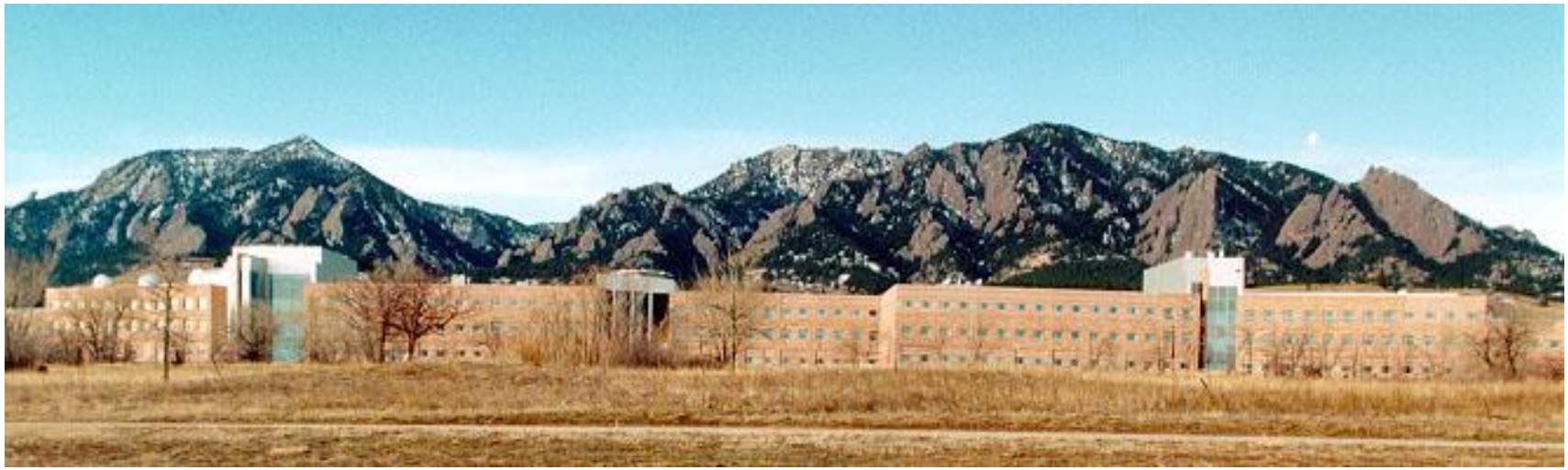


# *NOAA Operational Space Env Monitoring*

## Paper J1.2 - AMS

**W.F. Denig[1] & P Mulligan[2]**

**[1]National Geophysical Data Center**

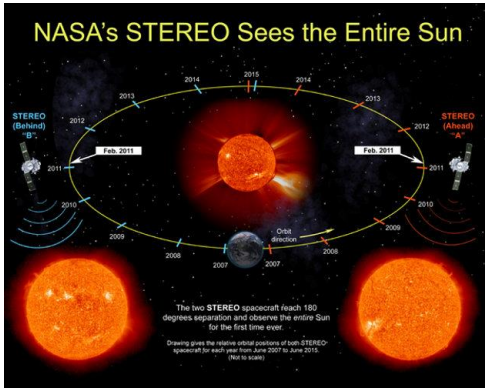
**[2]Office of Systems Development**

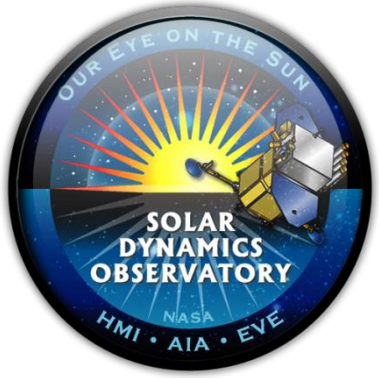
Wednesday, 05 Feb 14 / 4:15 PM / Rm C111

# NOAA Operational Space Weather

## Data Used in SWx Operations

**The NOAA Space Weather program relies on a variety of NOAA (top) and non-NOAA (bottom) satellite assets to conduct its operational mission**



# GOES Environmental Data

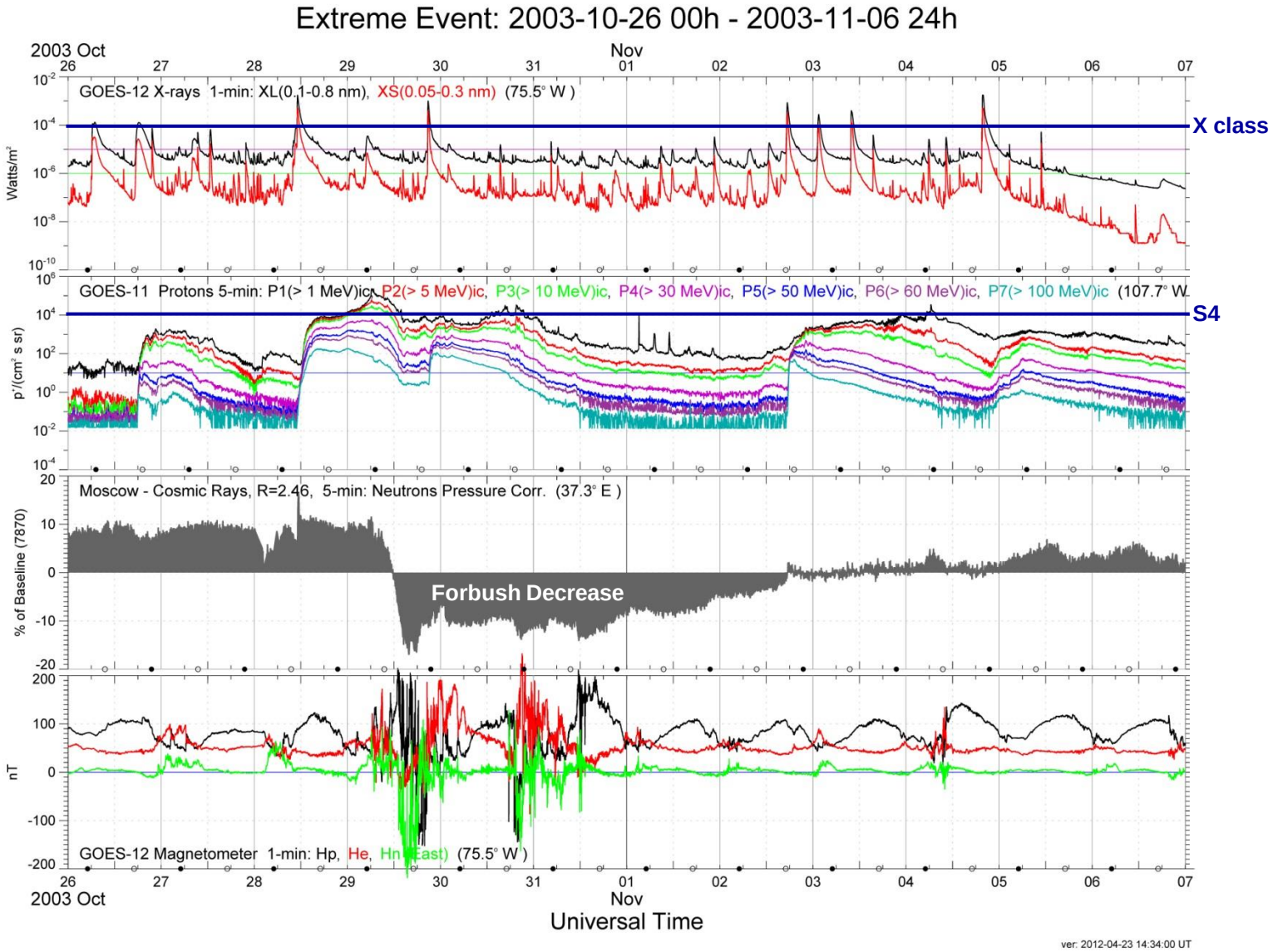
## 40 Years of Geostationary Measurements

