Vector Synoptic Maps at NSO

Luca Bertello

National Solar Observatory
Boulder, Colorado

Limitations Affecting Quality of the Vector Maps

- Uncertainties related to magnetic field measurements (e.g. noise level, calibration issues, etc...).
- Choice of inversion code
- Choice of disambiguation method
- Assumptions used to build the synoptic maps (e.g. time evolution, SDR, polar fields, etc...).

SOLIS/VSM

Several types of maps, in different flavors, derived from Full-disk vector Fe I λ630.25 nm magnetograms. Maps are currently available for the period January 2010 to present.

HMI

Integral CR synoptic maps (magnetic field and uncertainty) covering 2010-2015. Maps are derived from:

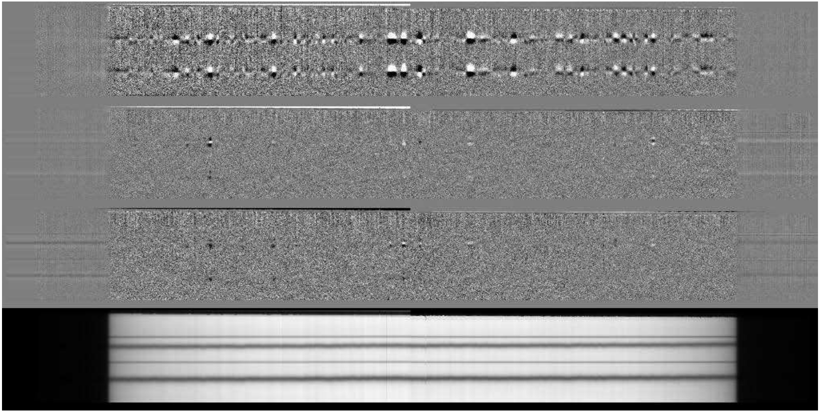
- Fully disambiguated full-disk vector magnetograms from the b_720s series.
- Weak-field disambiguation: Random, radial-acute.
- Number of magnetograms: 2/day.
- Generated synoptic maps: Low-res (360$\times$180).
- For a detailed description see: https://arxiv.org/pdf/1605.03500v1.pdf

All full-disk magnetograms have been processed through the NSO SOLIS/VSM pipeline.

SOLIS/VSM Vector Observations

- Photospheric full-disk vector-magnetograms using the FeI 630.15 and 630.25 nm lines
- Currently only the 630.25 nm line is inverted
- Derived quantities: field strength, azimuth, inclination, flux, Doppler velocity, continuum intensity
- Number of magnetograms: $\sim$1/day

Example of spectra for Fe I 630.15-630.25 nm



Stokes parameters (top to bottom) V, Q, U, and I

SOLIS/VSM Inversion Code

VFISV Milne-Eddington inversion code. The present code was originally developed by J. M. Borrero, and significantly modified by B. Harker specifically to work with SOLIS/VSM spectral data. The inversion code provides, among other quantities:

- Field Strength (B).
- Inclination (γ): The inclination of the magnetic field, relative to the line-of-sight. A magnetic field vector parallel to the line-of-sight (out of the image plane) has an inclination of 0 degrees, while an anti-parallel vector (into the image plane) has an inclination of 180 degrees.
- Azimuth (ϕ): The transverse orientation of the magnetic field vector, in the plane perpendicular to the line-of-sight An azimuth of 0 degrees points to solar North (vertical direction in the images) and increases counter-clockwise.
- Filling factor (α): Between 0 and 1.

SOLIS/VSM Vector Reduction Code

1. Apply filling factor: $B' = \alpha B$
2. Derive LOS (B_z) and transverse field (B_t):
   $B_z = B' \cos(\gamma), B_t = B' \sin(\gamma)$
3. Split B_t into its x and y components:
   $B_x = B_t \sin(\phi), B_y = B_t \cos(\phi)$
4. Azimuth disambiguation (Rudenko & Anfinogentov 2014):
   $(B_x, B_y) \longrightarrow (B'_x, B'_y)$
5. Image plane to heliographic coordinates:
   $(B'_x, B'_y, B_z) \longrightarrow (B''_x, B''_y, B'_z)$

