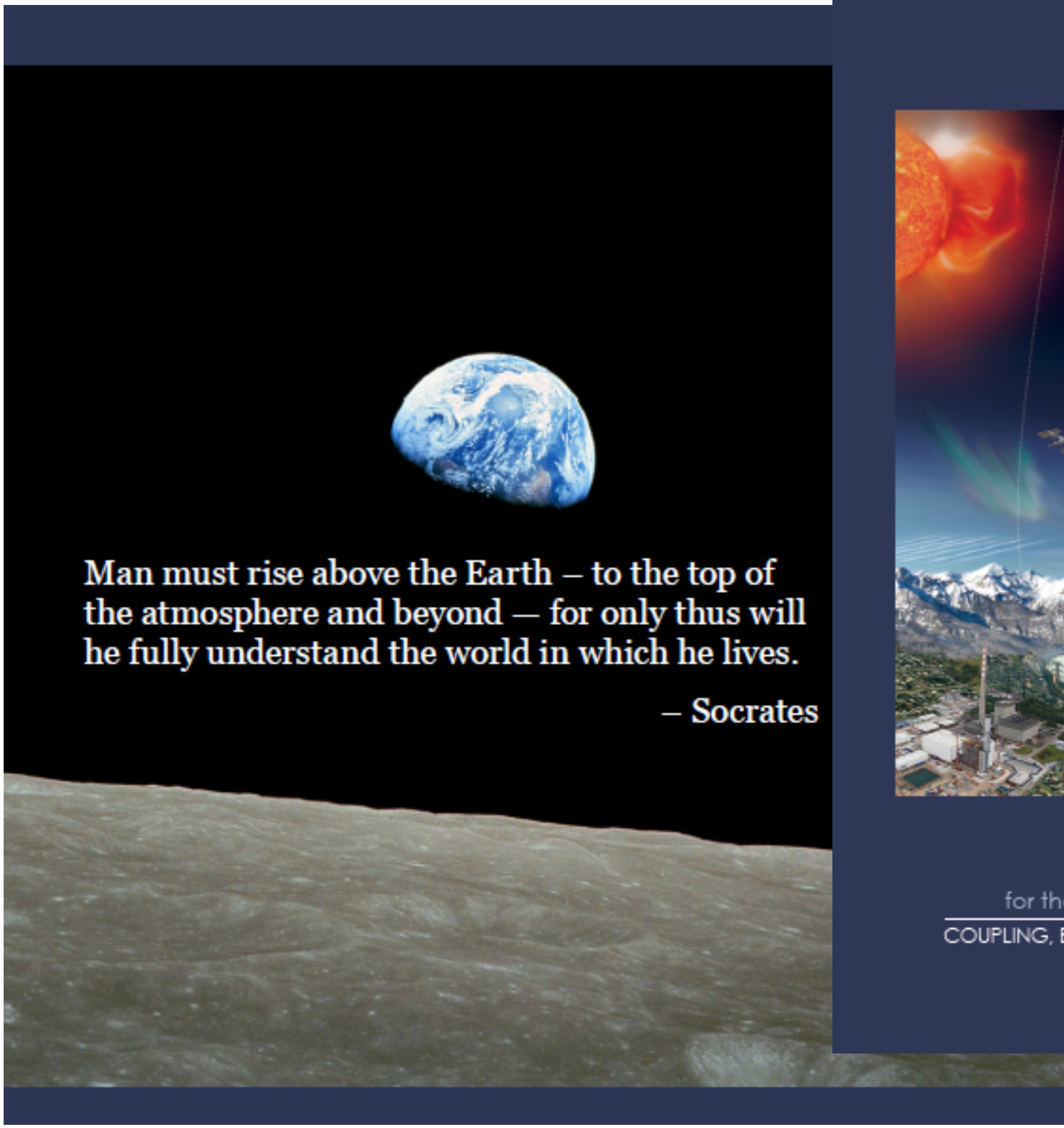

Feedback and outlook from the
CEDAR science community


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

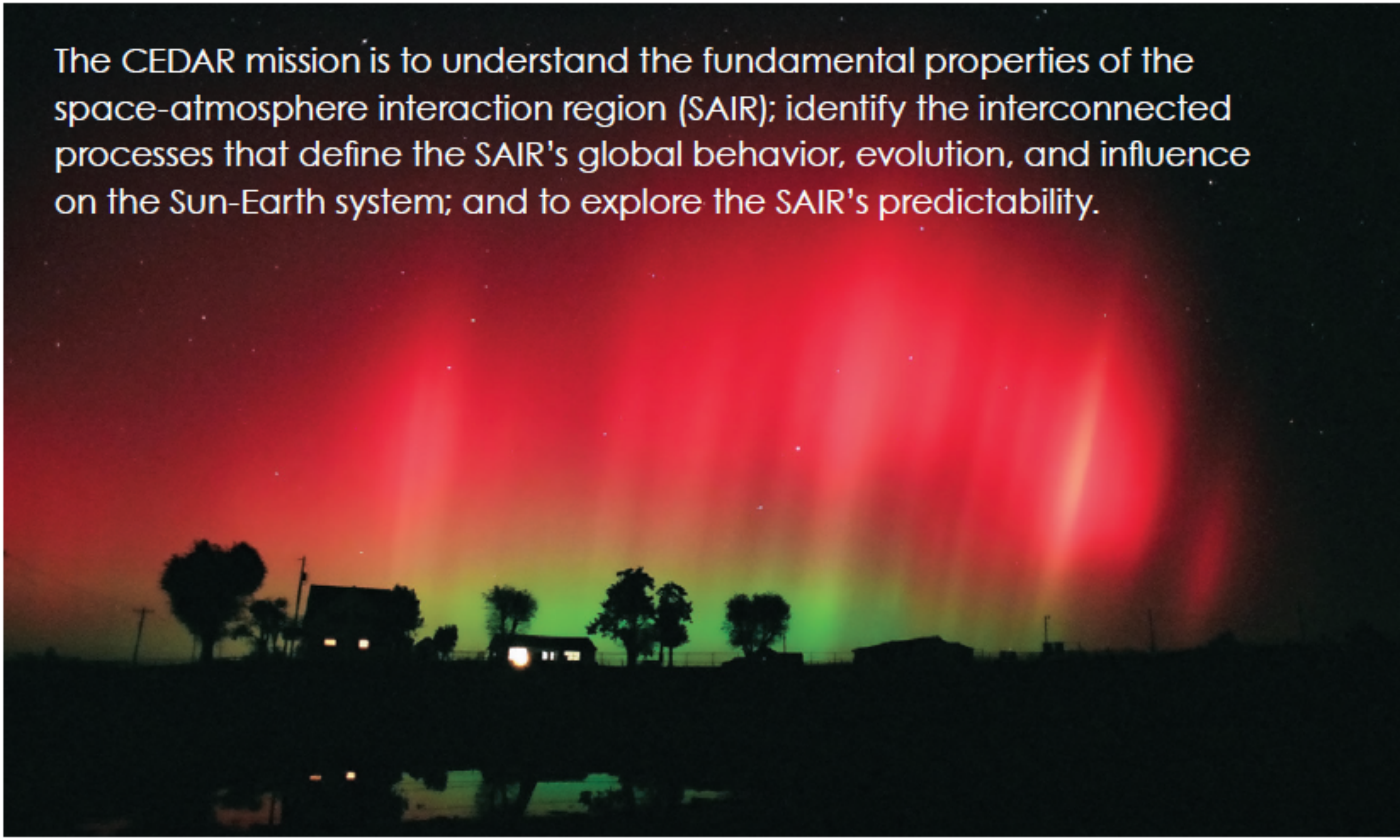

CEDAR
The NEW DIMENSION
STRATEGIC VISION
for the National Science Foundation Program on
COUPLING, ENERGETICS AND DYNAMICS OF ATMOSPHERIC REGIONS

CEDAR and CCMC

An uncertain landscape with many signposts

- Space Weather Action Plan
- Geospace Sciences Portfolio Review
- Exploring the Geospace Frontier: Quo Vadis?
- CEDAR Strategic Plan 2013
- Geospace Sciences Strategic Plan
- Heliophysics Decadal Survey
- NASA Roadmaps

