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MAY 5, 2015 SOLAR FLARE DATA ANALYSIS IN SUNPY

Abstract. In this paper was monitored solar flare registered on May 5, 2015. This flare, which peaked at 6:11 pm EDT from a sunspot called Active Region 2339 (AR2339), is classified as an X2.7-class flare. We have performed solar data analysis using the Python/SunPy tool. SunPy was chosen as the principle data analysis environment since it provides easy to use interfaces to the Virtual Solar Observatory (VSO).

Keywords: solar flares, emission measure, reconnection rate, SunPy.

INTRODUCTION

Solar flares are one of the most powerful energetic events in the solar atmosphere. Given their role in the energy balance of the solar corona and their role played in driving space weather, many studies investigated the energy build-up and initiation of flares, concentrating on the events preceding the onset of a flare [1].

Our study uses X-ray flare databases. The flare was collected using the dataset provided by the Geostationary Operational Environmental Satellite (GOES) [2]. GOES flares are classified as A, B, C, M, or X-class, according to their peak flux (W m^{-2}) observed in the 0.1 to 0.8 nm wavelength range. We selected the X-class flares corresponding to a flux in excess of 10^{-4} W m^{-2} at Earth, respectively. The GOES flare lists are available at NGDC/NOAA [3].

This research has made use of SunPy, an open-source and free community-developed solar data analysis package written in Python [4]. Python/SunPy chosen as the principle data analysis environment since it provides easy to use interfaces to the Virtual Solar Observatory (VSO). SunPy is a data analysis toolkit, which provides the necessary software for analyzing solar and heliospheric datasets in Python. SunPy aims to provide a free and open-source alternative to the current standard, an IDL based solar data analysis environment known as SolarSoft (SSW) [5-9].

In this work, we have observed solar flare occurred on May 5, 2015. This flare, which peaked at 6:11 pm EDT on May 5, 2015 from a sunspot called Active Region 2339 (AR2339), is classified as an X2.7-class flare.

SOLAR DATA VISUALIZATION

To find and overplot the location of the brightest pixel, we first created the Map using the FITS data and imported the coordinate functionality. In the Figure 1 shown the brightest pixel location in different wavelengths obtained by Python/SunPy.

