ENGR/PHYS 150: Fundamentals of Physics and Engineering

Space Physics/Weather Research Paper

Introduction

The Sun is constantly bombarding the Earth with radiation and charged particles. How does this affect us and the technologies we use? In this paper, you will explore at least one way solar energy can adversely affect communications here on Earth. In doing so, you will not only become familiar with the fields of space weather and space physics, but also basic techniques for data visualization and analysis, as well as how to write a scientific paper.

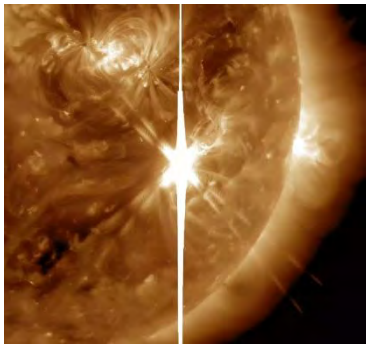

Figure 1: NASA SDO Observation of X9.3 Solar Flare on Sept 6, 2017

A **Solar Flare** is a sudden flash of increased brightness on the Sun, as shown in Figure 1. In addition to visible light, solar flares can produce X-rays that cause increased ionization of the Earth's atmosphere that will lead to absorption of radio waves and a breakdown of communications on the High Frequency (HF) bands from about 3 to 30 MHz. This is known as a **radio blackout.**

To write your paper, you will be working with data from the Geostationary Operational Environmental Satellite (GOES) spacecraft, as well as amateur (ham) radio data collected by Reverse Beacon Network (RBN, reversebeacon.net) and the Weak Signal Propagation Reporting Network (WSPRNet, wsprnet.org). Examples of these data are shown in Figure 2, taken from *Frissell et al.* (2014). Panel (a) shows the x-ray solar flare as detected by the GOES 15 satellite. Panel (b) shows a large amount of HF amateur radio activity occurring around the world in the hour prior to the flare. Panel (c) shows the state of HF radio activity immediately after the flare… it has decreased significantly!

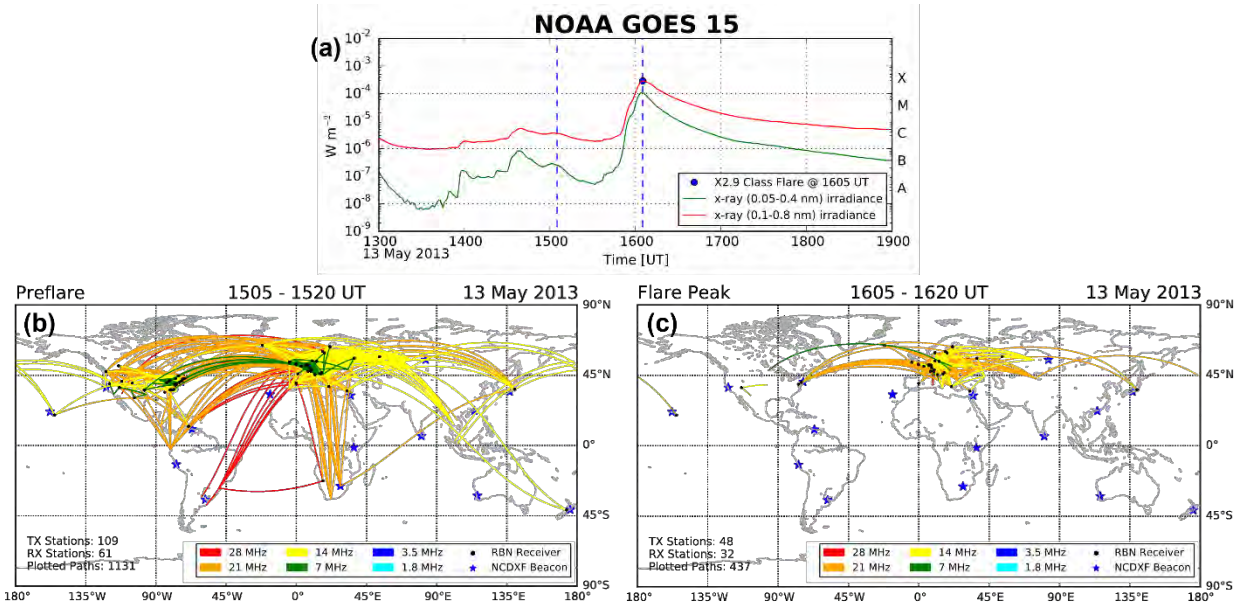

Figure 2: (a) GOES x-ray data showing an X2.9 class solar flare at 1605 UT. (b) RBN Ham radio communications map before the solar flare. (c) RBN Ham radio communications map after the solar flare.

Project Statement

Your task is to write a short research paper studying the effects of at least one solar flare on the RBN/WSPRNet amateur radio data. You should use the provided GOES data to identify a solar flare that you want to study, and then look at the provided RBN/WSPRNet data to see how the amateur radio communications were affected. Your paper should meet the Paper Requirements described later in this document.

