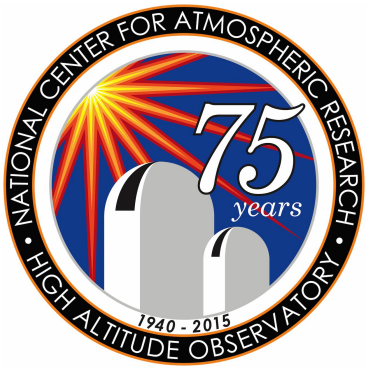


Soaring Beyond 2020

NCAR High Altitude Observatory Strategic Implementation Plan 2016–2021

This Implementation Plan has been developed In parallel with our 2016–2021 Strategic Plan "2020: Connecting Our Star and Our Home." This document outlines the steps required to ensure the maximum return on that strategy. A return that has benefits beyond HAO, into the NCAR community and the worldwide solar-terrestrial physics community.

As it stands, this implementation plan exploits the three historical bases of HAO science in solar spectropolarimetry, solar interior dynamics, and terrestrial upper atmospheric physics to attack scientific problems at the crucial boundaries of the Sun-Earth connection. In addressing these problems, established in the strategic challenges and goals of the Strategic Plan, we will build observational and modeling capability that will actively involve the worldwide solar-terrestrial physics community.

HAO's staff will be challenged to participate in strategic working groups (SWGs) focused on tackling specific problems and developing instruments, models, and analysis techniques to pursue the goals of the strategic plan. The SWGs will form the scientific operating structure for the Laboratory and the basis for our budgetary planning. It is hoped that the SWGs will engage all staff in pushing HAO and community science forward in addition to forming a concentrator for larger team proposal efforts. The function of the SWGs is described below. Membership of these working groups *will not be limited to HAO staff and visitors; we will actively seek participation from our NCAR partners and from the broader community*. In the case of the latter, we will use our visitor program to augment the working groups as needed, based on priority.

The limited nature of HAO's base budget requires considerable flexibility on the part of HAO's staff and visitors when participating in these working groups. *Not all working group activities will obtain substantial levels of base funding at the outset.* As a result, staff and visitors should use best judgement when joining working groups to make sure that the efforts committed to the working groups are aligned with their funding profile. They should also bear in mind that the activities being undertaken are to *build scientific*

capability that benefits the entire laboratory and the broader community—it is anticipated that said (the specific) research (objective) will increase the likelihood of attracting external funding that is clearly aligned with the HAO priorities in the future.

Below, we will outline the basis for operational structure, how we will report on progress on the strategic plan, how we will employ our visitor and post-doc programs to support our strategic vision, and lay out the structure and expectations of our advisory committees to provide oversight and governance over our activities. Following this text we will outline the SWGs and their objectives over the five years covered by the strategic plan.

HAO's Strategic Challenges

- Identify the processes responsible for the origin and the evolution of solar magnetism.
- Quantify the signatures of magnetism and the role of magnetic energy in the production of solar activity throughout the solar atmosphere with a view to building a comprehensive understanding of solar atmospheric coupling and solar wind formation.
- Explore the relationship between the solar plasma and magnetism that result in the measured distributions of electromagnetic radiation.
- Determine the range of impact that solar variability can have on the coupled terrestrial atmosphere and the geospace environment.
- Explore the interactions between neutrals and ionized plasmas in the extended geospace environment.

