

Next Generation GONG (ngGONG)

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Heliospheric microphysics in context

Working together to study the Sun

SOLAR ORBITER
Space-based: Remote sensing of photons and in-situ particles and fields
Orbit: Will fly within 0.28 AU of the Sun.
Out of the ecliptic orbits inclined by 30 degrees
The ESA/NASA Solar Orbiter will examine how the Sun creates the vast bubble of charged particles blown by the solar wind into the interstellar medium, known as the heliosphere.

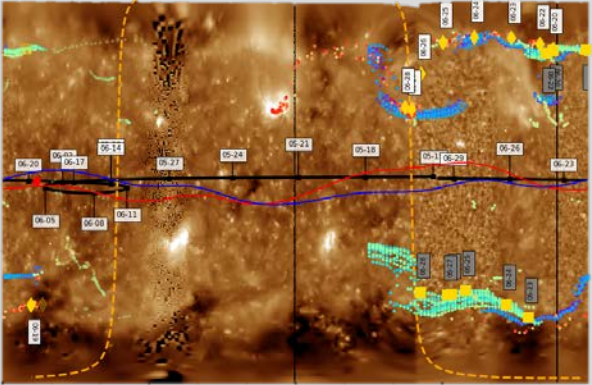
PARKER SOLAR PROBE
Space-based: In-situ particles and fields
Orbit: Will fly within .04 AU of the Sun
NASA's Parker Solar Probe will provide a statistical survey of the Sun's outer corona, tracing the flow of energy and exploring what accelerates and heats the solar wind.

DKI SOLAR TELESCOPE
Earth-based: Remote sensing of photons
Orbit: 1 AU
The NSF's Daniel K. Inouye Solar Telescope, the world's largest solar telescope, indirectly measures the magnetic fields to create maps of the corona and better understand how and why the corona heats up so dramatically.

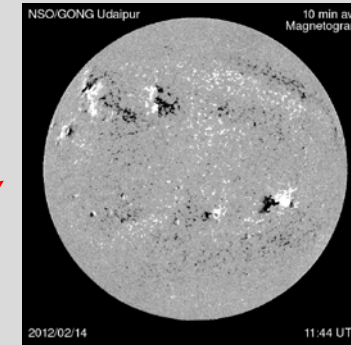
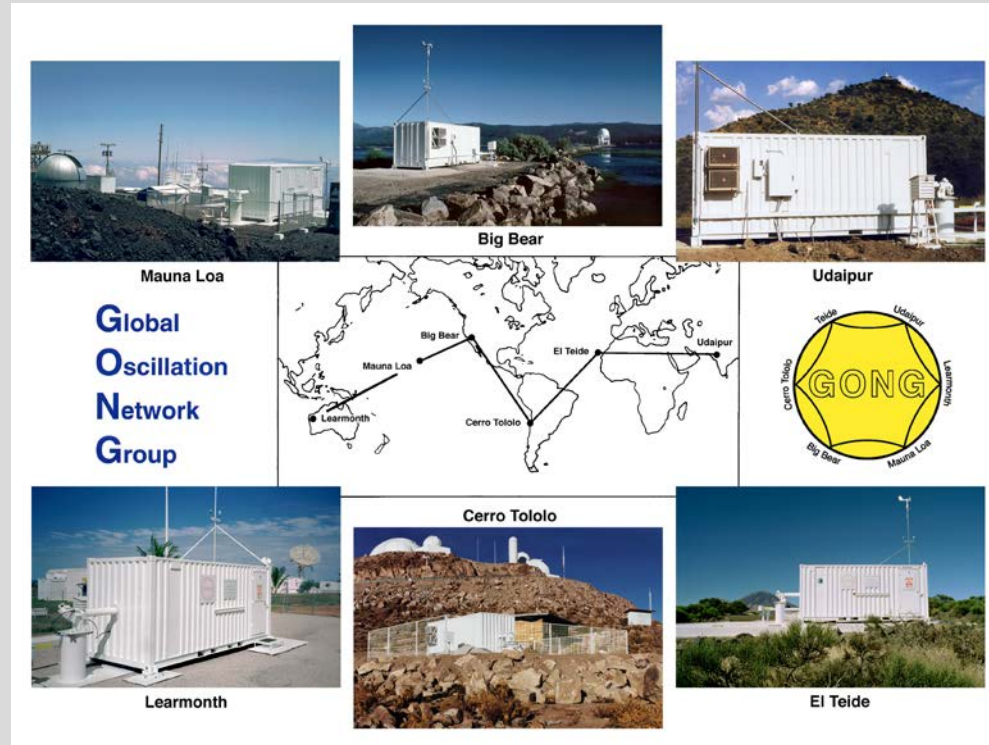




