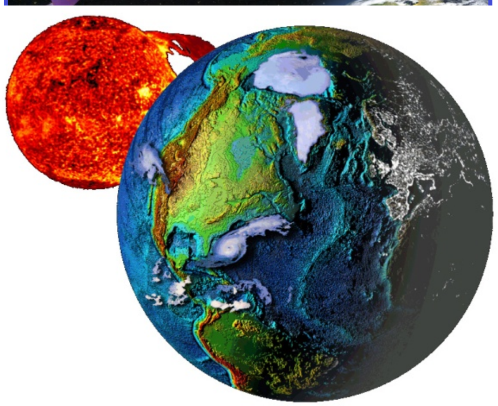
Assessing Geospace Models for Use in Space Weather Operations: Regional Activity



Outline:

- Customer Needs (e.g. Halloween Storms)
- Three Possible Methods for Evaluating Regional K's
- Selection Process
- Next Steps and Conclusions

Acknowledgments: Balch, Doggett, Onsager, Millward,
NASA CCMC (Kuznetsova, Pulkkinen, Rastaetter), Geospace Modelers

Howard J Singer- NOAA Space Weather Prediction Center
Geospace Environment Modeling Meeting
Snowmass, CO, June 20, 2012

Safeguarding Our Nation's Advanced Technologies

High-level government response…

Coordinating on ways forward to develop and implement mitigation strategies to safeguard critical infrastructure from the impacts of severe space weather.

- **The Shield Act (H.R. 668)** (*Feb 2011)*
  To amend the Federal Power Act to protect the electric infrastructure geomagnetic storm (and EMP)

- **Meeting at White House with National Security Staff and OSTP** *(18 Feb)*

- **Op Ed in NY Times on space weather by Holdren and Beddington** *(10 Mar)*

- **Electric Infrastructure Security Summit (EISS) in Washington D.C.** *(11 Apr)*

- **Effects of Geomagnetic Disturbances on the Bulk Power System** *(NERC, 2012)*


The New York Times

The Opinion Pages

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I.H.T. OP-ED CONTRIBUTOR

Celestial Storm Warnings

By JOHN P. HOLDREN and JOHN BEDDINGTON
Published: March 10, 2011

Weather is often in the headlines. But largely unnoticed last month was the weather that forced airlines flying the polar route between the United States and Asia to detour south over Alaska. This unusual routing was a response to a "space weather" event — an enormous ejection of charged gas from the Sun capable of scrambling terrestrial electronic instruments.

__John P. Holdren__ is the science and technology adviser to President Barack Obama. __John Beddington__ is the chief scientific adviser to Prime Minister David Cameron.


The New York Times

Opinion

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EDITORIALS COLUMNISTS CONTRIBUTORS

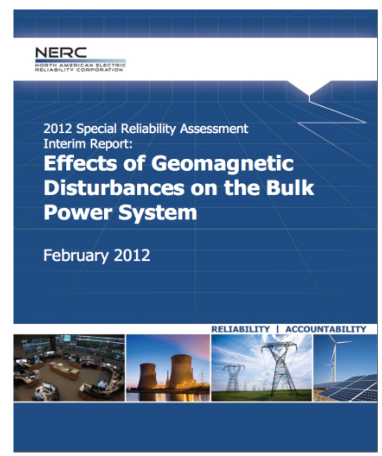
OP-ED CONTRIBUTOR

The Sun Also Surprises

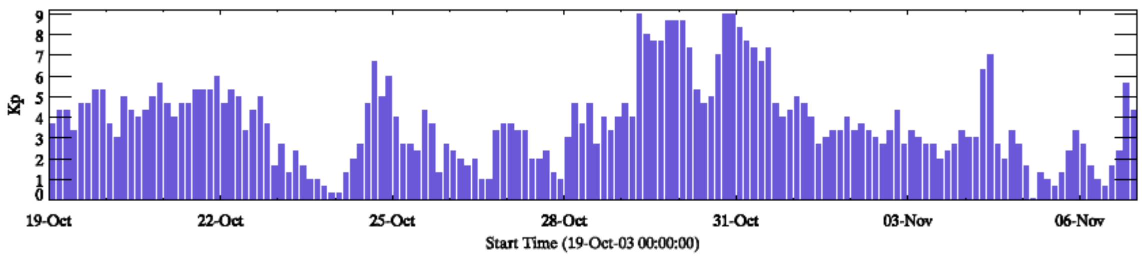
By LAWRENCE E. JOSEPH
Published: August 15, 2010

