Наблюдения магнитных полей с инстументами SOLIS и GONG.

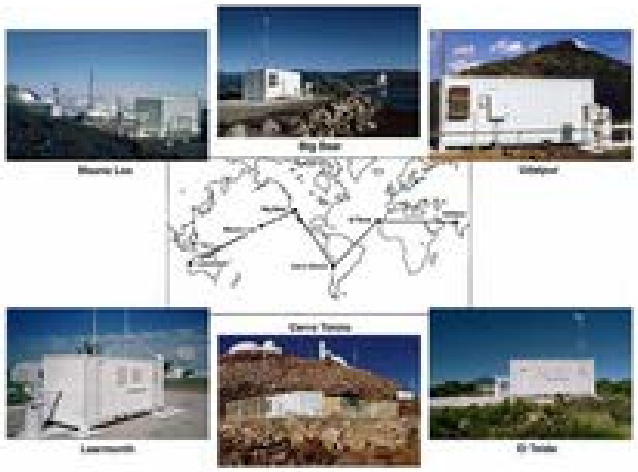
PART II

Алексей А. Певцов
US National Solar Observatory

NSO INTEGRATED SYNOPTIC PROGRAM

NISP

The NSO Integrated Synoptic Program (NISP) provides long-term synoptic observations of the Sun to national and international solar and solar-terrestrial physics communities in support of scientific research and for operational forecast applications in the framework of space weather and climate. NISP operates a suite of instruments from the Global Oscillation Network Group (GONG) and the Synoptic Optical Long-term Investigations of the Sun (SOLIS) programs.



The GONG Network

SOLIS instrumentation on Kitt Peak

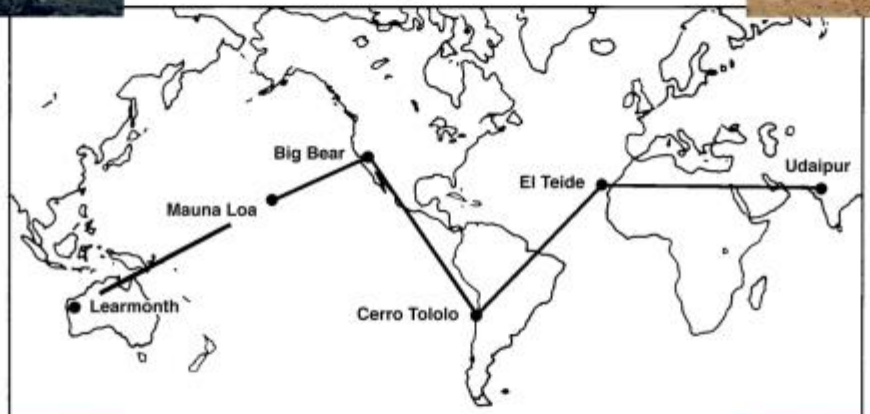
http://nisp.nso.edu/

Mauna Loa

Big Bear

Udaipur

Global Oscillation Network Group



Learmonth

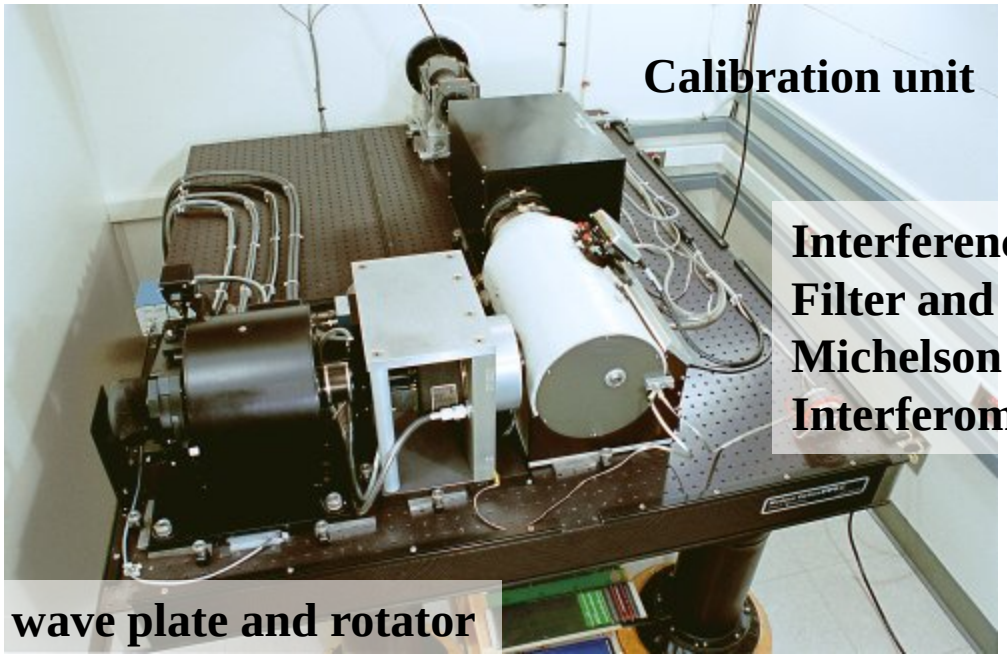
Cerro Tololo

El Teide

GONG: The Global Oscillation Network Group

- Operating since 1995
- Original goal: helioseismology, now also space weather
- Two instruments:
  - Michelson Interferometer
    - helioseismology Doppler velocity, intensity and LOS magnetic field
    - 1k x 1k full-disk images in Ni I 676.8 nm
    - 60-sec cadence
  - H_α filter system
    - H-α intensity
    - 2k x 2k full-disk images
    - 60-sec cadence at a given site, 20-sec cadence from network

