AFWA-NASA Space Weather Center Partnership
Space Weather Ops Tools & Services

Capt Janelle Jenniges
Flight Commander
AFWA SpaceWOC

Overview

- **AFWA SpaceWOC**

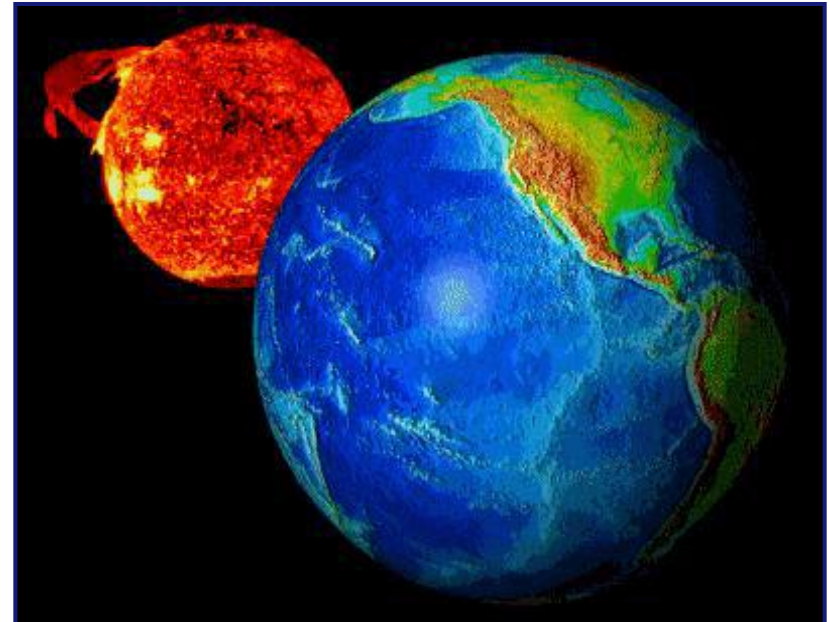- **iSWA in AFWA Ops**

- **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

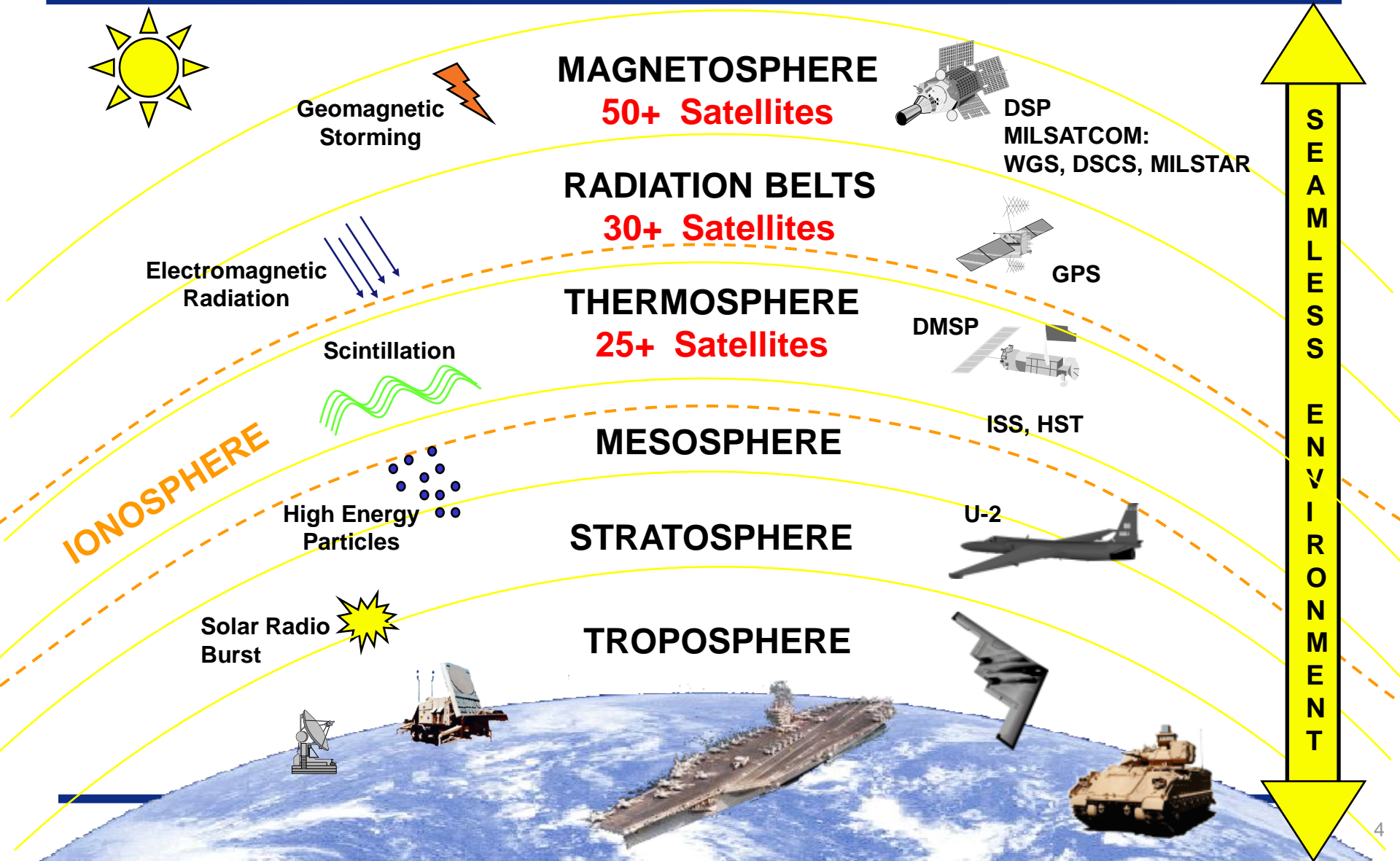- The DoD's only 24/7 space weather operations center

Near-Earth Space Environment

U.S. AIR FORCE

MAGNETOSPHERE
50+ Satellites

DSP
MILSATCOM:
WGS, DSCS, MILSTAR

Geomagnetic
Storming

