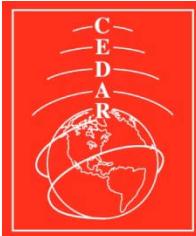




# CEDAR 2010 Strategic Plan

## The New Dimension

*Man must rise above the Earth - to the top of the atmosphere and beyond - for only thus will he fully understand the world in which he lives. -Socrates*

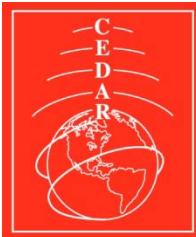


# CEDAR Strategic Plan

CEDAR is a community based initiative that provides the community an opportunity to self-organize and exchange ideas. It also provides strategic guidance to NSF. With its emphasis on ideas, inclusivity, and education, CEDAR has become the intellectual engine of aeronomy.

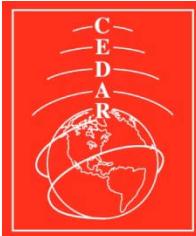
## Why Now?

- CEDAR Phase III document is out of date (13 years old)
- Research landscape is rapidly evolving
- Initiatives are pushing the research and resource envelop of CEDAR
- CEDAR needs to be better poised to contribute to high-priority, agency-wide research programs
- CEDAR has icon status as the preeminent aeronomic body and is the expert group to push concept forward to advance new opportunities for discovery



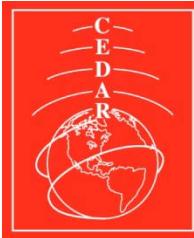
# What Does the Strategic Plan Do?

- **Unifies** the Aeronomic field and its connection to geospace
- **Demands** stronger collaboration with other research areas, such as lower atmosphere and magnetosphere
- **Explores** transformational research
- **Defines** resource needs
- **Responds** to the new research landscape
- **Provides** a platform for new initiatives
- **Connects** Aeronomy with societal issues
- **Affords** Opportunity for Discovery



# CEDAR Strategic Plan Document

- To unify and guide the CEDAR community for the next transformative step in CEDAR research.
- To provide a “New Dimension” to CEDAR research, by which, new discoveries and initiatives will continue to be born at all levels of scientific inquiry.
- To clearly define our mission to the larger geosciences community enabling cross-discipline activities and collaboration within existing and planned broad-scale initiatives

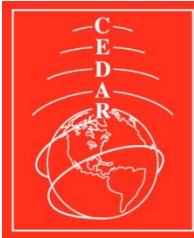


# CEDAR's Vision

To understand the mesosphere, thermosphere, and ionosphere (ITM) system in sufficient detail to characterize its fundamental processes, to explore the limits of its predictability and to define the interconnected processes that influence the global behavior and evolution of the Sun-Earth system.

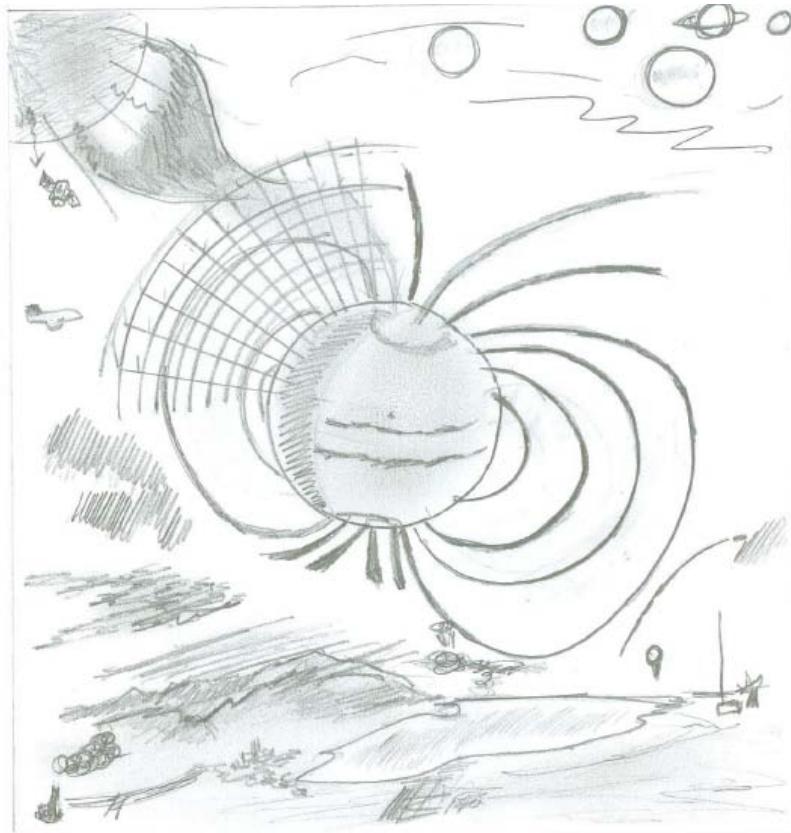


CEDAR 2010 June 21 Boulder, CO



# CEDAR: The New Dimension

Taking a system's approach to study the coupled, complex, and evolving GeoSpace environment