Generating the Synoptic Maps

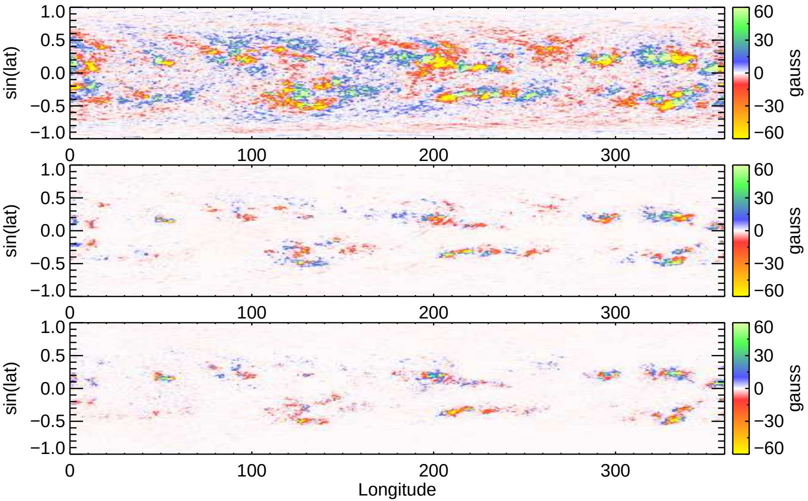
- Magnetic flux density is conserved during the transformation from full-disk magnetogram (B''_x, B''_y, B'_z) into heliographic coordinates, no interpolation.
- A $\cos^4$(CMD) taper is applied to the remapped (heliographic) magnetic flux density magnetograms.
- Corresponding spatial standard deviation maps are created according to the procedure described in Bertello et al. 2014.
- Individual heliographic magnetograms, covering a full Carrington rotation, are merged together to produce synoptic charts of the flux density and spatial standard deviation distributions.

Available SOLIS/VSM Vector Synoptic Maps

- Coverage: January 2010 to present
- Maps in both sin(lat)/Long and lat/Long
- Low-res (360$\times$180) and high-res (1800$\times$900)
- Map types: Near-real time, integral CR, Janus
- B components: Radial, Phi, and Theta
- Uncertainties maps for all components

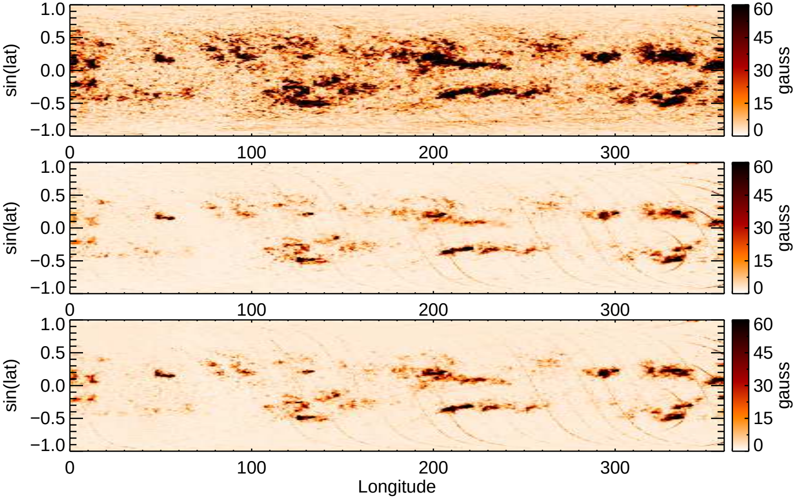
All products available from http://magmap.nso.edu/solis/

SOLIS/VSM Photospheric Vector Field Maps



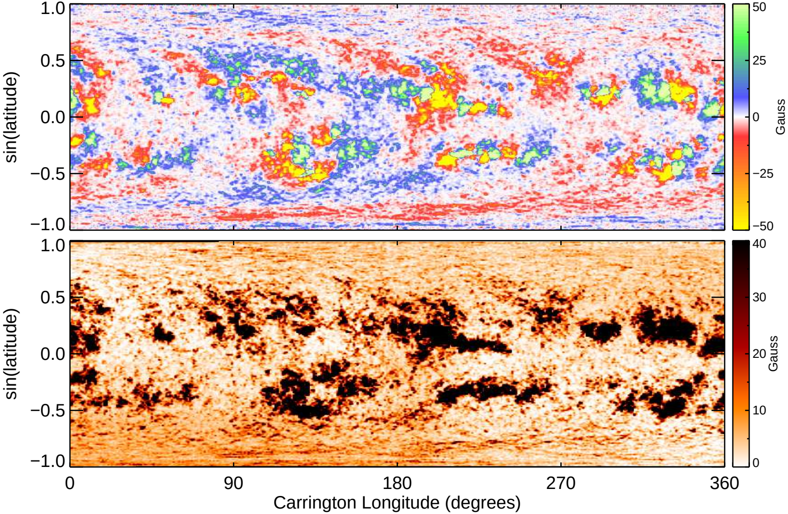
CR 2137 (May - Jun 2013). Radial (top), theta (poloidal, middle), and phi (toroidal, bottom) components

