

National Aeronautics and
Space Administration



Heliophysics Space Weather

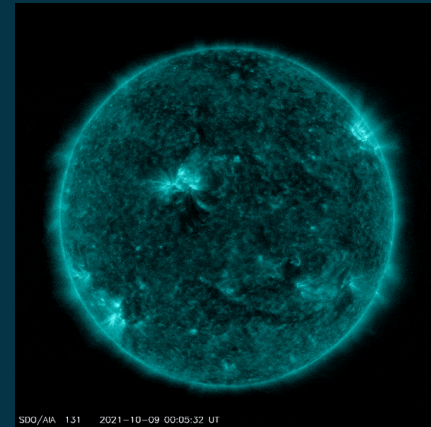
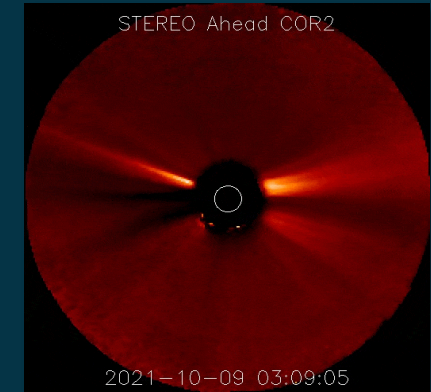
NASEM Weather Workshop Phase II

Dr. James Spann
Space Weather Lead
NASA Heliophysics Division
April 11, 2022

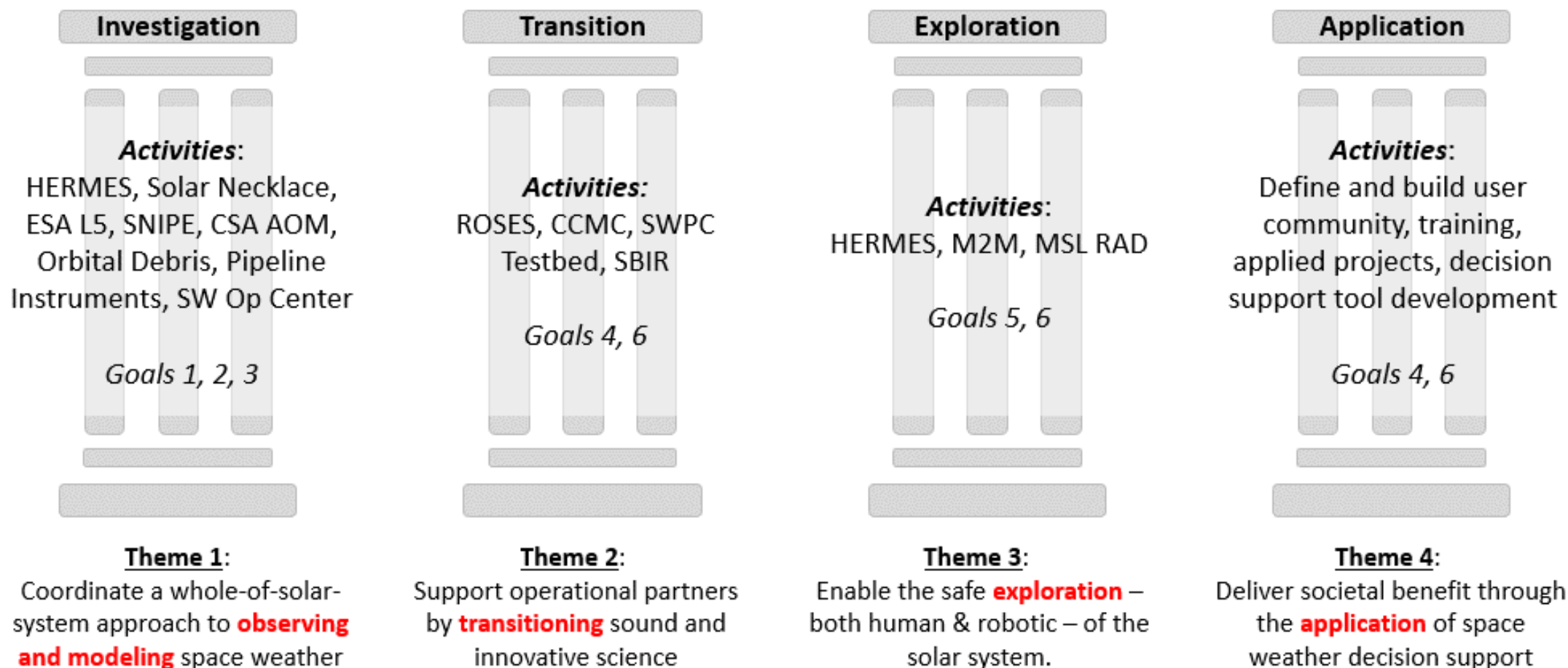
NASA Space Weather Program

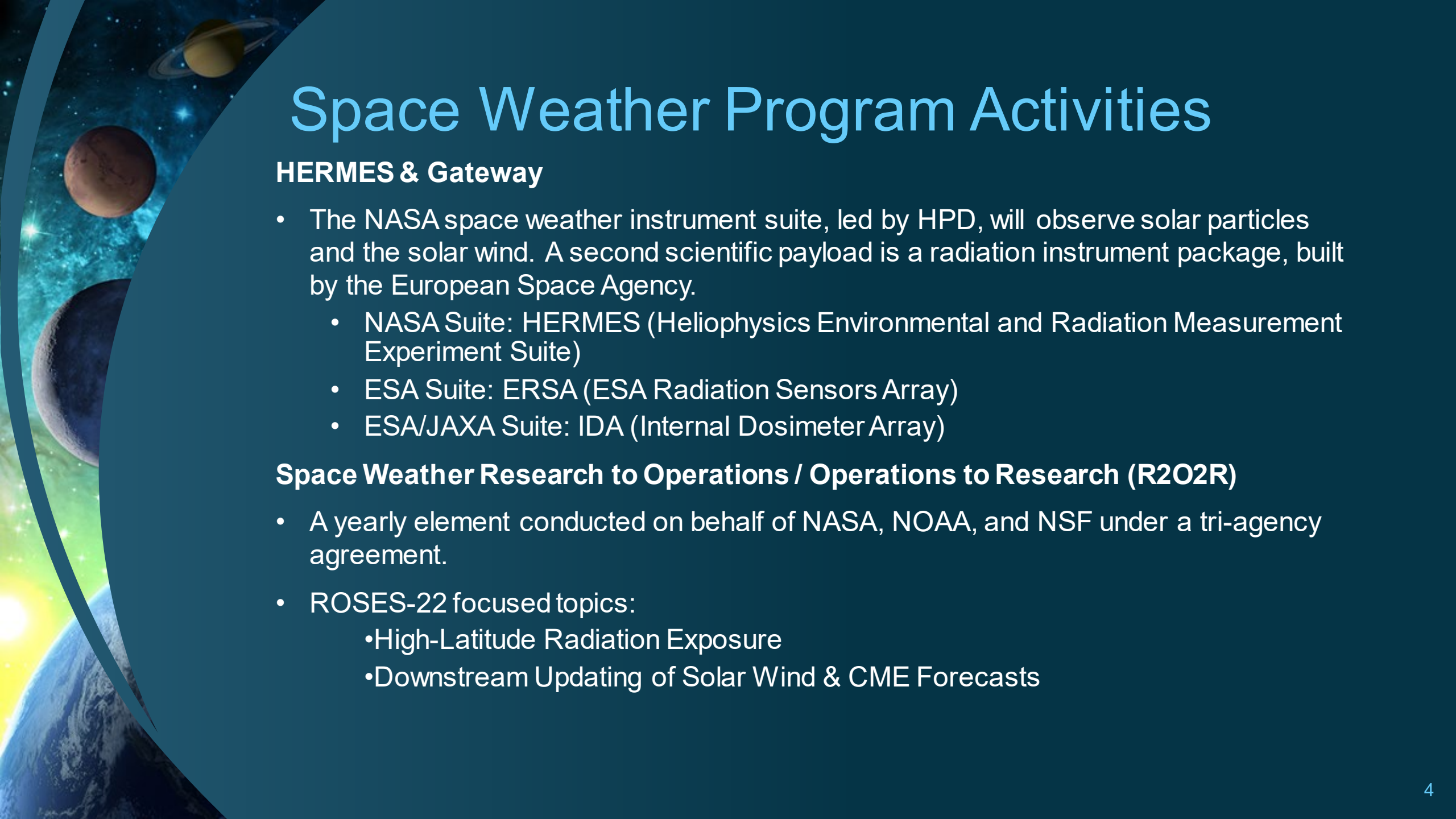
Space Weather Program Goal: Advance the science of space weather to empower a technological society safely thriving on Earth and expanding into space.

- NASA plays a vital role in space weather research by providing unique, significant, and exploratory observations and data streams for theory, modeling, and data analysis research, and for operations. SMD/HPD is uniquely poised to support needs of the National and International space weather enterprise and the Agency's Artemis mission.
- Various executive (NSW SAP) and legislative (PROSWIFT Act) mandates direct NASA to address research and application aspects of space weather. Operational agencies have a mandate to fulfill their mission, but NASA has the flexibility to "push the envelope"
- Making use of these unique capabilities and directly addressing the legislative mandate, HPD has established the new NASA Space Weather Program, a national resource to unify space weather research and drive our understanding of its risks, impacts and mechanisms into new realms.



