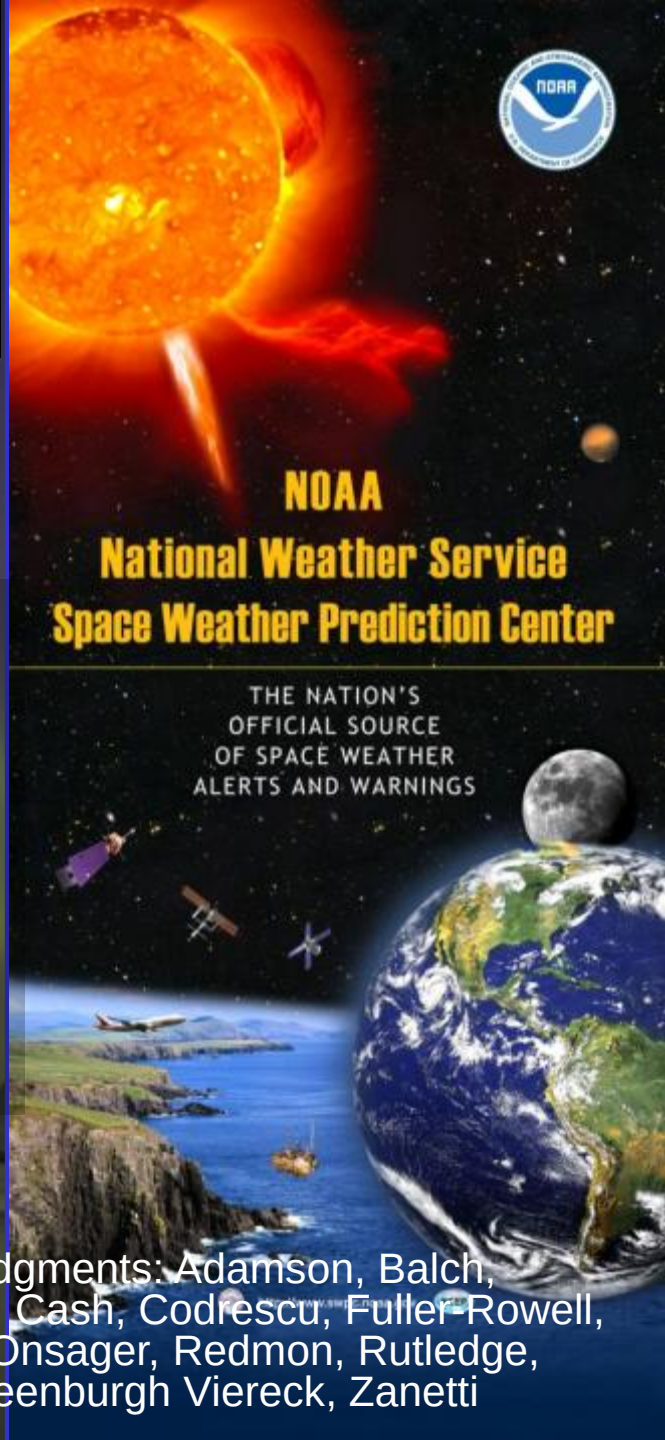
NOAA's Space Weather Prediction Center Update

Bill Lapenta, Director
National Centers for Environmental Prediction
NOAA Space Weather Prediction Center

Outline:

- **SWPC, Customers, & Recent Events**
- **Advances in Forecasting**
  - **Observations and Models**
  - **Experimental Products**
- **Policies and Plans**
- **Conclusions**



COMMITTEE ON SOLAR AND SPACE PHYSICS
March 27-29, 2018

Acknowledgments: Adamson, Balch, Biesecker, Cash, Codrescu, Fuller-Rowell, Murtagh, Onsager, Redmon, Rutledge, Singer, Steenburgh Viereck, Zanetti

Space Weather Prediction Center

Established 1946 as part of Central Radio Propagation Laboratory

Operations – Space Weather Forecast Office

Daily forecast since 1965.

Specifications; Current conditions
Forecast; Conditions tomorrow
Watches; Conditions are favorable for storm
Warnings; Storm is imminent with high probability
Alerts; observed conditions meeting or exceeding storm thresholds

R & D – Space Weather Prediction Testbed

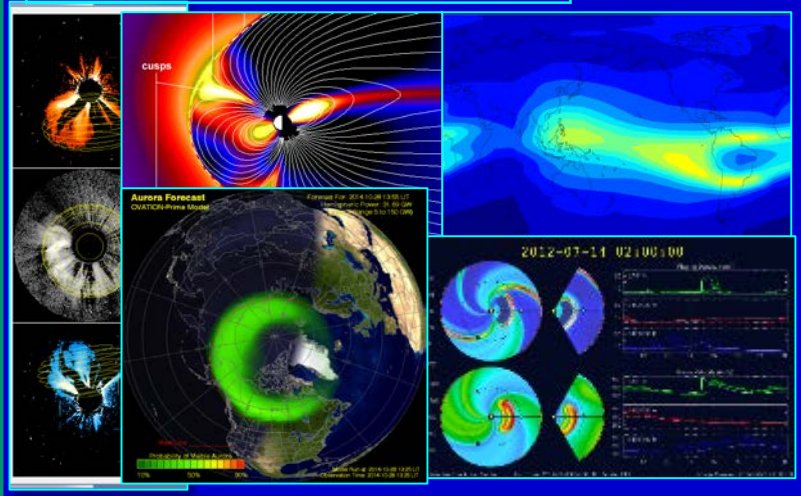
Transitioning models & data into operations

