Grand Challenge

UNIVERSITY OF COLORADO **BOULDER**

SPACE WEATHER CENTER

Space Weather Technology, Research, and Education Center

SWx-TREC

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CIRES

HAO

NSO

SwRI

ASTRA

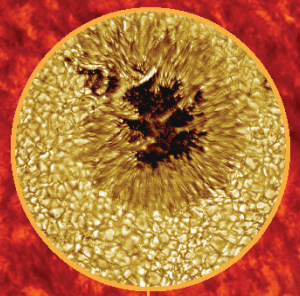
SWx TREC

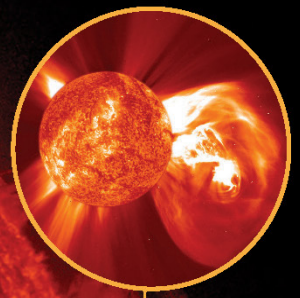
Space Weather

Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space-based and ground-based technological systems, as well as endanger life or health. Just like weather on Earth, space weather has its seasons, with solar activity rising and falling over an approximate 11 year cycle.

Sunspots

Sunspots are comparatively cool areas at up to 7,700° F and show the location of strong magnetic fields protruding through what we would see as the Sun's surface. Large, complex sunspot groups are generally the source of significant space weather.





Coronal Mass Ejections (CMEs)

Large portions of the corona, or outer atmosphere of the Sun, can be explosively blown into space, sending billions of tons of plasma, or superheated gas, Earth's direction. These CMEs have their own magnetic field and can slam into and interact with Earth's magnetic field, resulting in geomagnetic storms. The fastest of these CMEs can reach Earth in under a day, with the slowest taking 4 or 5 days to reach Earth.

Solar Wind

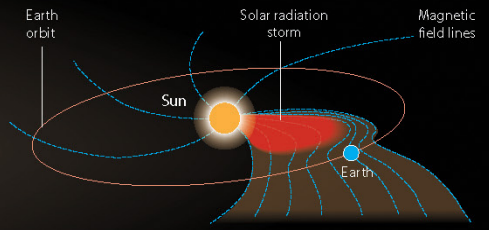
The solar wind is a constant outflow of electrons and protons from the Sun, always present and buffeting Earth's magnetic field. The background solar wind flows at approximately one million miles per hour!

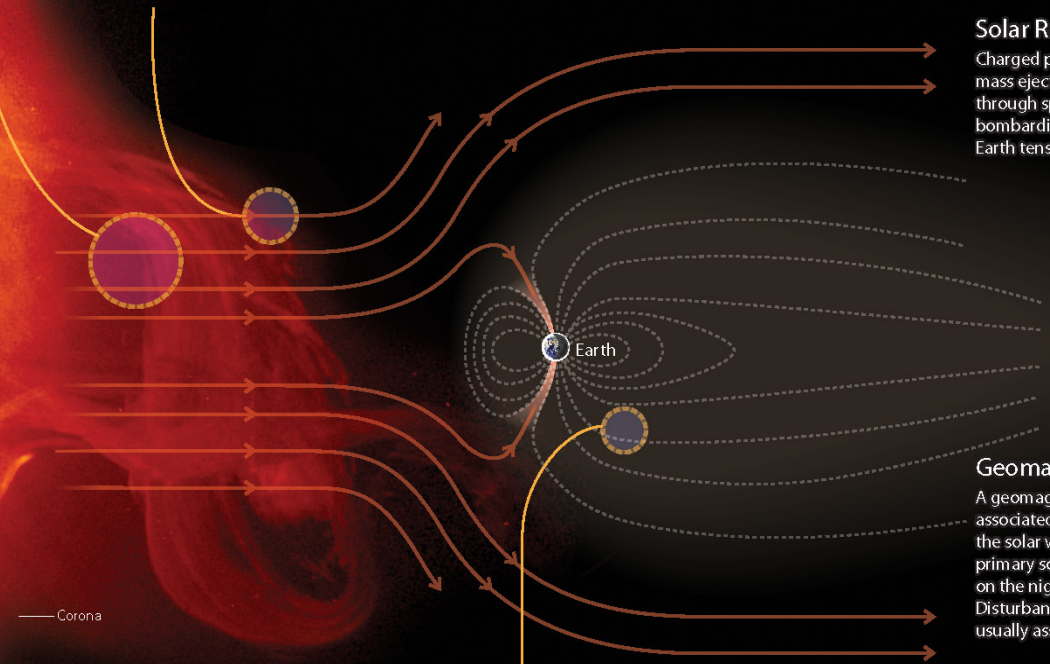
Sun's Magnetic Field

Strong and ever-changing magnetic fields drive the life of the Sun and underlie sunspots. These strong magnetic fields are the energy source for space weather and their twisting, shearing, and reconnection lead to solar flares.

Solar Radiation Storms

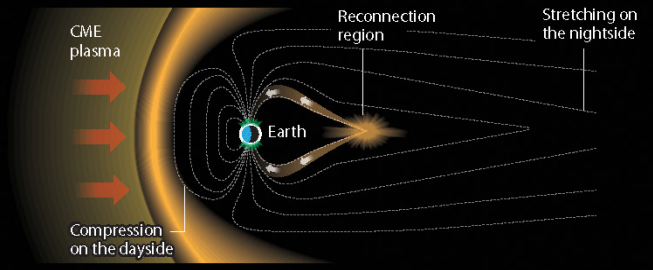
Charged particles, including electrons and protons, can be accelerated by coronal mass ejections and solar flares. These particles bounce and gyrate their way through space, roughly following the magnetic field lines and ultimately bombarding Earth from every direction. The fastest of these particles can affect Earth tens of minutes after a solar flare.