HAO's Strategic Goals

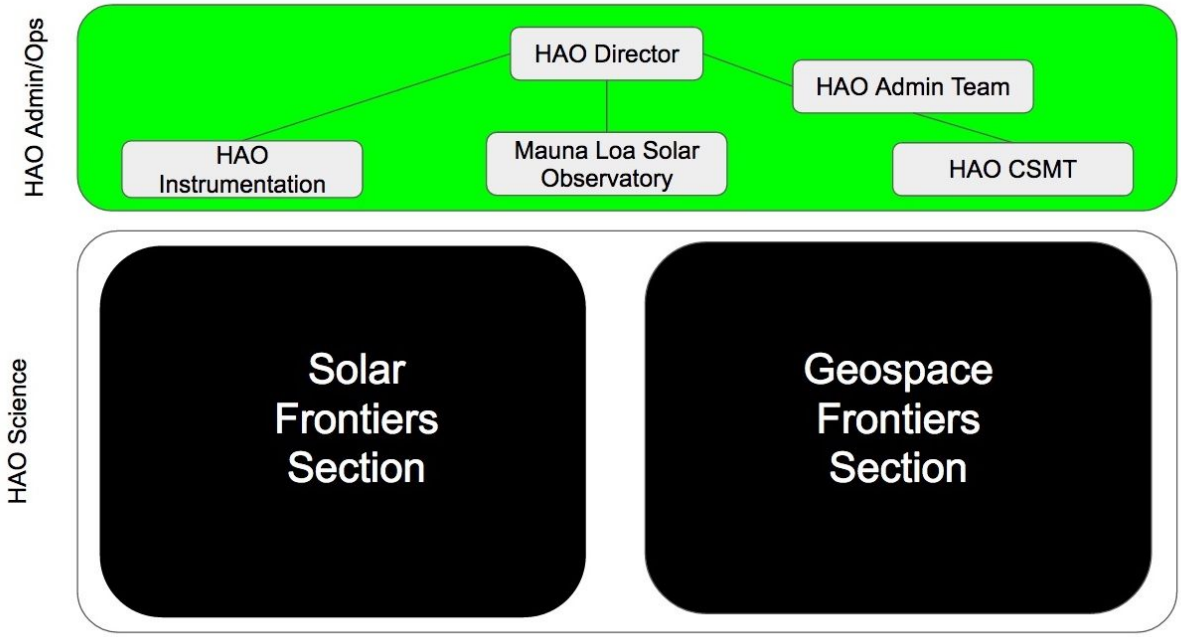
1. Solve critical problems of solar-terrestrial physics in collaboration with the broader community by providing support and a focus for fundamental research to advance knowledge of the coupled Sun-Earth system.
2. Develop capability to improve forecasting and attribution for the coupled Sun-Earth system in collaboration with, and for ultimate transfer to, the operational community by characterizing the physical state and isolating essential processes using observations, models and data assimilation to improve forecasting of space weather and climate hazards.
3. Develop, deploy, and maintain state-of-the-art observational facilities and science data services in support of the Geospace and Solar Physics communities through both internal programs and external collaborations to

provide solid observational and interpretational bases for the understanding of the coupled Sun-Earth system.

4. Develop and support advanced models of the coupled Sun-Earth system in collaboration with and in service to the solar-terrestrial physics community through community development of innovative numerical methods and open-access algorithms to provide tools for understanding the components and connections of the Sun-Earth system.

5. Identify, develop, and transfer critical knowledge of the coupled Sun-Earth system for the benefit for society by advocacy and communication to convey the excitement and relevance of heliophysics.

6. Educate and mentor a diverse and talented next generation of scientists in the disciplines of solar-terrestrial physics through undergraduate, graduate, and post-doctoral programs for the vitality of the broader solar-terrestrial physics community.