R2O

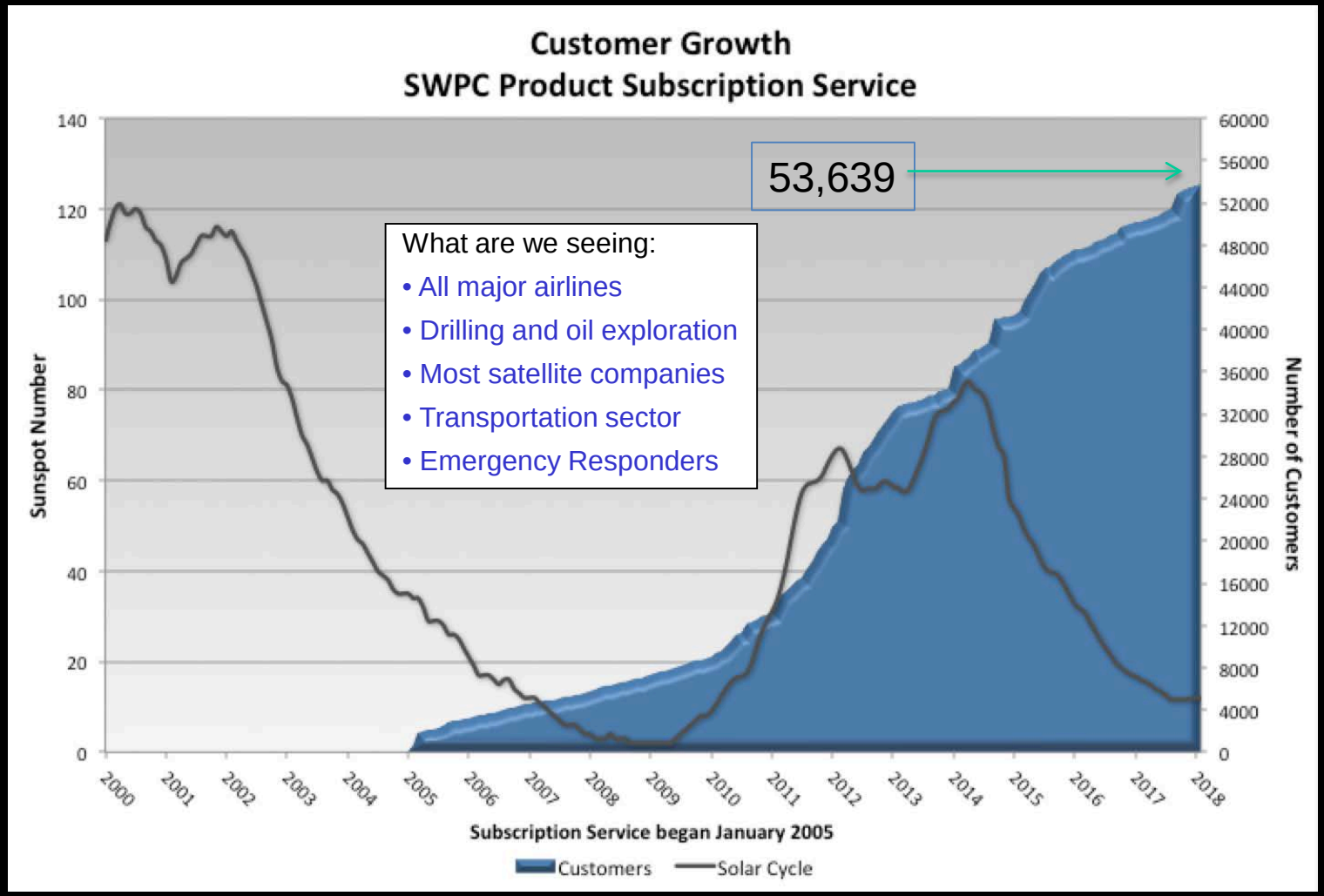
Research-to-Operations
- Applied Research
- Model Development
- Model Test/Evaluation
- Model Transition
- Operations Support

Operations-to-Research
- Customer Requirements
- Observation Requirements
- Research Requirements