Turret

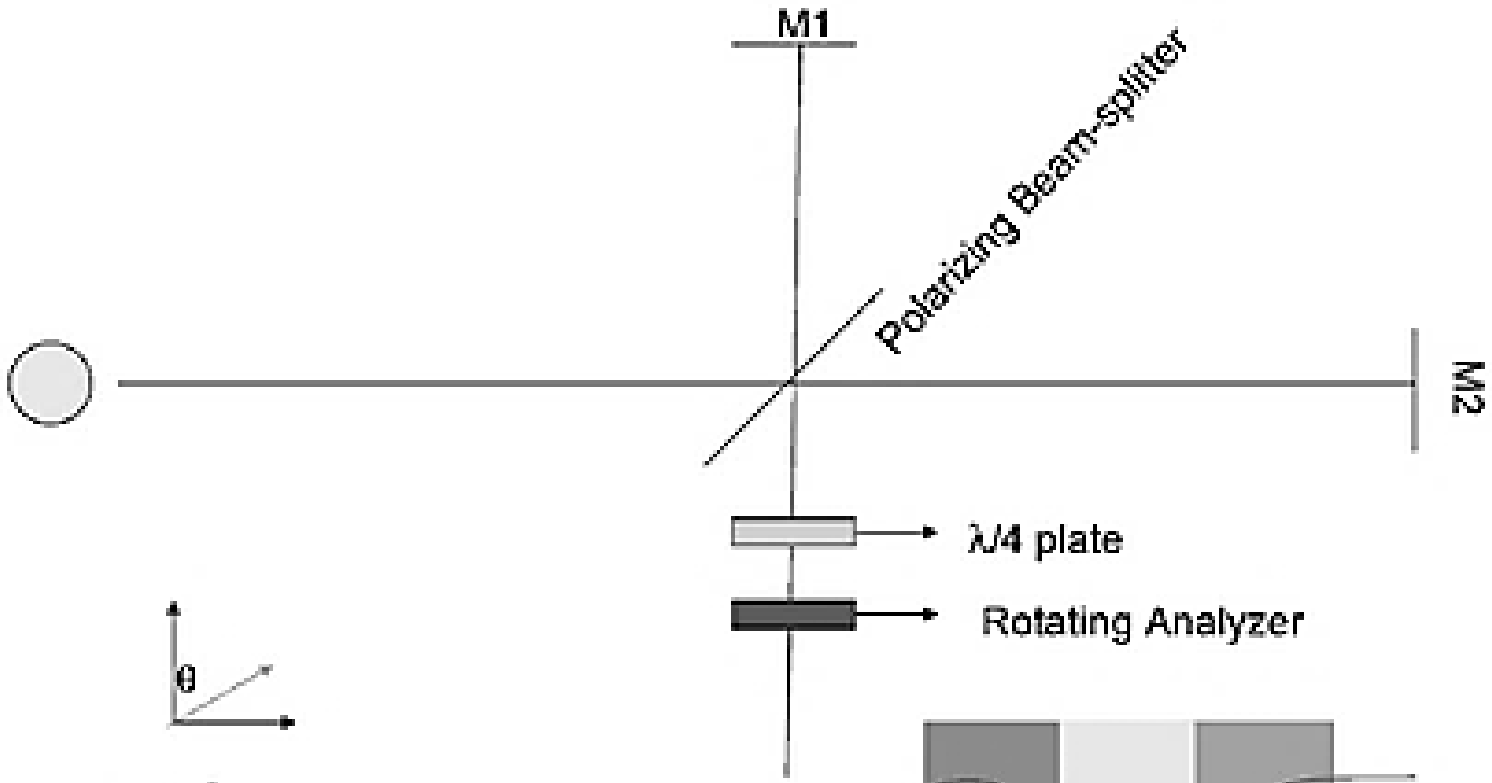


Calibration unit

Interference Filter and Michelson Interferometer

Camera, wave plate and rotator

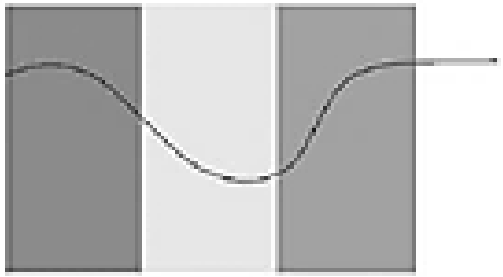
PRINCIPLE OF GONG MAGNETOGRAPH



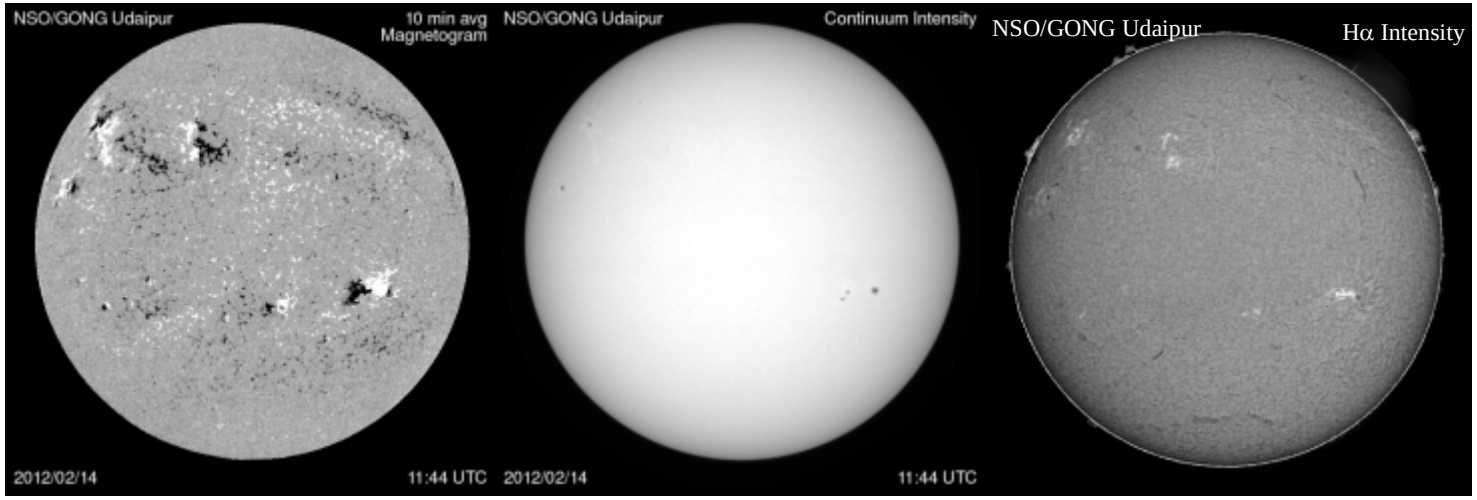
$\theta = \delta$

$2\pi \sim \Delta\lambda$

$B \sim (\lambda_{RCP} - \lambda_{LCP})$



Basic Data from GONG

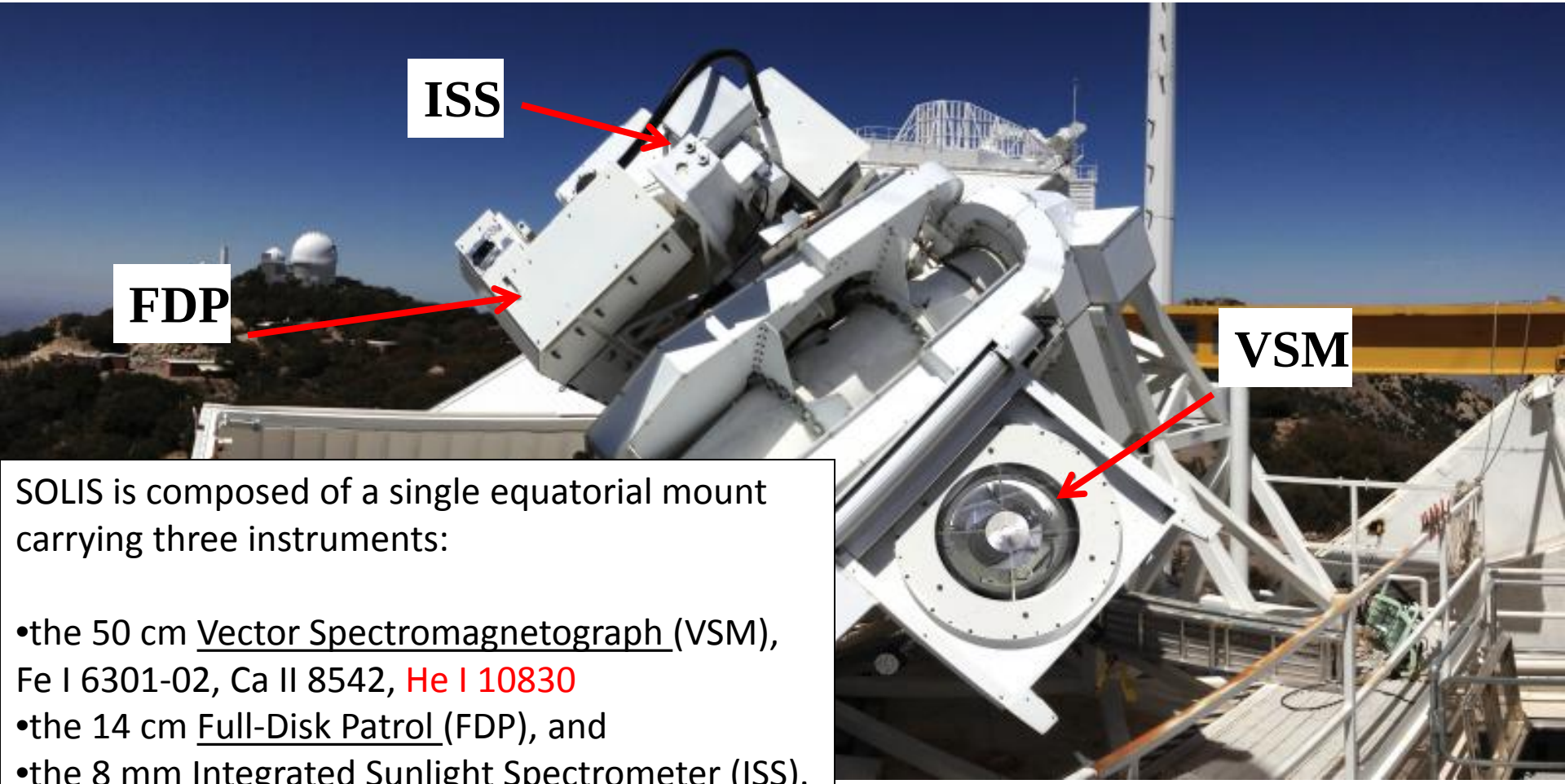


The above images are returned in near-real time and are available on the Internet

http://gong.noao.edu/

Dopplergrams for helioseismology. Left – full velocity field. Right – oscillatory velocity field

Synoptic Optical Long-term Investigations of the Sun (SOLIS)

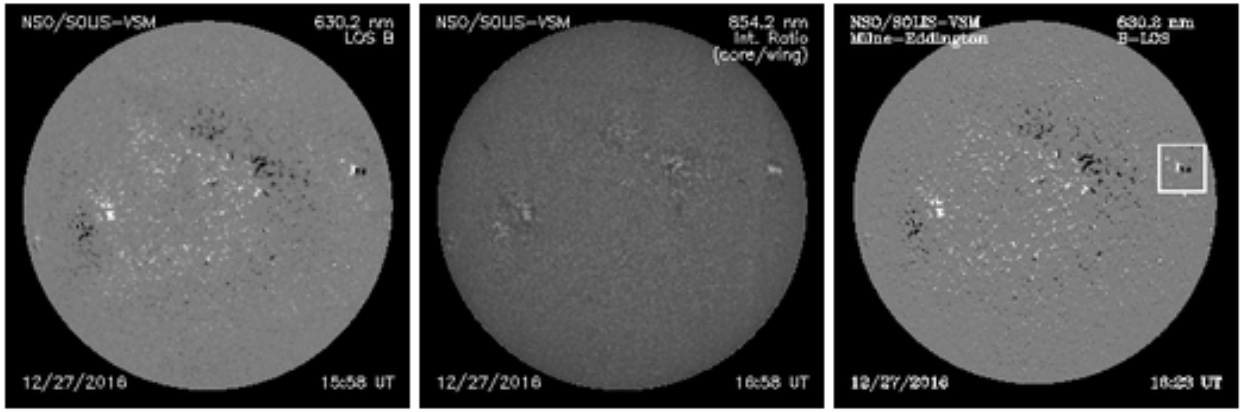


SOLIS is composed of a single equatorial mount carrying three instruments:

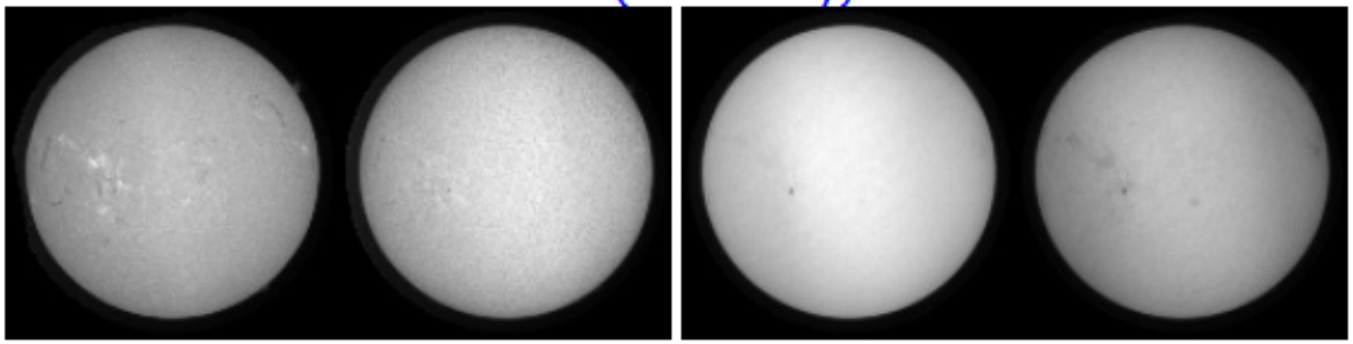
- the 50 cm Vector Spectromagnetograph (VSM), Fe I 6301-02, Ca II 8542, He I 10830
- the 14 cm Full-Disk Patrol (FDP), and
- the 8 mm Integrated Sunlight Spectrometer (ISS).
- In operation since 2003 (2006-2014 at Kitt Peak), in July 2014 moved to Tucson to prepare for relocation and upgrades

http://solis.nso.edu

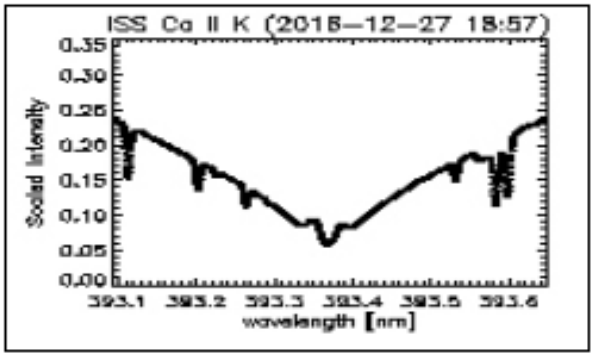
Latest VSM Data



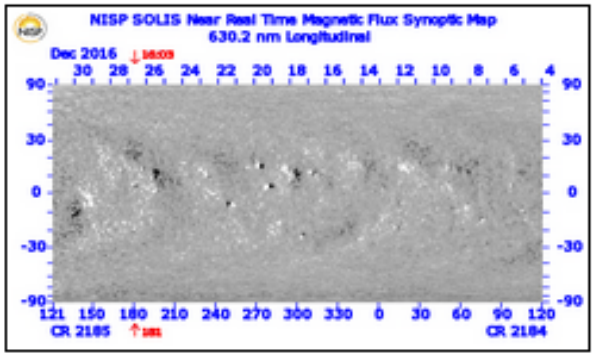
Latest FDP (Preliminary) Data



Latest ISS Spectra



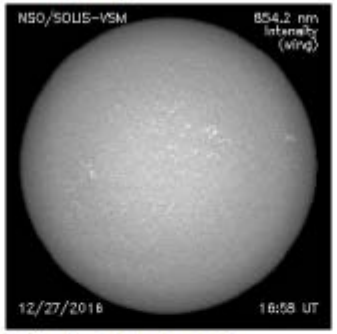
Latest Synoptic Maps



Photosphere (630.2 nm)
Intensity

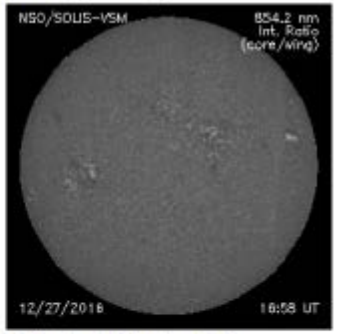
[2" jpg] [1" fits]

Chromosphere (854.2 nm)
Intensity (wing)



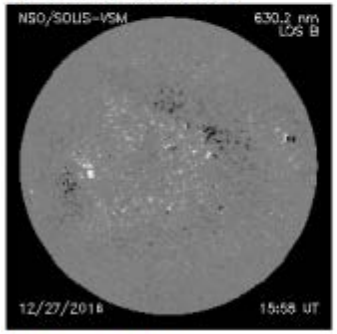
[2" jpg] [1" 9-plane fits]

Chromosphere (854.2 nm)
Intensity (core/wing)



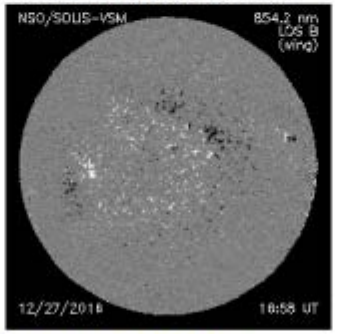
[2" jpg] [1" 9-plane fits]

Photosphere (630.2 nm)
Longitudinal Magnetic Field



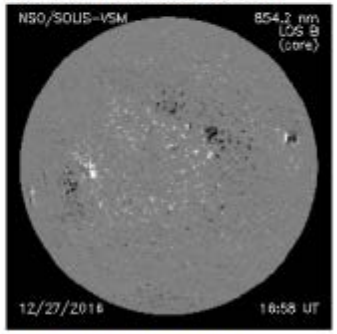
[2" jpg] [1" fits]

Chromosphere (854.2 nm)
Longitudinal Magnetic Field (wing)



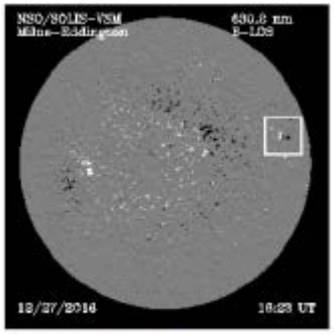
[2" jpg] [1" 9-plane fits]

Chromosphere (854.2 nm)
Longitudinal Magnetic Field (core)



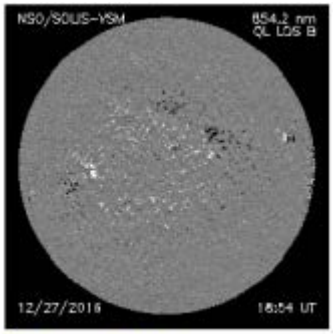
[2" jpg] [1" 9-plane fits]

