Predicting solar active region appearances using helioseismic far-side maps

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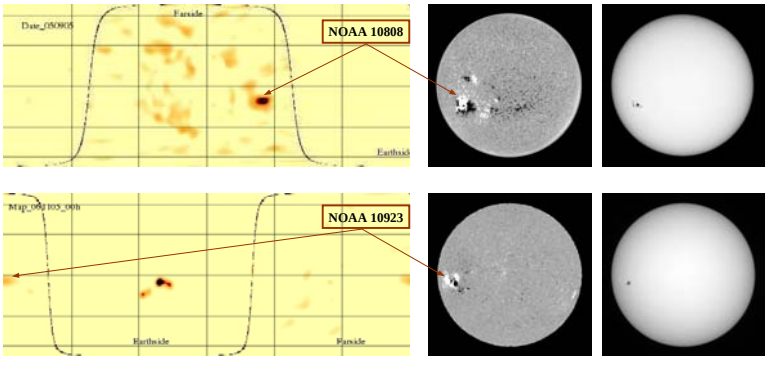
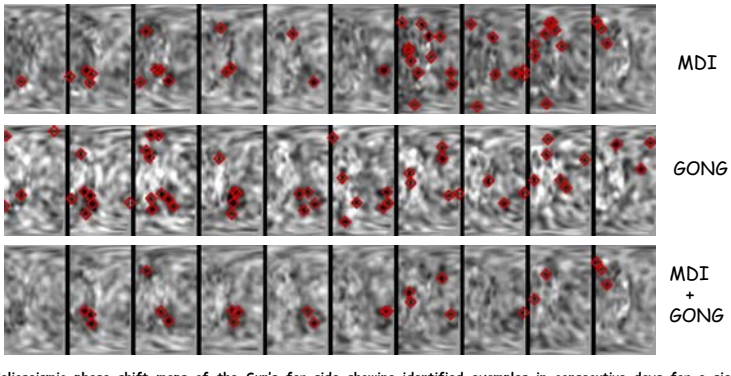
Both the Michaelson Doppler Imager (MDI) and the Global Oscillation Network Group (GONG) projects produce daily seismic maps of surface magnetic activity at the non-visible hemisphere of the Sun at http://soi.stanford.edu/data/farside and http://gong.nso.edu/data/farside. The technique has proven useful for detecting and following large active regions on the Sun's far side before they appear to face the Earth. Here we show preliminary work towards improving the detection capability of the technique by combining the results from both instruments. An automatic detection algorithm is also being developed to identify upcoming active regions and assign them a probability number.

Seismic signatures of NOAA 10808 (top) and NOAA 10923 (bottom) on the far solar hemisphere on September 9 2005 and November 5 2006. These two active regions presented very different signatures on the far-side maps calculated from both MDI and GONG data. A recent study showed that the seismic signature depends on the size and strength of the AR. In the Space Weather context, it would be useful to amplify the signal to noise to be able to detect weaker AR's and to simplify the identification of active regions by labeling them and assigning them a probability number. The final purpose of this work is to find an algorithm to automatically detect candidates in the far-side maps with an associated probability of appearing in the front side. We show here the first step in that direction: a study of the success rate for different signal levels for MDI, GONG and the combination of both.



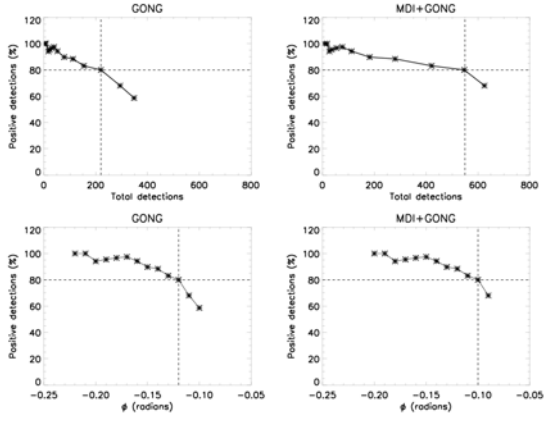
The far-side maps shown above were calculated using GONG near-real-time data. The corresponding magnetograms and intensity images are shown in the right panels. In the far-side maps, the abscissa represents Carrington longitude. The ordinate of each image represents the sine of the solar latitude, over the range -90°(south pole) to 90°(north pole). The far-side maps are overlaid on the daily GONG magnetograms which have been smeared to present a similar resolution to that of the far-side maps.

