# Project Details

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**Project Title:**
The influence of subsurface (and surface) dynamics on the activity cycle

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**Summary:**
We propose to study large-scale sub-surface flows of the Sun determined from SDO data on time scales of days to years in order to investigate the linkage of subsurface features with surface magnetic activity and to predict the properties of the new solar cycle. As shown by helioseismic studies, the zonal and the meridional flow in the upper convection zone vary with the solar cycle. The variation of these flows associated with the new cycle has been detected before any magnetic activity of cycle 24 was present on the surface of the sun.

The high-resolution observations available from SDO/HMI allow us to measure these large-scale flows at a great distance from disk center. Sub-surface flows derived from previous observations have been limited to about 60 degrees latitude, while they can be measured to at least 75 degrees using SDO, which is a substantial improvement. For the meridional flow, we will address the question whether there are multiple cells per hemisphere, which is of great importance for flux-transport dynamos. Second, we propose to derive the variation with depth in order to validate hints of multiple cells in depth. For the zonal flow and its cycle variation, we will focus on the poleward branch of this pattern in addition to the equatorward one. The cycle variations of the zonal and the meridional flow are usually studied separately. We propose to treat both flow components as part of a single system. How are these flow variations related to each other? Is their timing the same with regard to the activity cycle?

We plan to pursue the proposed goals with multiple techniques and data sets. Local and global helioseismic techniques will be applied to HMI Dopplergrams. The ring-diagram analysis will be used to derive subsurface flows in the upper shear layer of the convection zone, while the time-distance analysis will be used to derive the meridional flow in the deeper convection zone. Global helioseismology will be used to derive the zonal flow throughout the whole convection zone. Comparing zonal flows derived from global as well as local techniques allows us to cross-validate the results.

Another key benefit of using HMI observations is that it allows us to measure the near-surface flows with better spatial resolution, which is especially important near active regions. The patch size of the ring-diagram analysis can be a factor of three smaller than the one used with SoHO/MDI observations. Active regions are locations of converging or diverging horizontal flows depending on depth. How much do they contribute to the overall flow patterns? Do the large-scale flow patterns vary with longitude independent of active regions? As a side benefit, we will be able to determine the proper motions of active regions below the surface. It has been established that they rotate faster than the ambient quiet sun at the surface and in shallow sub-surface layers. How far does this extend with depth? Do they move toward or away from the mean latitude of activity? The answers promise to provide insights into the nature of the dynamo and its location (surface vs. base of convection zone).

In addition, we will apply cross-correlation and feature tracking techniques to HMI magnetograms to derive surface flows. This allows us to derive the flows in a consistent manner from the surface to the lower convection zone. The proposed investigation is timely, since the rising phase of the solar cycle is the epoch when large-scale flow patterns migrate with latitude and the flows show the most distinct variation with latitude.

## Publication References:

**Summary:** no summary

**Reference:** Komm, R.; Gosain, S.; Pevtsov, A.; (2014), Active Regions with Superpenumbral Whirls and Their Subsurface Kinetic Helicity, Solar Physics, Volume 289, Issue 2, pp.475-492, doi: 10.1007/s11207-012-0218-z

**Summary:** no summary

**Reference:** Komm, Rudolf; Gosain, Sanjay; (2015), Current and Kinetic Helicity of Long-lived Activity Complexes, The Astrophysical Journal, Volume 798, Issue 1, article id. 20, 13 pp, doi: 10.1088/0004-637X/798/1/20

**Summary:** no summary

**Reference:** Komm, R.; González Hernández, I.; Howe, R.; Hill, F.; (2015), Subsurface Zonal and Meridional Flow Derived from GONG and SDO/HMI: A Comparison of Systematics, Solar Physics, Volume 290, Issue 4, pp.1081-1104, doi: 10.1007/s11207-015-0663-6