A DEFT New Way to Forecast Flares

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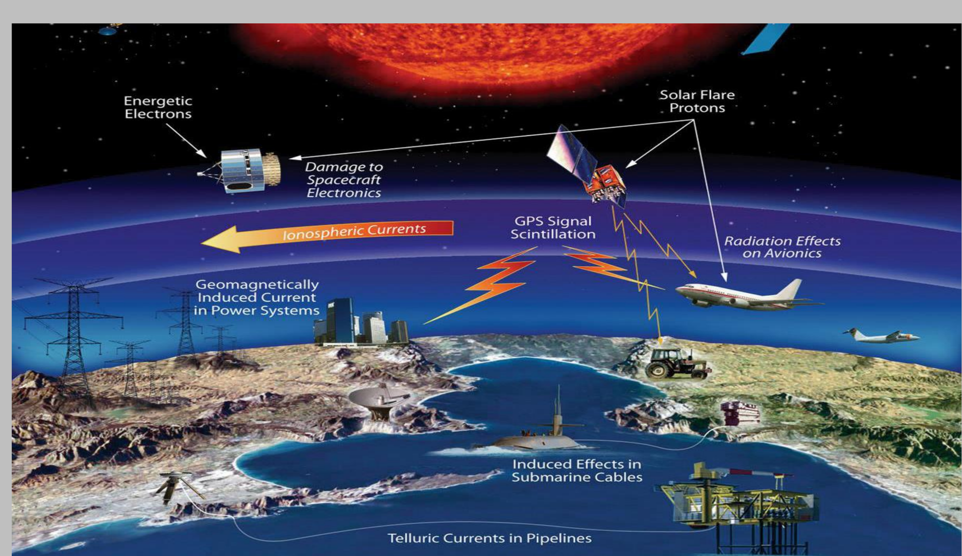
Flare Detection

Solar flares have the capacity to cause significant technological disturbances on Earth. For instance, they may interfere with satellite operations, aviation, navigation, and telecommunications. The effects of flares may impact Earth just minutes after a flare eruption, therefore early detection is essential to space weather forecasting.

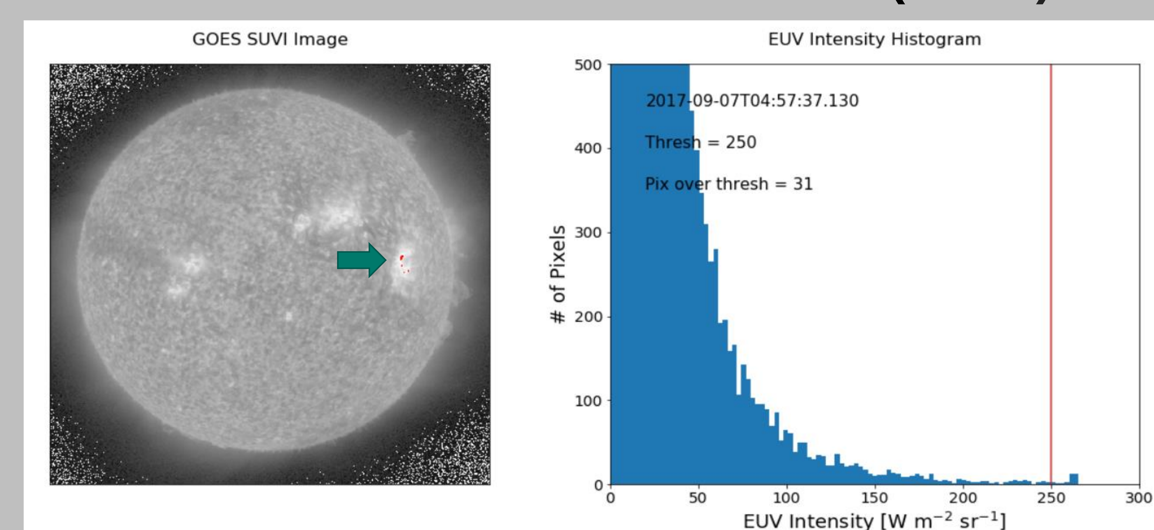
The current detection method used by the NOAA Space Weather Prediction Center (SWPC) requires a continuously increasing X-ray flux for four consecutive minutes that surpasses an alert threshold. After these criteria have been met, SWPC is able to issue a warning to help mitigate hazardous effects.



