

# ***Headquarters U.S. Air Force***

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*Integrity - Service - Excellence*

## **Air Force Space Weather Way Ahead**



**Col. Mike Gremillion  
HQ USAF/A3W  
23 April 2018**

**U.S. AIR FORCE**

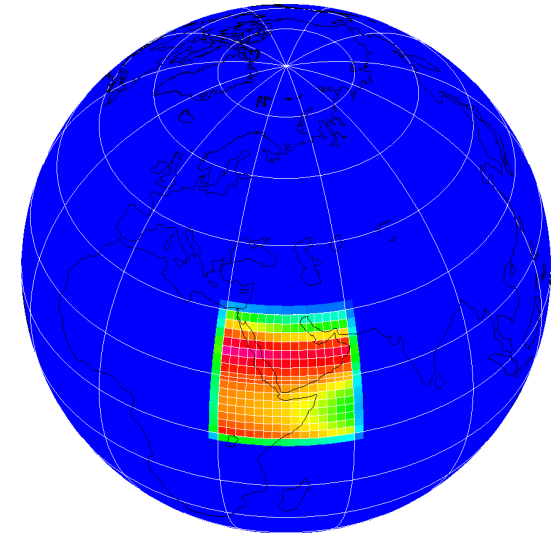
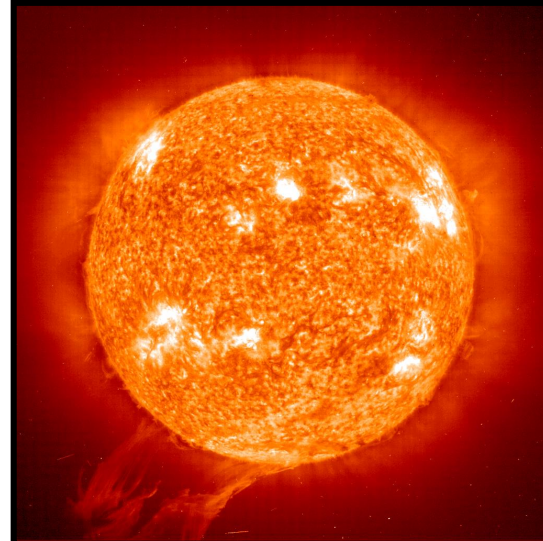
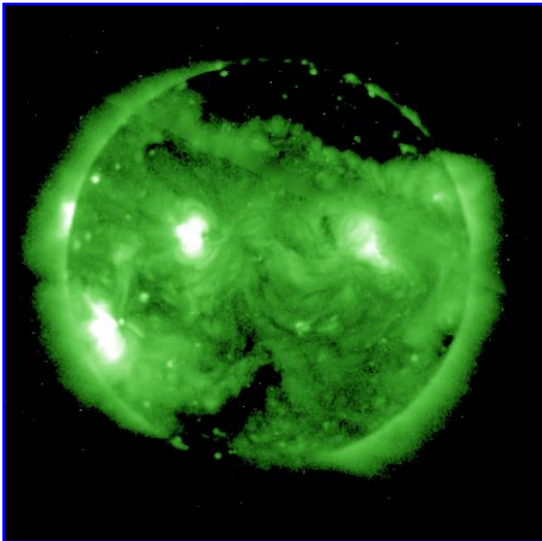
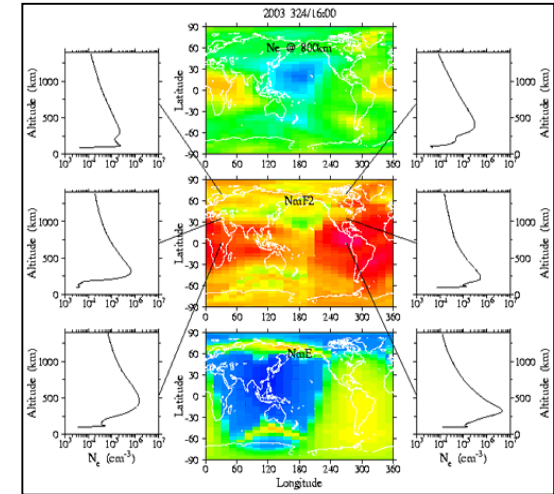
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# Air Force Space Weather Overview

