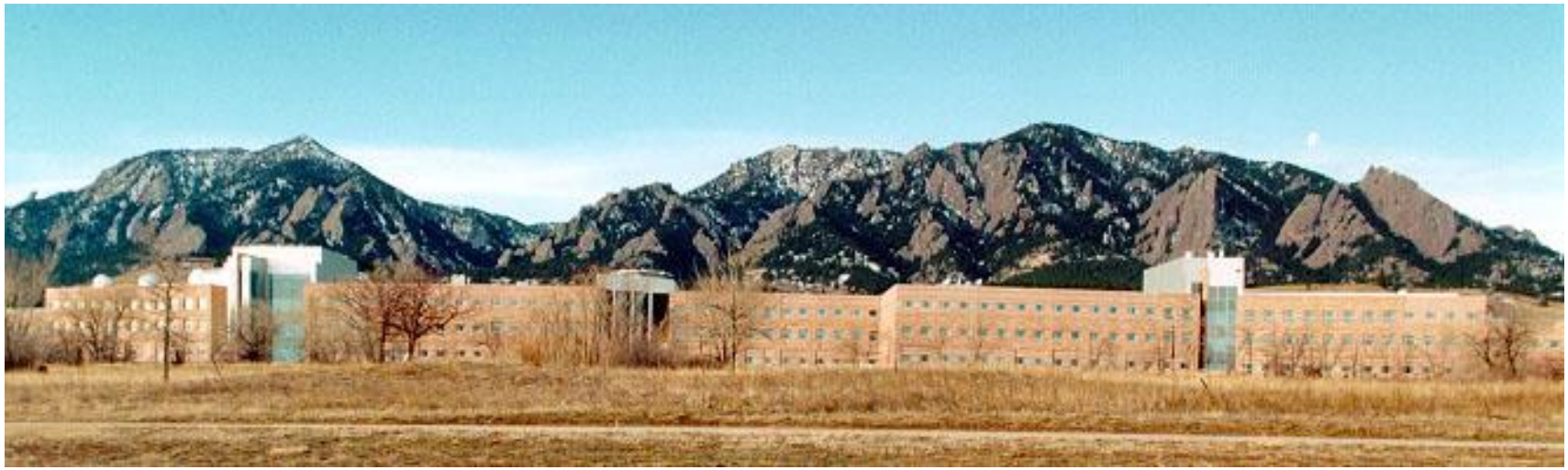


NOAA Satellites – Current & Future

W. Denig[1], R. Redmon[1] & P. Mulligan[2]

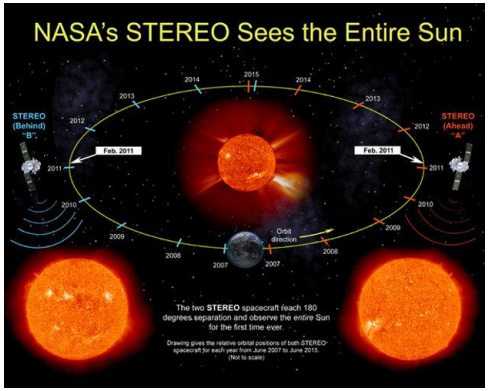
[1]National Geophysical Data Center

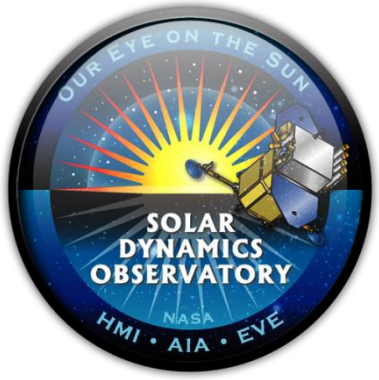
