User Guide for Parker Solar Probe / WISPR Investigation Data Products

Version 2 — October 5, 2020

Version 3 -- November 30, 2020

This document is developed and updated by the Wide Field Imager for Solar Probe (WISPR) team to provide a reference guide for users of WISPR data. This is a “living document” that will be updated as necessary, such as when new data products are developed.

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1. Introduction

1.1 Overview of WISPR

The WISPR instrument aboard the Parker Solar Probe spacecraft is a heliospheric imager of the type flown on the STEREO mission with the SECCHI instrument. WISPR was designed to take images of the solar corona with two telescopes, called WISPR-I (inner) and WISPR-O (outer). These telescopes have square fields of view (FOV), 40º on a side and 58º on a side, respectively.

The sunward edge of the inner telescope is at 13.5° from Sun center, so that the outer edge of WISPR is 108.5°, accounting for the 3° overlap of the two FOVs.

The passband is visible light, WISPR-I: 490-740 nm, WISPR-O: 475–725 nm. The primary signal is the F-corona, which is formed by the scattering of photospheric light by the interplanetary dust in orbit about the Sun. The secondary signal is the K-corona, which is the scattering of photospheric light by the free electrons flowing out from the Sun in the solar wind. Additional sources are the planets, comets and asteroids in the solar system, and also the galactic sources of stars, the milky way, etc.

We have stated the WISPR FOV as being from Sun center, but, actually, it is from the pointing vector of the PSP S/C. When PSP is within 0.25 AU, it is always pointed at the Sun center. When PSP is beyond ~0.75 AU it points off the Sun center to allow sunlight to heat the radiator panels. Between 0.25 and 0.75, it may offpoint to allow the HGA to point to Earth to dump the data. Thus, WISPR observations are definitely regular within 0.25 AU and less regular beyond.

The prime mission of Parker Solar Probe is to take data when within 0.25 AU of the Sun during its orbit. However, there has been some extended campaign outside of this distance. The data are available for those days that are within 0.25 AU as well as those days when the instruments were operational outside of 0.25 AU.

1.2 Data Providers and contact information

The WISPR team develops the observing program and prepares the resulting commands from the Naval Research Laboratory in Washington, DC. US Co-Investigators at the NRL, Johns Hopkins University Applied Physics Lab in Laurel, MD, the Jet Propulsion Lab in Pasadena, CA, and the NASA Goddard Spaceflight Center in Greenbelt, MD meet weekly to discuss and develop the observing program for each orbit.

Questions regarding the use or interpretation of these data may be directed to the individuals listed below.

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1.3 Data Use Policy

The WISPR data are made available freely and without restrictions to all parties and for all purposes. This is fully consistent with NASA's open data policy.

As part of the development of collaboration with the broader Heliophysics community, however, the PSP mission has drafted a "Rules of the Road" to govern how PSP instrument data should be used (https://sppgway.jhuapl.edu/psp_data_policy).

It is requested that scientists adhere to the following guidelines:

1. The PI shall make all scientific data products available to the public, as stated in the PSP Science Data Management Plan (https://sppgway.jhuapl.edu/docs/data/7434-9101_Rev_A.pdf).
2. Users should consult with the PI to discuss the appropriate use of instrument data or model results and to ensure that the Users are accessing the most recent available versions of the data and analysis routines. Instrument team SOCs and/or VOs should facilitate this process, serving as the contact point between PI and users in most cases.
3. Users should heed the caveats of investigators to the interpretation and limitations of data or model results. Investigators supplying data or models may insist that such caveats be published. Data and model version numbers should also be specified.
4. Browse products, Quicklook and Planning data are not intended for science analysis or publication and should not be used for those purposes without consent of the PI.
5. Users should acknowledge the sources of data used in all publications, presentations, and reports.

   " We acknowledge the NASA Parker Solar Probe Mission and [instrument name] team led by [PI Name] for use of data." [FIELDS: S. D. Bale, IS⊙IS: D. J. McComas, SWEAP: J. Kasper, WISPR: R. A. Howard]

6. Users are encouraged to provide the PI a copy of each manuscript that uses the PI's data prior to submission of that manuscript for consideration of publication. On publication the citation should be transmitted to the PI and any other providers of data.

