

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

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*Integrity - Service - Excellence*

## **United States Air Force Space Weather**



**Mr. Ralph Stoffler  
HQ USAF/A3W  
9 May 2017**



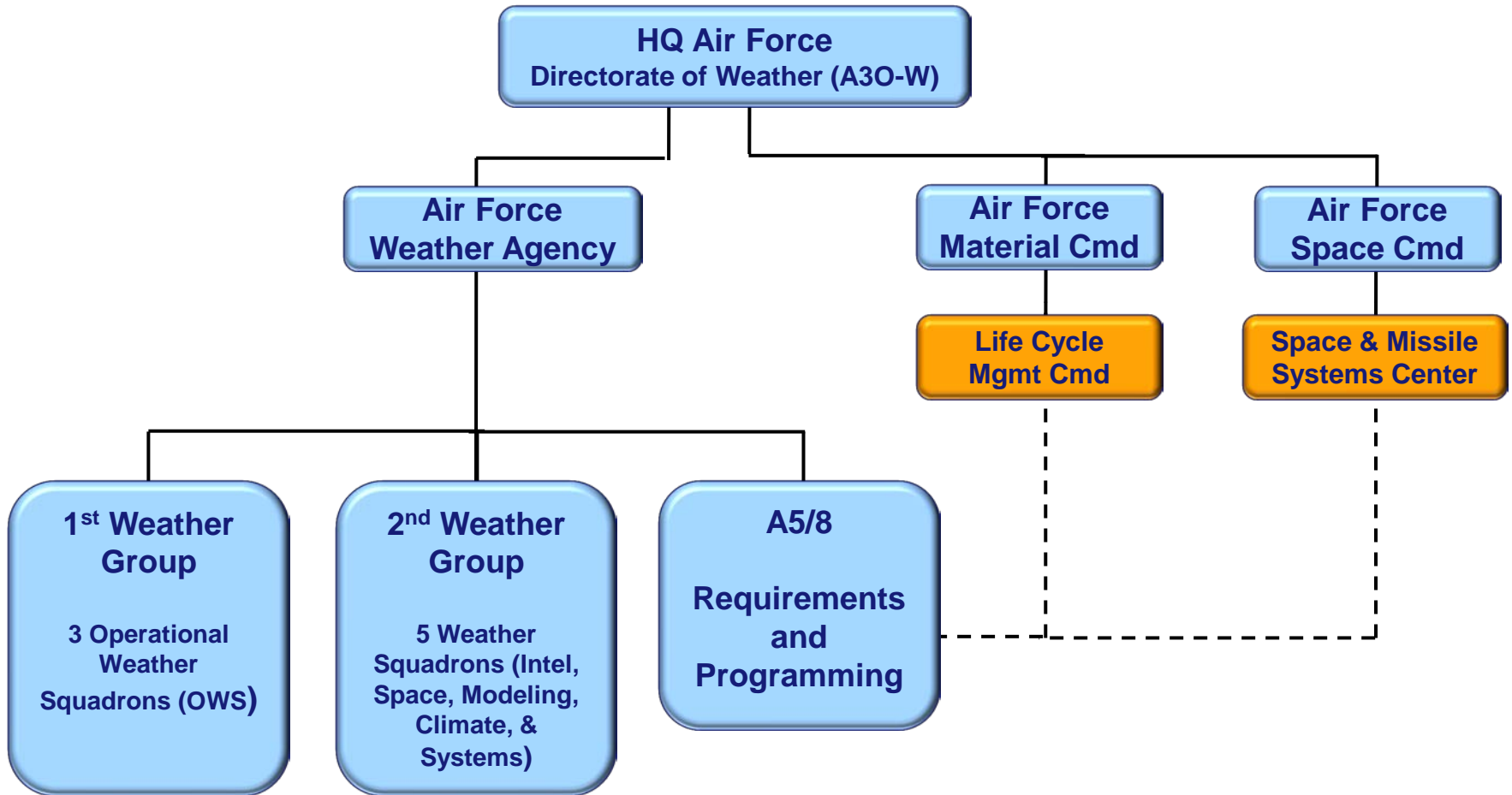
# Overview

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- **AF Weather: Previous & Current Organization**
- **Vision: Challenge and Future Investment**
- **National Space Weather Action Plan (NSWAP) Engagement**
- **Modeling and Research Priorities**
- **GAIM-Full Physics**
- **Commercial Weather Data Pilot Program**
- **Why DoD Space Weather: Sensor-to-Operator**
- **Summary**

