

Headquarters U.S. Air Force

Aim High...Fly, Fight, Win

Space Weather Workshop 2012 **Air Force Weather Activities**



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This Briefing is Approved for Public Release



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Overview

- **Our Common Challenges**
- **DoD Space Weather Support**
- **Space Weather Collection**
- **Analysis & Forecasting Tools**
 - **Space Weather Analysis & Forecast System (SWAFS)**
 - **Global Assimilation of Ionospheric Measurements (GAIM)**
 - **AFW-WEBS**
- **Recent Accomplishments & Way Ahead**
- **Summary**



Our Common Challenges

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- **Space Weather is a “Total Team Sport”... from Research to Ops**
- **Expand collection capabilities:**
 - **Ground-Based: Optical, Radio, Magnetic, and Ionospheric**
 - **Space-Based: Ionospheric, Magnetosphere, Solar Wind, & Radiation Belt**
- **Solve the tough forecasting problems:**
 - **Physics-based model improvements**
 - **Move from now-casts to physics-based forecasts ... easier said than done!**
- **Deliver Ops Focused Exploitation Tools:**
 - **An operational imperative to rapidly respond to “Solar Threat” of the day**
 - **Must be easily understood and operationally relevant**
 - **Build net-centric technologies for system-of-systems**
 - **An absolute must if we are to move science into operations and protect our Nation’s valued assets and technologies**

Team, Sense, Forecast, and Exploit...the Way Forward



DoD Space Weather Services

40+ Years Providing Support for Warfighters

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Environmental Inputs
(DoD, Civil, International)



Data Received/Models Run



All Levels of Support

Key Partnership
in Operations

Teamwork



Space Weather
Prediction Center

Partnership with DoD,
Government, and Educational
Labs Critical



Air Force
Research
Laboratory



COMMUNITY
COORDINATED
MODELING
CENTER



Naval Research
Laboratory

NASA



Department of Defense

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AF Weather Agency Space Weather Operations Center (SPACEWOC)



- DoD's only 24/7 Space Weather forecast center
 - Supported by five solar observatories
 - Close operational partnership with SWPC
- Issues alerts, warnings, forecasts and mission tailored products to DoD users worldwide



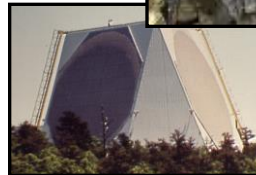
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Space Weather Warfighter Impacts

X-Rays, EUV, Radio Bursts

Arrival: 8 min / Duration: 1-2 days

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



Scintillation

Daily / ionospheric disturbance

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



Proton 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)



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



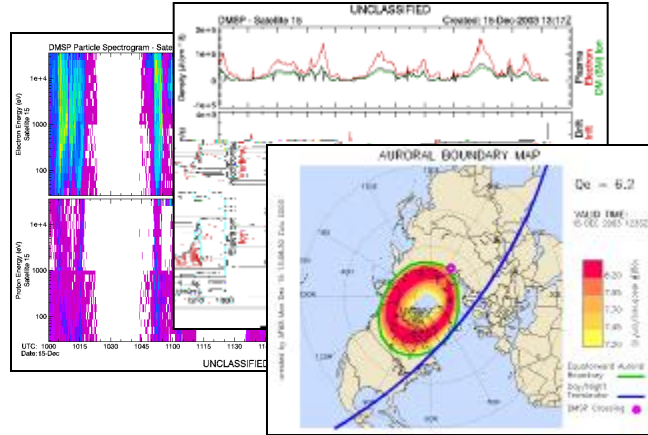


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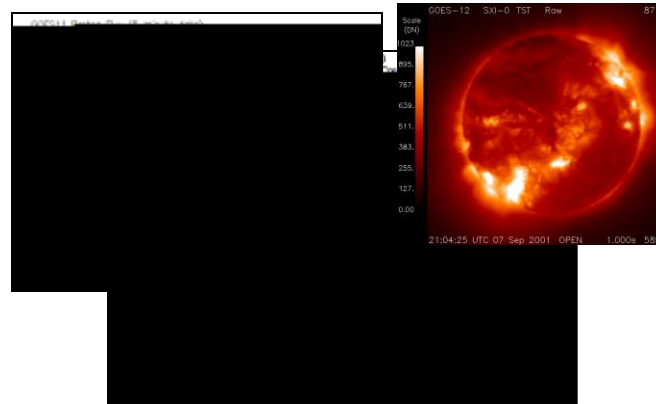
Space Weather

