SHARPs: A New Near Real-Time Space Weather Data Product from the Solar Dynamics Observatory (SH43B-2171)

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A data product from the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO), called Spaceweather HMI Active Region Patches (SHARPs), is now available through the SDO Joint Science Operations Center (JSOC) and the Virtual Solar Observatory. SHARPs are magnetically active regions identified on the solar disk and tracked automatically in time. SHARP data are processed within a few hours of the observation time.

The SHARP data series contains active region-sized disambiguated vector magnetic field data in both Lambert Cylindrical Equal-Area and CCD coordinates on a 12 minute cadence. The series also provides simultaneous HMI maps of the line-of-sight magnetic field, continuum intensity, and velocity on the same ~0.5 arc-second pixel grid. In addition, the SHARP data series provides spaceweather quantities computed on the inverted, disambiguated, and remapped data. The values for each tracked region are computed and updated in near real time. We present spaceweather results for several X-class flares.

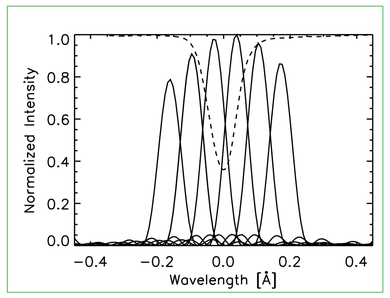
Motivation

[1] It is believed that parameterizations of the photospheric magnetic field can be correlated with solar activity (Falconer et al., 2002 ; Leka and Barnes, 2003a and 2003b; Schrijver 2007; Mason and Hoeksema, 2010).

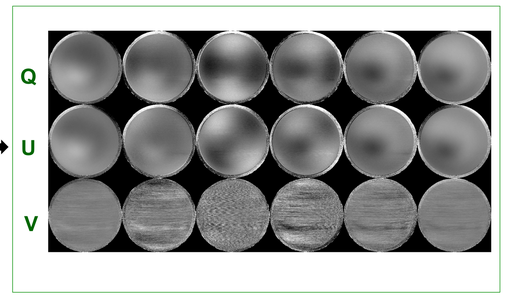
[2] It is challenging to collect, store, track, and analyze full-disk vector magnetograms when generally only a small portion of the visible disk, the active regions, produce events.

Section 1: Creating SHARPs

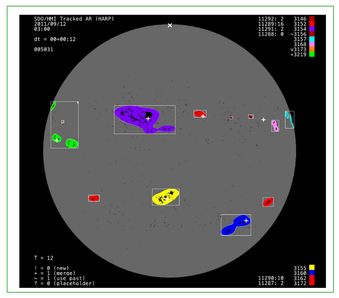
SHARP stands for Spaceweather HMI Active Region Patch. A SHARP is a data product that contains (1) various spaceweather quantities calculated from the photospheric vector magnetogram data and stored as FITS header keywords, and (2) 31 data types, including each component of the vector magnetic field, the line-of-sight magnetic field, continuum intensity, doppler velocity, error maps, and bitmaps. The data segments are partial-disk, automatically-identified active region patches. SHARPs are calculated every 12 minutes.



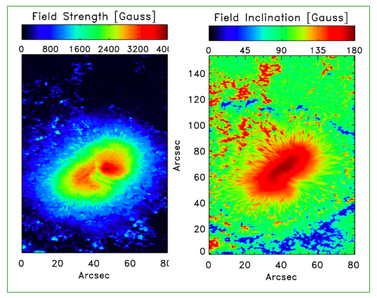
Step 1: In one 720-second interval, HMI samples 6 points across the baseline spectral line of 6173.3 Å, measures 6 polarization states (I, Q, U, V, LCP (I-V), and RCP (I+V)) per line, and takes 6 filtergrams per polarization state, for a total of 216 filtergrams.



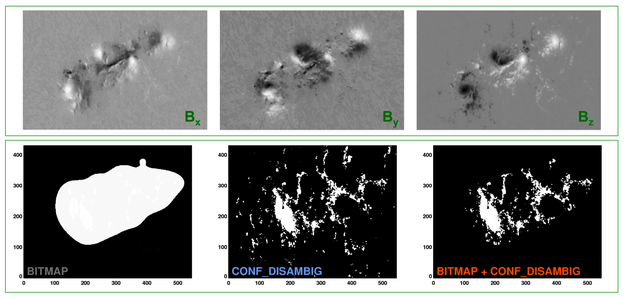
Step 2: The 6 filtergrams per unique combination of polarization state and wavelength are corrected for solar rotation and then temporally averaged to a target (or observation) time. A polarization calibration is applied to reduce these intermediate data product into the four Stokes polarization states (I, Q, U, and V) per wavelength (Schou et al., 2010).



Step 3: Active regions are automatically detected in the photospheric line-of-sight magnetograms, separate data from the vector magnetograms. These HMI Active Region Patches (HARPs) are tracked as they cross the face of the disk. Courtesy M. Turmon (see SH13A-2246).



