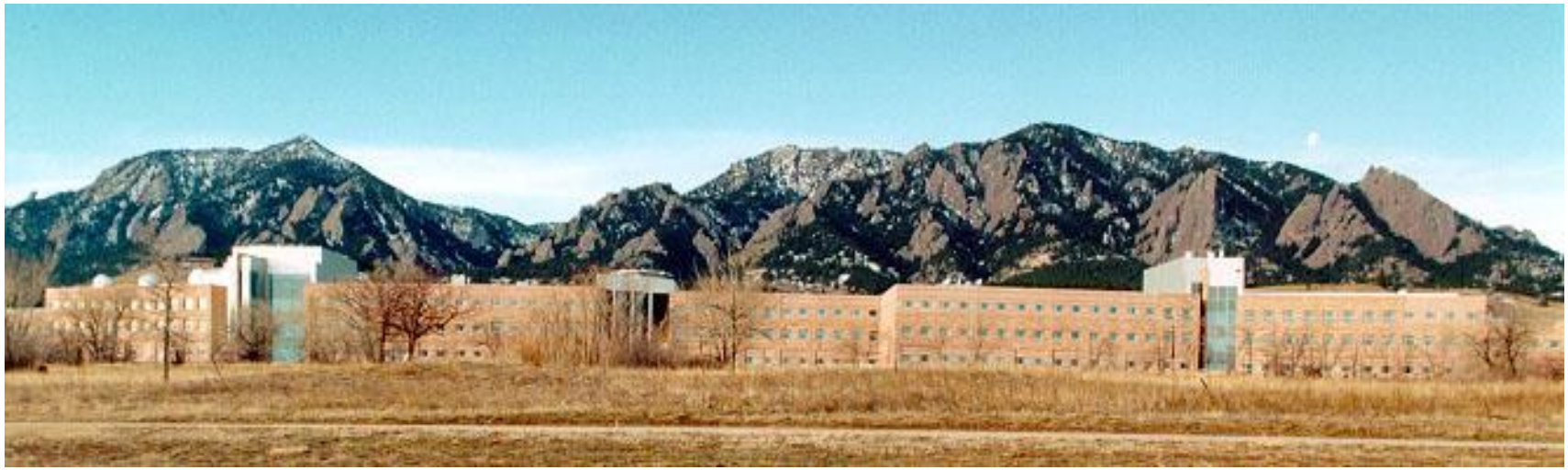


NOAA Satellites – Current & Future

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

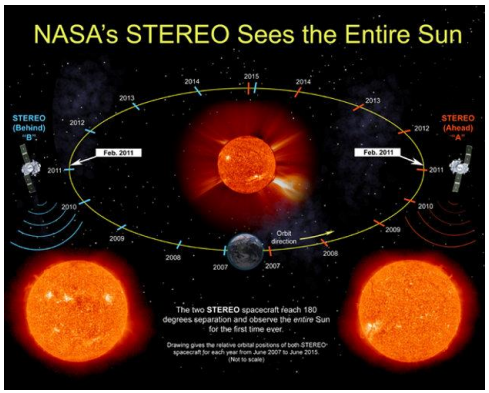
