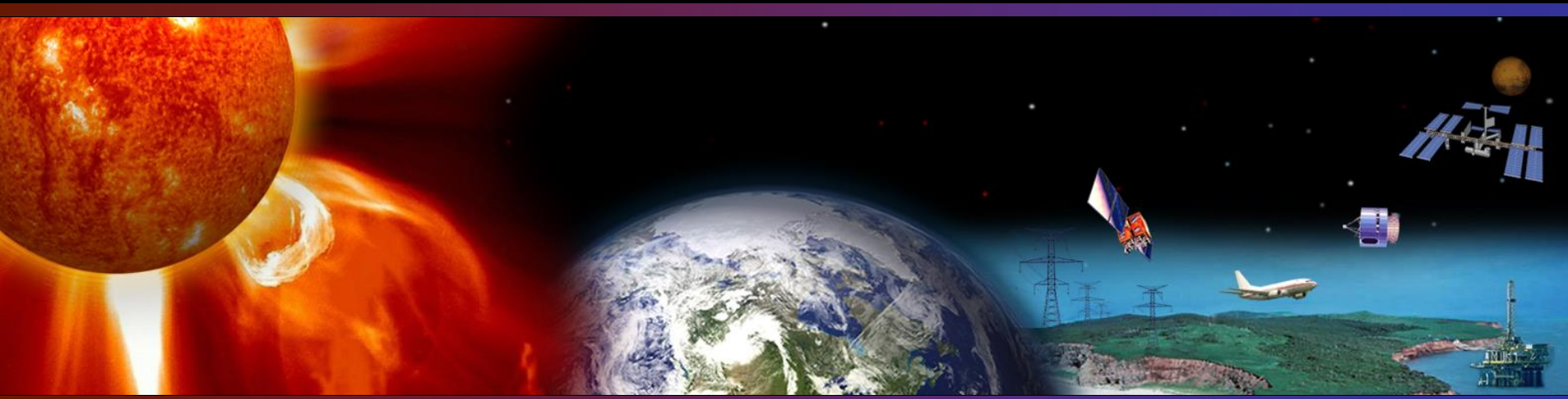
NOAA Space Weather —
Directions for Future Operational Services

