

**NASW-01007: Seismic Forecasting of Solar Activity**  
**Quarterly Progress Report: July 2, 2001 – October 1, 2001**

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The advent of holographic imaging techniques applied to the far surface of the Sun (Lindsey & Braun 2000 *Science*, **287**, 1799) introduced the immediate possibility of a synoptic monitor of far-side activity for purposes of space weather forecasting. This tool has long been needed for studies of active-region evolution as well. A collaboration with the SOI-MDI team at Stanford University has now given us such a synoptic program. This program applies our seismic-imaging software package to the medium-resolution MDI images within 24 hours of their acquisition by the *SOHO* spacecraft. The software package we adapted for the Stanford program is written in UNIX and C, is highly portable and can be adapted to a broad range of computational platforms and databases. For the first time, real-time seismic maps of large active regions on the Sun's far surface are publicly available. The synoptic images show examples of active regions persisting for one or more solar rotations, as well as those initially detected forming on the solar far side. These synoptic solar images can be accessed on the web at <http://soi.stanford.edu/data/farside>.

Until recently, imaging the far surface of the Sun has relied on what we call two-skip phase-sensitive holography. This scheme is essentially blind to active regions more than about 50 degrees from the antipode of disk center. Figure 1a shows the perspective involved when seismic methods are applied to a focal point placed beyond this range. Since only one side of the required two-skip pupil is actually visible on the solar disk, the phase correlation between the (outgoing) egression and (incoming) ingression amplitudes is insignificant, even while the amplitudes computed from the visible portion of the two-skip pupil, remain individually significant. Figure 1b, however, illustrates how a one-skip pupil and its three-skip specular reflection about the focus may be used to form images at this location of the focal point. Ingressions and egressions, coherently summed over the observed portions of the three- and one-skip pupils, give rise to favorable correlations with the focal point placed close to or even directly on the solar limb.

In a paper recently accepted for publication (Braun & Lindsey 2001), we have demonstrated how acoustic travel-time perturbations may be mapped over the entire portion of the Sun facing away from the Earth, including the polar regions. Figure 2 shows an example of farside imaging of the entire far hemisphere of the Sun over a four day interval. In addition to offering significant improvements to ongoing space weather forecasting efforts, the procedure offers the possibility of local seismic monitoring of both the temporal and spatial variations in the acoustic properties of the Sun over all of the far surface.

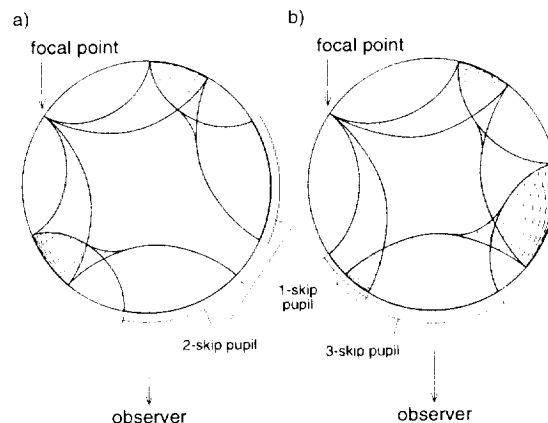


Figure 1: Far-side imaging for focal points significantly away from the antipode of disk center (ADC), showing (a) the limitations of using two-skip correlations, and (b) the advantages of using one/three-skip correlations.

