



**NSF SPACE WEATHER
RESEARCH PROGRAM:
*RESEARCH TO OPERATION***

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NSF's Role in Research Efforts

- *NSF is the only U.S. federal agency with a mission to support all fields of fundamental science and engineering, except medical sciences*
- *NSF, unlike many other federal agencies, does not hire researchers or directly operate its own laboratories or similar facilities.*
- *NSF supports scientists, engineers, and educators through their home institutions*
- *NSF's mission is to advance science frontiers, provide funding to support research endeavors, and create educational and training opportunities for next generation scientists and engineers*





Space Weather

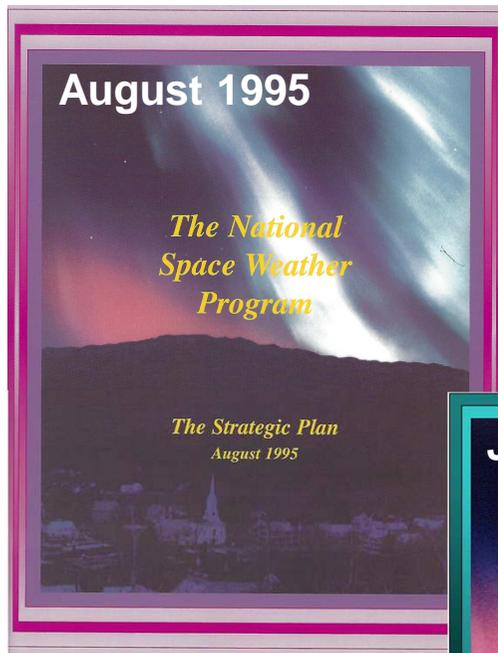
- *Space Weather refers to conditions in space that can influence the performance and reliability of space-borne and ground-based technological systems and can pose risk to human health*
- *Preparing for space weather requires a strong commitment to:*
 - *basic research, development of predictive models, advancement of state-of-the-art instruments, creative experiments exploiting space- and ground-based sensors*





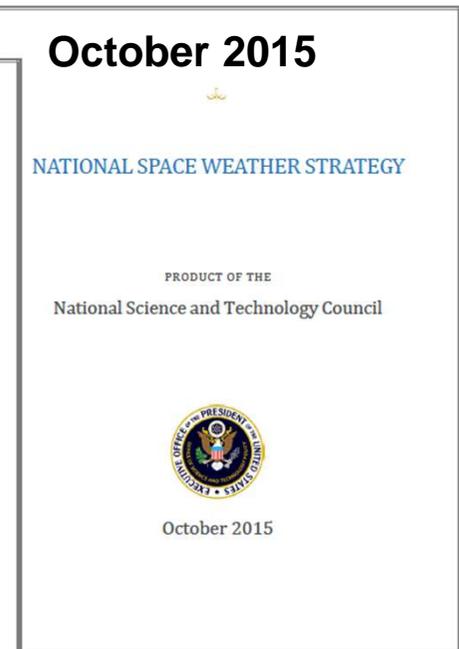
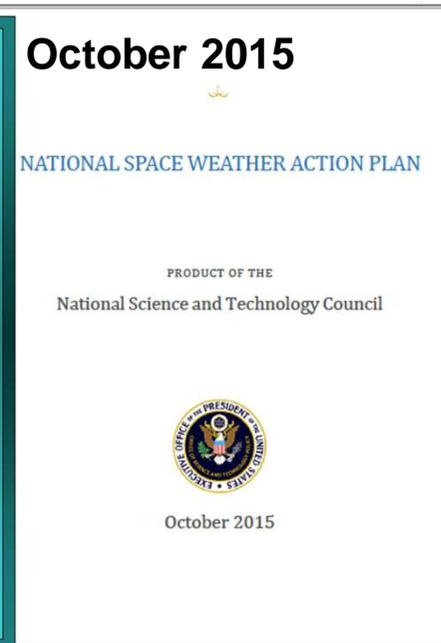
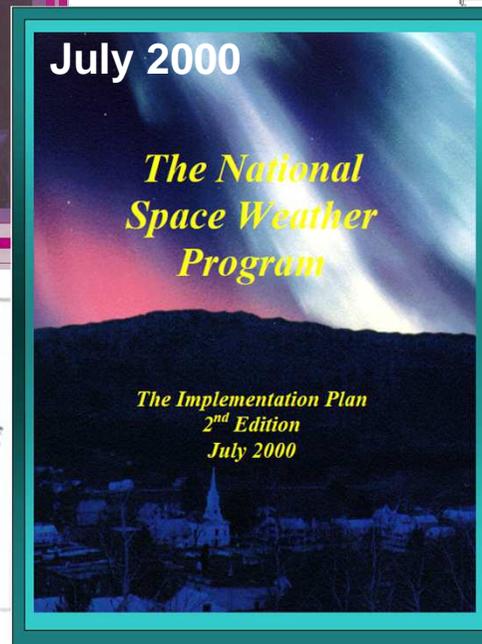
NSF Contributions to the National Space Weather Plan

