Headquarters U.S. Air Force

Integrity - Service - Excellence

DoD Space Weather Operations & Mission Impacts

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HQ USAF Director of Weather
26 June 2019

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Air Force Space Weather Mandate

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

The Air Force 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

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Air Force Space Weather Mission

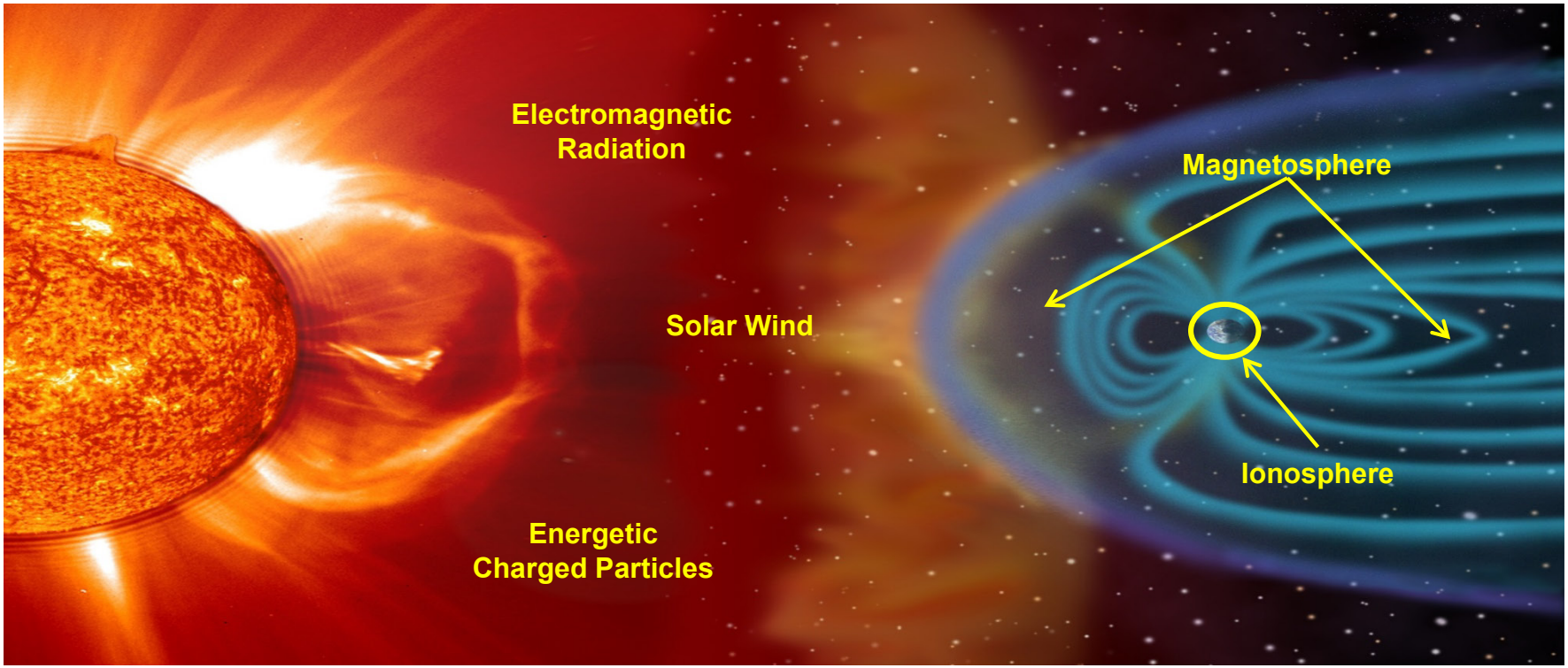
- Air Force Space Weather Operations Center (SpaceWOC)
  - Real-time operational support at all three security enclaves
    - Operational analysis & forecasts
    - National Security alerts and warnings
    - Mission-tailored warfighter impact products
  - Increased manning to improve warfighter support
  - Greater focus on anomaly assessment / attribution

- Provide classified support to
  - Combined Space Operations Center
  - National Space Defense Center
  - White House Situation Room
  - NORAD/NORTHCOM
  - Intelligence Community