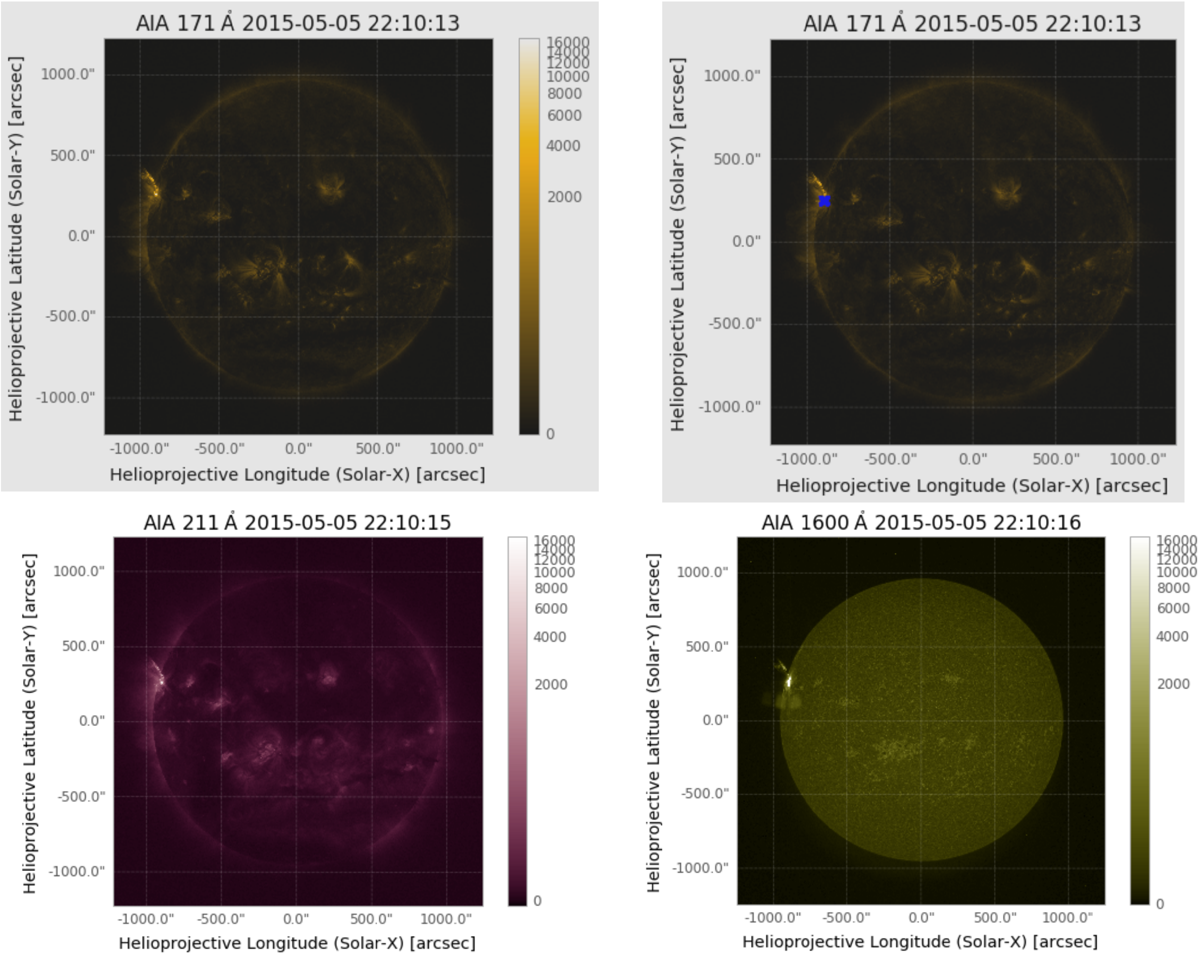

Figure 1 - The brightest pixel location (Active area 2339 in AIA 171 Å, AIA 211 Å and AIA 1600 Å)

To obtain the GOES flare intensity, we first grab GOES XRS data for a particular time of interest that is May 5, 2015. Then the data loaded into a TimeSeries. Next we grab the HEK data for this time from the NOAA Space Weather Prediction Center (SWPC). The Figure 2 shows the total flux of X-rays, which was registered on May 5, 2015.

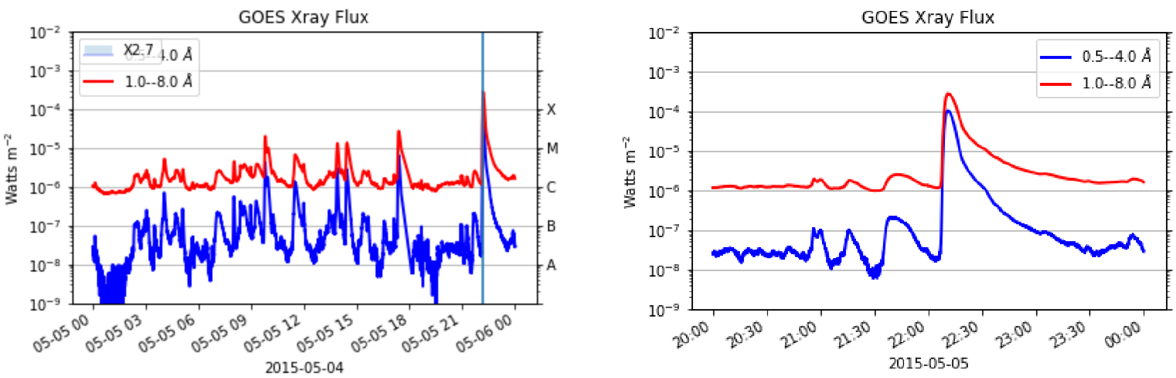

Figure 2 - Total X-ray flux obtained in GOES 13 and GOES 15

To enhance emission above the limb, we first created the Map using the FITS data. Next we build two arrays which include all of the x and y pixel indices. Then we converted this to helioprojective coordinates and created a new array which contains the normalized radial position for each pixel. Next we plot it along with a fit to the data. We fit the logarithm of the intensity since the intensity drops of very quickly as a function of distance from the limb [10-11].