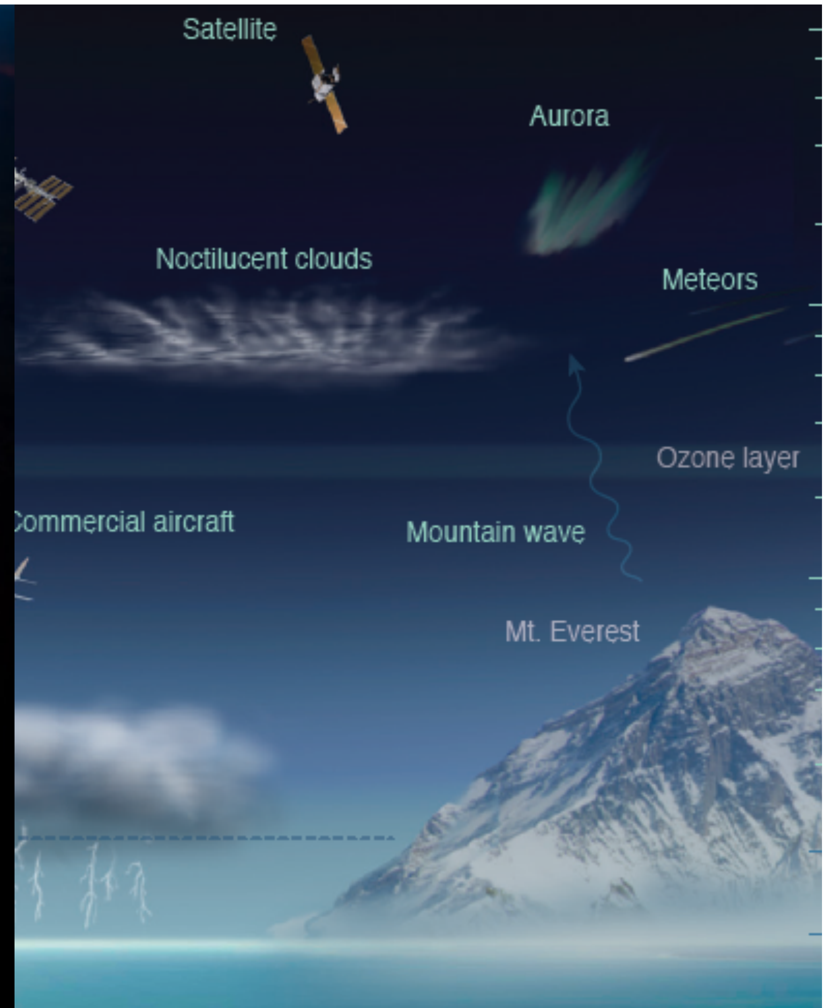
Look for common themes


The CEDAR mission is to understand the fundamental properties of the space-atmosphere interaction region (SAIR); identify the interconnected processes that define the SAIR's global behavior, evolution, and influence on the Sun-Earth system; and to explore the SAIR's predictability.