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- Mission
- Capabilities
- Forecasting Future
- Interagency Coordination
- Challenges and Opportunities





# Air Force Weather Mission

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Global Power



Global Reach



Air Ops



Agile Combat Support



***“Weather operations provides accurate, timely, relevant, and consistent air and space environmental information to AF and specified Army units, including their respective Reserve Components, and as directed, joint forces, coalition forces, and other agencies, such as those combat support agencies under the purview of the Under Secretary of Defense for Intelligence” - Weather Operations Mission, AF Policy Document 15-1, Nov ‘15***



Army Ops



Global Vigilance



Special Ops



Space Weather

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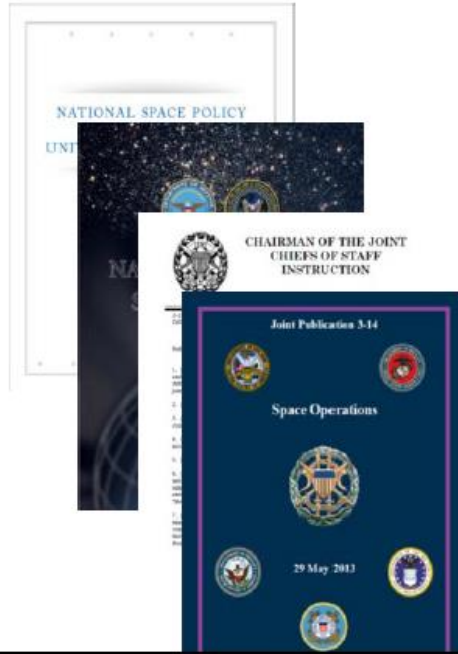




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# AF Mandate for DoD Space Weather Ops

**“CSAF is responsible for space weather operations and capabilities in support of all elements of the DOD”**  
– CJCSI 3810.01E (May 2016)



**“AFWA [557 WW] is the POC for all DOD and IC space weather information”**  
– JP 3-14 (May 2013)



National Space Defense Center (NSDC)

**“It is the sense of Congress that the SecDef should ensure the timely provision of operational space weather observations, analyses, forecasts, and other products to support the mission of the DOD including the provision of alerts and warnings for space weather phenomena that may affect weapons systems, military operations, or the defense of the United States.”**  
– NDAA FY18



# Warfighter Impacts

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**Tailors Space Weather Information -- satisfying Warfighter Mission Requirements and Delivers Support to appropriate Classification Level**

## X-Rays, EUV, Radio Bursts

Arrival: 8 min / Duration: 1-2 hours

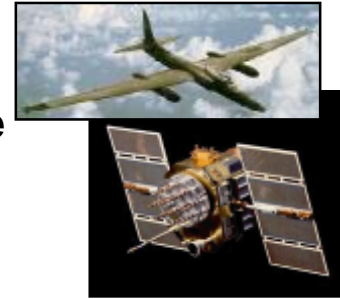
- SATCOM Interference
- Radar Interference
- HF Radio Blackout
- Geolocation Errors
- Satellite Orbit Decay



## Energetic Particle Events

Arrival: 15 min to hours / Duration: days

- High Altitude Radiation Hazards
- Spacecraft Damage
- Satellite Disorientation
- Launch Payload Failure
- False Sensor Readings
- Degraded HF Comm (high latitudes)



## Scintillation

Daily / Ionospheric Disturbance

- Degraded SATCOM
- GPS Error
  - Positioning
  - Navigation
  - Timing



## Geomagnetic Storms

Arrival: 1-3 days / Duration: days

- Spacecraft Charging and Drag
- Geolocation Errors
- Space Track Errors
- Launch Trajectory Errors
- Radar Interference
- Radio Propagation Anomalies
- Power Grid Failures





# AF Space Weather: Interagency Coordination

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- Interagency coordination drive by Executive Order (13744)  
Coordinating Efforts to Prepare the Nation for Space Wx Events
  - Overarching National Space Wx strategy
  - OSTP led SWORM efforts implement National Space Wx strategy
  - Partnering with federal agencies and academic community to develop models, observing systems, & technologies to enhance national preparedness
    - AFRL, NRL, JHU/APL, modeling, sensors & data



