Long-term Studies with DKIST: Synergies with NISP

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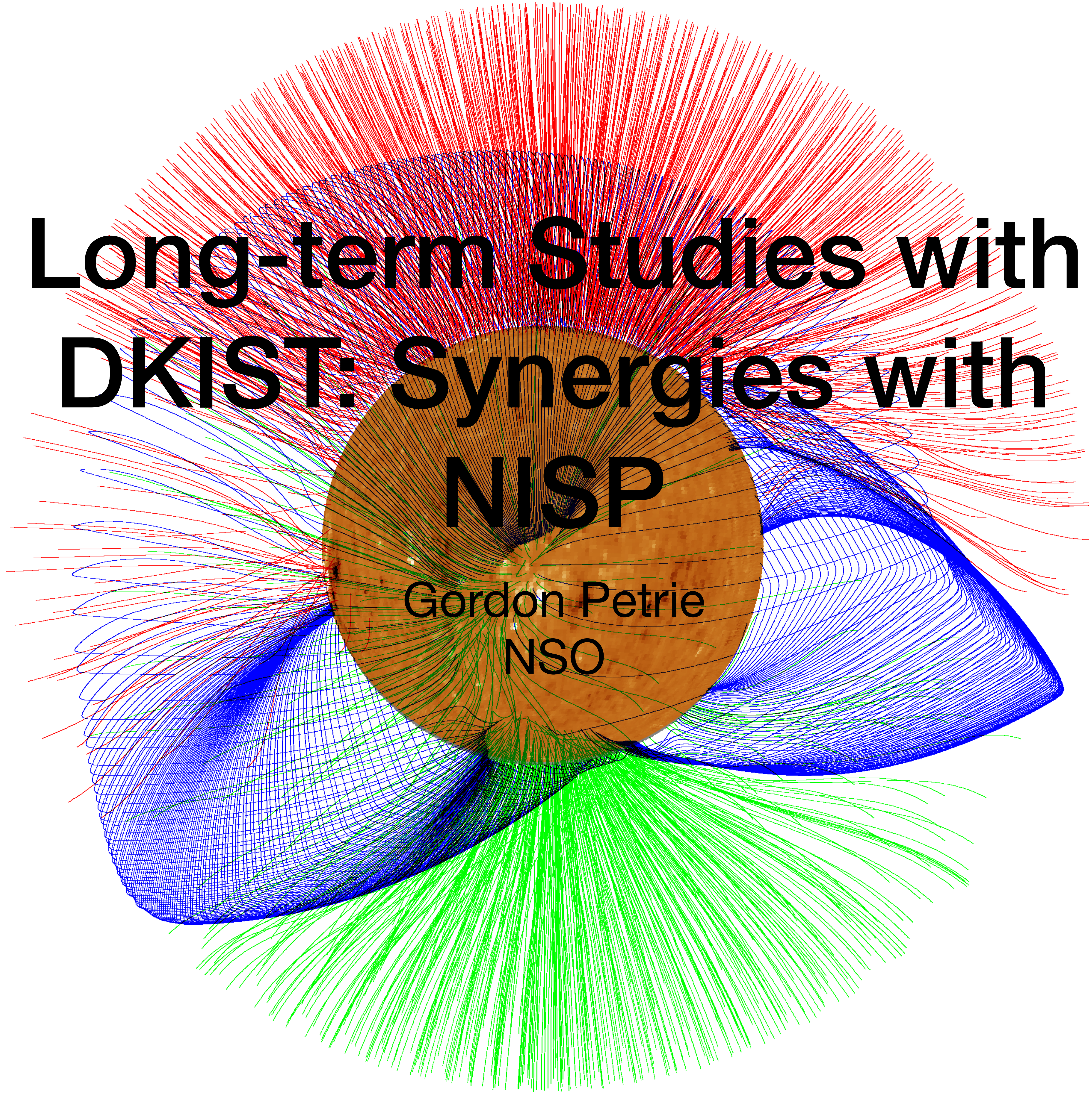
NSO



High-resolution & Synoptic Solar Physics

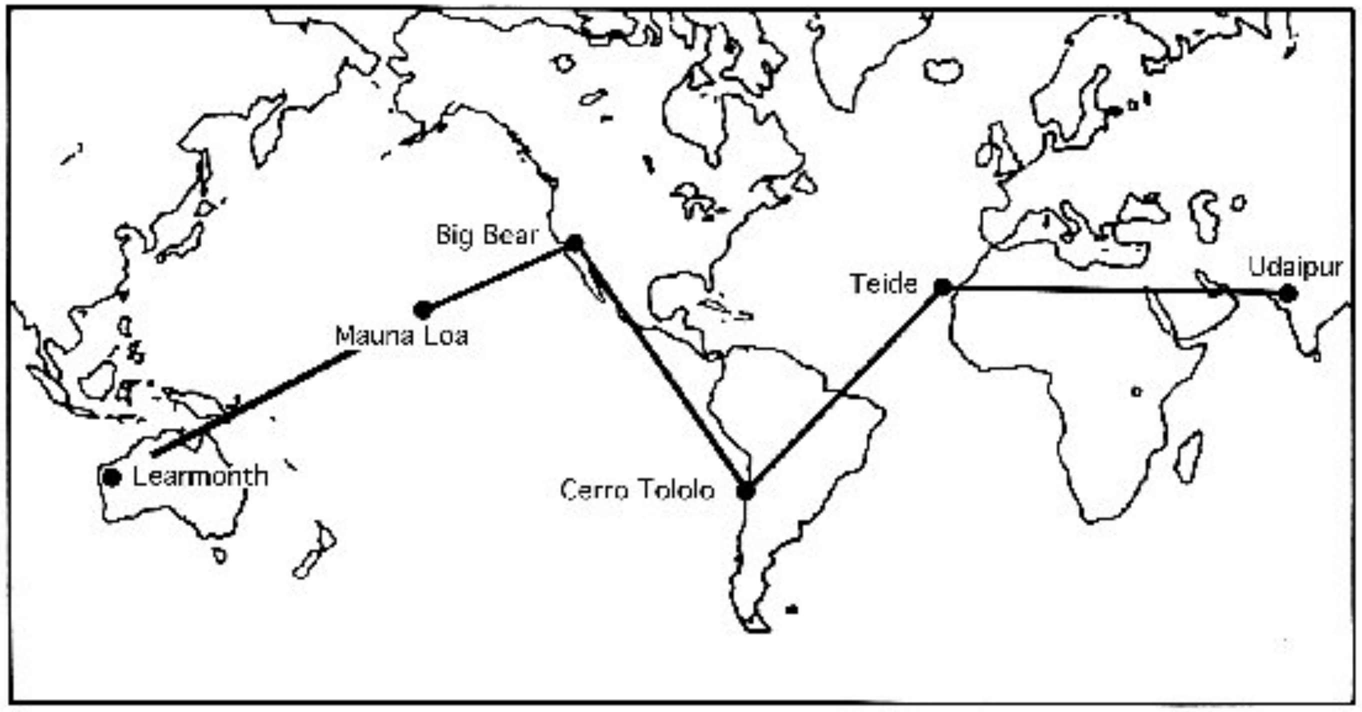
Targeted observations at high resolution are often driven by research into a specific problem in solar physics.

In contrast, sustained long-term synoptic observations are aimed at a global understanding of solar phenomena, and provide a detailed snapshot of our star in the context of stellar physics. Synoptic observations are indispensable to understanding the solar dynamo, space weather (climate) and radiative output.

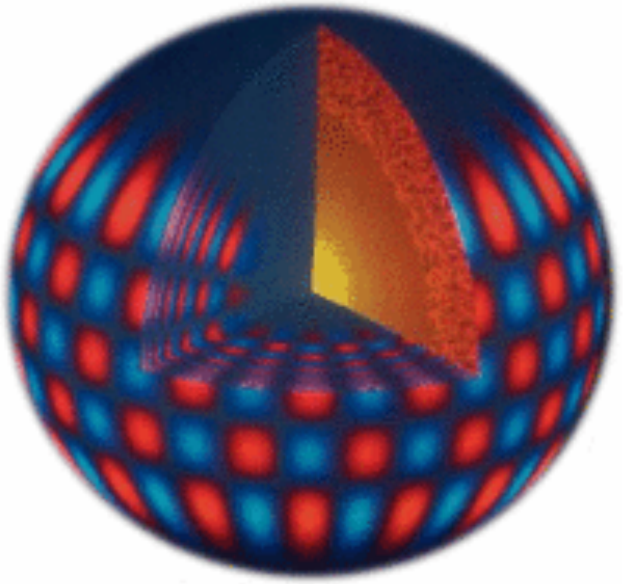
Synoptic programs are based on regular, reliable and consistent long-term measurements in a few spectral lines, imaging either with tunable filters scanning wavelength temporally, or with spectrograph scanning space temporally. Both methods (imperfectly) approximate a simultaneous measurement of the field over the full disk.

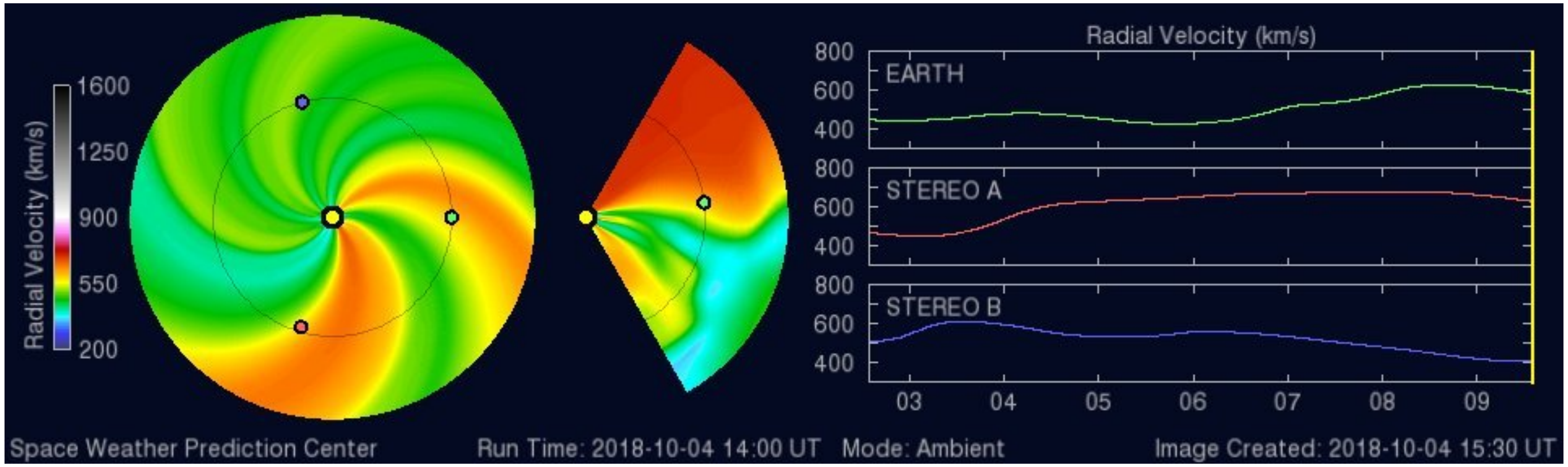
NISP is the NSO Integrated Synoptic Program, comprising the Global Oscillation Network Group (GONG) and Synoptic Optical Long-term Investigations of the Sun (SOLIS). Here *synoptic* indicates observations that cover the full solar disk, and extend over several complete activity cycles.