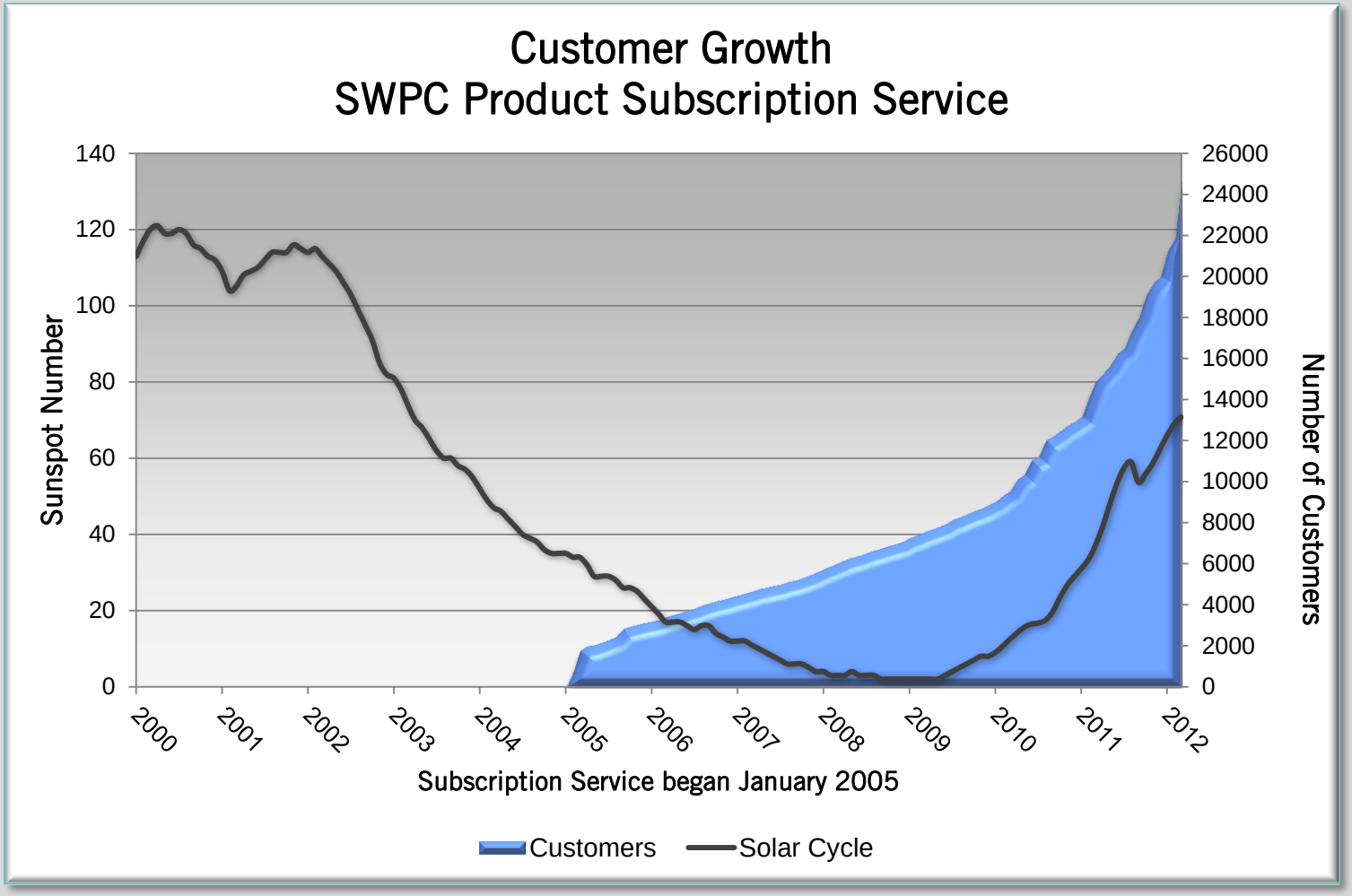


Louis Uccellini
NOAA National Weather Service
National Centers for Environmental Prediction
Space Weather Workshop
25 April, 2012

Outline

- Service Trends
- Improving Operational Services for a “Weather Ready Nation”
  - Observations
  - Models
  - Space Weather Prediction Testbed
- National Unification Efforts
- International Collaborations
- Summary