- Space Weather research was first supported by NSF in 1995
- Action 5.5.1: NSF lead agency for prioritizing space weather related research and identifying R&D opportunities



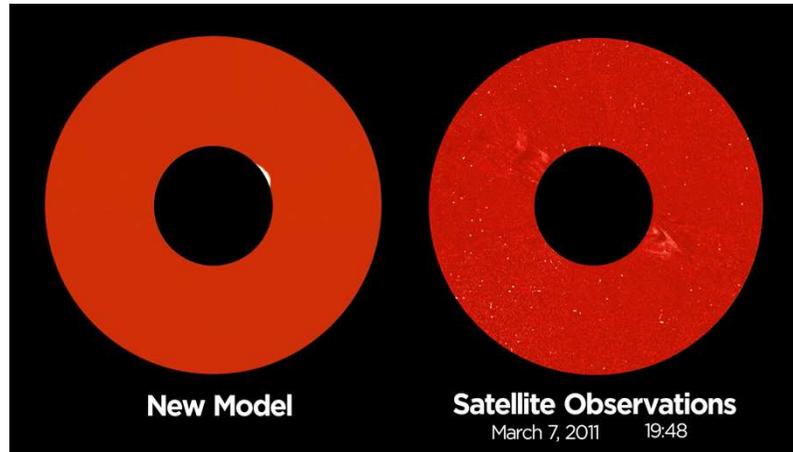
“While it is true that important applications will result from the National Space Weather Program, the science that will be accomplished will be first rate.... Indeed, the initiative provides a context in which much of solar-terrestrial physics can and should be done.”