[1]National Geophysical Data Center

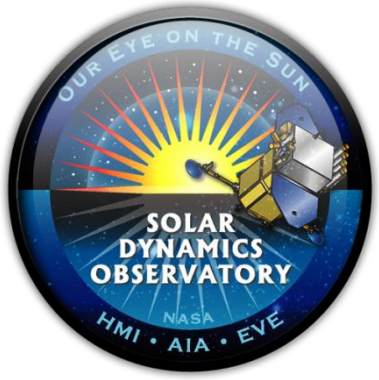
[2]Office of Systems Development

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

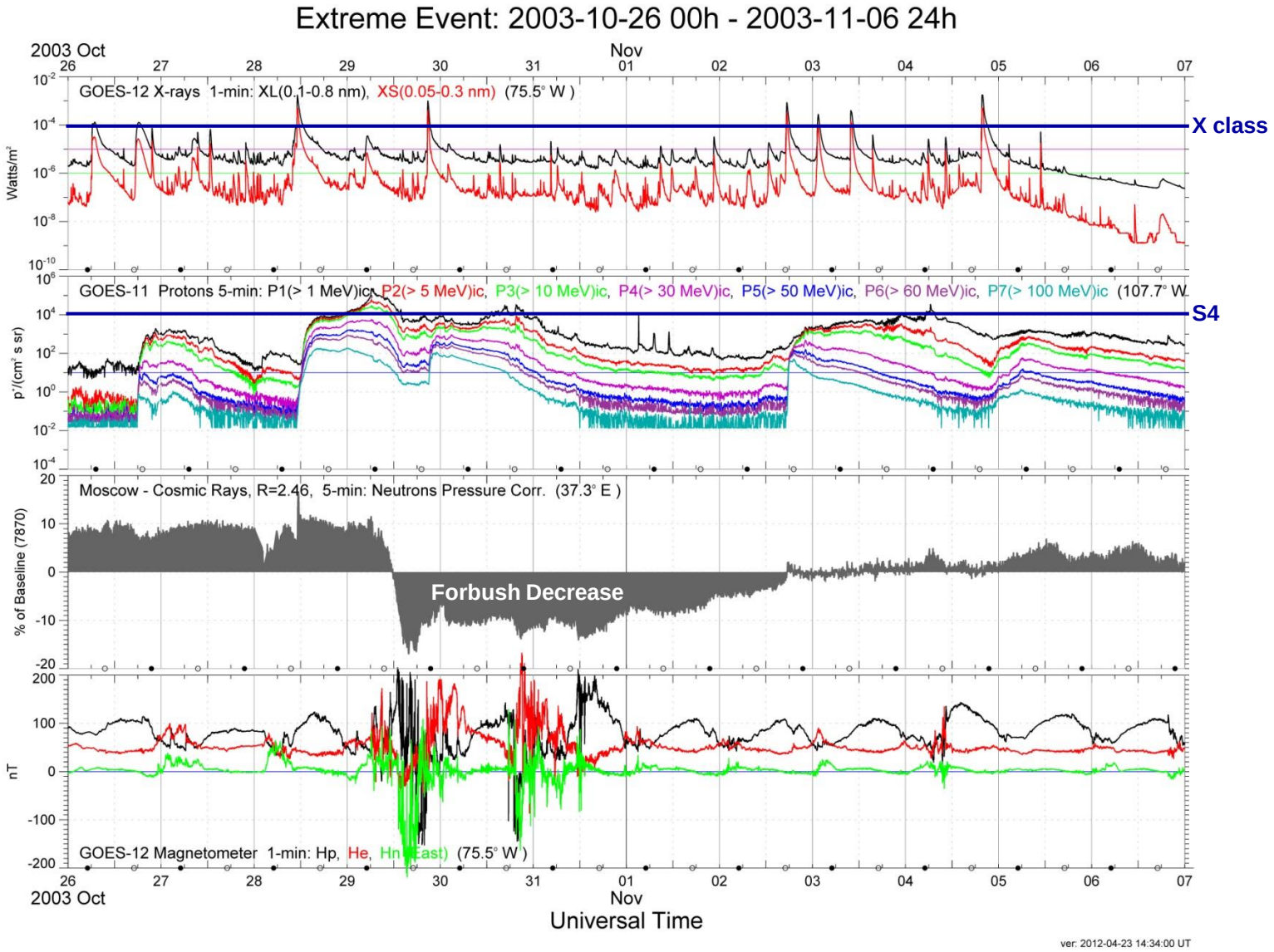
