

High Frequency Communications Response to Solar Activity in September 2017 as Observed by Amateur Radio Networks

Nathaniel A. Frissell, W2NAF¹

Joshua S. Vega¹, Evan Markowitz¹, Andrew J. Gerrard¹,
William D. Engelke², Philip J. Erickson³, Ethan S. Miller⁴,
R. Carl Luetzelschwab⁵, and Jacob Bortnik⁶

¹New Jersey Institute of Technology, K2MFF

²University of Alabama

³MIT Haystack Observatory

⁴Johns Hopkins University Applied Physics Laboratory

⁵HamSCI Community

⁶University of California, Los Angeles

Introduction

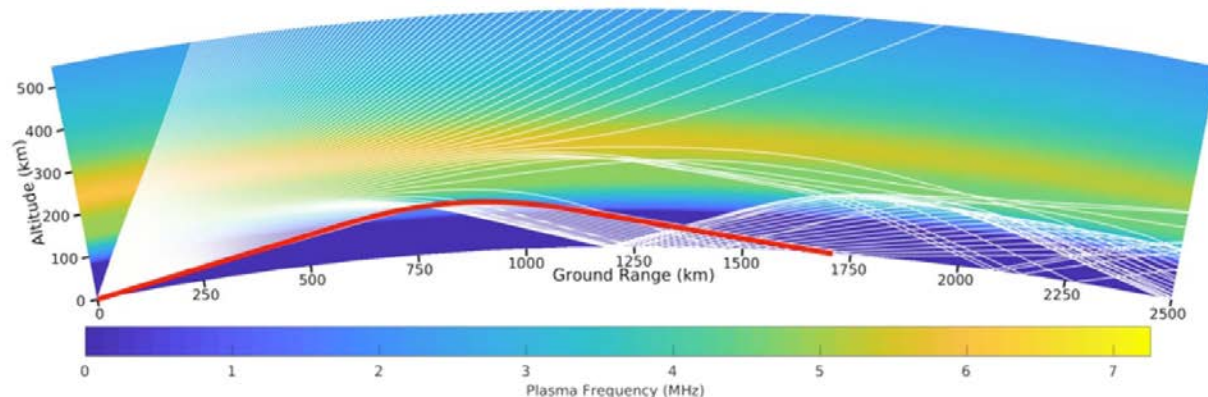
- Numerous solar flares and CME-induced interplanetary shocks occurred September 4-14, 2017, disrupting HF (3-30 MHz) communications.
- Simultaneously, Hurricanes Irma and Jose caused significant damage to the Caribbean Islands and parts of Florida.
- The timing was unfortunate, as HF radio was needed for emergency communications.
- We present of HF amateur radio observations during this period.
 - Reverse Beacon Network (RBN)
 - Weak Signal Propagation Reporting Network (WSPRNet)

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*

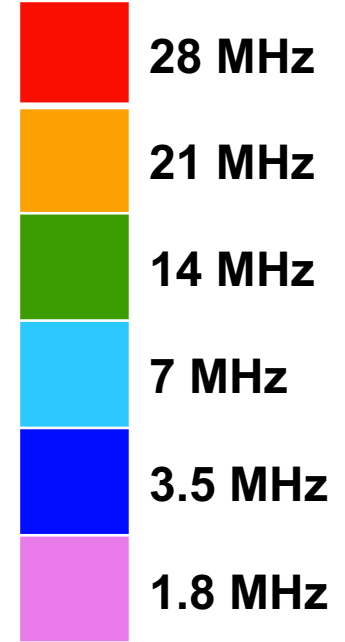
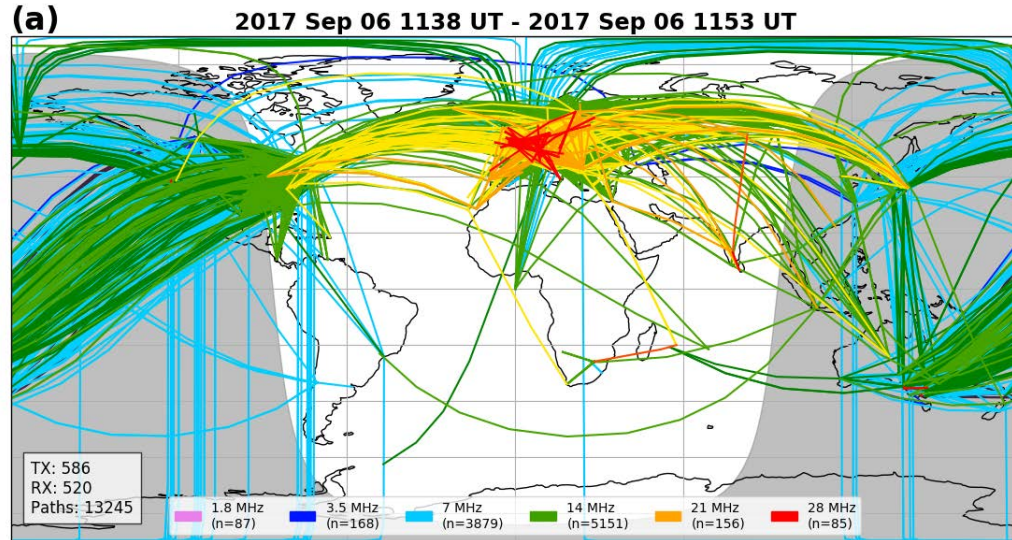


