

Headquarters U.S. Air Force

Integrity – Service – Excellence

Space Weather Workshop 2011 **Air Force Weather Activities**



Col John Egentowich, Ph. D.
AF Deputy Director of Weather
AF/A3O-W
27 April 2011

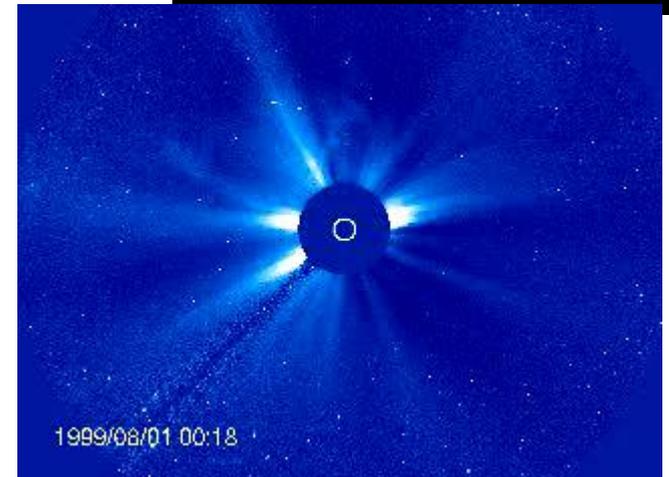
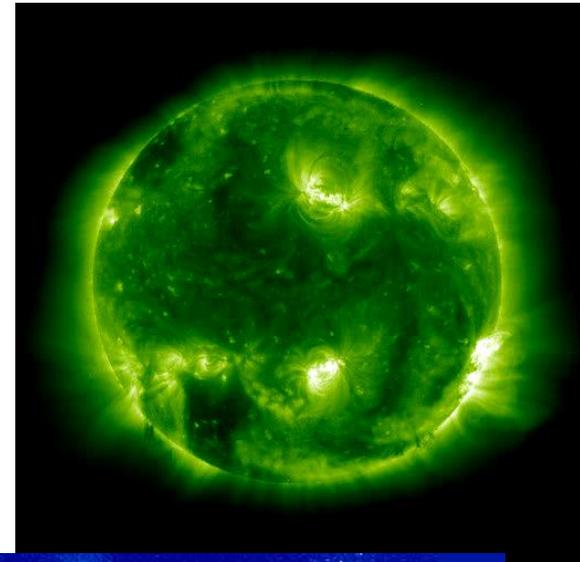
U.S. AIR FORCE



U.S. AIR FORCE

Overview

- Challenge
- DoD Support
- Partnerships are Key
- Space Weather Collection
- Space Weather Forecasting
- Way Ahead





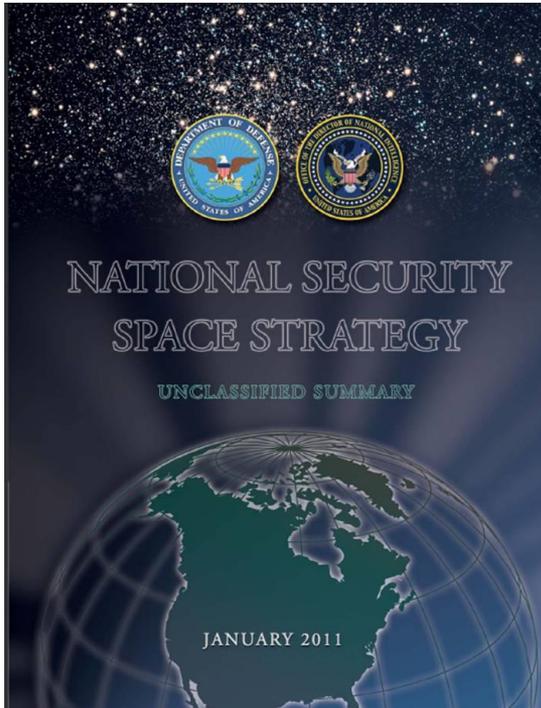
- **Space Weather is a “Total Team Sport”... From Research to Ops**
- **Expand collection capabilities:**
 - **Ground-Based: optical, radio, magnetic, and ionospheric**
 - **Space-Based: ionospheric, magnetosphere, solar wind, & radiation belt**
- **Solve the tough forecasting problems:**
 - **Physics-based model improvements**
 - **Move from nowcasts to “true” forecasts**
- **Deliver Ops Focused Exploitation Tools:**
 - **An operational imperative to rapidly respond to the “Solar Threat” of the day**
 - **Must be easily understood and operationally relevant**
 - **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



National Security Space Strategy

U.S. AIR FORCE



Dept of Defense and the Office of the Director of National Intelligence, January 2011

- National Space Policy discusses preservation and responsible use of the space environment, highlighting the need for space situational awareness (SSA), which includes the need to characterize and exploit the space environment for operational advantage.
- “The U.S. is the leader in SSA and can use its knowledge to foster cooperative SSA relationships . . . DoD will continue to improve the quantity and quality of SSA information it obtains.”
 - SSA includes awareness of conditions in the natural space environment
- “SSA . . . will continue to be top priorities, as they underpin our ability to maintain awareness of natural disturbances and the capabilities, activities, and intentions of others.”



U.S. AIR FORCE

AF Weather Space Weather Implementation Plan



- **Established priorities for improving ground-based space environment sensing for the next 5 years**
 - **Implement next increment of the AF's ground-based ionospheric sensing network: Next Generation Ionosonde (NEXION)**
 - **Upgrade AF's aging solar optical telescopes, Solar Optical Observing Network (SOON)**
- **AF Weather Agency (AFWA) will upgrade tools to improve characterization and exploitation of the space environment**
 - **Collaborate with research and academic partners to integrate, test, and deploy a full-physics version of the Global Assimilation of Ionospheric Measurements (GAIM) model**
 - **Transfer space weather databases into joint net-centric standards, allowing discoverability and accessibility of data for its users**

Working with Space Wx Architecture Community to further refine end-to-end implementation plans



DoD Space Weather Services

AF Weather: 40+ Years Providing Space Wx for DoD Warfighters

U.S. AIR FORCE

Environmental Inputs
(DoD, Civil, International)



Observations
Requirements

Space /
Space Wx
Operators



Data Received

AFWA – weather data
ingest/analysis/prediction & products
to the warfighter!



