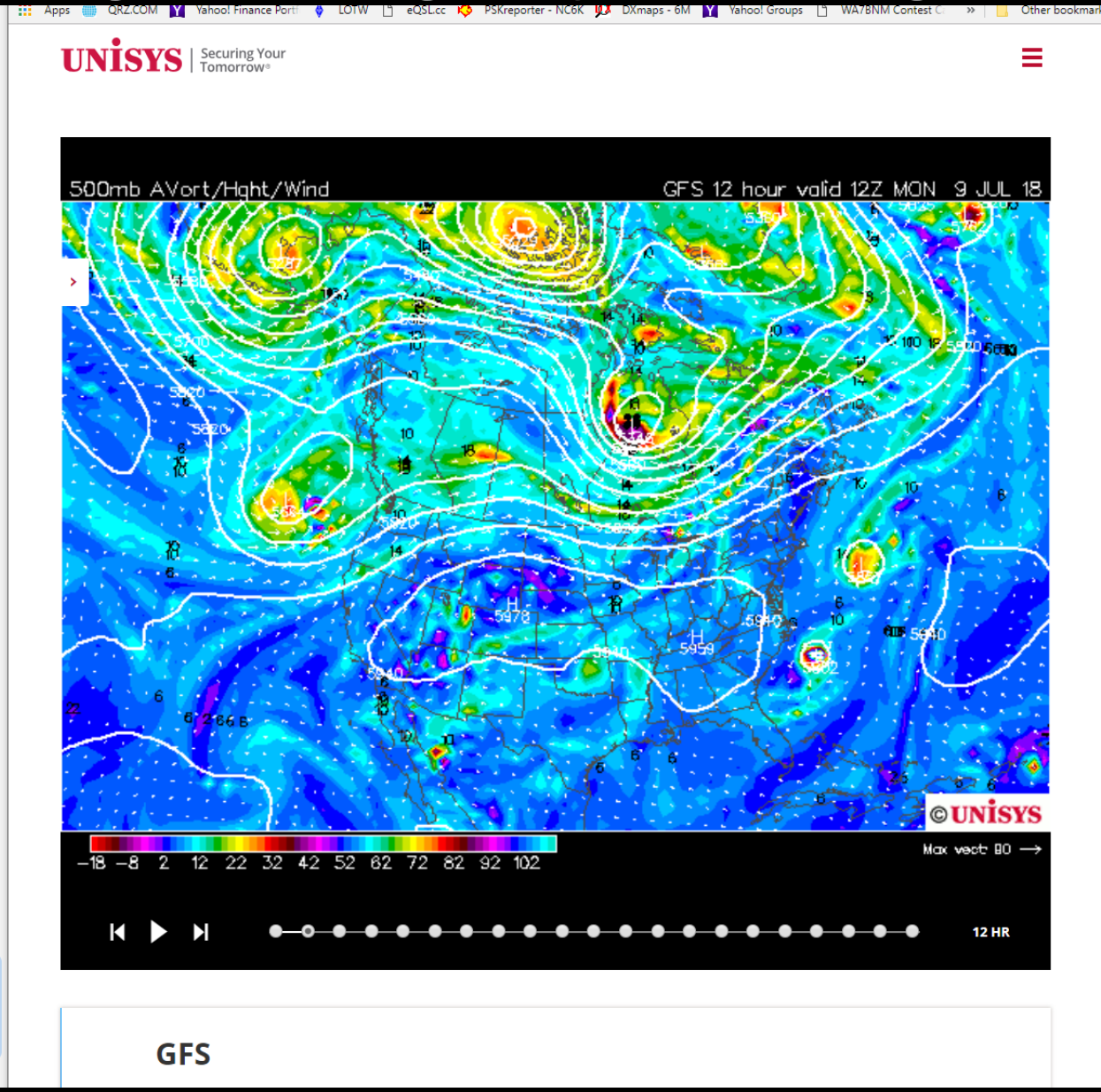