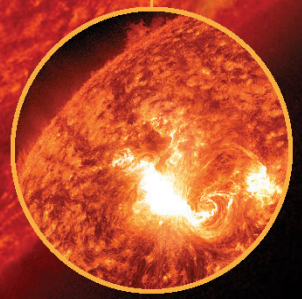




Geomagnetic Storms

A geomagnetic storm is a temporary disturbance of Earth's magnetic field typically associated with enhancements in the solar wind. These storms are created when the solar wind and its magnetic field interacts with Earth's magnetic field. The primary source of geomagnetic storms is CMEs which stretch the magnetosphere on the nightside causing it to release energy through magnetic reconnection. Disturbances in the ionosphere (a region of Earth's upper atomosphere) are usually associated with geomagnetic storms.





Solar Flares

Reconnection of the magnetic fields on the surface of the Sun drive the biggest explosions in our solar system. These solar flares release immense amounts of energy and result in electromagnetic emissions spanning the spectrum from gamma rays to radio waves. Traveling at the speed of light, these emissions make the 93 million mile trip to Earth in just 8 minutes.

Earth's Magnetic Field

Earth's magnetic field, largely like that of a bar magnet, gives the Earth some protection from the effects of the Sun. Earth's magnetic field is constantly compressed on the day side and stretched on the night side by the ever-present solar wind. During geomagnetic storms, the disturbances to Earth's magnetic field can become extreme. In addition to some buffering by the atmosphere, this field also offers some shielding from the charged particles of a radiation storm.

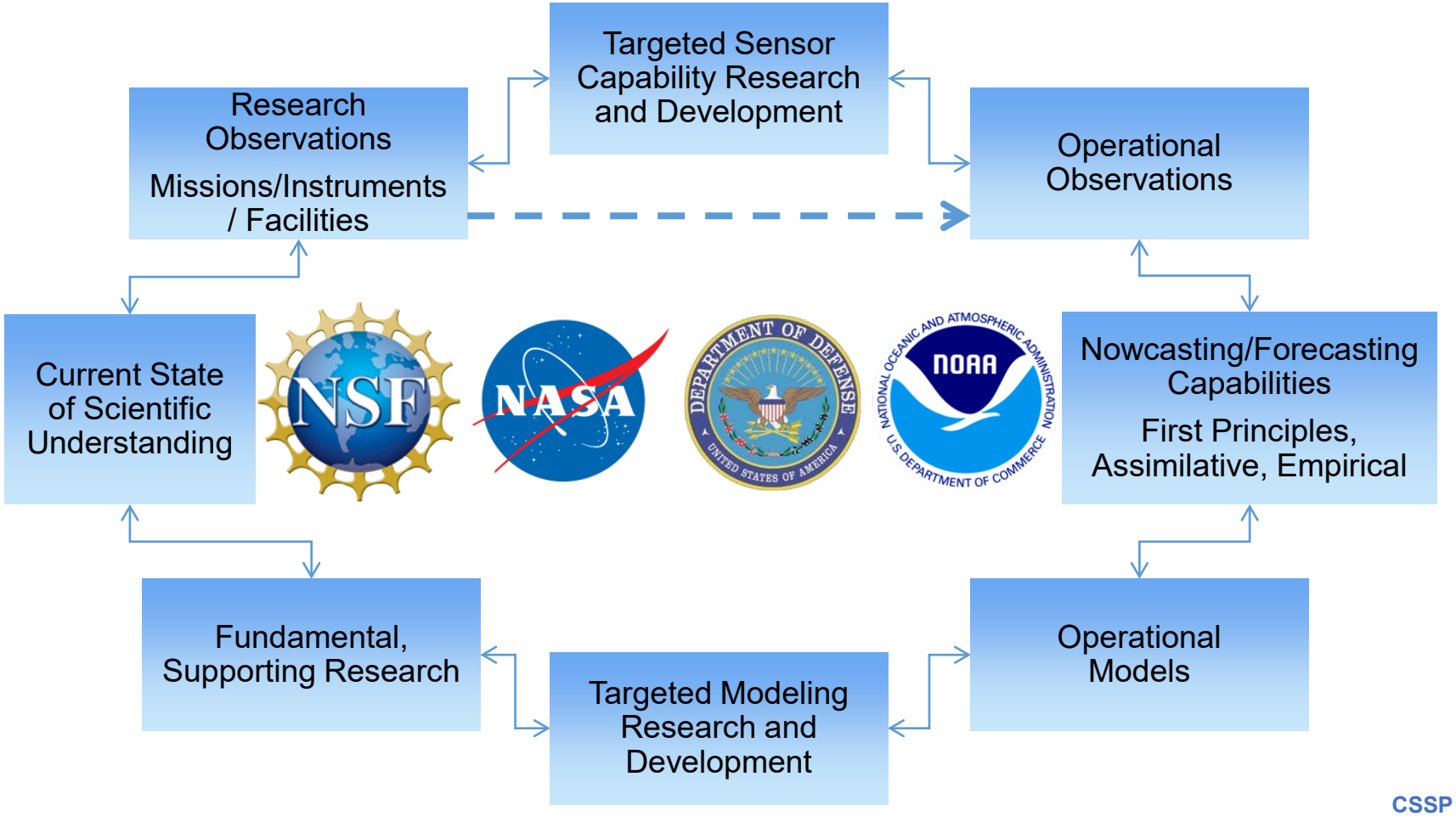
Source images: NASA, NOAA.

