DX ANALYTICS: HARC DATABASE FIRST LOOK

HamSCI Workshop, February 23- 24, 2018

New Jersey Institute of Technology

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HamSCI

THE UNIVERSITY OF ALABAMA ENGINEERING

CAPS | CENTER for ADVANCED PUBLIC SAFETY

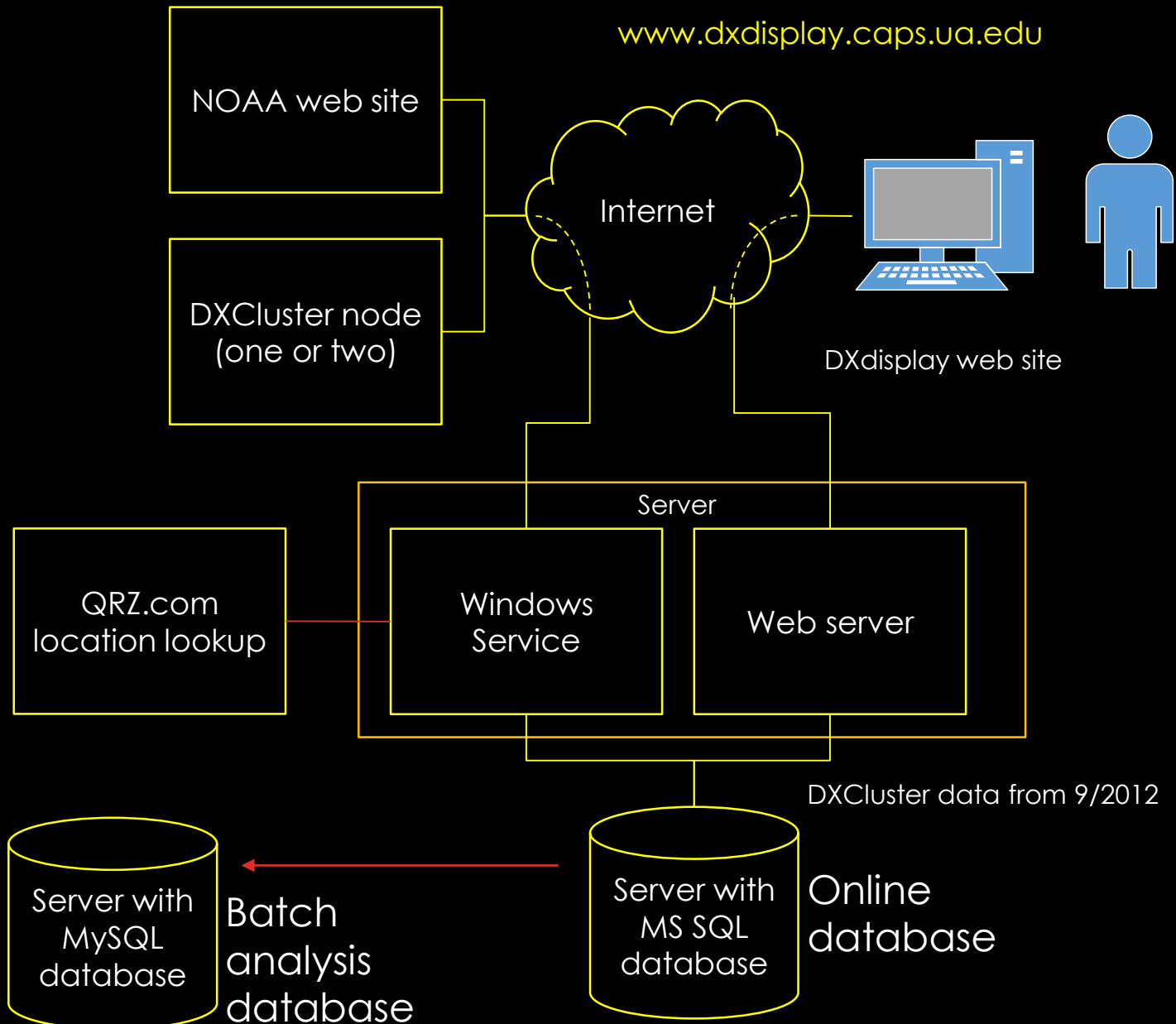
H.A.R.C.

HamSCI Amateur Radio Communications Database

- Uses MariaDB (open source version of MySQL)
- Current version at UA - keeps all spots in a single wide table
  - Both calls, lat/longs, frequency, sun elevations, etc.
    - DXCluster
    - RBN network
    - WSPR
    - So far, 1.22 billion spots
- Have built a variety of summary tables, including 5-minute and 1-hour spot volumes with sun elevation
- Includes 5 to 9 years of data from NASA OMNI (solar and magnetic data) and NOAA GOES (weather) satellites using compatible Epoch data

DATA COLLECTION AND ANALYSIS SYSTEM

Bulk Data Loads:
RBN spots back to 2011
WSPR spots back to 2008
NASA OMNI
NOAA GOES
NOAA WX event data



NASA OMNI

- Includes ~ 46 variables collected from Wind, IMP8, Geotail + other satellites
- Wind sat is at L1 libration (Lagrangian) point between earth & sun
- Mission is data on Magnetic Field, Plasma, Energetic Particles relevant to heliospheric (sun) studies

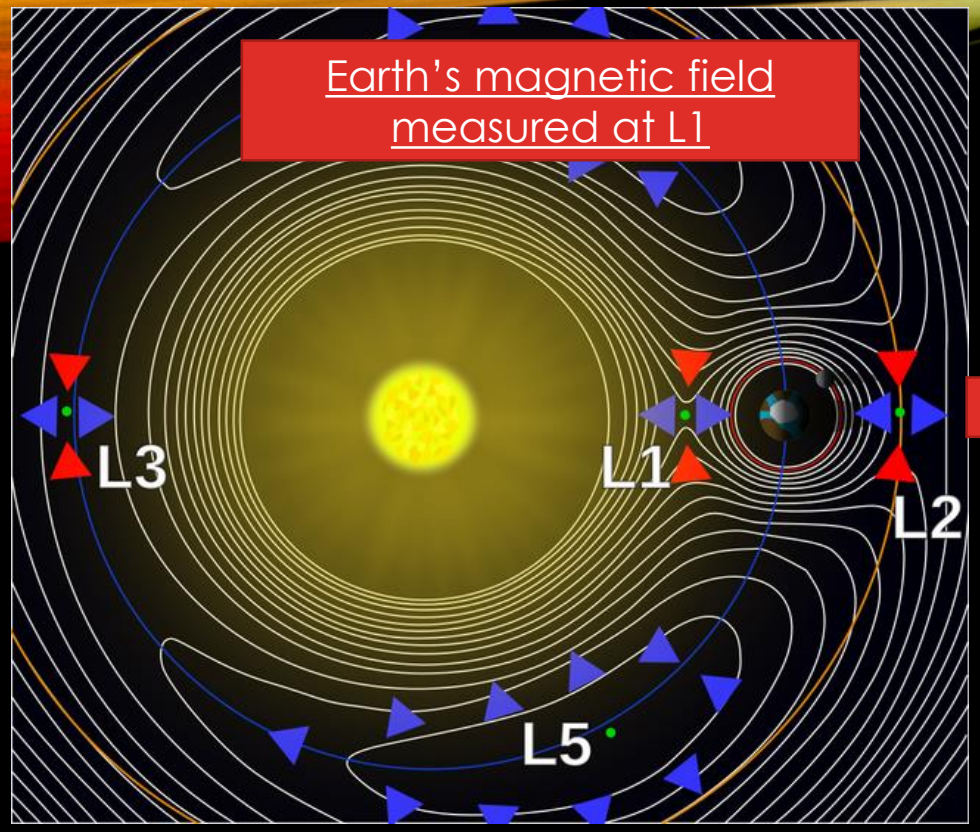
- First pass analysis was a correlation study between NASA OMNI data, and the volumes of spots, by band, across the 3 spots tables (cluster, RBN, WSPR)
  - 5-min., 1-hour, and 1-hour delayed quantities

