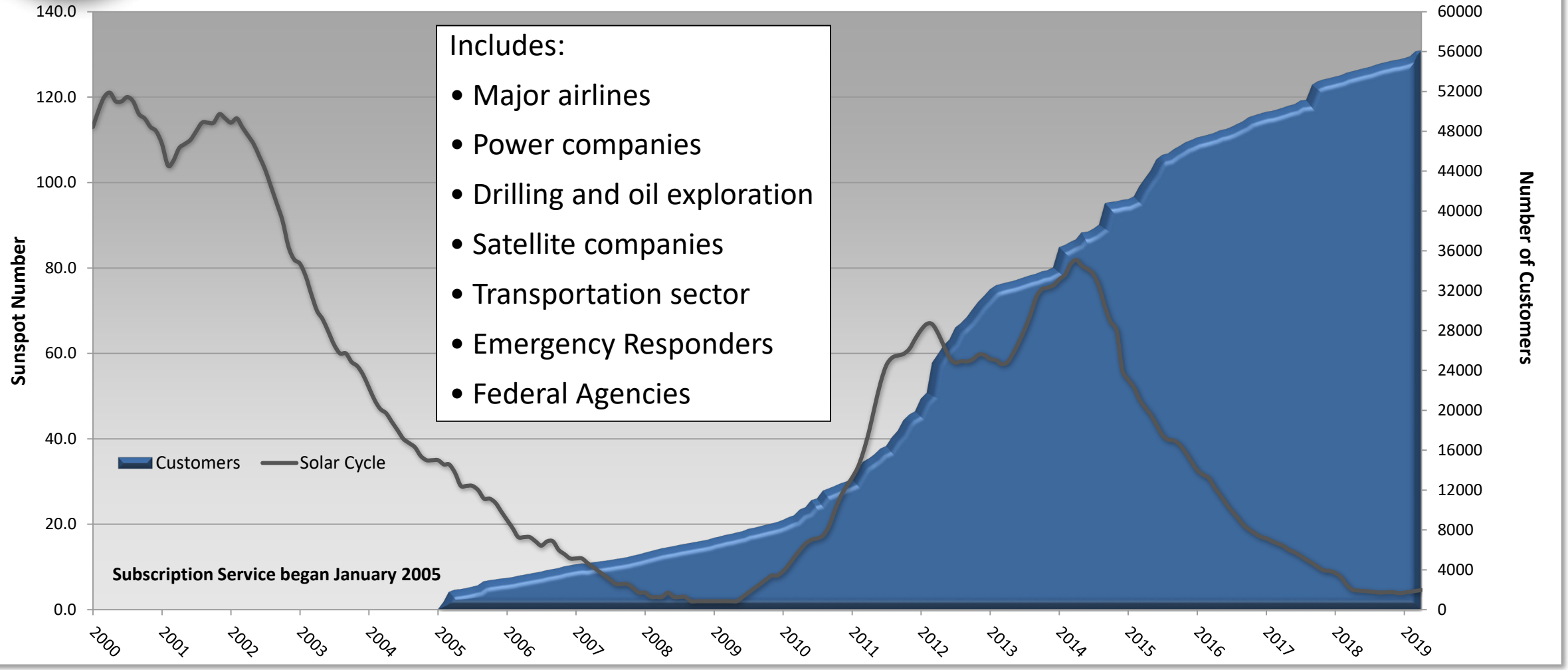
NOAA Space Weather Prediction Center: Advancing Space Weather Services for the Nation

Clinton Wallace
Director
Space Weather Prediction Center
National Weather Service
National Oceanic and Atmospheric Administration

Space Weather Enterprise Forum
26 June 2019

SWPC Customer Subscriptions
(through May 2019)



~200 new registrations every month

SWPC Space Weather Services Support Decision-Making

NOAA Space Weather Services Used Daily

Space Operations
- Postpone launch of satellite
- Turn of or safe-mode instruments and/or spacecraft in orbit

Electric Power Grid
- Adjust/reduce system load
- Disconnect components
- Postpone maintenance

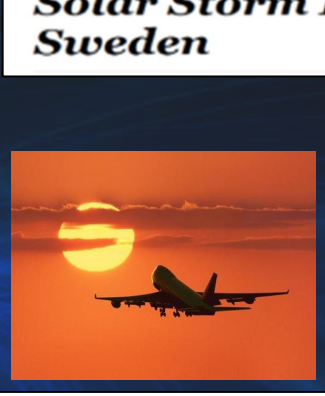
Airlines
- Divert polar flights
- Change flight altitude

GPS/Navigation
- Postpone activities
- Redo survey
- Use backup systems

SECTIONS HOME SEARCH The New York Times

Solar Storm Knocks Out Flight Control Systems in Sweden

Nov 2015

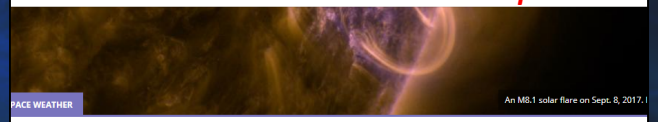


Mar 2012

Solar Flares Knock Out LightSquared Satellite As Run of Bad Fortune Continues

by Karl Bode Friday 16-Mar-2012 tags: satellite · business · wireless · alternatives wireless

