NJIT New Jersey Institute of Technology

HamSCI

HamSCI: The Ham Radio Science Citizen Investigation

N. A. Frissell, W2NAF[1,2]

J.R. Ackermann[1], J. Dzekevich[1], G.D. Earle[1,3], P.J. Erickson[1,4]
A.J. Gerrard[1,2], R.B. Gerzoff[1], S.W. Gunning[1,2], M. Hirsch[1,5], J.D. Katz[1,2],
S.R. Kaeppler[1,6], R.W. McGwier[1,3], E.S. Miller[1,7], M.L. Moses[1,3],
G. Perry[1,8], S.E Reyer[1], A. Shovkoplyas[1,9], H.W. Silver[1,10], J. Vega[1,2],
and the RBN Team[1]

[1]HamSCI Community, [2]New Jersey Institute of Technology,
[3]Virginia Tech, [4]MIT Haystack, [5]SciVision, Inc., [6]SRI International,
[7]JHU/APL,[8]Univ. Of Calgary, [9]Afreet Software, Inc., [10]ARRL

nathaniel.a.frissell@njit.edu

Outline

I. Introduction to Amateur Radio
II. Data and Methodologies
III. Research Activities
IV. The HamSCI Organization

nathaniel.a.frissell@njit.edu

Amateur/Ham Radio

nathaniel.a.frissell@njit.edu

What is Amateur Radio?

FCC Part 97.3(4)

Amateur service. A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

nathaniel.a.frissell@njit.edu

Amateur/Ham Radio

- Hobby for Radio Enthusiasts
  - Communicators • Builders • Experimenters
- Wide-reaching Demographic
  - All ages & walks of life
  - Over 730,000 US hams; ~3 million World Wide

[http://www.arrl.org/arrl-fact-sheet]

nathaniel.a.frissell@njit.edu

Amateurs? Well…

Station of Frank Donovan, W3LPL (Ethan Miller's Neighbor)

nathaniel.a.frissell@njit.edu

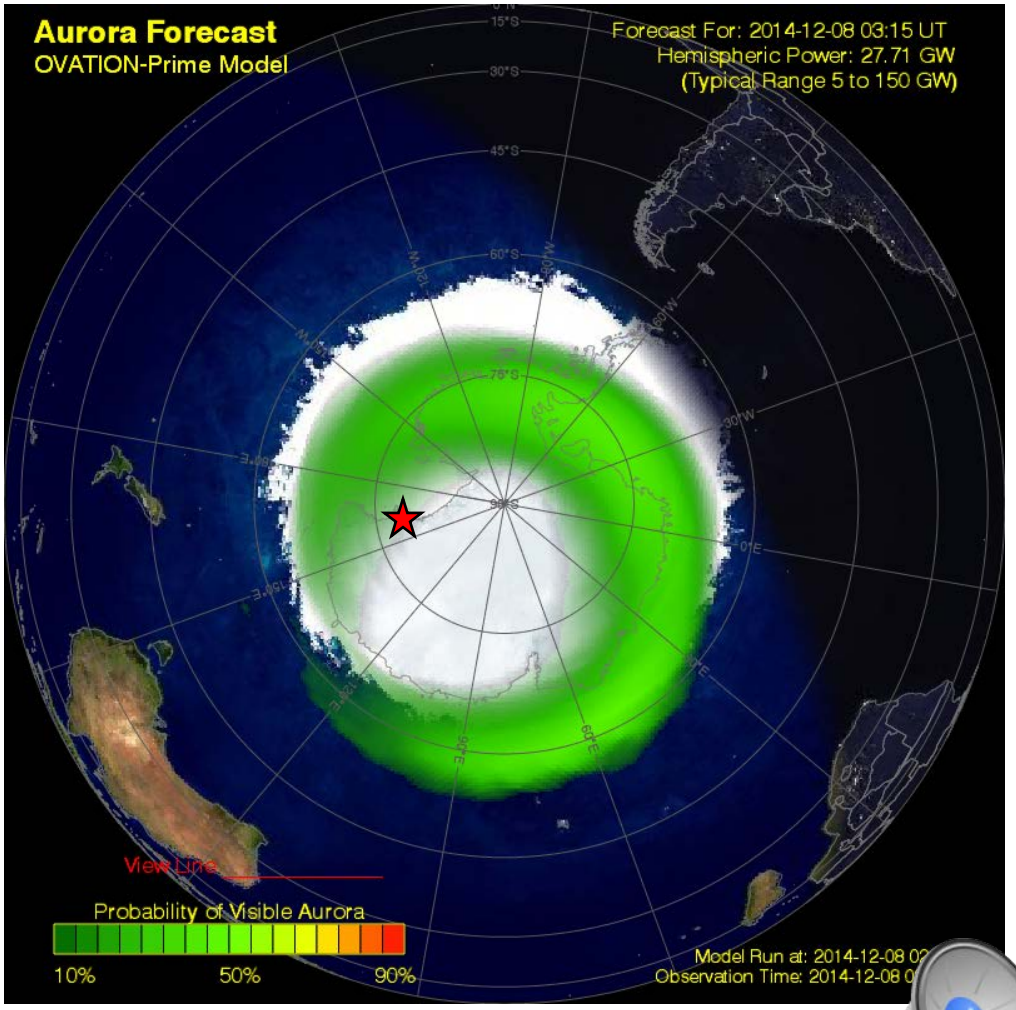
K3LR, Just Another "Amateur"

http://files.qrz.com/gallery/K3LR/356A3356.JPG

And Lars built his antenna with a few friends…

http://www.arrl.org/soapbox/view/7412

Auroral Propagation at McMurdo



20141227 0746 UT Aurora @ KC4USV 14010 kHz

Data & Methodologies

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Amateur Radio and the HF Bands

Frequency	Wavelength
1.8 MHz	160 m
3.5 MHz	80 m
7 MHz	40 m
10 MHz	30 m
14 MHz	20 m
18 MHz	17 m
21 MHz	15 m
24 MHz	12 m
28 MHz	10 m
50 MHz	6 m

K2MFF, The NJIT Ham Radio Station

- Hobbyists routinely use HF-VHF transionospheric links.
- Often ~100 W into dipole antennas.

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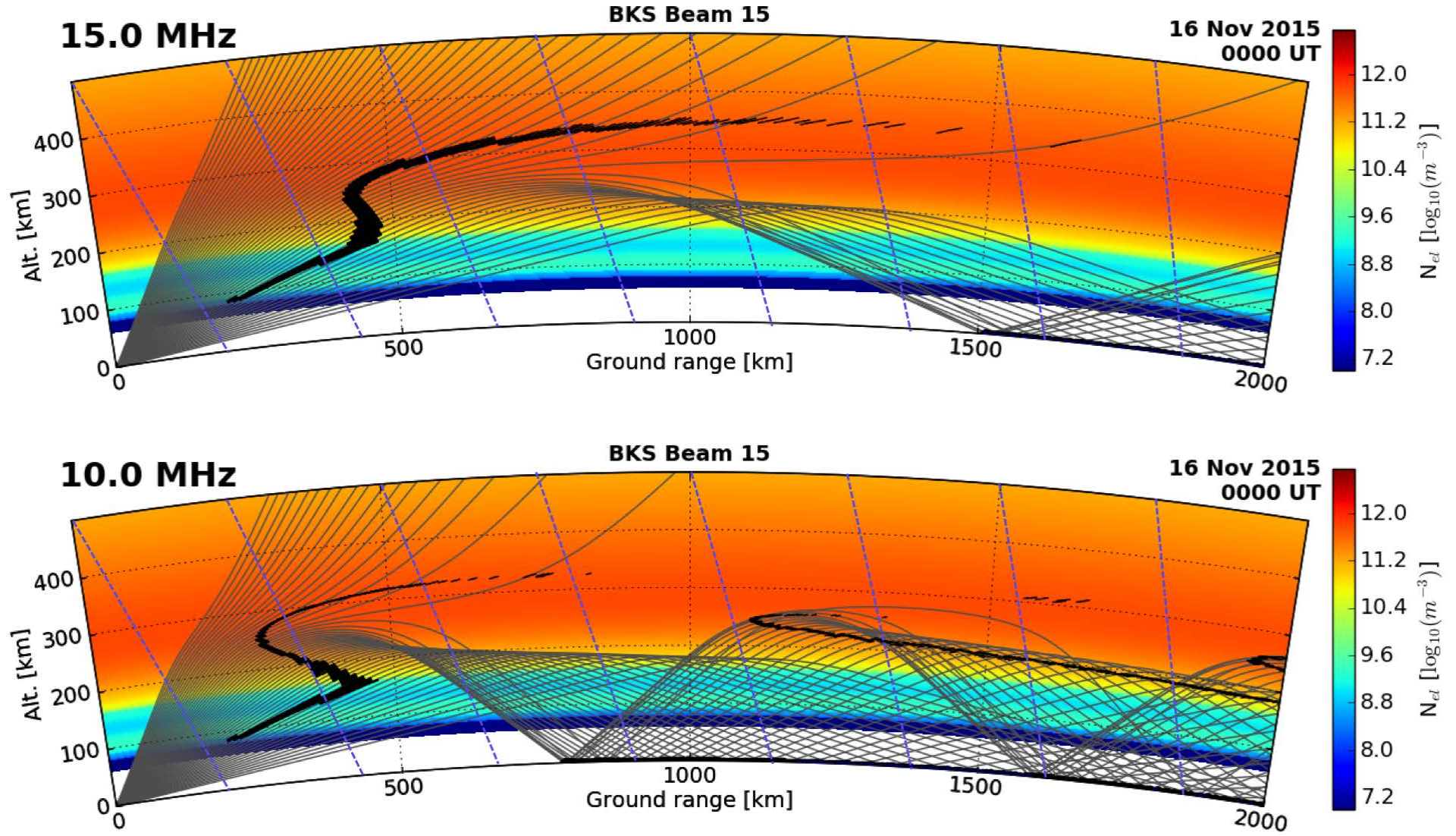
HF Propagation & The Ionosphere



