National Solar Observatory

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# GONG Magnetograms[1]

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## Abstract

Solar magnetic field information can most reliably be derived from photospheric data, from which model coronal fields are extrapolated. Incomplete temporal coverage, poor sensitivity and poor knowledge of the zero point of the measurements often limit the usefulness of such data. Line-of-sight photospheric magnetograms are produced every minute at GONG's six sites. Recent efforts to improve the quality of GONG magnetograms have yielded encouraging results. All modulators and driving circuitry have been replaced, improving the sensitivity and zero point by orders of magnitude. Improvements to the existing data include a zero-point correction and histogram equating of magnetograms. Past and future GONG data will provide unique continuous, high-cadence, sensitive coverage of the solar magnetic field. GONG is the official provider of magnetograms for NASA's STEREO mission.

## New modulators and driving circuitry

The magnetograph modulators and driving circuitry have been replaced across the network. The modulators have been characterized in the lab and thermal controllers incorporated into the optical table layout. Tests show that an uncertainty in the zero point of $< 0.1$ Gauss has been achieved. The new hardware has now been deployed at all sites, lowering the instrumental background by a factor of 10 and providing an unprecedented data set of full-disk, high-cadence, continuous, long-term magnetic field measurements.

## Zero-point correction

An asymmetric switching of the old LCD modulators between retardation states generates a zero error. At each site every day, we create a magnetic "flat field" from East and West calibration images to correct a nearly simultaneous regular magnetogram, giving a nearly error-free reference. We determine the zero-point error throughout the day by subtracting this reference magnetogram. This error is fitted with suitable functions, Zernike polynomials, smoothing the time-dependence of the Zernike coefficients. We use these to apply a correction at any time during the day (minute by minute).

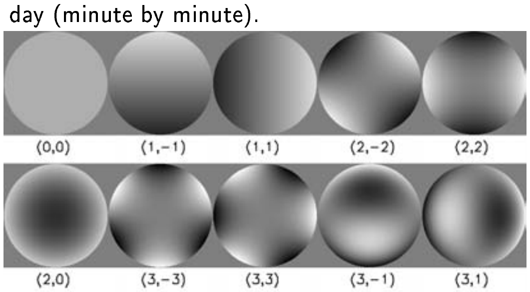


Fig. 1: The ten Zernike terms used in the correction of the full-disk magnetograms from the old modulators.

## Histogram equating of magnetograms

Although GONG's six sites employ identical hardware, inevitably small inconsistencies will appear in the flux distributions of data from different sites. To measure and correct errors between two magnetograms we calculate histograms of pixel values of each magnetogram, dividing the $N$ positive pixels into 1000 equally populated bins: the first $N/1000$ pixels are put in the first bin, the second $N/1000$ pixels into the second bin and so on. The same is done for the negative pixels. The set of 2000 average bin values forms the equating table of the magnetogram. The equating tables of two magnetograms are the relative magnetic field distributions which may be graphed against each other. Figure 2 shows how such graphs vary over several days. Histogram equating is used to make magnetic measurements across the GONG network consistent with each other.

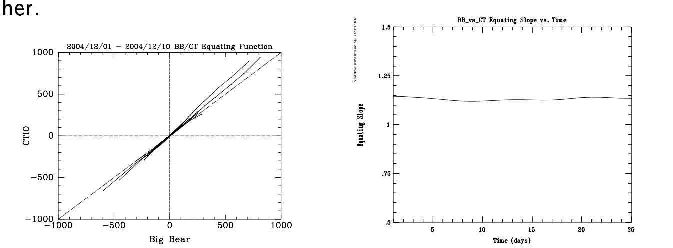


Fig. 2: Sample equating functions between two stations over several days (left) and equating function slope variation over this time period (right).

## Potential-field extrapolation

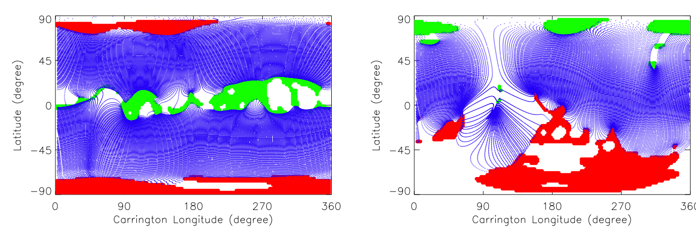


Fig. 3: Potential field source-surface extrapolation for the uncorrected data (left) and the corrected data (right).

We extrapolate a potential field model from the synoptic map derived from the uncorrected and corrected measurements taken during CR 2024. Figure 3 shows the influence of a poorly defined zero point: a spurious quadrupolar magnetic component dominates the global field topology (top pictures) while the corrections give the expected dipolar configuration (bottom pictures), also found from SOLIS and WSO maps for CR 2024. The corrections also eliminated a sizeable monopole component, not represented in the pictures.

AAS/SPD Meeting, Durham, New Hampshire, June 2006

[1]This work utilizes data obtained by the Global Oscillation Network Group (GONG) Program, 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 Astrofsica de Canarias, and Cerro Tololo Interamerican Observatory.

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