MOTHERBOARD *Sep 2017*



Solar Flares Interfered With Radio Network's Ability to Warn People About Hurricane Irma

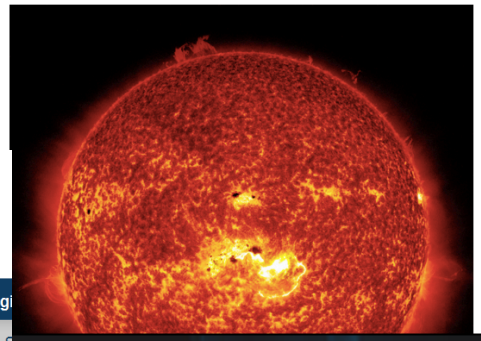
SPACE.COM TECH SPACEFLIGHT SCIENCE & ASTRONOMY

TRENDING: Skywatching Guide // Space Webcasts // Mars Rover Curiosity // Solar Flares // Space Phot

Huge Solar Flare Delays Private Rocket Launch to Space Station until Thursday

by Tariq Malik, Managing Editor | January 08, 2014 08:10am ET *Jan 2014*

392 Share 71 Tweet



STARS AND STRIPES *Mar 2012*

Home News Sports Travel Military Life Opinion Classifieds Rewards Digi

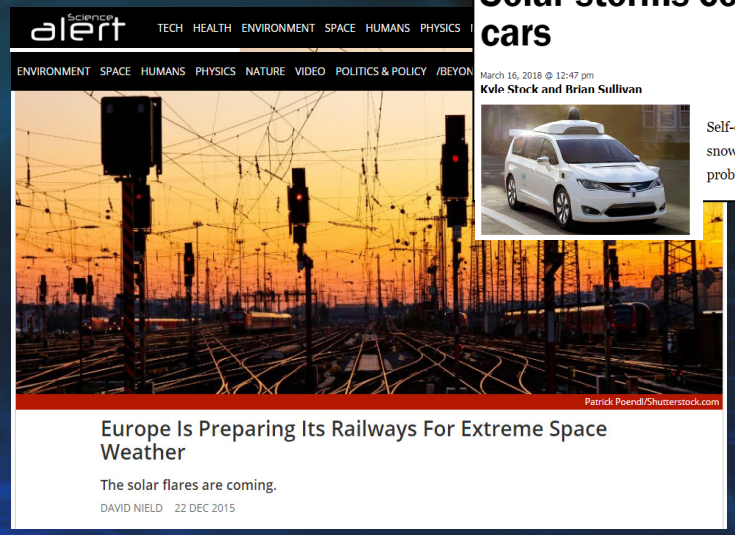
Branches Middle East Europe Pacific U.S. Americas Africa Stripes Central

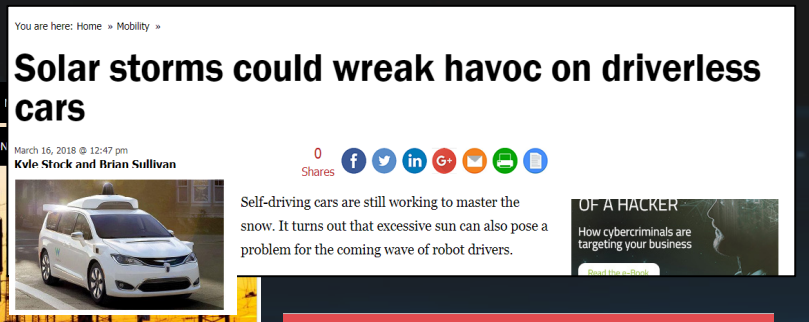
General: Recent solar storm interfered with Air Force satellite

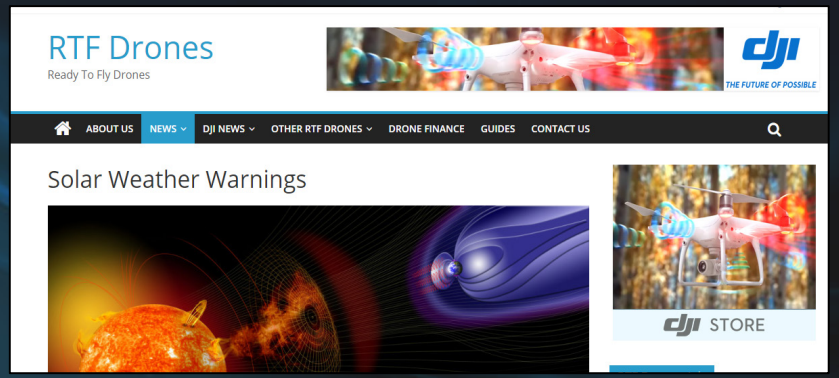
Adapting To Consumers Evolving Needs

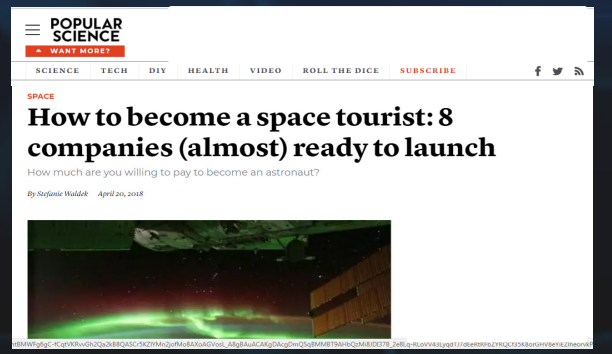
Community must anticipate products to support needs of a rapidly evolving technological society