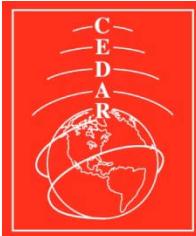
## The Broadest Impact

### **Habitability: Our Whole Earth System**

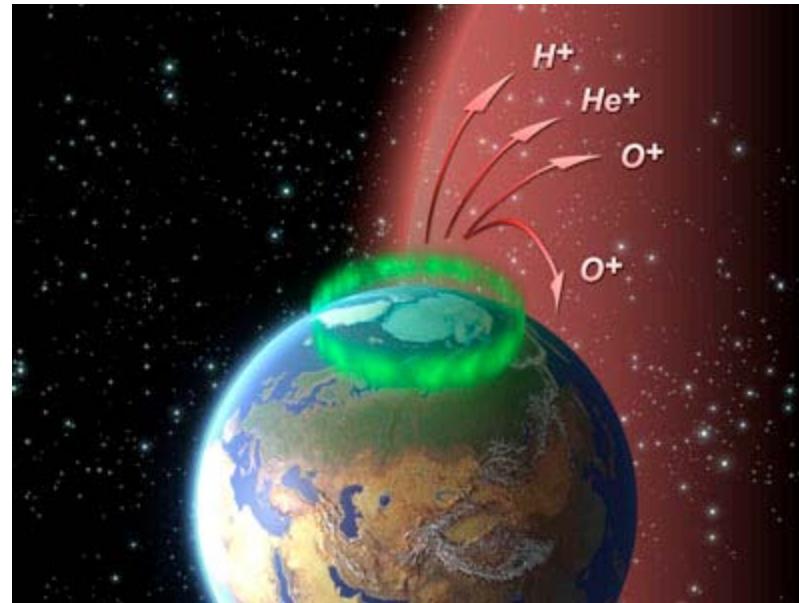
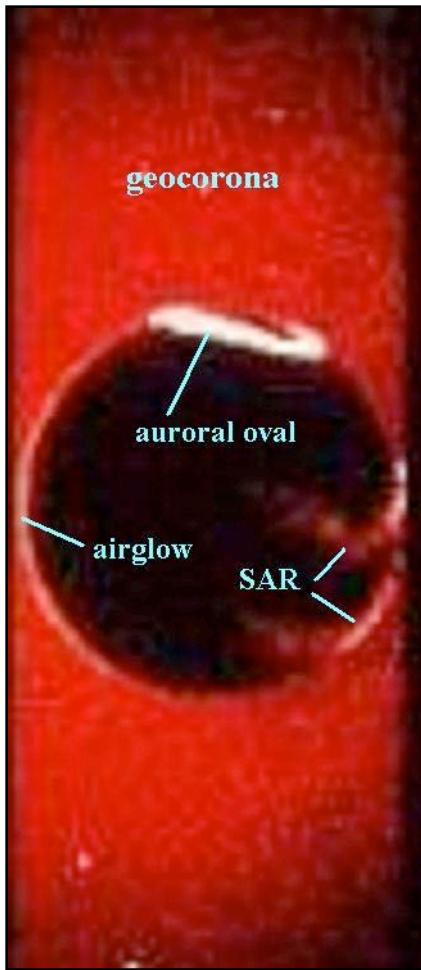
*As much as water and sunlight are imperative for initiating life, geospace is important to maintain it.*

### **Sustainability of our Technology-Reliant Society**

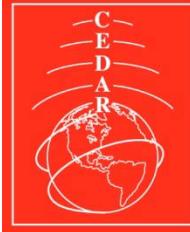
*As dependent as we have become on natural resources, our society has an ever increasing reliance on technology that is directly affected by the geospace environment*



# Habitability: Our Escaping Atmosphere



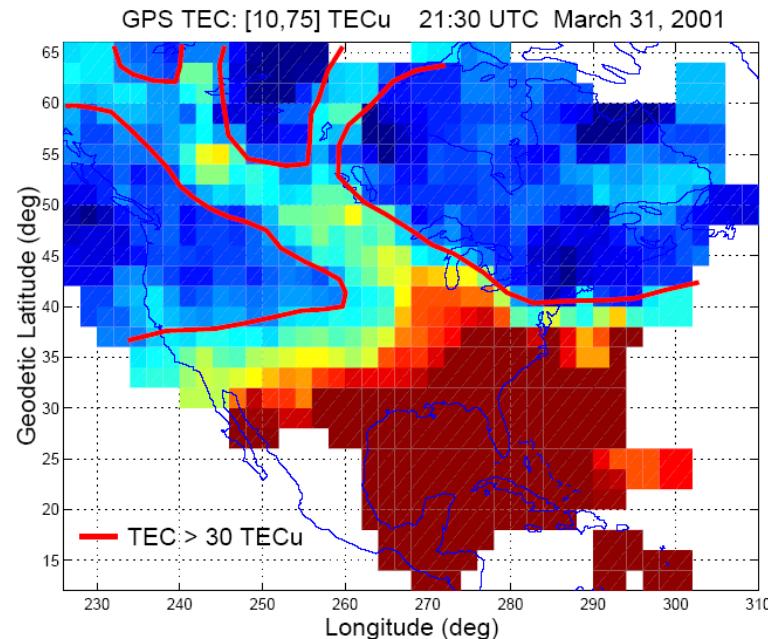
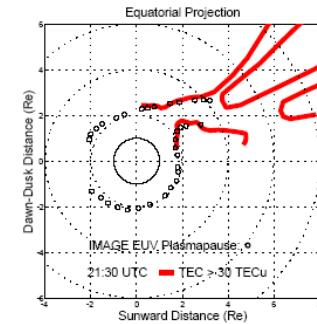
How is it replenished?  
Is the loss balanced and by what source?  
Does the Earth's magnetic field help retain and return the gas?  
Do we hold the same fate as our nearest neighbors?



# Sustainability of Our Technology Reliant Society

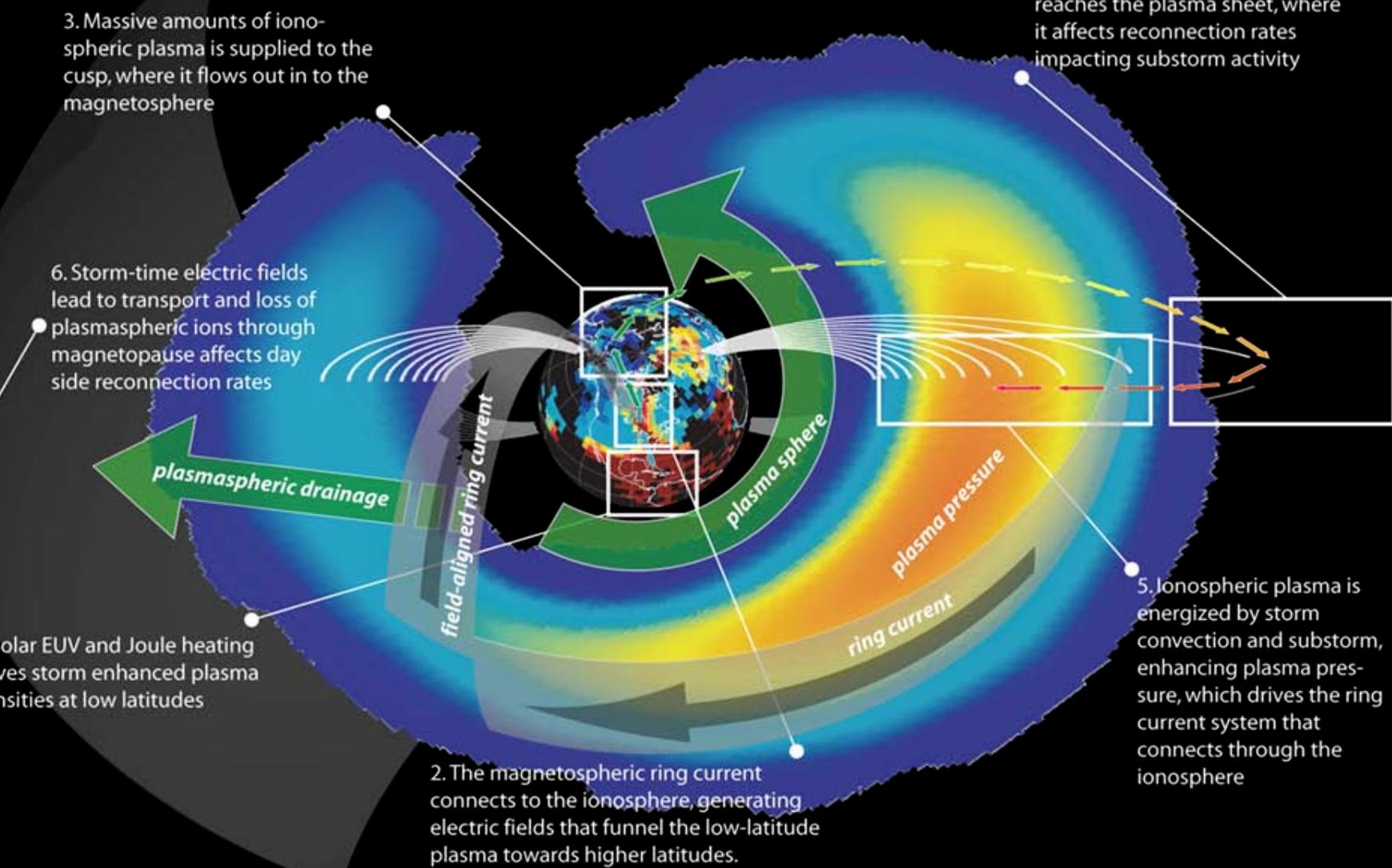
- Complementary technologies, not envisioned as contributors to CEDAR research in the past, are reshaping the research landscape
- Societal dependencies on space assets are helping to drive science development