**1600 UT 21 Aug 2017 14.03 MHz - Eclipsed SAMI3
TX: AA2MF (Florida) RX: WE9V (Wisconsin)**

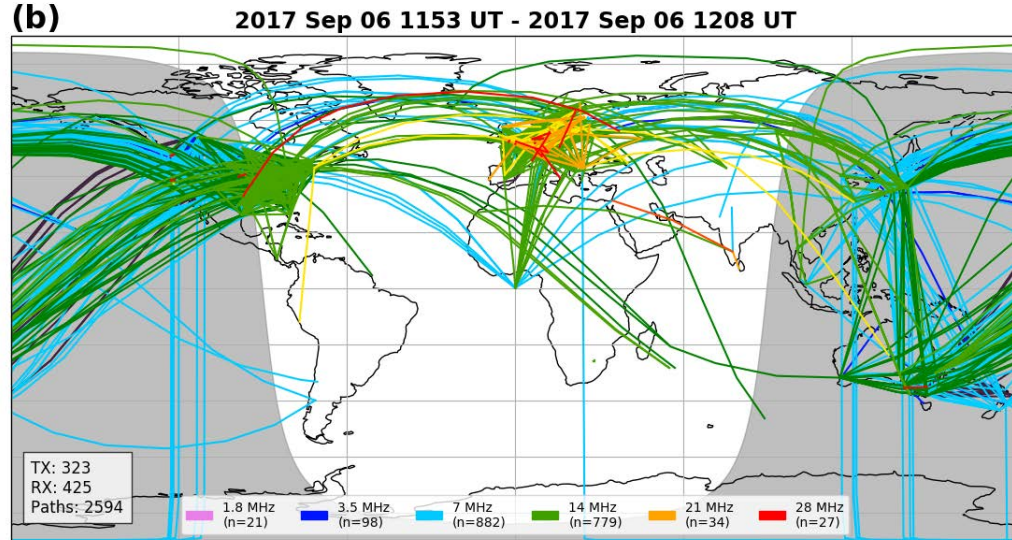
- Hobbyists routinely use HF-VHF transionospheric links.
- Often ~100 W into dipole antennas.

