Project Details

ROSES ID: NNH08ZDA001N
Selection Year: 2009
Program Element: Data, Tools, & Methods

Topic: Measure the properties of the solar dynamo that affect solar irradiance and active region generation.

Project Title:
Estimating Energy and Helicity Budgets and Monitoring the Evolution of Active Regions by Tracking Vector Magnetograms

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Summary:
We propose a four-year program to develop and test methods for estimating photospheric velocities from a sequence of vector magnetograms. Accurate and precise measurements of photospheric velocities are critical for estimating the coronal energy and helicity budgets and essential for effective use of measurements made by Living With a Star (LWS) satellite missions. Photospheric plasma velocities and energy and helicity fluxes are keys to understanding and predicting eruptions from active regions on the sun, which are a hazard to society, to space-based systems, and to human space-flight.

The proposed techniques determine photospheric velocities by applying the magnetic induction equation and an affine velocity model to a windowed subregion of the magnetogram sequence. This produces an overdetermined system that can be solved directly by standard least squares or total least squares techniques. These subspace methods are inherently statistical. Consequently, the optical flow estimates can be assessed for reliability and for uniqueness (resolution of the aperture problem). The result is a point-by-point optical flow field that is statistically consistent with the magnetic induction equation. Our algorithms have been and will be benchmarked with state-of-the-art MHD simulation codes ANMHD and RADMHD to establish the accuracy of the techniques. We will also participate in a community-wide collaborative effort to compare the accuracy of our methods with optical flow techniques developed by other groups such as local correlation tracking (LCT), inductive local correlation tracking (ILCT), minimum energy fit (MEF), and the inductive method (IM).

Our new techniques will make full use of high-resolution, high-cadence vector magnetogram data for the dual purposes of scientific analysis and augmentation of space-weather prediction through real-time monitoring of photospheric activity and the coronal energy and helicity budgets of active regions. The outputs of this program will be new methods and extensively documented performance characteristics of the algorithms and operational codes for satellite software pipelines. Furthermore, magnetograms will be analyzed and the estimated photospheric velocity, electric fields and associated uncertainties will be available to the solar physics community to (1) assess the energy and helicity budgets of active regions for their forecasting ability, (2) investigate CME initiation, (3) monitor the evolution active regions, and (4) drive realistic MHD simulations. The prime measure of success for this work would be the widespread use of these tools for the determination of photospheric velocities from observational data. Therefore, the library of tools developed under this program will continue to be "open source" and accessible to the solar physics community.

The proposed program addresses the goal of the "Tools and Methods" component of the Living with a Star (LWS) Targeted Research and Technology Program (TR&T). Our program will develop the tools and scientific understanding needed for the United States to effectively address those aspects of the Sun-Earth System that may affect life and society by developing methods for accurately estimating photospheric velocities from magnetogram sequences. Our work will provide the necessary tools to deliver significant new understanding of solar eruptions through the energy and helicity budgets of active regions and resolve persistent controversies concerning the spatial scales and flow structure of solar active region processes and will therefore contribute to advance-warning space environment predictions along the path of robotic and human exploration.

Publication References:

no references