# Whither Space Weather?

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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

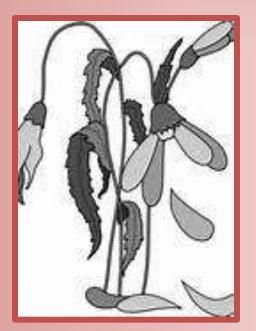
# Identification of Future Users of Space Weather Forecasts

- 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