While a great deal is already known about radio blackouts, there are still many questions to be answered. For instance, how long does it take the radio communications (and hence the ionosphere) to recover after different sized flares? How does the recovery vary as a function of frequency? How are the communications and the ionosphere affected by solar flares that happen at different times of day, or under different geomagnetic conditions? All of these are questions that you can explore in your paper.

Grading

This final paper and oral presentation constitute 10% of your total course grade. A grading rubric for this project is available on Brightspace.

Data and Sample Code

GOES data, RBN/WSPRNet data, sample code, and a LaTeX paper template are all available at the following Google Drive address:

https://github.com/HamSCI/ENGR-150-Paper

You are welcome to use other data in your paper as well, but this will get you started, and may be all that you need!

Paper Requirements

Each paper must include original figures made by the student using the python plotting and analysis ecosystem. You should have at least 1 figure in your paper.

The paper must be written in LaTeX and use the BibTex referencing system. You should use the "`ENGR PHYS 150 Overleaf Template.zip`" template provided in class. Each paper must have at least 5 properly cited scholarly journal articles as references.

There is no explicit page count requirement, but each of the component sections should be well developed. The text body (includes abstract, introduction, methodology, results, discussion, summary, and acknowledgments) should be at least 5 pages.

Your paper should have the following components:

- **Title**
- **Author List:** Your name.
- **Abstract:** One paragraph (350 words or less) summarizing your entire paper.
- **Introduction:** Give a brief history of what you are studying, what question you are trying to answer, why it is important, and what you are doing to answer it. Make sure you include references here.
- **Methodology:** In this section explain where you obtain your data and a description of how the measurement was made. Because you are using data provided by someone else, you do not need to go into great detail here. However, you should give a reasonable overview of how the data was collected, as well as a citation to a more detailed explanation.
- **Results:** Present and describe your results. The best thing to do here is to put your figures and/or tables in this section, and then describe them in words. **You must describe your figures in words. It is not enough to only have figures in this section. Also, your figures must have descriptive captions.**
- **Discussion:** Explain what your results mean in the context of the other research papers you have read. This is also the section where you can answer the additional questions in the project description.
- **Summary and Future Work:** Summarize your paper and include your ideas on future work.
- **Acknowledgments:** If you have more than one student working on the project, write a sentence for each student explaining what parts of the project they worked on. This is also a place you can thank other people who have helped you with the project.
- **References:** You must use the BibTex referencing system. The default format in the provided template is acceptable.

References

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

Space Physics Research Paper

Course: MRG-ENGR-150-2_PHYS-150-2 (Fall 2023)

Criteria	**Excellent** 10 points	**Good** 8 points	**Average** 6 points	**Poor** 2 points	**Criterion Score**
Abstract: One paragraph 350 words or less summarizing the entire paper	350 words or less and properly summarizing the entire paper	Over word count OR not adequately summarizing	Over word count AND not adequately summarizing	Significant errors	/ 10
Introduction: Give a brief history of what you are studying, what question you are trying to answer, why it is important and what you are doing to answer it.	All parts are present and complete	Most parts are present and complete	Many missing parts	Significant errors	/ 10
Methodology: Explain where you obtained your data and a description of how the measurements were made.	All parts present and complete	Most parts present and complete	Unclear explanations	Significant errors	/ 10
Results: Present and describe your results	All parts are present and complete with all figures labeled.	Most parts are present and complete	Unclear explanations	Significant errors	/ 10
Discussion: Explain what your results mean in the context of the other research papers you read.	All parts present and well explained.	Most parts are present and complete.	Unclear explanations	Significant errors	/ 10
Summary/Future work: Summarize your paper and include your ideas on future work	All parts present and well thought-out	Most parts are present and complete.	Unclear explanations	Significant errors	/ 10
Acknowledgements	All parts present, clear, and well thought-out	Most parts are present and complete	Many missing parts	Significant errors	/ 10
References	Correct referencing system used	Minor errors in referencing system used	Major errors in referencing system used	Significant errors	/ 10

Paper Overview	**Excellent** 10 points	**Good** 8 points	**Average** 6 points	**Poor** 2 points	**Criterion Score**
Grammar and organization	Good grammar is used throughout, including no spelling or punctuation errors	Minor grammatical errors and/or additional errors	Major grammatical errors and/or additional errors	Signficiant errors	/ 10
Proper format	Overleaf was used successsfully	Minor Overleaf errors	Major Overleaf errors	Overleaf was not used.	/ 10

Total	/ 100

Overall Score

Excellent 90 points minimum	**Good** 80 points minimum	**Satisfactory** 70 points minimum	**Developing** 60 points minimum	**Not Passing** 0 points minimum

Where to listen… Ham Radio

Band Name (Wavelength)	Phone Frequency Range [kHz]	Phone (Voice) Mode	"Best" Time
160 m	1800 - 2000	LSB	Night
80 m	3600 - 4000	LSB	
40 m	7125 - 7300	LSB	Both
20 m	14150 - 14350	USB	
17 m	18110 - 18168	USB	Day
15 m	21000 - 21450	USB	
12 m	24930 - 24990	USB	
10 m	28300 - 29700	USB	