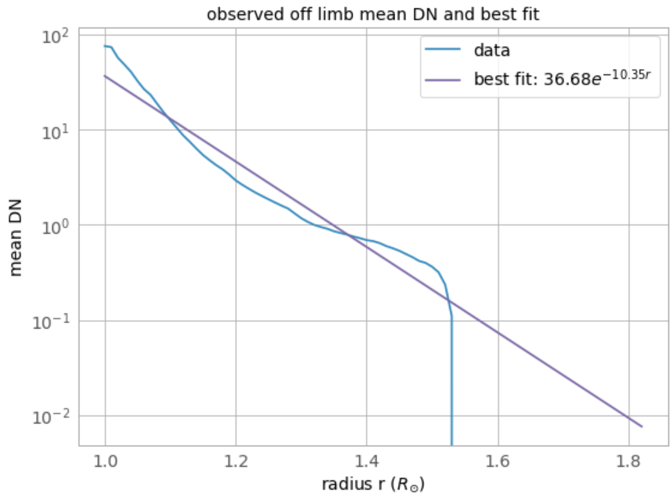

Figure 3 - Observed off limb mean DN and best fit

The National Oceanic and Atmospheric Administration (NOAA) launches and maintains a set of satellites called Geostationary Operational Environmental Satellites (GOES), carrying weather monitoring instruments. Each GOES satellite alsocarries a solar X-ray package (the “X-Ray Sensor”, or XRS) consisting of a collimator that feeds a pair of ion chambers. These ion chambers measure the Sun’s spatially integrated soft X-ray flux in two wavelength bands, 0.5–4 and 1–8Å, with a 3-s cadence. The GOES soft X-ray detectors have provided an essentially uninterrupted monitor of the Sun’s activity for 30 years, and are a valuable resource for the study of past solar activity and the prediction of space weather [12-16].

For quantitative physical understanding of processes in the Sun’s atmosphere, the X-ray fluxes themselves are of limited use. However, they reflect the temperature and emission measure of the plasma that produces the soft X-rays, and these physical quantities are of great importance: from them, the energetics of solar flares and other energy releases can be deduced [17-18].

Corresponding volume emission measure of the solar soft X-ray emitting plasma observed by the GOES/XRS is shown in Fig.4. The volume emission measure were obtained in SunPY using the methods of White et al. [17] who used the CHIANTI atomic physics database to model the response of the ratio of the short (0.5-4 angstrom) to long (1-8 angstrom) channels of the XRSs onboard various GOES satellites.

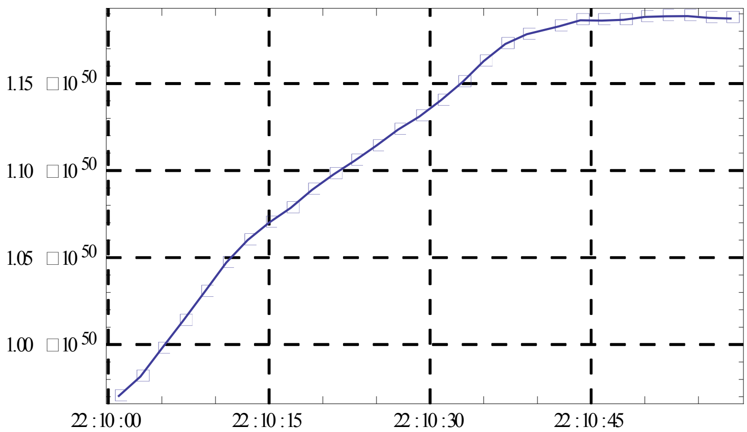

Figure 4 - Obtained emission measure of the solar soft X-ray emitting plasma observed by the GOES/XRS

CONCLUSION

The scientific python community is much more established in other disciplines than it is in solar physics. SunPy is making use of existing scientific python projects, with deeper integration with projects like Astropy and scikit-image possible in the future. Using SunPy package we have obtained the values of temperature and emission measure from a GOESLightCurve. This function calculates the isothermal temperature and corresponding volume emission measure of the solar soft X-ray emitting plasma observed by the GOES/XRS.

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5 МАМЫР, 2015 КҮН ЖАРҚЫЛЫН SUNPY АРҚЫЛЫ ТАЛДАУ

Аннотация. Осы мақалада 2015 жылдың 5 мамырында тіркелген күн жарқылдарының бақылауы жүргізілді. 2339 (AR2339) активті аймақта ШБС сағат бойынша сағат 6:11-де максимум мәнінде X2.7-класс күн жарқылы болып тіркелді. Python/SunPy құралы арқылы күн деректері талданды. SunPy виртуалды күн обсерваториясына (VSO) интерфейстерді пайдалануды жеңілдететіндіктен негізгі деректерді талдау құралы ретінде таңдалды.

Түйін сөздер: күн жарқылы, шығарындылар өлшемі, қайта ұштасу жылдамдығы, SunPy.

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АНАЛИЗ СОЛНЕЧНЫХ ВСПЫШКОВ, ЗАРЕГИСТРИРОВАННЫХ 5 МАЯ 2015 В SUNPY

Аннотация. В этой статье отслеживалась солнечная вспышка, зарегистрированная 5 мая 2015 года. Солнечная вспышка, которая достигла максимума в 6:11 вечера по восточному поясному времени от солнечного пятна, называемого активным регионом 2339 (AR2339), классифицируется как вспышка класса X2.7. Мы проводили анализ солнечных данных с помощью инструмента Python/SunPy. SunPy была выбрана в качестве основной среды анализа данных, поскольку она предоставляет простые в использовании интерфейсы для Виртуальной солнечной обсерватории (VSO).

Ключевые слова: солнечные вспышки, мера эмиссии, скорость пересоединения, SunPy.

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