Headquarters U.S. Air Force

Integrity - Service - Excellence

United States Air Force Space Weather

U.S. AIR FORCE

Mr. Ralph Stoffler
HQ USAF/A3W
14 October 2015

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Overview

- Space Weather Community
- AF Space Weather Observing Systems – Current & Future
- Space-based Energetic Charge Particle Observing
- Global Assimilation of Ionospheric Measurements Gauss Markov
- Modeling and Research Priorities
- Space Weather Application
- Space Weather Collection
- AF Space Weather Products and Services
- Sensor-to-Operator Examples
- Summary

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Space Weather Community

- Space weather is a team sport!
- Actively engaged in global community
- Training
  - Space weather course (2 weeks) at 557 Weather Wing
  - Students from France, Italy, Netherlands, Germany – working to bring in Japan and South Korea
- Engaging with UK, South Korea on Ops Centers stand-up
- Data sharing via web services – national & international partners
- Cooperative efforts
  - NOAA SWPC – analysis and forecasting
  - AFRL, NRL, JHU/APL – modeling and data
  - Academic community

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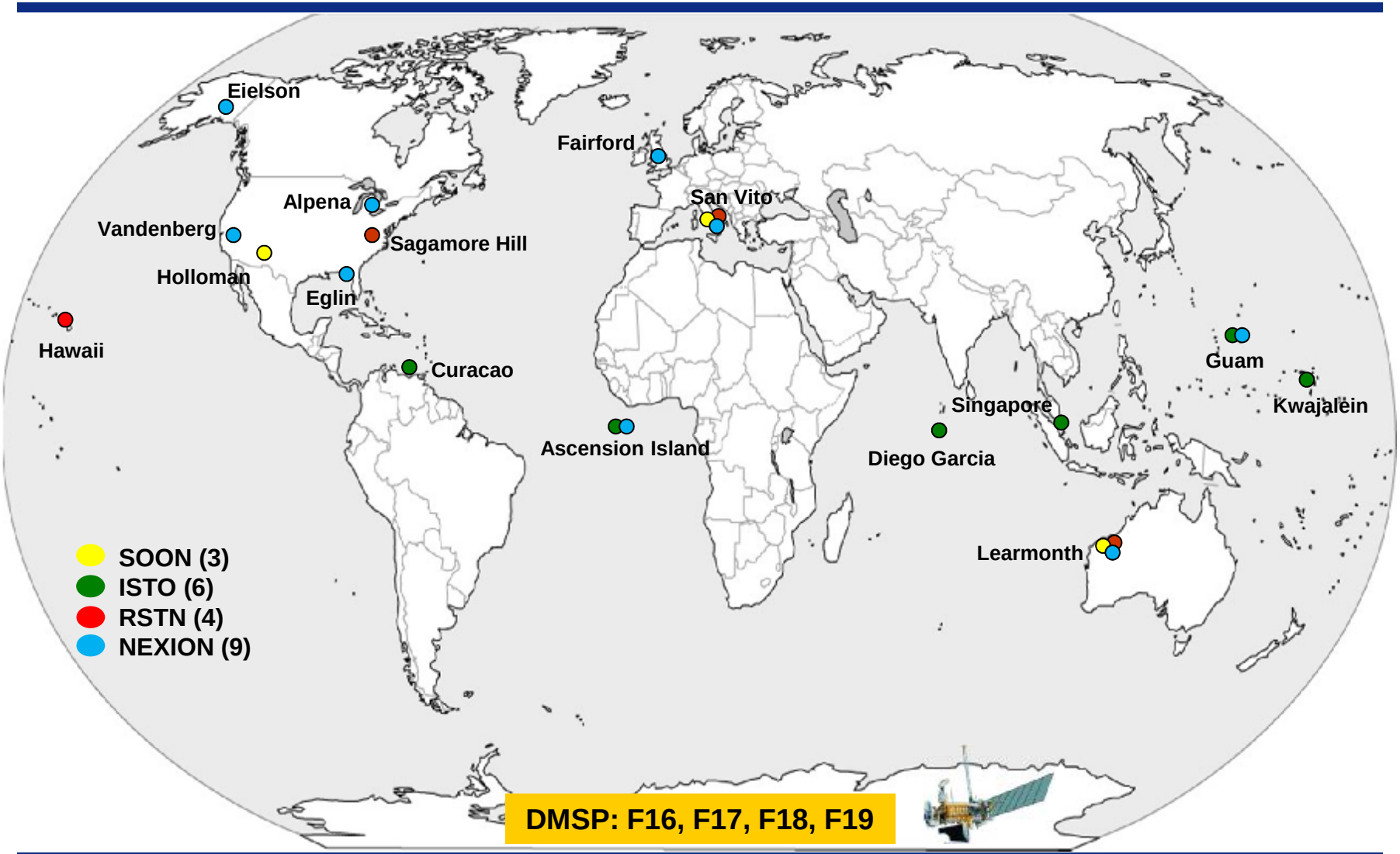
AF Space Weather Observing