40 Years of Geostationary Measurements

Solar X-Rays

Proton Events

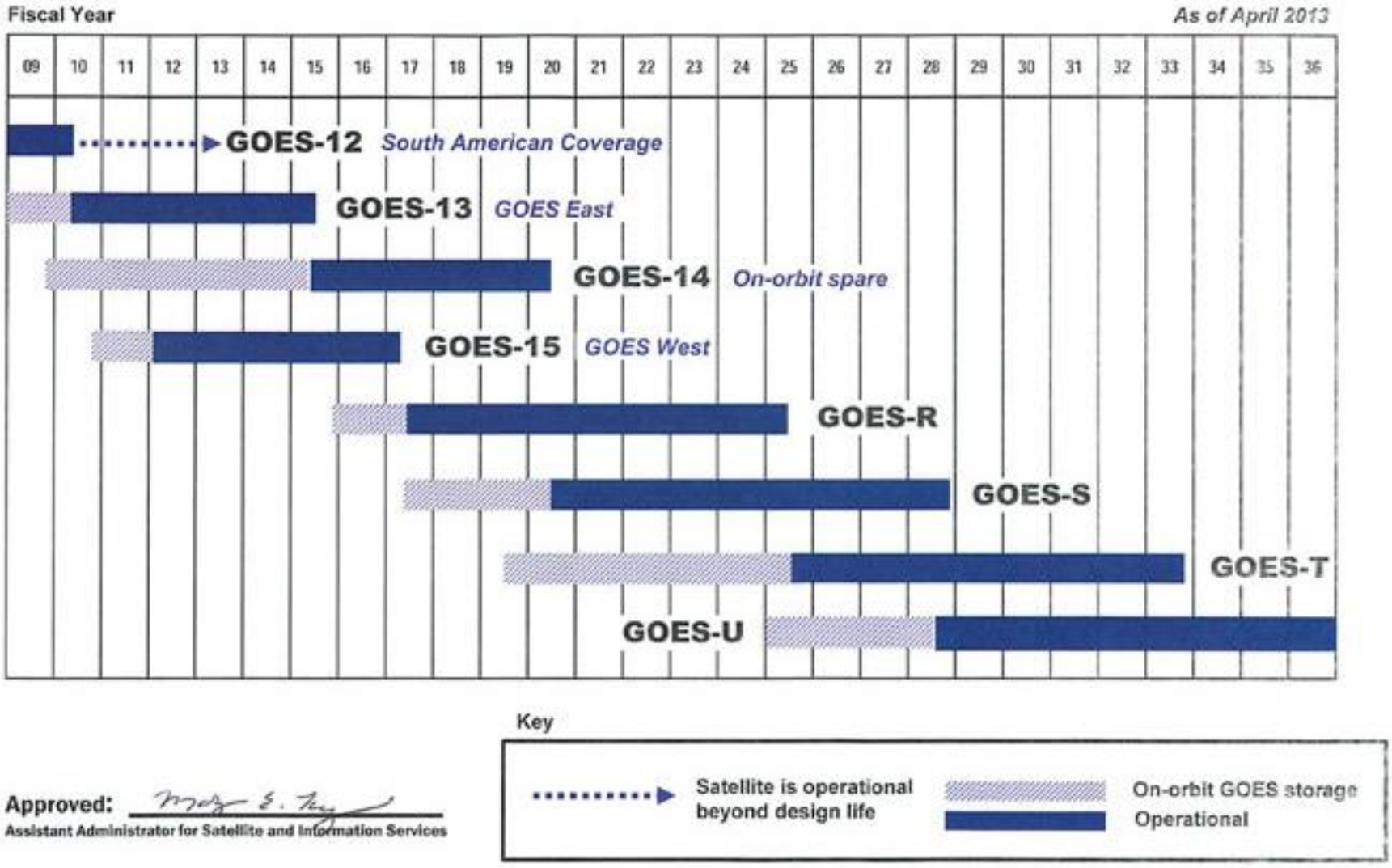
Cosmic Rays (non-GOES)

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.

