

National Aeronautics and Space Administration

US Research Programs to Improve Services

UN/US Workshop on the International Space Weather Initiative:

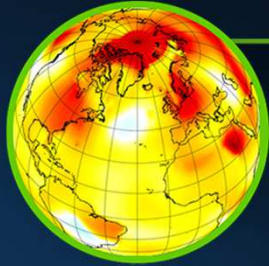
The Decade after the International Heliophysical Year 2007

Boston College

Steven W. Clarke
Director, Heliophysics Division
Science Mission Directorate

31 July 2017

NASA KEY SCIENCE THEMES



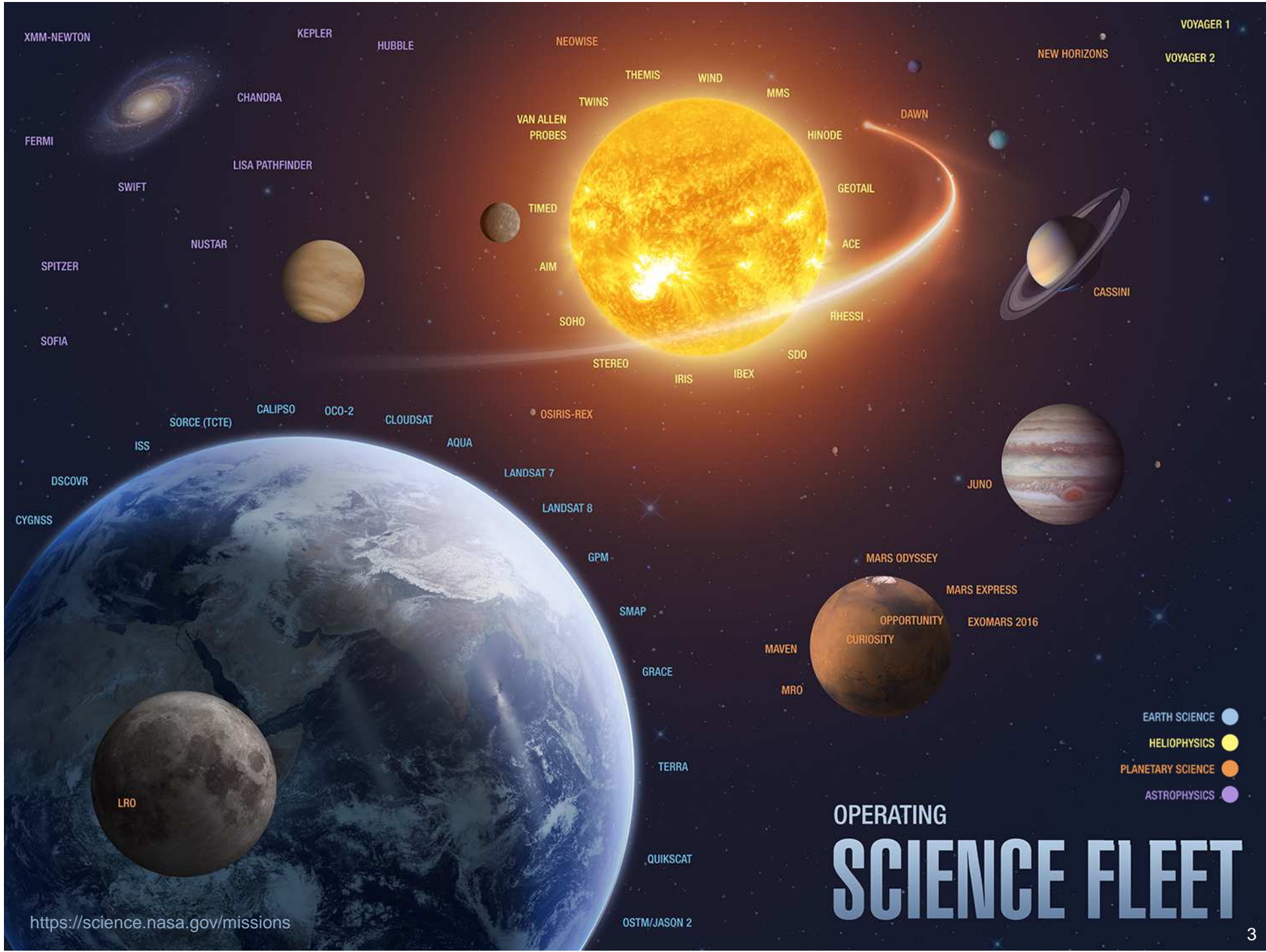
Safeguarding and
Improving Life on Earth



