NOAA’s Space Weather Prediction Testbed: Research to Operations
Operations to Research

Rodney Viereck, SWPT Director

Presentation to the Test Bed Proving Ground Annual Meeting
5 April, 2016
Outline:

• Accomplishments of last year
• Plans for the coming year
• High level directives (OSTP/OMB) Directives for Space Weather
  • Introduction of new R2O and O2R Centers for Space Weather

SWPT Mission

Accelerate and improve the quantitative use of scientific research in space weather specification and prediction to improve forecasts, alerts, watches, warnings and products for customers.
SWPT Staff and Funding (FY 14)

- 24 PhD scientists (6 Fed, 18 CU/CIRES)

- FY14 Non Fed Funding:
  - 60% NOAA,
  - 30% NASA Grants,
  - 10% NSF/AFOSR Grants

- New Staff
  - Magnetosphere scientific programmer: (Selection Made) GS 13-14
  - Solar wind scientist programmer (CIRES)
  - Ionosphere programmer (CIRES)

- Hiring soon (FY16)
  - Ionospheric scientific developer (CIRES)
  - Whole Atmosphere Model (WAM) developer (CIRES)
Modeling and Data for Space Weather Forecasting
(Partnering with the World)

Sun:
ADAPT (USAF)
WSA (USAF)
SDO (NASA)
RSTN (USAF)
GONG Solar Magnetograms (National Sol. Obs.)
Flare Prediction (SBIR)
Fareside Solar Imaging (SBIR)
EUV Irradiance (SWPC)

Solar Wind:
Enlil (G. Mason U.)
DSCOVR (NASA DOD)
L1-Earth Transit (SWPC)

Magnetosphere:
GOESPACE (U. Mich.)
GOES Magnetopause Model (SWPC)

Ionosphere:
IPE (SWPC)
US-TEC (SWPC)
NA-TEC (SWPC)
Global TEC (SWPC)
COSMIC II (NESDIS)
Ground GPS Data
GOLD (NASA)
ROTI (SBIR)
Equatorial Scintillation (SWPC)

Thermosphere
WAM (SWPC EMC)
CTIPe (SWPC)

Aurora:
30 Minute Forecast (JHU)
3 Day Forecast (SWPC)

Ground:
E-Field (SWPC, USGS, NASA)
Airline Radiation (NASA)
Current SWPC Products

- Synoptic Drawings
- Solar X-ray Flux
- Relativistic Electron Forecast Model
- US-TEC
- CME Analysis Tool
- WSA
- HF Com Absorption
- WSA-Enlil 2012-07-14 02:00:00
- Aurora Forecast Model - 30 Minute Forecast
- Satellite Environment Model
- Wing Kp Forecast
Models Under Development at the Testbed

Solar EUV Irradiance Model - Specification

Far-side Analysis

Solar Flare Forecast

Ionosphere/Plasmasphere/Electrodynamics Model

Whole Atmosphere Model

Global TEC Assimilative Model

Geospace Model

ROTIX GPS Product

Aurora Forecast Model - 3-Day Forecast

Electric Field Model

5 April 2016
Accomplishments of the Last Year
Geospace Model Delivery to NCO

• U. Michigan SWMF model was selected through a community wide competition in 2014
• Geospace model has been handed off to NCO for transition to operations.
  – Currently undergoing 30-day test run on WCOSS
  – Will provide regional forecasts to the electric power industry on where impacts may be greatest.
Accomplishments of Last Year
Whole Atmosphere Model Running in Real-time

• Coupled Atmosphere-Ionosphere modeling system is being developed at NOAA/SWPC
• Whole Atmosphere Model (Extended GFS/GDAS)
  – Running in realtime on WCOSS-Dev
    • Will provide input to ionospheric model
    • Will provide forecasts of thermospheric neutral density (satellite drag)
• Ionosphere Plasmasphere Electrodynamics model
  – Will begin parallel run this year
• Fully coupled model system in 2018

5 April 2016
Accomplishments of Last Year
Geoelectric Field Model Ready for Testing

- This model is being developed in conjunction with NASA and USGS
- Geoelectric Field Specification Product
  - Based on customer demands (regional electric field to input to electric grid models)
  - Test product developed
    - Being vetted with customers now
    - Released to public soon
Plans for the Coming Year

• Sun:
  – New ADAPT model from the Air Force Research Lab to be introduced as a test product
    • Provide input to the WSA-Enlil models
    • Provides forecasts of solar radio and EUV products

• Solar Wind:
  – DSCOVR satellite at L1 (in the solar wind) to become operational (21 April?)

• Magnetosphere:
  – Geospace:
    • Model to become fully operational
    • New products to be introduced and tested by customers

• Ionosphere:
  – Ionosphere-Plasmasphere-Electrodynamics (IPE) model to run in real-time on WCOSS-Dev
  – Initial one-way coupling to the Whole Atmosphere Model (Extended GFS)
Support for Space Weather from the highest levels

- White House OSTP Recognizes the Importance of Space Weather
  - Developed the Space Weather Operations, Research, and Mitigation (SWORM) program
  - Developed the companion Space Weather Action Plan (SWAP)
    - NOAA, DHS, NASA, DOD, DOI,
- Define a complete program for operational space weather support.
- Identify gaps (observations and research).
- Improve R2O and O2R
Space Weather Action Plan
Highlights Observations, Data, and Research

• Chartered under White House Office of Science & Technology Policy (OSTP)
• Chaired by OSTP, National Weather Service, and Dept. of Homeland Security.
  • OSTP: policy lead
  • NWS: operational forecasting
  • DHS: mitigation and response
• Released 29-October-2015
• Outlines goals for operations, research, mitigation, and response in preparation for extreme events.