RADIATION BELTS
30+ Satellites

GPS

Electromagnetic
Radiation

THERMOSPHERE
25+ Satellites

DMSP

Scintillation

MESOSPHERE

ISS, HST

IONOSPHERE

High Energy
Particles

STRATOSPHERE

U-2

Solar Radio
Burst

TROPOSPHERE

SEAMLESS ENVIRONMENT

4

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
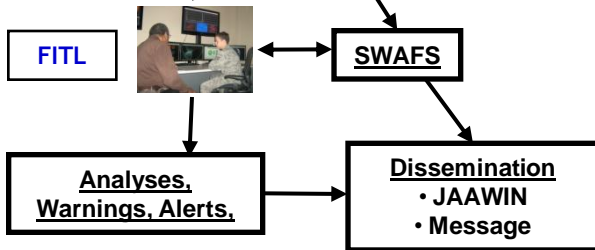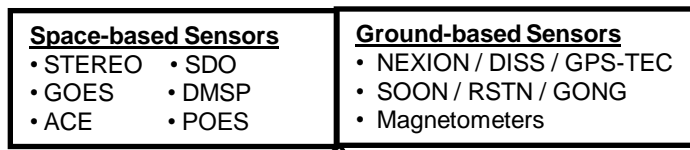
■ Used for SSA, anomaly assessments, and model input

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   • SDO
- GOES   • DMSP
- ACE   • POES