Current



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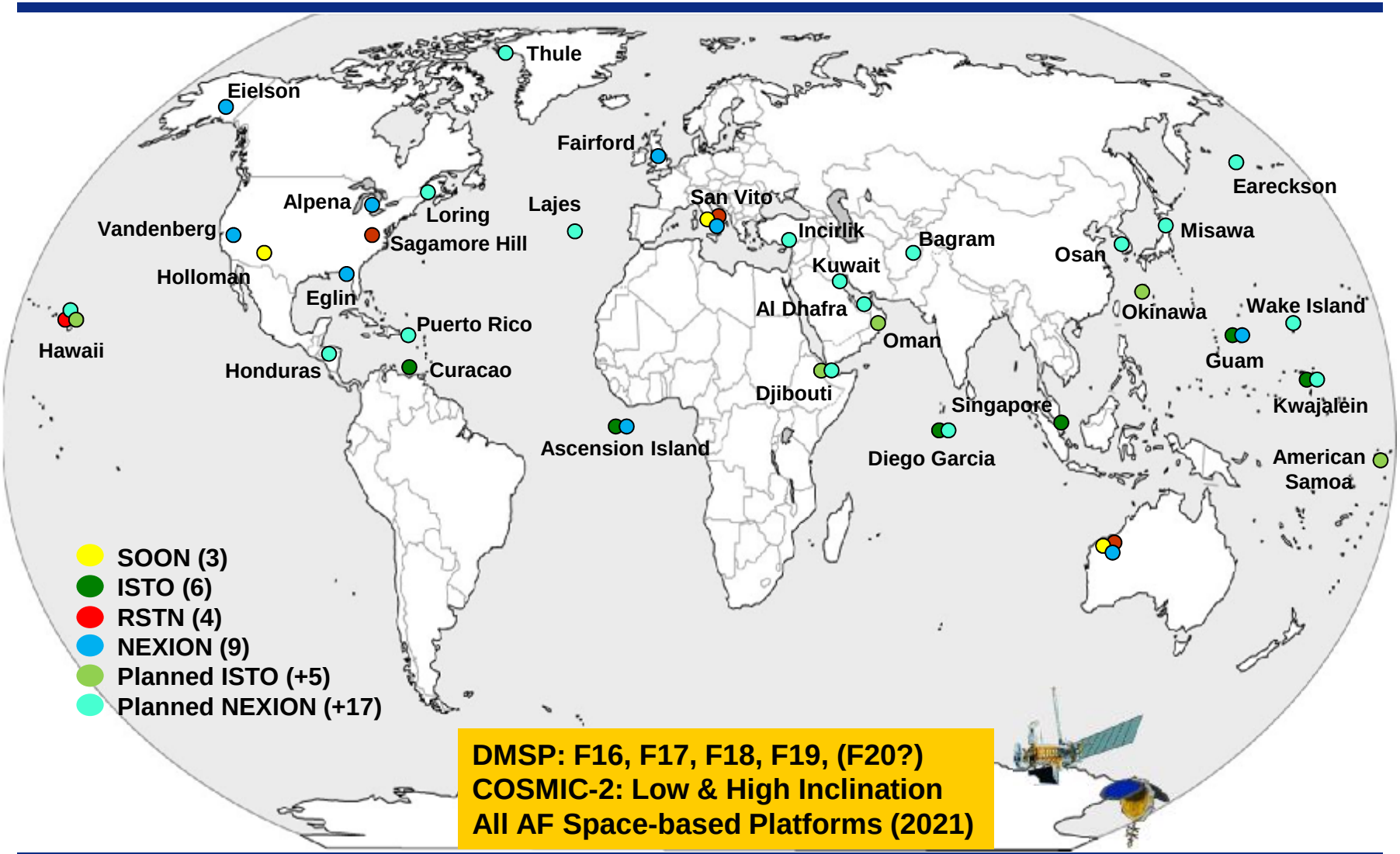
AF Space Weather Observing
Future