Space Weather Program Pillars



A decorative background on the left side of the slide featuring a curved view of Earth's horizon at the bottom, transitioning into a deep space scene with various celestial bodies. Visible are Saturn with its rings, Mars, and the Moon, set against a backdrop of a bright yellow sun and a starry blue and green nebula.

Space Weather Program Activities

HERMES & Gateway

- The NASA space weather instrument suite, led by HPD, will observe solar particles and the solar wind. A second scientific payload is a radiation instrument package, built by the European Space Agency.
 - NASA Suite: HERMES (Heliophysics Environmental and Radiation Measurement Experiment Suite)
 - ESA Suite: ERSA (ESA Radiation Sensors Array)
 - ESA/JAXA Suite: IDA (Internal Dosimeter Array)

Space Weather Research to Operations / Operations to Research (R2O2R)

- A yearly element conducted on behalf of NASA, NOAA, and NSF under a tri-agency agreement.
- ROSES-22 focused topics:
 - High-Latitude Radiation Exposure
 - Downstream Updating of Solar Wind & CME Forecasts

A dark blue background with a large, curved, light blue shape on the left side. The background features a collage of space-related images: a yellow planet with rings (Saturn) at the top left, a reddish planet (Mars) below it, a crescent moon, and a bright yellow sun partially visible at the bottom left. The stars are scattered throughout the dark blue space.

Space Weather Program Activities Cont.

Space Weather Centers of Excellence

- The purpose of these Centers will be to provide significant long-term investment in research and infrastructure development to address major challenges in space weather in an integrated multidisciplinary fashion, explicitly and fundamentally incorporating R20 and O2R.

Small Business Innovation and Research (SBIR)

- NASA's SBIR program seeks to transform scientific discovery into products and services through innovations that have the potential for infusion into NASA programs and missions, the potential for commercialization into NASA relevant commercial markets, and that have a societal benefit.
 - Phase II Selections: (1) Parallelization Toolkit for NASA CCMC (2325), (2) Advanced Climatology Innovations for Space Radiation Environments (3081).

Heliophysics System Observatory

- Effectively leverage current and forthcoming HPD Observatory assets to address Space Weather goals

HELIOPHYSICS SYSTEM OBSERVATORY

- 20 Operating Missions with 27 Spacecraft
- 14 Missions in Formulation or Implementation
- 1 Under Study

■ FORMULATION

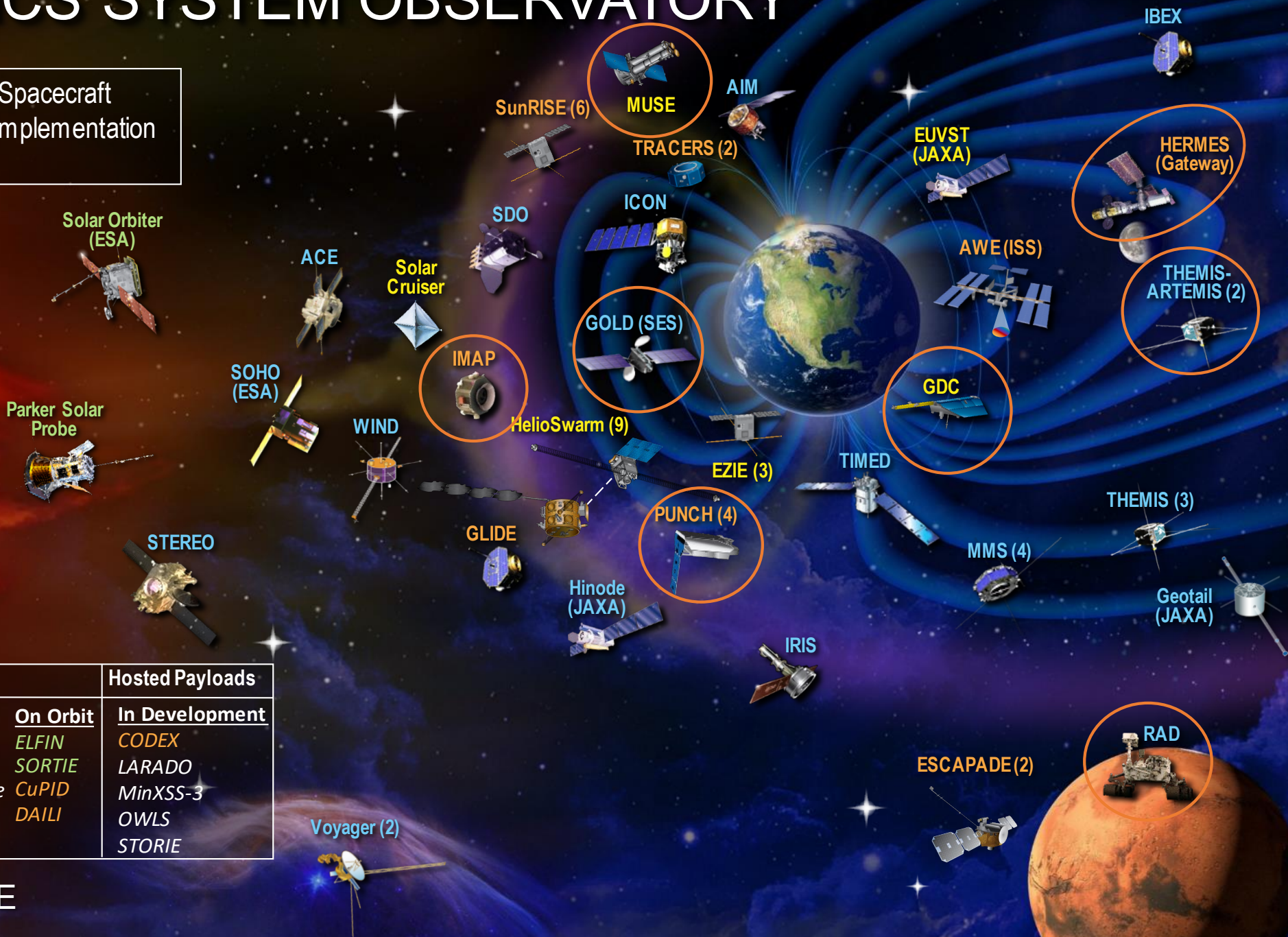
■ IMPLEMENTATION

■ PRIMARY OPS

■ EXTENDED OPS

CubeSats				Hosted Payloads			
In Development				On Orbit	In Development		
AEPEX	Dione	CubIXSS	SunCET	ELFIN	CODEX		
AERO / VISTA	GTOSat	petitSat	DYNAGLO	SORTIE	LARADO		
CIRBE	ICOVEX	REAL	WindCube	CuPID	MinXSS-3		
CURIE	LAICE	SPORT		DAILI	OWLS		
CuSP	LLITED	PADRE			STORIE		

OPERATING & FUTURE



Space Weather Gap Analysis

In response to the recommendations of the 2013 Decadal Survey and the actions delineated in the 2019 National Space Weather Strategy and Action Plan, HPD commissioned a space weather science and measurement gap analysis to:

1. Assess the current state of NASA's observational capability to address the science of space weather and its capacity to provide data input that significantly advances forecasting and nowcasting capability
2. Identify high-priority observations that are at risk or not currently available that are re-quired to significantly advance forecasting and nowcasting capability



Highest Priority Observational Gaps

1. Solar/solar wind observations, including off-Sun-Earth-Line
2. Ionospheric key observables
3. Solar wind in peri-geospace
4. Thermospheric key observables
5. Ionospheric D- and E-region energetic particle precipitation, and E- and F-region cusp and auroral precipitation
6. Ring current and radiation belt electrons
7. Plasma sheet electrons and injections/bursts from cislunar into GEO and MEO regions

Rank	Current Observation Gaps	Research Gaps
1	Solar/solar wind observations, incl. off Sun-Earth line (e.g., Sun-Earth L4 and L5) and beyond 1 AU	SEP occurrence and properties at a given inner Heliospheric location; IP propagation of solar transients (e.g., Bz, ToA)
2	Ionospheric key observables	Response to variable solar, solar wind, thermospheric, and magnetospheric conditions; high resolution global state; cross-scale and -altitude dependencies and variability; driving from lower atmosphere
3	Solar wind in peri-Geospace (i.e., within ~20 RE of Earth's dayside bow shock)	Fine-scale structure of SW-transients; spatiotemporal evolution and turbulence
4	Thermospheric key observables	Expansion, heating, and cooling processes over a range of scales (< 100 km to global) and altitudes; response to variable solar, ionospheric, and magnetospheric conditions; driving from lower atmosphere
5	Ionospheric D- and E-region EPP and E- and F- region cusp and auroral precipitation	Impacts of energetic particle, cusp, and auroral precipitation on ionosphere-thermosphere system; cross-scale (< 100 km to global) and spatiotemporal nature of precipitation and consequences on ionosphere-thermosphere system (e.g., conductivity, heating, chemistry and cooling, etc.)
6	Ring current and radiation belt electrons	Role of magnetospheric dynamics, meso-scale injections, and variety of wave-particle interactions acting in concert to shape these trapped energetic particle populations, driving geomagnetic storms and radiation belt enhancements and depletions
7	Plasma sheet electrons and injections/bursts from cis-lunar into GEO and MEO regions	Nature of kinetic- to meso-scale processes (e.g., reconnection, turbulence) affecting global-scale magnetospheric dynamics and magnetosphere-ionosphere coupling



