

# NSF & Space Weather Research

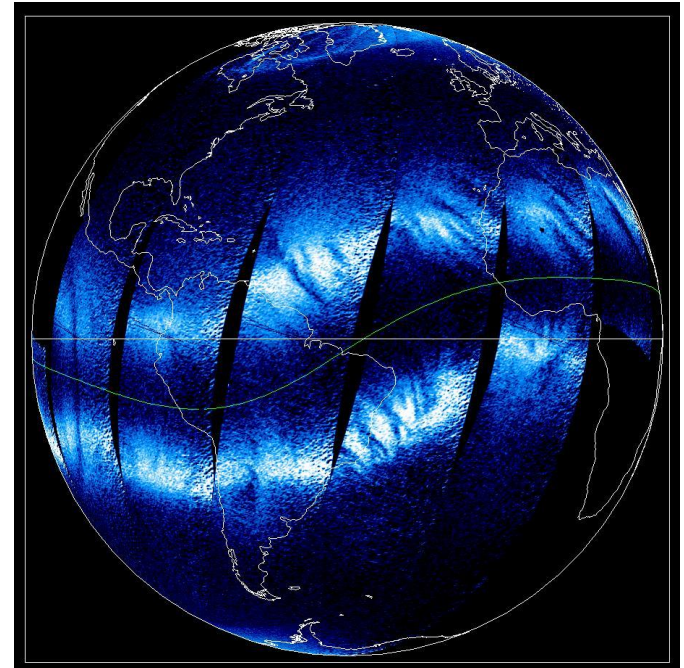
Paul Shepson

Division Director

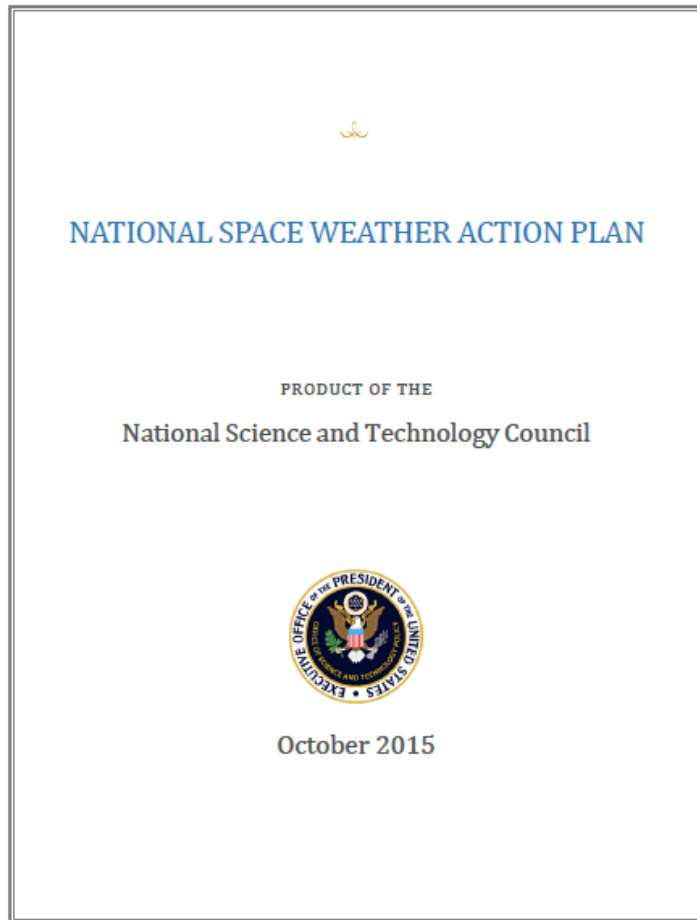
NSF Atmospheric and Geospace Sciences

# Space Weather is a Global Challenge

- Impacts effect the entire planet and are rarely localized to a single country.
  - Image shows Ionospheric irregularities extending from Africa to South America
- Modern global and technology-dependent society is highly susceptible to space weather impacts
  - Power grids, communications, satellites, pipeline, guidance & navigation, etc.
- Technological demands of the society demands “Space Weather Ready” Nations
- But, we are not there.