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# AF Space Weather Challenges

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- Threats in the future operating environment include:
  - Potential for engagement with near-peer adversaries
  - Space domain will become increasingly contested and congested
  - Counter-space technologies and operations
    - Space weather data has to expand to provide environment information to feed rapid anomaly attribution





# Modernize: Products

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## Orbit-Specific Stoplight Chart

Valid: 19-Oct-2017 1800Z

Today  
19-Oct

3 - Day Forecast

20-Oct

21-Oct

22-Oct

	night	day	day	night
Low Earth Orbits	Green	Green	Green	Green
Medium Earth Orbits	Yellow	Yellow	Yellow	Yellow
Geosynchronous Equatorial Orbits	Red	Red	Red	Red
Highly Elliptical Orbits	Yellow	Yellow	Yellow	Yellow

	night	day	day	night	night	day	day	night	night	day	day	night
Low Earth Orbits	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow
Medium Earth Orbits	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green
Geosynchronous Equatorial Orbits	Red	Red	Red	Red	Red	Red	Red	Green	Green	Green	Green	Green
Highly Elliptical Orbits	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green

Low Earth Orbits  
Medium Earth Orbits  
Geosynchronous Equatorial Orbits  
Highly Elliptical Orbits

**Discussion:** VHF radio communication are predicted to be extremely unfavorable, mostly at high latitudes, due to warning-level geomagnetic storms. A geomagnetic storm is caused by an increase in charged particles emitted from the sun, which temporarily disturb the magnetic field around the Earth. These storms will modify the ionosphere and interfere with VHF signal propagation. Satellite communications in this region will also be degraded or completely unavailable, which includes the ability to track LEO satellites. Please visit [www.spaceweather.af.mil/VHF](http://www.spaceweather.af.mil/VHF) for additional details.

VHF	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
UHF	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Green	Green	Green	Green	Green	Orange
L Band / GPS Single Freq	Yellow	Green	Green	Yellow	Green	Yellow	Green	Yellow	Yellow	Green	Green	Yellow	Yellow
SHF (S, C, X, Ku)	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Green	Green	Green	Green	Green	Green
EHF (Ka, V)	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Green	Green	Green	Green	Green	Green