ABOUT CORRELATION

- A correlation simply means that two (independent) variables tend to move together, or in opposite directions (negative correlation)
- Correlation does not, by itself, prove a cause-and-effect relationship

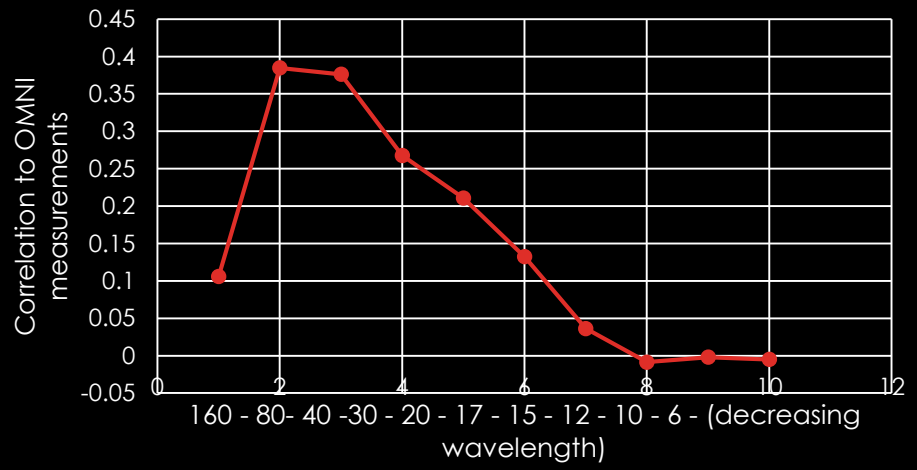
Value of r	Strength of relationship
-1.0 to -0.5 or 1.0 to 0.5	Strong
-0.5 to -0.3 or 0.3 to 0.5	Moderate
-0.3 to -0.1 or 0.1 to 0.3	Weak
-0.1 to 0.1	None or very weak
From explorable.com web site	

CORRELATIONS FOUND



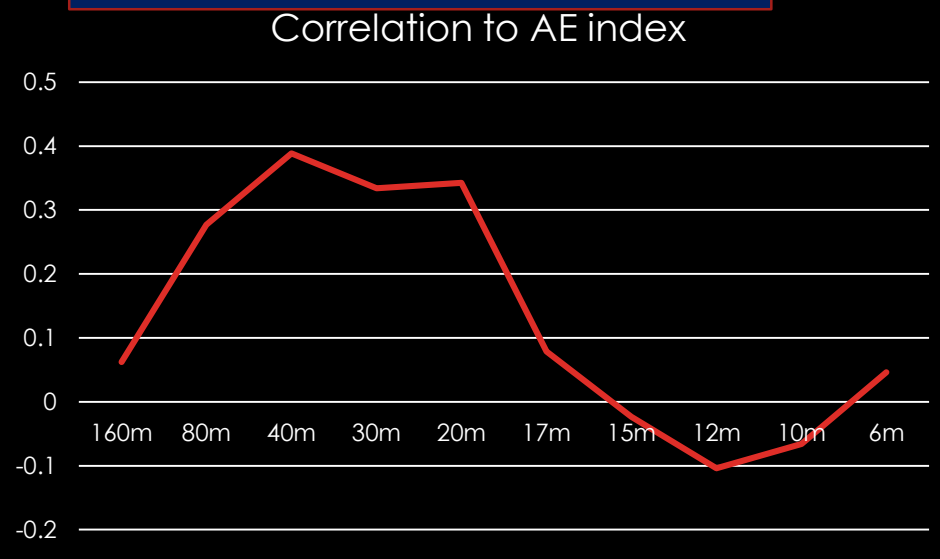
OMNI parameter	Data Source	Band	R (correlation)
|B| (magnetic field at L1)	DX Cluster spot counts by hour	80 M	0.38
AL index and AU index	DX Cluster and WSPR counts by hour	40 M	0.39
AL index and AU index	DX Cluster and WSPR counts by hour	20 M	0.42
Solar Lyman Alpha	DX Cluster and RBN counts by hour	12 M	0.32
PC-N index	WSPR counts by hour and by 5 minute intervals	30 M	0.64

|B| and F correlations to Qvols



CORRELATIONS FOUND

AL index and AU index: Westward and Eastward electrojet currents in northern auroral ionosphere (~110 km)
[AE = AU – AL]



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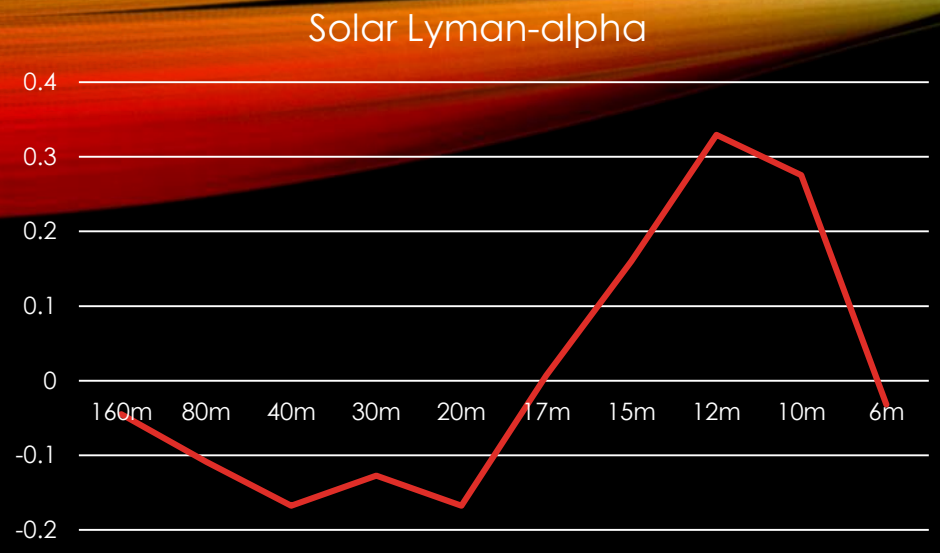

Solar Lyman Alpha
This is a measure of a particular wavelength (121.6 nm) of solar radiation that is known to ionize the D region ionosphere and cause HF absorption.

