# Status of Space Weather Effort

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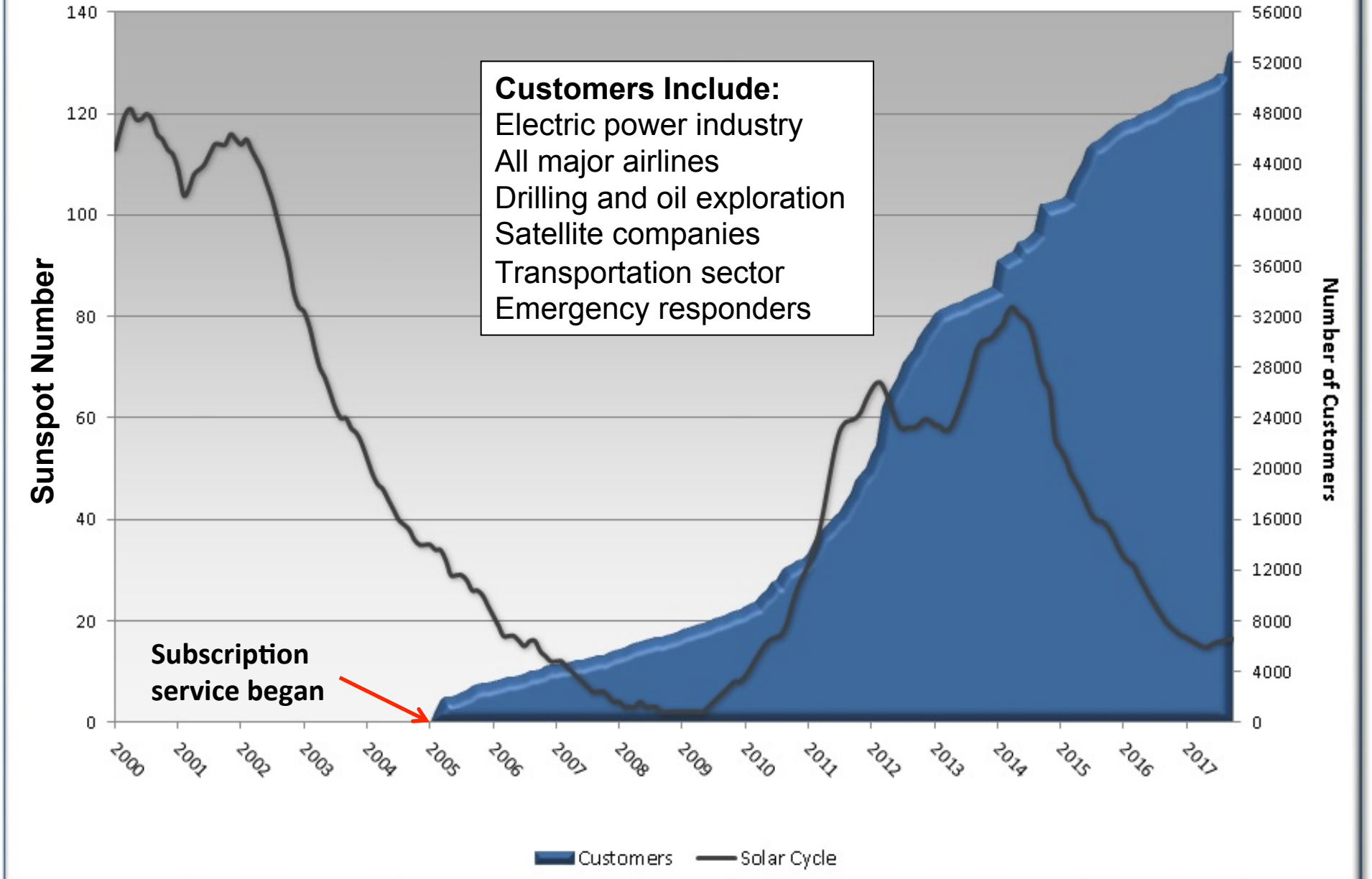
# Main Points

Goal: Provide information (forecasts, nowcasts, retrospective) that enables economically important decisions

- Growing space weather product demand
- Policy directives and national/international efforts
- NASA

# Customer Growth
## NOAA Space Weather Prediction Center – Product Subscription Service



# Recent U.S. Policy Directives

**U.S. Congress - 2010 NASA Authorization Act:**

- "Space weather events pose a significant threat to modern technological systems."