1.4 File naming conventions and glossary

All WISPR image data are in the FITS file format and are named according to the following convention:

psp_LX_wispr_YYYYMMDDTHHMMSS_VX_WXYZ.fits

where
LX is the file level (L1, L2 L3),
YYYYMMDD is the year, month and day,
T separates the date and time,
HHMMSS is the time in hours, minutes and seconds
VX is the file release version (V1, V2, etc.) see Section 1.5
WXYZ are parameters that describe the type of image

- W is 1 or 2 to indicate whether the image is WISPR-I or WISPR-O, respectively
- XY are digits that identify the camera readout microcode used to control the camera
- Z is an indication of the camera microcode region [0…6] and is 1 or 2 for synoptic images

1.5 Revision Management

The data product version number (VX in the FITS file name) indicates how many times the product has been generated. Modifications to processing software, changes to calibration or other input files, and header (metadata) changes are all examples that would cause the version number to increase. Data entry errors, transmission problems or other types of failures may also cause a product to be re-released and thus have the data product version number incremented. The data product version is tracked by the VERSION keyword in the FITS header and also indicated in the filename. Version zero (V0) in the filename indicates a quicklook data product; it's VERSION number in the header may increment but the quicklook filename will not change.

1.6 FITS Header definitions

The FITS image file contains an ASCII header followed by the binary image data. The header consists of keywords followed by the value. The following table defines all the WISPR keywords. The table has 6 columns: KEYWORD, TYPE, VALUES, DESCRIPTION, SOURCE, and L-1?:

KEYWORD gives the name of the FITS keyword and may be up to 8 characters.
TYPE refers to the data type of the header value:

- S String (max 68 chars)
- I Integer
- R Real

L Logical (ASCII char, T or F)

The size of the data depends upon the data type. For example S*2 is a 2 character string, whereas I*2 is a 2 byte integer (16 bits).

VALUES: shows the range of values that the KEYWORD can take.

DESCRIPTION: gives a short description of the keyword.

SOURCE: gives information about where the keyword value comes from.

L-1?: Has an X if the keyword is NOT included in the Level-1 header

1.7 FITS Keyword Definition Table

The source for the FITS keyword definitions is an internal NRL document SSD-DOC-WISPR-029.doc.

Keyword	**Type**	**Values**	**Description**	**Source**	**L1?**
APID	S*3		Hex string Application ID for the telemetry from which this image is generated	Basehdr.appid	
BITPIX	I*2	16, 32, -32, -64	Number of bits per pixel (negative is floating point)	FITS	
BLANK		Zero or NaN	Value marking undefined pixels; 0 for integer, NaN for floating point	Constant	
BSCALE	R*4	Any	Ratio of physical to array value at 0 offset	Constant	
BUNIT	S	varies	Unit of physical value, varies with data Level	Definition	
BZERO	R*4	Any	Physical value for the array value 0	Derived	
CAMERA	S*5	Any	<CC Version><DIB Version>	Basehdr.pproicam	
CAMSATPX	I*4		Pixels above saturation level	Basehdr.ppsatpixels	
CAMSTRVX	I*4		Pixels below saturation level	Basehdr.ppstarvepixels	
CAR_ROT	I*2		Carrington Rotation number		
CCEXPCTL	I*2		Exposure control value from camera frame header	Basehdr.ppexpcontrol	
CCIMGCTR	I*2		Image (frame) count from cameras	Basehdr.ppimgcount	
CCIMGSEQ	I*2		Sequence time from camera frame header	Basehdr.ppseqtime	
CDELT1	R*4	Any	Deg/pixel along axis 1	Ground Table	
CDELT2	R*4	Any	Deg/pixel along axis 2	Ground Table	
CICUCODE	S*3	Any	CIC ucode version ID hex string	Basehdr.ucodecrc	
CIE_T	R*4	Any	DEG C	Basehdr.adccie	
COMMENT	S*71	Any	Comments. Can be repeated	Varied	
COMP_RAT	R*4	0.0..1.0	Compressed/uncompressed quality ratio	Derived from Ipconf.bitsperpixel, basehdr.ipimgsize, NAXIS1 and NAXIS2	