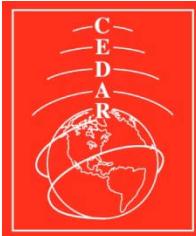
## Storm-Time Enhanced Electron Density



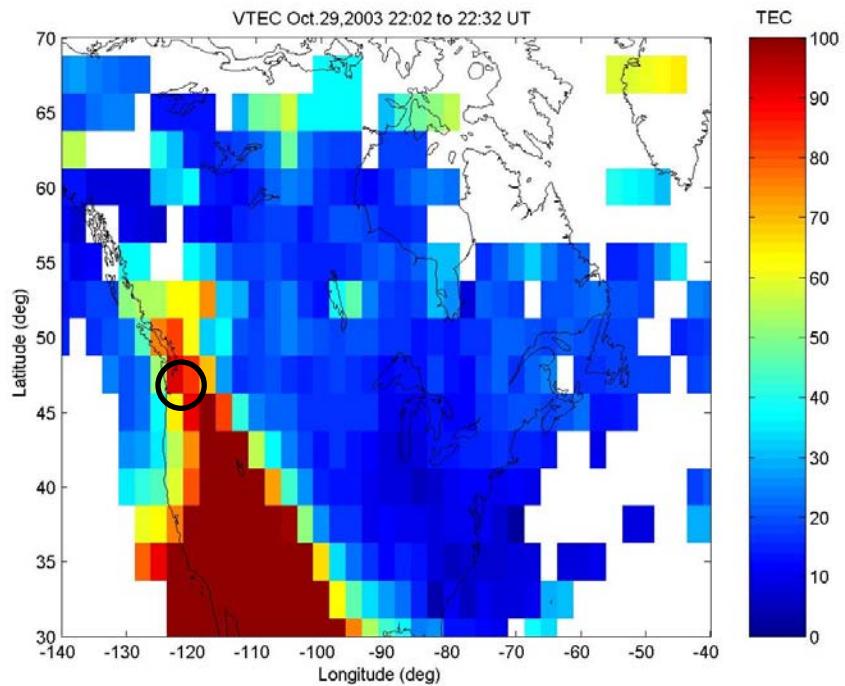
[Foster, J. C., P. J. Erickson, A. J. Coster, J. Goldstein, and F. J. Rich, Ionospheric signatures of plasmaspheric tails, *Geophys. Res. Lett.*, 29(13), 10.1029/2002GL015067, 2002.]

# Plasmasphere-Ionosphere Coupling

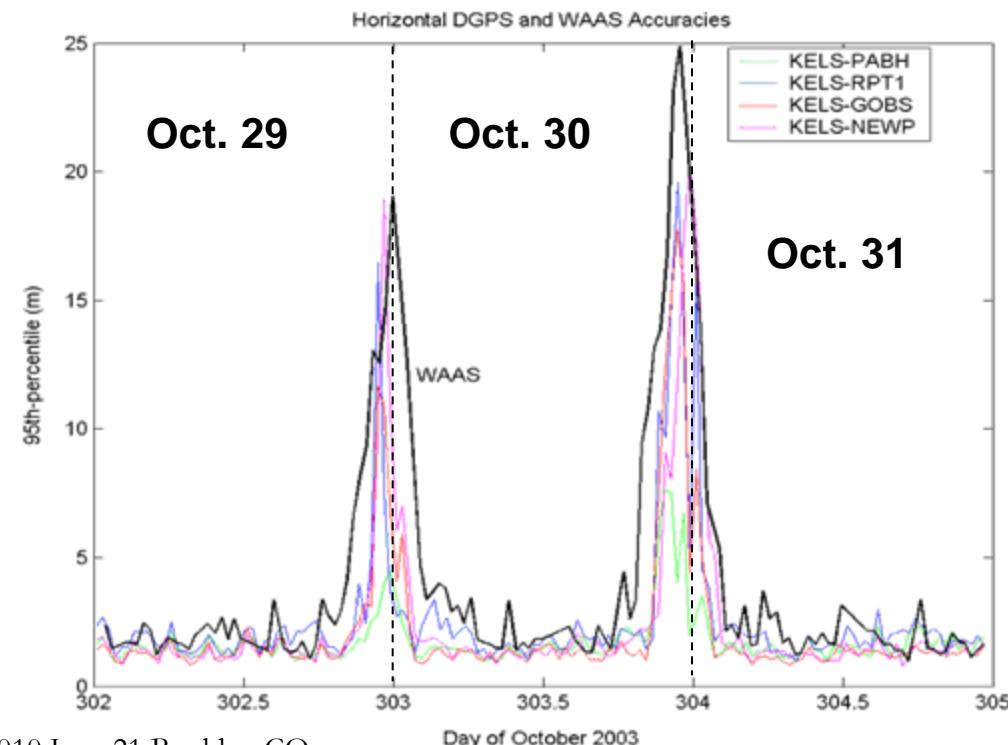




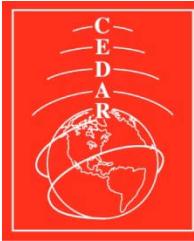
# GPS Navigation Position Errors due to SEDS



