

# Coupling, Energetics, and Dynamics of Atmospheric Regions

March 9, 2026

## The Strategic Value of Upper Atmospheric Science

Every day, Americans rely on satellites for GPS navigation, banking transactions, airline travel, weather forecasting, precision agriculture, emergency response, and national defense. The signals that make these services possible must pass through Earth's upper atmosphere - a region that is constantly changing due to forces from the Sun above and weather systems below. When this region becomes disturbed, communication can degrade, navigation errors grow, satellites can lose altitude more quickly due to increased drag, and critical systems are put at risk. Hence, America's strength in space begins with understanding the dynamic upper edge of our atmosphere - the region that shields life on Earth and controls how our satellites and communications systems operate.

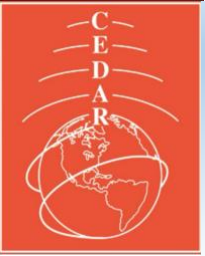
The National Science Foundation (NSF)'s Aeronomy program and the American scientist-driven CEDAR (Coupling of Energetics and Dynamics of Atmospheric Regions) program provide foundational knowledge that allows the United States to understand, predict, and manage the complex near-Earth space environment. Through the development of advanced sensors and cutting-edge computer models integrated with artificial intelligence, the CEDAR community is transforming our understanding of Earth's upper atmosphere. These efforts ensure that our nation remains unrivaled in making the scientific discoveries that make access to space safer and more economic, while improving our ability to predict and respond to space environment conditions.

CEDAR scientists study the region where Earth's atmosphere meets space. This environment is shaped by: the sun through solar flares and particle storms, Earth's weather systems, winds, and waves rising from the lower atmosphere, and chemical and physical changes in the upper atmosphere. These processes affect how radio waves travel, how satellites move, and how space systems operate. Understanding this region is essential for safe space access, reliable communication, and national security. CEDAR research directly supports NSF's mission to advance the progress of science, promote national welfare, and secure the national defense, while furthering current national priorities in advanced technology, economic strength, resilience, and preparedness.

CEDAR science directly protects and enables:

- **Navigation & Transportation:** GPS supports aviation, precision agriculture, shipping, emergency vehicles, and everyday navigation.
- **Communications:** Satellite capabilities connect rural communities, aviators, disaster zones, and military operations.
- **Economic Vitality:** Satellite services underpin finance, agriculture, logistics, and infrastructure management.
- **National Security:** Defense and intelligence systems rely on stable space-based communications and positioning.
- **Space Sustainability:** Understanding atmospheric drag helps prevent satellite collisions and supports safe and sustainable space traffic management.

As satellite use rapidly expands — including new commercial constellations flying lower than ever before in Very Low Earth Orbit — accurate knowledge of atmospheric conditions is more critical than ever for safe and economical space operations.



# Coupling, Energetics, and Dynamics of Atmospheric Regions

NSF's CEDAR science advances national priorities and delivers measurable benefits to the Nation in key areas:

- **Advanced Sensors and Facilities:** A nationwide network of ground-based radars, optical instruments, lidars, GNSS receivers, sounding rockets, and satellite missions provide continuous monitoring of the upper atmosphere. These long-term facilities are a strategic national investment and a cornerstone of U.S. scientific leadership. The scientific and technological advances described above are possible because of these facilities and the sustained national commitment that supports them.
- **Artificial Intelligence & Cyberinfrastructure:** Modern AI and data systems allow scientists to combine vast streams of satellite and ground data into models that improve prediction of space weather, turbulence, satellite drag, and communication blackouts.
- **Preparedness & Resilience:** By improving forecasts of atmospheric disturbances, CEDAR science helps agencies and industry reduce risks to power grids, communications, aviation, and satellite operations.
- **Translational Research:** Discovery science supported by NSF feeds directly into operational space weather services, satellite mission planning, and defense applications — ensuring that basic research produces real-world impact that benefits our nation.

To maintain U.S. leadership and protect national interests, continued investment is needed to:

- Sustain and modernize national geospace observing facilities
- Expand AI-enabled modeling and forecasting tools
- Advance research that keeps space operations safe, reliable, and affordable
- Strengthen partnerships with NASA, NOAA, DoD, and industry
- Train the next generation of scientists and engineers

The Aeronomy and CEDAR programs are essential to America's technological future, economic prosperity, and national security. CEDAR research on the upper atmosphere and near-Earth space environment drives innovation in advanced sensor systems, AI-enabled modeling, and high-performance computing, all of which are essential to maintain our technological edge. By understanding and predicting the atmosphere and space environment surrounding Earth, CEDAR science safeguards critical systems, enables emerging space industries, and ensures that the United States remains the world leader in space science and technology.

Prepared by members of the CEDAR Science Steering Committee's Strategic Planning Subcommittee, on behalf of the CEDAR research community.