  **Action**: Director of Office of Science and Technology Policy (OSTP) to improve space weather preparedness and coordinate among U.S. government agencies

**Federal Energy Regulatory Commission – Order No. 779, 2013**

- Directed standards to address effects of space weather on the reliable operation of the electric power grid.

# Recent U.S. Policy Directives

**Space Weather Operations, Research, and Mitigation Task Force**

- Established by OSTP National Science and Technology Council - 2014
- Developed National Space Weather Strategy and Action Plan - 2015

**National Defense Authorization Act - 2017**

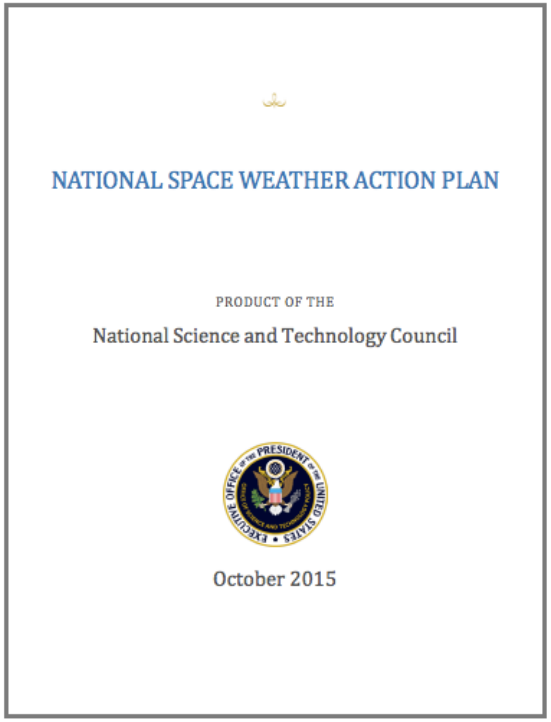
- Strategy to prepare for natural and adversarial electromagnetic pulses

**Space Weather Research and Forecasting Act**

- Passed by the U.S. Senate by unanimous consent – May, 2017
- Currently under review in the U.S. House of Representatives

# U.S. Perspective: National Space Weather Strategy and Action Plan

1. Establish benchmarks for extreme events
2. Enhance response and recovery
3. Improve protection and mitigation
4. Improve modeling of impacts on critical infrastructure
5. Improve services through advancing understanding
6. Increase international cooperation


NATIONAL SPACE WEATHER ACTION PLAN

PRODUCT OF THE

National Science and Technology Council

October 2015

20 Government Departments, Agencies and Service Branches

# Goal 1: Benchmarks

Provide a clear description of space weather events based on scientific and historical knowledge: 1 in 100 year event and theoretical maximum

- Induced electric fields
- Ionizing radiation (NASA lead)
- Ionospheric disturbances
- Solar radio bursts
- Upper atmospheric expansion

Phase 1 document was released through the Federal Register, and input has been addressed

Broader national and international input will be obtained through upcoming community meetings

# Goal 4: Impacts on Critical Infrastructure - Economic Impact Study

**FINAL REPORT**

**Social and Economic Impacts of Space Weather in the United States**

**September 2017**

Abt Associates
Bethesda, Maryland

**Written under contract for the NOAA National Weather Service**
***www.nws.noaa.gov***

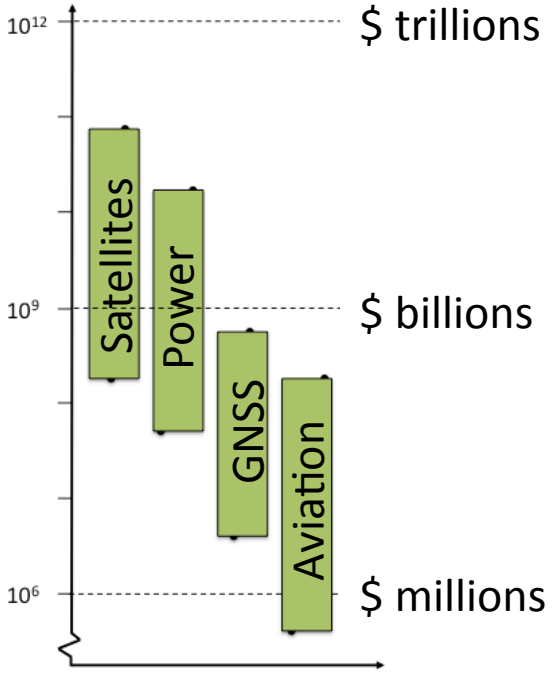
www.weather.gov/news/171212_spaceweatherreport