Problem Statement(s)

1. **Space weather (SWx) forecasting is not as accurate, reliable, or timely as we'd like. Mitigation requires longer lead times and tighter windows.**
   - 24-hour flare forecasting is not much better than climatology (average rate forecast).
   - Radiation storms remain a mystery: some very large flares cause events, some don't.
   - Current error in geomagnetic storm onset (CME arrival time) forecasts ~ ±12 hours.
2. **Transition of new research models, mission data, and tools to operational forecasting is slow and inefficient. "R2O problem"**
   - In addition to models, new *data sources and forecasting tools* are also needed.
   - Van Allen Probes mission data just now getting to forecasters. End of mission: Jan 2020!
   - Artificial intelligence for space weather forecasting will require new collaborations.
3. **Researchers are not aware enough of the requirements (and shortcomings) of operational models and tools. "O2R problem"**

Addressing the R2O and O2R Problems

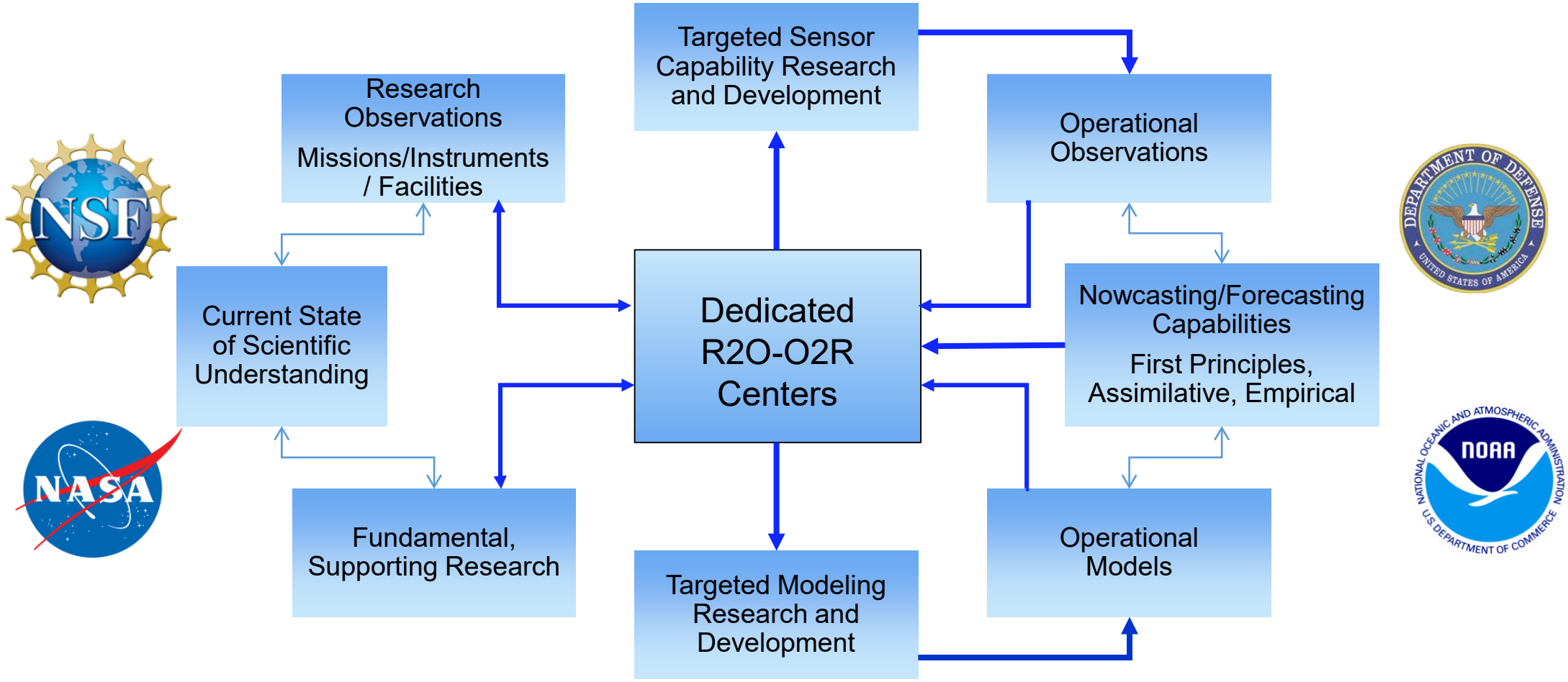
Original Version



CSSP Meeting 30-March-2016

Addressing the R2O and O2R Problems

R2O-O2R Center Enhanced Version



Our Space. Our Future.

For over 50 years, CU Boulder has been a leader in Earth and space sciences. We have sent instruments to every planet in our solar system and are among the world's leading public universities in producing astronauts. We explore our own planet from the depths of the ocean to the upper limits of the atmosphere.