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Space-based ECP Observing

- Energetic Charged Particles (ECP)
  - DoD requires specification of natural environmental conditions at the satellite
  - March 2015, SECAF mandated all AF satellites fly ECP sensor
  - AF currently working though requirements & acquisition process to field sensor
  - Application
    - SpaceWOC – Space Situational Awareness (SSA), data assimilation & modeling
    - JSpOC – SSA and anomaly assessment
  - Timeline: IOC – 2021 / FOC – TBD

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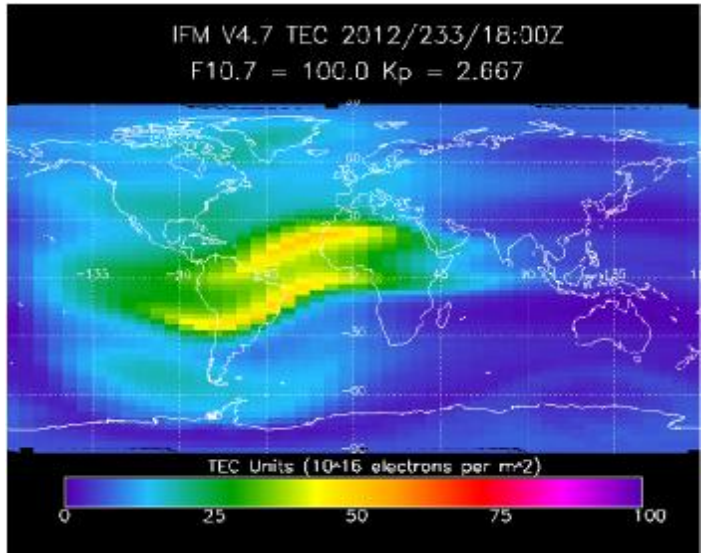
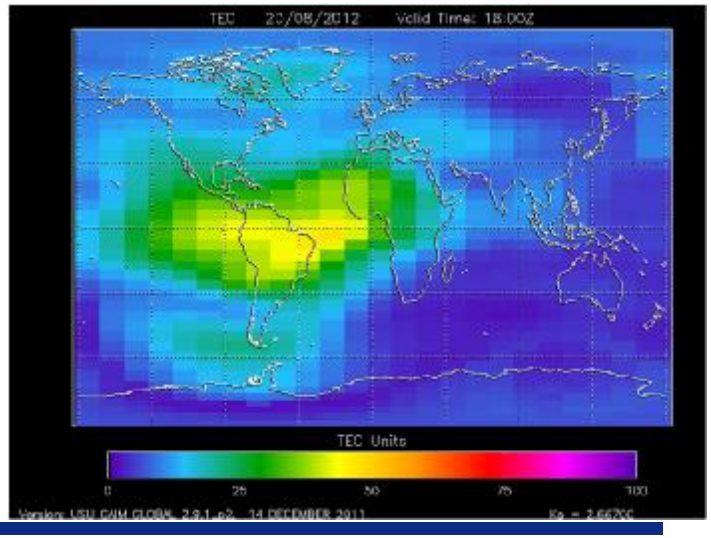
Global Assimilation of Ionospheric Measurements Gauss Markov (GAIM-GM)

- Nation's only operational ionospheric forecast model
- IOC at the AFWA in 2006
- Global electron density specification every 15 minutes
- 24-hour forecast produced at the top of each hour
- Available resolutions
  - Global mode (current)
  - High resolution regional mode (available)
- Vertical extent à 1,600 km
- GAIM Full-Physics IOC est Spring 2016
  - Finer horizontal resolution
  - Increased vertical extent