Keyword	Type	Values	Description	Source	L1?
COMPRESS	S*19	None, Lossless, Lossy[1..5]	Data Compression Quality For Lossy, varies from 1 (lowest compression) to 5 (highest compression)	basehdr.compression	
COSMICR	L	T/F	Cosmic Ray Removal was enabled	basehdr.algorithm	
COSMICS	I*4		CRS corrected pixels	Basehdr.ppcrscorr	
CREATOR	S	Any	<software name + version> / FITS creation software & version	make_wispr_hdr.pro	
CRLN_OBS	R*8		[deg] S/C Carrington longitude		
CRLT_OBS	R*8		[deg] S/C Carrington latitude (B_0)		
CRPIX1	R*4	Any	Pixel coordinate of reference point	Pre-flight calibration	
CRPIX2	R*4	Any	Pixel coordinate of reference point	Pre-flight calibration	
CRVAL1	R*4	Any	[arcsec] x-coordinate of reference point	SPICE	
CRVAL2	R*4	Any	[arcsec] y-coordinate of reference point	SPICE	
CTYPE1	S*8	ALON-ZPN	WCS axis X	Constant	
CTYPE2	S*8	ALAT-ZPN	WCS axis Y	Constant	
CUNIT1	S*3	deg	WCS axis X units (theta_x, longitude)	Constant	
CUNIT2	S*3	deg	WCS axis Y units (theta_y, latitude)	Constant	
DATAAVG	R*4	Any	Average non-zero pixel value	Derived	
DATAMAX	R*4	Any	Maximum valid physical value	Derived	
DATAMDN	R*4	Any	Median non-zero pixel value	Derived	
DATAMIN	R*4	Any	Minimum valid physical value	Derived	
DATAP01	I*4	Any	1% of non-zero pixels are LE this value	Derived	
DATAP10	I*4	Any	10% of non-zero pixels are LE this value	Derived	
DATAP25	I*4	Any	25% of non-zero pixels are LE this value	Derived	
DATAP50	I*4	Any	50% of non-zero pixels are LE this value	Derived	
DATAP75	I*4	Any	75% of non-zero pixels are LE this value	Derived	
DATAP90	I*4	Any	90% of non-zero pixels are LE this value	Derived	
DATAP95	I*4	Any	95% of non-zero pixels are LE this value	Derived	
DATAP98	I*4	Any	98% of non-zero pixels are LE this value	Derived	
DATAP99	I*4	Any	99% of non-zero pixels are LE this value	Derived	
DATASAT	I*4	Any	Number of saturated pixels	Derived	