Space-Based Environmental Monitoring

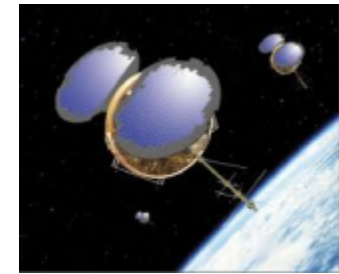
Defense Meteorological Satellite Program (DMSP) – particles/fields



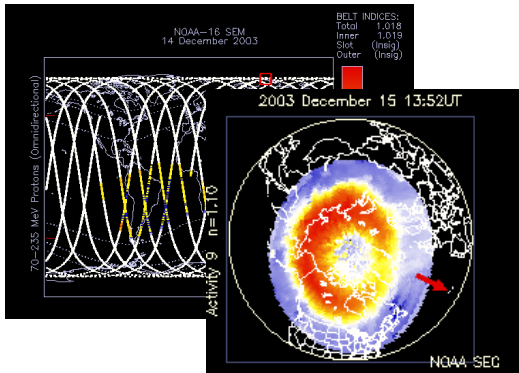
Geostationary Operational Environment Satellite (GOES) – X-ray, particles and fields



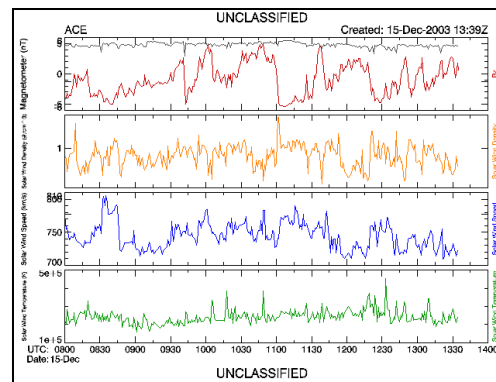
Constellation Observing System for Meteorology, Ionosphere & Climate (COSMIC) – Ionospheric specification



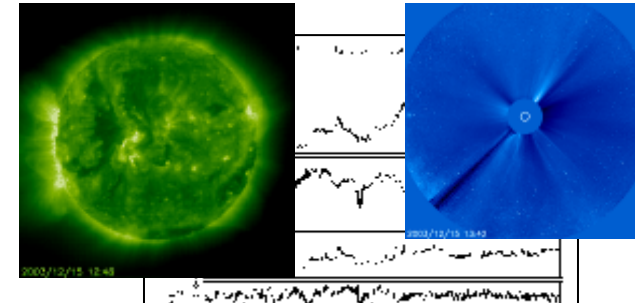
Polar-Orbiting Environmental Satellite (POES) - particles



Advanced Composition Explorer (ACE) – solar wind



Solar Heliospheric Observatory (SOHO) – CME tracking
Solar Dynamics Observatory (SDO) – EUV Emissions



AF Weather relies upon a network of DoD and partner systems.