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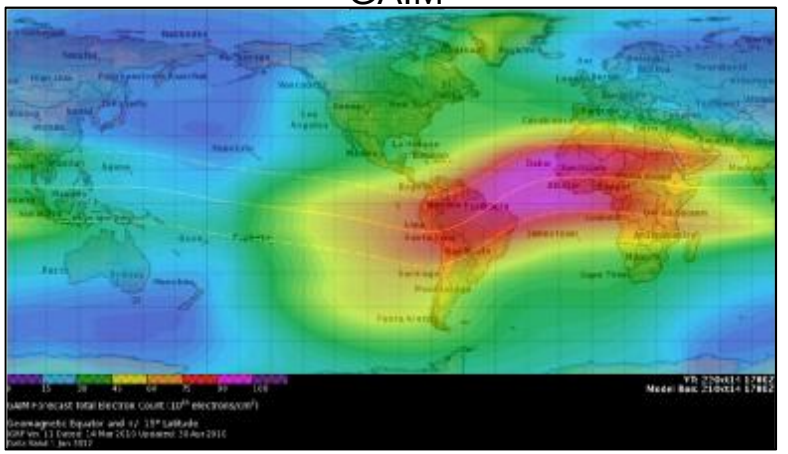
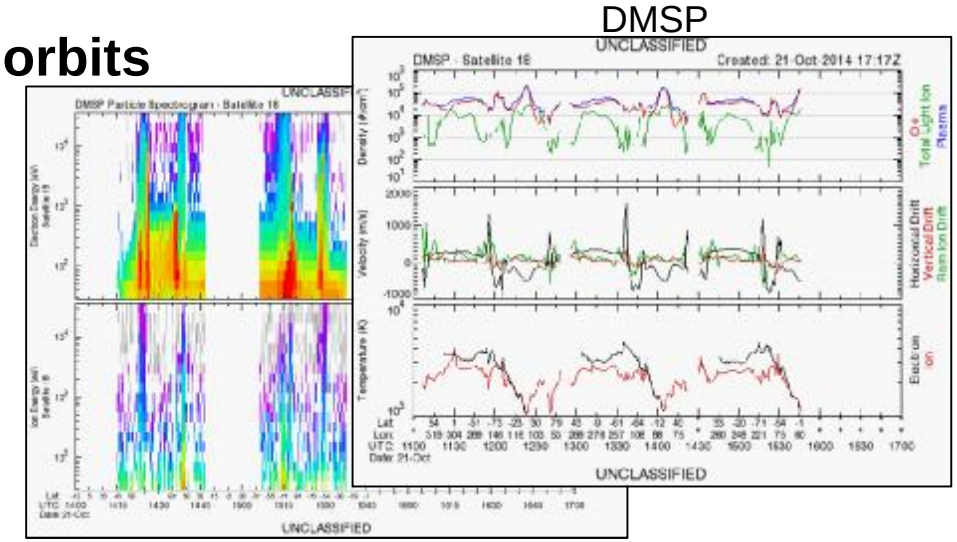
Modeling and Research Priorities

- 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
- Research to Operations

GAIM



DMSP



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Space Weather Application

- 557th Weather Wing Space Weather Operations Center (SpaceWOC)
  - Mission-tailored analysis, forecasts, warnings
  - Disseminate system-impacting space weather
    - DoD operators and decision makers
    - United States Government (USG)
  - Anomaly assessment support

- Joint Space Operations Center (JSpOC)
  - C2 system executing USSTRATCOM space control mission
  - Focal point for space force integration & employment in military ops
  - Detect, track, and identify all artificial objects in Earth orbit