Service Trends

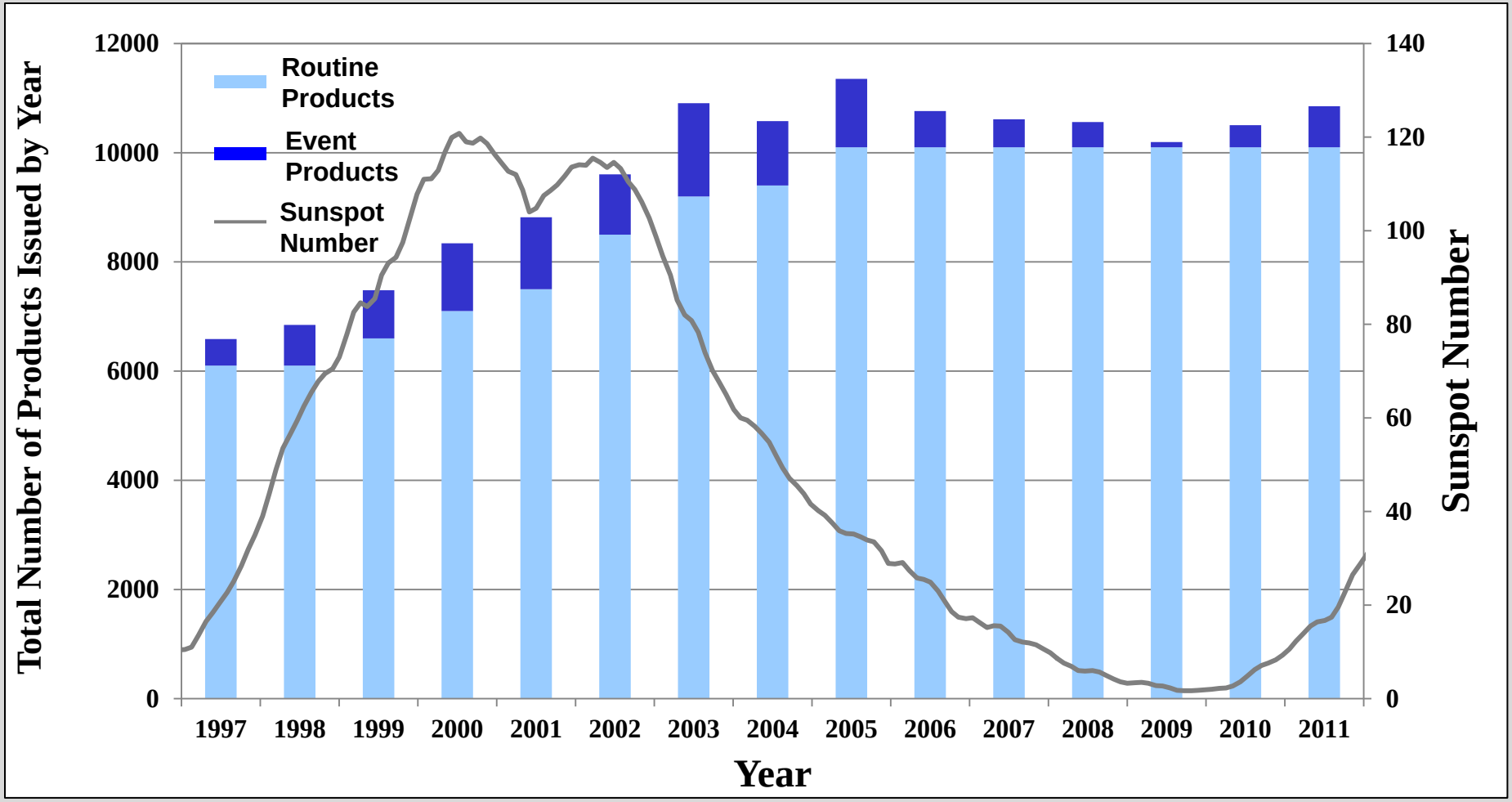


SES Satellite	Inmarsat	FEMA	Boeing	FAA
Alaska DOT	Chrysler	Motorola	British Petroleum America	Multiple Electric Utility Companies
Washington St. Dept of Transportation	John Deere & Caterpillar, Inc.	Major Airlines – UAL, AA, CO, Delta	United Launch Alliance	Barclays

Sample Recent Registrants

http://www.swpc.noaa.gov/ (“Email Products”)

Annual Number of Routine and Event Driven Space Weather Products Issued



Annual number of forecaster generated products

Does not include automated analysis, model guidance, satellite products

Improving Operational Services for a "Weather Ready Nation"[1]

- Observations
- Models
- Space Weather Prediction Testbed

[1] *Based on NOAA and National Weather Service strategic plans*

NOAA's Commitment to Improve Operations

Continue and Expand Coverage of Critical Observations

GOES – flagship space weather satellite

GOES-R – improve support for the detection and observations of space weather phenomena that directly affect public safety, and economic health and development.

- EXIS – X-ray sensor, expanded dynamic range and flare location
- SEISS – energetic particle detectors
- SUVI – solar imager
- Launch ~FY2016

NOAA's Commitment to Improve Operations

Expand Coverage of Critical Observations

Deep Space Climate Observatory (*DSCOVR*)

- DSCOVR is an existing NASA satellite with solar wind sensors (launch summer 2014)
- NASA/GSFC refurbishes with NOAA funding
- NOAA ($30.1M funded FY12)
  - NESDIS operations, data processing, archive, calibration/validation
  - NWS/SWPC forecasts & warnings
- Air Force launch ($134.5M funded FY12)
- International Real Time Solar Wind Network (RTSWnet) downlinks data

NOAA's Operational Model Production Suite
"From the Sun to the Sea"