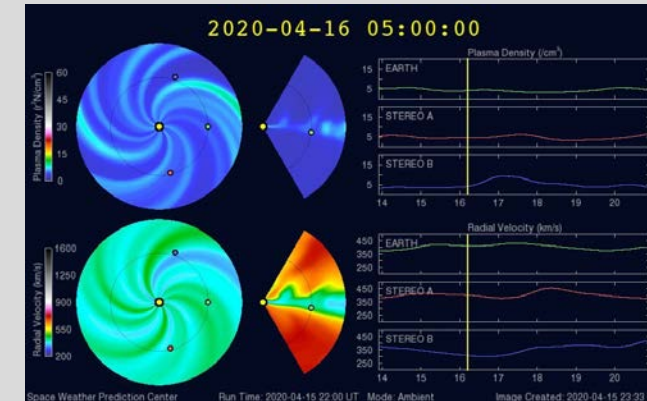
Multimessenger solar & heliospheric astronomy



GONG today



Magnetograph from NSO's



Space Weather Prediction from NOAA

- GONG 6 sites network to monitor the Sun all the time (91% duty cycle)
- Started in 1995 to measure solar oscillations (unrelated to Space Weather)
- Modified for magnetic field measurements (Space Weather) in 2006
- Not designed with Space Weather in mind (**polar fields**)



GONG today



- Operations **funded** by NOAA (\$1M/year).
- Interagency agreement with the NSF (exp. 2021)
- Used by the Air Force Weather Service
- Used by NASA's Virtual Solar Observatory
- UK Met office, and international partners
- NOAA considers GONG an essential facility
- Two (TF & UD) stations down during lockdown



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
National Centers for Environmental Prediction
Space Weather Prediction Center
325 Broadway W/NP9
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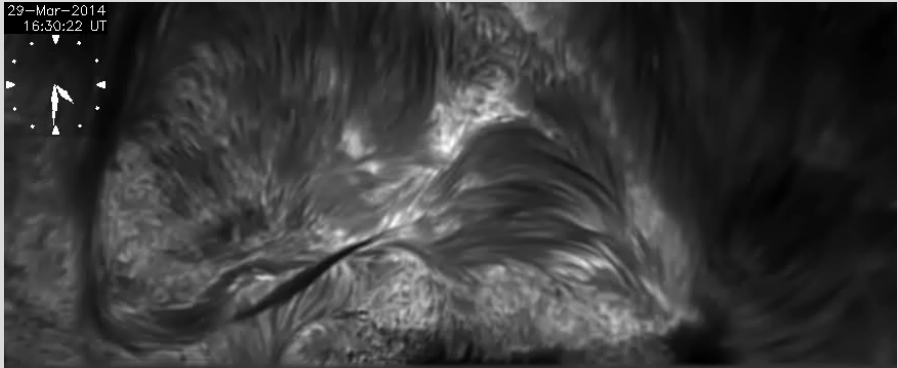
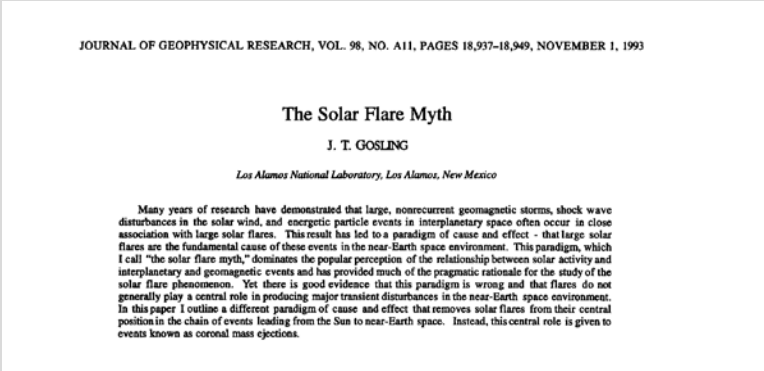
22 January 2018