HF Response to Solar Flare

13,245 Paths

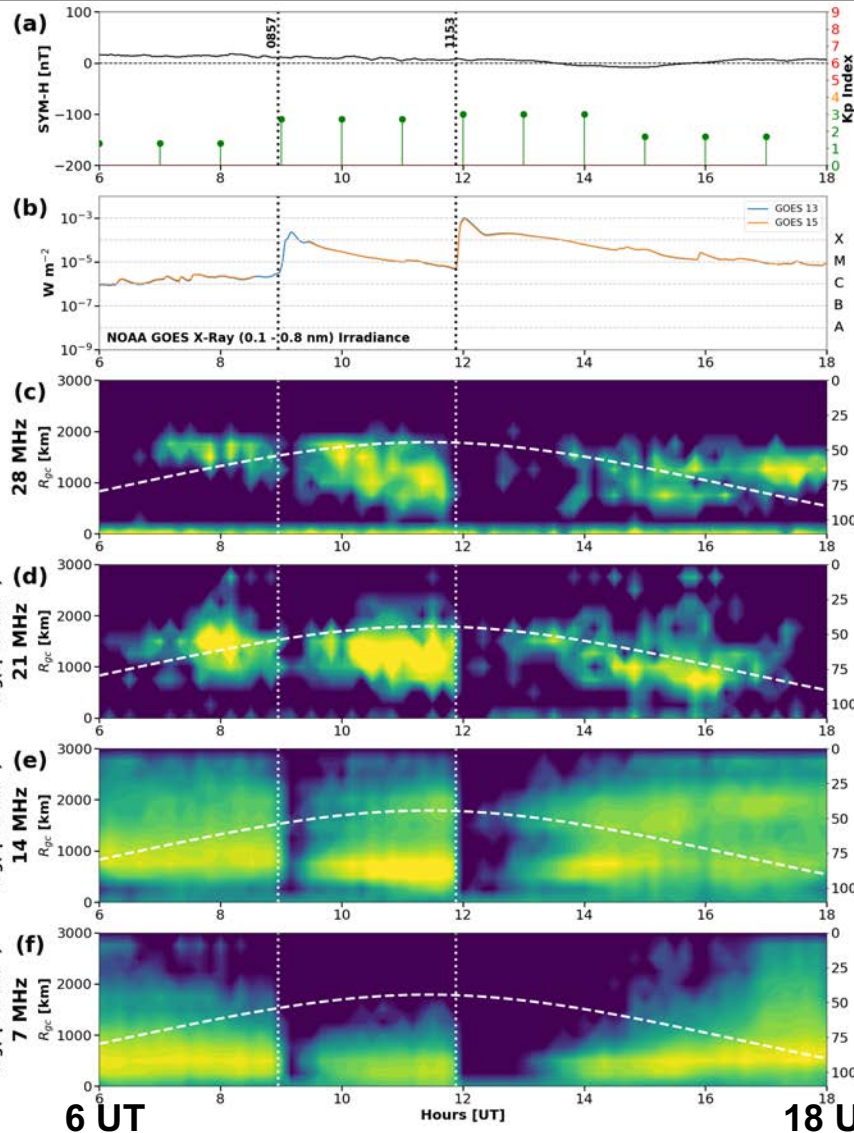


2,594 Paths



EU Response to Solar Flares

06 Sep 2017
 Ham Radio Networks
 N Spots = 185579
 RBN: 14%
 WSPRNet: 86%



Quiet Kp/Sym-H

GOES Flares
 X2.2 & X9.3

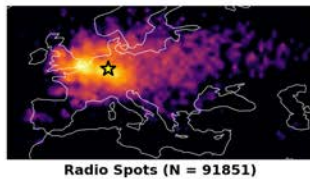
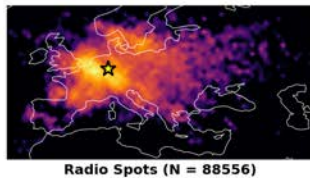
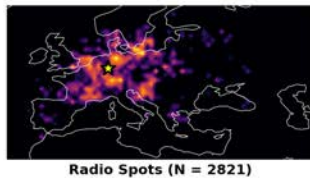
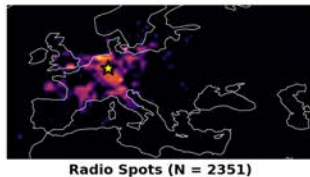
28 MHz