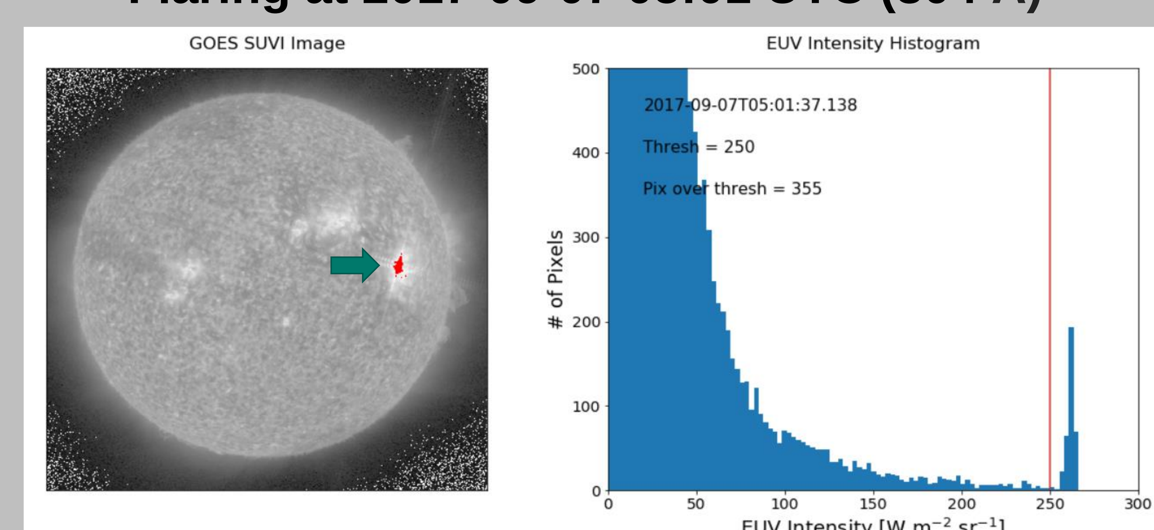
DEFT Method

DEFT creates histograms from images taken by the GOES Solar UltraViolet Imager (SUVI) in six wavelengths. An EUV intensity threshold is set for each of the wavelengths. A significant signal observed above the threshold is indicative of a flare.

No flare at 2017-09-07 04:57 UTC (304 Å)

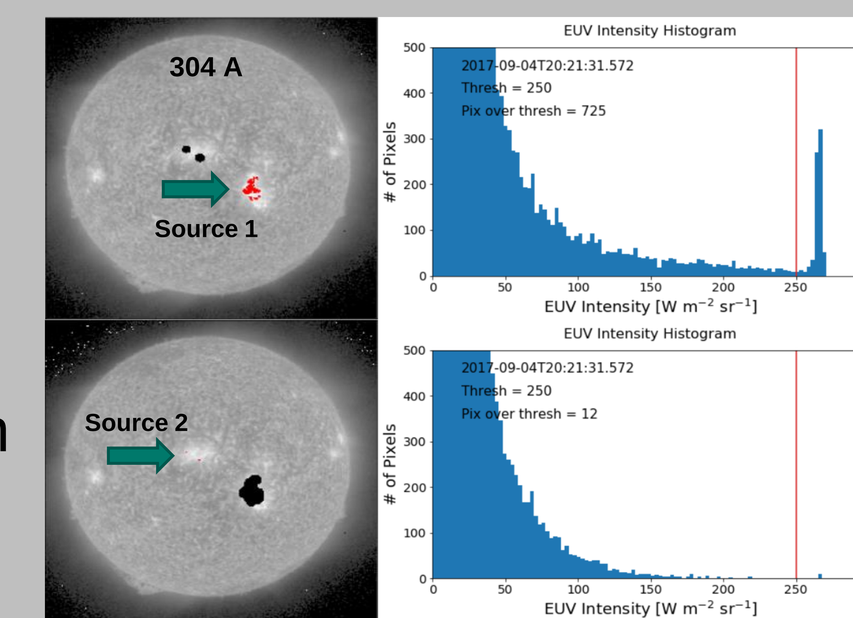


Flaring at 2017-09-07 05:01 UTC (304 Å)