O2R

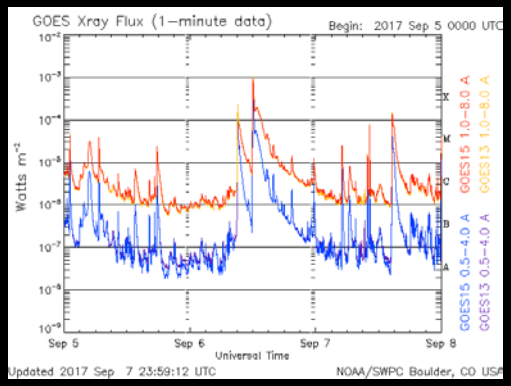


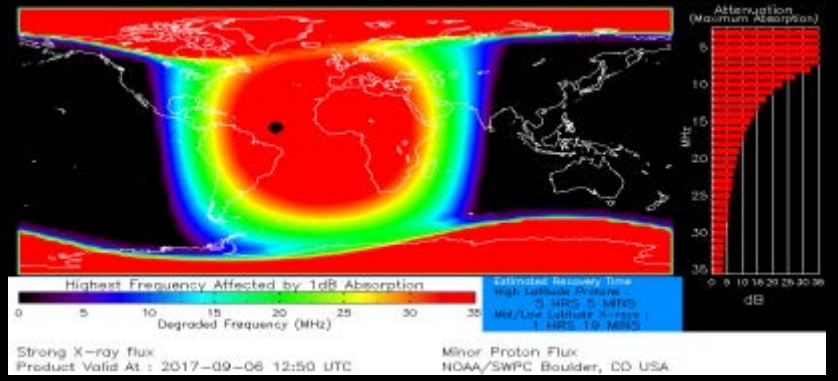
Customer Subscriptions Skyrocket… (through February 2018)



Registrations continue to rise,
even as we head toward solar minimum

Customer Impact Example--September Storms Solar Flares, Solar Particle Events and Geomagnetic Storms





September 6, 2017 X-class Flare

French Civil Aviation authorities reported that HF radio contact was lost with one non-Controller Pilot Data Link Communications (CPDLC) equipped aircraft off the coasts of Brazil and French Guyana for approximately 90 minutes, triggering an alert phase until a position report was received by New York radio.

September 6, 2017 D-Region Absorption Prediction due to Solar flare (sub-solar) and solar protons (polar)

Approximate area (black disc) where HF communication was lost with a non-CPDLC equipped aircraft on September 6 at about 12:00 UTC.

R. Rutledge

Space Weather Workshop - 2018

- UCAR organized (+ Steering Comm.)
- Co-sponsored NOAA, NASA, NSF
- Highlights
  - September 2017 Storms
  - Space Weather Action Plan
  - Economic Impact Assessments
  - Power Grid and Aviation Impacts
  - Space Weather Research, Observations and Modeling
  - Research to Operations
  - Banquet Speaker – Thomas Zurbuchen – NASA AA Science Mission Directorate
  - Monday Side Meetings: Satellite Anomaly Project, SWORM Benchmarks, O2R-R2O
  - Student support and participation

OBSERVATIONS

NOAA NESDIS
Space Weather Platform Status - DSCOVR

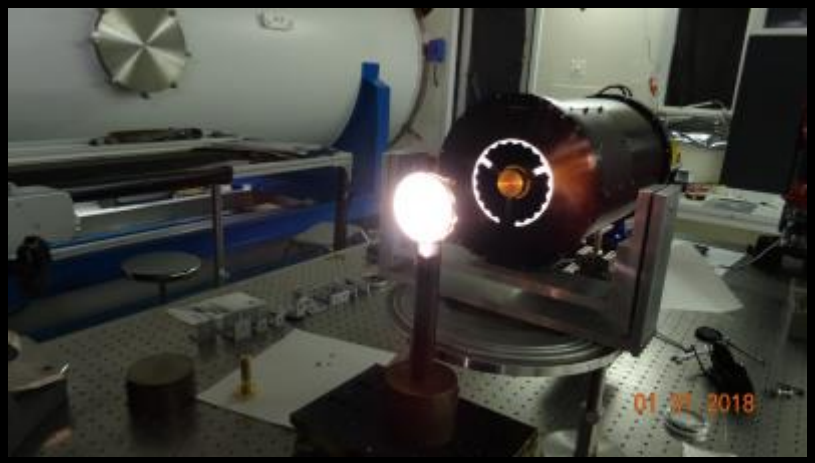
- DSCOVR: NOAA's first operational deep space mission, at L1
  - First NOAA dedicated space weather platform, operational mid-2016
  - Measuring L1 In-situ solar wind parameters
  - DSCOVR parameters drive SWPC space weather warnings and Geospace model
  - Occasional ACE backup
  - Launch 2015, 5 year mission life, propulsion resources for 10 plus years (longevity studies in process)
  - Solar wind characteristics from L1: bulk solar wind density, velocity, magnetic field (enables 15 - 60 min warnings)

- Software changes improve Faraday Cup data quality
- Some problems remain during low density

L. Zanetti, NOAA NESDIS

NOAA NESDIS
Space Weather Platform Status - CCOR

- CCOR: NOAA's first operational coronagraph
  - Presently using NASA/ESA SOHO CME images to define the inner boundary of the CME propagation code WSA/Enlil (1-3 day warnings of Earth arrival)
  - FY 17, 18 funds towards NRL Compact CORonagraph (CCOR) development