CORRELATIONS FOUND

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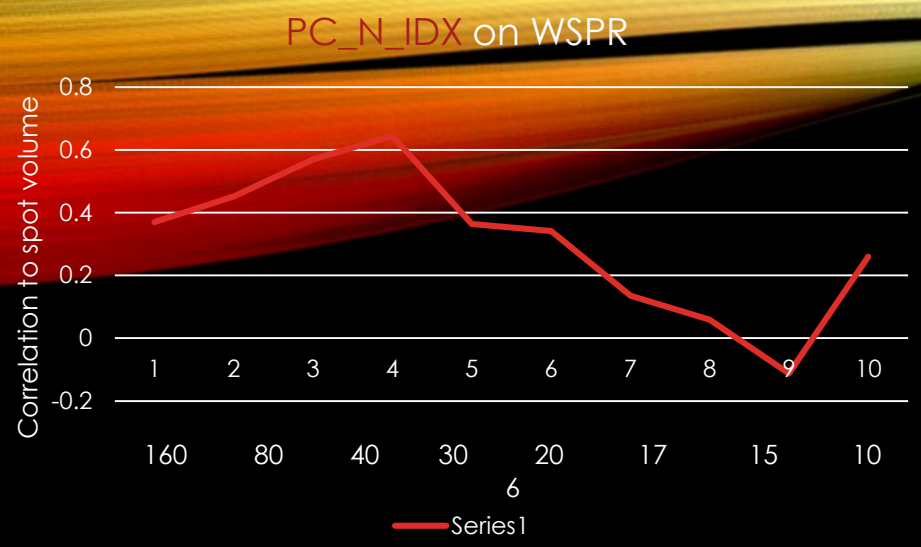

CORRELATIONS FOUND

PC-N index
Polar Cap Index – a measure of polar cap magnetic activity caused by solar wind – used to estimate energy transferred from solar wind into earth's magnetosphere

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However: when you plot the data, you see:
Relationships are non-linear
Large amount of randomness
(numerous other variables at work)
Need to consider a multivariate analysis

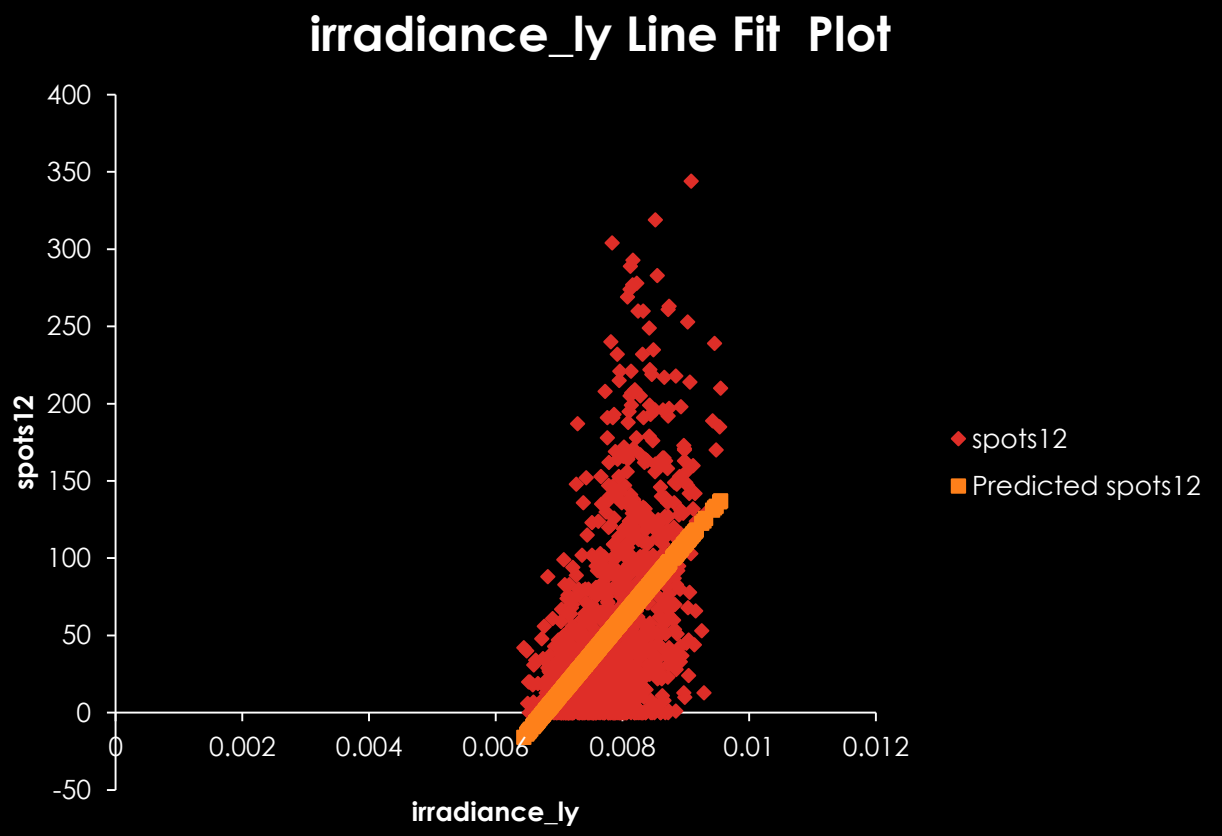
NOAA GOES-15

- Geosynchronous satellite (at 26,199mi/42,164 km altitude)
- Over North America
- Collects a range of near-earth solar and terrestrial data

EUV IRRADIANCE FROM GOES-15 SATELLITE

	irradiance	irradiance_ly
spots160	0.04336529	0.045295644
spots80	0.152410784	0.211715153
spots40	0.028886376	0.106805053
spots30	0.20345095	0.280572524
spots20	-0.067130119	-0.03042363
spots15	0.180658017	0.191861007
spots12	0.466457232	0.515865642
spots10	0.314152041	0.354519639
spots6	-0.113588965	-0.14948124

We see a moderate to strong correlation between EUV irradiance and 12-meter spots, but…



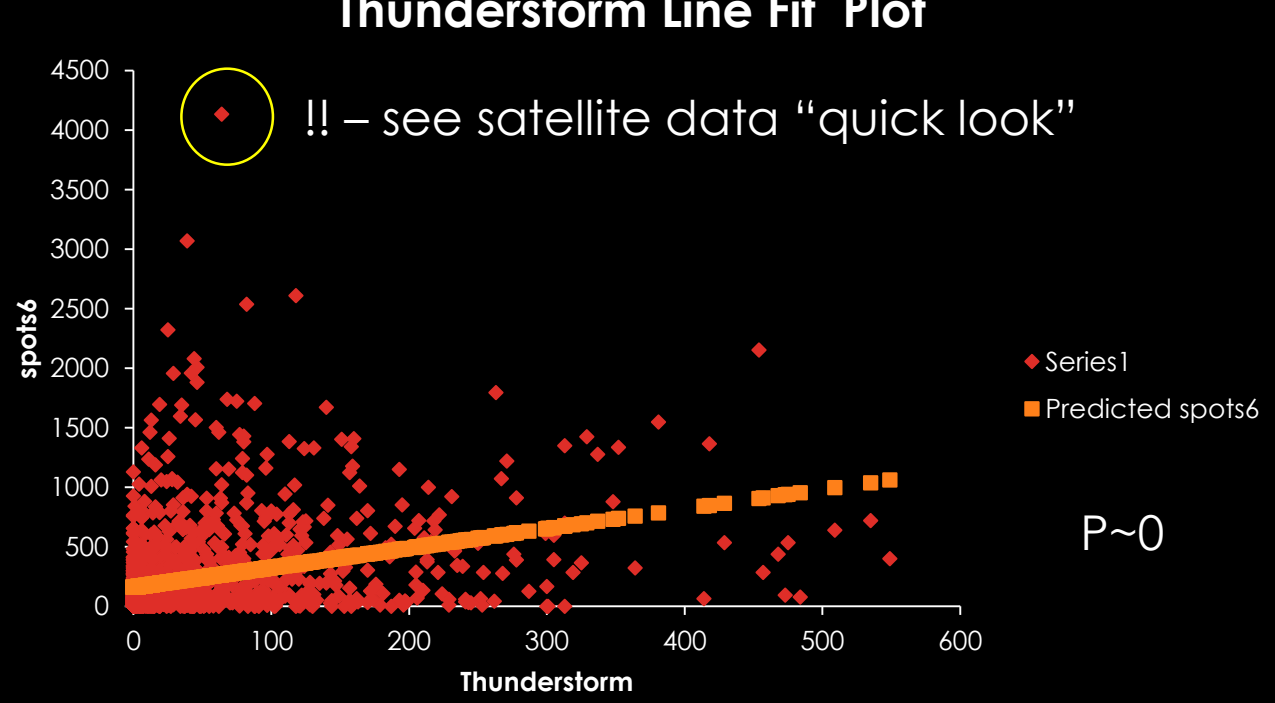
As with others, linear model is a poor fit.