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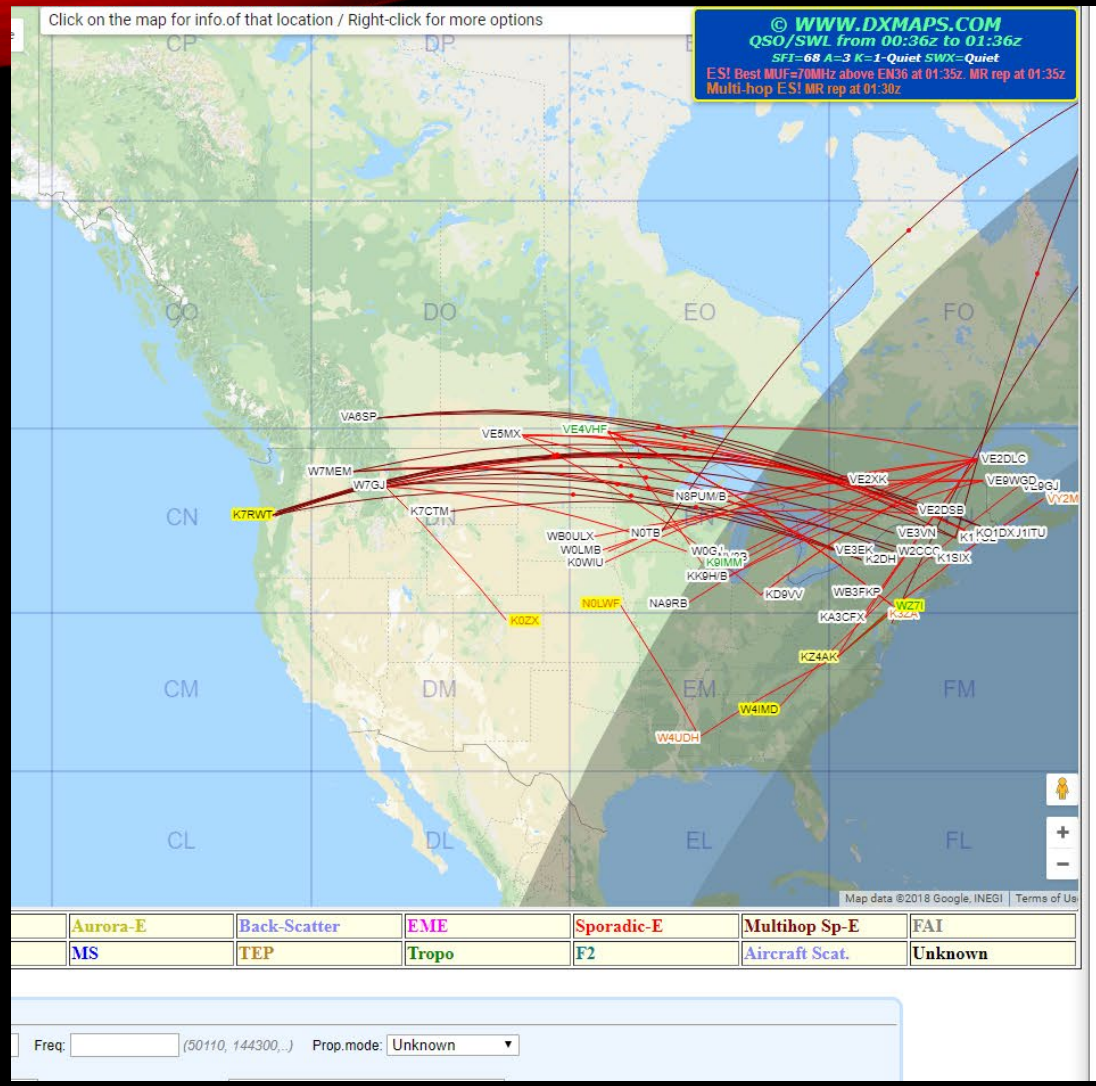