Mission Focused DoD & USG Operational Support

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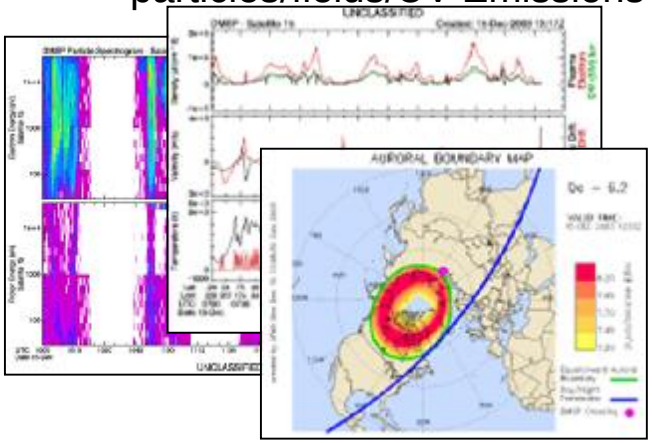
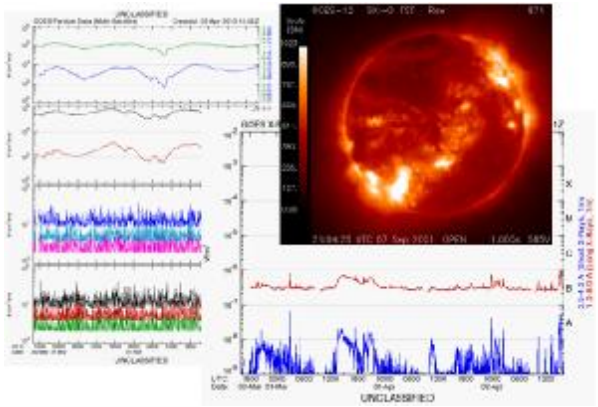
Space Weather Collection

Space-Based Environmental Monitoring

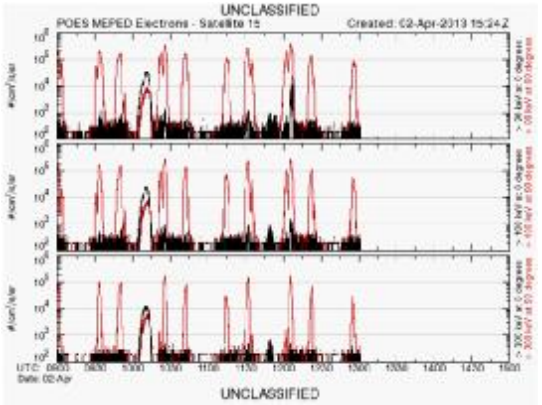
Defense Meteorological Satellite Program (DMSP) – particles/fields/UV Emissions



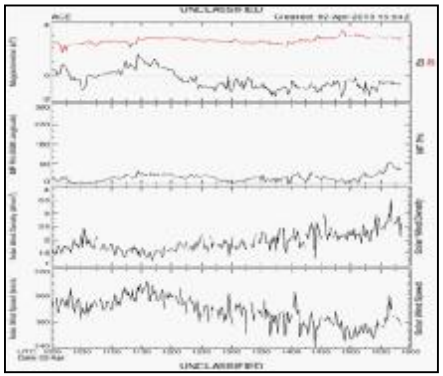
Geostationary Operational Environment Satellite (GOES) – X-ray, particles and fields



Polar-Orbiting Environmental Satellite (POES) - particles

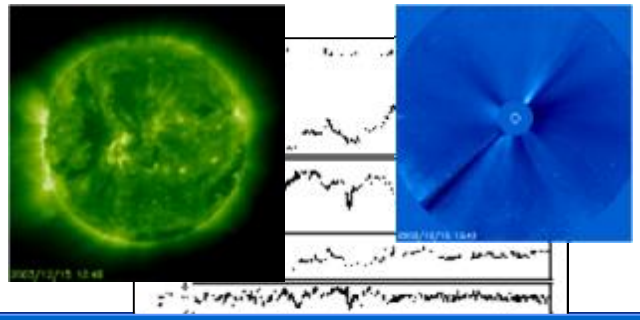


Advanced Composition Explorer (ACE) – solar wind

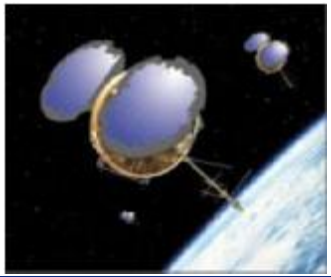


Solar Heliospheric Observatory (SOHO) – CME tracking

Solar Dynamics Observatory (SDO) – evaluating for solar flare patrol



Constellation Observing System for Meteorology, Ionosphere & Climate (COSMIC) – Ionospheric specification



