Helioseismic Space Weather Predictors from GONG

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Helioseismology and GONG

- Solar oscillations sample the sun’s interior
- Ring diagram technique provides picture of active region subsurface structure
- Acoustic holography provides picture of activity on solar farside
- Global Oscillation Network Group (GONG) program of the NSO operates 24-7
- GONG also obtains a full-disk magnetogram every minute, 24-7.
Ring Diagrams - I

- Three-dimensional power spectrum of solar oscillations
- Subsurface flow displaces rings

No tracking for solar rotation

With tracking
Ring Diagrams – II

• Perform analysis over solar disk

• Invert for horizontal flows as function of location and depth
Ring Diagrams -III

- Assuming incompressible flow and using solar model density
- Derive vertical velocity and fluid dynamics descriptors: divergence, vorticity, helicity, enstrophy
Fig. 4.— Zonal vorticity, $\omega_z$, at 300° longitude in CR 1993 as a function of latitude and depth. Top: gross magnetic flux (solid line) and binned over 15° (dotted line); 2nd: the z-component of vorticity ($\omega_z$); 3rd: the signal-to-error ratio. The arrows represent the meridional and vertical velocity components with the vertical one increased by a factor of 10 for visibility. Bottom: idealized schematic for flows below a strong active region (with arbitrary amplitudes).
Correlation between kinetic helicity and flare activity

Fig. 5.— Linear correlation between maximum kinetic helicity density and X-ray intensity (square), magnetic flux (+), and square of magnetic flux (×) as a function of depth. The correlation between X-ray intensity and magnetic flux (dotted line) and square magnetic flux (dot-dashed line) is included for comparison. The dashed line indicates the 99.9% confidence level for a given sample size. Top: CR 1982, 28 active regions; Bottom: CR 2009, 20 active regions.
Temporal behavior of kinetic helicity before a flare
Farside imaging

- Uses acoustic holography
- Time reverse observed wave field to an impulse at a specific depth
- Depth can be located at the farside surface
- Presence of active region causes phase shifts
Farside images of AR10808

8/29/05
8/30/05
8/31/05
9/01/05
9/02/05
9/03/05
High-cadence magnetograms

- Full-disk, moderate resolution (800 \times 800)
- One per minute per site
- 24 hour coverage, 87% duty cycle
- 1G noise, 10G zero point (improvement underway)
- SSL use for potential field computations
### Status of GONG space weather products

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<tr>
<th>Product</th>
<th>Forecast period</th>
<th>Needed development</th>
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<td>Subsurface vorticity</td>
<td>1-7 days when region is on front side</td>
<td>1. Measure false alarm &amp; predictive probabilities&lt;br&gt;2. Speed up data acquisition &amp; processing</td>
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<tr>
<td>Farside imaging</td>
<td>1-14 days before region appears on front side</td>
<td>Calibration of phase signal, magnetic field, and flare probability</td>
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<tr>
<td>High-cadence magnetograms</td>
<td>1-7 days when region is on front side</td>
<td>1. Reduction of zero point (new modulator)&lt;br&gt;2. Speed up data acquisition &amp; processing</td>
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