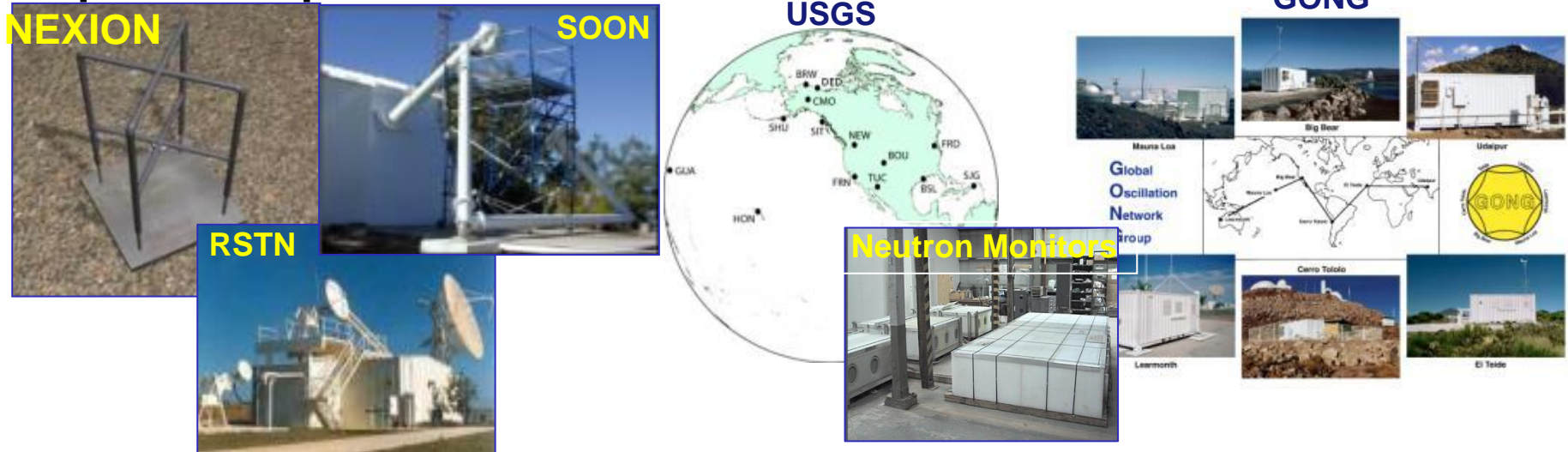


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Space Weather

Ground-Based Environmental Monitoring

- DoD sensors include Solar Electro-Optical Observing Network (SEON), Next Generation Ionosonde (NEXION) and Scintillation Decision Aid (SCINDA)
- Also exploit data from many government & non-government sources: USGS Magnetometers, Global Ionosonde Networks, TEC (JPL), GONG (NSF), Neutron Monitors (UDeI), and others... data partnerships are crucial

