Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
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Synoptic Magnetic Fields Measurements of the Solar Chromosphere from SOLIS/VSM at NSO

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Abstract. Full disk magnetic field measurements of the photosphere and chromosphere have been performed at National Solar Observatory (NSO), USA for many decades. Here we briefly describe recent upgrades made to this synoptic observing program. In particular, we present the full Stokes polarimetry observations made using the chromospheric Ca II 854.2 nm spectral line. These new observations have the potential to probe vector nature of magnetic field in the chromosphere above the active regions and provide improved estimates of magnetic free-energy, which is released during flares and coronal mass ejections (CMEs). We emphasize that these observations could improve estimates of polar fields, as compared to photospheric observations, due to magnetic field expansion in higher layers and perspective effect near the polar regions. The global coronal potential field models and solar wind speed estimates depend critically on polar field measurements.

Keywords. Instrumentation: polarimeters, Sun: chromosphere, Sun: chromosphere

1. Introduction

The long-term continuous and accurate monitoring of magnetic fields is crucial for better understanding and modeling of the 22-year solar magnetic cycle. Such observations provide important constraints for the theoretical models of solar dynamo mechanism operating inside the Sun. Full-disk long-term observations of the solar magnetic field have continued since 1970s at NSO and Wilcox Solar Observatory (WSO). There are however missing or poorly observed areas which limit the best utilization of these datasets. Such areas being the far-side of the Sun and the observations of weak polar regions which are obscured due to large projection angle and limited sensitivity of measurements.

2. Challenges and Advantages of Chromospheric Field Measurements

Majority of observations of the magnetic fields are done using photospheric spectral lines because, (a) signals are relatively stronger due to higher field strengths in denser photosphere as compared to less dense chromosphere, (b) availability of higher Landé g-factor lines as compared to chromospheric lines. Despite these difficulties, the magnetic field information in the chromosphere offers several advantages over photospheric observations (Lagg *et al.*(2017)). Since 1996, NSO started to observe full-disk longitudinal magnetograms in the chromospheric Ca II 854.2 nm spectral line. For such measurements the simple interpretation in terms of weak-field approximation (WFA) is enough to deduce LOS magnetic flux density, and computationally expensive NLTE inversions are avoided. These chromospheric LOS magnetograms are now continued at NSO with the

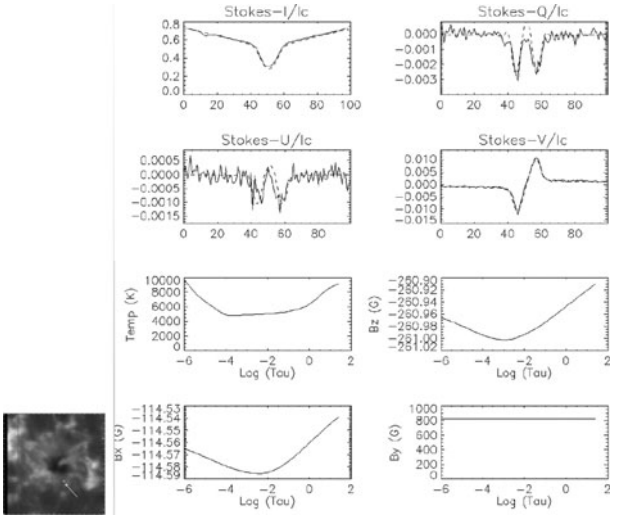

Figure 1. Sample profiles and model fits for penumbra

Synoptic Optical Long-term Investigations of the Sun (SOLIS), Vector Spectro-Magnetograph (VSM) instrument.

Vector magnetograms are essential for assessing true magnetic flux over the polar regions and to derive magnetic-free energy of the active regions. Over the last decade or so, technological advancements have led to fast and sensitive detectors and the computational power has also increased drastically. SOLIS/VSM was recently upgraded to observe full Stokes profiles of the Ca II 854.2 nm spectral line (Gosain & Harvey (2015), Gosain *et al.* (2016)). Here we shall present a sample of Stokes profiles over a sunspot and their NLTE inversions.

3. Sample Observations and Inversions of SOLIS/VSM Full Stokes Observations in Ca II 854.2 nm

We show some example profiles from the observations taken by SOLIS/VSM in Ca II 854.2nm, in Figure 1, corresponding to penumbra. These observations correspond to a large sunspot in NOAA AR No. 12539 observed on 13 April 2016. The second and third row in Figure 1, shows the Stokes I,Q,U and V profiles (solid line) and model fit (dashed line) from NLTE inversion code NICOLE (Socas-Navarro *et al.*(2015)). The Stokes profiles are normalized to quiet sun intensity at disk-center. The fourth and fifth rows in Figure 1 shows the retrieved model parameters, i.e., temperature and three magnetic field components at different optical depths. The magnetic field components are in the plane-of-sky and are not disambiguated for azimuth.

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