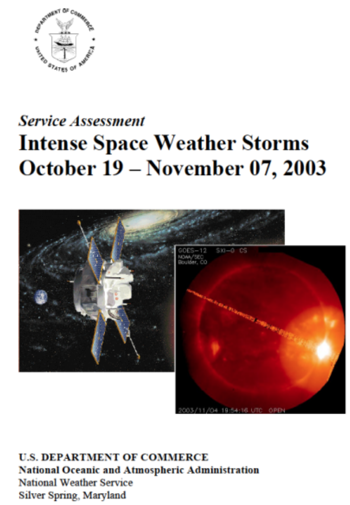
Los Angeles

DESPITE warnings that New Orleans was unprepared for a severe hit by a hurricane, America was blindsided by Hurricane Katrina, a once-in-a-lifetime storm that made landfall five years ago this month. We are similarly unready for another potential natural disaster: solar storms, bursts of gas on the sun's surface that release tremendous energy pulses.



Why Regional Forecasts?
Halloween Storms Example




Service Assessment
Intense Space Weather Storms
October 19 – November 07, 2003

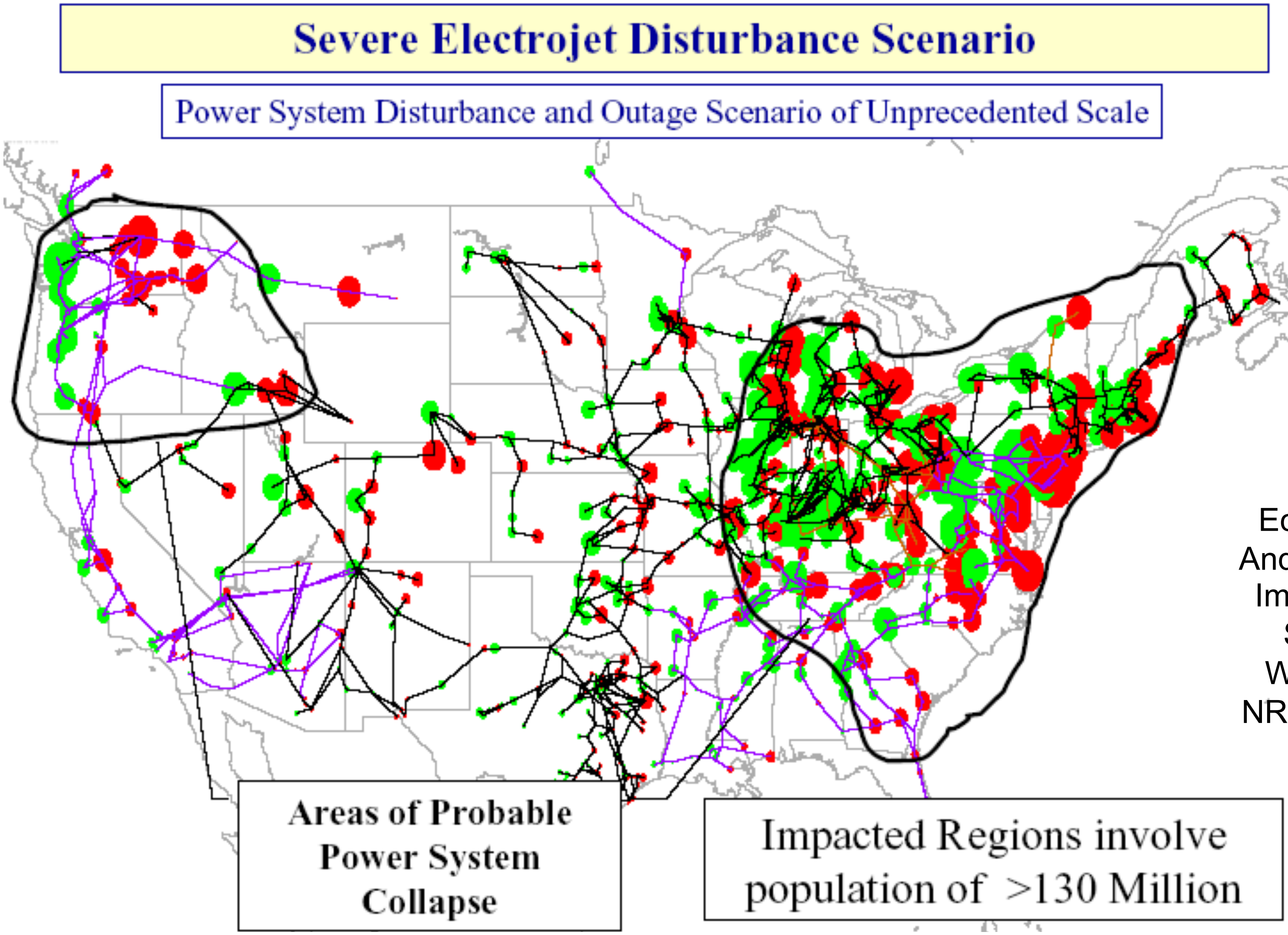
U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Maryland

