SDO/HMI Time-Distance Helioseismic Far-side Images

Overview

The far-side images presented on this webpage, as well as the FITS files downloadable from JSOC pages, are made based on the codes and analysis processes described in this paper: Zhao, J. et al. 2019, ApJ, 887, 216 (https://ui.adsabs.harvard.edu/abs/2019ApJ...887..216Z)

Users of the far-side imaging results are suggested to either refer to this paper, or consult Dr. Junwei Zhao (junwei AT sun.stanford.edu), the preparer of this document and the webpage, for questions or more details of the imaging technique and/or the scientific scopes of these far-side images.

The time-distance far-side images are made using 31-hr (not 24-hr as some users assume) HMI continuous low-resolution Dopplergrams, centered at 00:00 UT and 12:00 UT of each day. The solar B-angle is not considered when making the far-side image computations, i.e., if the solar equator at the near-side central meridian is $\theta^\circ$ below the disk center, the equator crosses the far-side central meridian at $\theta^\circ$ above the far-side image center.

Data averaging and Background Removal

One far-side image, obtained from 14 different sets of measurement schemes, often does not have a quality sufficiently high to warrant its use in far-side modeling. Therefore, we overlap one far-side image with 7 of its prior images (i.e., a total of 4 days and 8 images) to further averaging the images. Considering the Sun’s rotation, the number of overlapping times is different for the fraction near the far-side west limb, and this results in that for the west-most longitudes of 45° or so, the closer to the west limb, the shorter the averaging window, and the poorer the data quality. The rest ~135° of the image is averaged over the same averaging windows, but its quality is often different due to that different parts of the far side are made using different measurement schemes (refer to above-mentioned paper), hence different helioseismic modes. The images shown in this webpage and the FITS data that are accessible through JSOC are both 4-day overlapped images, instead of instantaneous images obtained from 31-hr observations. However, one can contact the authors if instantaneous images are needed in their research.

What the far-side images display are acoustic travel times, whose variations are highly correlated with the Sun’s magnetic activity; therefore, the mean travel-times shown in our raw far-side images vary substantially with the solar cycle. For the results displayed here, we remove from each far-side image a background image, which is obtained by averaging 90-days images (180 separate images) prior to the present image. This practice helps making far-side active regions appear uniform through the whole solar cycles, and easily stand out from quiet regions; however, one also needs to keep in mind that this process makes transforming acoustic signals to magnetic signals (e.g., through machine learning or through statistical studies) more complicated.

Webpage

To facilitate the use of our results for different research purposes, the far-side images, together with the HMI near-side magnetograms, are displayed in two different formats on this webpage -- synchronic image and two-hemisphere image, examples of which are shown below. Either format has still images (in jpeg format) of near-real-time or videos of last 30 days (in mp4
Note that the far-side images for the most recent 5 days are calculated using HMI’s uncalibrated NRT (near-real-time) data for a quick look purpose, although from our experiences, they are of similar quality to the calibrated data. The NRT images are then replaced with the calibrated images once they become available.

Figure 1. Examples of synchronic image (left) and two-hemisphere image (right), composing of far-side helioseismic images (reddish color) showing acoustic travel-time shifts and near-side magnetic field (grey background with red-green color). Dark patches in the far-side images often represent active regions.

Past Images

Only the most recent image (or video) is displayed on the website, and all the past images (since May 2010 when SDO/HMI was commissioned) are available by clicking the button “Past Images” on the webpage. The past images are organized into years and months, and then into the two display formats: “synch” and “two_hemi”. Once again, the images of 5 most recent days are “NRT” results and would be replaced once the calibrated results become available.

These past images are directly downloadable from our web server.

FITS Data Access

The FITS files for the far-side images, with 4-day overlapping instead of instantaneous images, are available for downloading through JSOC page with a series name: hmi.td_fsi_12h. Note that we do not archive the NRT data for downloading.

The FITS data are of a dimension of 225×121, covering 180° in far-side longitude and 120° in latitude. While the longitude grids are uniform with a size of 0.8° pixel$^{-1}$, the latitude is uniform in sine from $-\sin(60^\circ)$ to $+\sin(60^\circ)$. One also needs to note that, as already pointed out at the beginning of this document, the far-side center is the antipode of the near-side disk center, regardless of the solar $B$-angle or the Carrington longitude of the near-side central meridian. Therefore, the FITS data is saved as the image shown below. Note that the same dataset used to make Figure 2 is also used to make the synchronic and two-hemisphere images shown in Figure 1 after coordinate transform. The key information for these images, such as the solar $B$-
angle and the Carrington longitude of the near-side central meridian, can be found in the FITS files’ header keywords.

Figure 2. An example far-side image showing how the FITS file from the JSOC page looks like. The same data is also used to make Figure 1 after coordinate transform. Note that the longitude and \( \sin(\text{latitude}) \) in this image are apparent coordinate instead of the Carrington coordinate.