Solar X-Rays

Proton Events

Cosmic Rays (non-GOES)

Magnetic Field

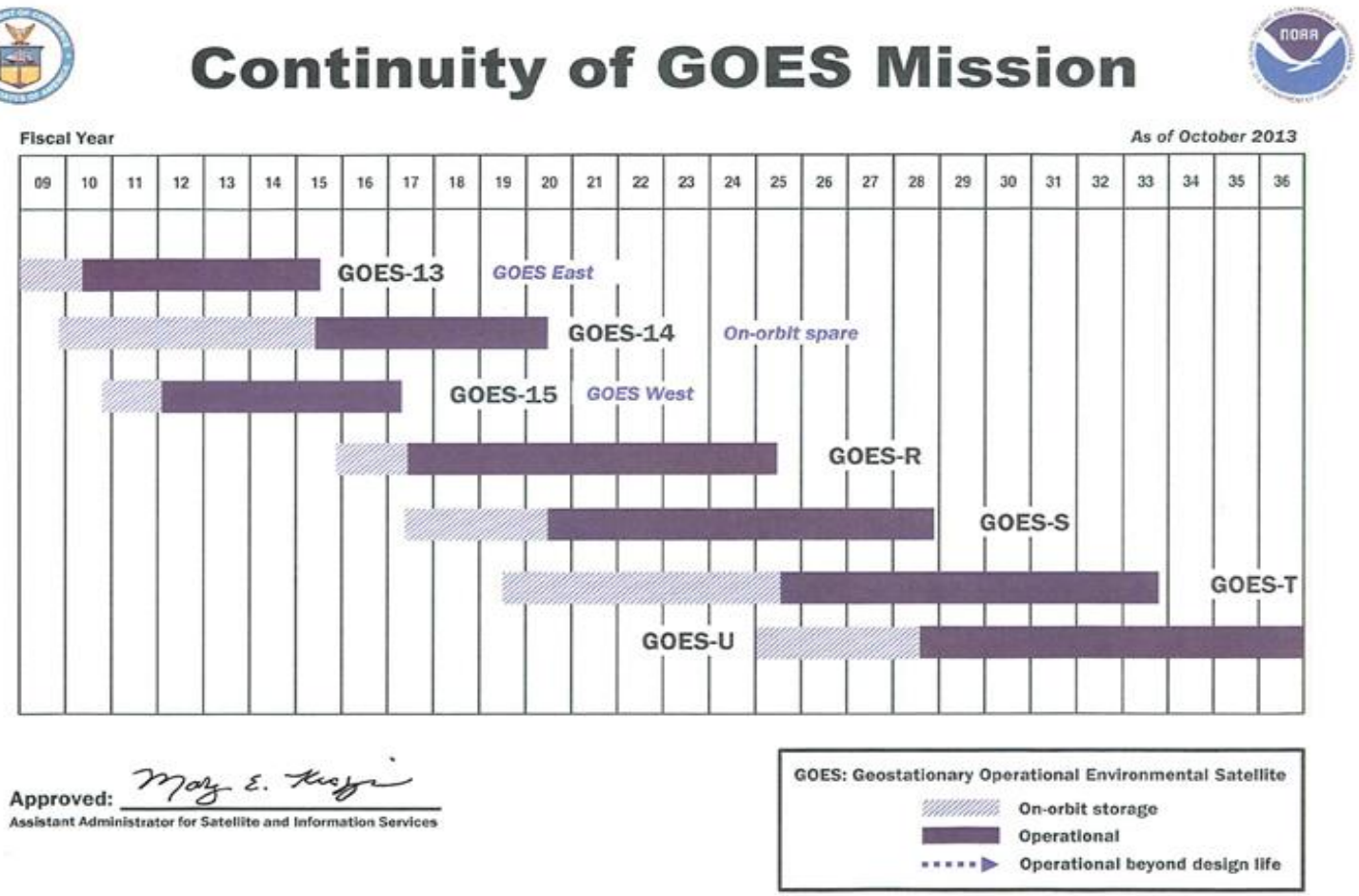





http://www.ngdc.noaa.gov/stp/satellite/goes/index.html

# Continuity of GEO Measurements

## Transitioning to GOES-R/S/T/U



# GOES-R (R/S/T/U) Series
## Improved SWx Capabilities

The GOES-R series space/solar sensors provide incremental improvements to current NOAA GEO space weather monitoring. First launch date of the GOES-R series is late 2015 / early 2016.

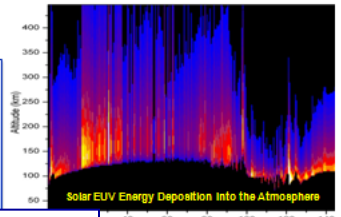
Credit: Lockheed-Martin

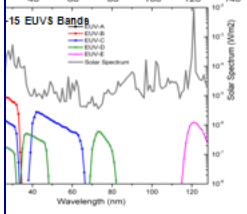
### Solar X-Ray Sensor (XRS)

- Measures the irradiance (total brightness) of the sun in two x-ray channels
  - 0.05 to 0.4 nm
  - 0.1 to 0.8 nm
- Provides a first alert of impending solar storms and space weather events.
- Observes solar flares and provides absolute brightness information.
- Drives space weather scales and operational models.