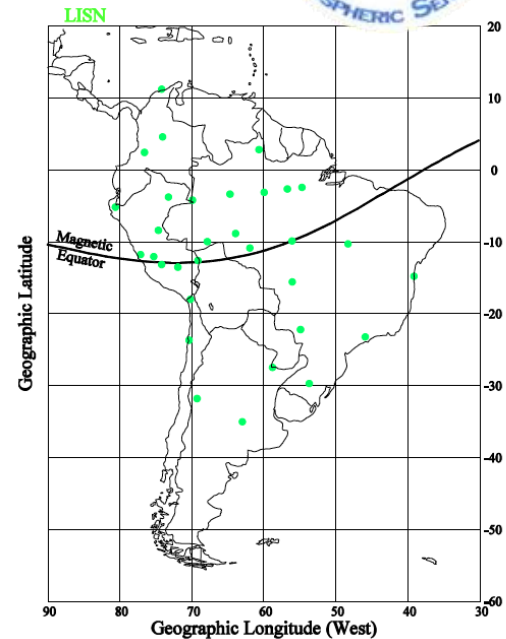
# NSF Contributions to a Space Weather Ready Nation



- NSF participates in 4 of the 6 NSWAP goals, including Goal 6 – Increase International Collaboration.
- Our role is to support the space weather enterprise by funding basic and fundamental research across several NSF directorates.

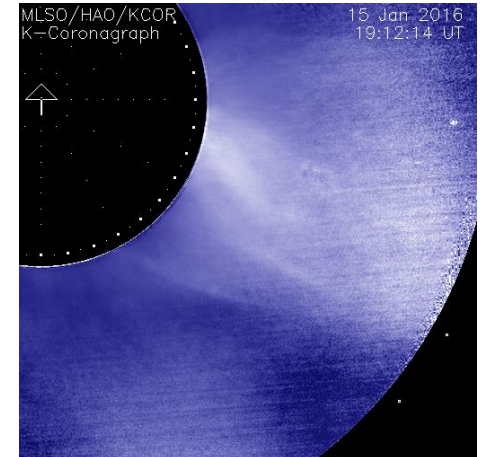
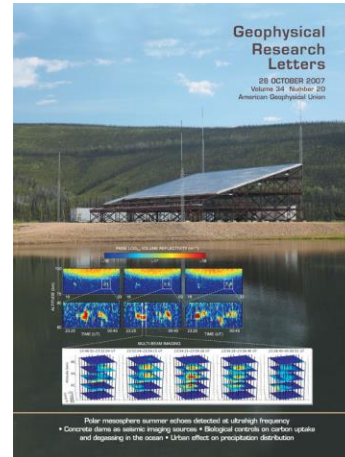
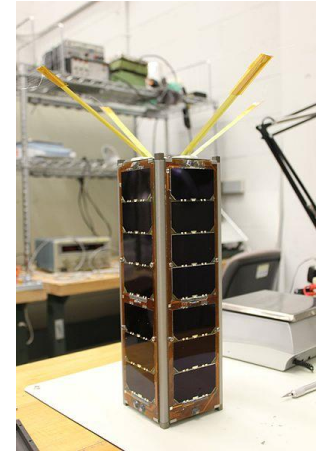
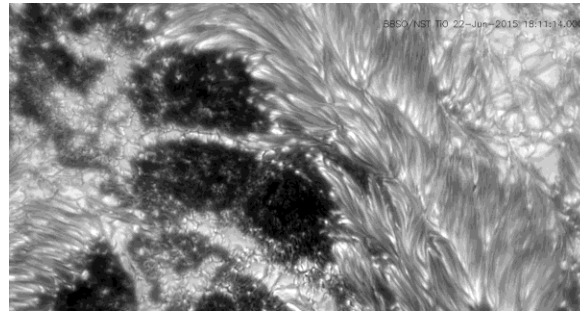
# International Collaborations

- Support international travel and scientific collaborations through science grants
- International workshops on Space Weather
  - AGU Chapman conference (China in 2017)
  - International Space Weather Initiative (ISWI)
- Ground Based Observations through distributed networks across many countries and Antarctica