What will the next 50 years bring?

About the Grand Challenge

Latest News

Climate Change & Health Symposium spotlights CU opportunity to collaborate on emerging global issue

Researchers from the University of Colorado Anschutz and the University of Colorado Boulder led a Climate Change and Health Symposium on the Anschutz Medical Campus on March 12 to explore the imminent challenges and opportunities arising from the nexus of these two interdependent arenas. Read more

Daily Camera: CU Boulder 'Grand Challenge' puts space weather research front and center

The Great American Eclipse has come and gone, but the fiery star of that show remains a crucial target of scientists' continuing investigations, and is a central player in studies to be fueled by the newly announced Grand Challenge winners at the University of Colorado. Read more

Grand Challenge expands portfolio with three new projects

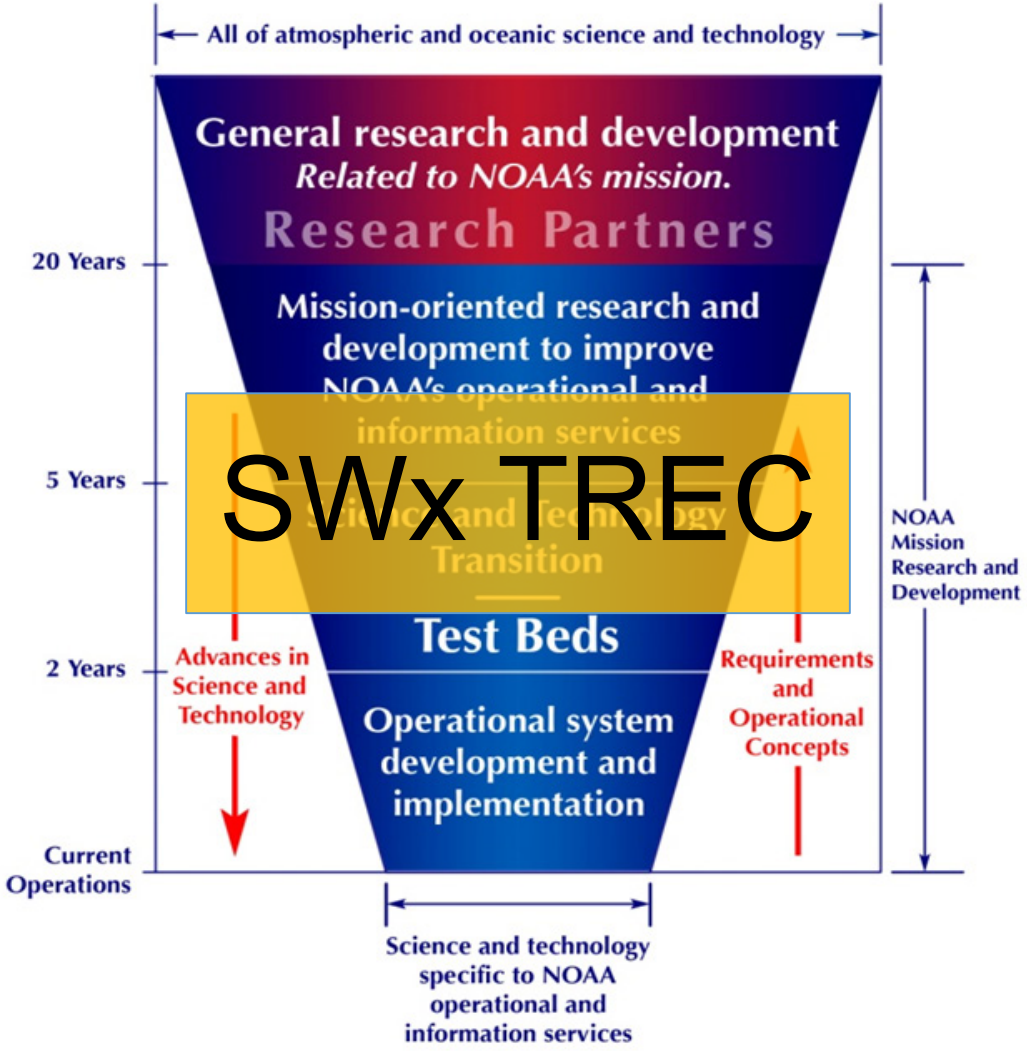
The cross-campus Grand Challenge initiative this week announced the selection of three new additions to the Grand Challenge portfolio starting this fall. The call for proposals, which was announced in June, funded one large research initiative at approximately $1 million per year and two smaller projects at $250,000 per year, each for at least three years. Read more

SWx-TREC Mission Statement

The University of Colorado SWx-TREC is a **center of excellence in cross-disciplinary research, technology innovation, and education**, enabling federal agencies, academia, commercial partners, and industry to collaborate in addressing the nation's evolving space weather forecasting, mitigation, and response requirements.

SWx-TREC produces breakthrough applied research and innovative mission technologies that are **directly tied to the needs of the operational forecasting enterprise** to ensure closure of the R2O and O2R loop. This will result in new models, tools, missions, and data that will significantly advance our ability to understand and predict space weather phenomena, from the Sun to the Earth.