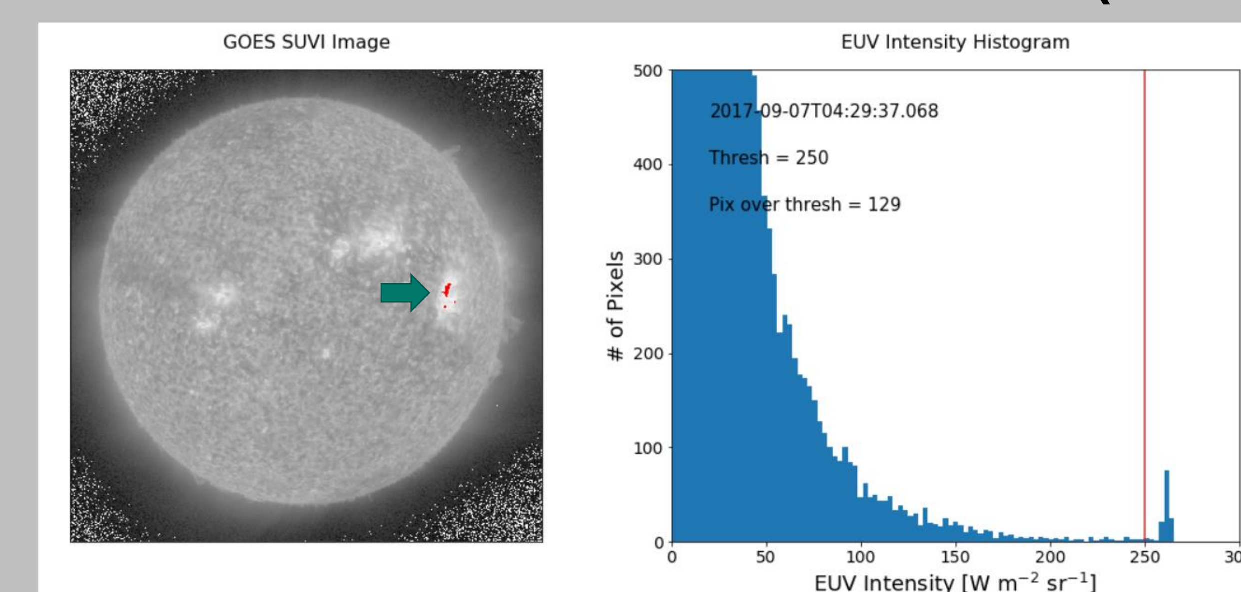
Advantages of DEFT

- Spatial resolution allows the location of a flare to be easily identified
- DEFT can distinguish concurrent EUV signatures



- ***Precursors to flares can be detected***

Precursor Detected at 2017-09-07 04:29 UTC (304 Å)



Results

We determined optimal intensity thresholds for each of the six SUVI wavelengths. The thresholds were applied to 27 flares with a C class magnitude or greater across four active regions. We manually identified flare precursor and main stage flare detection times and then compared them to the earliest time SWPC could have issued an alert. When present, the precursors occurred approximately 30 minutes, on average, before the first signs of a flare could be detected using the current method. The 195 Å and 304 Å wavelengths were identified as the most successful for early flare detection. In the 304 Å wavelength, a precursor signature was found in 74% of the flares and the main stage flare was detected earlier than the current method could 85% of the time. Instances where a flare/precursor was not detected were omitted from the means in the tables on right.

All Wavelengths

Flare Precursor Signatures	C Class (11)	M Class (13)	X Class (3)	All (27)
Mean advantage over SWPC [mins]	-40.83	-26.38	-39.10	-33.82

Main Stage Flare Signatures	C Class (11)	M Class (13)	X Class (3)	All (27)
Mean advantage over SWPC [mins]	-1.46	0.88	-1.50	-0.21

304 Å

304Å Precursor	C Class (11)	M Class (13)	X Class (3)	All (27)
Mean advantage over SWPC [mins]	-44.78	-25.78	-43	-36.05
Success rate of finding precursors	82%	69%	67%	74%

304Å Flare	C Class (11)	M Class (13)	X Class (3)	All (27)
Mean advantage over SWPC [mins]	-2.60	-3.00	-2.33	-2.77
Success rate of beating SWPC's detection time	82%	85%	100%	85%

Future Plans

Ultimate goal: Identify flare and precursor signatures up to or over an **hour in advance** *and* forecast the flare magnitude.

- Expand number of active regions studied
- Apply DEFT to data with no flares and do blind tests
- Determine success rate depending on limb distance
- Investigate flare EUV signature lifetimes
- Automate DEFT

References

Schwenn, R., "Space Weather: The Solar Perspective", *Living Rev. Solar Phys.*, (2006) 3: 2.

Toriumi, S. and Wang, H., "Flare-productive active regions", *Living Rev. Solar Phys.*, (2019) 16: 3.

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