Key Partnership



SWPC

Data & Products
Provided

AFWA: Space Wx
provider for DoD

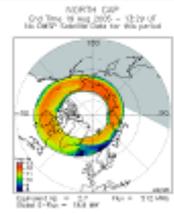


2 Weather Squadron
Space Weather Flight

Teamwork



Tailored Products





Space Weather Warfighter Impacts

U.S. AIR FORCE

X-Rays, EUV, Radio Bursts

Arrival: 8 min / Duration: 1-2 days

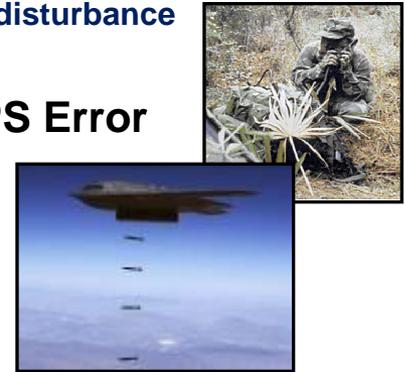
- SATCOM Interference
- Radar Interference
- HF Radio Blackout
- Geolocation Errors
- Low Orbit Decay



Scintillation

Daily / ionospheric disturbance

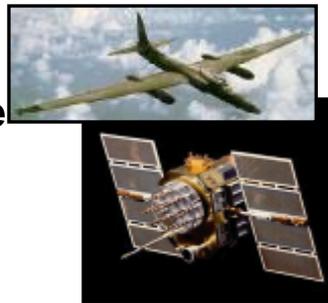
- Degraded SATCOM
- Dual Frequency GPS Error
 - Positioning
 - Navigation
 - Timing



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: 2-3 days / Duration: days

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





Partnerships

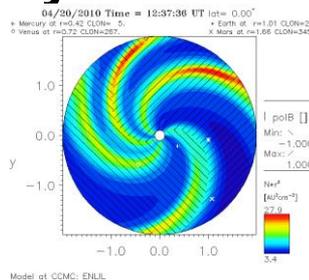
U.S. AIR FORCE

■ Our partner in operations

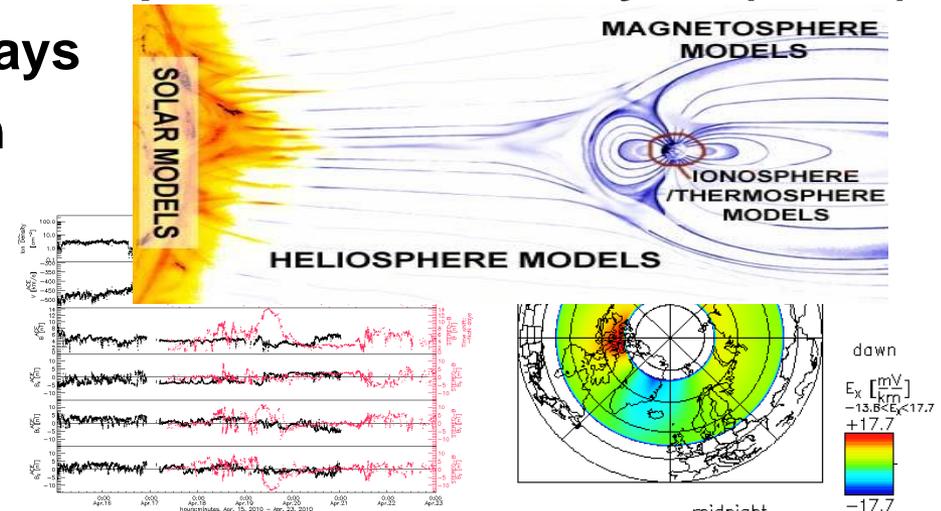


■ Collaboration with CCMC: Integrated Space Weather Analysis (iSWA)

- User-friendly data/model displays
- Model Comparisons/Validation
- “Ensemble” displays



Model at CCMC: ENLL



Model at CCMC: GIC

midnight

■ Collaborations: AFRL SWFL, AFSPC, SMC, ESC, NRL



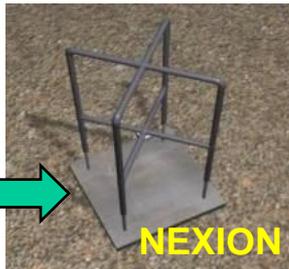
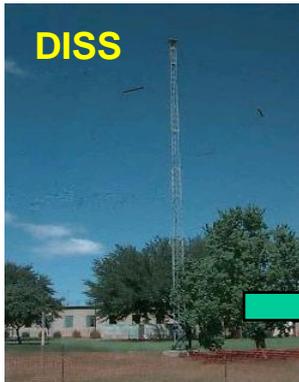


U.S. AIR FORCE

Space Weather Ground-Based Sensing

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

- Sensors include SOON, RSTN, DISS, NEXION, USGS Magnetometers, SCINDA, TEC (JPL), and others
- Data from many government & non-government sources, GONG ... Data partnerships are crucial

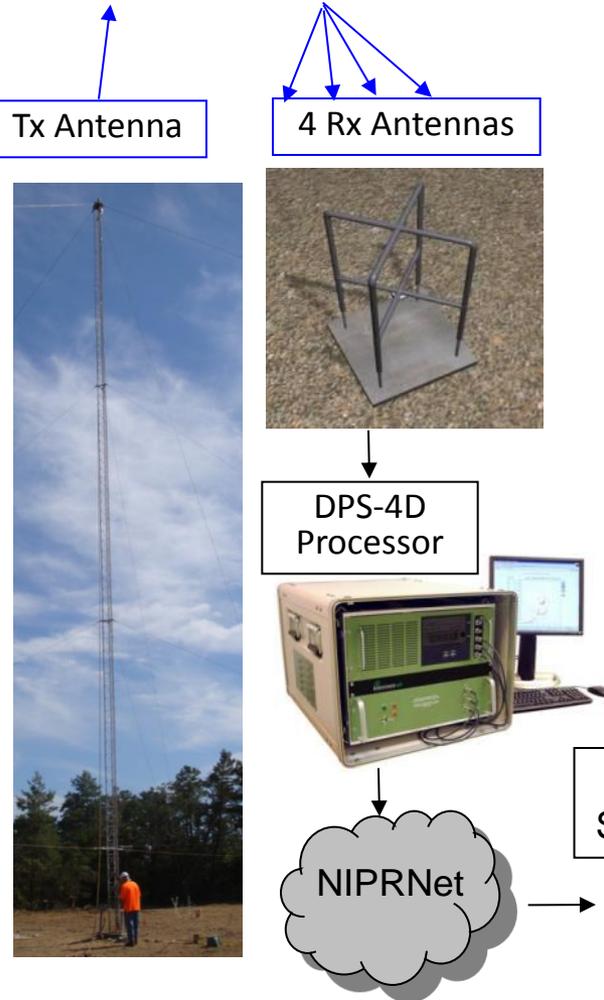




Next Generation Ionosonde NEXION

U.S. AIR FORCE

IONOSPHERE



■ Replacement for Digital Ionospheric Sounding System (DISS)