NSF SPACE WEATHER UPDATES

MANGALA SHARMA

Program Director, Space Weather
www.nsf.gov

Space Weather Operations and Research Infrastructure Workshop, Phase II
April 11, 2022

New Strategic Plan (2022-26)

VISION

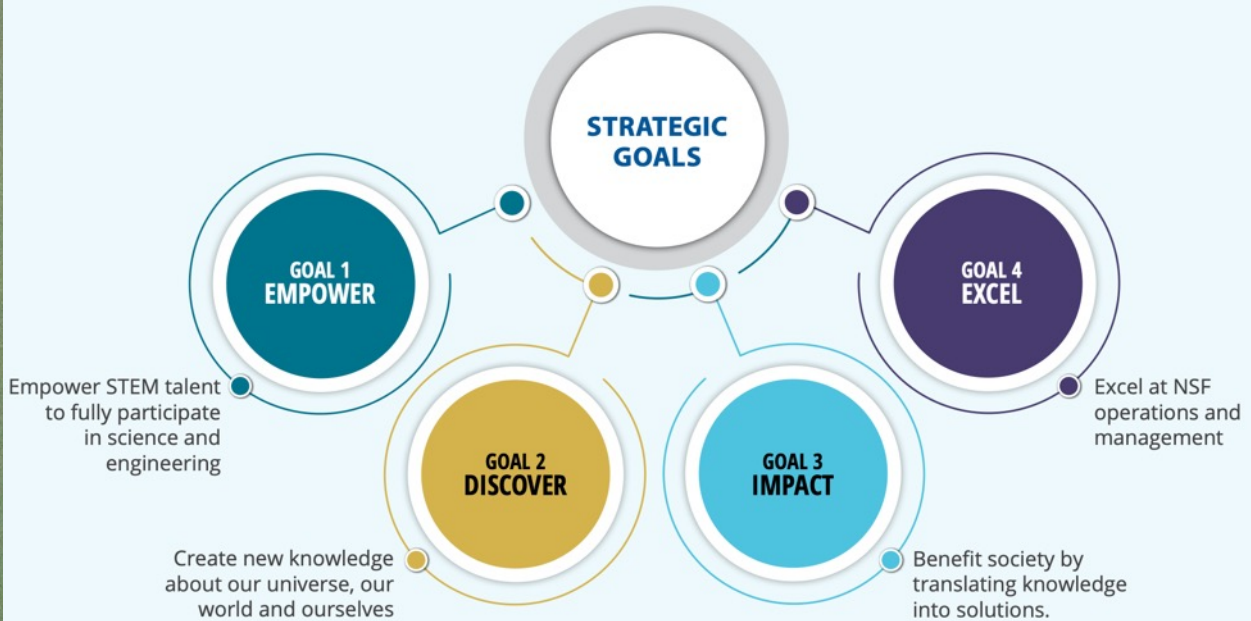
A nation that leads the world in science and engineering research and innovation, to the benefit of all, without barriers to participation.

MISSION

To promote the progress of science; to advance the national health, prosperity and welfare; to secure the national defense; and for other purposes.

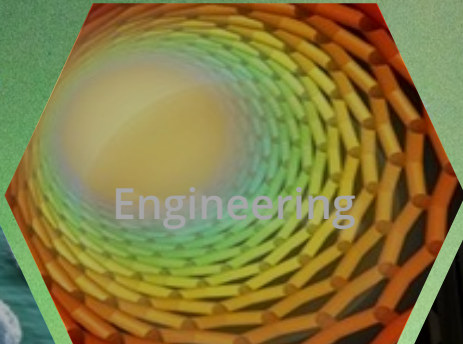
CORE VALUES

NSF's strength is scientific leadership. We value diversity and inclusion, demonstrate integrity and excellence in our devotion to public service, and prioritize innovation and collaboration in our support of the work of the scientific community and of each other.

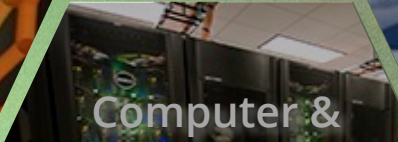


New Directorate

- Use-inspired, challenge-driven, convergent research
- Innovation and technology translation
- Leveraging the virtuous cycle of foundational and use-inspired research
- Long-term, large scale
- Public-private partnerships
- Education, workforce, diversity



Engineering



Computer &
Information
Engineering

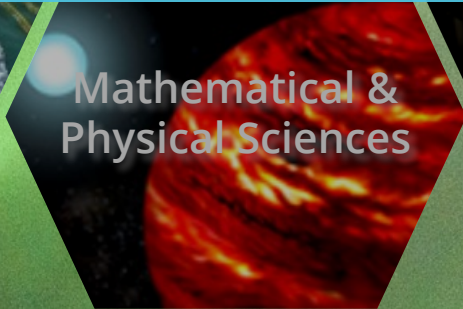


Geosciences
(including Polar
Programs)



Social, Behavioral &
Economic Sciences

DIRECTORATE FOR TECHNOLOGY, INNOVATION AND PARTNERSHIPS (TIP)



Mathematical &
Physical Sciences



Integrative
Activities



International
Science &
Engineering

FY 2023 Budget Request: NSF Budget by Appropriation (Dollars in Millions)

Account	FY 2021 Actual ¹	FY 2021 ARP Actual ²	FY 2022 Enacted	FY 2023 Request ¹	FY 2023 Request change over FY 2021 Actual		FY 2023 Request change over FY 2022 Enacted	
					Amount	Percent	Amount	Percent
Research and Related Activities	\$6,761	\$196	\$7,159	\$8,426	\$1,665	25%	\$1,267	18%
Education and Human Resources	\$1,111	\$24	\$1,006	\$1,377	\$266	24%	\$371	37%
Major Research Equipment and Facilities Construction	\$161	\$9	\$249	\$187	\$26	16%	-\$62	-25%
Agency Operations and Award Management	\$385	\$12	\$400	\$473	\$89	23%	\$73	18%
Office of Inspector General	\$17	-	\$19	\$23	\$6	36%	\$4	23%
Office of the National Science Board	\$4	-	\$5	\$5	\$1	14%	\$0	10%
Total, NSF	\$8,440	\$240	\$8,838	\$10,492	\$2,052	24%	\$1,654	19%

Totals may not add due to rounding.

¹ Funding re-stated for comparability in FY 2021 and FY 2023 to capture the requested consolidation of GRFP into EDU (formerly EHR). FY 2022 Enacted is not yet re-stated to capture this shift.

² This represents FY 2021 obligations of the \$600 million provided by the American Rescue Plan Act of 2021 (P.L. 117-2).

FY2023 BUDGET REQUEST TO CONGRESS



National Science Foundation



Multiple NSF programs support SWx research

<https://www.nsf.gov/awardsearch>

The screenshot shows the NSF Award Search website. At the top is the NSF logo with the tagline "WHERE DISCOVERIES BEGIN". Below the logo is a navigation bar with links: RESEARCH AREAS, FUNDING, AWARDS, DOCUMENT LIBRARY, NEWS, and ABOUT NSF. Under the AWARDS link, there are sub-links: Simple Search, Advanced Search, Popular Searches, Download Awards, Send Comments, and Award Search Help. The main content area is titled "Awards Simple Search" and includes a link for "Overview of Award Search Features". There is a search bar with the text "Search award for:" followed by a text input field containing "space weather". To the right of the input field is a "Search" button with a magnifying glass icon. Below the search bar, there is a note: "Use double quotes for exact search. For example 'water vapor'." and two radio buttons: "Active Awards" (which is selected) and "Expired Awards".

NSF Organization

- Office Of The Director(23)
- Direct For Mathematical & Physical Scien(118)
- Direct For Social, Behav & Economic Scie(1)
- Direct For Computer & Info Scie & Enginr(56)
- Directorate For Geosciences(1409)
- Directorate For Engineering(15)
- Direct For Education and Human Resources(2)

GEO Directorate:

- Division of Atmospheric and Geospace Sciences: *Geospace programs* (AER/CEDAR, STR/SHINE, MAG/GEM, GF, SWR) and *NCAR/Facilities Section* incl. HAO
- Office of Polar Programs: Antarctic Research
- Etc.

