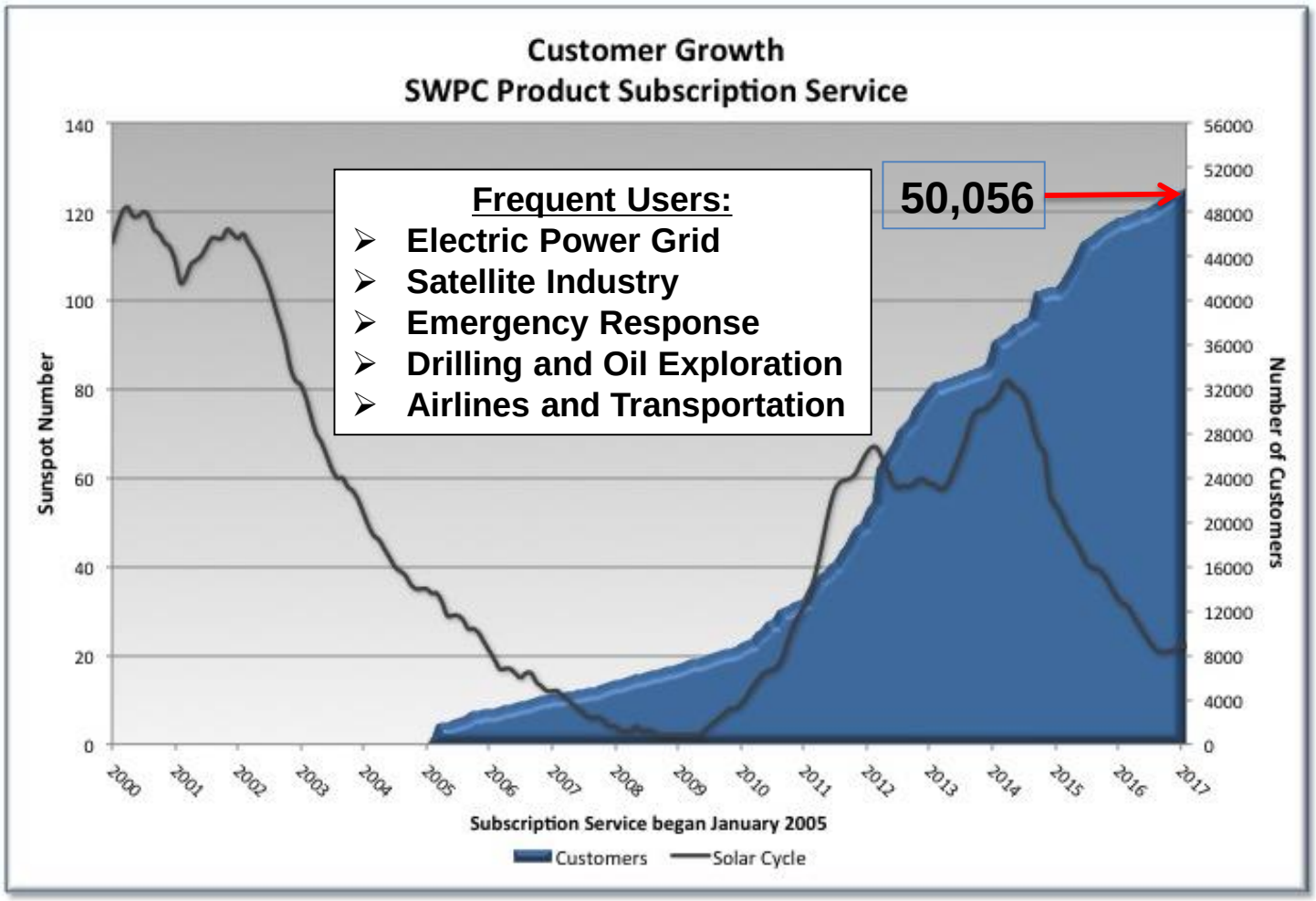
NOAA Space Weather Prediction Center Data and Services