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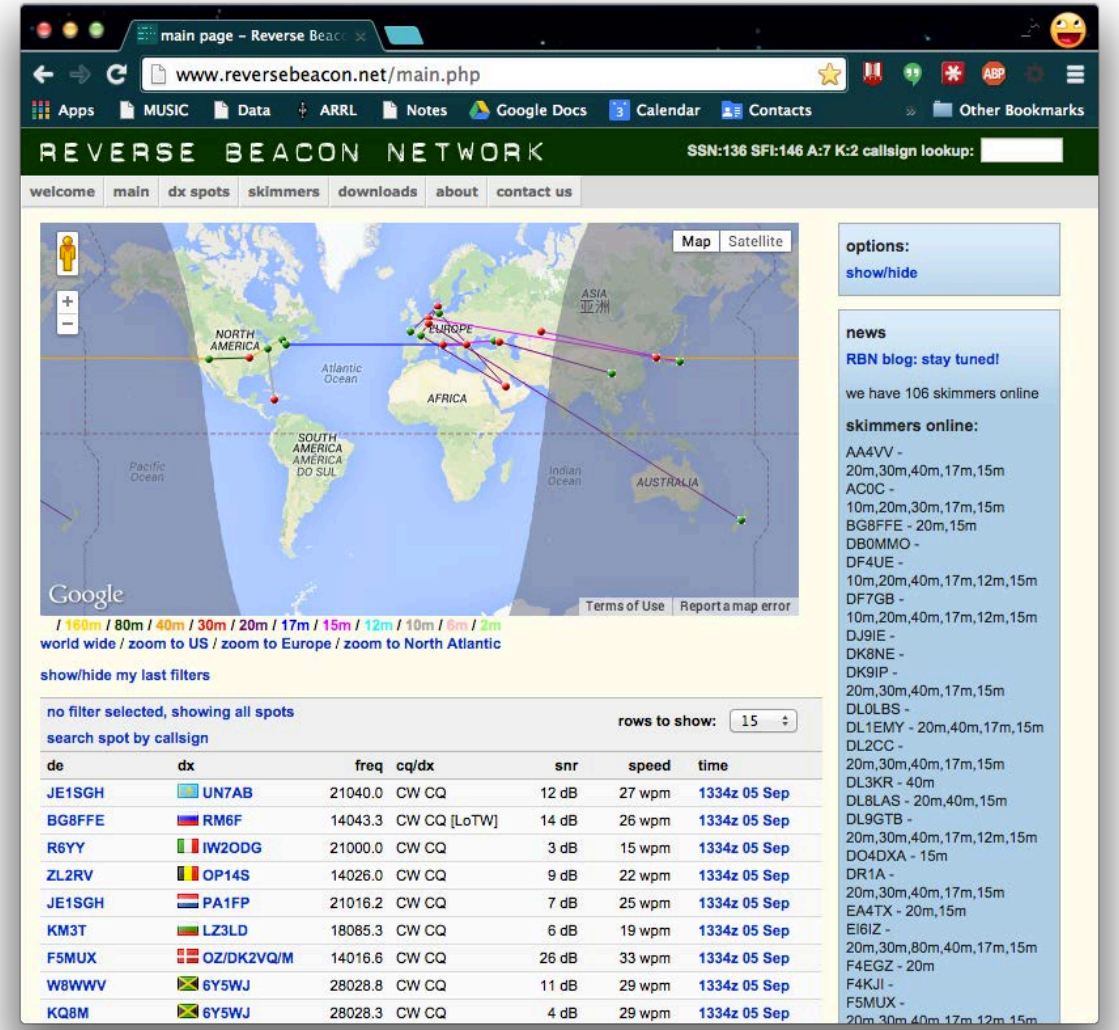
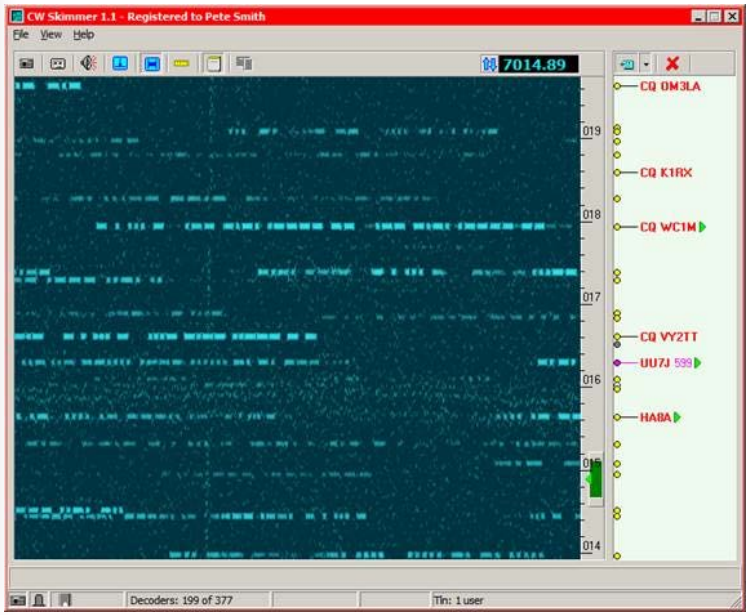
Reverse Beacon Network



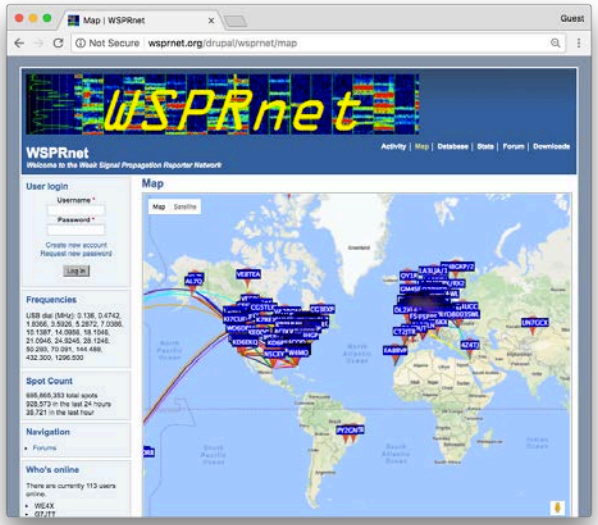
de	dx	freq	cq/dx	snr	speed	time
JE1SGH	UN7AB	21040.0	CW CQ	12 dB	27 wpm	1334z 05 Sep
BG8FFE	RM6F	14043.3	CW CQ [LoTW]	14 dB	26 wpm	1334z 05 Sep
R6YY	IW2ODG	21000.0	CW CQ	3 dB	15 wpm	1334z 05 Sep
ZL2RV	OP14S	14026.0	CW CQ	9 dB	22 wpm	1334z 05 Sep
JE1SGH	PA1FP	21016.2	CW CQ	7 dB	25 wpm	1334z 05 Sep
KM3T	LZ3LD	18085.3	CW CQ	6 dB	19 wpm	1334z 05 Sep
F5MUX	OZ/DK2VQ/M	14016.6	CW CQ	26 dB	33 wpm	1334z 05 Sep
W8WWV	6Y5WJ	28028.8	CW CQ	11 dB	29 wpm	1334z 05 Sep
KQ8M	6Y5WJ	28028.3	CW CQ	4 dB	29 wpm	1334z 05 Sep

