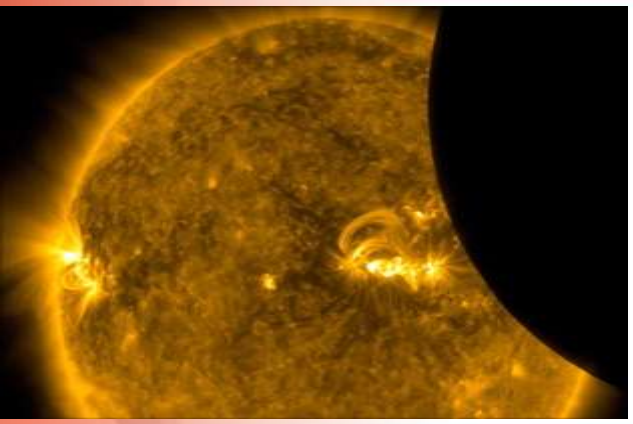
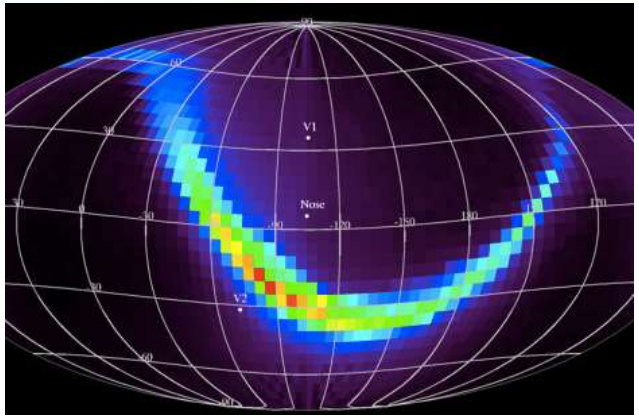
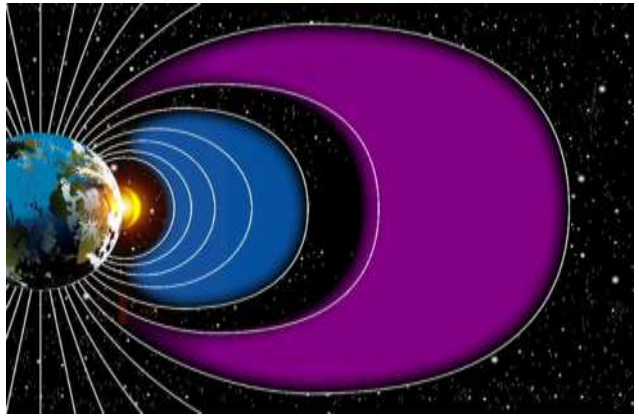
SCIENCE

National Aeronautics and Space Administration







NASA Living With a Star TR&T Town Hall

Renaissance Washington, DC Downtown

13 December, 2018

LWS Town Hall Agenda

Item	Time	Agenda Item	Presenter
1	6:30 PM	Welcome	Nicky Fox
2	6:35 PM	LPAG Status	Anthea Coster / Mark Linton
3	6:55 PM	LWS Program Status	Jeff Morrill / Simon Plunkett
4	7:15 PM	Multi-Agency Collaborations & Space Weather Activities	Janet Kozyra
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7	8:00 PM	ADJOURN	

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NASA Living with a Star Program Analysis Group (LPAG)

Executive Committee (EC) Co-Chairs:

- Anthea Coster (MIT Haystack Observatory)
- Mark Linton (Naval Research Laboratory, NRL)

EC Members:

- Joe Borovsky (Space Science Institute)
- Richard Collins (University of Alaska)
- Seebany Datta-Barua (Illinois Institute of Technology)
- Matina Gkioulidou (JHU / APL)
- Fan Guo (Los Alamos National Laboratory)
- Jorg-Micha Jahn (Southwest Research Institute)
- Enrico Landi (University of Michigan)
- John Leibacher (National Solar Observatory)
- Sabrina Savage (NASA / MSFC)
- Brian Walsh (Boston University)

See website at https://lwstrt.gsfc.nasa.gov/lpag

Living with a Star LPAG, continued

Liaison Members:

Charles N. Arge, *NASA GSFC*
Barbara Giles, *NASA GSFC*
Terry Onsager, *NOAA*
Vyacheslav Lukin, *NSF*
S. Irfan Azeem, *NSF*
Ghee Fry, *NASA MSFC*
Ekaterina M. Verner, *NASA HQ*
James Spann, *NASA MSFC*
Maria Kuznetsova, *NASA GSFC*
Simon Plunkett, *NASA HQ*

LWS Program Ex Officio:

Jeff Morrill, LWS Program Scientist (NASA HQ)
Janet Kozyra, LWS Science Lead (NASA HQ)
Shing Fung, LWS Website Manager (NASA GSFC)

2018 Charge from NASA Headquarters to LPAG Executive Committee

- Solicit community input for science topics; use this input to develop new Focused Science Topics (FSTs) for consideration by NASA for ROSES 2019 and beyond.
- Discuss the upcoming opportunity for Strategic Capabilities.
- Discuss methods for evaluating progress by FSTs in advancing LWS goals.

Development of LWS Focused Science Topics

- Solicited community input to TR&T science topics (5/7 – 7/2)
  - 46 distinct community inputs submitted.
- Four LPAG town halls held at conferences during summer of 2018:
  - at TESS, SHINE, GEM, and CEDAR.
- July 2018: Executive Committee drafted 21 topic write-ups from these community inputs, as well as from previous, as-yet un-competed TR&T topics, at first LPAG meeting
- Solicited community comment on these draft topics (9/7 – 10/19)
- October 2018: Executive Committee finalized 22 topic write-ups at second LPAG meeting (note - one topic was split into two).

Titles for 20 Focused Science Topics, Plus Two “Other” Topics

- Understanding the Impact of Thermospheric Structure and Dynamics on Orbital Drag
- Understanding and Predicting Radiation Belt Loss in the Coupled Magnetosphere
- Pathways of Cold Plasma through the Magnetosphere
- Understanding the Variability of the ITM System Due to Tides, Planetary Waves, Gravity Waves, and Traveling Ionospheric Disturbances
- The Variable Radiation Environment in the Dynamical Solar and Heliospheric System
- The Origin and Consequences of Suprathermal Particles that Seed Solar Energetic Particles

Titles for 20 Focused Science Topics, Plus Two “Other” Topics

- Connecting Thermospheric Composition and Space Weather
- Understanding Ionospheric Conductivity and Its Variability
- Modeling and Validation of Ionospheric Irregularities and Scintillations
- Fast Reconnection Onset
- Extreme Solar Events – Probabilistic Forecasting and Physical Understanding
- Connecting Auroral Phenomena with Magnetospheric Phenomena

Titles for 20 Focused Science Topics, Plus Two “Other” Topics

- Understanding Space Weather Effects and Developing Mitigation Strategies for Human Deep Space Flight
- Solar Photospheric Magnetic Fields
- Magnetospheric and Ionospheric Processes Responsible for Rapid Geomagnetic Changes
- Coupling of Solar Wind Plasma and Energy into the Geospace System
- Combining Models and Observations to Study CME Plasma Energetics in the Inner Corona

Titles for 20 Focused Science Topics, Plus Two "Other" Topics

- Atmospheric Evolution and Loss to Space in the Presence of a Star
- Sun-Climate: Long Term Variability and Predictability of the Solar-Driven Earth System
- Hemispherical Asymmetries in Magnetosphere-Ionosphere-Thermosphere Coupling Processes: Fundamental Causes and Myriad Manifestations
- Data Science and Analytics (Tools and Methods Topic)
- Correcting or Mitigating Artifacts in HMI Photospheric Magnetic Fields (likely outside scope of TR&T – possible HGI or Tools and Methods?)

Discussion of LWS Strategic Science Areas

Strategic Science Areas (SSAs) for LWS Targeted Research and Technology (TR&T) program articulated in the LWS Ten Year Vision from 2015:

Physics–Based Understanding to Enable Forecasting of

- **SSA-0:** Solar electromagnetic, energetic particle, and plasma outputs driving the solar system environment and inputs to Earth's atmosphere
- **SSA-1:** Geomagnetic Variability
- **SSA-2:** Satellite Drag
- **SSA-3:** Solar Energetic Particles
- **SSA-4:** Total Electron Content (TEC)
- **SSA-5:** Ionospheric Scintillation
- **SSA-6:** Radiation Environment

Discussion of Strategic Science Areas

- Based on community input, two Focused Science Topics were drafted that highlighted a need for updates to the SSAs. Proposed updates are as follows:

- For the FST "Understanding Space Weather Effects and Developing Mitigation Strategies for Human Deep Space Flight," it is suggested that SSA-6 be updated to extend beyond low earth orbit:
  - SSA-6, Physics-based Radiation Forecasting Capability for Spacecraft, Aviation, and Human Space Flight from the Near-Earth to the Deep Space Environment

- For the FST "Atmospheric Evolution and Loss to Space in the Presence of a Star," it is suggested that a new SSA be drafted. An initial version of this is available in the report as:
  - A proposal for a new Strategic Science Area (SSA-7) for the Living With A Star Program - The Heliophysics of Planetary Habitability

Review: Strategic Capabilities Founding Guidelines (2003 SDT Report)

1) The project delivers a model that is deemed by the review panel to be essential for making progress toward the ultimate goal of forecasting and specifying the coupled Sun-Earth system.
2) The model can serve as a prototype for operational capability; it must use actual data as input and produce useful output.
3) The project delivers a tool that is deemed by the review panel to have broad, cross-disciplinary science applicability. The size of the likely user base for the proposed tool should be a major factor in its selection.
4) The project provides easy access to the model, either directly by the developers or through a modeling center. In the case of software, the source code and documentation should be required to be delivered to one of the modeling centers utilized by LWS.

Discussion of Upcoming Strategic Capability Opportunity

The consensus of the LPAG Executive Committee was that it would be beneficial for the Strategic Capability to be open to all topics relevant to LWS goals (as for the 2012 call), subject to the founding guidelines for the Strategic Capability program (see previous slide).

Other priorities supported by the LPAG EC discussion:

- Transition to CCMC: That the proposals include an explicit plan for transition of the proposed capability to the Community Coordinated Modeling Center (CCMC), with milestones along the way, and that communication with the CCMC be established early in the project.

- Model Compatibility: For cases where the project develops output of one model for input into another, that the proposal includes a plan to ensure that the output is compatible with the required input.

Discussion of Upcoming Strategic Capability Opportunity

Other priorities supported by the LPAG EC discussion, continued:

- Robustness: That plans be specified in the proposal to ensure a certain level of robustness for the capability to be produced, namely, that error analysis, metrics, validation and/or sensitivity analysis be included. In addition, that the use of data for validation be encouraged.

- User Utility: That the proposal makes the case that it will develop and transition capabilities that will be useful to prospective users, and that are not already in CCMC, or that could add to the CCMC capabilities for doing ensemble model simulations.

- Training: That the proposals make a case that the proposed team contributes to the training of the next generation of researchers and model developers.

Metrics for Evaluating Progress Towards Achieving LWS-TR&T Goals

- The LPAG discussed ways to evaluate the progress made by FSTs in addressing NASA Heliophysics and LWS goals.
- In particular, the discussion focused on how the LPAG could use information from past and ongoing FSTs as input for new FSTs.
- The discussion also focused on ways to enable the flow of information from one FST to the next, and to identify results from one FST that would enable progress in a following one.
- This discussion is ongoing, and will be continued at next year's LPAG meetings.

Metrics for Evaluating Progress Towards Achieving LWS-TR&T Goals

Primary conclusion - strong benefit if FST team leads prepared final reports to be posted on the LWS TR&T website, including:

Extended summary

- What was accomplished by the FST, both by the individual proposal units, and by the team as a whole? What scientific capabilities were added or improved?
- What are the next steps for this topic? What challenges and open questions arose which could not be addressed by this FST, and which would therefore be good challenges for future FSTs? What are the remaining gaps that need to be filled?
- What synergies emerged from the team dynamic?

Brief summary (~ 1 page) with bulletized lists of:

- Research highlights
- Remaining challenges and open questions
- Team dynamics

Possible Discussion Topics for 2019 LPAG

- Revisit and review topic write-ups from 2016 and 2018 reports which have not yet been selected by NASA.
- Solicit community input on these remaining topics, as well as input for possible new topics.
- Revisit SSAs 0 – 6, and possible new SSA 7. Solicit community input on these SSAs.
- Continue discussion of metrics for evaluating progress towards achieving LWS – TR&T goals.

Background Slides

2016 TR&T Committee Report: Focused Science Topics

- Mid-latitude and Equatorial Dynamics of the Ionosphere-Thermosphere System **(ROSES 2018)**
- Origins, Acceleration and Evolution of the Solar Wind **(ROSES 2018)**
- Ion Circulation and Effects on the Magnetosphere and Magnetosphere - Ionosphere Coupling **(ROSES 2017)**
- Toward a Systems Approach to Energetic Particle Acceleration and Transport on the Sun and in the Heliosphere **(ROSES 2017)**
- Coupling Between Different Plasma Populations by Means of Waves

2016 TSC Report: Focused Science Topics

- Probabilistic Forecasting and Physical Understanding of Extreme Events
- Understanding Physical Processes in the Magnetosphere--Ionosphere / Thermosphere / Mesosphere System During Extreme Events **(ROSES 2017)**
- Understanding the Impact of Thermospheric Structure and Dynamics on Orbital Drag
- Solar Magnetic Inputs to Coronal and Heliospheric Models
- Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures **(ROSES 2018)**

2016 TSC Report: Focused Science Topics

- Heliospheric and Magnetospheric Energetic Precipitation to the Atmosphere and Its Consequences
- Understanding The Onset of Major Solar Eruptions **(ROSES 2017)**
- Understanding Ionosphere-Thermosphere (IT) responses to high-latitude processes and Magnetospheric energy input
- Enabling Geospace System Science Through Imaging and Distributed Arrays
- Understanding Global-scale Solar Processes and their Implications for the Solar Interior **(ROSES 2018)**

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Welcome to the Heliophysics Division!