Favorable
  Marginal
  Degraded
  Unfavorable



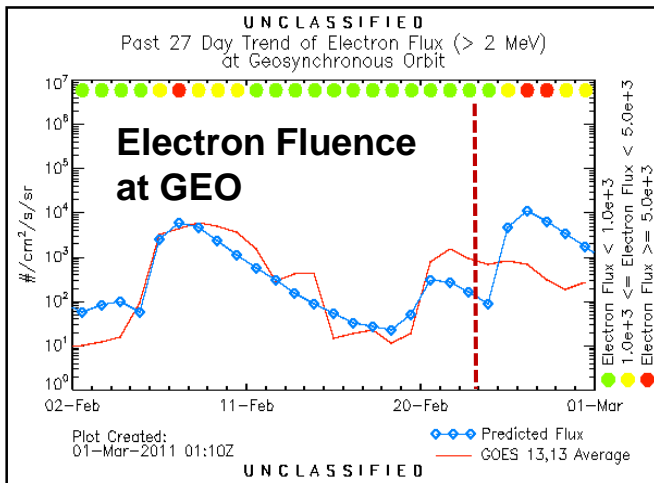




# Anomaly Assessments

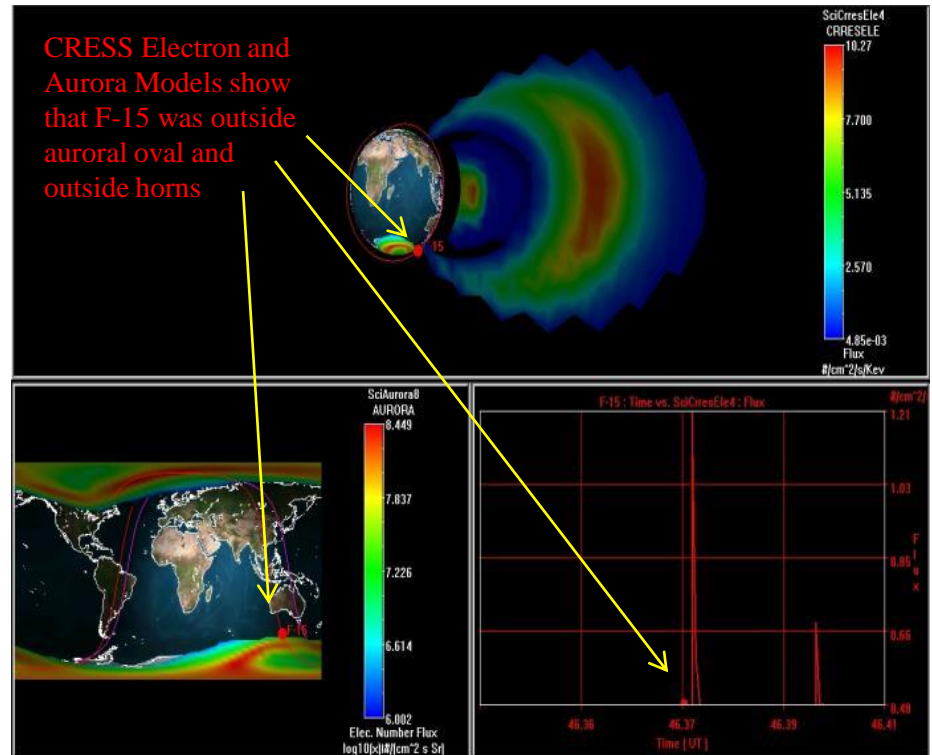
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- Assessment of Space Weather Environment in support of Spacecraft Anomaly Resolution- Quick-look minutes; Detailed Study follows days/weeks later



Assessments Completed by 2 WS

Year	Number	Increase
2014	92	
2015	175	87%
2016	281	63%
2017	382	27%



Global Radiation Belt Model



# ***AF Space Wx Forecasting Future Investments***

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- **Workforce Development & Training**
  - Force of highly educated military and civilian operators
  - Trained to support national security, warfighter needs; understand and communicate global space environment impacts
- **Next Generation Technology & Responsive RDT&E**
  - All AF space-based sensors to have ECP sensors onboard
  - Whole-atmosphere/coupled modeling & impact assessment tools
  - Develop next generation ground/space-based sensing technologies
  - Energize RDT&E relationship with labs, academia, industry; emphasize open architectures, Gov't data rights, rapid development/adoption
- **Warfighter Engagement & Civil Collaboration**
  - Integration into planning/employment systems
    - Multiple security enclaves
  - Complementary support to federal partners for national security issues

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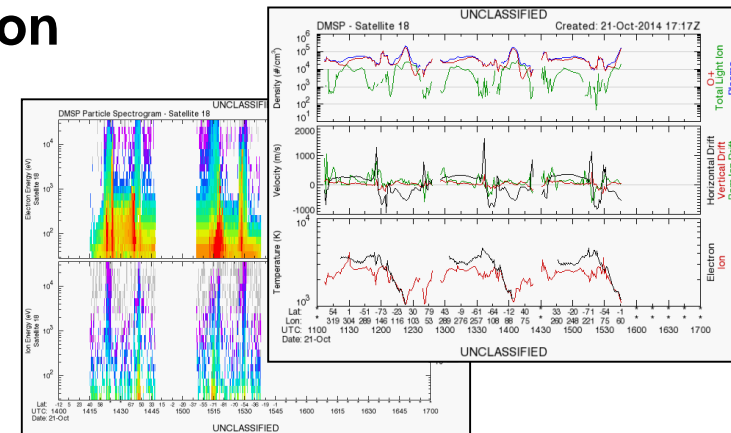
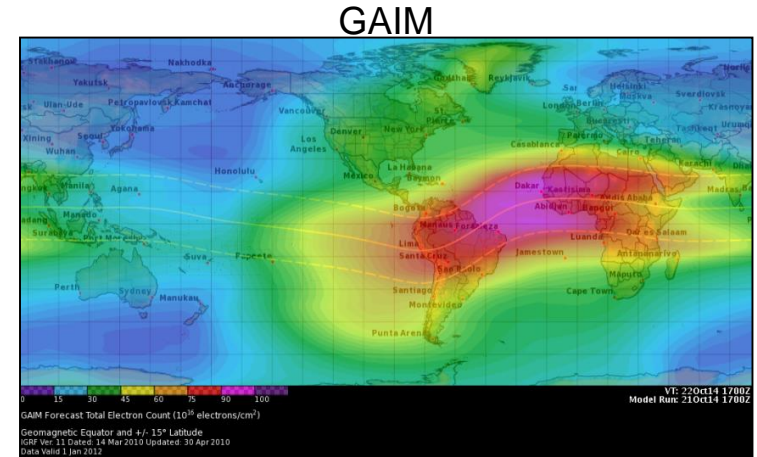
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# AF Space Wx Forecasting Future, Modeling & Research Priorities