21 MHz

14 MHz

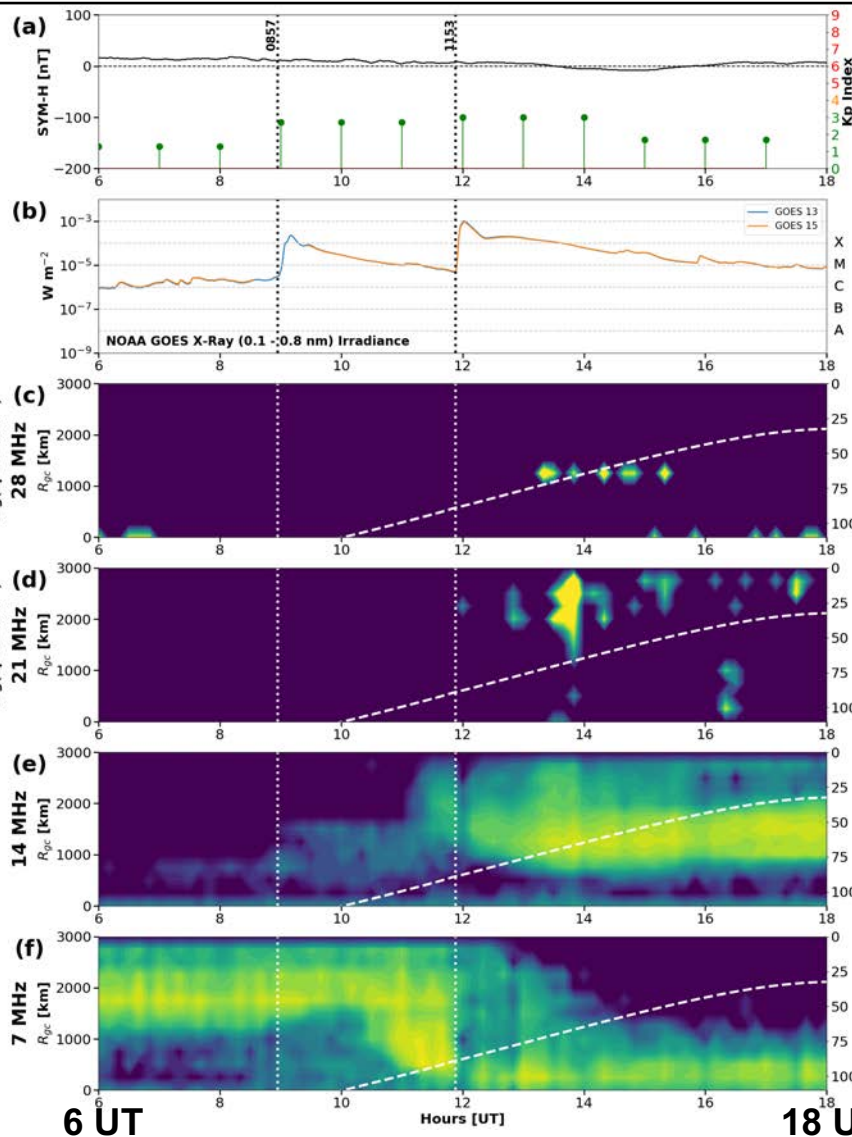
7 MHz

- Europe in daylight.
- Both flares cause deep blackouts.



US Response to Solar Flares

06 Sep 2017
 Ham Radio Networks
 N Spots = 50813
 RBN: 12%
 WSPRNet: 88%



Quiet Kp/Sym-H

GOES Flares
 X2.2 & X9.3

28 MHz

21 MHz

14 MHz

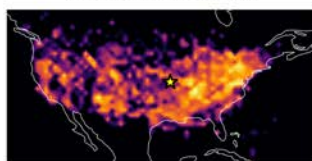
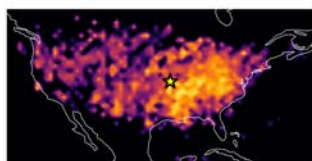
7 MHz

- US is at dawn.

- Diurnal variations evident

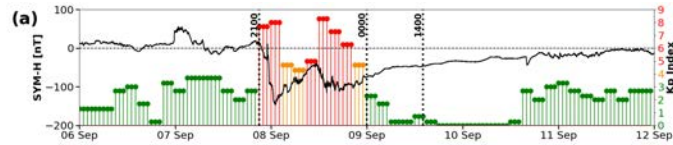
- 1st Flare has little effect

- 2nd flare has small effect

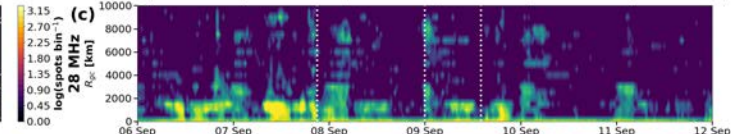
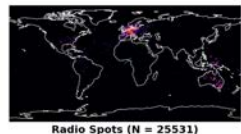
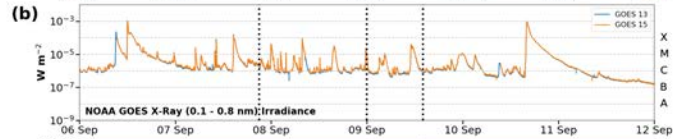


