

Whither Space Weather?

Presentation to the
Committee on Solar and Space Physics
March 4, 2014

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Space Weather has Matured

- **Improved understanding of the underlying physics:**
 - Advances in Space Physics modeling
 - Increased observational data to test and distinguish between models
 - Significant coordination/collaboration
- **Improved forecasting/nowcasting**
 - Availability of real-time/near-real-time data
 - Emergence of space weather forecasting “centers”
- **Improved public understanding of space weather impacts**
 - Significant outreach activities and new media outlets
 - NRC workshop report was widely distributed

Space Weather Has Emerged from a “Niche” Role

- **Impacts were understood, but viewed as marginal**
 - Communication satellite failures impacted daily lives...for a few hours to a few days
 - GPS accuracy degrades...sometimes, slightly, briefly
 - Local power grids failed...for a few hours
 - Satellite lifetimes were affected...but mitigated by design improvements and operational procedures
 - Astronauts radiation risk to health...but in ISS for nominal missions the exposure is well below limits and readily mitigated
- **Until there was a focus on Space Weather’s potential threat to the National Power Grid**
 - Leading to inclusion in National Space Policy
 - Increased planning within DHS/FEMA
 - Increased attention within OSTP

We are in the Prime of Space Weather

- **More real-time space-based observational data than ever**
 - GOES/POES (work horses of NOAA SWPC)
 - Ace (still going...)
 - SDO (high resolution, full disk imaging, at incredible cadences)
 - Stereo (still producing “far side” images)
 - Van Allen Probes (formerly RBSP)
 - COSMIC
- **Continued availability of ground-based sources**
 - GONG
 - SCINDA
 - SEON
 - Neutron Monitor
 - GPS Receivers
- **Multiple sources of forecast and nowcast**
 - NOAA SWPC (Nation’s operational forecasts)
 - NASA (supports NASA operations and provides test bed for emerging models)
 - Commercial entities (tailored forecasting)
- **Growing Community of Space Weather Users**

But for How Long...?

- **Budgets are not keeping up with expectations**
 - “Flat is the new growth”
 - NSWP partners each have tremendous pressures just to maintain status quo
- **Relatively quiet solar maximum**
 - Fewer “reminders” of the impacts
 - Decreased number of operators with direct experience
 - Risk of complacency, even in the face of potentially more vulnerable systems
- **Aging science platforms threaten loss of key observations**
 - More use is made of real-time science platform observations
 - Lack of sustainable acquisition plan for operational platforms

Generalized Space Weather Observation Needs

- **Monitor Solar Wind, other Plasma Properties, “upwind” of Earth**
 - L1 (0.99 AU)
 - Further “upwind” (.90 to .95 AU)
- **Monitor Magnetic Complexity of Solar Active Regions**
 - East Limb: What is coming (L4)
 - Head on: What is facing the Earth (Earth Orbit, L1)
 - West Limb: Threat region for Solar Energetic Particles (L5)
- **Characterize CMEs (velocity, extent) as they erupt**
 - From East or West Limb (L4 or L5)
 - Head on: (least effective)
- **Characterize Radiation and Plasma Properties in GEOSpace (Charging, total dose, SEU risks)**
 - GEO
 - MEO
 - LEO
- **Characterize State of Ionosphere (TEC, Scintillation)**
 - High, Medium, Low latitudes

Identification of Future Users of Space Weather Forecasts

- Last decade has seen an explosion of interest in space weather
 - Increased reliance on GPS
 - Increased Polar Flights by Airlines
 - Need to monitor Power Grid vulnerability
 - Emergence of Commercial Space Tourism
- Will terrestrial solutions slow or reverse the trend?
 - Ground-based monitoring of GPS signals
 - Real-time monitoring of GIC
 - Engineering solutions to GIC
 - Redundant and Reconfigurable Communications Satellite Nodes

Looking Ahead

Wither Space Weather?



Or Thrive?



Meeting the challenge of maintaining a robust national space weather capability will not “just happen”... it requires coordinated advanced planning.

Possible Study Topics for CSSP

- **Assess national—both civil and defense—needs for space weather information and forecast products**
 - Evaluate against current and anticipated space weather capabilities (models and observations)
 - identify potential gaps (including needs for targeted space weather products)
 - provide options for a path forward
- **Review the National Space Weather Program implementation plan**
- **Determine to what extent the nation’s space weather science missions are contributing to the needs of space weather service providers**
- **Examine the space weather “climate” to characterize the space environment and provide information on the frequency and severity of hazardous space weather events**

List derived from document prepared by Art Charo