NOAA Research-to-Operations Funnel

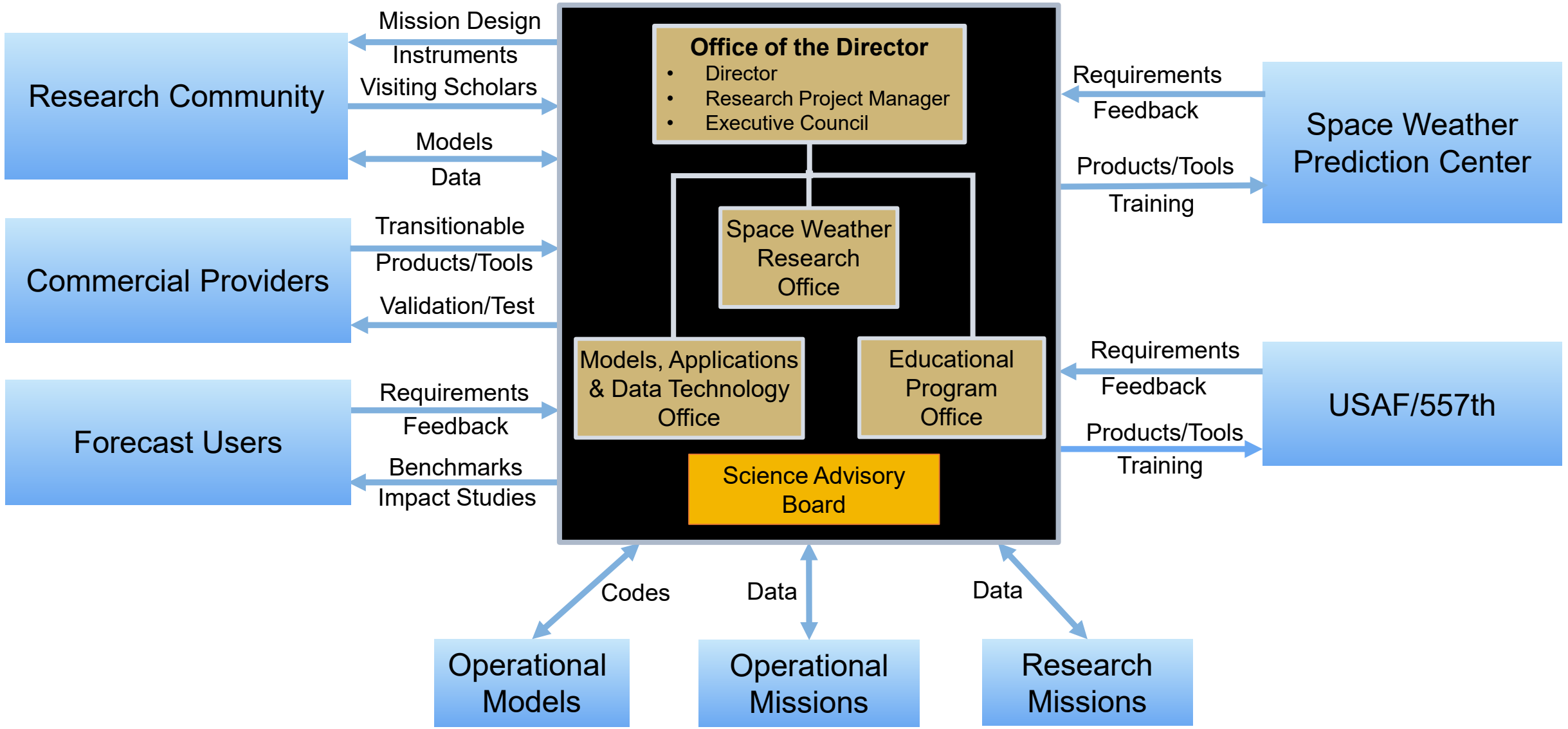


SWx TREC

To accelerate R2O, we need to support O2R and provide researchers access to operational observations, data assimilation, and modeling systems: "Keep R2O and O2R coupled"*

*SWORM R2O Workshop Report, 2016

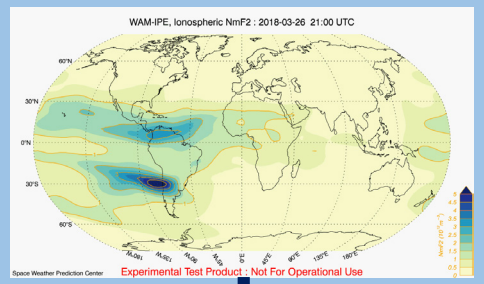
SWx TREC: Bridging R & O



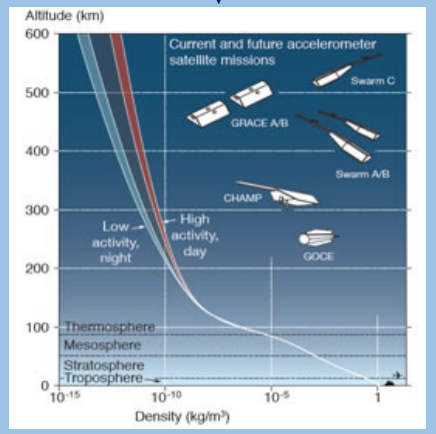
TREC Research

Focused on applying basic research results from models, missions, and tools to the improvement of operational space weather forecasting

