National Aeronautics and Space Administration

Living With a Star: Science that Matters to People

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NASA Headquarters

Eddy4 Symposium
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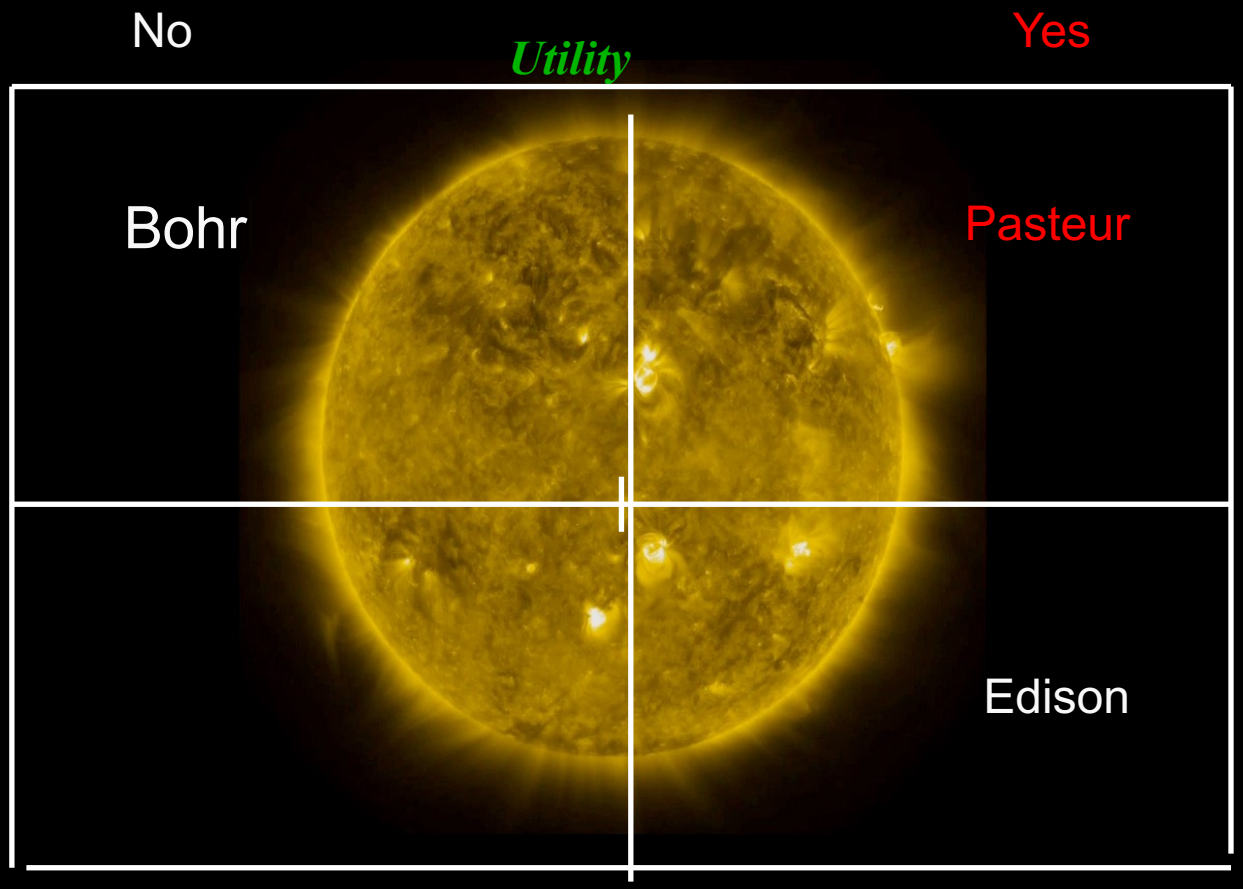
Why Do Science?



Understanding the Sun and its interactions with the Earth and the Solar System.

Solve fundamental mysteries of Heliophysics
Understand the nature of our home in space
Build the knowledge to forecast space weather throughout the heliosphere

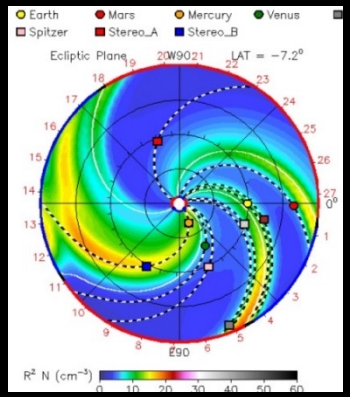
What is Heliophysics

Heliophysics is an environmental science:

a unique hybrid between meteorology and astrophysics

It has an applied branch

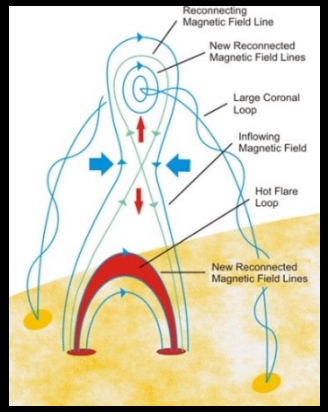
Space weather



Propagation models of solar disturbances out to 2 AU

And a pure branch

Fundamental physical process



Magnetic reconnection

In the US National Space Weather Program 1995
Living With a Star 2000, ILWS 2003
International Heliosphysical Year 2007

