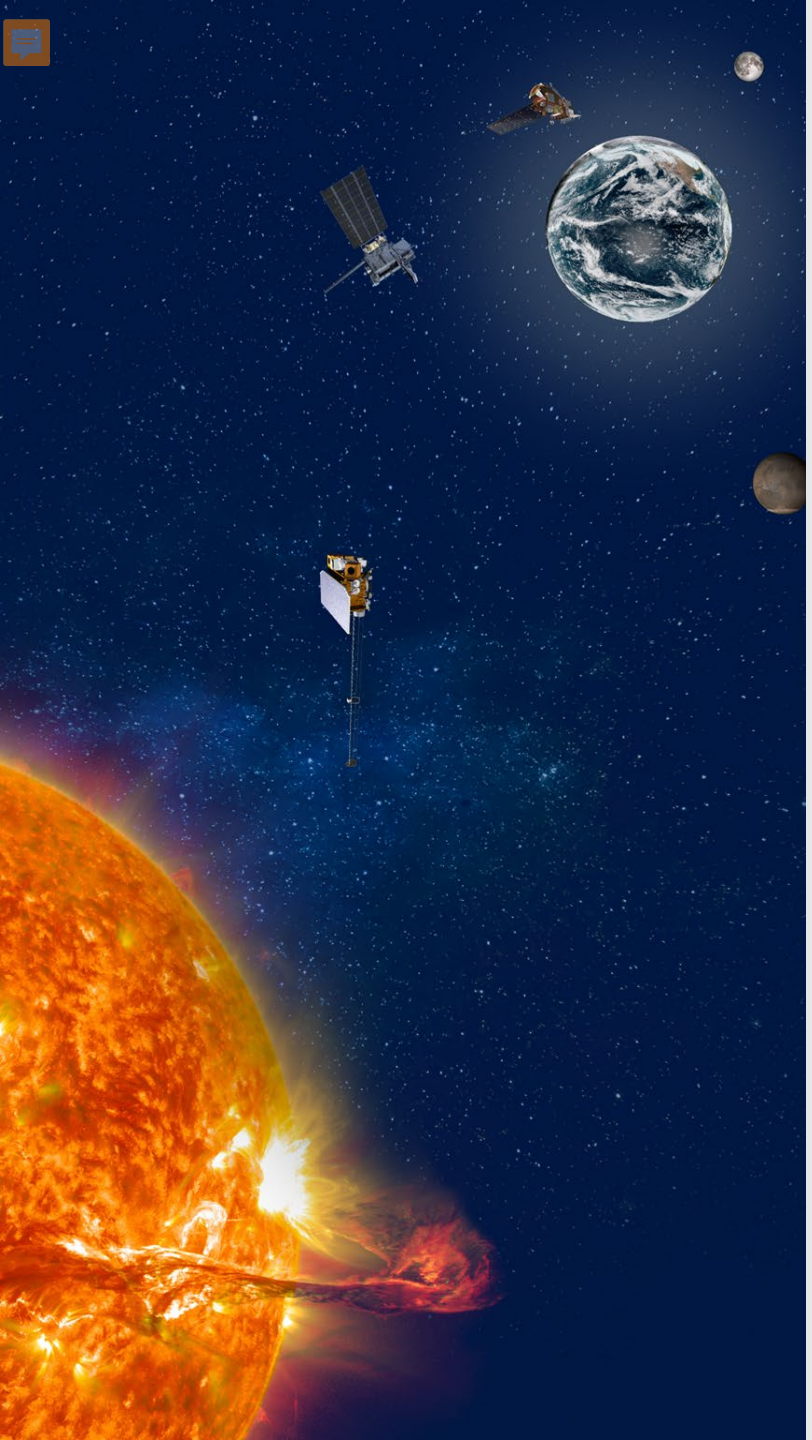
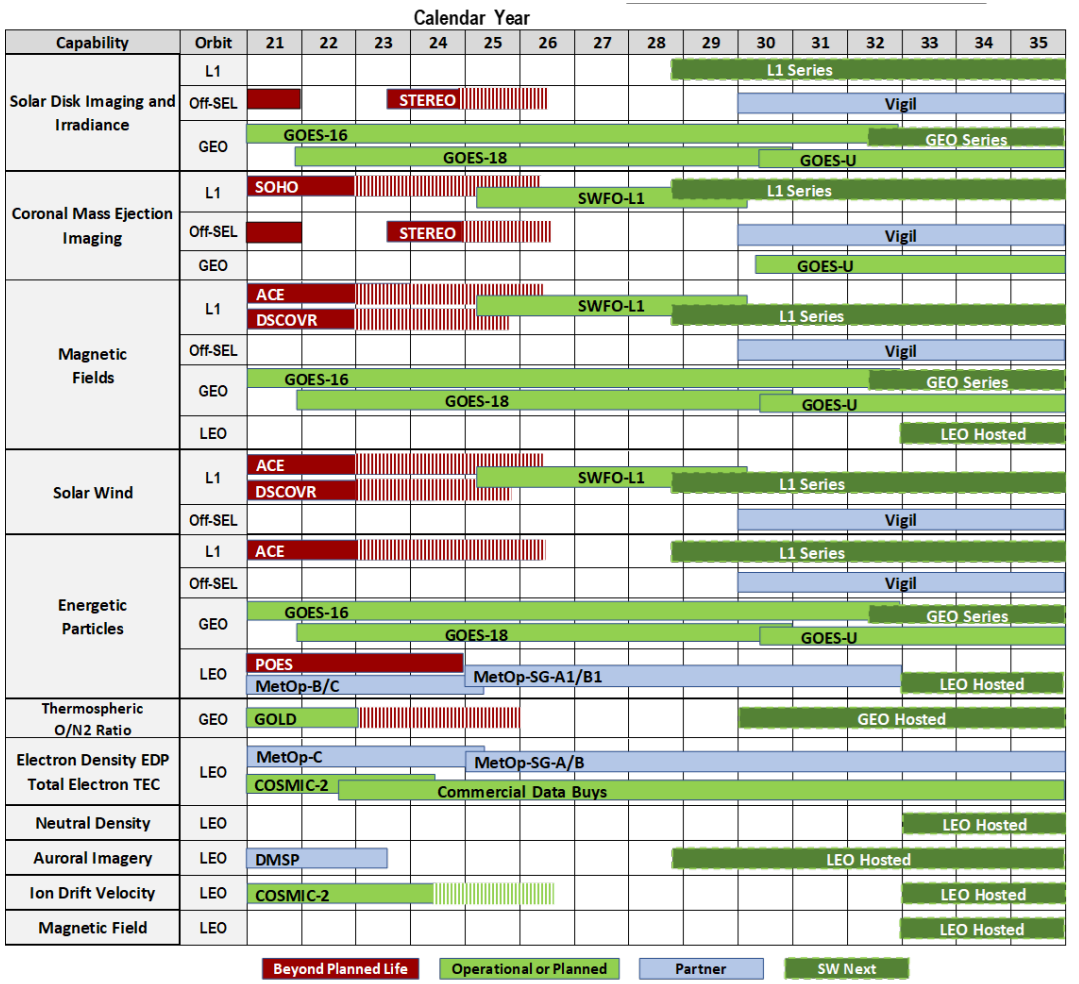