Keyword	Type	Values	Description	Source	L1?
DATASIG	R*4	Any	Standard deviation of non-zero pixels	Derived	
DATAZER	I*4	Any	Number of pixels=0	Derived	
DATE	S*23	Any	YYYY-MM-DDThh:mm:ss.sss [UTC] Time of file creation	IDL	
DATE-AVG	S*23	Any	YYYY-MM-DDThh:mm:ss.sss [UTC] Average time of observation	Basehdr: derived from firsttime, firsttimefrac, lasttime and lasttimefrac	
DATE-BEG	S*23	Any	YYYY-MM-DDThh:mm:ss.sss [UTC] Start time of first exposure	Basehdr: derived from firsttime + firsttimefrac	
DATE-END	S*23	Any	YYYY-MM-DDThh:mm:ss.sss [UTC] End time of (last) exposure	Basehdr: derived from lasttime and lasttimefrac	
DATE-OBS	S*23	Any	YYYY-MM-DDThh:mm:ss.sss [UTC] Start time of first exposure	Basehdr: = DATE_BEG	
DET1_T	R*4	Any	Inner detector Op degC	Basehdr.adcdet1	
DET2_T	R*4	Any	Outer detector Op degC	Basehdr.adcdet2	
DETECTOR	S*1	1,2	1=Inner, 2=Outer	Basehdr.pproicam	
DRB1_T	R*4	Any	Inner DRB degC	Basehdr.adcdrb1	
DRB1UCOD	S*3	Any	DRB1 ucode Version ID hex string	Basehdr.ucodecrc	
DRB2_T	R*4	Any	Outer DRB degC	Basehdr.adcdrb2	
DRB2UCOD	S*3	Any	DRB2 ucode Version ID hex string	Basehdr.ucodecrc	
DRBUCODE	S*3	Any	DRB1 or DRB2 ucode (for single frame)	Basehdr.ucodecrc	
DSTART1	I*2	1	First column of image array on data array	wispr_ucode_vals.pro	
DSTART2	I*2	1	First row of image area on data array	wispr_ucode_vals.pro	
DSTOP1	I*2	Any	Last column of image array on data array	wispr_ucode_vals.pro	
DSTOP2	I*2	Any	Last row of image area on data array	wispr_ucode_vals.pro	
DSUN_OBS	R*8	Any	[m] S/C distance from Sun	Basehdr.sppsolardistanc e	
EAR_TIME	R*8		[s] Time(Sun to Earth) - Time(Sun to S/C)	sunspice	
EXTEND	L	T/F	Indicates there is (not) an extension	Pipeline	
FILE_RAW	S*14	Any	Downloaded image filename	Basehdr	

Keyword	Type	Values	Description	Source	L1?
FILENAME	S*34	→	Name of fits file : psp_<level>_wispr_<DATE-BEG*>_<tel><microcode><region>.fts level=[L1,L2,L3,cal]; tel=[1,2], region=[0..6] microcode=LSB of DRB1 Microcode CRC [5] DATE-BEG= UTC YYYYHHMMThhmmss *[from constant epoch]	Basehdr: derived from pprimetag, pprimetagfrac, pproicam, readout, and ucodecrc	
GAINCMD	I*1		Commanded gain value from register 0x50 (4 bits) for inner or outer	Basehdr.cregs	
GAINMODE	S*6	LOW, HIGH, SIMADC	(1=LOW=MIMON, 0=HIGH=MIMOFF, 2=SIMADC)	Basehdr.cregs	
HAEi_OBS	F*8		[m] S/C Heliocentric Aries Ecliptic X,Y,Z	sunspice	
HCIi_OBS	F*8		[m] S/C Heliocentric Inertial X,Y,Z	sunspice	
HCIi_VOB	F*8		[m/s] S/C Heliocentric Inertial X,Y,Z Velocity	sunspice	
HEEi_OBS	F*8		[m] S/C Heliocentric Earth Ecliptic X,Y,Z	sunspice	
HEQi_OBS	F*8		[m] S/C Heliocentric Earth Equatorial X,Y,Z	sunspice	
HGLT_OBS	F*8		[deg] S/C heliographic latitude	sunspice	
HGLN_OBS	F*8		[deg] S/C heliographic longitude (B_0)	sunspice	
HISTORY	S	Any	Comments of processing history, can be repeated	Varied	
IMGCTR	I*2	Any	Image counter from IDPU	Basehdr.totalimagecounter	
INSTRUME	S*5	WISPR	Instrument Name	Definition	
IP_CMD	I*2	Any	Number of IP processing commands	(delete?)	
IP_FUNC	I*2	Any	Pixel processing algorithm controls	Basehdr.icpixelalg	
IP_INIT	I*2		Initial (?) Bits (no first/last sum)	Basehdr.icinit	
IP_TIMET	I*2	Any	Time between image received from camera and ship time	Derived	
IPBIAS	I*1	0=Off, 1=Median, 2=Image	Bias function commanded	Ipconf.bias	
IPBITSPP	I*1		Bits per pixel before compression	Ipconf.bitsperpixel	
IPCMBUFF	I*2		Image buffer size and base	Basehdr.iccmpbuff	
IPCMPCTL	I*2	Any	Compression control	Basehdr.iccmpconfig	