### Solar Extreme Ultra-Violet Sensor (EUVS)

- Observations of the Solar EUV Spectrum from 5 to 125 nm
- Provides solar EUV input to thermosphere and ionosphere models which provide specification and forecasts
- Models provide specification and



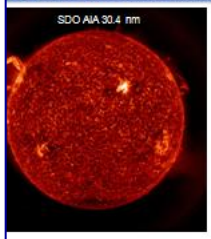

### Solar Ultra-Violet Imager (SUVI)

**Completely Different than GOES NOP:**
- GOES NOP SXI observes in x-rays (0.6-6 nm)
- SUVI will observe in the Extreme Ultra-Violet (EUV) (10-30 nm)

**Narrow band EUV Imaging:** Permits better discrimination between features of different temperatures
- 30.4 nm band adds capability to detect filaments and their eruptions
- 6 wavelengths (9.4, 13.1, 17.1, 19.5, 28.4, and 30.4 nm) 2 minute refresh for full dynamic range

**SUVI will provide**
- Flare location information (Forecasting event arrival time and geo-effectiveness)
- Active region complexity (Flare forecasting)
- Coronal hole specification (High speed solar wind forecasting)

provides improved proxy data:
many pixels as SUVI
cadence
in 8 EUV bands, 5 of which match SUVI exactly




### Space Environment In-situ Sensor Suite SEISS

*Four Subsystems*
*Measuring Electrons, Protons, and Heavier Particles*

**MPS-Low: Spacecraft charging, ground-induced currents (electric power grid)**
- 30ev-30keV electrons
- 30ev-30keV protons
- 14 angular bins

**MPS-High: Spacecraft charging, deep dielectric charging**
- 40keV-4MeV electrons
- 80keV-10MeV protons
- 10 energy bands at 5 angles

**SGPS: Solar Energetic Particle events (SEP), solar radiation storms (protons), HF communication (airlines), astronaut radiation, satellite degradation.**
- 1 MeV-500MeV protons
- 4MeV-500MeV alphas
- 10 energy bands at 2 angles

**EHIS: Satellite single event upsets, astronaut radiation**
- 10MeV/nucleon-200MeV/nucleon
- Distinguishes H, He, C-N-O, Ne-S and the Fe group, Z=17-28
- 5 energy bands

**SEISS Algorithms**
- **SEISS.16**: One-minute averages - all MPS channels
- **SEISS.17**: Five-minute averages - all MPS and SGPS channels
- **SEISS.18**: Convert differential proton flux values to integral flux values
- **SEISS.19**: Density & temperature moments & level of spacecraft charging
- **SEISS.20**: Event detection based on flux values

25

Increased # of wavelength bands

Solar UV imagery versus soft x-rays

Improved particle energy coverage

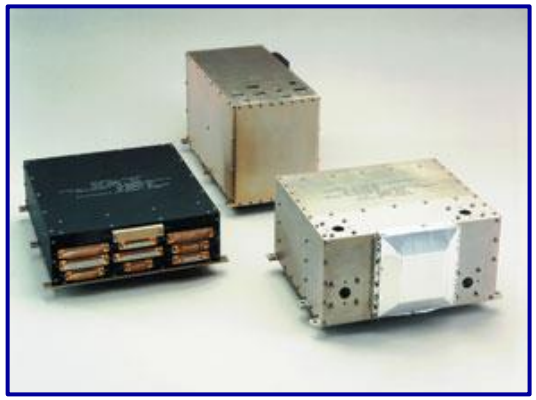
**Not shown: GOES-R Magnetometer**

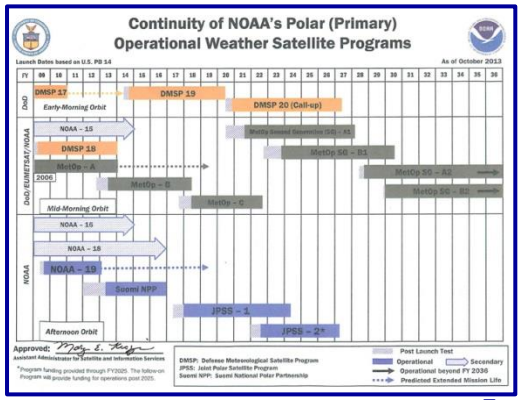
# An End of an Era (since 1978)

## LEO Space Environmental Monitor (SEM)

http://www.ngdc.noaa.gov/stp/satellite/poes/index.html

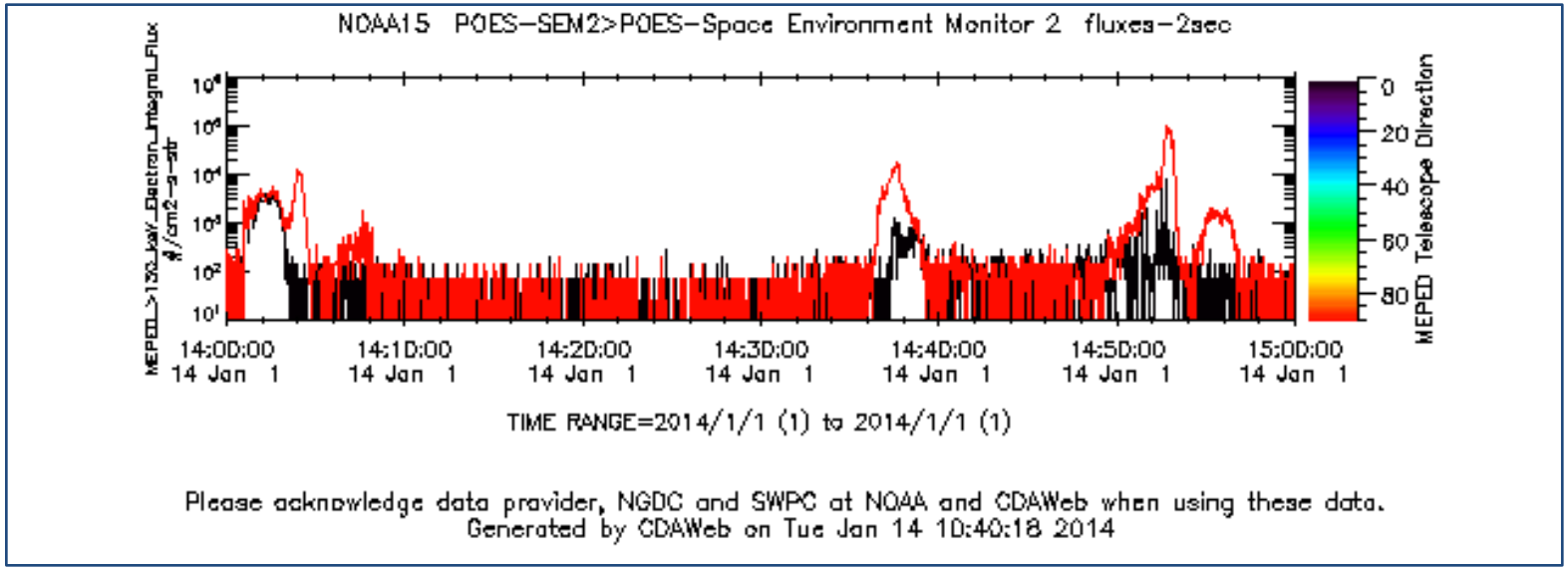
- NOAA-19 is the last NOAA satellite in polar LEO to provide operational SWx data
  - NOAA-19 Extended EOL – CY19
  - NOAA-15/16/18 still provide SEM data
- European MetOp satellites carry NOAA SEM-2 packages
  - MetOp A – CY2006 – 2014 (SEM-2)
  - MetOp B – CY2013 – 2018 (SEM-2)
  - MetOp C – CY2018 – 2022 (SEM-2)