MPS Directorate:

- Division of Astronomical Sciences: Astronomy and Astrophysics Research Grants (AAG), National Solar Observatory (incl. DKIST and GONG), etc.
- Division of Physics: Plasma Physics

Division of Atmospheric and Geospace Sciences (AGS)

Geospace Section



Candace Major
Division Director



Tai-Yin Huang
Data Infrastructure
Aeronomy (AER)



Chia-Lin Huang
Magnetospheric
Physics (MAG)



Lisa Winter
Solar-Terrestrial
Research (STR)



Section Head
Geospace



Mangala Sharma
Space Weather Research
(SWR)

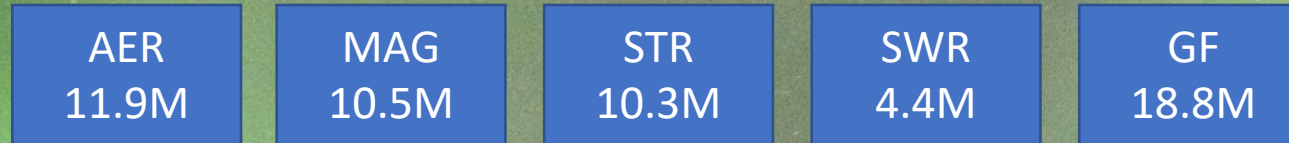


Roman Makarevich
Geospace Facilities
(GF)

Recruiting program director for
Aeronomy

Quick Facts about NSF Geospace Section: FY21

- Overall spending in GS was \$55.9M, including ARP fund, up 6.3% from FY20 \$52.6M*



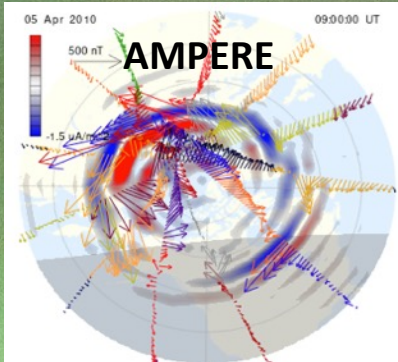
- Additional facts about AER, MAG, STR, SWR grants in FY21
 - 70 new award actions
 - Vast majority of new awards are standard grants

* Excluding Arecibo clean up.

NSF supports array of solar & geospace observing approaches

Some examples!

To space

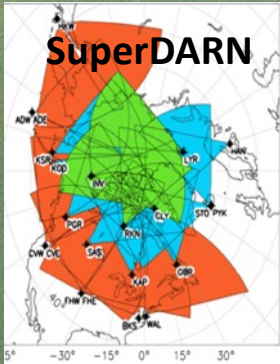
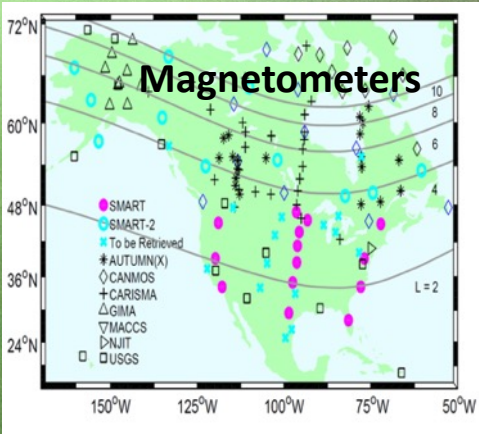


And in-between

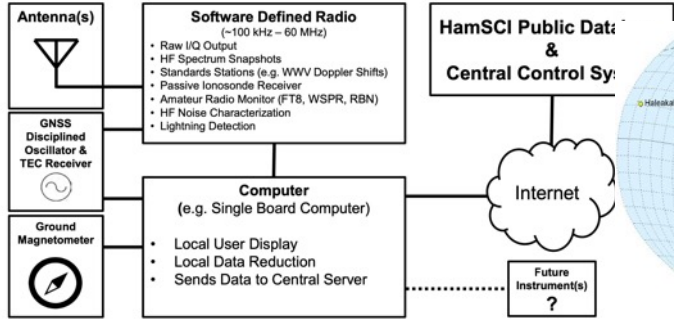


From the ground

BBSO



HamSCI Personal Space Weather Station



Neutron monitor network



Millstone Hill Observatory

Two-year award, Sept 2021 – Aug 2023

PI: Frank Lind, MIT

To upgrade and extend lifetime of radar,
double sensitivity



Jicamarca Radio Observatory

High-power operations restarted in
Sept 2020

Repaired AMISR-14



Subauroral Geophysical Observatory

Five-year award Apr 2021 – Mar 2026

PI: Robert McCoy, UAF GI

200 hours/year of baseline HF heating
operations



Expanded Owens Valley Solar Array

Three-year award, Sept 2021 – Aug 2024

PI: Dale Gary, NJIT



Chen [2020]

The Simpson Neutron Monitor Network (funded by the STR and SWR)

Three-year award, Aug 2021 – Jul 2024

PI: James Ryan, UNH

PI: Surujhdeo Seunarine, Univ of
Wisconsin-River Falls

PI: John Clem, Univ of Delaware

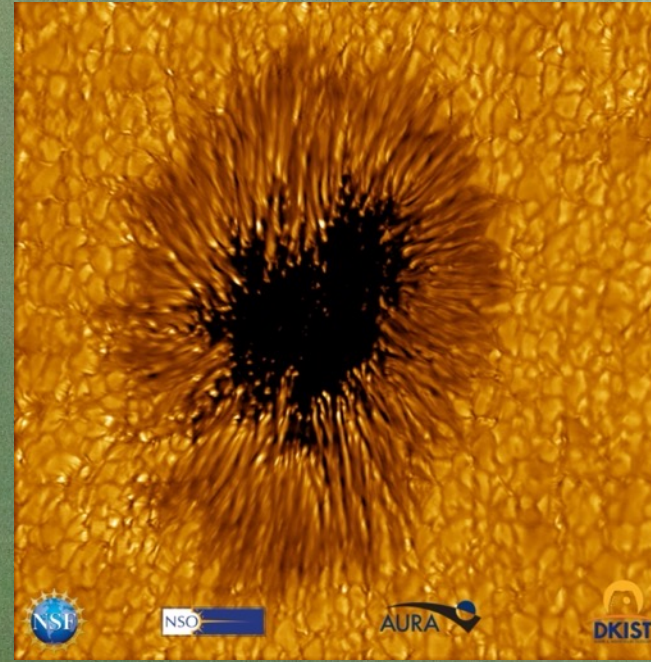
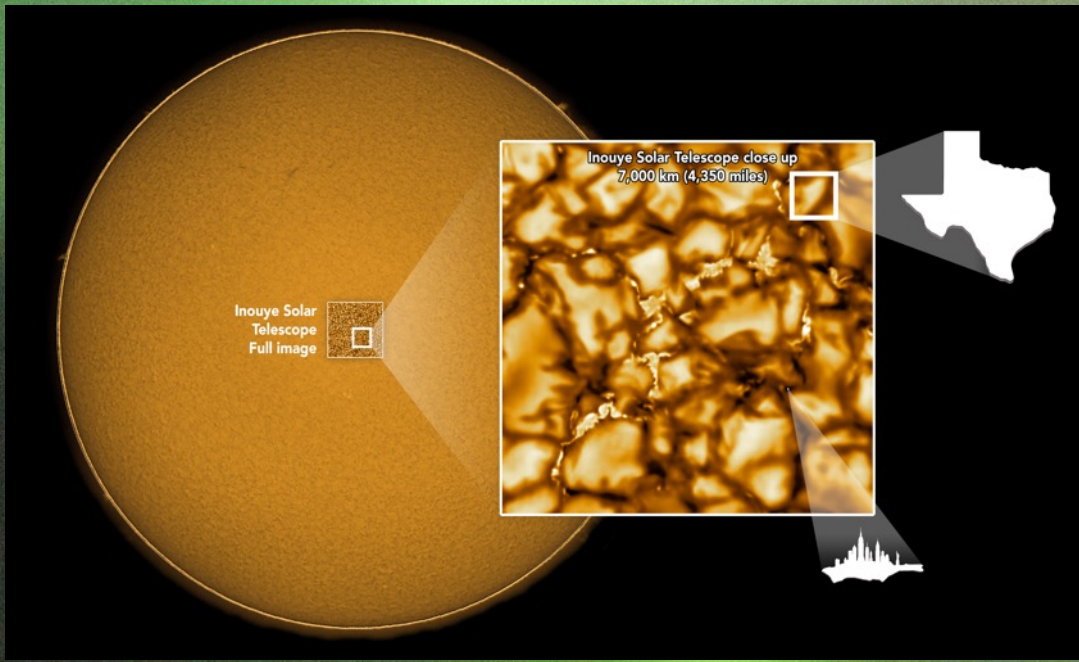
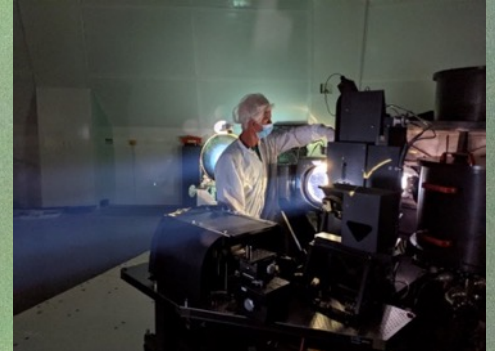