Terry Onsager and Howard Singer
NOAA Space Weather Prediction Center
Terry.Onsager@noaa.gov

Customer Subscriptions to Space Weather Services



Continuous customer growth throughout the solar cycle

GOES Energetic Particle Sensors:

Monitor, specify, and predict the energetic particle environment that impacts systems and human activity in space

Measurements:

- Solar Energetic Particles
- Energetic Heavy Ions
- Energetic Electrons
- Medium and Low Energy Electrons and Protons

Impacts:

Single Event Upsets
Solar Panel Degradation
Spacecraft Bulk Charging
Spacecraft Surface Charging
Human Radiation Dose
Enhanced Geomagnetic Activity

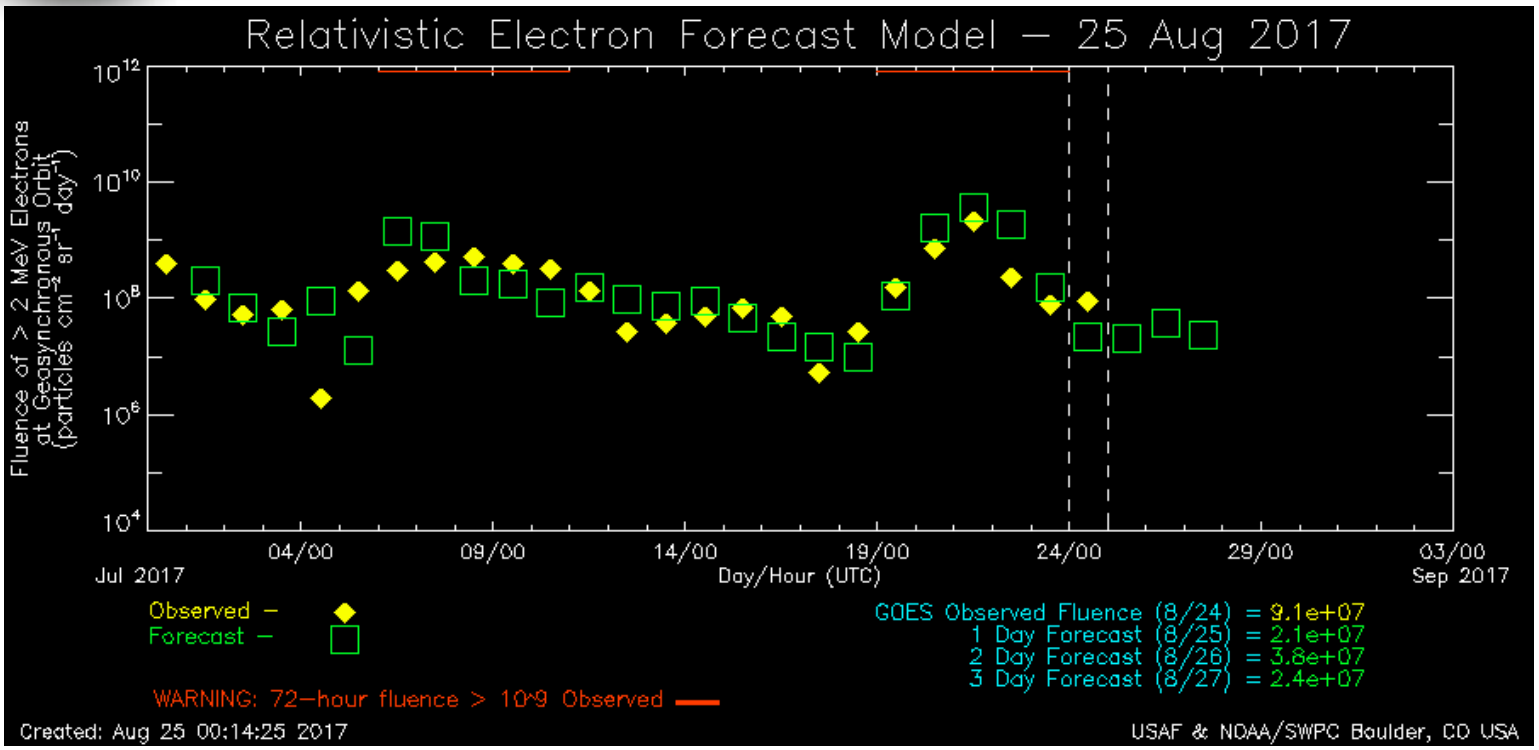
Products:

- Alerts and Warnings
- 3-day Electron Fluence Forecast
- Anomaly Assessment Tool (SEAESRT)
- Continuous Observations of the Environment

Actions:

Satellite Operations
Anomaly Resolution
Spacecraft/Instrument Design
Risk Assessment
Research Development
Model Development and Validation
Data Assimilation

Relativistic Electron Forecast Model



- Prediction of >2 MeV electron fluence +1, +2, and +3 days ahead
- Linear Prediction Filter technique using past 30 days of measured solar wind speed as input
- Prediction is scaled by ratio of previous day's predicted to measured fluence

Spacecraft Environmental Anomalies Expert System – Real Time (SEAESRT)

Real-time hazard levels for:

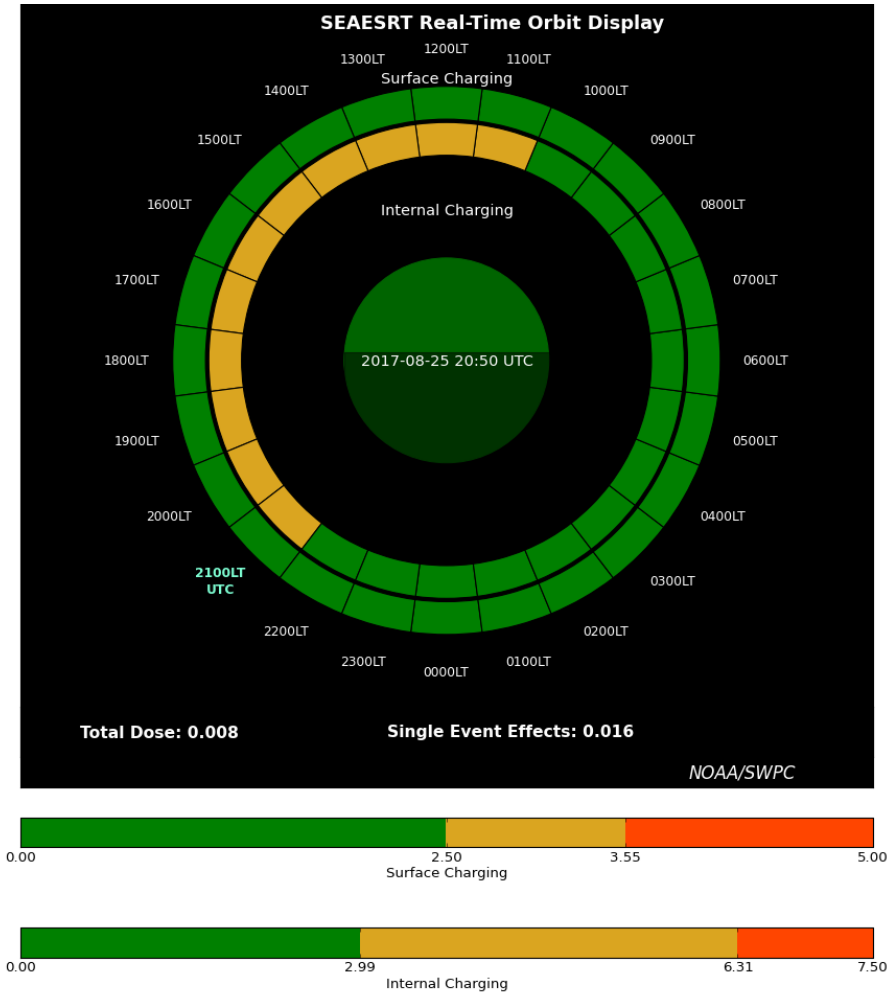
- Internal charging
- Surface charging
- Single event upsets
- Total dose (solar arrays)