Dr. Nicky Fox

Director

Dr. Simon Plunkett

Program Scientist

Dr. Roshanak Hakimzadeh

Program Scientist

Dr. Patrick Koehn

Program Scientist – IPA

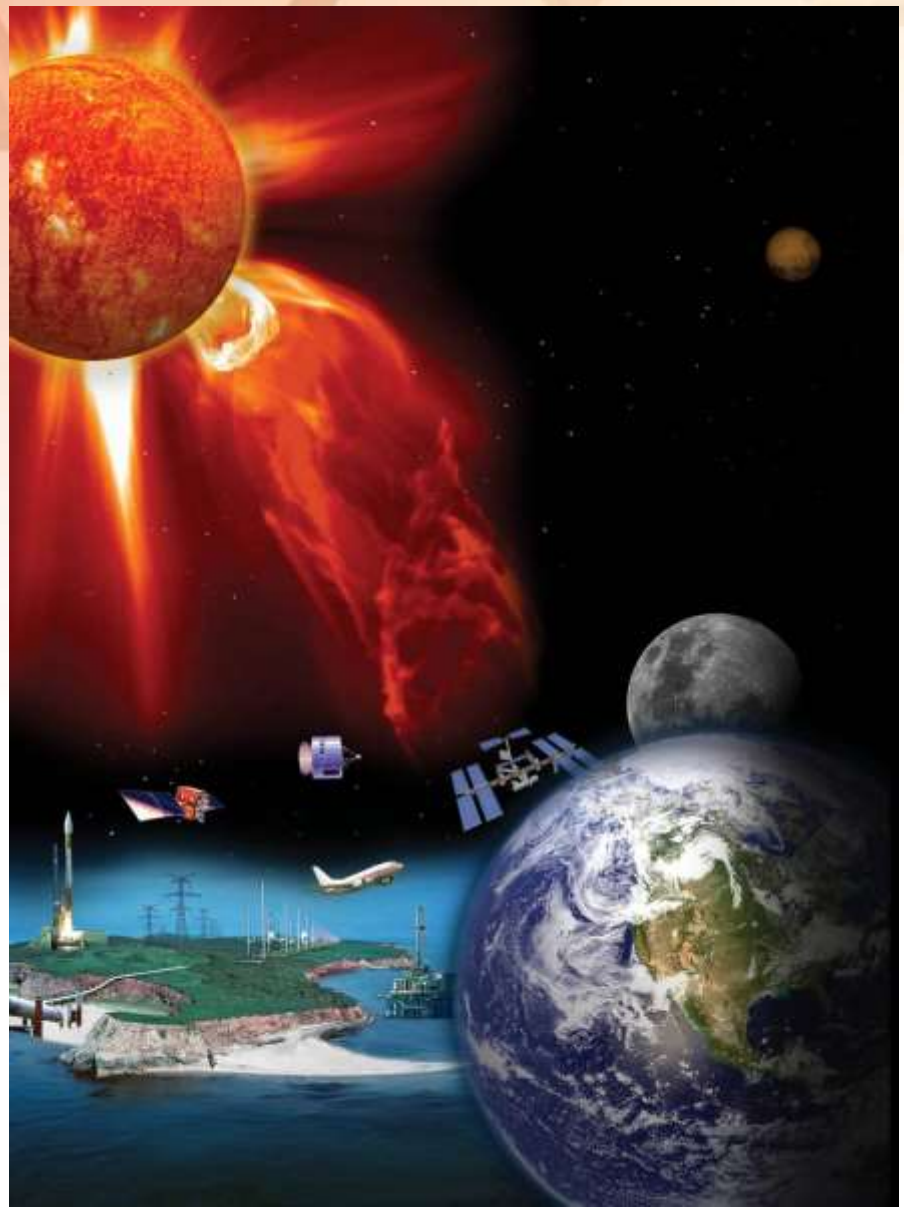
Nicole Turner

Management Analyst – Detailee from GSFC

Susie Darling

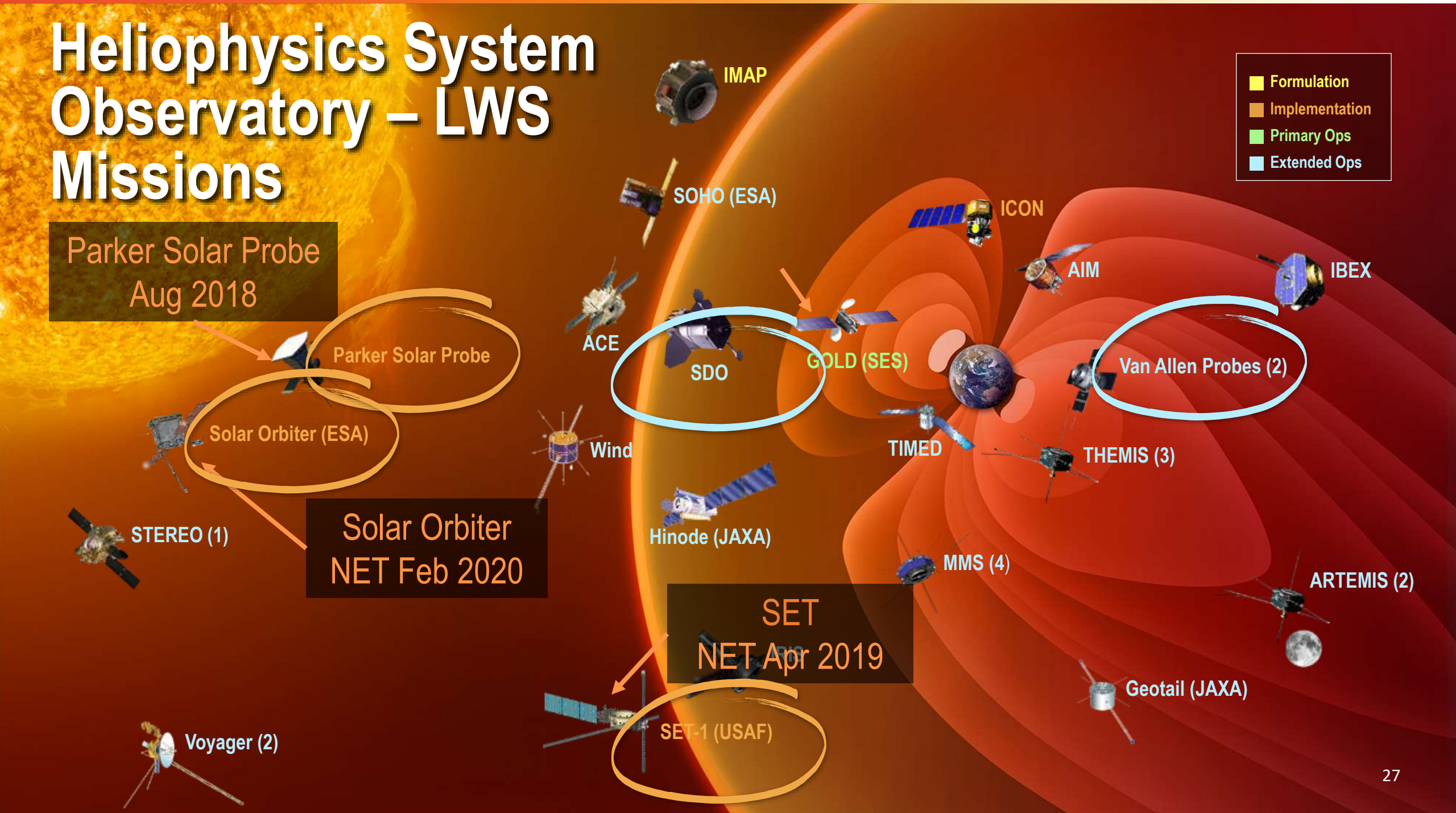
Outreach Coordinator and Public Engagement Writer

Living With a Star (LWS)

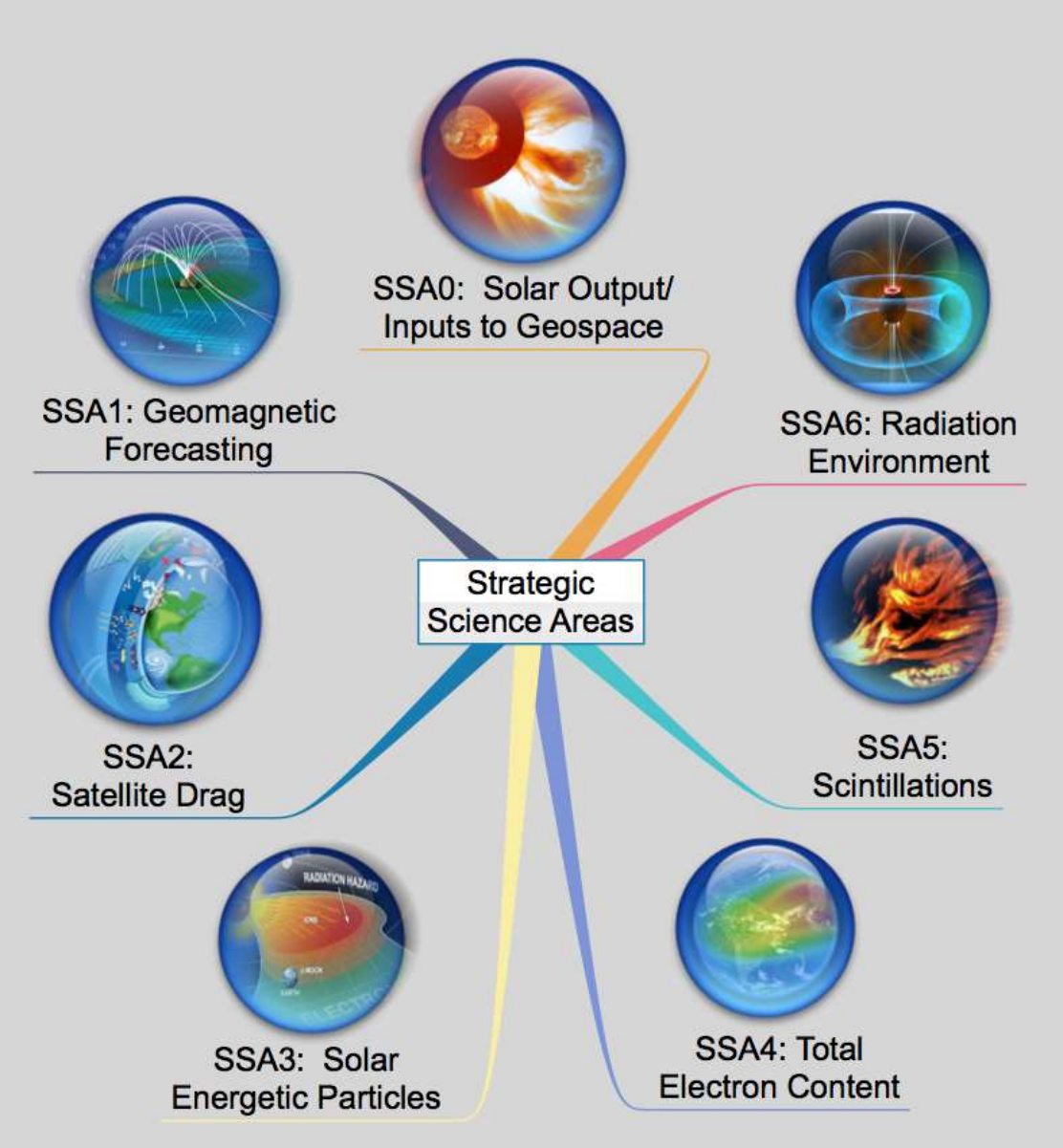


- LWS program emphasizes the science necessary to understand those aspects of the Sun and Earth's space environment that affect life and society and that enable human and robotic exploration of the solar system.
- LWS goal is to provide a scientific understanding of the system that leads to predictive capability of the space environment conditions at Earth, other planetary systems, and in the interplanetary medium.
- LWS objectives:
  - Understand how the Sun varies and what drives solar variability
  - Understand how the Earth and planetary systems respond to dynamic external and internal drivers
  - Understand how and in what ways dynamic space environments affect human and robotic exploration activities.

Heliophysics System Observatory – LWS Missions



Strategic Science Areas



- Seven LWS Strategic Science Areas (SSAs) requiring cross-disciplinary collaboration for predictive development
- SSAs represent long-term goals of the LWS program that will be developed through Focused Science Topics (FSTs), Strategic Capabilities (SCs), and Targeted Science Teams (TSTs).

LWS Science Selections – ROSES 2017

- Proposals were solicited for 4 FSTs:
  - Understanding the Onset of Major Solar Eruptions
  - Toward a Systems Approach to Understanding Energetic Particle Acceleration and Transport on the Sun and in the Heliosphere
  - Ion Circulation and Effects on the Magnetosphere and Magnetosphere – Ionosphere Coupling
  - Understanding Physical Processes in the Magnetosphere – Ionosphere/Thermosphere/ Mesosphere System During Extreme Events
- Proposals were due in February 2018
  - A total of 117 Step 2 proposals were received
- Selections were announced in October 2018
  - 30 proposals (26%) were selected for funding, and organized into 4 FST teams (see next slide).

New FST Teams – ROSES 2017

FST #1: Understanding the Onset of Major Solar Eruptions	FST #2: Toward A Systems Approach to Understanding Energetic Particle Acceleration and Transport	FST #3: Ion Corculation and Effects on the Magnetosphere and Magnetosphere – Ionosphere Coupling	FST #4: Physical Processes in the Magnetosphere – ITM System During Extreme Events
Linton (NRL) - LEAD	Cohen (Cal Tech) - LEAD	Kistler (UNH) - LEAD	Fuller-Rowell (UC Boulder) - LEAD
Antiochos (GSFC) Barnes (NWRA) Fan (UCAR) Lynch (UC Berkeley) Savcheva (SAO) Scherrer (Stanford)	Dayeh (SWRI) Gary (NJIT) Lario (JHU/APL) Li (UAH) St. Cyr (GSFC) Vourlidas (JHU/APL) Zhao (Florida Tech)	Chi (UCLA) Jahn (SWRI) Jordanova (LANL) Lyon (Dartmouth) Sanchez (SRI Int'l)	Bazulukova (UMD) Coster (MIT) Datta-Barua (Illinois Tech) Kang (CUA) Oppenheim (BU) Pulkkinen (GSFC) Siskind (NRL) Sitnov (JHU/APL)

Enhancing the Effectiveness of Multi-Team Science

- Identify a shared overarching goal or set of goals that is central to the FST, is compelling to all participants, and may be attainable within the timeframe of the project
- Identify roles and responsibilities for each team and team member
- Develop team charters that lay out the scope of work for each team and achieve consensus on the approach.

- Be aware of the characteristics of effective teams (and teams of teams), and the challenges of working in teams (particularly diverse, geographically separated virtual teams)
- See the 2015 NRC Report on *Enhancing the Effectiveness of Team Science*.

LWS Science Solicitation – ROSES 2018

ROSES 2018 FSTs

- Understanding Global-Scale Solar Processes and their Implications for the Solar Interior
- Origins, Acceleration and Evolution of the Solar Wind
- Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures
- Mid-Latitude and Equatorial Dynamics of the Ionosphere – Thermosphere System

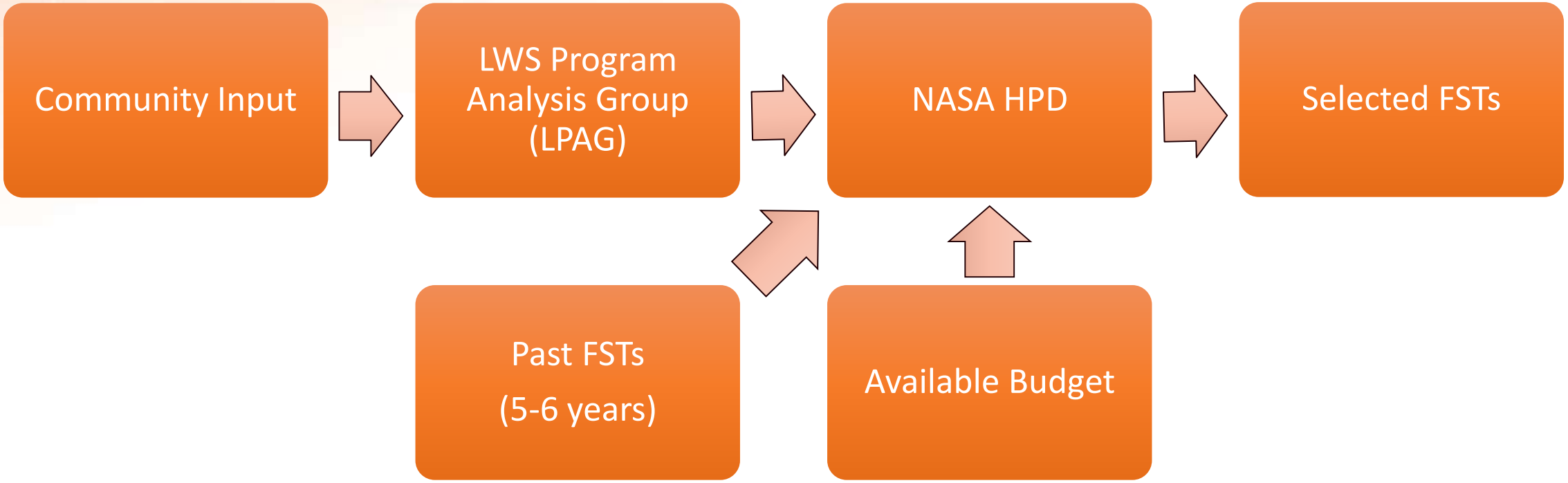
Important Dates

- ROSES 2018 LWS Amendment: December 2018
- Step 1 Proposals: February 14, 2019
- Step 2 Proposals: April 11, 2019

FST Development and Selection Process

Community are LPAG members

Acts as Executive Committee



Draft FSTs and Dates – ROSES 2019

ROSES 2019 Draft FSTs

- The Variable Radiation Environment in the Dynamical Solar and Heliospheric System
- Fast Reconnection Onset
- Magnetospheric and Ionospheric Processes Responsible for Rapid Geomagnetic Changes
- Hemispherical Asymmetries in Magnetosphere – Ionosphere – Thermosphere Coupling Processes: Fundamental Causes and Myriad Manifestations

Important Dates

- ROSES 2019 LWS Amendment: February 2019
- Step 1 Proposals: ~October 2019 – after ROSES 2018 selections
- Step 2 Proposals: ~January 2020

FST #1: Variable Radiation Environment

Goals

- Determine the influence of solar and heliospheric plasma dynamics on high-energy particle radiation environments within the heliosphere
- Determine the influence of major solar eruption events on the high-energy particle environment near Earth and in interplanetary space
- Improve models of cosmic ray modulation in the heliosphere, high-energy particles from major solar eruptions, and Forbush decreases due to extreme CME events.

Applicability to NASA Heliophysics and LWS

- Addresses SSA-0, SSA-3, and SSA-6.

FST #2: Fast Reconnection Onset

Goals

- Establish an understanding of the critical conditions for the onset of fast reconnection at a current sheet in various regimes relevant for heliophysics
- Determine onset criteria for fast reconnection, and how the reconnection speed depends on these various regimes
- Investigate global- and local-scale processes that lead to reconnection in the solar corona, solar wind, and Earth's magnetosphere
- Establish predictive parameters for the onset of reconnection that can be implemented in large-scale MHD codes for the solar corona, solar wind, and Earth's magnetosphere.

Applicability to NASA Heliophysics and LWS

- Addresses SSA-0, SSA-1, SSA-3, and SSA-6.

FST #3: Magnetosphere – Ionosphere Processes Responsible for Rapid Geomagnetic Changes

Goals

- Determine solar wind parameters, magnetospheric conditions, and ionospheric properties that affect the rate of change of the geomagnetic field in the coupled solar wind – magnetosphere – ionosphere system
- Establish a predictive capability for geomagnetically induced current (GIC) events.

Applicability to NASA Heliophysics and LWS

- Addresses SSA-0 and SSA-1.