[2]Office of Systems Development

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

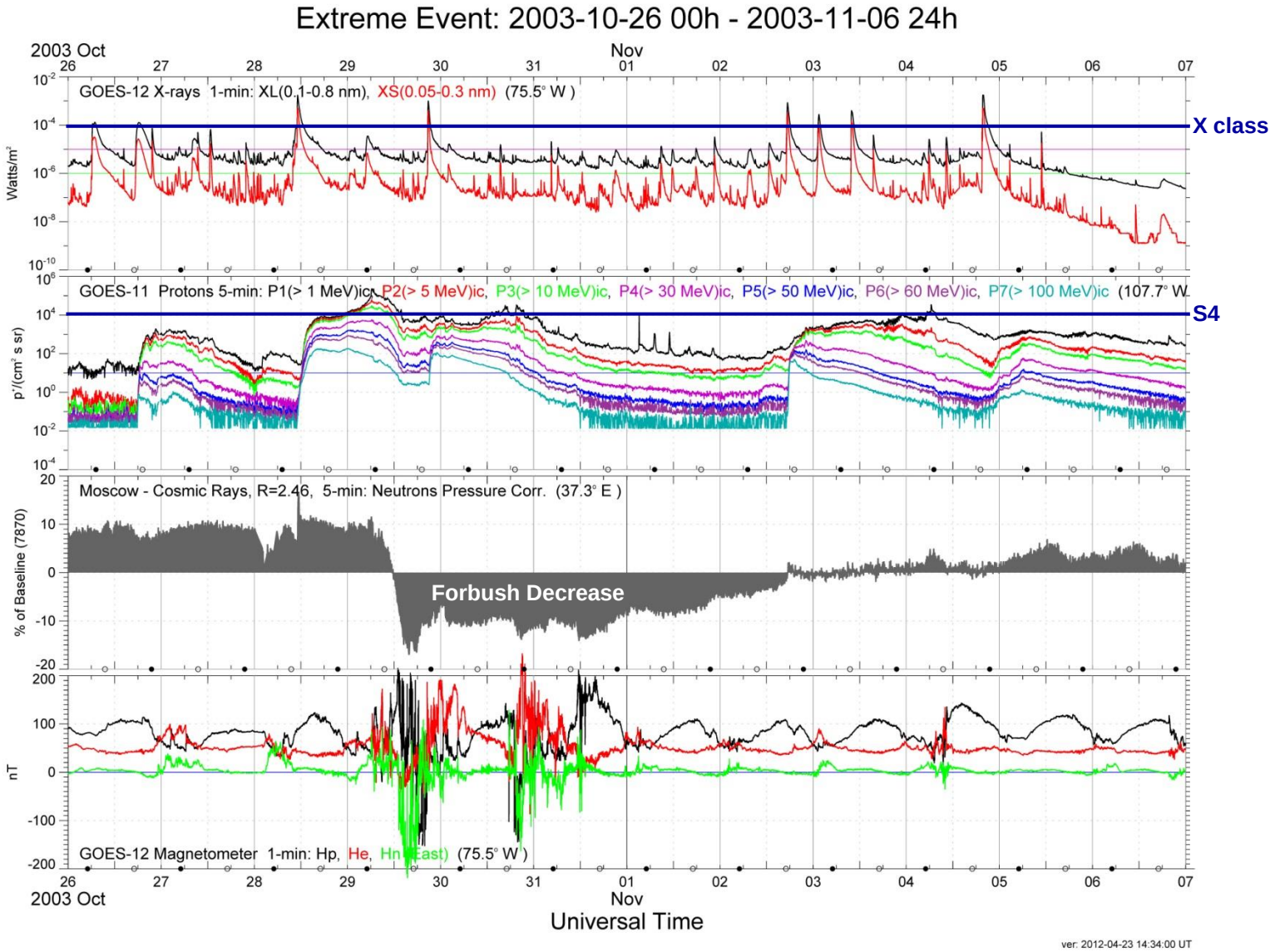
40 Years of Geostationary Measurements

Solar X-Rays

Proton Events

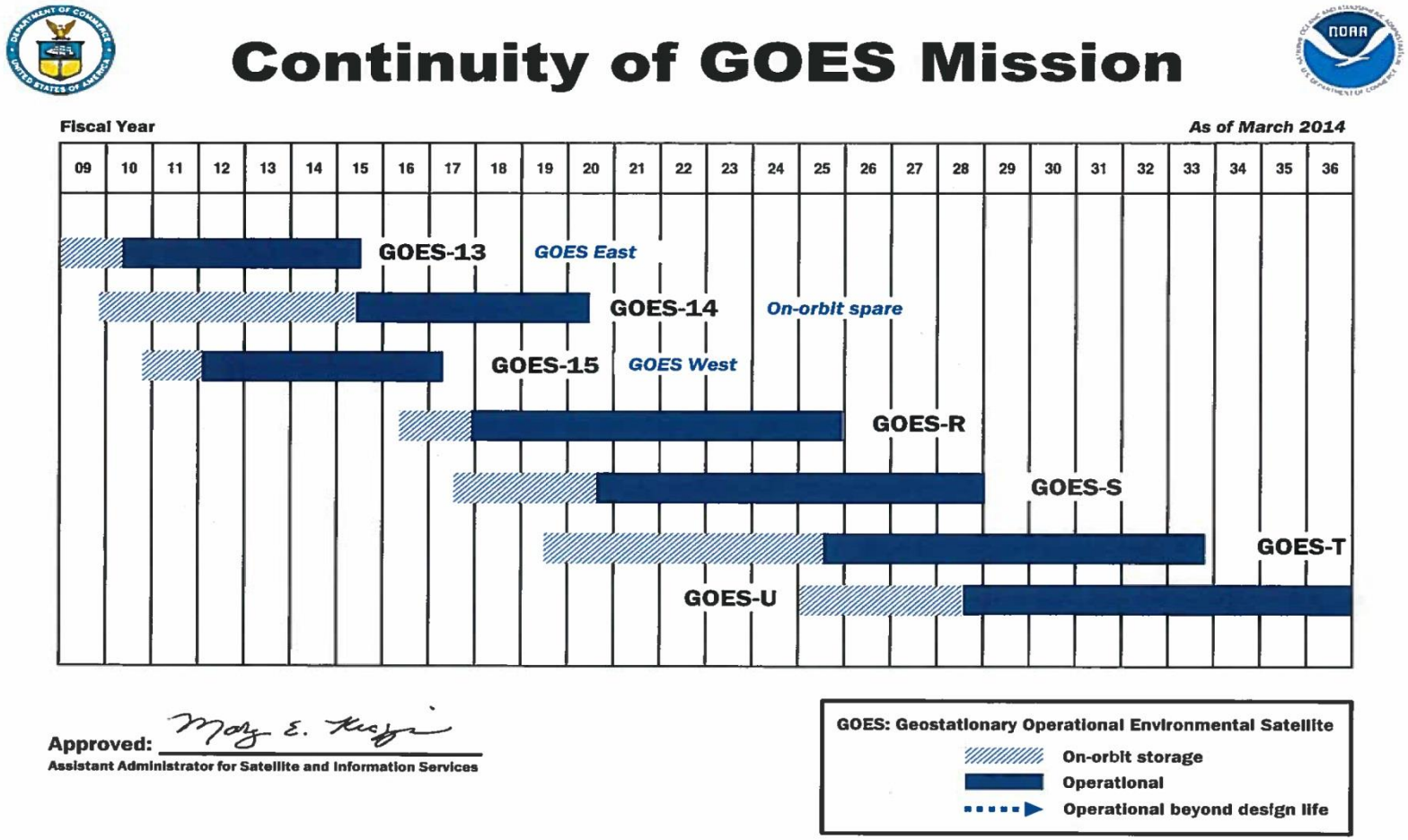
Cosmic Rays (non-GOES)