# Secondary Provider

## Coordinated Data Analysis Web




***New NOAA datasets will soon be available via CDAWeb***

**NOAA15/16/18/19; MetOp-A/MetOp-B**

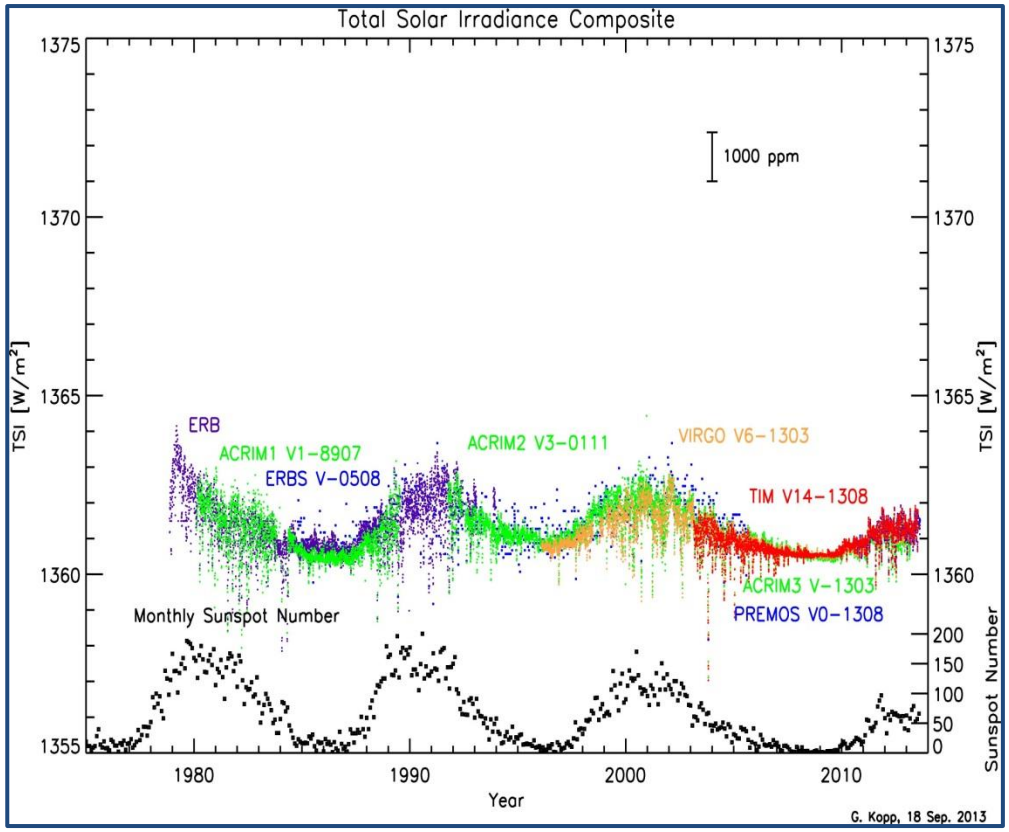
| | | |
|---|---|---|
| **MEPED:** | **e: >40; >130; >287; >612 keV** | **integral energy flux** |
| | **p: 39; 115; 332; 1105; 2723 keV** | **differential energy flux** |
| **TED:** | **e: 50 eV – 1 keV; 1 keV – 20 keV** | **channel energy flux** |
| | **p: 50 eV – 1 keV; 1 keV – 20 keV** | **channel energy flux** |