NSF's Daniel K. Inouye Solar Telescope

The largest, most powerful solar observatory on planet Earth

Now in operations



Faculty Early Career Development Program (CAREER) 2022



Piyush Mehta



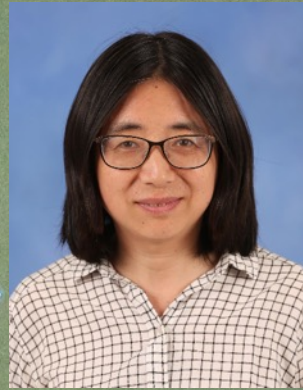
AER



Diana Loucks



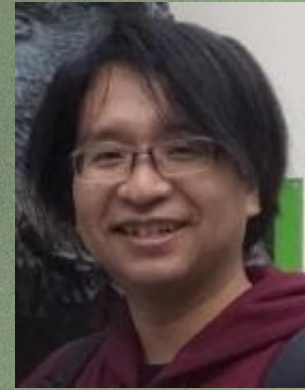
AER



Haihong Che



STR



Satoshi Inoue



STR

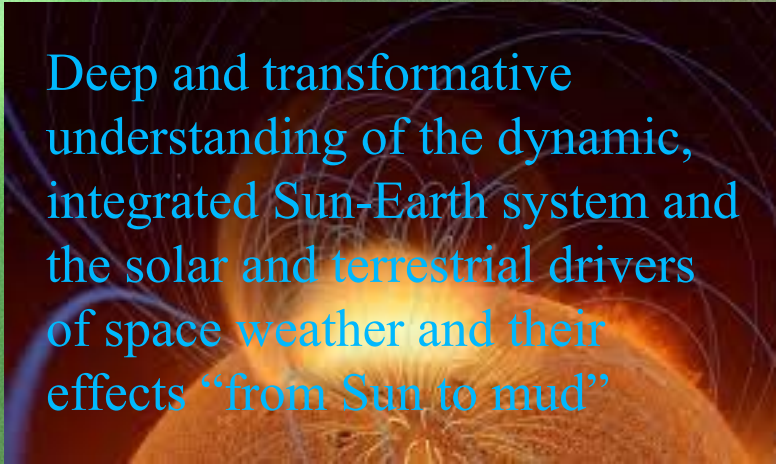


Yi-Hsin Liu

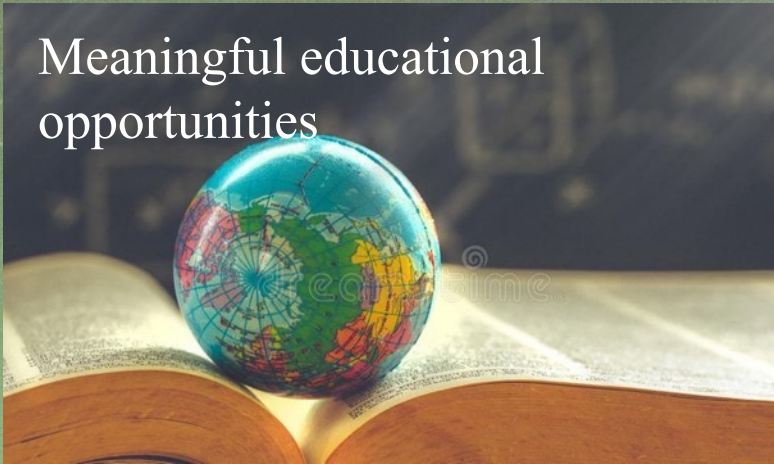


MAG

Grand Challenges in Integrative Geospace Sciences: Advancing National Space Weather Expertise and Research toward Societal Resilience



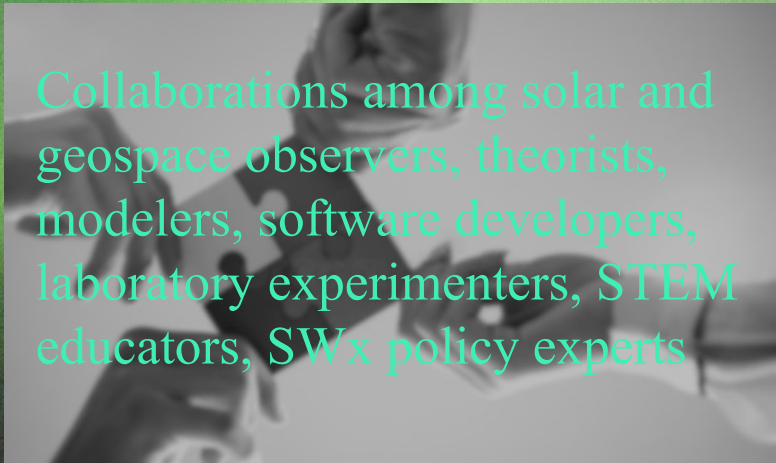
Deep and transformative understanding of the dynamic, integrated Sun-Earth system and the solar and terrestrial drivers of space weather and their effects “from Sun to mud”



Meaningful educational opportunities



Convergence: Solar
& Space Physics &
Space Weather



Collaborations among solar and geospace observers, theorists, modelers, software developers, laboratory experimenters, STEM educators, SWx policy experts



Partnerships between research-intensive and minority-serving institutions encouraged

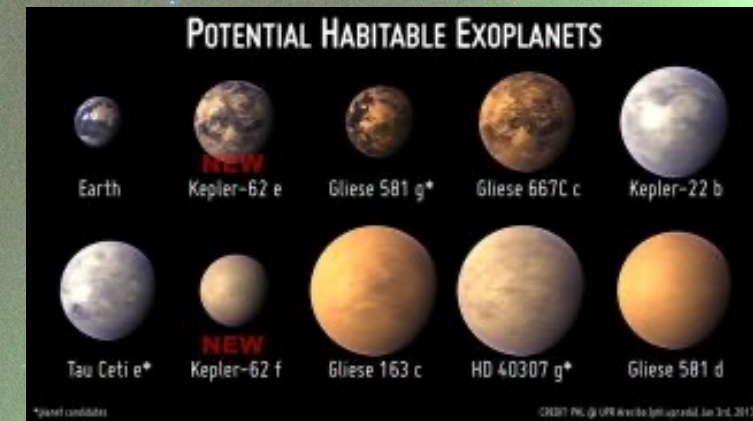
- Deadline 8/23/2021
- max \$900K for small teams (6 or fewer members) and 2.5M for large teams over 3-4 years
- Expect to make award announcements later this month

contact: Mangala Sharma msharma@nsf.gov

New CEDAR / GEM / SHINE Solicitations

Solicitation	Target Date
Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR in AER)	5/20/2022, 1 st Friday in May annually thereafter
Geospace Environment Modeling (GEM in MAG)	3/30/2022, 9/30 annually thereafter
Solar, Heliospheric, and INterplanetary Environment (SHINE in STR)	5/11/2022, 10/7 annually thereafter

Dear Colleague Letter: Geoscience Lessons for and from Other Worlds (GLOW)



(Image credit: PHL@UPR Arcibo)

Bring together researchers and experts to develop projects which:

- use the study of other worlds to broaden and deepen our understanding of the Earth and its evolution
- use our geoscience knowledge to understand the environments of other worlds.

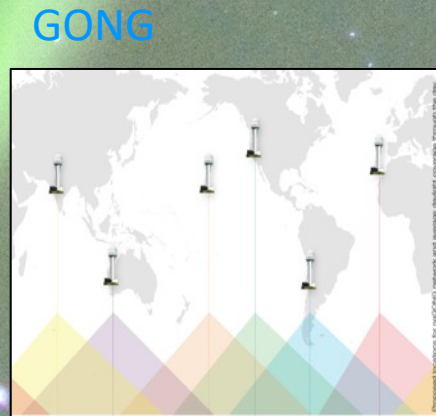
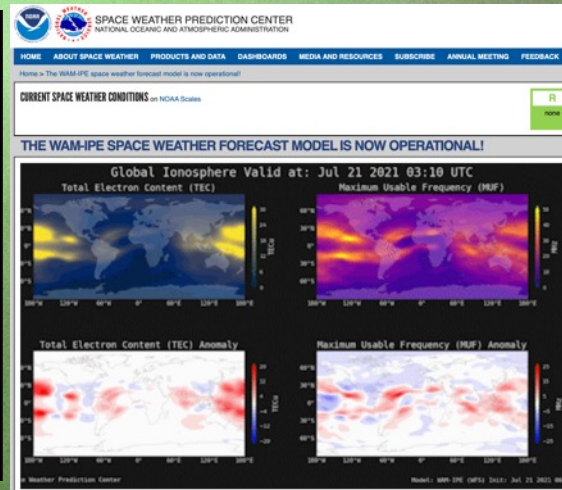
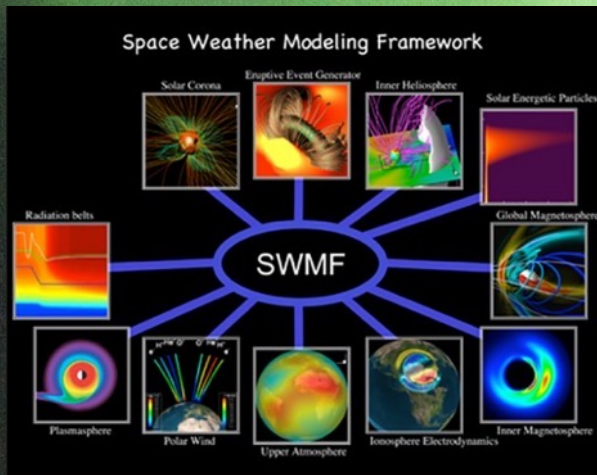
Participating Divisions:
Earth Sciences (EAR)
Atmospheric and Geospace Sciences (AGS)
Astronomical Sciences (AST)

