www.SolarMonitor.org

Michael Tierney, Peter T. Gallagher,
Eoin Carley, David Pérez-Suárez, Paul Higgins

School of Physics, Trinity College Dublin, Ireland , South African National Space Agency - Space Science

What is Solar Monitor?

On a daily basis, the sun releases large amounts of magnetic energy (10^{25} Joules) in the form of X-rays, EUV (Extreme ultra-violet), radio waves and high energy particles. Such activity can be detrimental to space and ground based technological infrastructure. It is for this reason that there is a need to monitor solar activity for any potential threats to earth. The main purpose of Solar Monitor is to provide near real-time information on solar activity and in order to characterise this potential threat. It is accessible to a wide variety of users, ranging from solar physicists to amateur astronomers. It has an easy-to-use layout with many features including active region information, flare forecasting and full solar disk images. The purpose of this project was to improve the flare prediction page in order to allow for a quicker and more intuitive interpretation of flaring probabilities.

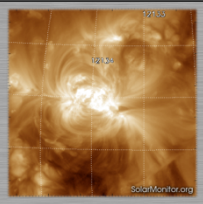

Figure 1 – Magnified image of the active region 12134 as seen from SDO/ AIA 193 Å

Flare Forecasting

Solar Monitor offers its own Flare Prediction System, using a combination of TCD's Poisson-based model[1,2] and **NOAA's** (National Oceanic And Atmospheric Administration) Space Weather Prediction Center data.

Active Regions are given, along with their percentage probability of producing C-,M- or X-Class events in the following 24 hour period. These percentage probabilities are based on the number of flares produced by regions, classified using the McIntosh Classification Scheme[3], during the 21st and 22nd solar cycle.

This data was used to calculate the average number of events expected (μ) in a given time interval. Thus an equation for calculating flare probability (P_μ) in a 24 hour period can be given as follows:

$$P_\mu(N \geq 1) = 1 - e^{-\mu}$$

Mobile Version

The website has been modified for use on smartphones or tablets.

The site can be simply accessed by scanning the QR code below:

Changes

Flare probabilities for C-,M- and X-class flares can now be estimated by eye using the HMI full-disk image on the flare forecasting page. This along with other changes makes it quicker and easier to assess solar activity.

Active Regions, Sunspots and Flares

The surface of the Sun is not quiescent and uniform but is in fact dotted with **Active Regions (AR) - Fig. 1**. An active region is a region of the sun with very strong magnetic fields. These fields can prevent the normal convective processes on the solar surface leading to regions with lower than average temperatures. These features are called **Sunspots.** These sunspot systems can be very complex and sometimes the AR associated with them can give rise to events called **Solar Flares.** A solar flare is a sudden release of magnetic energy (10^{25} J) in the form of a broad spectrum of electromagnetic radiation (Gamma rays to Radio waves). Flares are classified into a A, B, C, M, X scale based off the peak flux of X-rays produced by the flare. X-class flares are the most energetic.

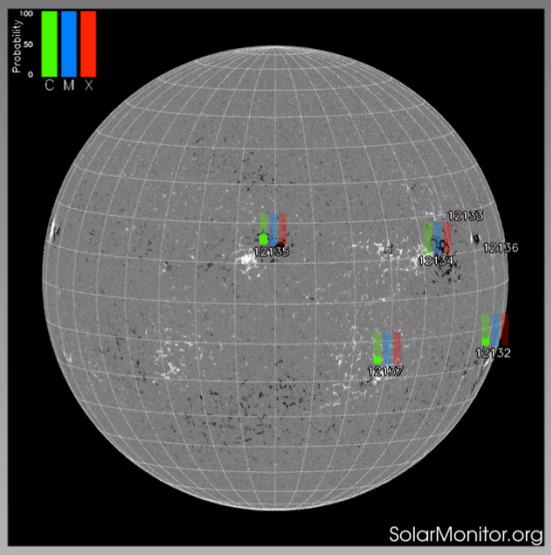

Figure 3 – HMI magnetogram with flare probabilities. Measures the strength of the magnetic field. Black and white are opposite polarity. Grid shows latitude and longitude. Numbers are NOAA tags for active regions.