Source: Stacey Worman, Abt Associates

## Key Findings

- Impacts are a real concern
- Stakeholders are interested
- Topic is complex
- Mitigation may be inexpensive
- Help value NOAA investments

Estimated cost of moderate/extreme event




Note: Costs represent first pass estimates not to be taken out of context or quoted without appropriate caveats. Qualitative information and quantitative framework are the more important contributions of this effort.

# Goal 5: Improve Services Through Advancing Understanding

## Coordinated interagency space weather research funding

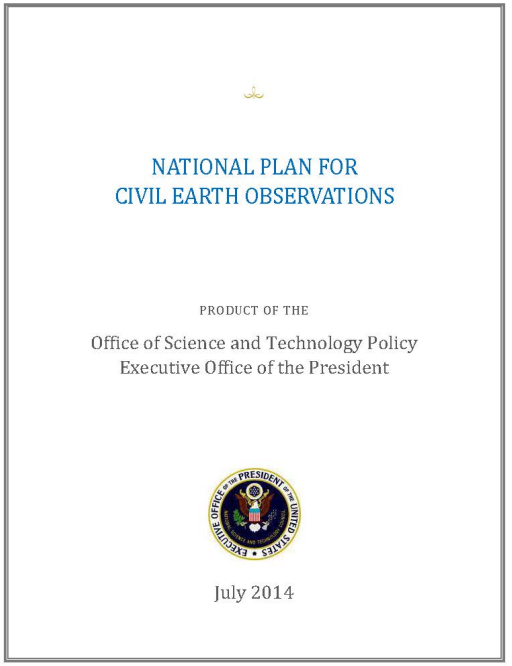
Joint NASA/NOAA operations-to-research pilot funding opportunity:

- Follows direction of the National Space Weather Action Plan to facilitate research to improve operational services
- First research focus is to **improve forecasts** of solar wind and coronal mass ejections – proposals due March 30, 2018
- Future funding opportunities will address other space weather research and service priorities, including SBIR opportunity
- NSF released separate opportunity – tri-agency MOU drafted for future opportunities

# U.S. National Assessments of Space Weather Observations

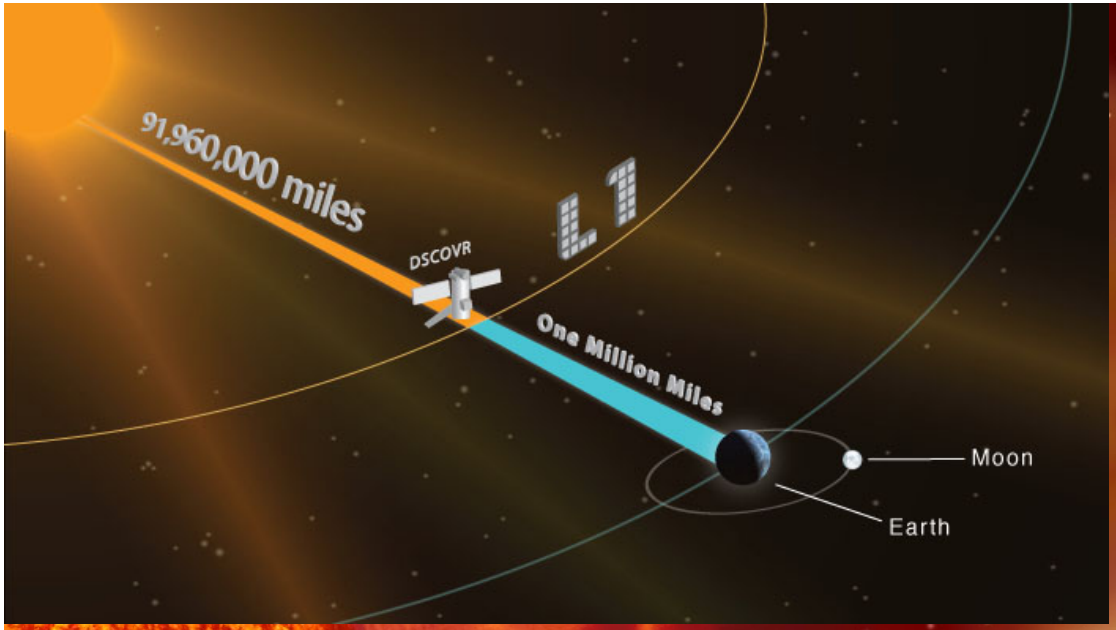
US National Plan released in July, 2014:

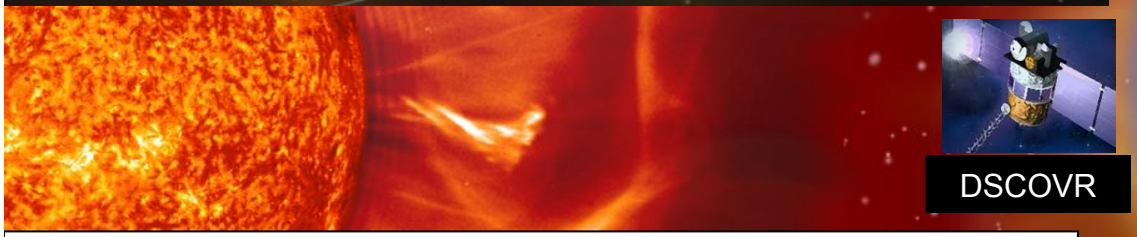
- Established priorities and actions to advance civil Earth observing capabilities
- Second Earth Observations Assessment completed in 2016




NOAA Assessments of Data Value:

- Evaluation of data impact on product value
- Cost-benefit analysis of satellite architectures needed to acquire operational data
- Includes baseline observations, plus solar imaging, auroral imaging, thermospheric parameters





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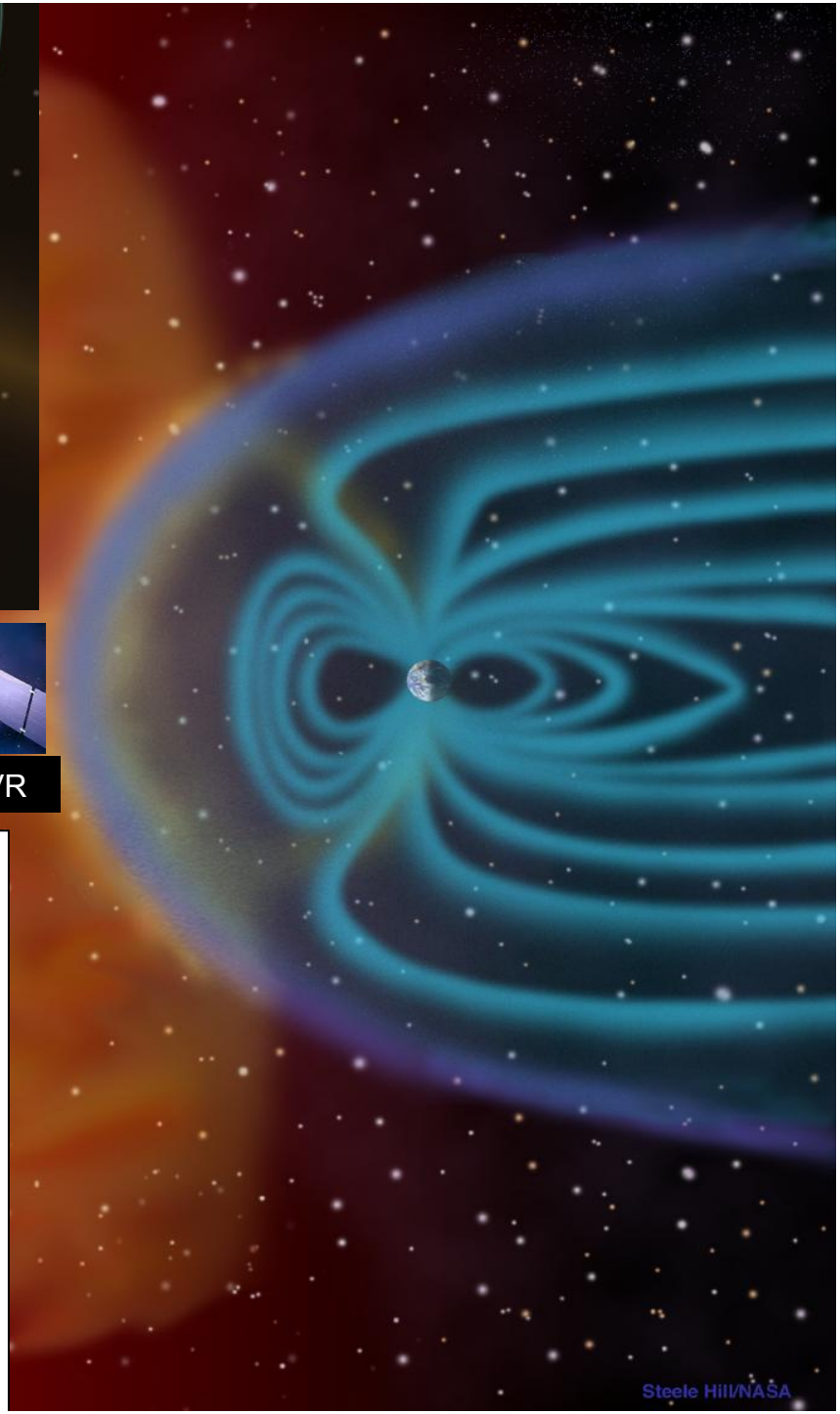
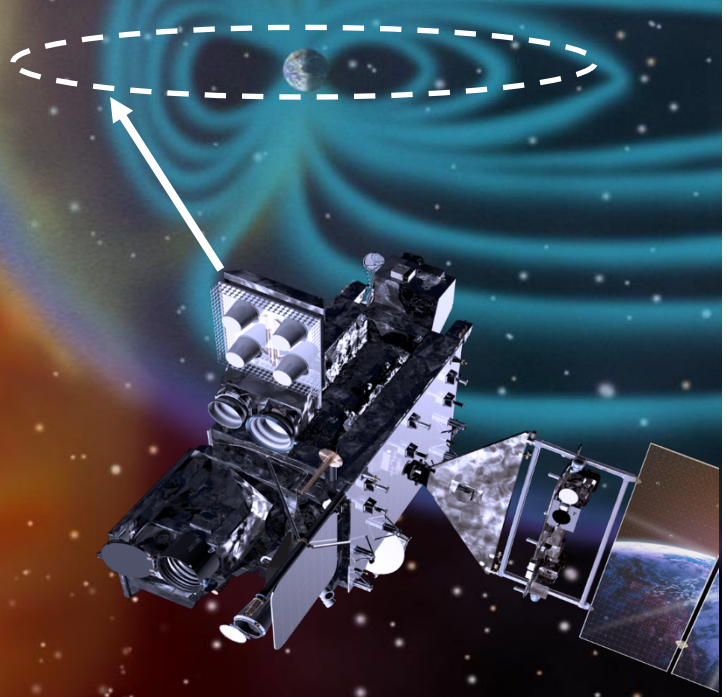



- Launched: February 11, 2015
- To replace operational use of NASA ACE spacecraft
- Space weather measurements:
  - Solar wind density, velocity, temperature
  - Solar wind magnetic field
- High-reliability warnings of geomagnetic storms
- Requires international real-time data network
- Follow-on mission and coronograph in planning