NISP complements DKIST, which will provide extremely detailed high-resolution observations over a small area. Both types of observations – high-resolution from DKIST and long-term global views from NISP – are essential to understand the Sun and its activity.



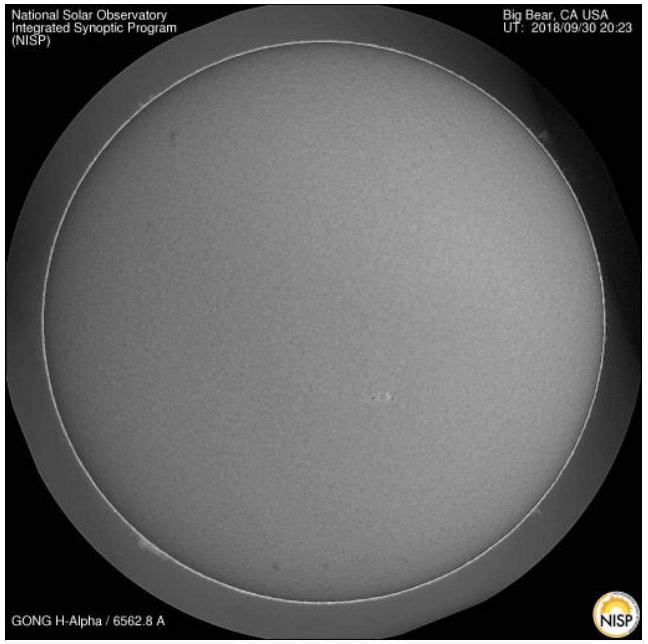
Deployed in 1995, GONG is a set of six observing systems geographically distributed around the Earth so that the Sun can be observed as continuously as possible. With these sites, GONG typically can observe the Sun ~90% of the time, 24/7.

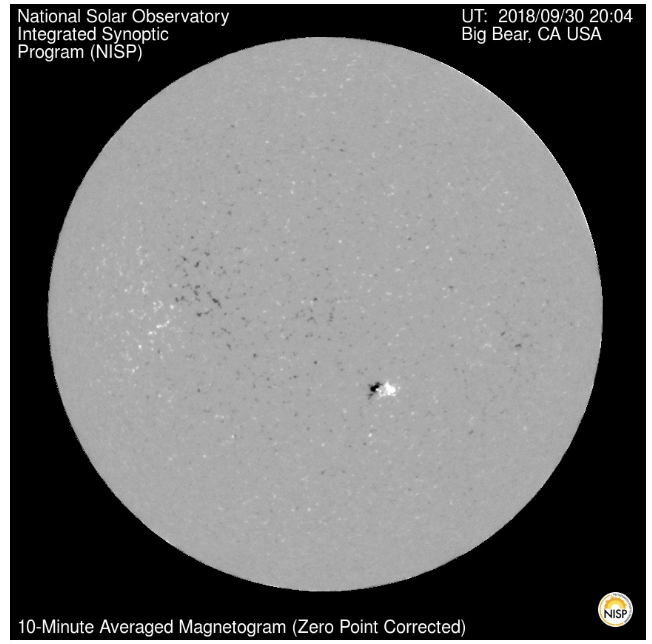


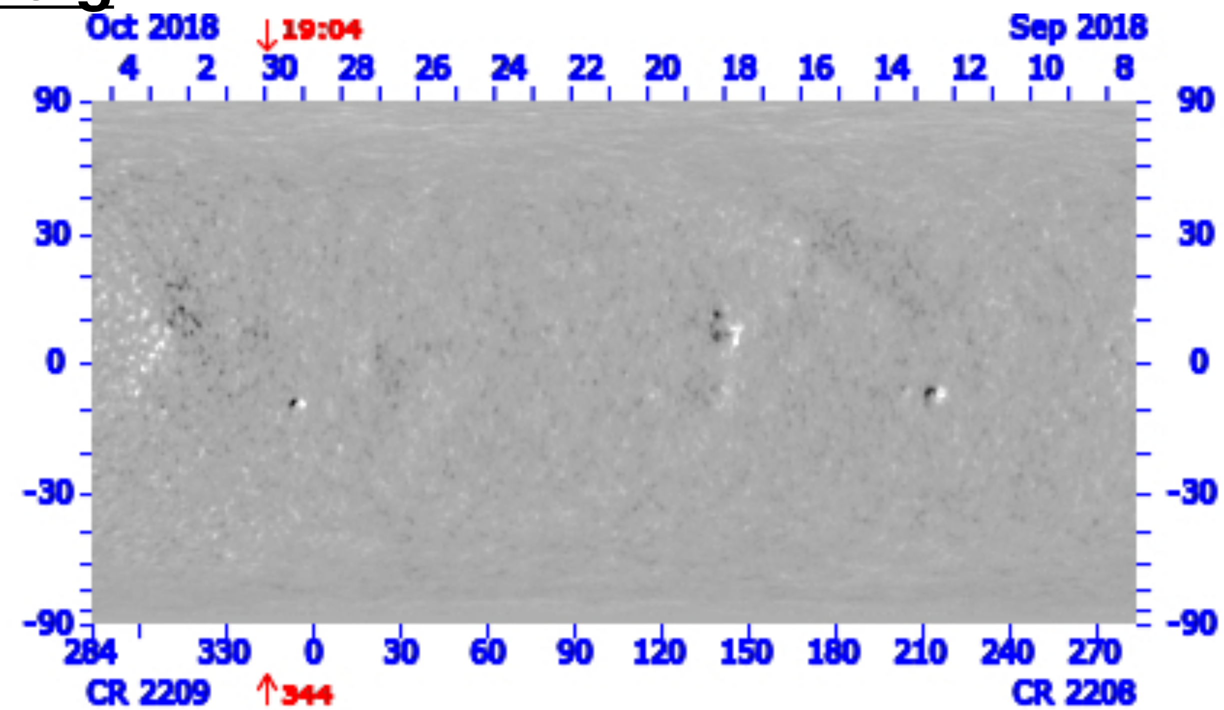


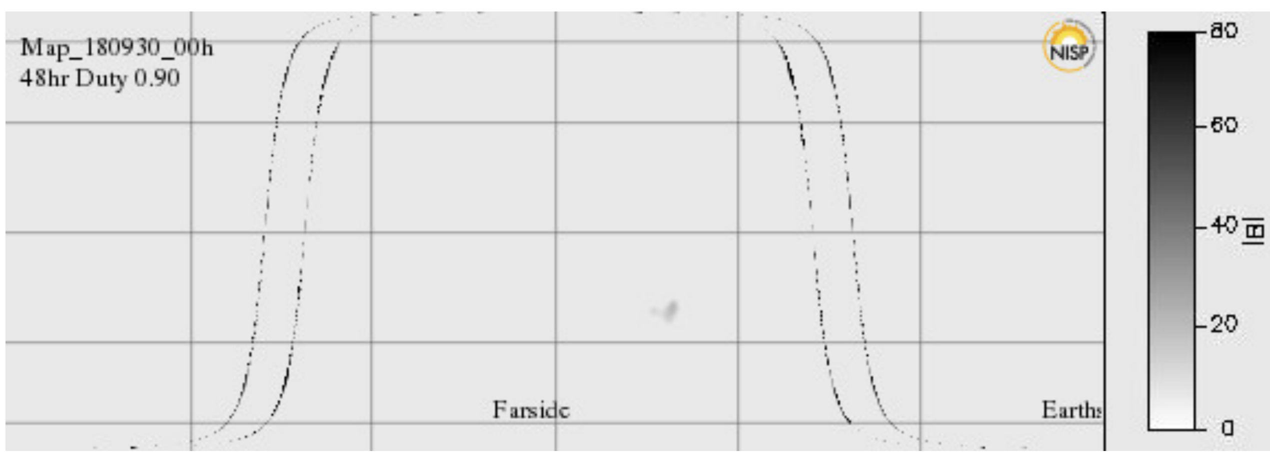
GONG was constructed to provide observations for helioseismology. GONG now also provides full-disk solar magnetic field maps (magnetograms) every minute and full-disk images of the Sun in the wavelength of the Hα spectral line every 20 seconds. These data products are used for research into the solar magnetic field and chromosphere but are also essential inputs into forecasts of space weather. The NOAA Space Weather Prediction Center (SWPC), the US Air Force 557th Weather Wing, and the NASA Community Coordinated Modeling Center (CCMC) all use GONG data to predict space weather conditions.

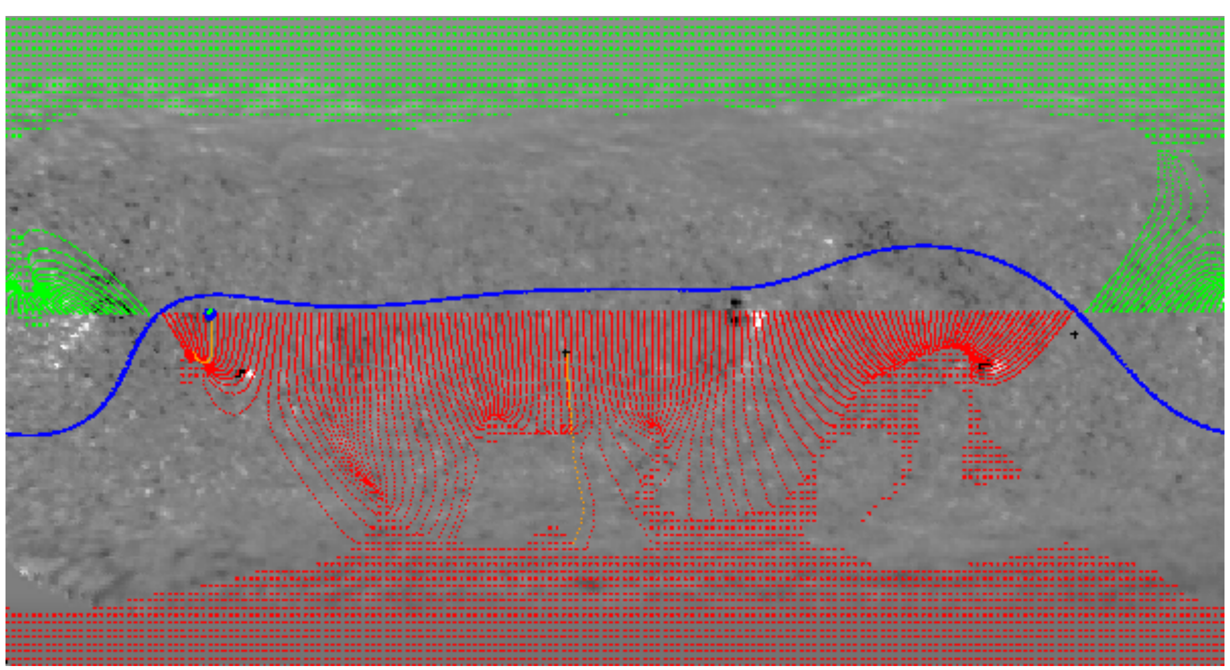
Images from https://gong2.nso.edu/products/mainView/table.php?configFile=configs/mainView.cfg