Program of Record 2025 and Partner Missions

Nai-Yu Wang, Dimitrios Vassiliadis, Erin Lynch
NOAA/NESDIS/SWO

Introduction

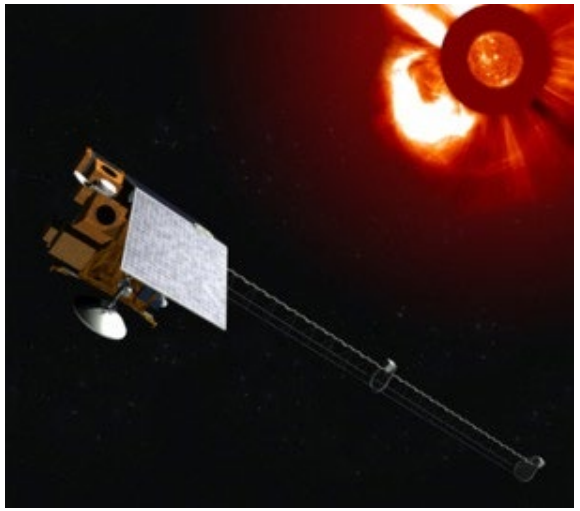
- NESDIS has several implementation options for resolving the operational needs of its space weather information users, including SWPC. The typical path is to design, build, and fly missions in their optimal orbits, which then acquire critical imagery and other data.
- Two key priorities are continuity and expansion of current capabilities. NOAA's Program of Record 2025 is a snapshot of the current and near-term observational capabilities at a specific timeframe. It is an important reference point for mission planning.
- In addition to its own missions, NOAA uses real-time satellite data from partner organizations. As new observations become available, NOAA continuously evaluates them for future use.