Searching for
Life Elsewhere



Expanding our Knowledge



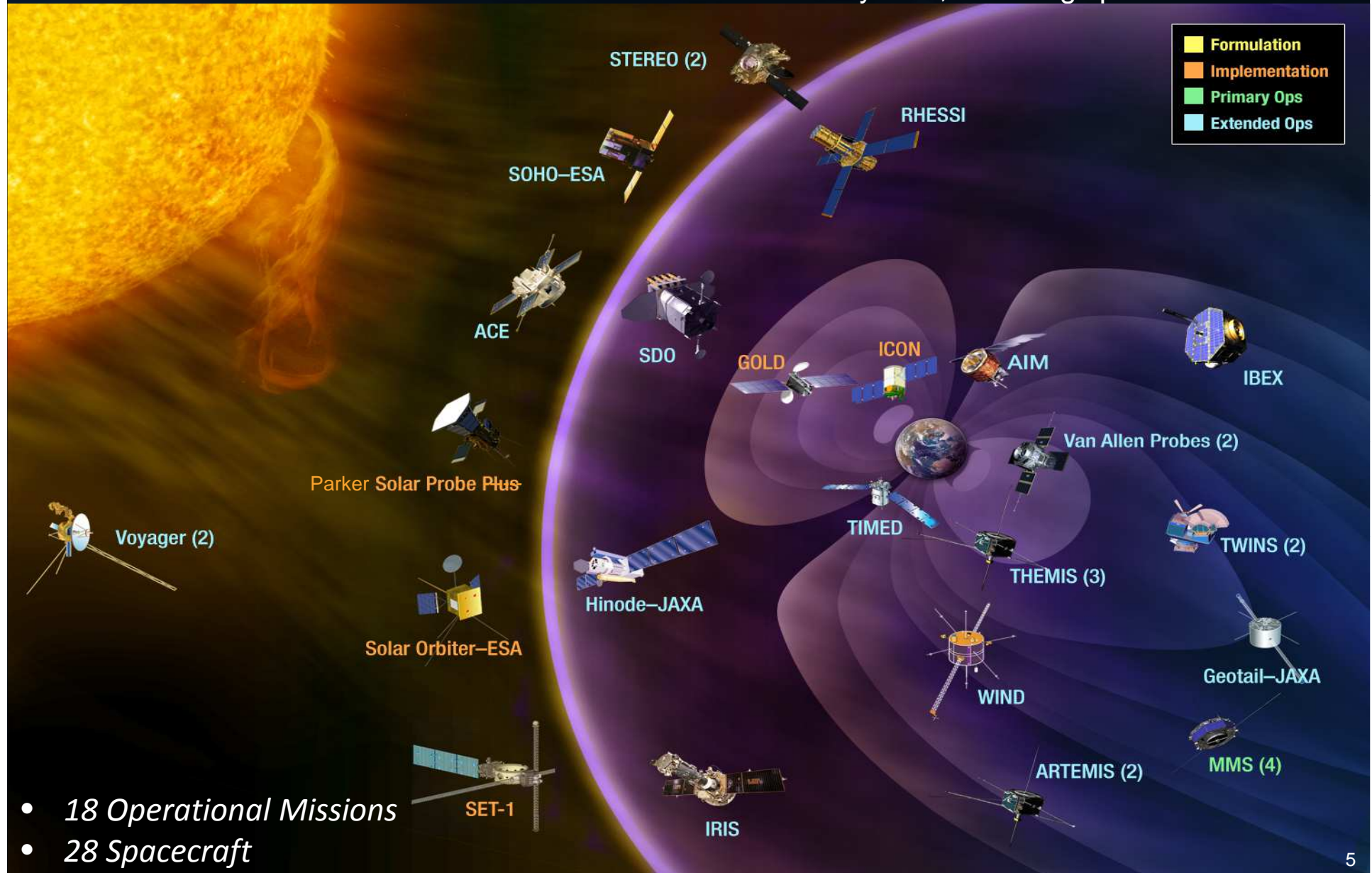
<https://science.nasa.gov/missions>

OPERATING SCIENCE FLEET

- EARTH SCIENCE ●
- HELIOPHYSICS ●
- PLANETARY SCIENCE ●
- ASTROPHYSICS ●

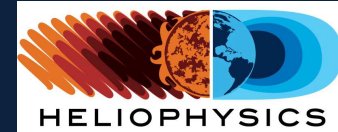
Heliophysics System Observatory

A coordinated and complementary fleet of spacecraft to understand the Sun and its interactions with Earth and the solar system, including space weather





Future Mission Opportunities



Explorer mission AO/MO in FY16

- 5 Phase A awards on 28 July
- Final award in Fall 2018
- Launch readiness date August 2022



STP-5 (IMAP) mission AO/MO in FY17

- Draft AO released in April; Final AO in July
- MO in July/August
- Technology Development MO in Dec/Jan

STDT to assess STP-6 & -7 science objectives will be established and started in FY18

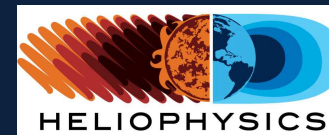


LWS-7 (GDC) mission AO/MO in late FY18

STDT will be established and started in FY17



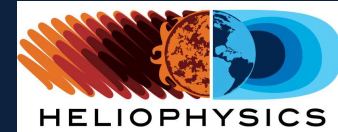
SMEX Awards



- **Mechanisms of Energetic Mass Ejection – eXplorer (MEME-X)**
 - MEME-X will map the universal physical processes of the lower geospace system that control the mass flux through the upper atmosphere to space potentially transforming our understanding of how ions leave Earth's atmosphere.