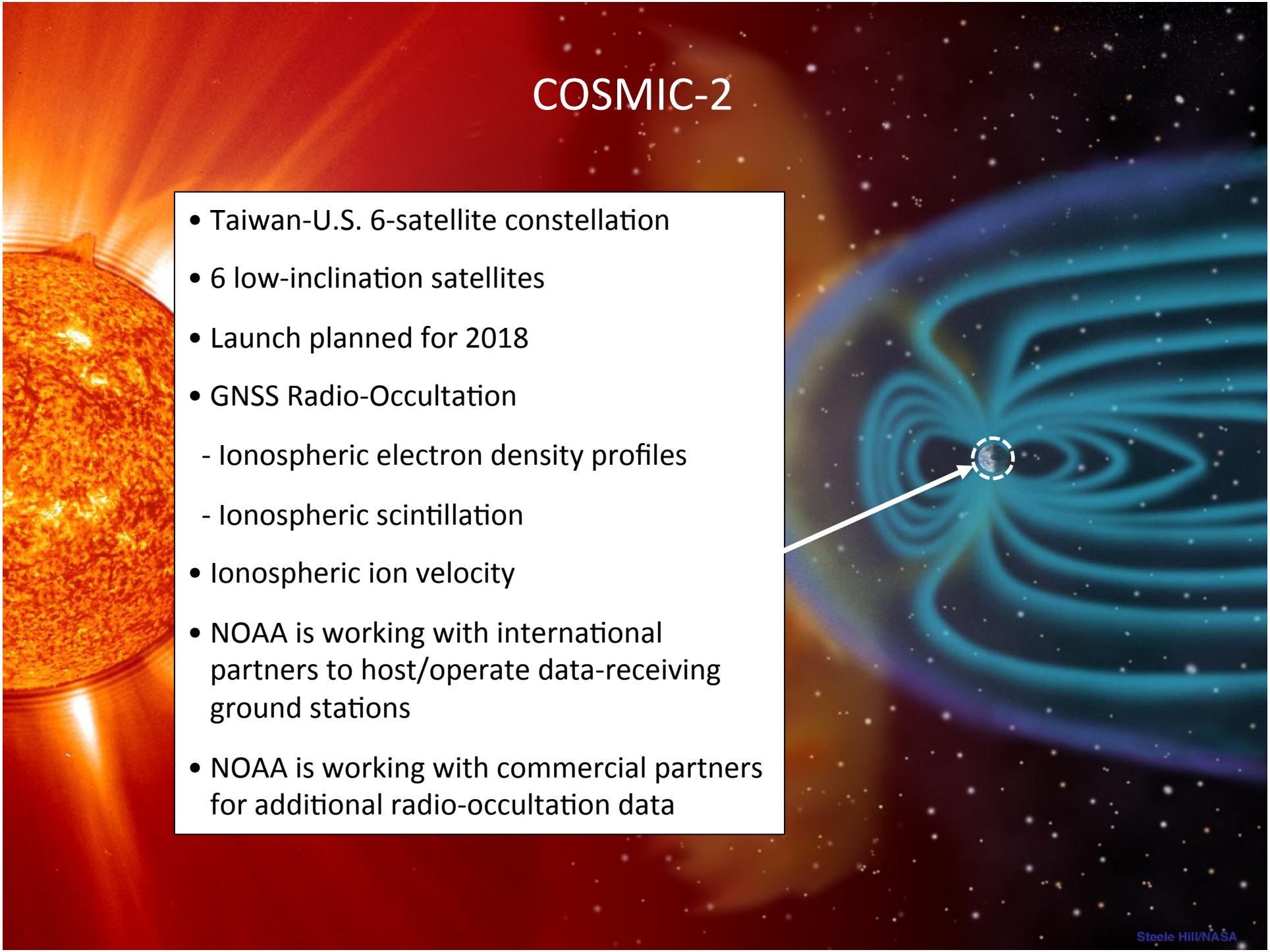
# Geostationary Operational Environmental Satellite Series
# GOES-16 and GOES-17

- Launched:
  - GOES-16: November 19, 2016
  - GOES-17: March 1, 2018
- Space weather measurements:
  - Solar EUV
  - Solar X-rays
  - Energetic particles
  - Magnetic field
- Energetic electron intercalibration
  - Himawari-8 comparison conducted by NICT, Japan



# COSMIC-2

- Taiwan-U.S. 6-satellite constellation
- 6 low-inclination satellites
- Launch planned for 2018
- GNSS Radio-Occultation
  - Ionospheric electron density profiles
  - Ionospheric scintillation
- Ionospheric ion velocity
- NOAA is working with international partners to host/operate data-receiving ground stations
- NOAA is working with commercial partners for additional radio-occultation data



