Bradley Hindman/University of Colorado Helioseismic Tools that Incorporate Corrections Arising from Magnetic Active Regions

One of the primary goals of the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO) is the study of magnetic active regions using local helioseismic techniques. We know from the pioneering work of Braun (1995) and Braun, Duvall & LaBonte (1988) that active regions and sunspots are insatiable absorbers of acoustic waves, absorbing as much as 50% of the incoming wave energy. Subsequent work has concentrated on understanding the physical mechanism responsible for this absorption (Bogdan & Cally 1995; Crouch & Cally 2005). Conversely, inadequate attention has been paid to the effects that such absorption has on other helioseismic measurements, such as the determination of flows in the immediate vicinity of active regions. Such effects are likely to be rather important since the absorption is strong and is an increasing function of wave frequency. Therefore, even outside of the region of strong field, the acoustic shadow cast by the active region will alter the acoustic line profile for waves that have passed through the activity. This anisotropic absorption could be interpreted as a flow by most local helioseismic techniques. Here we propose (1) to directly measure the changes induced in p-mode line profiles by active regions and sunspots, and (2) to develop procedures that incorporate such magnetic modifications in flow and sound-speed determinations using the local helioseismic techniques of ring analysis and time-distance tomography. These new helioseismic tools will be implemented into the HMI data-analysis pipelines, allowing robust measurement of flows and circulations that form around active regions. With such reliable procedures we will be able to assess the importance that flows may have in the evolution and stability of active regions as they age.