# NSF – Supported Space Weather Observations

- Support observations into all aspects of the space weather system
  - Sun – MLSO, Big Bear, DKIST (On track for first light in 2019-2020)
  - Magnetosphere – AMPERE, magnetometer chains
  - Ionosphere – SuperDARN, AMISR, ISRs
  - CubeSats

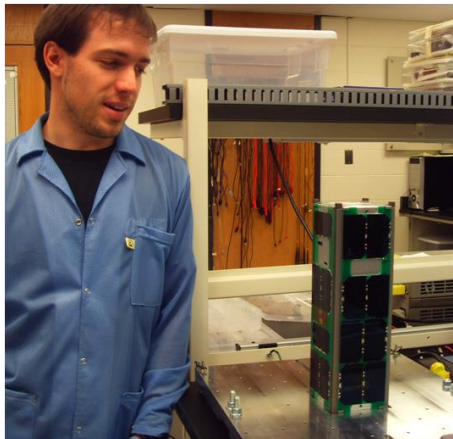


# NSF CubeSat Program



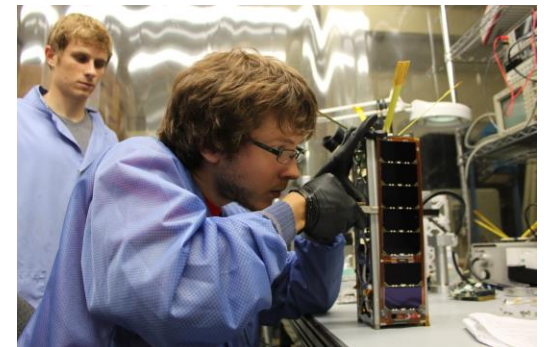
- Geospace section has pioneered CubeSats for space weather research, now a disruptive technology
- We are the primary source for student training in this area
- Currently reevaluating the program to engage other scientific disciplines and to determine how best to support the advancement of the technology.

Colorado Student Space  
Weather Explorer - Outer belt,  
solar energetic protons and  
electrons

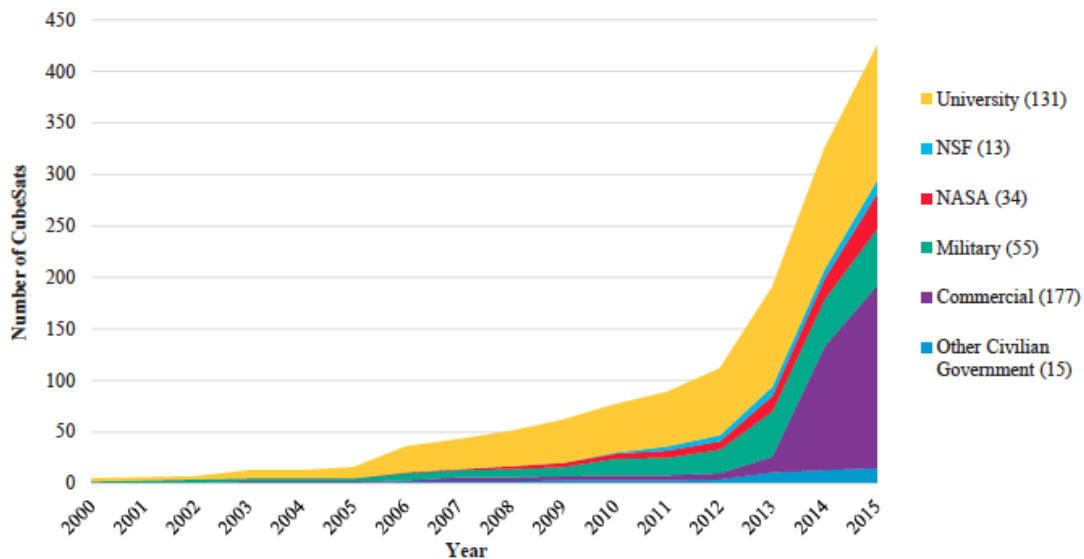
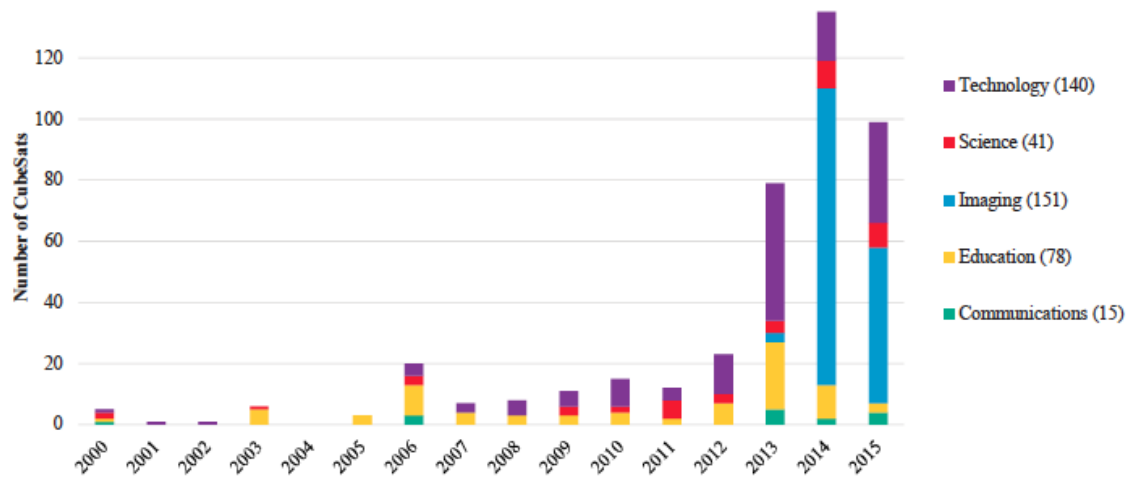