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

FITL

SWAFS

Analyses, Warnings, Alerts,

Dissemination
- JAAWIN
- Message

SCI

Secret

GAIM GEOMAG IES

SCINDA HF Illum

GPS Nav users

OTH Radar

High Fliers

Deployed Comm

Warfighter Impacts

X-Rays, EUV, Radio Bursts

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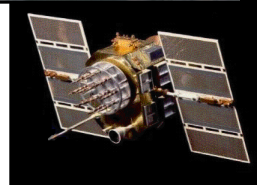- **Geolocation Errors**
- **Satellite Orbit Decay**

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**

Aim High···Fly, Fight, Win
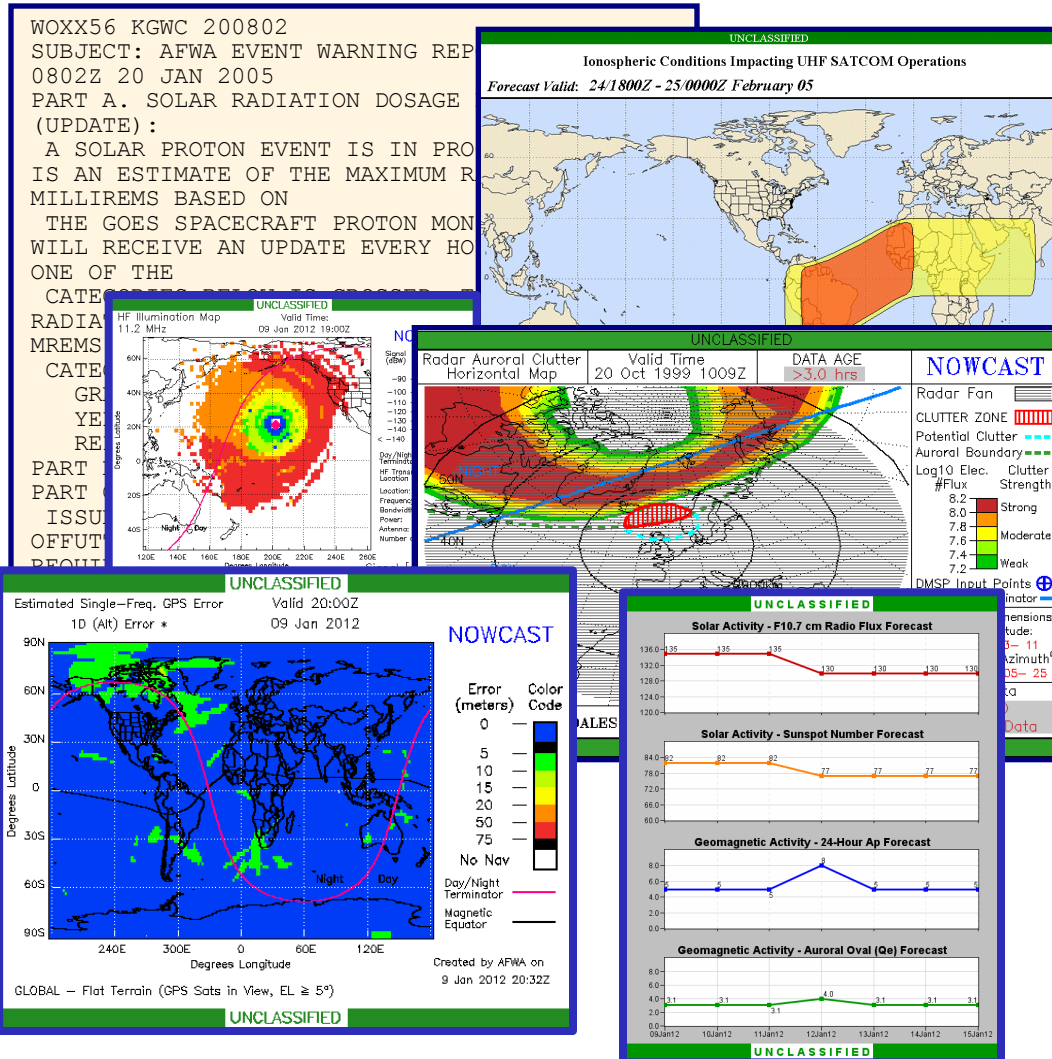
Impact Mitigation