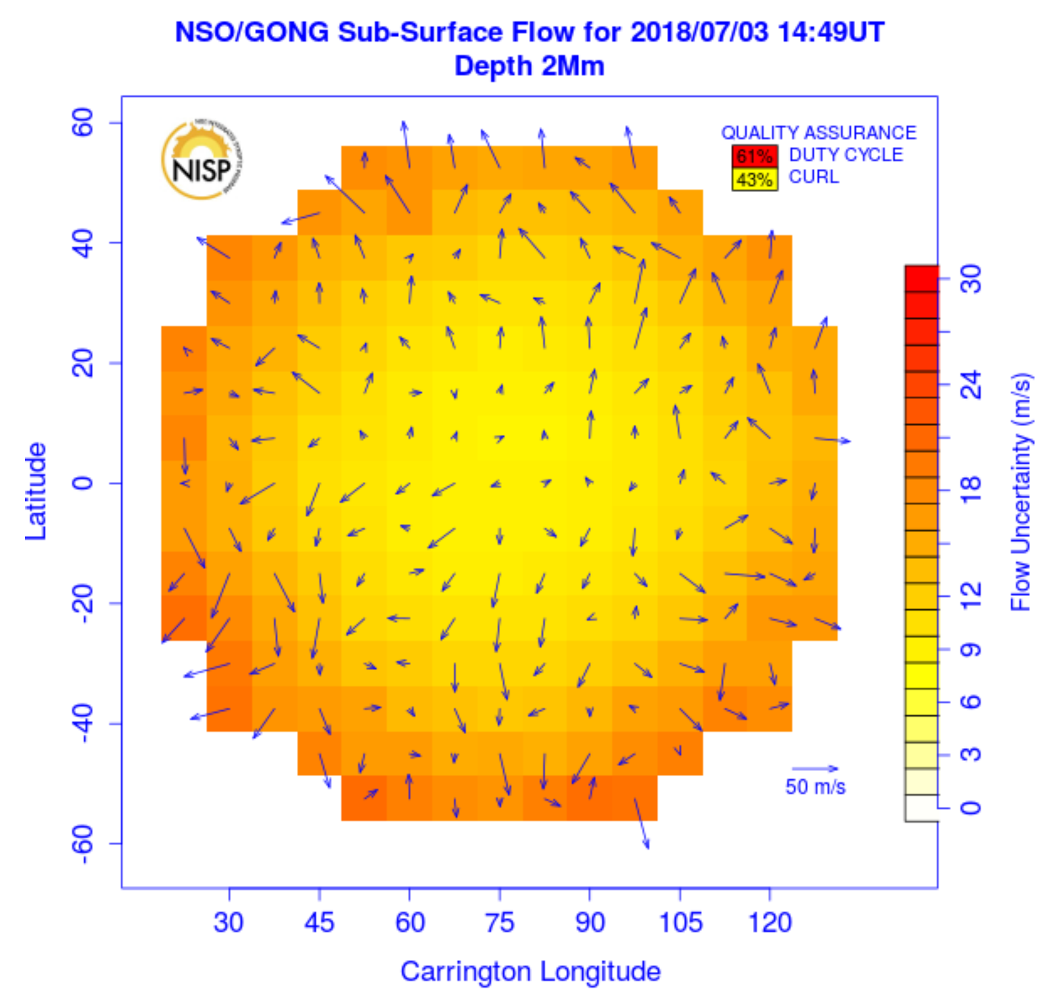


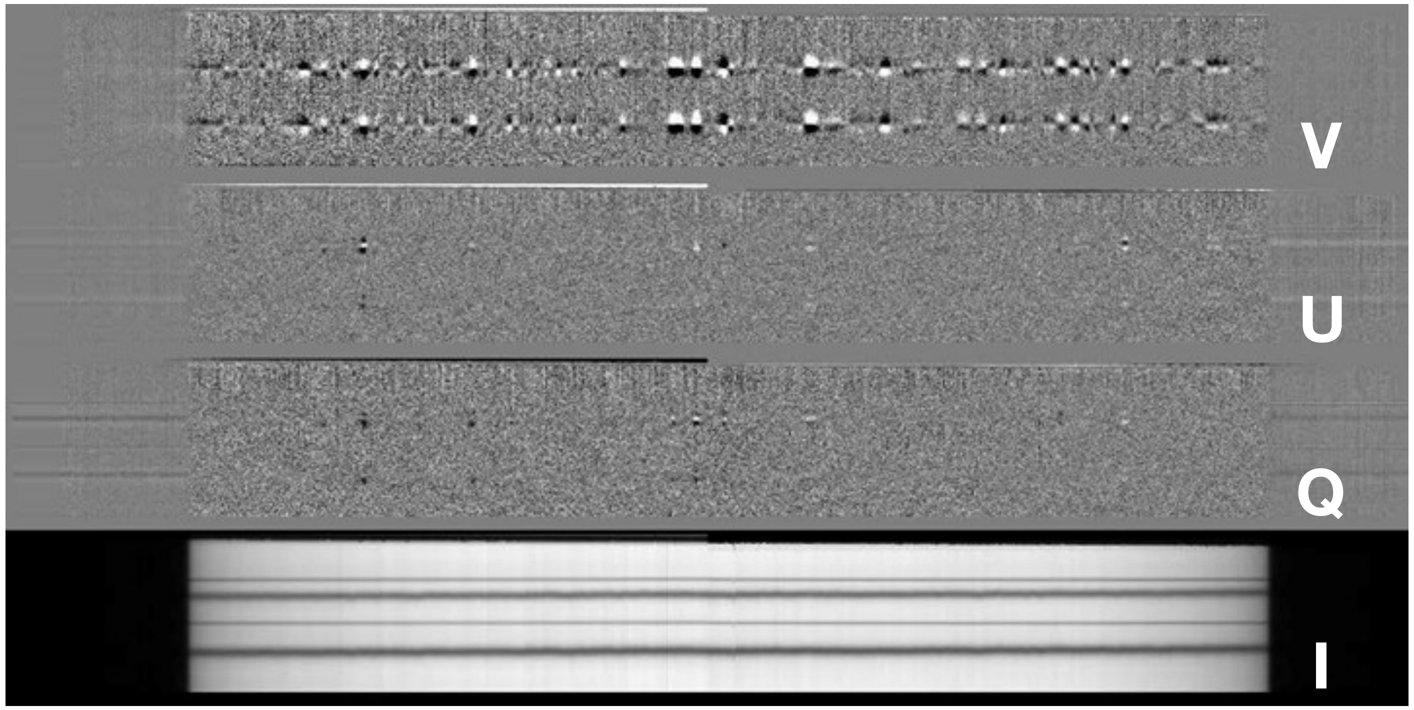


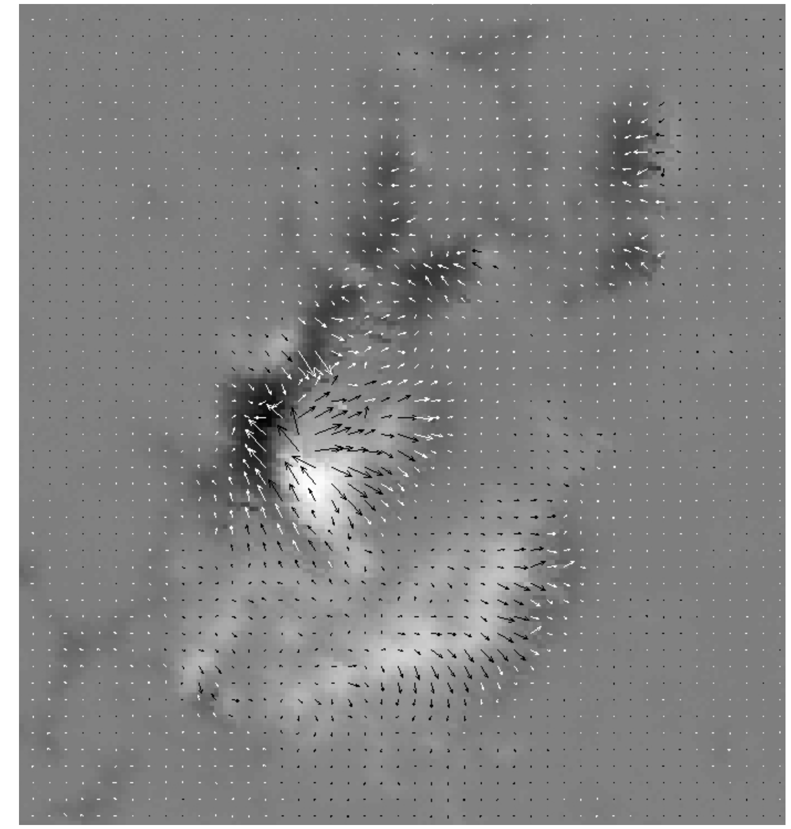












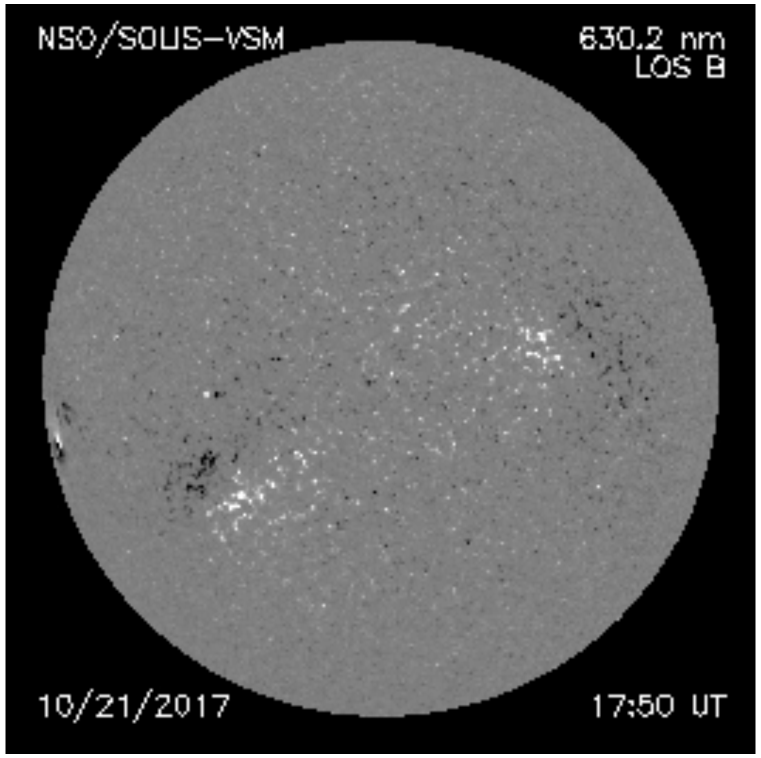
SOLIS is a single set of three instruments mounted on a common observing platform. The instruments are the Vector Spectromagnetograph (VSM), the Integrated Sunlight Spectrometer (ISS), and the Full-Disk Patrol (FDP).