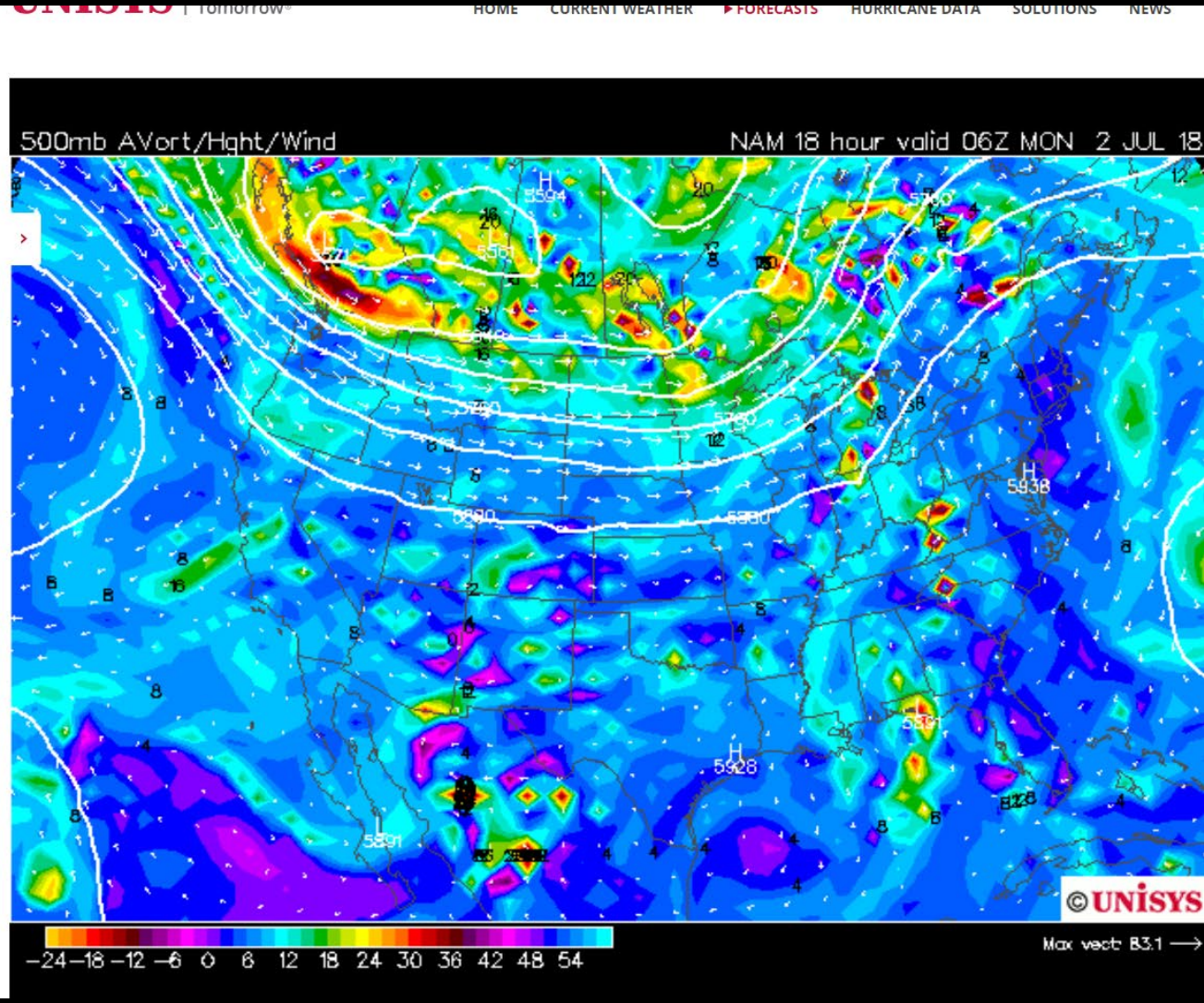

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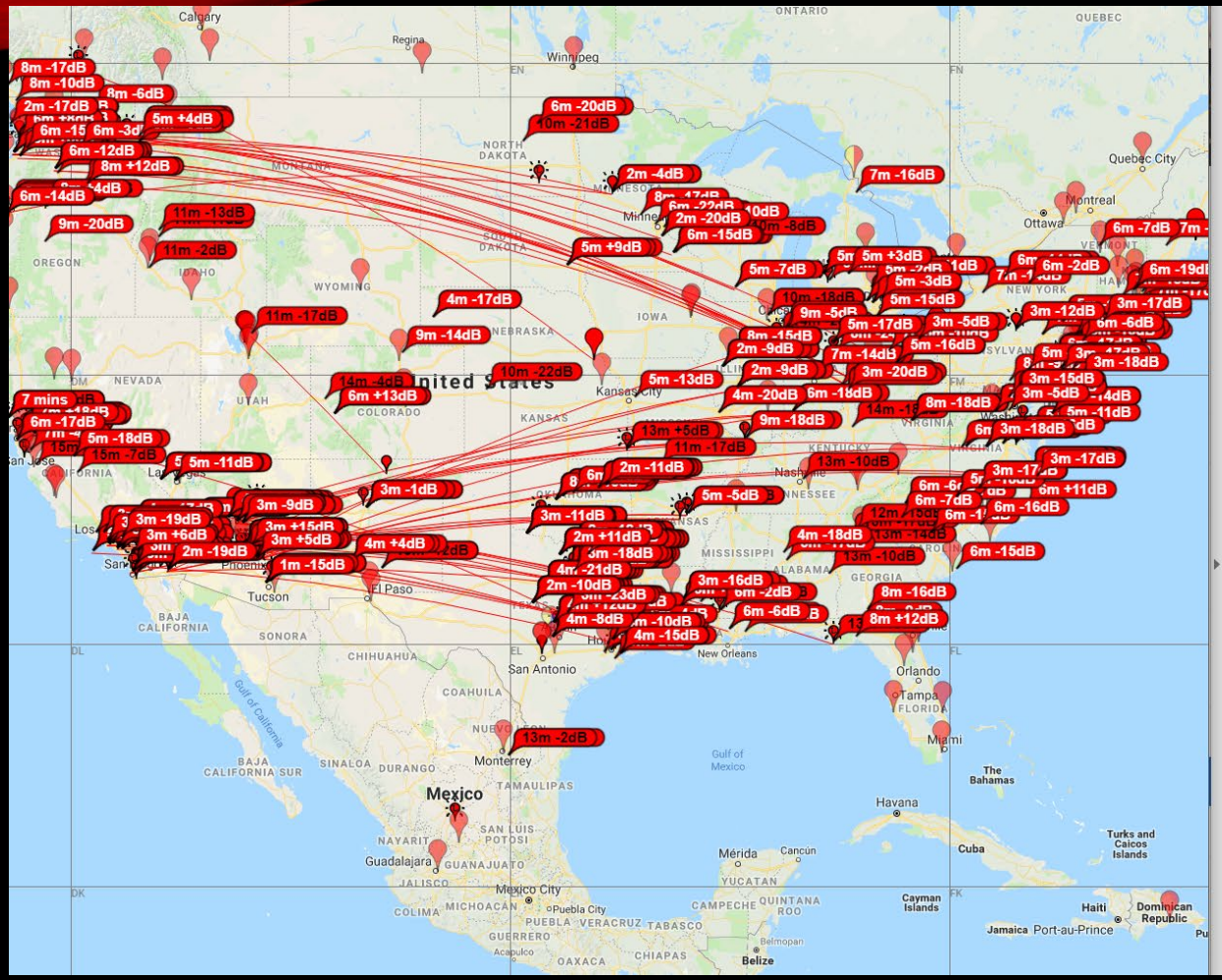