~2B Obs/Day
Satellites + Radar
99.9%

Global Data Assimilation

Global Weather Forecast

Climate Forecast

Hurricane

Coupled

Oceans (HYCOM)

Waves

NOS – OFS

Great Lakes

Bays
- Chesapeake
- Tampa
- Delaware

Regional DA

Regional Model

Dispersion

Severe Weather

Air Quality

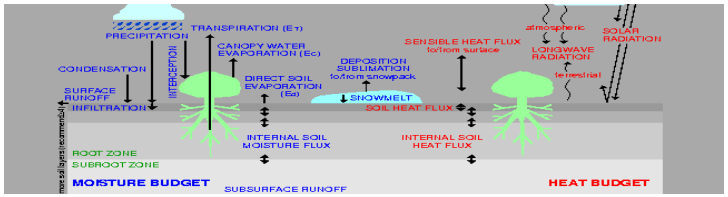
Aviation

Regional DA

Short-Range Ensemble

Global Weather Ensemble

Space Weather (Enlil)



NOAH Land Surface Model

Space Weather Operational Model: WSA-Enlil

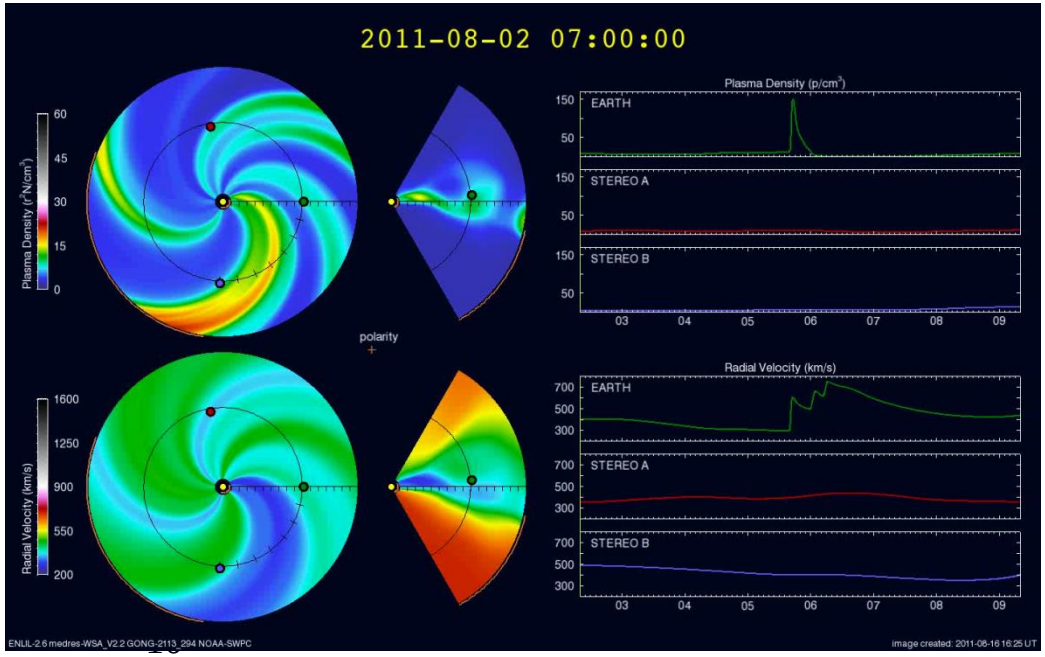
First operational implementation of a space weather model on the NCEP operational computer

Jointly developed by scientists with the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder, NOAA, NASA, the Air Force Research Laboratory, Boston University, the National Center for Atmospheric Research, and George Mason University.