Magnetic Field



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. The first launch date of the GOES-R series is late 2015.

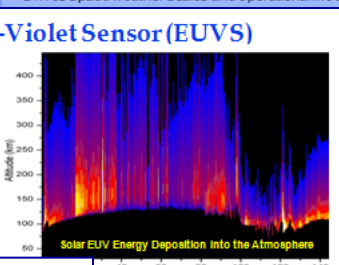
Credit: Lockheed-Martin

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



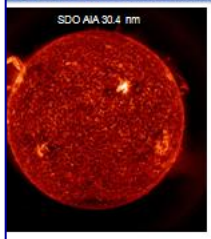
Solar Ultra-Violet Imager (SUVI)

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

Increased # of wavelength bands

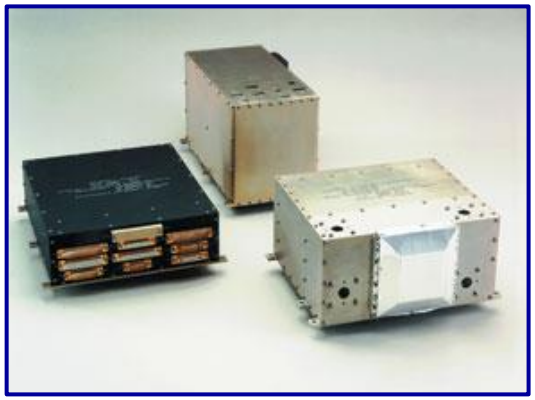
Solar UV imagery versus soft x-rays

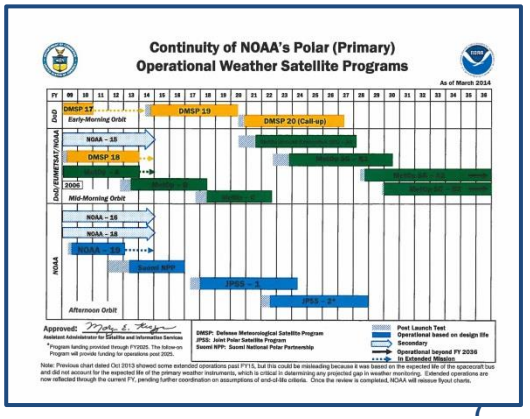
Improved particle energy coverage

Not shown: GOES-R Magnetometer

~~Continuity of LEO Measurements~~
An End of an Era (since 1978)

- NOAA-19 is the last NOAA satellite in polar LEO to provide operational SWx data
- European MetOp satellites carry NOAA Space Environmental Monitor (SEM) packages
  - MetOp A – CY2006 – 2012 (SEM)
  - MetOp B – CY2012 – 2017 (SEM)
  - MetOp C – CY2016 – 2020 (SEM)
- Data from POES/MetOp will continue to be available through the end of these programs



