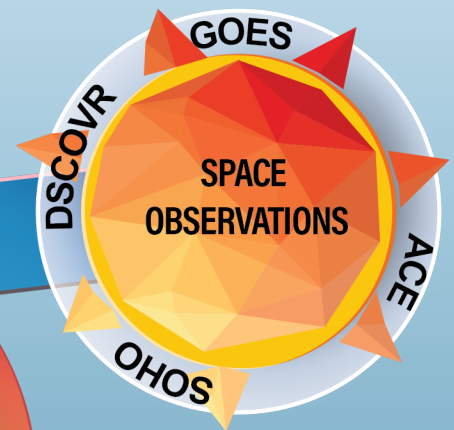
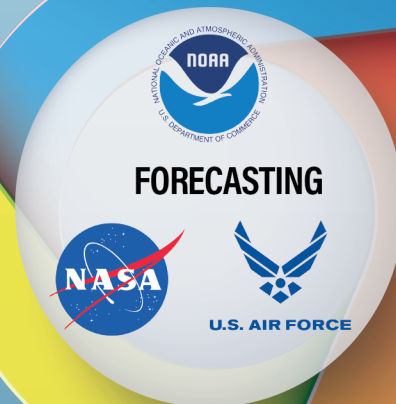




Fundamental Research...

...Increasing space weather warning from 48 minutes to 48 hours



Fundamental Research

Fundamental research investigates the driving mechanisms responsible for space weather events, with a goal of providing more than two days notice for these events (i.e. *before* they occur).

Unlike operations, fundamental research is not done in real time and not used directly for space weather forecasts. Researchers use high-fidelity theoretical models to understand solar processes. To verify model accuracy, scientists compare the model results to high-resolution observations such as those provided by NSO's Daniel K. Inouye Solar Telescope (DKIST), NASA's Solar Dynamics Observatory (SDO) and upcoming Parker Solar Probe (PSP). Continued innovation and technological advancement allows for better quality and more reliable observations. This in turn facilitates the refinement of the theoretical models which may be adapted for operational use in the future.

Operational Models

Operational models provide input to daily space weather forecasts. Developments in fundamental research inform these models, and are frequently adapted from those developed for research purposes.

Operational models not only must be stable and reliable but also depend on parameters that can be obtained in near real-time. Incomplete data available to forecasters prior to the arrival of space weather at Earth represents the biggest challenge in implementing these models. This is a major difference between operational models and fundamental research models.

Future operational models will benefit from refining existing research models using high-fidelity observations. This ensures that space weather forecasts continue to be as accurate as possible.

Forecasting

Space Weather forecasts are primarily conducted by NOAA's Space Weather Prediction Center and the United States Air Force. These centers focus on providing real-time updates on near-Earth current conditions and space weather forecasts.

Combining operational datasets with operational models enables forecasters to predict conditions at Earth in the near future.

Adapting fundamental research models and theories for operational use (R-O) ensures continued improvement of space weather forecasting capabilities.

Ground Observations

Observations from the ground are invaluable to space weather operations particularly, due to the ability to conduct repairs and upgrades to hardware to ensure the facilities' longevity.

Ground-based observatories do not have the restrictions on telemetry, size, or weight that space-based facilities do, and data from these facilities can be accessed in real time if necessary.

Networks, such as NSO-GONG with a distributed network of 6 telescopes, create a continuous watch of the Sun; 24 hours a day, 7 days a week. This ensures we have the most up-to-date information for space weather prediction. GONG provides real-time observations of the Sun's magnetic field for use in space weather operations.

Magnetometers provide global magnetic field changes resulting from space weather events.

Space Observations

Operational satellites such as GOES, DSCOVR and ACE provide observations of space weather parameters such as magnetic field magnitude and orientation, as well as the velocity, density, and temperature of the solar wind.

Combined with NSO-GONG magnetograms, these data provide the input to observational models used for space weather predictions. In addition, satellites such as DSCOVR and ACE are located 1.5 million km closer to the Sun than Earth (at L1 - the first Lagrange point), giving approximately 48 minutes warning of space weather impacts at Earth.

There is increasing interest by the space weather operational and research communities to observe solar magnetic fields from vantage points such as the Lagrange point L-5, that offer several days advance notice for solar activity bound for Earth.