https://ntrs.nasa.gov/search.jsp?R=20160007447 2019-08-31T02:46:24+00:00Z

Analysis of an Anemone-Type Eruption in an On-Disk Coronal Hole

Mitzi Adams[1], Allyn Tennant[1], Caroline Alexander[1], Alphonse Sterling[1], Ronald Moore[2], Robert Woolley[3]

1. NASA/MSFC, Huntsville, AL; 2. University of Alabama in Huntsville, AL; 3. BASIS Chandler, Phoenix, AZ

We report on an eruption seen in a very small coronal hole (about 120" across), beginning at approximately 19:00 UT on March 3, 2016. The event was initially observed by an amateur astronomer (RW) in an H-alpha movie from the Global Oscillation Network Group (GONG); the eruption attracted the attention of the observer because there was no nearby active region. To examine the region in detail, we use data from the Solar Dynamics Observatory (SDO), provided by the Atmospheric Imaging Assembly (AIA) in wavelengths 193 Å, 304 Å, and 94 Å, and the Helioseismic and Magnetic Imager (HMI). Data analysis and calibration activities such as scaling, rotation so that north is up, and removal of solar rotation are accomplished with SunPy. The eruption in low-cadence HMI data begins with the appearance of a bipole in the location of the coronal hole, followed by (apparent) expansion outwards when the intensity of the AIA wavelengths brighten; as the event proceeds, the coronal hole disappears. From high-cadence data, we will present results on the magnetic evolution of this structure, how it is related to intensity brightenings seen in the various SDO/AIA wavelengths, and how this event compares with the standard-anemone picture.

Sunpy, as a data analysis tool, offers many advantages including: 1. Sunpy data cubes are powerful and useful since they include data and header, 2. the default plots have the correct color table and units (arcsec), 3. the Python language is becoming more of a standard in astrophysics and other fields, 4. no dollar cost.

From start to finish, data were analyzed using python and sunpy. Problems encountered included:
1. Too many open files
2. When animating a cube, the color bar "bounces" due to different scaling of each image.
3. Position of plt.grid is important, if plt.grid appears after a derotation line,many errors are displayed on the terminal and no plot appears.
4. When plotting a Sunpy data cube, the title appears twice.
5. When plotting an image (ipython), as long as plot window is up, the command line is not available.
6. Removing the title for animated plots (with intent to use something else).

Fixes:
1. This issue is caused by astropy defaulting to using memory mapping to access FITS files. Thus if you open a FITS file, read the data into an array, and close the file, the system does not actually read the data from disk into memory but just points to where the data are stored on disk. Thus, the system keeps the file open for the lifetime of the array. Currently Sunpy does not provide a means to override this default. An ugly solution is to increase the number of files that the system can open. Another almost as ugly solution is to modify the sunpy/io/fits.py source code (as shown below), adding the "memmap=False" parameter to the fits.open call.
   Under Linux, go to location of installed version of sunpy/io directory, e.g.,
   /usr/local/lib/python2.7/site-packages/sunpy/io
   Copy fits.py --> mv fits.py to fits.sav
   Make this change to the line that opens the FITS file::
   hdulist = fits.open(filepath, memmap=False)

2. Sunpy provides no way to set the plotting min and max values for the entire cube. However, it is possible to manually set the norm for each frame of the animation. Since we did not find this to be obvious we list the actual code that does this here:
   norm=colors.Normalize(vmin=-1000,vmax=1000)
   for i in range(len(derotated)):
      derotated[i].plot_settings['norm']=norm

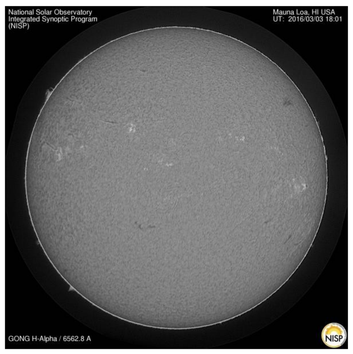
3. Commands to modify the plot sometimes need to occur before the plot function and sometimes after. This may be obvious to experienced matplotlib/sunpy users, but not to new ones. Our suggestion is, if it doesn't work after, try positioning the command before the plot. Here's an example:
   plt.grid(b=False)
   mp4=derotated.plot(interval=100)
   plt.colorbar()
   plt.show()