AF Weather relies upon a network of DoD and partner systems

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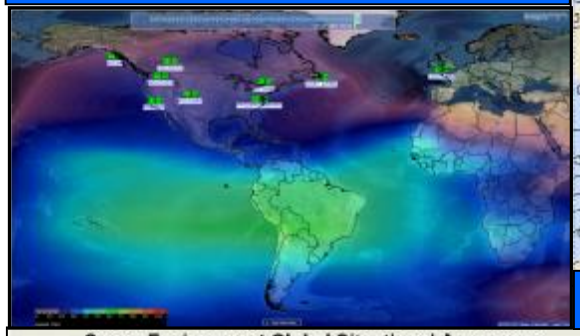
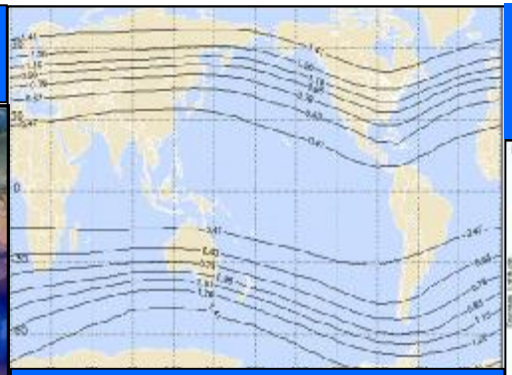
Air Force Space Weather Products & Services

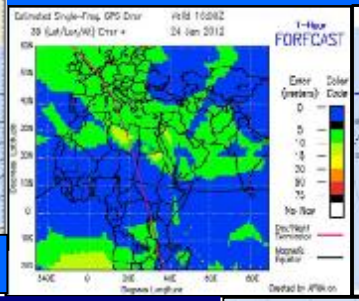
Web Mapping Services for GIS/Google Earth formats

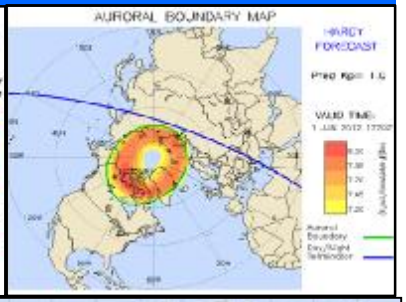


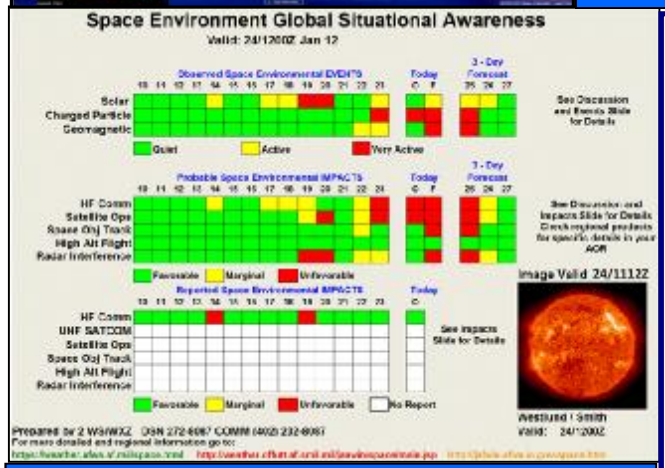


Hi-flyer Radiation Dosage

Space Weather Analysis and Forecast System (SWAFS)
- **Models & derived products**