Photosphere (630.2 nm)
Vector Magnetic Field



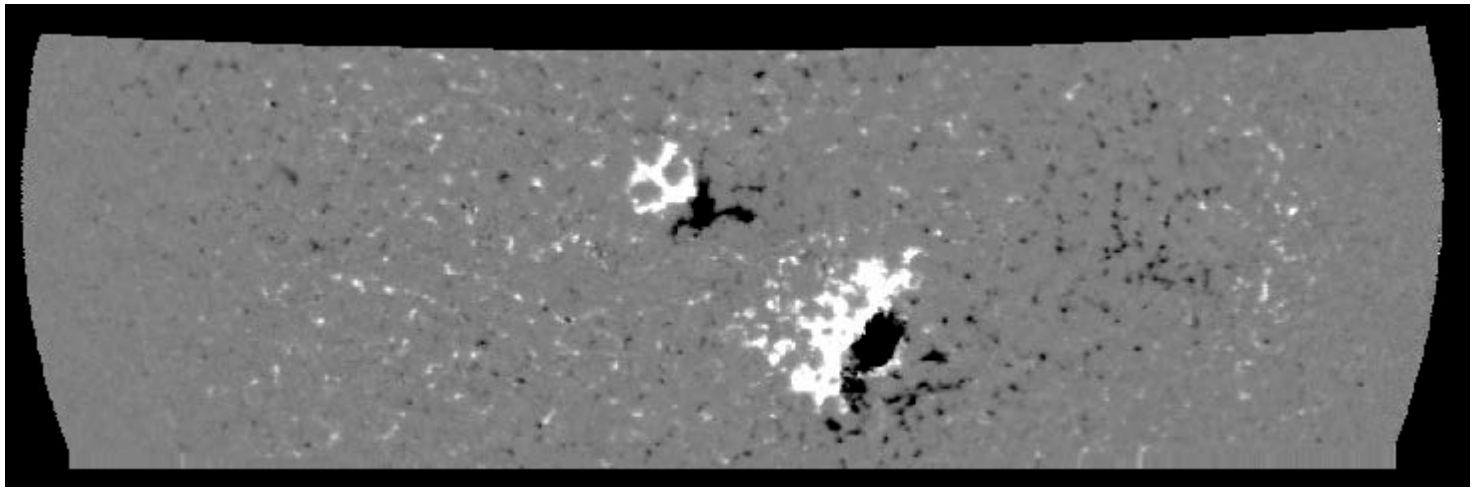
More 6302v Products

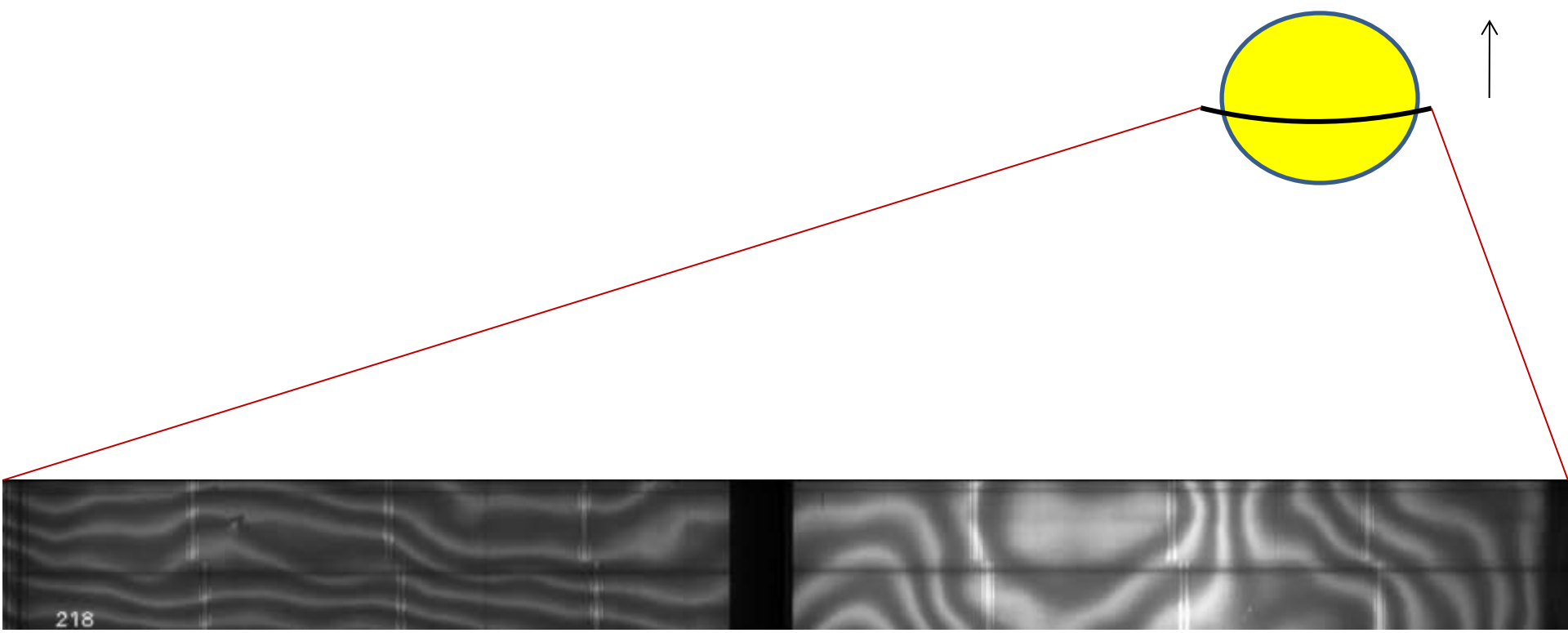
Chromosphere (854.2 nm)
Vector Magnetic Field

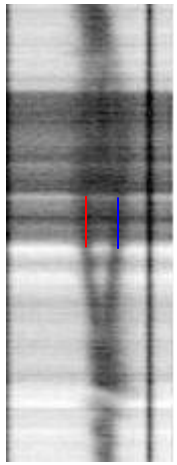


[2" jpg] [1" fits]

Area Scans



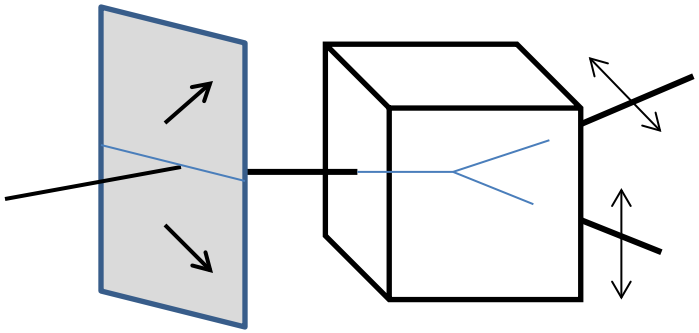


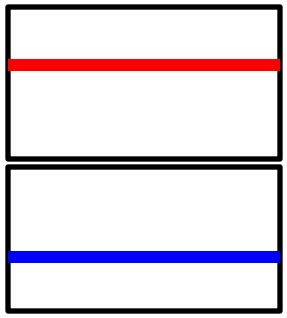


¼ WL

P

σ+



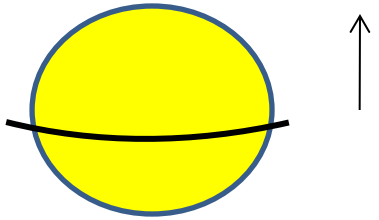


σ-

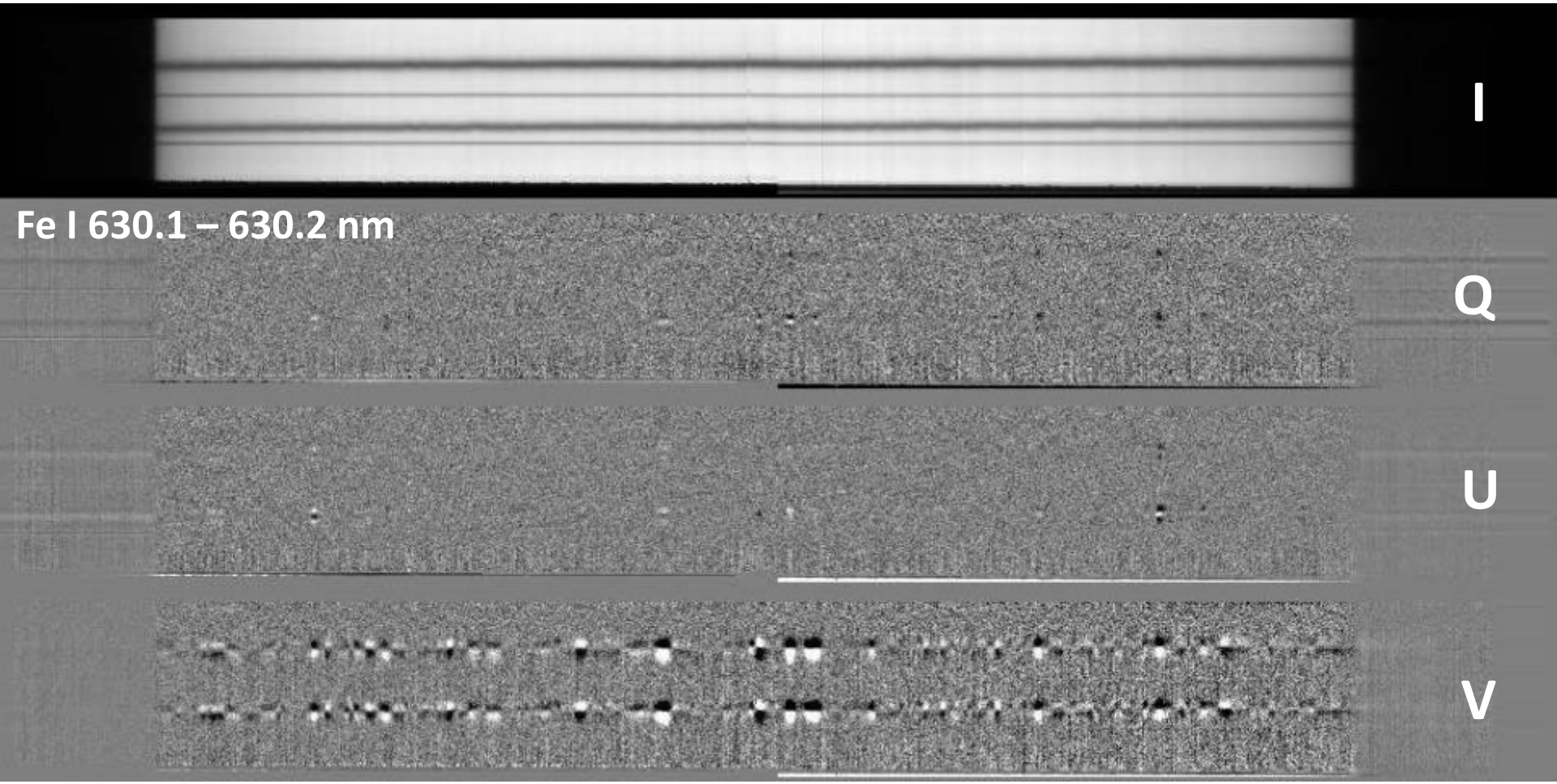
I-V

I+V

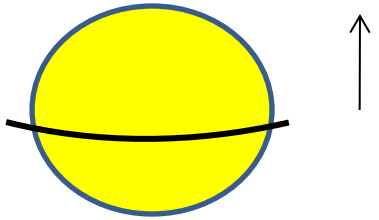
SOLIS/VSM



The Vector Spectromagnetograph (VSM) is designed to obtain high-quality magnetic field observations in the photosphere and the chromosphere.



SOLIS/VSM



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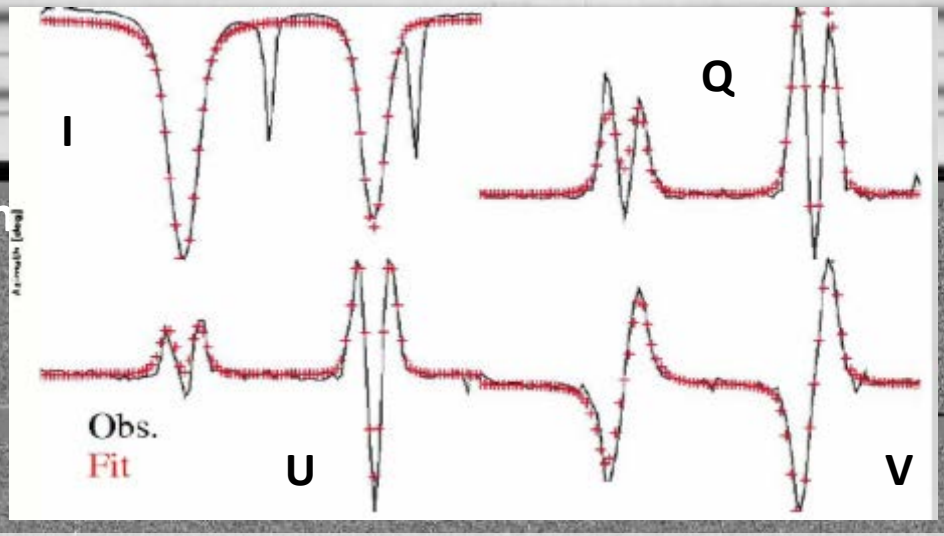


Fe I 630.1 – 630.2 n

I

Q

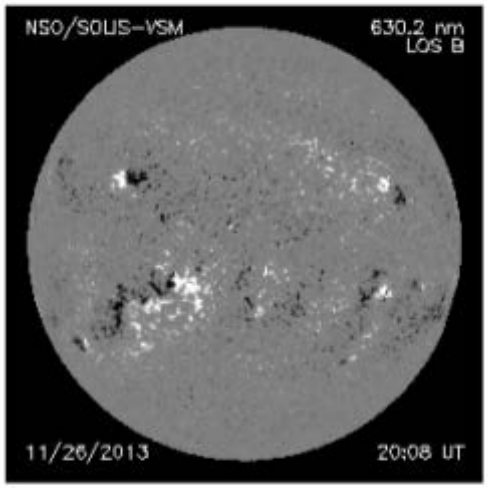
U

V

Data are inverted using VFISV (Very Fast Inversion, ME) code (Borrero et al 2009) similar to SDO/HMI. LOS mags – Center-of-Gravity method.

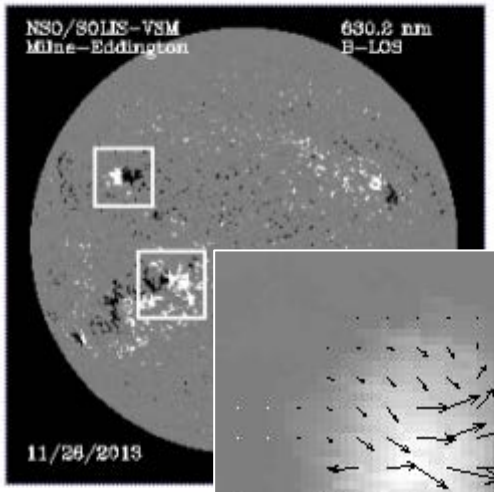
Magnetic fields everywhere!