Global Response to Geomagnetic Storm

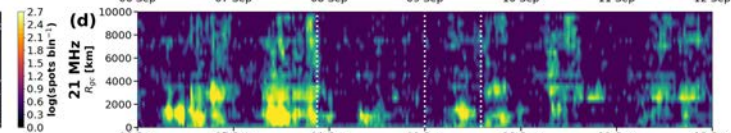
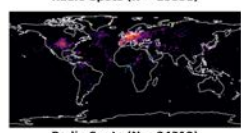
06 Sep 2017-
12 Sep 2017
Ham Radio Networks
N Spots = 3849836
RBN: 22%
WSPRNet: 78%



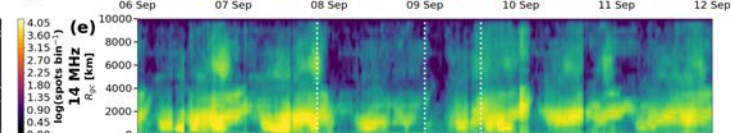
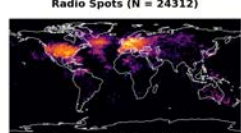
$Kp_{max} = 8+$
 $SYM-H_{min} = -146 \text{ nT}$



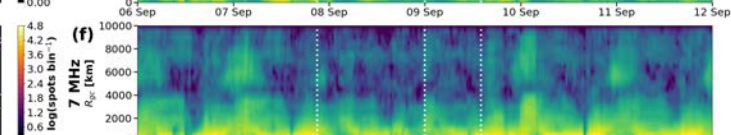
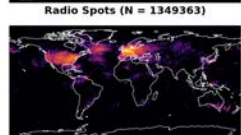
28 MHz



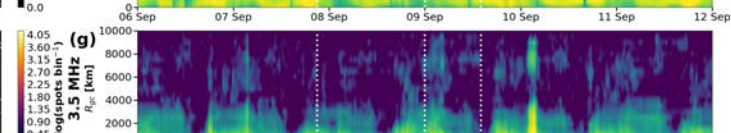
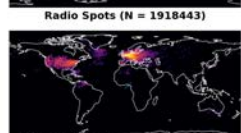
21 MHz