Keyword	Type	Values	Description	Source	L1?
IPCRSMUL	R*4		Threshold for replacement = IPCRSMUL * sqrt(current pixel)	basehdr.algorithm	
IPIMBUFF	I*2		Image buffer size and base	Basehdr.icimagebuff	
IPMASK	I*2		Mask control (from lsb): 0 Enable rectangular mask; 1 Invert rectangular mask; 2 Enable Non-rectangular mask; 3 Invert Non-rectangular mask; 4..8 Non-rectangular mask ID; 9..15 unused;	Basehdr.icmask	
IPMASKCR	S		Comma separated list of following 4 dec values (indicating UNMASKED region): • mask lower-left column • mask upper-right column • mask lower-left row • mask upper-right row	Derived from basehdr: icmaskrowll, icmaskcolll, icmaskfowur, icmaskcolur	
IPMAXPX	I*2		Pixel clamp maximum	Basehdr.icmaxpixel	
IPMINPIX	I*2		Pixel clamp, minimum	Basehdr.icminpixel	
IPSATPX	I*2		Pixel saturation	Basehdr.icpixelsat	
IPSTRVPX	I*2		Pixel starvation	Basehdr.icpixelstarve	
IPTRUNC	I*1		Truncate command	Ipconf.truncate	
ISPREGi	I*2	Any	CIC Registers, i=[0..6]	Basehdr.cregs	
LATPOLE	R*8	Any	[deg] Native latitude of the celestial pole	Constant	
LEDSTATE	S*8	LED1/LED2/LED1LED2/Off	State of LED1 and LED2	Basehdr.cregs	
LEDDAC	I*2	0..4095	Last commanded setting of LED1 or LED2	Basehdr.cregs	
LEVEL	I*1	1,2,3	Data processing Level	Pipeline	
LONPOLE	R*8	Any	[deg] Native longitude of the celestial pole	Constant	
NAXIS	I*1	0,2,3	Number of axes in array	FITS	
NAXIS1	I*2	Positive	Number of pixels in horizontal axis	Basehdr.columns	
NAXIS2	I*2	Positive	Number of pixels in vertical axis	Basehdr.rows	
NBIN	R*4		Number of pixels binned; this will change to reflect any correction to the data.	Derived	
NBIN1	I*1		Number of pixels binned along axis1; this will change to reflect changes in dimension.	basehdr.algorithm	
NBIN2	I*1		Number of pixels binned along axis2; this will change to reflect changes in dimension.	basehdr.algorithm	

Keyword	Type	Values	Description	Source	L1?
NSUMBAD	I*2	Any	Number of images with invalid pixel counts	Basehdr.pixelErrors	
NSUMEXP	I*2	Any	Total number in sequence	Basehdr.frames	
OBJECT	S	Any	Type of object observed	pipeline	
OBS_MODE	S	Any	Name of instrument-specific study or observation mode	pipeline	
OBSRVTRY	S*18	Parker Solar Probe	Satellite Name	Definition	
OBT_BEG	R*8	Any	MET when first pixel of first image is received from camera	Basehdr: firsttime + firsttimefrac	
OBT_END	R*8	Any	MET when first pixel of last image is received from camera	Basehdr: lasttime + lasttimefrac	
OFFSET	I*2		Commanded offset value used in camera	Basehdr.cregs	
ORIGIN	S*4	NRL	Where file was written	Pipeline	
PCj_i	R*8	Any	WCS coordinate description matrix	sunspice	
PRIORITY	I*2	Any	Downlink priority	Basehdr.priority	
PV1_1	R*8	Any	[deg] Native longitude of the reference point	Constant	
PV1_2	R*8	Any	[deg] Native latitude of the reference point	Constant	
PV1_3	R*8	Any	[deg] Alias for LONPOLE (has precedence)	Constant	
PV2_m	R*8	Any	ZPN projection parameters m=[0..5]	Optical Calibration	
PXBEG1	I*2	1..1920	First read-out detector row	wispr_ucode_vals.pro	
PXBEG2	I*2	1..2048	First read-out detector column	wispr_ucode_vals.pro	
PXEND1	I*2	1..1920	Last read-out detector row	wispr_ucode_vals.pro	
PXEND2	I*2	1..2048	Last read-out detector column	wispr_ucode_vals.pro	
RiCOL	I*2	1..1920	X subscript of start/end of readout on rectified detector	wispr_rectify.pro	
RiROW	I*2	1..2048	Y subscript of start/end of readout on rectified detector	wispr_rectify.pro	
READOUT0	I*1	[1..6]	Readout region if region=0	Basehdr.Readout0	
READTIME	R*4	Any	Time to readout raw image from camera in sec	Basehdr.readtime	
RECTIFY	L	T[F]	Image has been rotated so ecliptic north is up	wispr_rectify.pro	
RECTROTA	I*1	0..7	Argument for rotate.pro used to rectify image	wispr_rectify.pro	
REGION	I*1	[0..6]	Region	Basehdr.readout	
RSUN_ARC	R*8		[arcsec] photospheric solar radius	sunspice	
RSUN_REF	R*8		[m] Assumed physical solar radius	sunspice	
SC_PITCH	R*4	Any	[deg] S/C yaw at DATE-AVG	ah	
SC_ROLL	R*4	-90..+90, 90..270	[deg] S/C roll at DATE-AVG	ah	