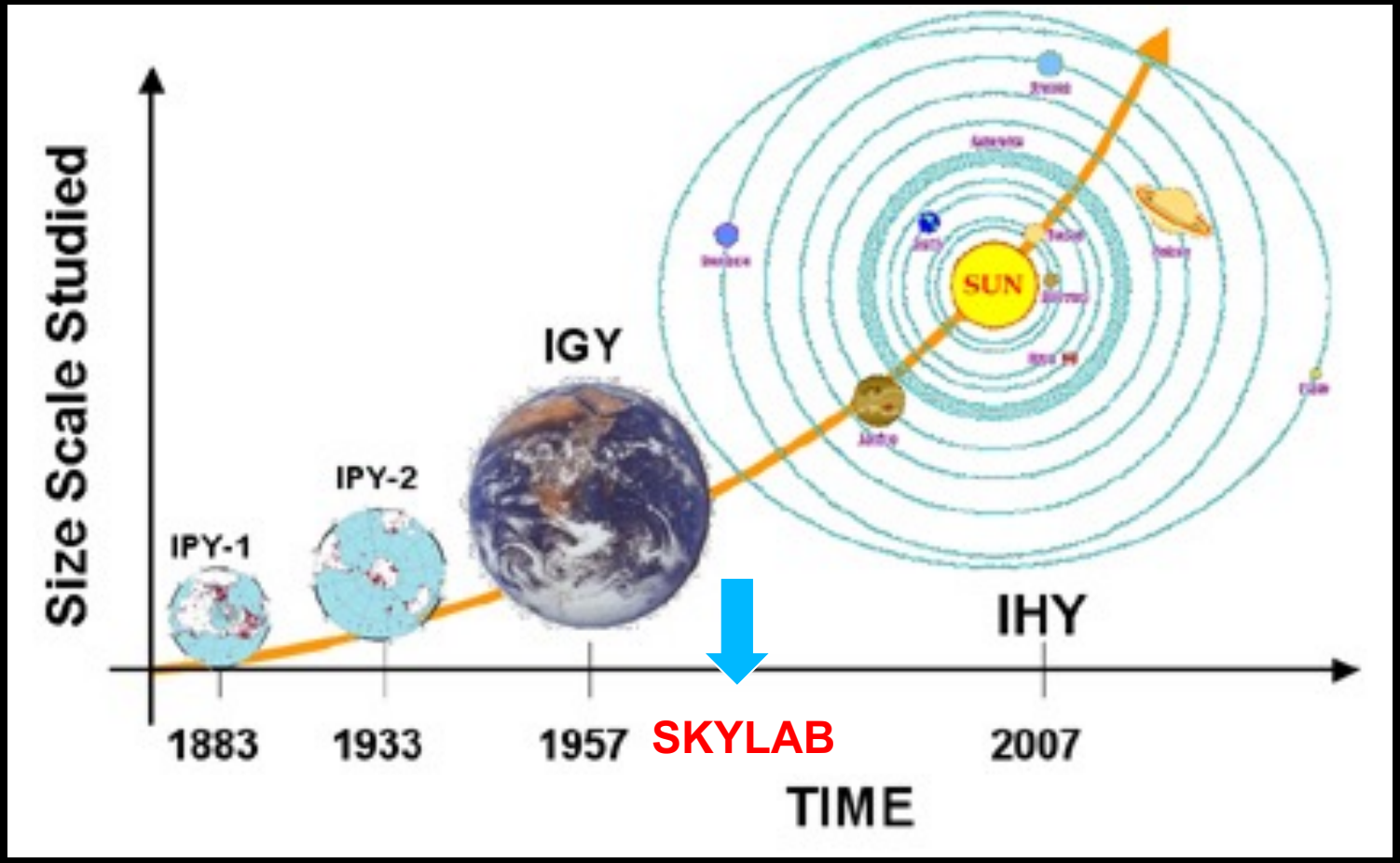
Applications directed science coordinated by NSF community