—Louis Lanzerotti
A. T. & T. Bell Laboratories



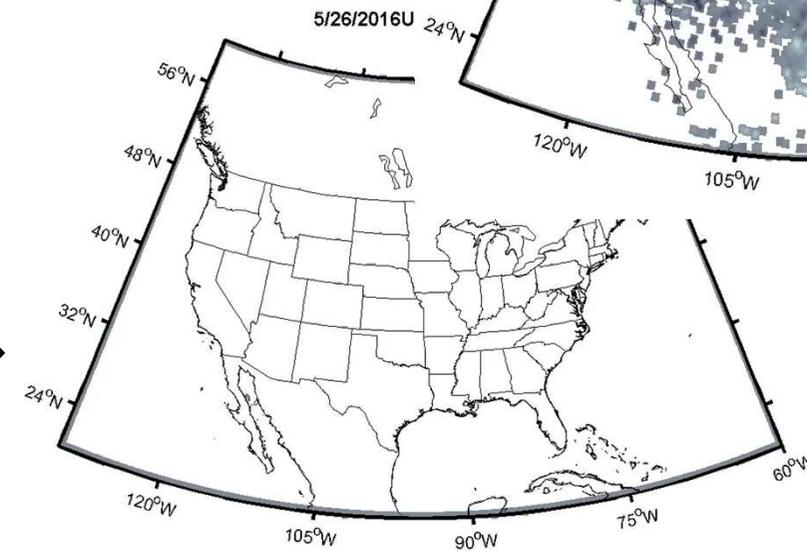
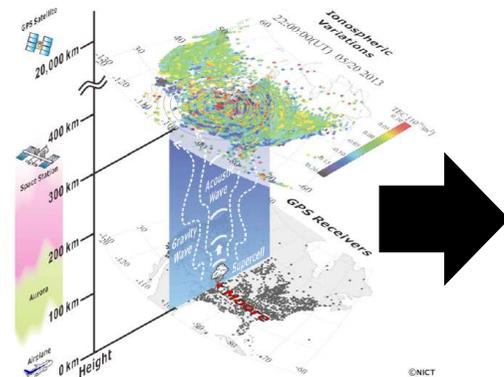
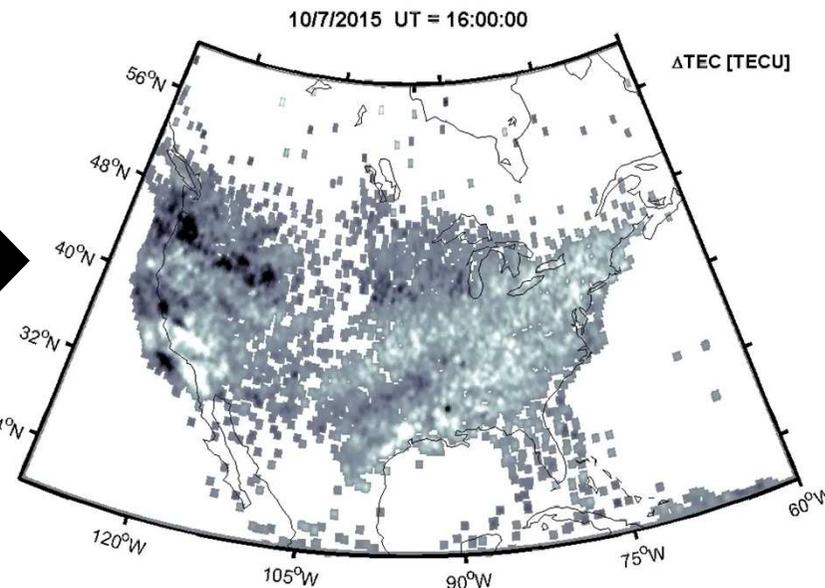
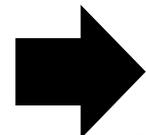