CADRE and MINXSS  
Release May 2016

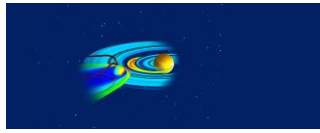
RAX – Auroral Turbulence



# Trends in CubeSats



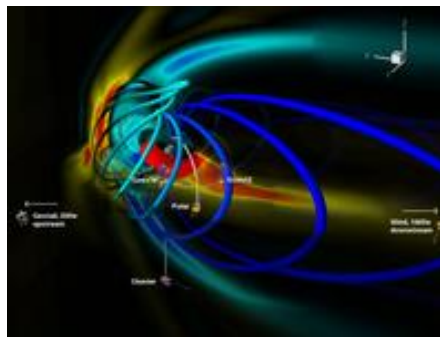
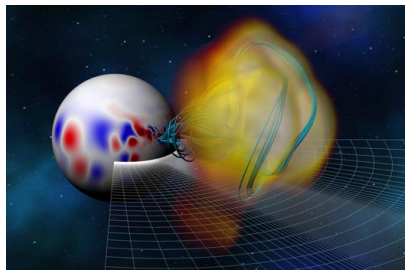
Achieving Science with CubeSats: Thinking Inside the Box, NAP 2016



# Space Weather Modeling

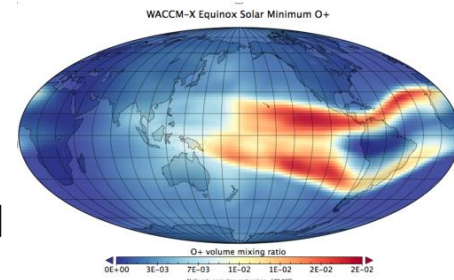
- Geospace section supports modeling of the complete Sun to Earth chain.
- The connection to operations (R2O2R) is growing in importance to the community.
- Many of the premier models that are now operational at NOAA have been developed with NSF support.
- The relationship between NSF/NASA-funded Community Coordinated Modeling Center (CCMC) and NOAA Space Weather Prediction Center. provides a pathway to transition research models to operations.

PSI – CME Modeling



SWMF – Geospace Model

WACCM-X –  
Ionosphere/Thermosphere







# Conclusions

- Understanding Space Weather is a global challenge.
- Researchers across the planet need to work together to solve the science problems at hand.
- NSF recognizes that R2O2R is important to move the field forward worldwide. It is important for operational capability and for improving fundamental research.
- Through grants to PIs and support of international workshops, NSF supports basic research and cutting edge new technologies that propel the Space Weather Ready movement forward.



**Questions?**