Long intervals of high Kp, yet…effects regional

- GIC impacts were **more significant in Northern Europe** where heating in a nuclear plant transformer was reported and a power system failure occurred on 30 October in Malmo, Sweden
- A representative from the North American Electric Reliability Council (NERC) commented: “Although the bulk electric system was not significantly affected by the solar activity, **some systems** reported higher than normal GIC’s that resulted in fluctuations in the output of **some generating units**, while the output of other units was reduced in response to the K-index forecast.” Responses to warnings included reducing system load, disconnecting system components, and postponing maintenance.

South Africa Transformer overheating
15 Transformers damaged

Regional Power Grid Disruptions



The Economic And Societal Impacts of Space Weather, NRC Report

Regional K Prediction

Challenge

- Can MHD or empirical models predict a regional (TBD) K that better represents a local geomagnetic disturbance than the currently available global Kp over specified time interval (TBD)?

- Currently Available: Wing Kp predicted from solar wind input at 15-min cadence and AF 3-hour near-real time Kp observed index

Regional K Prediction

Current Kp, Observations, Models

Costello Kp, AF Kp (Global)	Observed ΔB At ground station (Regional)	MHD Model ΔB At ground station (Regional)

Convert Δ B's to K values*

Costello Kp, AF Kp	Ground Station K	MHD model K

Compute skill (or other metric) for each model

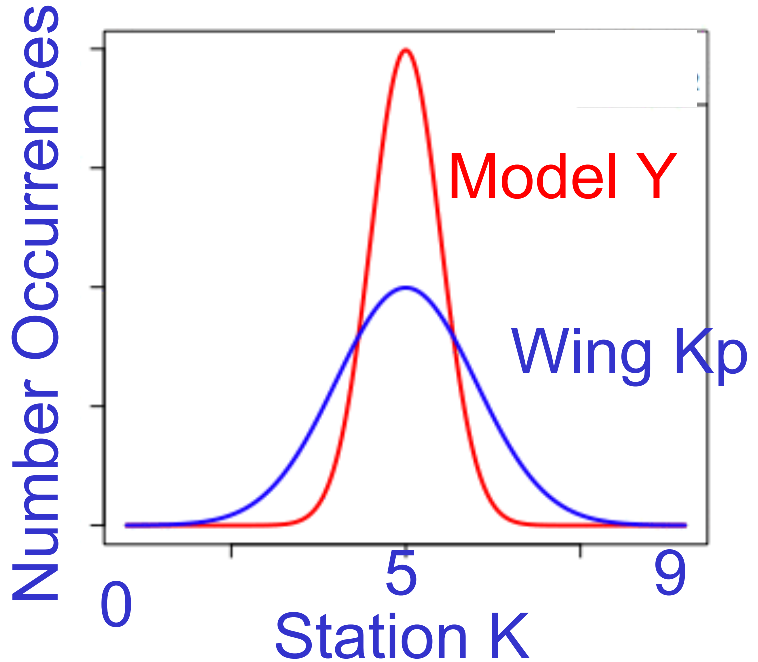
Costello or AF K / Observed K	Model K / Observed K