FST #4: Hemispherical Asymmetries in Magnetosphere – Ionosphere – Thermosphere Coupling

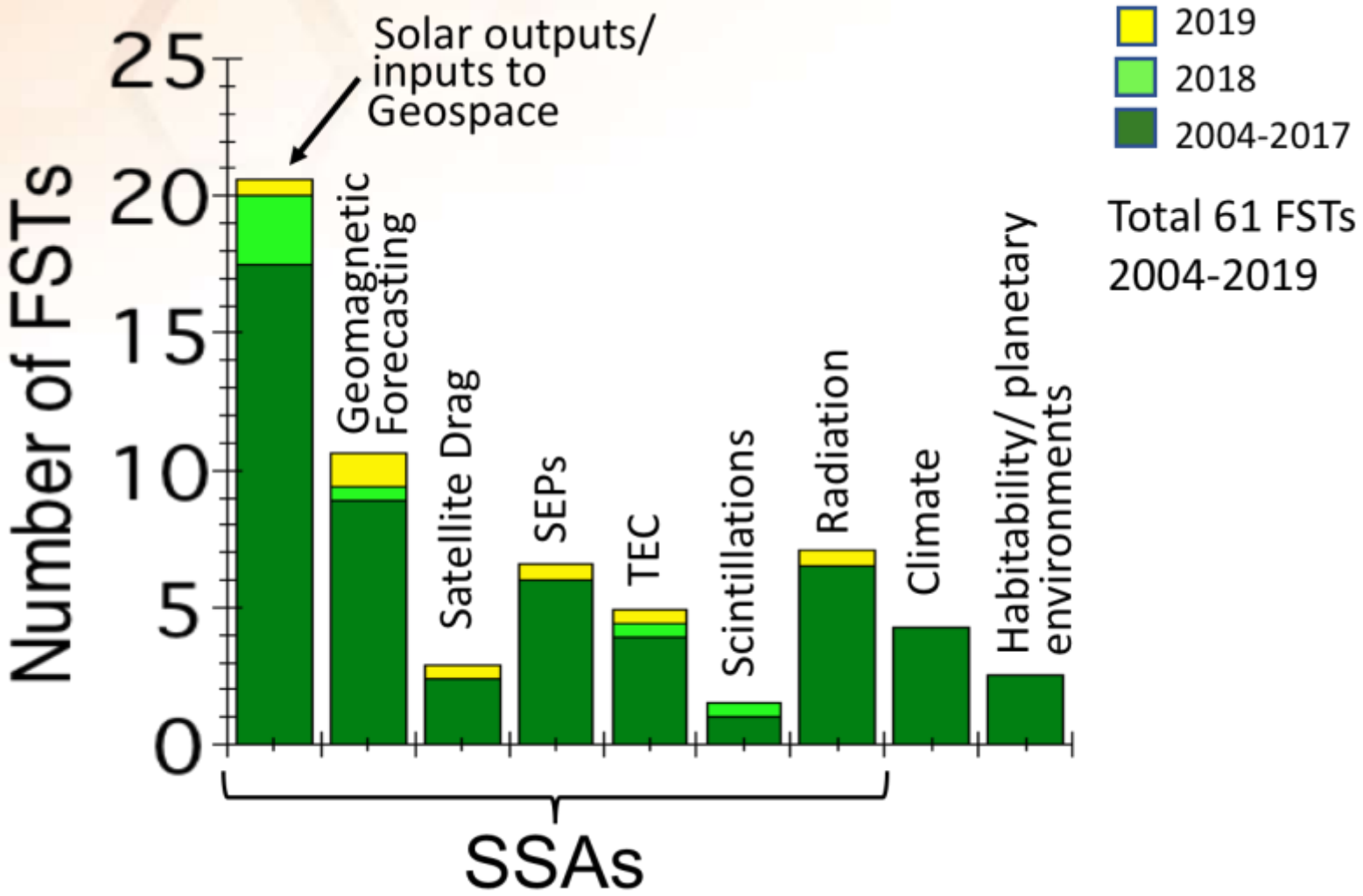
Goals

- Understand the fundamental causes of hemispherical asymmetries in magnetosphere – ionosphere – thermosphere coupling processes
- Determine the drivers of the observed asymmetries and how these drivers interact with each other
- Determine how these asymmetries affect time-dependent changes in TEC and neutral density.

Applicability to NASA Heliophysics and LWS

- Addresses SSA-2 and SSA-4.

LWS FSTs Related to SSAs (2004 – 2019)



Note: Some FSTs fall under multiple SSAs. Counted as fractional FSTs that sum to 1.0

Strategic Capabilities

- Strategic Capabilities (SCs) are large-scale models and tools that can test understanding and serve as prototypes for prediction schemes
- SCs were last competed as a NASA – NSF Partnership for Space Weather Modeling in ROSES 2011 (successful proposals funded in CY 2013)
- ROSES 2019 will include a call for SC proposals
- Potential topics for investigation may include (based on 2015 LWS Vision):
  - Derive a model, or coupled set of models, to specify the global neutral density in the heliosphere and its variations over time
  - Derive a unified model of CME propagation, SEP acceleration and transport within the context of realistic models of the corona and inner heliosphere
  - Derive a model, or coupled set of models, to specify the global ion density in the ionosphere and plasmasphere and its variation over time under varying geomagnetic conditions
  - Provide improved specification and prediction of the radiation environment from geosynchronous orbit, through the radiation belts and thermosphere, into the troposphere.

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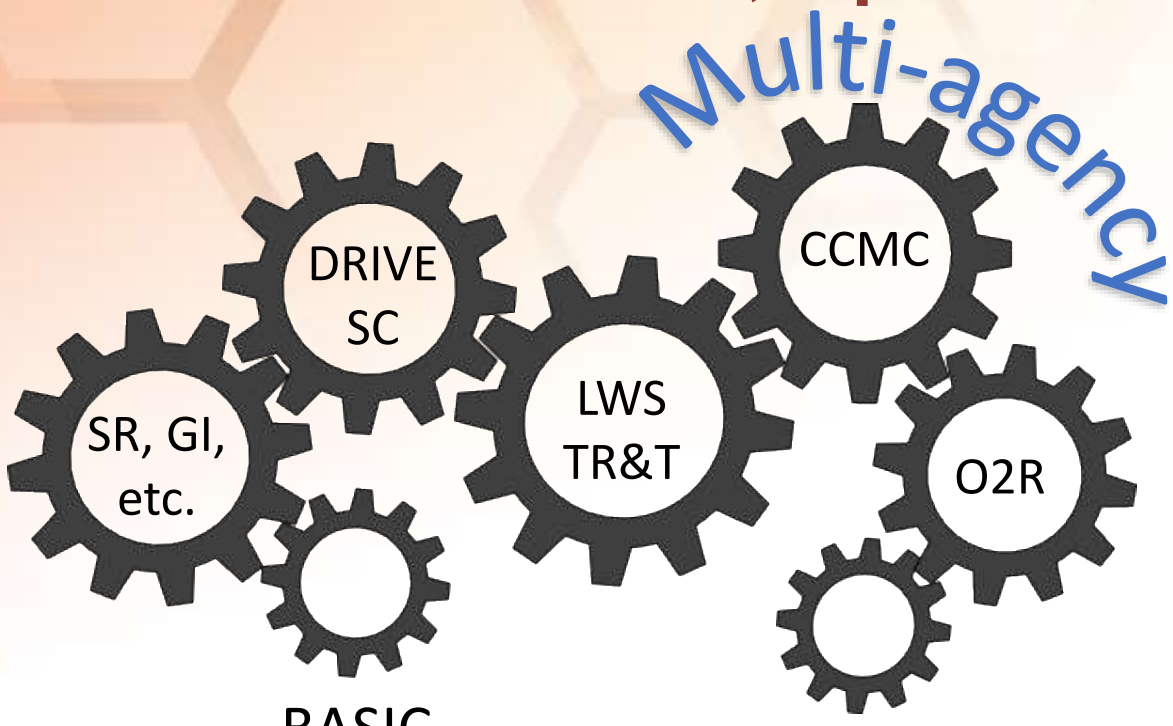
Synergies: LWS Science, DRIVE Science Centers, Space Weather Elements, Operations to Research



BASIC

APPLIED

(National Space Weather Strategy & Action Plan, International Collaboration)

Heliophysics Research → Space Weather Services

- LWS Science (TR&T, Strategic Capabilities, Tools & Methods, Initiatives, LWS Institutes, Jack Eddy Fellows)
- Heliophysics DRIVE Science Centers (DSCs)
- Space Weather Program Elements
- NASA-NOAA Operations to Research Program
- NSF-NASA Space Weather Modeling

Moving forward on the most compelling science questions in Heliophysics

Relationship: LWS Science & DRIVE Science Centers

"NASA and NSF together should create science centers to **tackle the key science problems of solar and space physics** that require multidisciplinary teams of theorists, observers, modelers, and computer scientists."

- 2013 Solar and Space Physics Decadal Survey

Implemented as a component of the Grand Challenges Research program.

Space Weather R2O elements in the DSCs can be included to connect exciting science results with societal benefits. Not core focus. Frontier science is the focus.

Timeline for DRIVE Science Center Proposals

Deadline for public comments on Draft Solicitation. Draft released for comment on Sept 7.

Step-1 proposal due date

Dec 2017 → **Sept 21, 2018** → **Nov 30, 2018** → **Jan 15, 2019** → **Mar 15, 2019**

Gathering Inputs

- CSSP HSC Report, 2017
- RFIs deadline 9/5/17
- NSF collaboration on program design
- LWS Town Hall

Call Released for Phase I DRIVE Science Centers. FAQs to be uploaded in the very near term

Step-2 full proposal due date

NASA-NSF Collaborations on Space Weather Modeling

NASA-NSF Partnership for Collaborative Space Weather Modeling (2013-2019)

- Aligned with ***LWS strategic capabilities*** element
- Final year 2019
- Models made available for community usage at CCMC
- User friendly interfaces
- Assessment of future needs

New NSF-NASA Partnership, starting in 2019

- Computational Aspects of Space Weather
- Collaboration with NSF Directorate for Mathematics & Physical Science (MPS), the Directorate of Geosciences (GEO), and the Directorate for Computer & Information Science and Engineering (CISE)
- Expands and complements *LWS Strategic Capabilities* element
- Advances the objectives of the National Space Weather Strategy and Action Plan
- Call anticipated in 2019

Status of Space Weather Efforts – Recent US Policy Directives

U.S. Congress - 2010 NASA Authorization Act:

- "Space weather events pose a significant threat to modern technological systems."
- **Action**: Director of Office of Science and Technology Policy (OSTP) to improve space weather preparedness and coordinate among U.S. government agencies

Federal Energy Regulatory Commission – Order No. 779, 2013

- Directed standards to address effects of space weather on the reliable operation of the electric power grid.

Status of Space Weather Efforts – Recent US Policy Directives

Space Weather Operations, Research, and Mitigation Task Force

- Established by OSTP National Science and Technology Council - 2014
- Developed National Space Weather Strategy and Action Plan - 2015

National Defense Authorization Act - 2017

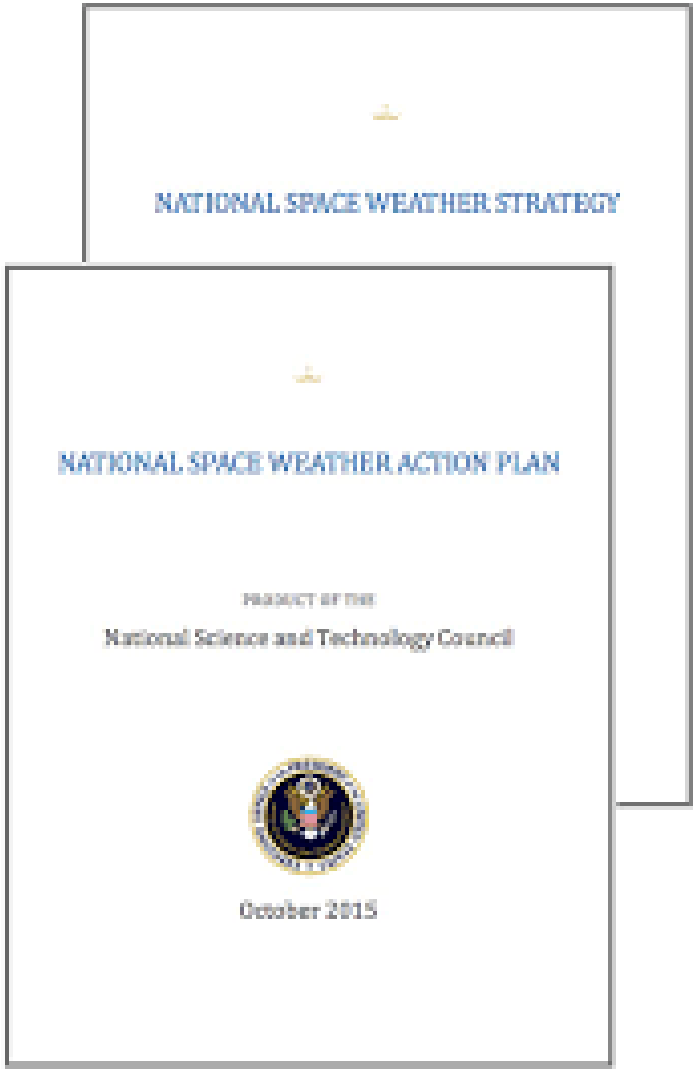
- Strategy to prepare for natural and adversarial electromagnetic pulses

Space Weather Research and Forecasting Act

- Passed by the U.S. Senate by unanimous consent – May, 2017
- House Science Committee approved July 24, 2018 a modified version - tasking the National Space Council with overseeing the national coordinating framework
- House and Senate now need to reconcile their bills.

National Space Weather Strategy and Action Plan

1. **Establish benchmarks for extreme events**
2. Enhance response and recovery
3. Improve protection and mitigation
4. Improve modeling of impacts on critical infrastructure
5. **Improve services through advancing understanding**
6. Increase international cooperation



20 Government Departments, Agencies and Service Branches

Goal 1: Benchmarks

Provide a clear description of space weather events based on scientific and historical knowledge: 1 in 100 year event and theoretical maximum

- Induced electric fields
- Ionizing radiation (NASA lead)
- Ionospheric disturbances
- Solar radio bursts
- Upper atmospheric expansion

Phase 1 document was released through the Federal Register, and input has been addressed

Broader national and international input will be obtained through upcoming community meetings

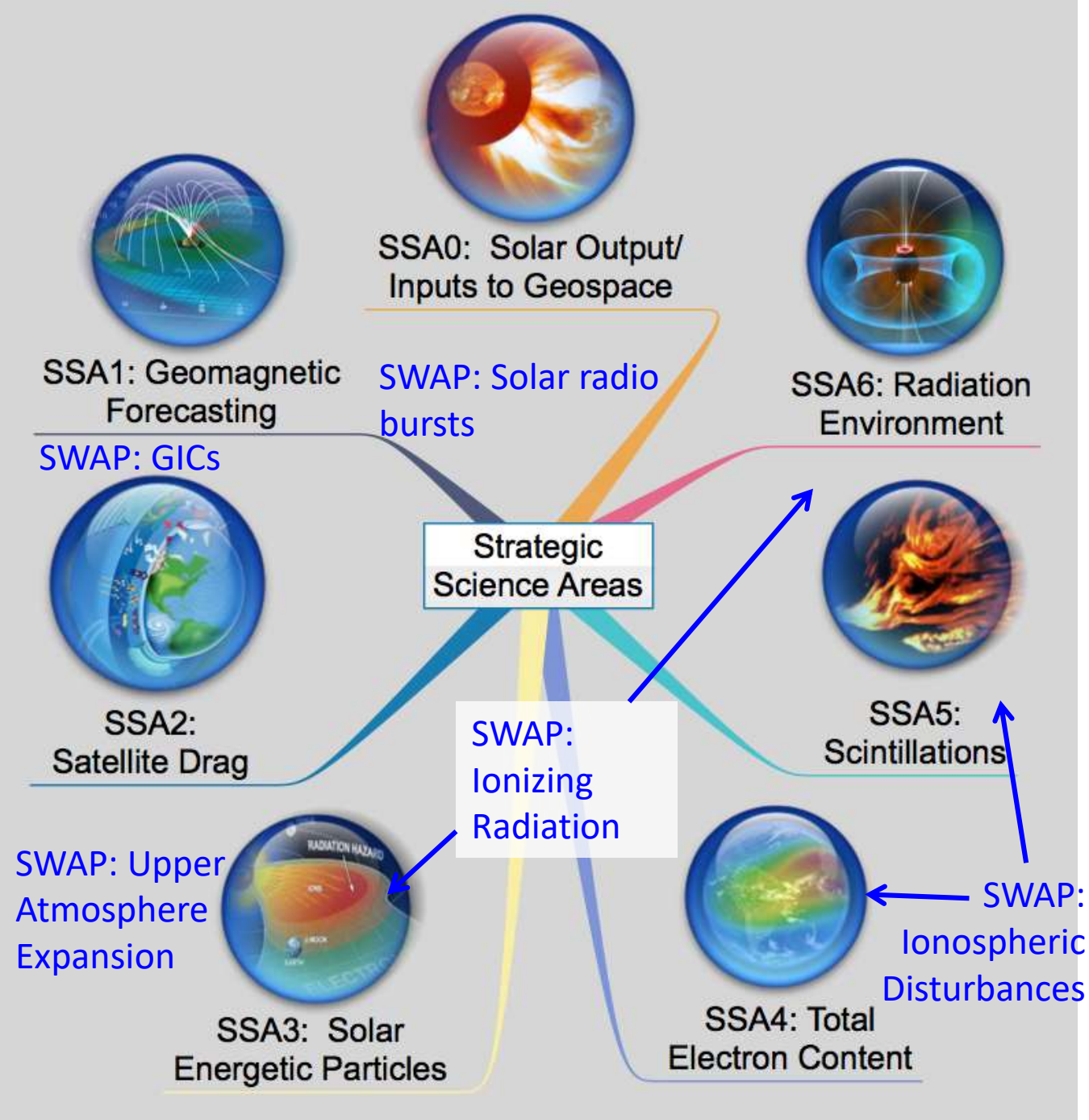
Goal 5: Improve Services Through Advancing Understanding

Coordinated interagency space weather research funding

Joint NASA/NOAA operations-to-research pilot funding opportunity. (more details in later slide)

NSF released separate opportunity – tri-agency MOU drafted for future opportunities

LWS Strategic Science Areas (SSA) versus SWAP Benchmarks



Existing areas of focus in LWS align with research needed to achieve National priorities in extreme space weather prediction

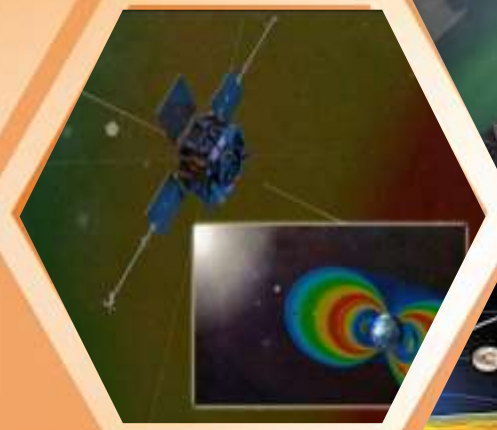
Synergies accelerate progress on LWS goals and benefit national preparedness.