- Morse Code & RTTY
- Volunteer Network
- ~130 Nodes
- Data back to 2009

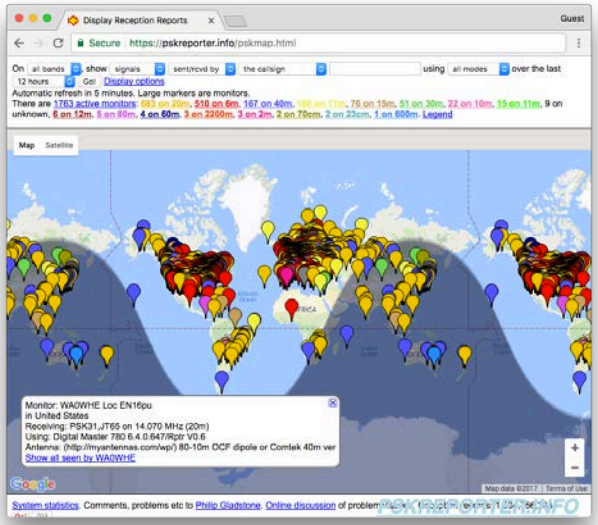


Big Data – Other Ham Networks

RBN
reversebeacon.net



WSPRNet
wsprnet.org



PSKReporter
pskreporter.info

Network	Start Year	# Spots	DB Size
RBN	2009	578,000,000	36 GB
WSPRNet	2008	535,000,000	44 GB
PSKReporter	2013	1,000,000,000	100 GB

There is A LOT of data!