Keyword	Type	Values	Description	Source	L1?
SC_YAW	R*4	Any	[deg] S/C yaw at DATE-AVG	ah	
SCFLAGS	S*8	Any	Hex representation of 4 bytes of SPP flags	Basehdr.sccflags	
SIMPLE	L	T/F	Conforms to fits standard	FITS	
SOLAR_EP	F*8		[deg] S/C ecliptic North to solar North angle	sunspice	
STUDY_ID	I*2	Any; ref allos.txt	Observing Sequence ID = ISPREG7	Basehdr.cregs	
STUDYCNT	I*2	Any	Image count for observing sequence	Basehdr.ipimagecount	
SUN_TIME	F*8		[s] LightTravelTime(Sun to S/C)	sunspice	
TARGET	S	Any	Type of target from planning	pipeline	
TELAPSE	R*4	Any	Elapsed time between beginning and end of exposure(s)	basehdr	
TIMELINE	S*12	"index(dec), address(hex)"	string combination of Timeline index and address of OS run	Basehdr.iptimeline, Basehdr.ipobssequid	
TIMESYS	S*3	UTC	System used for time keywords	Definition	
UCODREGi	I*4	Any, i=[0..7]	Values in readout microcode programmable registers	Basehdr.cregs	
VERS_CAL	S*7	Any	Combination of header (FSW) version and pipeline version, separated by ;	Basehdr.version; Revision of make_wispr_hdr.pro	
VERSION	I*1	Any	Version of file, starting at i=1	Pipeline	
WCSNAME	S*25	Helioprojective-cartesian	Coordinate System	Definition	
XFBYTES	I*4	Any	Number of bytes sent	Basehdr.ipimgsize	
XPOSURE	R*4	Any	Effective exposure time (computed on ground)	wispr_ucode_vals.pro	

2. Accessing the Data

2.1 Universal access from anywhere

Three months after the data from an orbit are downlinked to the ground, they are released to the public and are available through the WISPR website at http://wispr.nrl.navy.mil/pub/data, which are mirrored at the NASA/GSFC Solar Data Analysis Center (SDAC) https://spdf.gsfc.nasa.gov/pub/data/psp/wispr/00readme.html and may be accessed through the VSO at https://sdac.virtualsolar.org/cgi/search. The data are also available at the JHU/APL PSP Gateway at https://sppgway.jhuapl.edu/wispr_img.

At the NRL website, you have two ways to access the data. Using the database search, https://wispr.nrl.navy.mil/query_concept, you can use an on-line form to select the particular images based on date, image size, telescope, etc. After you have made your selection, the images will be collected and you may download them to your computer. The second way to access the data is to download an entire orbit. The volume of data collected in an orbit is relatively small

(~10 Gbit). To access the data by orbit go to https://wispr.nrl.navy.mil/wisprdata. Then you can click on the link for the zip file of the desired orbit and data level or data type (see section 2.2) to download the file.