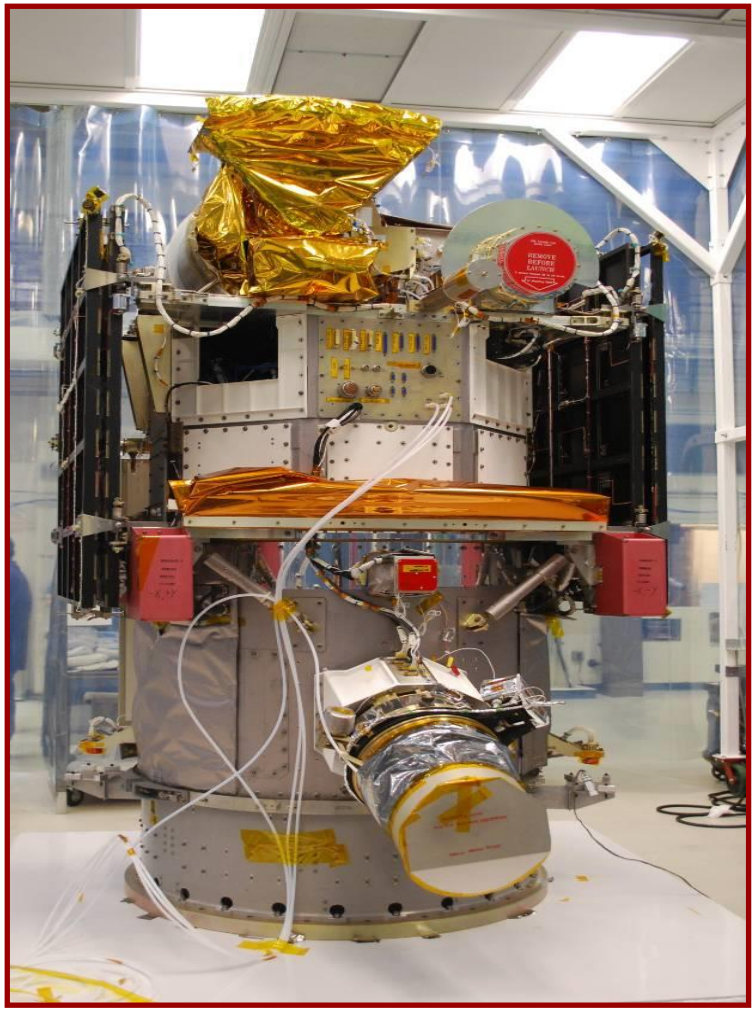


http://www.ngdc.noaa.gov/stp/satellite/poes/index.html

New Capability
Operational SWx Data from L1

NOAA currently relies on the NASA ACE spacecraft to provide advanced warning of hazardous space weather conditions

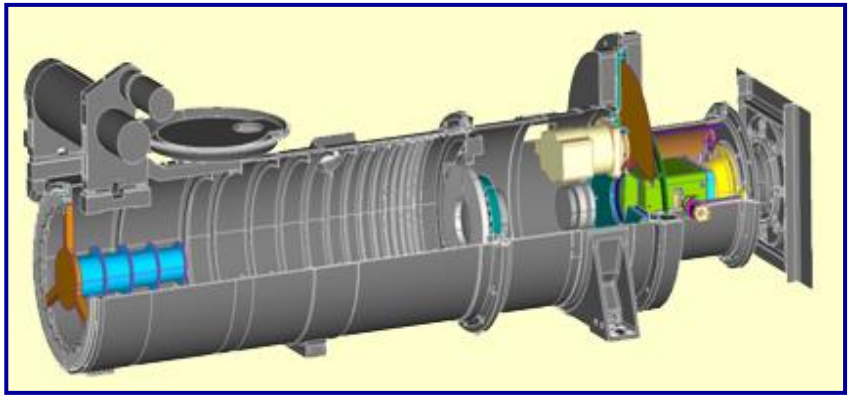
- The DSCOVR spacecraft will measure the solar wind (n_p, v_p, t_p) and the interplanetary magnetic field at 240 R_e forward of the earth
- The DSCOVR spacecraft refurbishment is nearing completion for a launch in Jan 2015
  - ✓ Recalibration of Plas/Mag – complete
  - ✓ Magnetic cleanliness testing – complete
  - ➢ Mag is being relocated to end of boom
  - ➢ Integration phase of the project is beginning
- USAF plans on a Space-X Falcon 9 launch
- DSCOVR solar wind/IMF data downlinked via the Real-Time Solar Wind Network (RTSWnet)
- Mission transfers to NOAA at L+90 days
- Secondary mission – Earth Observations