 - Principal investigator: Thomas Moore at NASA's Goddard Space Flight Center in Greenbelt, Maryland
- **Focusing Optics X-ray Solar Imager (FOXSI)**
 - FOXSI is a solar-dedicated, direct-imaging, Hard X-Ray telescope that would detect hot plasma and energetic electrons in and near energy release sites in the solar corona.
 - Principal investigator: Steven Christe at Goddard
- **Multi-Slit Solar Explorer (MUSE)**
 - MUSE will provide data to advance understanding of the difficult problems of mechanisms responsible for energy release in the corona and the dynamics of the solar atmosphere.
 - Principal investigator: Ted Tarbell at Lockheed Martin Inc. in Palo Alto, California
- **Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS)**
 - TRACERS will fill a fundamental gap in our knowledge of the global variability in magnetopause reconnection by providing an abundant, well targeted set of new and unique in situ measurements.
 - Principal investigator: Craig Kletzing at the University of Iowa, in Iowa City
- **Polarimeter to Unify the Corona and Heliosphere (PUNCH)**
 - PUNCH will advance our understanding of how coronal structures fuel the ambient solar wind with mass and energy, and the dynamic evolution of transient structures in the young solar wind (near the source surface).
 - Principal investigator: Craig DeForest at Southwest Research Institute in Boulder, Colorado