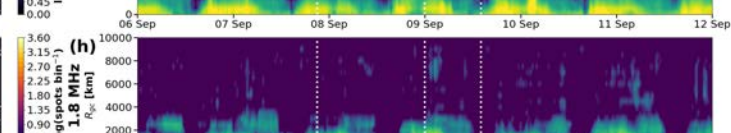
14 MHz



7 MHz



3.5 MHz



1.8 MHz

6 Sept 7 Sept 8 Sept 9 Sept 10 Sept 11 Sept 12 Sept

8 Sept 2100 UT

- Storm Onset

9 Sept 0000 UT

- Geomagnetic Quiet

9 Sept 1400 UT

- Radio Recovery

Z-Score

$$z = \frac{x - \mu}{\sigma}$$

06 Sep 2017-
12 Sep 2017
Ham Radio Networks
N Spots = 3849836
RBN: 22%
WSPRnet: 78%

Quiet Time Baseline

- 2016-2017
- $-25 < \text{SYM-H} < 25$ nT
- $K_p < 3$
- $n = 283$ days

7, 14 MHz

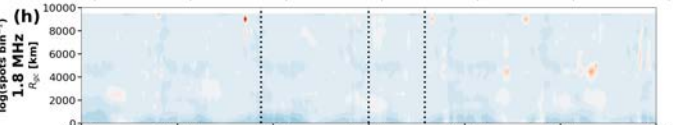
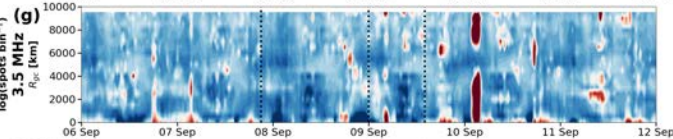
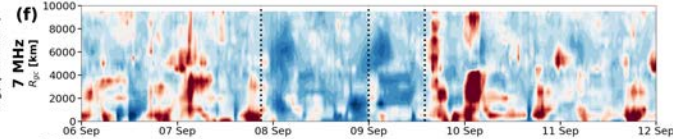
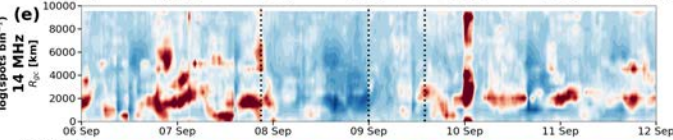
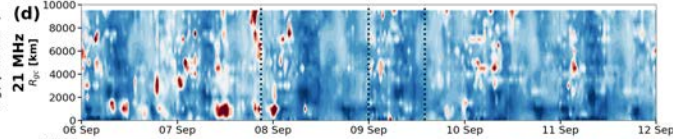
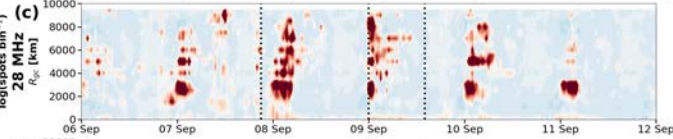
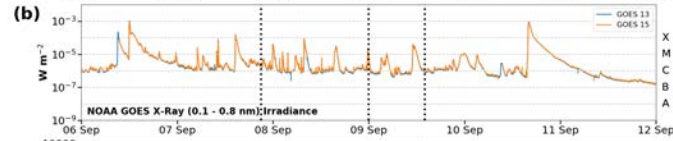
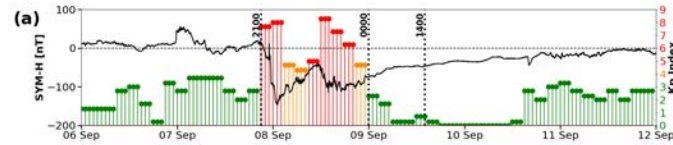
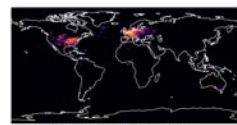
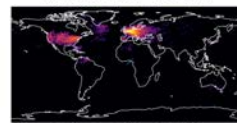
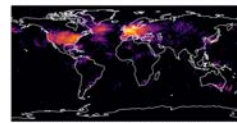
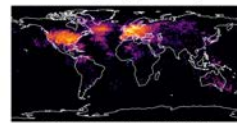
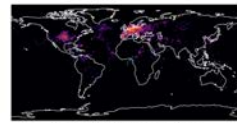
- Clearly below average during storm

1.8, 3.5, 21 MHz

- Inconclusive

28 MHz

- Above average... more work to be done here...