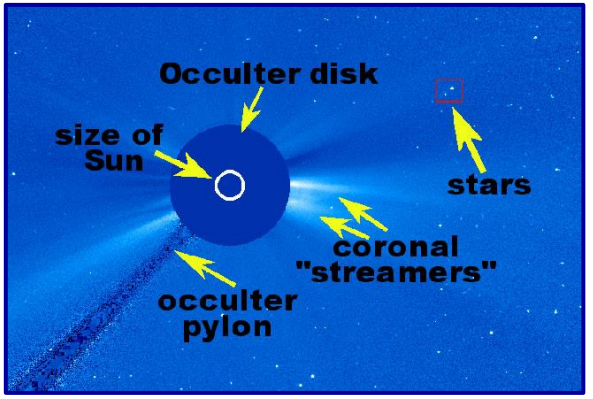


Deep Space Climate Observatory (DSCOVR)

Under Development
Compact Coronagraph (CCOR)

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



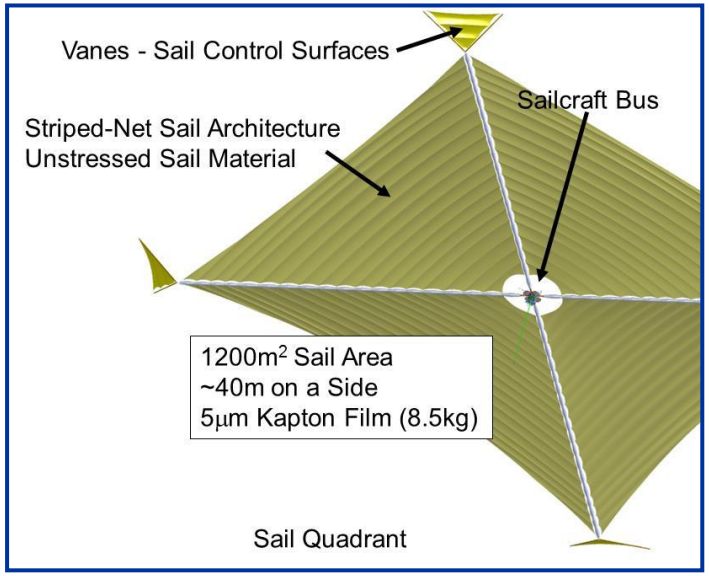


- CCOR design offers reduced sensor mass and volume at lower cost
  - 6 kg telescope, 17 kg for sensor
  - Optical train is 1/3 length of traditional coronagraphs & uses multiple occulters
- NRL completed Phase A study & successfully bench tested the optical design
- NOAA will continue to fund risk reduction studies at NRL
- 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 continue to provide space weather data (possibly at 2x L1 [TBD])
- NOAA plans to partner with L'Garde, Inc to provide data reception, analysis and archive
- Mission is an important indicator for the viability of commercial space missions
- Space weather instruments:
  - Particle spectrometer – MSSL
  - Magnetometer – Imperial College London
- NOAA will assist in evaluating the data



Sunjammer Quadrant Deployment Test 9.30.2013

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; i.e. extending DSCOVR Plas/Mag measurement range
- 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

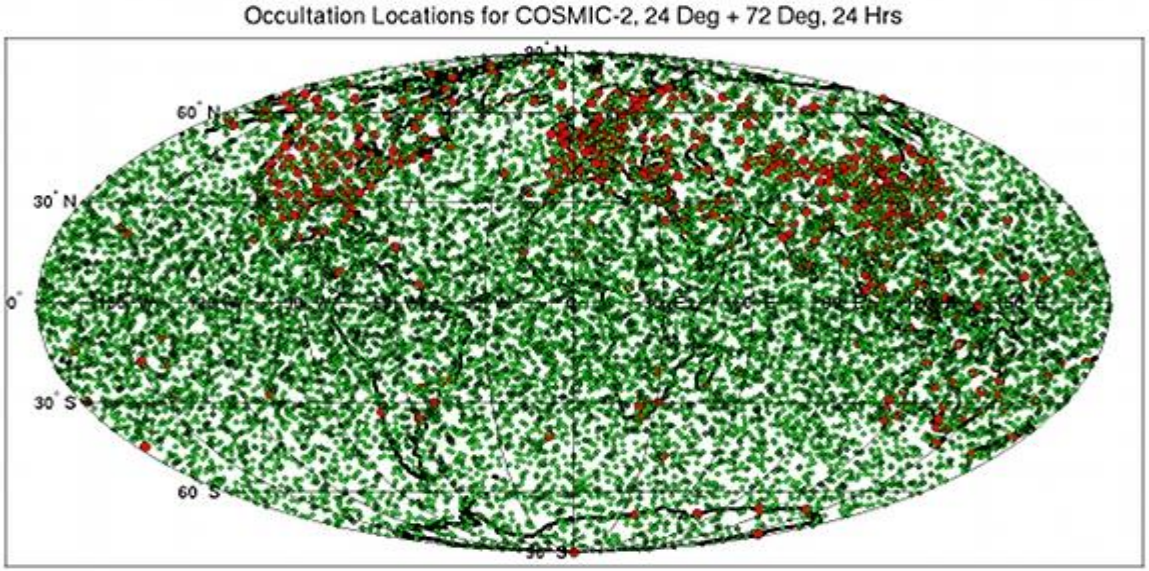
NOAA L1 Requirements Workshop – 7 April 2014 (SWPC/Boulder, CO)

