GONG: A Global Ground-Based Network for Continuous Solar Observations

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ABSTRACT

The US National Science Foundation's (NSF) Global Oscillation Network Group (GONG) is a network of 6 robotic telescopes around the globe to provide continuous observations of the Sun. GONG delivers full-disk observations of Doppler measurements, line-of-sight magnetograms, white light and H-alpha images at a cadence of one minute, achieving a median duty cycle of about 0.9 (90% of a 24-hour day) for fully calibrated dataset or 0.95 for quick reduced (space weather operations) data. The data are transmitted in near-real time to NOAA/SWPC and NSO/NISP Data Centers and made available for operational space-weather forecasting and for the broader research community. GONG has been in operation since 1995.

This poster presents a high-level overview of the project and introduces its three major components: network operations, data processing, and science support. Each of these components is described in more detail in coordinated posters. We also discuss current plans for maintaining GONG operations, and its future replacement – the next-generation GONG (ngGONG).

OVERVIEW OF GONG PROJECT

- Continuously observe the Sun at 6 sites with robotic instruments; in operation since 1995
- Each station takes observations of full disk Doppler velocity, LOS magnetic field, intensity, and H-alpha image at a 1-minute cadence
- Data to NISP and SWPC DCs

Figure 1: Map showing location of GONG stations. Mauna Loa station (shown in red) is currently not operational in aftermath of a volcanic eruption.

GONG data are used for Research and SW Forecast:
Helioseismology: Plasma flows inside the Sun (dynamo, cycle prediction, far-side imaging etc)
Magnetic fields: LOS photosphere, 3D structure and evolution, flare & CME initiation, irradiance, modeling of solar wind, geomagnetic disturbances, etc

GONG OBSERVATIONS

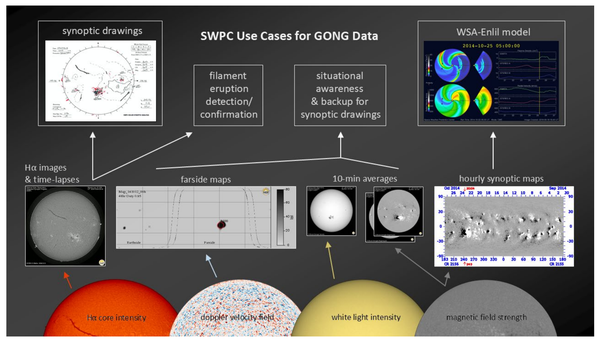


Figure 2: GONG data usage in operational space weather forecast at SWPC. Image courtesy Andrew Marble.

GONG/NISP STAKEHOLDERS

- Research community
  - A major provider of observations for helioseismology research
  - All modeling groups use GONG magnetograms.
  - Recent "explosion" of GONG data use in AI/Machine Learning
- NASA Missions
  - CCMC; PSP, other NASA missions;
- Operational space weather
  - NOAA, UK MET, South Korea (KSWC), Japan (JASDF), DoD/USSF, AirForce Data Assimilative Photospheric Flux Transport (ADAPT) model, TSI modeling
- Education and public outreach
  - NISP blog - https://gongnisp.blogspot.com/ (> 15K visits)
  - EPO activity: REU students, collaboration with CINE/CU, CU Library (DOI)

GONG DUTY CYCLE

Figure 3: The GONG duty cycle averaged over 36 days using merged network datasets from both fully-calibrated and quick-reduced data. The horizontal green dashed line indicates the mean duty cycle for fully-calibrated data, while the dotted orange line denotes the mean for quick-reduced data. The impact of the GONG/ML site shutdown due to the volcanic eruption at the end of 2022 can be seen as a decrease in duty cycle. Used by permission from Jain et al (2026).

Near-real time data to all users (50% of GONG data are made public within 10 minutes)

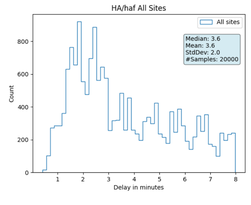


Figure 4: Delay in transfer of H-alpha data.

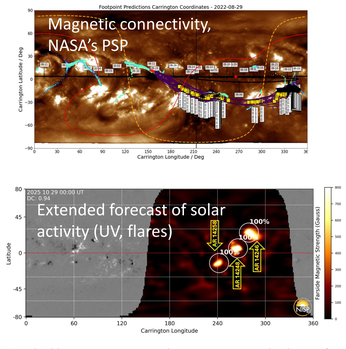


Figure 5: Modeling magnetic connectivity for PSP, (upper panel) and (lower) extended forecast of solar activity (UV, flares).

GONG ACHIEVEMENTS

GONG science contributions include 6400+published papers, 105K+ citations, H-index=130

GONG major discoveries
- Resolved interface between convective envelope and radiative core (tachocline)
- Discovered differential rotation in the convection zone and along radii (not on cylinders)
- Pioneered far-side imaging
- Identified high-frequency retrograde solar vorticity waves

GONG data immediately public

GONG provides crucial support for operational space weather forecasting (NOAA/SWPC, DoD/USAF 575th Weather Wing, UK Met Office, Japan's Space Weather Forecast Center)

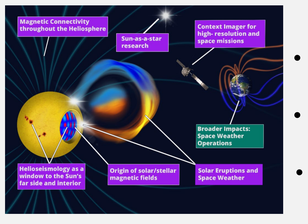
GONG designated by NOAA as National Critical Infrastructure - a key component of national security

MAJOR GONG PROJECT COMPONENTS

- GONG network operations (see Poster #41)
- GONG data processing (see Poster # 43)
- GONG science support (see Poster # 42)

GONG FUTURE

- GONG operational lifetime extension (+10 years)
  - replacing several critical subsystems
  - Regular replacing of aging systems: HVAC, computers, cameras etc.
- Design and build next generation GONG (Pevtsov et al 2024).



- vector magnetic fields and Doppler velocities in the photosphere and chromosphere,
- photospheric Doppler velocity measurements for helioseismology and far-side imaging
- rapid imaging of solar disk in different spectral wavelengths
- Sun-as-a-star observations
- (optional) coronal white light and spectropolarimetric observations
- Full disk, high cadence (60 second), near simultaneous observations, >90% duty cycle (network), near-real time data for operational space weather, robotic instruments, continuous operations for ~2 solar magnetic cycles (45+ years)

References:
1. Jain, K., Harvey, J.W., Hill, F., Komm, R.W., Leibacher, J.W., Petrie, G.J.D., Pevtsov. A.A. and Tripathy, S.C.: 2026, "**Three Decades of Global Oscillation Network Group (GONG): From Helioseismology to Magnetic Field and Space Weather (Invited Review)**", Solar Phys., **301**, article number 50, DOI: 10.1007/s11207-026-02639-9
2. Pevtsov, Alexei, A. Pillet, V.M., Warner, M., Gosain, S. and Bertello, L.:2024, "**ngGONG: future ground-based facilities for research in heliophysics and space weather operational forecast**", Proc. SPIE 13096, Ground-based and Airborne Instrumentation for Astronomy X, edited by Julia J. Bryant, Kentaro Motohara, Joël R. D. Vernet, Vol. **13096**, 1309618 (18 July 2024); DOI: 10.1117/12.3019489

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