- Ionospheric data feeds AFWA's ionospheric model
- Generates products critical to space situational awareness

■ Advantages

- Reduced footprint -- 5 acres for DISS/1 acre for NEXION
- Characterizes ionosphere over 1000 km radius
- Improved spatial resolution
- Modernized network and remote sustainment functions

■ NEXION network will consist of at least 30 sites

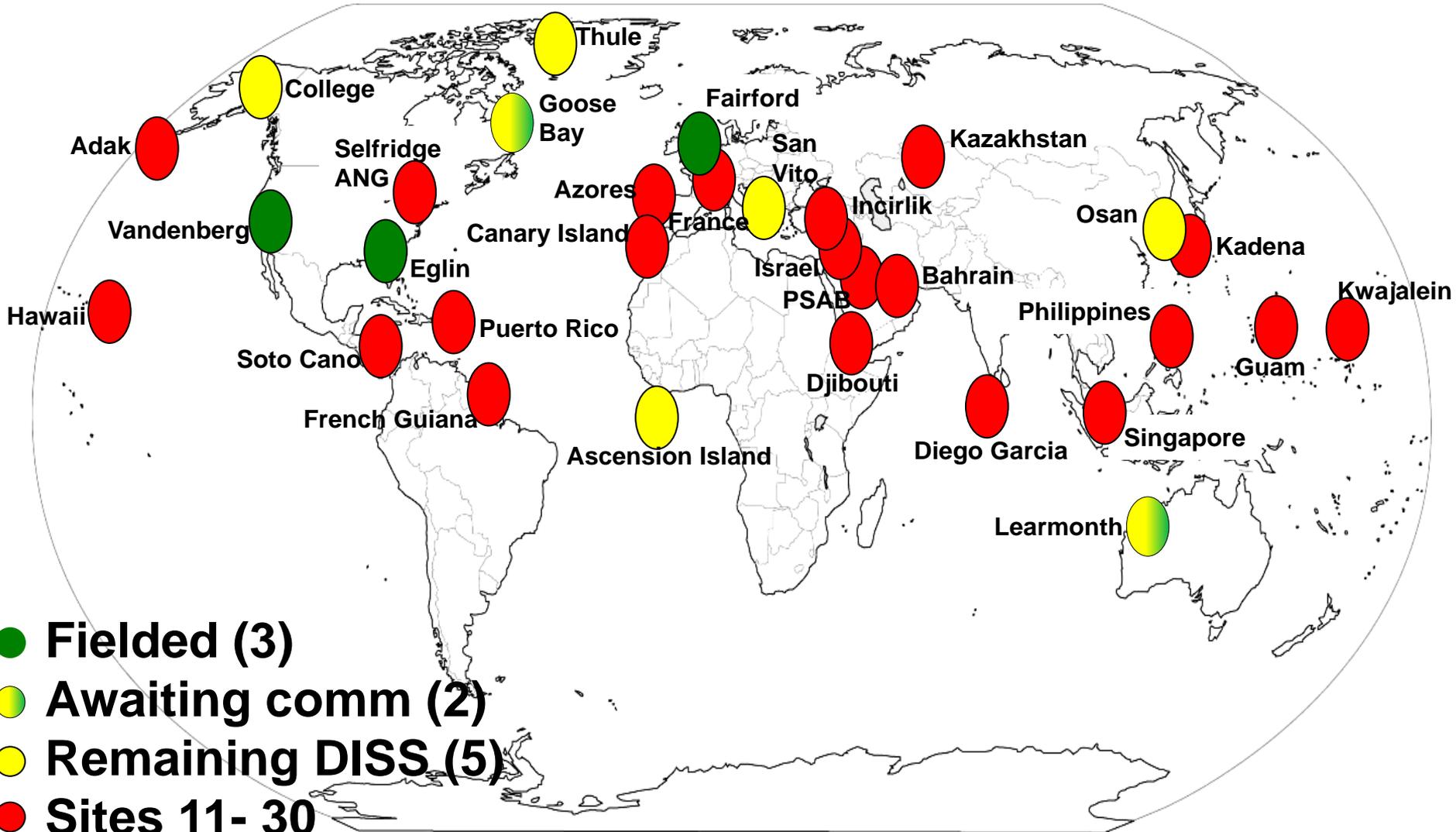
- 3 sites currently operational; 2 awaiting comms
- New acquisition contract in place; install 3 sites per year: worldwide fielding