Add comparative heliospheric studies

Applications directed science coordinated by NSF community

Add comparative NASA & international heliospheric studies community

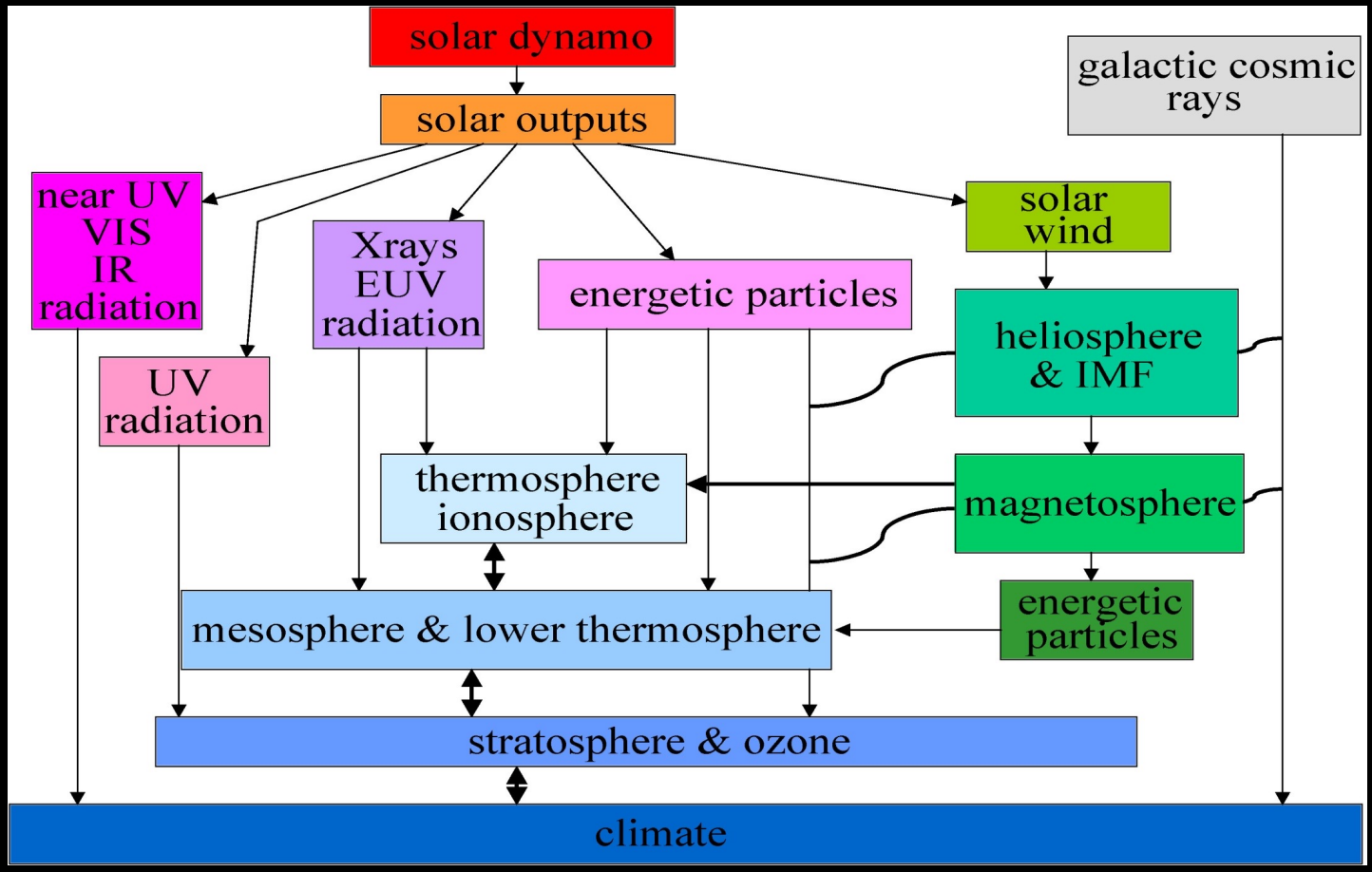
Evolution of System Studies



Heliophysical: A broadening of the concept "geophysical," extending the connections from the Earth to the Sun & interplanetary space.

