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GONG Near-real-time Synoptic Magnetograms and Coronal Models[1]

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Abstract

Line-of-sight photospheric magnetograms are produced every minute at GONG s six sites. All modulators and driving circuitry have recently been replaced, improving the sensitivity, accuracy and zero point by orders of magnitude. Information on the solar atmospheric field can most reliably be derived from such photospheric data, from which model coronal fields are then extrapolated. Near-real-time synoptic magnetogram are produced by GONG every hour capable of representing the steady-state field or hour-by-hour field changes on the earthward side of the Sun. Potential-field source-surface (PFSS) models are produced from the standard steady-state magnetogram every hour yielding insight into large-scale coronal field changes caused by quasi-static evolution and by flares and coronal mass ejections. GONG is the official provider of magnetograms for NASA's STEREO mission.

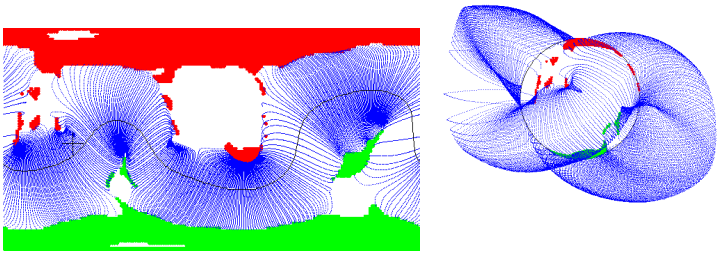

Fig. 1: The coronal hole (open flux) source regions and the equatorial streamer belt in Carrington coordinates (left) and in spherical coordinates showing a line-of-sight view (right). Green indicates positive polarity and red negative polarity. On the GONG synoptic magnetogram page, http://gong.nso.edu/data/magmap/, archives and movies of these products are available.

Figures 1-3 show potential-field source-surface coronal models based on GONG near-real-time photospheric data. In Figure 1 only the tallest closed coronal field lines are shown. All field lines reaching $r = 2.5\times$ the solar radius are open by assumption, being dragged outward by the solar wind. The tallest closed lines separate regions of open and closed magnetic flux and are therefore a useful simple representation of the global magnetic field topology. Regions of open flux correspond to coronal holes. Knowledge of coronal hole locations is important because the fast solar wind is believed to originate from coronal holes.

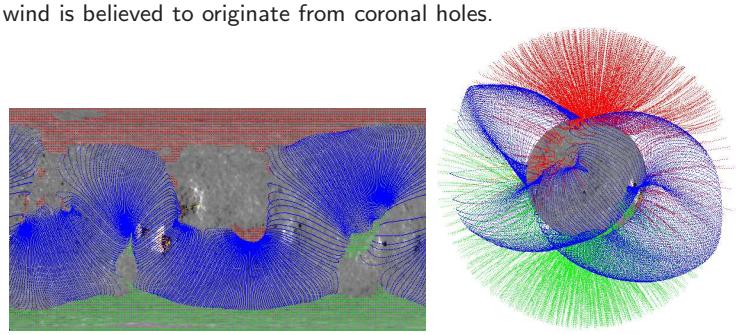

Fig. 2: Model coronal field lines overplotted on their associated photospheric synoptic near-real-time magnetogram. The magnetogram is represented in greyscale with maximum positive (outward from the Sun) flux white and maximum negative flux black. For the coronal field lines, open positive flux is in green, open negative flux in red and closed flux in blue. Only the tallest closed field lines are shown as in Figure 1. On the GONG synoptic magnetogram page, http://gong.nso.edu/data/magmap/, archives and movies of these products are available.

We plot in Figure 2 open positive magnetic lines, open negative lines and the set of tallest closed lines. Since the model at $r = 2.5\times$ the solar radius is open and is dominated by the low-order, large-scale terms of the solution, the field at there is divided into a large region of positive open flux associated with one pole and a similarly large region of open negative flux associated with the other. Between these two regions is a single neutral line which meanders in a quasi-sinusoidal pattern. This neutral line corresponds to the apexes of the tallest closed loops in the field model - loops that together form a meandering arcade around the circumference of the Sun, the equatorial streamer belt.

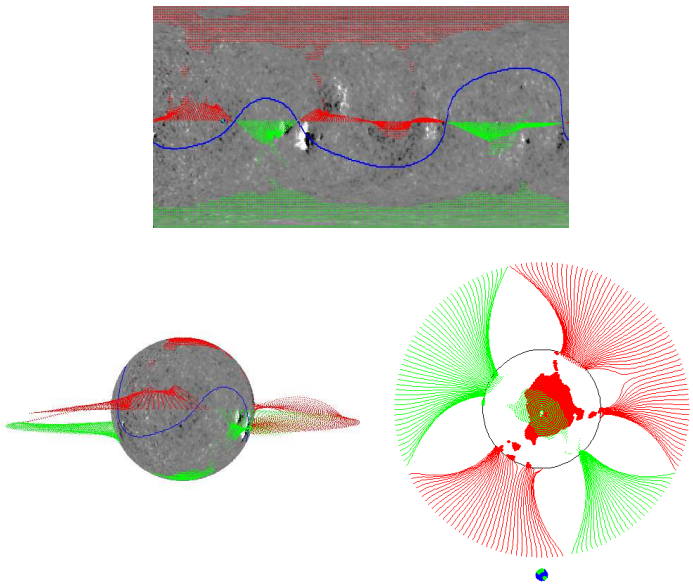

Fig. 3: Model field lines that are open to the heliosphere at the ecliptic plane. Also shown are the associated magnetogram and the polarity inversion line, which divides the lines into same-polarity groups, and coronal holes, which are represented by green (positive polarity) and red (negative) dots. In the top picture, the current location of the sub-Earth point is shown by the small blue/green circle. The view of the model from the north pole shows northerly coronal holes represented by solid shading and southerly by stripes. The current earthward direction is indicated by the blue/green circle. On the GONG synoptic magnetogram page, http://gong.nso.edu/data/magmap/, archives and movies of these products are available.

We plot in Figure 3 only field lines that are open to the heliosphere at the ecliptic plane. These trajectories are likeliest to channel dangerous energetic particles associated with flares and CMEs to Earth, and determining whether their photospheric foot points are located in active or quiet regions provides a means of forecasting such scenarios. The solar wind speed at Earth can be estimated several days in advance by considering the relative expansion of flux tubes open to the ecliptic plane.

[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 Astrofísica de Canarias, and Cerro Tololo Interamerican Observatory.

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