**Contact Rob Redmon or Bob McGuire for details**

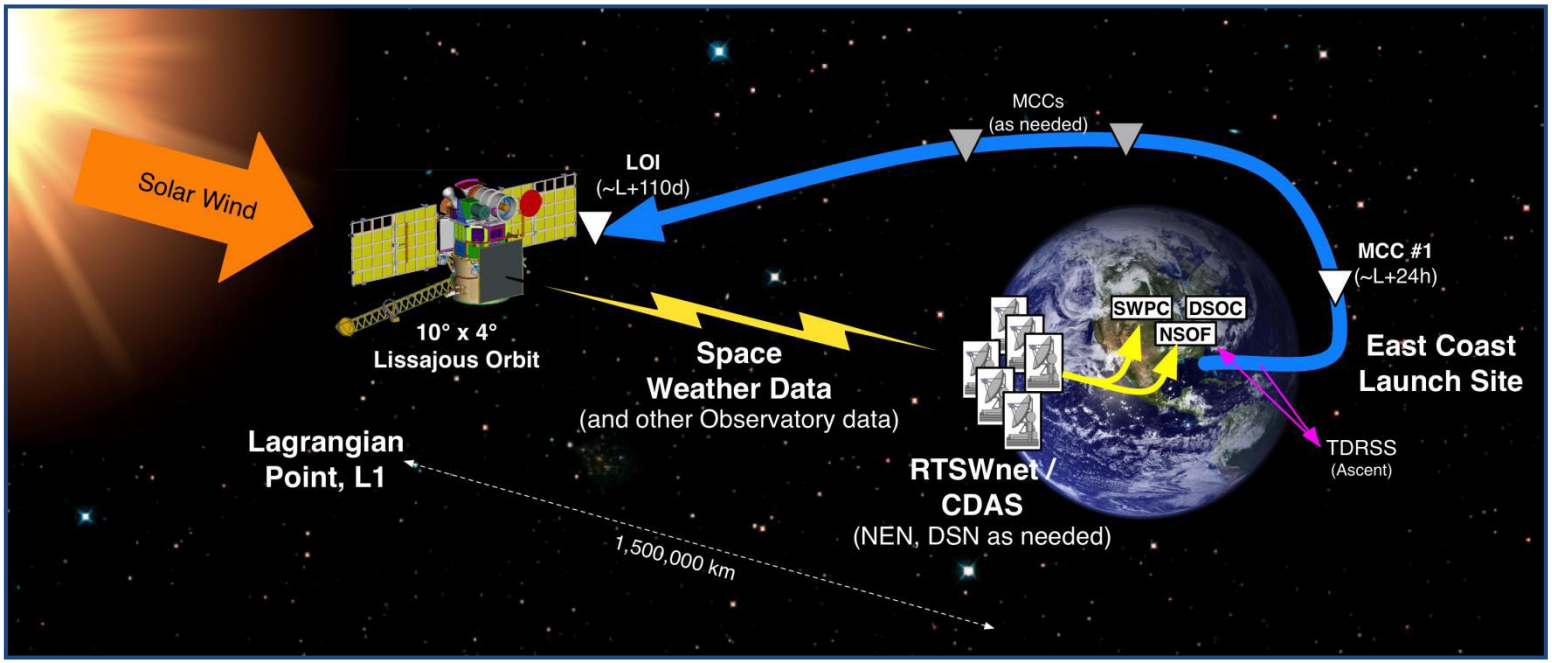
# Total Solar Irradiance

## TSI Calibration Transfer Experiment (TCTE)

TCTE was launched on the Air Force's STP-Sat3 on 19 Nov 2013 and put into a planned 500-km, 40-deg inclination orbit. After commissioning and outgassing, data acquisition started on 13-Dec with at least 1 orbit/day of solar observations. Overlapping Total Solar Monitor (TIM) measurements with SORCE were made in late December. Strategies for a F/O TSI mission under consideration.



# New Capability
## Operational SWx Data from L1

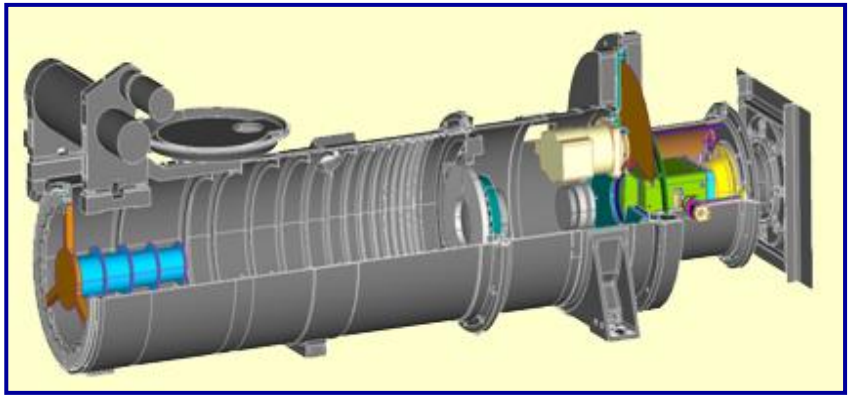


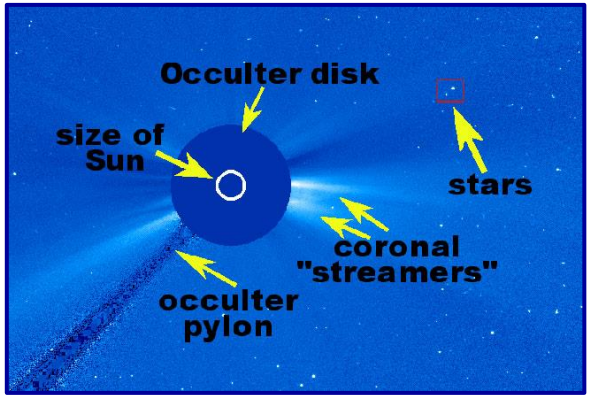

- The DSCOVR spacecraft will measure the solar wind ($n_p$, $v_p$, $t_p$) and the interplanetary magnetic field at 240 $R_e$ forward of the earth
- Space-X Falcon 9 launch scheduled for 13 Jan 2015; DSCOVR on-station in 110 days
- DSCOVR solar wind/IMF data downlinked via the Real-Time Solar Wind Network (RTSWnet) as is currently done for ACE
- SWPC provides real-time data / NGDC provides retrospective data (>1 day)

**SWPC plans to host a NOAA Solar Wind and L1 Requirements Workshop**
**06-07 April 2014 in conjunction with the Space Weather Workshop**
**Contact Doug Biesecker for details**