SOLIS/VSM Photospheric Vector Uncertainty Maps



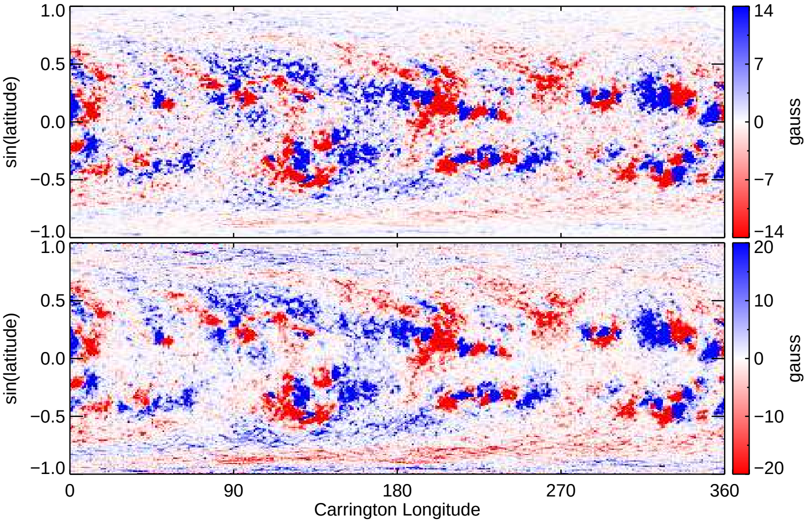
CR 2137 (May - Jun 2013). Radial (top), theta (poloidal, middle), and phi (toroidal, bottom) components

HMI Radial Maps - CR 2137



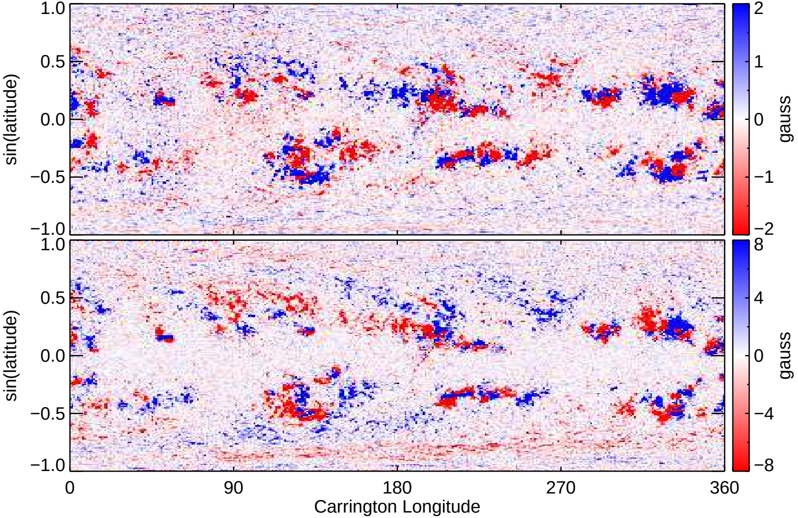
Photospheric magnetic flux density distribution (top) and corresponding standard deviation map (bottom).

SOLIS/VSM vs HMI Radial Field - CR 2137



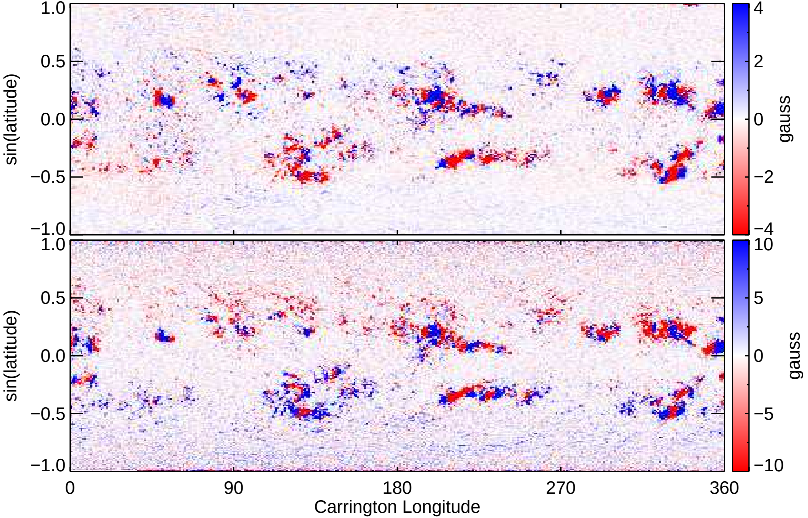
SOLIS/VSM (top) and HMI (bottom) synoptic magnetic field maps.

SOLIS/VSM vs HMI Poloidal Field - CR 2137



SOLIS/VSM (top) and HMI (bottom) synoptic magnetic field maps.

SOLIS/VSM vs HMI Torodial Field - CR 2137



SOLIS/VSM (top) and HMI (bottom) synoptic magnetic field maps.