2 The Space-Atmosphere Interaction Region

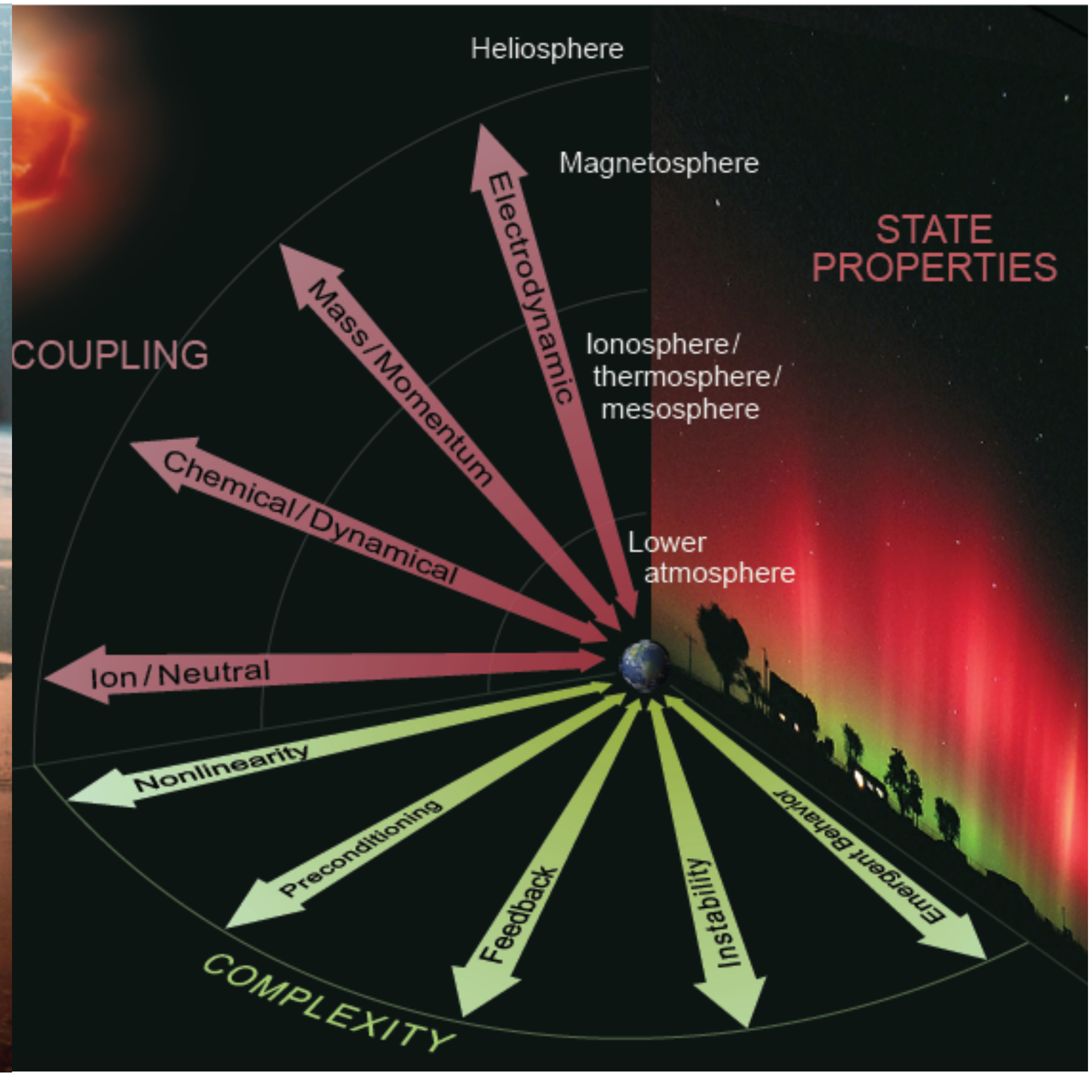
To understand the processes that govern the coupling, energetics, and dynamics of the upper atmosphere, it is useful to envision this as an *interaction region*, coupling the lower atmosphere with space and the universe beyond.

Sunset over western South America. International Space Station Imagery, NASA.