THUNDERSTORMS AND 6 METERS

- Is Es related to thunderstorm activity?
- Correlated NOAA weather event reports ("Thunderstorm Wind") to 6 meter spots for each day 2013 thru 2017
- A weak to moderate correlation is found

CORRELATION	
spots6	0.341889

This, by itself, tells us very little about whether thunderstorms enhance 6 meters – remember that 6 meters is always more active in summer, and so are thunderstorms



WHAT ANALYSIS CAN WE DO RELATED TO SPORADIC E?

- Sporadic-E propagation is theorized to have many contributing factors…

Micrometeoroids

E-layer ionization

Lorentz forces

Electron fountain

Plasma fountain

Wind shear

Atmospheric tides

Vortices

Equatorial electrojet

Planetary waves

Iron ion fountain

Thunderstorm effects

(See articles from Jim Kennedy, KH6MIO/KH6, and others)

- Many of these phenomena cannot be directly measured. Can we see any of the effects in satellite data?

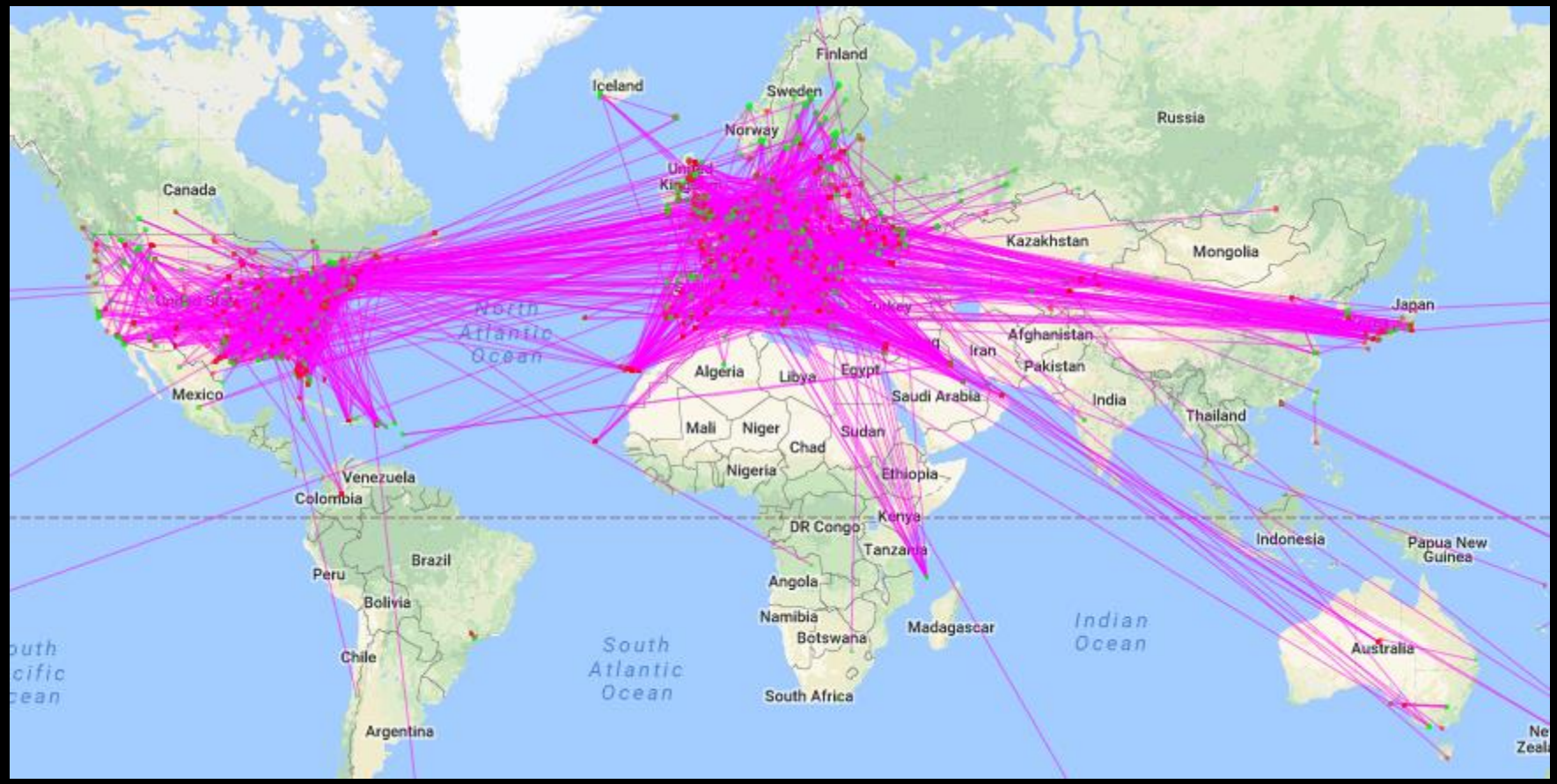
FIRST LOOK

- A full correlation analysis is needed, but the quantity of data is such that this is still just in the preparation stages.
- However – for a first quick look, let's look to see if we notice anything in a data overview in cases where there is a dramatic difference in 6 meter propagation between one time and another…

- Consider June, 2016
  - Joe Dzekevich, K1YOW, writes about this event in Dec. 2017 QST article