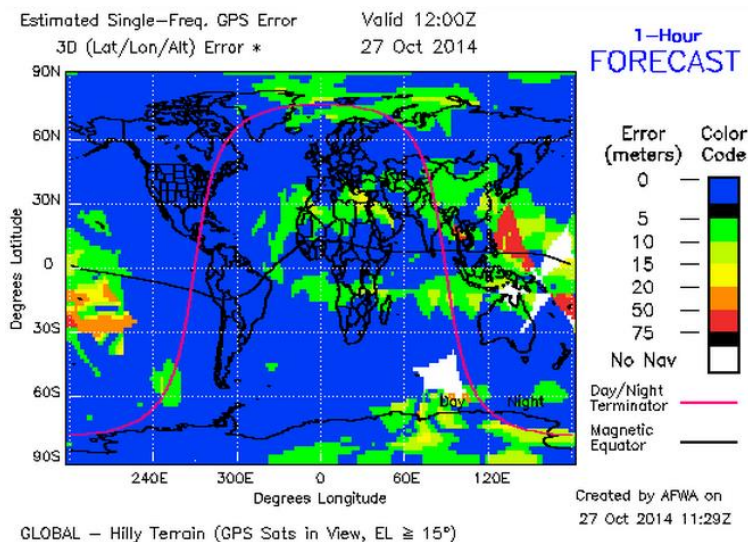
- Ionosphere
  - Scintillation
  - Total electron content (TEC)
  - Electron density profile (EDP)
- Magnetosphere
  - LEO energetic particle characterization
  - Spacecraft charging in all orbits
- Solar event forecasting
  - X-ray flares
  - Radio bursts
  - CMEs
- Space wx impact tool / anomaly assessments





# AF Space Wx Forecasting Future, the Ionosphere

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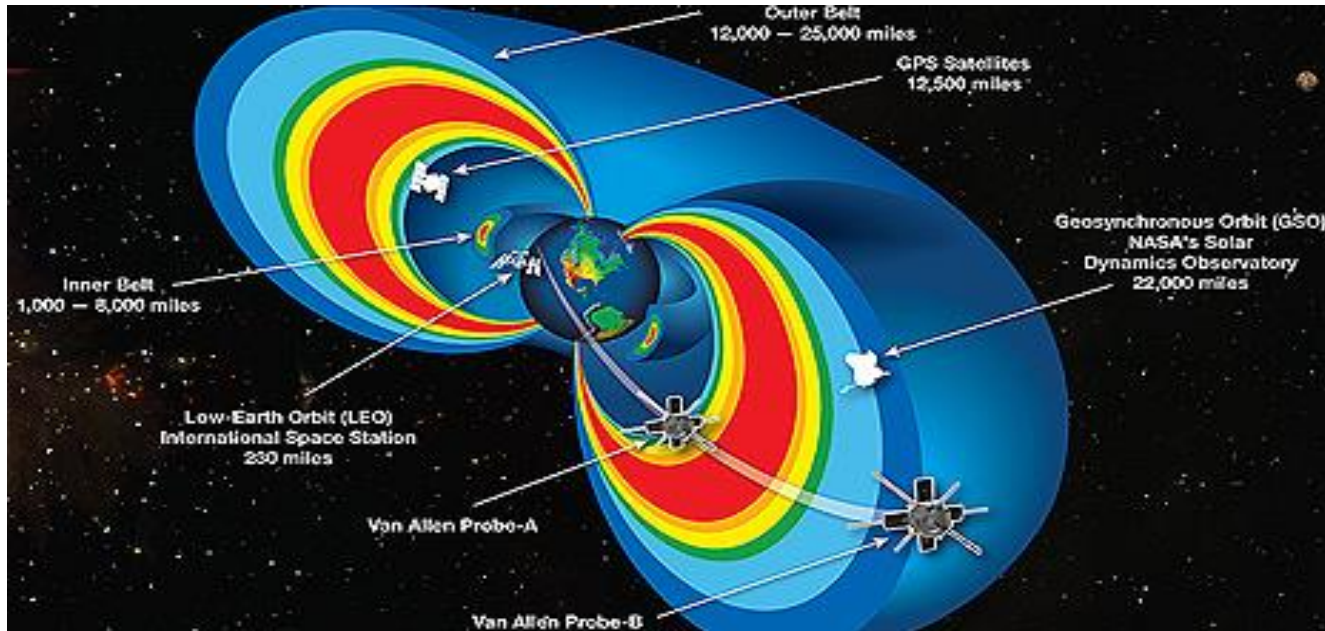
- **GPS Block III coming online: transmits over several frequencies**
  - More accurate estimates of TEC
  - More accurate scintillation S4 index spectra
- **GPS Block III will transmit at higher power levels**
  - More disperse ground location of TEC columns
  - More disperse ground location S4 measurements