2.2 Data Formats/Products

We are making several data products available including raw and processed images (science data and PNGs), and movies (animations) in different formats. The science data is provided in the FITS (Flexible Image Transport System), for which three different products are available: Level-1, Level-2 and Level-3, described below.

- Level-1 (L1): de-compressed, uncalibrated image data with no correction applied, except for rectification, so that solar north is (approximately) up. Data units are DN.
- Level-2 (L2): calibrated data in units of Mean Solar Brightness (MSB), with bias, stray light and vignetting corrections applied.
- High-cadence L2: approximately half of WISPRs observations are high-cadence narrow field of view observations, designed for the high temporal resolution studies of solar outflow. These data are separated from the full-field science data as they are fundamentally different types of observations.
- Level-3 (L3): data designed to reveal the variations in solar K-corona via a subtraction of a "background" model (L2b data; see below) that primarily removes the dominant F-coronal signal. These data are usually in units of MSB, though this should be verified by inspection of the FITS headers. We do not provide L3 data for the high-cadence observations.
- Level-2b (L2b): Generating appropriate background models for use with WISPR observations is complex, requiring at the very minimum the consideration of an entire encounter of observations as well as numerous corrections for instrumental effects, distance from the Sun, and other observing parameters. We are making these background models available as a Level-2b (L2b) data product. We do not provide backgrounds for the high-cadence data.
- Summary: Plain ASCII text files that summarize the observations of each type recorded during each encounter.
- PNGs: Browse images created using the L3 data product. These data are separated by encounter and by camera ("inner" and "outer")
- MPGs and MVIs: movies in the MPEG and IDL/SolarSoft mvi formats.

In most circumstances, we recommend use of the Level-2 or Level-3 data products for essentially all scientific analyses, both qualitative and quantitative. The PNG and various movie formats are appropriate for browsing the data but should not be used as science products.

2.3 Computer setup

The FITS image files conform to the CCSDS standard, and so are readable through many different systems. The traditional system for us has been the Interactive Data Language (IDL). If using IDL, make sure to compile the appropriate Solarsoft libraries. Information on solarsoft is available here. Python is also a capability that can be used. There are also two stand-alone applications that are very useful for viewing FITS images, DS9 and JHelioviewer.

2.3.1 IDL

To read and process WISPR images, use the IDL procedures in the SECCHI tree in the Solarsoft directory. You will need to have loaded the Solarsoft libraries pointed to above. Analysis of the WISPR images can use the same routines as for SECCHI analysis. Here is a detailed overview of how to use the SECCHI routines,

2.3.2 Python

The Astropy Python library contains a suite of procedures that can be used to read, analyze, and visualize WISPR images. Numerous tutorials, documentation, and code examples can be found on the Learn.Astropy website, located here. For those just getting started with Python, here is a tutorial that demonstrates how to view and manipulate FITS images.

2.3.3 SAO Image DS9

To view the FITS files in a standalone mode, SAO Image DS9 is a very useful tool. It can be downloaded here and a user manual is here. It is a general astronomical imaging and data visualization application. DS9 is a free, stand-alone application supporting FITS images and binary tables, multiple frame buffers, etc. You can manipulate the images by zooming and changing the color table and see the FITS header.

2.3.4 JHelioviewer

Another useful tool for visualizing solar images of various types is JHelioviewer. It also a free, standalone application. For more information visit their website downloaded here. It is particularly useful for combining images of different spatial coverage such as EUV or magnetogram images of the solar disk with coronal imagery.