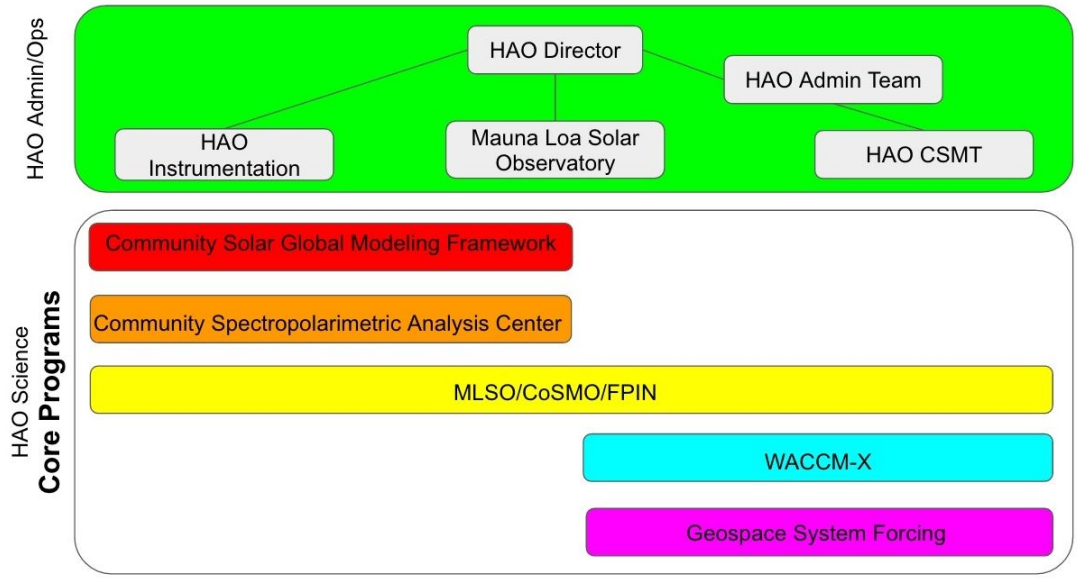


Operational Structure

As part of this implementation plan we will support two administrative sections on solar and geospace *frontier* science. These scientific sections will operate as “home rooms,” designed to coordinate administrative needs and facilitate broad discussion.

In addition to the two administrative sections, we identify HAO’s core programs as key activities for the Lab, and the NCAR- and Community-wide SWGs focussed around our long-term strategic challenges. These groups will give us the ability to focus effort and integrate an attack on broader, often cross-disciplinary, scientific issues that impact the

community and have the potential to push the entire discipline forward. HAO staff members will be expected to participate in one of these SWGs, but can opt to participate in more as they see fit. Those groups and the expectation placed on those groups will be discussed below.



HAO's Core Programs

HAO's core programs are the focal points of our program in terms of community interaction. They are the projects through which primarily "facility" interfaces with the community. The scientific advance of these core programs is fed through the research of the SWGs. Each core program has two co-leads who guide the effort and communicate progress to the HAO Director.

WACCM-X Group
[Leaders: Stan Solomon & Dan Marsh]
FY16 saw a constituted effort to push WACCM-X forward, exploiting years of heritage developed through the TIE*GCM and other associated modeling efforts in the AIM section. With the upcoming release of WACCM-X in CESM 2.0 we are continuing our commitment to developing the world's finest [extra] high-top coupled atmosphere model as a means to explore the short- and long-term evolution of the thermosphere-ionosphere system and their connection to the plasmasphere and magnetosphere. The Geospace Frontiers Section will be in a position to exploit WACCM-X in conjunction with the observations from ICON, GOLD, and COSMIC-II to demonstrate the power of the coupled model's ability to prove top-down and bottom-up forcing on the Earth's upper atmosphere.

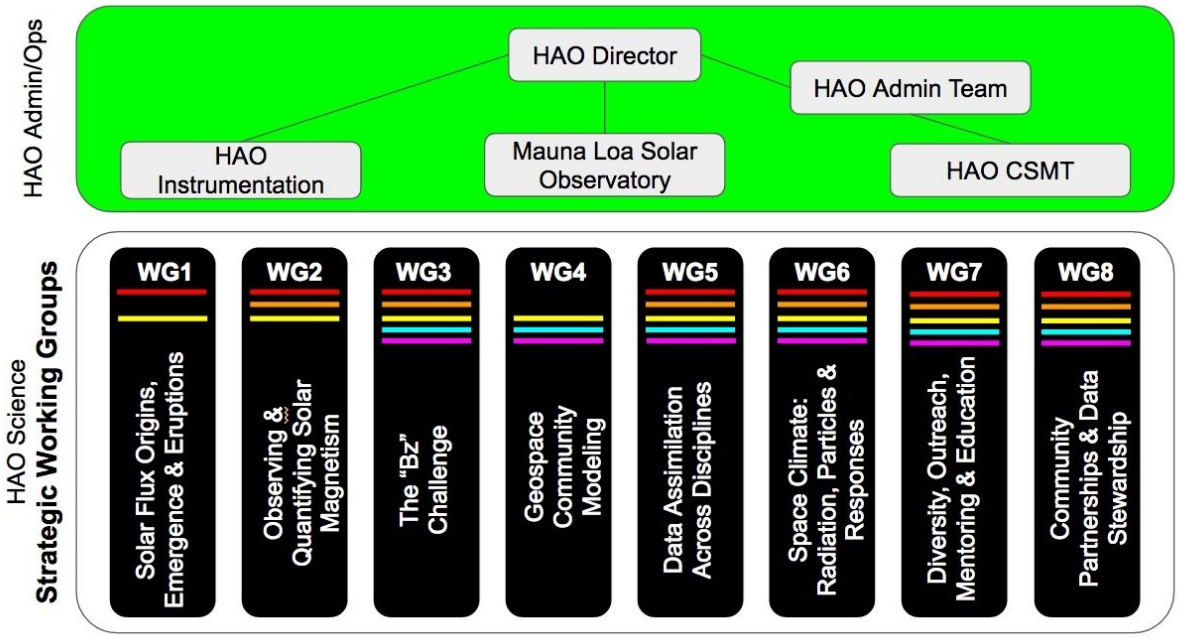
Observation, the MLSO/CoSMO/FPIN, Group
[Leaders: Steve Tomczyk & Sarah Gibson]
Delivery of the Coronal and Solar Magnetism Observatory (CoSMO) is this core program's highest priority. While CoSMO is not, at the time of writing, funded for construction, it is imperative that HAO staff strengthen ties to the potential CoSMO user community (through the development of extended science use cases and data modeling/interpretation workshops) to demonstrate utility of the observatory for breakthrough science and improvement of operational space weather forecasting. To that end, this program will leverage existing observations at MLSO to include KCor and CoMP [plus UCoMP and ChroMag in FY17] to cement the case for CoSMO and demonstrate its utility in fundamental synoptic science and capability for significantly advancing our understanding of space weather processes. In addition to CoSMO and MLSO, this program houses the network of Fabry-Perot interferometers distributed across the globe. We need to concentrate the data from these instruments and provide access to it where possible.