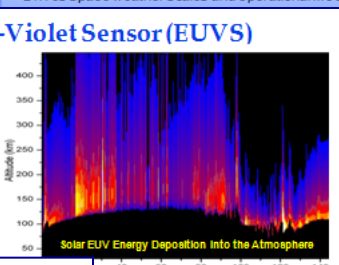
Credit: Lockheed-Martin

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



Increased # of wavelength bands

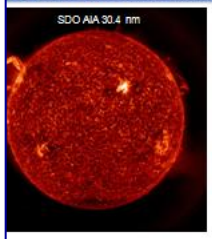
Solar Ultra-Violet Imager (SUVI)

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



Solar UV imagery versus soft x-rays

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

Improved particle energy coverage

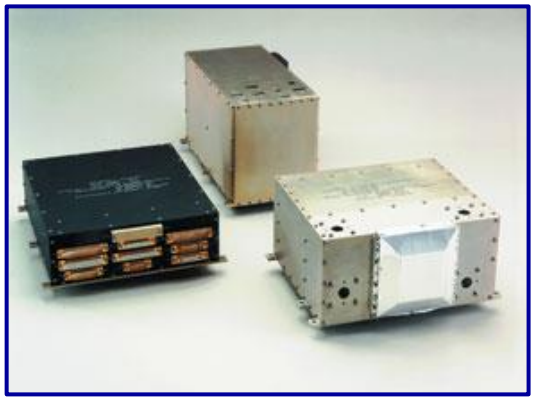
Not shown: GOES-R Magnetometer

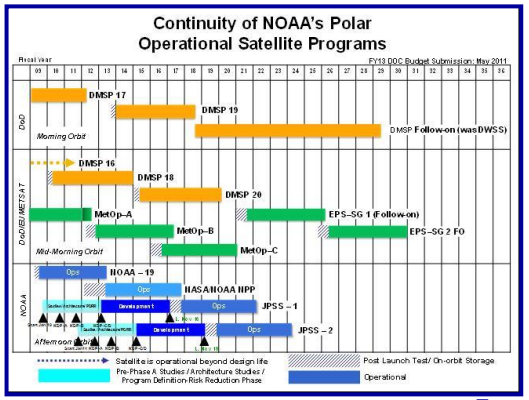
~~Continuity of LEO Measurements~~

An End of an Era (since 1978)

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
- 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

