AFWA-NASA Space Weather Center Partnership

Space Weather Ops Tools & Services

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AFWA SpaceWOC
Overview

- AFWA SpaceWOC
- iSWA in AFWA Ops
- CME Forecasting
- Other Forecaster Tools
Space Weather Operations Center

- Provide mission-tailored analyses, forecasts, and warnings of system-impacting space weather to National agencies and DoD operators, warfighters, and decision-makers

- The DoD’s only 24/7 space weather operations center
Near-Earth Space Environment

- **MAGNETOSPHERE**: 50+ Satellites
  - Geomagnetic Storming
  - DSP
  - MILSATCOM: WGS, DSCS, MILSTAR

- **RADIATION BELTS**: 30+ Satellites
  - Electromagnetic Radiation
  - Scintillation
  - GPS

- **THERMOSPHERE**: 25+ Satellites
  - High Energy Particles
  - Scintillation
  - DMSP
  - ISS, HST

- **MESOSPHERE**

- **STRATOSPHERE**

- **TROPOSPHERE**

- **IONOSPHERE**
  - Solar Radio Burst
  - U-2
Space Situational Awareness

Data received from multiple sources
- GOES: 11, 13, 14, 15; XRS, EPS, Magnetometer, SXI
- DMSP: F-15 – F-18, SSIES, SSJ, SSM, SSUSI, SSULI
- POES: 15-19, SEM
- ACE: SWEPAM, MAG, EPAM, SIS
- SOHO: EIT, LASCO
- STEREO
- SDO
- COSMIC: GOX RO & S4
- GPS: Dual-Frequency Receivers
- Solar Electro-Optical Network
- GONG: H-alpha & Magnetogram images
- SCINDA
- USGS Magnetometers
- DISS/NEXION Sites
- Neutron monitors

*Blue text indicates planned data ingest/use

Used for SSA, anomaly assessments, and model input
Space Situational Awareness

- Provide Space Situational Awareness (SSA) to DoD
- Produce both routine and event-driven products (~16,000/day)
- Manned 24/7 with 1 forecaster and 1 analyst

**Space-based Sensors**
- STEREO
- GOES
- ACE
- POES

**Ground-based Sensors**
- NEXION / DISS / GPS-TEC
- SOON / RSTN / GONG
- Magnetometers

**Analyses, Warnings, Alerts,**
- JAAWIN
- Message

**Dissemination**
- FITL
- SWAFS

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**High Fliers**
- Deployed Comm

**GPS Nav users**
- Secret

**SCI**
- Secret

**SCINDA**
- HF Illum

**FITL**
- SWAFS

**OTH Radar**
- GPS Nav users

**Aim High…Fly, Fight, Win**
Warfighter Impacts

X-Rays, EUV, Radio Bursts
- SATCOM Interference
- Radar Interference
- HF Radio Blackout
- Geolocation Errors
- Satellite Orbit Decay

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

Proton Events
- High Altitude Radiation Hazards
- Spacecraft Damage
- Satellite Disorientation
- Launch Payload Failure
- False Sensor Readings
- Degraded HF Comm (high latitudes)

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

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Impact Mitigation

- **Warnings**
  - Geomagnetic Activity
  - Solar Event, Flare, Radio Burst
  - Energetic Particle/Charging
  - Short Wave Fade

- **Specification & Forecast**
  - Ionosphere
  - Magnetosphere
  - Solar Wind

- **Products**
  - Radar Auroral Clutter
  - HF Illumination
  - GPS Error
  - HF/UHF Point-to-Point
  - Ap/F10 Forecast
  - Anomaly Assessments
  - UHF SATCOM Scintillation
Anomaly Assessment Support

- Assessment of space weather environment in support of spacecraft anomaly resolution
  - Quick-look w/in 30 min; detailed study follows days/weeks later

![Past 27 Day Trend of Electron Flux (> 2 MeV) at Geosynchronous Orbit](image)

- CRESS Electron and Aurora Models show that F-15 was outside auroral oval and outside horns

![DMSP Energetic Particle Flux at LEO](image)

![Global Radiation Belt Model](image)
Current Data Display

- Relies on operational partnership
- Utilizes SWPC data feed & website
- Optimized for screens/resolution
Current Uses
- Primarily a SSA tool
- Many of the same capabilities as current display
- Coronagraph galleries useful for CME detection/tracking
iSWA in AFWA Ops

Advantages

- Web accessible
- Historical time lookup
- Looping / Time synch of all cygnets
- Layouts can be customized & saved
- New ‘Super Timeline’

Possible Improvements

- Improved IE browser compatibility- standard AF config
- Make more data plots/plot options configurable
- More model output - i.e. AFWA current ops models
iSWA in AFWA Ops

- Future Uses: custom layouts tailored to operator needs
  - Secondary/Backup Data Display
  - Anomaly Assessments
  - Training Simulator
CME Forecasting

- Cooperation between AFWA SpaceWOC and CCMC

- AFWA SpaceWOC:
  - Monitors sun 24/7
  - Provides CCMC with times of CME occurrence based on LASCO and/or STEREO imagery

- CCMC:
  - Uses AFWA notification/input to initiate WSA-ENLIL Cone Model
  - Provides results back to AFWA
    - Estimated arrival time
    - Kp Prediction
    - Gridded output
Monitor CME propagation in real-time or in historical mode

- Monitor in real-time
- Date selection tool for historical analysis
- Left/Right controls for single steps within time window

Future

User selectable image pairs to trigger automated CCMC Cone Model execution for CME time of arrival predictions.
CME Forecasting

Arrival time = 2011/11/28 23:48 (confidence level ±7 hours)

Duration of the disturbance (hr) = 8.8 (confidence level ±8 hours)

Minimum magnetopause standoff distance: $R_{min}(Re) = 5.4$

Min & Max possible Kp: $(Kp)_{min} = 1$, $(Kp)_{max} = 6$
CME Forecasting

- Prompt response by CCMC: 2 - 6hr turnaround
- Arrival time has shown ~ 3-4 hour average error
- Will leverage CCMC-AFIT validations

Possible Improvements:
- Include time series analysis of velocity/density
- Enable start/stop, step forward/back capability for graphics
- Improve confidence level intervals
- Provide probabilistic Kp forecast instead of min/max
- Ensemble forecasting approach
Other Forecaster Tools

- iSWA Tutorials
- Seminars
  - Done through site visits and possibly online videos
  - Utilize CCMC expertise
  - Cover basic space wx phenomena
  - Model capabilities and use
- Automated CCMC Alerts
- Model Validations / Rules of Thumb
  - CCMC-AFIT Collaboration
  - CCMC-AFWA (Modeling/V&V) Collaboration
Summary

- AFWA SpaceWOC
- iSWA in AFWA Ops
- CME Forecasting
- Other Forecaster Tools
Questions?

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