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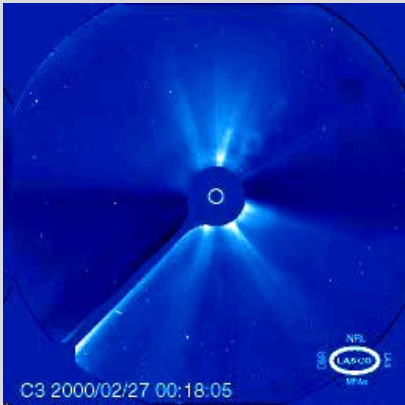
Dear Dr. Pillet:

During the current federal government shutdown, the Space Weather Prediction Center (SWPC) is continuing to function uninterrupted in its role of providing the Nation's official space weather alerts and warnings. One of the most important SWPC responsibilities involves the prediction of geomagnetic storms which are well-recognized to present a serious threat to the infrastructure of this Nation and the world. SWPC currently relies on the Wang-Sheeley-Argge (WSA)-ENLIL model in the prediction of this phenomenon. The data from the National Solar Observatory's Global Oscillation Network Group (GONG) are critical to the proper initialization of the WSA-ENLIL model, and in fact, the model cannot currently be initialized and run in the absence of these input data.

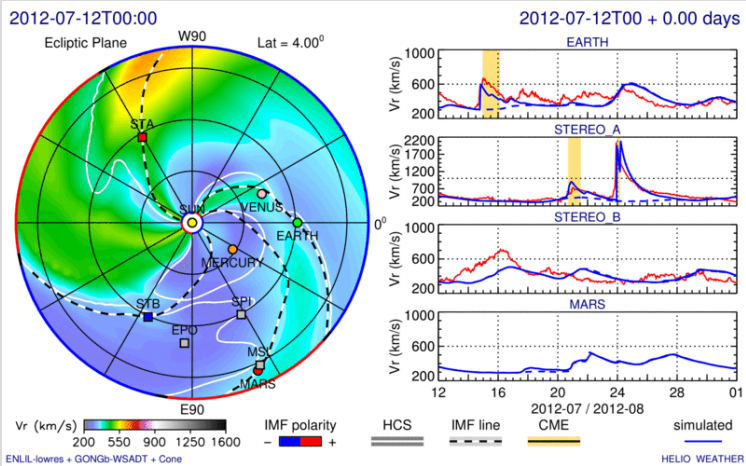
What are we missing?