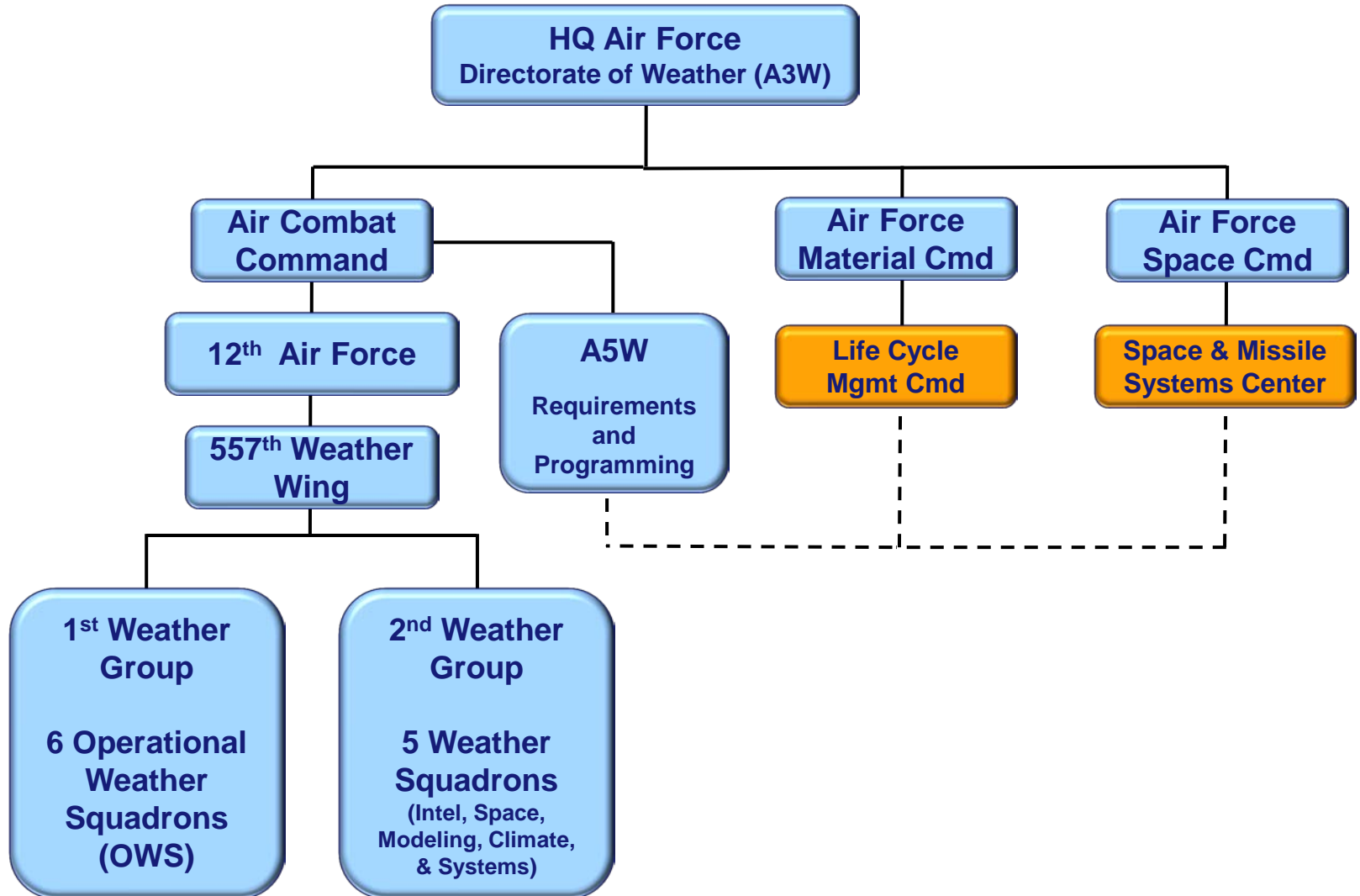


# Previous AFW Organization





# Current AFW Organization





# ***Vision: Challenge***

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- **Executive Order (13744) on Coordinating Efforts to Prepare the Nation for Space Weather Events charges the SECDEF with:**
  - **Ensuring provision of operational space weather data & products supporting DoD & coalition partner operations, weapons systems, and Nation Security**
  - **Partnering with federal agencies to develop models, observing systems, & technologies to enhance national preparedness**
  - **Addressing space weather events in preparedness planning**
  
- **Threats in the future operating environment include:**
  - **Engagement with near-peer adversaries**
  - **Anti-Access/Area Denial strategies**
  - **Cyber and spectrum warfare**
  - **Counterspace technologies and operations**



# ***Vision: Future Investment***

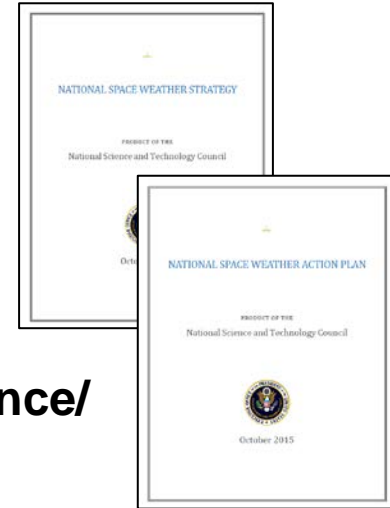
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- **Workforce Development & Training**
    - Force of highly educated military and civilian operators
    - Trained to support national security, warfighter needs; understand and communicate space environment impacts
  
  - **Next Generation Technology & Responsive RDT&E**
    - Advance whole-atmosphere/coupled modeling & user applications
    - Advocate/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 and employment systems at all echelons
    - Complementary support to civil mission for national security issues
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# NSWAP Engagement

- **Co-lead or Supporting Agency for 34 NSWAP tasks**
  - Drawing expertise from range of DoD organizations – AFRL, NRL, AFOSR, SMC, AFSPC, JSpOC, 557 WW
- **Lead for NSWAP task 5.3.5 to sustain ground-based solar radio observing & provide data to partners**
  - Radio Solar Telescope Network (RSTN) parts obsolescence/ replacement project
- **Engaged with community in defining benchmarks and enhancing assessment and forecasting capabilities (R2O/O2R)**
- **Developing Annex covering items not contained in NSWAP that impact military operations**
  - Examples include – satellite drag, geolocation, over-the-horizon-radar