Provides 1-4 day advance warning of geomagnetic storms

Provides perspective on structures 1-27 days in advance

Reduces error in geomagnetic storm onset time from ±15 hrs to ±6 hrs



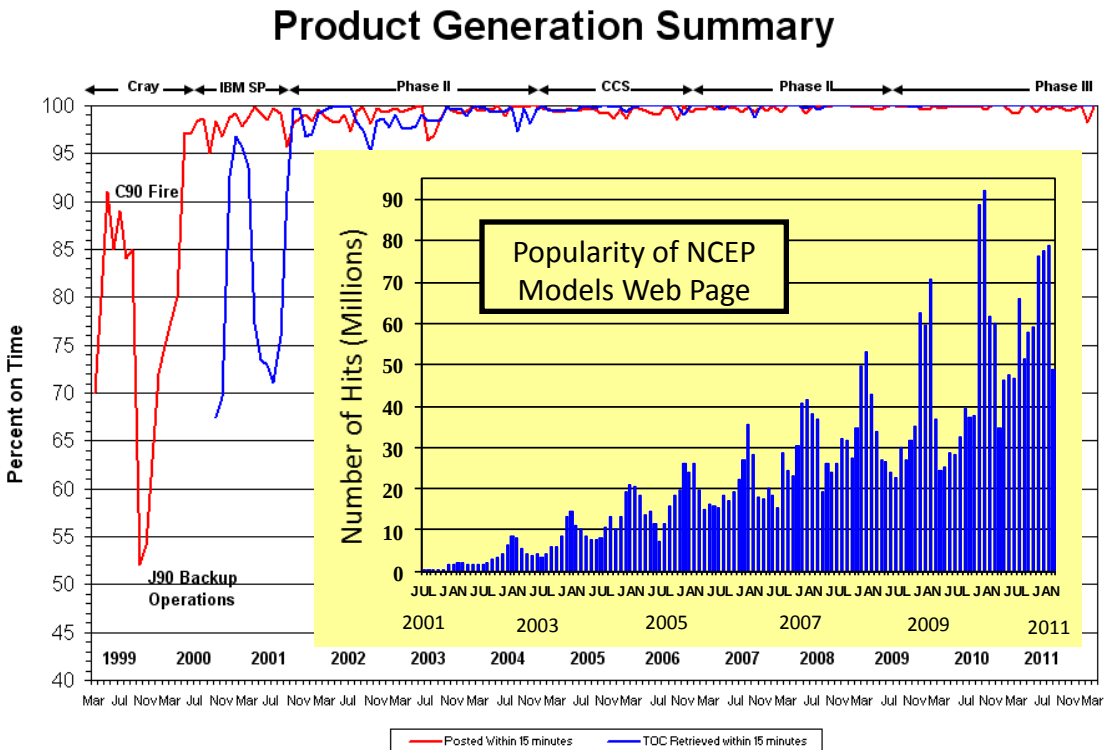
Computing Capability

Current computers

- IBM Power6
- 73.1 trillion calculations/sec
- 2 billion observations/day
- 27.8 million model fields/day
- Primary: Gaithersburg, MD
- Backup: Fairmont, WV
- Guaranteed switchover in 15 minutes

Next generation computer: by Oct 2013

- IBM iDataPlex Intel/Linux
- 143 trillion calc/sec
- Primary: Reston, VA
- Backup: Orlando, FL