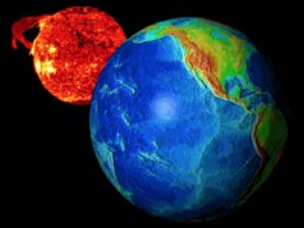
- CCOR Optical Testbed-Initial Illumination Test
- CCOR In Phase B
- NRL Preliminary Design Review 9/28/18
- Possible deployment on GOES U 2024

L. Zanetti, NOAA NESDIS

NOAA NESDIS
Space Weather Platform Status – Space Weather Forward Observatory (SWFO)

- Partnership under consideration with NASA to fly separate solar wind monitor with IMAP (Interstellar Mapping and Acceleration Probe) launch 2024
- NESDIS Office of Planning, Projects and Analysis (OPPA, now led by Elsayed Talaat) developing path forward
- FY 18/19 budget concerns regarding implementation
- Solar wind monitor of in-situ solar wind and coronagraph
- L5 mission is an ESA project with UK role in instrument development
- ESA and NESDIS partnership being explored for coordination (with ESA going to L5 and NOAA NESDIS to L1)

GOES-16 & 17 Status



GOES-16: Operational East (75W)

GOES-S → GOES-17 on March 12.

Space Weather Instruments

- Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS: XRS, EUVS)
- Solar Ultraviolet Imager (SUVI)
- Space Environment In-Situ Sensor Suite (SEISS)
- Magnetometer (MAG)
- Expect all GOES-16 SpWx Provisional maturity (operational utility) in 2018.

Dissemination plans

- NESDIS/NCEI/STP is the steward for all GOES-R SpWx products.
- Graphics from Ground System can be shared now with a disclaimer.
- Data shareable post-Provisional, possibly sooner on an ad hoc basis.
- Public dissemination of L1b and initial L2 products anticipated mid to late 2018.
    - See https://www.ngdc.noaa.gov/stp/satellite/goes-r.html for details.

Contact: Rob.Redmon@noaa.gov

STP SpWx Satellite Services: DSCOVR, GOES, POES, GPS & LANL GEO, DMSP

STP's comprehensive Space Environmental Data Services

Satellite Data Entry
http://www.ngdc.noaa.gov/stp/satellite/

DSCOVR - solar wind dynamic plots, data, docs
http://www.ngdc.noaa.gov/dscovr/

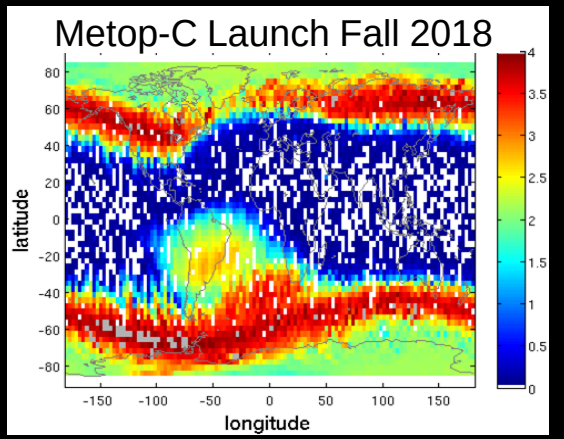
GOES - SEM plots, data, SXI browser, docs
https://www.ngdc.noaa.gov/stp/satellite/goes/

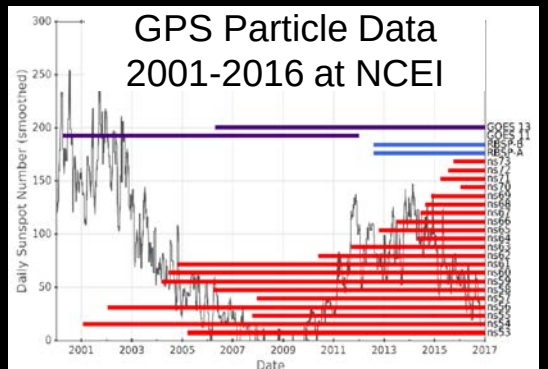
GOES-R – SUVI, SEISS, EXIS, MAG, early data, docs
https://www.ngdc.noaa.gov/stp/satellite/goes-r.html

LANL GPS & GEO - energetic particles
https://www.ngdc.noaa.gov/stp/space-weather/satellite-data/satellite-systems/

POES / Metop - SEM plots, data, belt indices, internal charging, docs
https://www.ngdc.noaa.gov/stp/satellite/poes/

DMSP - SSJ (new), SSIES (ops), SSM (ops, planned)
https://www.ngdc.noaa.gov/stp/satellite/dmsp/