- **Autonomous vehicles**
- **Advanced Rail Technologies - Positive Train Control (GPS-based safety system)**
- **Supersonic and Hypersonic transport**
- **Space Tourism**
- **Drone technology**
- **Deep space exploration**









Customer Needs and Requirements Survey

Key Customer Needs and Requirements:

- Transition to GeoElectric field forecasts
- Improved localization of geomagnetic disturbances
- Satellite information in MEO, LEO, and GEO
- Improved ionospheric products: TEC and scintillation

Preparing for Space Exploration Initiatives

- Continue daily support for JSC Mission Control for ISS support
- Crewed space exploration outside the magnetosphere presents many challenges
- Defining new support requirements for Lunar (2024) & Mars support

New Space Weather Services for Global Aviation

U.N. International Civil Aviation Organization (ICAO) called for the establishment of space weather information services for global aviation

- Three centers selected for the provision of services:
  - SWPC - United States
  - PECASUS – A Pan-European Consortium including Finland (Lead), Belgium, UK, Poland, Germany, Netherlands, Italy, Austria, and Cyprus
  - ACFJ – Consortium of Australia, Canada, France, and Japan

- New products in development now to address space weather impacts on communications, navigation, and health (radiation exposure)

- Services begin in November 7, 2019

NOAA-NASA-NSF Partnership

Continued Coordination of NOAA, NASA, NSF research

- Jan 2018 – Solar wind, solar wind structures, and CMEs (NOAA-NASA Proof)
- May 2018 – Energetic particles and plasma at spacecraft (NOAA-NASA)
- **Nov 2018 – Solar energetic particles and heavy ions (NOAA-NASA-NSF)**
- **April 2019 – Open call (NOAA-NASA-NSF)**

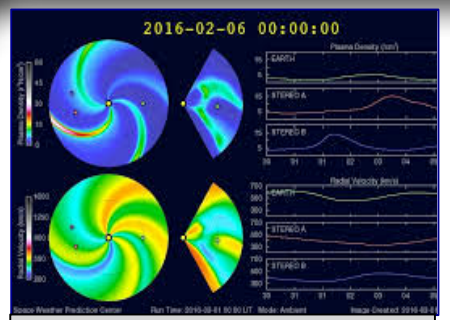
Tri-Agency Memorandum of Understanding signed between NOAA-NASA-**NSF** in Nov 2018

- Allows for the interagency coordination of funding for applied space weather research

The "Conveyor Belt" of new space weather science has been created!

- Operational space weather centers be ready to on-board new science and technology
- The next great R2O challenge is in effectively and efficiently evaluating the results of these AO's and plugging them into operations

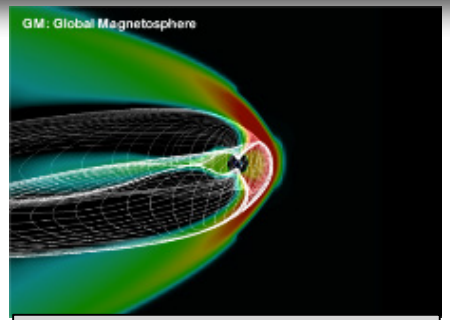
Operational Space Weather Modeling at NOAA
A Sun to Earth Continuum



GMU/AFRL WSA-Enlil

Understand the structure of the solar wind as it propagates from the Sun to Earth

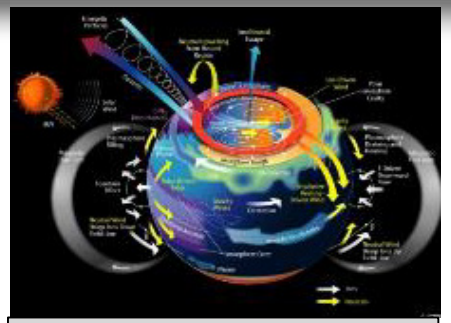
Operational Upgrade May 29, 2019



U. Michigan Geospace

Understand the geomagnetic response to changes in solar wind; provide regional predictions of geomagnetic storms

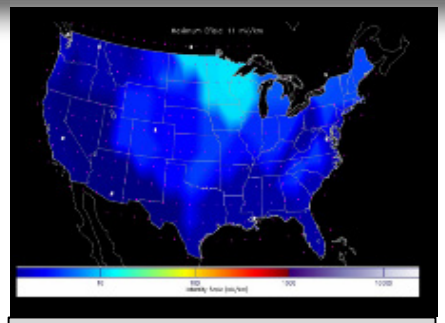
Operational Sept 2016 Upgrade 2020



NOAA/CIRES WAM-IPE

Understand details in the mesosphere, exosphere, and ionosphere, to understand links between the lower and upper atmosphere

R2O Transition Operational 2020



NOAA/USGS Geoelectric

Characterize and predict the regional electric field and the associated currents that impact electric power grids