'The Solar Flare Myth' by Gosling published in 1993

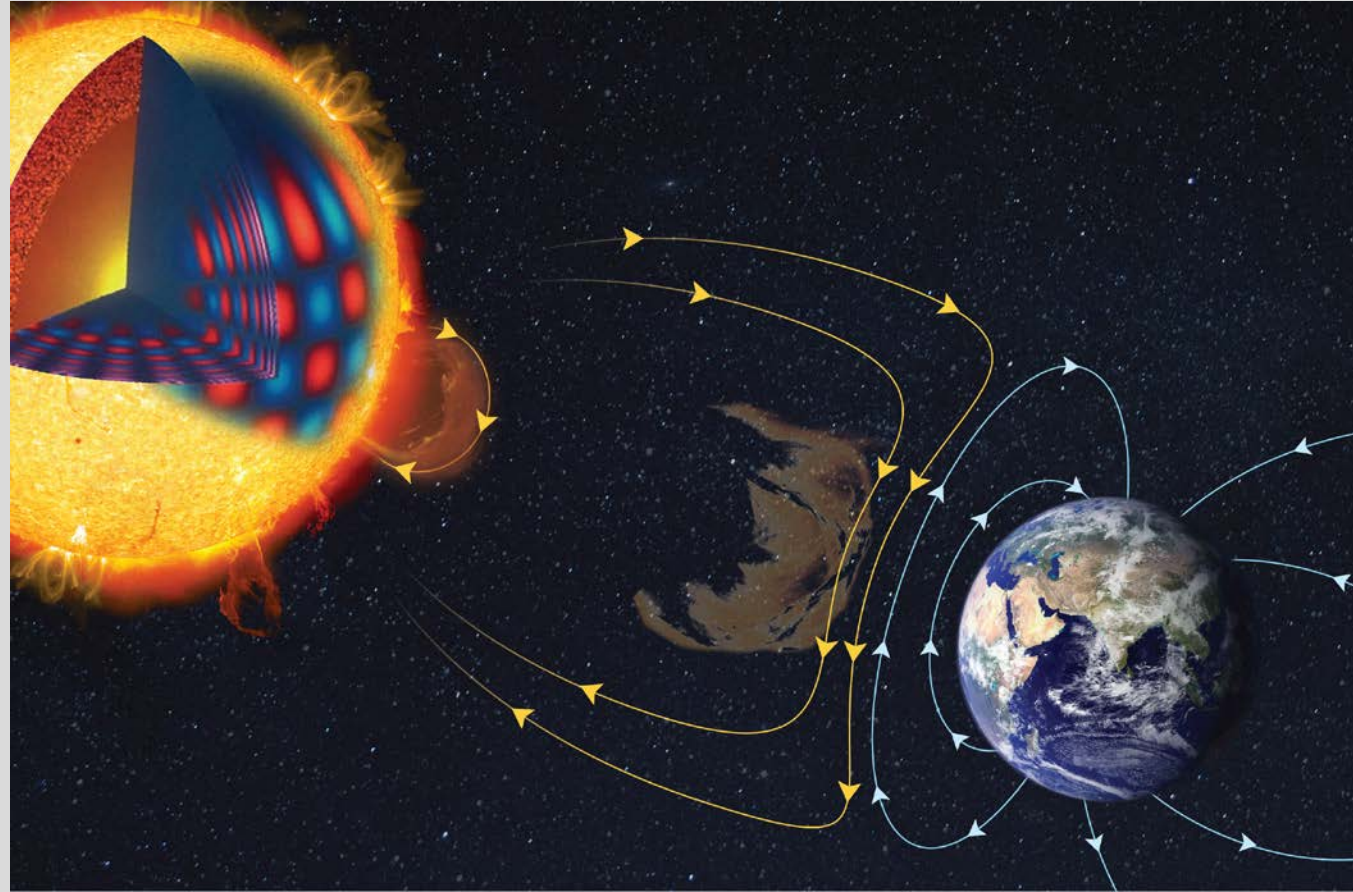


SOHO/LASCO



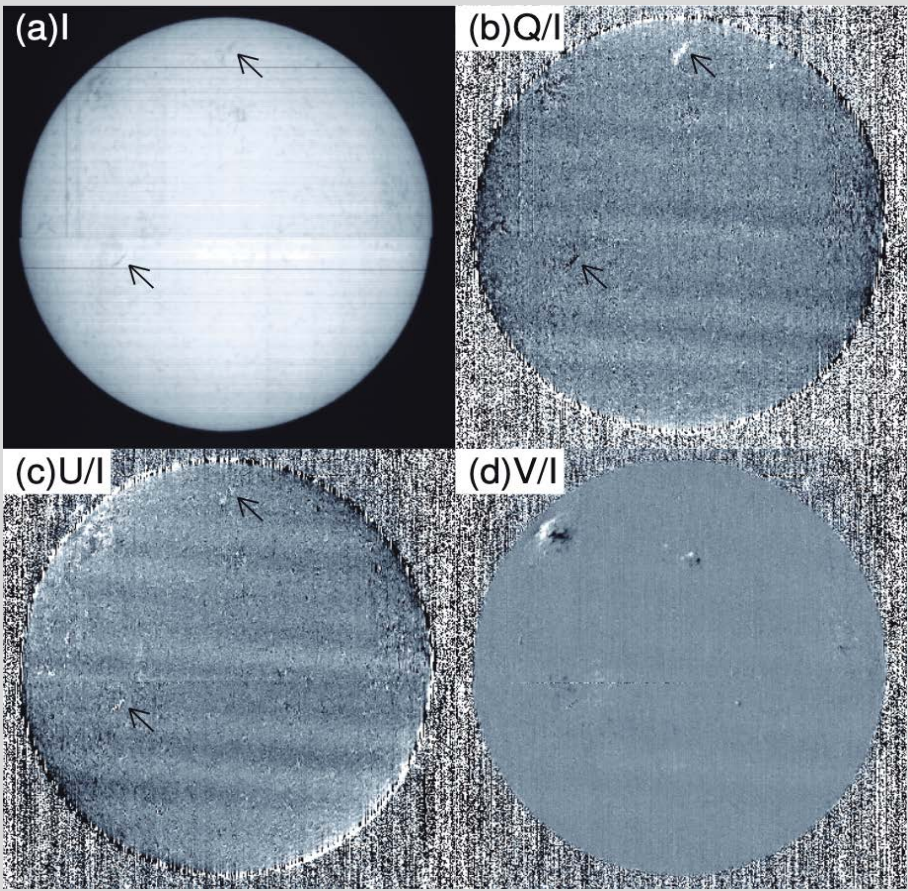
Despite all this monitoring and modeling, we currently cannot predict the orientation of the magnetic field of the coronal mass ejections (CMEs) when they arrive Earth: **the Bz problem**