Photosphere (630.2 nm)
Longitudinal Magnetic Field



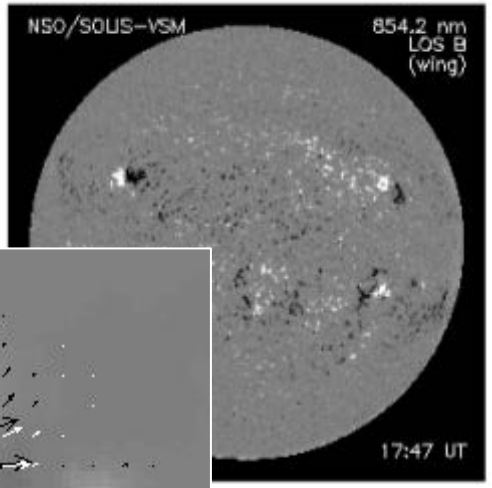
[2" jpg] [1" fits]

Photosphere (630.2 nm)
Vector Magnetic Field

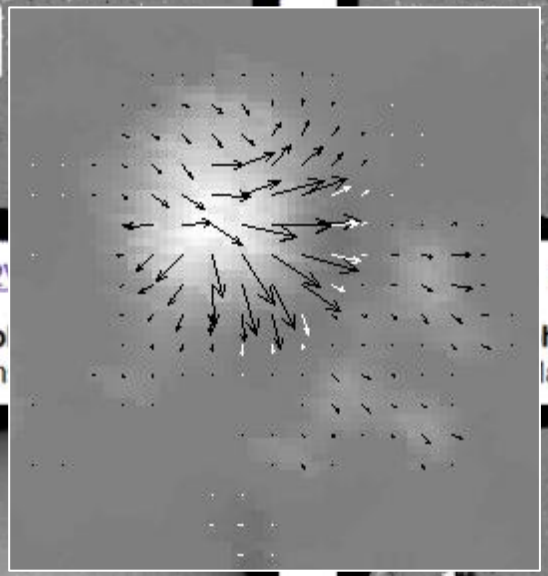


VSM 6302'

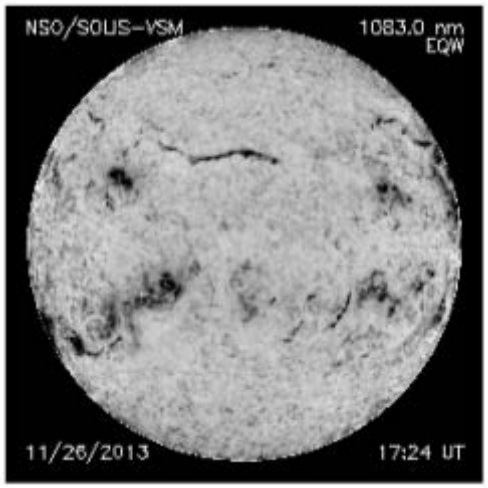
Chromosphere (854.2 nm)
Longitudinal Magnetic Field (wing)



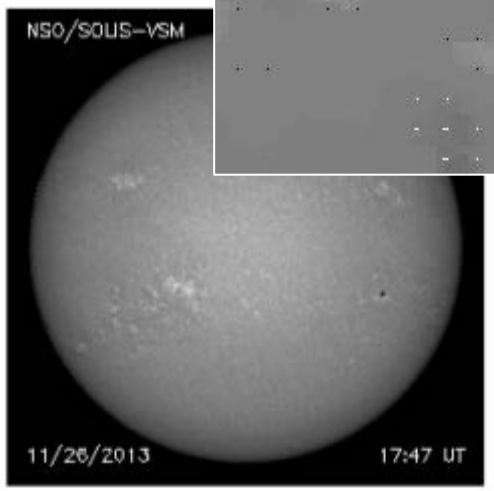
[1" 8-plane fits]



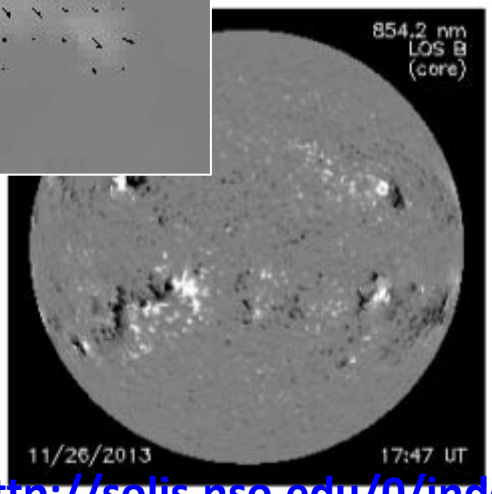
Chromosphere (1083.0 nm)
Equivalent Width



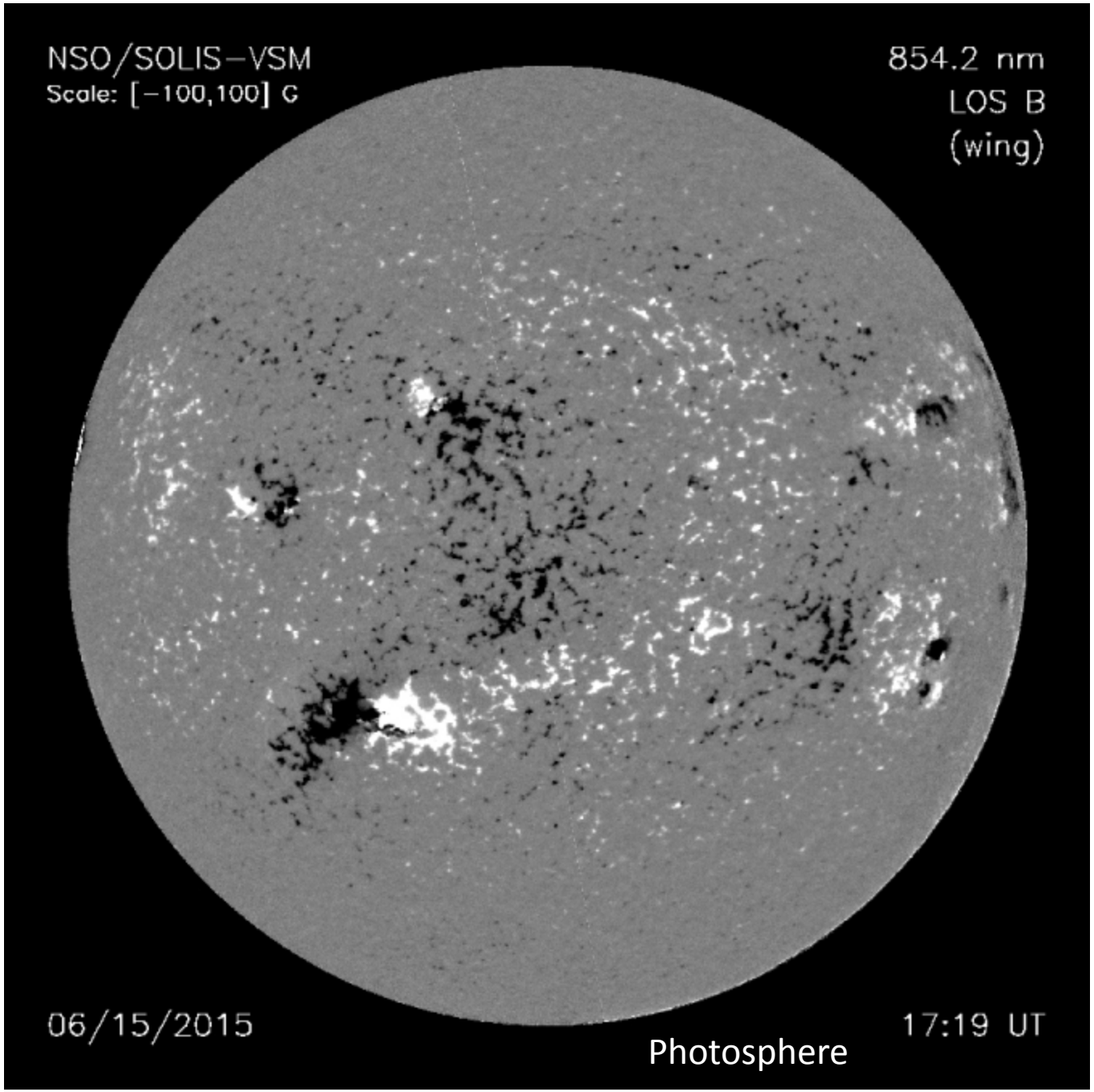
Chromosp
Inten

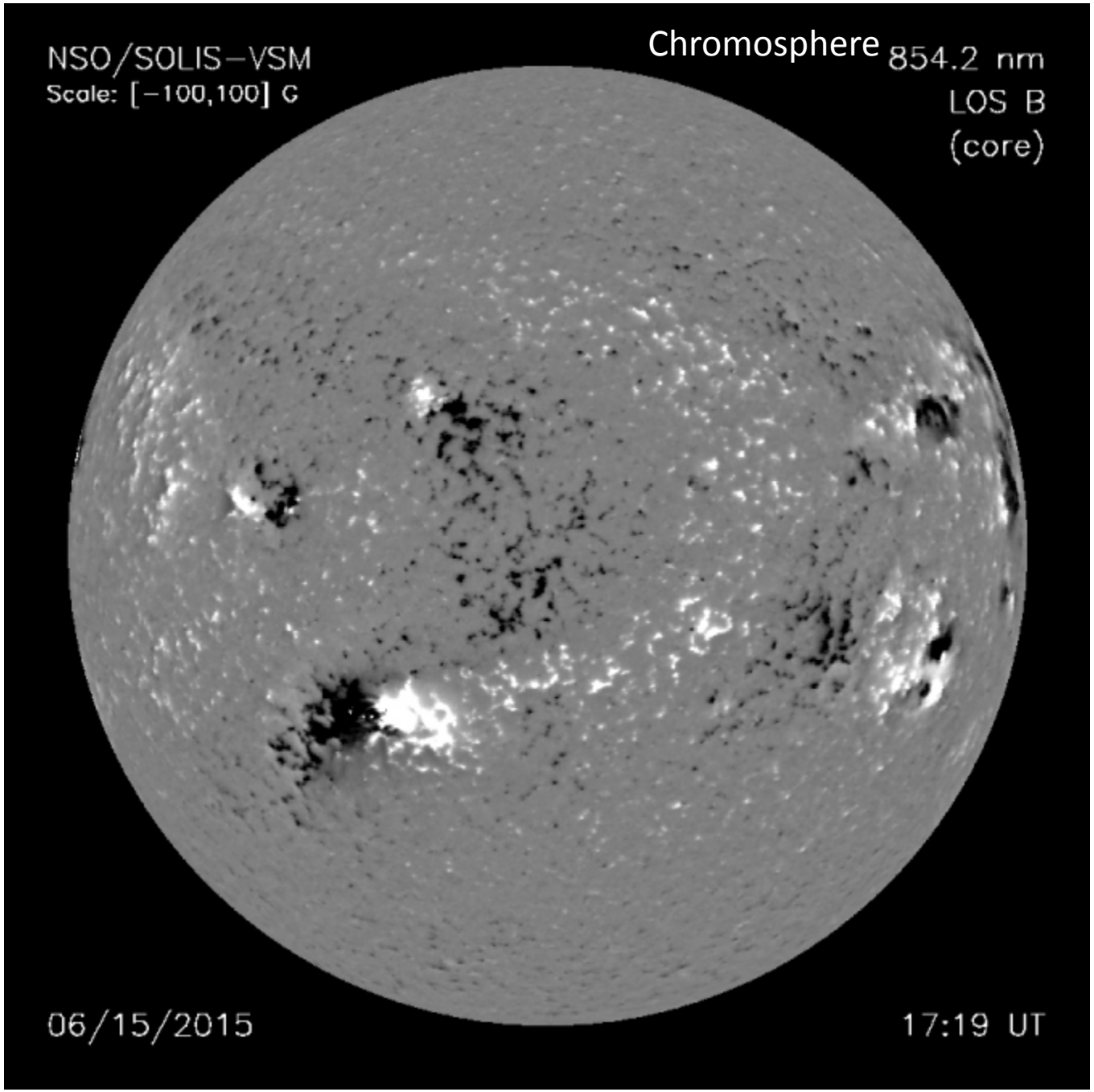


here (854.2 nm)
lagnetic Field (core)



http://solis.nso.edu/0/index.html


NSO/SOLIS–VSM
Scale: [–100,100] G
854.2 nm
LOS B
(wing)
06/15/2015
17:19 UT
Photosphere


NSO/SOLIS–VSM
Scale: [–100,100] G
Chromosphere 854.2 nm
LOS B
(core)
06/15/2015
17:19 UT