LWS, Space Weather Collaboration on Extreme Space Weather in Geospace

- 2017 LWS FST4: Understanding Physical Processes in the Magnetosphere - Ionosphere / Thermosphere / Mesosphere System During Extreme Events

- Space Weather Program partnered with LWS
  - Funded two additional proposals
  - Covering science areas that broaden and enhance the FST team
  - Topic closely aligned with SWAP priorities

NASA-NOAA Space Weather Operations to Research (O2R) Program



- Supports National Space Weather Strategy & Action Plan
- Objective =Improvements of operational capabilities and advancements in related fundamental research
- Facilitate O2R activities to improve space weather prediction
- NSF, NASA-NOAA independent pilot studies. Jointly selected topic
- <u>NASA-NOAA O2R Pilot</u>
  - **2017**: ~$1.0M available, 8 one-year awards August 2018
    - *Focus*: Improve forecasts of the background solar wind, solar wind structures, and coronal mass ejections using solar and solar wind data and models, if possible employing data assimilation techniques
- <u>NASA-NOAA 02R Program</u>
  - **2018**: ~$4.0M available, 9 two-year awards October 2018
    - *Focus*: Improve specifications and/or forecasts of the energetic particle and plasma conditions encountered by spacecraft
  - **2019**: ~$2.0M available
    - Call released Nov. 2018; Step-1 proposals due Feb 1, 2019
    - *Focus*: Improve forecasts of the energetic proton and/or heavy ion conditions in the heliosphere due to solar eruptions

Summary

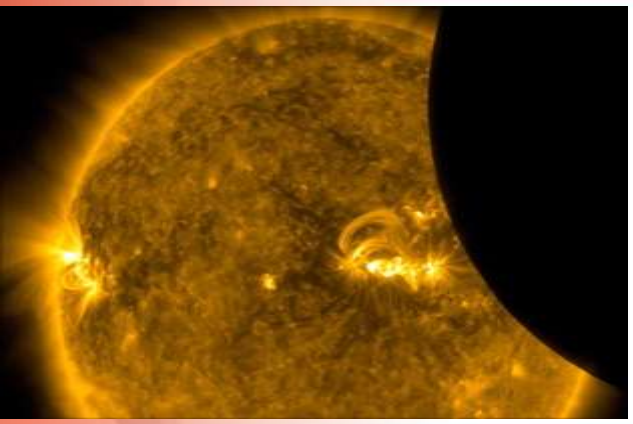
- LWS Science is at the center of collaborating programs that connect heliophysics research advances to space weather service capabilities
- The LWS Strategic Science Areas (SSA's) are closely aligned with National Priorities
- In keeping with national policy directives, LWS is central to multi-agency partnerships on space weather modeling and O2R
- Coordinated multi-agency funding has been initiated to support both of these partnerships

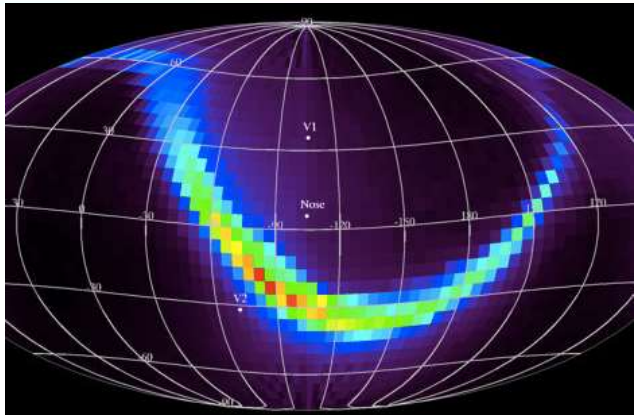
LWS Town Hall Agenda

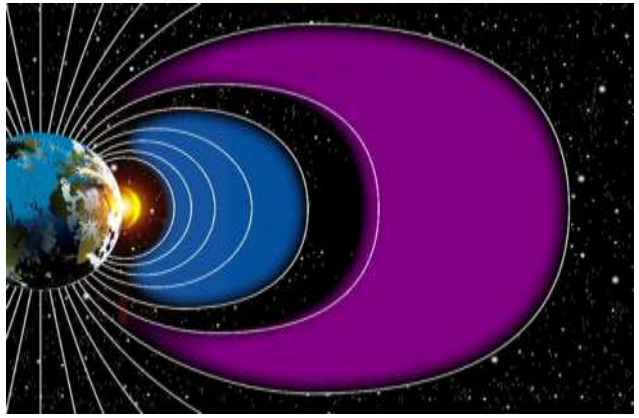
Item	Time	Agenda Item	Presenter
1	6:30 PM	Welcome	Nicky Fox
2	6:35 PM	LPAG Status	Anthea Coster / Mark Linton
3	6:55 PM	LWS Program Status	Jeff Morrill / Simon Plunkett
4	7:15 PM	Multi-Agency Collaborations & Space Weather Activities	Janet Kozyra
5	7:30 PM	GDC STDT Status	Jared Leisner
6	7:45 PM	LWS Infrastructure & New Initiatives	Lika Guhathakurtha
7	8:00 PM	ADJOURN	

SCIENCE

National Aeronautics and Space Administration







Geospace Dynamics Constellation Status

Jared Leisner

GDC Program Scientist

Heliophysics Division

December 13, 2018

Introduction

- The Decadal Survey recommended GDC as the LWS strategic mission.
  - The DS gave broad science goals and a nominal mission implementation to show feasibility.
- HQ formed the STDT to update the science objectives and to constraint possible mission implementations.
  - The STDT is chartered as a subcommittee for the Heliophysics Advisory Committee (HPAC), just as last year's Senior Review was.
- STDT in-person meetings have invited the public's virtual attendance and all presentations to the STDT are posted on the STDT webpage (link on final slide).
- The final STDT report will be delivered to HPAC, who will discuss the report and will deliver their recommendation (along with the report) to NASA.

Scope of Work

- Definition of a compelling science investigation for the GDC mission.
  - Prioritized science objectives updated from the Decadal Survey science goals
  - Geophysical parameters and measurement requirements to close on the prioritized science objectives
- Constraining resource requirements for mission implementations that would meet science requirements.
  - The STDT is discussing multiple potential implementations for the final report.
  - The STDT is not charged with recommending a particular mission implementation.

Timeline

• Aug. 2017	Call for Letters of Application published
• Oct. 2017	Request for Information released
• May 2018	STDT first in-person meeting
• July 2018	STDT second in-person meeting
• Nov. 2018	STDT third in-person meeting
• **Dec. 19, 2018**	**STDT mid-term report to HPAC**
• Sp./Su. 2018 (exp.)	STDT report delivered to HPAC
	STDT disbanded
	HPAC delivers recommendation to NASA

Questions?

http://bit.ly/HPAC-Dec2018
http://bit.ly/GDC-STDT

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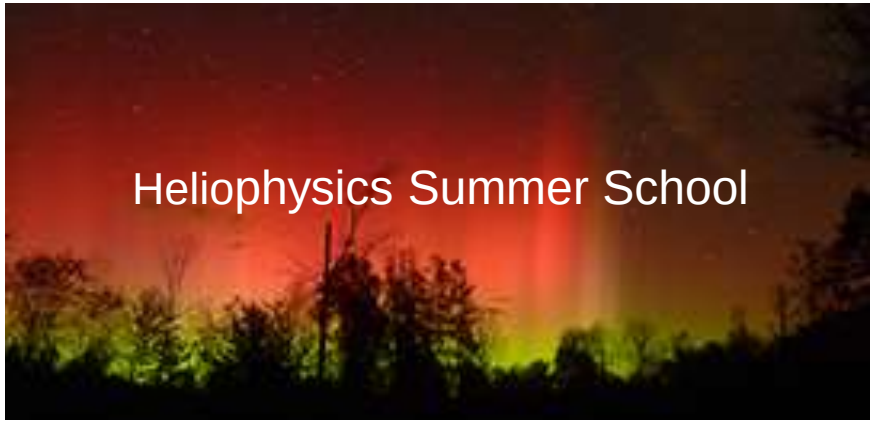
7	8:00 PM	ADJOURN	

CPAESS

Cooperative Programs for the Advancement of Earth System Science

Part of the University Corporation for Atmospheric Research (UCAR)



UCAR COMMUNITY PROGRAMS

December 2018

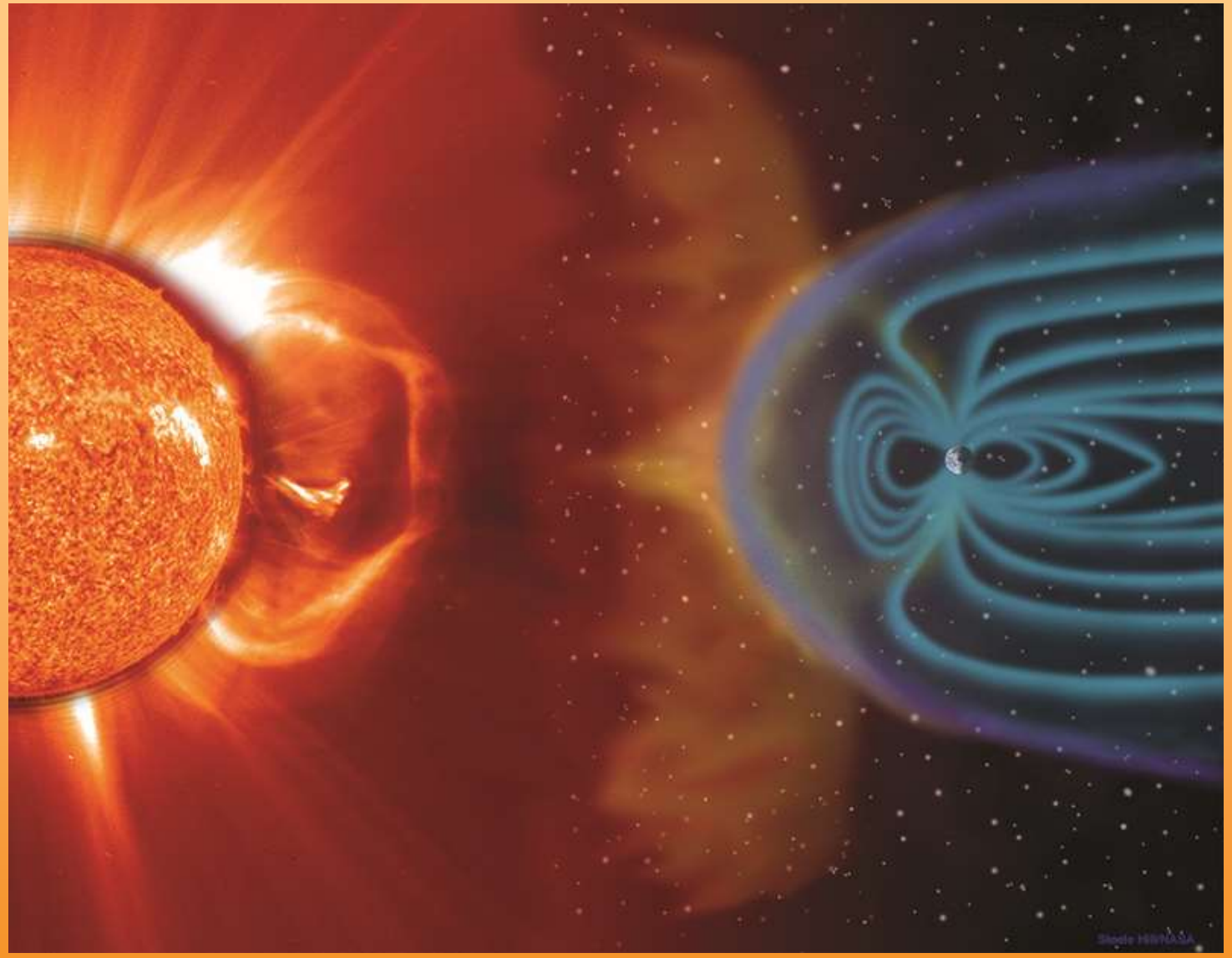
Madhulika Guhathakurta
Lead Program Scientist for New Initiatives
NASA Ames Research Center

- HISTORY-

NASA's Living With a Star Program has been working with UCAR's Cooperative Programs for the Advancement of Earth System Science since 2006 to develop a new generation of heliophysicists through science-based education, training, and support for the Heliophysics community.

Heliophysics Summer School	Jack Eddy Postdoctoral Fellowships	Living With a Star Institutes
Purpose: To teach the next generation of scientists about the physics of space weather events that start at the Sun and influence atmospheres, Ionospheres and the Magnetospheres throughout the solar system. • 383 Students to date • First School held in 2007	**Purpose:** To train the next generation of scientists needed in the field of Heliophysics. • First batch appointed in 2010 • 26 Jack Eddy Postdoctoral Fellows to date	**Purpose:** Bring many research disciplines and applications communities together to deepen the understanding of the system of systems created by the Sun-Earth connection. • 2015 first Institute held • 3 Institutes held to date

Teaching the next generation of scientists about the physics of space weather events that start at the Sun and influence atmospheres, Ionospheres and the Magnetospheres throughout the solar system



HELIOPHYSICS SUMMER SCHOOL

- 2019 Heliophysics Summer School -

Heliophysics Exploration

The 2019 Summer School will focus on the Heliophysics System Observatory (HSO). The school will focus on several new spacecraft including:

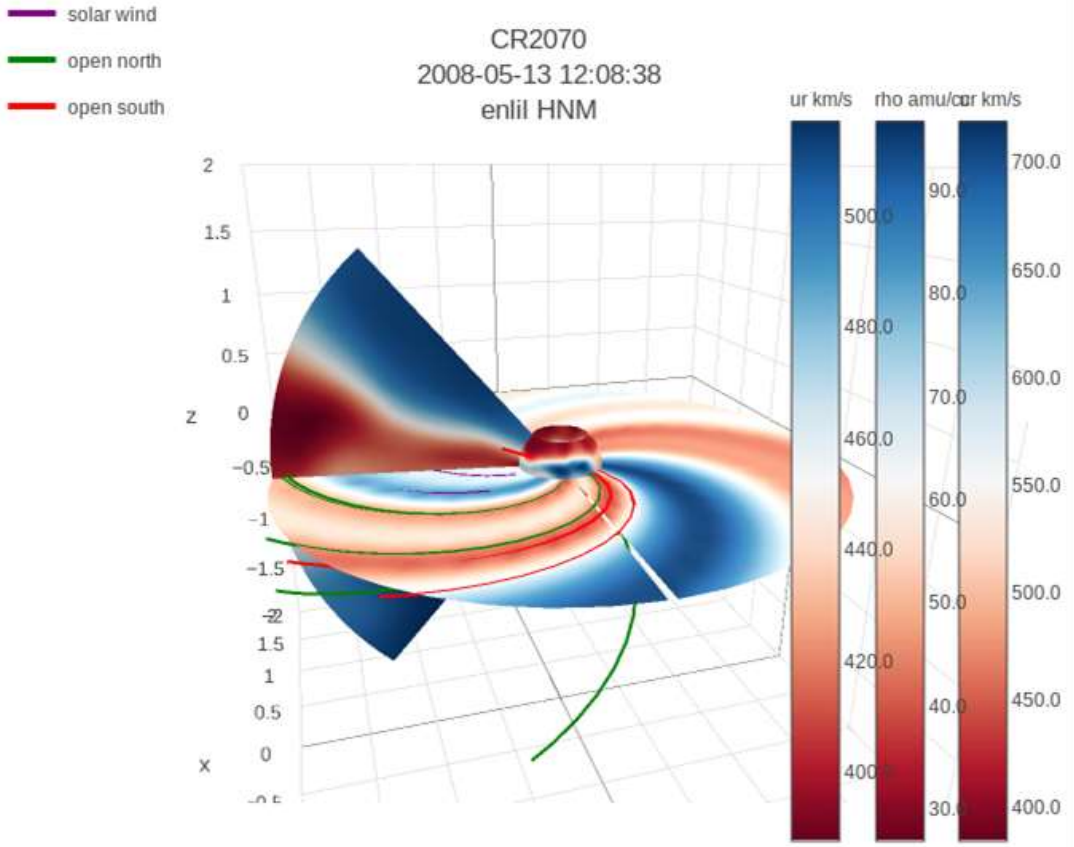
- Magnetospheric Multi-scale (MMS)
- Parker Solar Probe (PSP)
- ICON (soon to be launched)

These will provide new measurements and discoveries that will fuel and focus our scientific research over the coming years.

The School will focus on the fundamental scientific principles underlying the area these measurements will probe. Providing students with the background and understanding needed to do research and make discoveries in the heliophysics system in years to come.