Space Weather is Multi-Domain and Multi-Scale



Simulations of CME/flare onset and propagation

Traveling Ionospheric Disturbances after a geomagnetic storm

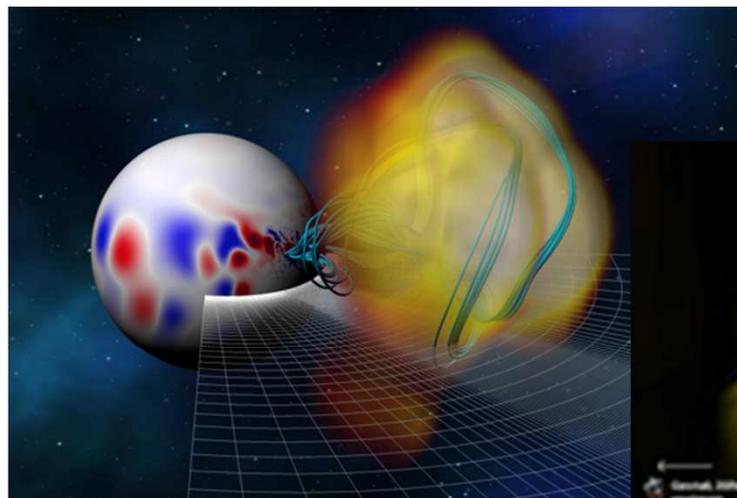


Ionospheric Space Weather from weather

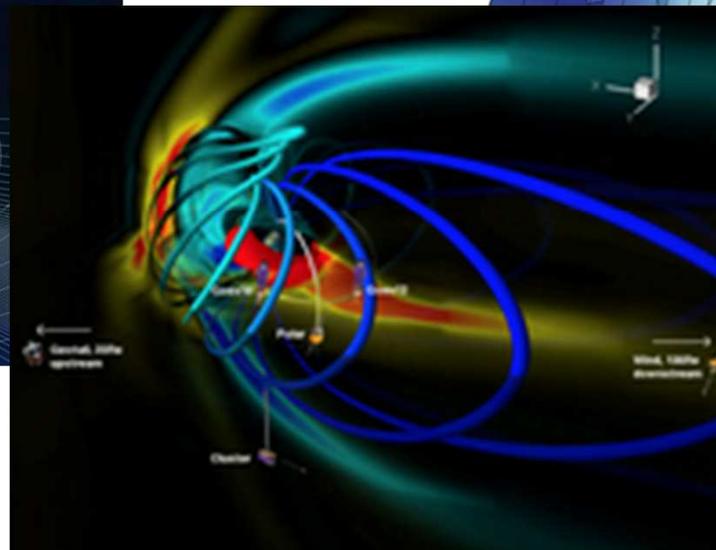


Space Weather Modeling

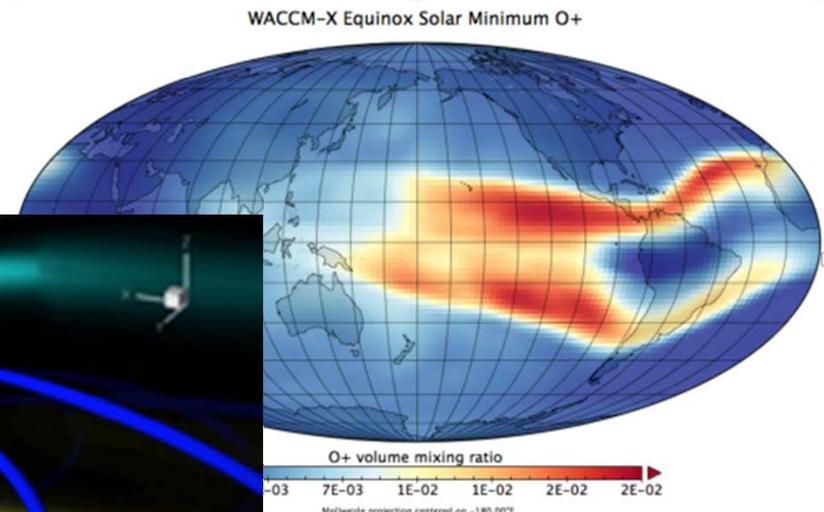
- Support for numerical modeling of the complete Sun-to-Earth chain
- Many of the NSF-funded '*research*' models now transitioned to CCMC for community use and to NOAA SWPC for operational support
- Continue support for capability building for Space Weather prediction



PSI – CME Modeling



SWMF – Geospace Model



WACCM-X –
Ionosphere/Thermosphere



Space Weather Observations

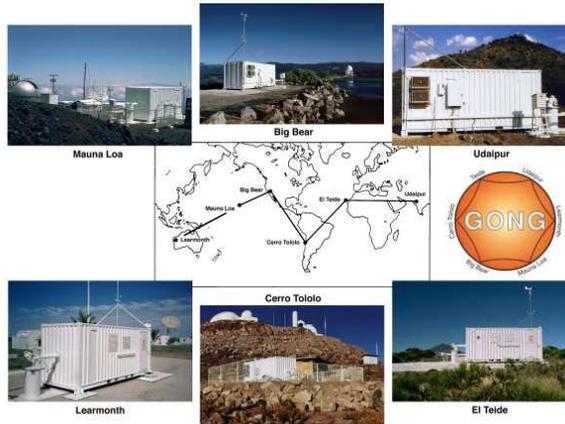
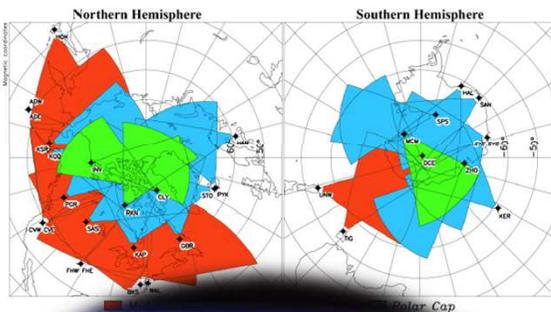