Details, details…

- **Curved slit; 2-camera system**

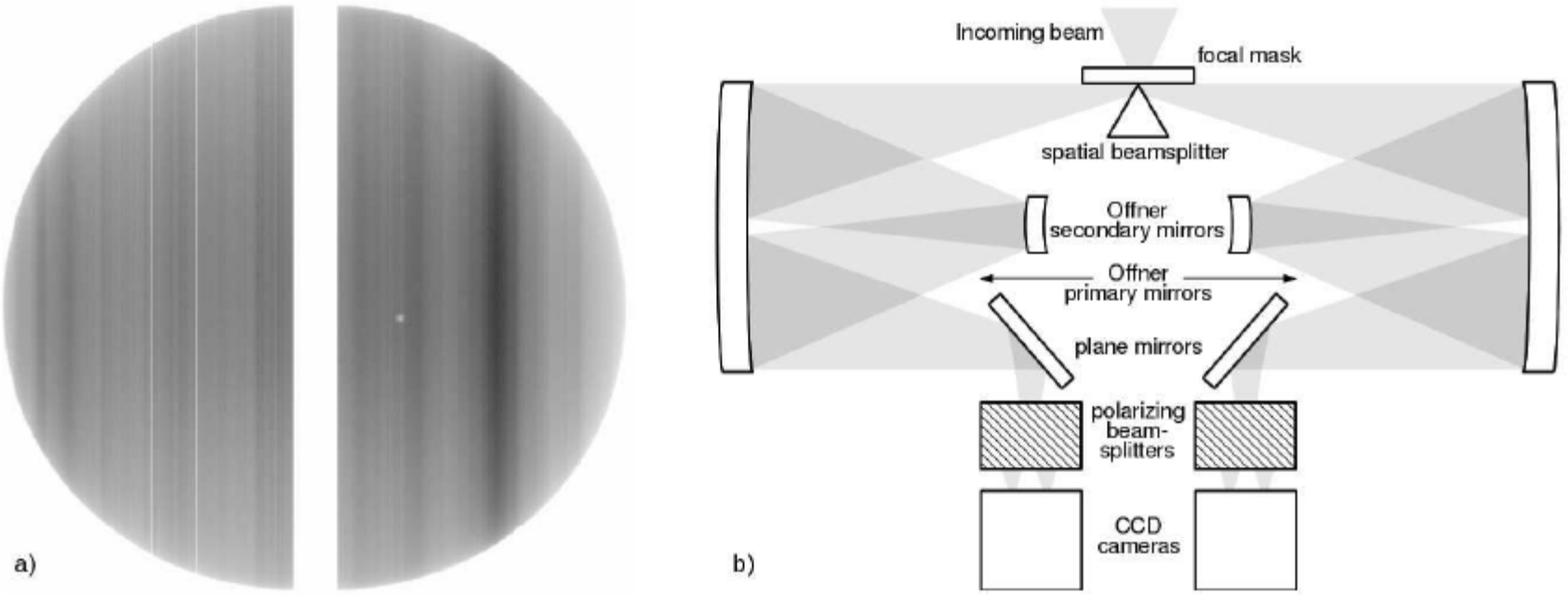
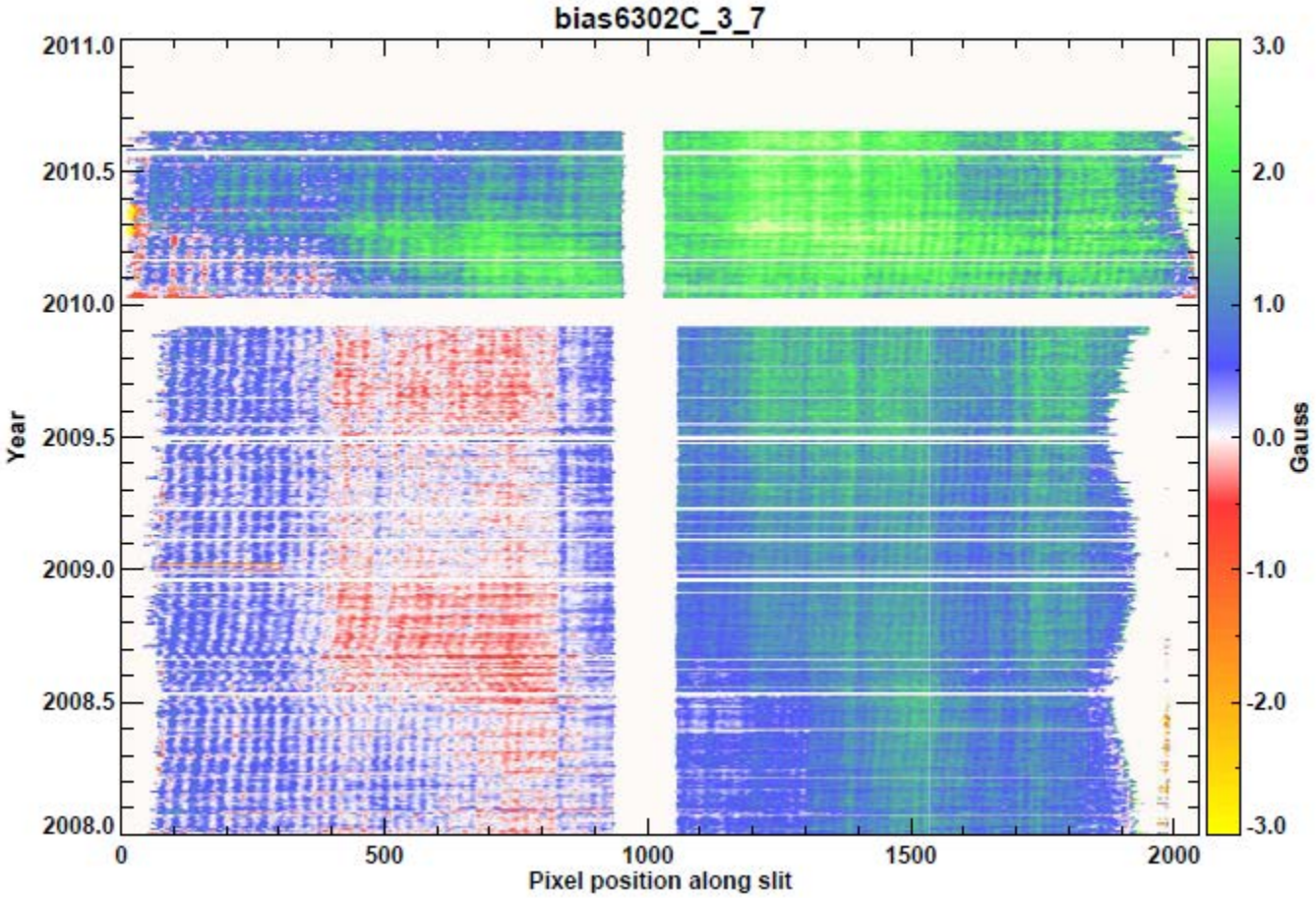


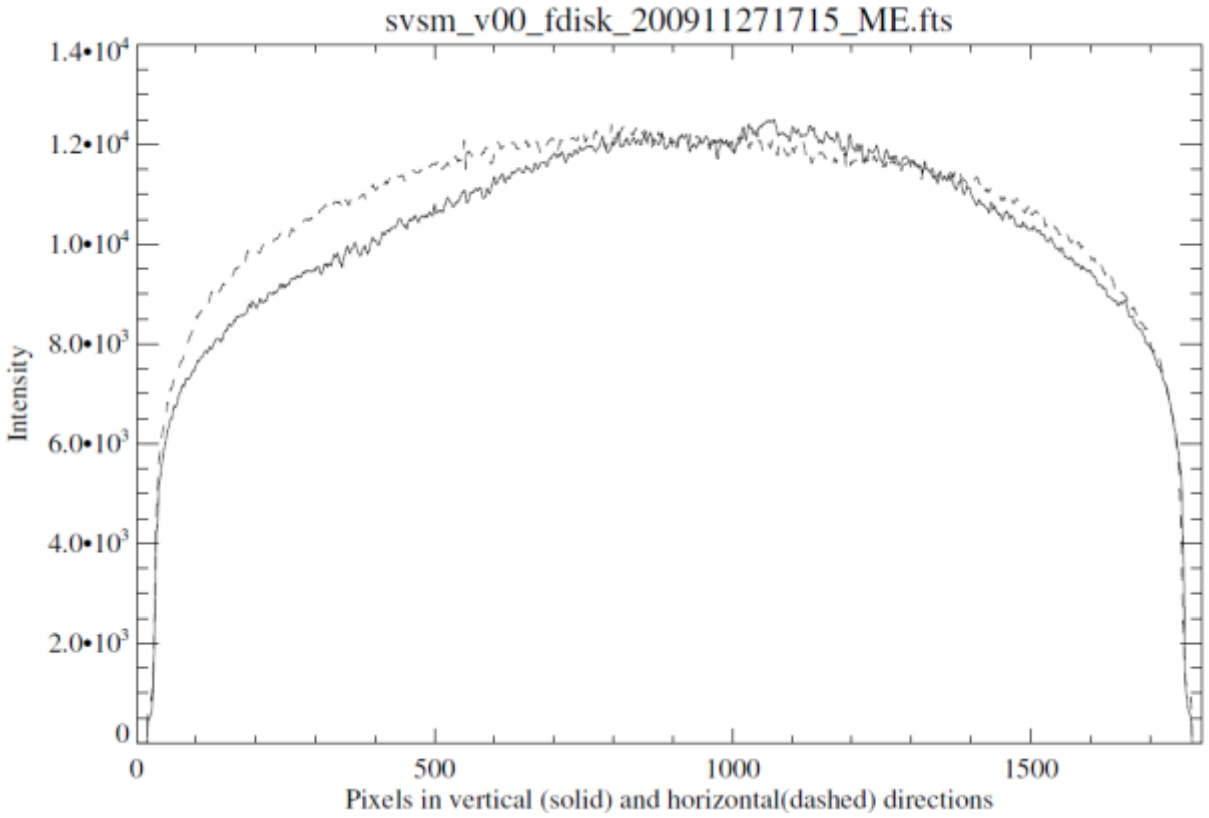
Figure 1 – *(a) Level-1 6302L intensity image (without flat-field corrections) exhibiting the gap. (b) Schematic of the reimaging system within the VSM on SOLIS.*

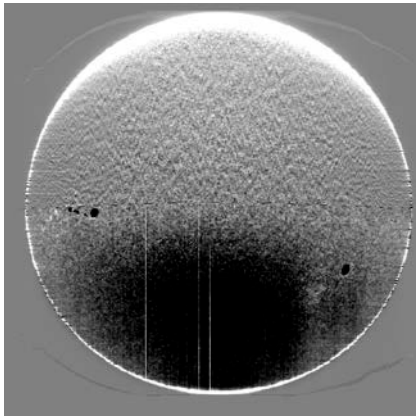
Marble, A.R., Callahan, L., Pevtsov, A.A.: 2013, *Camera Gap Removal in SOLIS/VSM Images*, Technical Report No. NSO/NISP-2013-003

