

Report on GONG and Its Successor

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Introduction:

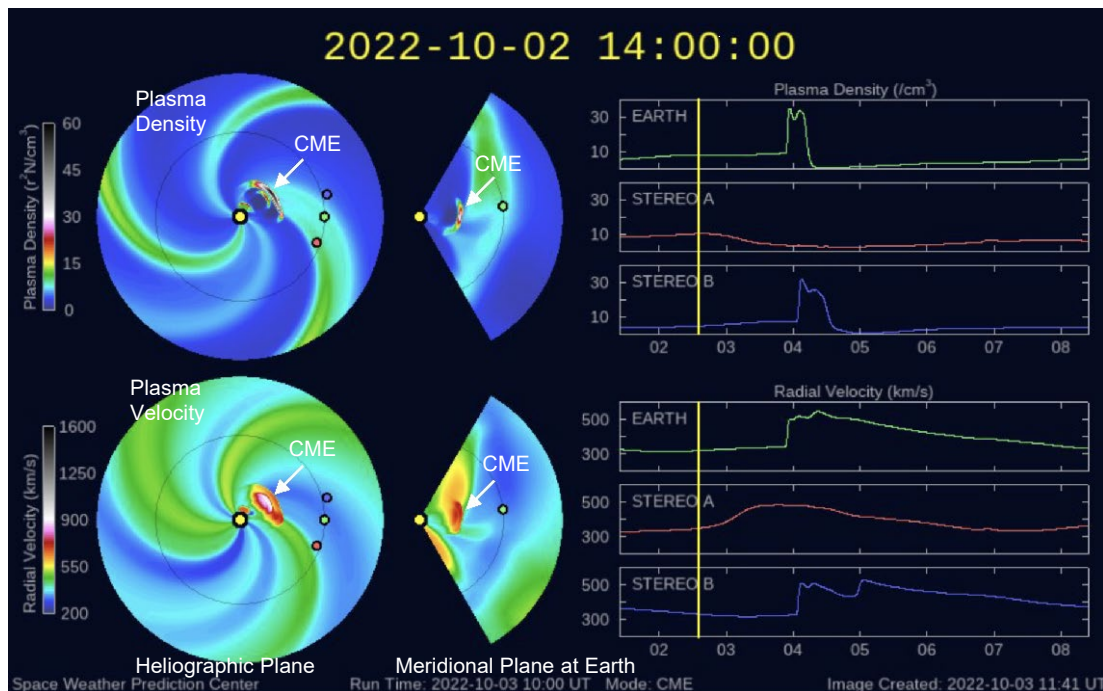
- NOAA's Space Weather Prediction Center (SWPC), 1 of the 9 National Centers for Environmental Prediction, is charged with nowcasting and forecasting space weather conditions.
- Geomagnetic storms and associated geomagnetic activity can be hazardous to civilian and defense infrastructure.
- Anticipating their onset is one of the major priorities for NOAA SWPC.
- The Global Oscillations Network Group (GONG) of the National Solar Observatory (NSO) provides key observations for space weather forecasts. NOAA contributes \$1.17M/year to maintenance, about 50% of cost.
- GONG is nearing end of life. Continuation beyond 2030 is problematic, and beyond 2032 unlikely.
- There is no replacement plan at this time. All options will involve years of design, construction, and deployment, so it is important to embark on a replacement plan immediately.

Forecasting Geomagnetic Activity



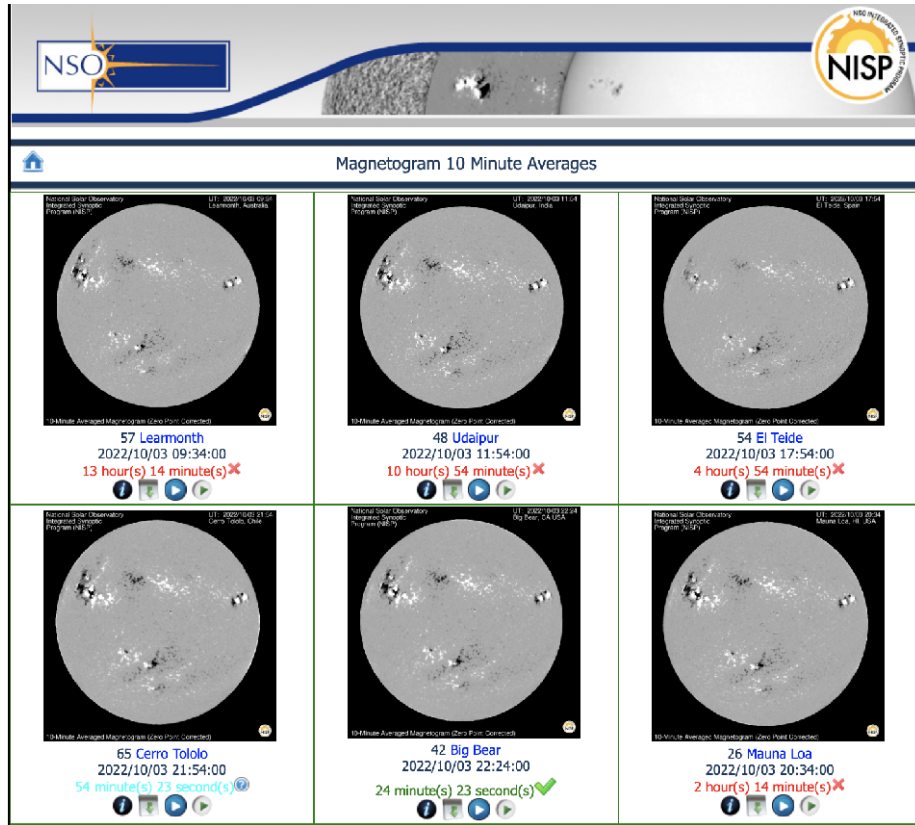
- The WSA-Enlil model is used to help forecast Geomagnetic Activity, by modeling CMEs and fast solar wind streams
- The model relies on magnetic maps from GONG.
- GONG provides other space-weather data as well.