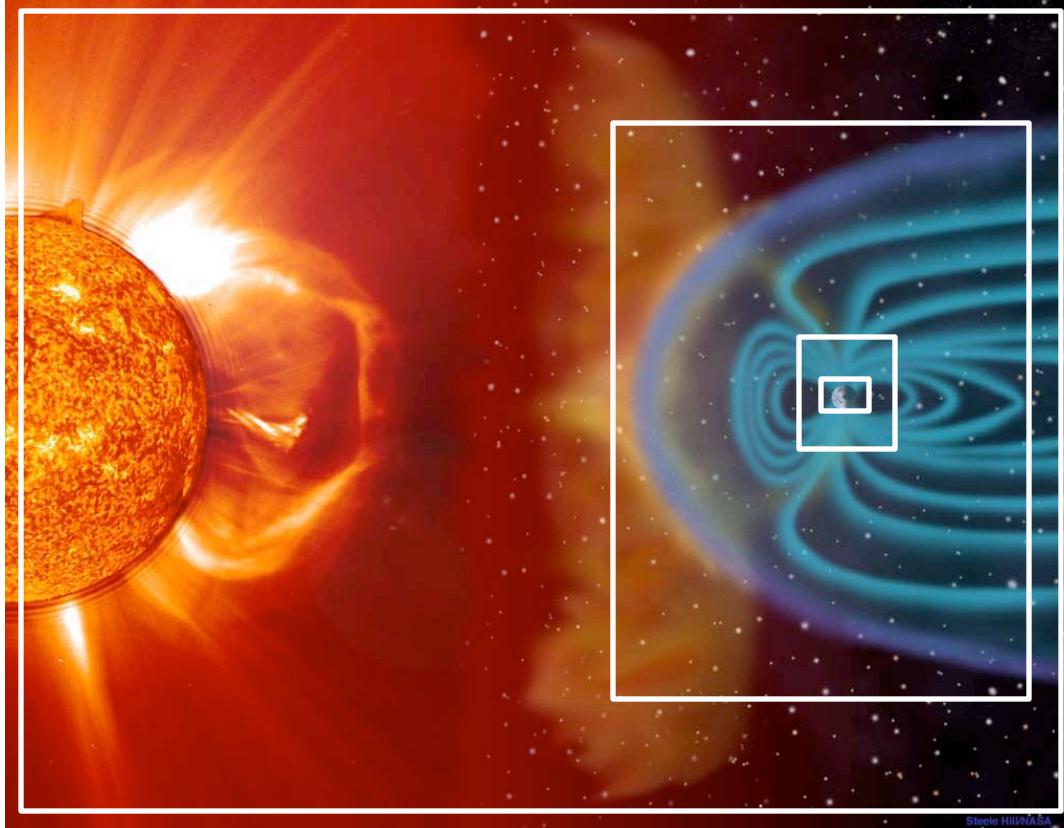
Typical positioning errors are a few meters but during storm enhanced density (SEDS) events errors can be 15-25 meter.



Storm Enhanced Density  
(SED).



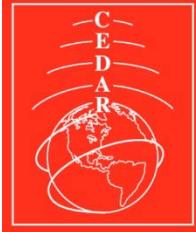
# Sun–Earth System: Systems within Systems



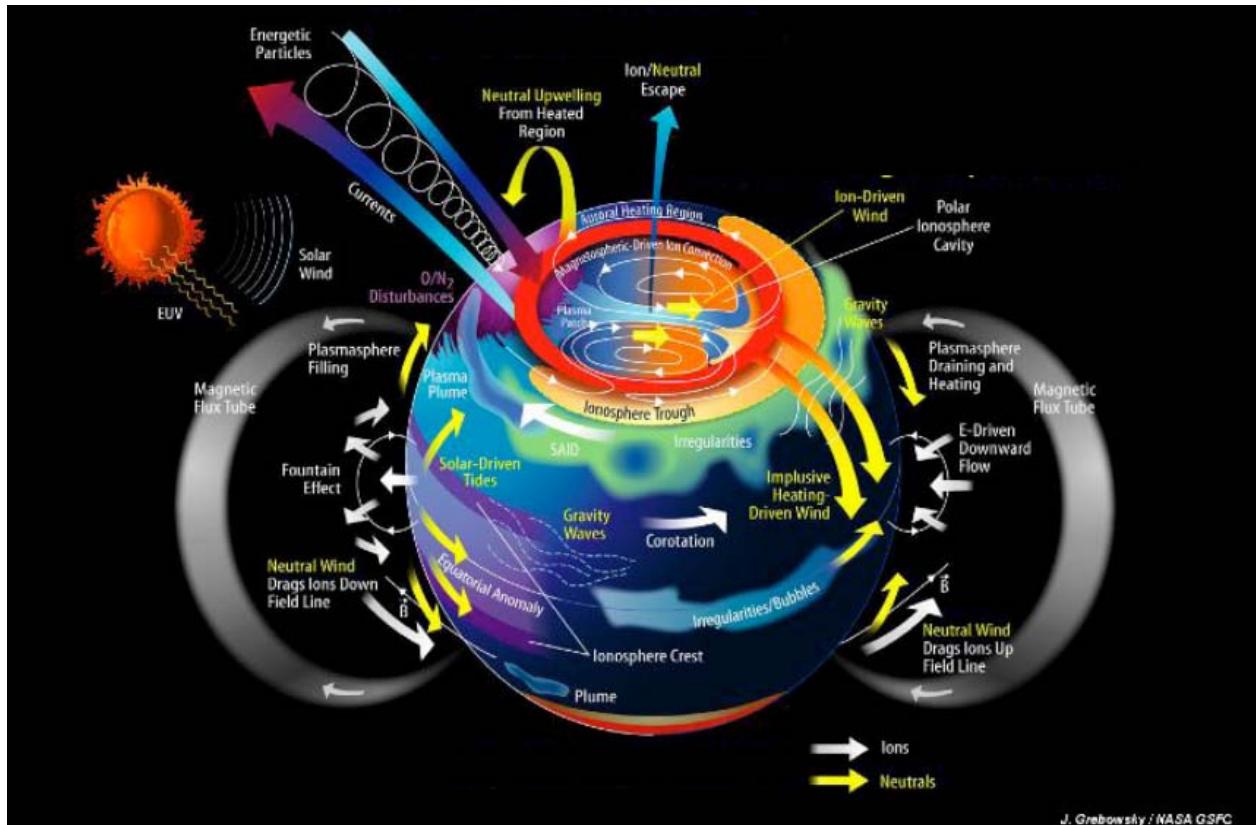
The intellectual framework of the system view enables transferable concepts across systems and disciplines to advance and facilitate progress in understanding our whole sun-earth system

The system view engages the entire community by providing broad unifying goals

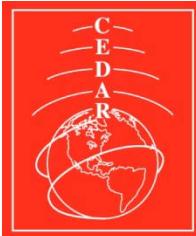
The system view provides new insight into geospace



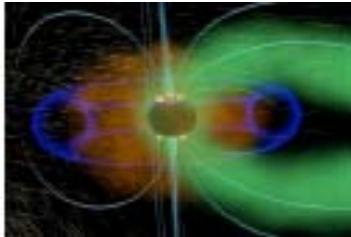
# ITM: The Interaction Region of Geospace



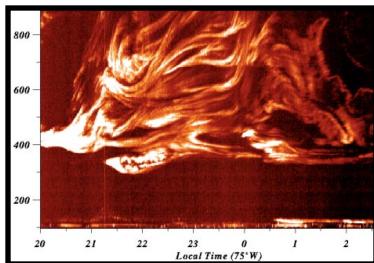
The CEDAR research domain embodies the ionosphere-thermosphere-mesosphere (ITM) and represents the system where the atmosphere and space interact.