June 12, 2016

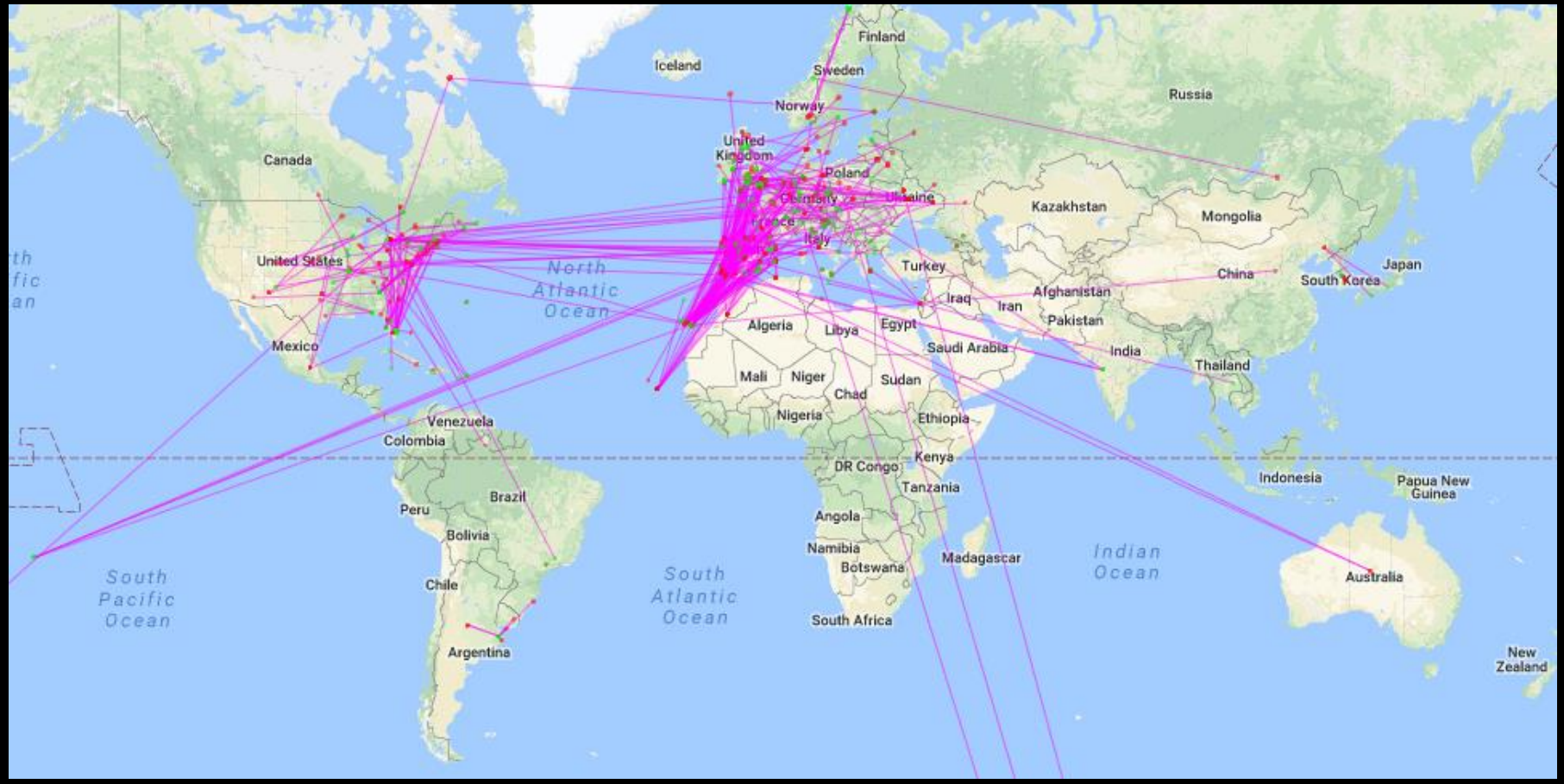
Highest number of spots in any one day in period 2013 thru 2017