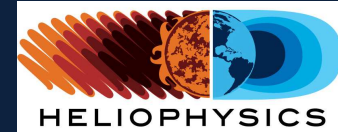
Mission of Opportunity Awards



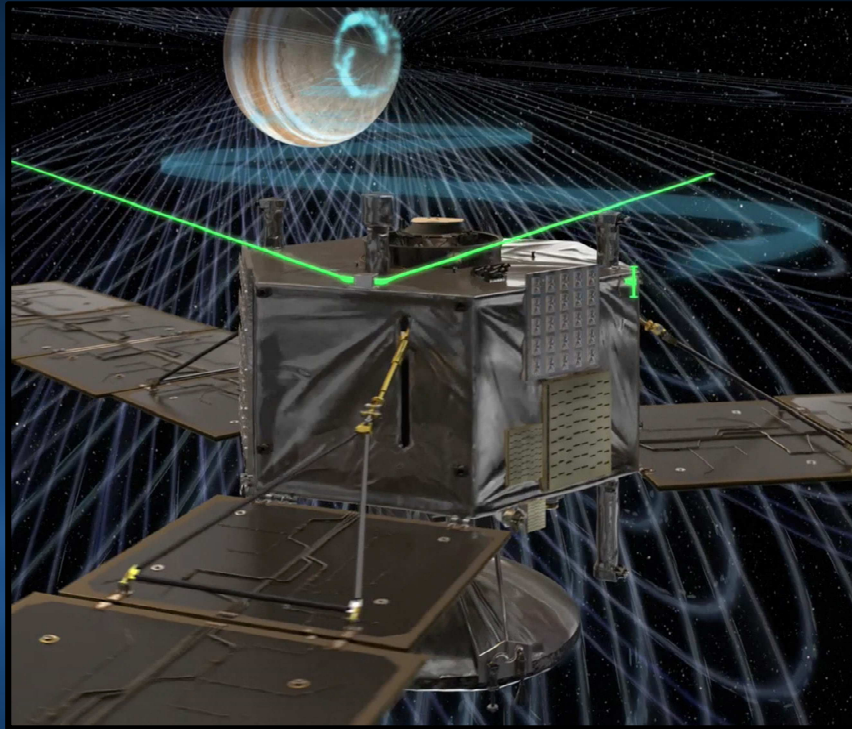
- **Sun Radio Interferometer Space Experiment (SunRISE)**
 - SunRISE will consist of a constellation of cubesats operating as a synthetic aperture radio telescope to address the critical heliophysics problems of how solar energetic particles are accelerated and released into interplanetary space.
 - Principal investigator: Justin Kasper at the University of Michigan in Ann Arbor
- **Atmospheric Waves Experiment (AWE)**
 - AWE will investigate how atmospheric gravity waves, including those generated by terrestrial weather, impact the transport of energy and momentum from the lower atmosphere into near-Earth space, a fundamental question in Heliophysics.
 - Principal investigator: Michael Taylor at Utah State University Research Foundation in Logan
- **U.S. Contributions to the Turbulence Heating ObserveR (THOR) mission (Partner Mission of Opportunity with ESA)**
 - THOR-US will provide components and scientific analysis for an investigation into how plasma is heated and accelerated by the dissipation of turbulent fluctuations through kinetic processes. The concept study for THOR-US was conducted prior to its selection for NASA's Explorer Program, so the team is positioned to move into the detailed design phase if its host mission is selected.
 - Principal investigator: Harald Kucharek at University of New Hampshire in Durham
- **COronal Spectrographic Imager in the Extreme ultraviolet (COSIE) (further tech dev)**
 - COSIE would provide a missing link between the physics of the low corona and that of the heliosphere with a unique and innovative instrument based on the International Space Station.
 - Principal investigator: Leon Golub at the Smithsonian Institution/Smithsonian Astrophysical Observatory in Cambridge, Massachusetts