SuperDARN

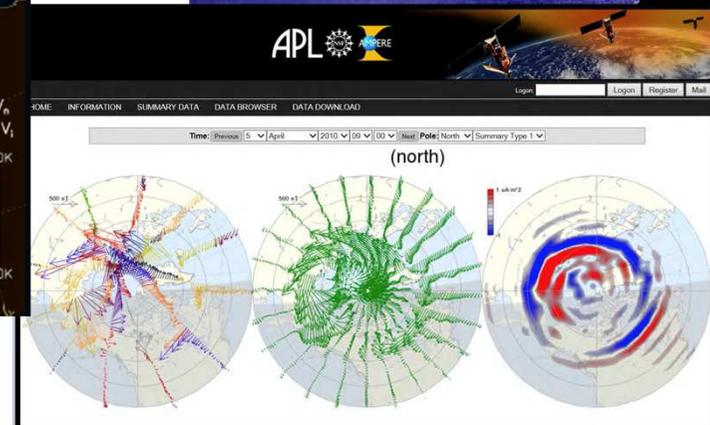
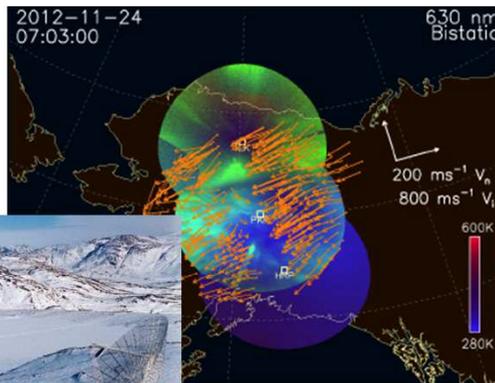
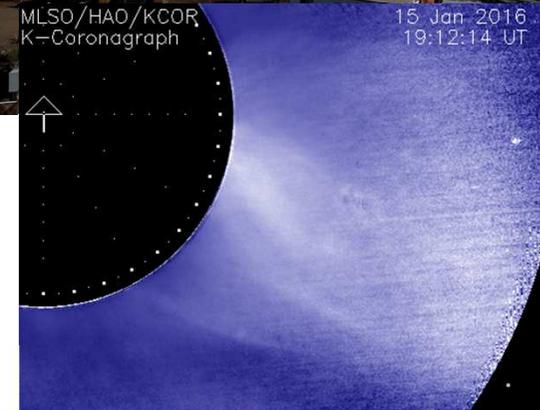
Super Dual Auroral Radar Network



An International Radar Network for Studying the Earth's Upper Atmosphere, Ionosphere, and Connection into Space



