Project Details

ROSES ID: NNH10ZDA001N
Selection Year: 2011
Program Element: Solar Dynamics Observatory

Project Title:
Magnetic flux transport in the Sun's surface shear layer

PI Name: David Hathaway
PI Email: david.hathaway@nasa.gov
Affiliation: NASA Marshall Space Flight Center, NSSTC
Project Member(s):
- Upton, Lisa A; Graduate/Undergraduate Student; null

Summary:
We will investigate the transport of magnetic flux elements embedded in the Sun's surface shear layer using data from HMI. The transport of magnetic flux by flows in the surface shear layer is crucial to the evolution of the Sun's global magnetic field which in turn serves as the inner boundary condition for space weather forecasting. The evolution of the global field is the source of changes involved in producing open field regions (with associated high-speed solar wind streams) and in triggering prominence eruptions and coronal mass ejections. The poleward transport of magnetic flux by meridional flow and diffusion is responsible for producing the polar fields that successfully forecast the amplitude of the following solar cycles.

Recent results indicate that magnetic flux transport is controlled by the supergranules. Supergranules have long been associated with the diffusive random walk of the magnetic elements. We now find that the differential rotation and meridional motion of the magnetic elements are produced in response to the differential rotation and meridional motion of the supergranules themselves - and that these motions are functions of the depth to which the supergranule cells extend. We also find that the motions of the magnetic elements show a dependence on the magnetic field strength - stronger elements appear to be rooted deeper and have motions that reflect those roots.

We will use tools developed for analyzing MDI data to explore these new aspects of flux transport processes with HMI data. These tools include correlation tracking of magnetic elements in the HMI magnetograms; correlation tracking of supergranules in HMI Dopplergrams; correlation tracking of granules in HMI intensity images; and direct Doppler measurements of the photospheric flows. This suite of tools provides detailed information on the flows in the surface shear layer as functions of latitude, time, and depth (size of convective features) along with direct measurements of the associated magnetic element motions. We will also produce and use simulations of the flows in the Sun's surface shear layer to aid in our interpretation of the results. Preliminary results suggest revolutionary changes to our models of the Sun's magnetic dynamo.

Publication References:

Summary: no summary

Reference: Hathaway, David H.; (2011), The Sun's Shallow Meridional Circulation, eprint arXiv:1103.1561

Summary: no summary

Reference: Hathaway, David H.; (2012), Supergranules as Probes of Solar Convection Zone Dynamics, The Astrophysical Journal Letters, Volume 749, Issue 1, article id. L13, 4 pp, doi: 10.1088/2041-8205/749/1/L13

Summary: no summary

Reference: Hathaway, David H.; (2012), Supergranules as Probes of the Sun's Meridional Circulation, The Astrophysical Journal, Volume 760, Issue 1, article id. 84, 6 pp, doi: 10.1088/0004-637X/760/1/84