- **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**

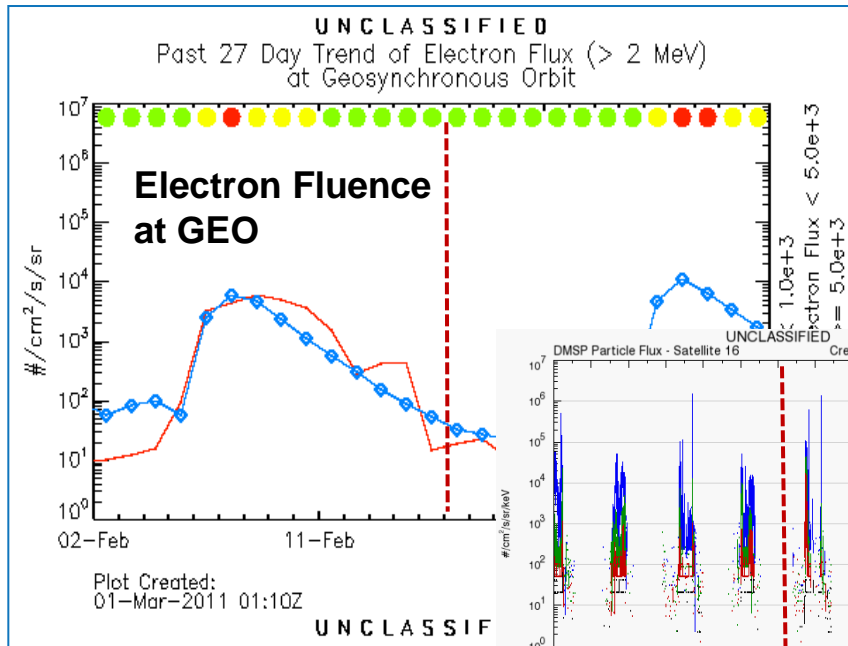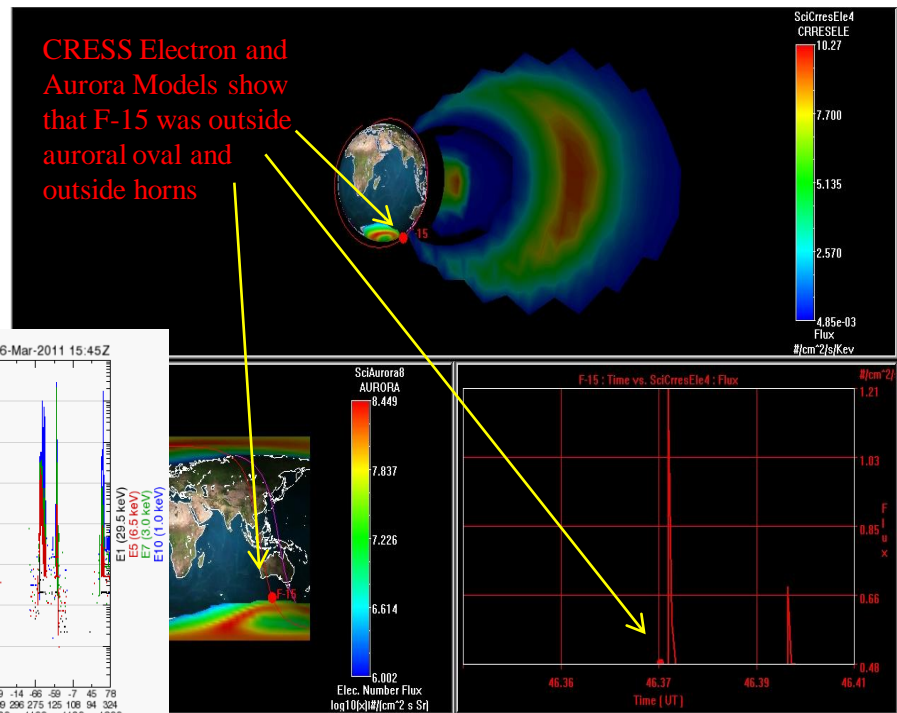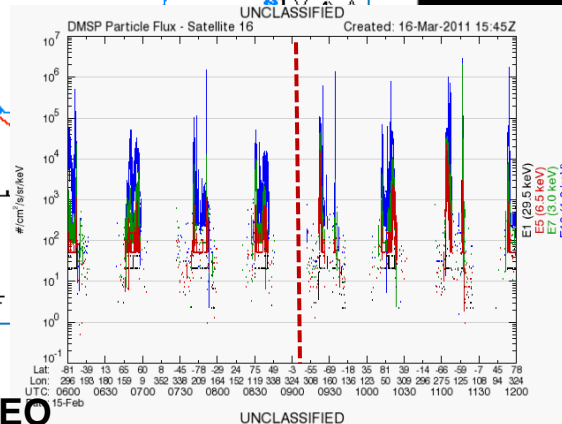# *Anomaly Assessment Support*