# Continuing Studies
## Compact Coronagraph (CCOR)

**NOAA currently uses SOHO coronagraph to detect and characterize coronal mass ejections (CMEs)**



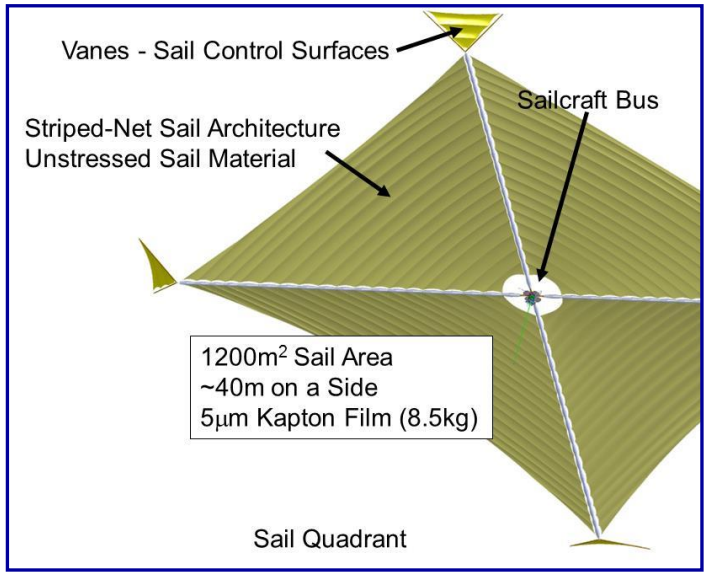


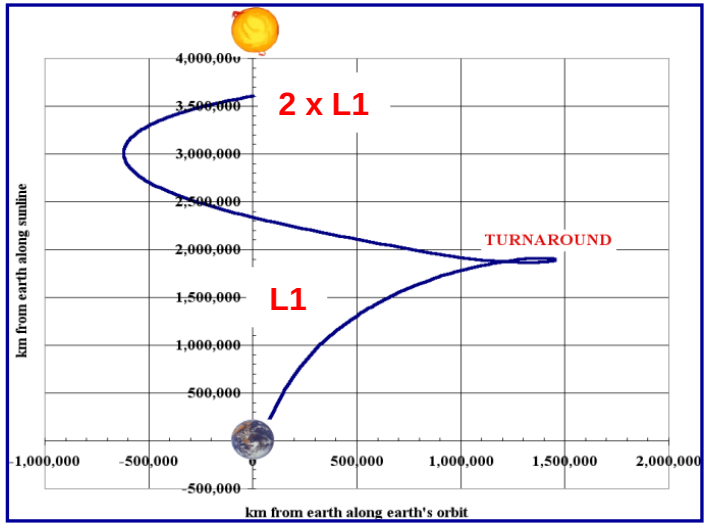

- CCOR design offers reduced sensor mass and volume at lower cost
  - 6 kg telescope, 17 kg for sensor
  - Optical train is 1/3 length of traditional coronagraphs & uses multiple occulters
- NRL completed Phase A study & successfully bench tested the optical design
- NOAA will continue to fund risk reduction studies at NRL during FY13-14
- CCOR ranked in DoD Space Experiments Review Board for STP launch
- CCOR under consideration for DSCOVR follow-on mission options

# Technology Demonstration

## Sunjammer – Solar Sail Demonstration

- Sunjammer is a NASA technology demonstration mission (TDM) to examine the propellantless propulsion potential of solar sails
- Mission will demonstrate sail maneuvers in its first 30 days – then fly to 2 x L1 and then out of the ecliptic plane if within orbital constraints
- NOAA plans to partner with NASA to provide data reception, analysis and archive
- Space weather instruments:
  - Particle spectrometer – MSSL
  - Magnetometer – Imperial College London
- Previously co-manifested with DSCOVR – now looking for a GEO-transfer launch



# DSCOVR Follow-on

## Operational Solar Wind / CME Imagery Missions

**NOAA is committed to continued solar wind/CME monitoring**

Solar Wind – Commercial and other options:

- Evaluate Sunjammer mission performance data for improved space weather forecasts
- Evaluate business case for Sunjammer commercial data buy option
- Examine sensor concepts for improved sensor performance
- Refresh cost estimates for other options such as government satellites

CME Imagery

- Continue CCOR risk reduction studies at NRL
- Pursuing STP launch option
- Include CME imagery option in DSCOVR follow-on studies

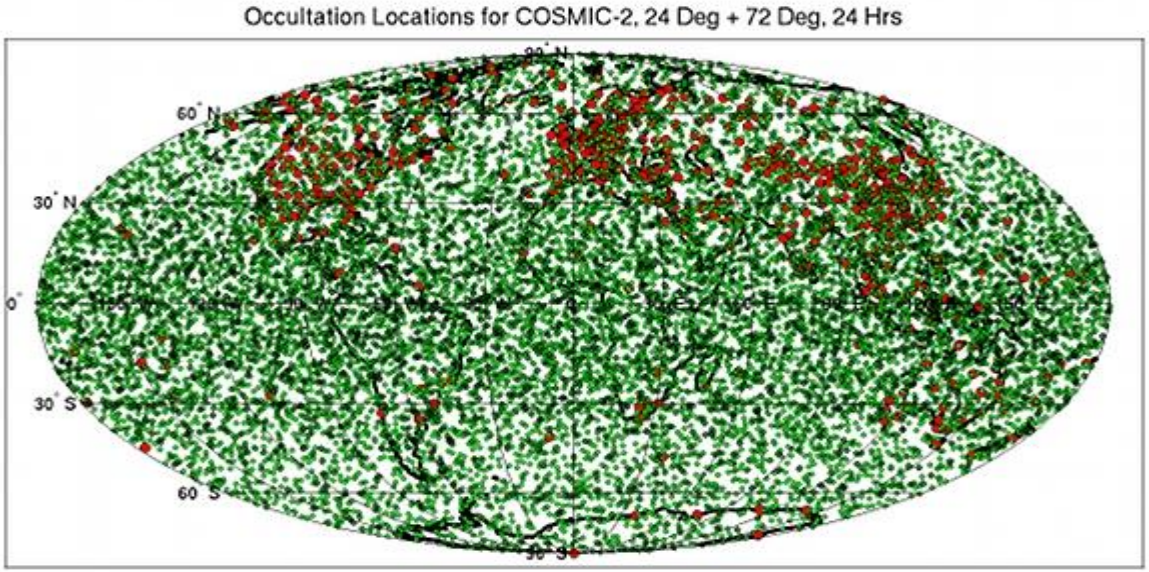
NOAA Solar Wind and L1 Requirements Workshop (Pre-announcement)

- 06-07 April 2014 – Boulder, Colorado (just before Space Weather Workshop)
- If interested, send an e-mail to Doug Biesecker (doug.biesecker@noaa.gov**)**

# New Capability
## GNSS Radio Occultation – COSMIC II

Constellation Observing System for Meteorology, Ionosphere & Climate

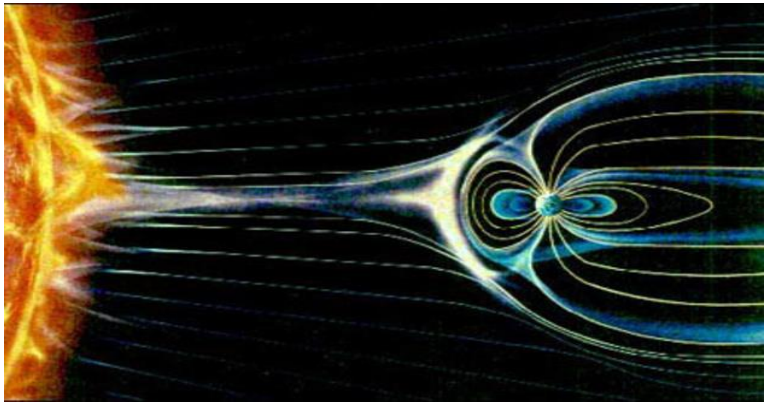
- Taiwan-USAF-NOAA Partnership
- 12 satellite constellation – 6 @ 24$^{o}$ inclination (low) / 6 @ 72$^{o}$ inclination (high)
- Phase 1 launch planned for March 2016 – low inclination; Phase 2 launch - >2018
- NOAA coordinating with international partners to host/operate ground receptors
- Full up constellation will acquire more than 8000 ionospheric soundings per day