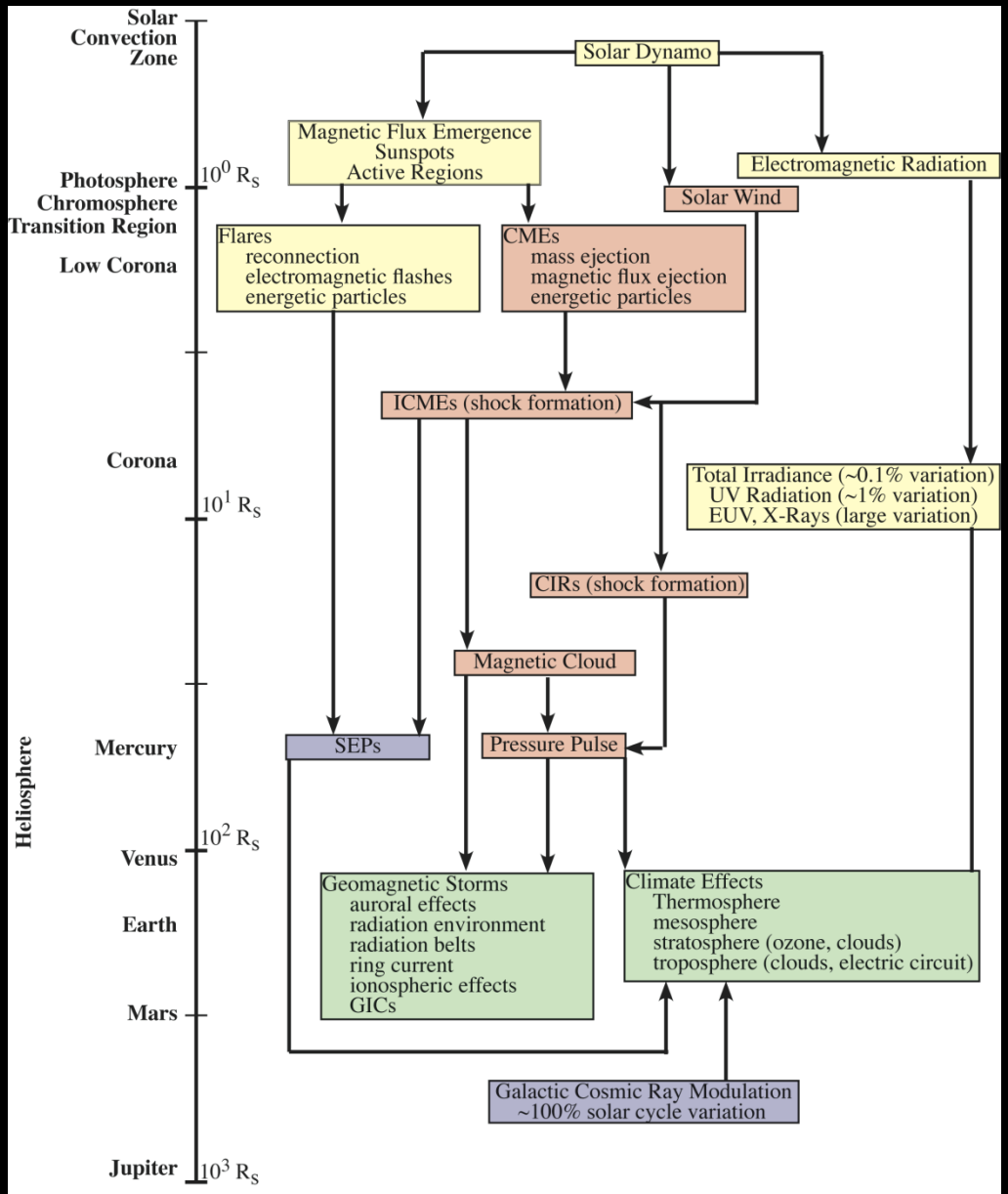
LWS is a Systems Approach

LWS focuses not on any one region of space, but rather on our Sun Earth Region as one system.



A very important part is the study of the connection between the regions and how one drives a response in another.

Key Elements of the LWS Systems Approach



Space Weather Occurs at all Phases of the Solar Cycle...

Solar La Niña (low sunspot number)

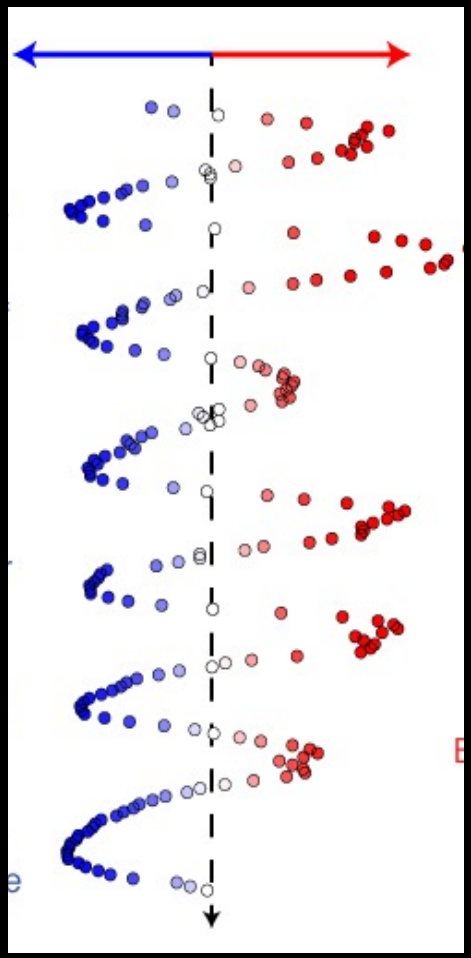
extreme galactic cosmic rays

rapid accumulation of space junk

sharp contraction of the heliosphere

collapse of the upper atmosphere

total solar irradiance changes



Solar El Niño (high sunspot number)

super solar flares

extreme solar “cosmic rays” (energetic particles)