- **Assessment of space weather environment in support of spacecraft anomaly resolution**

    - **Quick-look w/in 30 min; detailed study follows days/weeks later**

Electron Fluence at GEO

DMSP Energetic Particle Flux at LEO

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

Global Radiation Belt Model

AFWA SpaceWOC

- ## **Current Data Display**
  - ### **Relies on operational partnership**
  - ### **Utilizes SWPC data feed & website**
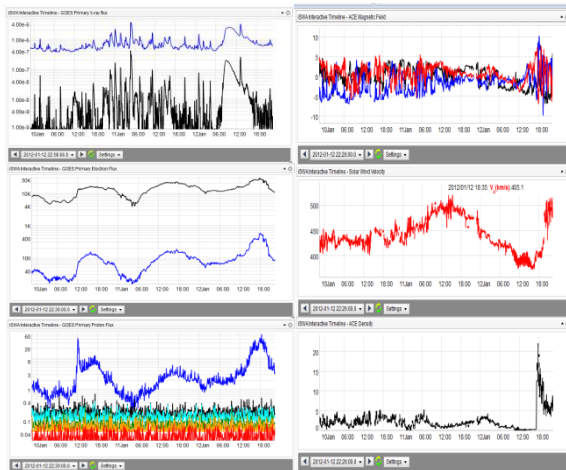 - ### **Optimized for screens/resolution**
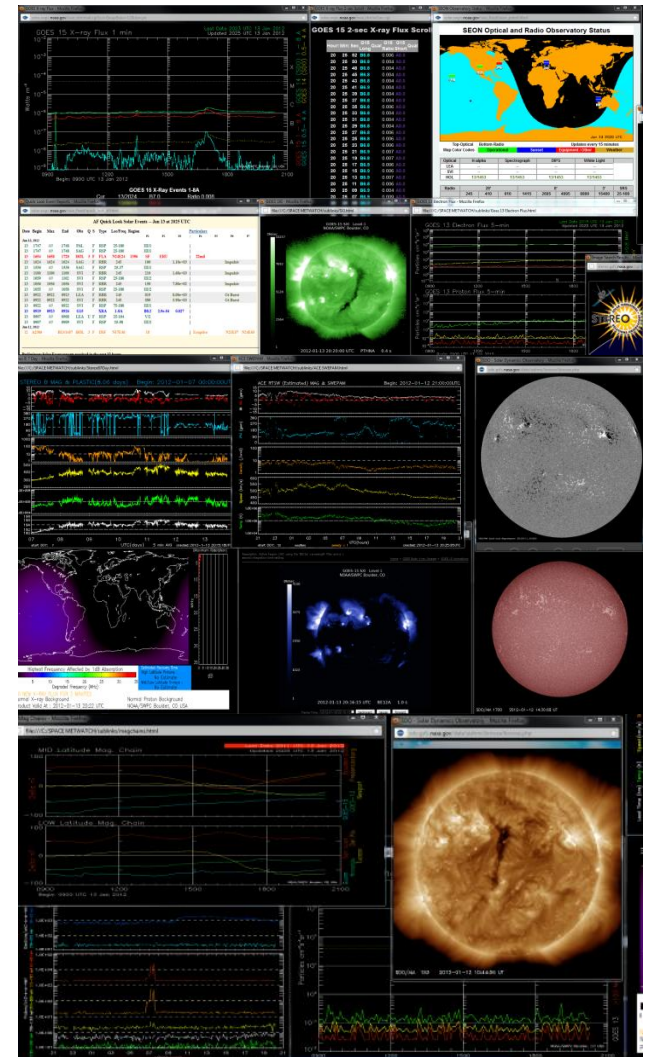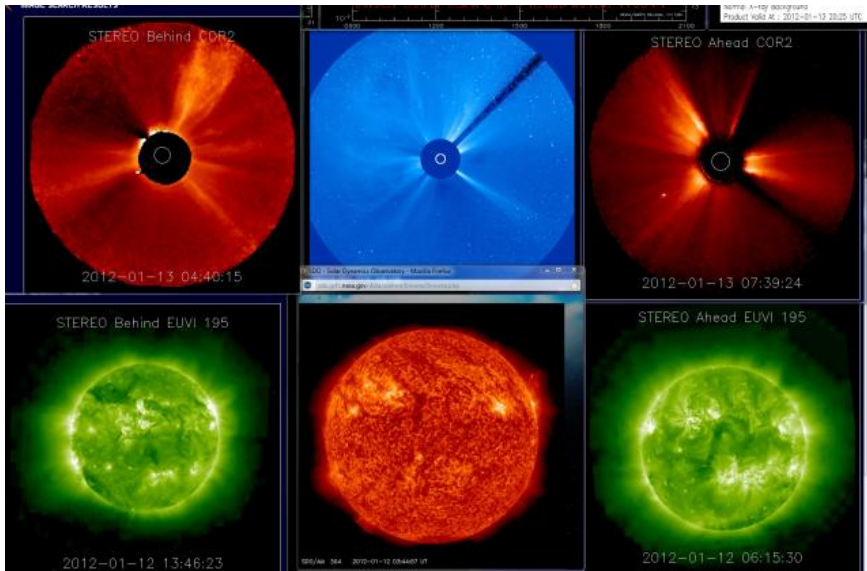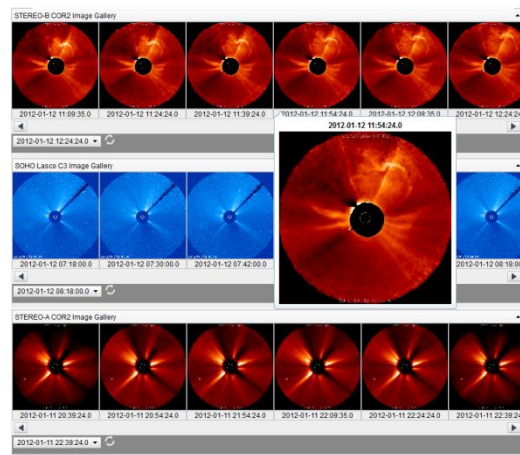
iSWA in AFWA Ops

