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!

# Introducing Undergraduates to Research Through Solar Flares, Python, and Amateur Radio

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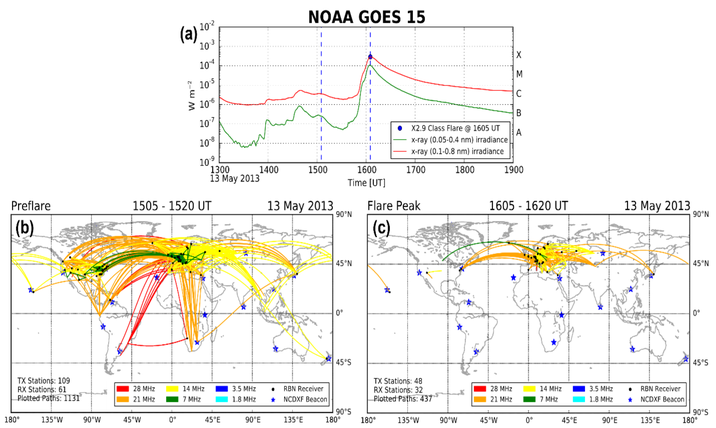
## Abstract

In an effort to introduce research and scientific writing earlier to physics and engineering undergraduate students, we designed a Space Physics Project in Fall of 2021 to add to Foundations of Physics and Engineering at the University of Scranton.

To complete the project, students worked 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 the Figure below, 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!




(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.

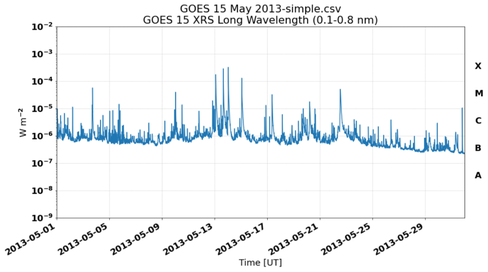
## Introduction

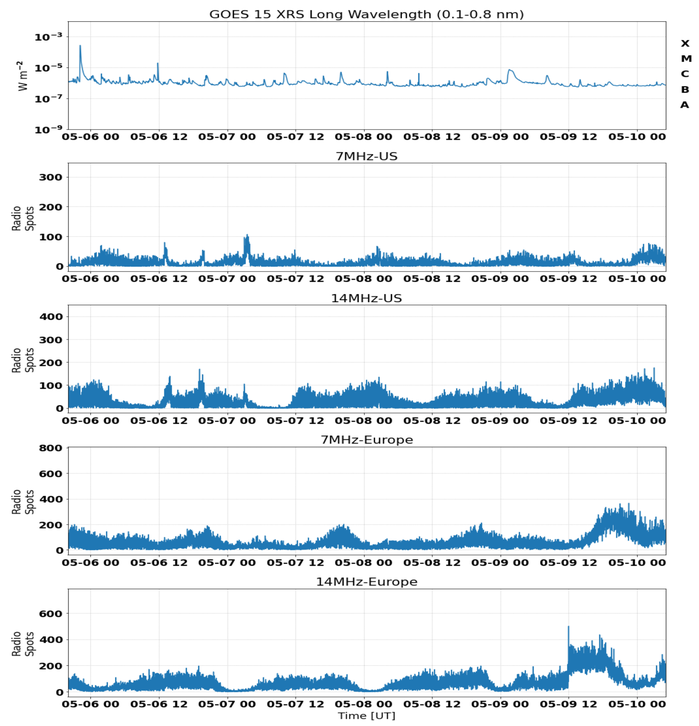
- As part of a introduction to physics and engineering course, students work a research paper about the effects solar flares have on amateur radio data
- Geared towards first-year students, it provided them with a basis of scientific writing as well as data analysis

## Method/Experiment

Students were given the following **tools**:

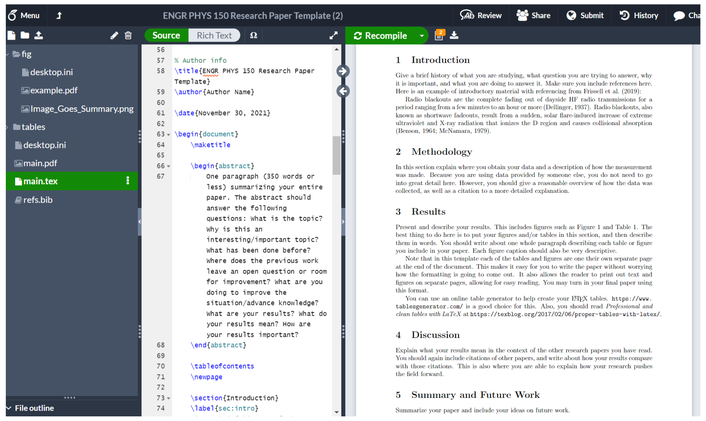
- JupyterLab which contained GOES-15 satellite data for the times of May 2013, April 2014, and May 2015
  - Students chose an X-class flare
- JupyterLab which contained amateur ham radio data from the same times
- JupyterLab worksheet on plotting




## Data and Analysis

- Students analyzed their plots and wrote their findings in the given Overleaf Template which is a standard scientific research paper format. They also gave an oral presentation to the class.




## Conclusion

- Three different sections of the same course completed this project in fall 2021.
- The time budgeted for the project was a little short – approximately 7 weeks would be ideal
- We would suggest to not scatter parts of this through the course, it would likely work as a better project for the second half of a semester and completed in a time-block.
- We believe the goals were meet and in some categories, exceeded.
- In the future, this project could rotate to highlight different research areas in the department.

## References

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