Region Flare Probabilities (%)

NOAA Number	McIntosh Class	C-class		M-class		X-class	
		SolMon	NOAA	SolMon	NOAA	SolMon	NOAA
12127	Dso	30	30	7	5	1	1
12130	Fac	...	70	...	20	...	5
12131	Hsx	5	15	3	1	0	1
12132	Eai	71	60	29	15	1	5
12133	Hrx	6	5	1	1	0	1
12134	Dso	30	45	7	10	1	1

Figure 4 – Region Flare Probabilities Table. NOAA number refers to a particular active region. McIntosh class is the sunspot classification.

New Active Region Table

This table (**Fig. 6**) contains the properties of each active region. These properties are extracted from the Solar Region Summary for the current and previous date – **Today** / Yesterday

Recent Flares provides information on the type, magnitude, start time and the number of the flares that have occurred in an active region. By clicking on one of the flares, you are brought to a new page which contains more information about the flare. Light blue implies that the event occurred yesterday.

Today's/ Yesterday's **NOAA Active Regions**

NOAA Number	Latest Position	Hale Class	McIntosh Class	Sunspot Area [millionths]	Number of Spots	Recent Flares
12132	S19W83 (888",-318")	β/β	Cao/Eao	0060/0180	07/16	C1.3(08:59) / -
12134	N08W45 (664",56")	α/β	Axx/Bxo	0010/0010	02/15	-
12135	N12W00 (0",92")	β/βγ	Dso/Dso	0220/0240	10/15	-
12137	S19W31 (462",-393")	β/α	Cao/Hrx	0030/0010	05/03	- / C1.6(21:29)
12133	N18W60 (781",240")	/	/	/	/	-
12136	N08W79 (920",110")	/α	/Axx	/0010	/01	-

Class (HH:MM) -Today
Class (HH:MM) -Yesterday

Events not associated with currently named NOAA regions: None

Figure 6 – Active Region Table. The latest position is given in heliocentric (earth equatorial) and heliographic co-ordinates. "/" entries indicate that there are no sunspots associated with the region.

Solar Monitor Images

Solar Monitor takes data from a range of instruments including

AIA : Atmospheric Imaging Assembly (Flux)

HMI : Helioseismic and Magnetic Imager (B field strength and polarity)

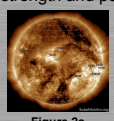

Figure 2a AIA Full-disk

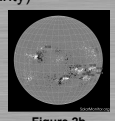

Figure 2b HMI Full-disk

New Forecast Page

The full disk HMI magnetogram shown in **Fig. 3** was produced using **IDL.** The flare probabilities were calculated using NOAA McIntosh class data and then used to generate bar-charts. These bar-charts were over-plotted using the **Coyote Graphics**[4] library for IDL.

C-Class Flare Probability

M-Class Flare Probability

X-Class Flare Probability

Zoomed images like the one shown in **Fig. 5** are accessed by clicking on the active regions present on the full disk image.

Numerical probabilities are shown in the Region Flare Probabilities table (**Fig. 4**). Both the Solar Monitor (TCD Poisson method) and the NOAA probabilities are clearly shown in bisected columns.

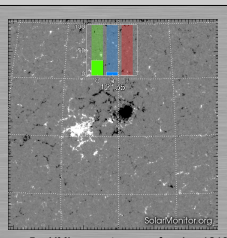

Figure 5 – HMI magnetogram of region 12135 showing associated flare probabilities

1. Gallagher, P. T., Moon, Y. -J., Wang, H., Solar Physics, 209, 171, (2002).
2. Bloomfield et al., 2012, The Astrophysical Journal Letters, 747, L41
3. McIntosh, P., 1990, *Solar Physics*, 125, 251
4. http://www.idlcoyote.com , David W Fanning.