Web access to models as they run on the CCS

WSA-Enlil Verification Statistics

WSA-Enlil ran with forecaster modified initial state: Coronagraph input

Negative Diff → Model Prediction too early
Neg diff: 6.37hrs

Positive → too late
Pos diff: 6.37hrs

EVENT START	Shock at ACE	WSA/ENLIL NOAA	DIFF
02/13/2011 01:44	02/18/2011 00:49	02/17/2011 15:00	-09:49
03/08/2011 20:14	03/10/2011 06:10	03/10/2011 08:00	+01:50
06/02/2011 07:57	06/04/2011 19:58	06/04/2011 08:00	-11:58
06/21/2011 03:25	06/23/2011 02:26	06/23/2011 12:00	+09:34
08/02/2011 06:19	08/05/2011 17:22	08/05/2011 17:00	-00:22
09/06/2011 00:00	09/09/2011 11:49	09/09/2011 17:00	+05:11
09/14/2011 02:00	09/17/2011 02:56	09/16/2011 21:00	-05:56
09/24/2011 10:00	09/26/2011 11:53	09/26/2011 16:00	+04:07
10/01/2011 00:00	10/05/2011 06:47	10/05/2011 16:00	+09:13
10/26/2011 10:00	10/30/2011 08:55	10/30/2011 10:00	+01:05
11/09/2011 13:54	11/12/2011 05:30	11/12/2011 02:00	-03:30
11/26/2011 08:00	11/28/2011 21:15	11/29/2011 12:00	+14:45
12/25/2011 02:00	12/28/2011 09:56	12/27/2011 20:00	-13:56
01/16/2012 02:48	01/21/2012 05:02	01/20/2012 04:00	-25:02
01/23/2012 04:00	01/24/2012 14:31	01/24/2012 14:00	-00:31
02/10/2012 21:30	02/14/2012 07:00	02/14/2012 07:00	00:00
02/24/2012 03:46	02/26/2012 20:58	02/26/2012 20:00	-00:58
03/07/2012 01:24	03/08/2012 10:45	03/08/2012 10:00	-00:45
AVERAGE			**06:35**
RMS Error			**09:17**

Attempt to improve:

- Average forecast error/RMS: Possible Government Performance and Results Act (*GPRA*) measure?
- Testbed activity: reach out to model developers to improve model performance

Space Weather Prediction Testbed

Principal Objectives:

- *Accelerate the transition of research models to operations*
- *Improve operational space weather services at SWPC and AFWA*

SWPT Tasks:

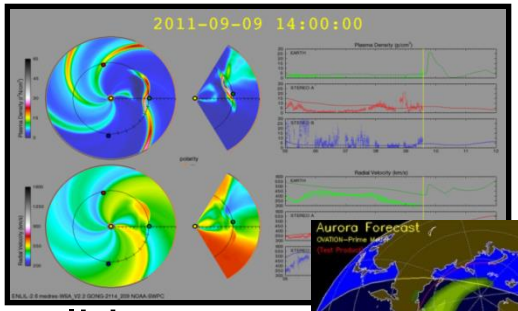
- *In partnership with research community, identify, investigate, and recommend models, research, and observational advances*
- *Facilitated focused research on data-analysis techniques, models, observational systems*
- *Validate and verify numerical codes and forecast techniques emerging from research*
- *Develop usable customer-based metrics*
- *Issue documentation, training materials, and evaluations*
- *Implementation through established NCEP operational implementation process*

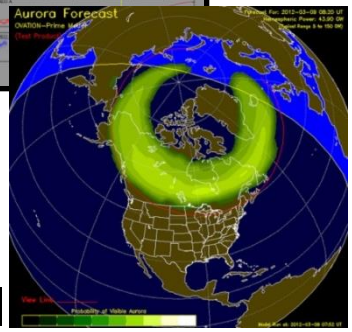
SWPC POCs: Brent Gordon; Rodney Viereck

NOAA's Commitment to Improve Operations

Testbed Plans and Activities

WSA-ENLIL Model





Ovation Model

- Modify and update the WSA-Enlil model
- Ovation Model in transition
- In partnership with NASA CCMC, evaluate and validate Geospace models for transition to operations
- Partner in the development of the Whole Atmosphere Model (WAM = extended GFS) and couple it to the Ionosphere Plasmasphere Electrodynamics (IPE) model
- Upgrade operational product suite – critical new data sets
  - Geomagnetic storm products
  - USGS and INTERMAGNET data
  - Develop and apply within AWIPS-2 environment

SWPC POCs: Brent Gordon; Rodney Viereck

National Unification Efforts

Unified National Space Weather Capability

Federal agencies working together to develop a unified approach to understand and mitigate impacts of space weather on our Nation

- **Improve use and integration of available space weather observations into operations**
- **Improve and accelerate research to operations**
- **Develop new and improved mission-tailored space weather products and services**
- **Improve collaboration between National Space Weather Program agencies**
- **Improve coordination & cooperation with international community**

NOAA's Reliance on UNSWC Partners

National Science Foundation – basic research and modeling advances

Air Force Weather Agency –Solar Electro Optical Network (SEON), Joint Operations, SWPC backup