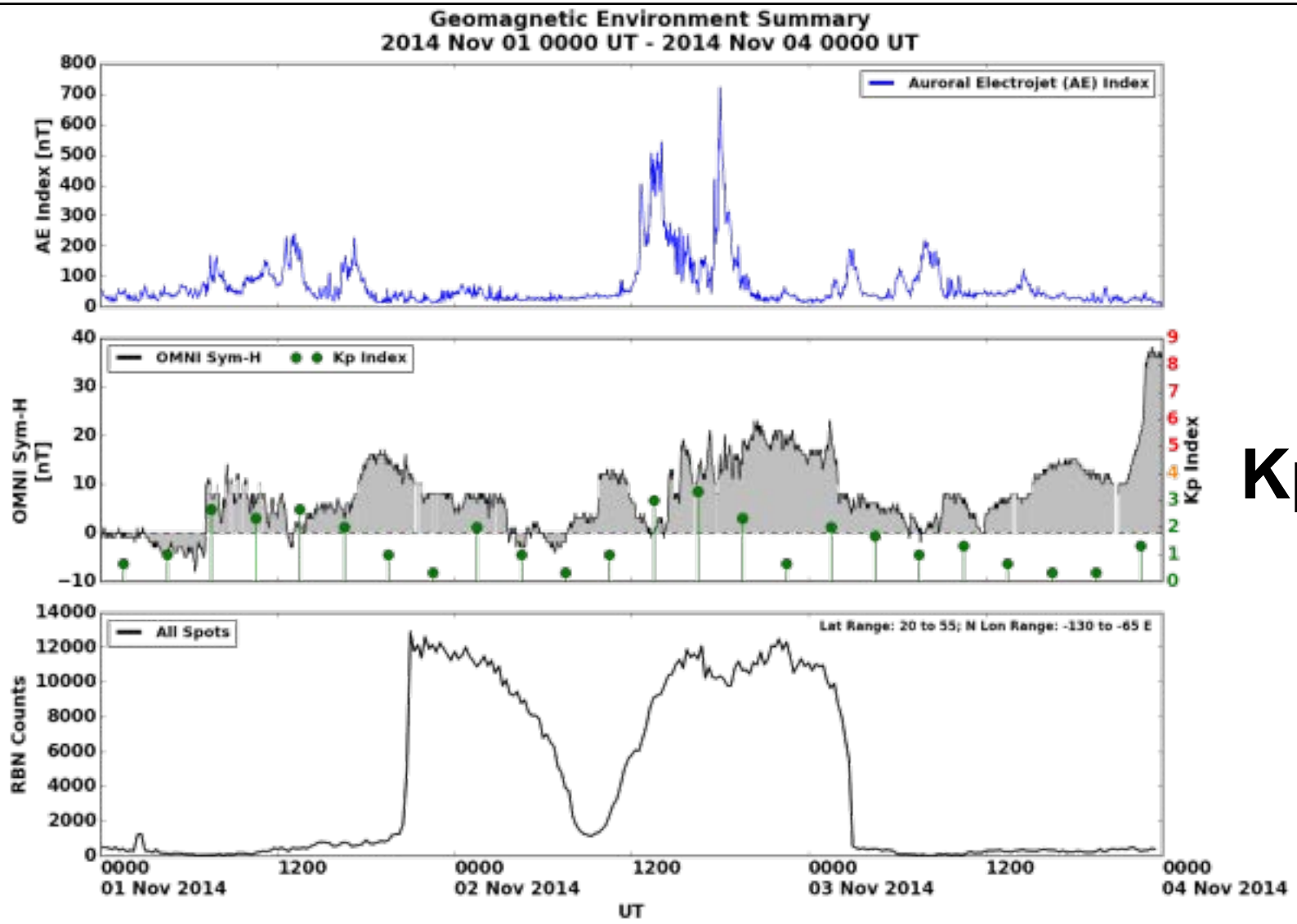
nathaniel.a.frissell@njit.edu

November SS CW 2014

AE

SYM H

RBN



Kp

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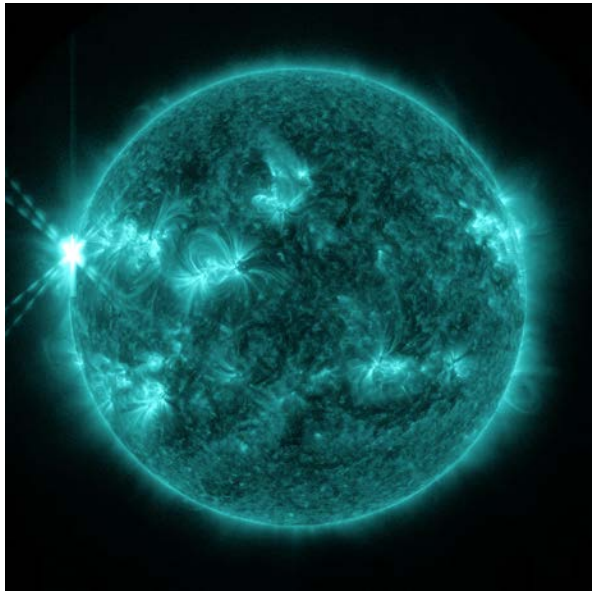
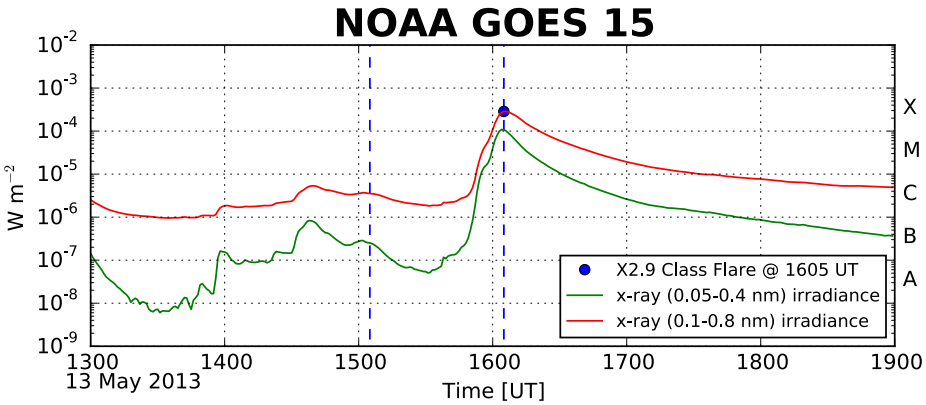
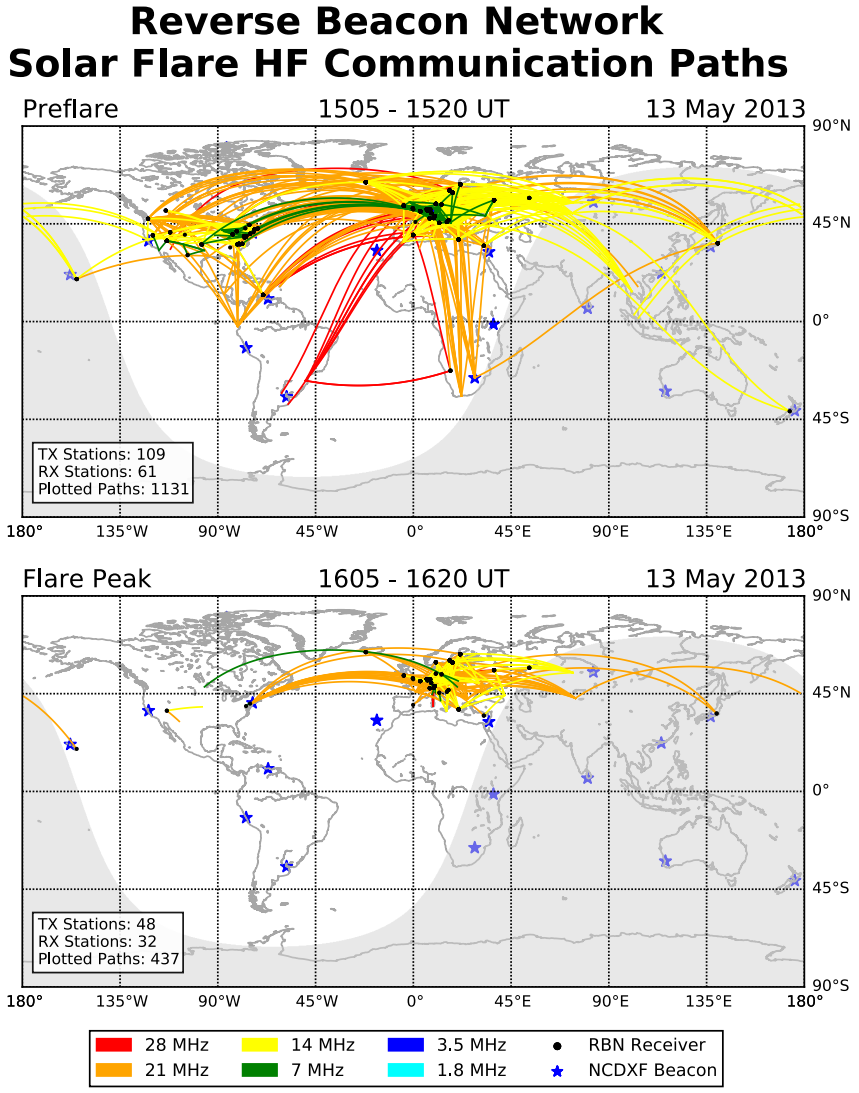
RBN & A Solar Flare



[NASA SDO]



[*Frissell et al.*, 2014, *Space Weather*]



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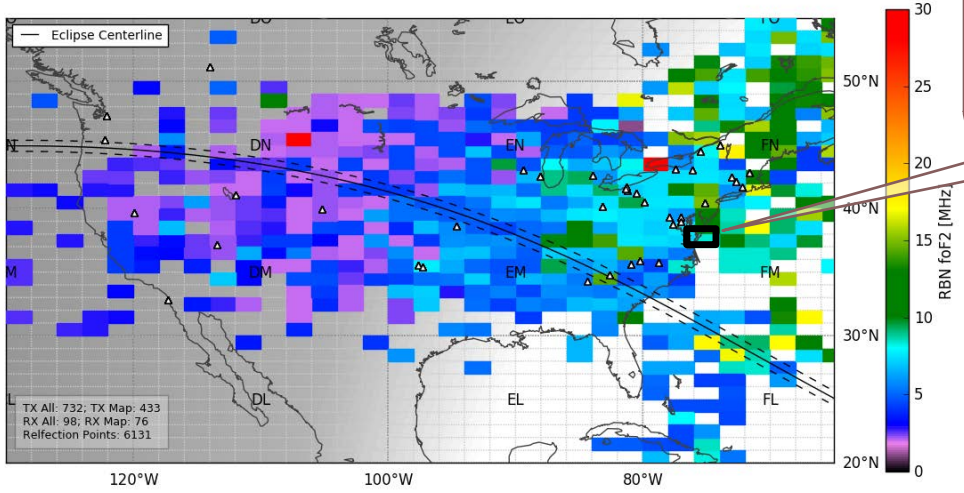
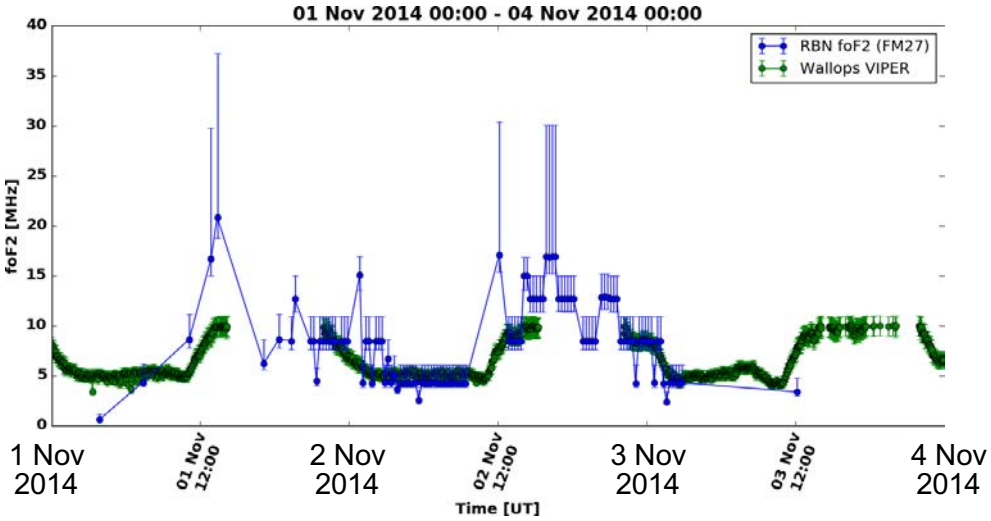
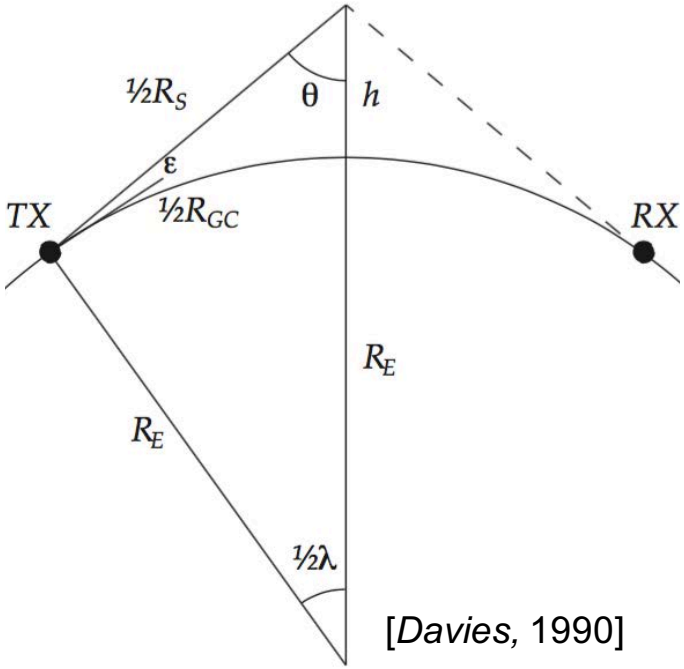
RBN foF2

RBN foF2 1245 – 1259 UT 2 Nov 2014



Wallops Island VIPER Ionosonde
(Grid Square FM27)





[*Davies*, 1990]

$$f_o = f_{MUF_{RBN}} \cos\theta$$

RBN foF2 algorithm adapted from Miller et al. AGU 2015 presentation.