NOAA Space Weather: Program of Record 2025

The Program of Record includes all satellite systems and observational capabilities available in the near term through NOAA's own missions and through partnerships. The POR-2025 includes:

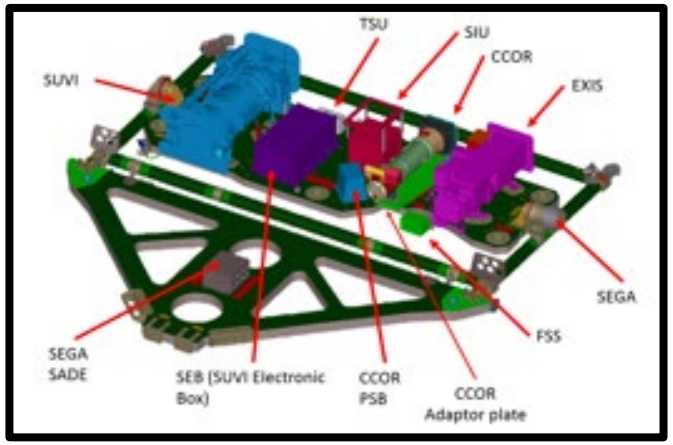
- DSCOVR and SWFO-L1
- GOES SpWx including CCOR-1 on GOES-U
- COSMIC-2, MetOp SpWx data
- Lagrange 5 observations implemented via ESA's Vigil mission (has since moved to a later launch)



SWFO-L1 (2025)

COSMIC-2 (2019)

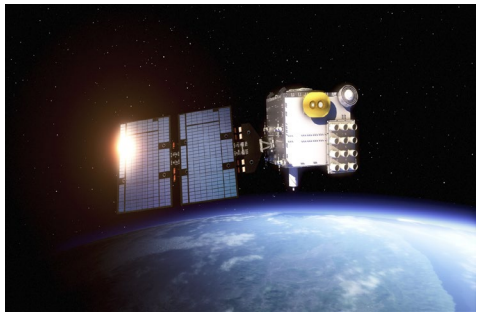
GOES-T (2022): Launch

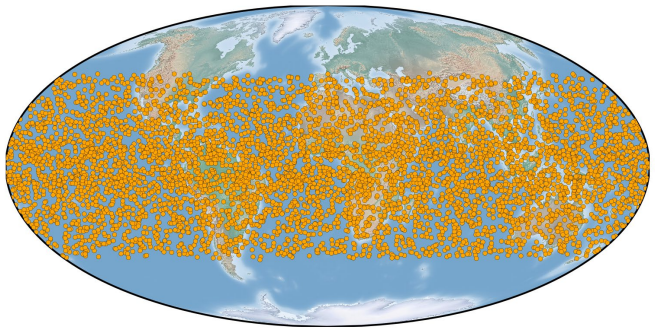


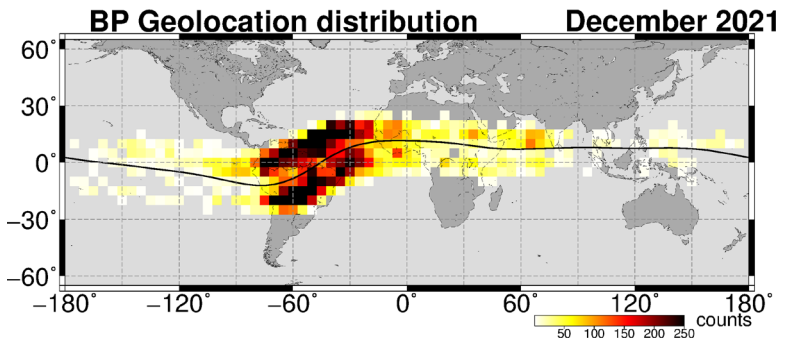
GOES-U (2024): SPP

COSMIC-2

- US/Taiwan partnership (NOAA, USSF, NASA, NSF, TASA)
- Spacecraft constellation
  - Launched June 25, 2019
  - 6 satellites, orbit inclination 24 deg, altitude ~520 km
  - Final orbit configuration reached in March 2021
- Payloads
  - Primary: TGRS, a JPL/BRE GNSS instrument tracking GPS and GLONASS
  - Secondary: ion velocity meter (IVM), tri band RF beacon, laser retro reflector
- All neutral atm. and ionosphere products routinely produced, except IVM drifts
- Neutral atm FOC reached 9 month after launch
- Achieved several “firsts” for RO
  - GLONASS radio occultation for neutral atm and ionosphere
  - Demonstrated GPS & GLONASS absolute total electron content accuracy < 3 TECU
  - Scintillation geolocation and all-clear
  - Requirements of 12,000 profiles/day and 30-min latency met.