* Alternative: convert Costello and AF Kp's to ΔB' at test station location; also need to consider valid latitude range (~48-62 deg) for K index

1. Regional K Distribution Metric

- For 6 events, high and mid lat, at each station convert observed delta B's to 15 min K values; same for model results at each station; Wing Kp also available
- For all the times the model gives e.g. K = 5 at station x, tabulate the number of occurrences of each K value observed at station x
- This results in a possible distribution as shown on right
- The possible outcome shown indicates that the model gives a narrower and preferred distribution with less error than Wing Kp
- The same could be done for each model
- The results can be used by forecasters to give guidance that if model Y gives a K of 5, then there is a certain probability that station X will observe a specific K

Model Results in K = 5
All events, station x



Note: The opposite procedure could also be done by choosing an observed K value for a specific station and determining the distribution of model K values

2. Regional K Contingency Metric

- For 6 events, high and mid lat, at each station convert observed delta B's to 15 min K values; same for model results at each station; Wing Kp also available

  - Specific Station (or separately high and mid-latitude), for K>5 (and 7), Each Event Separately (or All), for each Model and for Wing Kp Forecast

  - Compute Skill Metrics from Contingency Table and compare for models and Wing Kp

Event Forecast	Event Observed		
	Yes	No	Marginal Total
Yes	A (Hit)	B (False Alarm)	A + B
No	C (Miss)	D (Correct Negative)	C + D
Marginal Total	A + C	B + D	A+B+C +D = N

3. Regional K Skill Metric

- For 6 events, high and mid lat, at each station convert observed delta B's to 15 min K values; same for model results at each station; Wing Kp also available
- We want to demonstrate e.g. that (1) the model K is closer to the observed K than (2) Wing Kp (what we use today) is to the observed K
- Choose station, and for all events (or separately for each event), for each model and Wing Kp's, compute the mean square error (MSE) between the model and observation and between Wing Kp and the observation
- Compute Skill

Skill = 1 – MSE model forecast/MSE reference

where the reference is Wing Kp and

MSE is the usual mean square error

High-Latiude (Mid-latitude) Stations Each Event Separately (or All Events)

	MSE between Wing Kp and Observed K	**MSE between Model K and Observed K**
Model 1	?	?
Model 2	?	?
…		
Model 6	?	?

Issues

- Should we compare delta B's instead of K's by converting Wing Kp to the equivalent K value at each station? (The model and observations already provide delta B's.)
- Do we average over all events? Probably yes. As it is, statistics may be poor.
- I've talked with Simon Wing about running his model for Kp for these events. We just initiated this discussion, and while he is enthusiastic about participating, we need to follow up with a discussion about how much effort this might be for him.

Geospace Model Recommendation Process

- Models will be evaluated on four criteria:
  - Strategic Importance
  - Operational Significance
  - Implementation Readiness
  - Cost to Operate, Maintain, and Improve
- Evaluation team will consist of internal and external participants
- Modelers to review and comment on draft Recommendation Report prior to delivery to SWPC Director
- The final Recommendation Document will be made public
- Selection will be made by SWPC Director

Possible Findings/Recommendations

- One (and only one) MHD model has sufficient value to justify transition and operation costs – Recommend transition
- Multiple MHD models have sufficient value – Recommend one model based on highest long-term value and lowest cost
- No MHD model has sufficient value, but near-term improvements could be made – Recommend SWPC support for additional development and testing
- One or both empirical models have sufficient value – Recommend either or both for transition
- No model has sufficient value – Recommend no SWPC action