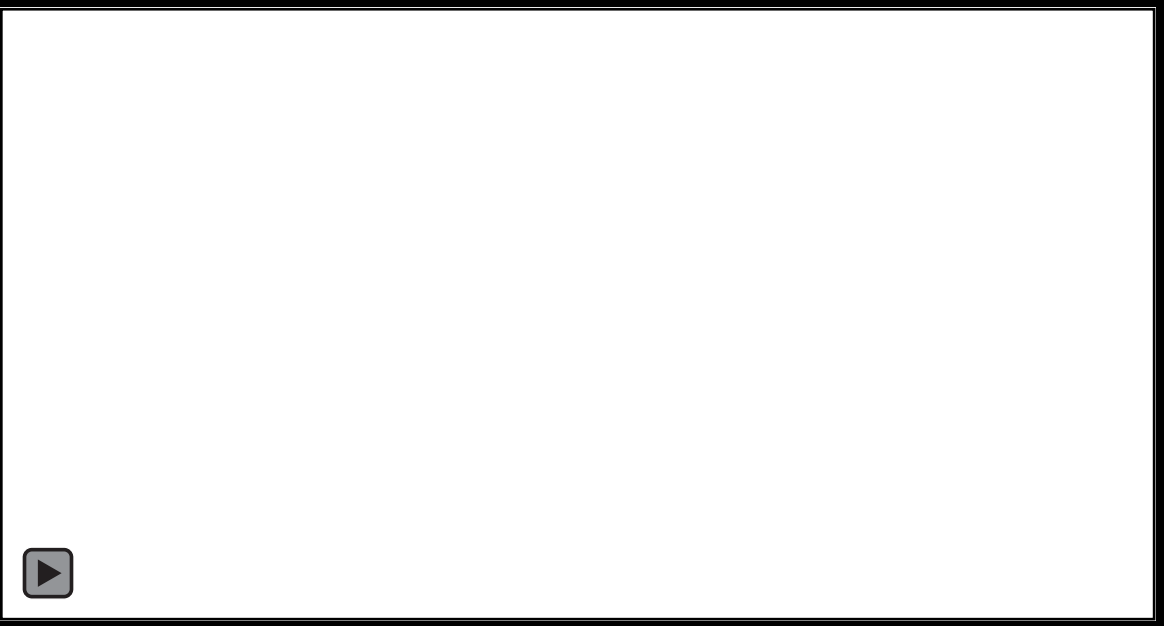
Contact: Rob.Redmon@noaa.gov

NOAA's Commercial Weather Data Pilot

- NOAA will evaluate commercial data to demonstrate the quality of the data and its impact to weather and space weather forecast models, and to inform NOAA's process for ingesting, evaluating, and utilizing commercial data in the future.
- NOAA has selected GNSS radio occultation (GNSS-RO) as the most suitable data type for the CWDP
- Commercial providers will be asked to deliver space weather data obtained from radio occultation instruments (RFP to be released soon)
- For space weather, these data can fill the gap that was left when COSMIC-2 polar orbits were not funded
- SWPC is supported to assess the data quality for fulfilling operations needs; including assimilation into a global total electron content product (GloTEC) and comparisons to US TEC and other models

MODELS

WSA-Enlil Heliospheric Model



Models ambient background solar wind and CME propagation - informs forecasts of timing and magnitude of Geomagnetic disturbances

Major model upgrades scheduled for 2018

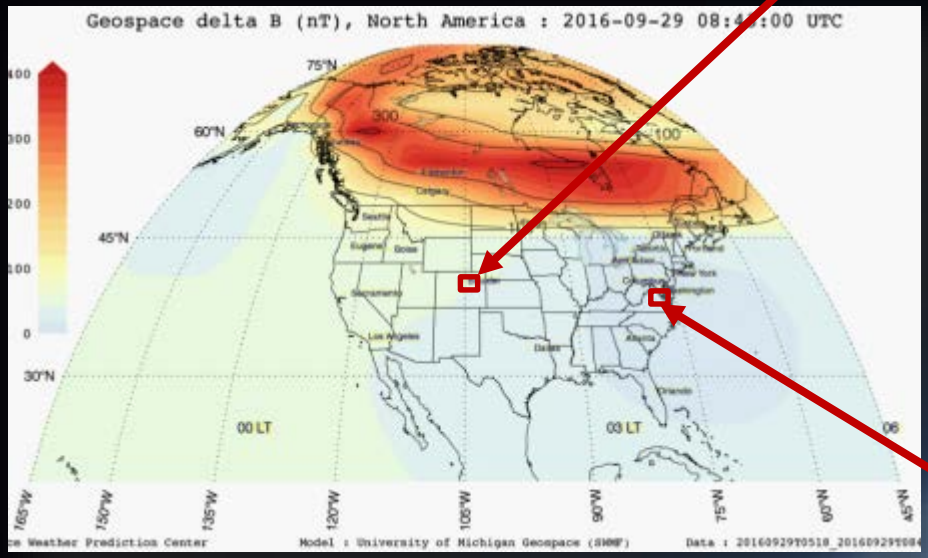
- Improved model inputs through enhanced processing of solar photosphere observations
- Increased operational robustness
- ADAPT compatible - enabling more accurate and time-dep. Driving
- Partnership with USAF

Collaborative effort underway with NASA's CCMC to validate and quantify advancements in space weather prediction afforded by impending upgrades + ADAPT