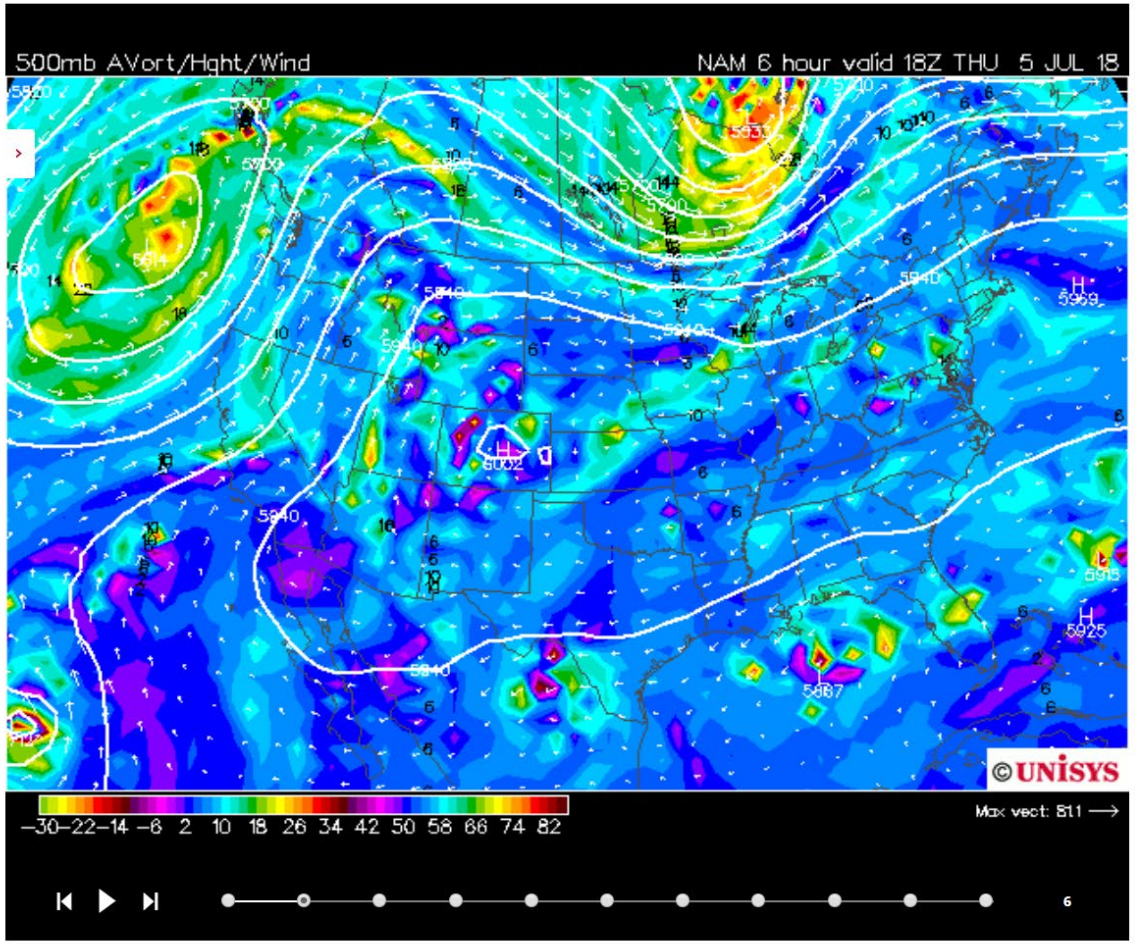

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