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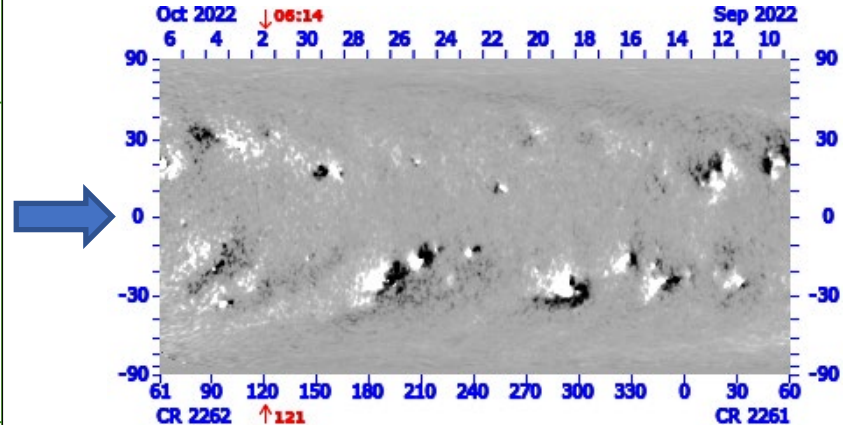


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GONG Magnetograms & Maps:



- GONG was built in 1995 for helioseismology - re-purposed for Space Weather
- Telescopes at 6 sites around the world provide continuous measurements of the Sun's magnetic field.
- Full-disk magnetograms are stitched into full Sun maps that provide boundary conditions



ngGONG

- NSO has planned for the design of a next generation Ground-based solar Observing Network (ngGONG)
- It has been discussed for several years within the Science community, DOD, and NOAA.
- In 2021, a ngGONG proposal was submitted and reviewed under NSF's Mid-Scale Research Infrastructure Program in 2021. It received positive reviews but was not funded.
- Interest from Operational agencies was noted, but the lack of a definitive commitment was seen as impediment to selection.
- NSO is preparing a new proposal:
 - The design phase is expected to take ~3 years, at a total cost of \$17M.
 - Construction is expected to take 5-7 years, with a total cost ranging from \$90-\$210M.
 - It is nominally planned to last two complete solar cycles (~44 years).
 - NSO will submit to the Mid-scale R-1 NSF program for the design phase (must be less than \$20M). They have submitted a pre-proposal, and have been invited to submit a full proposal, due on 5/5/2023.
- NSF indicated that a modest commitment (e.g. \$1M year) would greatly increase the chances.
- Initiating design would give time to solidify plans, possibly bring in other agencies (DOD).

Possible Alternatives

- While there are other space-based and ground-based telescopes, there are no suitable alternatives with expected lifetimes longer than GONG.
- It is possible for NESDIS to fly a magnetograph on a future GOES mission or space weather dedicated satellite. There are no plans at the present time for doing this.
 - The timeline for implementing this approach would likely be many years.
 - If no ground-based alternative materializes, it seems that this approach would be necessitated.
 - This approach would commit NOAA/NESDIS to continuously flying magnetographs to maintain operational capabilities.
 - If this approach were not initiated rapidly, a disruption of operational services is likely.

Impacts

- Estimates of the impacts of extreme space weather can be $> \$10^{12}$.
- Present forecasting and future improvements can help to mitigate these impacts.
- If/when GONG ceases to operate and if there is no replacement of the data source:
 - Forecasting of solar wind conditions likely returns to pre-2011.
 - NOAA has invested in coronagraphs, but the model that utilizes these observations will not run.
- Future models may improve on present system; all require solar magnetic field observations.
- If ngGONG is constructed, it will provide Earth-based solar observations for 44 years.
- Proposed new capabilities of ngGONG may lead to improved models and forecasts.

Findings:

- The GONG network is a crucial resource, and is approaching its end of life. If GONG ceases operations without a replacement, an important operational capability will be lost. This will compromise the NWS's ability to forecast potentially hazardous space weather phenomena.
- ngGONG is the most obvious replacement for GONG.
- Design and construction of ngGONG will take a minimum of 8 years (probably longer). It is imperative that this begin as soon as possible, to avoid a disruption to operations.
- ngGONG was unsuccessful in obtaining NSF funding in 2021. The lack of tangible support from any operational agency was seen as an important factor in the declination.
- NSO is submitting a new proposal for the design phase to the NSF Mid-scale R-1 program in May 2023. A relatively small commitment (e.g., \$1M/year for three years) would greatly enhance the chances of success.
- If ngGONG is not constructed, the only viable alternative to continue operations would appear to be for NESDIS to fly a magnetograph on a GOES or space weather dedicated satellite, and to continue such missions into the future. Cost for this approach is unknown, but likely to be expensive. The timeline to operations for such an instrument would also be many years.

Recommendation:

- We recommend that NOAA/NWS financially support the design phase for ngGONG, to insure the initiation of the project.