Temporal Variation of Travel Time Differences from GONG++

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We present preliminary results of a search for variations of North-South travel time differences from GONG data for 2001 - 2005. To isolate different wave packets propagating to different depths of the solar interior we apply a phase-velocity filter to spherical harmonic coefficients and reconstruct images in sin(latitude)-longitude coordinates. Separation distances between pairs of points in the cross-correlation range from 2 to 10° corresponding to depths from .988 to .94 R_o.

Data Analysis

We use GONG++ data for three Carrington rotations, from October 2003 to January 2004.

-Individual daily images are decomposed into spherical harmonic (ℓ) coefficients for the range 0-500.

-Phase-velocity filters are applied to the time series to isolate acoustic signals propagating to different depths. One set of data was filtered with central ℓ_0 = 370 and ν_0 = 3 mHz and another set with ℓ_0 = 140 and ν_0 = 3 mHz. The corresponding lower turning points for these filters are about 9 and 40 Mm respectively. Images were then reconstructed back in a spherical coordinate system using the filtered SH coefficients.

-Cross-correlation functions (CCF) were computed between a point and points ±20° arc in the North-South direction separated by corresponding angular distances. For ℓ_0 = 370, the separation between endpoints was ~2° and for ℓ_0 = 140 it is about ~10°. In this case cross-correlations correspond to waves propagating only in North-South direction. To improve the signal-to-noise ratio, all CCFs for a longitudes within 3° were averaged. The corresponding range of lower turning points for these separations is approximately 0.988 and 0.94 R_o.

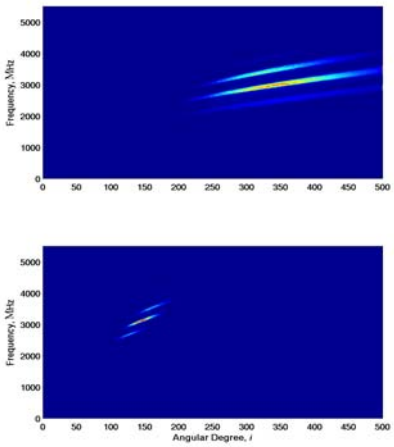
-Travel times are measured by fitting a Gabor wavelet to the CCFs peaks.

Discussion

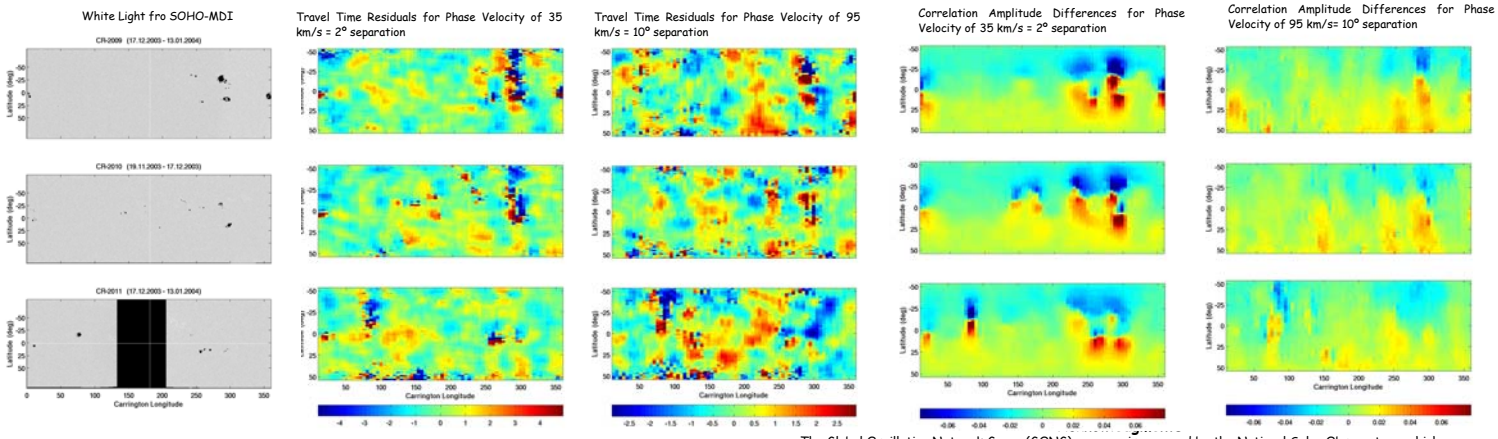
The main goal of this study was to look for active longitudes if they present from our travel time differences. In these maps we can not see any significant active longitudes. There are wave-like structure in longitude in the northern hemisphere (see CR 2011).
Another interesting fact is that around all active regions changes of travel times are visible. Moreover, these changes flips sign in two South-North opposite directions from active region. We think that it is outflows moving from the active regions.
In some of active regions we also see extension of negative travel time changes to the high latitudes, which indicates existing of some additional flow in these latitudes, or meridional flow speed is faster than other latitudes.

North-South travel time maps

We have used more than 115 days of GONG data. For each day were computed CCF for all pixels located ± 54° in both latitude and longitude. Travel time differences in the latitudinal direction were measured and averaged for an area 2° in latitude and 3° in longitude. Then travel time maps were constructed for Carrington rotations 2009-11. In figure 2 and figure 3 we present these three maps for two different depths. The maps show features very similar to the synoptic maps produced from intensity images. Even relatively small active regions in the intensity synoptic maps are apparent in the travel-time maps.



Power spectrum after the phase velocity filters have been applied.



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