Partners: UMass - Lowell, SMC



U.S. AIR FORCE

NEXION Fielding





U.S. AIR FORCE

Investing in a Global Solar Observing Network



- SOON / RADIO
- SOON ONLY
- RSTN (RADIO) ONLY
- RESEARCH ISOON
- GONG

Solar Optical Observing Network
• Upgrades finished by 2016



U.S. AIR FORCE

Improved Optical Observations

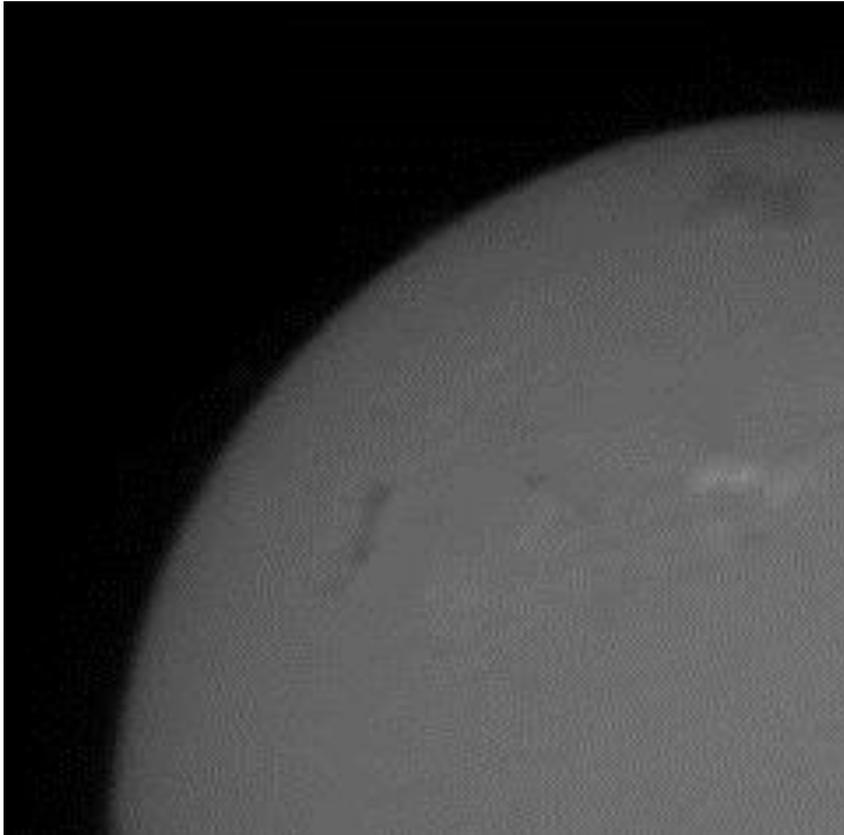
SOON and SOON Upgrade

08 Apr 2010

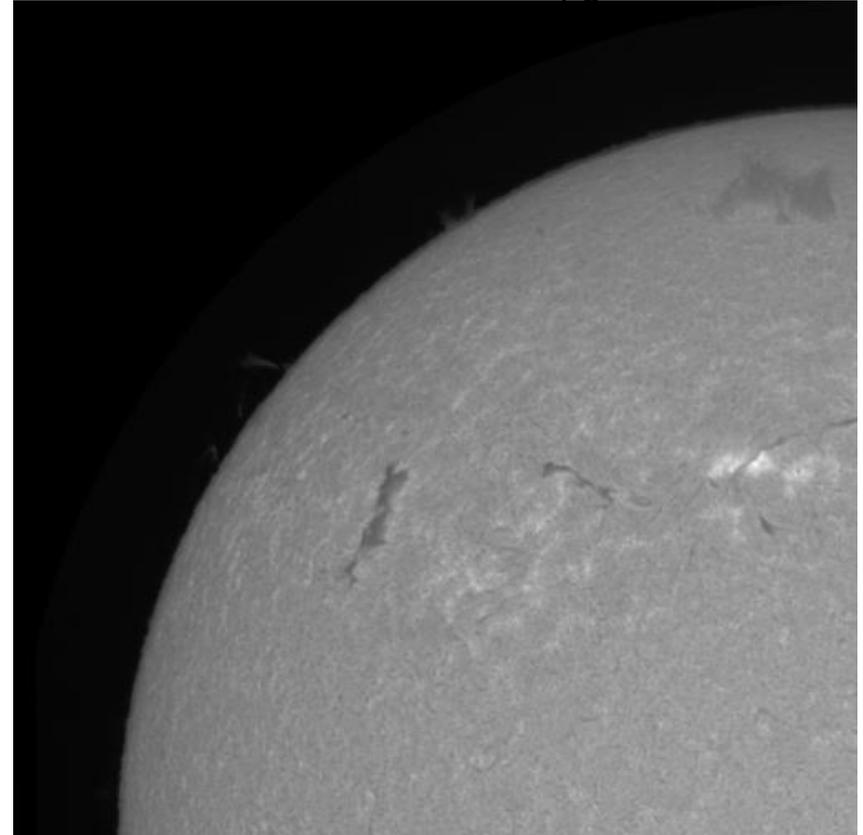
H α 14:29UT

Partners: AFRL, SMC

SOON



SOON Upgrade

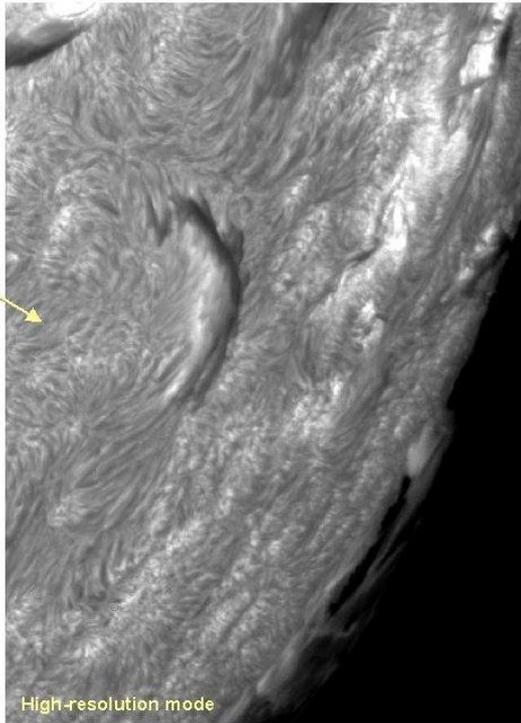
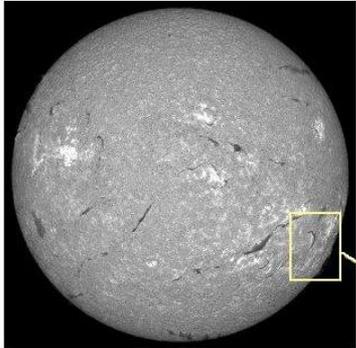




