First Use of Synoptic Vector Magnetograms for Global Nonlinear Force-Free Coronal Magnetic Field Models

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The magnetic field permeating the solar atmosphere is generally thought to provide the energy for much of the activity seen in the solar corona, such as flares, coronal mass ejections (CMEs), etc. To overcome the unavailability of coronal magnetic field measurements, photospheric magnetic field vector data can be used to reconstruct the coronal field. Currently, there are several modelling techniques being used to calculate three-dimensional field lines into the solar atmosphere. For the first time, synoptic maps of a photospheric-vector magnetic field synthesized from the vector spectro-magnetograph (VSM) on Synoptic Optical Long-term Investigations of the Sun (SOLIS) are used to model the coronal magnetic field and estimate free magnetic energy in the global scale. The free energy (i.e., the energy in excess of the potential field energy) is one of the main indicators used in space weather forecasts to predict the eruptivity of active regions. We solve the nonlinear force-free field equations using an optimization principle in spherical geometry. The resulting three-dimensional magnetic fields are used to estimate the magnetic free energy content for the global solar corona. For two Carrington rotations 2121 and 2124, we found that the global nonlinear force-free field (NLFFF) magnetic energy densities are about 15% higher than their respective potentials. Most of this free energies are located above active regions. In the study, we found that spatially, the low-lying, current-carrying core field demonstrates strong concentration of free energy in the AR core, from the photosphere to the lower corona (about 70Mm).