LSB = Lower Side Band
USB = Upper Side Band
Bandwidth: 3 kHz

Full list of ham radio frequencies available at http://www.arrl.org/graphical-frequency-allocations

Communicating with Other Hams

Contact Basics: Good Amateur Practices

Q-Signals

Q-signals are a system of radio shorthand as old as wireless and developed from even older telegraphy codes. Q-signals are a set of abbreviations for common information that save time and allow communication between operators who don't speak a common language. Modern ham radio uses them extensively. The table below lists the most common Q-signals used by hams. While Q-signals were developed for use by Morse operators, their use is common on phone, as well. You will often hear, "QRZed?" as someone asks "Who is calling me?" or "I'm getting a little QRM" from an operator receiving some interference or "Let's QSY to 146.55" as two operators change from a repeater frequency to a nearby simplex communications frequency.

Q-Signals

Abbr.	Questions
QRG	Your exact frequency (or that of _____) is _____kHz. Will you tell me my exact frequency (or that of _____)?
QRL	I am busy (or I am busy with _____). Are you busy? Usually used to see if a frequency is busy.
QRM	Your transmission is being interfered with _____ (1. Nil; 2. Slightly; 3. Moderately; 4. Severely; 5. Extremely.) Is my transmission being interfered with?
QRN	I am troubled by static _____. (1 to 5 as under QRM.) Are you troubled by static?
QRO	Increase power. Shall I increase power?
QRP	Decrease power. Shall I decrease power?
QRQ	Send faster (_____wpm). Shall I send faster?
QRS	Send more slowly (_____wpm). Shall I send more slowly?
QRT	Stop sending. Shall I stop sending?
QRU	I have nothing for you. Have you anything for me?
QRV	I am ready. Are you ready?
QRX	I will call you again at _____hours (on _____kHz). When will you call me again? Minutes are usually implied rather than hours.
QRZ	You are being called by _____ (on _____kHz). Who is calling me?
QSB	Your signals are fading. Are my signals fading?
QSK	I can hear you between signals; break in on my transmission. Can you hear me between your signals and if so can I break in on your transmission?
QSL	I am acknowledging receipt. Can you acknowledge receipt (of a message or transmission)?
QSO	I can communicate with _____ direct (or relay through _____). Can you communicate with _____ direct or by relay?
QSP	I will relay to _____. Will you relay to _____?
QST	General call preceding a message addressed to all amateurs and ARRL members. This is in effect "CQ ARRL."
QSX	I am listening to _____ on _____kHz. Will you listen to _____on _____kHz?
QSY	Change to transmission on another frequency (or on _____kHz). Shall I change to transmission on another frequency (or on _____kHz)?
QTC	I have _____messages for you (or for _____). How many messages have you to send?
QTH	My location is _____. What is your location?
QTR	The time is _____. What is the correct time?

ITU Phonetic Alphabet

Letter	Word	Pronunciation
A	Alfa	**AL** FAH
B	Bravo	**BRAH** VOH
C	Charlie	**CHAR** LEE
D	Delta	**DELL** TAH
E	Echo	**ECK** OH
F	Foxtrot	**FOKS** TROT
G	Golf	GOLF
H	Hotel	HOH **TELL**
I	India	**IN** DEE AH
J	Juliet	**JEW** LEE ETT
K	Kilo	**KEY** LOH
L	Lima	**LEE** MAH
M	Mike	MIKE
N	November	NO **VEM** BER
O	Oscar	**OSS** CAH
P	Papa	PAH **PAH**
Q	Quebec	KEH **BECK**
R	Romeo	**ROW** ME OH
S	Sierra	SEE **AIR** RAH
T	Tango	TANG GO
U	Uniform	**YOU** NEE FORM
V	Victor	**VIK** TAH
W	Whiskey	**WISS** KEY
X	X-Ray	**ECKS** RAY
Y	Yankee	**YANG** KEY
Z	Zulu	**ZOO** LOO

Note: The **boldfaced** syllables are emphasized. The pronunciations shown in this table were designed for those who speak any of the international languages. The pronunciations given for "Oscar" and "Victor" may seem awkward to English-speaking people in the US.

Ham KiwiSDR Listening Log - Ham Radio Single Sideband (SSB)

Instructions:
Visit http://map.kiwisdr.com to listen to and log SSB ham radio stations.
Use the drop-down band menu to select amateur radio band to listen to.
Use the chart on the right to help you pick an appropriate frequency range and mode (Upper Sideband USB or Lower Sideband LSB).
Log at least five different stations in the chart below. Use your cell phone to record videos of the most interesting QSO you hear.
You can get more information about a station by looking up the call sign on qrz.com. (Make a free account to see all of the information!)
Upload your log and video recording to the Brightspace Dropbox.

Name:	

	Date	UTC	Frequency [kHz]	Band [m]	Transmitter Call Sign	QTH (Location)	Comments	Call Sign & QTH of KiwiSDR Receiver	KiwiSDR Local Time
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
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