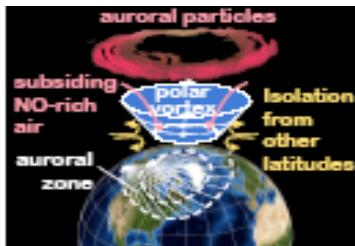
# System Science Applied to the Coupled, Complex, and Evolving GeoSpace System



**Coupling** considers the physical, dynamical, chemical, and electrodynamic interactions that transform energy within GeoSpace.



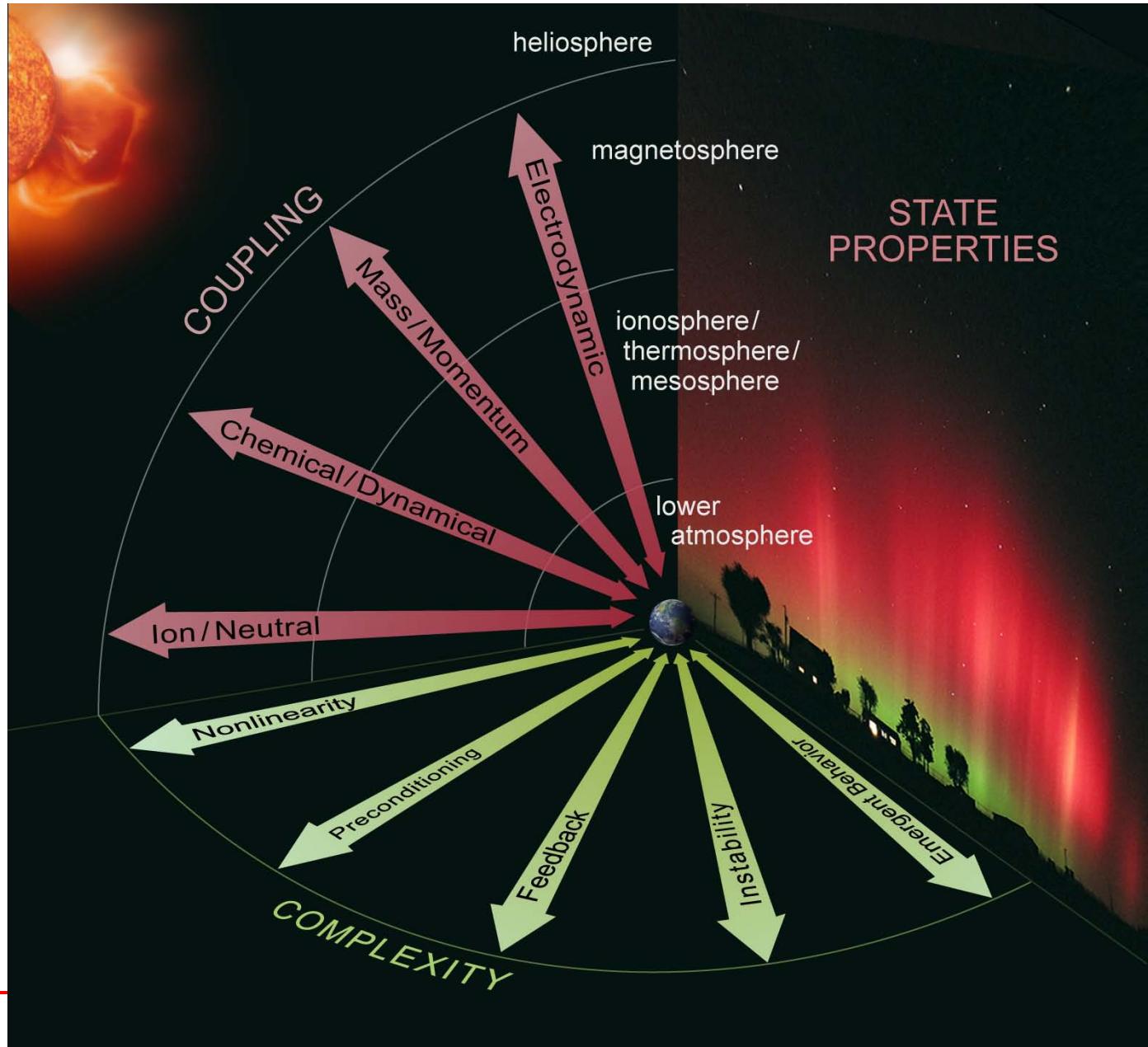
**Complexity** considers the system characteristics and the response to the exchanging energy, mass and momentum leading to alterations of state properties.

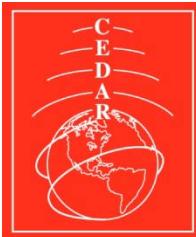


**Evolving** considers the dynamic response of the system at multiple temporal scales as constituents, external sources, and internal processes change over time.



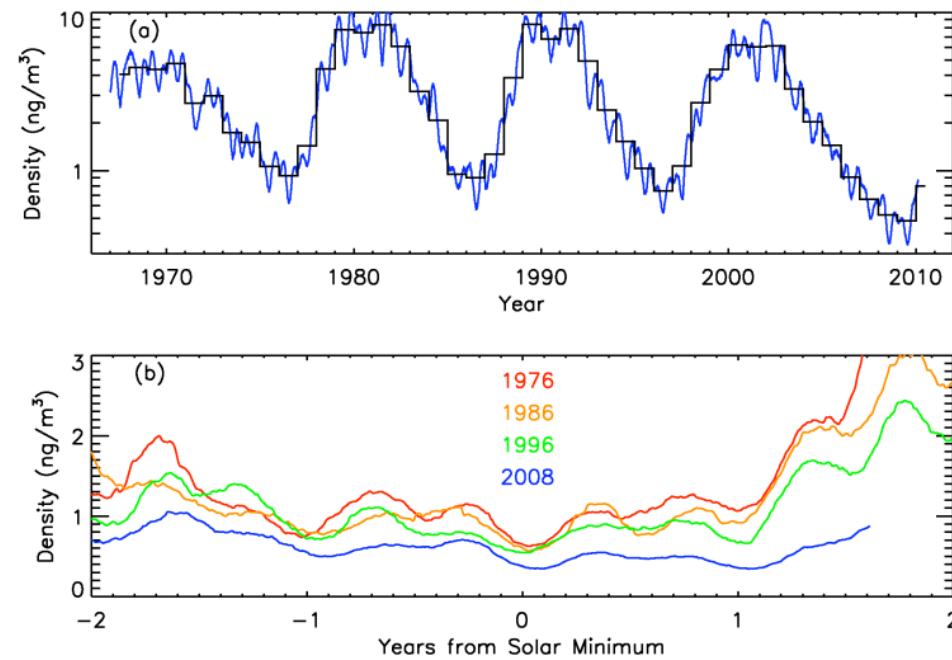
Complexity  
adds  
another  
Dimension  
to  
CEDAR  
Research