ECosystem for Leading Innovation in Plasma Science and Engineering (ECLIPSE)

- Joint “meta-program” between MPS, ENG, and GEO directorates
 - To bring fundamental plasma science investigations to bear on problems of societal and technological need – stimulated by the recommendations of the Physics 2020 Decadal Assessment of Plasma Science
 - To foster an inclusive community of scientists and engineers, spanning multiple NSF Directorates, in the pursuit of translational research
 - Proposals should address
 - fundamental scientific and/or engineering challenge
 - how a resolution will address specific societal and/or technological needs
- ❑ AGS accepts full proposals anytime. Contact: Mangala Sharma msharma@nsf.gov

NSF supports SWx research and applications

- Multi-agency (NOAA, NASA, NSF, DoD) partnership for R2O2R activities
- NSF-NOAA partnership on GONG; NSF research support to advance NOAA operational models
- Partner with NASA on their annual ROSES SWx R2O2R solicitation and on CCMC



Solar and Space Physics Decadal Survey (2024)

Work with our agency partners at NASA and NOAA as well as participating NSF Programs from:

- Division of Atmospheric and Geospace Sciences
- Division of Astronomical Sciences
- Division of Physics
- Office of Polar Programs

NSF Decadal Priorities are to define:

- The **SCIENCE** Priorities
- The **INFRASTRUCTURE** needed to achieve the science
- Support for the diverse range of the **PEOPLE** we want to be engaged in science

Help organizing community workshops to identify and organize white paper submissions



Thank you for your input at this workshop!

MANGALA SHARMA

Program Director, Space Weather
Msharma@nsf.gov

Space Weather Operations and Research Infrastructure Workshop, Phase II
April 11, 2022



NOAA

**Satellite and
Information
Service**

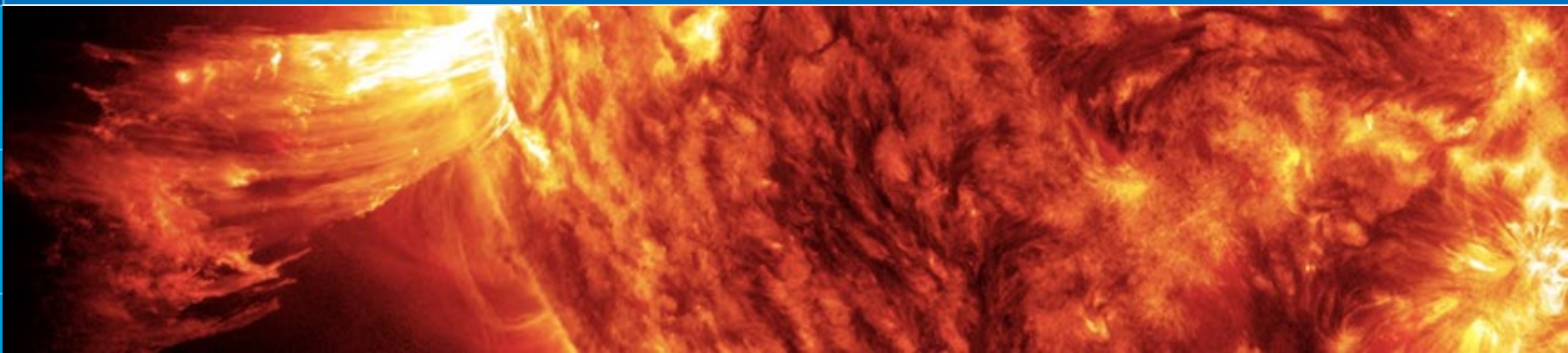
11 April 2022

NOAA's Current and Future Space Weather Architecture and Notification System

Dr. Elsayed Talaat

Director, Office of Projects, Planning, and Analysis

NASEM Workshop on Space Weather Operations and Research
Infrastructure – Phase 2





NOAA Space Weather Charter

- **Building capacity to advance space weather policy**
 - Inception and implementation of National Space Weather Strategy and Action Plan
 - PROSWIFT (Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow) Act
- **Accelerating growth in NOAA and its space weather services**
 - Identify and sustain fundamental observations to support operations
 - Provide timely, accurate, and relevant models and forecast products
 - Transition scientific and technological advances into operations (R2O2R)
 - Support growing private sector activities to fill data and technology gaps and provide value-added services and products
- **Integrating approach and collaboration between research and operations**





Pillars of NESDIS Observing System Implementation



Integrated, Adaptable and Affordable: Orbits, Instruments & Systems

GEO

Continuous real-time observations supporting warnings and watches of severe weather and hour-by-hour changes. High-inclination orbits to observe northern latitude & polar regions.

LEO

Miniaturized instruments on small, affordable and proliferated satellites and partner data improving forecasts through better and additional data. Better precipitation forecasts, wave height predictions, ocean currents, and more.

Space Weather

Reliably monitoring space weather from L1, GEO and LEO can protect the nation's valuable, vulnerable infrastructure. New capabilities at L5 and HEO can provide additional insight and improve forecasts.

Common Ground Services

Secure ingest of data in different formats from different partners requires a flexible, scalable platform. Common Services approach integrates Cloud, AI and machine-learning capabilities to verify, calibrate and fuse data into new and better products and services.



JASON-3

OPERATIONAL JULY 1, 2016

Sentinel 6 Michael Freilich – Fall 2020

DSCOVR

OPERATIONAL JULY 27, 2016

SWF O-L1

LRD: FY202 5

COSMIC-2

COSMIC-2 - June 2019

GOES-R SERIES

GOES-16 - OPERATIONAL Dec 18, 2017
GOES-17 - OPERATIONAL Feb 12, 2019
GOES-T - FY 2022
GOES-U - FY 2025

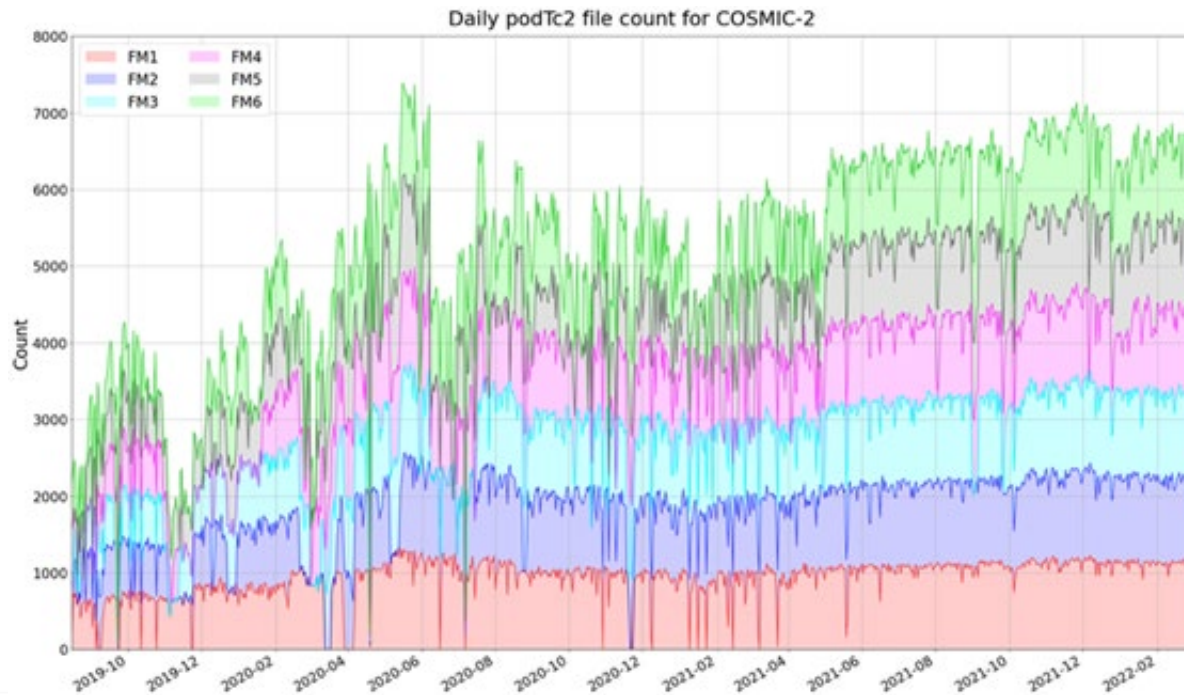
JPSS SERIES

NOAA-20 - OPERATIONAL May 30, 2018
JPSS-2 - FY 2023
JPSS-3 - FY 2026
JPSS-4 - FY 2031

NESDIS Program of Record



COSMIC-2 Daily Ionospheric Files



COSMIC-2 podTc2 file

- Contains all TGRS ionospheric data
 - Total Electron Content (TEC)
 - Scintillation Phase and Amplitude
- Total Files: 4,970,876