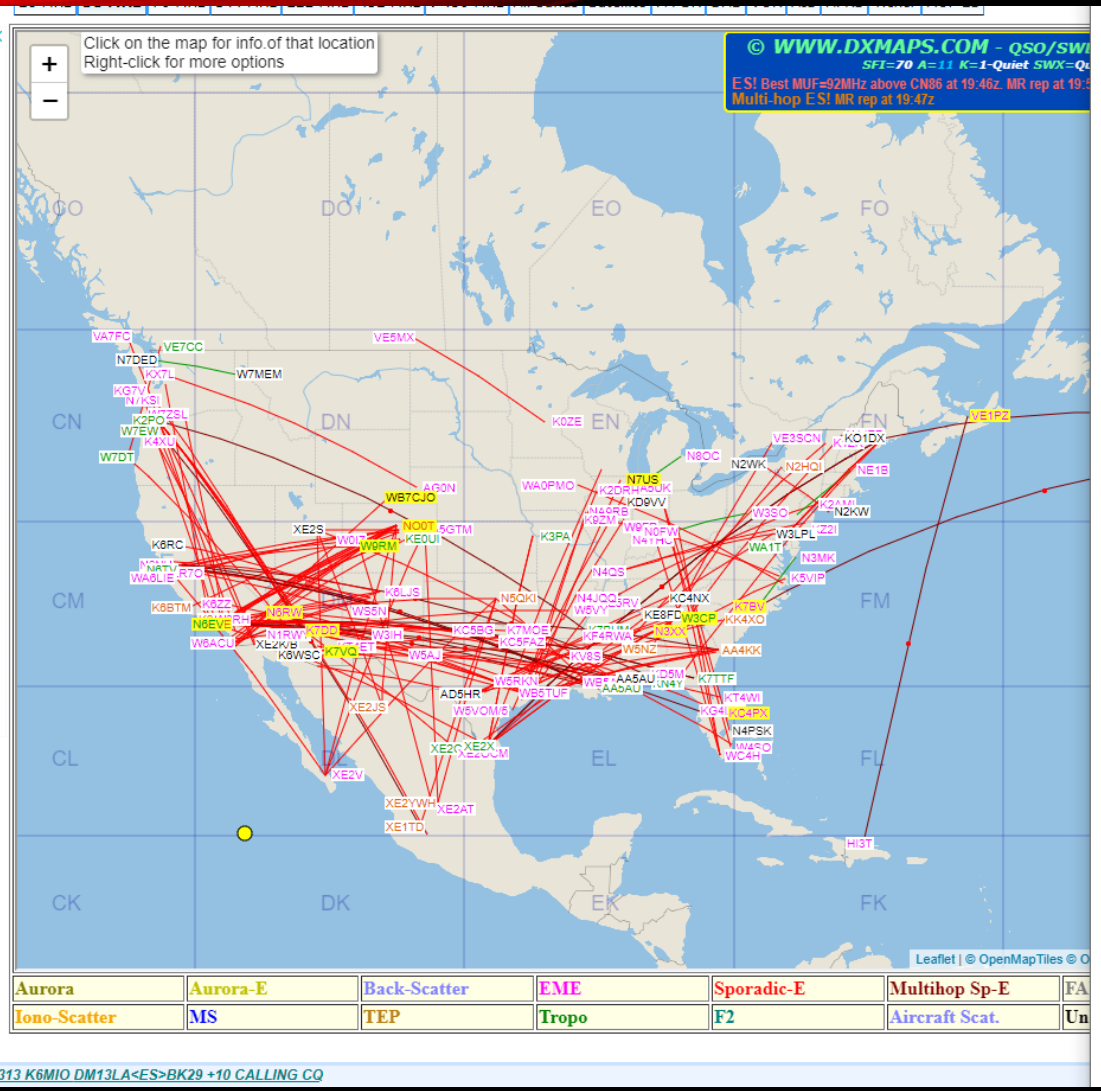
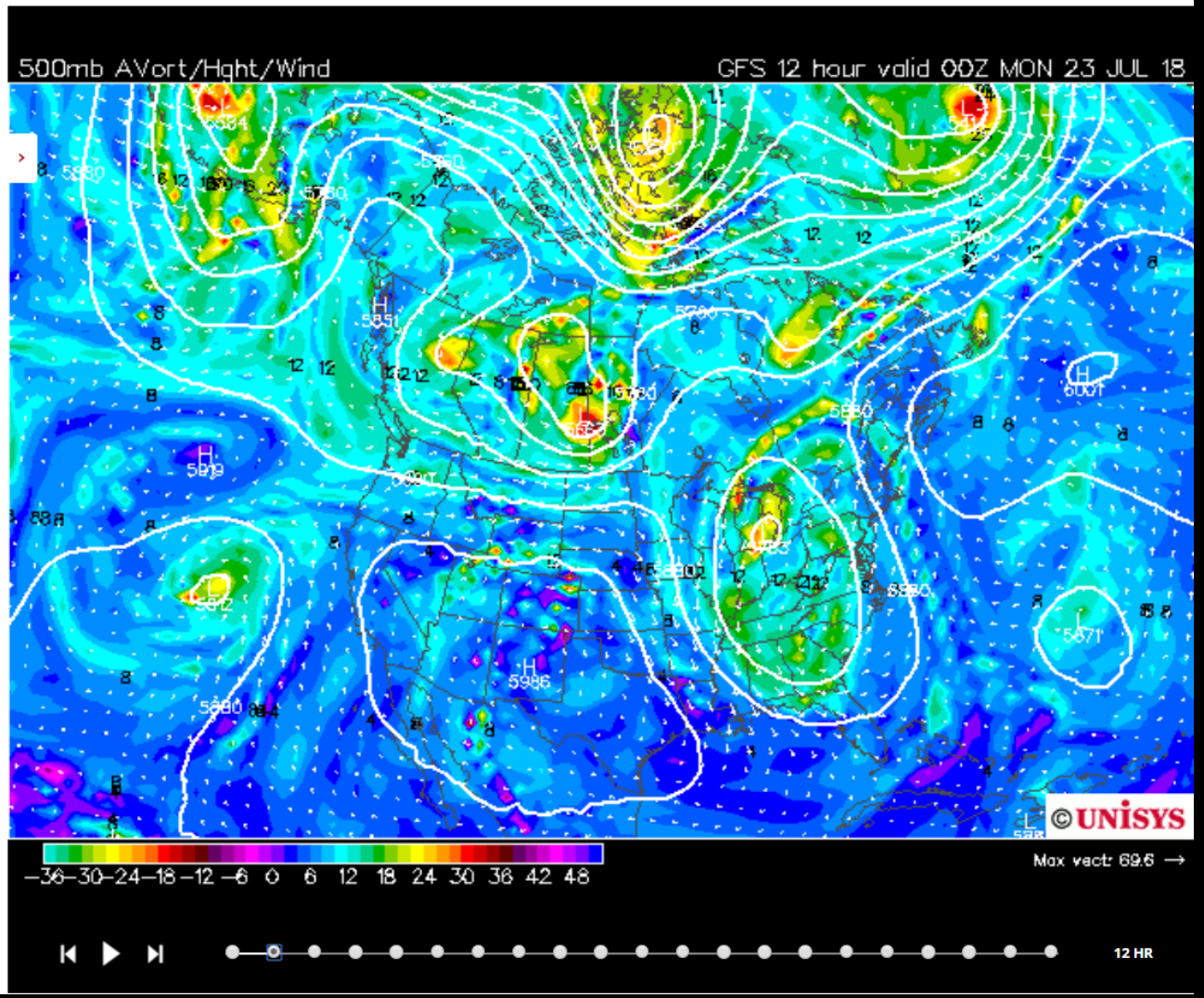