radio blackouts

extreme geomagnetic storms

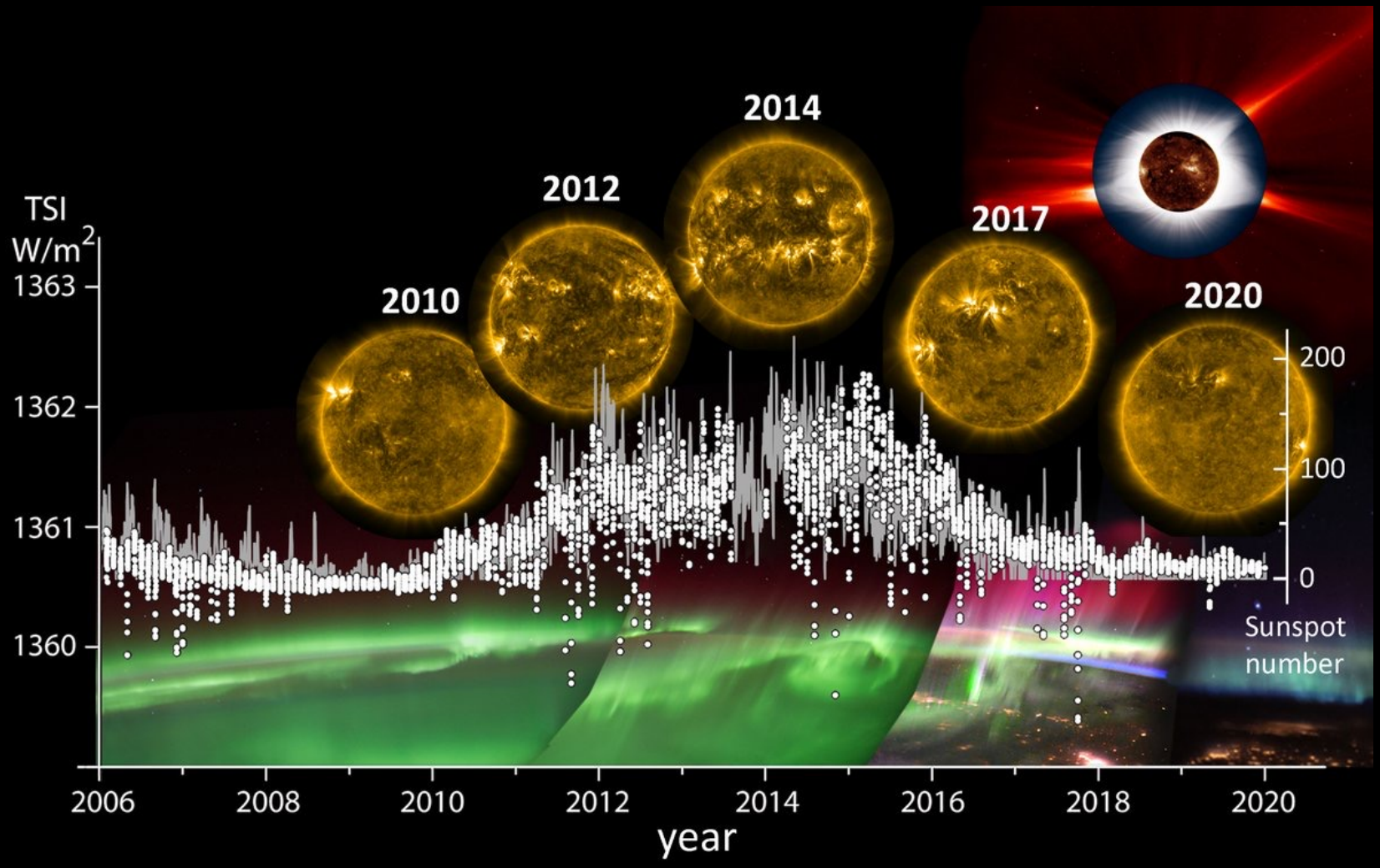
melted power grid transformers – power blackouts

solar wind streams hit Earth

Illustration shows smoothed monthly sunspot counts from the past six solar cycles plotted horizontally instead of vertically. High sunspot numbers are in red and on the right, low sunspot numbers are in blue and on the left. Associated with each high and low sunspot numbers are different space weather impacts experienced at Earth (doi: 10.1002/swe.20039).

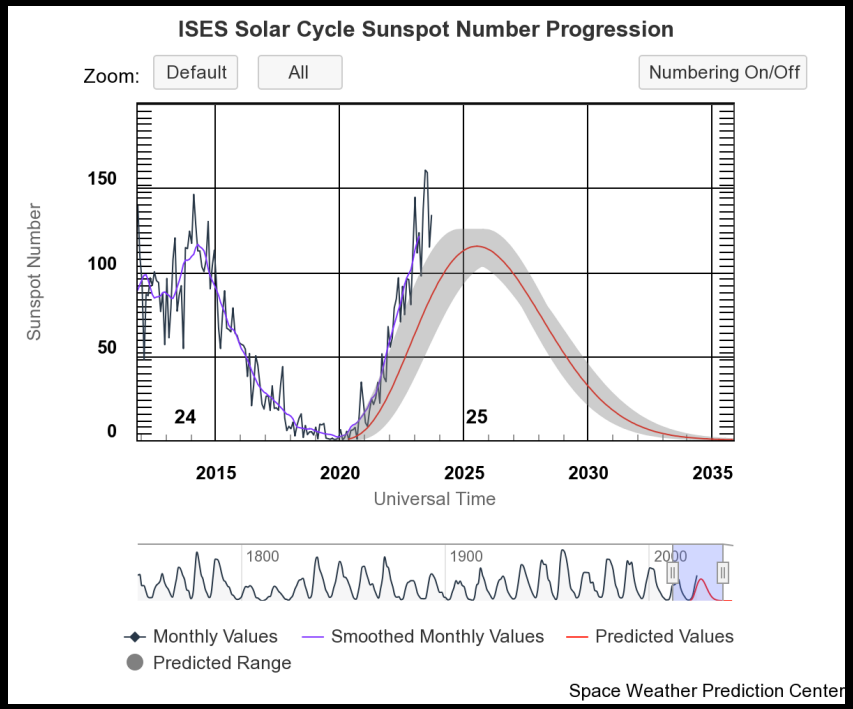
Everey day Space Weather:

Illustration of solar activity impacts on the Earth’s space environment during Solar Cycle 24.