Spots reported

7,479 DX cluster
24,268 RBN
1,752 WSPR

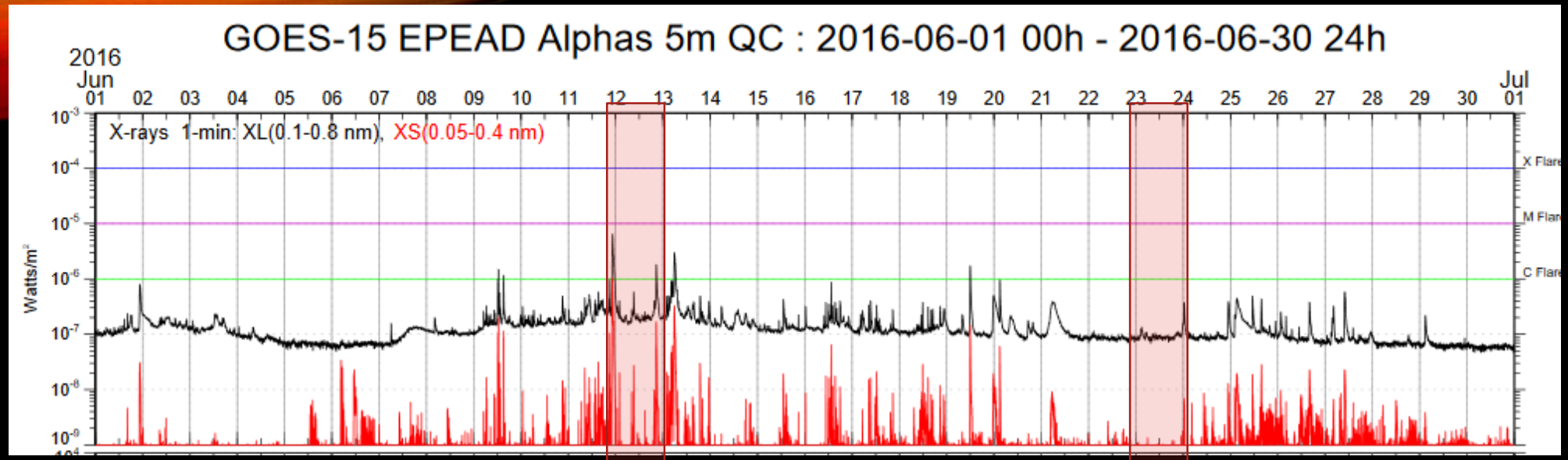
June 23, 2016



Spots reported

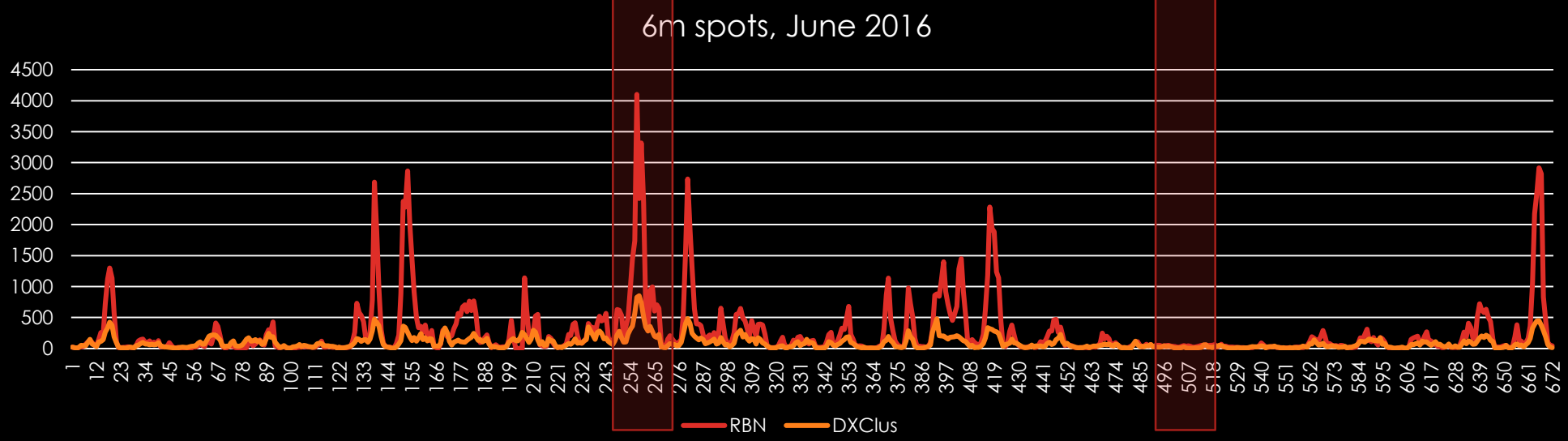
509 DX cluster
909 RBN
1,034 WSPR

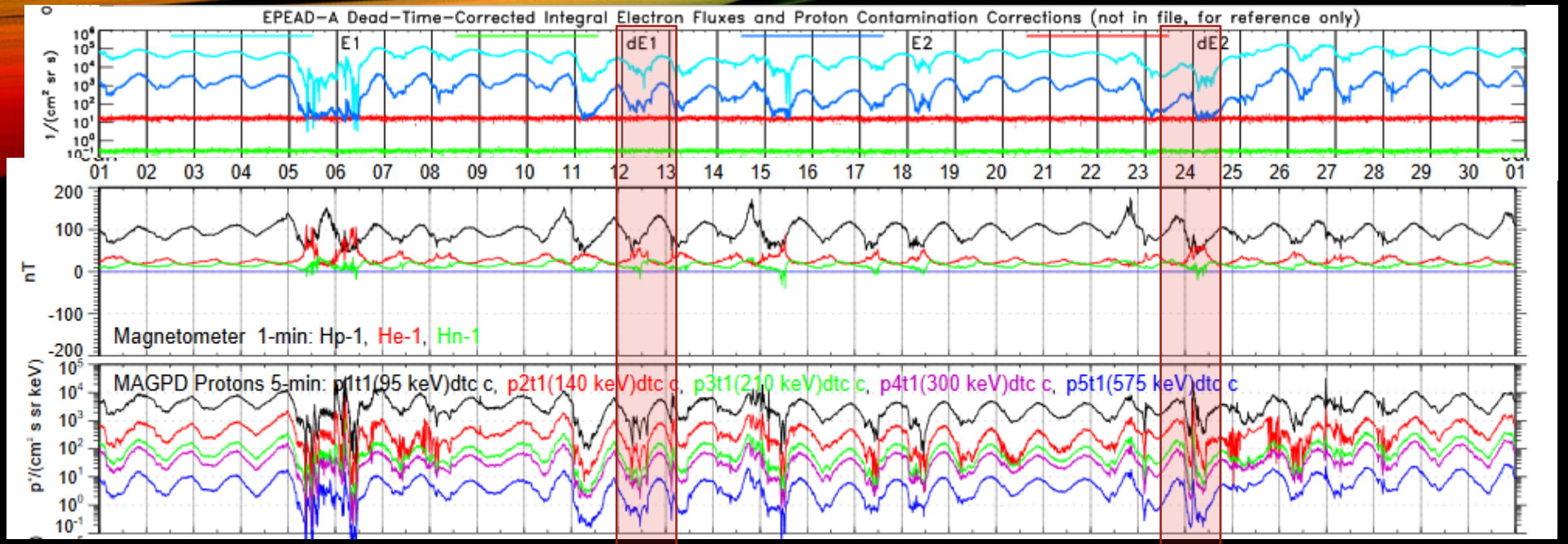
X-RAY FLUX



JUN 12

JUN 23

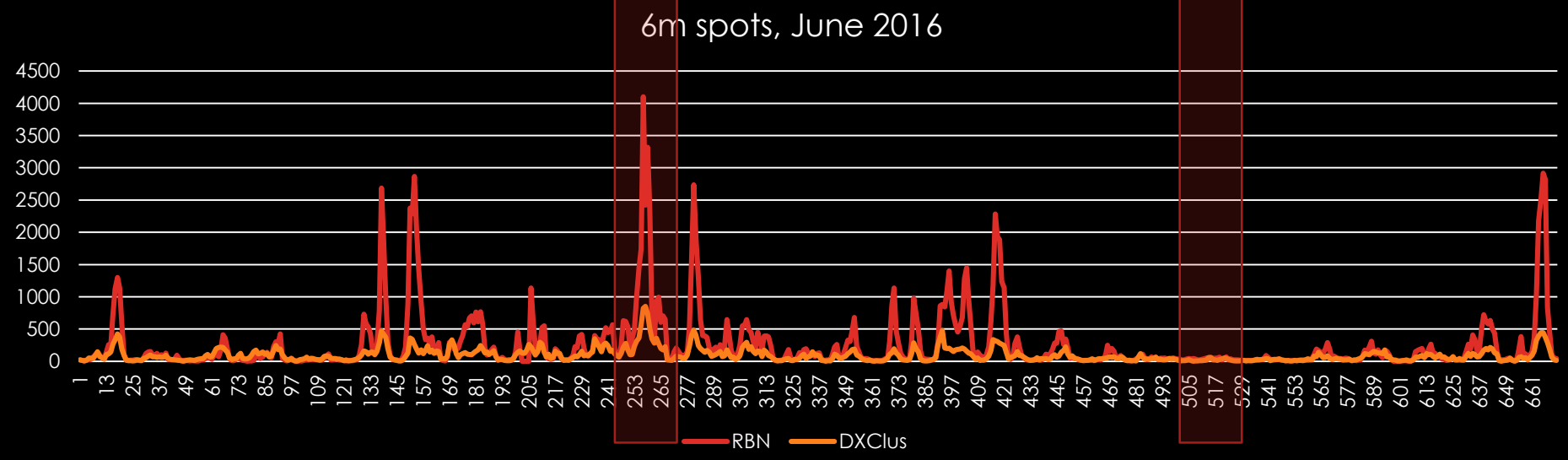




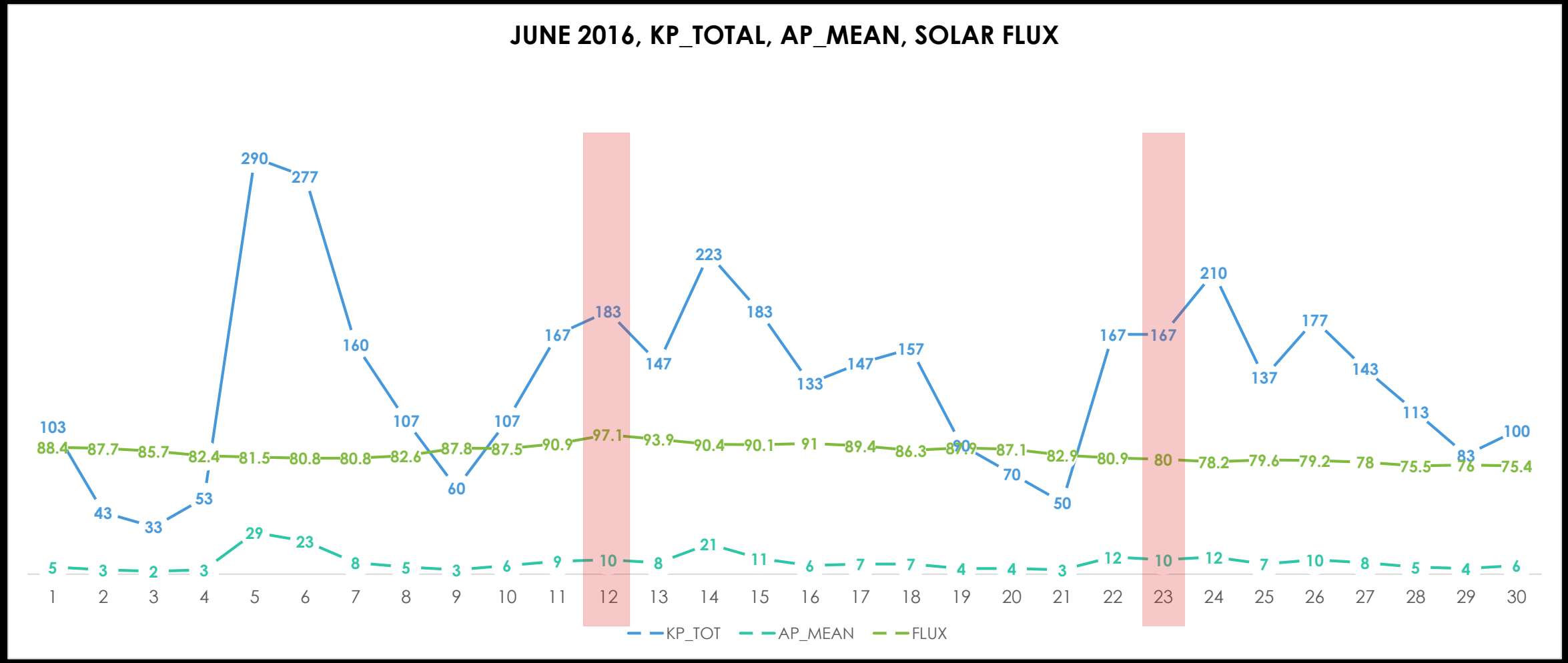
ELECTRON FLUX

EARTH'S MAGNETIC FIELD

PROTON FLUX

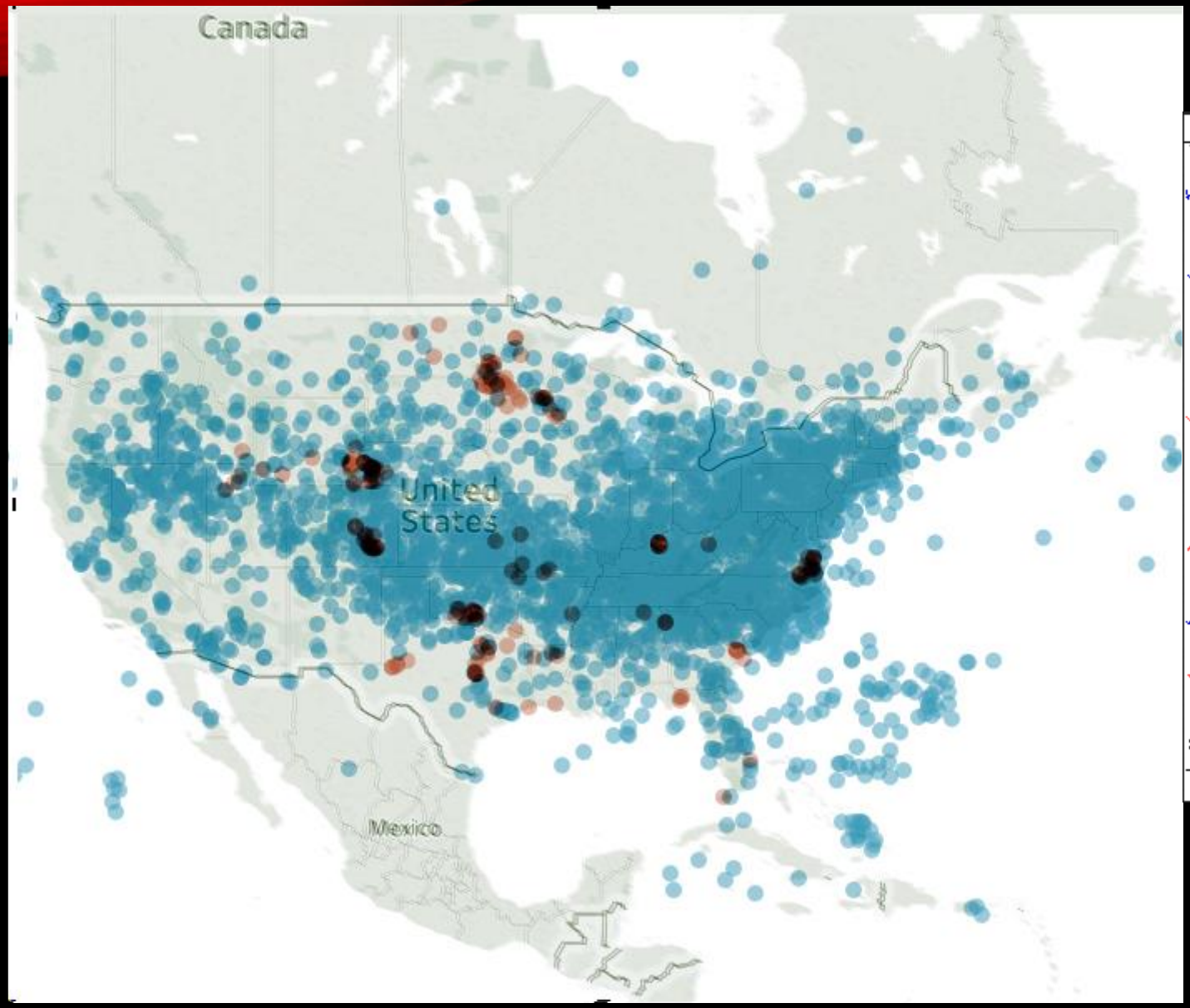


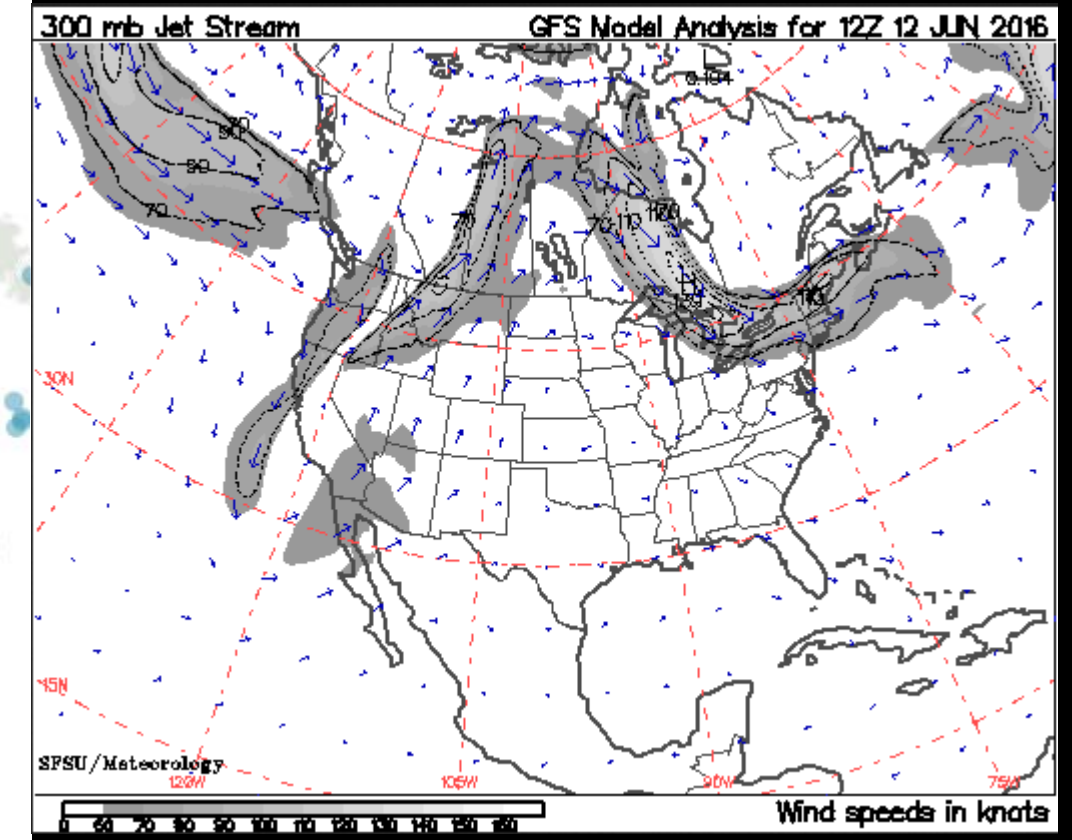
GEOMAGNETIC INDICES



2016-06-12 T-STORMS VS SPOTS VS JET STREAM

Blue = 6m reflection points
Red = thunderstorms

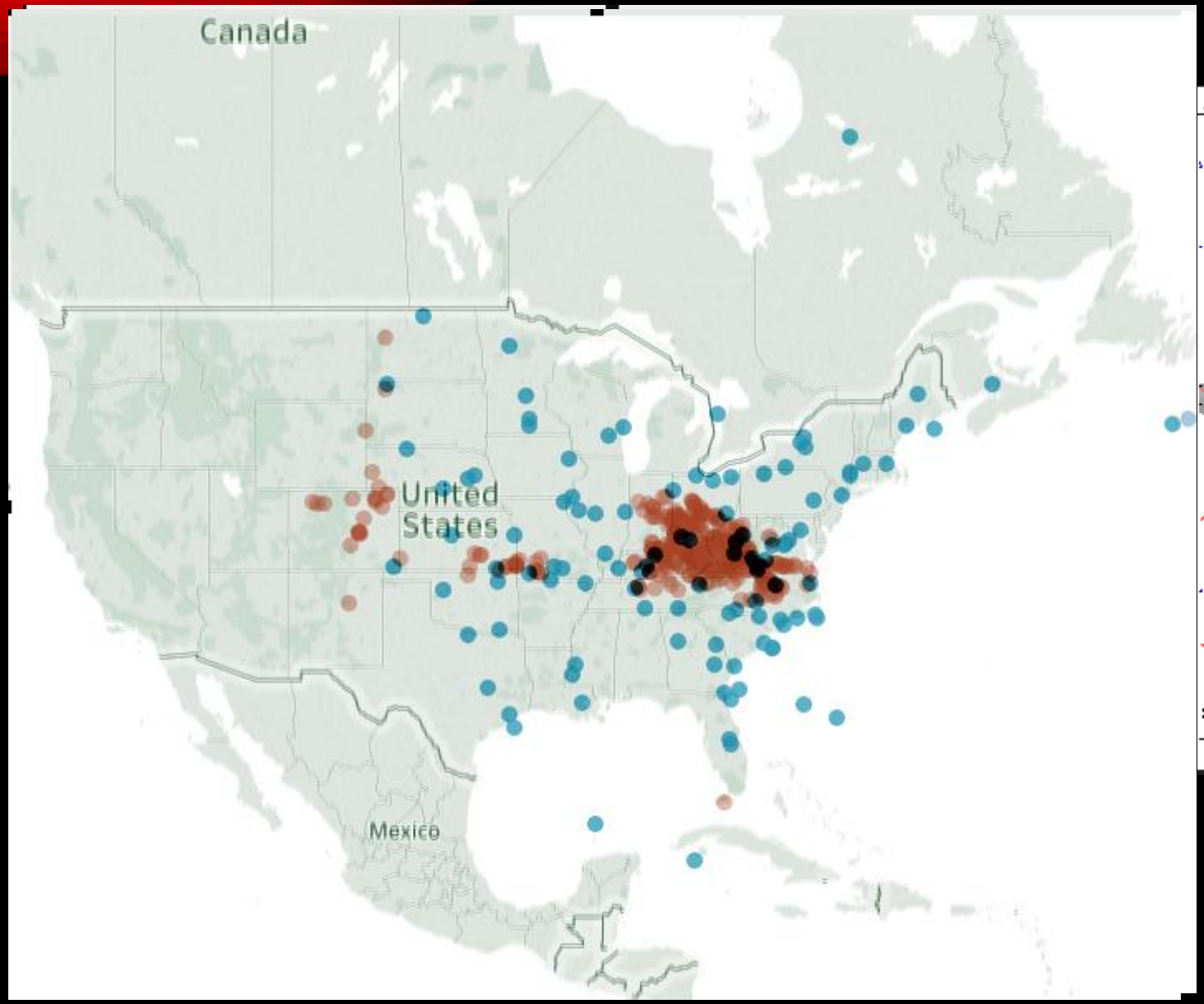