For copies, google “OSTP space weather”
https://www.whitehouse.gov/sites/default/files/microsites/ostp/final_nationalspaceweatheractionplan_20151028.pdf
Space Weather Action Plan
Table of Contents

1. Establish Benchmarks (how big could a storm be?)
2. Enhance Response and Recovery
3. Improve Protection and Mitigation
4. Improve Assessment, Modeling, Prediction of Impacts on Critical Infrastructure
5. Improve Services through Advances in Understanding and Forecasting
   5.3 Establish Baseline Observations
   5.6 Improve Transition of Research to Operations
6. Increase International Cooperation
## Baseline Operational Observing System
### Critical measurements for operational SWx forecasting

**SWAP Section 5.3**
Defines observations required by operational space weather forecasting centers to execute baseline mission.

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Current Capabilities</th>
<th>Future Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.3.2</td>
<td>Sun-Earth line (L1) Orbit: sustain solar coronagraph CME and solar wind measurements</td>
<td>NASA SOHO, NOAA DSCOVR</td>
<td>NOAA SWx Follow-On</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Geostationary Orbit: sustain or enhance solar imagery, X-ray irradiance, energetic particle, mag field</td>
<td>NOAA GOES RSTU</td>
<td>?</td>
</tr>
<tr>
<td>5.3.4</td>
<td>Ground-based: sustain or enhance solar imaging and magnetic field measurements</td>
<td>NOAA-NSF GONG</td>
<td>?</td>
</tr>
<tr>
<td>5.3.5</td>
<td>Ground-based: sustain or enhance solar radio measurements</td>
<td>USAF RSTN</td>
<td>?</td>
</tr>
<tr>
<td>5.3.6</td>
<td>Ground-based: sustain or enhance the real-time geomagnetic field measurement network</td>
<td>USGS MagNet</td>
<td>INTERMAGNET?</td>
</tr>
<tr>
<td>5.3.7</td>
<td>LEO/MEO: enable and sustain GNSS radio occultation measurements for ionospheric characteristics</td>
<td>NCAR COSMIC</td>
<td>COSMIC-2, CSP Data?</td>
</tr>
<tr>
<td>5.3.8</td>
<td>Ground-based: sustain or enhance the worldwide neutron monitoring (NM) network</td>
<td>NSF Polar NM</td>
<td>NOAA-NSF Global NM Net</td>
</tr>
</tbody>
</table>

5 April 2016
SWAP Actions 5.6.2 and 5.6.3
Formalize/Define R2O and O2R processes in SWx

- 5.6 Improve the effectiveness and timeliness of the process that transitions research to operations

5.6.1 NASA and NSF lead: signed memorandum of understanding between modeling and forecasting centers (R2O).

5.6.2 DOC and DOD lead: complete plan for improving, testing, and maintaining operational forecast models and enabling operations to research feedback (O2R).

Progress to date:
- MOU drafted between NASA and NOAA/NWS/SWPC.
- OMB briefed on R2O and O2R concepts by NASA, NSF, NOAA, DOD on 2/29/16.
- Draft white paper on O2R requirements outlined.
Elements of R2O and O2R System

Research

- Research Observations
  - Missions/Instruments/Facilities

- Current State of Scientific Understanding

- Fundamental, Supporting Research

Operations

- Operational Observations

- Nowcasting/Forecasting Capabilities
  - First Principles, Assimilative, Empirical

- Operational Models

Observations

Targeted Sensor Capability Research and Development

Targeted Modeling Research and Development

Modeling
Elements of R2O and O2R System

Research

- Research Observations
- Missions/Instruments/Facilities
- Targeted Sensor Capability Research and Development
- Fundamental, Supporting Research
- Targeted Modeling Research and Development

Operations

- Operational Observations
- Nowcasting/Forecasting Capabilities
- Operational Models
- Targeted Modeling Research and Development
- Empirical, Assimilative, First Principles Models

Current State of Scientific Understanding

Missions/Instruments/Facilities

Research Observations
An Operations to Research Paradigm

• Problem:
  – The research community looses access to the (sometimes heavily modified) operational code.
  – The research community lacks sources of funding for “applied research” work on operational models.
  – The research community is very concerned over intellectual property rights.
  – The operations community typically lacks the scientific knowledge to upgrade the codes with new physics and/or algorithms.

  Example: The first SWx model in operations (WSA-Enlil) has not been updated since it became operational in 2011.

• Proposal:
  – An O2R “facility” where parallel versions of operational codes can be modified by researchers and tested with real-time or archived data against original code.
  – Multi-agency support for “applied research” grants to the model development community.
O2R Vision
Bridge between Operations and Research Communities

Operations

- NOAA Space Weather Prediction Center
- USAF 557th Weather Wing

Research

- Executive Committee
- Management Board
- Science Advisory Board
- Grants Program
- Visitor Program
- Contributed Code
- Model Development Community

O2R Center
Parallel Development Environment

- Operational Codes
- Operational Data

- Supercomputing Centers
- Real-time Data Distribution

Terrestrial weather analogs: JCSDA, NCAR DTC, CTB, NGGPS project, etc.

5 April 2016
R2O & O2R: Next Steps

5.6.1: R2O Center: Finalize MOU between NASA and NOAA/NWS/SWPC.

5.6.2: O2R Center: Multi-step process

- Defining the issue and requirements (Publish June 2016)
- Gather input and feedback: Community meeting on concepts of operation, logistic issues, charter development, etc: August 16—17, 2016, Boulder, Colorado
- Finalize O2R plan for submission to OSTP: October 2016.
Summary

• SWPT is making progress towards the introduction of new space weather models to support operations.

• New recognition of the importance of space weather at high levels in government is providing leadership and guidance for agencies to coordinate:
  – Research to Operations
  – Operations to Research