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# AF Space Wx Forecasting Future, the Magnetosphere



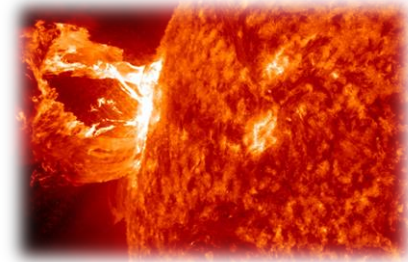
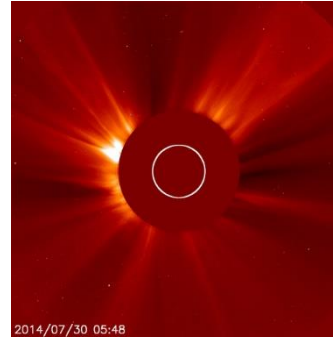
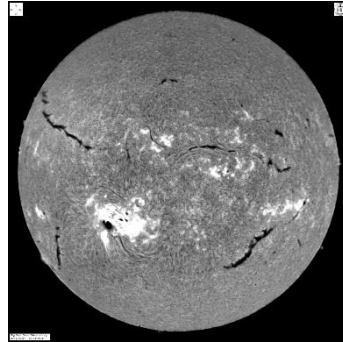
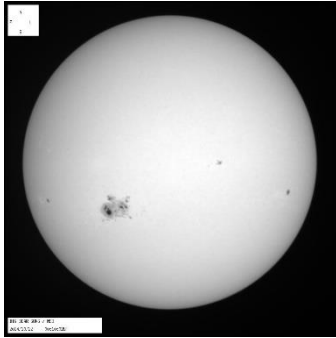
Utilize data from DMSP and GEOS with new understanding of Magnetospheric processes from Van Allen Probes

Future real-time access to ECP data from GPS and other Assets



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# AF Space Wx Forecasting Future, Solar Flare & CMEs



- Operational data from upgraded RSTN
- Operational data from SOON (hopefully SOON follow-on)
- Close in CME observations from Parker Probe and Solar Orbiter
- Non-operational research data from NASA Parker Probe
- Non-operational research data from ESA Solar Orbiter



# Summary

## U.S. AIR FORCE

- Air Force committed to space weather observing...now & future
- Team with national & international community for DoD support
- Sensor-to-shooter – accurate, timely, relevant effects delivered for warfighting operations

Global Power



Global Reach



Air Ops



Agile Combat Support



***“Air Force weather enables Joint Warfighters to anticipate and exploit the weather...for air, ground, space, cyberspace and intel operations.”***