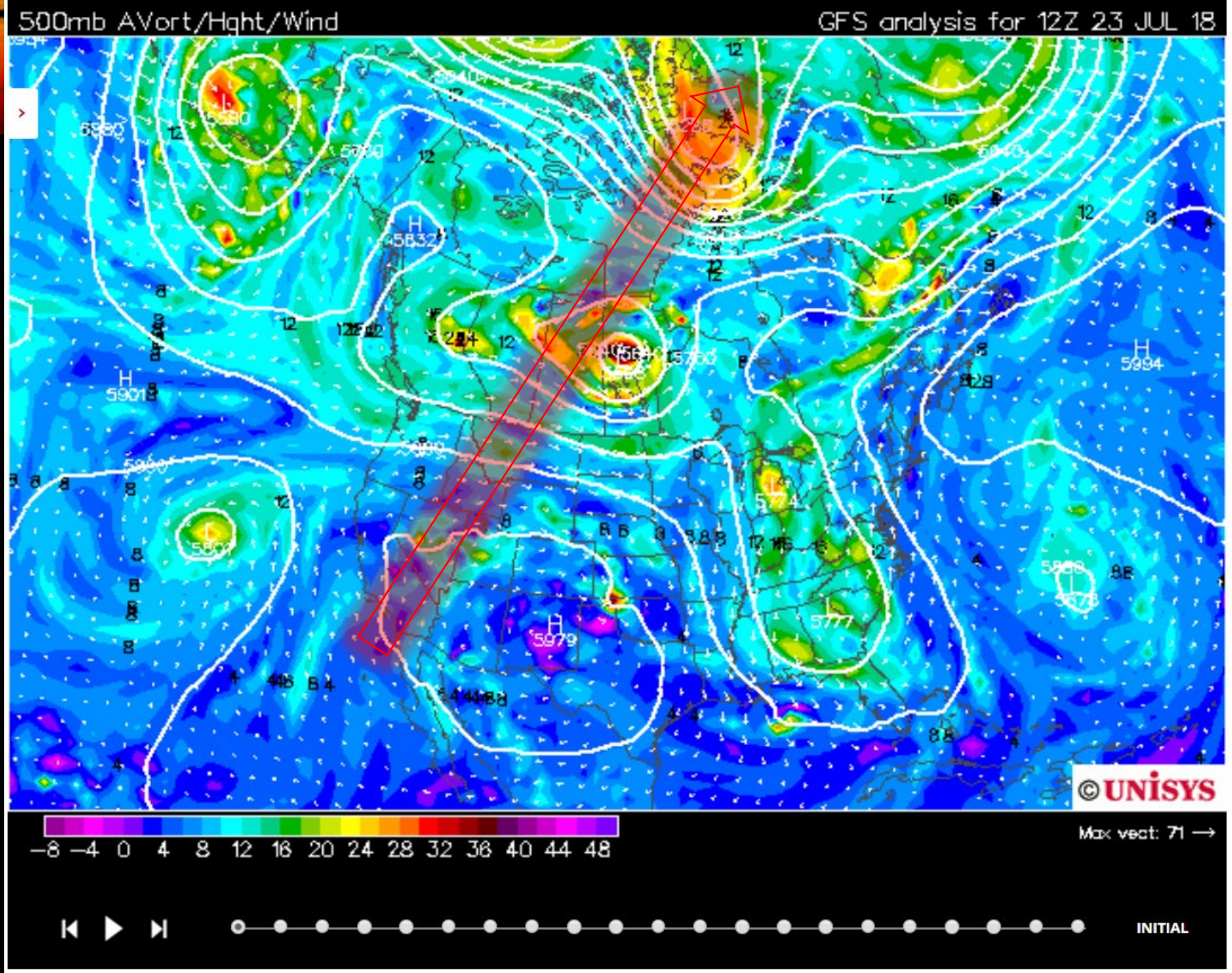
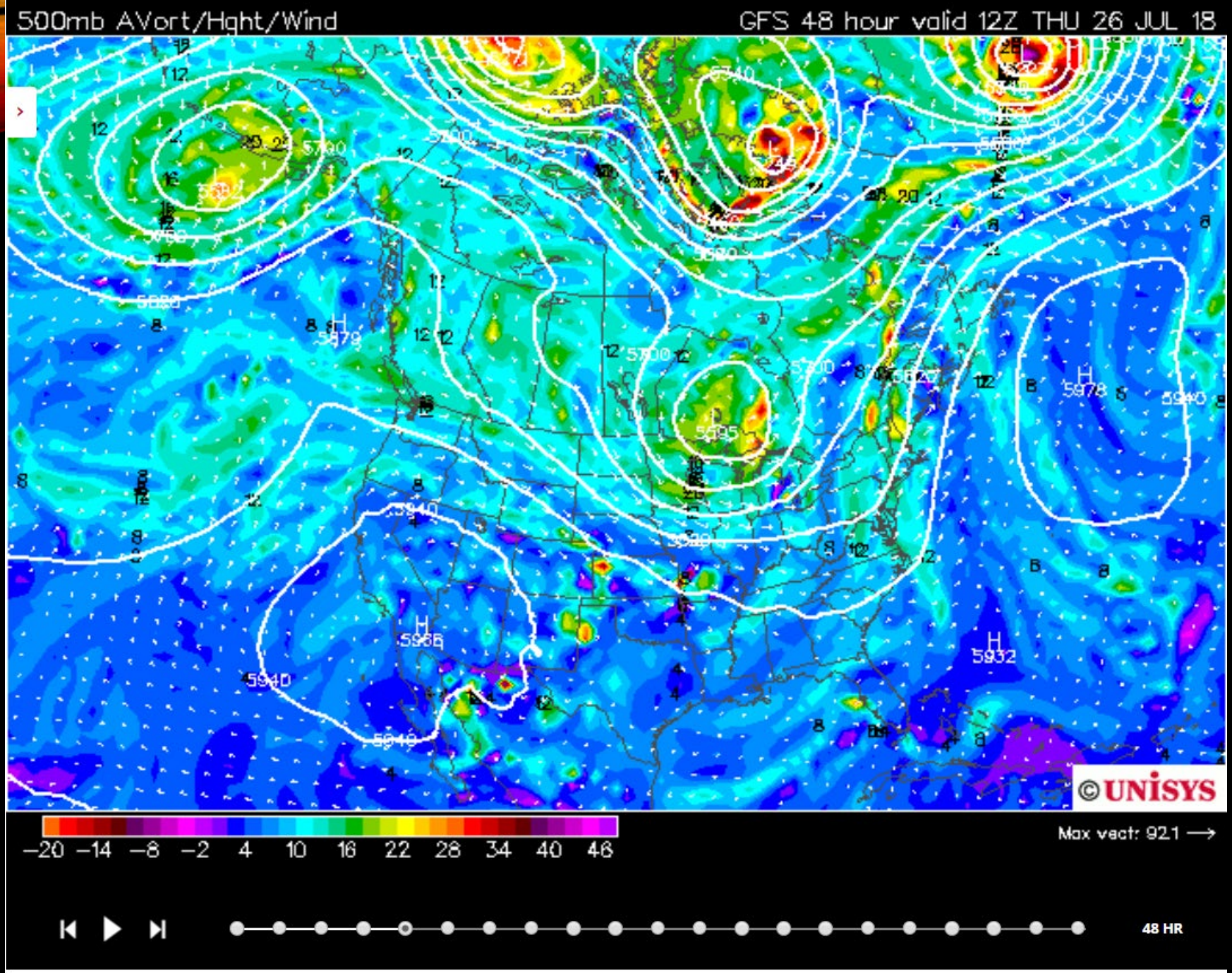




