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Proposal Title: Tools Enabling Rapid Mapping of Solar Subsurface Weather with Time-Distance Tomography

Abstract:
The Helioseismic and Magnetic Imager (HMI) to be launched aboard the Solar Dynamics Observatory (SDO) will enable major new initiatives to study the complex coupling of turbulent convection and intricate magnetism within the sun's convection zone. HMI will provide continuous Doppler and magnetic imaging of the entire solar disk with fourfold better spatial resolution than is regularly available with any current ground- or space-based instruments. Helioseismology has revealed that strong winds and flow structures, called solar subsurface weather (SSW), are present beneath the solar surface. These flows clearly interact with magnetic active regions and are likely the signature of giant cells, the largest scales of solar convection which span the entire depth of the convection zone. We propose to develop new time-distance tomography procedures designed to explicitly resolve the role of giant cells in the evolving SSW. The primary goal of these tools will be to permit nearly real-time mapping of such flows and their interaction with photospheric magnetism on a continuous basis using HMI. Numerical simulations of solar convection indicate that giant cells can readily propagate and evolve in an intricate manner, often organizing into larger-scale patterns. Present helioseismic observations indicate that SSW interacts strongly with the magnetic fields that pierce the solar surface in the form of active regions, sunspots and plage. In particular, active regions usually appear as zones of convergence near the surface and often exhibit strong diverging flows at greater depths. It is likely that giant cells and larger-scale organizations of such convection may contribute to instabilities within the tachocline that yield the active regions, particularly in the case of active nests where new magnetic flux repeatedly emerges at the same location on the solar surface.