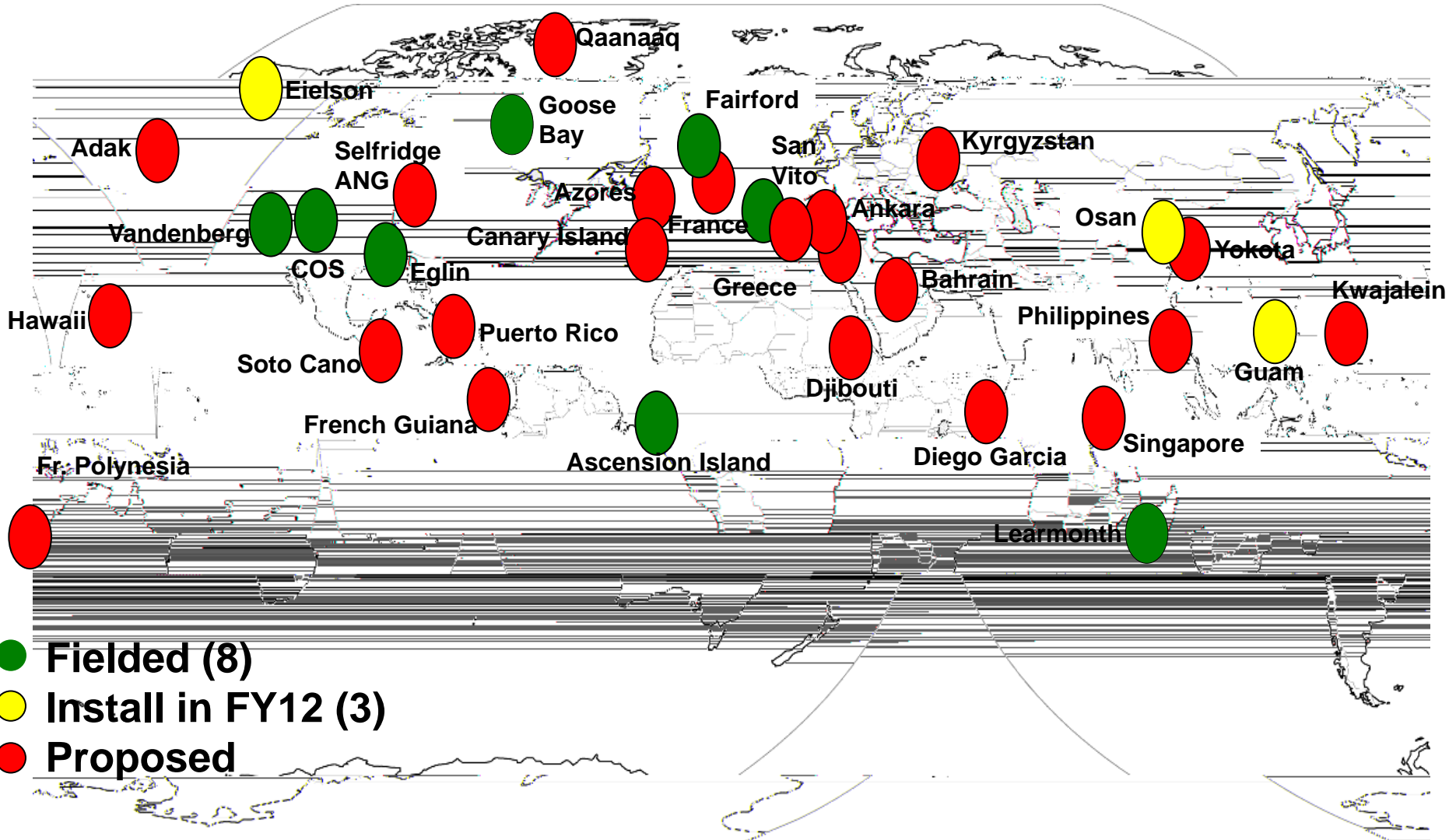


AF and other agencies collect space weather data from ground-based sensors



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NEXION Fielding



- Fielded (8)
- Install in FY12 (3)
- Proposed

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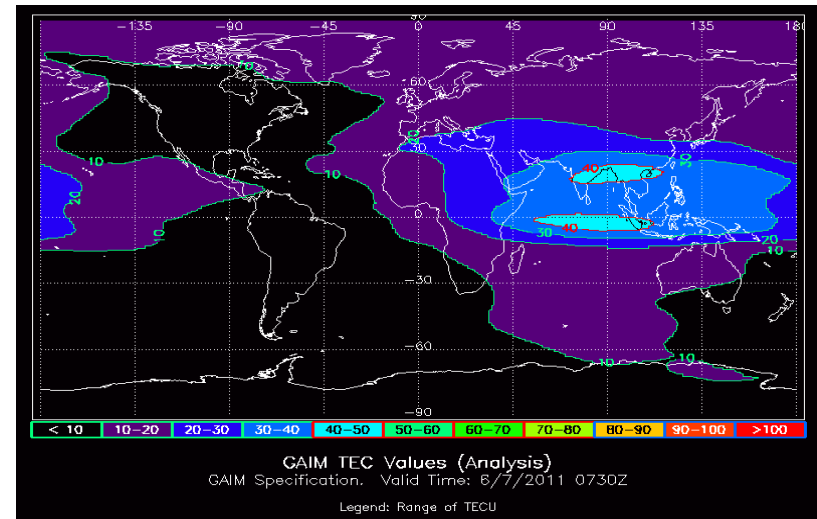
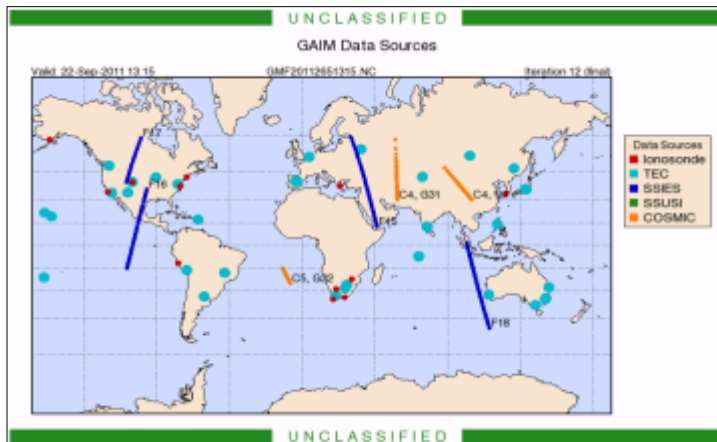
Space Weather Analysis & Forecast System (SWAFS)

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Single integrated baseline of over 30 space weather models and applications. Used for operational analysis, forecast, and space weather impacts

FY12 (Planned)

- Proton warning/monitoring system
- Net-centric data display and dissemination
- Assimilation of F-18 SSULI and SSUSI data into GAIM
- Visualize GONG/SOON imagery and database for 30 days
- Integrate D-Region Absorption Prediction code upgrade
- Full Physics-GAIM development