- Sun
- Magnetosphere
- Ionosphere/Thermosphere





NSF CubeSat Missions

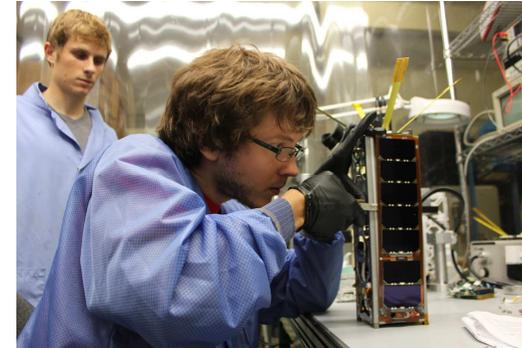
14 missions to date
20 CubeSats

CSSWE

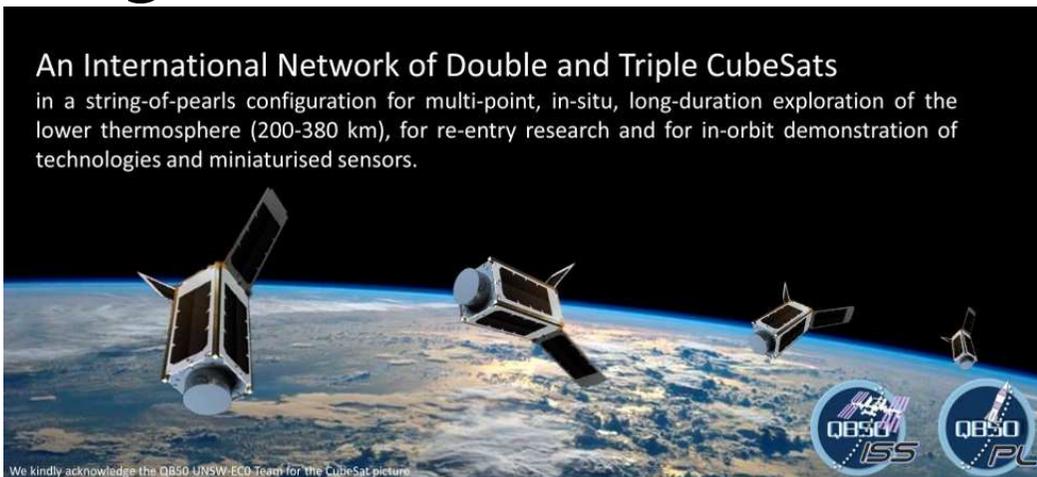


CADRE and MINXSS
Released May 2016

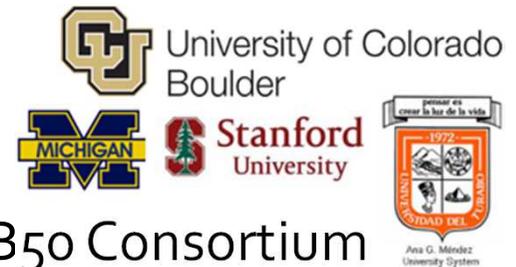
RAX – Auroral Turbulence



QB50



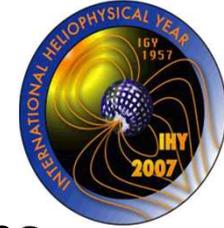
QBUS



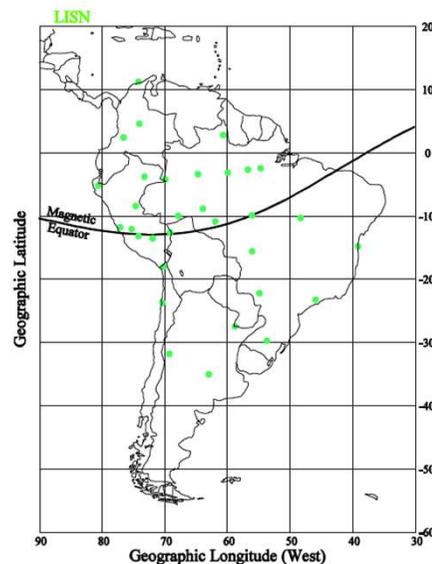
- US QB50 Consortium
 - Four Universities
 - ITM science expertise
 - Over 100 students involved