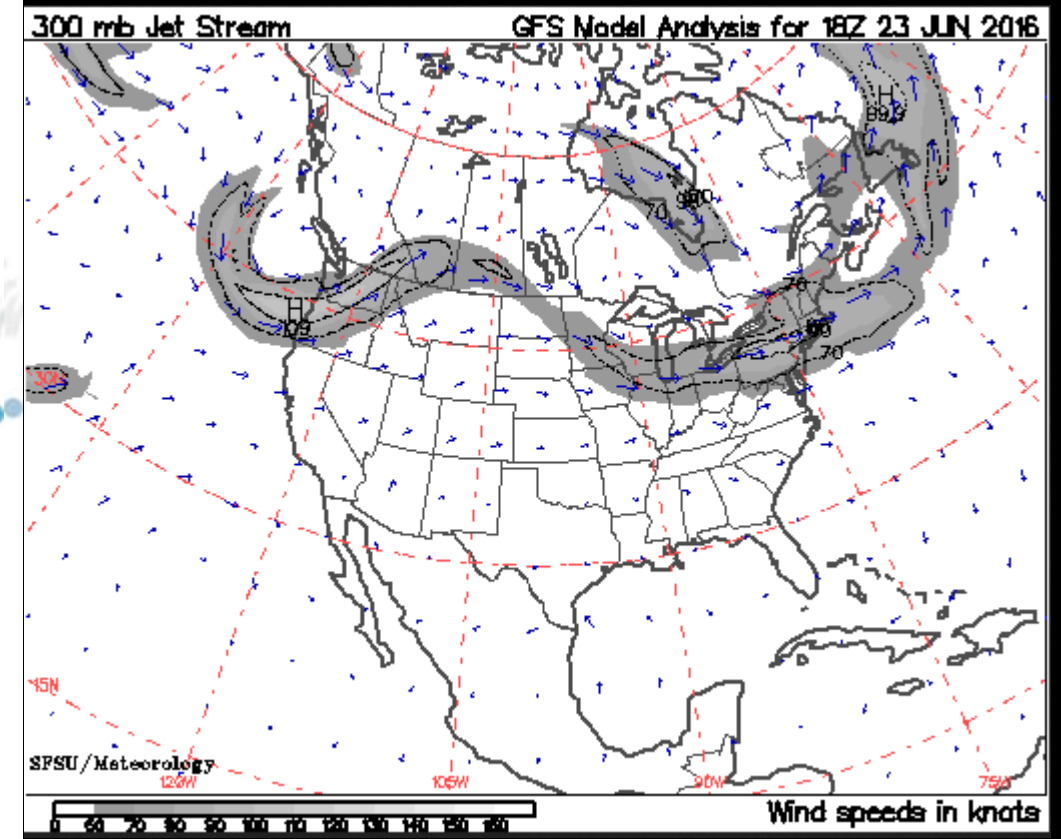


Total spots: 33,499
T-storms: 64

2016-06-23 T-STORMS VS SPOTS VS JET STREAM

Blue = 6m spots
Red = thunderstorms





Total spots: 2,452
T-storms: 287

CONCLUSIONS

- There *may* be weak to moderate relationships as follows:
  - Ultraviolet radiation and 12 meter propagation
  - Solar wind's magnetic field and 80 m propagation
  - Auroral Zone Magnetic Activity and 40m thru 20m propagation
  - X-ray flux, the jet stream and sporadic-E

- Geomagnetic indicator Kp and sporadic-E do not seem to be related
- Relationships (if they exist) appear to be non-linear & stochastic
  - …meaning with a random component and/or involvement of other variables
- Need to do:
  - *Multiple* regression / multivariate analysis with much of the data
  - Include QSO/spot distance and sun elevation
  - Create & study summary datasets which are Epoch-matched to spot counts for GOES-15 and GOES-16 data; compare x-ray & jet stream data to sporadic-E
- All data is available to others for study

ACKNOWLEDGEMENTS

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- Dr. Nathaniel Frissell, W2NAF
- Joshua Katz, KD2JAO
- Felipe Ceglia, PY1NB
- Joe Dzekevich, K1YOW
- SLALIB – Positional Astronomy Library, Starlink Project
  - https://github.com/Starlink/starlink/tree/master/libraries/sla