6 Sept 07 Sept 08 Sept 09 Sept 10 Sept 11 Sept 12 Sept

28 MHz

21 MHz

14 MHz

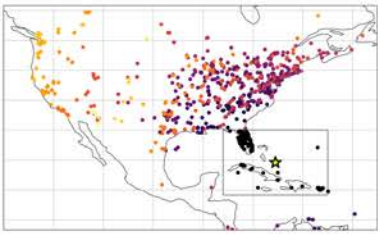
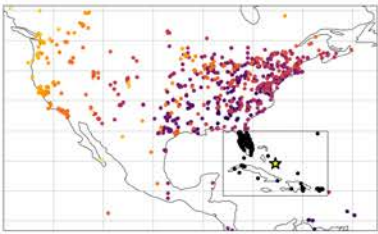
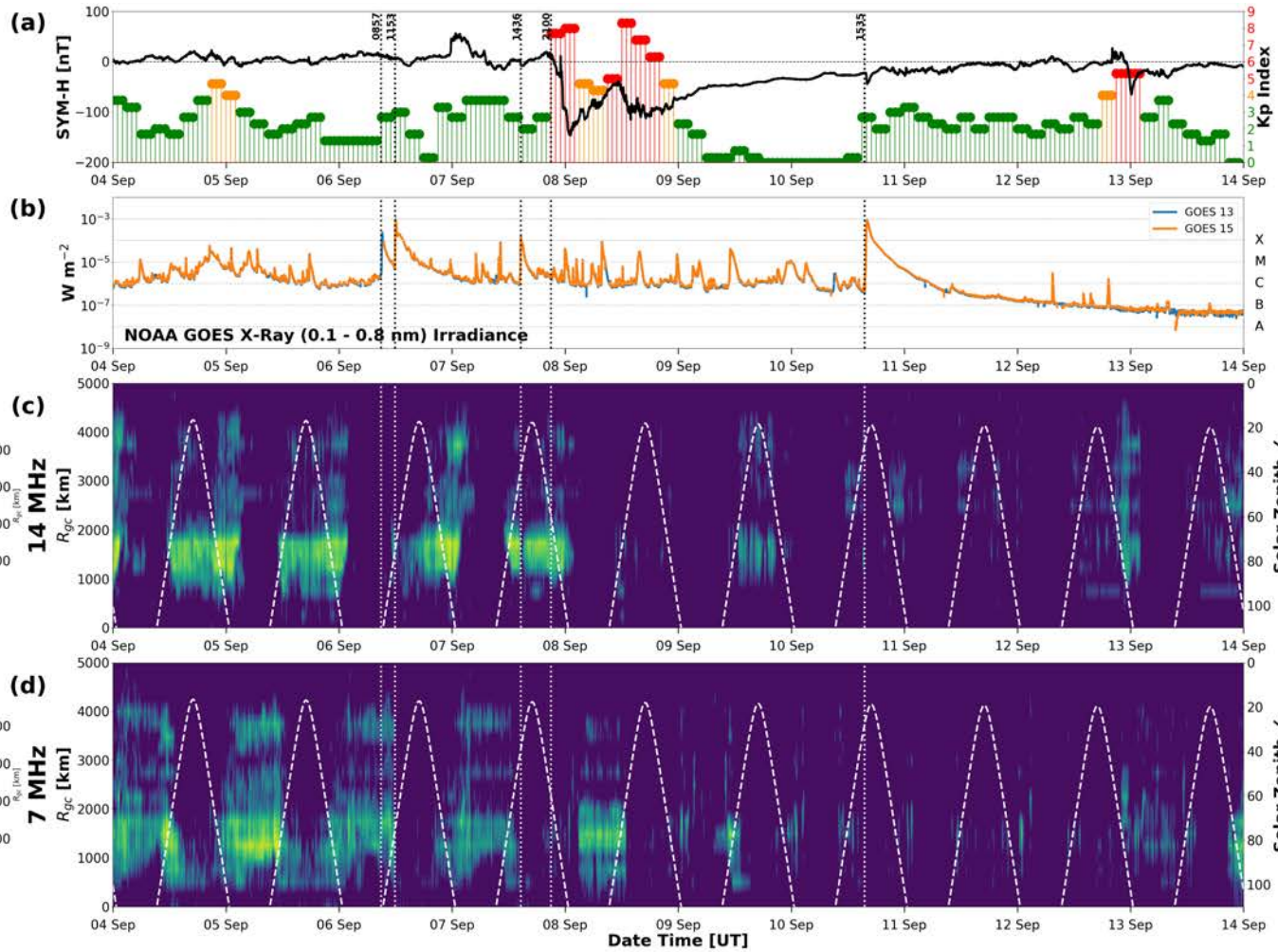
7 MHz

