Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
Proceedings IAU Symposium No. 340, 2018
D. Banerjee, J. Jiang, K. Kusano & S. Solanki, eds.

doi:10.1017/S1743921318001758

Role of the background regimes towards the Solar Mean Magnetic Field (SMMF)

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Abstract. The Solar Mean Magnetic Field (SMMF) is generally defined as the disc-averaged line-of-sight (LOS) magnetic field on the sun. The role of the active regions and the large-scale magnetic field structures (also called the background) has been debated over the past few decades to understand whether the origin of the SMMF is either due to the active regions or the background. We, in this paper have investigated contribution of sunspots, plages, networks and the background towards the variability of the SMMF using the datasets from the SDO-AIA & HMI, and found that 89 % of the SMMF is due to the background whereas the remaining 11 % originates from the active regions and the networks.

Keywords. Sun:mean magnetic field, Sun:Origin of MMF, Sun-as-a-star, Sun:photosphere.

1. Introduction

Studying the SMMF gives an idea of the *sun-as-a-star* magnetic field and its variation. It also reflects the imbalance in the magnetic flux of opposite polarity on the visible disk (Svalgaard *et al.* (1975)). Several studies like Scherrer *et al.* (1977) & Gough *et al.* (2017) have suggested that the imbalance is primarily due to the large scale magnetic field structure, also termed as the background magnetic field whereas recent investigations led by Kutsenko *et al.* (2017) suggests that the active regions (sunspots) play a pivotal role in the SMMF. In this paper, we follow a conventional approach of detecting the sunspots, plages, and the network features using intensity images from SDO-AIA 1600 Å and 4500 Å datasets and thereby studying the contribution towards the SMMF with HMI.720s LOS magnetograms.

2. Contribution of various surface magnetic features to the observed variability in the SMMF

We developed an automated detection algorithm that segregated plages & enhanced networks from AIA 1600 Å images following an adaptive intensity thresholding technique based on μ_{image} + K σ_{image} (where μ is the mean, σ is the standard deviation and K = 1.71) and imposing an area threshold criterion. Further, we segregated the active networks and sunspots from AIA 1600 Å & 4500 Å respectively, by implementing only the adaptive thresholding procedure. A sample detection is shown in figure 1 left panel. The details of the algorithm and the processing steps can be found in Bose & Nagaraju (2018).

The pixels corresponding to each of the regions were grouped into three categories, namely (1) sunspots, (2) plages, enhanced and active networks (as one entity) and (3)

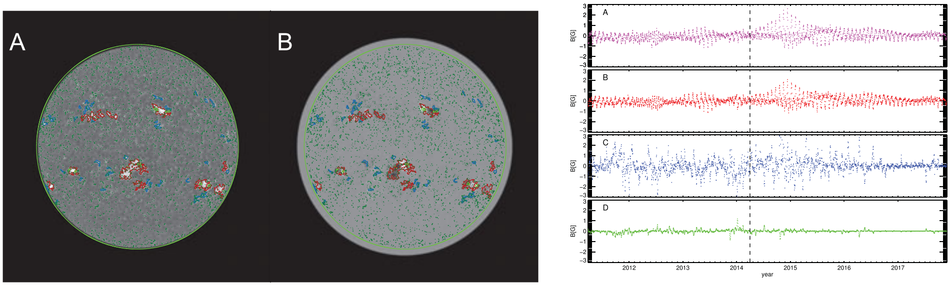

Figure 1. Left panel: Automated detection of various features on: (A) AIA 1600 Å data & (B) Corresponding HMI Magnetogram. Right Panel: Mean Magnetic field for the various segments shown in the four panels-(A) SMMF, (B) Mean background field, (C) Mean plage and network fields, & (D) Mean sunspot field.

background regimes that do not belong to either (1) or (2). The magnetic field contributions corresponding to each of these regions towards the SMMF was computed using linear regression analysis (Bose & Nagaraju (2018)) with the HMI LOS magnetograms between 21.03.2011 & 30.11.2017

The right panel of figure 1-(A), shows the temporal variation of the SMMF. It is found to have a peak value of about 2.5 G that is consistent with Kutsenko *et al.* (2016). The mean background field (figure 1-(B)) emulates the SMMF quite distinctly, both peaking around December 2014. However, it is clear that the mean of the plages, the networks and the sunspots, as in figure 1-(C) & (D), has no correlation with the SMMF whatsoever. This is in contrast with Kutsenko *et al.* (2017), whereas it is consistent with the earlier pioneering works of Svalgaard *et al.* (1975) & Scherrer *et al.* (1977).

A linear regression analysis shows that the weighted plages and the network fields contribute only about 9 % towards variation in the SMMF with a Pearson R of 0.316, whereas the background contributes about 88.9 % with Pearson R of 0.943. The contribution of the sunspots is found to be statistically insignificant at 95 % confidence level. Details can be found in Bose & Nagaraju (2018).

3. Conclusions

The mean variation of the LOS field corresponding to the different segments clearly suggest that the background field is the major contributor to variation in the SMMF while the active regions including the networks provide a minimal contribution. Based on these results, we conclude that the origin of the SMMF lies in the large scale magnetic field structures on the sun.

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