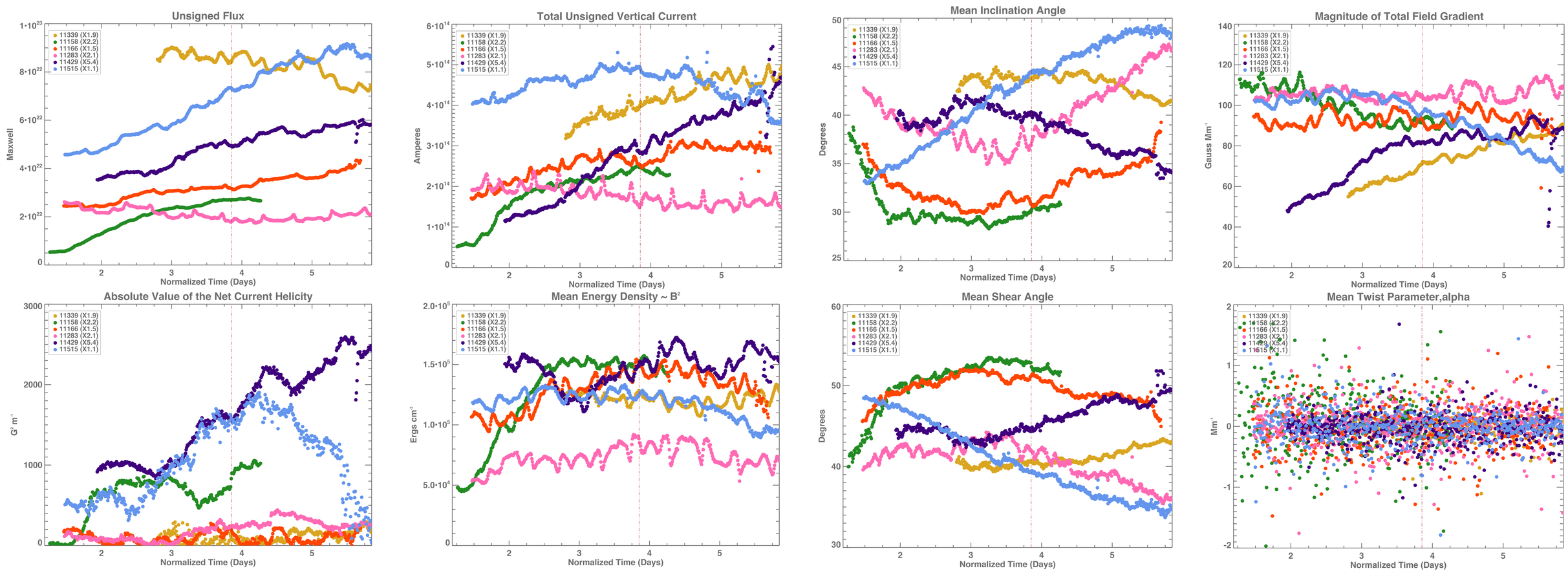
Step 4: The 24 I, Q, U, and V data from Step 2 are inverted only in the HARP patch by using the Very Fast Inversion of the Stokes Vector (VFISV) code, which assumes a Milne-Eddington model of the solar atmosphere, to yield the vector magnetogram data (Borrero et al, 2010).



Step 5: Using various methods to resolve the 180º ambiguity, the inverted vector data are disambiguated to yield the vector magnetic field components (Metcalf, 1994; Leka, K.D. et al. 2009). The data arrays containing each of these components are then reprojected using the Lambert Cylindrical Equal-Area projection and the vector **B** is decomposed into Cartesian coordinates. SHARP quantities are calculated on the pixels within the smooth bounding curve above a certain threshold (bottom right panel).

Section 2: SHARP Results

The HARP analysis code (Step 3, Section 1) outputs a rectangular (in CCD coordinates) bounding box, which contains a smooth bounding curve, as a bitmap file. The bounding box is defined as a HARP; the area within the bounding curve is defined as an active region. There are two kinds of SHARPS: (i) near-real time SHARPS and (ii) definitive SHARPs. Near-real time HARPs are calculated as soon as possible; in this case, the heliographic bounding box for the active region can change from one instant in time to another. Definitive SHARPs are defined only after an active region has crossed the face of the disk or 5 days after an active region disappears (whichever comes first); in this case, the heliographic coordinates enclosed by the bounding box for the active region are constant over time. Spaceweather parameters are calculated on each disambiguated and remapped vector magnetogram using only pixels that are both (1) within the smooth bounding curve, and (2) pixels above the noise threshold (determined by a non-linear noise mask as a function of radius). When necessary, a potential field is calculated using Green's functions and a monopole depth of 0.00001 pixels. Below are plots of spaceweather quantities calculated on several NOAA Active Regions that produced X-class flares. The flare peak is indicated in the plots by a red dashed vertical line. The plots are normalized to the GOES X-Ray flux peak time and span a period of five days. More plots and information on SHARP data can be found at http://jsoc.stanford.edu/doc/data/hmi/sharp/sharp.htm and SDO/HMI data are available at http://jsoc.stanford.edu/ajax/lookdata.html.



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Conclusion and Future Work

Based on the SHARP parameters, we see that (1) HMI has a clear overall advantage of not only spatial but also temporal resolution, (2) HMI vector magnetic field data are of high quality and useful for the purpose of calculating space weather parameters, (3) the signed spaceweather parameters are the most noisy, and (4) it is unclear which spaceweather quantities are useful for prediction.

At the moment, on-demand plots of data are available on the JSOC website. Future works includes: (1) creating a special spaceweather page for constantly-updating near real-time plots of space weather quantities, (2) determining which space weather parameters should be included in the SHARP dataset, and, once a significant sample has been established, (3) developing thresholds that flag potentially flaring active regions.