more details…



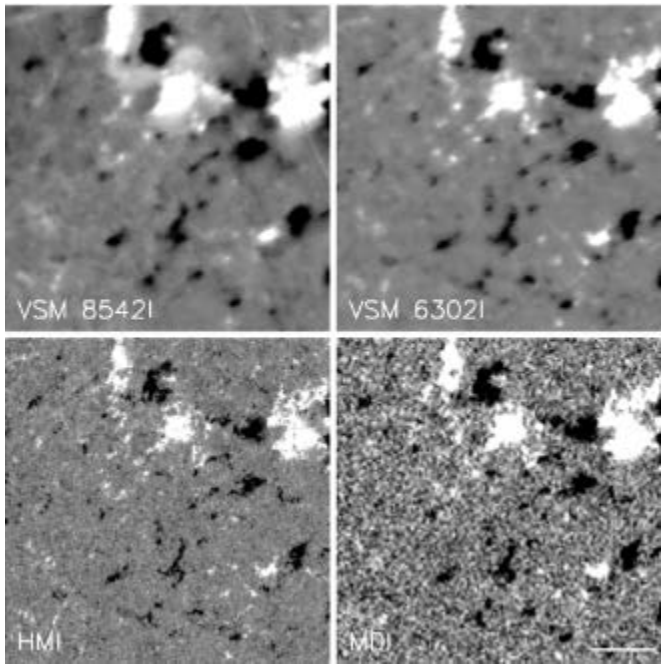
And even more details…



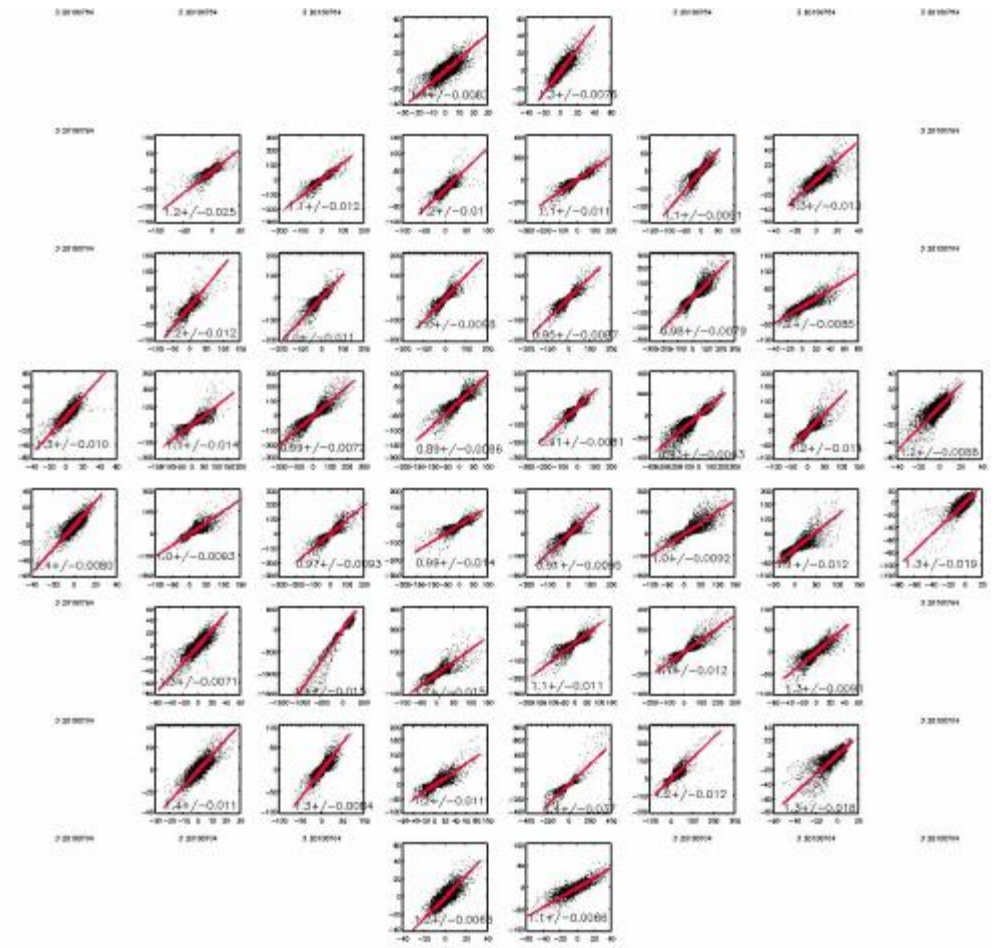


VSM vs. HMI

SOLIS/VSM



HMI **MDI**

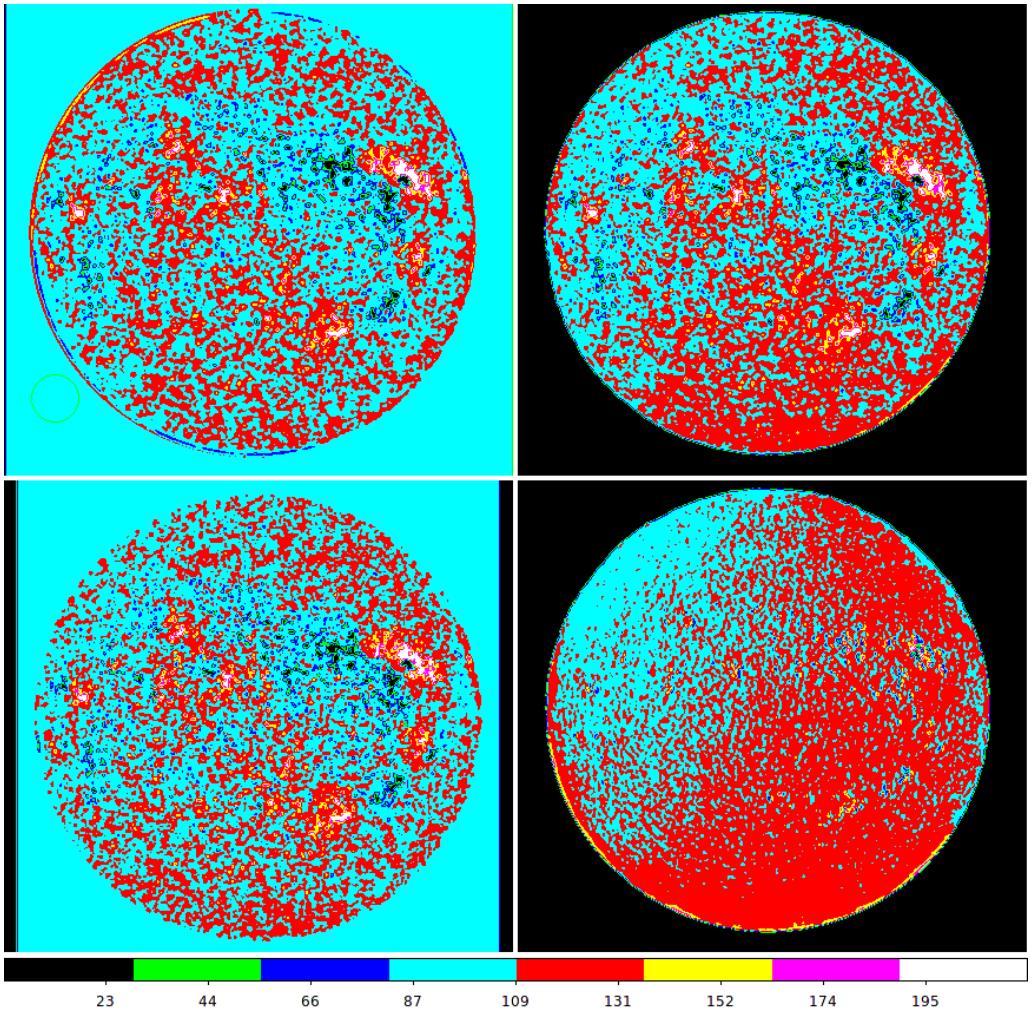


Pietarila et al (2012)

Instrumental Polarization in GONG

GONG Mag. – Instr. Polarization

SOLIS/VSM Mag.

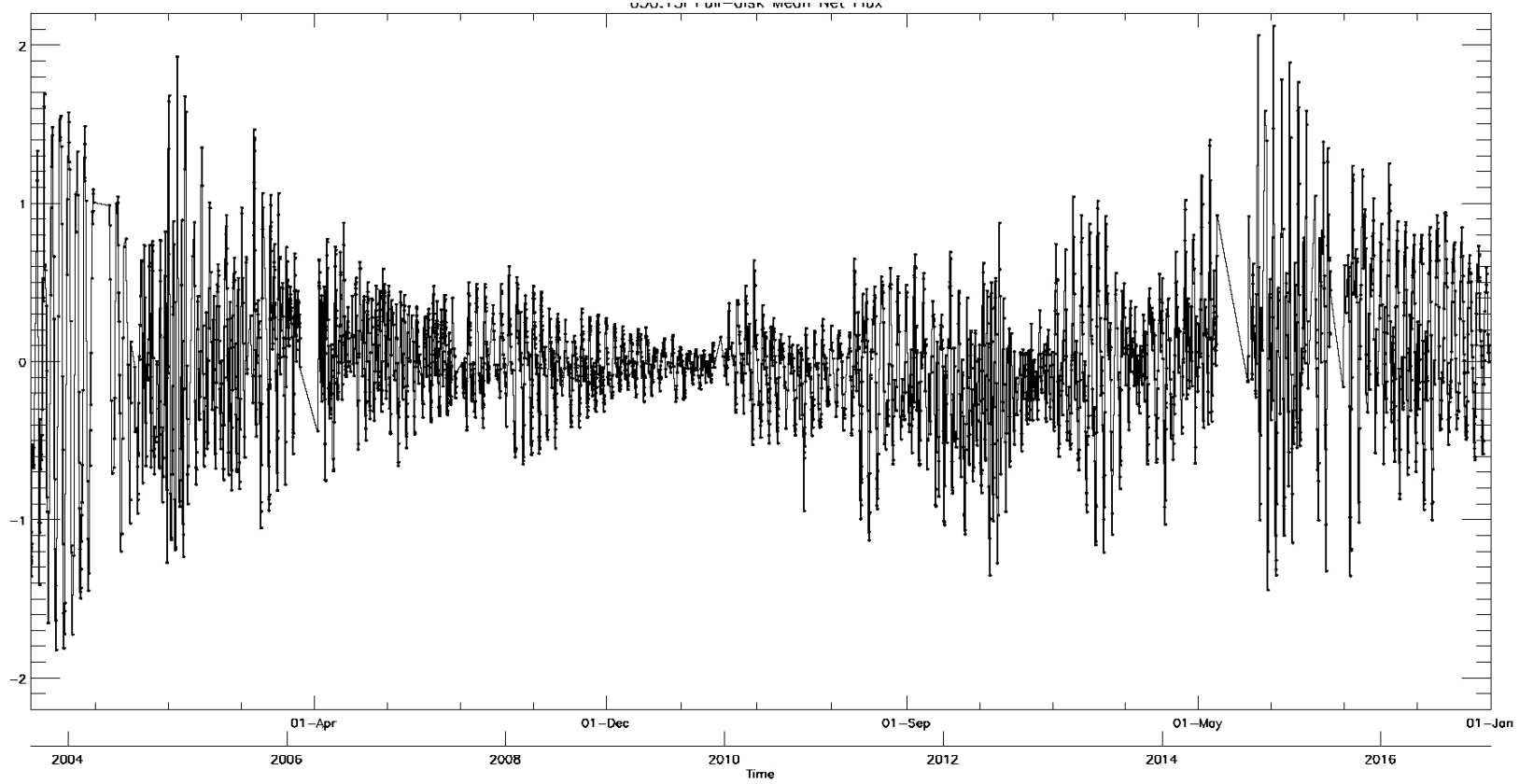


GONG Mag.

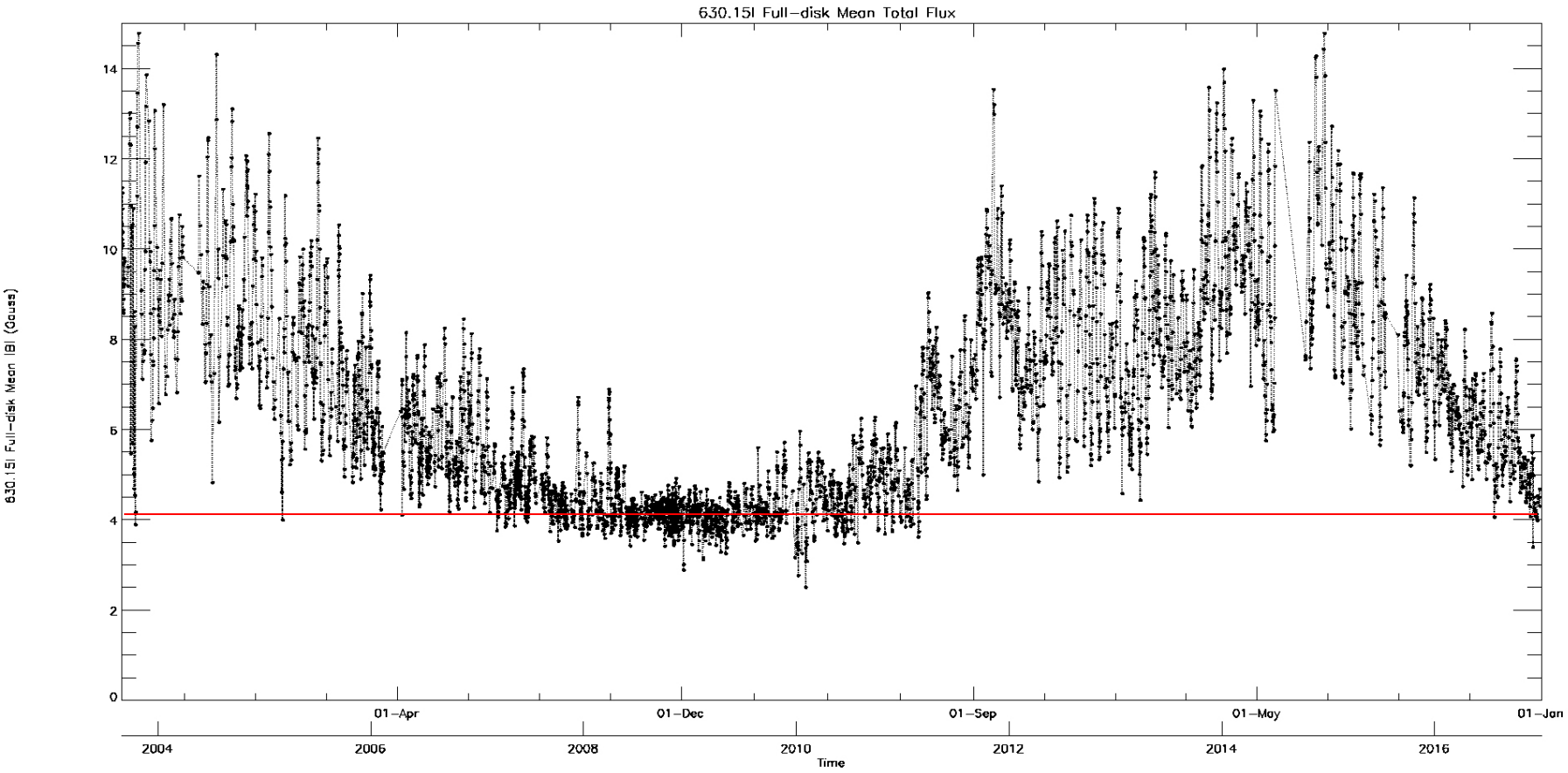
Instrumental polarization

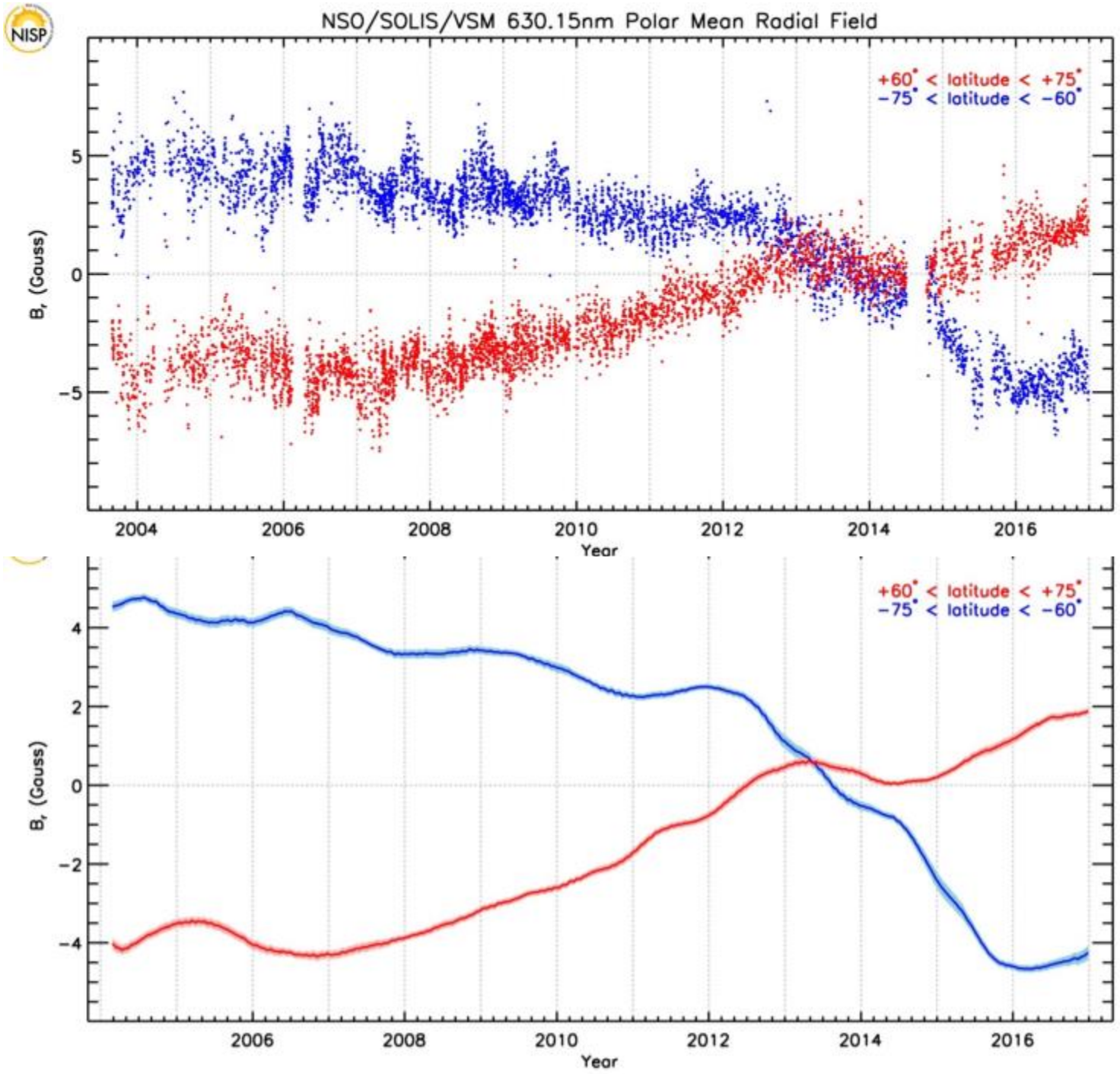
Derived Data Products

- Total/net magnetic flux
- Polar fields

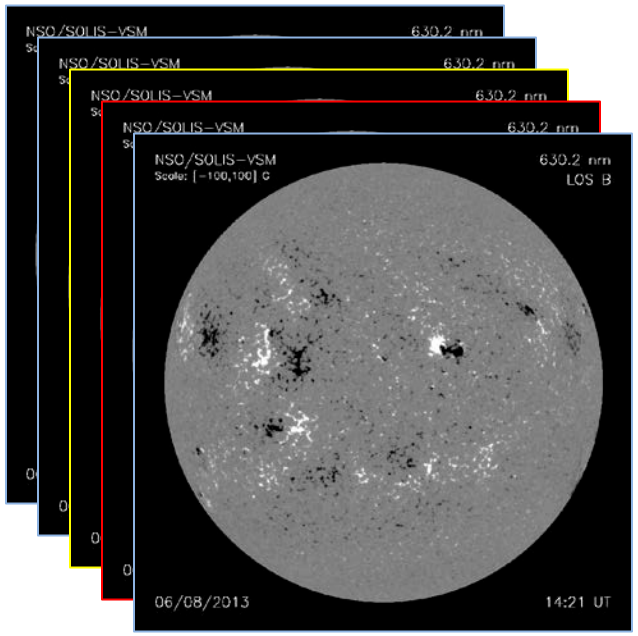


Total (unsigned) flux




NSO/SOLIS/VSM 630.15nm Polar Mean Radial Field
+60° < latitude < +75°
−75° < latitude < −60°
B_r (Gauss)
Year
2004
2006
2008
2010
2012
2014
2016
5
0
−5
4
2
−2
−4

