Current and Planned Operational Requirements (Observations)

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What is currently being done to nowcast/forecast at SWPC?

SWPC Models (Operational, Under Development)

Sun:
- WSA
- ADAPT

Ionosphere:
- D-RAP
- Global TEC / NA-TEC
- ROTI
- IPE

Aurora:
- Ovation 30 Minute Forecast
- Ovation 3 Day Forecast

Solar Wind:
- Enlil

Thermosphere:
- CTIPe
- WAM

Ground:
- E-Field
- Airline Radiation

Magnetosphere:
- Geospace Model
- SEAESRT
- REFM
- GOES Magnetopause Model

WHAT ARE SWPC'S PLANS FOR THE DECADE AHEAD

Space Weather (5-year) Strategic Priorities:

- Improve lead-time/spatial resolution of geomagnetic activity forecasts
- Improve forecasts of coupled ionosphere/atmosphere system for GNSS Positioning, Navigation, Timing (PNT), communication, and satellite/debris orbit determination
- Improve forecasts of space radiation for space infrastructure: satellite reliability, human and robotic applications, and commercial space

Space Weather Service Benefits:

- Efficient electric power supply and mitigation of blackouts
- Safe and efficient air and space traffic management
- Reduced human radiation risk and satellite failures

NOAA Space Weather Program of Record 2025 (What will be available)

L1 (SWFO-L1)

Coronagraph

Magnetometer

Solar Wind Thermal Plasma

SupraThermal Ions (& electrons)

X-Ray irradiance (hosted payload)

GEOSTATIONARY (GOES)

EXIS EUV and X-Ray irradiance

SUVI solar EUV imager

Magnetometer

SEISS in-situ particles (low-, medium-, and high-energy particle flux)

CCOR Coronagraph

LEO (COSMIC-2 & GOLD)

TGRS electron density profile and scintillation

IVM ion velocity

GOLD FUV imagery

Other Agencies SWx Program of Record (2025)

- USAF Radio Solar Telescope Network
- USAF Solar Observing Optical Network
- NSF Global Oscillation Network Group
- NSF Neutron Monitors
- USGS Ground based Magnetometers
- Ground based GNSS for TEC and Scintillation

What's next for Space Weather?

- National Space Weather Strategy and Action Plan
- Action 2.1: Identify baseline ground-based, sea-based, air-based, and space-based operational observation capabilities
  - National needs, not any one agency's needs. [NOAA, NASA, NSF, DOD, USGS]
  - General thinking is 2030-2050
    - Systems we put in place by 2030 may be operational for 20+ years
  - IN PROGRESS
    - Identify necessary observations
    - Identify observation key requirements
    - Identify customer groups who benefit [Power Grid, GNSS, Satellites, Aviation and Emergency Managers, NASA Human/Robotic and Tourism]
    - Identify observation gaps (*i.e.* What's not in the Program of Record?)
  - STILL TO DO
    - Prioritize gaps
- What follows is an unprioritized Space Weather List of Gaps (29)
  - DOD has contributed to Gap identification and will do their own prioritization
  - Requirements can be met with observations, modeling, or both

Number of gaps by domain – literally Sun to Mud

- Solar – 4
- Interplanetary – 6
- Solar & Interplanetary – 2
- Magnetosphere – 4
- Ionosphere – 4
- Thermosphere – 2
- Troposphere – 2
- Lithosphere – 3

What would improve forecasting (aka filling the gaps)? randomly sorted

Upstream solar wind monitor
- How far upstream?

Global electron density profiles
- Above 30°, better spatial resolution overall

Heliospheric imagery
- From Sun-Earth line or L5 or more?

Atmospheric global distribution of winds
- Stratosphere to Thermosphere

Aviation radiation/dosimetry

Medium energy interplanetary protons

Solar disk imaging
- Includes H-α white light intensity and dopplergrams, He 10830, LOS magnetic field, doppler velocity field , and vector magnetic field

Exospheric Hydrogen (Lyman-α)
- Satellite drag

NASA crew vehicle instrumentation
- Moon/Mars

Atmosphere neutral density and temperature
- Mesosphere & Lower Thermosphere

Ground based magnetometers (CONUS & OCONUS)
- CONUS plan delivered to SWORM 12/2019

Plasma, energetic particle, magnetic field and wave field environments at all Geocentric orbits
- GEO/GTO/MEO/LEO/Tundra at least
- LEO will be prioritized separately to match DOD requirements

Radio Absorption
- Non-deviative absorption in the D&E regions

Whole Sun surface magnetic field
- Yes. We do mean the entire Sun

What would improve forecasting (aka filling the gaps)? randomly sorted

Ground based neutron monitors
- Plan delivered to SWORM in 4/2020

Off-Sun-Earth line remote sensing
- Generalize beyond L5

Auroral location and energy deposition

Low corona (~1.05 - ~3 Rsun)
- EUV and/or white light?

Ionospheric scintillation

Off-Sun-Earth line *in-situ* mag, thermal plasma, and suprathermals
- Generalize beyond L5

Magnetotelluric survey
- Need higher spatial resolution in certain regions

Off-Sun-Earth line high energy protons and electrons
- Value to human space flight and Earth

X-ray irradiance 3rd band
- Removes degeneracies in calculating temperature & Emission Measure

Ground/space based radio for solar and heliosphere
- Ionosphere covered elsewhere

Thermosphere neutral composition

Magnetotail observations

Global ionospheric plasma drifts
- Focus on low latitudes

ULF waves measured at the ground
- Additional benefit for EMP's

A gap that applies to all domains

Observing System Simulation Experiments (OSSE)/Observing System Experiments (OSE)

- An OSSE quantifies the value of a potential new data source before it exists
  - Uses simulated or model derived data.
  - What accuracy, frequency, spatial resolution is required to get a particular improvement?
- An OSE
  - is a study to determine the value of existing observations.
  - e.g. run a model both with and without an existing data set and quantify the difference.
- We rarely know the quantitative value of an observation.
- Budget managers want this kind of information.
- This information will help us make arguments for our prioritized improvements. In fact, it might even be required.