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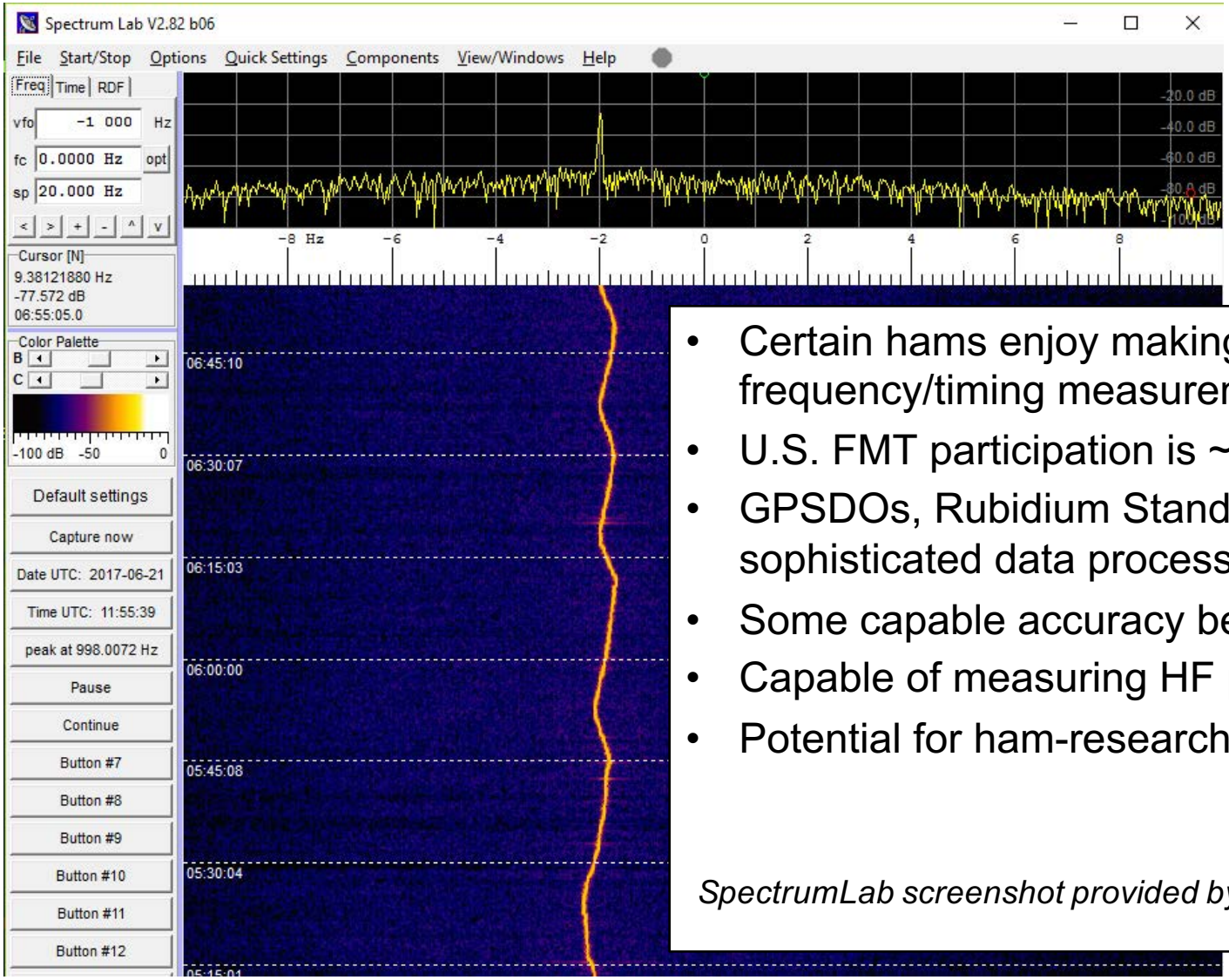
Frequency Measurement Community



- Certain hams enjoy making high precision frequency/timing measurements.
- U.S. FMT participation is ~100 RX stations
- GPSDOs, Rubidium Standards, and sophisticated data processing.
- Some capable accuracy better than 0.001 Hz.
- Capable of measuring HF path Doppler shift.
- Potential for ham-researcher collaboration.

SpectrumLab screenshot provided by Steve Reyer, WA9VNJ.

Amateur Radio Complementary Data

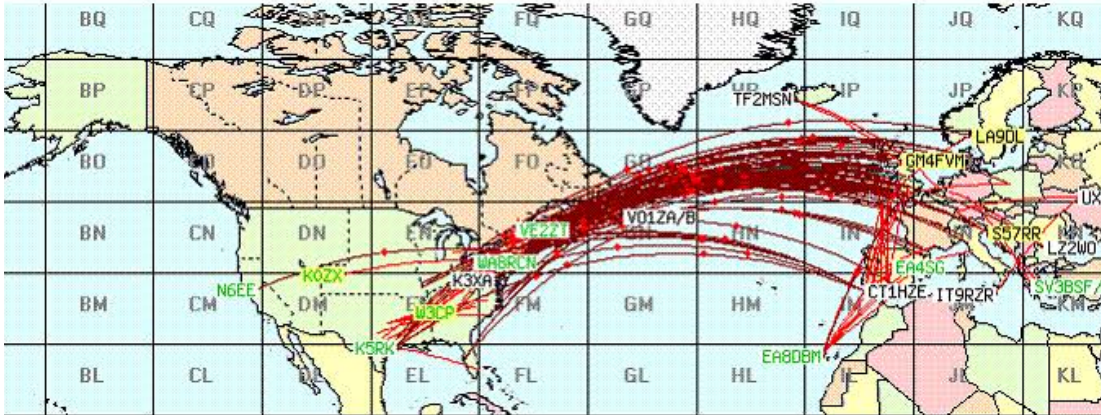
- Ham radio data can complement traditional measurement techniques.
- These datasets are **large**, **unique**, and have **tremendous spatial coverage**.
- Possible Uses
  - Model verification
  - Data/model assimilation
  - Real-time applications
  - Exploratory Science