CSAC Group
[Leaders: Phil Judge & Rebecca Centeno-Elliott]
Initialized as an NCAR Strategic Initiative in 2007, the Community Spectropolarimetric Analysis Center (CSAC) was conceived with a mission to mainstream the analysis and interpretation of spectro-polarimetric measurements of the solar photosphere. The dawn of NSO/DKIST (and CoSMO) is creating a growing number of spectropolarimetric investigations that thread the solar atmosphere, pushing into the chromosphere and extending capabilities of instruments like CoMP in the corona. There is a growing need in the community to provide access to these data and provide interpretative tools to manipulate them. This is no easy task, but HAO is committed to supporting the users of polarimetric instrumentation of MLSO, CoSMO, and the DKIST/ViSP, through the CSAC Group. The CSAC group should exploit their expertise to develop a portfolio beyond HAO's own instrumentation packages.

Community Solar Global Modeling Framework
[Leaders: Mark Miesch & Mausumi Dikpati]
In early 2015 HAO's researchers specializing in the solar interior were tasked with conceiving a plan to start the development of a community modeling framework for the global solar interior. This effort would intimately blend observational and modeling insights. It would build upon, and coalesce HAO's expertise, in solar interior modeling from the deep convective interior through to the near-surface layers, include data assimilation methodologies, and leverage NCAR's existing infrastructure to reach the scientific goals we have set for ourselves.

Geospace System Forcing
[Leaders: Mike Wiltberger & Wenbin Wang]
With the ongoing development of WACCM-X and the lessons learned from the fusion of the LFM magnetospheric model with the TIE-GCM in the Coupled Magnetosphere-Ionosphere-Thermosphere (CMIT) model, we will begin to develop the next-generation whole geospace modeling framework to comprehensively study the forcing of geospace inward from the Sun and outward from the Earth's troposphere as well as the interaction between the regions in the coupled system. This program will exploit NCAR's existing infrastructure in coupled earth system modeling, computational science, and data assimilation to reach the scientific goals set.

HAO's Strategic Working Groups (SWGs)



SWGs will develop around the strategic challenges stated above and will be focused on tackling tough, fundamental physical problems with a desire that outcomes help build capability across the geospace discipline. The SWGs will drive Core Program efforts forward, establish their own charter and membership, *including members of the broader community*, with internal leadership appointed by the HAO Director. The colorized diagram above indicates the potential mapping between the Core Programs and the SWGs.

SWGs will hold frequent meetings, engage broader community input through the development of a grand-challenge workshop series, and specifically purpose use of visitor funds, post-doctoral, and affiliate scientist positions within HAO. SWG leads will provide overarching project management, develop web content around their activities, provide input into group members year-end reviews, and be responsible for reporting activities around the effort.