R2O Transition Operational 2019

WSA–Enlil Heliospheric Model

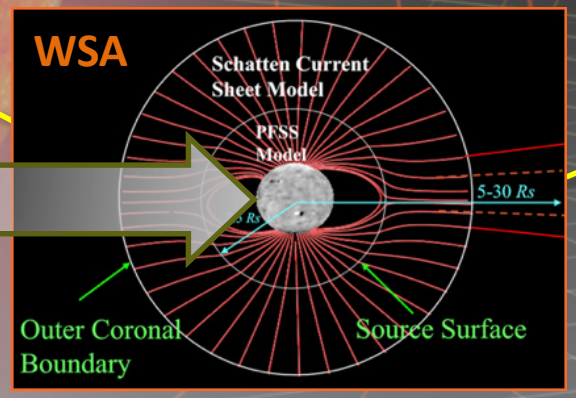
Coupled modeling framework: WSA (corona) + Enlil (Heliospheric MHD) affording predictive knowledge of Heliosphere

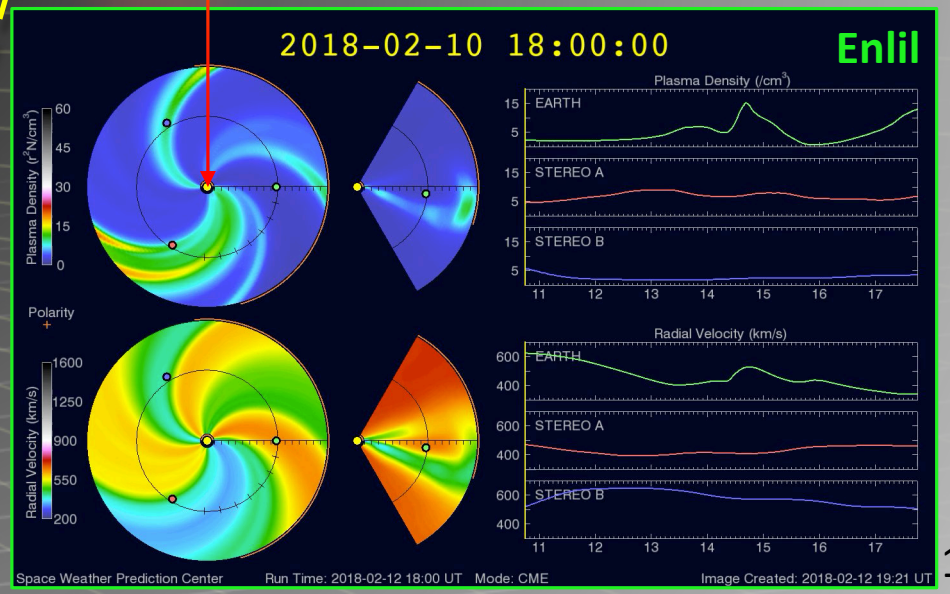
Upgraded May 29, 2019

GONG Magnetogram

CME Characterization

Impact of ambient retuning compared to prior version of model (2007 – 2017)		
Solar Wind Parameter	**Metric**	**Improvement**
Radial Velocity	**Δmean**	87%
	RMSE	32%
Plasma Density	**Δmean**	123%
	RMSE	0.52%



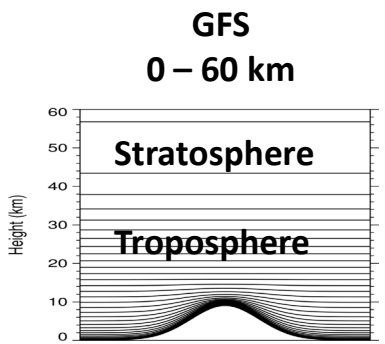


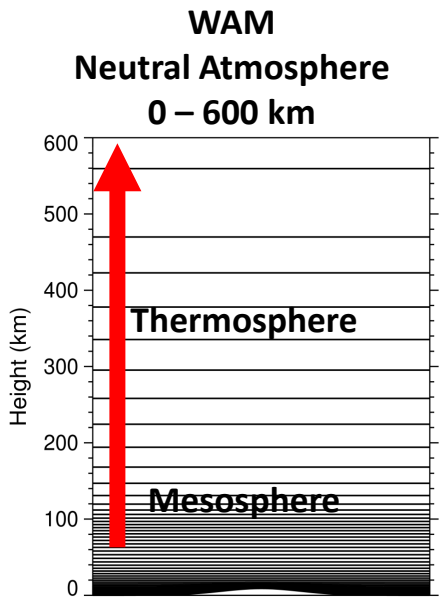
Background image credit: NASA

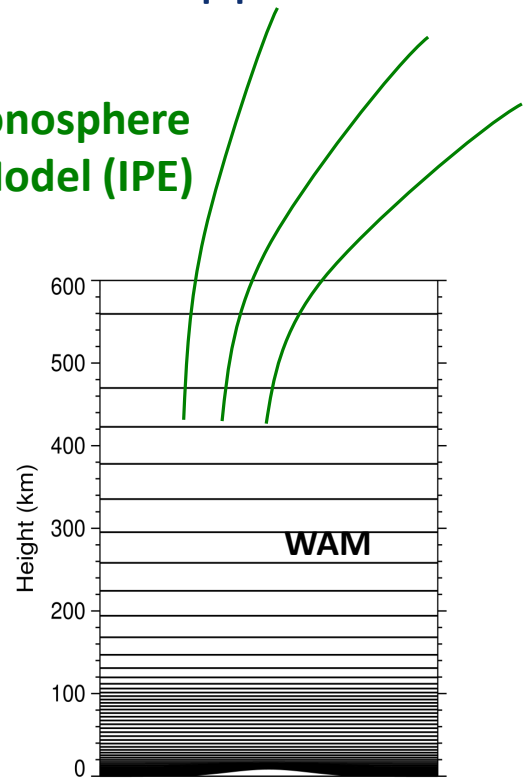
WAM + IPE
Model Development in the Thermosphere-Ionosphere