*– AFW Mission*



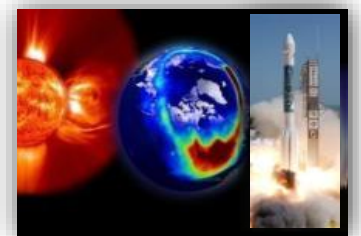
Army Ops



Global Vigilance



Special Ops



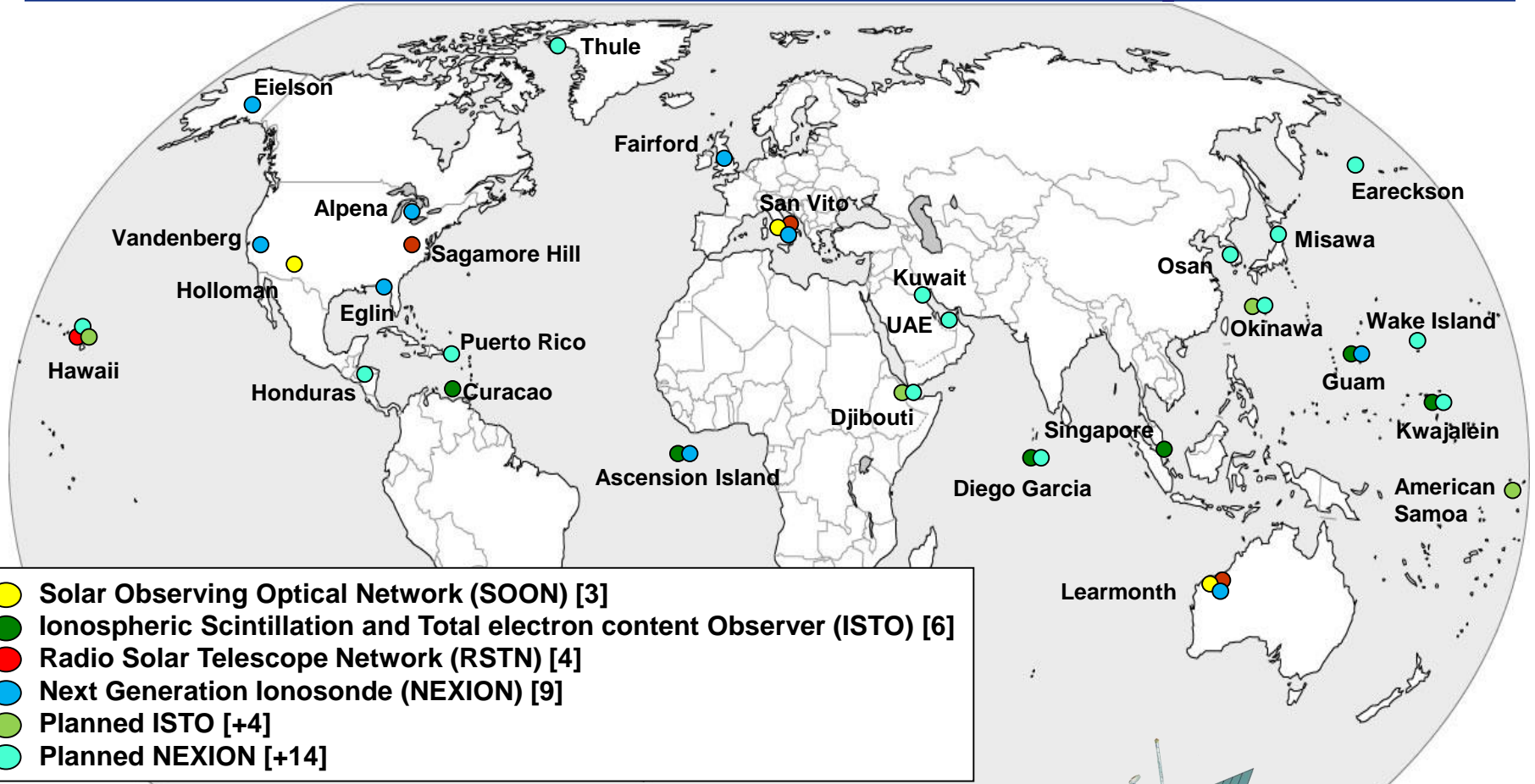
Space Weather

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# Current AF Current Space Wx Capabilities



**Defense Meteorological Satellite Program (DMSP): F16, F17, F18,  
Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-2): Low Inclination  
All AF Space-based Platforms (2021)**