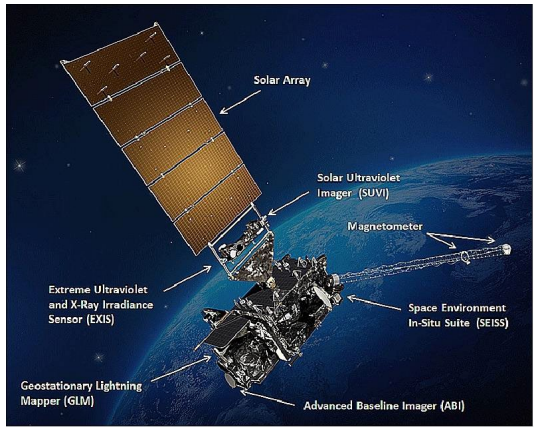




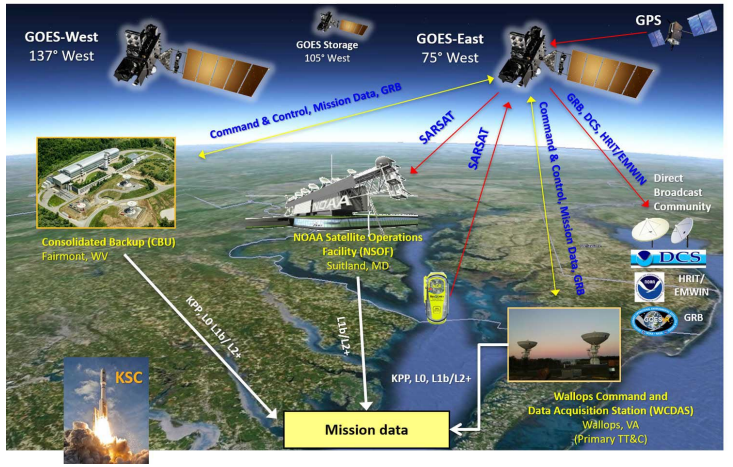


GOES-R Series

- The Geostationary Operational Environmental Satellite-R (GOES-R) Program supports forecasting of terrestrial and space weather and enables research in meteorology and space science.
- It comprises four satellites with GOES-16 launched in 2016 and GOES-U to be launched on June 25, 2024 and become GOES-19 upon commissioning.
- All GOES-R satellites carry solar viewing instruments (EUV imagery and irradiance; X-ray irradiance) and in situ sensors (particle detectors and a magnetometer suite). These are important measurements that are planned to be continued for NWS and research needs.
- GOES-U will carry the CCOR-1 coronagraph. It will be activated as an operational satellite after launch and operate as GOES EAST.