TEC Data as of Feb, 2022

- Daily Average Arc+Occ Counts: 12,141
 - Requirement: 12,000 (28/30 days)
- Daily Median Latency: 27.4 min
 - Requirement: <30 min daily

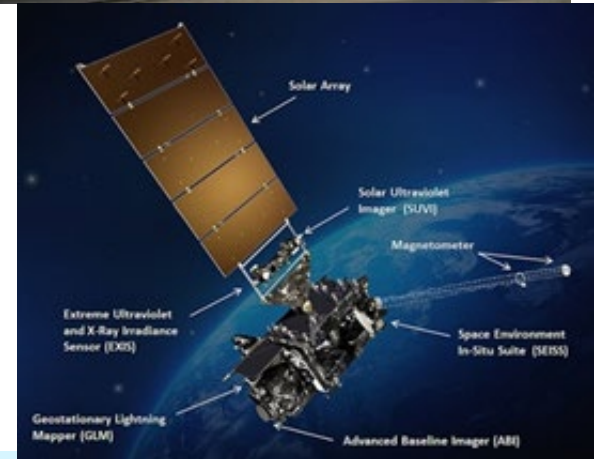
Achieving over 12,000 TEC arc+occ counts on average daily with under 30-min latency



GOES-18 Products

- **GOES-18 Product Schedule**

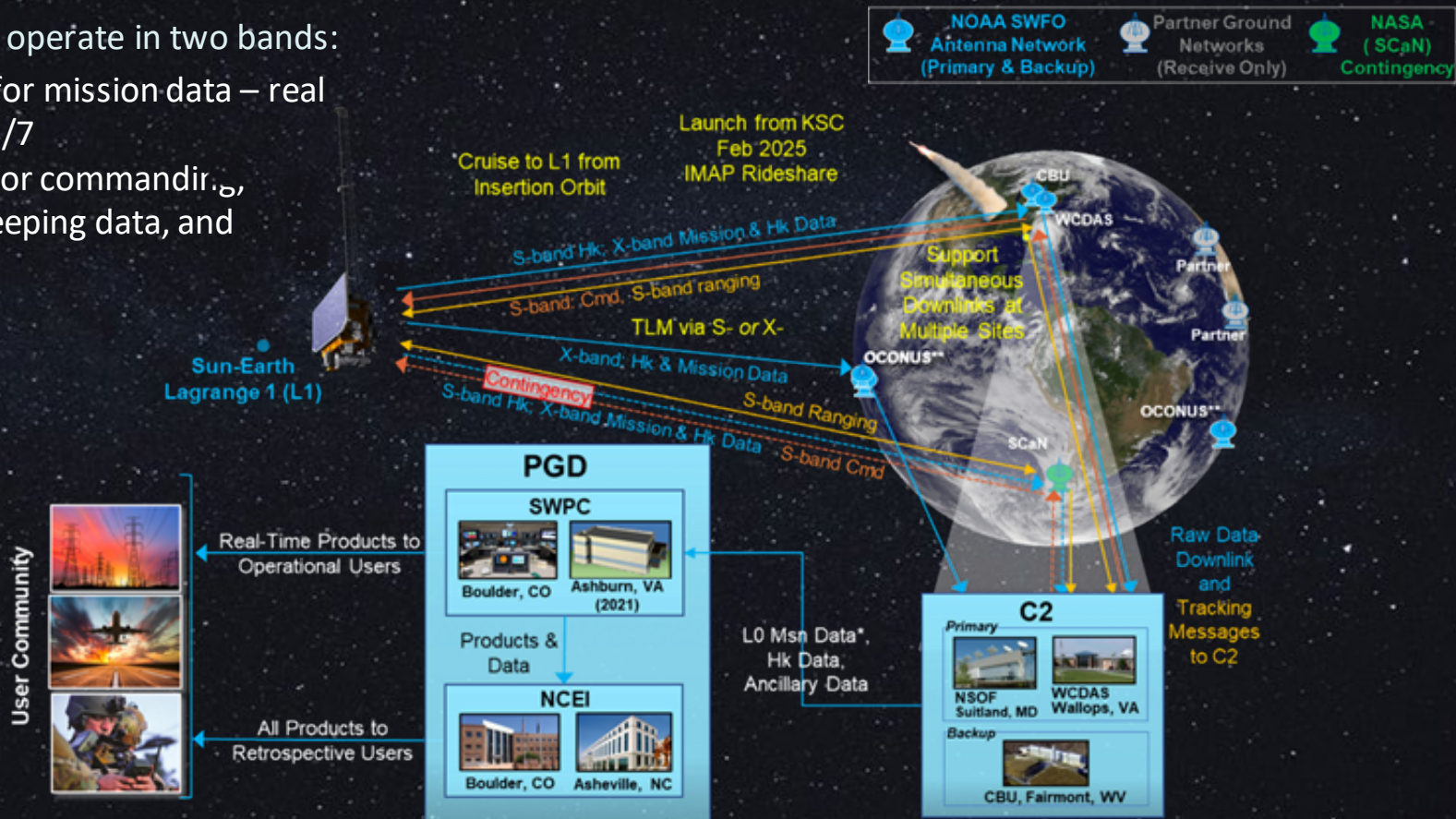
- GOES-T launched 01 March 2022
- GOES-18 - On orbit 24 March 2022
- Operational replacement of GOES-17 Jan 2023
- Much work to be done at NESDIS & NWS
- SWx data will not complete validation until Nov 2022
- Anticipating 1-2 months with only one geostationary satellite for space weather data (GOES-16)
- Updates for schedule details will be at SWPC website (spaceweather.gov)



SWFO-L1 Mission Architecture

SWFO-L1 will operate in two bands:

- X-band for mission data – real time, 24/7
- S-band for command, housekeeping data, and ranging



*GOES-U CCOR-1 data provided to SWPC directly from GOES-R

** OCONUS SAN Stations are implemented as a service



NOAA/NESDIS Formulating a Space Weather Program

- Diverse observing requirements must be made from diverse vantage points (LEO, GEO, Sun-Earth line, L1 and off the Sun-Earth line)
- Continuity and anticipated product improvement need dates are varied:
 - Long Lead Instrumentation
 - Next Generation L1 & off-Sun-Earth-axis
 - Space Weather Ground Operations
 - Geostationary Observations
 - Tundra/High Elliptical Orbit Observations
 - Low Earth Orbit Observations
- Program formulation will initialize a loosely coupled program with an initial set of projects.



NOAA advancing a space weather paradigm similar to terrestrial weather to address user needs

Observations: Collecting and providing critical, real-time, continuous, operationally-dedicated space weather data and imagery for alert, watch, and warning services, and predictive modeling systems

Modeling and R2O2R: Introducing a formal framework that incorporates the contributions from industry, agency, and academic partners

- Test and evaluate emerging science that may contribute to operations
- Accelerate the transition of new models/research results into operations
- Enable the improvement and maintenance of existing operational models

Forecasts, Watches, and Warnings: Providing regional and local specification and forecasts of space weather hazards, using indices and products suitable for objective decision-making

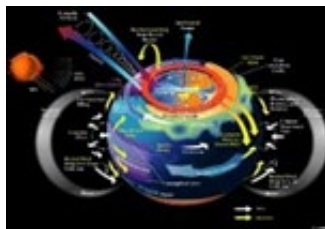
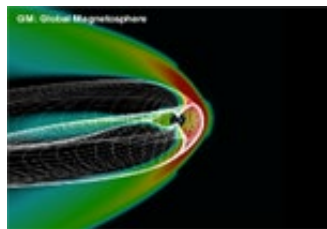
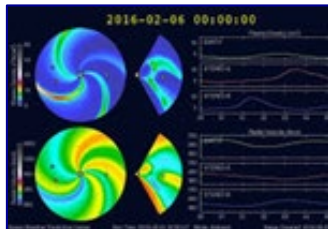


Providing the Nation with space weather forecasts, warnings, and data critical to public safety, disaster preparedness, and the protection of the Nation's critical infrastructure.