U.S. AIR FORCE

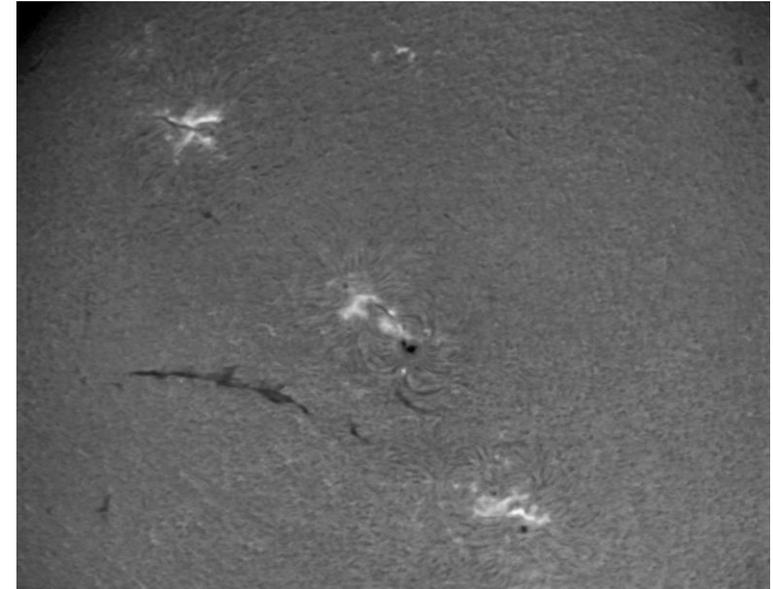
SOON – GONG Operational Integration

SOON Upgrade



- 1 arc/sec resolution
- Meets AFSPC and Natural Environmental Parameters Collection (NEPC) requirements
- Remote operation will collocate solar analysts with space weather forecasters

GONG



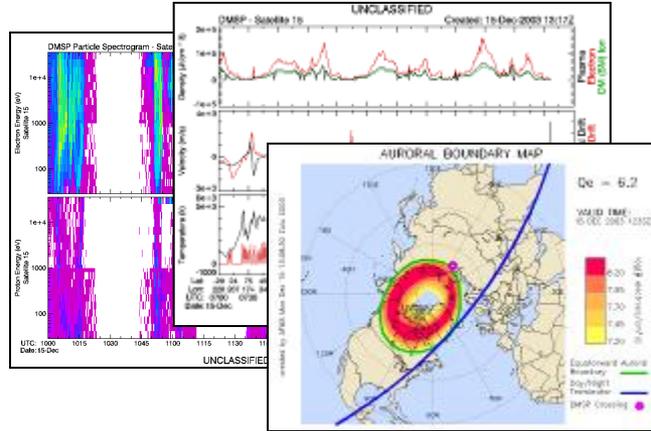
- Upgraded Mar 11 to provide H-alpha capability to 2nd Weather Squadron
- 2.5 arc/sec resolution
- Flare patrol during gaps in SOON coverage
- 6-site network assures eyes on Sun
- Feb 12: Incorporation of GONG data into Space Weather Forecast Laboratory (SWFL) Interactive Flarecast Tool (SWIFT) into SWAFS



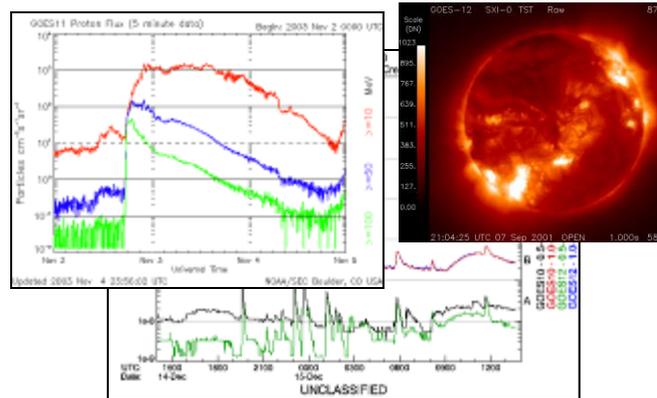
U.S. AIR FORCE

Space Weather Space-Based Sensing

Defense Meteorological Satellite Program (DMSP) – particles/fields



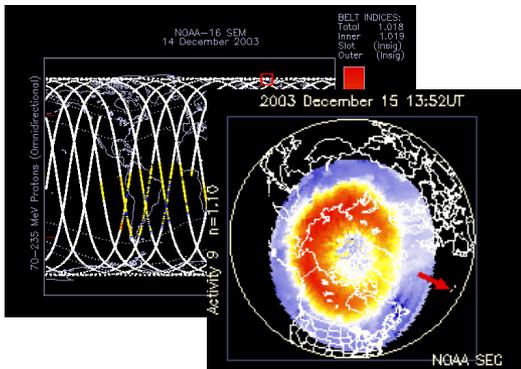
Geostationary Operational Environment Satellite (GOES) – X-ray, particles and fields



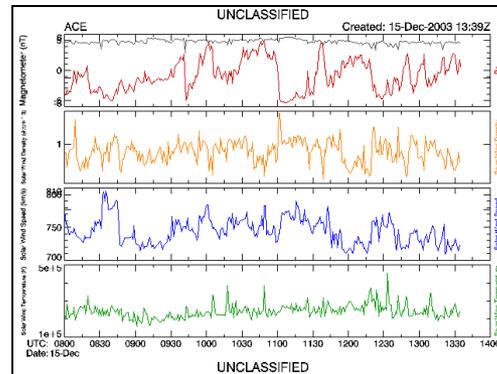
Communications/Navigation Outage Forecast System (C/NOFS) – scintillation



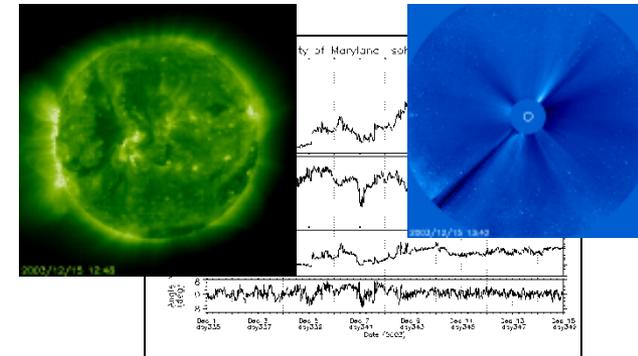
Polar-Orbiting Environmental Satellite (POES) - particles