nathaniel.a.frissell@njit.edu

Research Activities

nathaniel.a.frissell@njit.edu

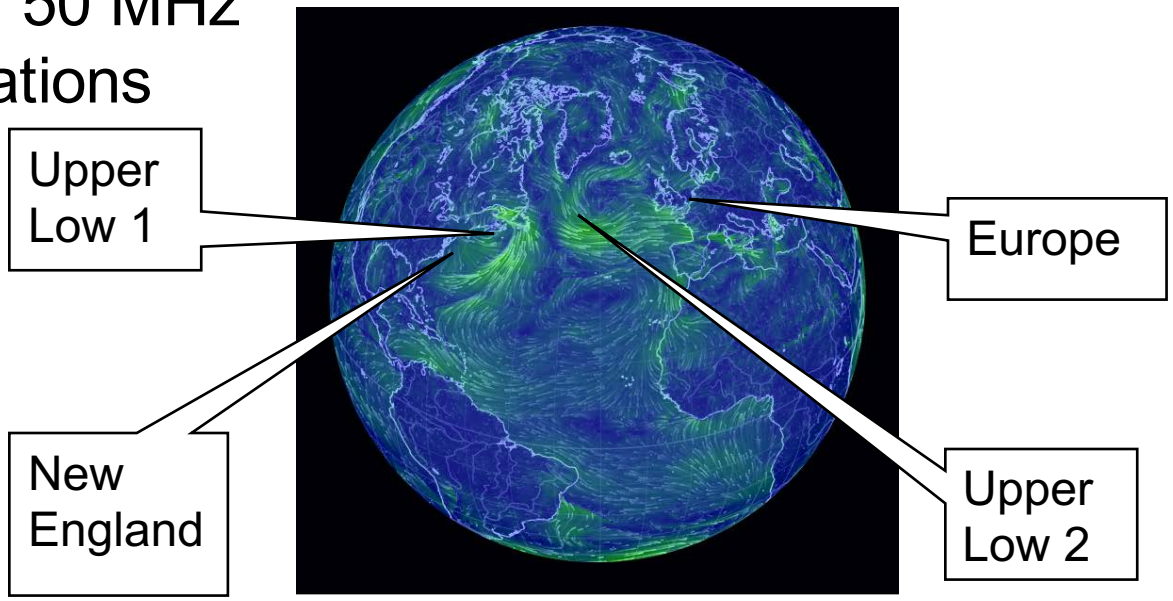
50 MHz Sporadic E



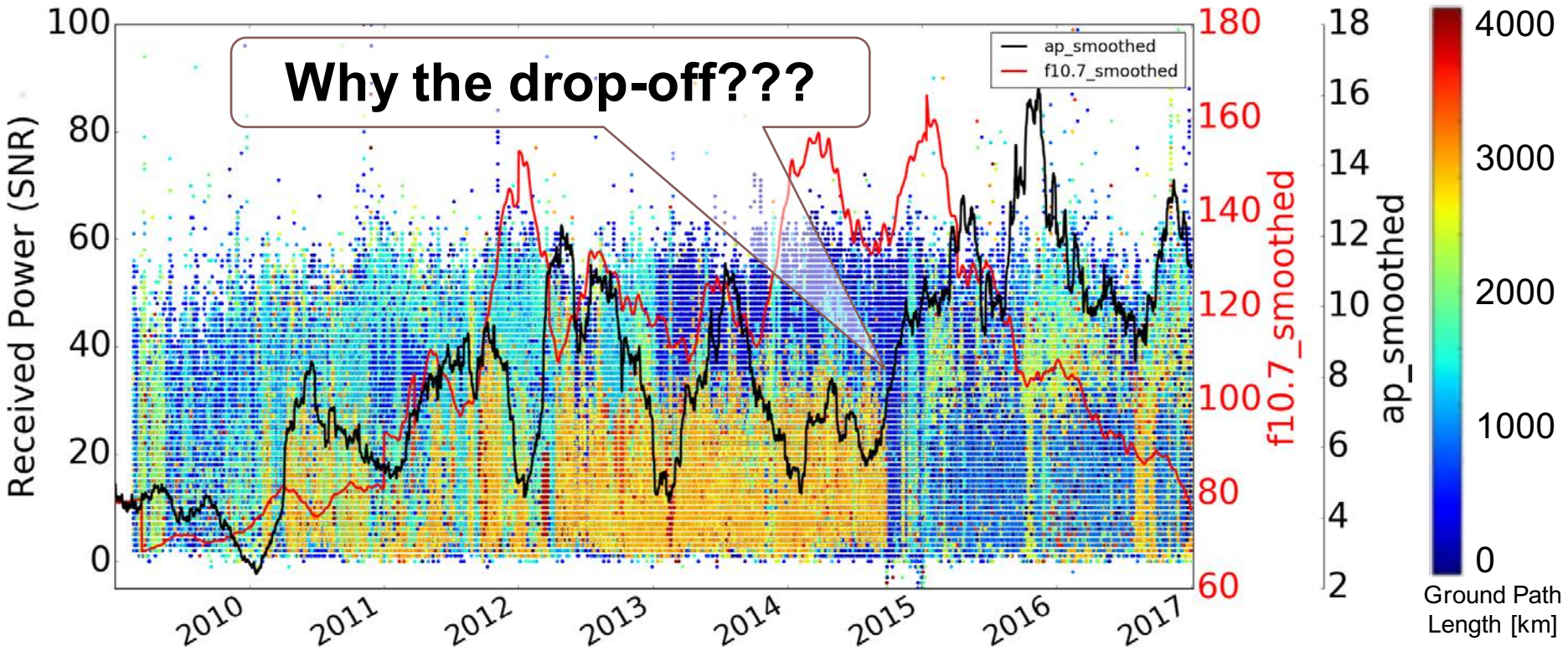
This Es research is by Joe Dzekevich, K1YOW.

June 13, 2016 50 MHz Communications

Sporadic E has formed where these two storms are, thus enabling trans Atlantic 6M contacts because they are within reach of each other and the coasts.



7 MHz RBN SNR Investigation

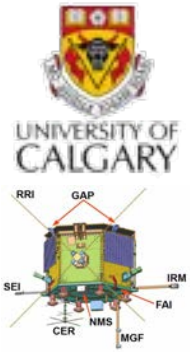


- Only path lengths < 4000 km.
- Long distance propagation during solar cycle rise/active period.
- Sudden drop October 2014.
- Localized to European Night.
- Why?

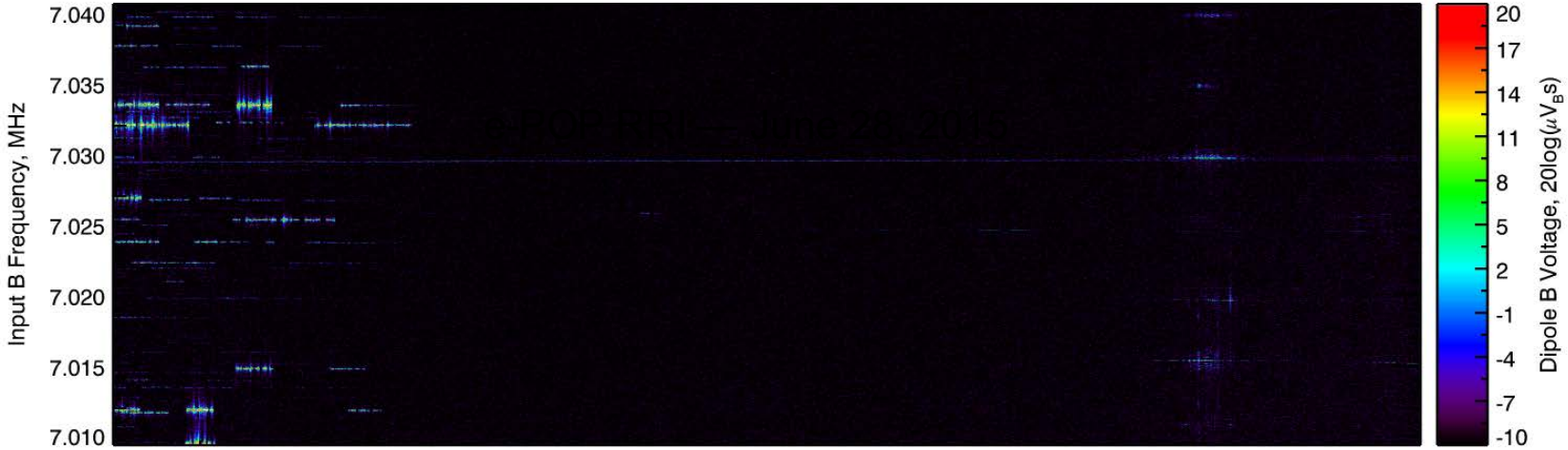
[*J.D. Katz, N.A. Frissell, et al.*]

nathaniel.a.frissell@njit.edu

e-POP RRI & ARRL Field Day



- e-POP RRI activated for 2 minutes (01:16 — 01:18 UT).
- Several Morse code transmissions from ham users were detected.
- 23 ham radio call signs were decoded (aurally), in 40 m band.
  - Call signs provide point of origin of HF rays for raytracing.
- Transmissions *cut-off* after 30 seconds.
  - Attributed to spacecraft entering region of higher f_oF_2.