Cross-Discipline Science



Planetary's Juno Mission and Solar Wind-Magnetospheric Interactions



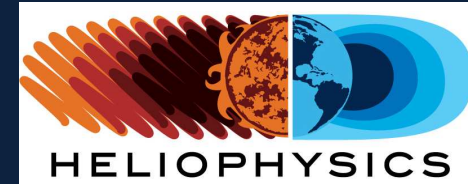
Increased opportunity to perform Heliophysics Decadal Survey Science: *Solar Wind-Magnetosphere Interactions*

- Magnetic reconnection
 - Comparative magnetospheres
- ### *Atmosphere-Ionosphere- Magnetosphere Interactions*
- Night-time aurora
 - Plasma sources and processes
 - Occultations

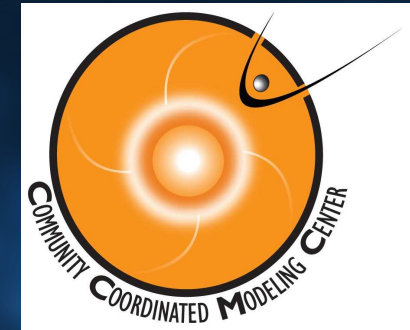
HPD is participating in joint *Participating Scientist* opportunities to engage Heliophysics scientists as a part of the Juno Science Team



Core Capability: CCMC



- Leverage current capability to:
 - bring-in the best space weather modeling & data products to serve NASA missions & science community
 - define and implement internationally recognized metrics for space weather capabilities evaluations
 - leverage expertise, access to information
- Enables:
 - agile responses to new requirements
 - rapid implementation and evaluation of newly emerging techniques
 - an access portal to simulation results and observations
- International CCMC Workshop held 3-7 April 2017
- CCMC Programmatic Review held on 22-24 May 2017
 - Multi-agency review panel
 - Assessed current portfolio
 - Inform strategic planning

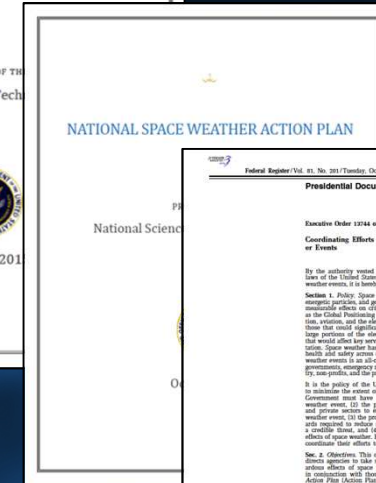
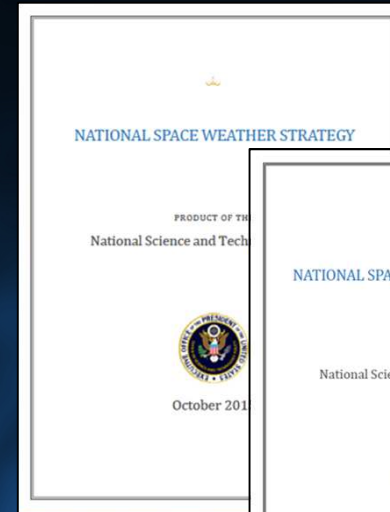




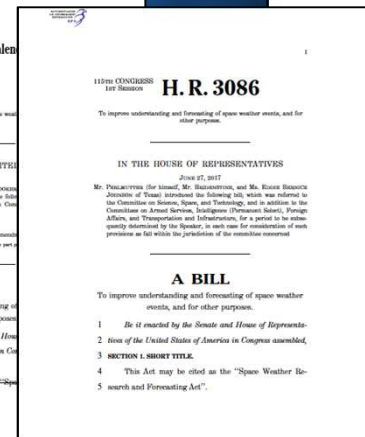
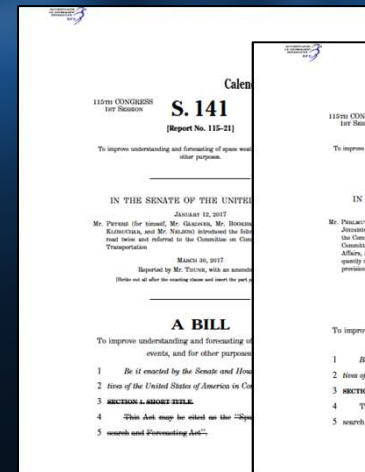
USG National Effort