- >60 participants – held in conjunction with Space Weather Workshop
- Meeting report to be released [*TBD*]

New Capability
GNSS Radio Occultation – COSMIC 2

Constellation Observing System for Meteorology, Ionosphere & Climate (COSMIC 2)

- Taiwan-USAF-NOAA Partnership
- 12 satellite constellation – 6 @ 24^{o} inclination (low) / 6 @ 72^{o} inclination (high)
- Phase 1 launch planned for May 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

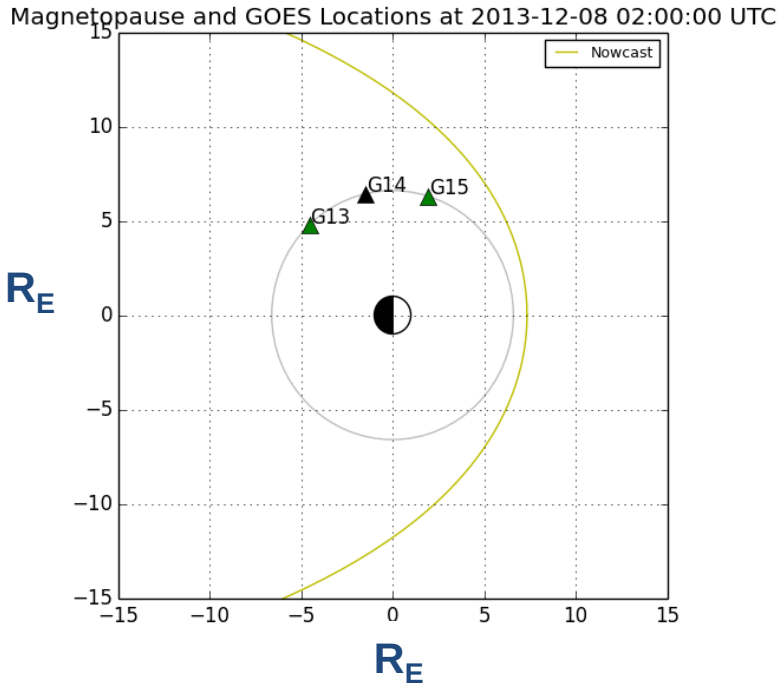


Expanded Products & Services

Geosynchronous Magnetopause Crossings

December 8, 2013, model predicts magnetopause crosses GEO. No GOES near noon to confirm

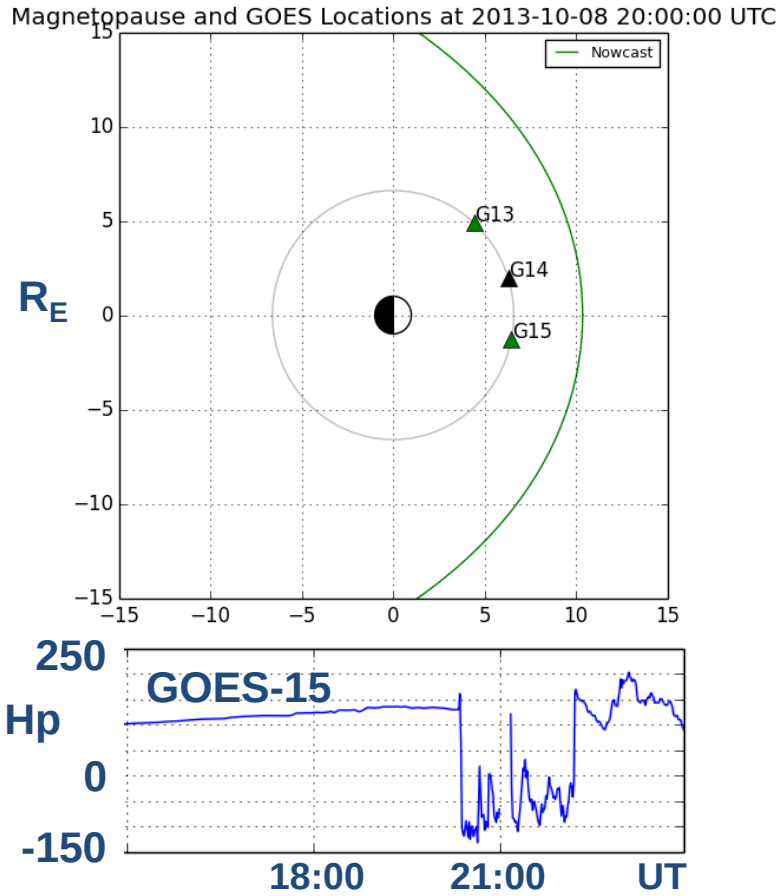
Predicted Crossing



Note: GOES-14 is currently not operational and thus is not providing magnetometer measurements (black triangle)