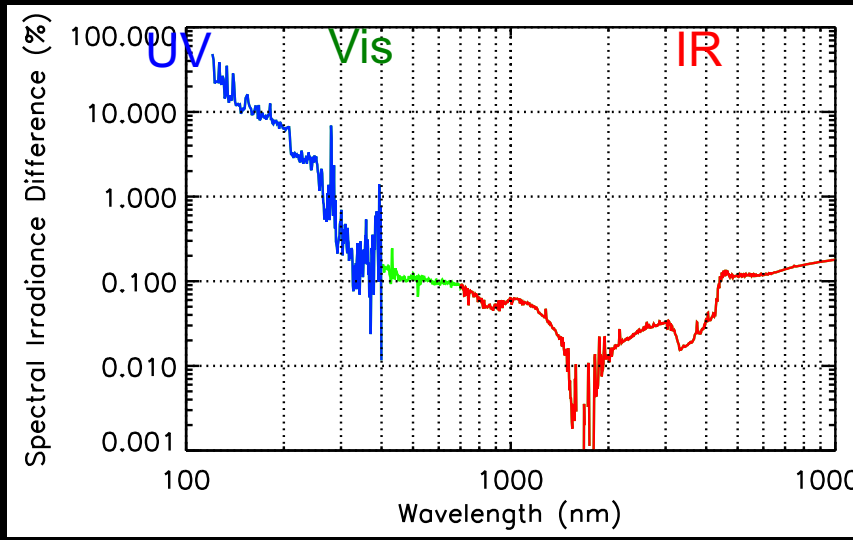


As the scope of space weather forecasting expands to other planets, it is also expanding in directions traditionally connected to climate research. Climate refers to changes in planetary atmospheres and surfaces that unfold much more slowly than individual storms. There is no question that solar activity is pertinent to climate time scales.

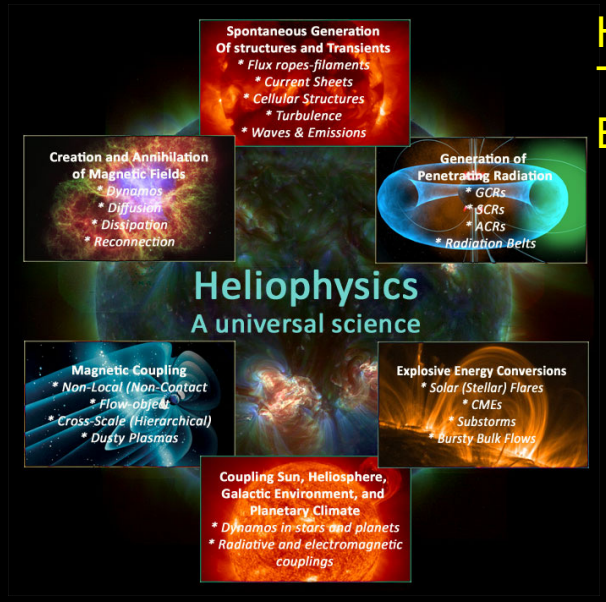
The radiative output of the Sun, the size and polarity of the Sun's magnetic field, the number of sunspots, and the shielding power of the Sun's magnetosphere against cosmic rays all change over decades, centuries, and millennia.



Spectral Solar Irradiance (SSI): SMax vs. SMin



Small variations in the visible (0.1%), but big changes in the UV. ***(UV, EUV and X-ray spectral irradiances are drivers of space weather)***



Heliophysics Cross Discipline Infrastructure:
Text Books. Summer Schools, Institutes
Eddy Postdoctoral Fellowships Administered by UCAR CPAESS

Heliophysics I:
"Plasma physics of the local cosmos"
Heliophysics II:
"Space storms and radiation: causes and effects"
Heliophysics III:
"Evolving solar activity and the climates of space and Earth"
Heliophysics IV:
"Active stars, their astrospheres, and impacts on planetary environments"
Heliophysics V: *(Online only)*
"Space weather and society"