- **Current Uses**
  - **Primarily a SSA tool**
  - **Many of the same capabilities as current display**
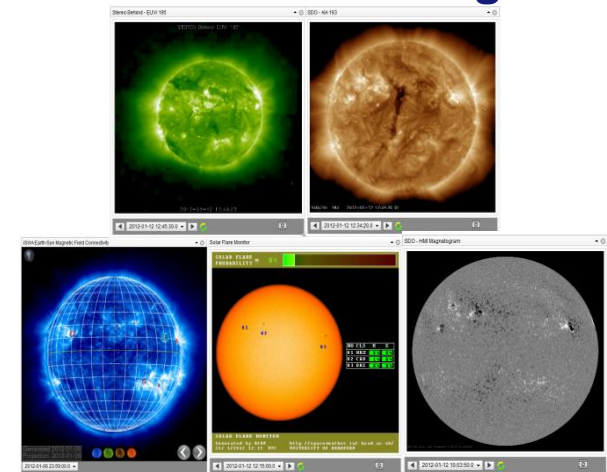 - **Coronagraph galleries useful for CME detection/tracking**

Data Monitoring

CME Detection

Solar Monitoring

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**
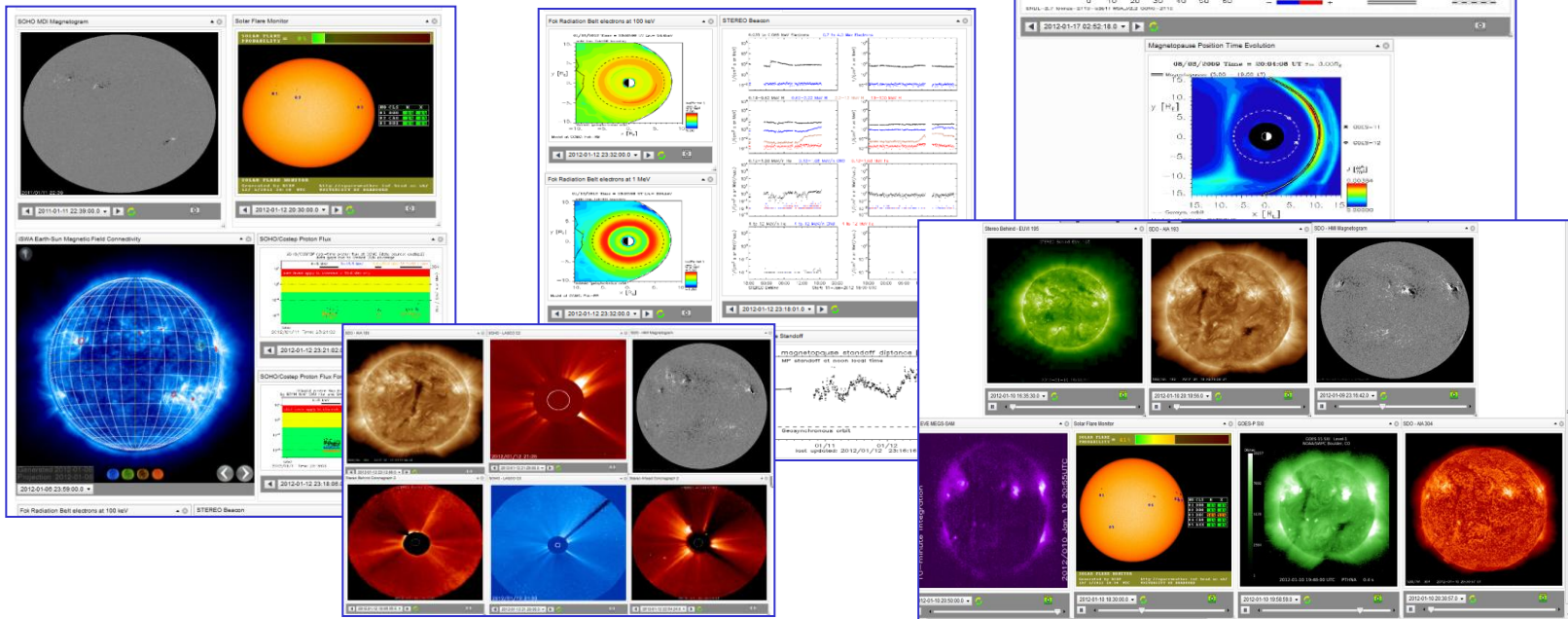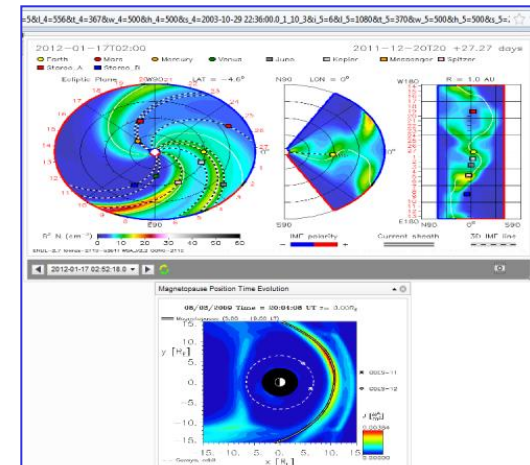 - **More model output - i.e. AFWA current ops models**