Hazard Quotient:

- Probability current environment will result in an anomaly relative to long-term average

Input data:

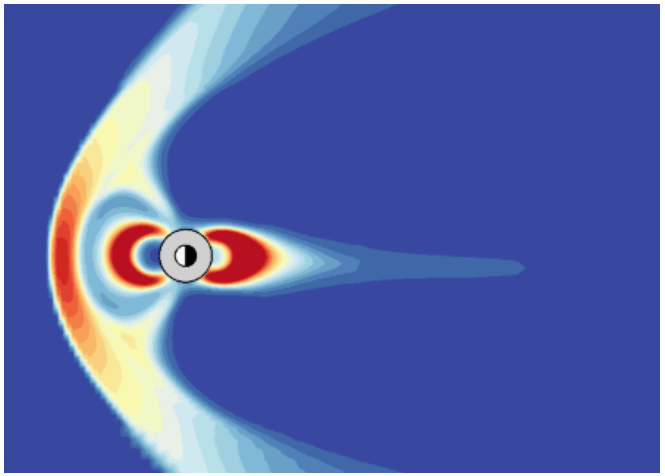
- GOES >2 MeV electrons
- Geomagnetic activity – Kp
- GOES >30 MeV protons
- GOES >5 MeV protons



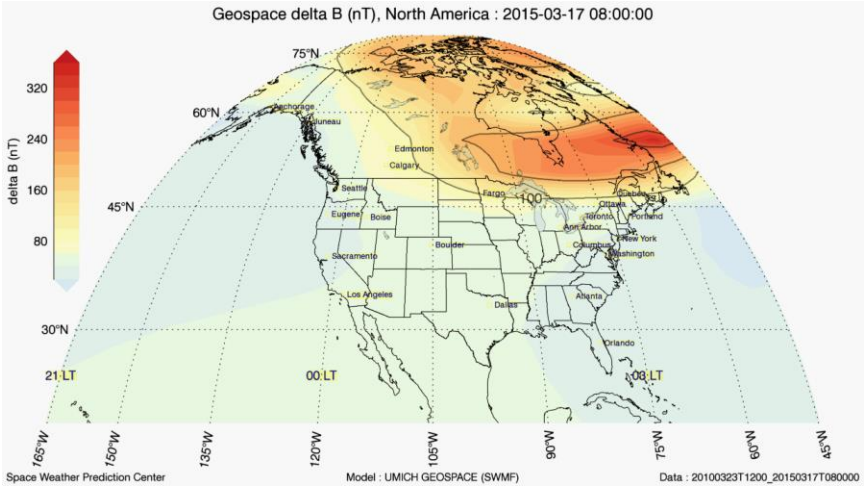
O'Brien, Space Weather, 2009

Geospace Model

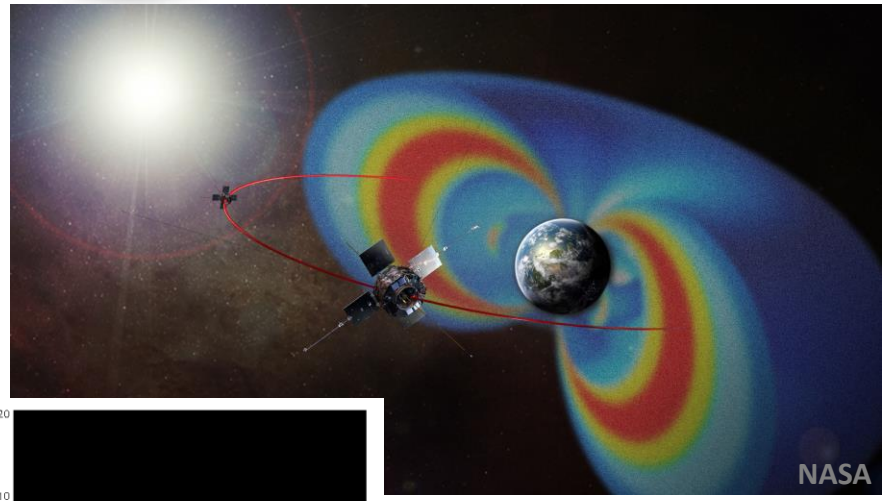
Operational as of October 2016

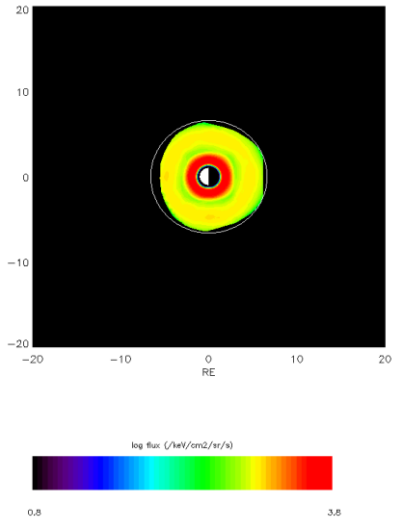


- Geospace model:
  - MHD model of Earth's magnetosphere
  - 32 Re upstream to ~120 Re down tail
  - U. Michigan's Space Weather Modeling Framework (SWMF)
  - Running every minute as long as solar wind data are available
- Regional delta-B information
- Provides regional geomagnetic storm predictions supporting space weather forecasters and electric power industry



New module added: Radiation Belt Environment (RBE)