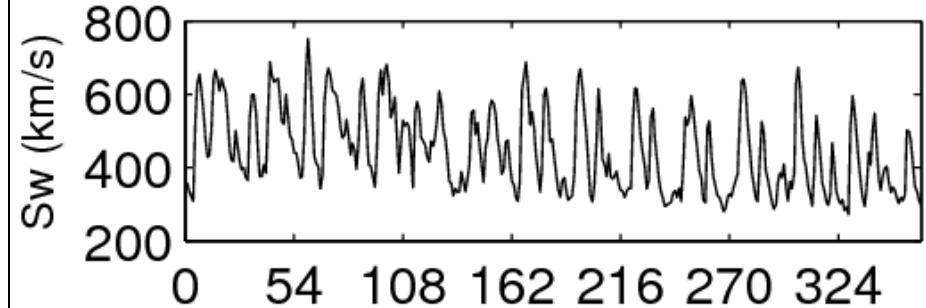


# Preconditioning of the Thermosphere

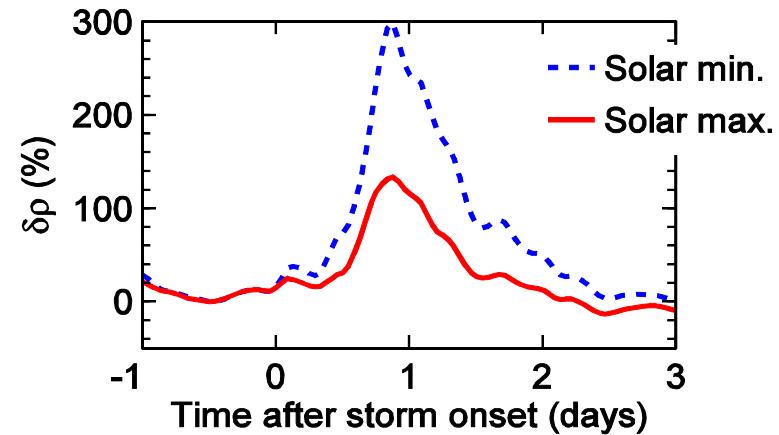
Solar EUV Effect



Solar Wind Disturbances in 2008



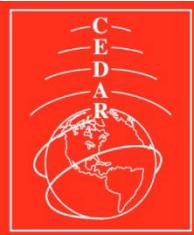
Relative Density Response at 400 km  
For same geomagnetic storm input  
but different levels of EUV flux



