Demonstration of operational real-time space weather prototypes for aviation radiation and magnetospheric sub-storms

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http://SpaceWx.com
Thanks to team members

**Magnetosphere Alert and Prediction System (MAPS)**
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- *Dartmouth College*: Brian Kress
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- *NIOSH*: Barbara Grajewsky
- *Prairie View A&M University*: Brad Gersey
- *Boeing*: Bill Atwell
Space weather systems’ status

New systems transitioning into operations

- **MAPS** – Magnetosphere Alert and Prediction System (Operational Real-time and Forecast Dst)
  - TRL status: 7 (Q4 2010), 8 (Q3 2011), 9 (Q4 2011)
  - Users: LEO satellite operators who require operational geomagnetic Dst index for atmosphere density specification and forecast

- **RAPS** – Radiation Alert and Prediction System (Aviation radiation)
  - Validation process: ARMAS project flights of TEPC instrument for comparison with NAIRAS system results (March-September 2011)
  - TRL status: 7 (Q4 2010), 8 (Q2 2011), 9 (Q1 2012)
  - Users: commercial and military aviation crew and frequent fliers
MAPS: Magnetosphere Alert and Prediction System (Operational Real-time and Forecast Dst)

- **Concept:** provide a real-time ring current disturbance storm time index (Dst) characterizing the magnetosphere’s perturbation by the solar wind that can be used by operational systems for neutral thermospheric densities, that is calibrated with the Kyoto definitive Dst, and that has a 72-hour forecast.

- **Implementation status:** Phase I SBIR study complete with overall system definition; internal team website running with 4 Dst data sets (Kyoto, USGS, RDst, CCMC) in real-time at TRL 8; Phase II on contract in March 2010.

- **Tasks in 2011:** USGS Dst, SEC RDst TRL 9 capability; system level redundancy with multiple operational Dst data streams; ensemble modeling Dst forecast to 72 hours using ENLIL solar wind; and a functioning distributed network.

- **Users:** AFSPC and LEO satellite operators who require operational geomagnetic Dst index for atmosphere density specification and forecast; the JB2008 model system will be a primary user of Dst.
Motivation: JB2008 improves LEO satellite orbit determination

For LEO satellite users

- **Legacy capabilities (2010) (global historical):**
  - neutral mass density accuracy based on empirical JB2008 with S10, M10, Y10, F10 solar indices and ap, Dst geomagnetic indices
  - 137-day forecast daily densities, updated hourly, latency 1 hour
  - global 3D density visualization is available

- **Coming capabilities (2011) (global):**
  - improved global 3D density visualization and forecast data access for given orbits
  - **Improved Dst redundancy and forecast using USGS Dst**
  - Improved 0-7 day solar forecast

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JB2008 densities and temperatures
JB2008 website
http://sol.spacenvironment.net/~JB2008/

Dear Colleague,

Welcome to the JB2008 empirical thermospheric density model website. Please provide your name and email address if you desire to be notified about updates to the JB2008 model, and the availability of forecasts.

[click here to register for updates]

Please note that cookies must be enabled in your Browsers Preferences to register. Your local installation may have firewall implementations that prevent cookies or Java servlet protocols, in which case you should email spacenvironment@spacenvironment.net with "JB2008" in the subject line to receive updates.

Thank you,

Space Environment Technologies

Current Server Status

Last Website Update 15 Nov 2009
Dst Validation: Use Kyoto definitive and quick-look Dst

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Real-time Dst redundancy – 1

Kyoto Dst, nT

Time, Hourly, 2009-12-27 to 2009-12-31

SEC RDST, nT (SET plot created at: 2009-12-31 21:49 UT)

RDst

Time, 1-hour cadence, 20091201 to 20091231

USGS

Black: USGS 1-minute Dst
Red: Kyoto quicklook Dst

SWMF

last updated: 2009/12/31 23:34:00
Real-time Dst redundancy – 2

DMSP

USGS

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MAPS and RAPS

MAPS will provide forecast of Dst

Magnetosphere perturbed by solar wind

12/31/2009 Time = 23:56:00 UT z = 0.0OR

Ring current

12/31/2009 Time = 23:56:00 UT E_{n} = 1.70keV

solid line: fast-R boundary

dashed line: ghost-R boundary

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MAPS hierarchy for operational Dst

Hierarchy of definitive, real-time, and forecast Dst redundancy

<table>
<thead>
<tr>
<th>historical mean</th>
<th>Dst = -15; ap = 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>stream B</td>
<td>persistence</td>
</tr>
<tr>
<td></td>
<td>small storm Dst template</td>
</tr>
<tr>
<td></td>
<td>medium storm Dst template</td>
</tr>
<tr>
<td></td>
<td>large storm Dst template</td>
</tr>
<tr>
<td></td>
<td>climatological solar wind templates</td>
</tr>
<tr>
<td>stream A</td>
<td>EXPI: HAFv2</td>
</tr>
<tr>
<td></td>
<td>CCMC: ENLIL, WSA, SWMF</td>
</tr>
<tr>
<td>hours from current epoch</td>
<td>ACE</td>
</tr>
<tr>
<td>-48</td>
<td>-24</td>
</tr>
<tr>
<td>mag observatory -&gt; Dst</td>
<td>0</td>
</tr>
<tr>
<td>solar wind -&gt; Dst</td>
<td>+24</td>
</tr>
<tr>
<td></td>
<td>+48</td>
</tr>
<tr>
<td></td>
<td>+72</td>
</tr>
</tbody>
</table>
MAPS uses a distributed network for producing operational Dst
MAPS website
http://sol.spacenvironment.net/~maps/