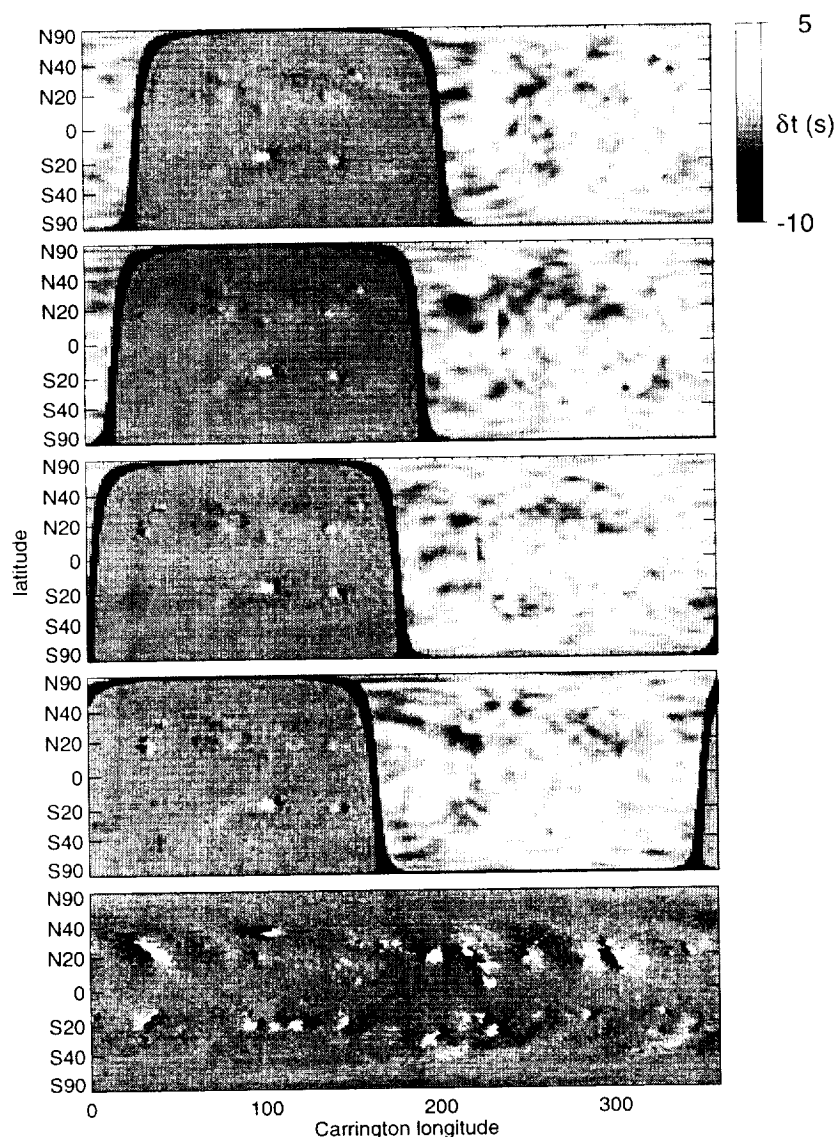


Figure 2: Composite images of the near-side magnetic flux density and far-side acoustic travel-time perturbations for the four days spanning 1999 April 22 – 25 (top four panels, proceeding downward). The circular discontinuities apparent around the center of the far-side images divide the two-skip correlations, computed within  $48^\circ$  of ADC, from the one/three-skip correlations computed outside. The bottom panel shows a synoptic magnetogram for the subsequent Carrington rotation (1999 May 1 – 28). (From Braun & Lindsey 2001)

#### Refereed Publications

Braun, D. C. and Lindsey, C. 2001, "Seismic Imaging of the Far Hemisphere of the Sun," *Astrophys. J.*, in press.

#### Abstracts

Braun, D. C. 2001, "Progress in Helioseismic Holography (Invited Talk)," *Eos. Trans. AGU* (82)20, S384.  
 Lindsey, C. and Braun, D. C. 2001, "Prospects for Helioseismic Holography in the Deep Solar Interior," *Eos Trans. AGU* (82)20, S384.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 24 September 2001	3. REPORT TYPE AND DATES COVERED 1st Quarterly Progress Report 7/02/01 - 10/01/01		
4. TITLE AND SUBTITLE Seismic Forecasting of Solar Activity		5. FUNDING NUMBERS NASW-01007		
6. AUTHORS Dr. Douglas Braun				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Northwest Research Associates, Inc. 14508 N.E. 20 <sup>th</sup> St. Bellevue, WA 98007-3713		8. PERFORMING ORGANIZATION REPORT NUMBER  NASA-1007-QPR1		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Delia B. Robey, Contracting Officer Code 210.H NASA, Goddard Space Flight Center Greenbelt, MD 20771		10. SPONSORING/MONITORING AGENCY REPORT NUMBER		
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT		12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words) We have developed and improved helioseismic imaging techniques of the far-side of the Sun as part of a synoptic monitor of solar activity. In collaboration with the MDI team at Stanford University we are routinely applying our analysis to images within 24 hours of their acquisition by SOHO. For the first time, real-time seismic maps of large active regions on the Sun's far surface are publicly available ( <a href="http://soi.stanford.edu/data/farside">http://soi.stanford.edu/data/farside</a> ). The synoptic images show examples of active regions persisting for one or more solar rotations, as well as those initially detected forming on the solar far side. Until recently, imaging the far surface of the Sun has been essentially blind to active regions more than about 50 degrees from the antipode of disk center. In a paper recently accepted for publication, we have demonstrated how acoustic travel-time perturbations may be mapped over the entire hemisphere of the Sun facing away from the Earth, including the polar regions. In addition to offering significant improvements to ongoing space weather forecasting efforts, the procedure offers the possibility of local seismic monitoring of both the temporal and spatial variations in the acoustic properties of the Sun over the entire far surface.				
14. SUBJECT TERMS		15. NUMBER OF PAGES 1		
		16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT  UL	