Operational Metrics for Geospace Models

NOAA
National Weather Service
Space Weather Prediction Center

THE NATION'S
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OF SPACE WEATHER
ALERTS AND WARNINGS
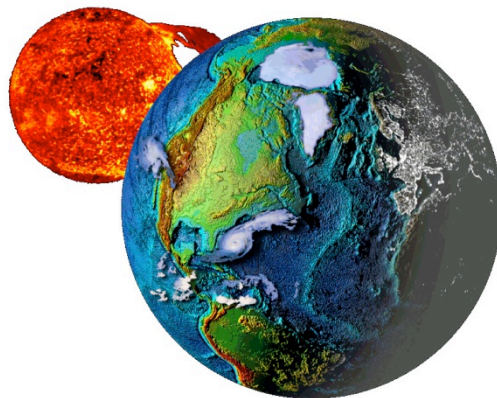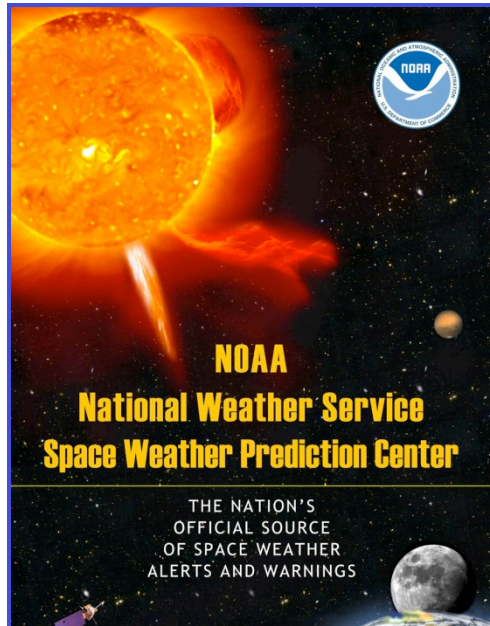

- **Goal**: Validation of Geospace prediction models to determine which model or models should be transitioned to operations at SWPC in 2012

- **Focus**: Models that can predict regional geomagnetic activity

- **Timeline**: About 12 months

- **First Steps**: CCMC leads evaluation; Build on GEM Storm Challenge; Establish partnerships; Decide on metrics; Conduct evaluation

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Safeguarding Our Nation's Advanced Technologies

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Community Recommendations

Excerpt from "Space Weather Modeling to Forecasting: Community Recommendations on Transitions to Civilian Operations" (Quinn et al. presentation at Space Weather Workshop, 2009)

- **Make public the assessment metrics and associated data.**

  - Allows developers, CCMC, AFRL, commercial enterprises, to compare against operational state-of-art and to target improvements to capabilities of established importance.

  - Forecast community must establish metrics that accurately reflect needs

The Process for Establishing Operational Metrics

- Derived from operational needs and customer requirements
- But, also needs model developer participation
  - For example: an operational metric might be specification of the dB/dt disturbance amplitude at a particular location and time; but the developer might suggest a metric that specifies the magnetic field at geosynchronous orbit. The later may indicate the quality of the former, but isn't a product for the user.
- Metrics must be defined by operational needs but tuned by working with developers
- Scientific models contribute to operations (R2O), and metric studies will identify where model improvements are needed (O2R)