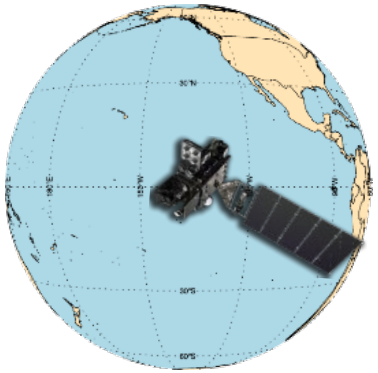
GOES-R, -S, -T



GOES-R system architecture

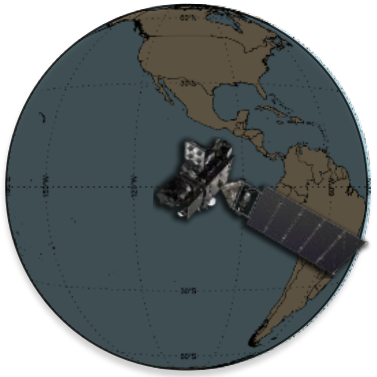
GOES-R Program: Space Wx Products

GOES-West
GOES-18
137.0°W



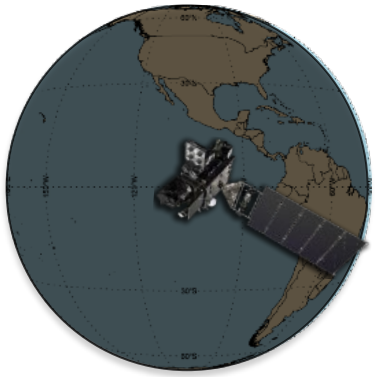
EXIS
G-Magnetometer
SEISS
SUVI

GOES Standby
GOES-17
104.7°W



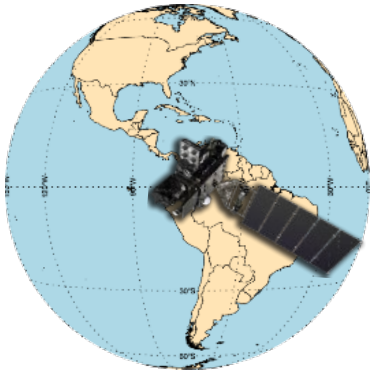
EXIS
Magnetometer
SEISS
SUVI

GOES-Future
GOES-U/19
89.5°W

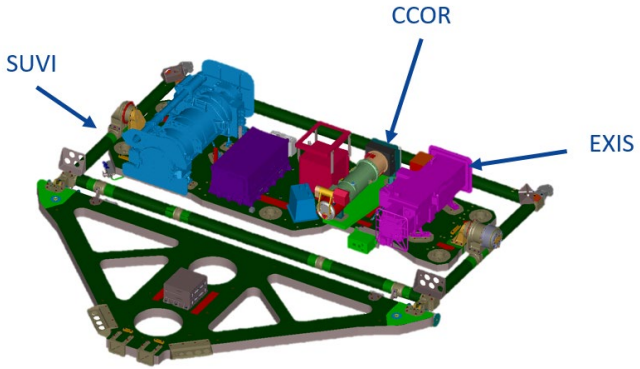


CCOR
EXIS
G-Magnetometer
SEISS
SUVI

GOES-East
GOES-16
75.2°W



EXIS
Magnetometer
SEISS
SUVI

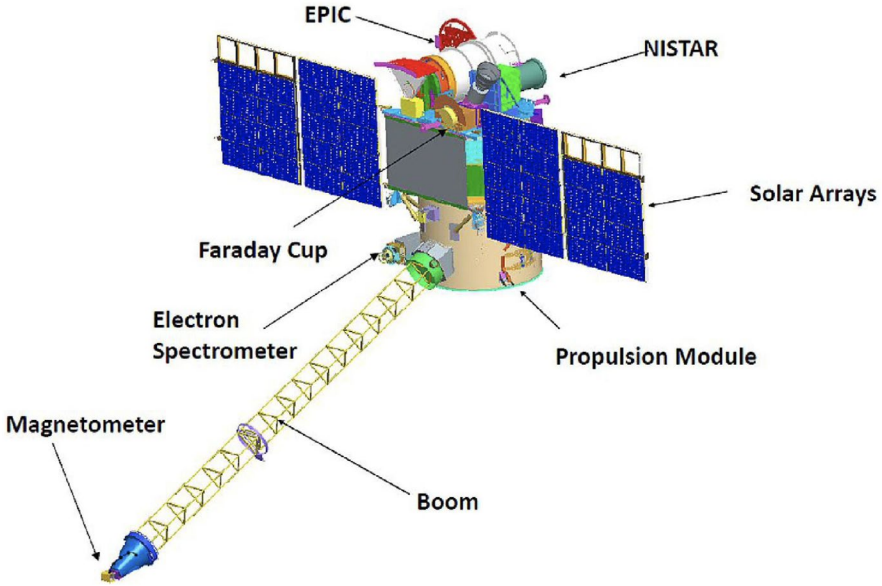


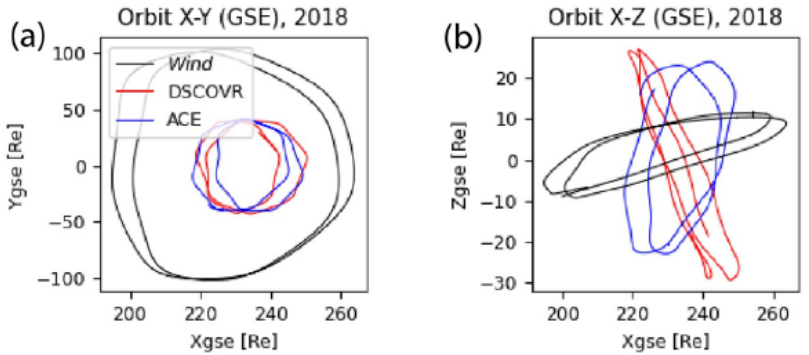
GOES-U Sun-Pointing Platform

For GOES, L0 and L1b are generated and distributed from GEO Ground Segment except for CCOR, which is only L0.