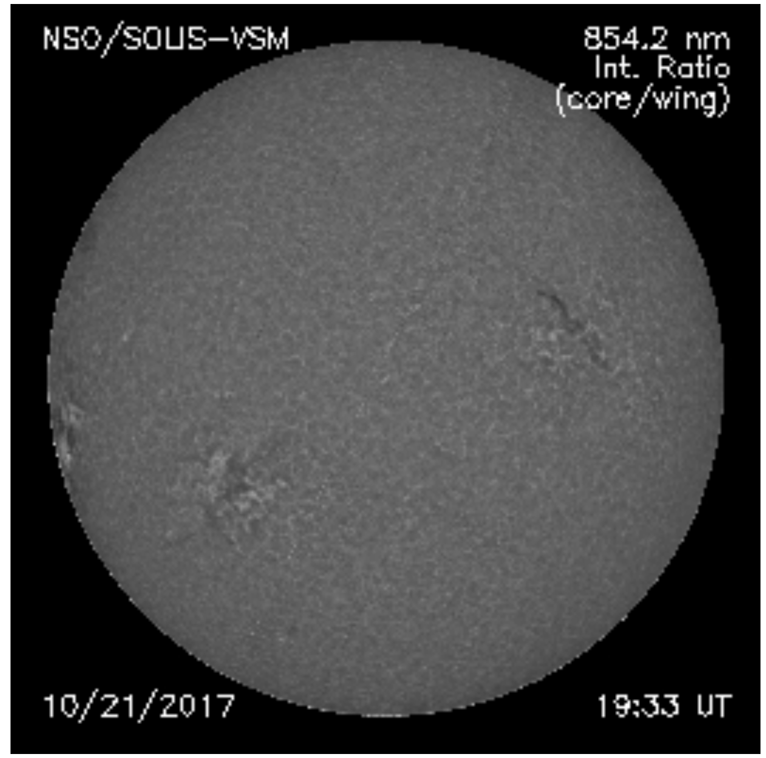
The VSM provides both line-of-sight and full-disk vector maps of the solar magnetic field both in the photosphere and in the chromosphere on a daily basis, continuing the 40-year record of NSO magnetic field observations. Stokes I, Q, U, V data cubes for the photospheric (6302Å) and chromospheric (8542Å) spectral lines are also available.

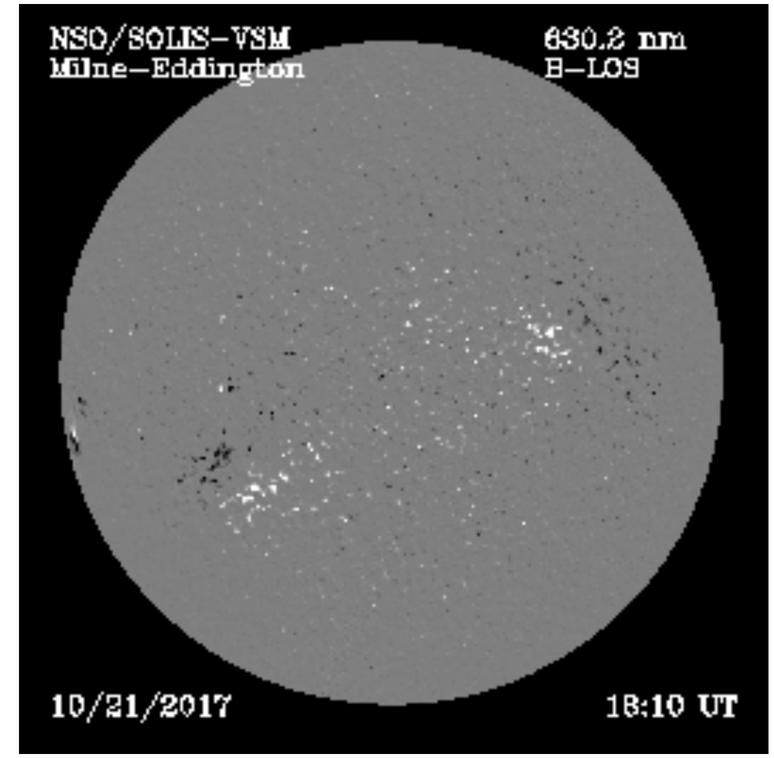
The ISS obtains spectra of the Sun integrated over the solar disk, so the Sun appears as it would as a much more distant star. The combination of data from the ISS and the VSM is useful for studies of exoplanet systems as it allows the modeling of the influence of a star's magnetic field on its spectrum giving clues to the activity level that the exoplanets may be subject to.

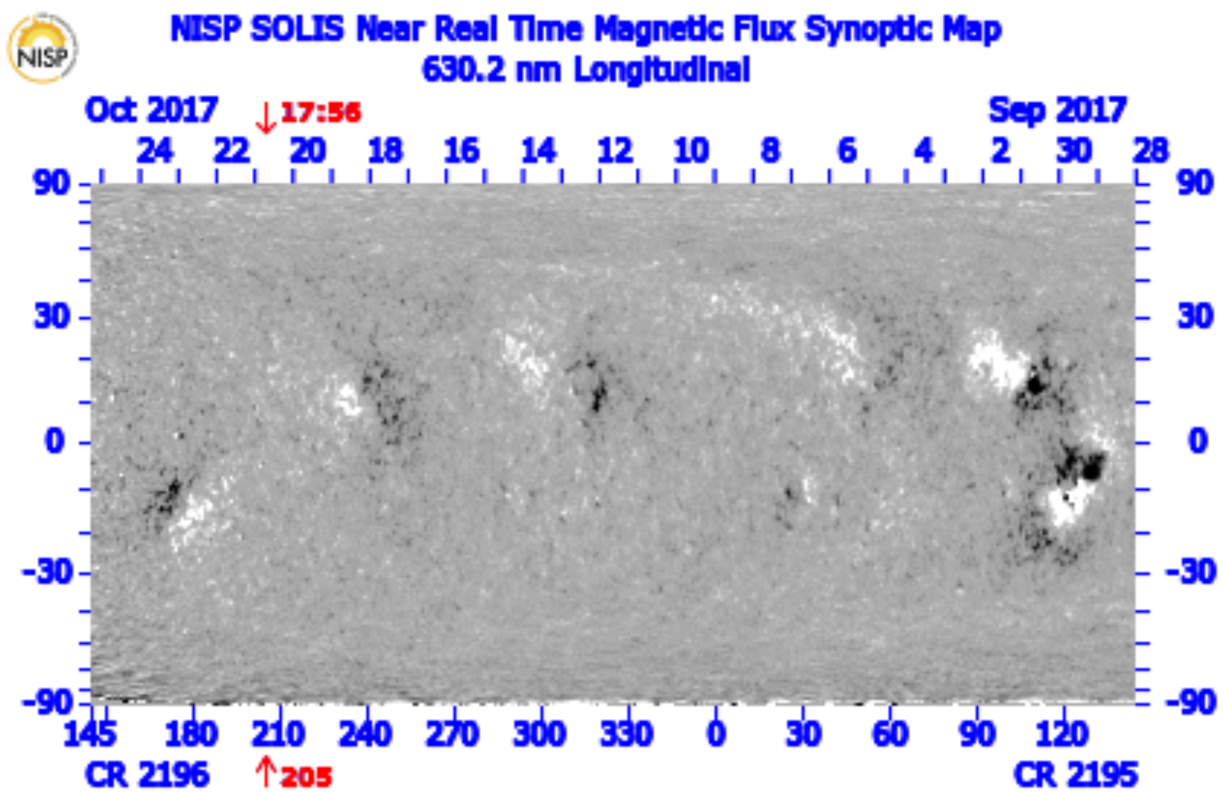
The FDP provides full-disk images of the Sun in a variety of spectral lines (Hα, He I 10830) with a cadence as high as 10 seconds. SOLIS was installed at Kitt Peak in 2003, then moved to Tucson in 2013.

It is currently at Big Bear Solar Observatory where a permanent site is under development.



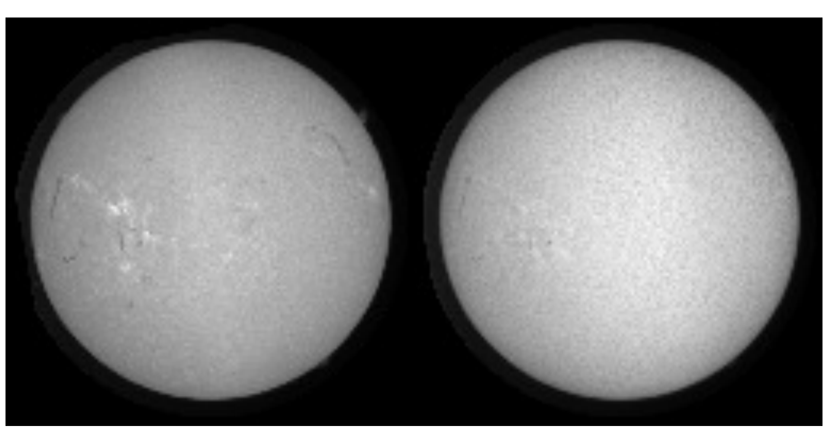


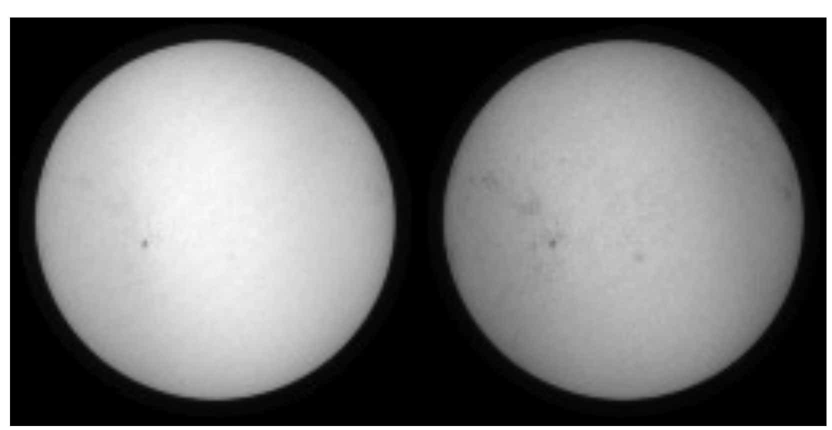


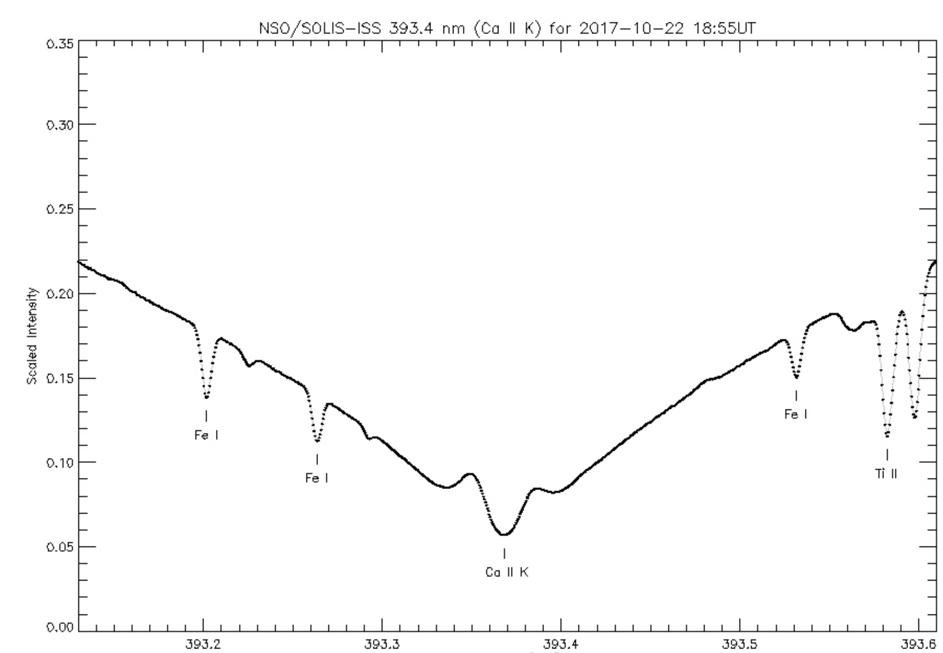


SOLIS comprises three instruments:

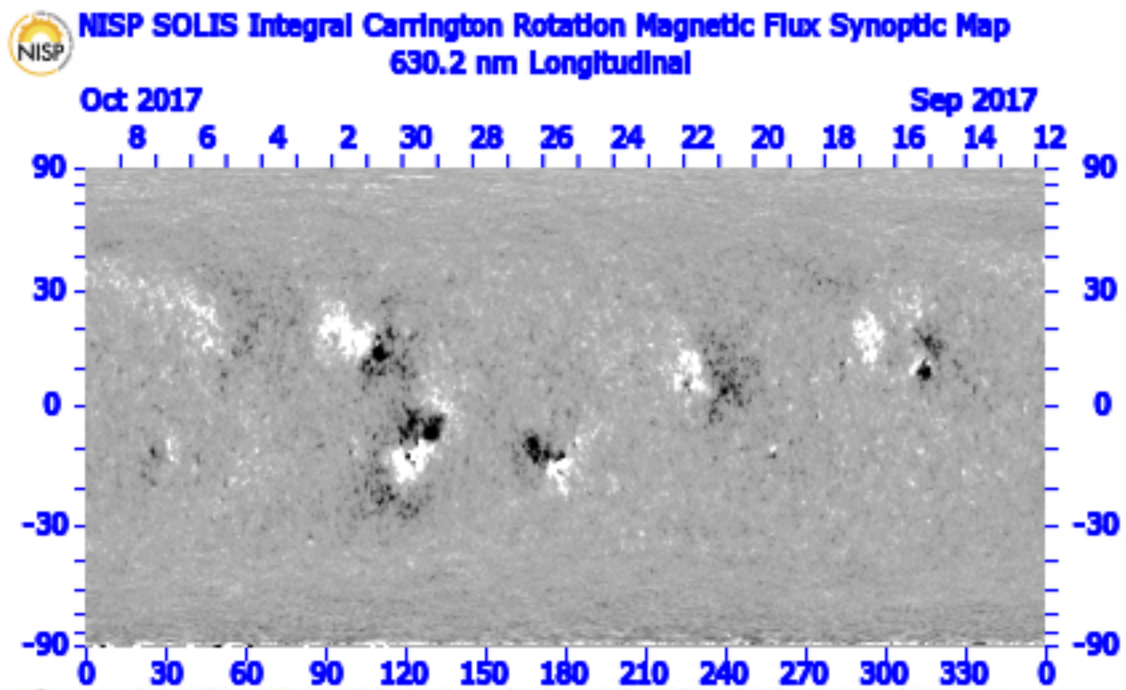
- the 50 cm Vector Spectromagnetograph (VSM), observing Fe I 6301-02 Å, Ca II 8542 Å
- the 14 cm Full-Disk Patrol (FDP)
- the 8 mm Integrated Sunlight Spectrometer (ISS)

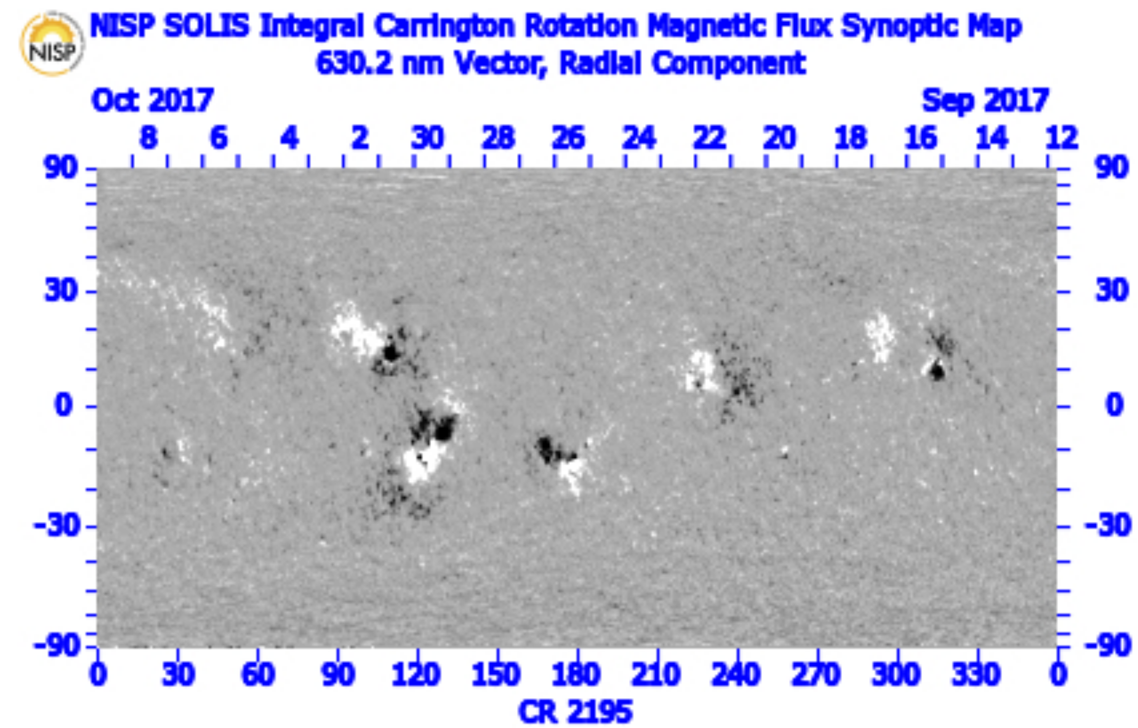


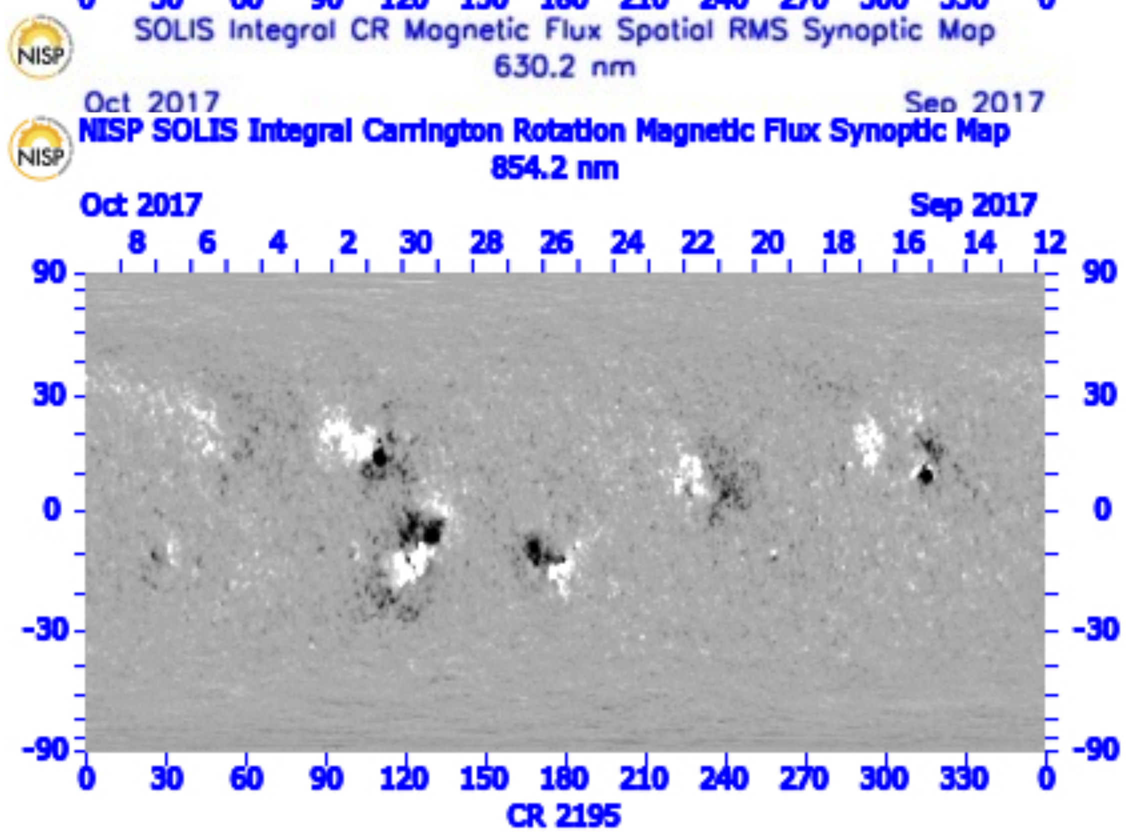


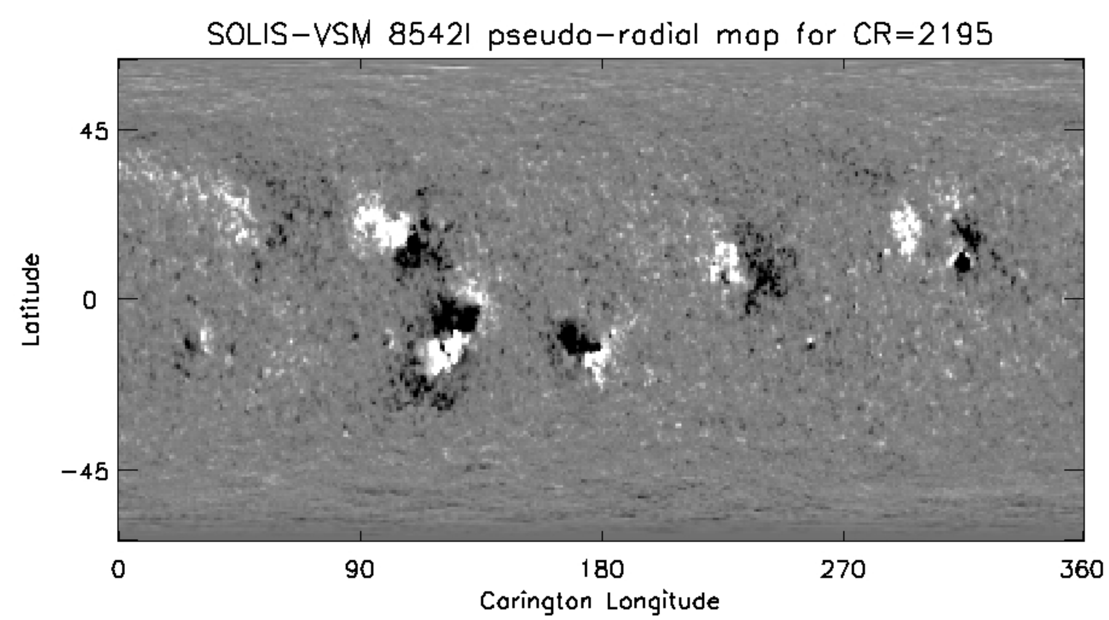


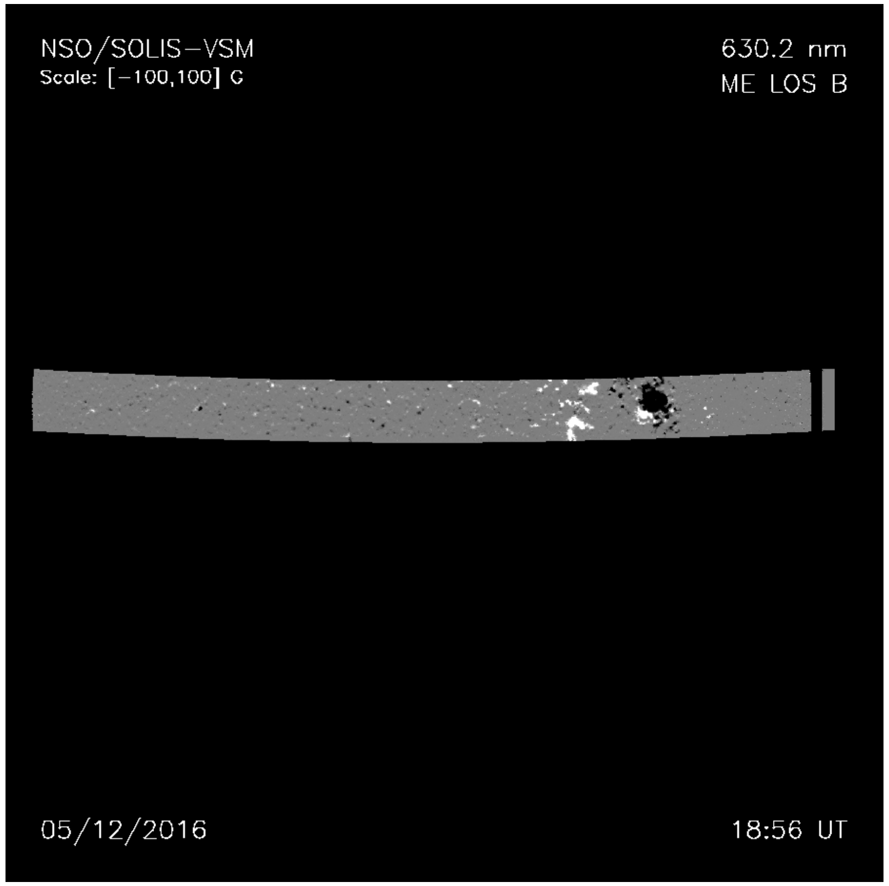
Example SOPLIS/VSM Synoptic Integral Carrington Maps