3.5 MHz

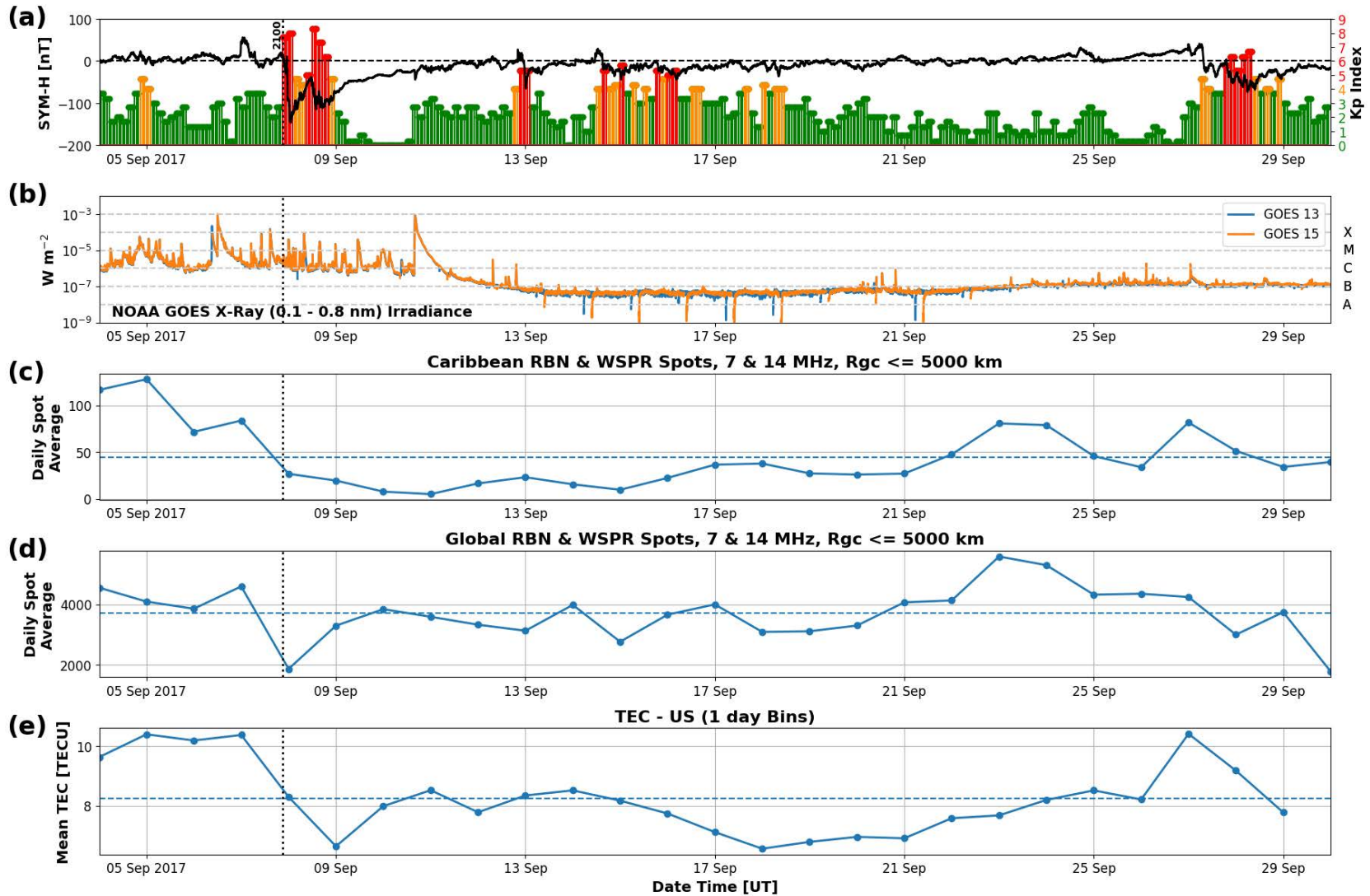
1.8 MHz

Caribbean Response

04 Sep 2017-
14 Sep 2017
Ham Radio Networks
N Spots = 71856
RBN: 18%
WSPRNet: 82%



Comparison to Mean US TEC



Summary and Conclusions

- X-class flares on 6, 7, and 10 September 2017
 - acute radio blackouts during the day in the Caribbean
 - with recovery times of tens of minutes to hours, based on the decay time of the flare.
- Severe geomagnetic storm 7-10 September 2017
 - $Kp_{\max} = 8+$ and $SYM-H_{\min} = -146$ nT
 - wiped out ionospheric communications first on 14 MHz and then on 7 MHz starting at ~1200 UT 8 September.
- This storm, combined with effects from additional flare and geomagnetic activity, contributed to a significant suppression of effective HF propagation bands both globally and in the Caribbean for a period of 12 to 15 days.

Thank you!

THIS WORK WAS PARTIALLY SUPPORTED BY
NSF GRANT AGS-1552188/479505-19C75.