- 2018 Heliophysics Summer School Highlights -

Student Generated Image from Solar Wind Lab



95% of participants thought the Summer School "exceeded" or "met expectations"

Lectures:

Stuart Bale (UC Berkeley) presented "*Solar Wind Kinetic Physics and the NASA Parker Solar Probe mission"* 3 weeks prior to the launch of the FIELDS instrument on the Parker Solar Probe (PI Stuart Bale)

Labs:

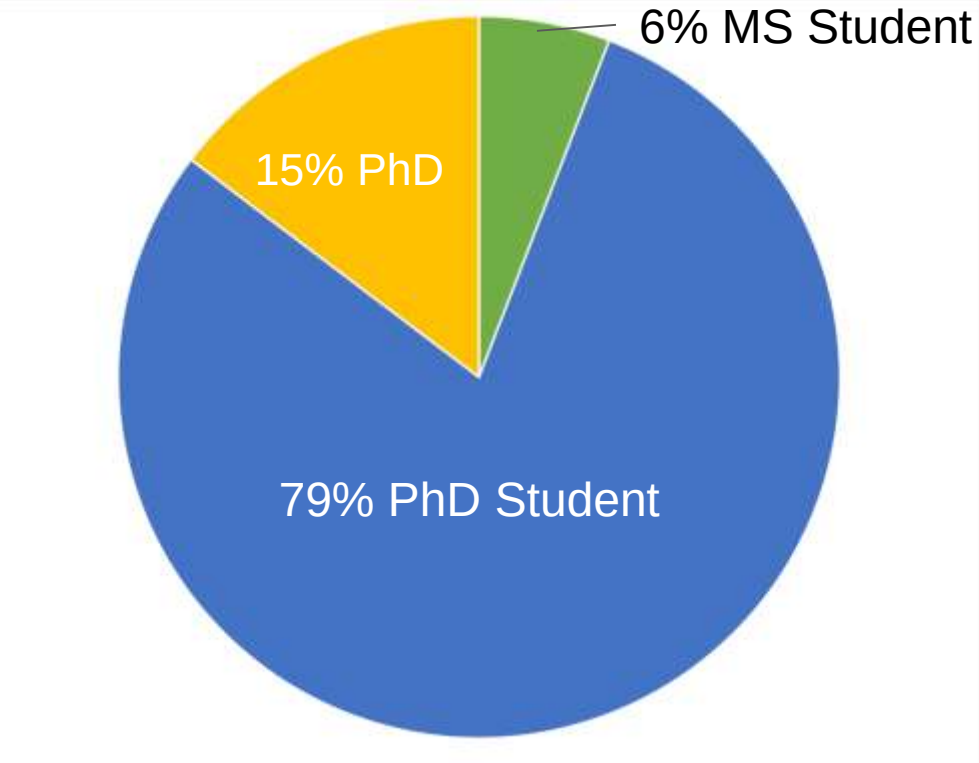
Utilized state of the art visualization software developed by Goddard's CCMC.

26 Short Student Presentations Including:

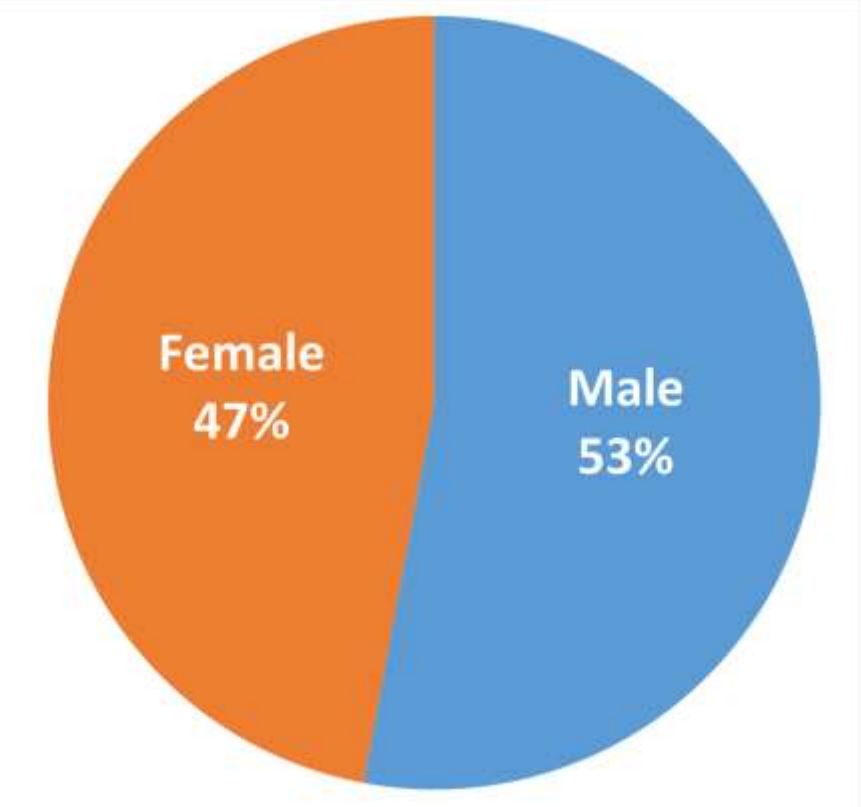
- Radio Spectral Analysis of the Sun
- Studying the Origin of the Solar Wind
- Magnetosphere-Ionosphere Coupling in the Gordon MHD Code
- Dayside magnetosphere & ionosphere

- 2018 Heliophysics Summer School Demographics -

2018 Awardee Education Level



Awardee Gender Distribution



- Heliophysics Summer School Deans -

2016 - 2019

Amitava Bhattacharjee | Princeton University
Dana Longcope | University of Montana-Bozeman

2013 – 2015

Karel Schrijver | Lockheed Martin Advanced Technology Center
Jan Sojka | Utah State University
Frances Bagenal | University of Colorado/LASP/APS

2010 – 2012

Amitava Bhattacharjee | University of New Hampshire
Dana Longcope | University of Montana-Bozeman
Jan Sojka | Utah State University

2007 – 2009

Karel Schrijver | Lockheed Martin Advanced Technology Center
George Siscoe | Boston University

- Heliophysics Summer School -

Student Award Home Institution Locations

- Heliophysics Summer School-

Past Themes

2018 - Comparative Heliophysics

2017 - Long-term Solar Activity and the Climates of Space and Earth

2016 – Explosive Energy Conversions and Particle Acceleration

2015 – Seasons in Space: Cycles of Variability of Sun-Planet Systems

2014 – Comparative Heliophysics

2013 – Heliophysics of the Solar Systems

2012 – Heliophysics Exploration

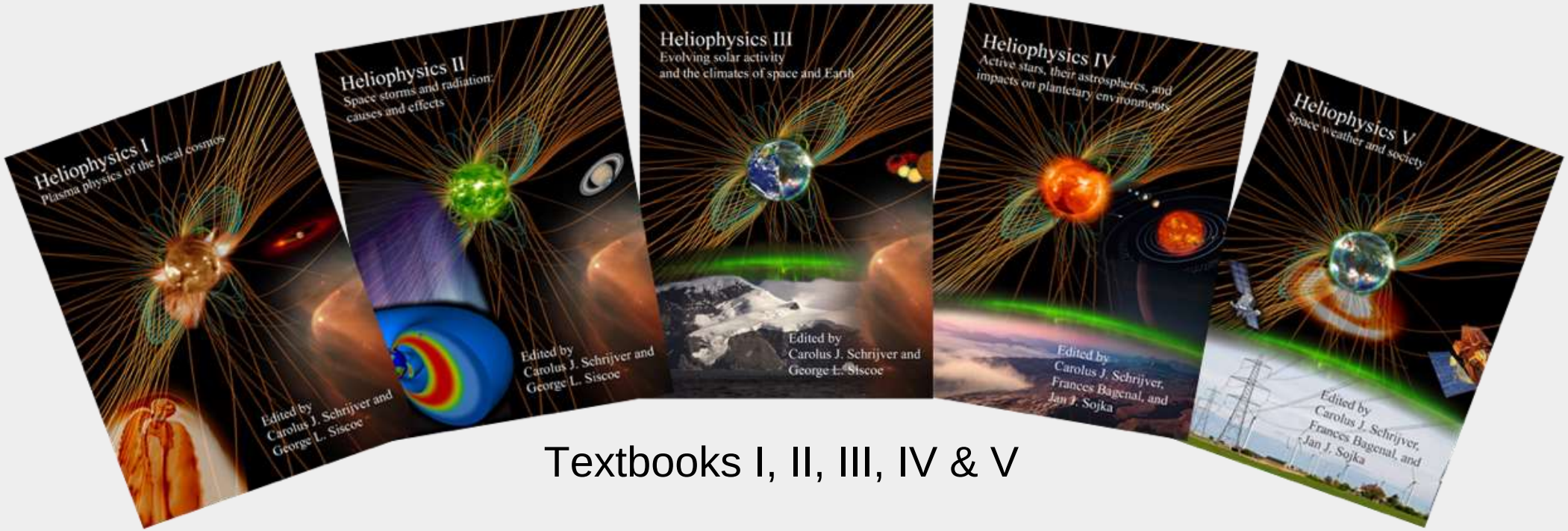
2011 – Long-term Solar Activity and the Climates of Space and Earth

2010 – Space Storms

2009 – Evolving Solar Activity and the Climates of Space and Earth

2008 – Space Storms and Radiation: Causes and Effects

- Heliophysics Summer School Resources-



Textbooks I, II, III, IV & V

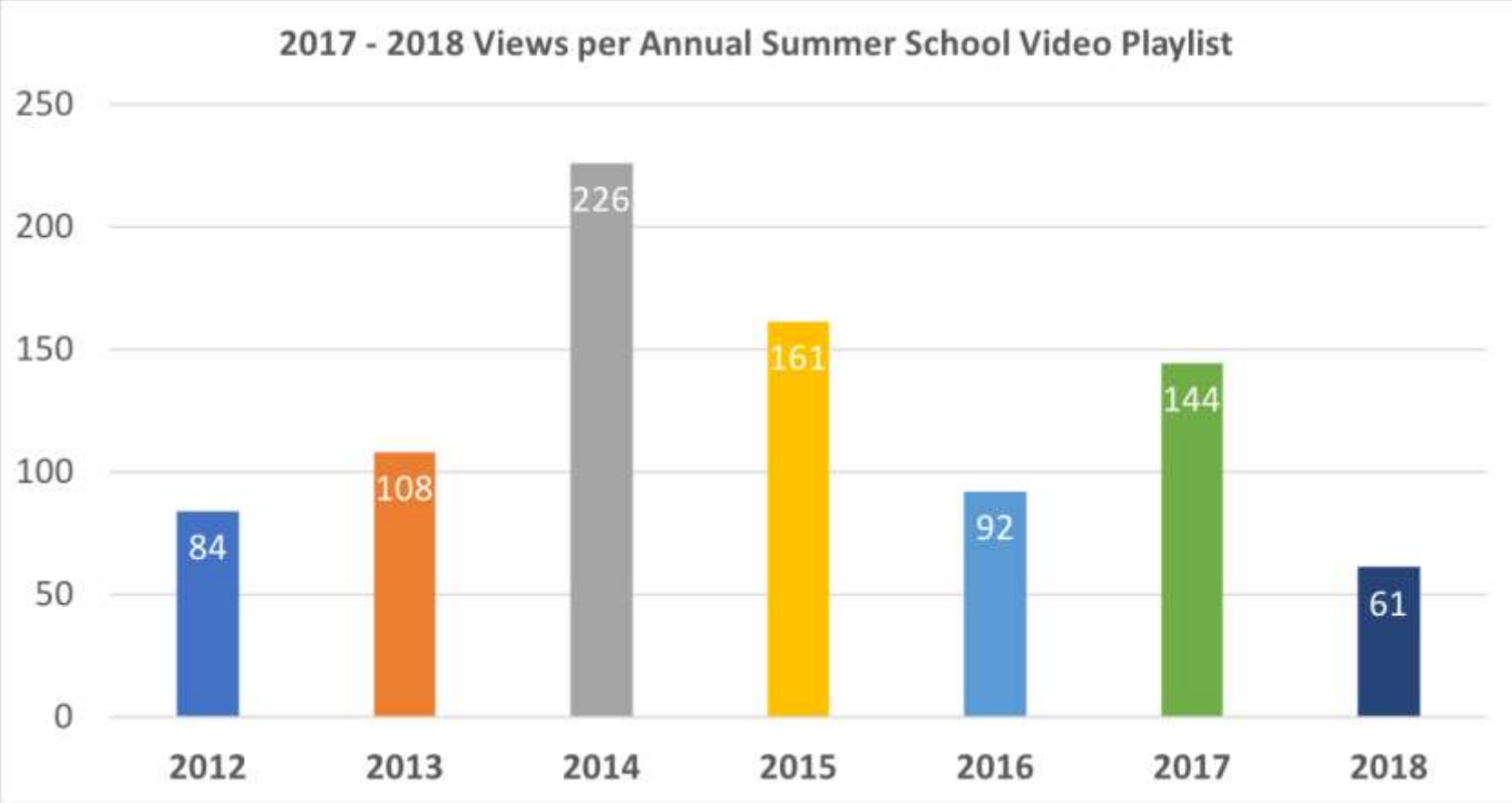
Laboratory primers created by Goddard's Community Coordinated Modeling Center (CCMC):

- Use the CCMC tools designed to interrogate Heliophysics models at CCMC, and
- Obtain a top-level view of the connectivity and naming of regions and parameters that comprise the heliophysics system.

- Heliophysics Summer School Resources-

Additional resources, compiled from ten years of Heliophysics Summer Schools, include:

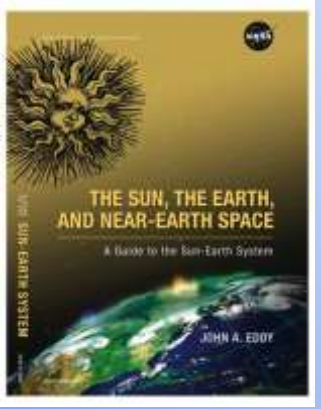
- Textbook problem sets and solutions
- Slide presentations from lectures
- 140 Videos of lectures hosted on [CPAESS YouTube Channel]