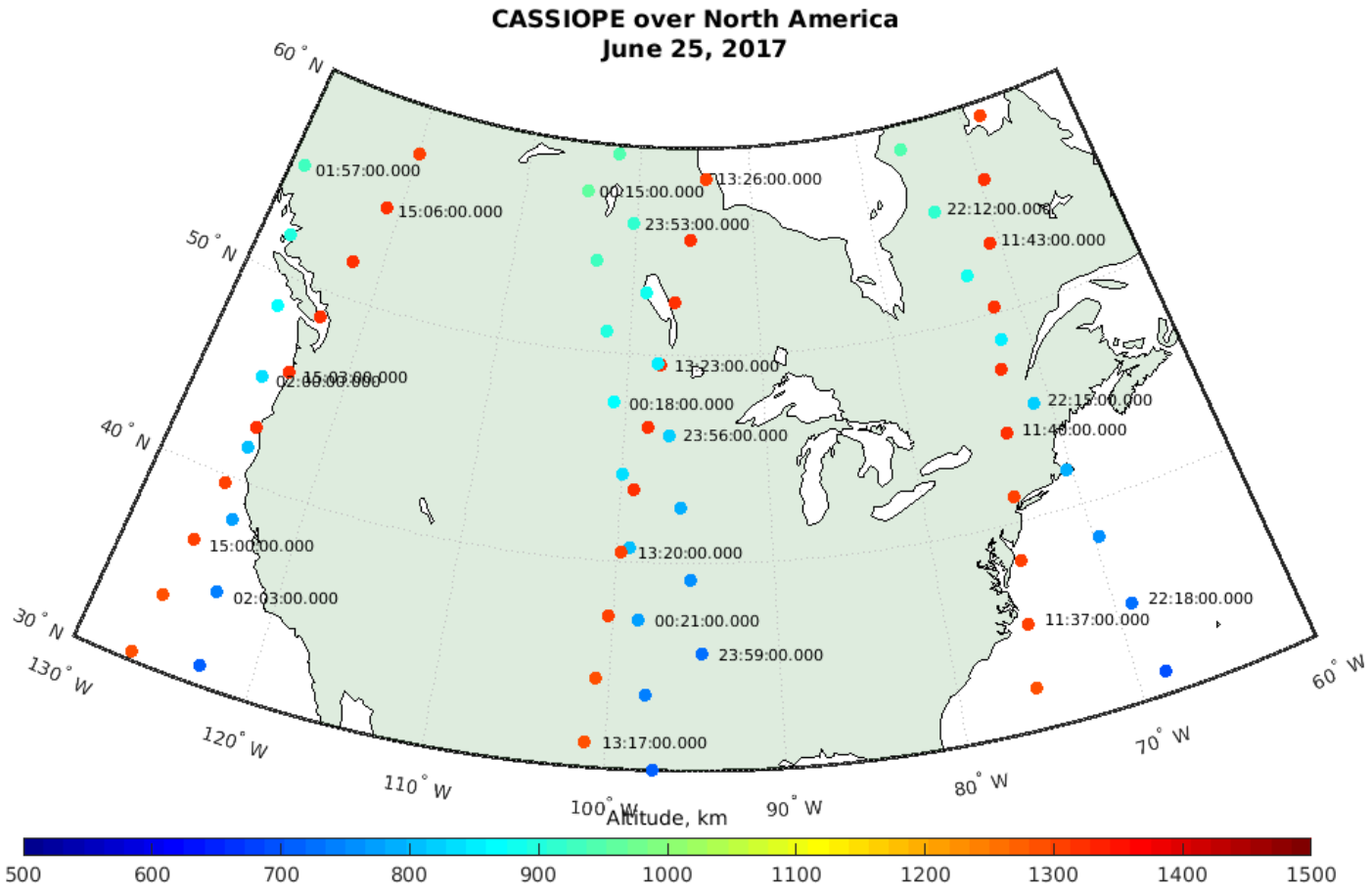


UT	01:16:14.59	01:16:34.08	01:16:53.58	01:17:13.07	01:17:32.56	01:17:52.06	01:18:11.55
Geo. Lat, °	43.67	42.39	41.11	39.82	38.53	37.23	35.94
Geo. Lon, °	-88.06	-87.76	-87.48	-87.21	-86.95	-86.70	-86.47
Altitude, km	386.31	381.00	375.90	371.03	366.38	361.96	357.77
Mag. Lat, °	52.74	51.48	50.21	48.94	47.67	46.39	45.11
Mag. Lon, °	-18.54	-18.03	-17.55	-17.11	-16.68	-16.28	-15.90
MLT	19.33	19.37	19.40	19.44	19.47	19.51	19.54

[*G. Perry, E.S. Miller, N.A. Frissell, et al.*]

e-POP RRI & ARRL Field Day

- For 2015 ARRL Field Day, e-POP RRI was activated for 2 minutes.
- For 2017 Field Day, e-POP RRI will be activated for 60 minutes total.



[*G. Perry, E.S. Miller, N.A. Frissell, et al.*]

Solar Eclipse Ionospheric Effects?

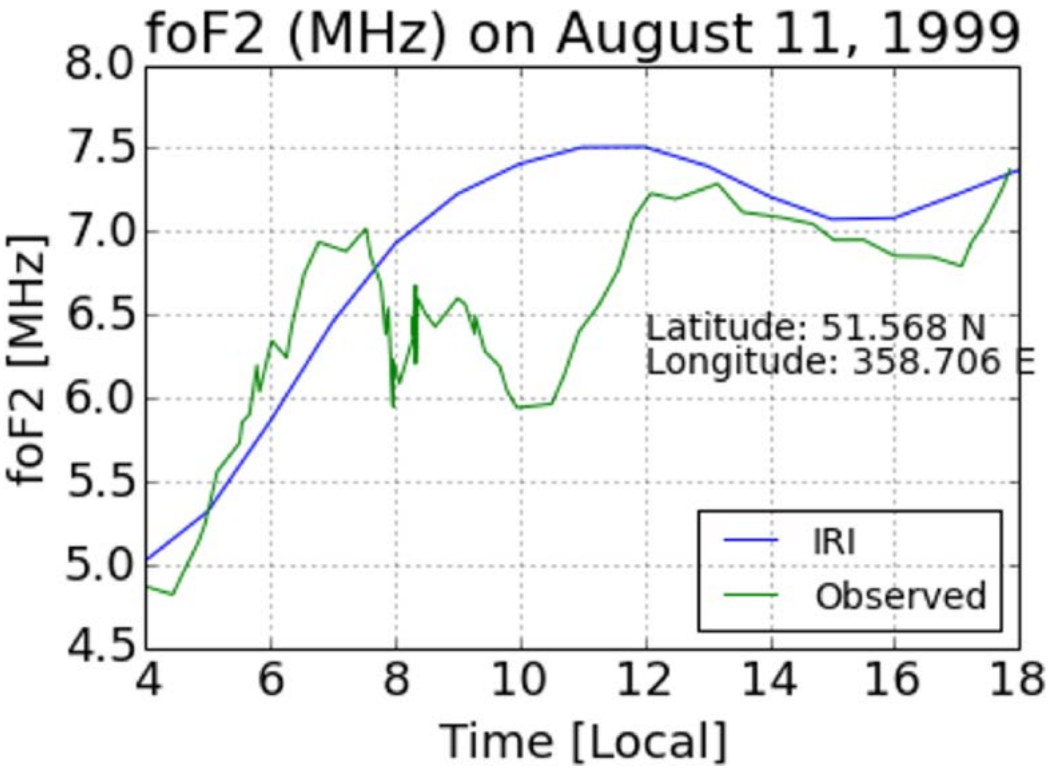
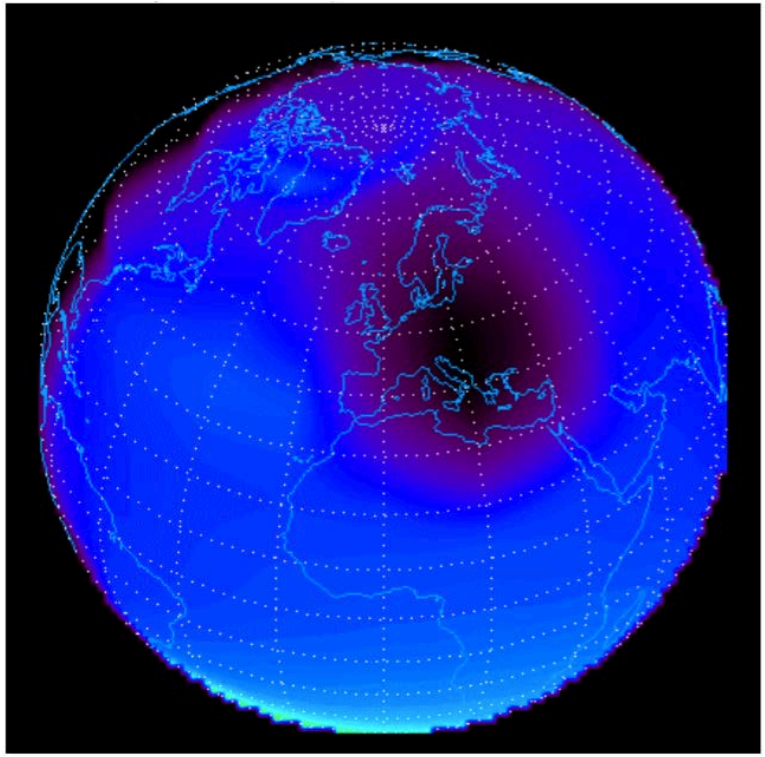


Figure: M. Moses after *Afraimovich et al.*, 2002



Model Electron Density at ~280 km alt. during 1999 Eclipse
M. Harris from *Bamford* 2000.