Air Force Space Weather Operations Provide an Asymmetric National Security Advantage

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 and ground-based technological systems, as well as endanger life or health
- Solar electromagnetic radiation and energetic particles impact the Earth's Magnetosphere and Ionosphere, causing space weather disturbances



Space Weather Phenomena

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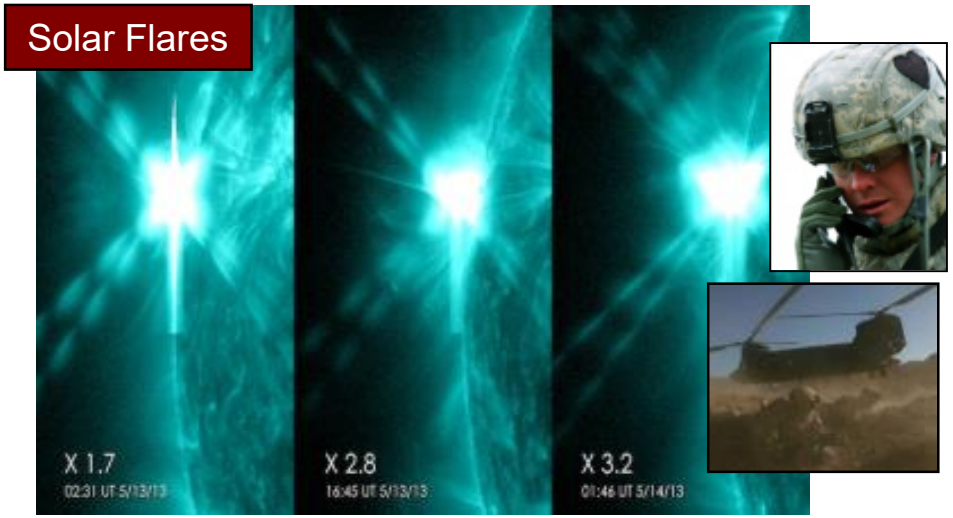
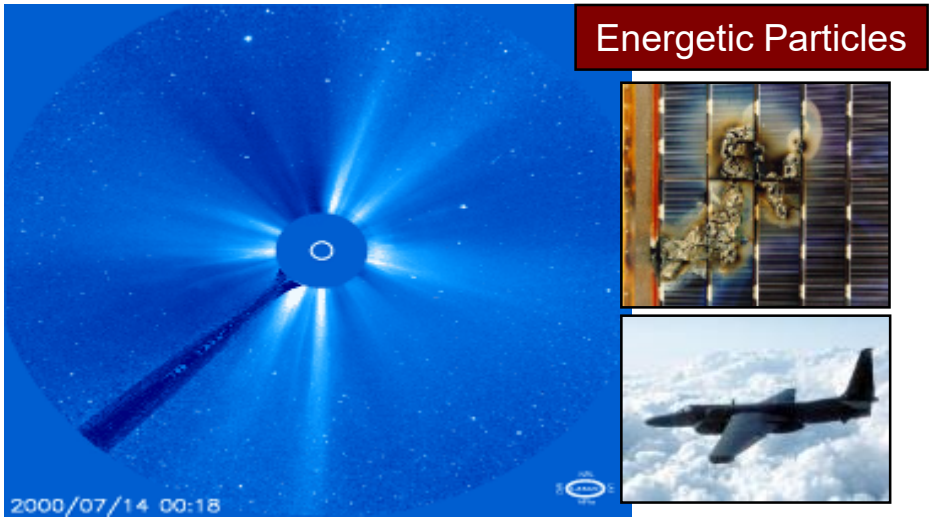
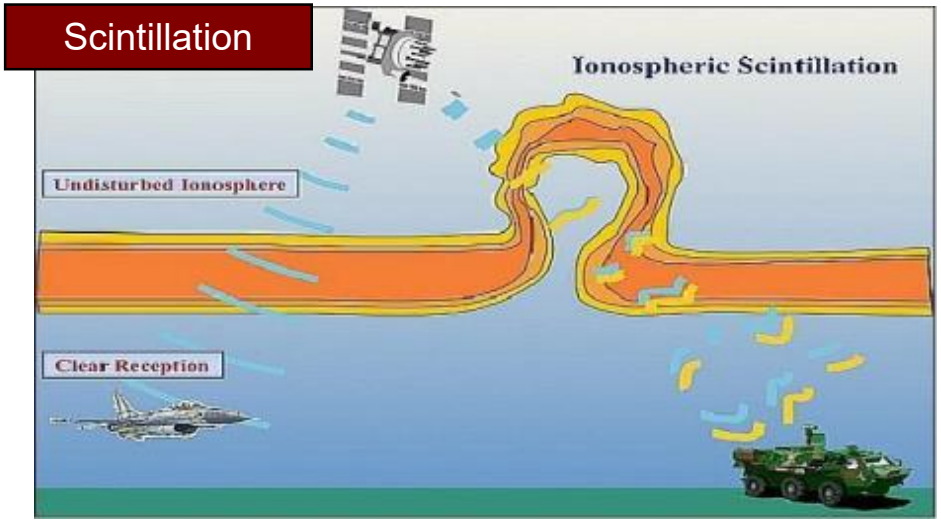
Solar Flares