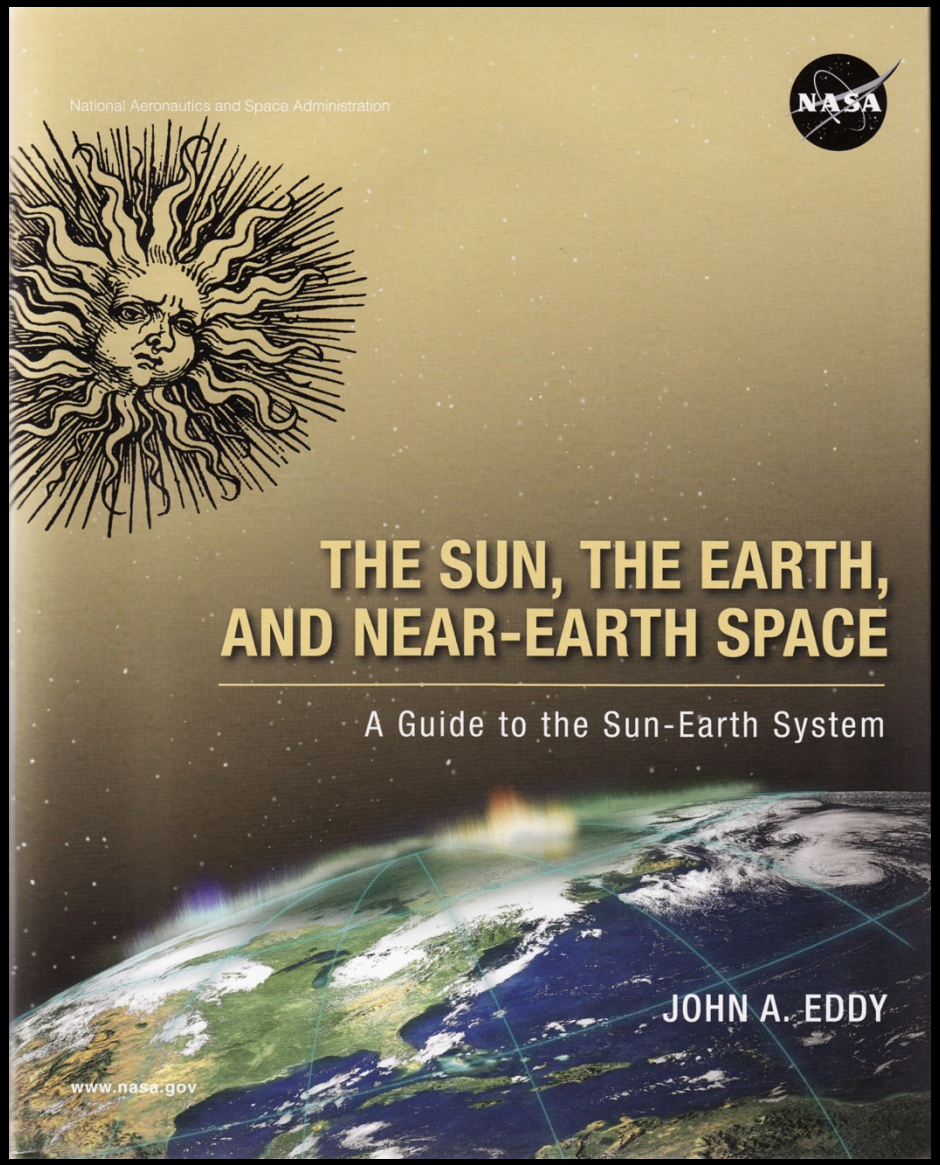
Since 2007-2023, we have had:

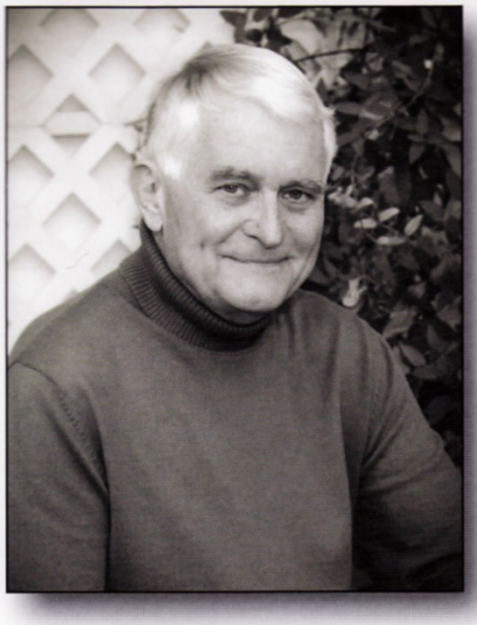
Total Students ~550
International Students ~220
PhD Level ~380
Masters Level ~170

Jack Eddy Postdoctoral Fellowship 2010-2022, ~35 appointments

To train the next generation of researchers needed in the emerging field of heliophysics, in honor of the pioneering interdisciplinary researcher, Jack Eddy.

Primer for Heliophyscs





JOHN A. EDDY

Dr. John A. Eddy is a graduate of the U.S. Naval Academy and the University of Colorado who is best known for his work in recovering the history of the Sun and establishing the reality and nature of extended periods of anomalous solar behavior in the distant past, such as the Maunder Minimum of 1645 to 1715. He is known as well for his investigations of the astronomy of early Indians of the American plains; as a scientific editor and popular interpreter of science; and for many years, in promoting the interdisciplinary study of global environmental change. He is a fellow of the American Association for the Advancement of Science and a recipient of the Arctowski Prize of the National Academy of Sciences for pioneering work in solar-terrestrial physics.