Advanced Composition Explorer (ACE) – solar wind



Solar Heliospheric Observatory (SOHO) - solar wind/radiation





U.S. AIR FORCE

Space-Based Sensor Options

Exploit Current Capabilities

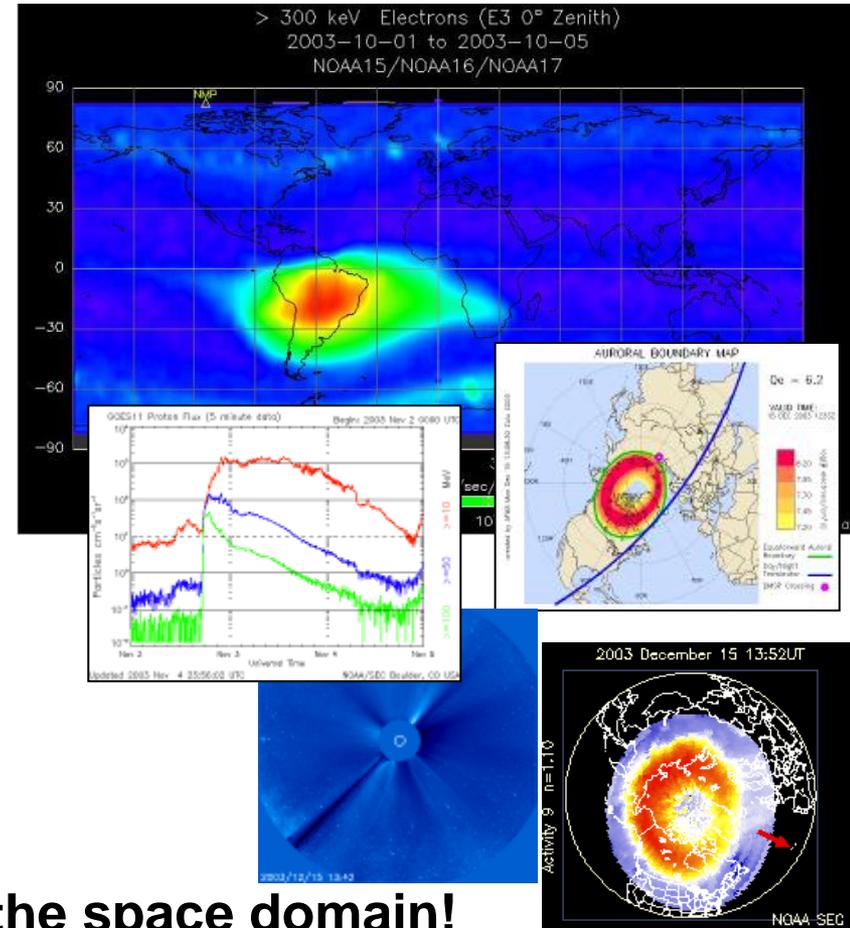
- DMSP, GOES, POES, SOHO, ACE
- C/NOFS, STEREO, SDO & GPS-RO/COSMIC
- Non-traditional sources

Future Options

- DWSS (SEM-N)
- DSCOVR (ACE Follow-on)
- SSAEM, COSMIC-II
- Radiation Belt Storm Probe
- Non-traditional sources

Advocacy and Partnering

- Need partnerships to collect from the space domain!
- CSESMO ... proposed national space-based sensing architecture





Space Weather Analysis and Forecast System (SWAFS)

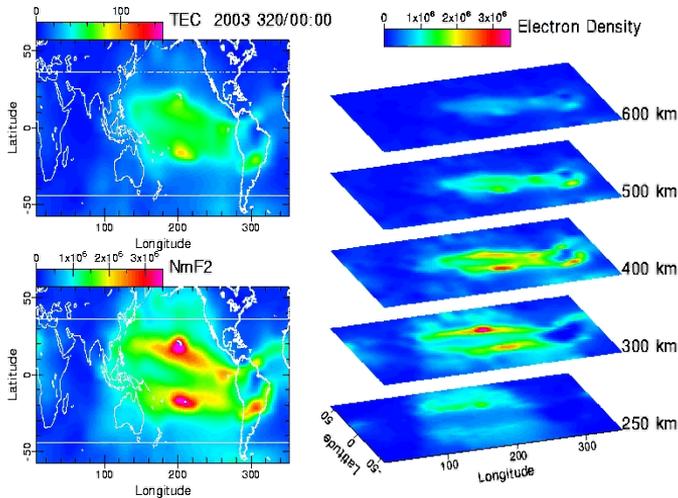
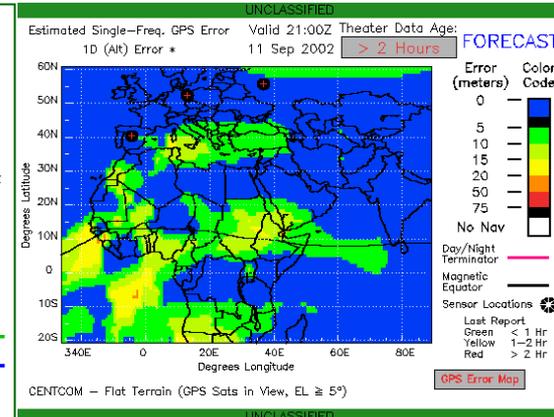
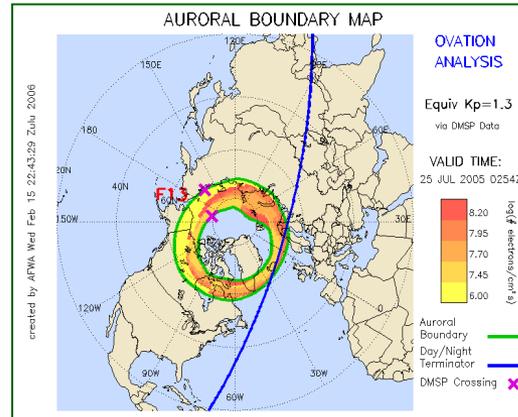
U.S. AIR FORCE

May 11

- Incorporate 4-wave signature and F-17 SSUSI data into GAIM
- Assimilate new SCINDA and ionosonde data into SWAFS

Jun 11

- Incorporate NEXION data as sites come online



Jul 11

- GAIM Block F—includes radio occultation data
- JMSESS modifications – resolve missing/late Wing Kp data issues with SWPC
- Magnetospheric Specification & Forecast Model (MSFM) modifications – reduce start-up time