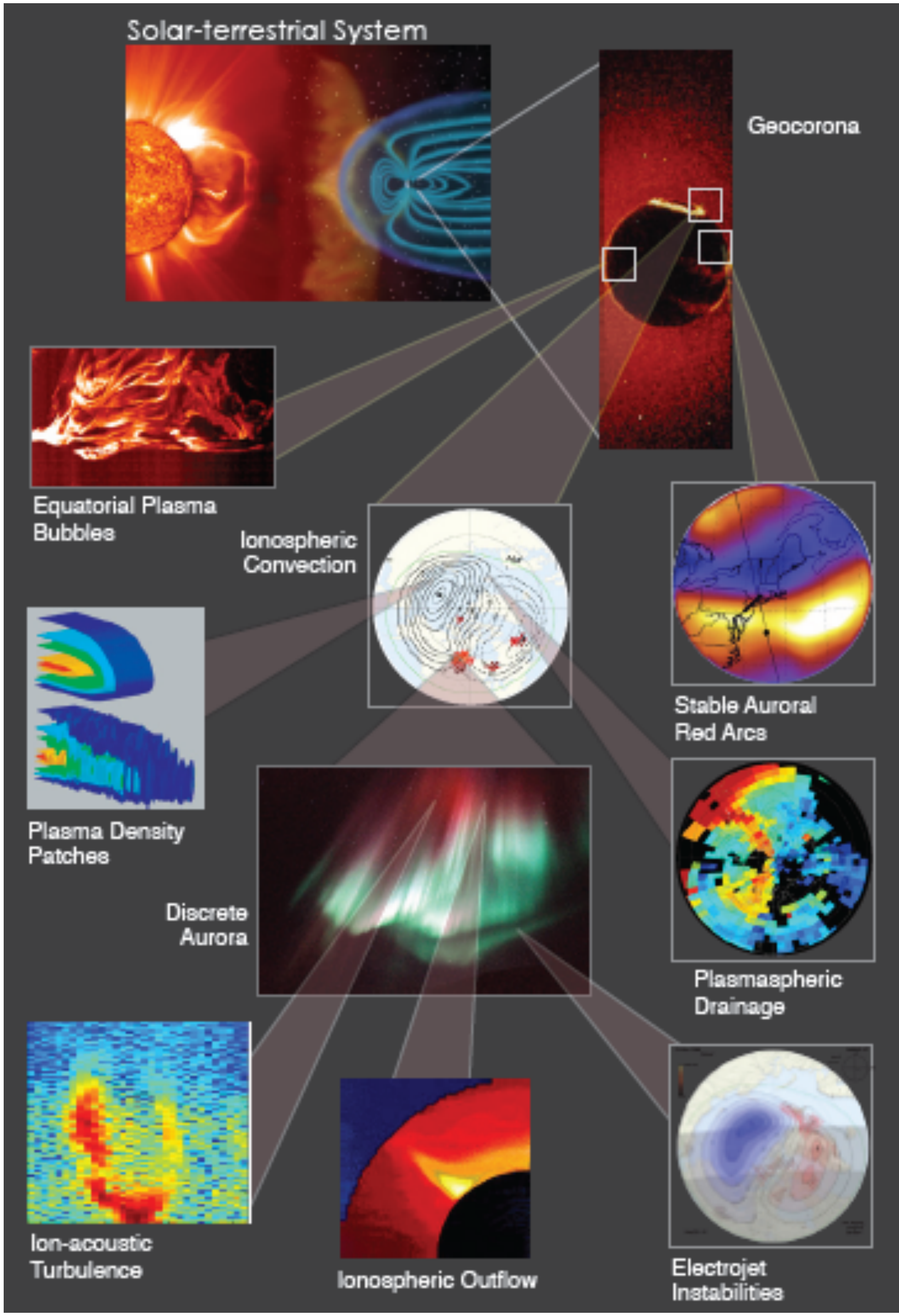


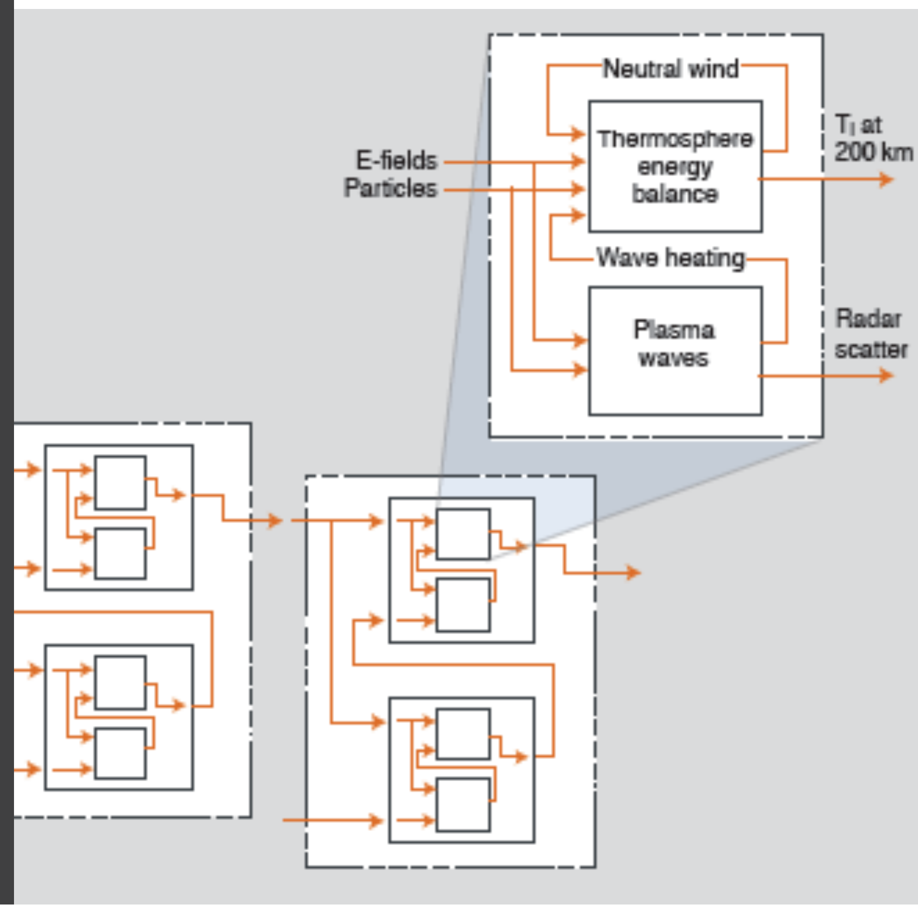
3 The Systems Perspective

The systems approach transcends the concept of scale, enabling the characteristics of a complex system to be generally applied to many problems in the Sun-Earth system.



Systems Perspective





4 The Way Forward

The 21st century approach to understanding the Sun-Earth system is to explore new avenues of progress, building on past decades of accomplishments.

1. Encourage and undertake a Systems Perspective of Geospace
2. Explore Exchange Processes at Boundaries and Transitions in Geospace
3. Explore Processes Related to Geospace Evolution
4. Develop Observational and Instrumentation Strategies
5. Fuse the knowledge Base across Disciplines
6. Manage, Mine, and Manipulate Geoscience/Geospace Data and Models

Where does the CCMC fit in?

- Access to ionosphere-thermosphere models
- Provides mechanisms for studying linkages to
  - the magnetosphere and solar wind
  - impacts on technical systems
- Facilitates model validation and testing—grand challenges

The ultimate goal is to expand its user base, without sacrificing its science mission.