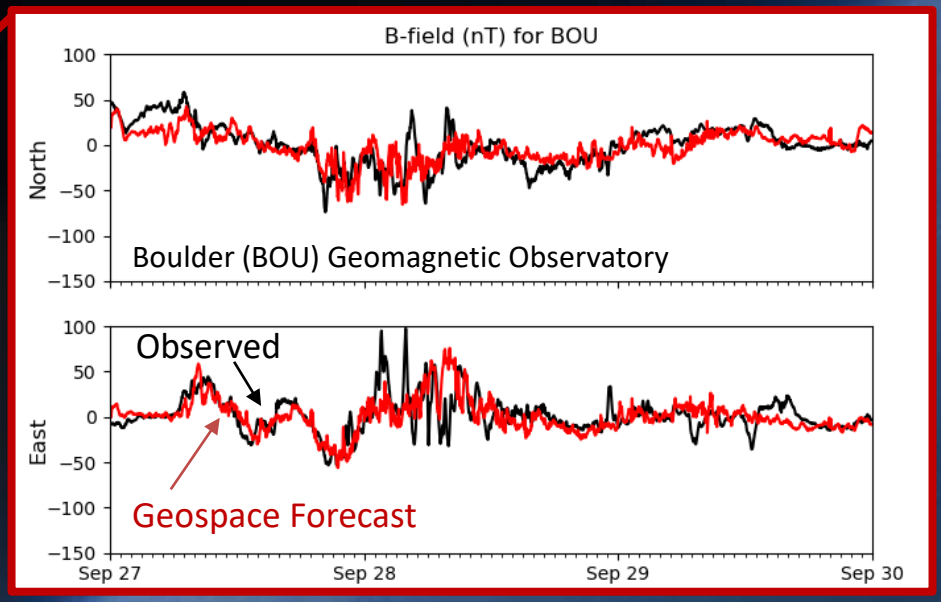
E. Adamson

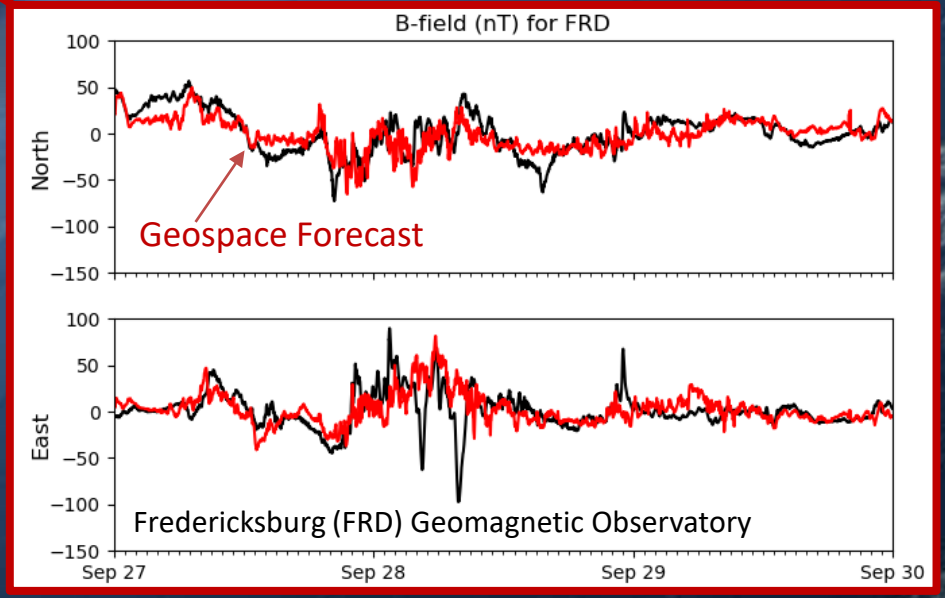
Geospace Model

Current Focus on Regional Validation



- Captures activity well during active periods
- More validation is needed to provide confidence levels
- Provides regional geomagnetic storm predictions supporting space weather forecasters and electric power industry





University of Michigan SWMF; Cash and Singer SWPC

Coupling Weather and Space Weather Models

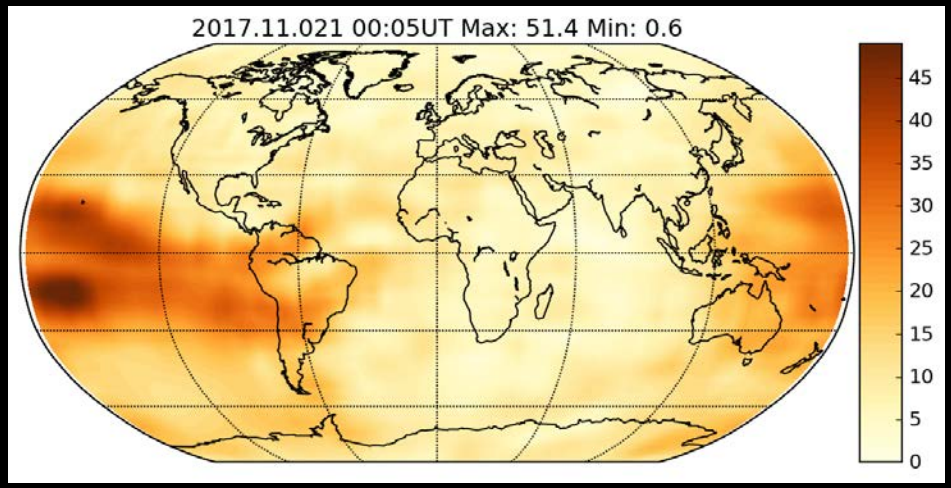
Whole Atmosphere Model (WAM) and Ionosphere Plasma Electrodynamics Model (IPE)