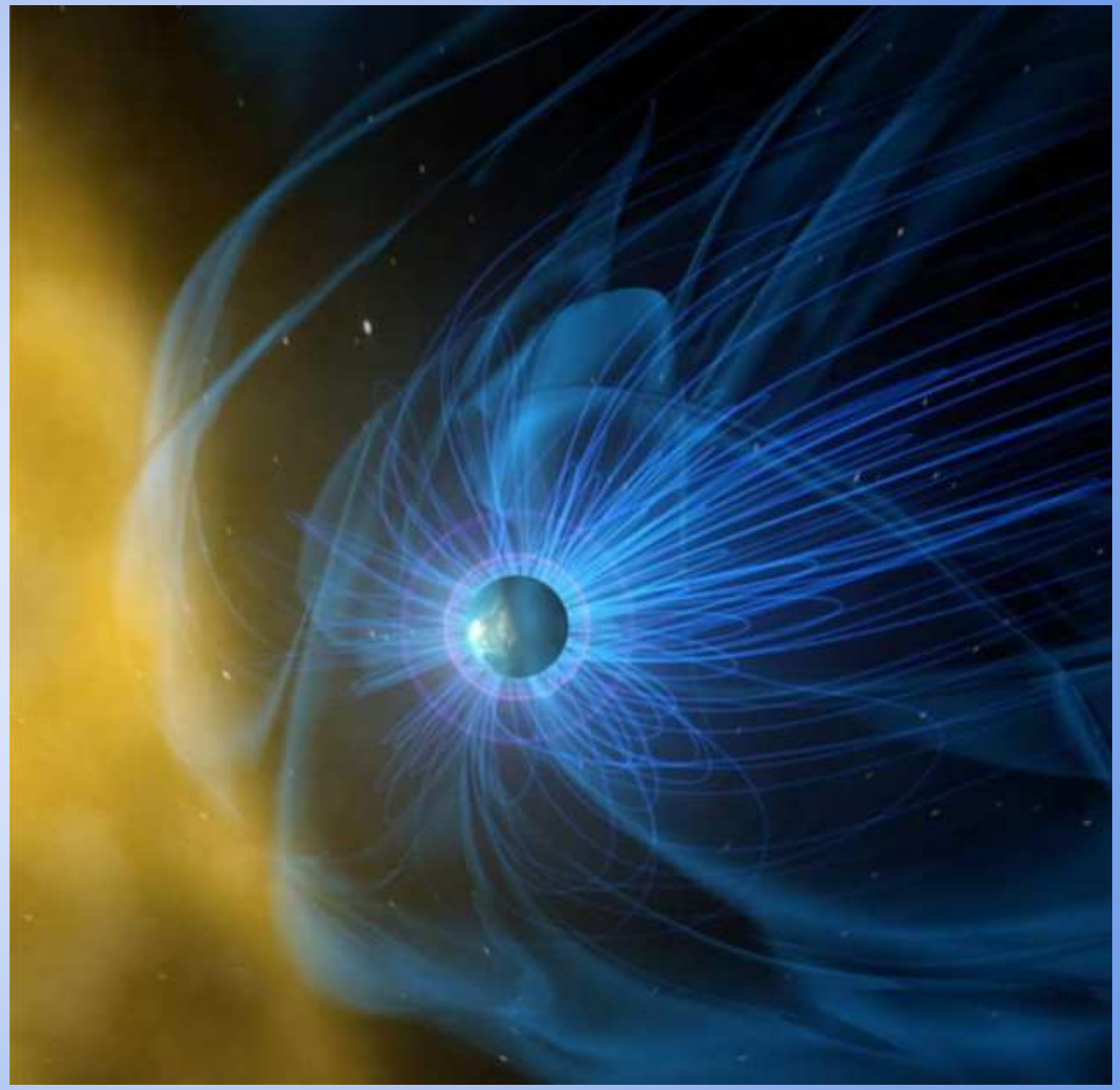


Training the next generation of scientists needed in the field of Heliophysics

JACK EDDY POSTDOCTORAL FELLOWSHIP

THE SUN, THE EARTH, AND NEAR-EARTH SPACE: A Guide to the Sun-Earth System





https://lwstrt.gsfc.nasa.gov/images/pdf/john_eddy/SES_Book_Interactive.pdf

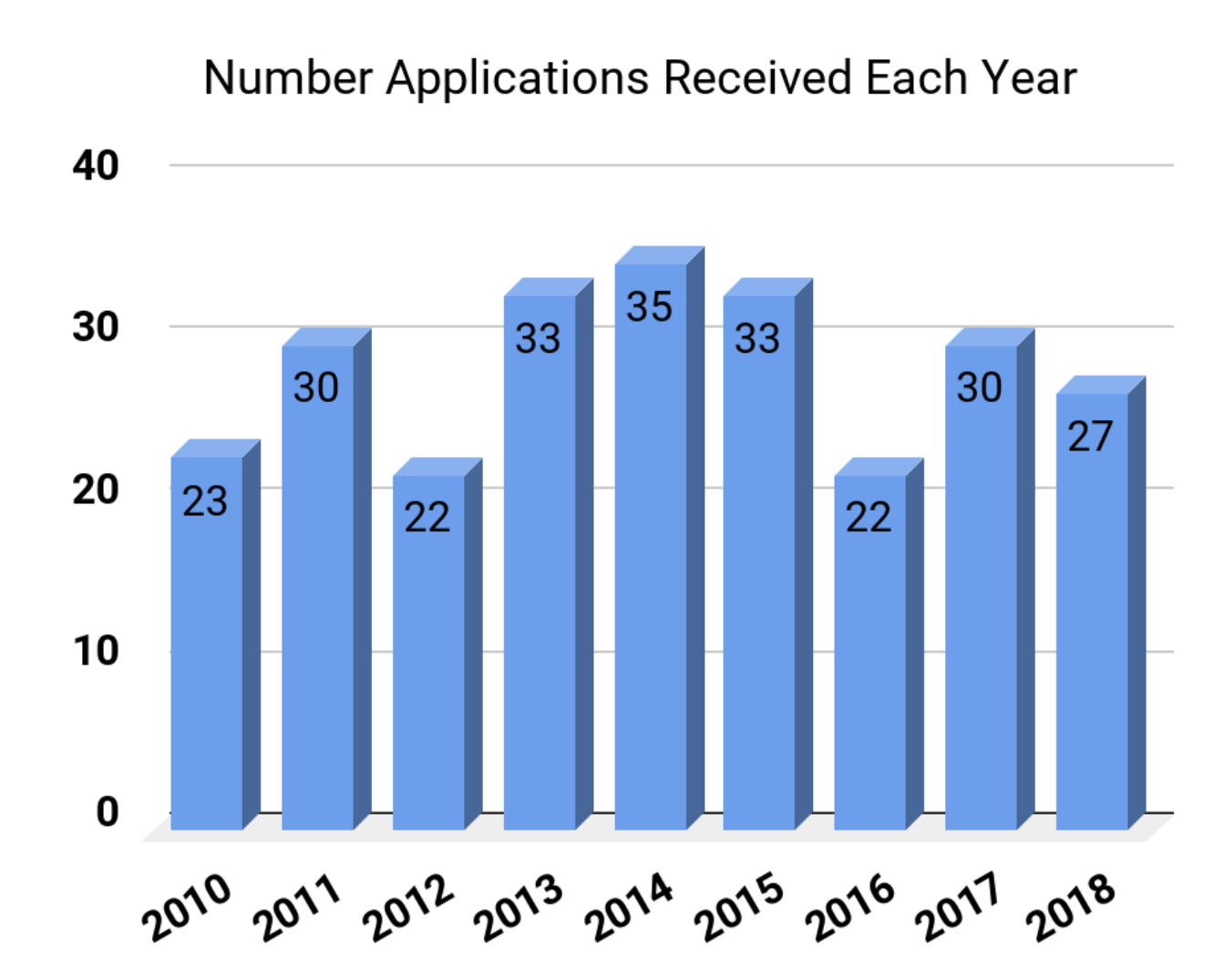
- Jack Eddy Postdoctoral Fellowship -
Highlights

John "Jack" Eddy (1931-2009) was a pioneering solar researcher, and was honored with the debut of the Jack Eddy Postdoctoral Fellowship.

- 26 Jack Eddy Fellows appointed

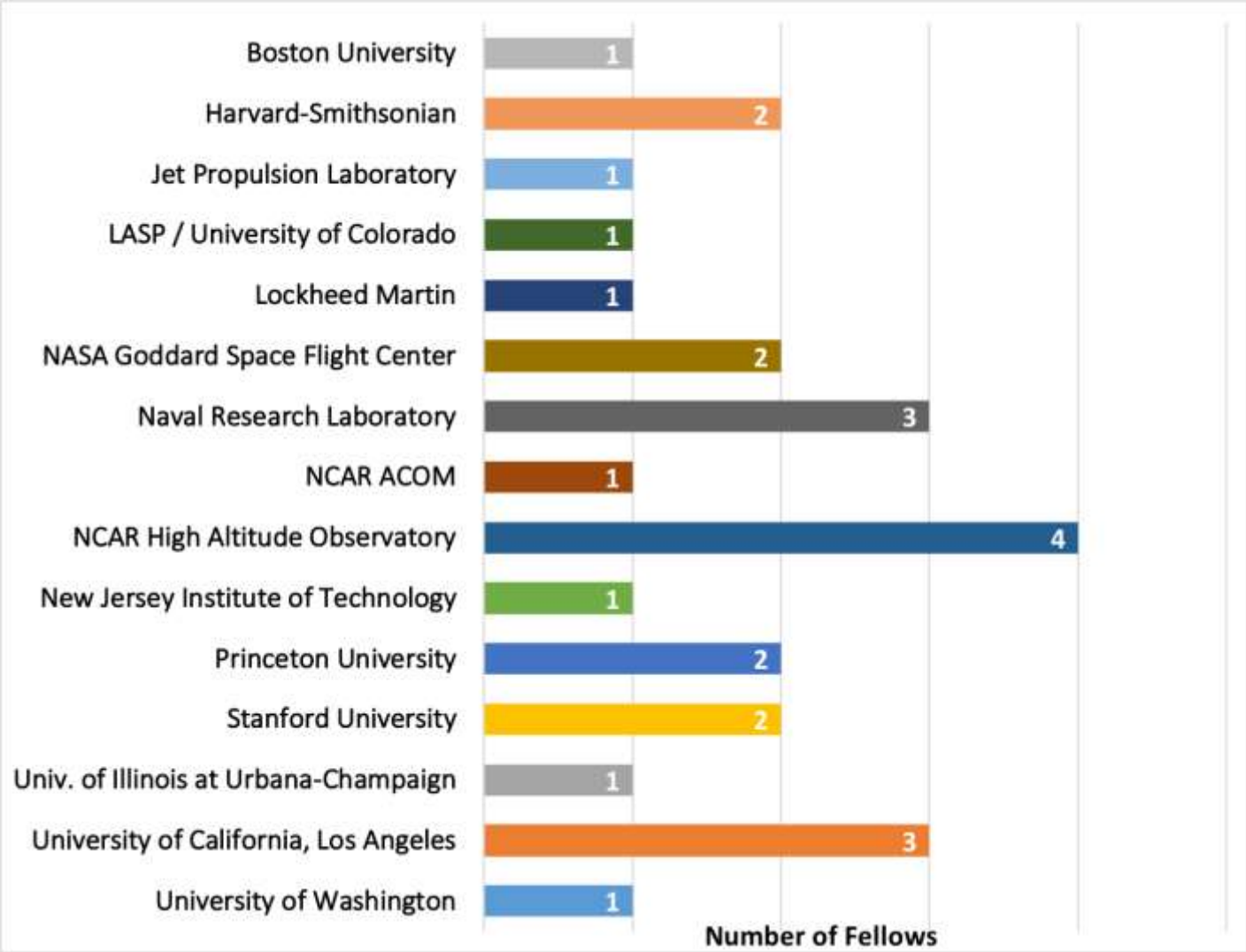
2010 - 2018 Fellow Statistics

- Total of 81 publications
- Average of 3.5 publications per fellow
- 57 first-author papers published
- Average of 2.5 first-author publications per fellow

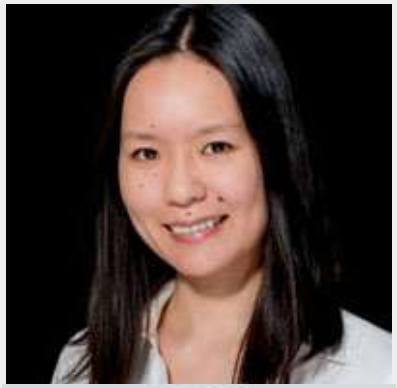


- Jack Eddy Postdoctoral Fellowship -

Hosting Institutions



- 2018 Jack Eddy Postdoctoral Fellowship Awards -



Natsuha Kuroda

"Evaluation of the Magnetic Null Points as The Locations of The Solar Energetic Particle Seed Population Production"

- PhD: Applied Physics, New Jersey Institute for Technology
- Host: Martin Laming, Naval Research Laboratory, Washington, DC

Ramesh Karanam

"Solar and Tidal Influence on Upper Atmosphere CO2 Cooling"

- PhD: Sri Venkateswara University
- Host: Anne Smith, NCAR Atmospheric Chemistry, Observations and Modeling Laboratory

Samuel Totorica

"Particle acceleration in plasmas: from space physics to the laboratory"

- PhD: Stanford University
- Host: Amitava Bhattacharjee, Princeton University

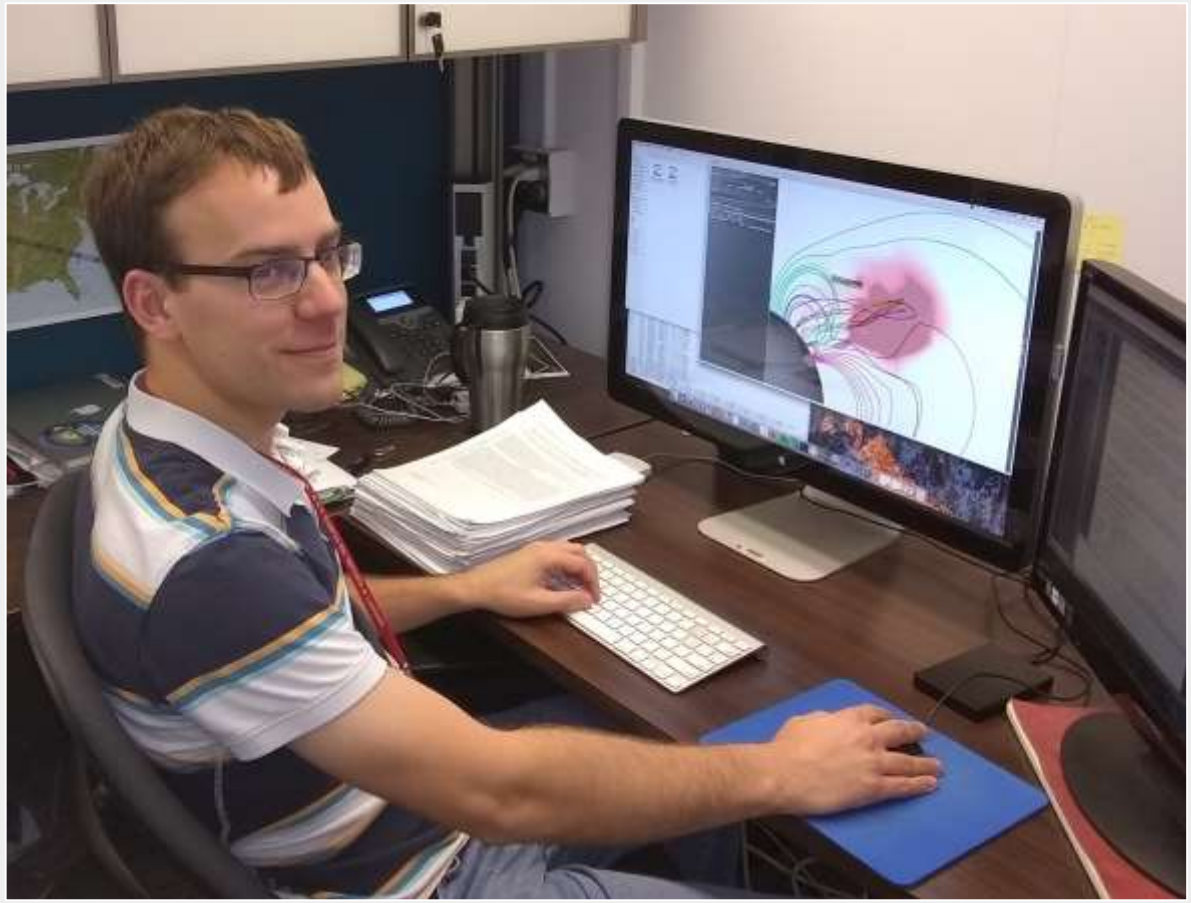
- 2016 Jack Eddy Fellow Achievements-

"How do solar flares accelerate energetic particles?"

JOEL DAHLIN

Host: Spiro Antiochos, NASA Goddard Space Flight Center

- 2017 article "*The roll of three-dimensional transport in driving enhanced electron acceleration during magnetic reconnection*" featured as a Physics of Plasmas science highlight.
- Presented invited talk "*First Demonstration of a Coronal Mass Ejection with Self-Consistent Driving*" at 2018 Japan Geoscience Union Meeting
- Presented invited scene-setting talk "*Suprathermal Seeds for Solar Energetic Particles*" at 2017 SHINE Conference



Joel Dahlin

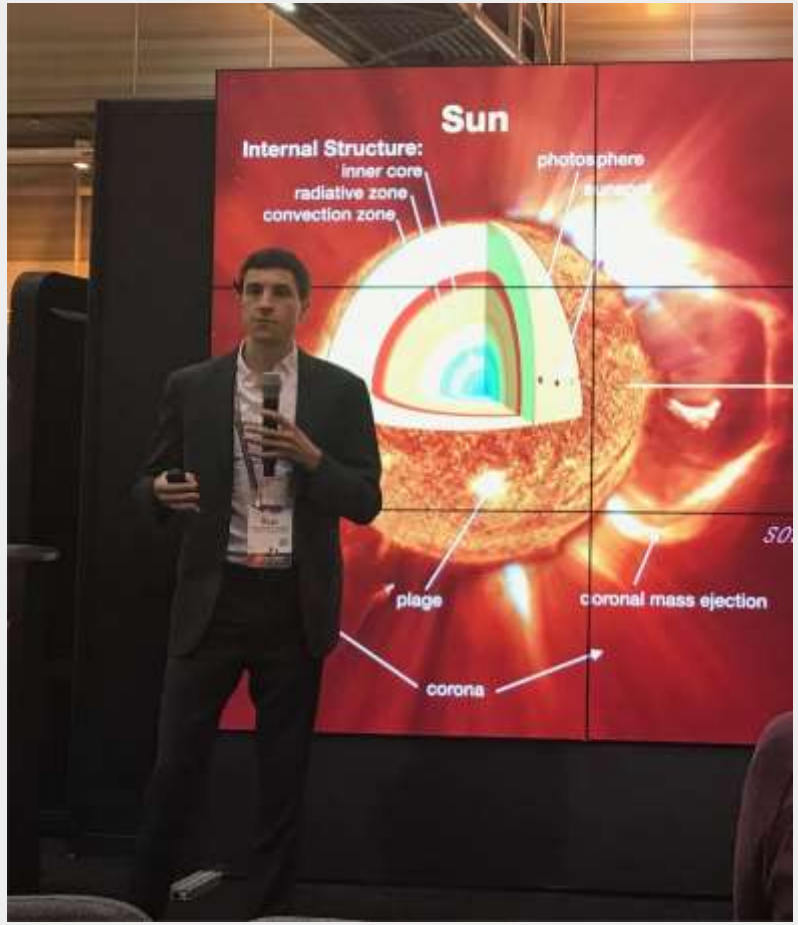
- 2016 Jack Eddy Fellow Achievements-

"Using GNSS data to investigate multi-scale features of field-aligned currents at high-latitudes"

RYAN McGRANAGHAN

Host: Anthony Mannucci, Jet Propulsion Laboratory

- 7 peer-reviewed publications, 4 as first-author
- 2018 Selected as a New Leader in Space Science by the National Academy of Sciences
- 2018 Research spotlight article in Eos.org "*Tracing Electric Currents That Flow Along Earth's Magnetic Field*"
- Interviewed regarding space weather on the NASA in Silicon Valley Podcast
- Invited member of the first Heliophysics-focused National Science Foundation EarthCube Research Coordination Network



Ryan McGranaghan presenting at 2017 AGU Conference

Bringing many research disciplines and applications communities together to deepen the understanding of the system of systems created by the Sun-Earth connection

LWS INSTITUTES

- LWS Institute Topics-

2015 Topic Area

Principles in relation to the effects of geomagnetically induced currents (GICs) during CME-driven geomagnetic disturbances (GMDs)

2016 Topic Areas

- Nowcasts of radiation storms (proton events) at energy levels that could create a radiation hazard for aircrew and passengers
- Nowcasts of atmospheric drag for LEO spacecraft

2017 - 2018 Topic Areas

- TEC and ionospheric scintillation for GPS applications
- Prediction and specification of >10 MeV proton flux

Principles in relation to the effects of geomagnetically induced currents (GICs) during CME-driven geomagnetic disturbances (GMDs)

2016 Annual AMS Conference – 13th Conference on Space Weather

Posters

- Geomagnetically induced currents in the ground beneath our feet: The view from outer space (N. Savani)
- Geomagnetically induced currents in the ground beneath our feet: The view from near space (D. Welling)
- Geomagnetic storms: How bad can they be? (C. Ngwira)

Panel Session Geomagnetically Induced Currents: Science, Engineering, and Future Challenges

Publications The group wrote a collection of 10 papers published in a special section of *Space Weather Journal titled NASA's Living With a Star: Geomagnetically Induced Currents*. This Special Collection is composed of two overview papers and eight technical papers addressing specific elements of the GIC problem.