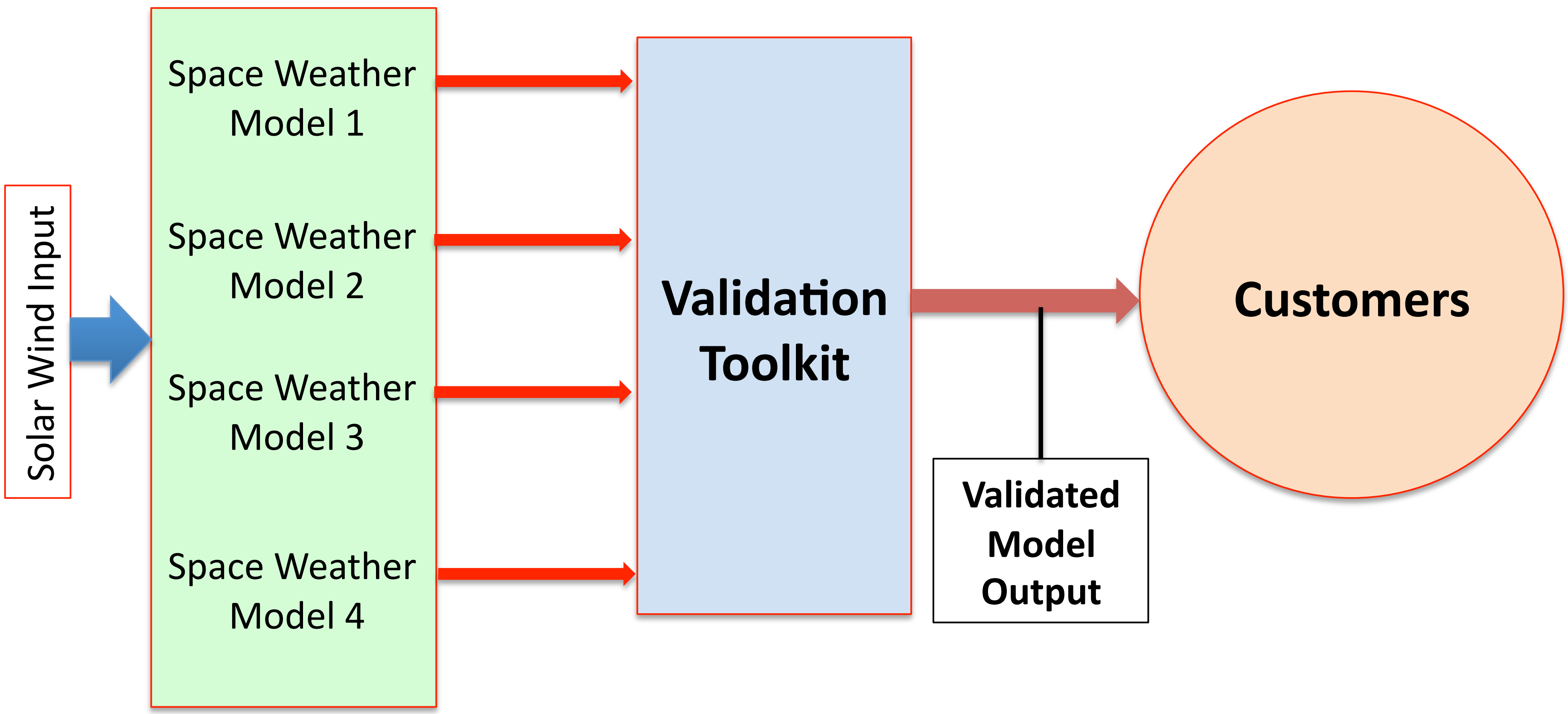
R2O: The Current Model

- Researchers develop models
- Preliminary testing identifies those ready for operations
- Transition to operations commence
- Operational model use commences
- Models are upgraded as necessary

Disadvantages

- Long time in development and testing
- Long time in transitioning
- Only one model transitioned; the others are relegated to CCMC runs-on-request

This model for R2O is outdated; high-speed (cloud) computing has made other approaches possible.