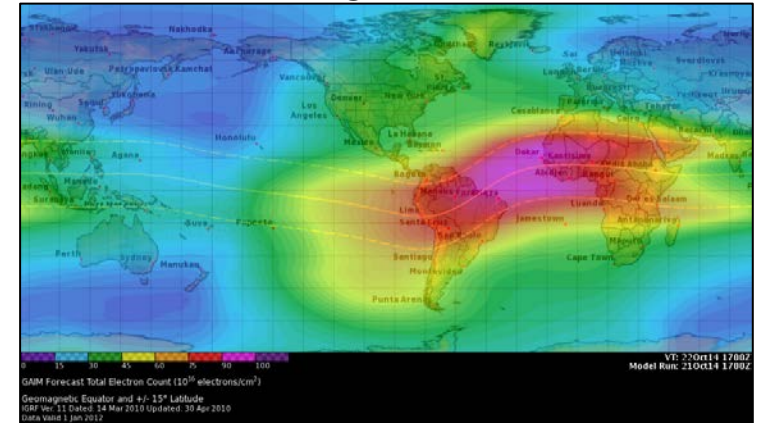




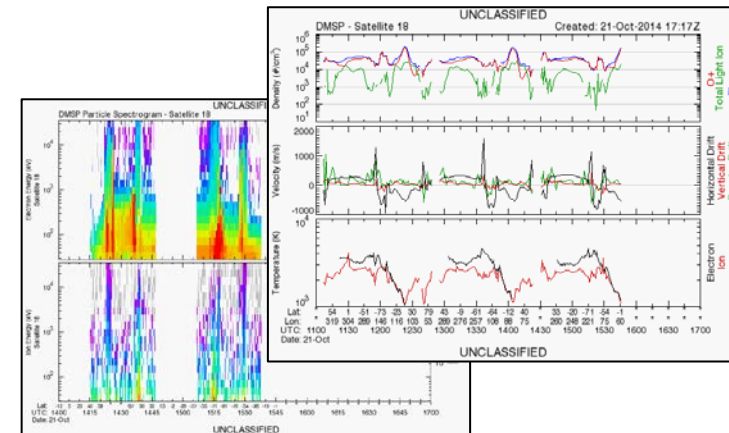
# Modeling and Research Priorities

- 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
- Transitioning Research to Operations

GAIM



DMSP

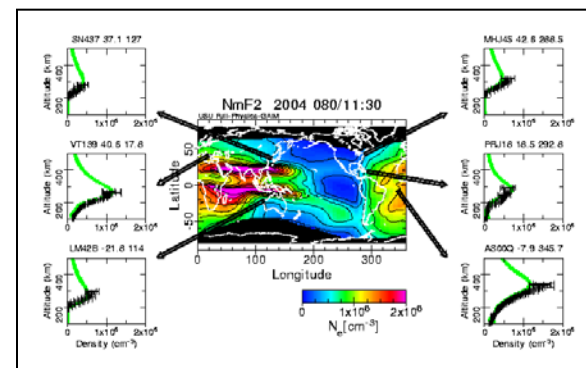
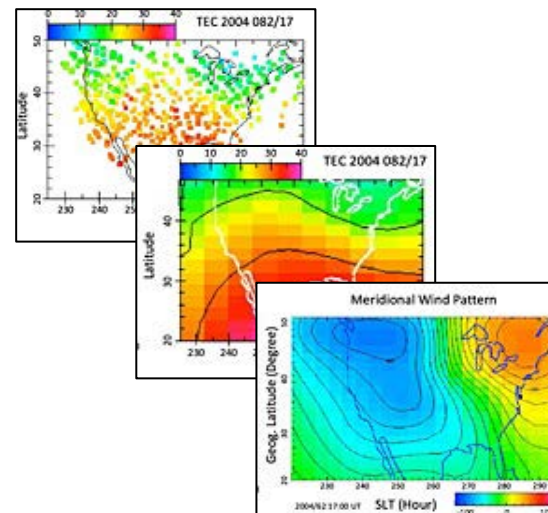






# Global Assimilation of Ionospheric Measurements-Full Physics (GAIM-FP)

- Next version of Nation's sole operational ionospheric forecast model
- Implementation at the 557<sup>th</sup> Weather Wing CY17
  - Initially provide FP data in GM data format
- Utilizes physics-based Ionosphere-Plasmasphere model (IPM)
  - Ensemble Kalman filter approach evolves electron density field and associated errors
- Improved resolution and vertical extent compared to GAIM-Gauss Markov (GM)
  - GM:  $4.5^\circ \times 15^\circ$ , FP:  $1^\circ \times 7.5^\circ$  (lat/lon)
  - GM: 1400 km, FP: ~30,000 km (altitude)
- Includes Data-Driven D-region model (DDDR) – extends lower boundary from 90 km to 34 km
- Incorporates ionospheric plasma instability and bubble information based on SSUSI observations