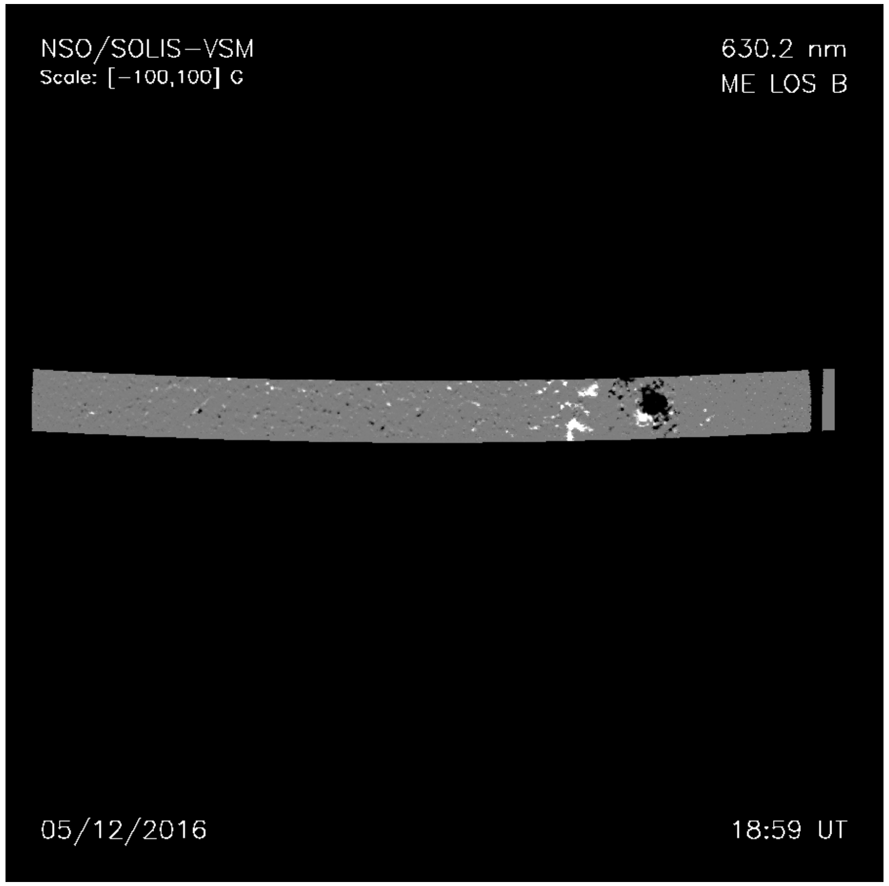


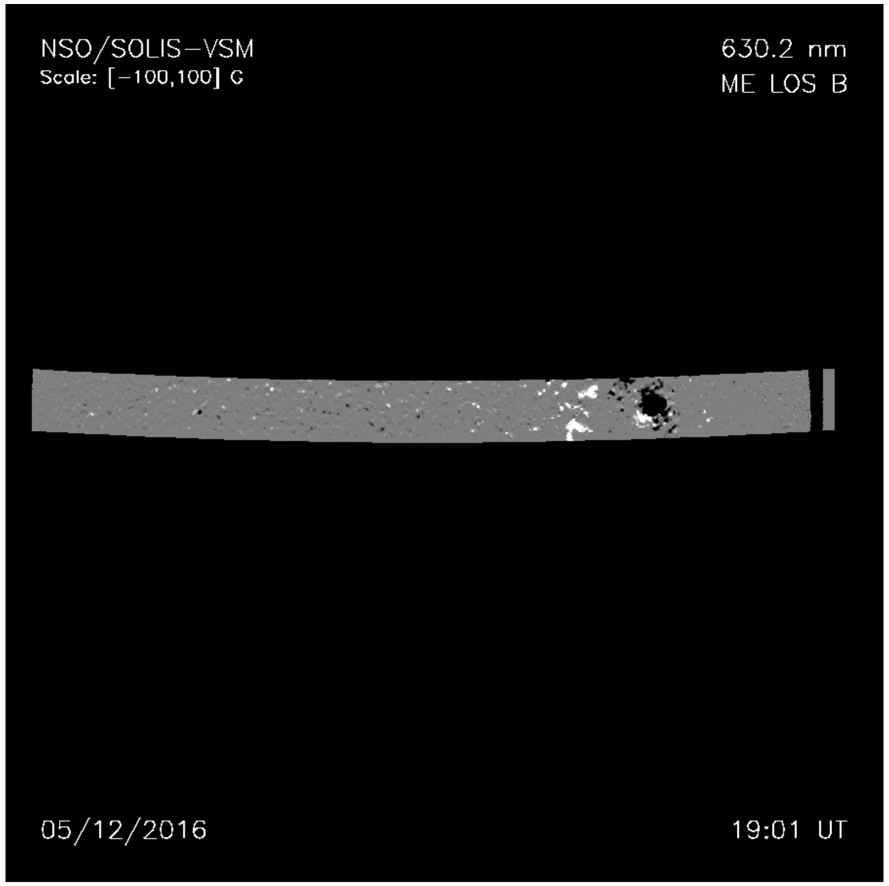








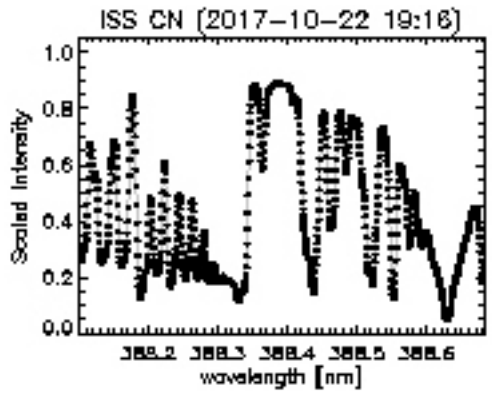




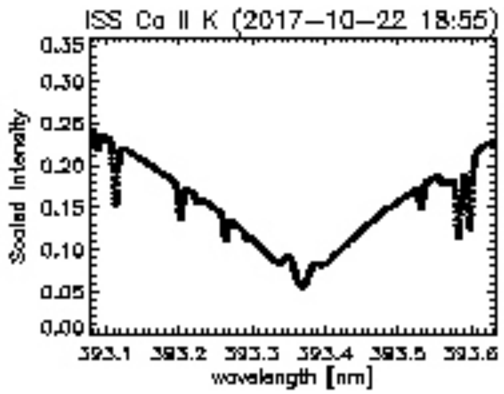
Advantage of VSM: high-cadence area scans with the VSM could provide vector data, photospheric or chromospheric.

ISS spectra

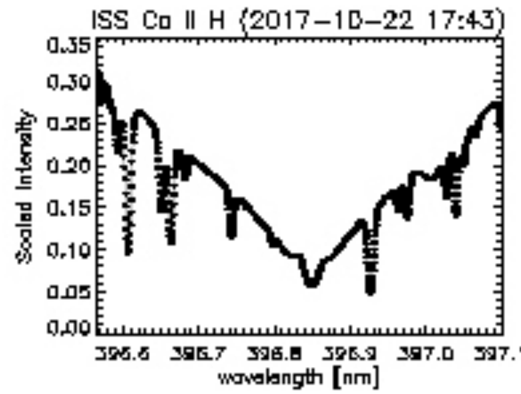
388.4 nm (CN bandhead)



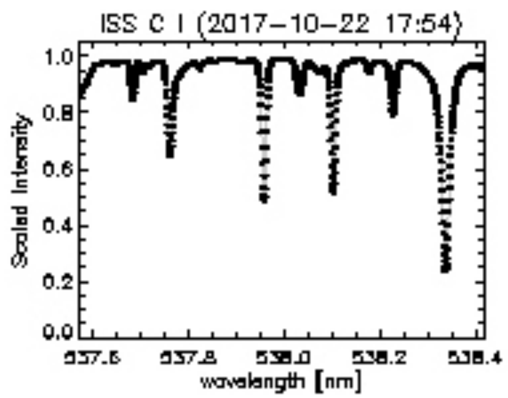
393.4 nm (Ca II K)



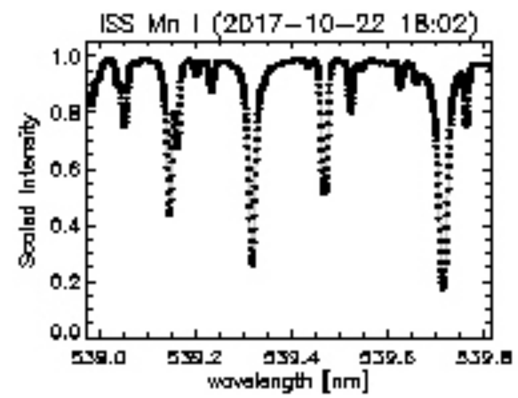
396.8 nm (Ca II H)



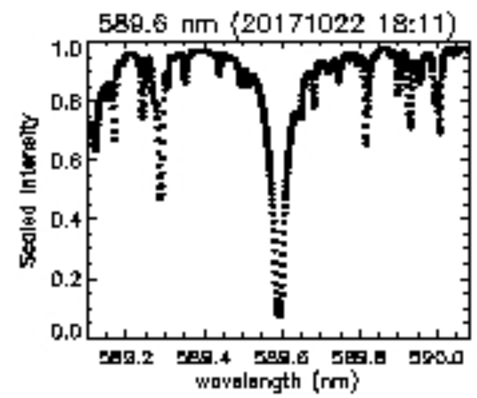
538.0 nm (C I)



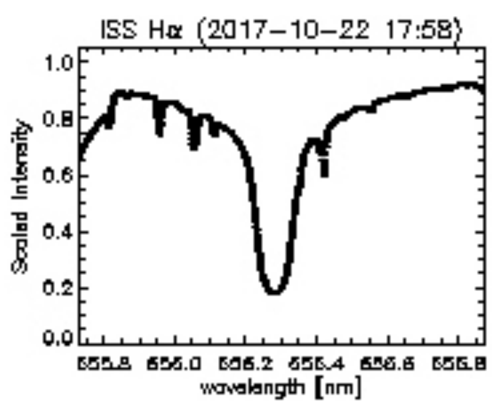
539.4 nm (Mn I)