Old paradigm
Reliance on research observations
R2O2R is ad hoc, no formal framework, lacked input
Reliance on global indices



Sun-to-Earth Modeling Continuum for Space Weather



GMU/AFRL
WSA/Enlil

U. Michigan
Geospace

NOAA/CIRES
WAM-IPE

NOAA/USGS
Geoelectric field

FAA
CARI-7

Predict solar wind
as it propagates
from the Sun to
Earth

Predict and
understand regional
geomagnetic
response to solar
wind

Predict and
understand links
between the upper
and lower
atmosphere during
space weather
events

Characterize and
predict the regional
electric field and
associated currents
that impact electric
power grids

Characterize the
radiation
environment at
airline altitudes

Operational 2011
Upgraded 2019

Operational 2016
Upgraded 2021

Operational
June 2021

3D Operational
Sept 2020

Operational
2019

- Modeling framework captures critical domains of the Sun-Earth system, from Sun and Earth's surface
- Enabled by **SWORM** - a space weather watch/warning paradigm similar to terrestrial weather





Research-to-Operations-to-Research (R2O2R)

- Partnerships with Government Agencies (NOAA, NASA, and NSF), Academia, Private Sector, International Partners
- Includes Community Coordinated Modeling Center (CCMC) at NASA GSFC in R2O partnership, priorities, and process
- New Space Weather Capabilities Research-to-Operations (R2O)
- Evaluate, Prototype, Transition within Space Weather Testbed at SWPC



NASA
CCMC

Operations-to-Research (O2R)

- Continuous improvement of the existing operational models
- Informs future capabilities
- Establishes research priorities

NWS
SWPC



Capabilities

- ✓ Products
- ✓ Models
- ✓ Observations
- ✓ Applications
- ✓ Techniques



NATIONAL WEATHER SERVICE



Space Weather Workshop 2022

April 26-28, 2022 (Virtual Meeting)



Space Weather Workshop

The Meeting of Science,
Research, Applications,
Operations, and Users

April 26-28, 2022 Virtual Meeting



Registration Open Now! - No registration fee
<https://www.swpc.noaa.gov/content/annual-meeting>





NOAA support of 2024 NASEM Solar and Space Physics Decadal Survey

- **Advances to improve NOAA's predictive and specification capabilities**
 - Understand the Sun – Earth connection, cause and effect
- **Research to Operations to Research**
 - Heritage of space weather operations' dependence on science research, modelling, and platforms
 - Transition research to operation based system with transition through testbeds
 - Provide operations' feedback to research to improve overall system performance
- **Encourage and enable non-traditional space weather providers**
 - Uccellini quote: Tell community what government is doing but also what it is not doing; as government tasks have gaps, commercial tasks compensate
- **Assess evolving technologies as appropriate to operations**
 - Technology advances in hardware, communications, AI, modelling, machine learning, etc.





Space Weather-Ready Nation

A Nation Ready, Responsive, and Resilient to Space Weather



GOES-R

Critical Observations

DSCOVR

ACE

STEREO

SOHO

SDO

COSMIC-II

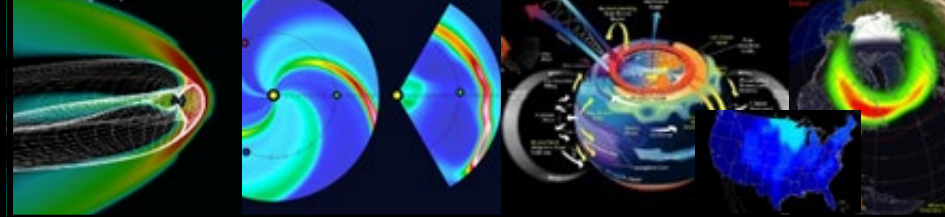


*Partnerships – the entire
Space Weather Enterprise
working together*



*Improved understanding
with new modeling and R2O2R capabilities*

SPACE WEATHER PREDICTION
TESTBED



*Better information connected to key stakeholders
for better decisions - enhance National resilience*



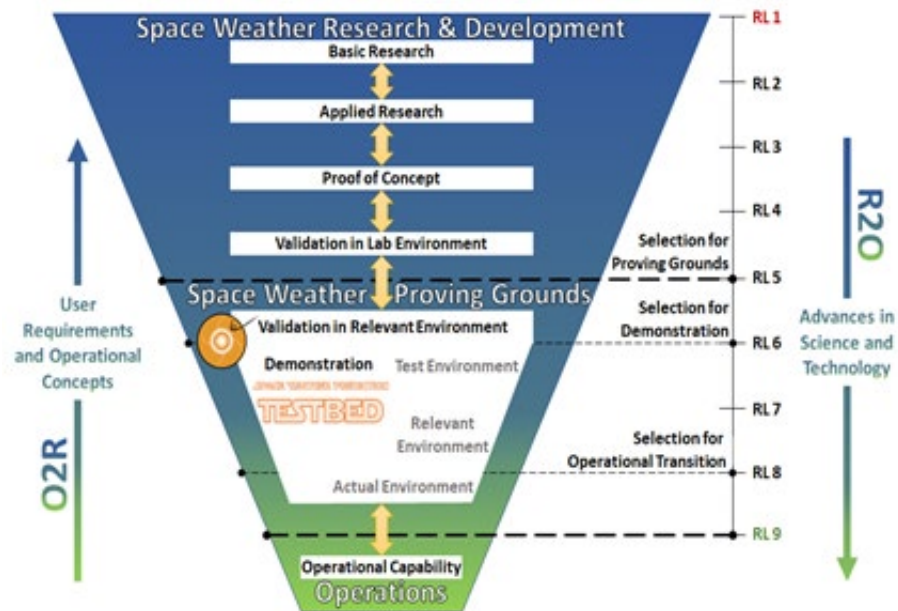
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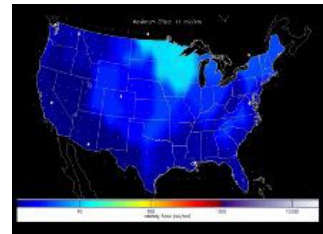
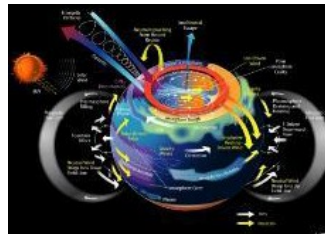
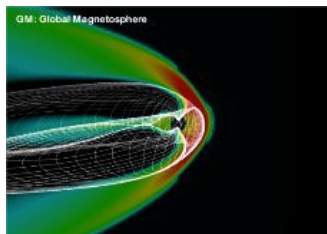
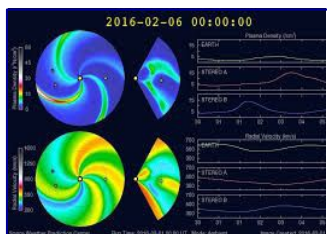
Space Weather Prediction Testbed R2O2R Process Definition

- **Roles & Responsibilities of Research,** Proving Ground, & SWPC R2O2R process
- Describes activities associated with each Readiness Level (RLs)
- Provides checklists activities required to advance from one RL to the next
- Draft being discussed with governmental partners
- Goal is to make public by end of this calendar year



Operational Space Weather Modeling at NOAA

A Sun-to-Earth Continuum



GMU/AFRL
WSA/Enlil

Understand the structure of the solar wind as it propagates from the Sun to Earth

U. Michigan
Geospace

Understand the geomagnetic response to changes in solar wind; provide regional predictions of geomagnetic storms

NOAA/CIRES
WAM-IPE

Understand details in the mesosphere, exosphere, and ionosphere, to understand links between the lower and upper atmosphere

NOAA/USGS
E-field

Characterize and predict the regional electric field and the associated currents that impact electric power grids

The space weather community working together on a modeling framework that captures critical domains of the Sun-Earth system, beginning at the Sun and ending at the Earth's surface

Supporting a space weather watch/warning paradigm similar to terrestrial weather





Summary (if needed to be worked)

2024 Solar and Space Physics Decadal Survey is the first co-sponsored by NOAA/NESDIS, with primary interest in space weather improvements in products and forecasts of Earth and space event consequences.

The decadal survey committee's recommendations will be framed around national needs, including, but not limited to research priorities to improve space weather specification and prediction capabilities.

Recommendations may be organized around 1) how new technology may enhance current operations, and 2) what new science is needed to expand current operations, either to enable new capabilities or to include new areas of interest.





NESDIS Strategic Objectives

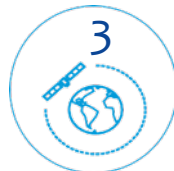
NESDIS
Reimagined



Advance terrestrial observational leadership in geostationary and extended orbits



Advance Space Weather observational leadership in LEO, GEO, and extended orbits.



Evolve LEO architecture to enterprise system of systems that exploits and deploys new observational capabilities



Develop agile, scalable ground capability to improve efficiency of service deliverables and ingest of data from all sources



Provide consistent ongoing enterprise-wide user engagement to ensure timely response to user needs



Deliver integrated program development to provide a suite of products and services





Space Weather Prediction Testbed Aviation Experiment

- **Planned for week 19 Sep 2022 - 3 Days**

- Boulder, CO
- Training, Table-top exercises, Requirements
- Application and modeling demonstrations

- **Key Participants**

- Researchers
- Forecasters
- Industry (airlines, Air Traffic Control, Regulators)

- **Goals**

- Better understand needs of industry, forecasters, res
- Understand process and key restraints of all participants
- Identify steps for mission (everyone's) improvement





Critical Observations - Support Operations and Validate Research

GONG

- NOAA supporting the operations and maintenance of the six GONG observatories
- SWPC has worked with NSF/NSO to operationalize processing of GONG data

Ground-based Magnetometers - USGS

- Critical input to SWPC's geomagnetic storm warnings and alerts
- Funding for the magnetotelluric (MT) survey was included in the USGS Geomagnetism Program's FY 2020 appropriation; funding for the second year of the survey is included in the President's FY 2021 budget request - on course for 2023 completion
- New NOAA-USGS Geoelectric Field model relies on MT data