Validating WAM-IPE with GloTEC

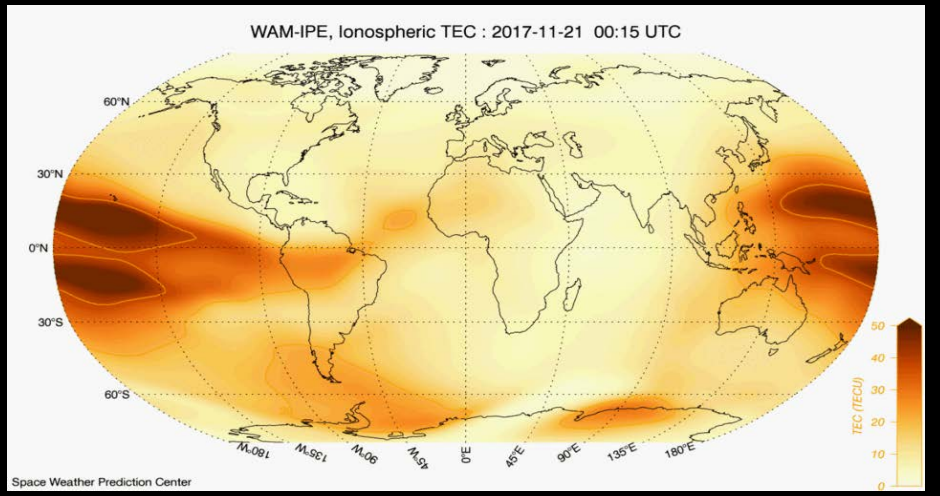
Global Total Electron Content (GloTEC) provides specification (observed) of ionosphere TEC

WAM-IPE: Provides forecasts of Ionosphere total electron content (TEC)