MODELS

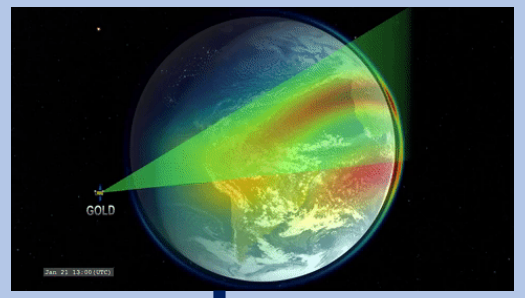


WAM-IPE
WACCMX

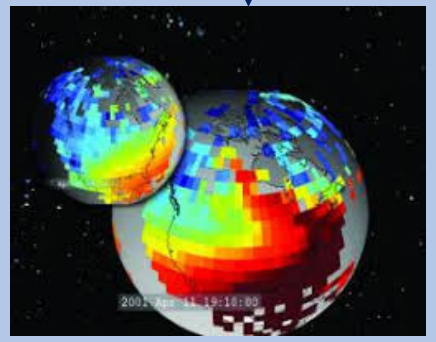


Storm-time
Satellite
Drag
Forecast

MISSIONS



GOLD
ICON
IMAP



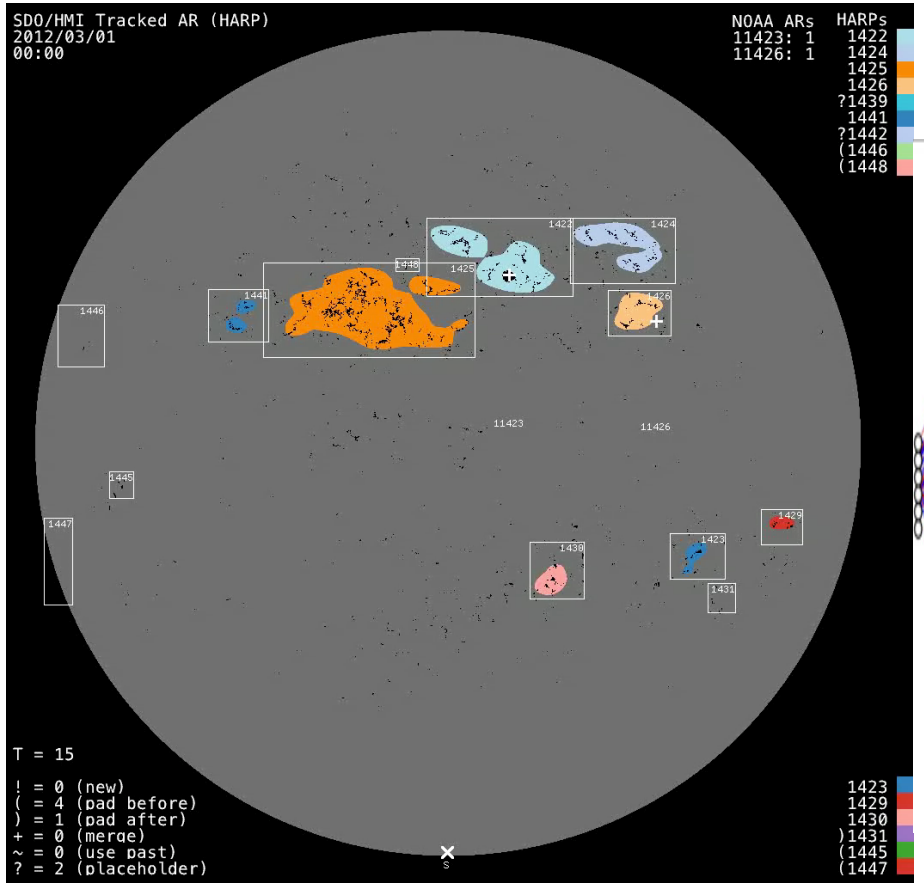
Ionospheric
Data Assimil.
& Nowcasting

TOOLS