Inclusion, Diversity, Equity, and Accessibility (IDEA) in Heliophysics

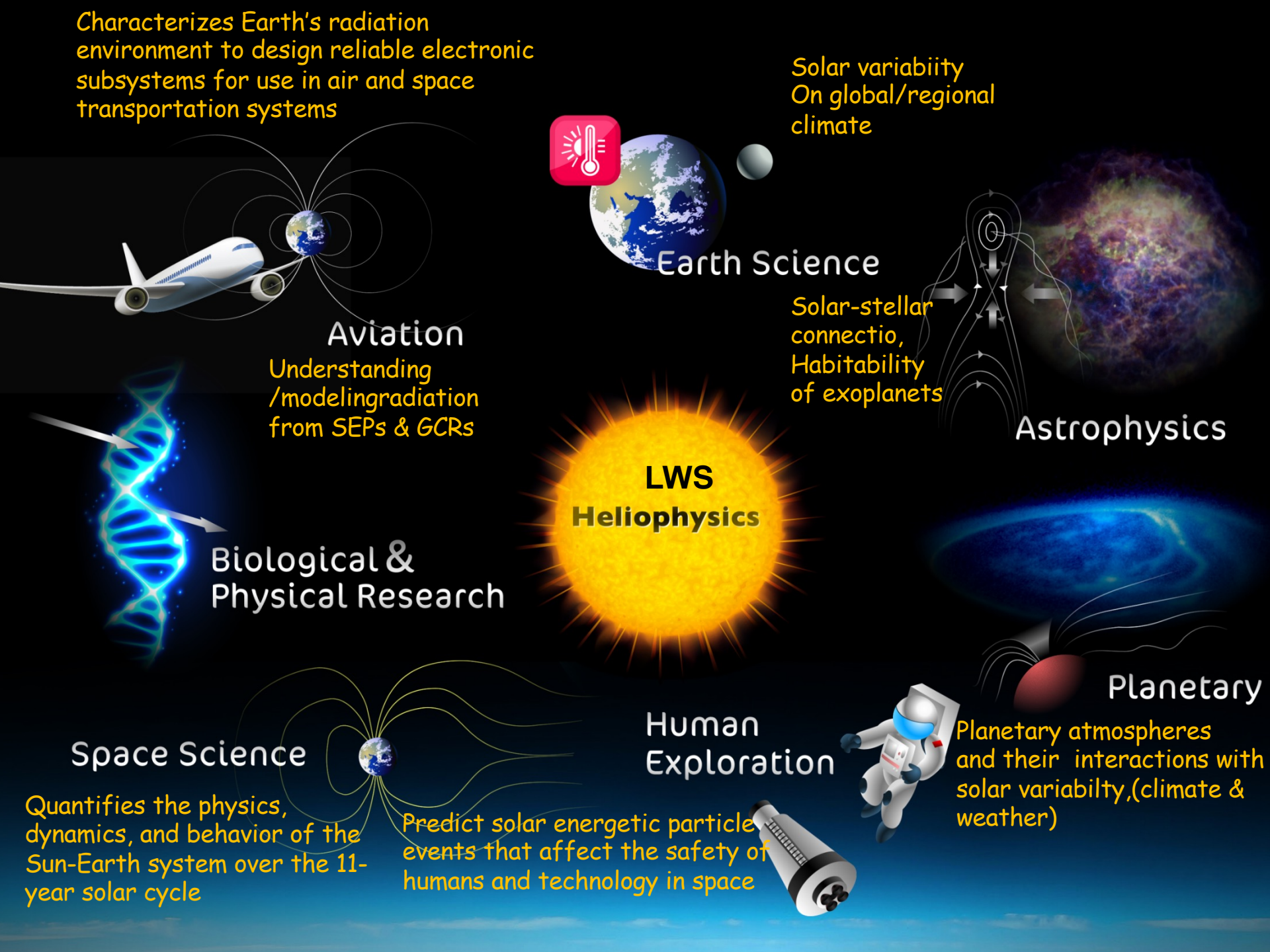
IDEA initiatives in SMD recognized as a long-term effort, but immediate action and problem solving will advance initiatives in parallel with systemic, enduring activity.

Heliophysics Division Goal

Incorporate IDEA into the Heliophysics Division mission, vision, and strategy, resulting in a Division-wide commitment to lasting and specific IDEA goals and objectives.

Ongoing and Exploratory Efforts

- Members of HPD participating in various trainings and working groups to identify potential near-, mid-, and long-term Division actions .
- Identify Division and SMD leadership opportunities for staff.
- Explore best practices for IDEA recruitment efforts, including hiring panels.
- Adopt inclusive R&A code of conduct.
- Sponsor and incentivize enhanced and innovative mission outreach activities with IDEA as a major focus (e.g., PUNCH, IMAP).
- Establish a community-wide early- and mid-career support network pilot in partnership with other SMD Divisions, professional and scientific societies with a focus on providing mentors and mentees training and resources that consider the “whole” STEM individual.
- Develop targeted and innovative R&A solicitations with an IDEA emphasis.


Characterizes Earth's radiation environment to design reliable electronic subsystems for use in air and space transportation systems
Solar variabiity On global/regional climate
Earth Science
Aviation
Understanding /modelingradiation from SEPs & GCRs
Solar-stellar connectio, Habitability of exoplanets
Astrophysics
LWS
Heliophysics
Biological & Physical Research
Planetary
Space Science
Quantifies the physics, dynamics, and behavior of the Sun-Earth system over the 11-year solar cycle
Human Exploration
Predict solar energetic particle events that affect the safety of humans and technology in space
Planetary atmospheres and their interactions with solar variabilty,(climate & weather)

Grand Challenge : *Integration* of the knowledge provided by plasma and other models to understand and predict the behavior of heliophyisics systems

"I think the…21st century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don't know how the laws fit together, and what happens under extreme conditions….There is no limit to the complexity we can build using those basic laws."----Stephen Hawking

1942-2018