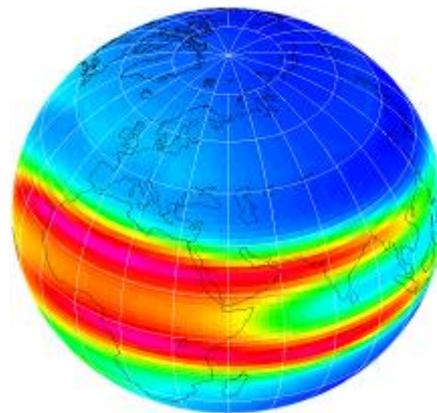
Sep/Oct 11

- Incorporate SCINDA data from 4 new sites
- Add ionosonde data from new NEXION sites

Partners: NRL / AFRL / SMC / Utah St & academia / CCMC



- **Global Assimilation of Ionospheric Measurements (GAIM) Model**
 - Provides 24 hour forecast of ionospheric conditions
 - Output used for HF communication and geolocation error analysis
- **Upgrades:**
 - May 11 upgrade: incorporation of DMSP F-17 SSUSI data
 - Mar 12 upgrade: incorporation of COSMIC, GOES EUV, and DMSP F-18 SSULI data
 - Follow-on “full physics” upgrade operational 2012-2013



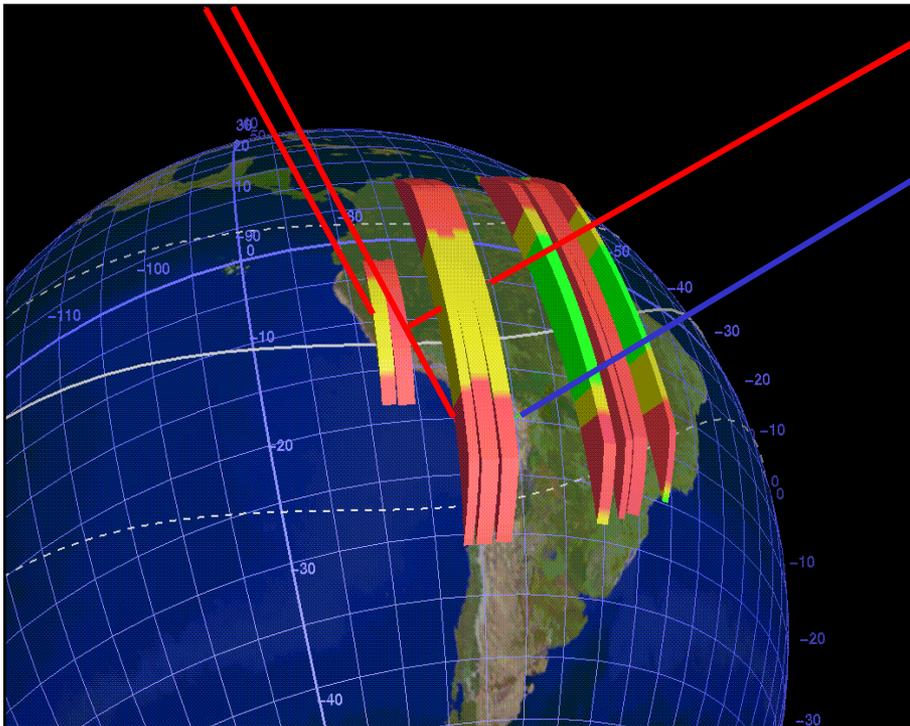
Ionospheric Impacts



SCINTILLATION NETWORK DECISION AID (SCINDA)

U.S. AIR FORCE

A regional nowcasting system to support users of space-based communication and navigation systems