Energetic Particles



Scintillation



Geomagnetic Storms

Space Weather Mission Impacts

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Solar Flares (X-Rays, EUV, Radio Bursts)

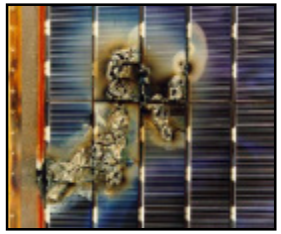
Arrival: 8 min / Duration: 1-2 hrs

- Satellite Orbit Decay
- Geolocation Errors
- RadioRadar Interference
- Frequency Interference
- High Frequency Radio Blackout
- Satellite Communication Interference

Energetic Particle Events

Arrival: 15 min to hrs / Duration: days

- High Altitude Radiation
- Spacecraft Damage
- Satellite Disorientation
- Launch Payload Failure
- False Sensor Readings
- Degraded Polar High Frequency Communication



Scintillation

Daily / Ionospheric Disturbance

- Degraded Satellite Communications
- GPS Error
  - Positioning
  - Navigation
  - Timing

Geomagnetic Storms

Arrival: 1-3 days / Duration: days

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

Space weather events create effects that impact missions across the Department of Defense

Space Weather Mission Impacts

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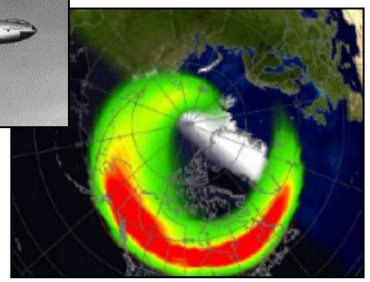
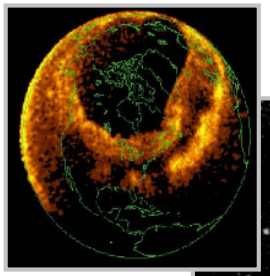


- 23 May 1967 – Cold War Crisis and NORAD
  - Early warning radar degradation
    - Thought Russians were jamming US radars
    - US Forces in a "ready to launch" status
    - AF bombers trained to complete nuclear mission
  - Large sunspots – major solar flare/unprecedented radio waves
  - Geomagnetic storm – aurora visible in New Mexico



- 13 March 1989 – Quebec Power Outage
  - Power grid blackout for 9 hours
  - NE US/Midwest power grid nearly collapsed
  - Extreme geomagnetic disturbance
    - Induced currents overloaded circuits/transformers
    - In 92 seconds, blackout affected 6 million people
  - Geomagnetic storm – aurora visible in Texas and Florida