Courtesy of Stan Solomon, NCAR

CEDAR 2010 June 21 Boulder, CO

Courtesy of Jiuhou Lei, CU

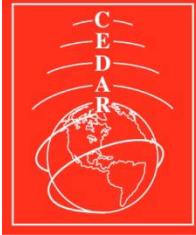


# System Approach Helps to Offer New Insight

## Example: Energy Exchange Across Geospace

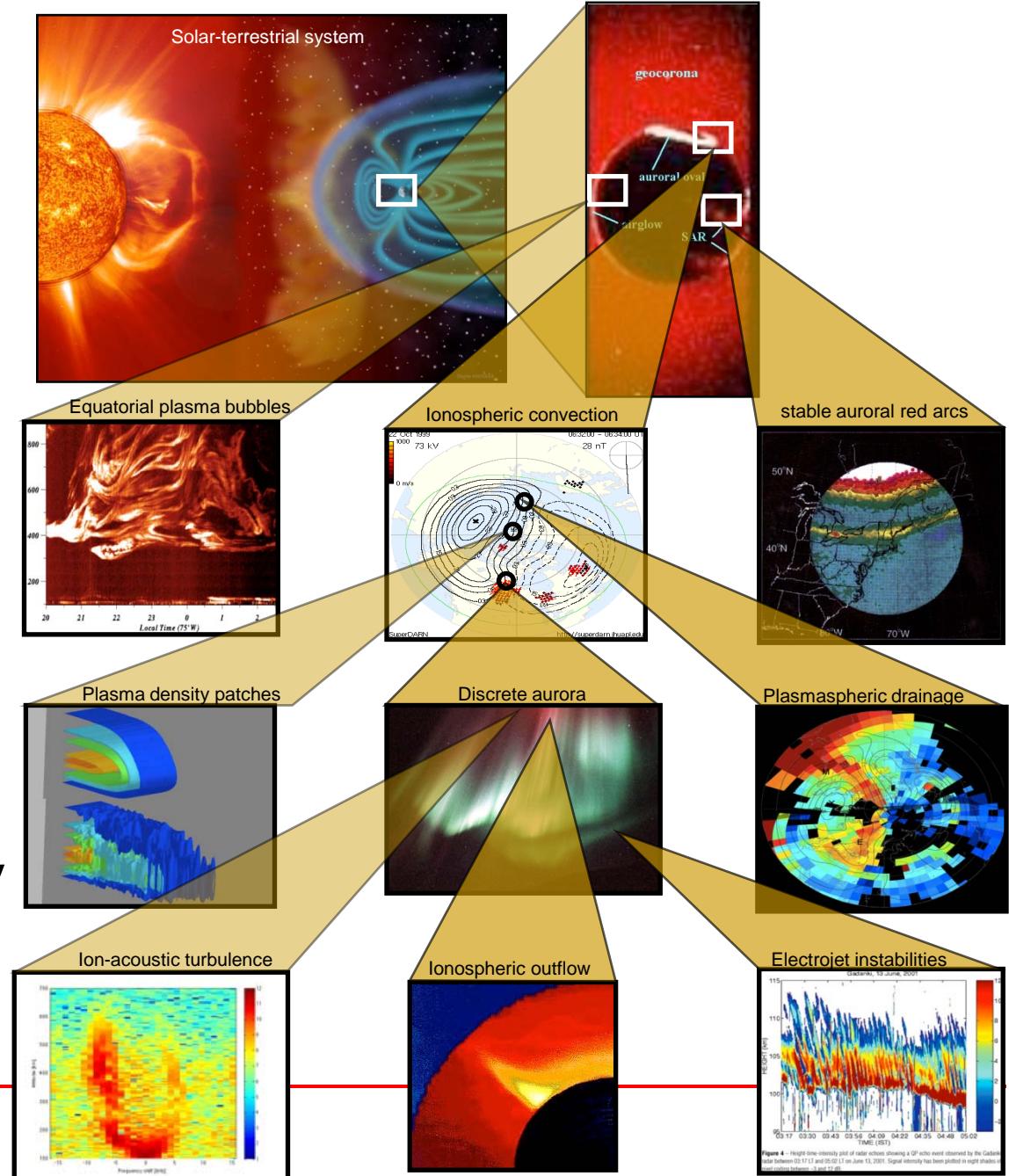
### ■ Complexity

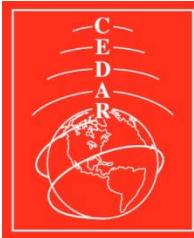
- Feedback on sources and sinks of energy
  - Nitric Oxide production during auroral particle precipitation enhancing cooling – The “Thermostat” Effect
- Emergent behavior altering energy exchange
  - Saturation of the cross polar cap potential limiting the transfer of energy from the solar wind to the ionosphere
- Nonlinear processes mask energy sources
  - Wave-mean interactions produce nonlinear responses that can be challenging to identify with a particular source
- Preconditioning change the energy source type
  - Daylight ionosphere conductivity alters the ionospheric load and the response of the magnetosphere



# System Scalability

The same system concepts can be applied to any prescribed subsystem but must be done so in the context of the larger system.





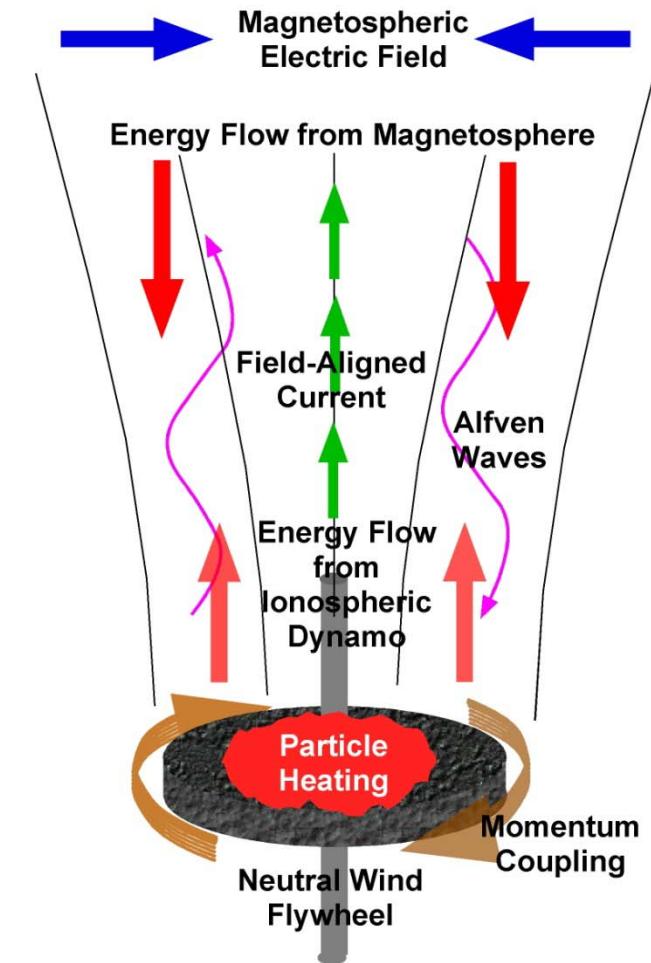
# The Neutral System of the ITM

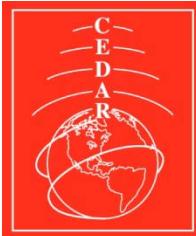
## ■ Complexity

- Feedback
- Preconditioning and Memory
- Instability

## ■ Needed State Parameters

- Neutral wind, temperature, composition and density





# The Electrical System of the ITM

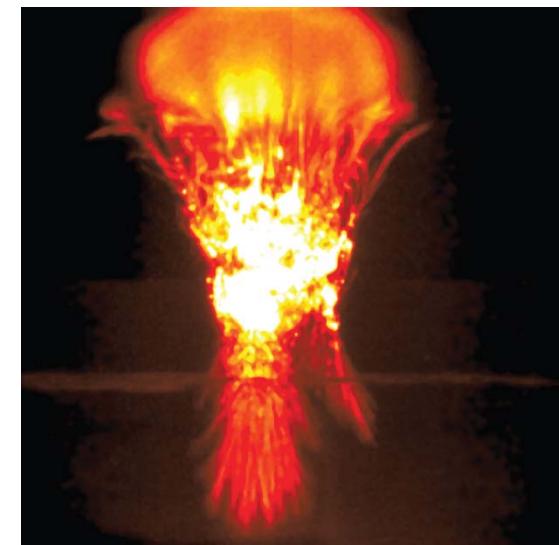
## ■ Complexity

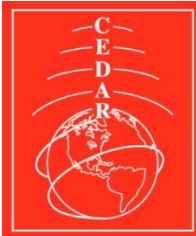
- Feedback
- Preconditioning and Memory
- Instability



## ■ Coupling Issues

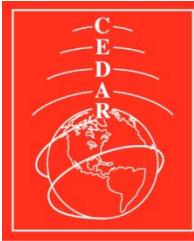
- Magnetosphere-ionosphere
- Thermosphere-ionosphere
- Lower atmosphere-ionosphere





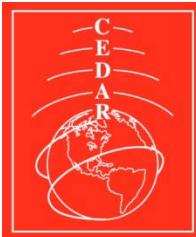
# The Evolving Geospace System

- Multiscale temporal changes in geospace ranging from wave cycles to solar cycles
- Variability in geospace properties can exceed their mean state values
- Long term evolutionary change in space climate or earth climate may alter system variability or multiscale temporal response in geospace
  - Carbon Dioxide in the Upper Atmosphere
  - Geomagnetic field changes

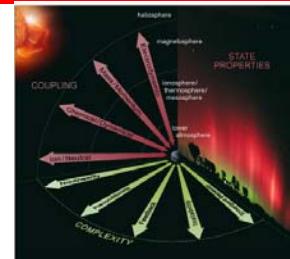


# Discovery and Breakthroughs Enabled by the “New Dimension”

- A new way of viewing problems that provides fertile ground for innovation and enables broader, global questions that lead to transformative research.
- With the rapid evolution of the field in recent times, classic discovery mode science takes on a new meaning that includes the discovery of hidden linkages necessary to understand the complex system driven by internally and externally coupled components.