# International Organizations Engaged in Space Weather Services

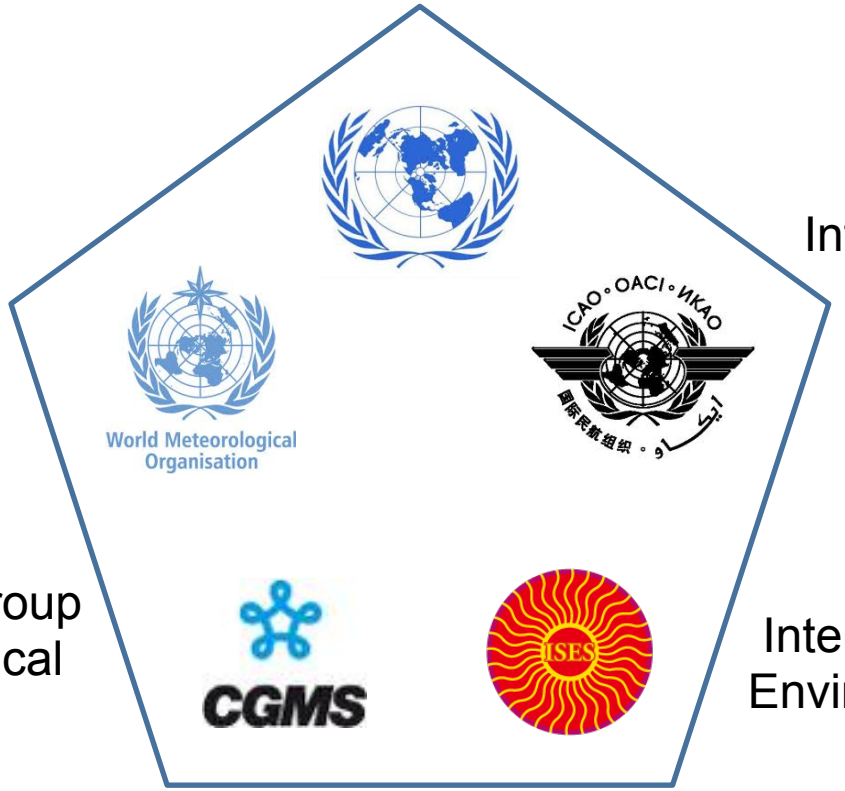
UN Committee on the Peaceful Uses of Outer Space

World Meteorological Organization

International Civil Aviation Organization

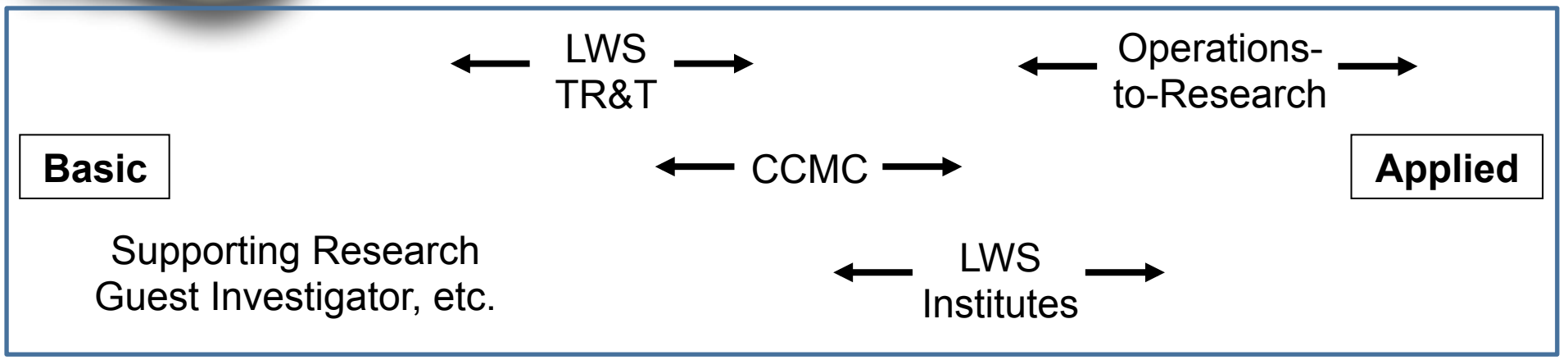
Coordination Group for Meteorological Satellites

International Space Environment Service




Numerous other groups are active in space weather research (COSPAR, ISWI, ILWS, IAU, URSI, SCOSTEP, etc.)

# Connecting Heliophysics Research to Space Weather Services




- Funding opportunities are now available across the spectrum from basic to applied
- Operations-to-Research-2017 was funded as a one-year pilot
- Operations-to-Research-2018 and beyond could be multi-year
- CCMC-SWPC collaboration tasks initiated
- Challenge is to enhance and evolve the research-community participation in applied research and have all elements work synergistically

# Summary

- Demand is increasing for space weather services – electric power, aviation, satellites, navigation, communication
- National policy directives identify the need for interagency coordination to advance research and observing capabilities
- Coordinated multi-agency funding has been initiated to support applications-focused research
- Elements are now in place to connect heliophysics research advances to space weather service capabilities
- Challenges include: fostering interest in the research community, partnering effectively with industry, utilizing international efforts, etc.