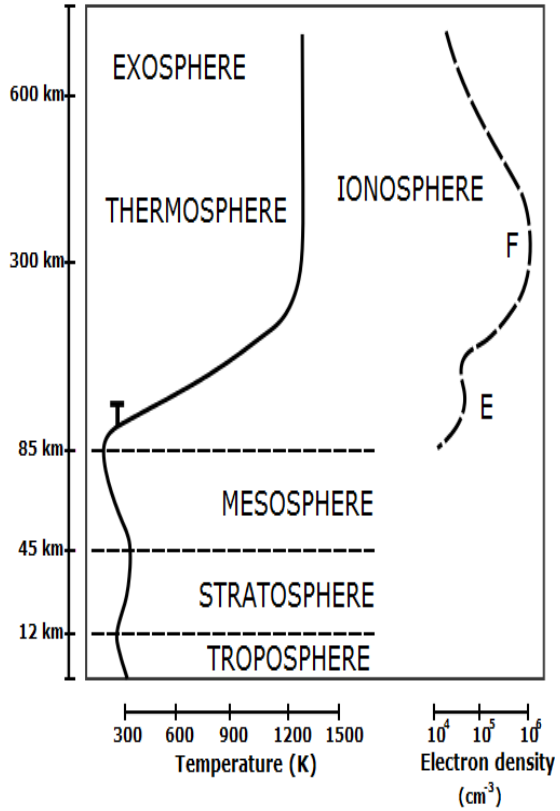
Whole Atmosphere Model (WAM = Extended GFS) + Ionosphere Plasmasphere Electrodynamics (IPE)

- Multi-day forecasts for GPS/GNSS and radio communication customers
- Ionosphere data assimilation in upper levels with GOLD and COSMIC-II

