Project Details

ROSES ID: NNH18ZDA001N
Selection Year: 2018
Program Element: Focused Science Topic

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

Project Title:
Do Flows in the Upper Solar Convection Zone Drive Global-Scale Magnetic Fields?

PI Name: Rudolf Komm
PI Email: rkomm@nso.edu
Affiliation: Association of Universities for Research in Astronomy, Inc.
Project Member(s):
- Jain, Kiran;Co-I;National Solar Observatory
- Kholikov, Shukirjon;Co-I;National Solar Observatory
- Tripathy, Sushanta C;Co-I;National Solar Observatory

Summary:
Science goal and objectives: We propose to measure the flows from the surface down to the upper shear layer in the convection zone around 5% below the surface and provide observational constraints for the latitudinal, longitudinal, and temporal variations of the flow components. The goal is to establish the extent to which these large-scale flows drive the emergence and evolution of magnetic flux at the solar surface and the subsequent poleward flux transport. This will lead to a better understanding of the generation and evolution of global-scale magnetic fields.
To achieve this goal, we will focus on surface and subsurface large-scale flows near locations of activity, including activity complexes and active longitudes, and search for subsurface markers or even precursors of magnetic activity. Second, we will focus on flows at mid- to high latitudes where diffusing flux is being transported poleward. Third, we will focus on the solar-cycle variation of flows derived from locations of high or low activity and the North-South asymmetry in magnetic activity and its connection to subsurface flows and whether these flows are precursors of the next-cycle activity. We will study the flows in three depth ranges: the layers close to the surface, where the density changes by several orders of magnitude, the near-surface shear layer (NSSL, at about 35 Mm), where the rotation rate shows a local maximum, and the layers in between these two. The flows in these layers have the most direct influence on surface activity.

Methodology: We will perform a comprehensive study of the large-scale horizontal flows (zonal and meridional flows) from the surface to a depth of about 40 Mm (94% solar radius) from the equator to 70 degree latitude or higher. We will focus on their variation with latitude, longitude, and time. We will study the variation from one rotation to the next and during the course of a solar cycle.
To derive the subsurface flow components, we will apply ring-diagram analysis (a well-established helioseismic technique) to SDO/HMI Dopplergrams. As a starting point, we will use the flow values derived from the standard HMI ring-diagram pipeline with three different tile sizes. We have previously studied the subsurface flows in the near-surface layers (to a depth of 16 Mm) with velocities from the HMI 15-degree ring-diagram pipeline. For the proposed study, we will, in addition, use tiles as small as 5 degrees for a better spatial and temporal resolution near the surface and big tiles of 30 degree to cover the NSSL. We will then customize the ring-diagram analysis modifying the grid size as well as the grid spacing and the tracking rate to optimize the analysis for the proposed project. We will derive the systematic variations of the flows with disk position and correct them.
To derive the flows near the NSSL, we will also apply helioseismic time-distance analysis to SDO/HMI Dopplergrams. Since time-distance and ring-diagram analyses have different error characteristics, this will allow us to cross-validate the results from both techniques.
To derive flows at the solar surface, we will use f-modes derived from SDO/HMI Dopplergrams and an appropriate LCT technique applied to SDO/HMI Dopplergrams and vector magnetograms. This will allow us to compare three sets of surface flows from different techniques and data sets.

Proposed Contributions to the Focus Team Effort: The proposed study of the large-scale flows in the upper convection zone will provide observational constraints, which will be crucial for the modeling of the solar interior and the solar flux transport. This will lead to a better understanding of the generation and evolution of global-scale magnetic fields and, as a consequence, provide constraints for forecasting solar activity. The proposed study therefore addresses the objective of Focused Science Topic (4): Understanding Global-scale Solar Processes and their Implications for the Solar Interior.

Publication References:

no references