What are we missing? The B_z problem

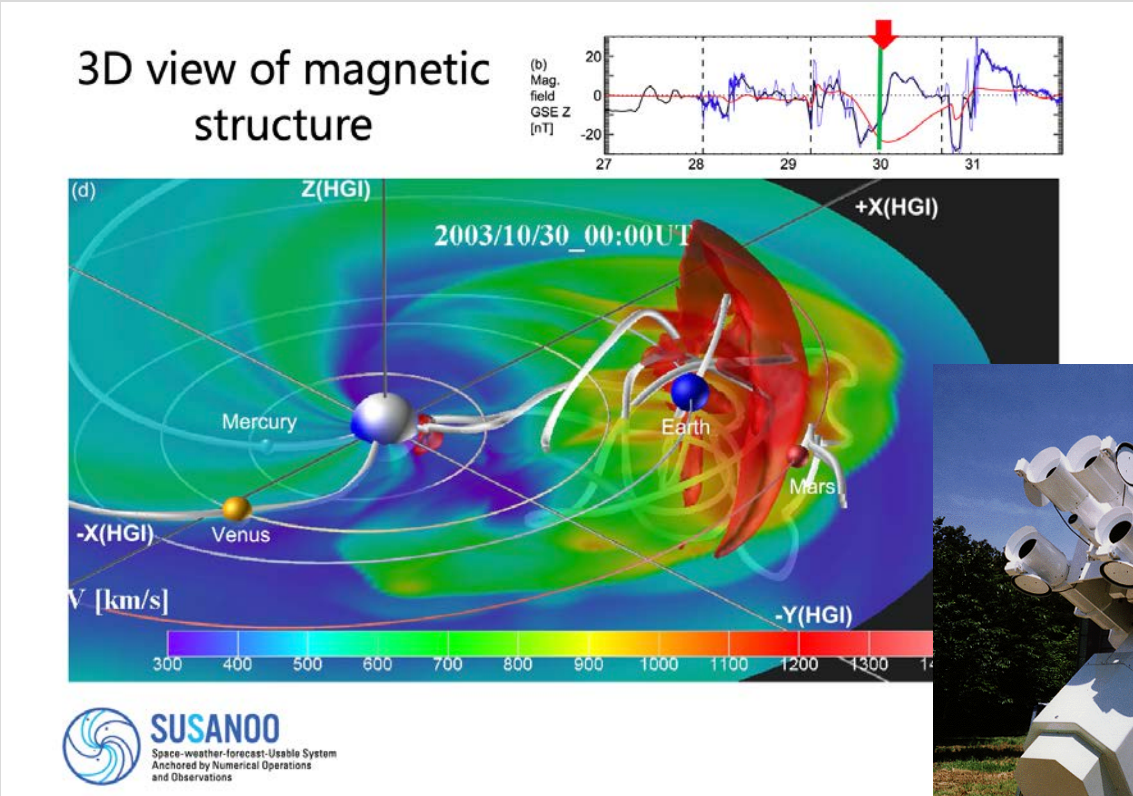


A ground-based network that includes Space Weather needs from its inception: ngGONG

Japan single-site synoptic program



Sakurai et al., 2018
Hanaoka et al., 2020

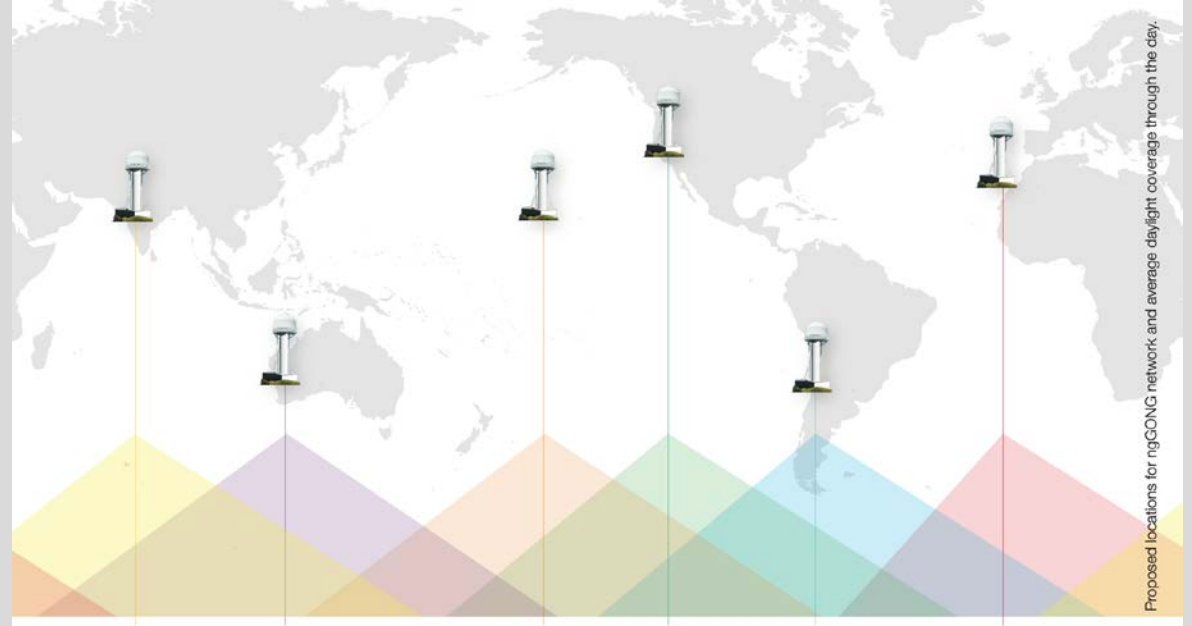


SUSANOO-CME (Shiota, 2016)