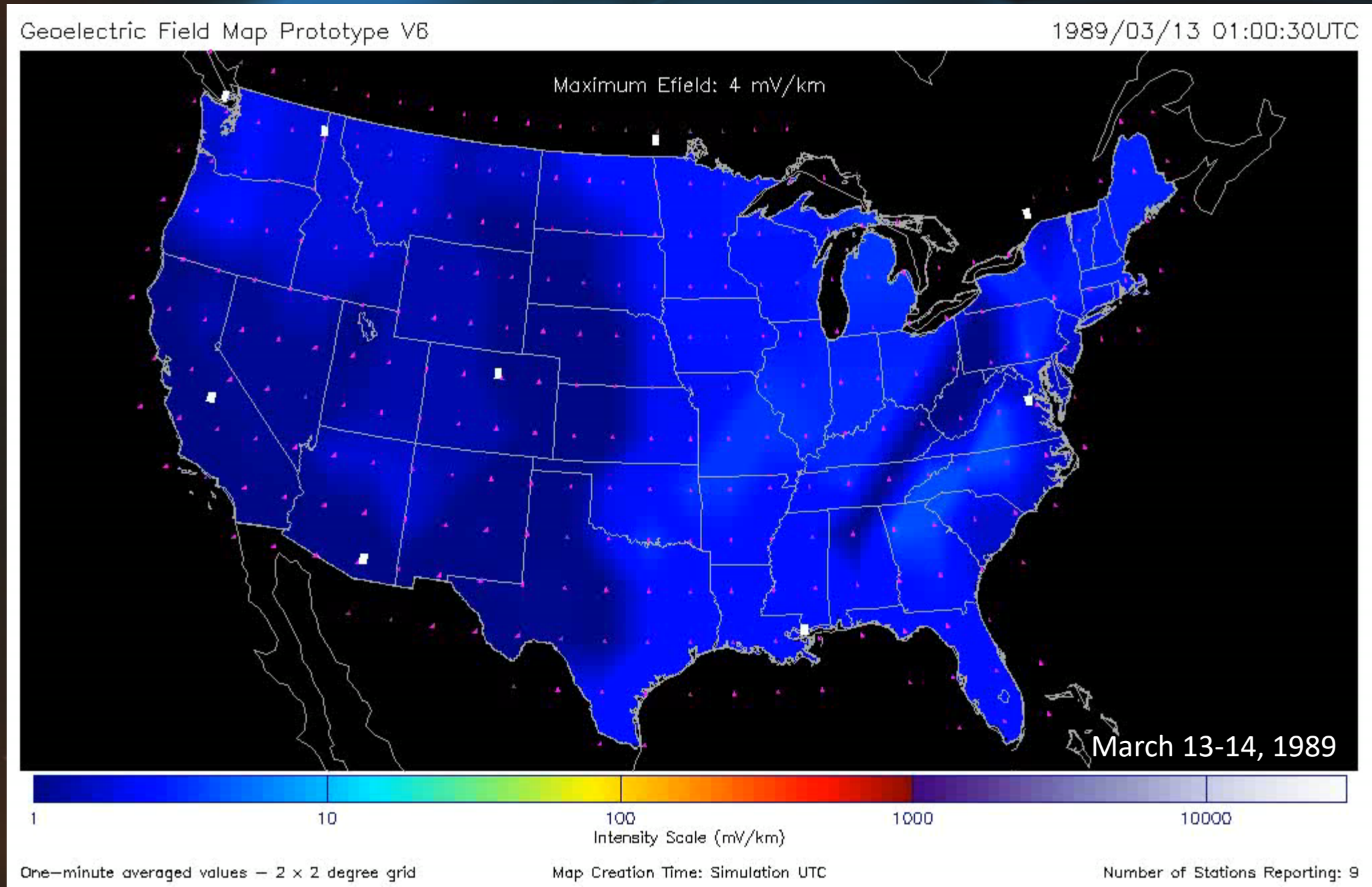


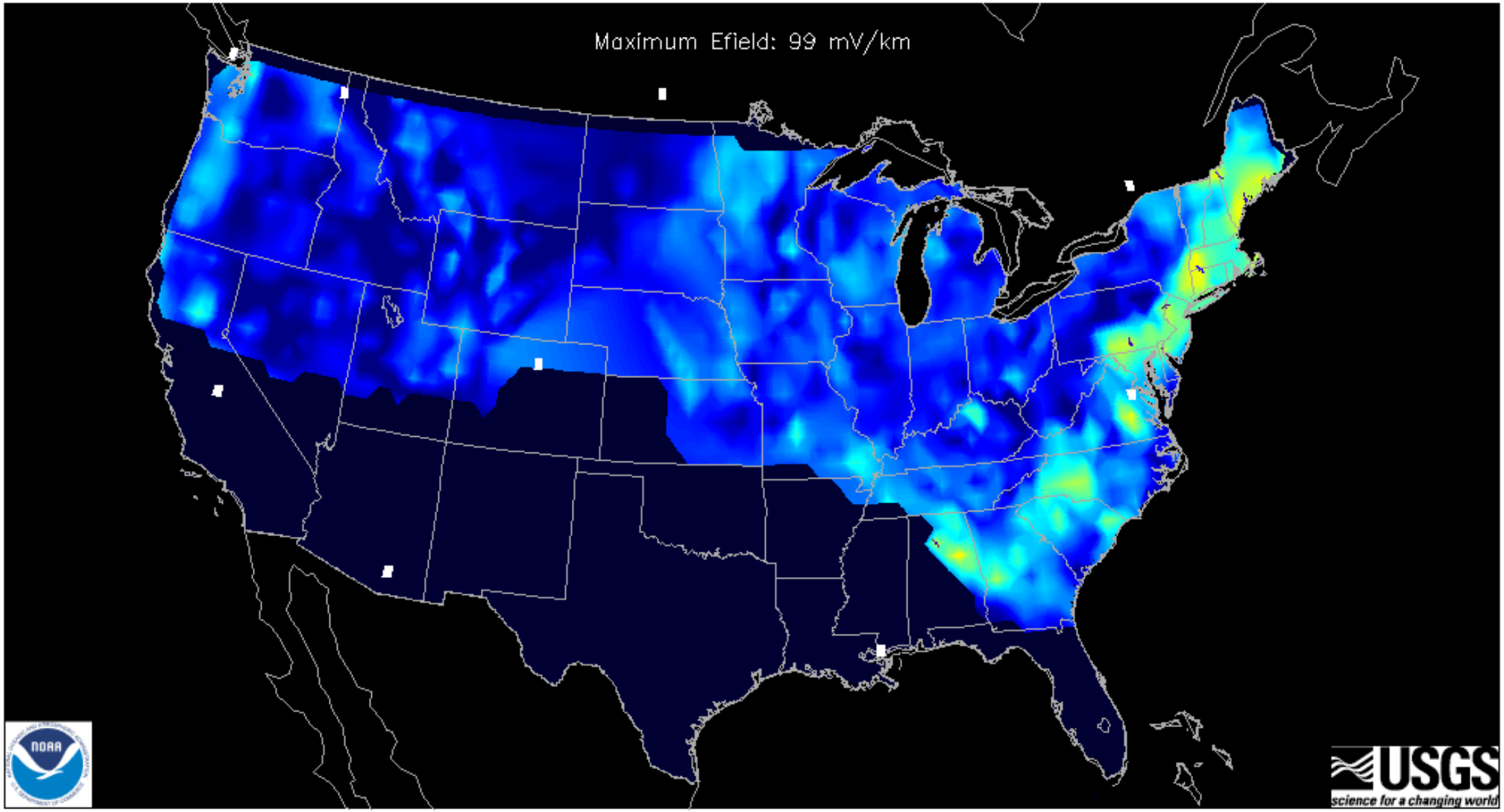






Joint NOAA-USGS Geoelectric Field Model




Geoelectric Field Map Experimental Prototype V1
2019/06/07 16:42:30UTC
Maximum Efield: 99 mV/km
NOAA
USGS
science for a changing world
1
10
100
1000
10000
Intensity Scale (mV/km)
Geomagnetic Data provided courtesy of USGS & NRCAN
This map is an experimental prototype for R&D purposes only
One-minute averaged values — 0.5 x 0.5 degree grid
Map Creation Time: 2019-06-07T17:31:53.713UTC
Interpolation method — SECS
Earthscope Empirical GMTF interpolated to 0.5 degree grid
Number of Stations Reporting: 13