Far-side maps of individual days from January 1 2003 to December 31 2004 were used to evaluate the success rate. A candidate in the far-side maps is defined as a local minimum phase-shift larger in magnitude than a particular threshold and persistent for at least two consecutive days.



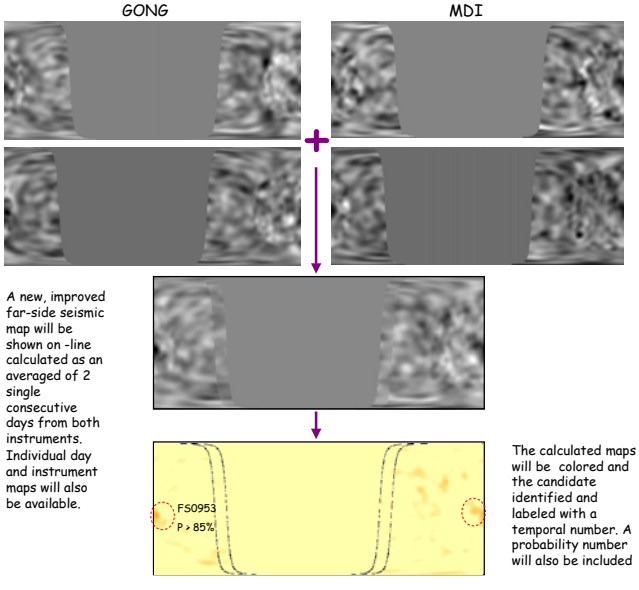
Helioseismic phase-shift maps of the Sun's far side showing identified examples in consecutive days for a signal threshold level of -0.15 radians. The different rows correspond to MDI (top), GONG (center) and the combination of both (bottom). Only the last 90 degrees inside the limb are used for the analysis, that is, the active region will appear in 7 days or less on the front side. The combined far-side maps are clearly less noisy and the signal more stable.

Once the candidates are identified in the far-side maps, the location is matched with that of the NOAA active regions appearing in the front side in the following days, to establish the positive identifications. The figure below shows the results.



Positive detections versus number of total detections (top) and phase-shift (bottom) for GONG (left) and the combination of GONG and MDI (right) calculated far-side maps. It can be seen that the combined far-side maps achieve a larger success rate as well as increasing the probability of detection for smaller/weaker active regions.

Applying the results to the on-line seismic far-side maps



A new, improved far-side seismic map will be shown on -line calculated as an averaged of 2 single consecutive days from both instruments. Individual day and instrument maps will also be available.

The calculated maps will be colored and the candidate identified and labeled with a temporal number. A probability number will also be included

The combination of two consecutive far-side maps (Nov 02-03 2006) from both GONG and MDI considerable reduces the noise, enhancing the signature of active region NOAA10923 that appeared on the front side 5 days later, Nov. 8 2006 coinciding with the Mercury transit. The seismic signature on the combined map has a maximum magnitude of 0.125, which correspond to a probability larger than 85%

This work utilizes data obtained by the Global Oscillation Network Group (GONG++) Program and the SOI/MDI instrument on SoHO. GONG++ is managed by the National Solar Observatory, which is operated by AURA, Inc. under a cooperative agreement with the National Science Foundation. The data were acquired by instruments operated by the Big Bear Solar Observatory, High Altitude Observatory, Learmonth Solar Observatory, Udaipur Solar Observatory, Instituto de Astrofísica de Canarias, and Cerro Tololo Interamerican Observatory. SOHO is a project of international collaboration between ESA and NASA. This work has been supported by the NASA Living with a Star – Targeted Research and Technology program and the Stellar Astrophysics branch of the National Science Foundation.