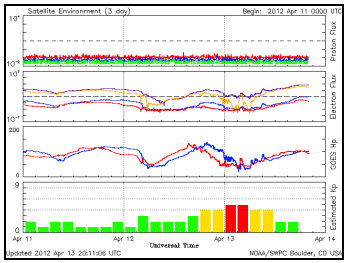
NASA – research satellite observations, modeling and real-time model assessments through Community Coordinated Modeling Center

U.S. Geological Survey – Magnetometer data

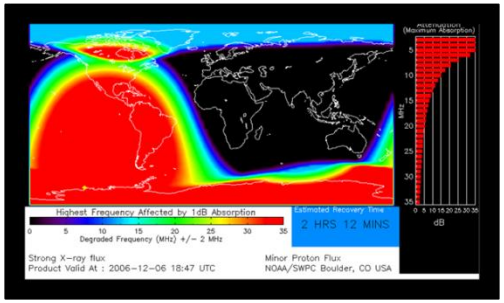
Office of the Federal Coordinator for Meteorology: Facilitating the development of the UNSWC agreement

NOAA's Contribution to UNSWC

- Observations – GOES X-rays, protons; Provision of ACE Real Time
- Running Models in Operational mode – research/community developed (WSA-ENLIL, Ovation, D-Rap)
  - Distribution to all users



- Space weather observations, forecasts, warnings 24x7
- Outreach and education
- International connection through WMO



UNSWC Portal

- Coordinated through OFCM/UNSWC signatories
- Provides a gateway to access federally funded space weather information, services, and activities.
- Connects to a system of existing portals and websites, providing national information to enhance understanding.
- Official rollout on June 5 at the Space Weather Enterprise Forum in D.C.
- Currently soliciting feedback

Spaceweather.gov/portal

POC: Genene Fisher

International Collaboration

Key Role for International Partnerships

Global Threat – Global Response

16th WMO Congress:

"a coordinated effort by Members is needed to address the observing and service requirements to protect against the global hazards of Space Weather."

Partnerships are required for:

- Reliable access to space-based and ground-based observations
- Improvements in our science and modeling capabilities
- Coordination of our global and regional products and services
- Growth of operational capabilities and capacities in every Nation

International Coordination of Space Weather

International Space Environment Service (ISES)

- Coordinating space weather services since 1962
- 14 Regional Warning Centers around the globe
- New ISES Director in July 2012 - Terry Onsager of SWPC

WMO Inter-Programme Coordination Team on Space Weather

- Established in 2010
- Expanding global effort in space weather services

Recent activities include:

- WMO Space Weather Product Portal
- Space Weather observing requirements and gap analysis
- WMO-ICAO coordination for aviation support
- Space weather training

SWPC POCs: Terry Onsager; Bill Murtagh

NOAA's Contribution to International Space Weather

Global Threat – Global Response

Space Weather at the UN

- World Meteorological Organization
- International Civil Aviation Organization
- UN Committee on the Peaceful Uses of Outer Space

International Space Weather Operations

- United Kingdom
  - *Partnering on model development, forecaster training, and collaborative operational concepts, R2O*
- Korean Radio Research Agency
  - *Providing key real-time data from ACE*
- European Space Agency
  - *Plans to build upon respective capabilities*

eSWW Met Office

Many other exciting collaborations underway or being explored

Summary

- SWPC/NCEP making progress in solidifying the operational capacity for providing real-time products and services
  - -- Working with the research and private sector communities
  - -- Collaborating with international partners to insure a unified and robust service provision
- Implemented first operational space weather model derived from the research community, extending forecast skill for advance warnings of geomagnetic storms out to 4 days
- Actively engaged with the National Unification Efforts to attain “Weather Ready Nation”
  - -- Rely on larger research community for advancing model capability
  - -- Solidify decision support services within U.S. government agencies
  - -- Support private sector’s expansion of space weather models and service
  - -- Embrace the developing unified portal
- Actively engaged with the international space weather community through the WMO
  - -- Current focus in on collaborative operational support with UKMet, Korea, European Space Agency

Partnerships: A Critical Element for Meeting National and Global Needs

Other Partners