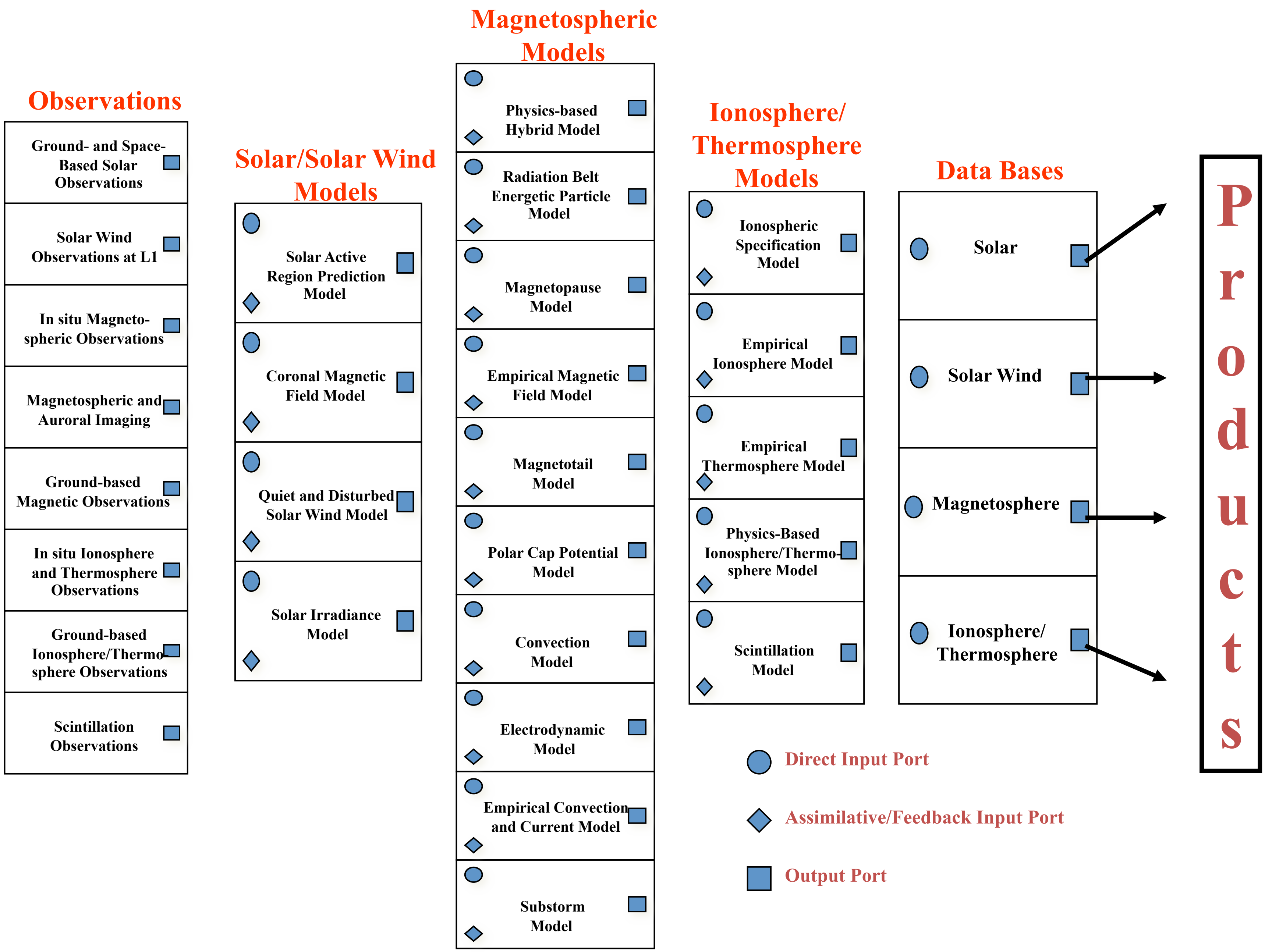


Solar Wind Input
Space Weather Model 1
Space Weather Model 2
Space Weather Model 3
Space Weather Model 4
Validation Toolkit
Validated Model Output
Customers

Alternative Approach

- Don’t transition models; transition model output
- Model output transitioning takes place continuously and rapidly
- Output from many models transitioned in parallel
- Some models may outperform others for specific types of events or for specific customer requirements

Patch-Panel Approach to Space Weather Modeling



On-the-fly Space Weather Model Transitioning

- Made possible by high-speed computing.
- Involves the development of a standard set of metrics to assess the validity of model results.
  - The metrics allow for a sequence of tests, largely, but not entirely, involving quantitative comparison of model results with available data, appropriately taking into account errors and uncertainties in both.
  - The metrics are applied to the output of multiple models running simultaneously in order to identify the model that is producing the most accurate and realistic results at the time in question.
- The approach allows for the fact that some models may work better than others for specific types of space weather conditions and events.

On-the-fly Model Validation

- The heavy lifting is in the development of a validation toolkit with definitive, quantitative, and efficient means to assess which model is producing the best results for any given time interval or event.
- Real-time data provide the optimum information to validate model results. The data might include measurements made from a single location, a satellite pass, or a global network. The more data that are used in the metric, the more definitive the assessment will be.
- Other tests based on physical constraints should also be applied; models that just fit the available data would only be selected if physics-based models fail to produce reasonable results.

Advantages of On-the-Fly R2O

- On-the-fly modeling allows for more rapid and robust incorporation of new or improved models as they emerge from their developers.
- Models will be in continuous competition to outperform others, while forecasters will accumulate a history of model performance over many events, information that might be fed back to model developers to aid in model improvement efforts.
- Mirrors what is now already done at forecast centers in using non-operational data--careful validation and verification of data before use in models or dissemination to space weather customers.
- The resources now expended to transition a few selected space weather models can be redirected to the development of the validation toolkit to verify and validate model output in the real-time operational centers.

The CCMC Mission

- Continue to demonstrate the feasibility and merits of linking models—across Space Weather domains and across Space Weather communities.
- Be a testbed for new approaches to transitioning advances in research to operations.
- Serve an ever-broadening user community without sacrificing its science mission. The two are NOT mutually exclusive.