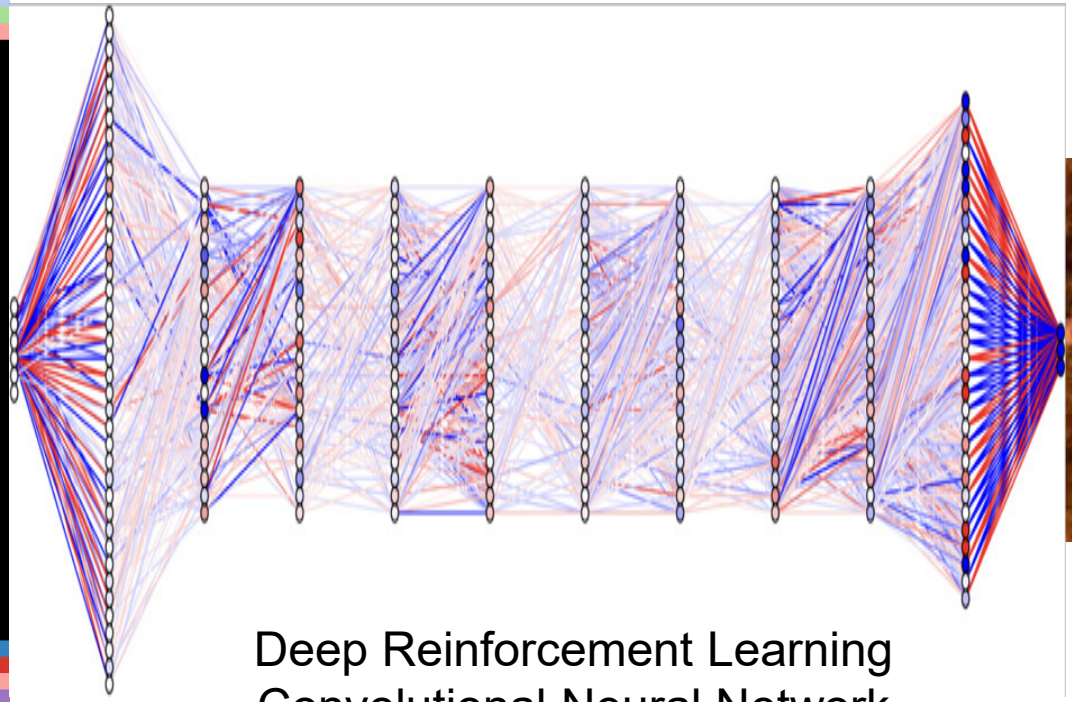
Deep
Neural
Networks

Solar
Eruption
Forecast

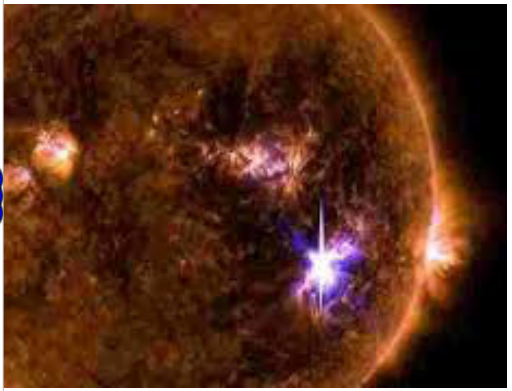
TREC Research: Deep Learning



SDO SHARPS product
HMI + AIA + EVE



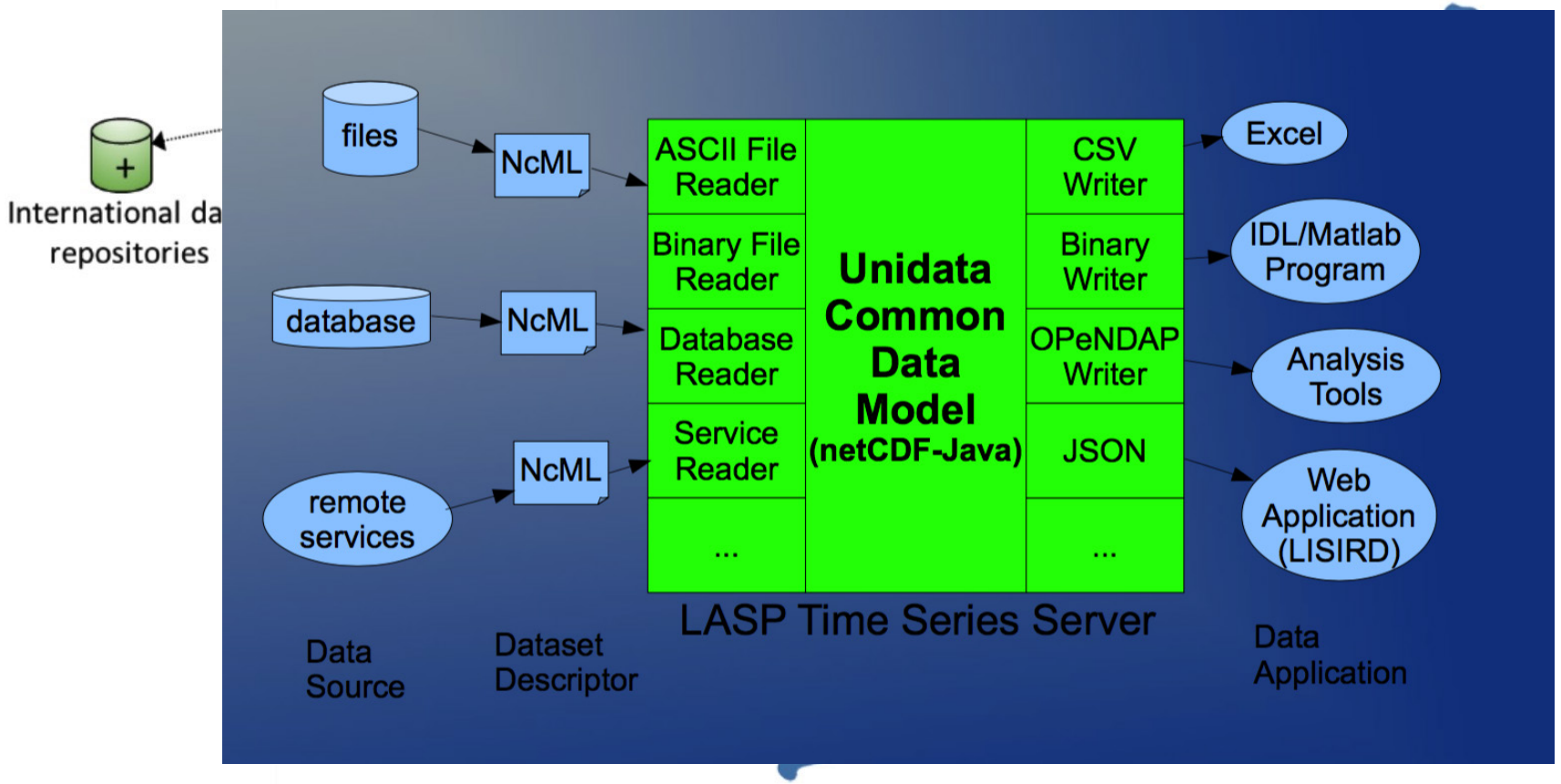
Deep Reinforcement Learning
Convolutional Neural Network