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**

CME Forecasting

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

Zoom functionality

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: Rmin(Re) = 5.4

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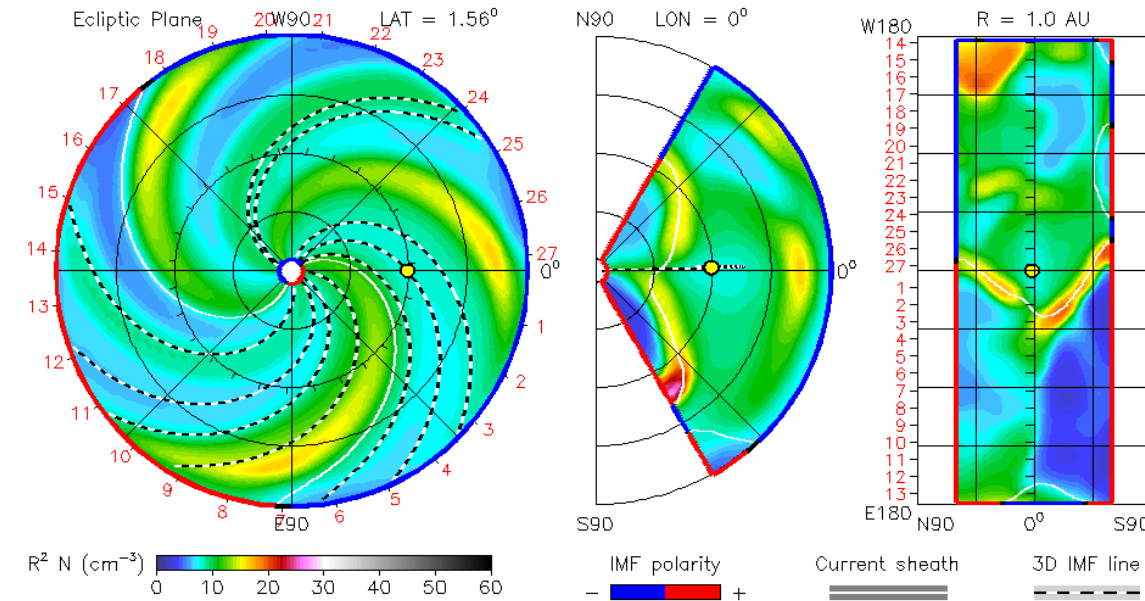
CME Forecasting

- **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**

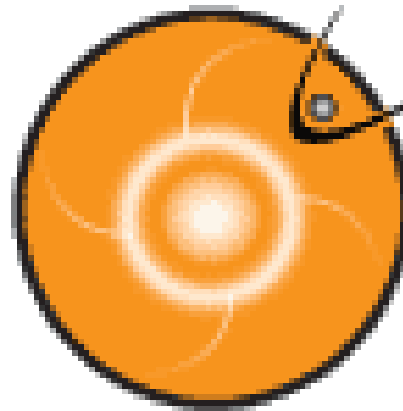# *Questions?*

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