Space Weather Operations Help Delineate between a Hazard and a Threat

Space Weather Mission Impacts

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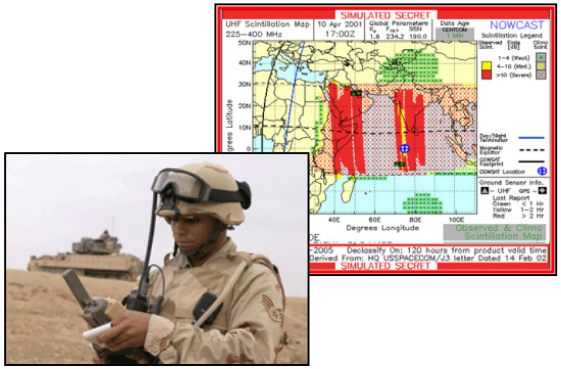
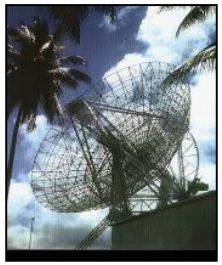
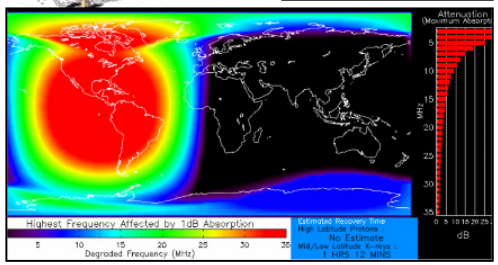
- **March 2002 – Operation Anaconda**
  - **Lost seven Special Forces troops, and many more were injured, in the mountains of Afghanistan**
  - **SATCOM degradation limited ground forces' ability to wave off a Quick Reaction Force to avoid a "hot" landing zone being overrun by Al-Qaeda insurgents**
  - **Ionospheric disturbances were occurring at the time of the event causing UHF SATCOM outages**





- **13 December 2006 – GPS Outage**
  - **All GPS satellite signals 'lost' for several minutes on sunlit side of Earth**
  - **Extreme solar radio burst on GPS frequencies**
  - **Solar Radio Emission >> GPS Transmissions**
  - **Solar radio emissions can swamp satellite C2, NAV, SATCOM, and radars during space weather events**



Space Weather Operations provide warfighters an accurate picture of the space weather impacts as they plan and execute their missions

Space Weather Mission Impacts

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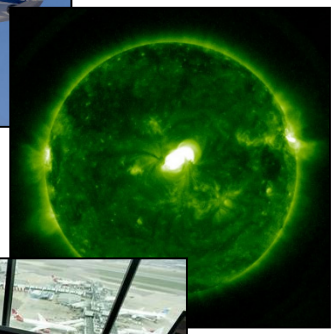


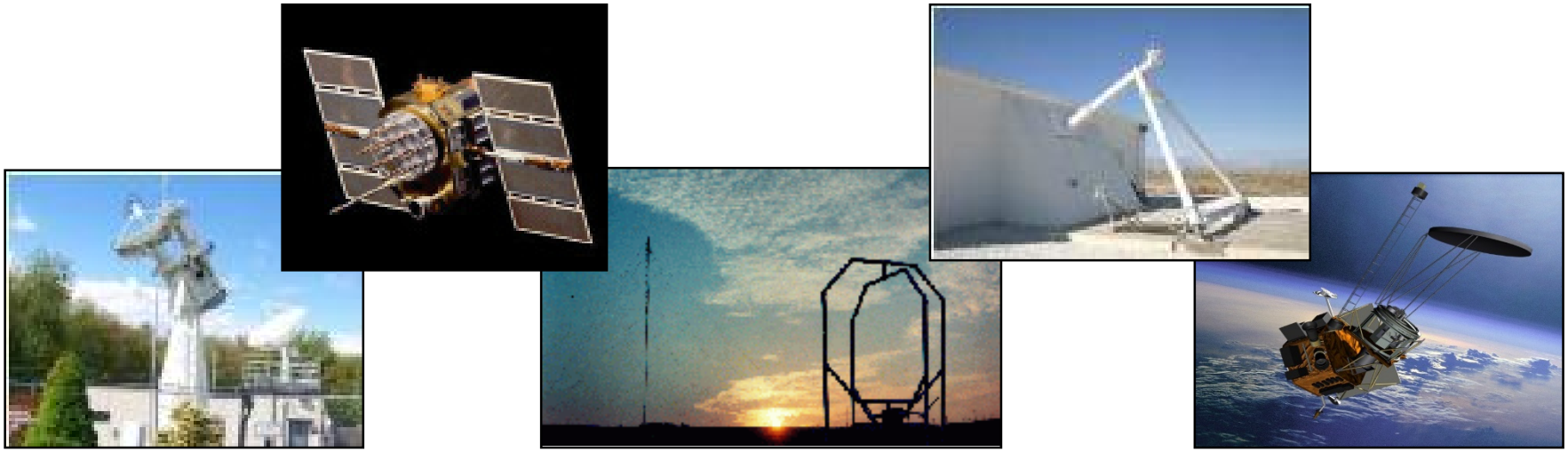
- **4 November 2015 – Swedish ATC Outage**
  - **Radar stations not relaying correct data to air traffic control for around 90 minutes**
    - **Controllers restricted planes into airspace**
  - **Outage coincided with an extreme radio burst associated with a medium solar flare**
  - **Suspected Russian hacking of the system**
  - **Swedish Civil Aviation Administration publicly blamed the solar storm for the outage**