SWPC Customer Requirements - Example

ELECTRIC UTILITIES			
User Requirement	**Timeliness**	**Customer**	**Rationale**
K-7 Geomagnetic Storm Warnings	Minutes to hours Operators want as much lead time as possible, but any lead time is considered useful	North America Electricity Reliability Corp. Independent System Operator Electricity Reliability Coordinators	The Midwest Independent System Operator receives the K-index forecast. If the index is K-7 or higher, MISO notifies all NERC reliability coordinators concerning the level and expected duration of the specific event. These forecasts are shared with all power system operating entities throughout so that those power systems that are particularly susceptible to this phenomenon can institute preventive procedures
Geomagnetic Storm Warnings/ Watches	1-2 days >50% accuracy	Various Power Companies	Allows maintenance procedures that shut down some facilities to be rescheduled, thus maintaining the full reserve for emergency situations.
Geomagnetic Storm Warnings (K-5 through K-9)	2-3 hours >80% accuracy	Various Power Companies	Bring reserve or maintenance generation on line
Geomagnetic Storm Warnings (K-5 through K-9)	15-30 minutes >90% accuracy	Various Power Companies	Reduce loading: use more conservative margins
Geomagnetic Storm Warnings (K-5 through K-9)	5 minutes >99% accuracy	Various Power Companies	Desensitize SVAR device protective relay setting. These circuits are used in power grids to isolate problems that are unrelated to GICs but can also be tripped by a secondary reaction to GICs when the GIC magnitude is large but not in itself damaging.
Geomagnetic storm outlook	3-Day	Various Power Companies	Valuable tool for planning purposes
Real-time geomagnetic monitoring data for GIC confirmation.	Every 15 minutes	Various Power Companies	Real-time measurements from sensors located regionally would better assess the GIC threat for any given station

SWPC Customer Requirements – Example (con't)

ELECTRIC UTILITIES (con't)			
User Requirement	**Timeliness**	**Customer**	**Rationale**
Graphical Products - Regional Auroral Electrojet	Updating in real time	Various Power Companies	Improved determination of the electric fields produced during geomagnetic disturbances by including the effect of the structured source fields produced by the auroral electrojet
Graphical Forecast Products of real-time GIC flow throughout the power system	Updating in real time	Various Power Companies	Needed to determine the GIC distribution regionally across the system, and examination of factors affecting transformer saturation, harmonics that are produced and where they flow in the system.
Geo-alert status	As needed	Various Power Companies	Continual updating of geo-alert status so that power system operations can return to normal as soon as possible.
Spatially resolved forecasts of large geomagnetically induced currents, to allow mitigation measures to be taken	>1 hour (1-2 days preferred)	Various Power Companies	1-2 days warning is preferred since it allows rescheduling of generator and circuit downtime. However, useful mitigation can be taken based on warnings at shorter notice.
GEOPHYSICAL OPERATIONS			
Forecasts of perturbations in the geomagnetic field	>1 day	Geophysical surveyors Mining and drilling operations	Long lead time needed for planning surveys. Shorter warnings will ensure poor quality surveys are avoided. Some users request data 1-3 days in advance.
Post-event knowledge of perturbations in the geomagnetic field	<1 day	Geophysical surveyors and drilling industry	It is estimated that correction of magnetically oriented drilling requires a time-scale of about 1 day to prevent drilling errors from becoming unacceptable.

Complete Customer Requirements document at: http://www.swpc.noaa.gov under customer services

Geomagnetic Disturbance Model Performance Measures / Issues

Set Up:

- **Choice of events or intervals for model performance comparisons**
  - **E.g. Storms caused by CME's, by corotating interaction regions**
- **Use of Level 2 data or real-time data that includes gaps and other data quality issues**
- **Method of propagation from of L1 data to the magnetopause**
- **Choice of selectable model parameters: e.g. conductivities, spatial and temporal resolution**

Performance Measures:

- **Ground-based ΔB variations compared to ground magnetometer chain observations**
- **Skill scores: using either mean values or persistence as the standard model for comparison; comparisons for individual stations, as well as for overall average and averages for different longitude sectors and latitudes**
- **Performance during the course of a storm from pre-storm, to main phase, to recovery phase, and how models perform in general for different activity levels**

Geomagnetic Disturbance Model Performance Measures / Issues

Performance Measures (con't)

- **Improvements over current products: demonstrate that the regional model skill provides improved value over the global Kp prediction from the Costello or Wing models**

- **Utility Metrics: Determine how well models succeed at detecting the timing, amplitude and duration of an event (e.g. large magnetic perturbation) in a long time series of data.**

  - **Questions need to be examined such as how many hits, false alarms and missed events occur and the various statistical properties that can be determined from accumulation of this information. As shown in Pulkkinen et al. (2007) this sort of examination can be performed on a long run of data to look for various event thresholds. Events can be defined with different amplitude thresholds and time windows and then plots can be made showing properties such as the ratio of hits to misses for different model runs.**

Other Issues:

- **Intellectual property agreements, publishing metrics and results, pathways to operations (CCMC, AFRL, universities, laboratories…)**