- White House
 - National Space Weather Strategy and Action Plan
 - Executive Order 13744 (SWORM Subcommittee)
 - Executive Order 12675 (revival) (National Space Council)

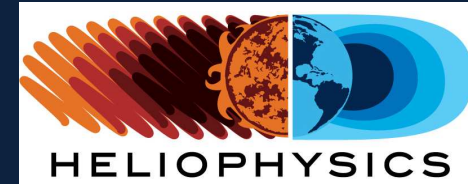


- Congress
 - Space Weather Research and Forecasting Acts
 - Senate (S.141) - passed
 - House (H.R.3086) - introduced

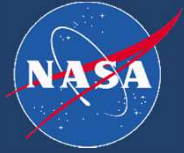




USG Partnerships



- NOAA-NASA MOU
 - Defines joint modeling activities to streamline the transfer of research models to operational use
 - Approved by both agencies
 - Kickoff meeting held in June
- NSF-NASA MOU
 - Final language under review
- NSF-NASA Research Award Opportunity – “*Computational Aspects of Space Weather*”
 - 3 -Year Research Award (FY18-20)
 - Includes NSF Directorates of Geosciences, Mathematical and Physical Sciences, and Computer and Information Science and Engineering
 - NASA anticipates contribution ~\$2M/YR from LWS Science funding
- Heliophysics Science Centers
 - Request for Information (RFI) released to community for implementation inputs
 - Committee for Solar and Space Physics issued a report in June 2017 recommending options for implementation and making the HSCs unique from other research elements



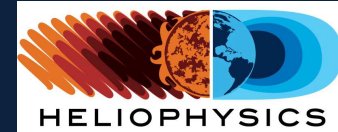
USG Partnerships



- NASA-NOAA-NSF O2R Pilot Project
 - Phase 1 of the R2O2R Capability White Paper in response to the National Space Weather Action Plan
 - ❖ Implement a prototype O2R project: Use one or more test cases to achieve near-term success and better define the O2R process and establish requirements
 - Solar data assimilation for predictive modeling
 - Includes use of GONG data, and preparatory development endeavors for DKIST (the Daniel K. Inouye Solar Telescope)
 - \$500k/each agency
 - Implementation in FY18



International Partnerships



- NASA-Space Situational Awareness (SSA) discussions (re: L5 mission)



- Geospace Model @ CCMC
- Development continuing for flying prototype coronagraph on a balloon flight in 2019



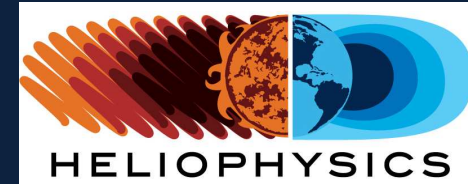
- Next Generation Solar Physics Mission (NGSPM) Science Objectives Team (SOT) draft delivered in May; final delivered on 31 July



- 3 sub-working groups established - 1) Aditya-1 mission collaboration, **2) space weather modeling,** 3) long-term strategic collaboration focus areas



Summary



- Significant progress is being made in US research programs to improve predictive capabilities.
- Current and future space-based and ground-based observatories will provide enhanced data for research and operational forecasts.
- The White House and the Congress support space weather research and improved forecasting capabilities to protect life on earth and human exploration beyond low Earth orbit.
- US government agency partnerships are becoming increasingly robust with the common goal of enhancing the Nation's space weather forecasting capabilities.
- Long-term interagency, international and public-private collaborations are critical to successfully *global* space weather preparedness.