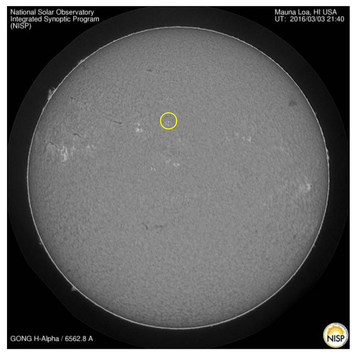
4. When plotting an animated data cube, you can set annotate=False which removes this title. (Alas, this also gets rid of the X and Y labels, but since these never change, these can be easily added back via:
   mp4=derotated.plot(interval=50,annotate=False)
   plt.xlabel('X-position [arcsec]')
   plt.ylabel('Y-position [arcsec]')

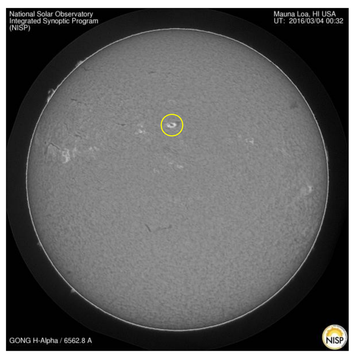
5 The matplotlib default is to wait after each plot. To change the default just type "pylab" at the ipython prompt.

6. This fix is a part of number four:
   plt.xlabel('X-position [arcsec]')
   plt.ylabel('Y-position [arcsec]')
   mp4=derotated.plot(interval=100,annotate=False)
   plt.title('SDO Composite Plot ')
   plt.colorbar()
   plt.show()

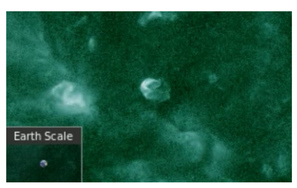
DISCOVERY

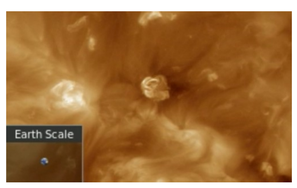


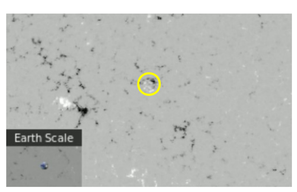


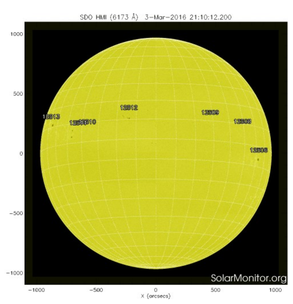


Searching for Data

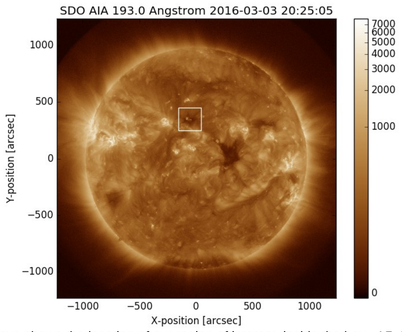






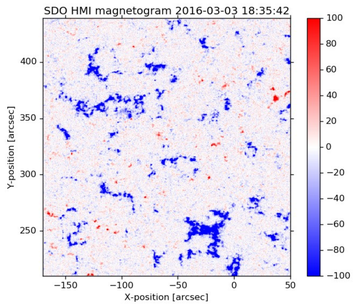


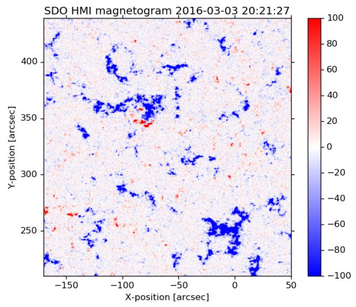
Event seen in AIA 94, 171, 193, 211, and HMI, but no spots.

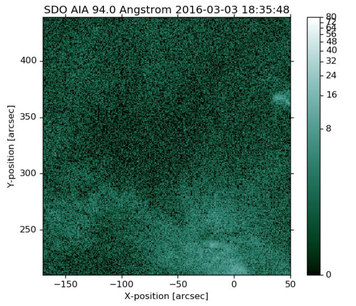


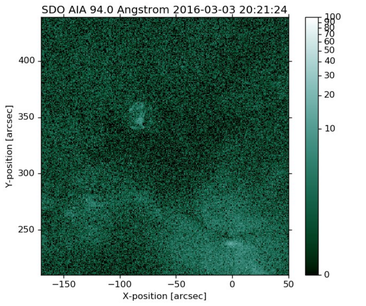
The image above shows the location of our region of interest, inside the box. AR 12512 is to the east.