The set of HAO SWGs will comprise:

"Solar Flux Origins, Emergence & Eruptions" – A group dedicated to understanding the formation and eruption of solar magnetism and how it shapes the heliosphere and its energetics. **Leaders:** **Yuhong Fan, Matthias Rempel**

"Observing & Quantifying Solar Magnetism" – A group dedicated to the measurement and understanding of magnetism throughout the solar atmosphere. **Leaders:** **Roberto Casini, Philip Judge**

"The 'Bz' Challenge" – A group dedicated to the understanding of the coupled Geospace environment from the Sun to the Stratosphere. **Leaders:** **Sarah Gibson, Michael Wiltberger**

"Geospace Community Modeling" – A group dedicated to the development and maintenance of HAO's leadership and heritage in community geospace modeling activities. **Leaders:** **Gang Lu, Hanli Liu**

"Data Assimilation Across Disciplines" – A group dedicated to the development and utilization of best practices in data assimilation for the betterment of understanding that (ultimately) leads to better forecast skill across the geospace discipline. **Leaders:** **Nick Pedatella, Mausumi Dikpati**

"Space Climate: Radiation, Particles & Responses" – A group dedicated to the climatology of the geospace environment and understanding drivers and responses of the coupled Sun-Earth system. It is anticipated that this SWG seeks active involvement from the worldwide solar-terrestrial physics community. **Leaders:** **Stan Solomon, Giuliana de Toma**

"Diversity, Outreach, Mentoring & Education" (DOME) – A group to develop and maintain a framework for ensuring a coordinated and meaningful community outreach effort across K-12, undergraduate, graduate, and the general public across the SWGs. **Leaders:** **Mark Miesch, Scott Sewell, Astrid Maute**

“Community Partnerships & Data Stewardship” (PDS) – A group charged with understanding who our community is, understanding community needs, ensuring effective interface to the community, and acting as a conduit to staff groups to implement tools and products as appropriate. This team is charged with overseeing HAO’s data products, simulation output, website content (macro-level),user databases, metrics, etc. This group will be charged with developing a framework for one data interface, maintaining it, and cultivating a comprehensive list of HAO’s community worldwide. **Leaders: Rebecca Centeno Elliott, Mike Galloy**

Visitor Program

It is desired that HAO’s staff think strategically about the use of our visitor program to leverage the range of visits possible, from days to weeks and months, to help their working groups and/or Core Programs reach the scientific and technical goals set.

Post-Doctoral Program

It is desired that HAO’s staff think strategically about the use of our graduate and post-doctoral researcher programs to help their working groups and/or Core Programs reach the scientific goals set. For the most part we have typically brought the academically strongest candidates into HAO, but in the period while we are working to grow our base support and scientific strength we should be balancing strategic need with academic strength equally.

Reporting Outcomes

Section Heads, leaders of HAO’s Core Programs, and the SWGs will assist HAO senior leadership in the development of necessary reporting on scientific activities in the Laboratory.

Advisory Committees

Internal

HAO Appointments Committee (AC) – To advise the HAO Director on personnel matters, scientific appointments, and promotions.

Director’s Strategic Advisory Committee (DSAC) – To advise the HAO DIrector on strategic matters affecting the Laboratory. The Appointments Committee is a standing sub-committee of the DSAC.

HAO Instrumentation Advisory Committee (HIAC) – To advise the HAO Director on the priorities of HAO's Instrumentation program and provide scheduling and strategic oversight of the Instrumentation Group (IG) and Mauna Loa Solar Observatory (MLSO).

External

External Advisory Committee (EAC) – The EAC is charged with monitoring the progress of HAO's strategic programs and priorities, providing feedback on the direction of the work taken with respect to the broader community.

MLSO/COSMO Advisory Committee (MAC) – The MAC is charged with monitoring progress of HAO's function in Hawaii, including the day-to-day operations, oversight of campaigns, and data products delivered to the community.

CSAC Advisory Committee (CAC) – The CAC is charged with the oversight of CSAC, consulting on prioritization of diagnostic developments, analysis methods, and tools.

WACCM-X Advisory Committee (WAC) – The WAC is charged with the oversight of WACCM-X development.