Nowcasts of atmospheric drag for LEO spacecraft

Publications The group wrote a collection of 16 papers published in a special section of Space Weather Journal titled *NASA Living With a Star Institute Special Section on Low Earth Orbit Drag: Science and Operational Impact*.

- Variations in LEO satellite drag is dominated by changes in the thermospheric neutral density and composition
- A better solar EUV proxy is needed for thermospheric modeling. Satellite conjunction is greatly impacted errors in themospheric density

- 2017-2018 LWS Institute Working Group -

TEC and ionospheric scintillation for GPS applications

Working Group Members

Keith Groves (Team Lead) - Boston College
Eric Altshuler - Sequoia Research Corp.
Yannick Beniguel - IEEA
Charles Carrano - Boston College
Anthea Coster - MIT Haystack Observatory
Seebany Datta - Barua - Illinois Inst. of Tech.
Tim Fuller-Rowell - NOAA CIRES
Larisa Goncharenko - MIT Haystack Obser.
Joseph Huba - Naval Research Laboratory
Robert Kursinski - PlanetIQ
Ryan McGranaghan - NASA JPL
Jade Morton - Univ. of Colorado, Boulder
Ludger Scherliess - Utah State University
Ja-Soon Shim - NASA CCMC
Sergey Sokolovskiy - UCAR
Jens Wickert - GFz
Endawoke Yizengaw - Boston College

Senior Advisory Panel

Sunanda Basu - NSF
Patricia Doherty - Boston College
John Foster - MIT Haystack Observatory
Norbert Jakowski - DLR
Charles Rino - Boston College

Unsupported Contributors

Sebastijan Mrak - Boston University
Toshi Nishimura - Boston University
Josh Semeter - Boston University

Thank you for your time!
For additional information on the programs please visit:

cpaess.ucar.edu/heliophysics/hom

FDL is a public / private research partnership between NASA, the SETI Institute and leaders in commercial AI and private space.

Over the past three years FDL has demonstrated a model for breakthrough AI application over a highly accelerated time period - and commercial and international partnership.

WHY PARTNER WITH SILICON VALLEY?

GPU POWER OUTSTRIPPING MOORE'S LAW

PETA-SCALE ERA OF DATA - ALGORITHM DEV IS 5% OF TASK

DEVELOPING INFERENCE MODELS IS COSTLY (FDL = $1M USD DONATED COMPUTE)

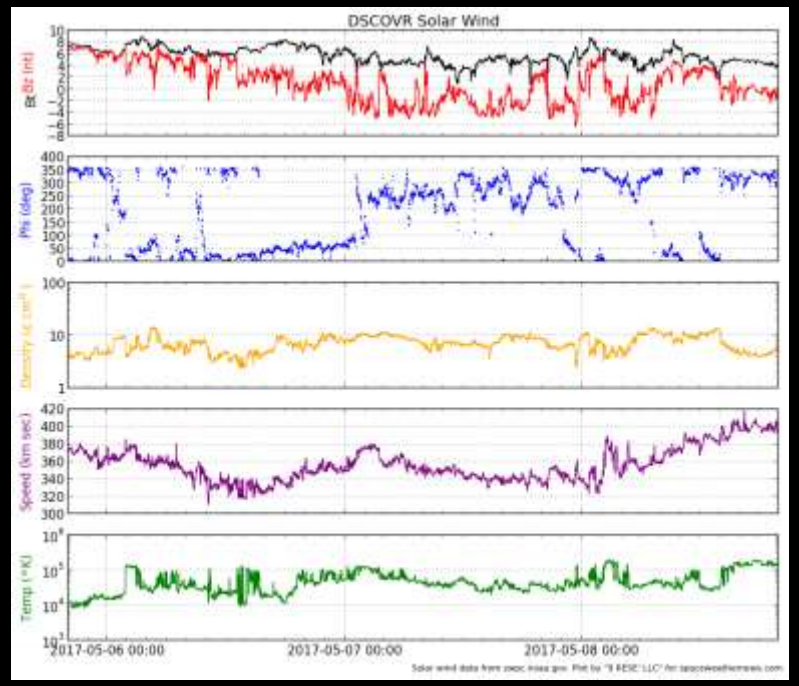
WHAT'S IN IT FOR SPACE?

Capital
(50% of FDL's capital requirement*)
Massive GPU compute = **rapid iteration**
Expertise and mentorship
Software services / Hardware
Locations and event hosting
New perspectives and Solutions
Validation as AI leader
Continuity

WHAT'S IN IT FOR PARTNERS?

Brand association / Outreach
Inspirational case studies
Access to talent
Critical learning about tools and user feedback
Relations with other partners.

SOLAR WIND DATA



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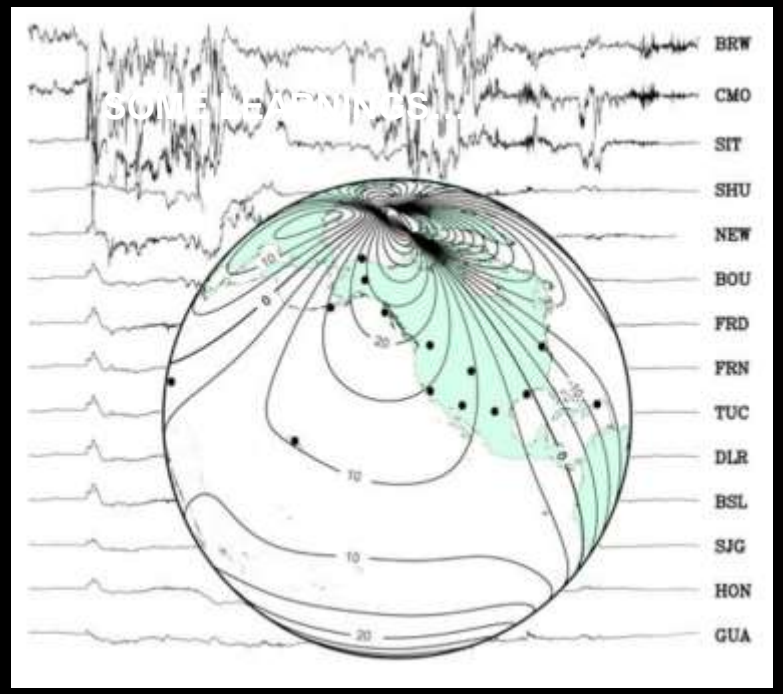
GEOMAG DATA



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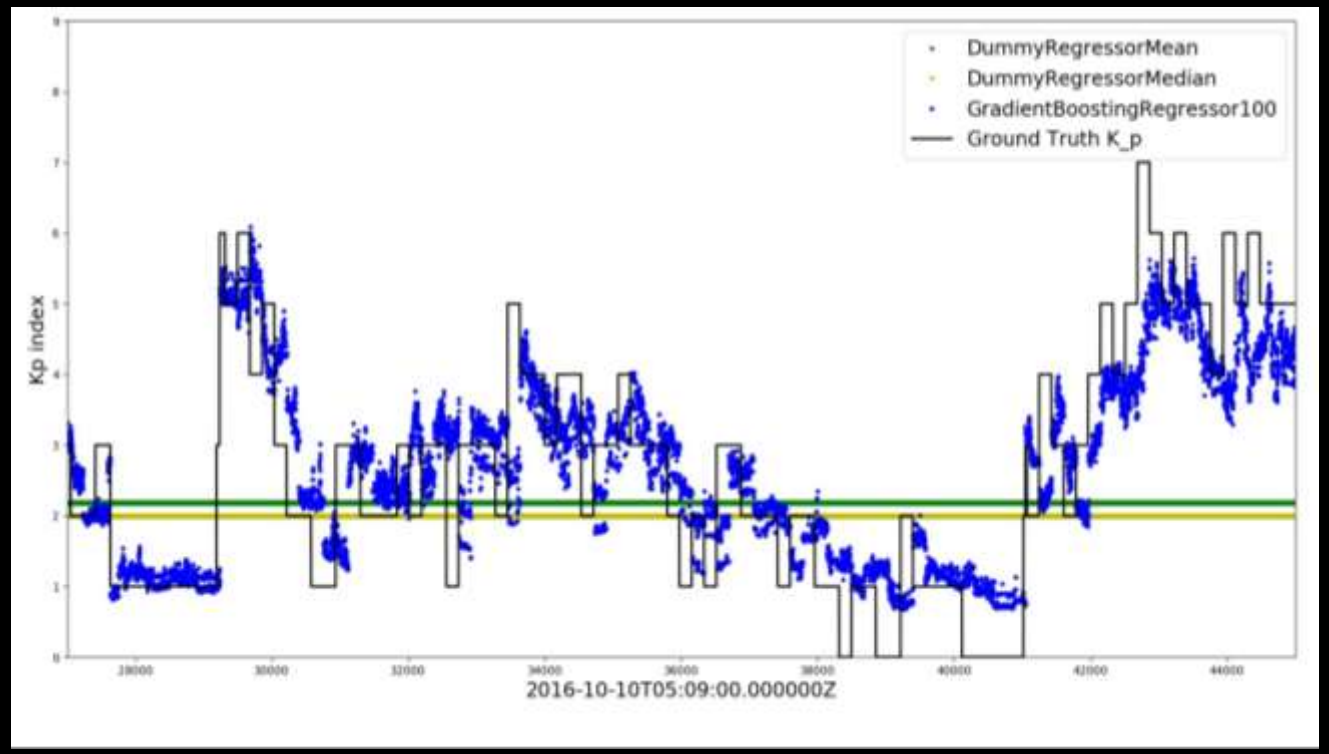
“STING”

(Solar Terrestrial Interactions Neural Network Generator)

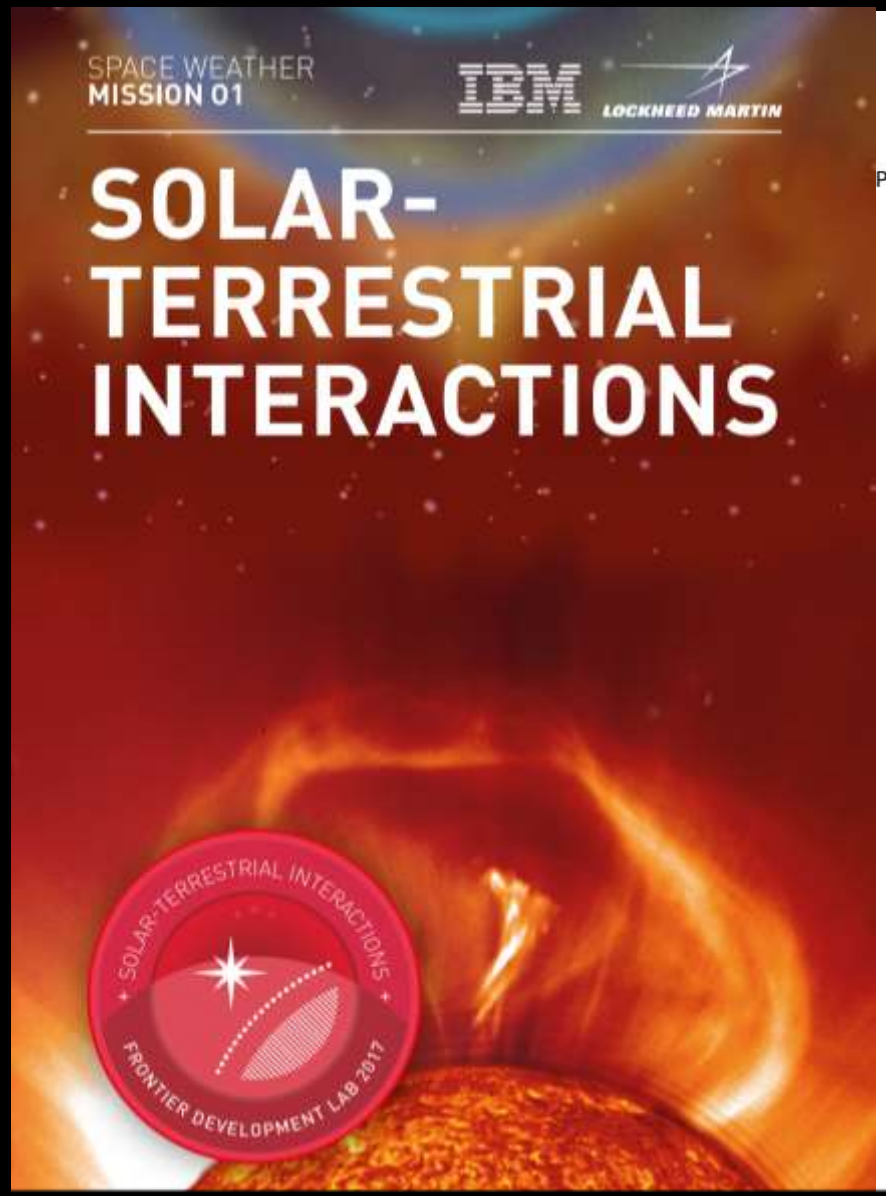
Kp Index

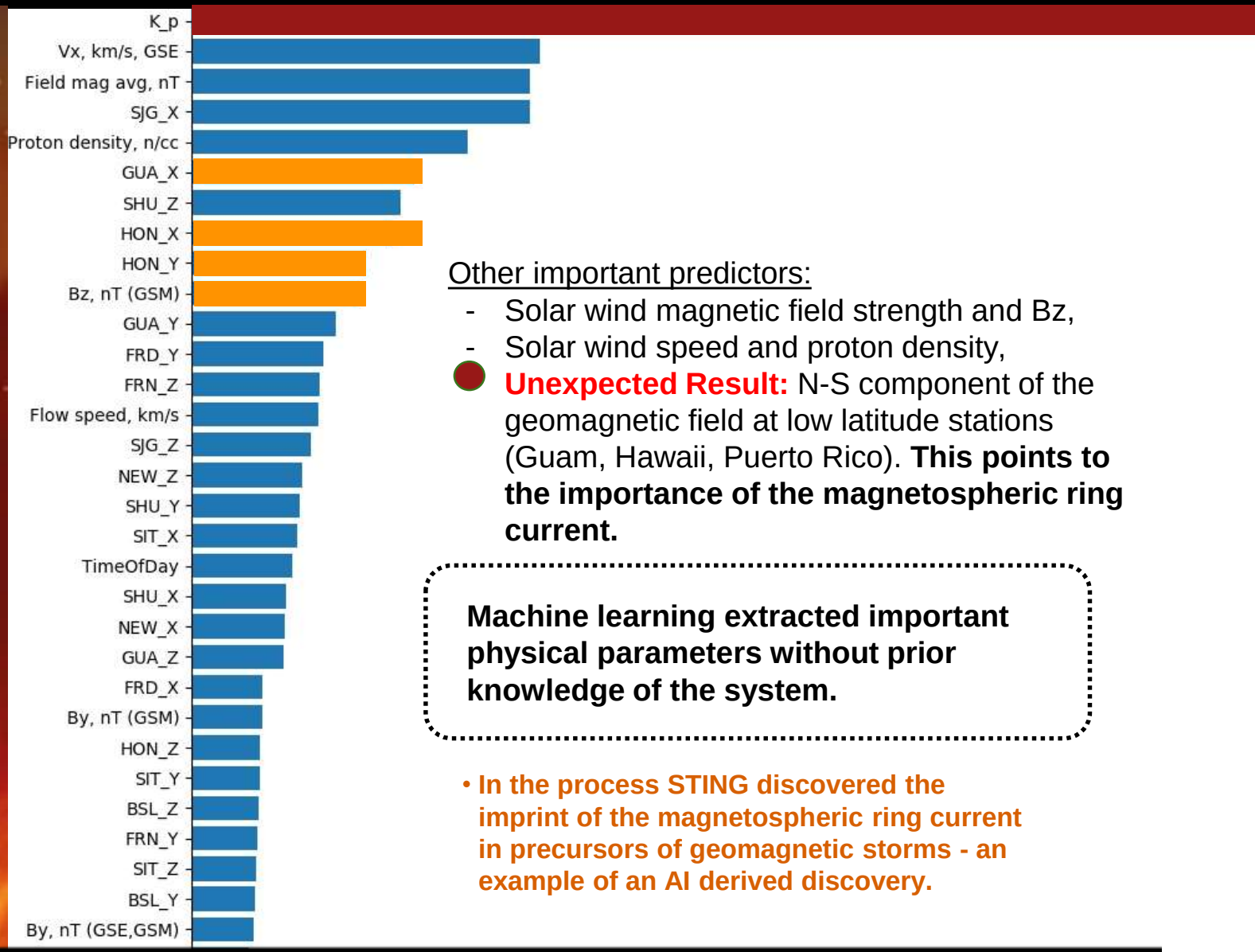
Refers to a range of geomagnetic activity levels within a 3-hr interval each day.



STING is able to predict Kp 3 hours in advance.

Accurately predicting the variability of Earth's geomagnetic fields in response to solar driving.