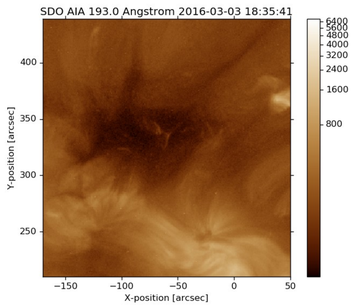
Event began at 18:44 UT in HMI (time estimated from movie)

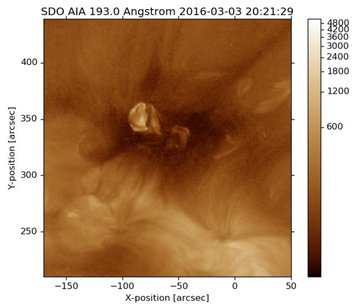


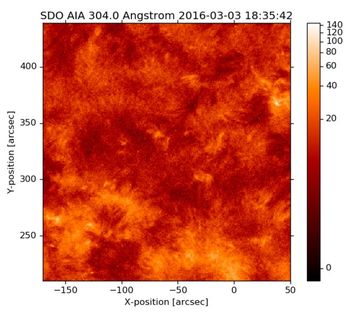


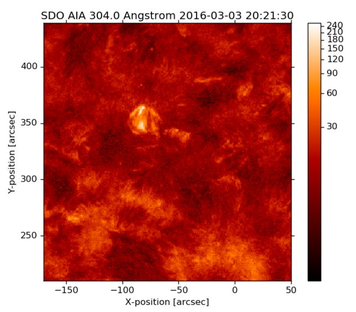


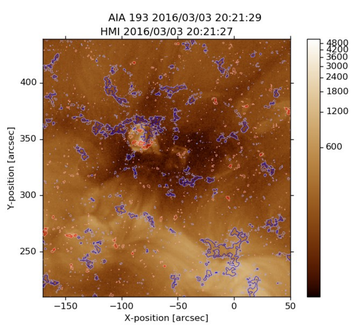


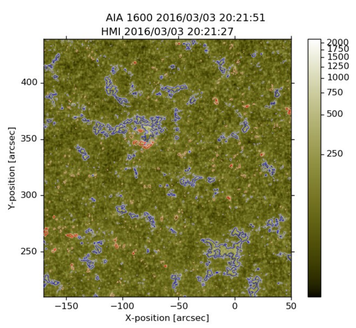




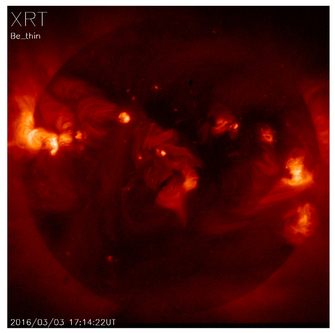


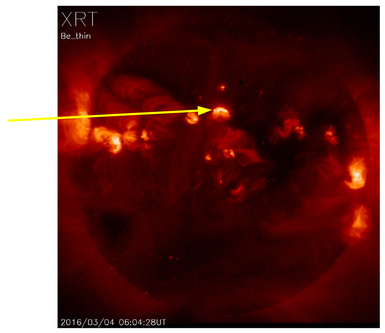




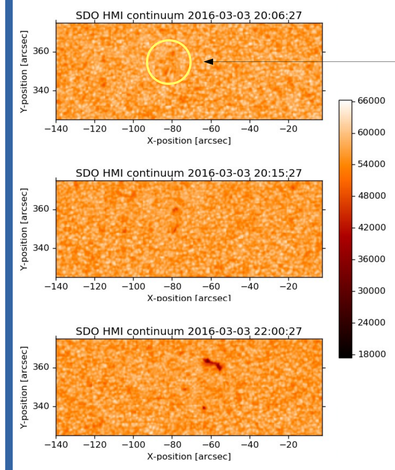


The Event was Also Seen in Hinode/XRT

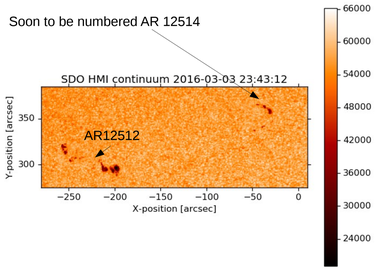




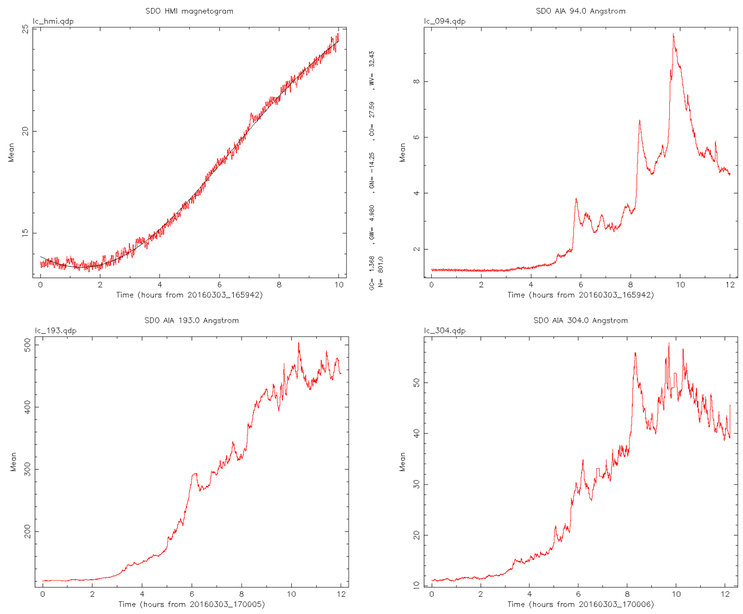
Using http://solarmonitor.org, on March 4 at 20:58, AR 12512 was seen on the central meridian. Sunspots were visible to the west of AR 12512 at the location of our region, where there were none the day before. NOAA had numbered the region AR 12514 by March 5 at 21:10. By March 8 when AR 12514 was close to the limb, no spots were visible.



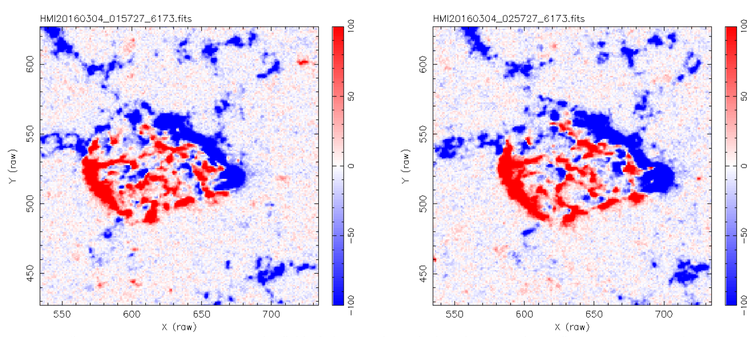
First appearance of a pore in HMI continuum, at 20:06:27 UT



Above is a larger field-of-view, showing AR 12512 to the east of our region of interest, which is highlighted in the three images to the left showing the development of spots. Solar rotation has not been removed in these images.



