Project Details

ROSES ID: NRA-NNH04ZSS001N
Selection Year: 2005
Program Element: Focused Science Topic

Topic: To determine the topology and evolution of the open magnetic field of the Sun connecting the photosphere through the corona to the heliosphere.

Project Title:
Understanding and Modeling the Evolution of the Sun's Open Magnetic Flux

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Summary:
RELEVANCE AND OBJECTIVES: This proposal directly addresses LWS TR&T Focused Science Topic (e) (``To determine the topology and evolution of the open magnetic field of the Sun connecting the photosphere through the corona to the heliosphere''). Our main goal will be to use our extensive observational and modeling background in this area to achieve a better understanding of the Sun's open flux, in collaboration with the other team members. We propose to focus on the following four objectives: (1) To identify and understand the sources of the Sun's open flux, and to develop further and test a model relating the observed photospheric field to the total open flux and radial IMF strength. (2) To simulate and understand the variation of the open flux over the solar cycle, and to investigate the role of stochastic processes (as opposed to organized ''active longitudes'') in producing the observed fluctuations on timescales of the order of a year. (3) To simulate the evolution of the Sun's open and closed flux from the Maunder Minimum to the present, in order to determine the secular variation (between cycle minima) of the open flux, of the total photospheric flux, and of the total solar irradiance. (4) To elucidate the role of interchange reconnection in the evolution of the open flux, to determine quantitatively the relative rates of interchange and opening-up/closing-down of flux, and to compare the predictions with observations. APPROACH: (1) Open field regions will be identified by applying a source surface extrapolation to the observed photospheric field. Far from the Sun (where the heliospheric current sheet dominates and the source surface model breaks down), the radial IMF strength will be taken to be proportional to the total open flux. (2) Building on our earlier modeling, the solar cycle evolution of the photospheric field will be simulated using a transport code that includes the effects of emerging flux (in the form of longitudinally randomized magnetic bipoles), differential rotation, supergranular diffusion, and meridional flow. The open flux will again be derived from the photospheric field using a source surface/current sheet model. (3) In our multi-cycle simulations, the flux emergence rates and latitudes will be constrained using sunspot data, while the poleward flow speeds will be allowed to vary from cycle to cycle, subject to the condition that the Sun's dipole moment continue to reverse its polarity. We will also examine the effect of locating the source surface closer to the Sun when the photospheric field is very weak. The long-term predictions will be compared with cosmogenic isotope data and geomagnetic activity records. (4) The rate of interchange reconnection will be estimated for a large variety of nonaxisymmetric, differentially rotating photospheric configurations, using a newly developed parameter that measures changes in the distribution of open flux between successive potential states. The predictions will be compared with SOHO/LASCO observations of streamer blobs and coronal inflows.

Publication References:

Summary: no summary

Reference: Wang, Y.-M.; Robbrecht, E.; Rouillard, A. P.; Sheeley, N. R., Jr.; Thernisien, A. F. R.; (2010), Formation and Evolution of Coronal Holes Following the Emergence of Active Regions, The Astrophysical Journal, Volume 715, Issue 1, article id. 39-50, doi: 10.1088/0004-637X/715/1/39