**Partners: AFSPC / SMC / SWPC / AFRL /
NRL / JHU-APL / Utah St & academia / CCMC
/ NGC / Aerospace**

Supports: DoD SSA & more

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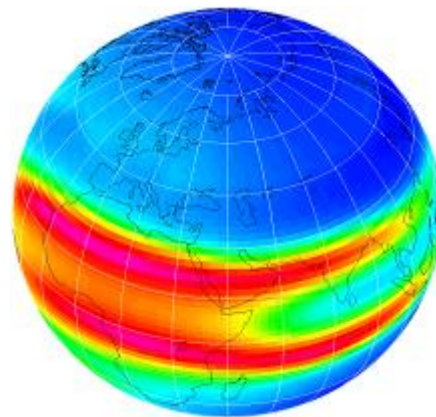
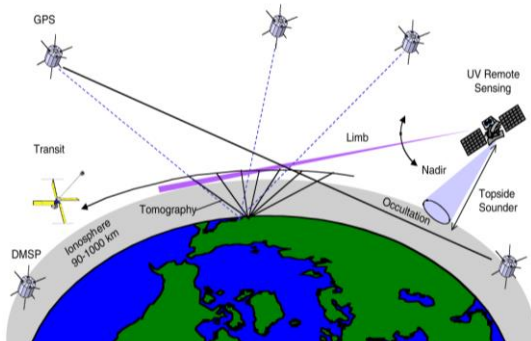


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Global Assimilation of Ionospheric Measurements (GAIM) Model

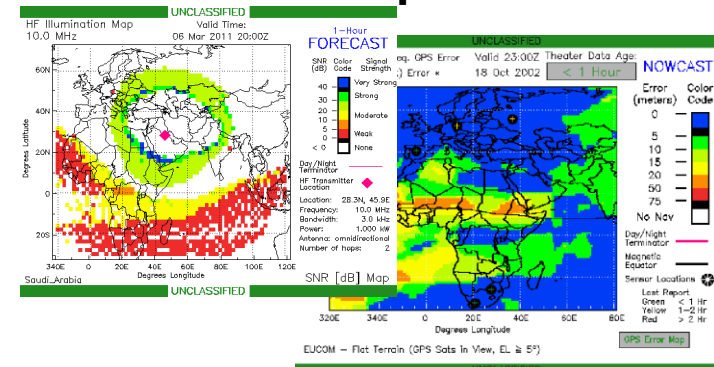
- **Global Assimilation of Ionospheric Measurements (GAIM)**
 - Provides current and 24 hr forecast of global electron/ion density from 90–1400 km, 82 vertical levels, 7.5° x 15° resolution
 - Assimilates remote ultraviolet from DMSP, in-situ ion density, satellite & ground-based total electron content, density profiles from ionosondes
- **Output feeds other models as well as DoD end users**
 - HF communication
 - Geolocation error analysis
- **Follow-on “full physics” upgrade operational in 2014**