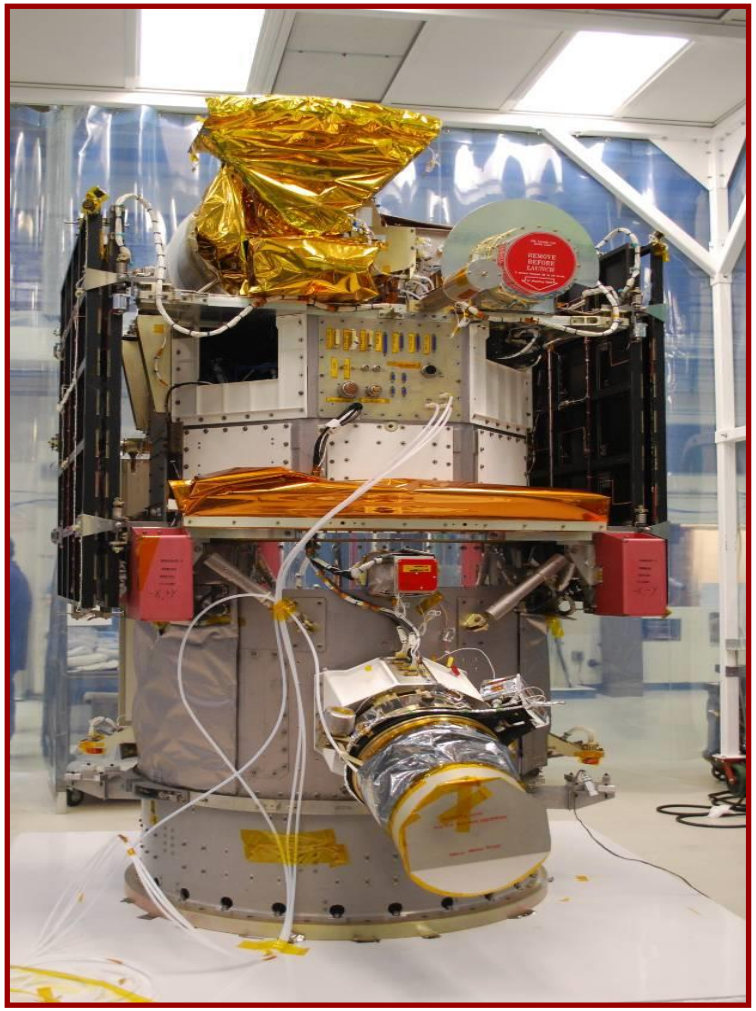




New Capability
Operational SWx Data from L1

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

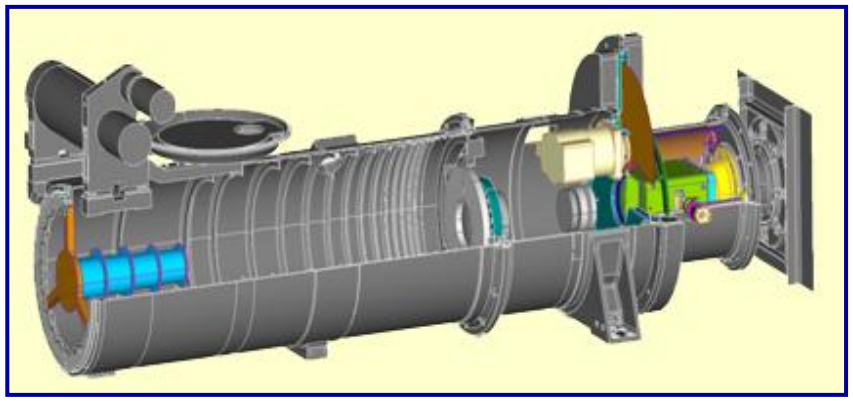
- The DSCOVR spacecraft will measure the solar wind (n_p, v_p, t_p) and the interplanetary magnetic field at 240 R_e forward of the earth
- The DSCOVR spacecraft refurbishment is nearing completion for a launch NET Nov 2014
  - ✓ Recalibration of Plas/Mag – complete
  - ✓ Magnetic cleanliness testing – 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 (co-manifested with Sunjammer (slide 10)
- 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

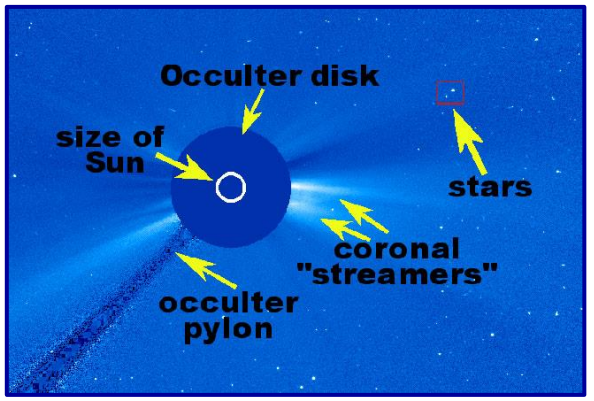


Deep Space Climate Observatory (DSCOVR)

Under Development
Compact Coronagraph (CCOR)

