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.

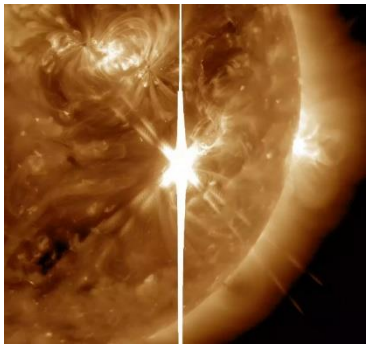

Figure 1: NASA SDO Observation of X9.3 Solar Flare on Sept 6, 2017

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!

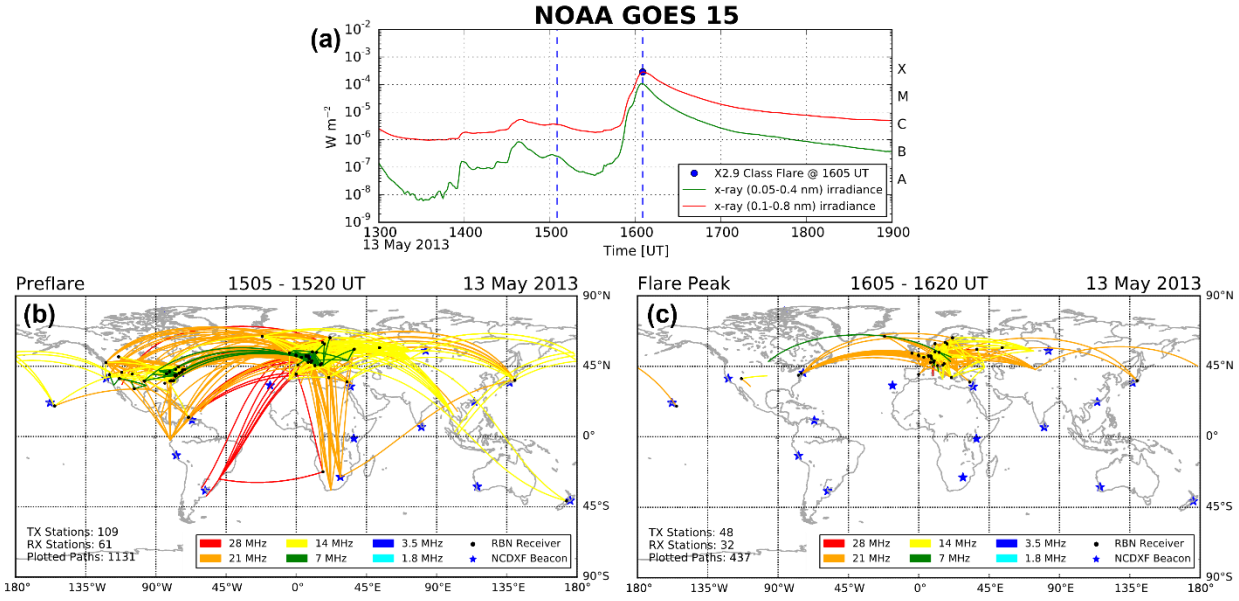

Figure 2: (a) GOES x-ray data showing an X2.9 class solar flare at 1605 UT. (b) RBN Ham radio communications map before the solar flare. (c) RBN Ham radio communications map after the solar flare.

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