LIST OF ACRONYMS

ASCII	American Standard Code for Information Interchange
AU	Astronomical Unit – the mean distance of the Earth from the Sun
CA	California
CC	Camera Card
CCSDS	Consultative Committee for Space Data Systems
CIC	Camera Interface Card
DC	District of Columbia
DEG C	Degrees Celsius
DIB	Digital Interface Board
DOC	Document
DRB	Digital Readout Board
F-corona	Fraunhofer Corona – scattering of photospheric light by dust
FITS	Flexible Image Transport System
FOV	Field of View
FSW	Flight SoftWare
GSFC	Goddard Space Flight Center
HGA	High Gain Antenna
ID	Identification
IDL	Interactive Data Language
IDPU	Instrument Data Processing Unit
IP	Image Processing, Instrument Processor
JHU	Johns Hopkins University
JHU/APL	JHU Applied Physics Laboratory
K-corona	Kontinuerlich Corona – scattering of photospheric light by electrons
L1, L2, L3	Data Processing Levels
LE	Less than or equal
MD	Maryland
MET	Mission Elapsed Time
MPG	A video format standardized by the Moving Picture Experts Group
MVI	A video format defined by NRL
NASA	National Aeronautics and Space Administration
NRL	Naval Research Laboratory
Op degC	Operational Thermistor Temperature in Degrees Celsius
OS	Observation Sequence
PI	Principal Investigator
PNG	**Portable Network Graphics** file – a common format for an image
PSP	Parker Solar Probe

SAO	Smithsonian Astrophysical Observatory
S/C	Spacecraft
SDAC	Solar Data Analysis Center
SECCHI	Sun-Earth-Connection Coronal and Heliospheric Investigation
SOC	Spacecraft Operations Center (or Coordinators)
SPP	Solar Probe Plus – original name of PSP
SSD	Space Science Division
STEREO	Solar Terrestrial Observatory
ucode	Microcode
VO	Virtual Observatory
VSO	Virtual Solar Observatory
WCS	World Coordinate System
WISPR	Wide Field Imager for Solar Probe
WISPR-I	WISPR Inner telescope
WISPR-O	WISPR Outer telescope
ZPN	Zenithal Polynomial Projection

Selected References

A list of all WISPR related references is at ADS. Here are a few selected references that describe the instrument in more detail.

Vourlidas, A. Howard, R.A., Plunkett, S.P. and 24 colleagues (2016) The Wide-Field Imager for Solar Probe Plus (WISPR)

Hellin, M.-L., Mazy, E., Marcotte, S., Stockman, Y., Korendyke, C., Thernisien, A. (2017) Stray light testing of WISPR baffle development model.'

Thernisien, A.F.R., Howard, R.A., Korendyke, C., Carter, T., Chua, D., Plunkett, S. (2018) Stray light analysis and testing of the SoloHI (solar orbiter heliospheric imager) and WISPR (wide field imager for solar probe) heliospheric imagers

Vasquez A.M., Frazin R.A., Vourlidas A., Manchester W.B., van der Holst B., Howard R.A., Lamy P., (2019) Tomography of the Solar Corona with the Wide-Field Imager for the Parker Solar Probe

Liewer P., Vourlidas A., Thernisien A., Qiu J., Penteado P., Nistico G., Howard R., et al., (2019) Simulating White Light Images of Coronal Structures for WISPR/ Parker Solar Probe: Effects of the Near-Sun Elliptical Orbit

Some references on the F- and K-corona applicable to WISPR:

Stenborg, G. and Howard, R. A., "A Heuristic Approach to Remove the Background Intensity on White-light Solar Images. I. STEREO/HI-1 Heliospheric Images", *The Astrophysical Journal*, vol. 839, no. 1, 2017. doi:10.3847/1538-4357/aa6a12.

Stenborg, G. and Howard, R. A., "The Evolution of the Surface of Symmetry of the Interplanetary Dust from 24° to 5° Elongation", *The Astrophysical Journal*, vol. 848, no. 1, 2017. doi:10.3847/1538-4357/aa8ef0.

Stenborg, G., Howard, R. A., and Stauffer, J. R., "Characterization of the White-light Brightness of the F-corona between 5° and 24° Elongation", *The Astrophysical Journal*, vol. 862, no. 2, 2018. doi:10.3847/1538-4357/aacea3.

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Stenborg, G. (2020) Generation of Background WISPR Images (in preparation)