Space Weather Workshop 2011
Air Force Weather Activities

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AF/A3O-W
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Overview

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

- 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

- 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.”
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

Environmental Inputs (DoD, Civil, International)

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

Data Received

Key Partnership

AFWA: Space Wx provider for DoD

Data & Products Provided

Teamwork

Tailored Products

2 Weather Squadron Space Weather Flight

Observations Requirements

Space / Space Wx Operators

AF Weather: 40+ Years Providing Space Wx for DoD Warfighters
<table>
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<tr>
<th>X-Rays, EUV, Radio Bursts</th>
<th>Scintillation</th>
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<tr>
<td><strong>Arrival:</strong> 8 min / Duration: 1-2 days</td>
<td>Daily / ionospheric disturbance</td>
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<tr>
<td>SATCOM Interference</td>
<td><strong>Degraded SATCOM</strong></td>
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<tr>
<td>Radar Interference</td>
<td><strong>Dual Frequency GPS Error</strong></td>
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<td>HF Radio Blackout</td>
<td>• Positioning</td>
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<td>Geolocation Errors</td>
<td>• Navigation</td>
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<td>Low Orbit Decay</td>
<td>• Timing</td>
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<td>Proton Events</td>
<td><strong>Geomagnetic Storms</strong></td>
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<tr>
<td><strong>Arrival:</strong> 15 min to hours / Duration: days</td>
<td><strong>Arrival:</strong> 2-3 days / Duration: days</td>
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<td>High Altitude Radiation Hazards</td>
<td><strong>Spacecraft Charging and Drag</strong></td>
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<td>Spacecraft Damage</td>
<td><strong>Geolocation Errors</strong></td>
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<td>Satellite Disorientation</td>
<td><strong>Space Track Errors</strong></td>
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<td>Launch Payload Failure</td>
<td><strong>Launch Trajectory Errors</strong></td>
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<td>False Sensor Readings</td>
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<td>Degraded HF Comm (high latitudes)</td>
<td><strong>Radio Propagation Anomalies</strong></td>
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<td><strong>Power Grid Failures</strong></td>
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Integrity - Service - Excellence

Partnerships

- Our partner in operations

- Collaboration with CCMC: Integrated Space Weather Analysis (iSWA)
  - User-friendly data/model displays
  - Model Comparisons/Validation
  - “Ensemble” displays

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

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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

IONOSPHERE

- DPS-4D Processor
- 4 Rx Antennas
- Tx Antenna

- 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
NEXION Fielding

Fielded (3)
Awaiting comm (2)
Remaining DISS (5)
Sites 11-30
Investing in a Global Solar Observing Network

Solar Optical Observing Network
- Upgrades finished by 2016

- SAGAMORE HILL
- KAENA POINT
- BIG BEAR
- MAUNA LOA
- KIRTLAND
- LEARMONTH
- SAN VITO
- UDAIPUR
- CERRO TOLOLO
- TEIDE

SOON / RADIO
SOON ONLY
RSTN (RADIO) ONLY
RESEARCH ISOON
GONG
SOON and SOON Upgrade
08 Apr 2010
Hα 14:29UT

Partners: AFRL, SMC
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
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
**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!
- CSESOMO … proposed national space-based sensing architecture
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
A regional nowcasting system to support users of space-based communication and navigation systems

- **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

Real-time to 2-Hr Forecasts
Proposed Operational SCINDA Locations

- Guam
- Kwajalein
- Diego Garcia
- Bahrain
- Qatar
- Soto Cano
- Ascension Is
- Kadena
- Guam
- Kwajalein

Existing (7)
Proposed (4)
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?

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