- **6 September 2017 – Numerous Operational Impacts**
  - **Strongest solar flare in the last 11 year solar cycle**
  - **Energetic charged particles contributed to multiple satellite anomalies**
  - **Flares/geomagnetic storming degraded over-the-horizon radars**
  - **Solar radiation disrupted HF comm - stopped airline polar routes**

Space Weather Operations Help Delineate between a Hazard and a Threat

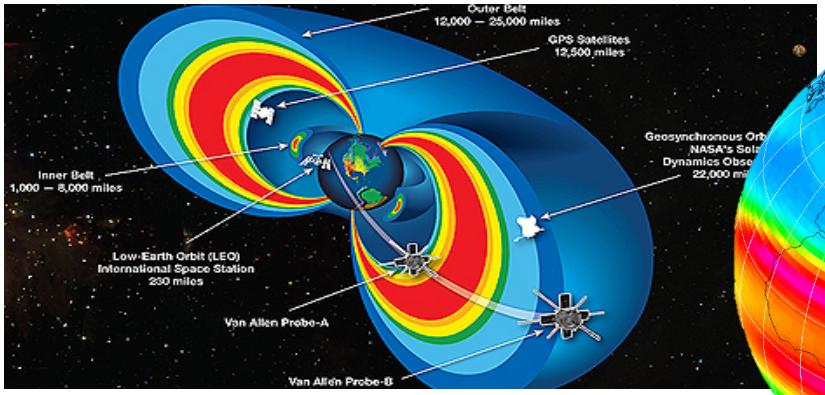
Air Force Space Weather Observing Systems

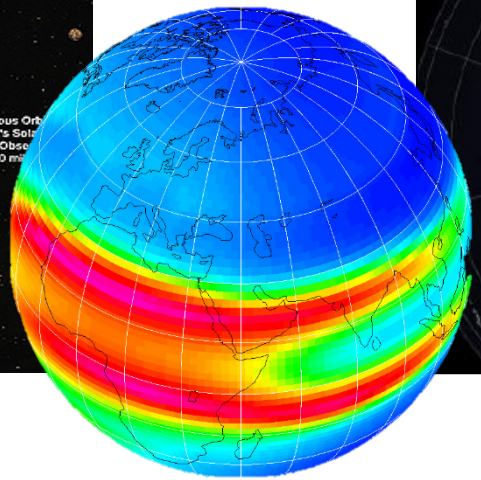
- Update current aging and limited observing systems
- Utilize commercial data sources to supplement DoD backbone
- Develop next gen ground and space-based sensing technologies
  - Smaller, more flexible, easily deployable systems
  - Non-traditional data sources
- Ingest ECP sensor data from future AF space-based platforms