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

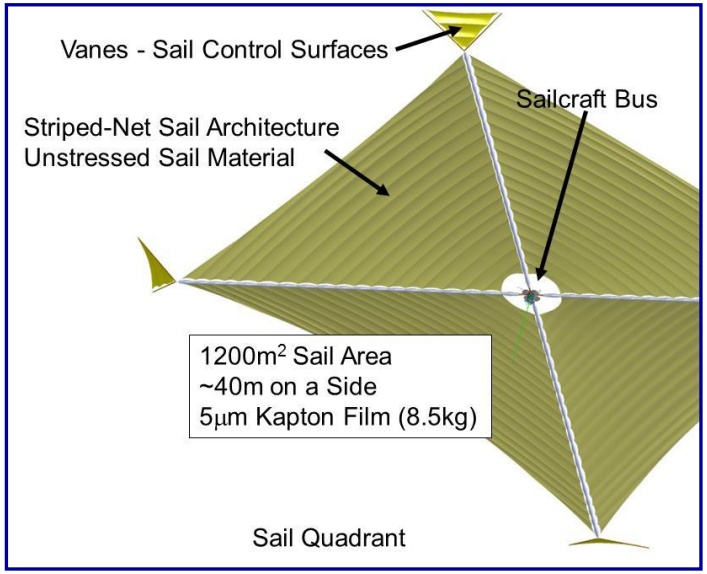


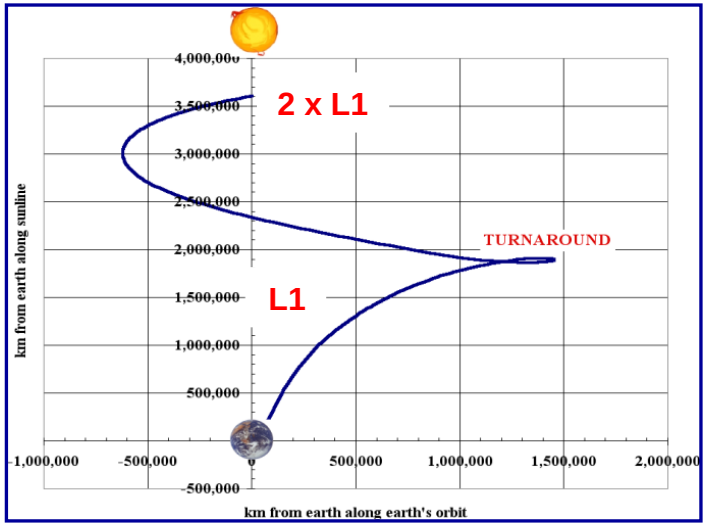


- CCOR design offers reduced sensor mass and volume at lower cost
  - 6 kg telescope, 17 kg for sensor
  - Optical train is 1/3 length of traditional coronagraphs & uses multiple occulters
- NRL completed Phase A study & successfully bench tested the optical design
- NOAA will continue to fund risk reduction studies at NRL 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
- NOAA plans to partner with L'Garde, Inc to provide data reception, analysis and archive
- Space weather instruments:
  - Particle spectrometer – MSSL
  - Magnetometer – Imperial College London
- SWPC will assist in evaluating the data
- Co-launched with DSCOVR – 11/2014