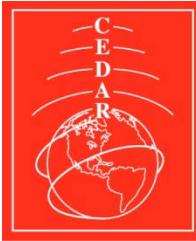
# Strategic Thrust #1: Encourage and Undertake a Systems Perspective of Geospace



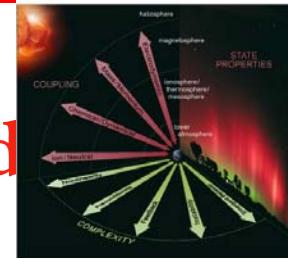
**Vision:** *To describe global connectivities & causal relationships involving the ITM, and their influences on geospace and the whole Earth system. This approach will contribute to broad community issues in geoscience and recognize and remedy gaps in knowledge.*

## **Implementation:**

- Develop CEDAR strategies for developing system-level issues in geospace with an emphasis on recognizing the importance of system complexity.
- Exploit the unique expertise in the CEDAR community to explore connections with the larger earth system.
- Consider restructuring the annual CEDAR proposal competition, the CEDAR Science Steering Committee and the Annual Workshop, to encourage system level approaches, broader participation and new interdisciplinary research.



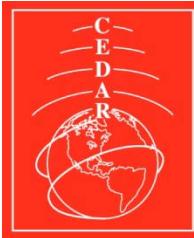
# Strategic Thrust #2: Explore Exchange Processes at Interfaces and Boundaries



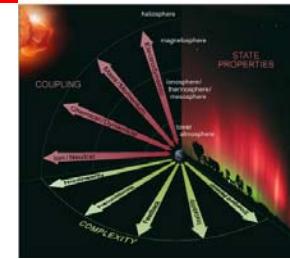
**Vision:** *To understand the transformation and exchange of mass, momentum and energy at interfaces within the ITM and through boundaries that connect with the lower atmosphere and the magnetosphere. Defining these interfaces and boundaries by physical processes creates new knowledge about the nature of interaction regions applicable to Earth and other planetary bodies' interaction with space.*

## **Implementation:**

- Encourage collaboration and the formation of working groups focused on identifying and understanding interfaces and boundary regions.
- Study sources and sinks and their possible alterations due to coupling at interfaces between disparate regions.
- Work to reduce model parameterizations by developing theories and coupled models that account for processes occurring at boundaries and interfaces.
- Develop novel computational thinking (resources, techniques, analysis...) that enable predictive capabilities



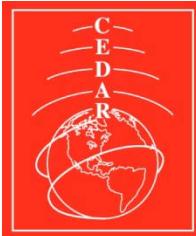
# Strategic Thrust #3: Explore Processes Related to Geospace Evolution



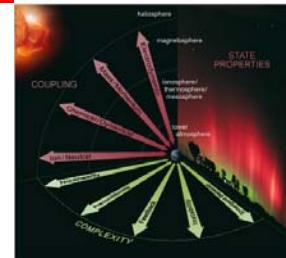
**Vision:** *To understand and predict evolutionary change in the geospace system and the implications on the whole earth system and other planetary systems.*

## **Implementation:**

- Continue long-term data bases that has been the hallmark of CEDAR science for many years.
- Ensure proper calibration and validation of long-term data sets to ensure they can be properly applied to global scientific issues.
- Conduct the requisite studies to identify and isolate observables that may be harbingers of change in geospace.
- Develop a more complementary program of comparative planetary aeronomy to test evolutionary models and physical understanding of the earth system



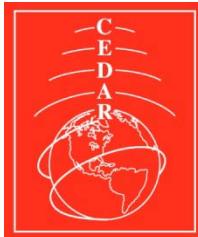
# Strategic Thrust #4: Develop Observation and Instrumentation Strategies for Geospace



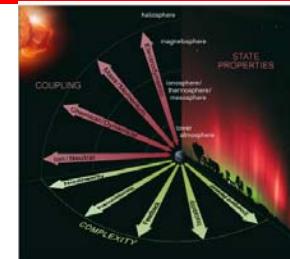
**Vision:** *To have instrumentation capable of measuring system properties necessary to examine the coupling and complexity processes responsible for producing the ITM behavior. To exploit existing and planned observational assets in order to optimize scientific return.*

## **Implementation:**

- Conduct studies to determine the optimum type and placement of large observatories or instrument campaigns to best serve the needs of the broader CEDAR community.
- Develop smart sensors, distributed processing, acquisition, and infrastructure, and reconfigurability to changes in geophysical conditions.
- Further the advancement of small satellites for CEDAR research.



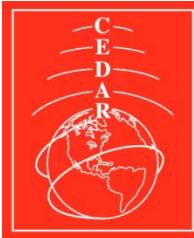
# Strategic Thrust #5: Fuse the Knowledge Base across Disciplines



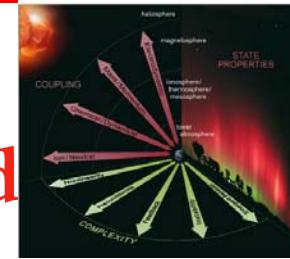
**Vision:** To develop collaborations in related but distinct disciplines of geosciences, mathematics, engineering, and physics to attract a greater variety of researchers and students spawning new ideas and methodologies that will more rapidly advance geospace studies.

## ***Implementation:***

- Work with the lower atmosphere, magnetosphere and solar communities to develop strategies for mutual scientific enterprises
  - Work with International organizations, such as CAWSES, ICESTAR, EISCAT, EGS, and AOGS , to advance progress and exchange ideas on tackling global issues
  - Provide an educational, research and technology framework that excites, trains, and supports future generations of researchers in the field



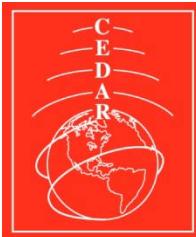
# Strategic Thrust #6: Manage, Mine and Manipulate Geoscience Data and Models



**Vision:** To tap the vast resources of burgeoning geoscience data to provide a new view of geospace, optimize information for proper deployment locations of key instruments and measurements to further scientific productivity, discover correlations and contribute to understanding of their causalities, contribute to determining the evolution of geospace by manipulation and evaluation of multiple observables over extended observing periods

## **Implementation:**

- Develop and implement protocols for optimizing data acquisition and establishment of virtual data bases that are accessible and easy to use
- Continue to evolve data assimilation schemes in physics based models for improved constraints on model prediction
- Plan for future instrument deployments and integration of observations into a comprehensive data depository with advanced software routines for effective use of the data.



*The most fruitful areas for growth of the sciences are those between established fields. Science has been increasingly the task of specialists, in fields which show a tendency to grow progressively narrower. Important work is delayed by the unavailability in one field of results that may have already become classical in the next field. It is these boundary regions of science that offer the richest opportunities to the qualified investigator.* – Norbert Wiener