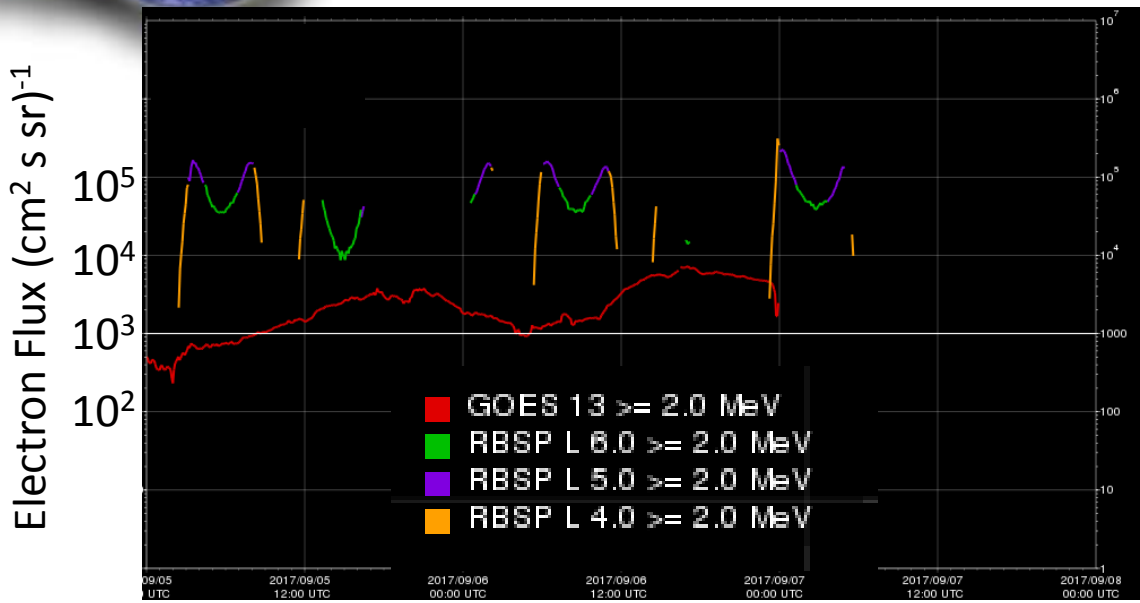


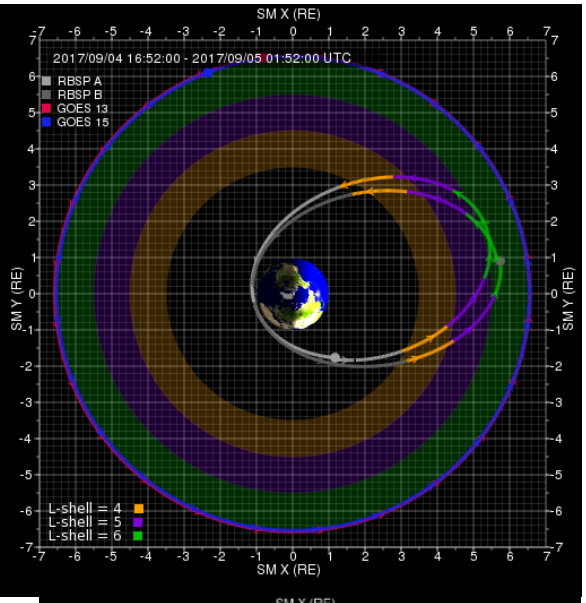


- Covers the very dynamic inner magnetosphere region (~2.5 to 7 Re)
- Allows for different particle species: electrons, protons
- Energies: 10keV to 4MeV

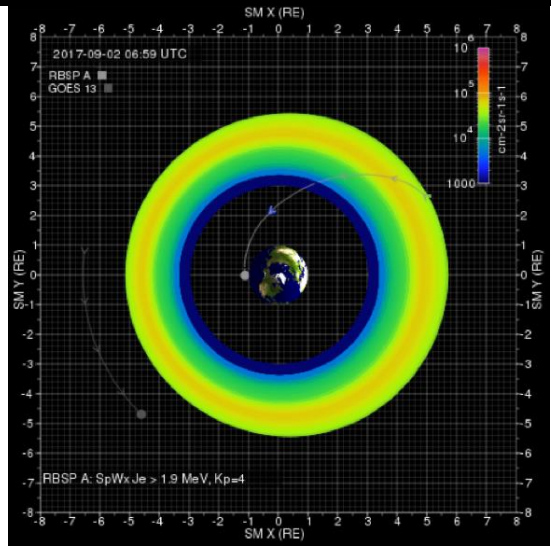
Provides opportunity for new products serving satellite customers