October 8, 2013, GEO orbit inside magnetosheath. Negative polar field (red triangle) and e-flux dropout observed near noon

Observed Crossing

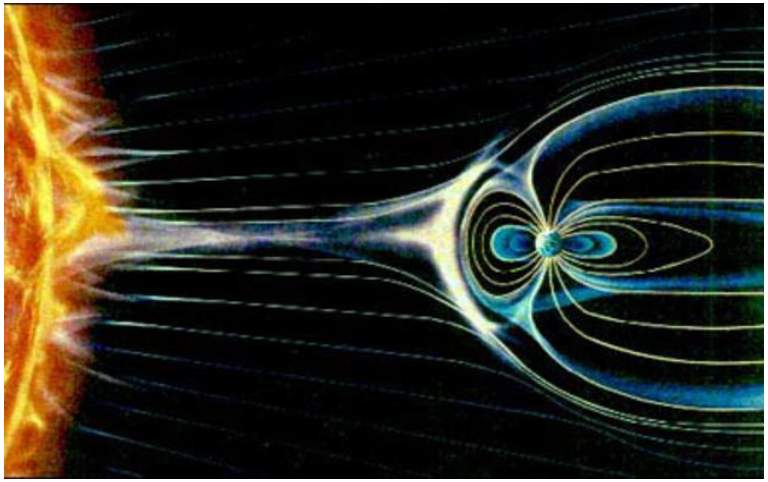


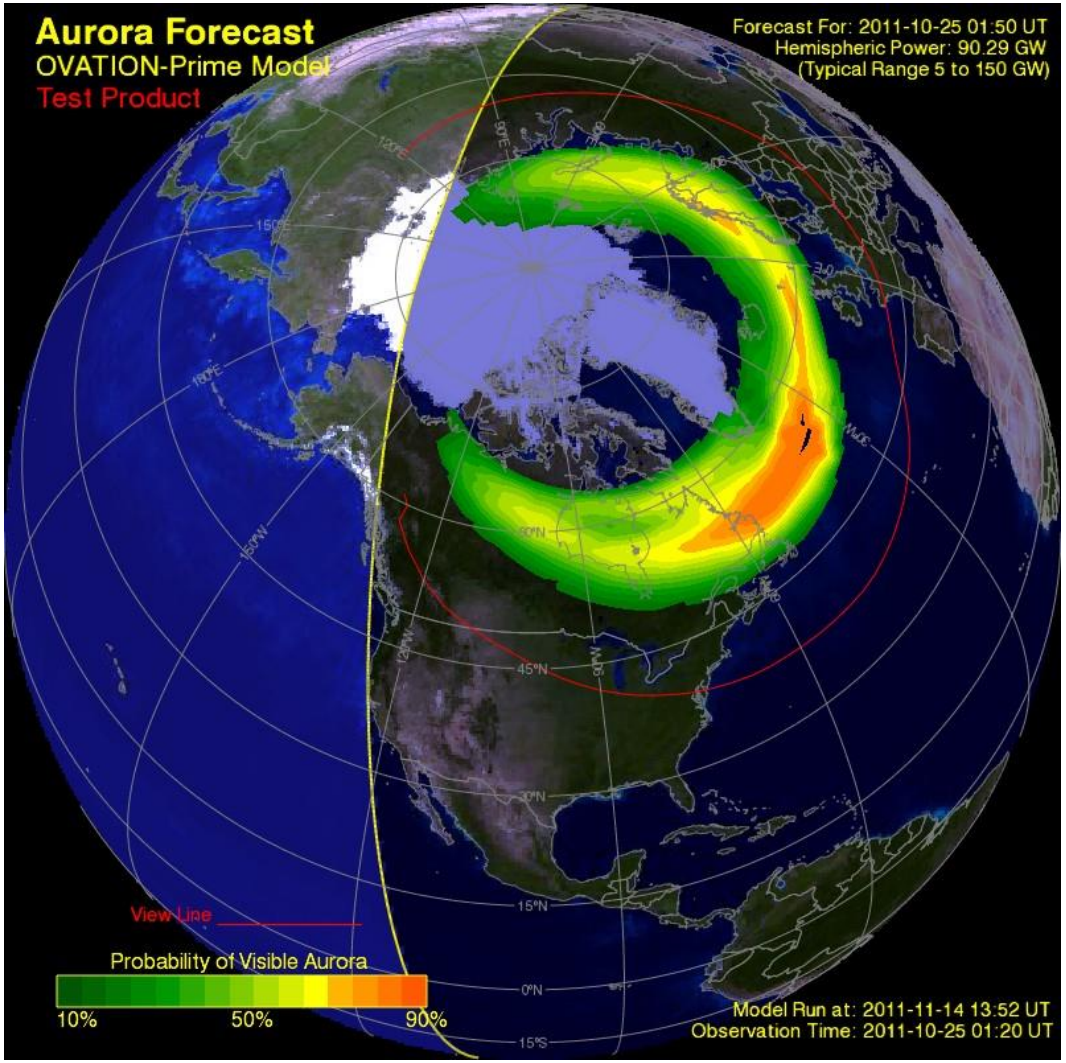
Expanded Products & Services

Ovation Auroral Forecast Model

Methodology developed at JHU/APL

- 30-40 min forecast driven by ACE solar wind and interplanetary magnetic field data
- Developed as a joint project between NGDC and SWPC
- Customer products now available from SWPC – link