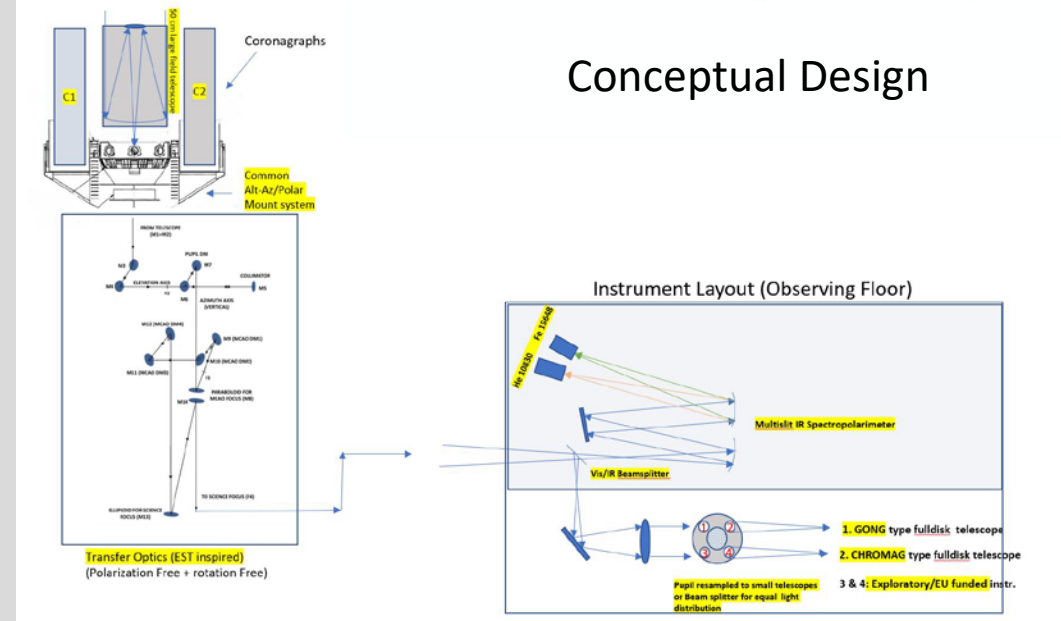


ngGONG Definition



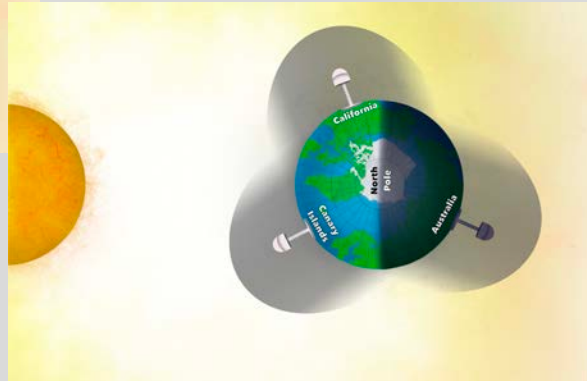
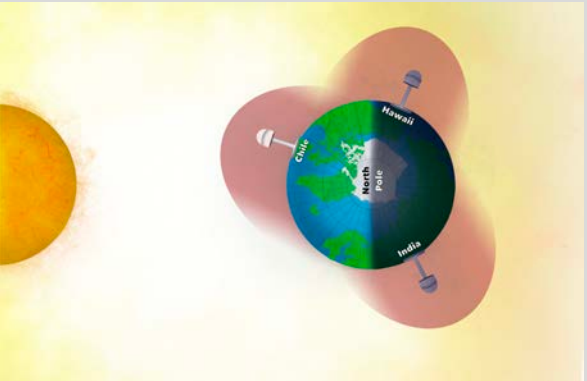
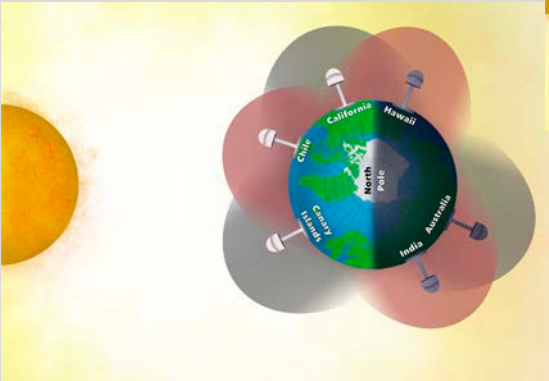
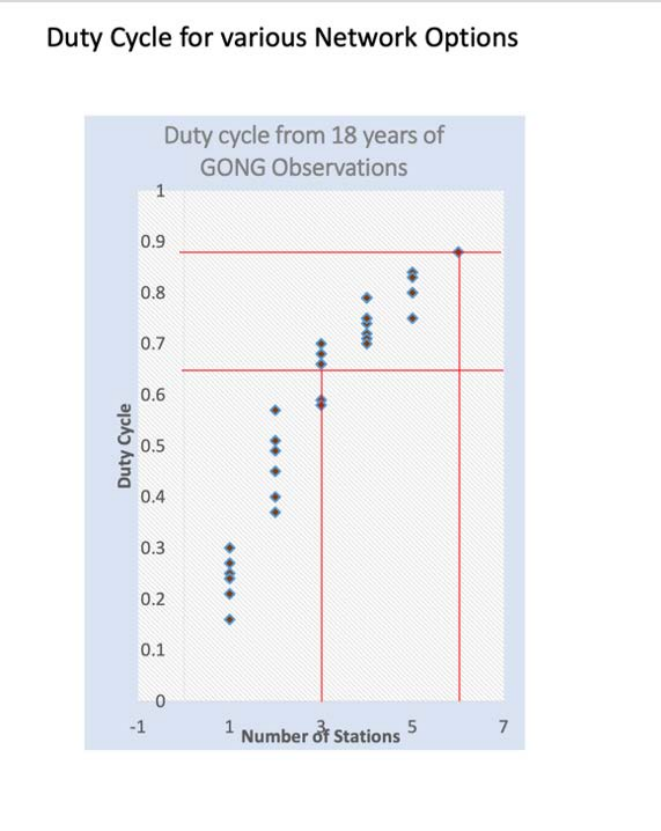
- ngGONG includes Space Weather considerations and requirements
- Provides the initial conditions to propagate **magnetic** CMEs & halo CMEs (from the ground)
- 24/7 boundary data for models that predict solar-wind & B_z . Requires bigger telescopes (**50 cm**)
- Requires constant, homogeneous image quality similar to space (**GLAO**). High transparency skies.
- Continues decades long observation of the solar interior & **far-side**
- Builds on **GONG** success: identical stations, autonomous operations

ngGONG Status



- **AFRL** contacted HAO & NSO for a next generation solar synoptic network
- Including **coronagraphs** (SOHO/LASCO). Prototype TBC.
- Concept proposed by HAO & NSO to AFRL sent to NSF (**AFRL requirements**)
- Site characterization effort (HAO-led, high transparency skies)
- AFRL & NOAA/SWPC have sent **operational** requirements to the NSF for ground based
- NSO & HAO finalizing **research** requirements (imminent)

ngGONG 6-site vs 3-site duty cycle



6 sites network provides 90% duty cycle, 3 sites network 60-70%
(Jain et al. 2020)



ngGONG Status

- ngGONG could (**must**) replace GONG this decade
- Focused on and designed for Space Weather **research & operations**
- Requirements definition has included the research and SW forecasting communities: R2O & O2R (far-side helioseismology)
- Which requirements are driven by operational constraints vs. research ones
- Ground-based vs. space solar synoptic observations can be **cost-effective**
- Ground based networks can be upgraded and repaired
- Limitations due to the Earth's atmosphere (UV, turbulence, transparency)
- They provide L1-LOS view (we need 4π)

What to operationalize from the ground vs space for SW forecasting over the next decades?