Deep Space Climate Observatory

- NOAA's Deep Space Climate Observatory (DSCOVR), commissioned in June 2016, is a solar wind monitor at Lagrange 1 (L1).
- Its SpWx data include solar wind plasma measurements measured by the Faraday Cup and magnetic field by the magnetometer. The data are used together with ACE and SWPC generates a single best measurement of these data at L1 and uses them to drive several magnetospheric and ionospheric real-time models
- These instruments will be replaced by SWFO-L1 sensors.
- DSCOVR and ACE will continue to be important for intercalibration and continuity.





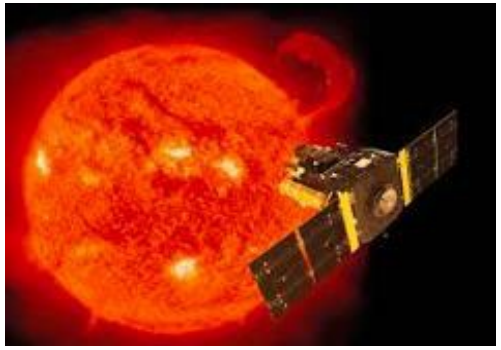
Orbits of DSCOVR, ACE, and WIND [Loto'aniu et al., 2022]

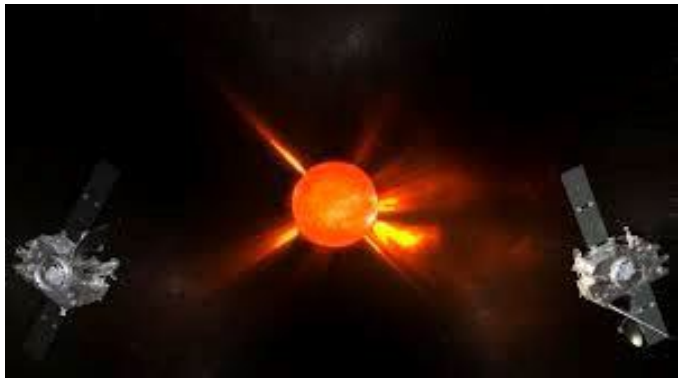
Operationally Used Data from Partner Organizations

- In addition to its own Program of Record, NOAA uses real-time data from other organizations.
- Data from several NASA missions are used operationally: ACE, SOHO, STEREO when they are available. IMAP will include the IMAP Active Link for Real Time data (I-ALiRT) designed specifically to cover NOAA SWPC real-time measurement needs in addition to SWFO-L1 and earlier missions.
- There has been investment in evaluating new capabilities from NASA missions such as PUNCH carrying polarized coronagraphs and heliospheric imagers; and from instruments such as the Global-scale Observations of the Limb and Disk (GOLD) imaging Earth's thermosphere.
- Data from international missions are used operationally: EUMETSAT's MetOp C (SG) carrying the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED) identical to those carried on NOAA LEO satellites. ESA's Vigil will operate at Lagrange 5 and will carry the CCOR-3 instrument, identical to CCOR-2.

ACE, SOHO, and STEREO

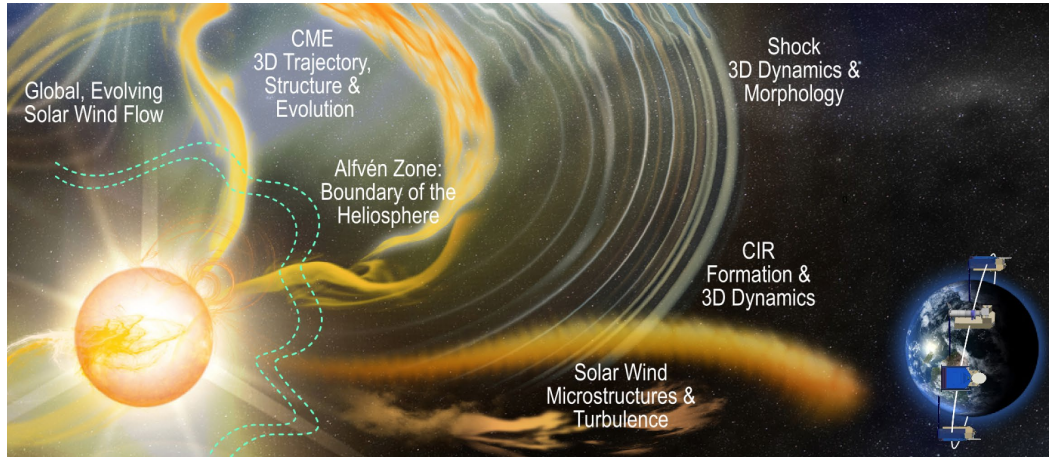
- NOAA has developed operational applications for SpWx data provided by ESA/NASA's Solar and Heliospheric Observatory (SOHO, launched in 1995), NASA's Advanced Composition Explorer (ACE, 1997), and the Solar TErrestrial RElations Observatory (STEREO, 2006).
- SOHO provides coronagraph imagery needed for operational CME forecasts. It has a significant latency which will be significantly improved by GOES-U/CCOR-1 and SWFO-L1.
- ACE is used for providing in situ plasma (velocity, density, temperature) and interplanetary magnetic field data which are crucial for situational awareness and for real-time driving of SWPC's magnetospheric and ionospheric models.
- STEREO provides valuable off-Sun-Earth line (off-SEL) coronal and heliospheric imagery. However, its latency is even longer than SOHO's and its orbital location changes with time.