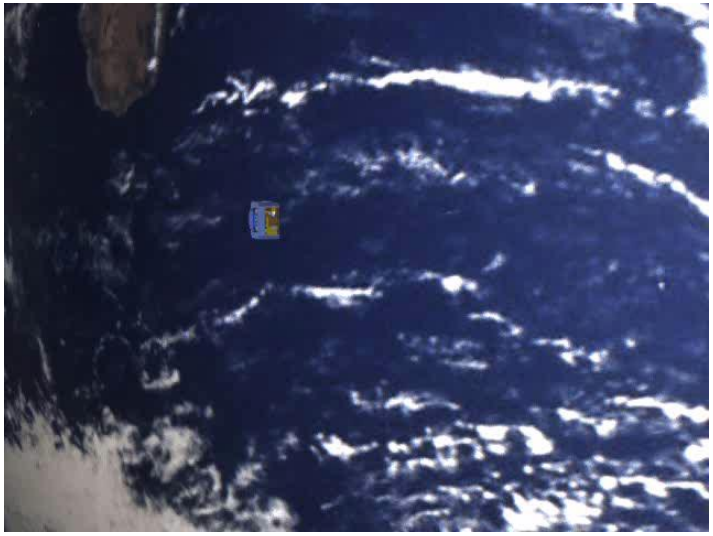




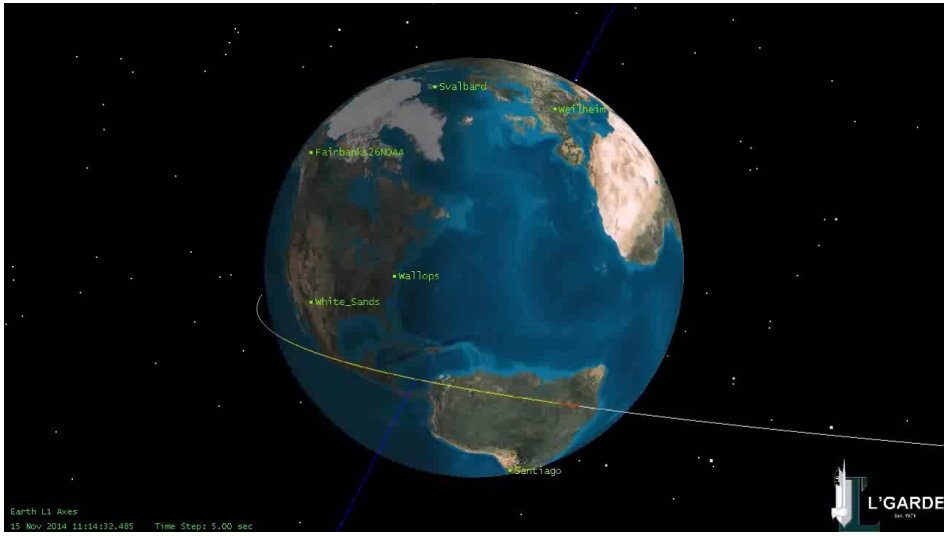
Technology Demonstration

Sunjammer – Solar Sail Demonstration

Optional Movies



Solar Sail Deployment



Sunjammer Trajectory

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

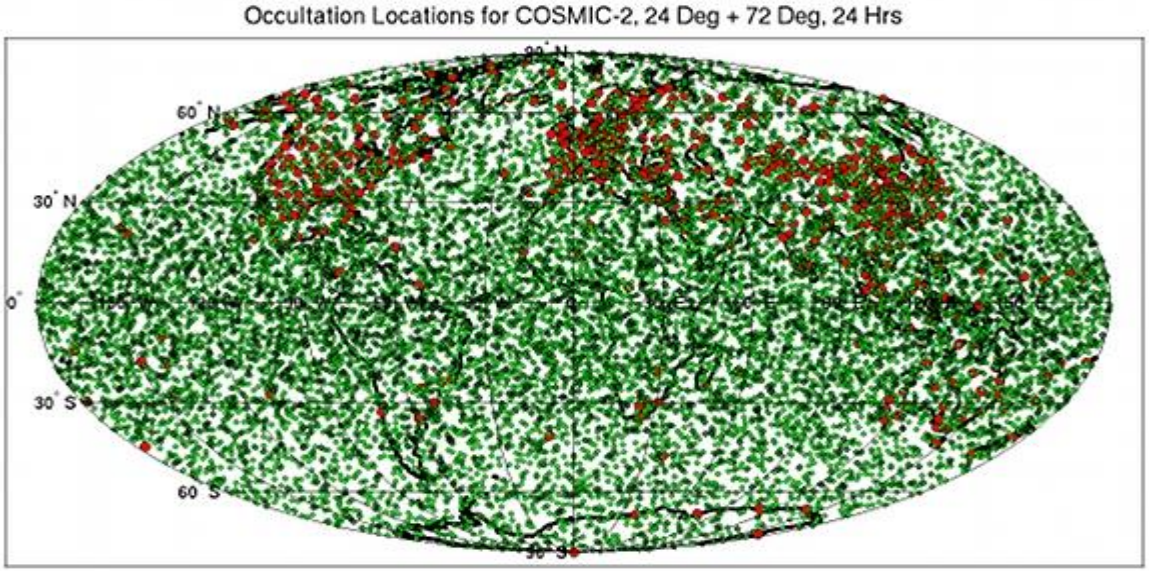
CME Imagery

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

New Capability
GNSS Radio Occultation – COSMIC 2

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

- Taiwan-USAF-NOAA Partnership
- 12 satellite constellation – 6 @ 24º inclination (low) / 6 @ 72º inclination (high)
- Phase 1 launch planned for late 2015 – 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



Thank You!