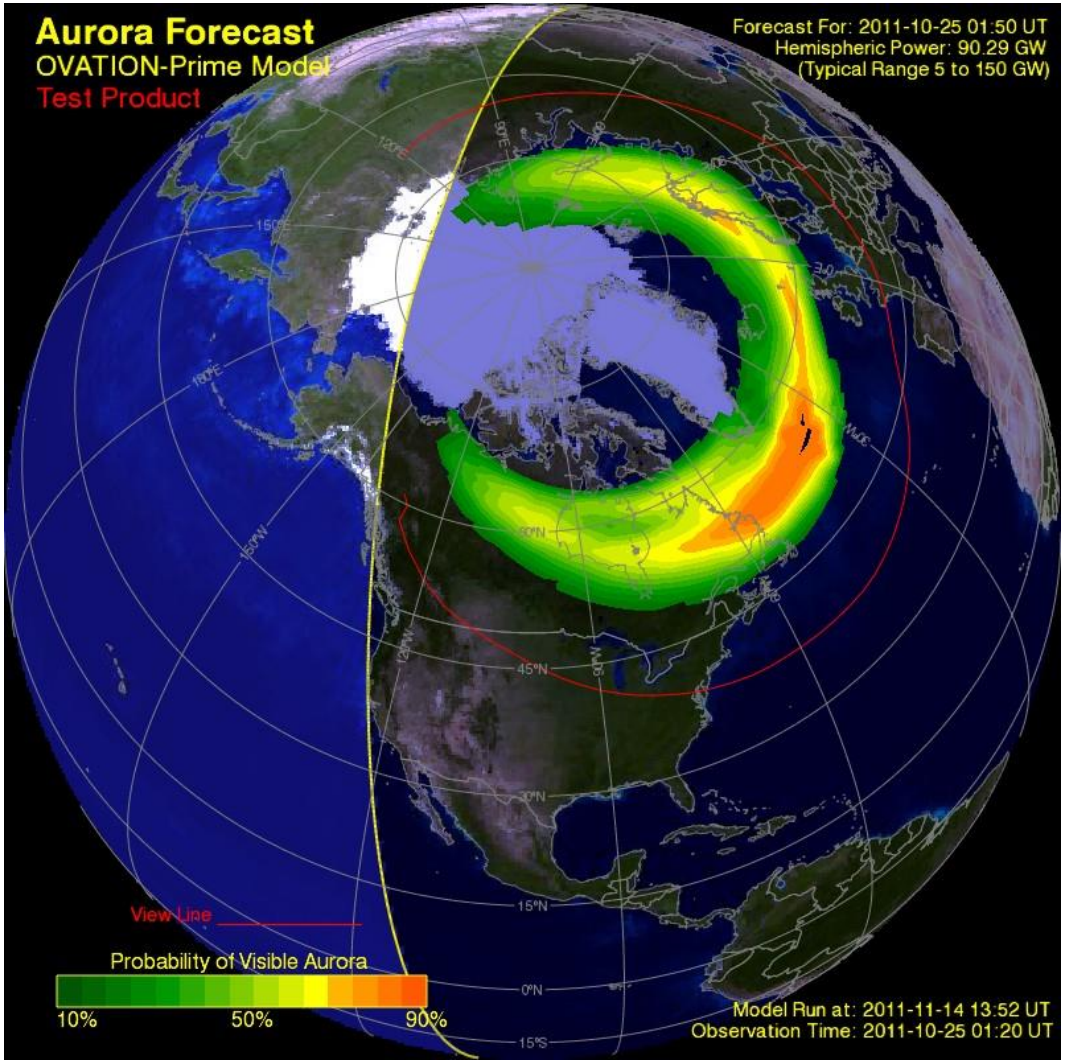


# Expanded Products & Services

## Ovation Auroral Forecast Model

- Methodology developed at JHU/APL
  - 30-40 min forecast driven by ACE solar wind and interplanetary magnetic field data – ops will transition to DSCOVR
  - Model currently running in real-time at NGDC – link
  - Customer products available from SWPC – link
- Plans:
  - Transition Ovation to full operations in March 2014
  - Test & implement model upgrades for reduced noise and capability to handle larger storms



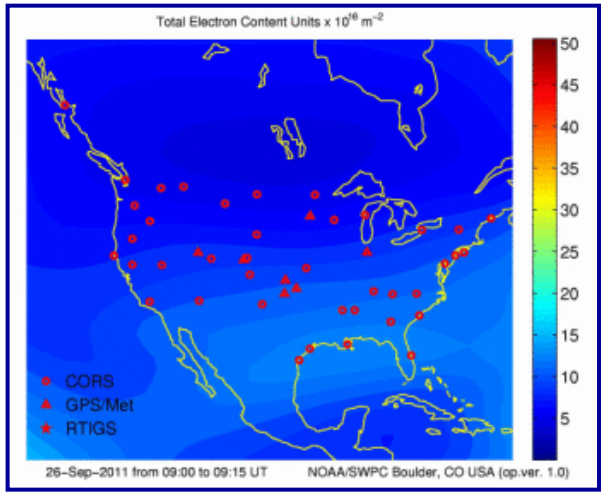



Send comments to Rod Viereck (SWPC)