Global SA

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WOXX56 KGWC 200802
SUBJECT: AFWA EVENT WARNING REPORT ISSUED AT 0802Z
20 JAN 2013
PART A. SOLAR RADIATION DOSAGE EVENT (UPDATE):
A SOLAR PROTON EVENT IS IN PROGRESS. BELOW IS AN
ESTIMATE OF THE MAXIMUM RADIATION IN MILLIREMS
BASED ON
THE GOES SPACECRAFT PROTON MONITORS.  YOU WILL
RECEIVE AN UPDATE EVERY HOUR OR WHENEVER ONE OF THE
CATEGORIES BELOW IS CROSSED. THE CURRENT RADIATION
DOSE CALCULATION AS OF 0701Z IS 212 MREMS.
CATEGORIES ARE:
GREEN = LESS THAN 10 MREMS
YELLOW = 10 - 99 MREMS
RED = 100 OR GREATER MREMS
PART B. N/A
PART C. REMARKS:
ISSUED BY THE AIR FORCE WEATHER AGENCY, OFFUTT
AFB, NE. IF YOU HAVE QUESTIONS OR REQUIRE FURTHER\
INFORMATION, CALL THE DUTY FORECASTER AT DSN 272-
8087, COMMERCIAL 402-232-8087. INFORMATION CAN ALSO
BE
OBTAINED AT https://weather.afwa.af.mil UNDER THE
SPACE WEATHER LINK.
FORECASTERS: Bauman/ Otero
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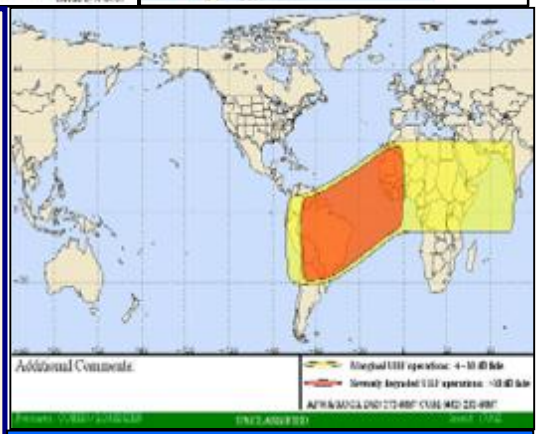
Observed & Forecast Warnings to DoD Forces, Intelligence Community, and Other National Users



Forecaster-In-The-Loop Products (UHF SATCOM Forecast)

40K+ products daily

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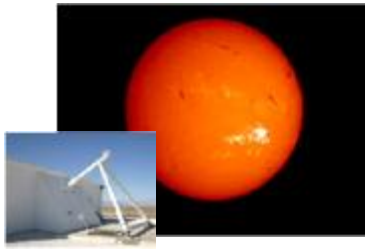
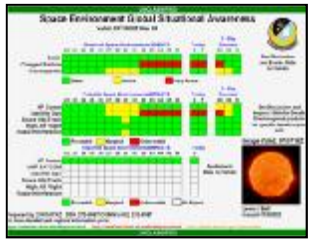
Sensor-to-Operator Examples

SOON – Hα



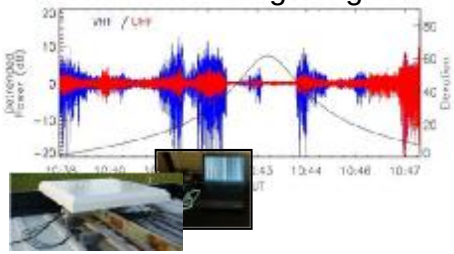
Forecaster analysis & sunspot classification

SpaceWOC forecast space wx & impacts

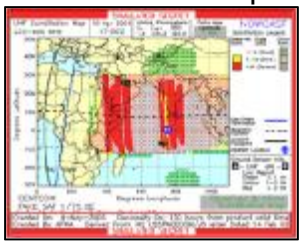


20th Space Control Sq alerted to space object tracking impacts

ISTO – Radio Frequency Beacon over flight signals



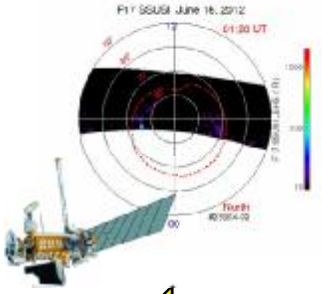
UHF SATCOM Scintillation Map



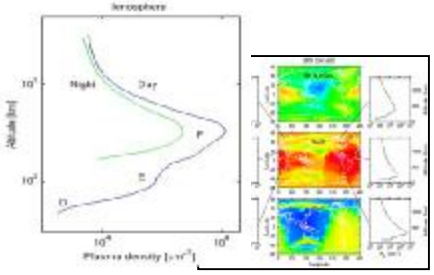
Combined Air Operations Center Theater ISR collection