Bayesian Probability
Eruption Forecast

MADTech: SWx Data Portal

Enabling SWx R2O



Based on established LaTIS architecture

MADTech: SWx Testbed

Enabling SWx O2R

Operational Model **Copies**

Near Real Time Operational Data

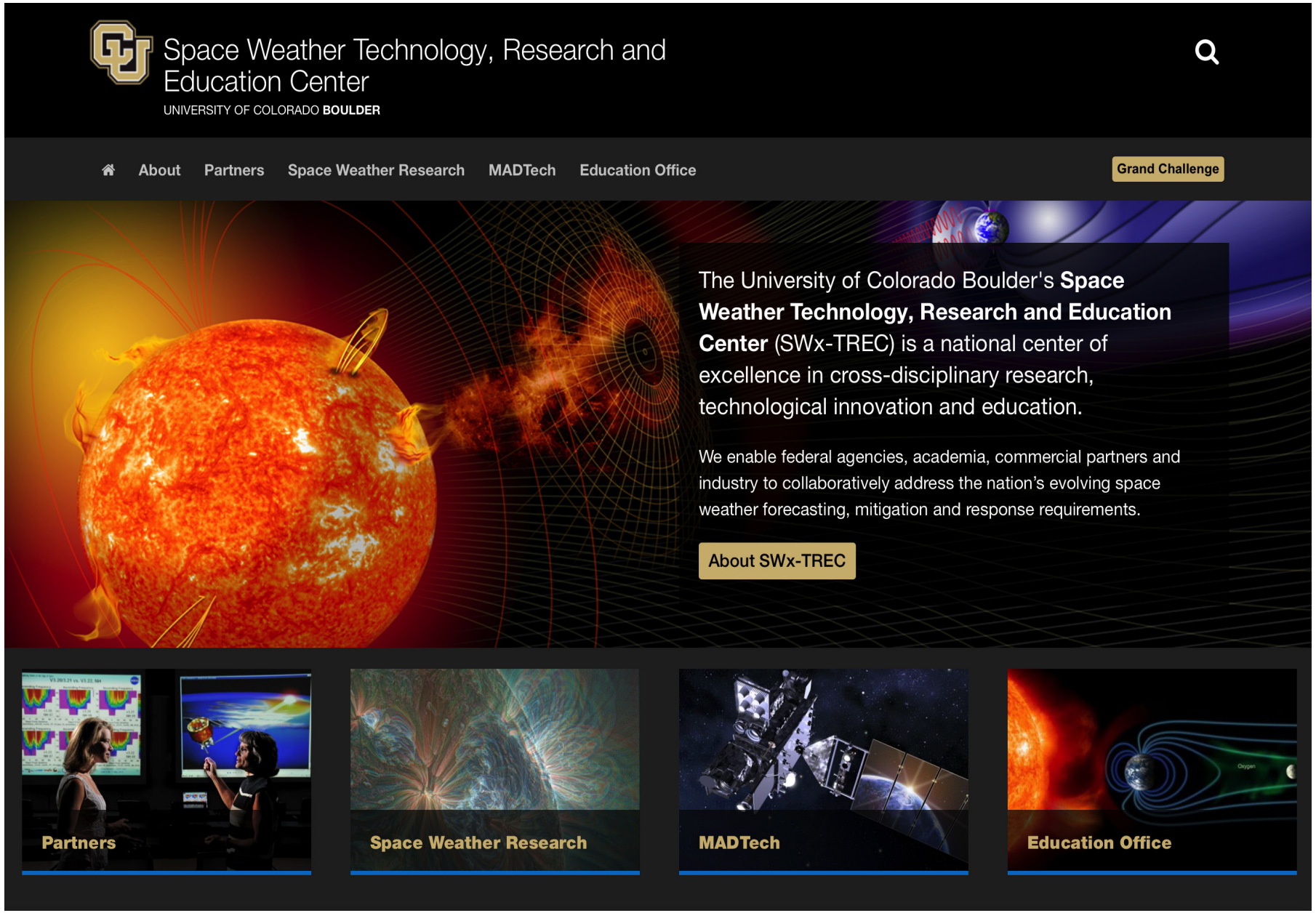
SWx Data Portal and Archive

Data Improvements

Model Improvements

Tool Innovations

Operationally Validated Product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About
Partners
Space Weather Research
MADTech
Education Office
Grand Challenge
The University of Colorado Boulder's Space Weather Technology, Research and Education Center (SWx-TREC) is a national center of excellence in cross-disciplinary research, technological innovation and education.
We enable federal agencies, academia, commercial partners and industry to collaboratively address the nation's evolving space weather forecasting, mitigation and response requirements.
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Thank you.