AUTOMATING THE CHARACTERIZATION OF SOLAR FLARES

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Abstract

The future Geostationary Operational Environmental Satellite (GOES) EUV and X-Ray Irradiance Sensors (EXIS) will continue the more than 30-year record of solar X-Ray measurements. Unlike previous GOES X-Ray Sensors (XRS) instruments the EXIS-XRS will use silicon detectors and by using a quadrant photodiode will be able to locate solar flares on the disk of the Sun. A similar photodiode on Solar Dynamics Observatory’s (SDO) Extreme ultraviolet Experiment (EVE) EUV SpectroPhotometer (ESP) instrument was launched in February of 2010, monitoring the Sun in the soft X-Ray 0.1 – 7 nm (0-order) band. I have created a database of recent flares, as recorded by the current GOES satellites and found the corresponding flare in ESP’s zeroth order channel. ESP’s significantly higher time cadence data provide a more detailed view of the evolution of a solar flare. This allowed me to examine the relationship between the magnitude and rise time of a flare. Using this correlation I developed a flare finding algorithm that automates the flare detection process, providing information on both flare location and magnitude.

INTRODUCTION

- Solar flares are sudden release of energy from the Sun in nearly all wavelengths.
  - Earth-directed solar flares pose a threat to astronauts and disrupt both ground and satellite based communications.
  - Solar laboratory closest look at accelerated particles and plasmas.
- GOES has been monitoring both Earth and Space weather for > 30 yrs.
- GOES XRS monitors solar X-Ray irradiance to detect solar flares and characterize their magnitude.
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![The GOES scale, is logarithmic with the smallest flares classified as A Class flares, going up to ten thousand times in Irradiance to X – class flares.](Image)

GOES–R EXIS

- GOES – R, will not only detect solar flares – but also locate them on the solar disk using quadrant photodiode.
- The GOES – R will be launched in 2015, however there is currently a similar quadrant photodiode on SDO-EVE-ESP instrument.

SDO’s EUV SpectroPhotometer

- The quadrant photodiode on ESP measures solar irradiance from 0.1 to 7 nm, at a cadence of a quarter second.
- Unprecedented time cadence for solar observations with potential for early flare detection and location.
- The ESP and GOES irradiances correspond to a power fit, as seen below.
- This fit matches a previous fit of SORCE XPS, also 0.1 – 7 nm, to GOES irradiance.

![SDO’s Atmospheric Imaging Assembly (AIA) image of the Sun on June 5, 2010](Image)

HOW TO DETECT A FLARE

- Flares are difficult if not impossible to predict.
- However, once they start the rise of the irradiance allows the irradiance of flare to be predicted, providing a basis for automated flare detection.

AUTOMATED FLARE FINDER

- Solar flare detection is currently done with a human interface, however this leads to a lack of standardization and very slow data collection.
- The FlareFinder algorithm uses a threshold slope, on a linear fit, to determine whether a flare has begun.
  - Locates the peak using the time derivative.
  - Can record any measurable flare statistics.
  - FlareFinder is particularly effective on higher magnitude fast rising flares.
  - All flares above C level recorded by GOES since the launch of SDO were found.

![Flare rise is a useful indicator for irradiance and the detection of a flare. Notably there have not been any flares larger than M2 observed by ESP](Image)

CONCLUSIONS & FUTURE WORK

- I have created a flare detection algorithm that is accurate for most C and up class flares.
- ESP provides high time cadence flare location and ...
- Quadrant diode flare location method works — further calibration needed.
- Expansion and improvements, including slow rising flares, B class events, HXR and real time applications.

References

L. Didkovsky et al., SDO ESP Radiometric Calibration.
T. Woods, Personal Communication, SOURCE XPS as a Proxy for GOES X-Ray Irradiance

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