Assimilated Data



Ionospheric Impacts

HF Illumination Maps



GPS Error Maps

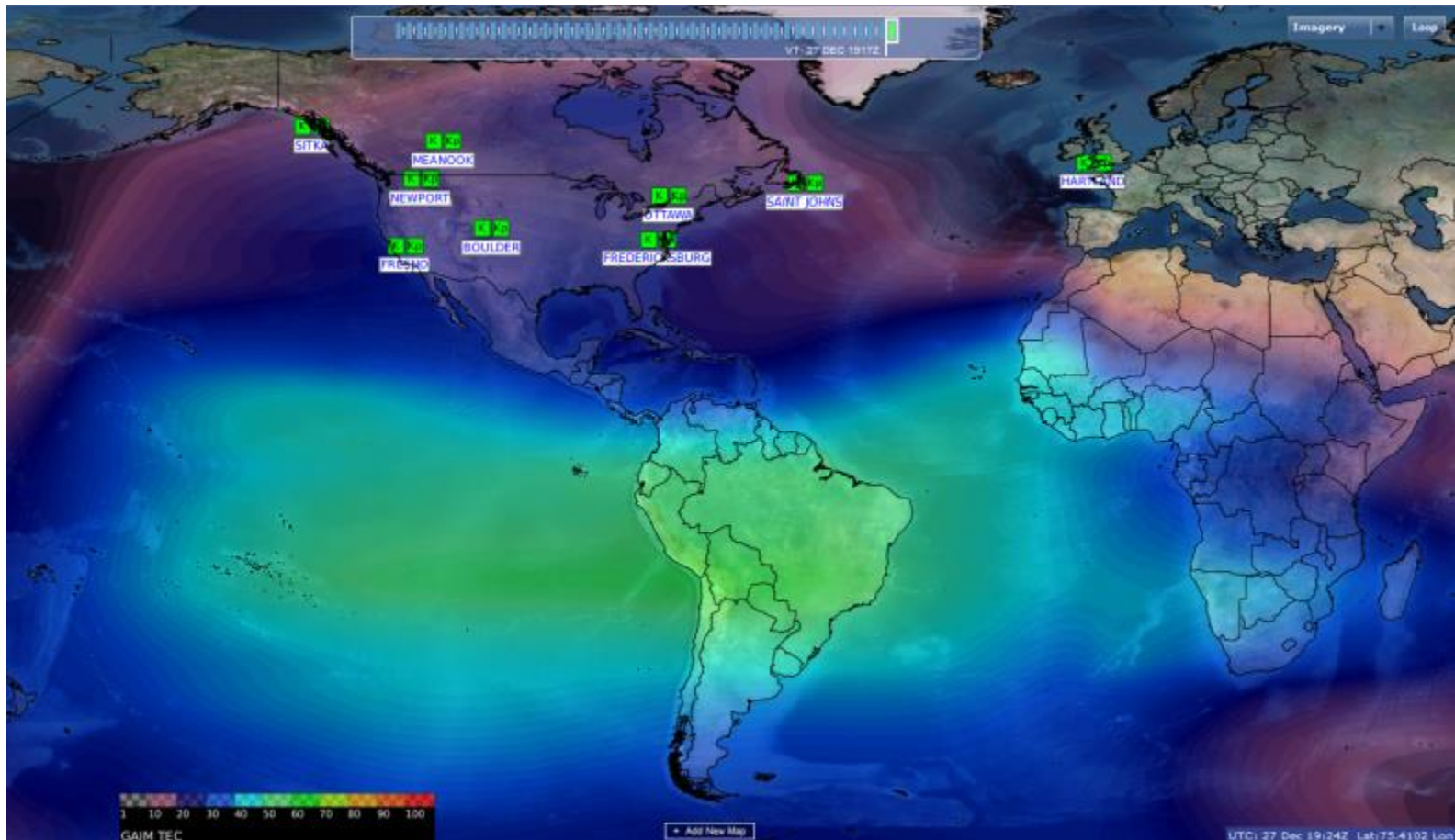
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AF Weather Web Services (AFW-WEBS)

- Space weather products in a GIS/Google Earth format





Recent Accomplishments

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- **Fielded three next generation ionosondes:**
 - **Guam**
 - **San Vito, Italy**
 - **Ascension Island**
- **Add two models (WBMOD and VOACAP) to the space weather software baseline**
- **Added COSMIC Radio Occultation Total Electron Content data to GAIM model**
- **Improved CME forecasts using ENLIL solar wind model (operational at NOAA FY11)**
- **Upgraded computer hardware & operating system**
 - **92% performance improvement**
- **Upgraded communication circuit at Learmonth Solar Observatory**



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Space Weather Mission Support Way Ahead

- **Must continue to team for solar max ... and beyond**
 - Plans in place to improve collection, forecasting, dissemination & exploitation
 - National partners working together ... e.g. National Space Wx Program Council
 - Collaborate with U.S. & Allied government/civilian agencies to increase sensing capability & reduce costs...
- **Invest in collection**
 - Modernize and leverage ground- and space-based sensing capabilities
- **Support national space wx forecasting needs**
 - Physics-based forecasting
- **Ensure exploitation of space wx expertise for Space Situational Awareness into the future**
 - Tailor products to specific missions and operational needs
 - Develop expertise/knowledge among operators and space weather professionals
 - Promote agency collaboration to share knowledge/expertise and avoid duplication of effort



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Summary

- **Air Force Weather is DoD's Space Weather provider**
 - Products tailored to specific missions, customers & operational needs
- **Space Weather has impacts across the DoD ... Space Situational Awareness, Satellite Ops/Health, GPS guided system, comms/radars, etc.**
- **We leverage organic, interagency & international sources of data to support military operations & resource protection**

Continue to partner with operational and research communities in support of national space weather needs