Other important predictors:

- Solar wind magnetic field strength and Bz,
- Solar wind speed and proton density,
- **Unexpected Result:** N-S component of the geomagnetic field at low latitude stations (Guam, Hawaii, Puerto Rico). **This points to the importance of the magnetospheric ring current.**

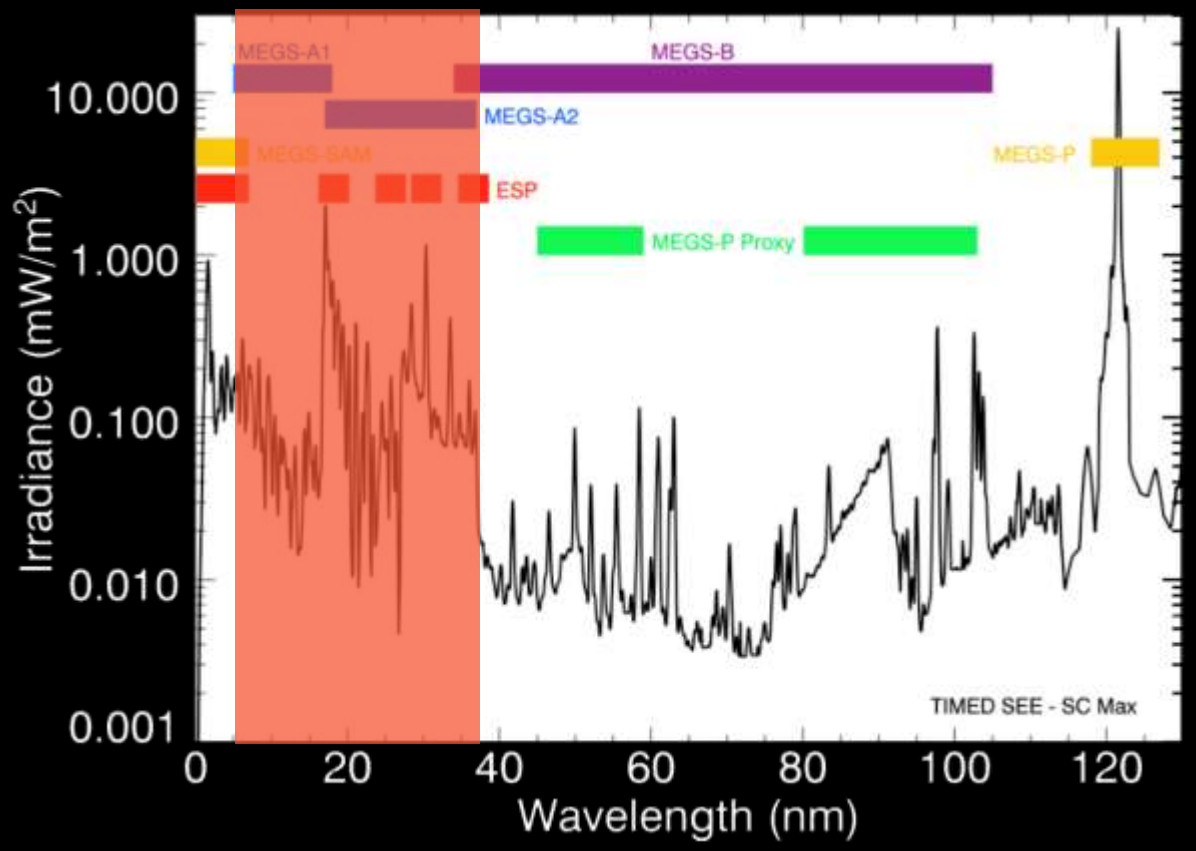
Machine learning extracted important physical parameters without prior knowledge of the system.

- **In the process STING discovered the imprint of the magnetospheric ring current in precursors of geomagnetic storms - an example of an AI derived discovery.**

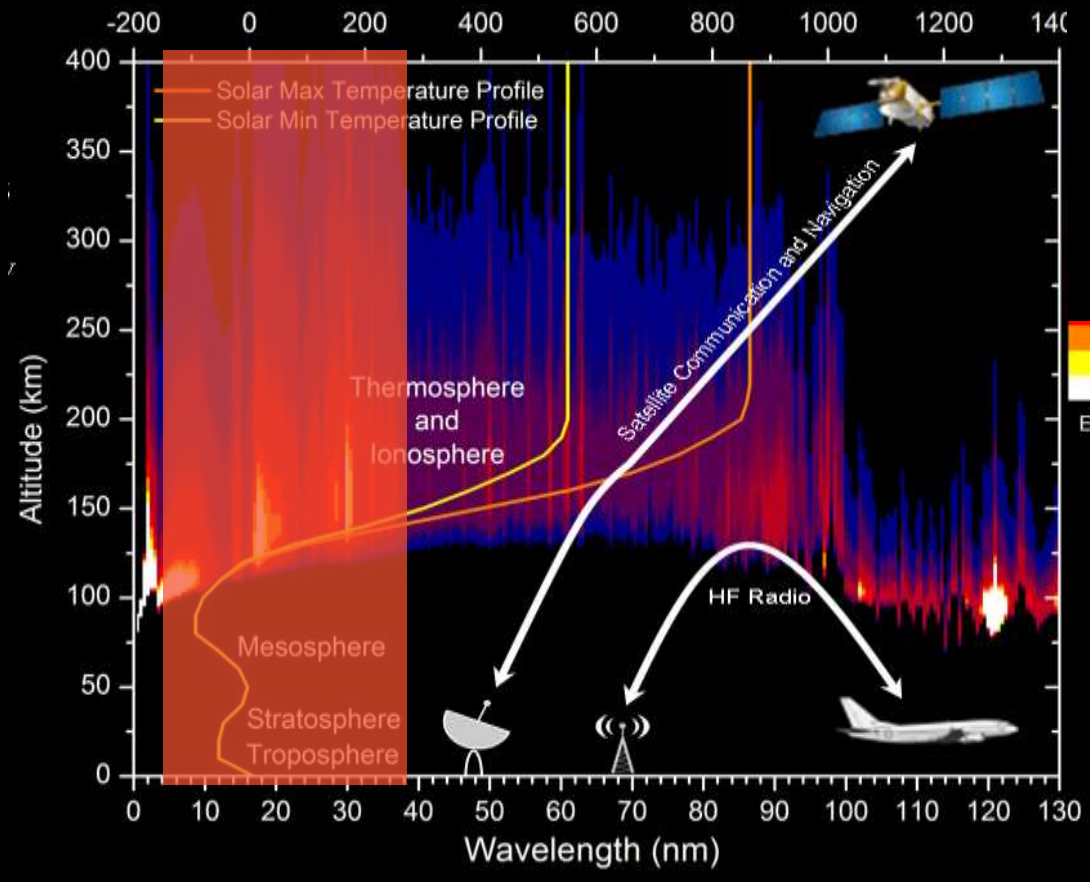
BRW_Z
FRN_X

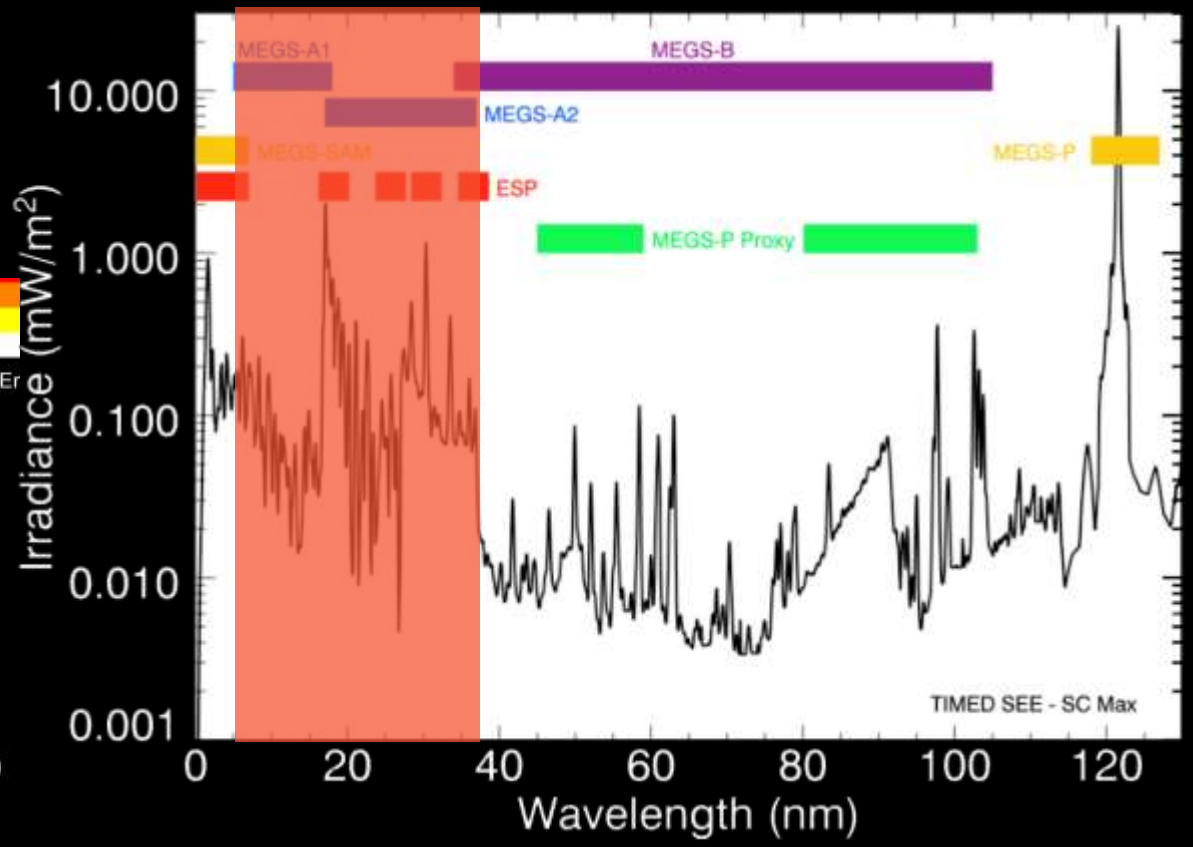
EUV Variability Experiment (EVE)

- **EUV spectrograph.**
- **EUV spectral irradiance.**
- **MEGS-A suffered electrical fault in 2014 and is no longer operational.**

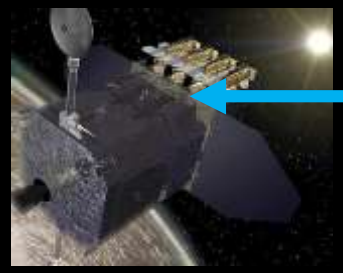


This left an observational blackout in the most energetic part of the EUV spectrum





NASA
Solar
Dynamics
Observatory
(SDO)



Failed in 2014

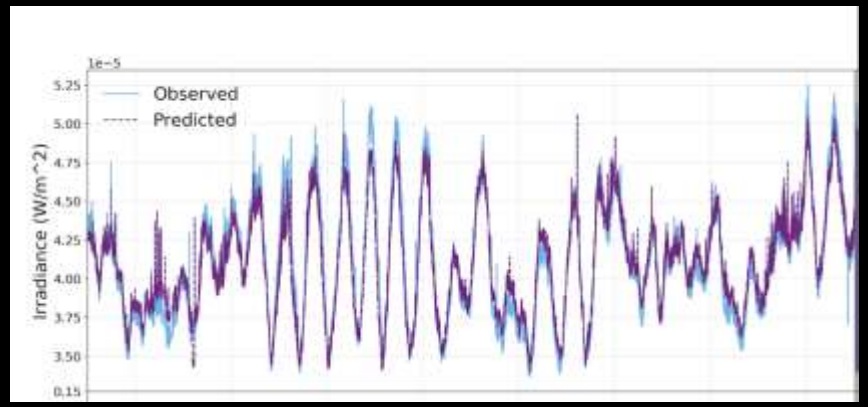
AI model reduced mean error of spectral irradiance prediction to 2.83%

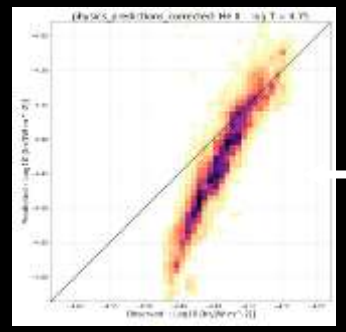
- **Need:** Measurement of solar spectral irradiance is needed for satellite orbit boost planning. Currently, this can be difficult because the MEGS-A module on SDO stopped functioning in 2014.

- **Goal:** The SDO AIA EUV imager co-observed with MEGS-A from 2011 to 2014 -- Can we use this data overlap to train a deep learning model to “virtually resurrect” the MEGS-A instrument and fill the observational gap left by the MEGS-A failure, thereby improving spectral irradiance prediction?

- **Methodology:** Develop a machine learning model using 2011/2014 data, test the accuracy using 2012/2013 data. After training and testing over 1000 machine learning configurations, the best implementation was found to be a Residual neural net model augmented with a Multi-Layer Perceptron.

- **Findings:** The neural net model significantly improved upon physics based models, **reducing mean error from 7.46% to 2.83%.** This improved accuracy may constitute a scientifically useful virtualization of MEGS-A.

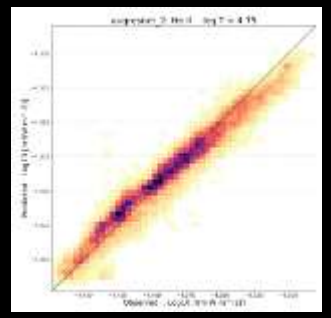




Plot of Predicted v.s Observed

Physics-based model

Improved AI model



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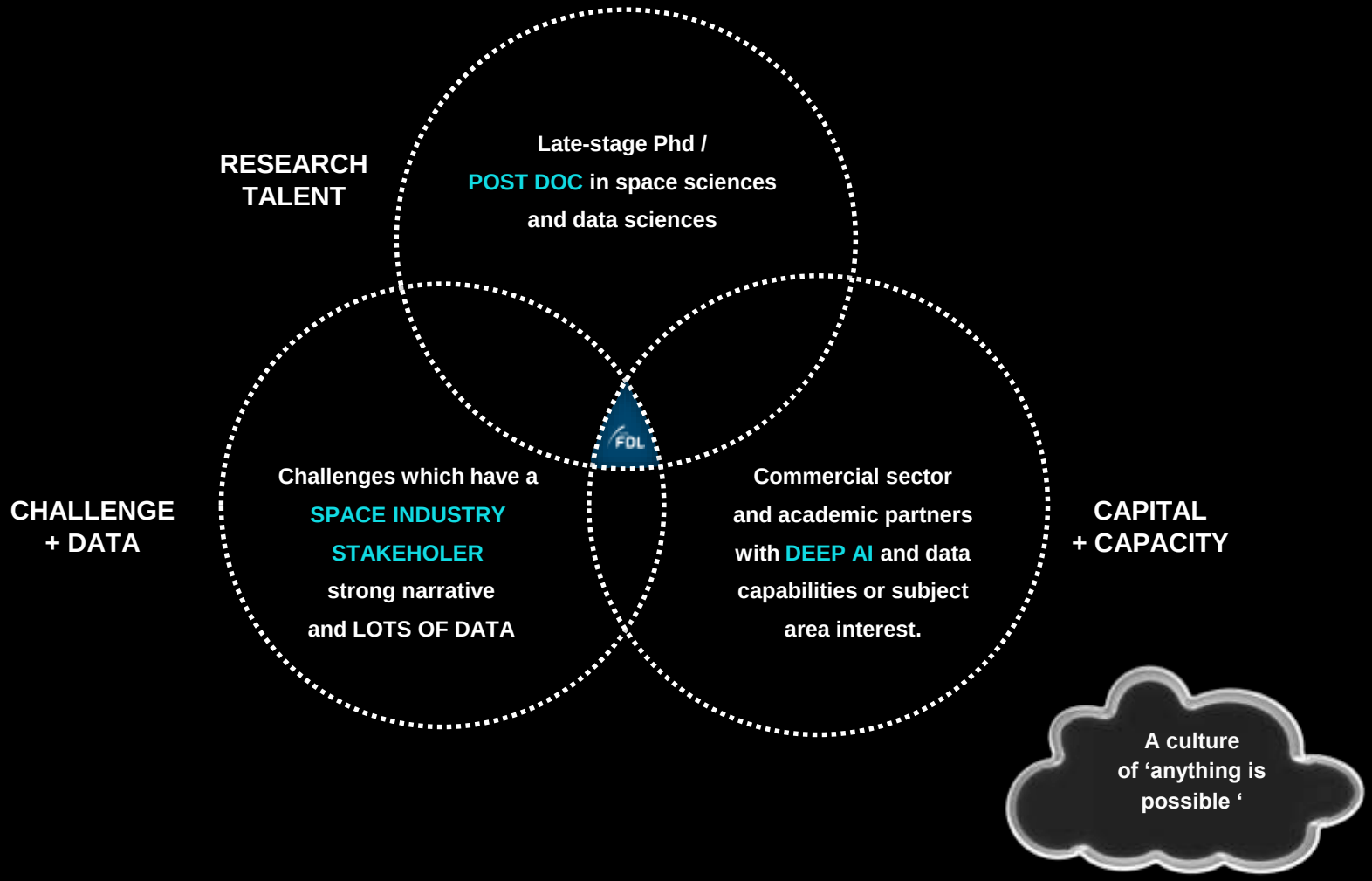

LWS Town Hall Agenda

Item	Time	Agenda Item	Presenter
1	6:30 PM	Welcome	Nicky Fox
2	6:35 PM	LPAG Status	Anthea Coster / Mark Linton
3	6:55 PM	LWS Program Status	Jeff Morrill / Simon Plunkett
4	7:15 PM	Multi-Agency Collaborations & Space Weather Activities	Janet Kozyra
5	7:30 PM	GDC STDT Status	Jared Leisner
6	7:45 PM	LWS Infrastructure & New Initiatives	Lika Guhathakurtha
7	8:00 PM	ADJOURN	