The light curves above help identify the beginning of the flux emergence and show times of brightening in various wavelengths.



These magnetograms represent the field-of-view used to calculate the approximate flux emergence rate between 19:00:27 and 19:10:12, which is 7.86 x 10^{15} Mx/s

Summary/Results:

1. The flux-emergence rate over ten minutes was 7.86 x 10^{15} Mx/s.
In contrast, From Vemareddy, et al. (2015) the rate of positive flux emergence over four days from NOAA 11158, a region that produced a X.2 flare, was 4.4 x 10^{16} Mx/s, suggesting that for larger regions, the flux rate will be higher.

2. The magnetic "bubble" increased in size from approximately 20" x 20" to 40" x 40" from 2016 03/03 18:44 UT to 2016 03/04 02:55, 8 hours 11 minutes.

3. Flux emergence begins between 17:30 UT and 18:44 UT, followed by brightening in AIA 304 (~19:12 UT), 193 (~19:30 UT), and 94 (~20:00 UT) Angstroms.

4. This work is a preliminary analysis of flux emergence and development of an active region in a unipolar, open-magnetic-field environment.

References: Vemareddy, P., Venkatakrishnan, S., Karthikreddy, S., *Flux Emergence in the Solar Active Region NOAA 11158: The Evolution of Net Current*, arXiv:1502.05458 [astro-ph.SR], 2015.