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ORIGINAL ARTICLE

Modeling coronal magnetic field using spherical geometry: cases with several active regions

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Abstract The magnetic fields in the solar atmosphere structure the plasma, store free magnetic energy and produce a wide variety of active solar phenomena, like flare and coronal mass ejections (CMEs). The distribution and strength of magnetic fields are routinely measured in the solar surface (photosphere). Therefore, there is considerable interest in accurately modeling the 3D structure of the coronal magnetic field using photospheric vector magnetograms. Knowledge of the 3D structure of magnetic field lines also help us to interpret other coronal observations, e.g., EUV images of the radiating coronal plasma. Nonlinear force-free field (NLFFF) models are thought to be viable tools for those task. Usually those models use Cartesian geometry. However, the spherical nature of the solar surface cannot be neglected when the field of view is large. In this work, we model the coronal magnetic field above multiple active regions using NLFFF extrapolation code using vector magnetograph data from the Synoptic Optical Long-term Investigations of the Sun survey (SOLIS)/Vector Spectromagnetograph (VSM) as a boundary conditions. We compare projections of the resulting magnetic field lines solutions with their respective coronal EUV-images from the Atmospheric Imaging Assembly (SDO/AIA) observed on October 15, 2011 and November 13, 2012. This study has found that the NLFFF model in spherical geometry reconstructs the magnetic configurations for several active regions which agrees to some extent with observations. During October 15, 2011 observation, there are substantial number of trans-equatorial loops carrying electric current.

Keywords Active regions: magnetic fields · Active regions: models · Magnetic fields: corona · Magnetic fields: photosphere · Magnetic fields: models

1 Introduction

The geometry and dynamics of the solar corona are determined by the evolving magnetic field at the Sun's surface (photosphere). Thus, magnetic fields are believed to play a dominant role for active phenomena carried out in the solar corona. In order to study solar eruptive phenomena, we have to understand how magnetic energy is stored in the pre-eruptive corona. Hence, the three dimensional (3D) structure of magnetic fields and electric currents in the pre-eruptive corona and the amount of free energy stored in the field have to determined (Schrijver and Title 2005; Jiang and Feng 2012). Unfortunately, reliable magnetic field measurements are still restricted to the level of the photosphere, where Zeeman effect in Fraunhofer lines is observable. Even if the measurement of magnetic fields in the solar corona has considerably improved in recent decades (Lin et al. 2000; Liu and Lin 2008), further developments are needed before accurate data are routinely available.

As an alternative to measurements in the solar atmosphere, magnetic field extrapolation have been implemented to calculate the field from the measured photospheric field using assumptions that the fields are force-free. In this

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