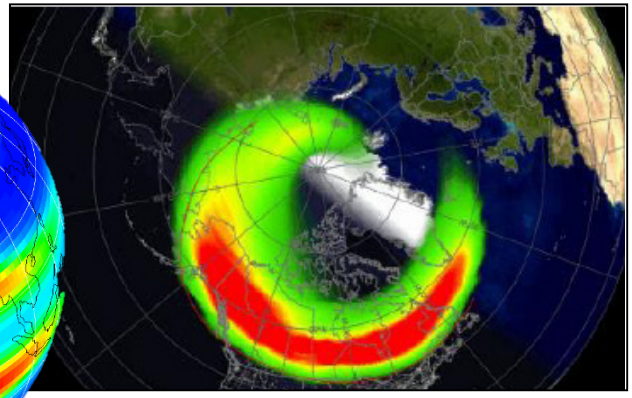


Air Force Space Weather Modeling & Forecasting

- Consolidate & upgrade legacy models
- Acquire next generation modeling technologies
  - Data assimilation models
  - Transition from empirical to physics-based models
  - Utilize artificial intelligence & machine learning techniques
- Whole-atmosphere/coupled modeling
- Transform architecture for modular “plug and play” integration

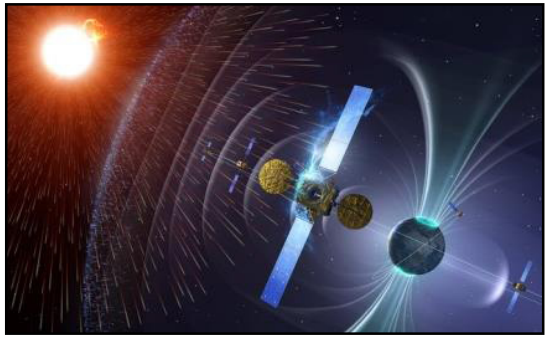






Air Force Space Weather Force Development

- Explore creating a dedicated space weather educational track
  - Need community engagement on determining best approach
  - Potential way forward: new GS-1300 series for space physics
- Develop a force of highly educated military and civilian operators
  - Train to support national security, warfighter needs
  - Understand & communicate global space environment impacts
- Embed space weather experts with operators



"Nations that develop a continuous loop of learning will succeed and nations and communities that don't will be left behind." – Honorable Heather Wilson, SECAF

Air Force Space Weather Research & Development

- National Space Weather Strategy & Action Plan
  - Emphasizes need to target research capabilities to operational needs and improve R2O transition into operational forecast process
- Hired Chief Scientist for Air Force Weather
  - Standing up AF Weather Science Coordination Committee
- Commercial Weather Data Pilot
  - FY17 funding used to purchase radio occultation data
  - FY18 BAA research areas ionospheric data & charged particle data
- Funding AFRL to transition energetic charged particle & radiation models to operations
- Working with NASA, NSF, & NOAA to amend O2R Collaboration MOU

Operational requirements drive DoD investments in research & development efforts

Air Force Space Weather Interagency Partnerships

- Executive Order 13744 (13 October 2016)
  - Coordinating Efforts to Prepare the Nation for Space Weather Events

- National Space Weather Strategy and Action Plan (26 March 2019)
  - Enhance protection, improve forecasts, establish response procedures
  - Identifying vulnerabilities and costs to national security missions/ops
  - Includes impacts from extreme and frequent space weather events
  - Partnerships with federal agencies, academic community, & industry

- Cooperative efforts
  - NOAA/SWPC – analysis & forecasting
  - NASA, AFRL, NRL, JHU/APL – modeling, sensors, & data
  - Academic community – research & development, R2O & O2R
  - Industry – modeling, sensors, & data

National Defense Strategy (2018)
Effectively Expanding the Competitive Space Requires Combined Actions with the U.S. interagency to Employ All Dimensions of National Power.

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Summary

- Air Force Space Weather Operations Critical to DoD Mission Success
- Accurate, Timely, Relevant Impacts Observed, Forecast, Delivered
- Modernization Underway to Meet Mitigate Future Mission Impacts

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."

Army Ops

Global Vigilance

Special Ops

Space Weather