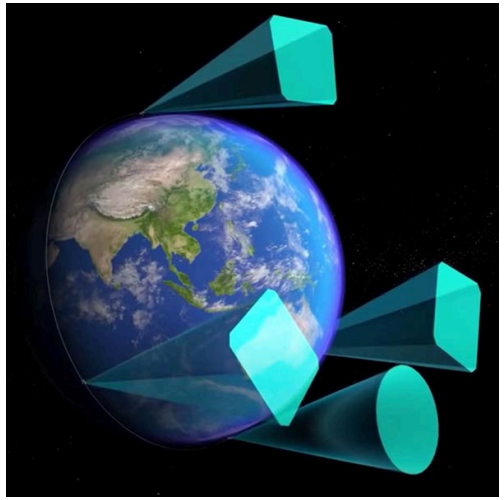


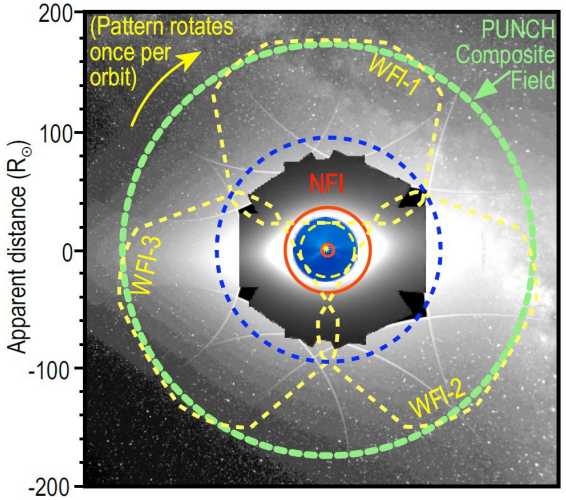


Polarimeter to UNify the Corona and Heliosphere

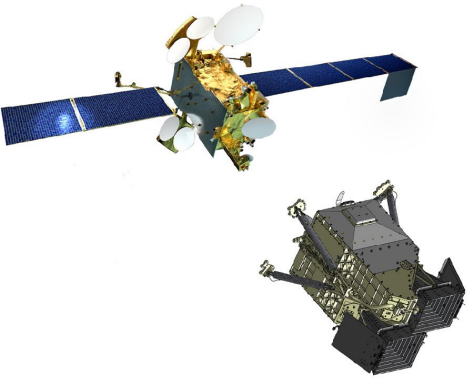
- PUNCH is a Small Explorer constellation in NASA's Heliophysics Division planned to image the transition zone between the solar corona and the solar wind, helping to unify the fields of solar and interplanetary physics.
- A constellation of four microsats in sun-synchronous LEO will produce deep-field, continuous, 3D images of the corona and solar wind in polarized visible light.
- A Narrow Field Imager (NFI) on one microsat captures the outer corona and is combined with Wide Field Imagers (WFIs) on the three other microsats.
- NESDIS' QuickPUNCH project is evaluating the utility of mission data for forecaster awareness and as input to heliospheric models.