MAPS is the Magnetoospheric Alert and Prediction System, an automated system delivering realtime Dst and Dst-related data products to the space weather community. They are being developed by Space Environment Technologies, U.S. Geological Survey, Space Environment Corporation, Carmel Research Center, Instrumental Software Technologies Inc., and the Community Coordinated Modeling Center under an Air Force Research Laboratory SBIR contract.

Future expansions of the MAPS site may include other magnetosphere-thermosphere-ionosphere energy inputs and drivers.

Objectives

Neutral atmosphere heating, whether from solar EUV, geomagnetic storms, or atmosphere dynamics (winds, waves, turbulence, eddies) is the main cause of density variations in the thermosphere between 100 and 1500 km altitude. For LEO satellites, these density changes can cause significant in-track errors within a single orbit. Because the Dst is an indicator of space weather disturbances by the solar wind upon the coupled magnetosphere-ionosphere-thermosphere system, there is a strong interest for having an operational index based on ground magnetometers located near the equator and/or from LEO satellites such as DMSP or potentially Iridium. This site provides access to Dst and Dst-products. Please also see links below.

- Related links:
  - USGS
  - SEC
  - CRC
  - ISTI
  - CCMC
  - Kyoto
  - SET
RAPS: Radiation Alert and Prediction System (Aviation radiation)

- **Concept:** need for nowcast prediction of air-crew radiation exposure from both background galactic cosmic rays (GCR) and from solar energetic particle (SEP) events that may result from solar storms; NAIRAS is being developed to provide global, data-driven, real-time radiation exposure predictions of biologically harmful radiation at commercial airline altitudes; dose and total dose will be provided at aviation altitudes in real-time.

- **Implementation status:** operational framework for distributed network has been developed at TRL 7; real-time data streams are being monitored and test case data has been collected.

- **Tasks in 2011:** link models in operational run testing with data streams, validate/verify, then move to TRL 8 prototype system demonstration.

- **Users:** commercial and military aviation crew and frequent fliers.
ACE solar wind data

Kyoto Dst (USGS Dst in 2011)

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RAPS data streams – 2

Neutron monitor data

University of Oulu Neutron Monitor, ending: 2011-01-04 02:45

Counts/Minute

Time, 1-minute cadence

GOES particles

GOES P2 4–9 MeV, start/end ymdhm: 200912302115, 201001022100

GOES P5 49–80 MeV, start/end ymdhm: 200912302115, 201001022100

GOES P8 350–420 MeV, start/end ymdhm: 200912302115–201001022100

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RAPS data streams – 3

NCEP air temperature data

Penticton F10.7, Observed Flux Density

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Real-time Neutron Monitor Data (e.g., Oulu, IZMIRAN, & LOMNICKY)

Fit to Climax NMC

Badhwar+O’Neill GCR Model

NOAA GOES Data

Spectral Fitting

HZETRN + Dosimetry

Magnetospheric Magnetic Field (e.g., T05) Effects on Cutoff Rigidity

NASA/ACE Solar Wind and IMF Data

Atmospheric Density

NCEP/GFS

Atmospheric Dose and Dose Equivalent

Space Environment Technologies

Space Weather Division

MAPS and RAPS

Cutoff Rigidity (IGRF)

HETRN

Dosimetry

Real-time Neutron Monitor Data (e.g., Oulu, IZMIRAN, & LOMNICKY)

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Atmospheric Dose and Dose Equivalent
NAIRAS effective dose during Halloween 2003 storm example
NAIRAS dose during Halloween 2003
NAIRAS validation with TEPC
ARMAS validation project
RAPS website
http://sol.spacenvironment.net/~nairas/

N A I R A S
A NASA-funded Applied Sciences Program to develop an operational prototype for a
global, real-time, data-driven predictive system needed to assess biologically harmful
radiation exposure levels for aviation.

OVERVIEW

Project Description: NAIIRAS provides a space weather decision support system related to
radiation impacts on crew and passengers of long-range aircraft.

DESIGN

System Design: A widely-distributed network architecture ensuring robustness and
extensibility, linking real-time space-weather measurements with state-of-the-art models
to deliver mission-critical information.

PROGRESS

Documents: Project Status, Presentations, Publications, Quarterly Reports
Current GCR Dose Rate: Effective Real-time Dose Rate Figure

STAKEHOLDERS

http://SpaceWx.com Tobiska