Solar Eclipse research is in collaboration with Virginia Tech. [Earle et al.]

Solar Eclipse QSO Party (SEQP)

- **August 21, 2017 from 1400 – 2200 UT**
- **Contest-like**
  - 2 Points CW or Digital
  - 1 Point for Phone
  - Multiply Score by # of Grids
- **Exchange**
  - RST + 6 Character Grid Square
- **Data sources**
  - Reverse Beacon Network
  - PSKReporter
  - WSPRNet
  - Participant-submitted logs

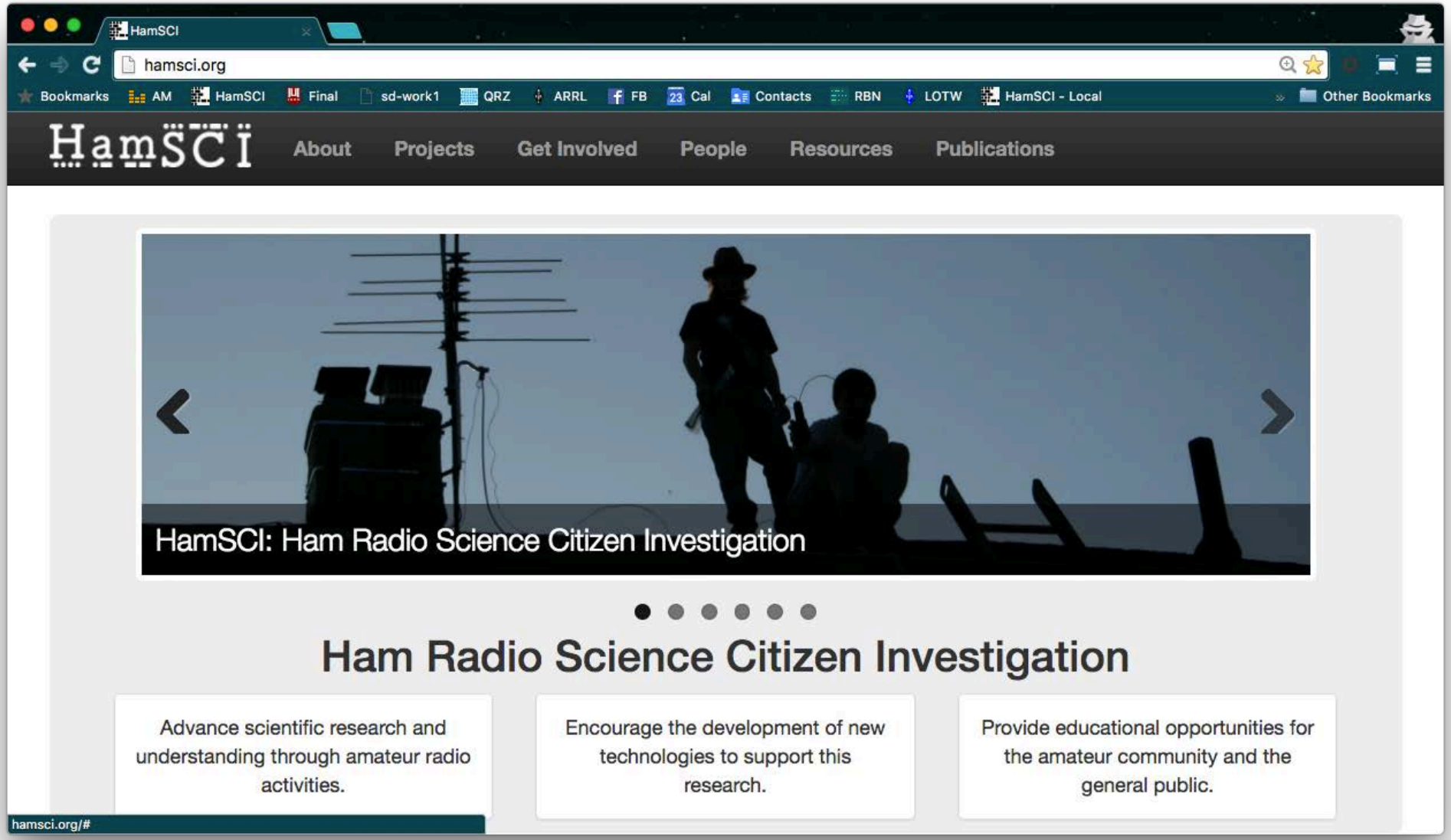
http://hamsci.org/seqp

nathaniel.a.frissell@njit.edu

The HamSCI Organization

nathaniel.a.frissell@njit.edu

HamSCI – http://www.hamsci.org



HamSCI @ Hamvention 2017

hamsci.org/dayton2017

Collaboration with the ARRL

August 2017 *QST*

American Radio Relay League

- National Organization for Ham Radio
- Over 170,000 members (Jan. 2016)
- Monthly magazine
- Publishes over 160 books
- Strong web/social media presence
- Education/Outreach Program

- **Promoting HamSCI and the Solar Eclipse QSO Party**

HamSCI Membership

Lead HamSCI Organizer:
Dr. Nathaniel A. Frissell, W2NAF
New Jersey Institute of Technology
Center for Solar-Terrestrial Research

HamSCI at the 2016
American Geophysical Union Meeting

Members from:

- New Jersey Institute of Technology
- Virginia Tech
- American Radio Relay League
- Afreet Software
- Bob Jones University
- Dartmouth College
- Instituto de Telecomunicações /Universidade de Aveiro
- Johns Hopkins University APL
- MIT Haystack Observatory
- Montclair State University
- Reverse Beacon Network
- The Radio Club of America
- Rice University
- Royal Military College of Canada
- SciVision, Inc.
- SRI International
- University of Alabama
- University of Calgary
- University of Michigan
- The Amateur Radio Community

nathaniel.a.frissell@njit.edu

Other Contest/Research Ideas?

- More coordinated e-POP experiments
- Auroral sounding competitions
- Earth-Moon-Earth (EME) Experiments
- Long-path contest; point antennas away from each other.
- Trans-equatorial propagation
- “Flash-mob” event… send alert out to ham community based on Space Weather alert and ask for certain types of communication attempts

nathaniel.a.frissell@njit.edu

How can HamSCI help you?

- Help you get/interpret ham radio data
- Plan ham radio research
  - We know ham radio culture
  - Thinking about experiments differently
- Public Relations Platform
- Provide access to
  - Public Outreach
  - Citizen Science
  - Broader Impacts

Hams are a highly skilled and interested community!!

nathaniel.a.frissell@njit.edu

References

E.L Afraimovich, E.A Kosogorov, O.S Lesyuta (2002), Effects of the August 11, 1999 total solar eclipse as deduced from total electron content measurements at the GPS network, Journal of Atmospheric and Solar-Terrestrial Physics, Volume 64, Issue 18, Pages 1933-1941, ISSN 1364-6826, http://dx.doi.org/10.1016/S1364-6826(02)00221-3.

Bamford, R. (2000), Radio and the 1999 UK Total Solar Eclipse, Rutherford Appleton Laboratory, Chilton, Didcot, UK.

Frissell, N. A., E. S. Miller, S. R. Kaeppler, F. Ceglia, D. Pascoe, N. Sinanis, P. Smith, R. Williams, and A. Shovkoplyas (2014), Ionospheric Sounding Using Real-Time Amateur Radio Reporting Networks, *Space Weather*, 12, 651–656, doi:10.1002/2014SW001132.

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Thank you!

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