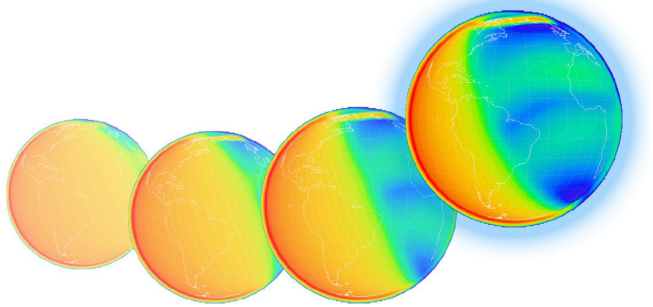




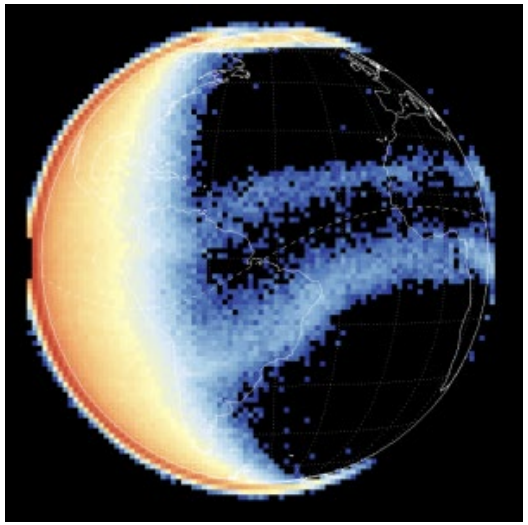


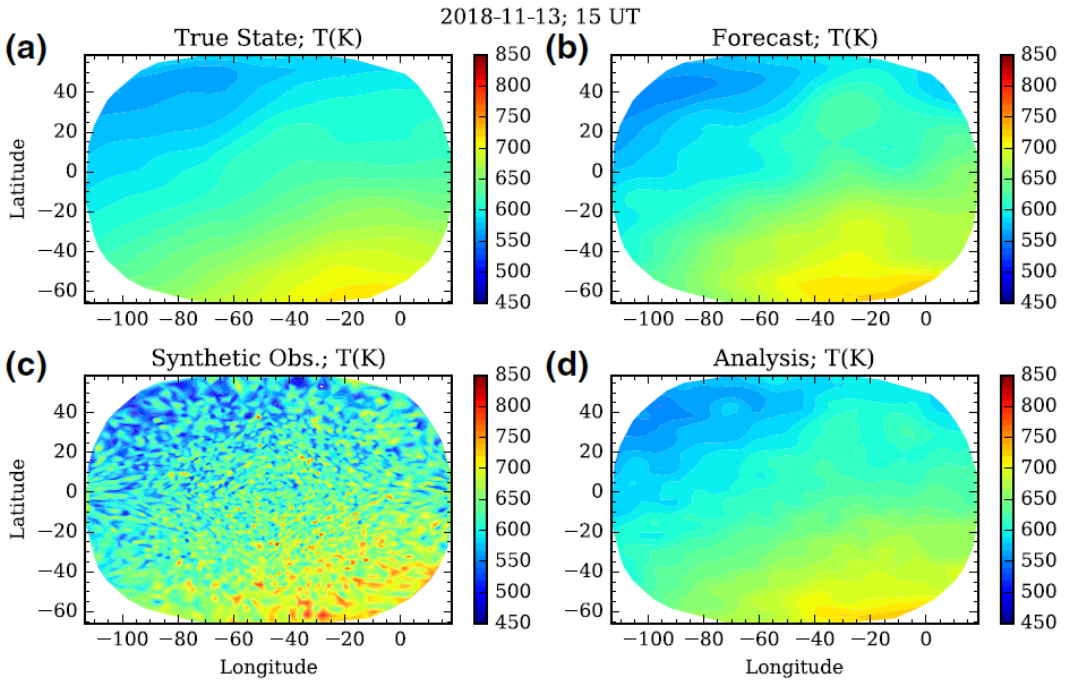
GOLD Thermospheric Imagery





- As with other partner organization payloads, NOAA has explored the value of imagery from NASA's Global-scale Observations of the Limb and Disk (GOLD, I. 2018) instrument hosted on a commercial GEO satellite.
- GOLD retrievals include thermospheric temperature and the O/N_2 ratio (below left). The Level 2 products are potentially important inputs into NOAA environmental models of the upper atmosphere and their forecasts(below right).





Summary

- NOAA's Program of Record 2025 contains the current and near-term missions and observational capabilities in the 2025 timeframe. It is an important reference point for mission planning since two key priorities are continuity and expansion of current capabilities of interest to users.
- In addition to the current program, NOAA uses real-time data from domestic and international partner organizations (NASA, EUMETSAT, etc.) for its operational models and forecasts. There are plans to continue this use with future missions (e.g., ESA's Vigil). NOAA regularly evaluates observational capabilities as they become available.
- Going forward, SW Next aims to upgrade these observational capabilities in several orbits.