Uninterrupted RQ-1 SATCOM data link to CAOC

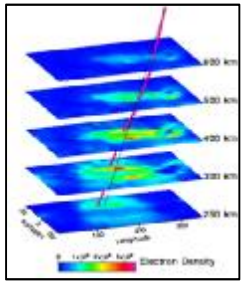
DMSP SSUSI – radiances



Ionosphere specification fed to GAIM



3D electron density - geolocation impacts



Warfighter alerted to GPS-guided munition impacts

SENSOR — SPACE WEATHER DATA & PRODUCTS — OPERATOR

Sensor-to-Operator Examples

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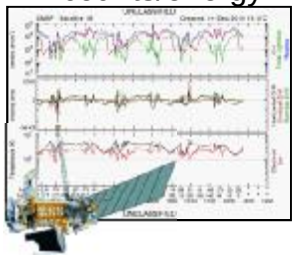
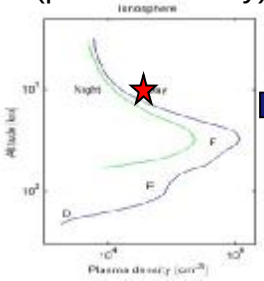
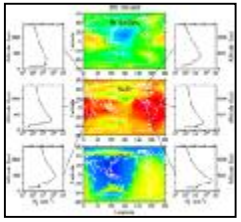
DMSP SSI/ES3
– counts/energy



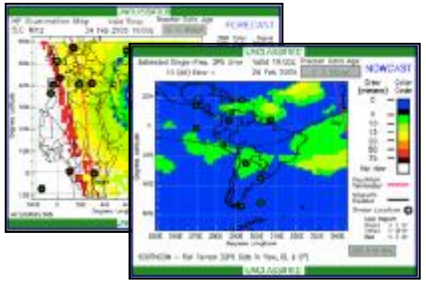
Ionosphere Specification
(plasma density)



Model – GAIM

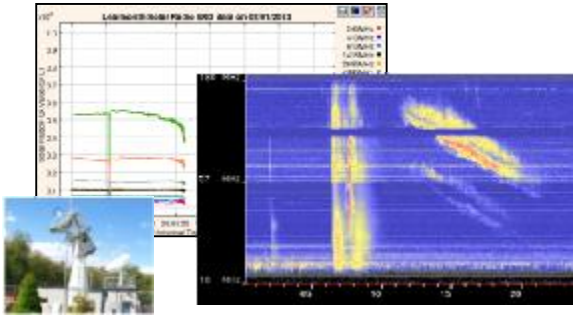


Impact products – GPS Error,
HF illumination



Infantry navigates via
hand-held GPS

RSTN RIMS & SRS

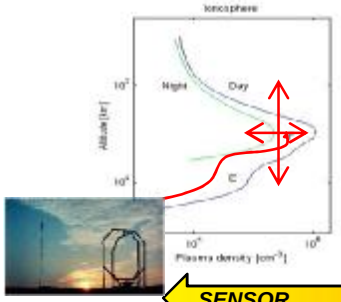


SpaceWOC
Forecaster SA

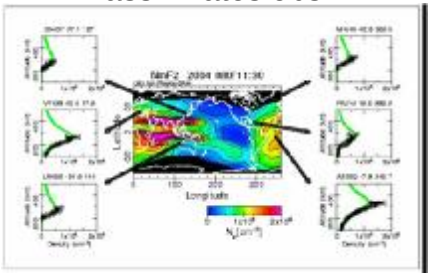
DoD Radar/SATCOM
RFI determination

Buckley AFB space
operators warned

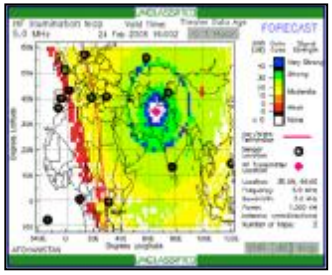
NEXION
– derived profiles



Models – GAIM
assimilates obs



Impact products
– HF illumination



Naval Special
Warfare RHIB C2
via HF Comm

SENSOR — SPACE WEATHER DATA & PRODUCTS — OPERATOR

U.S. AIR FORCE

Summary

- Air Force committed to space weather observing…now & future
- Team with national & international community for DoD Support
- Sensor-to-Operator – accurate, timely, relevant impacts delivered

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