# *Commercial Weather Data Pilot Program*

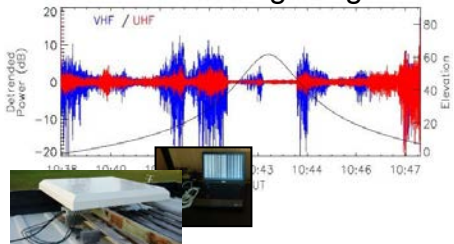
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- **DoD tasked to conduct assessment of available commercial satellite weather data**
  - Review existing spaced based commercial providers
  - Identify potential Space Based Environmental Monitoring applications to enhance DoD mission requirements
- **NOAA pilot evaluating commercial GPS Radio Occultation (RO) on-orbit data to demonstrate the data quality and value in atmospheric models**
- **DoD evaluation will focus on GPS RO Electron Density data stream**
  - Assess quality of commercial satellite-sensed RO electron density data
  - Compare Global Assimilation of Ionospheric Measurements (GAIM) model characterizations with and without commercial ionospheric data
  - Determine/quantify the military utility of commercial ionospheric data
- **DoD and NOAA pilot programs are mutually beneficial**

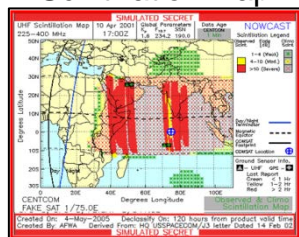


# Why DoD Space Weather: Sensor-to-Operator

**ISTO – Radio Frequency Beacon over flight signals**



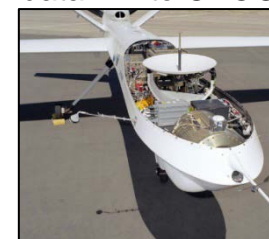
**UHF Satellite Communications Scintillation Map**



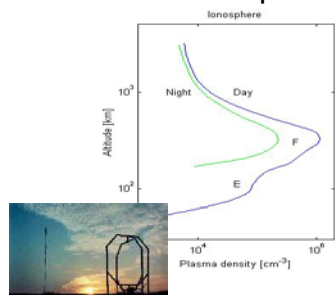
**Combined Air Operations Center (CAOC)  
Theater Intelligence, Surveillance  
Reconnaissance collection**



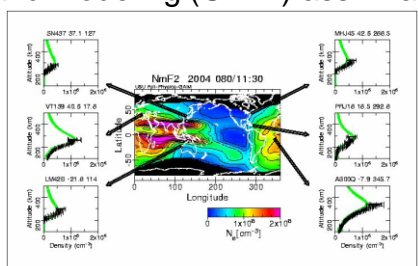
**Uninterrupted RQ-1 SATCOM data link to CAOC**



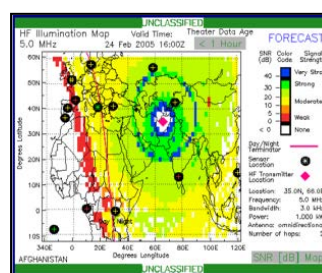
**NEXION – derived profiles**



**Models – Global analysis, Integration, and Modeling (GAIM) assimilates obs**



**Impact products – HF illumination**



**Naval Special Warfare Rigid Hull Inflatable Boat C2 via HF Comm**





# Summary

- Air Force committed to space environment needs...now & future
- Investment in Space Weather – People, Engagement, Collaboration
- Community partner supporting National-DoD research & 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

*Breaking Barriers ... Since 1947*