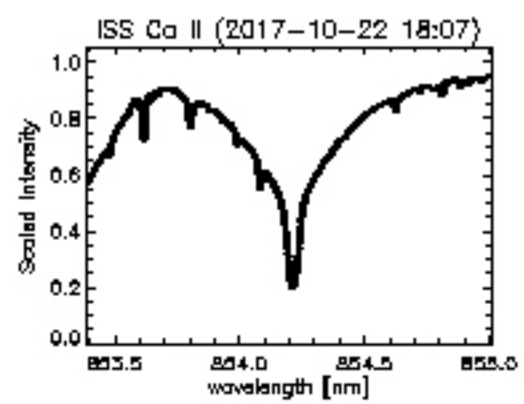
589.6 nm (Na D I)



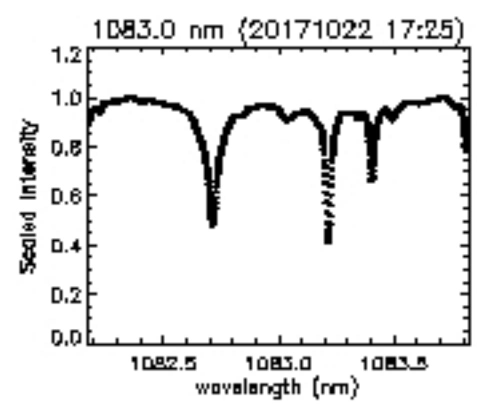
656.3 nm (H-alpha)



854.2 nm (Ca II)



1083.0 nm (He I)



Example combination of high-resolution & synoptic data: support for Parker Solar Probe (PSP) during its first solar encounter

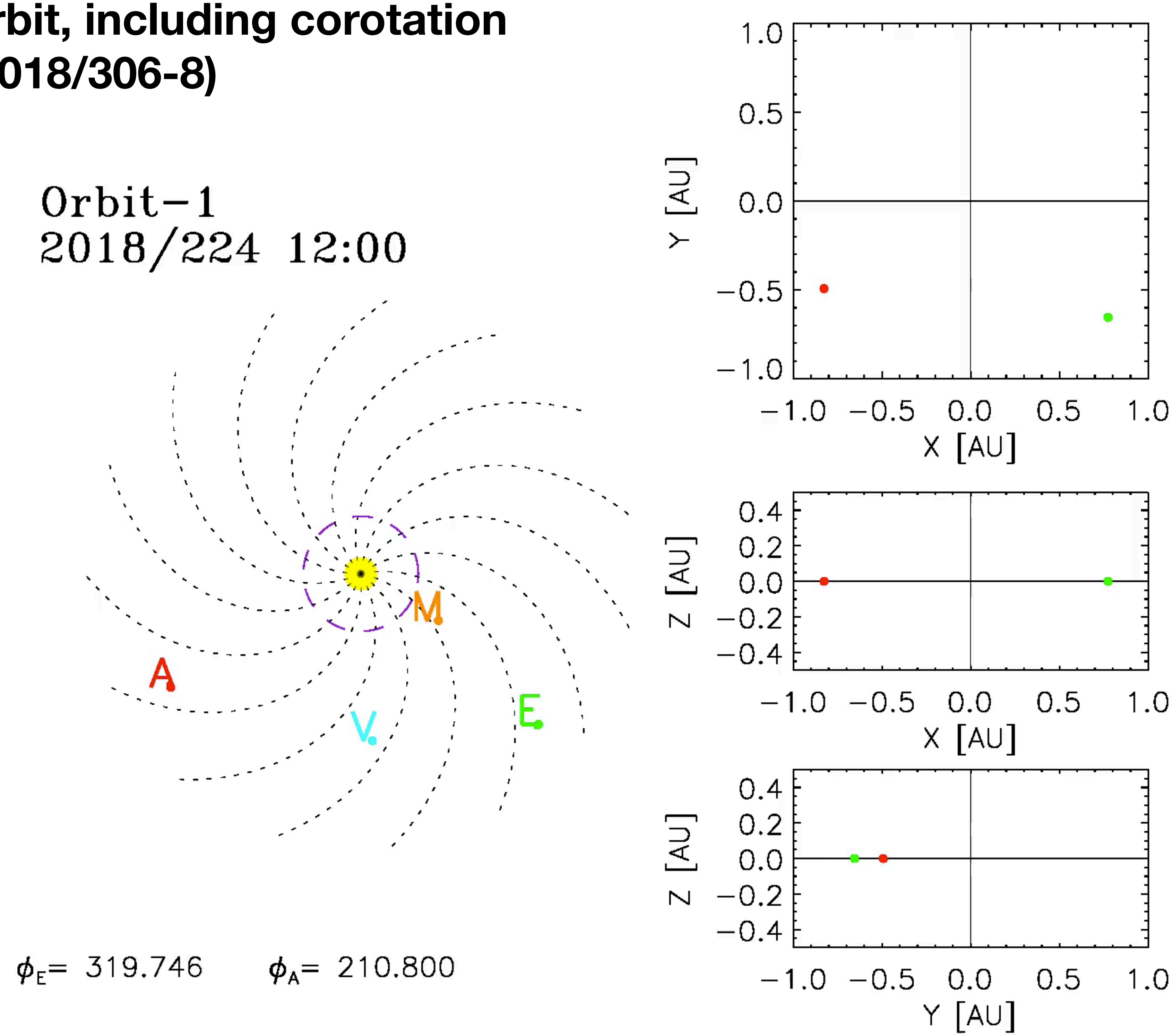
A corotation period (a time when PSP will be connected to the same region of the Sun) occurs from November 2nd to November 4th.

Corotation occurs when PSP is <90 degrees from the Earth-Sun line.

Use GONG near-real-time synoptic maps and potential-field source-surface coronal models too predict where PSP is going to be magnetically connected to the Sun, and observe this area at high resolution with the Dunn Solar Telescope (DST).



PSP 1st orbit, including corotation
Nov 2-4 (2018/306-8)



Movie from Nour-Eddine Raouafi

	Time	Lon Earth	Lat Earth	Lon PSP	Lat PSP	Distance (AU)
Start	2018-OCT-31 11:58:00	298.85	4.46	328.23	-0.24	0.25
Perihel	2018-NOV-06 03:29:01	224.39	3.87	327.60	-4.05	0.1659
Stop	2018-NOV-11 19:00:01	149.95	3.25	327.04	-1.24	0.25

COROTATION PERIOD FOR ORBIT 1

Duration [days] 1.85

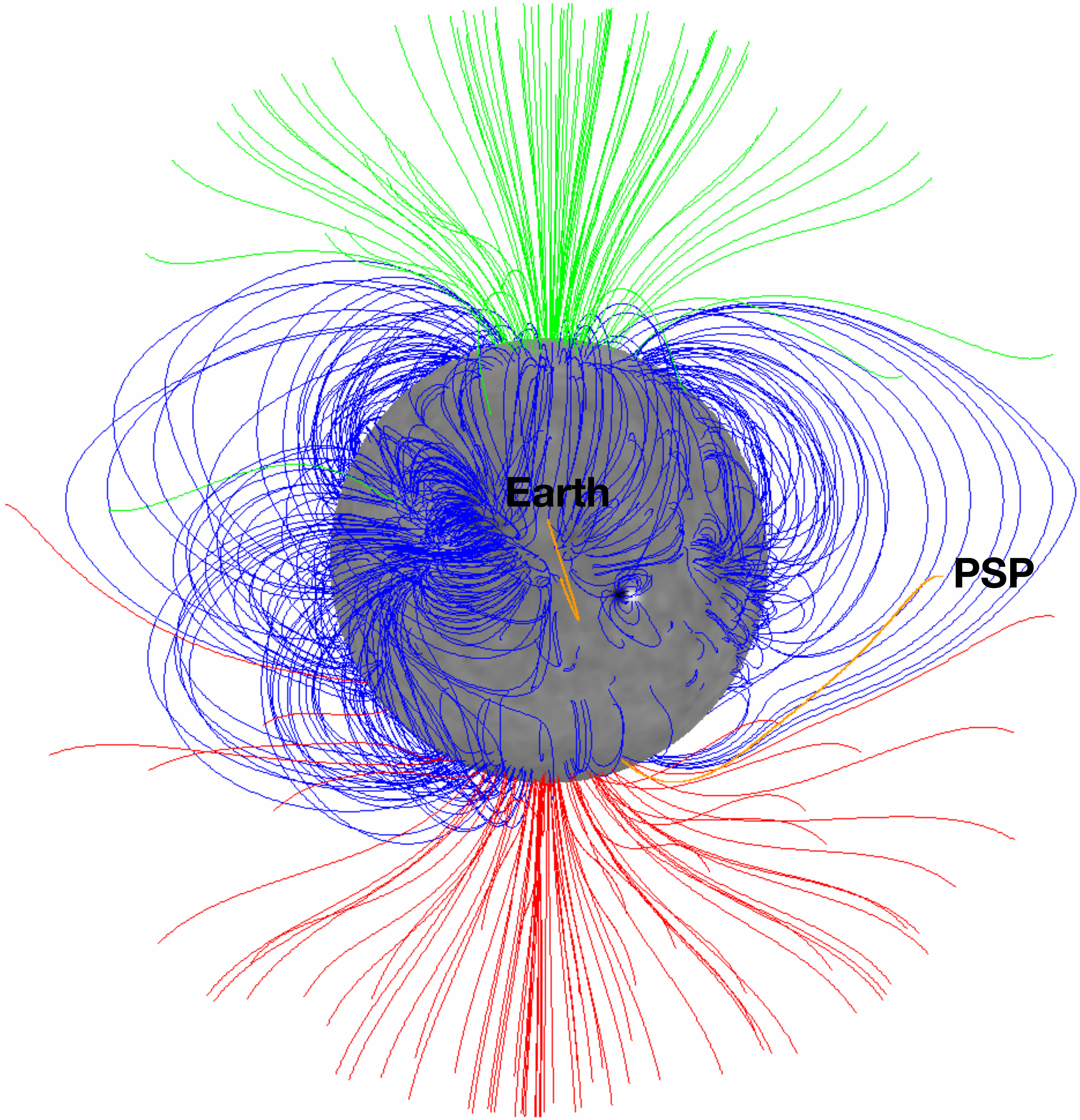
2018-NOV-02 08:22:45	274.45	4.27	320.40	-1.52	0.21
2018-NOV-04 08:25:29	248.05	4.06	320.40	-3.13	0.18