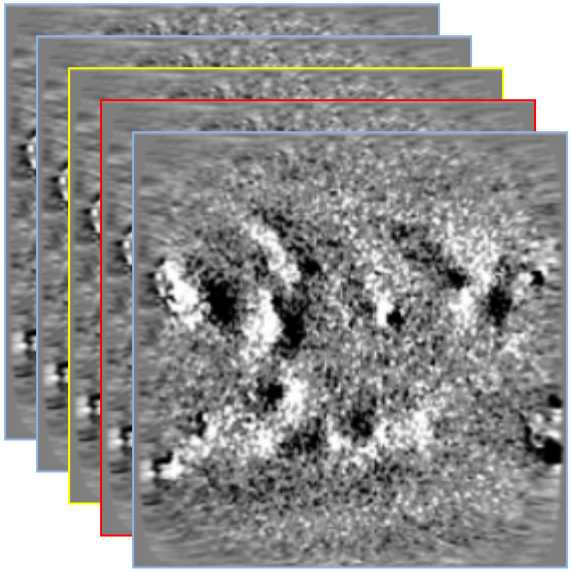
Synoptic maps – a “workhorse” of SW forecast



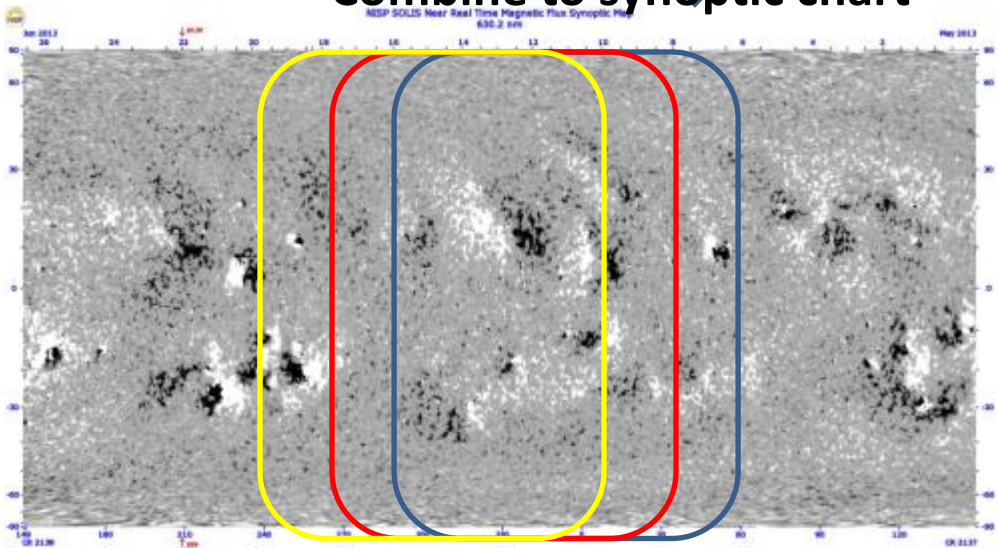
Full disk daily observations in sky-coordinates.

Pseudo-radial, pole filled

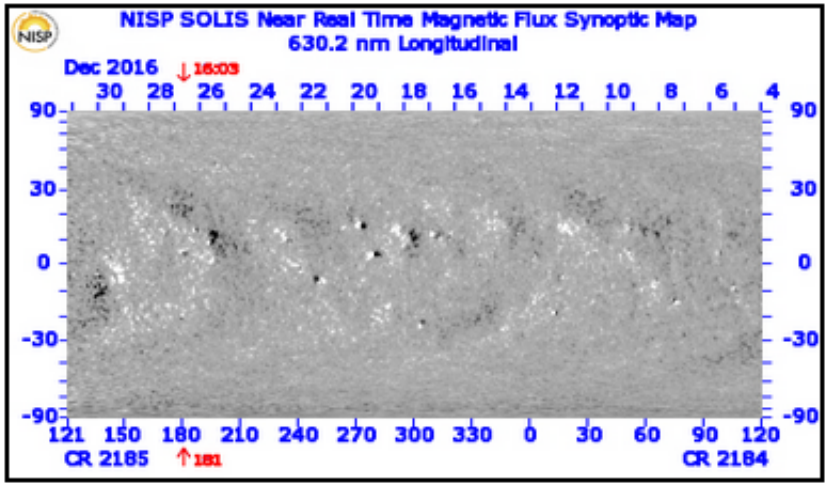
Remap to heliographic coordinates



Combine to synoptic chart

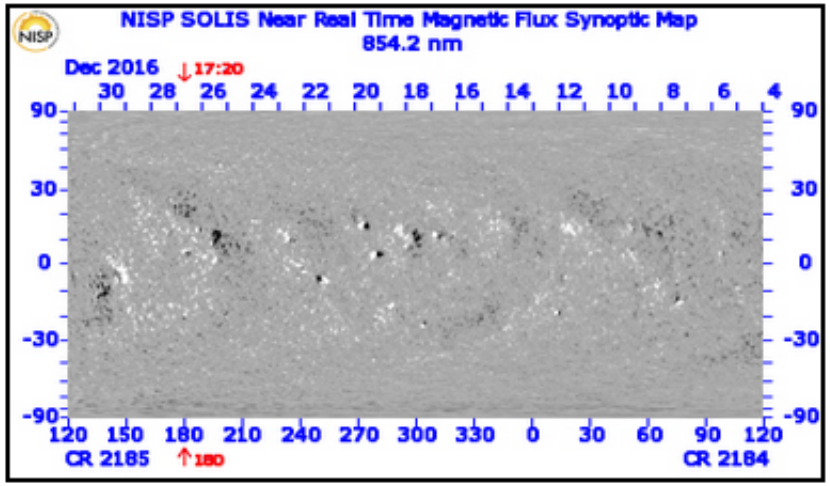


SOLIS/VSM Synoptic Maps



jpg
1 deg
0.2

fits
1 deg
0.2



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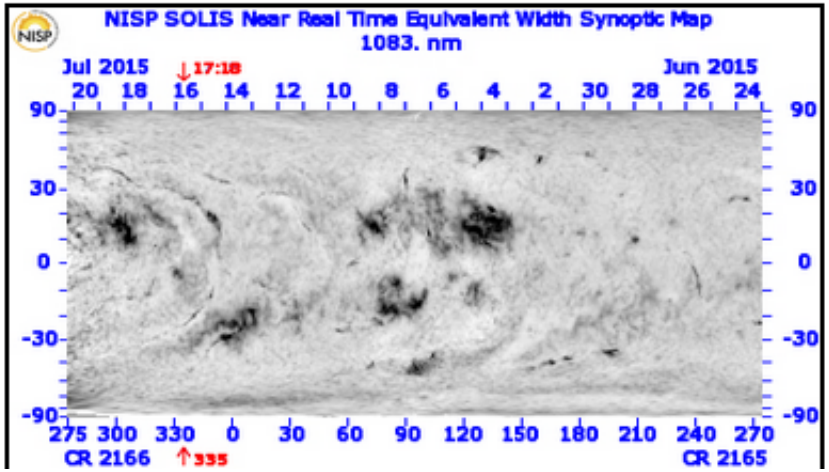

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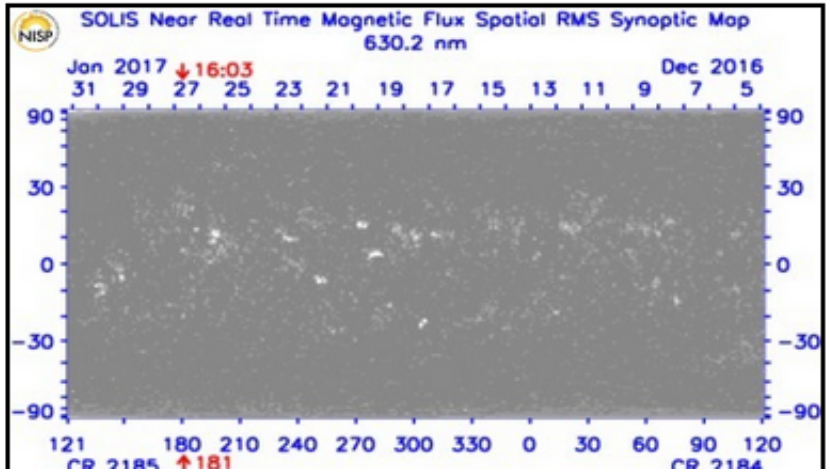
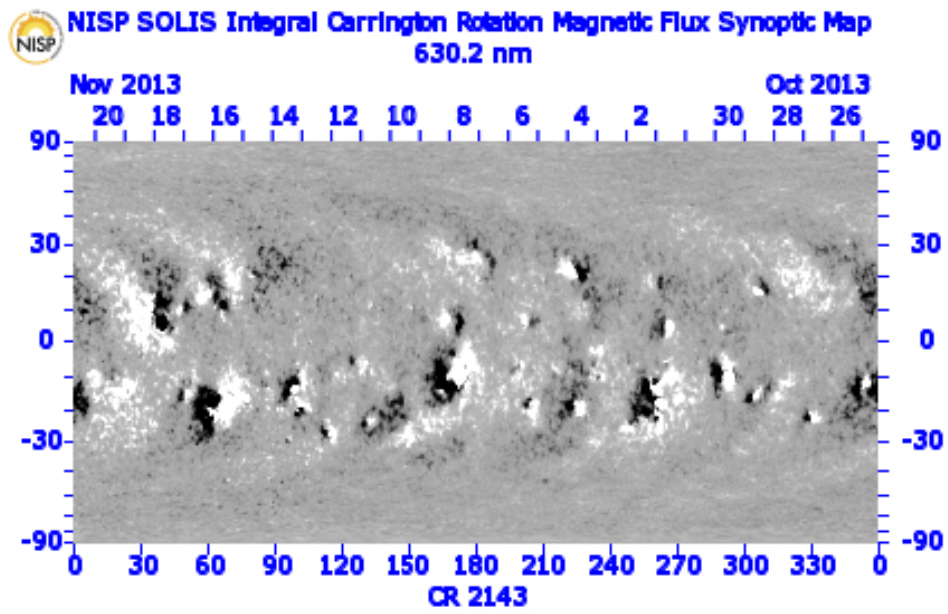