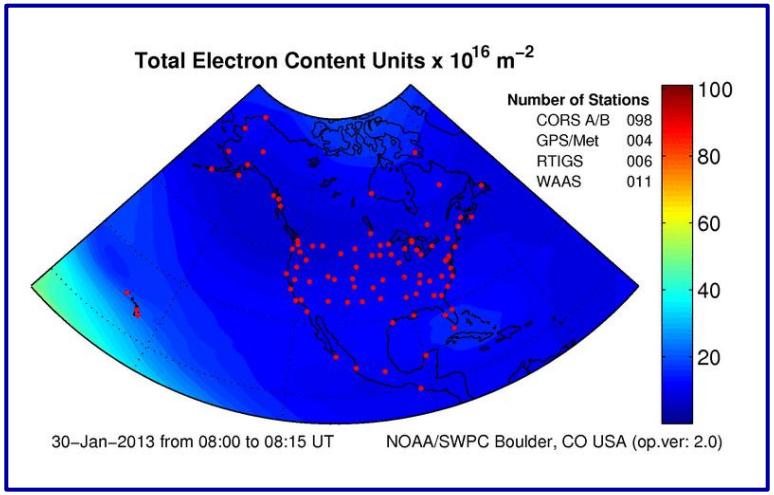
# Expanded Products & Services

## North America TEC

### *Extending current US-TEC product to NA-TEC*

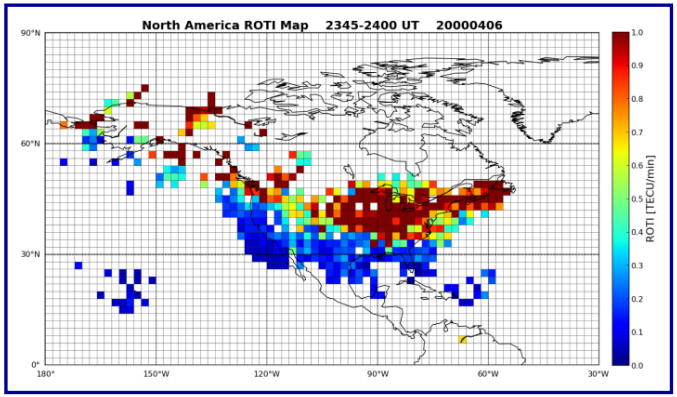



**Research to Operations**



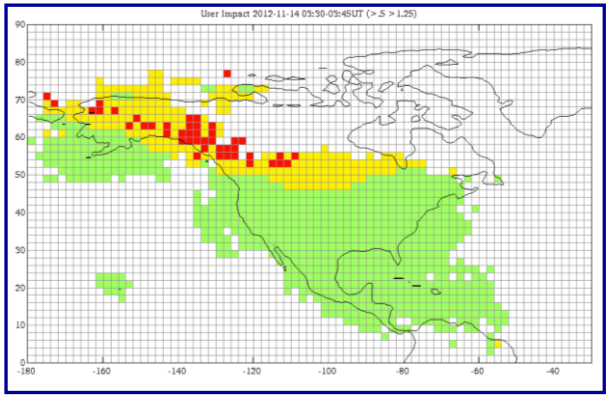

### *Related products*

**Rate of TEC Index Product**




**Research and Development**

**GPS Scintillation Specification**

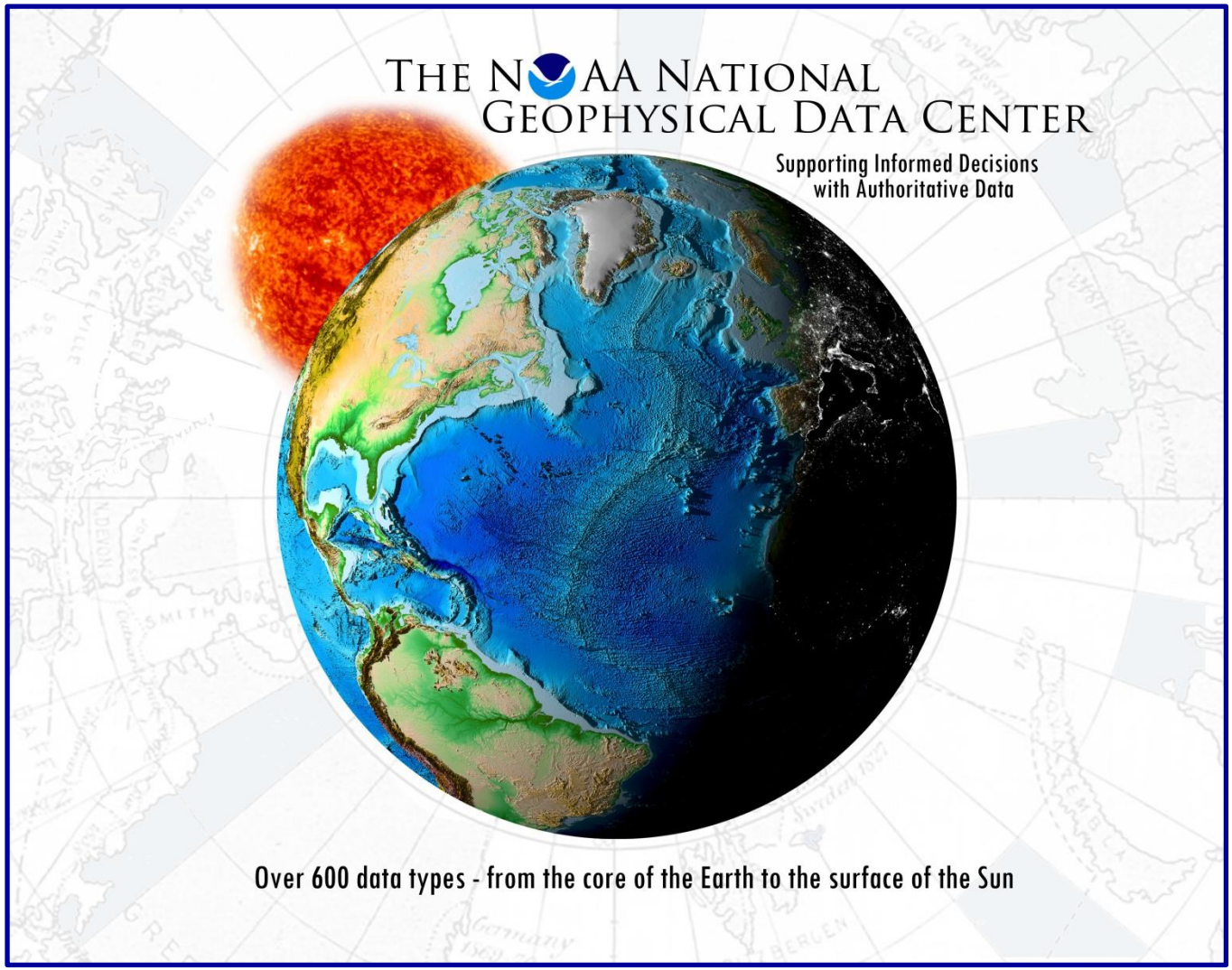


# Expanded Products & Services

## Summary – Take Aways

- NOAA currently provides a variety of operational space weather data and products from its existing fleet of environmental satellites (GOES and POES/MetOp)
- GOES-R/S/T/U will continue to acquire GEO measurements through 2036
- After POES/MetOp there are no planned operational (or otherwise) satellites acquiring particle/radiation data in LEO – possible AF initiative (HEALER – Joe Mazer/Aerospace)
- New near-term NOAA operational sources of space weather data include DSCOVR at the L1 Lagrange location and COSMIC-II in LEO – Sunjammer & DSCOVR follow-on are also in the mix
- NWS/SWPC has new products and services coming on line

# Thank You!


THE NOAA NATIONAL
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with Authoritative Data
Over 600 data types - from the core of the Earth to the surface of the Sun