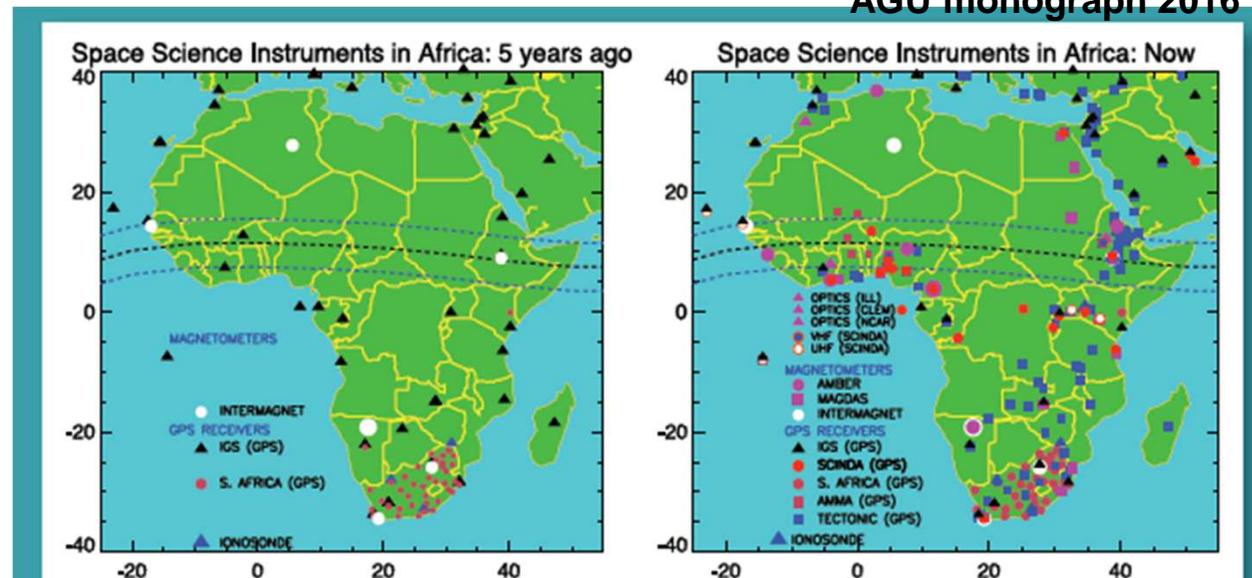
International Collaborations



- Support international travel and scientific collaborations through science grants
- International workshops on Space Weather
 - International Heliophysical Year (IHY) (Addis Ababa, Ethiopia, 2007)
 - AGU Chapman conference for Earth & Space sciences (Addis Ababa, Ethiopia, 2012)
 - AGU Chapman conference on Dayside Magnetosphere Interactions (Chengdu, China, 2017)



AGU monograph 2016



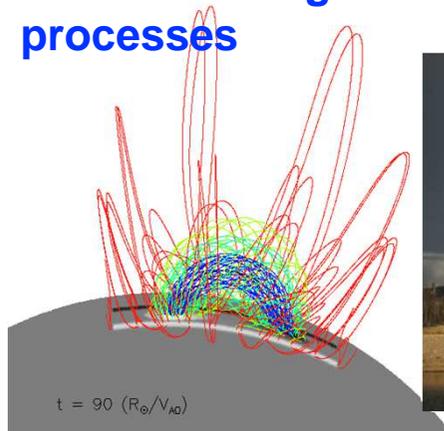


Conclusions

Advancing Fundamental Knowledge

Tackling the key science questions

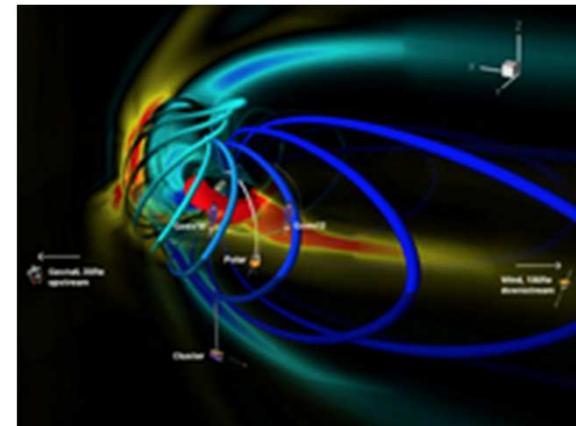
Understanding processes



Better observations



Improved Sun to Earth models



- Space Weather is a global concern
- NSF recognizes that R2O-O2R is important for Space Weather preparedness
- Fundamental understanding of Space Weather processes is critical for improving predictive capabilities
- NSF is committed to supporting cutting-edge research that will enable the global community to become *Space Weather Ready*