Pinpoint opening to EU on 7/23/18



No Es: dead band all day in SoCal



HOW TO SUCCEED ON 6 M

- Get a good receiver, preferably one with a panadapter, and get a mast-mounted preamp
- Invest in an amplifier – you can work just about anywhere with 50 W, but you will be competing with a lot of powerful stations during openings and may miss that once-in-a-lifetime QSO
  - This is especially true for openings to Japan and Europe – their noise level is very high and I've had difficulty being heard at times, even using 1 kW into a 7-element yagi at 62'
- Get a good directional antenna dedicated to the band
  - SteppIRs are not "good directional antennas" on 6 M (I speak from personal experience, and that of many others using them)
  - 4 or 5 elements is plenty, and will give you enough beamwidth to hear stations you're not pointing toward
  - 7 or more elements gives you "laser focus" if you have local QRM, but can be frustrating if openings are moving
- Watch the vorticity and weather predictions – if there's high pressure (dry, sunny days) over the Southwest, we're likely not going to have much Es
- Use spotting networks and chat groups to know who's on, who's hearing you, etc.
- Learn to operate the FT8 mode – it's becoming the predominant mode on 6 M
  - CW and SSB are still used, but the S/N can't compare to FT8
    - Signals can be decoded down to about -24 dB, while the best ear can only detect -15 dB on CW
- If you get bored and/or there's no Es, use MSK144 on 50.260 MHz to work stations within about 1000 miles pretty much any morning of the year

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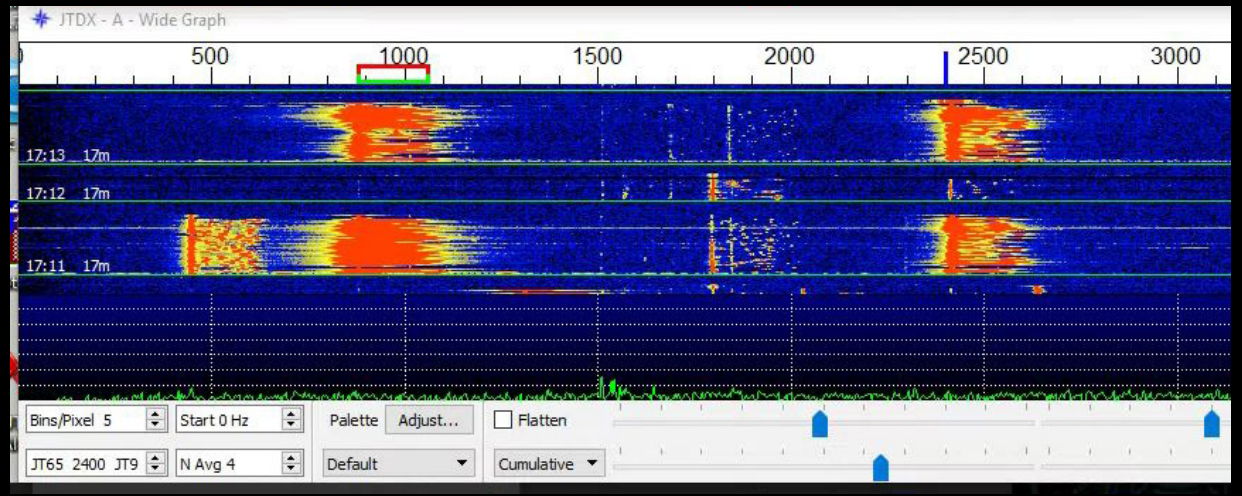
  - This is especially true for openings to Japan and Europe ve had difficulty at times, even using 1 kW into a 7-ele
- Get a good directional antenna dedicated to
  - SteppIRs are not "good direction personal experience, and that of many others using them
  - 4 or 5 elements is pl nwidth to hear stations you're not pointing towa
  - 7 or m as if you have local QRM, but can be frustrating if

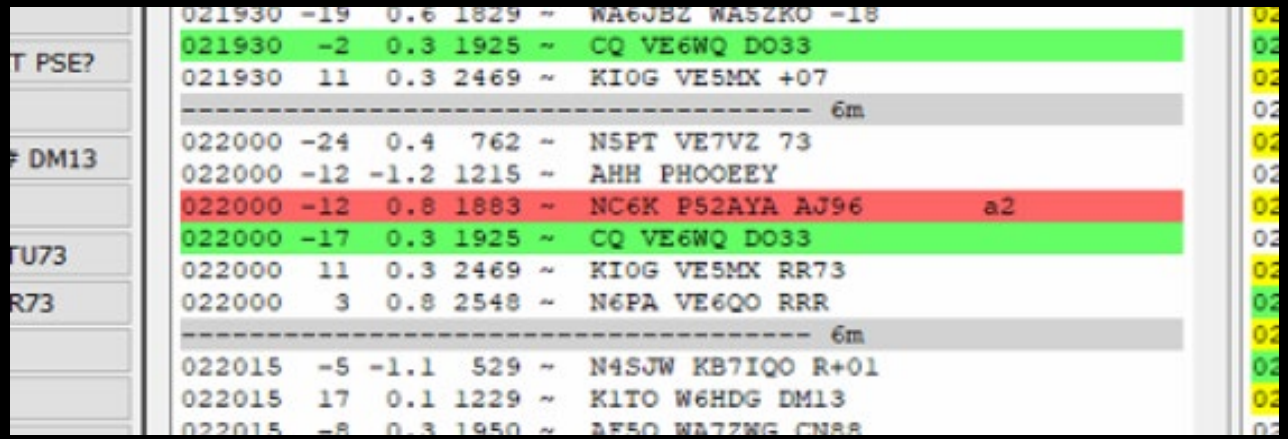
Move to the East Coast!