GloTEC: Data Driven Assimilative Model



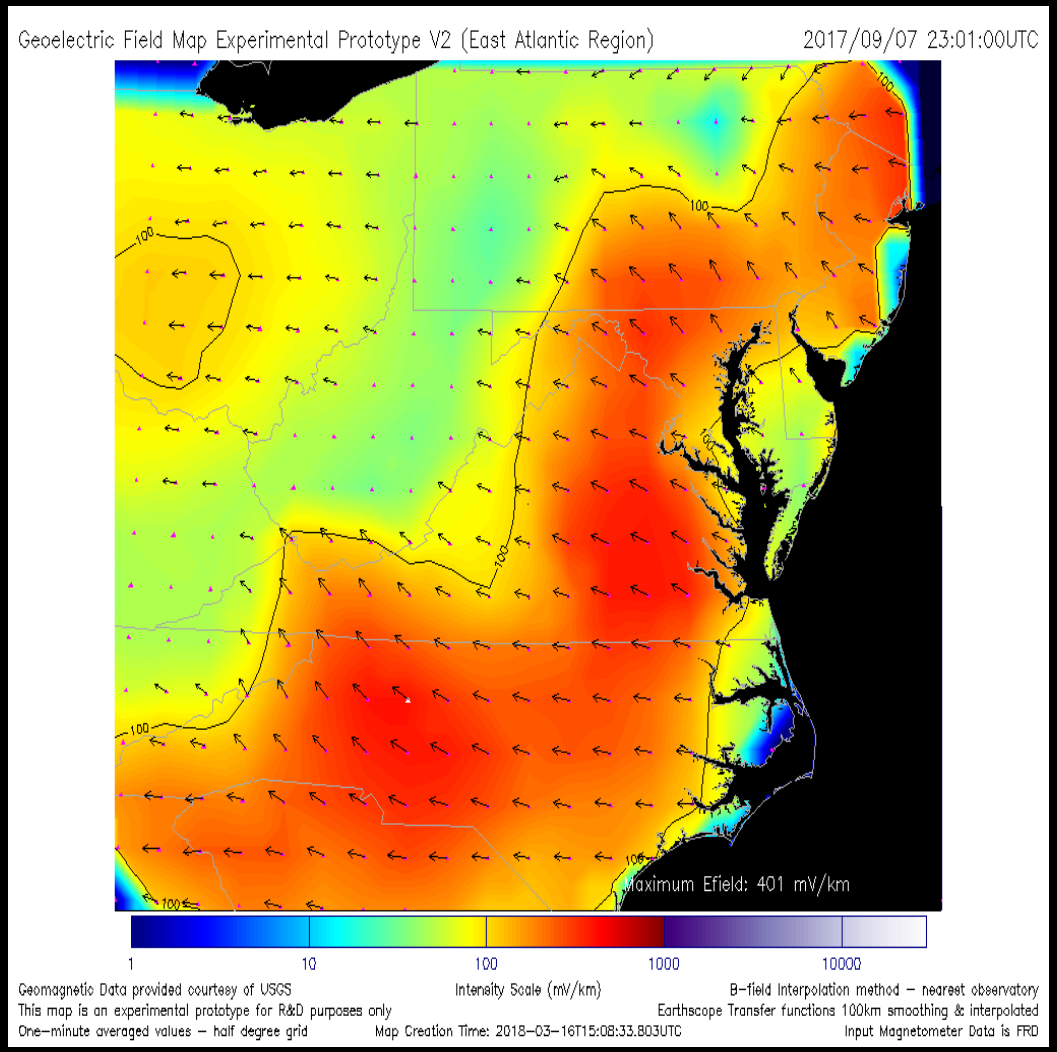
WAM-IPE TEC Physics-based Model



R. Viereck and team

Geoelectric Field (experimental)

- Computed from ground-based magnetometer data and ground-conductivity maps
- Upgrade for map products in progress
- Grid resolution increase from 2 degree to ½ degree
- Conductivity models improve from 1D (Fernberg) to 3D based (Earthscope) – in regions where surveys have been completed
- Validation work with user community is underway



Eastern Seaboard 9/7/2017
Max E field = 0.4 V/km

Collaborators: USGS, NASA, NRCAN, NSF-Earthscope Project

C. Balch

POLICIES AND PLANS

Coordinated Interagency Space Weather Research Funding

Joint NASA/NOAA pilot funding opportunity:

- **Follows direction of the National Space Weather Action Plan to facilitate research to improve operational services**
- **First research focus is to improve forecasts of solar wind and coronal mass ejections – Proposals were due March 30**
- **Future funding opportunities will address other space weather research and service priorities**

Space Weather Policy
Administration Priorities for
Federal Research and Development – FY19 Budget

Improving Preparedness for and Response to Natural Disasters:

"The Budget also continues to support space weather-related R&D, since space weather can affect not just the Nation's satellites and space explorers, but can potentially cause significant damage to our electrical grid and electronic systems."

Economic Impact Study – Abt Associates

FINAL REPORT

Social and Economic Impacts of Space Weather in the United States

September 2017

Abt Associates
Bethesda, Maryland

Written under contract for the NOAA National Weather Service
www.nws.noaa.gov

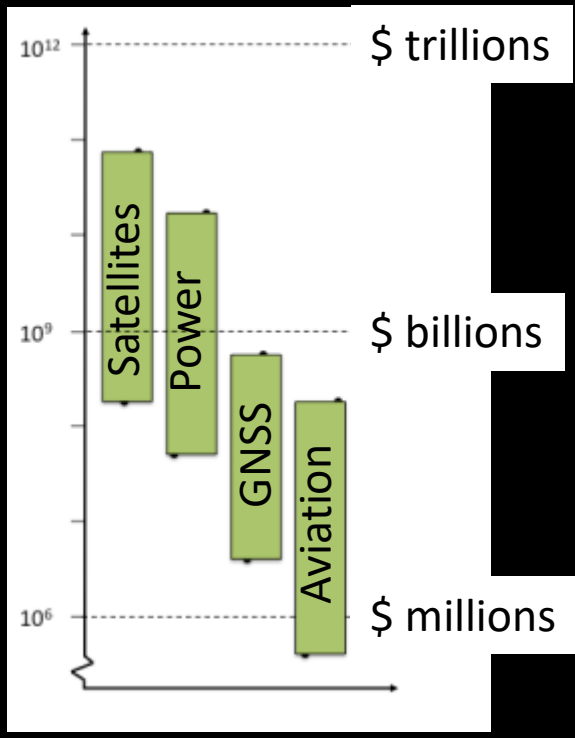
www.weather.gov/news/171212_spaceweatherreport

Source: Stacey Worman, Abt Associates

Key Findings

- Impacts are a real concern
- Stakeholders are interested
- Topic is complex
- Mitigation may be inexpensive
- Help value NOAA investments

Estimated cost of moderate/extreme event



Note: Costs represent first pass estimates not to be taken out of context or quoted without appropriate caveats. Qualitative information and quantitative framework are the more important contributions of this effort.

New work initiated on SWAP Action 5.1.1 to "**Conduct comprehensive user survey of space weather data and product requirements**"

Conclusions

Forecasting Space Weather will advance through:

- **new and sustained Observations**
- **improved and accurate Models**
- **advances in space science understanding and Research**
- **and the transition and improvement of tools and models through effective R20/O2R**

These actions, along with an understanding of user needs, will enable SWPC to serve customers with consistent, accurate, and actionable information.