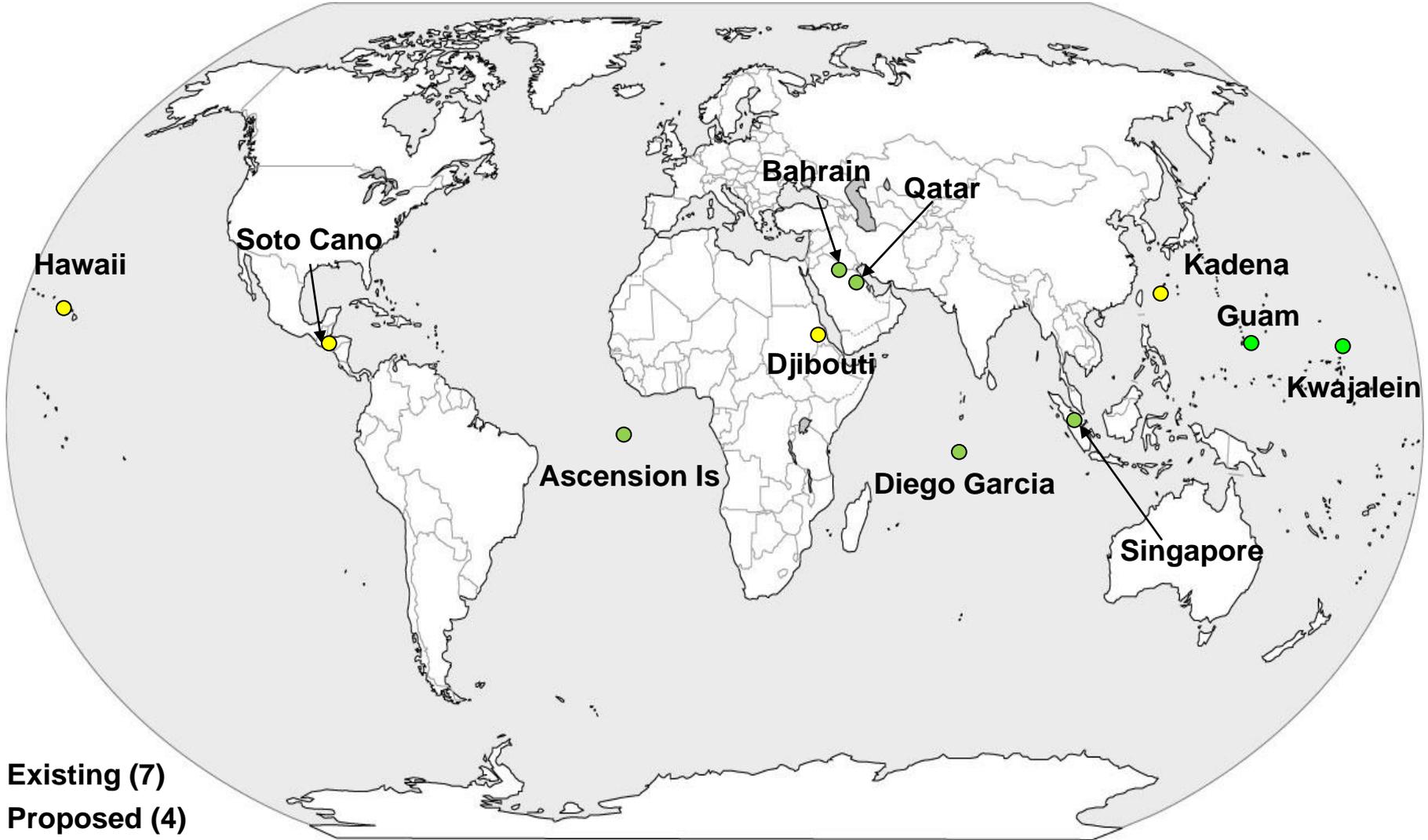
Real-time to 2-Hr Forecasts

- **Ground-based sensor network**
 - Passive UHF / L-band /GPS scintillation receivers
 - Measures scintillation intensity, eastward drift velocity, and total electron content (TEC)
 - Automated real-time data retrieval via internet
- **Data supports SATCOM users**
 - In theater and reach back support
- **Future work**
 - Communication\ Navigation Outage Forecast System (C\NOFS) and it's follow on Space Situational Awareness Environmental Monitor (SSAEM)
 - Multi-frequency GPS error work



U.S. AIR FORCE

Proposed Operational SCINDA Locations

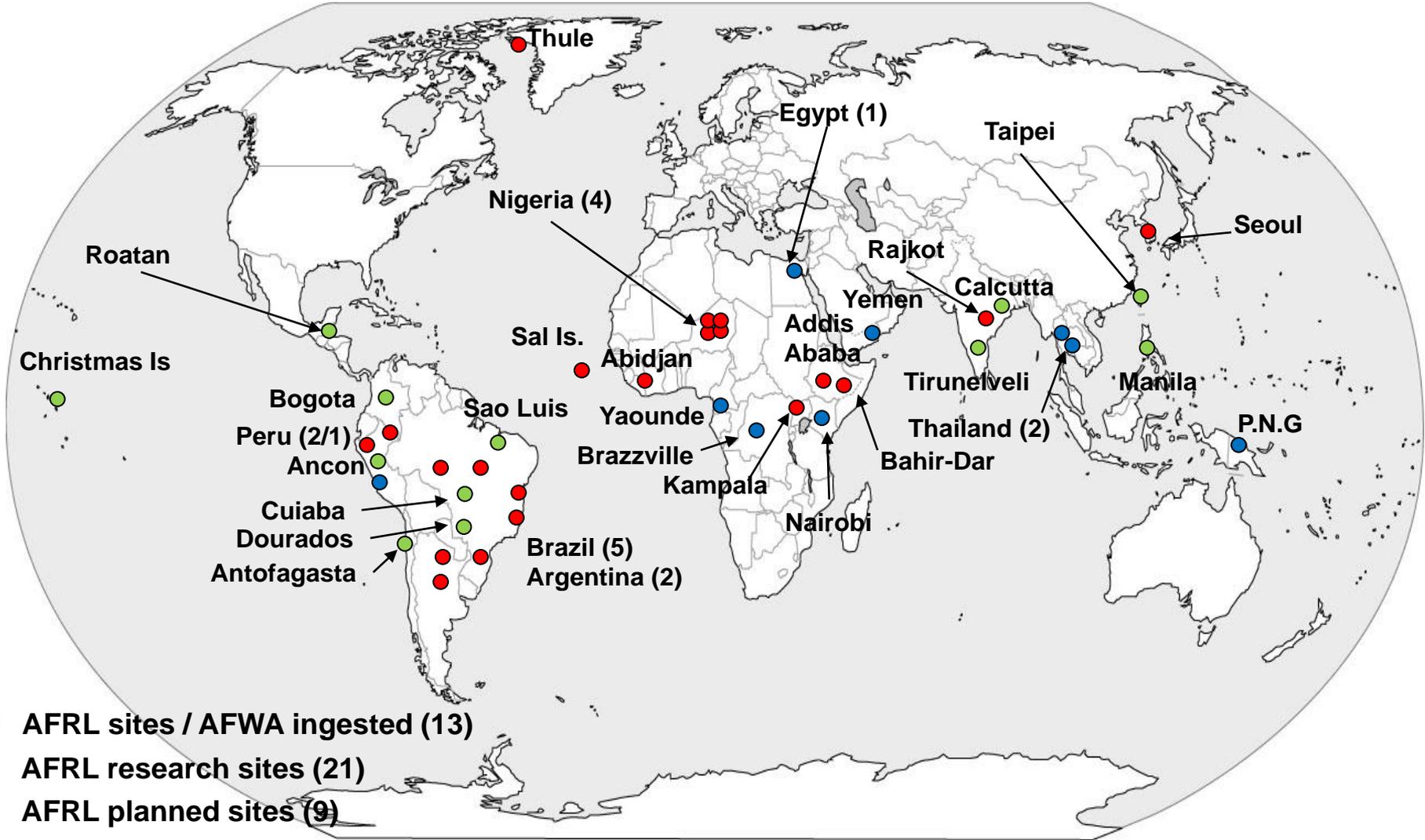


Integrity - Service - Excellence



U.S. AIR FORCE

AFRL SCINDA Locations



Integrity - Service - Excellence



U.S. AIR FORCE

Space Weather Mission Support Way Ahead

- **Must team for solar max ... and beyond**
 - Plans in place to improve collection, forecasting, & exploitation
 - OFCM, NOAA, NASA, DoD, and other national partners working to determine optimum way forward
 - Collaborate with U.S. & allied government/civilian agencies to increase sensing capability & reduce costs... NASA, NOAA, NSF, USGS, LANL, and others
- **Invest in collection...**
 - Modernize ground- and space-based sensing capabilities
- **Support national space wx forecasting needs**
 - Physics-based forecasting
- **Ensure exploitation of space wx expertise for SSA into the future**
 - Tailor products to specific missions and operational needs
 - Develop expertise/knowledge among operators and space weather professionals

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

Working with National Partners to support National Space Weather needs

Integrity - Service - Excellence

Questions?



U.S. AIR FORCE



Rising Sun Over Pyramid (painting) – Paul Greco, 2009