- hat groups to know who's on, who's hearing you, etc.
- he FT8 mode – it's becoming the preeminent mode on 6 M
  - nd SSB are still used, but the S/N can't compare to FT8
    - Signals can be decoded down to about -24 dB, while the best ear can only detect -15 dB on CW and less on SSB
- If you get bored and/or there's no Es, use MSK144 on 50.260 MHz to work stations within about 1000 miles pretty much any morning of the year

WARTS AND ALL

You will get frustrated at times





WARTS AND ALL

6/28/2018	02:33:00	JI4JKO	Japan	FT8	-24	-15	6m	Akito...		PM86	5673	6/27/2018	
6/28/2018	02:30:00	JH1RFR	Japan	FT8	-10	-10	6m	Atsuo...	TO...	PM96wr	5531	6/27/2018	7/7/2018
6/28/2018	02:28:00	JA5GYU	Japan	FT8	-15	-04	6m	Kon		PM95	5621	6/27/2018	
6/28/2018	02:25:00	JR1IZM	Japan	FT8	-04	-14	6m	Kiyos...	To...	QM06aq	5526	6/27/2018	
6/28/2018	02:25:00	JA4BXL	Japan	FT8	-14	-17	6m	Koh K...		PM64	5936	6/27/2018	7/7/2018
6/28/2018	02:23:28	JA9SJI	Japan	FT8	-13	-6	6m	MITSU...		PM86pl	5661	6/27/2018	
6/28/2018	02:21:00	JH4IUO	Japan	FT8	-02	-08	6m	Yoshi...		PM64fj	5965	6/27/2018	6/28/2018
6/28/2018	02:15:00	VE7KPB	Canada	FT8	-16	-16	6m	Kenneth		DN29	1145	6/27/2018	
6/28/2018	02:10:00	JA4FSH	Japan	FT8	-12	-20	6m	Toru ...		PM64uo	5899	6/27/2018	6/28/2018
6/28/2018	02:09:00	JA5BDZ	Japan	FT8	-19	-13	6m	Susumu *		PM64vg	5910	6/27/2018	7/1/2018
6/28/2018	02:07:00	JA4CUC	Japan	FT8	-15	-12	6m			PM65	5894	6/27/2018	
6/28/2018	02:05:00	JH4IFF	Japan	FT8	-12	-14	6m	Mitsu...		PM74ar	5879	6/27/2018	
6/28/2018	02:04:00	JH0INP	Japan	FT8	-14	-09	6m	Hiroshi		PM96cw	5600	6/27/2018	6/28/2018
6/28/2018	02:03:00	JA0DET	Japan	FT8	-10	-11	6m	Shige...	Ni...	PM97jk	5554	6/27/2018	7/9/2018
6/28/2018	02:01:00	JF2UPM	Japan	FT8	-17	-14	6m	KEIIC...		PM84gn	5773	6/27/2018	6/28/2018
6/28/2018	02:00:00	JH5KDY	Japan	FT8	-07	-22	6m			PM74	5845	6/27/2018	
6/28/2018	01:59:00	JA4NUE	Japan	FT8	-05	-07	6m	KEN T...		PM75cl	5840	6/27/2018	
6/28/2018	01:58:00	JR1LZK	Japan	FT8	-10	-23	6m			QM06	5490	6/27/2018	
6/28/2018	01:57:00	JA5MHD	Japan	FT8	-08	-23	6m	(Kats...		PM63rx	5938	6/27/2018	6/28/2018
6/28/2018	01:40:00	JF2MBF	Japan	FT8	-11	-12	6m	Mitsu...	Aichi	PM85mb	5730	6/27/2018	6/28/2018
6/28/2018	01:39:00	JE2PUC	Japan	FT8	-09	-12	6m			PM84	5753	6/27/2018	
6/28/2018	01:35:00	JR2HCB	Japan	FT8	-15	-14	6m	HIYOS...	AICHI	PM85nc	5722	6/27/2018	
6/28/2018	01:30:00	BA4SI	China	FT8	-05	-21	6m	DONGM...	JI...	PM01hd	6628	6/27/2018	6/28/2018
6/28/2018	01:27:00	JA8TR	Japan	FT8	-10	-18	6m	KIKUM...		PM86	7776	6/27/2018	
6/28/2018	01:23:00	JM1IGJ	Japan	FT8	-19	-19	6m	TAKAY...		PM95rl	5600	6/27/2018	6/28/2018
6/28/2018	01:13:00	JO4GGN	Japan	FT8	-06	-18	6m			PM75	5804	6/27/2018	
6/28/2018	01:07:00	JH2GZY	Japan	FT8	-13	-18	6m			PM94	5660	6/27/2018	7/8/2018

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NOW, GET OUT THERE AND MAKE SOME CONTACTS!

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