Experimental Test Product - >2 MeV Electrons
NASA Van Allen Probe Inside GEO





Sept. 5, 2017 Sept. 6 Sept. 7



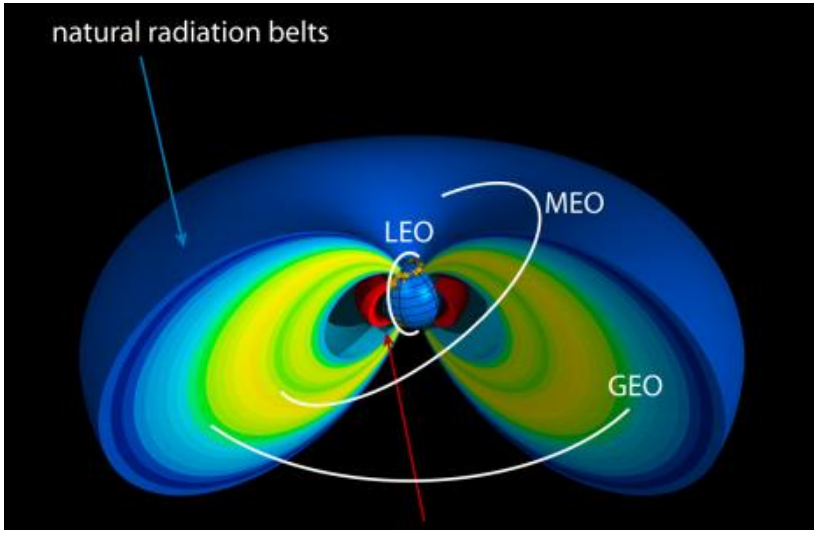
- Above: alert threshold (white line); fluxes inside GEO exceed fluxes at GEO (red)
- Right: GOES and Van Allen Probe Orbits shown; sun on right; bottom of scale (blue) is alert threshold; GOES flux levels will be added