Existing Critical Observations

National Strategy

Establish and sustain a baseline observational capability for space-weather operations

Satellite Observations

DSCOVR

DSCOVR

Operationally dedicated – Ensures continuity of solar wind measurements: Launched – Feb 2015

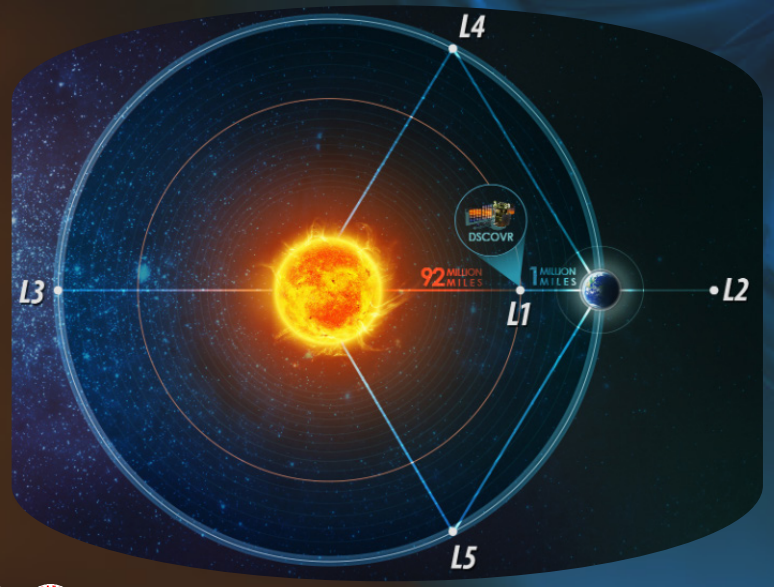
GOES 16 and 17

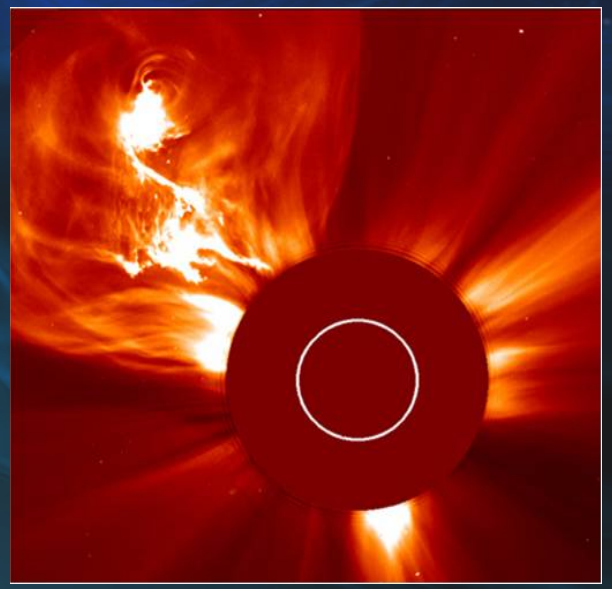
New imager, expanded energetic particle measurements to include heavy ions: Launched – Nov 2016, Mar 2018