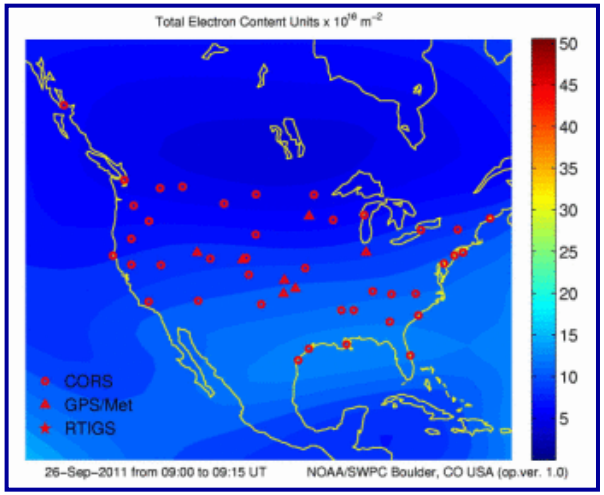




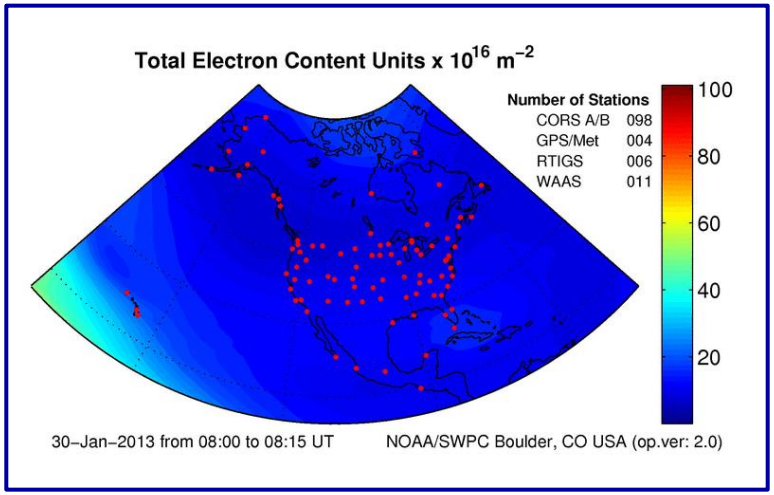
Expanded Products & Services

North America TEC

Extending current US-TEC product to NA-TEC

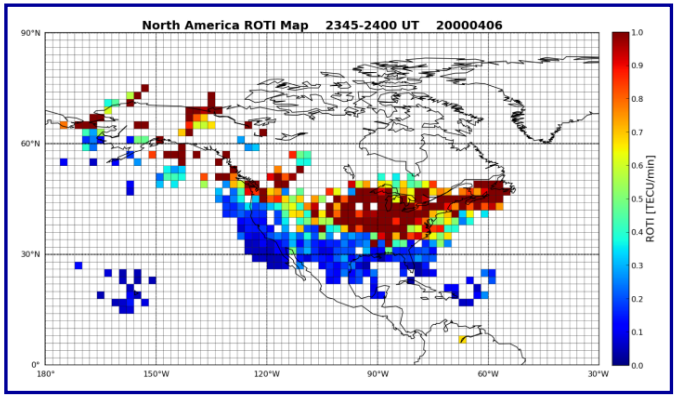


Research to Operations



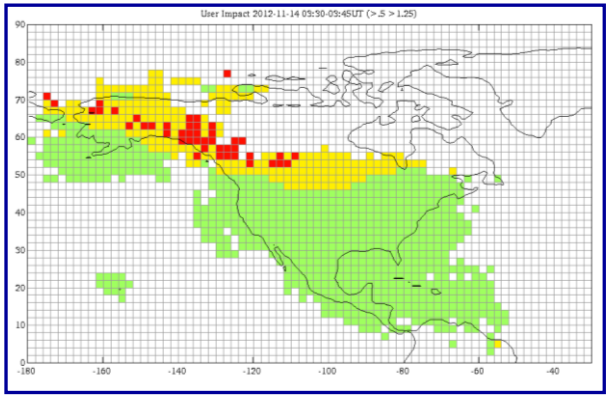
Related products

Rate of TEC Index Product



Research and Development

GPS Scintillation Specification



Thank You!