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

Project Title:
The Sun's Polar Fields and the Dynamo

PI Name: Yi-Ming Wang
PI Email: yi.wang@nrl.navy.mil
Affiliation: Naval Research Laboratory
CO-I(s):
- Neil R Sheeley (Naval Research Laboratory)

Project Information:
OBJECTIVES AND APPROACH: We will derive constraints on the solar dynamo as follows: (1) Using polar faculae counts since 1906, Greenwich sunspot data, and magnetograph measurements since 1967 as observational constraints, we will carry out surface flux-transport simulations of the photospheric field evolution during cycles 15--23. We will then explore the relationship between cycle amplitude and meridional flow speed (a time-varying parameter in our model), cycle amplitude and the strength of the polar fields, and cycle length and flow speed. In addition, we will determine whether the observed giant poleward surges of flux, and the accompanying fluctuations in the polar fields and faculae numbers near sunspot maximum, require higher flow speeds. (2) As a by-product of these long-term simulations, we will quantify the relationship between total photospheric flux (facular brightness) and total sunspot area, in order to verify our hypothesis that increased diffusive annihilation during high-amplitude cycles causes TSI to saturate. (3) Using MWO, WSO, NSO/Kitt Peak, and MDI photospheric field measurements, MDI 676.7 nm images of polar faculae, and flux transport simulations, we will address the question of why the polar fields ended up so weak in 2008. The flow speeds derived at low latitudes from our simulations will be compared with helioseismic measurements, keeping in mind that the latter may not refer to the same depths that control the magnetic field transport. We will also measure the axial tilts of cycle 23 active regions to see if they are systematically smaller than the cycle 21 tilts analyzed in Wang & Sheeley (1989). (4) We will determine how much leading-polarity flux diffuses across the equator during cycles 20--23 by measuring the steepness of the observed photospheric-field gradients at the equator, and check if the resulting values are consistent with the observed polar field strengths at the end of each cycle. We will ascertain whether these latitudinal gradients were smaller during cycle 23 than during the previous three cycles, which would account for the weak polar fields during the current activity minimum. (5) We will provide a physical explanation for the success of geomagnetic activity precursors in predicting the amplitude of the following solar cycle, by separating the aa index into its constituent parts (mainly solar wind speed and IMF strength). At the same time, we will test our hypothesis that the IMF strength near sunspot minimum provides a better cycle predictor than the aa index itself.

RELEVANCE: The proposed research directly addresses LWS TR&T Focused Science Topic (a): "Measure the properties of the solar dynamo that affect solar irradiance and active region generation." More specifically, it answers the call for analyses revealing how the magnetic characteristics of the solar poles affect the dynamo and the solar activity cycle, and for the "use of observations that discriminate between models that forecast the properties of cycle 24." Our flux transport model will also allow us to investigate how sunspot and plage areas interact to determine the solar irradiance variation.

ROSES ID: NNH08ZDA001N
Duration:
Selection Year: 2009
Program Element: Focused Science Topic

Citations:

Summary: no summary

Citation: Wang, Y.-M.; Sheeley, N. R.; (2009), Understanding the Geomagnetic Precursor of the Solar Cycle, The Astrophysical Journal Letters, Volume 694, Issue 1, pp. L11-L15, doi: 10.1088/0004-637X/694/1/L11

Summary: no summary

Citation: Wang, Y.-M.; Robbrecht, E.; Sheeley, N. R., Jr.; (2009), On the Weakening of the Polar Magnetic Fields during Solar Cycle 23, The Astrophysical Journal, Volume 707, Issue 2, article id. 1372-1386; doi: 10.1088/0004-637X/707/2/1372

Summary: no summary

Citation: Wang, Y.-M.; Grappin, R.; Robbrecht, E.; Sheeley, N. R., Jr.; (2012), On the Nature of the Solar Wind from Coronal Pseudostreamers, The Astrophysical Journal, Volume 749, Issue 2, article id. 182, 14 pp, doi: 10.1088/0004-637X/749/2/182