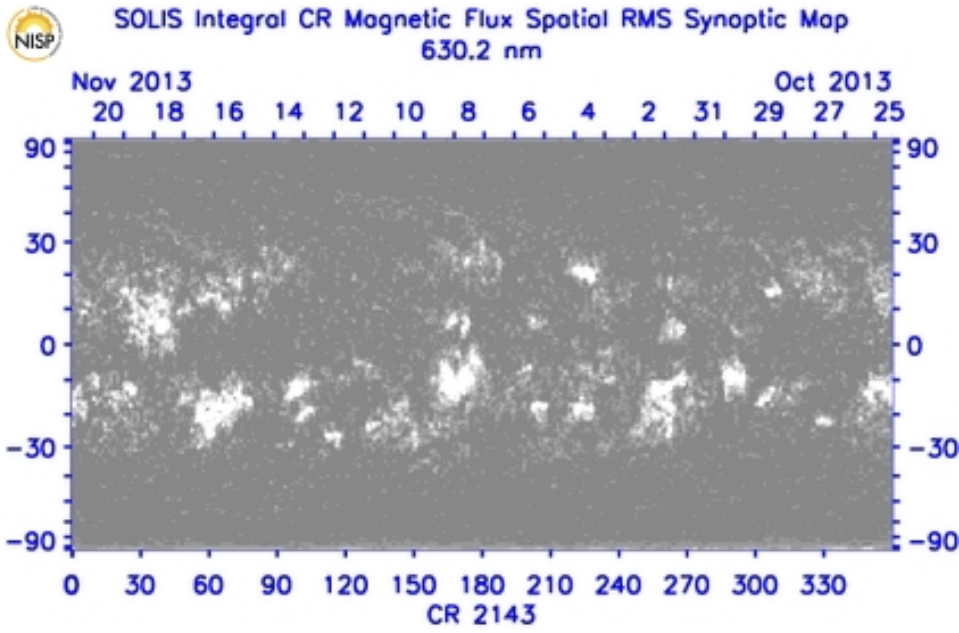
jpg
1 deg

fits
1 deg

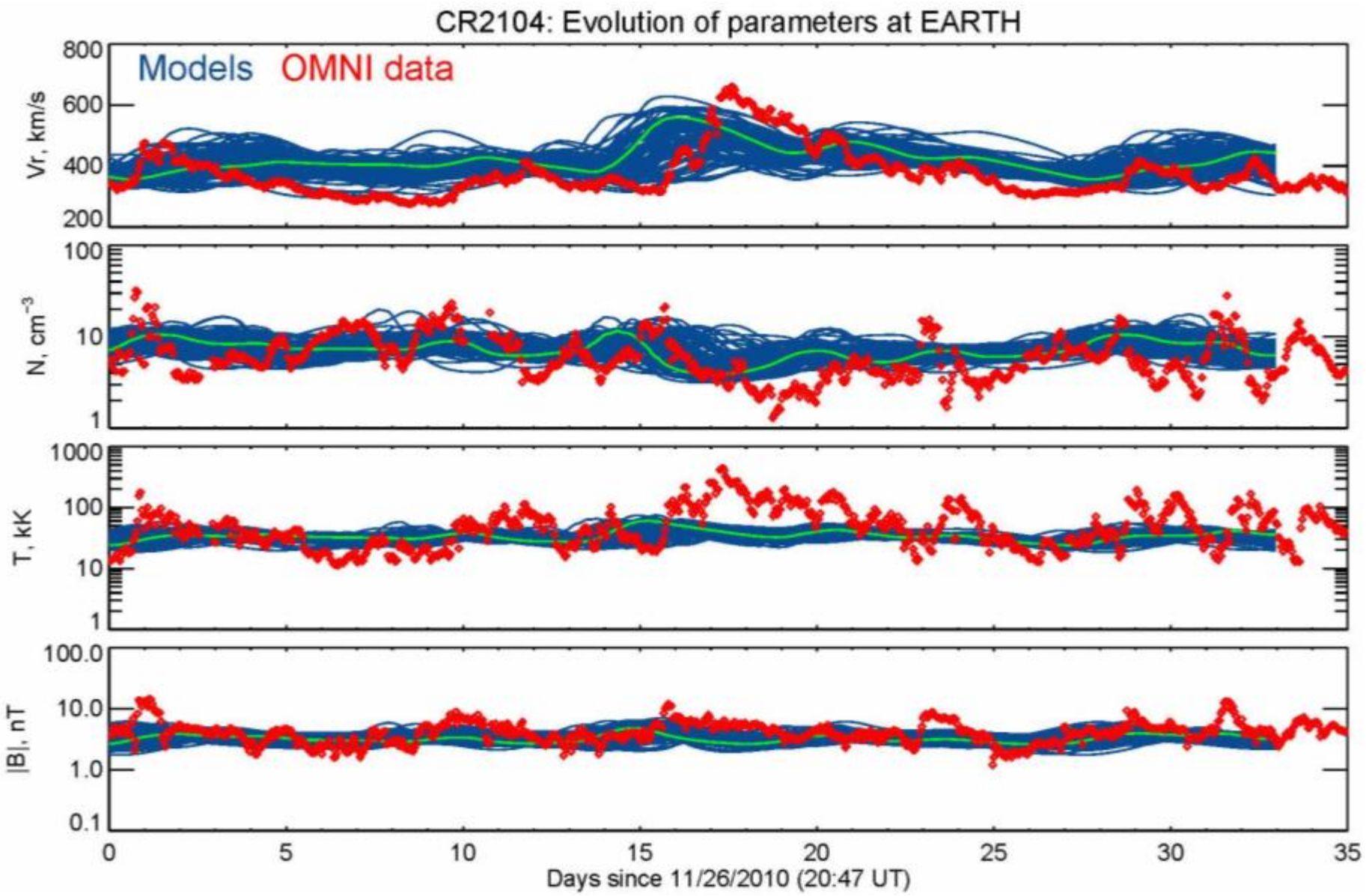
http://solis.nso.edu/0/vsm/vsm_maps.php

Uncertainties in synoptic maps





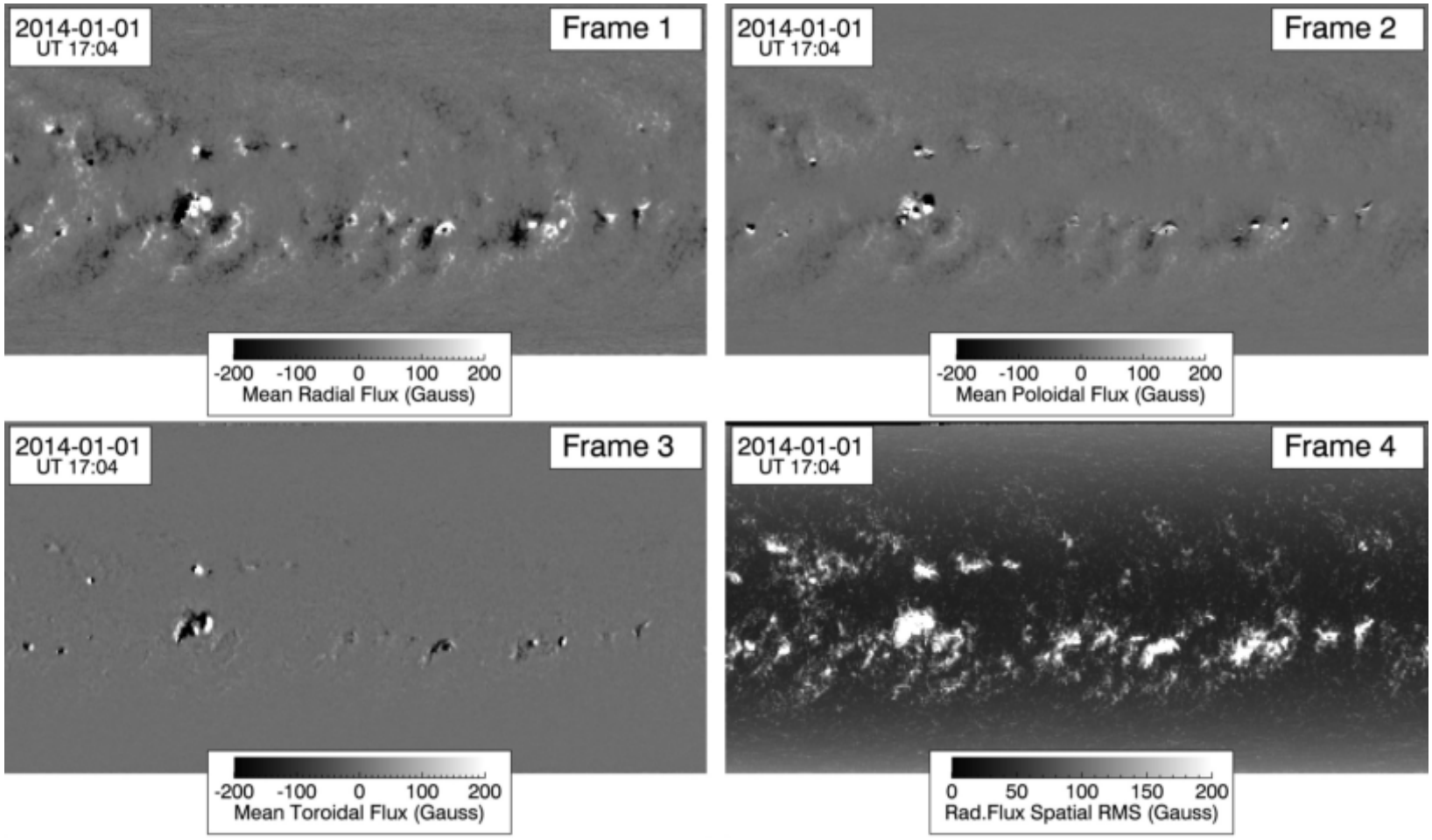
Bertello et al (2013)



Period of lower sunspot activity: Blue – ensemble modeling, red – in situ observations.

Pevtsov et al (2015), Adv.SR, DOI: [10.1016/j.asr.2015.05.043](https://doi.org/10.1016/j.asr.2015.05.043)

Vector Synoptic Maps



New Synoptic Measurements of Umbral Magnetic Fields

A. Hughes, A. Marble, J. Harvey, W. Livingston, A. Pevtsov, NISP/SOLIS Team (National Solar Observatory)

Main Points

1. There is contradictory evidence of umbral cyclic and/or secular field strength changes.

   Most measurements of umbral magnetic fields are compromised in one or more aspects.

2. SOLIS/VSM provides daily spectra of the full solar disk since 2003 (1x1 arcsec, 2.3 pm).

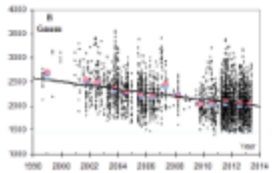
3. Sunspot intensity spectra of 630.25 nm are fit with a simple '***Zeemanfit***' triplet model.

4. *Zeemanfit* values are compared with MWO, CrAO, KPNO, SDO/HMI, Hinode/SP.

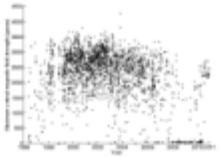
   Zeemanfit results are satisfactory >2500 G.

5. We plan to reduce all archived spectra and to produce these fits as a continuing data product.

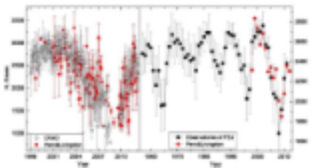
1. Umbral fields: Secular, cyclic, or no trend?



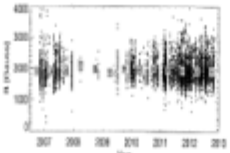
Livingston *et al.* 2012 ApJ 757, L8



Watson *et al.* 2011 A&A 533, 14

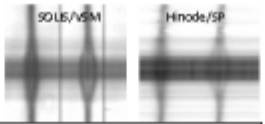


Nagovitsyn *et al.* 2012 ApJ 758, L20



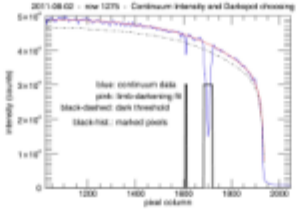
Schad 2013 SolPhys, submitted

2. VSM and Hinode/SP raw spectra 630.25 nm

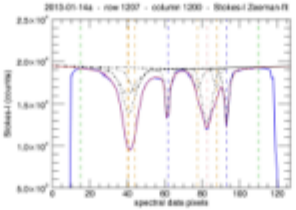


Both show 3100 G and molecular line blends

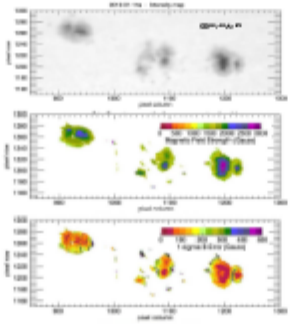
3a. Find sunspots as <95% of limb darkening fit



3b. Model spectrum

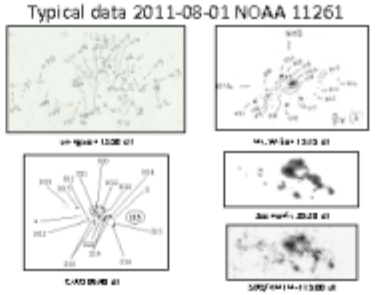


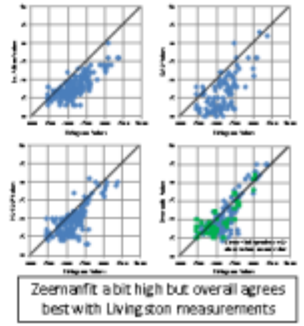
3c. Typical fit results



4a. Strongest fields in ~300 umbras compared with Livingston measurements

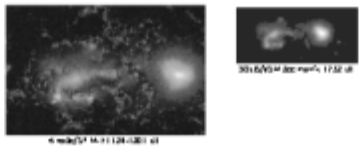
Typical data 2011-08-01 NOAA 11261

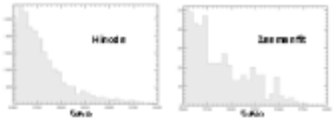




Zeemanfit a bit high but overall agrees best with Livingston measurements

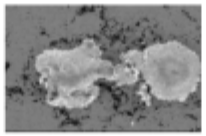
4b. NOAA 11263 active region histogram comparison





Shapes similar for >2500 G

4c. Zeemanfit minus Hinode pixel by pixel difference



Zeemanfit too strong in penumbras; okay in umbras (where B >2500 G)

Conclusion

Fitting SOLIS/VSM sunspot umbral intensity spectra appears to give robust results for B > 2500 G. When this technique is applied to available data since 2003 the results will help solve the problem of umbral field strength variations with time.

Acknowledgements: This work utilizes SOLIS data obtained by the NSO Integrated Synoptic Program (NISP), managed by the National Solar Observatory, which is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under a cooperative agreement with the National Science Foundation. *Hinode* is a Japanese mission developed and launched by ISAS/JAXA, with NAOJas domestic partner and NASA and STFC (UK) as international partners. It is operated by these agencies in co-operation with ESA and NSC (Norway). This study includes data from the synoptic program at the150-Foot Solar Tower of the Mt. Wilson Observatory. The Mt. Wilson 150-Foot Solar Tower is operated by UCLA, with funding from NASA, ONR and NSF, under agreement with the Mt. Wilson Institute. We are grateful to the NASA/SDO/HMI team, and the Crimean Astrophysical Observatory for providing data.