Project Details

ROSES ID: NNH05ZDA001N
Selection Year: 2006
Program Element: Data, Tools, & Methods

Topic: Shock acceleration of solar energetic particles by interplanetary CMEs

Project Title:
Tracking Photospheric Magnetic Footpoints with the Magnetic Induction Equation

PI Name: Peter Schuck
PI Email: peter.schuck@nasa.gov
Affiliation: Naval Reseach Laboratory
Project Member(s):
- Krall, Jonathan ; Co-I; Naval Research Laboratory
- LaBonte, Barry J; Collaborator; The Johns Hopkins University
- Huba, Joseph ; Collaborator; Naval Research Laboratory

Summary:
We propose a three-year program to develop techniques for accurate and precise estimation of solar surface flows from magnetogram data. Local Correlation Tracking (LCT) is the de-facto standard for estimating motion in solar image sequences. However, this technique has many documented limitations. Perhaps the greatest limitations of LCT are the absence of demonstrated accuracy, precision and a quantifiable local uncertainty associated with the velocities derived from this technique, and the introduction of artificial scales. This program will develop new techniques that are less susceptible to these limitations.

The proposed techniques determine the optical flow by applying the magnetic induction equation and an affine velocity model statistically to a windowed subregion of the magnetogram sequence producing 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 resolution of the aperture problem. The result is a point-by-point optical flow field that is consistent with the magnetic induction equation. Our new algorithms will be benchmarked against synthetic data to establish the accuracy of the technique and compared against the accuracy of previously developed optical flow techniques such as LCT, Inductive Local Correlation Tracking (ILCT), Minimum Energy Fit (MEF). Our new techniques will make full use of high-resolution, high-cadence vector magnetogram data and line-of-sight magnetograms for the dual purposes of scientific analysis and and to augment space-weather prediction through real-time monitoring of photospheric activity. The output of this program with be the new methods and the extensively documented performance characteristics of the algorithm. Furthermore, magnetograms will be analyzed and the estimated velocity fields and associated uncertainties will be provided to the solar physics community for the purpose of driving realistic MHD simulations. The prime measure of success for this work would be the widespread use of these ``tools'' for the determination of solar surface flows from observational data. Therefore, the library of tools developed under the program will be accessible to the solar physics community.

This program addresses the goals of the ``Tools and Methods'' component of the Living with a Star (LWS) Targeted Research and Technology Program (TR & T). The goal of our program is to 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. The proposed work will provide the necessary tools to deliver significant new understanding of solar eruptions and resolve persistent controversies concerning the spatial scales and flow velocities.

Publication References:

Summary: no summary

Reference: Schuck, P. W.; (2006), Tracking Magnetic Footpoints with the Magnetic Induction Equation, The Astrophysical Journal, Volume 646, Issue 2, pp. 1358-1391, doi: 10.1086/505015

Summary: no summary

Reference: Schuck, P. W.; (2008), Tracking Vector Magnetograms with the Magnetic Induction Equation, The Astrophysical Journal, Volume 683, Issue 2, article id. 1134-1152, pp, doi: 10.1086/589434

Summary: no summary

Reference: Welsch, Brian T.; Li, Yan; Schuck, Peter W.; Fisher, George H.; (2009), What is the Relationship Between Photospheric Flow Fields and Solar Flares?, The Astrophysical Journal, Volume 705, Issue 1, pp. 821-843, doi: 10.1088/0004-637X/705/1/821