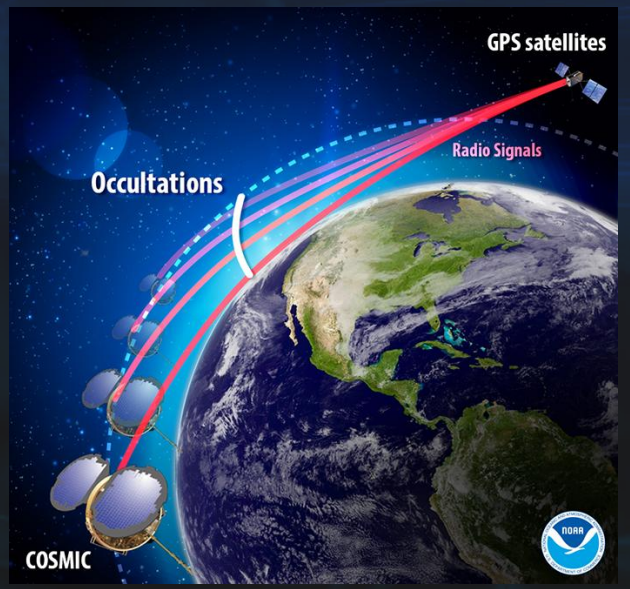
GOES 16

Future Observations

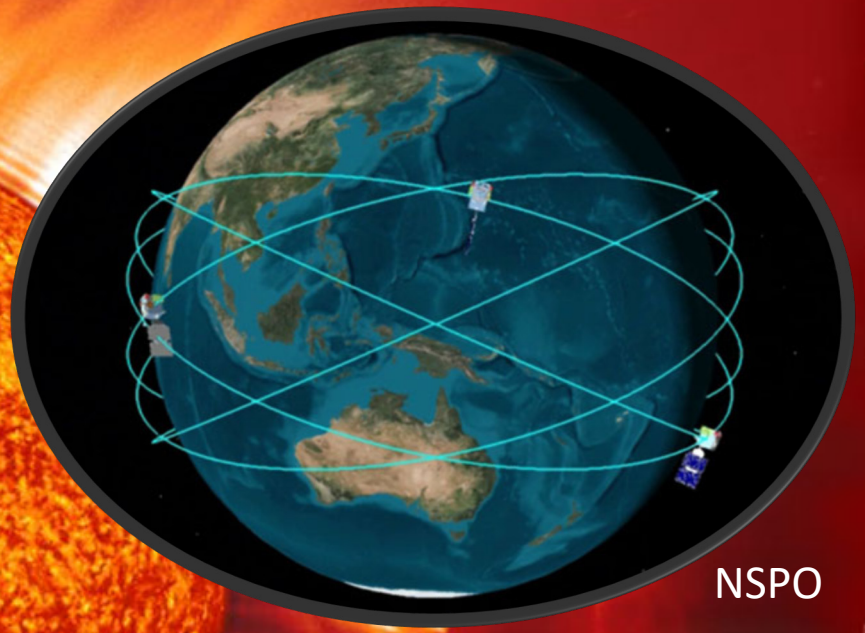
- Future L1: Space Weather Follow On (SWFO) 2024
  - NOAA operational mission to fly a compact coronagraph and solar wind monitor
  - Rideshare with NASA's Interstellar Mapping and Acceleration Probe (IMAP)
- European Space Agency (ESA) and NESDIS partnership being explored for coordination
  - ESA going to L5 and NOAA to L1
- COSMIC-2: radio occultation; Planned June 24, 2019 launch







Ionospheric Radio Occultation: COSMIC-II and Commercial Data Pilot

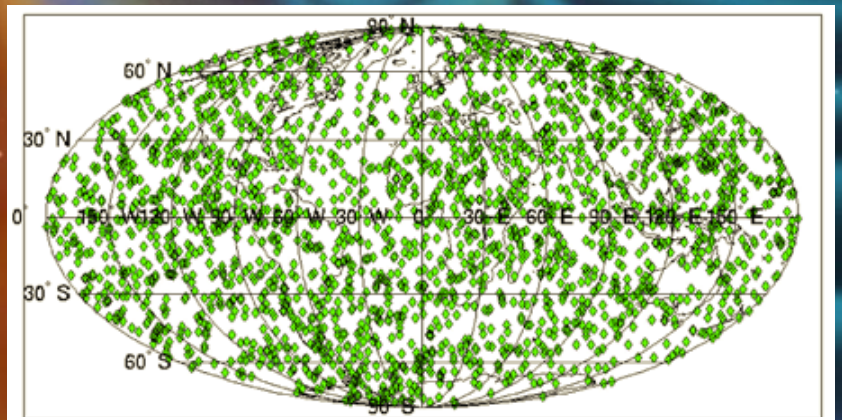


NSPO

NOAA Awards Commercial Weather Data Pilot Round 2

- Companies provide GNSS radio occultation measurements of upper atmosphere and ionosphere
- NOAA evaluates suitability for operational weather and space weather products
- Commercial data could potentially complement COSMIC-2

COSMIC-II Launch: June 24, 2019



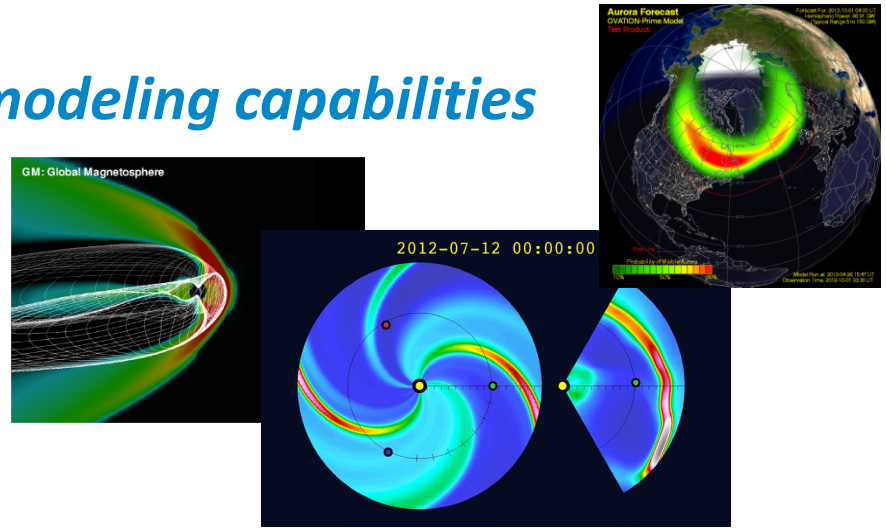
The Dream

Space Weather-Ready Nation:

Building a Nation Ready, Responsive, and Resilient to Space Weather

Essential observations

New modeling capabilities



Partnerships

Involves the entire US Space Weather Enterprise working together TOGETHER

Better information connected to key stakeholders for better decisions

Better forecasts and warnings

Consistent products and services

WRN
Weather-Ready Nation

Actionable environmental intelligence

Connecting forecasts to decisions