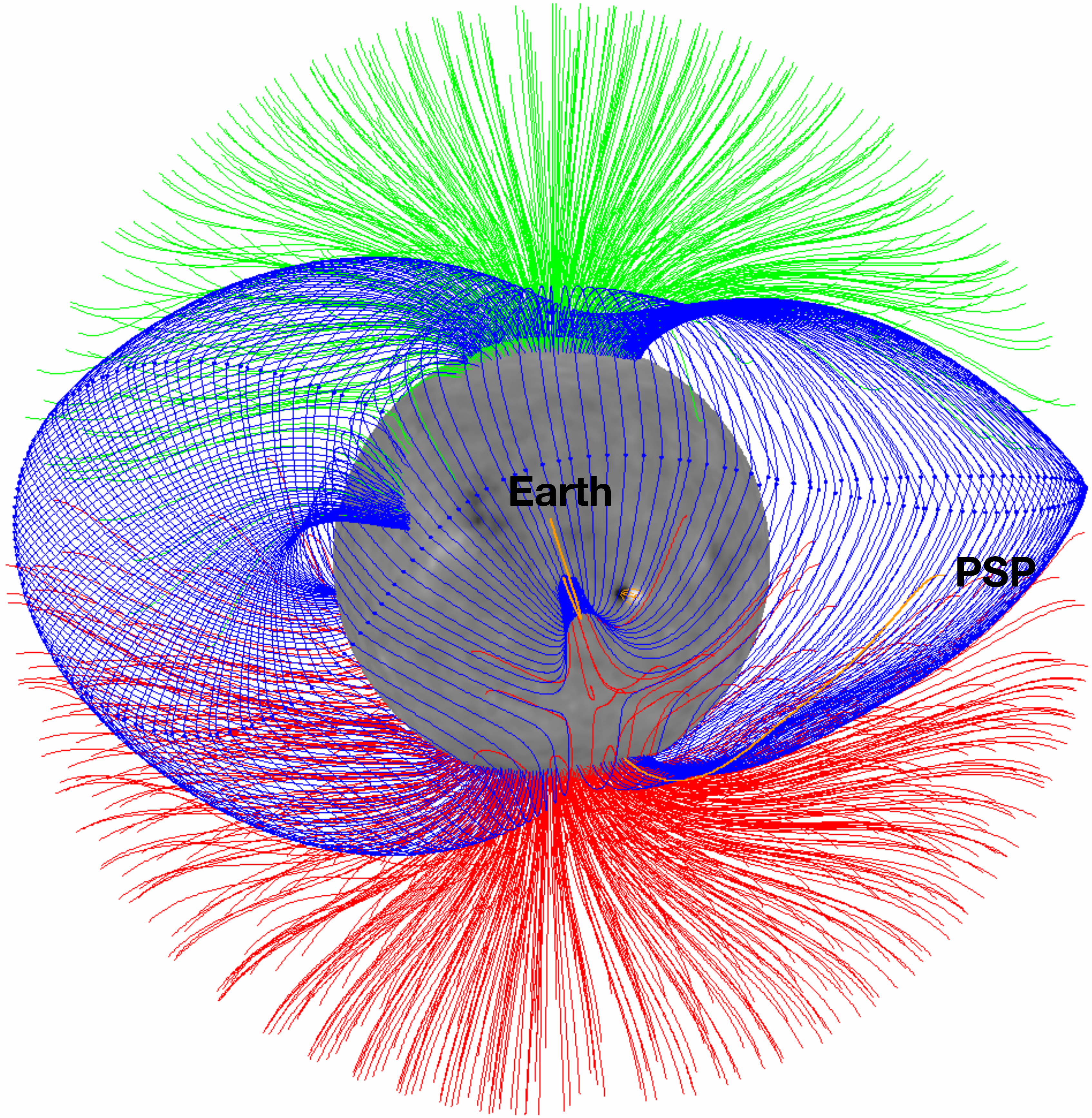
PSP 320.40-274.45=45.95 west of Earth on 2 Nov at 08:22:45.
PSP 320.40-248.05=72.35 west of Earth on 4 Nov at 08:25:29.

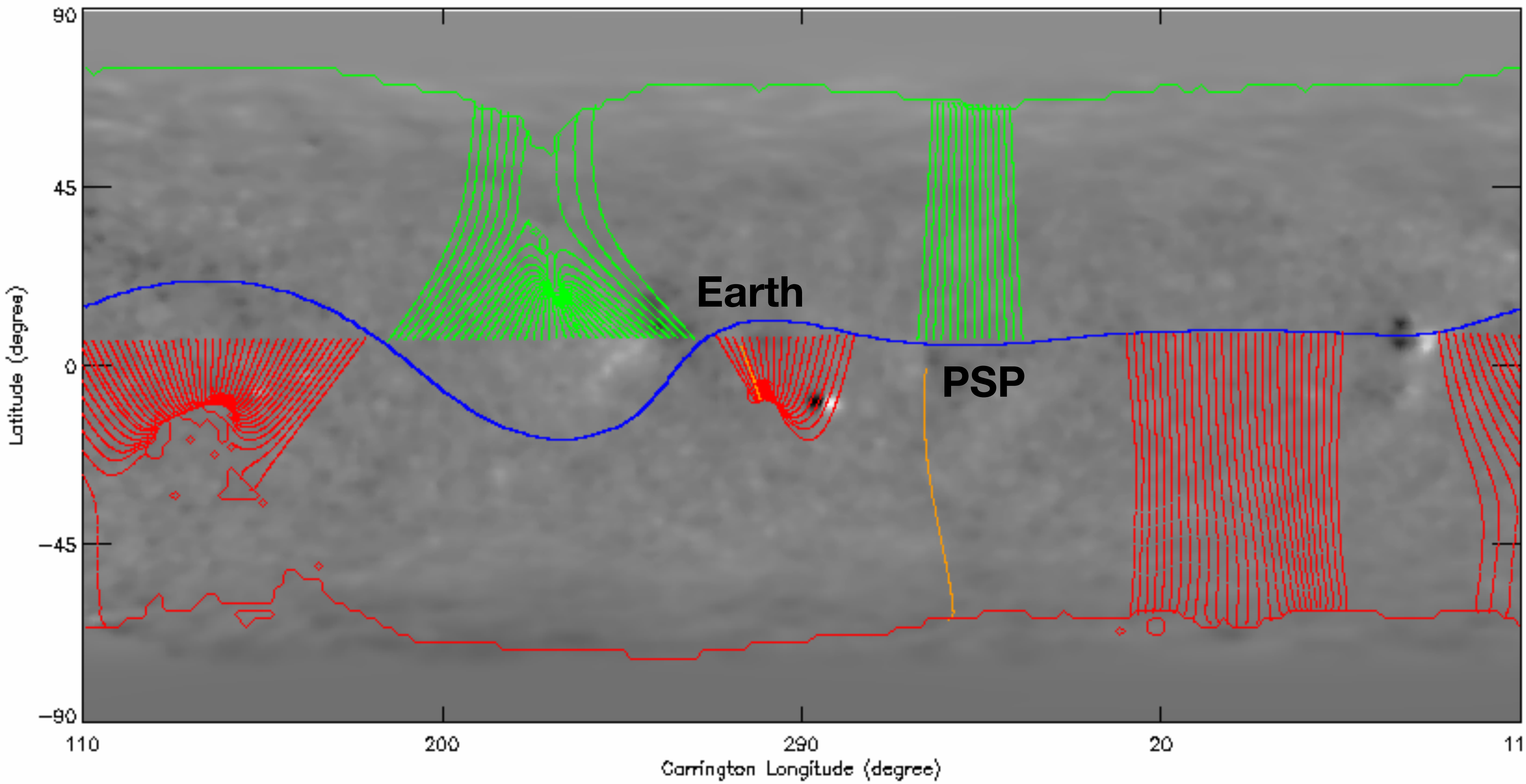
Fast solar wind speed 700km/s, slow solar wind about half that speed.

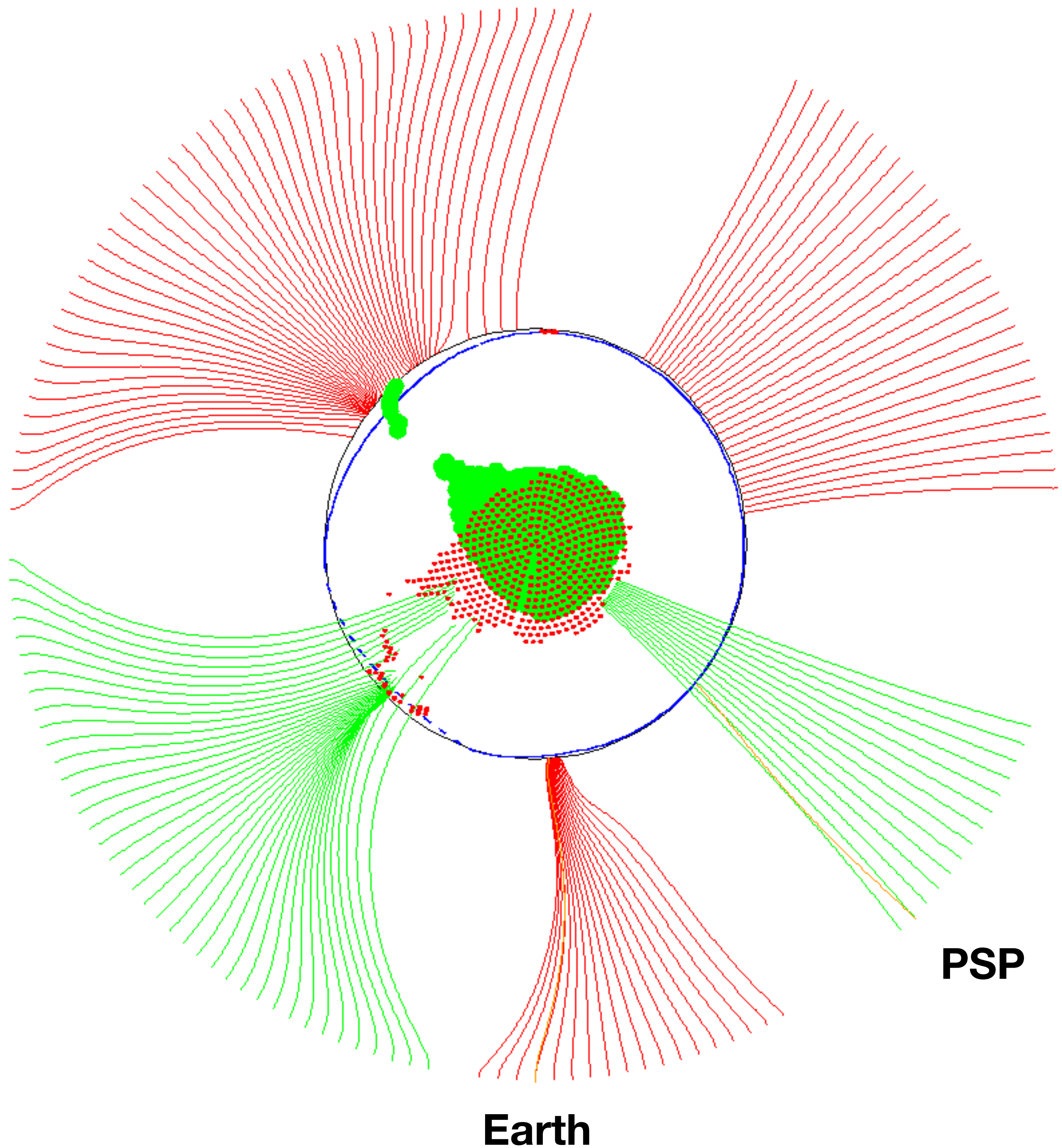
To travel 0.2 AU = 149.6/5 million km = 30 million km, at 700 km/s takes 11.9 hr.

2 Nov 2018 08:22UT is 02:22 Mountain Daylight Time, subtract >12hr travel time


Earth
PSP


Earth
PSP


90
45
0
−45
−90
Latitude (degree)
110
200
290
20
110
Carrington Longitude (degree)
Earth
PSP


PSP
Earth

NASA/Community Coordinated Modeling Center Wang-Sheeley-Arge model