Project Details

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Topic: Understanding Global-scale Solar Processes and their Implications for the Solar Interior

Project Title:
Linking Active Regions and Solar Cycles to Understand How Variable Flows in the Solar Interior Affect Surface Magnetic Field Evolution

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Summary:
Understanding the solar cycle is a fundamental and important scientific goal central to NASA's Heliophysics Division. Activity cycles differ substantially from one to another in various ways: the overall amplitude of magnetic activity, the timing of polar field reversal, and the asymmetry of magnetic properties between the northern and southern hemispheres. These observed properties are the result of interactions between magnetic fields and flows throughout each sunspot cycle. Such interactions are often subtle, but they play a key role in addressing questions of solar cycle activity and in improving cycle predictions.

Several studies during the SDO/HMI era have revealed correlations between variations of the poleward transport of photospheric magnetic fields with properties of both magnetic field in solar active regions as well as their decay products (Zhao et al. 2014; Sun et al. 2015). Features such as poleward surges often play an outsized role in advecting flux away from the activity belts. These studies therefore raise the question of whether predictions of indicators, such as the strength of solar-minimum polar fields, can be better constrained as a result of these relationships.

To this end, we propose to (1) better characterize the time-evolution of the near-photospheric, large-scale, zonal and meridional flow measurements, as inferred from helioseismology; and to (2) use these measurements to constrain the evolution of surface magnetic fields using a fast-running surface-flux transport (SFT) scheme of (Schrijver & DeRosa 2003). Uncertainties of the flow profile and the SFT model are well estimated. A primary goal will be to determine the effects of these flow profiles on the evolution of emerging magnetic flux and the resulting sunspot-cycle activity properties. Ensembles of flux transport models will be run to better determine the robustness of these results.

We anticipate that the proposed study of solar interior flows and surface flux evolution investigation will nicely complement the activities of the broader Focused Science Team. Importantly, we will provide to the Team improved, observation-based, active-region-modulated, time-dependent meridional and zonal flows, which are known to be a key constraint on all numerical models and dynamo theories. Additionally, we will be able to quickly model the effects of any time-evolving differential rotation and/or meridional circulations on the transport of flux across the photosphere.

The proposed work uses data from current and historical NASA spacecrafts, SDO and SOHO, together with numerical modeling, to establish the linkages of flows, polar field, and solar active regions, and to forecast solar cycles. This is highly related to one of the high level science goals from the Heliophysics Decadal Survey: Determine the origins of the Suns activity and predict the variations in the space environment. This is relevant to the scientific objectives of the Focused Science Topic (FST) 4 in this LWS program, to ``advance our understanding of the time-variable and large-scale internal solar dynamics, magnetic field creation, and emergence.'' This also fits into the ``overarching goal of the FST'' that is ``to produce a data-driven model for solar magnetic flux production to enable forecasting of active latitude and longitude regions on time scales ranging from years to decades. The capability of predicting next solar cycle maximum provides matrix for measuring success for this investigation.

Publication References:

no references