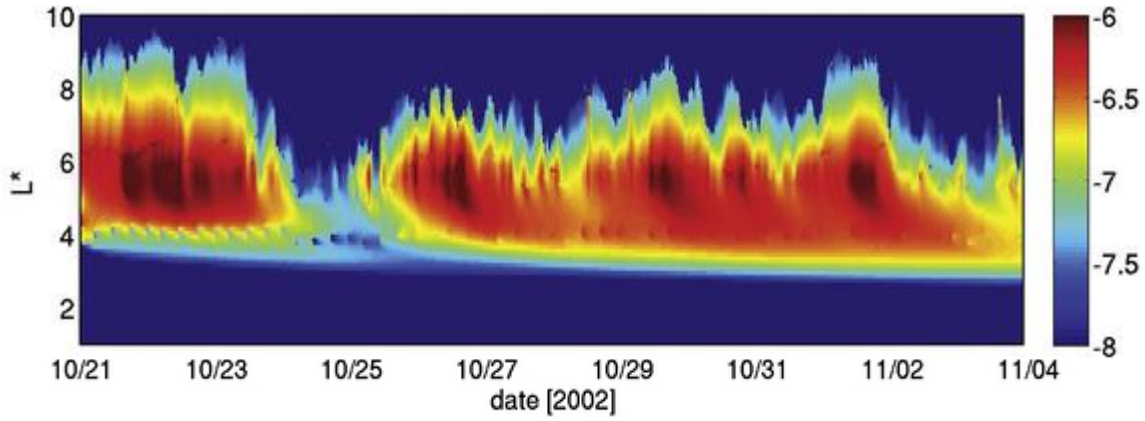
DREAM: Dynamic Radiation Environment Assimilation Model

Under consideration at SWPC

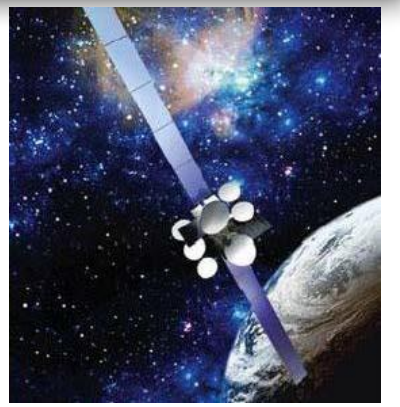
Data Assimilation:

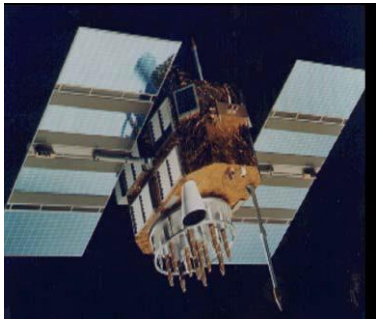
- Initially using GOES only
- Could potentially use additional GEO satellites and GPS for retrospective analysis





NOAA small-business innovative research funding: Satellite Environment Space Weather Products





Goal: Develop improved products to address the impacts of space weather on the satellite industry

- Evaluate satellite industry needs
- Recommend products

- Industry needs were highlighted, including improved communication on anomalies and rapid anomaly attribution
- Prototype tool was developed that could lead to commercial applications
- Phase 2 effort will validate model capabilities and develop operational products based on customer needs and requirements

Energetic Particle Requirements Workshop (1 of 3)

Summary Report

Workshop on Energetic Particle Measurements for the GOES R+ Satellites

Held at the
NOAA Space Environment Center
Boulder, CO
October 28-29, 2002

Workshop reporter: Dr. J. E. Mazur
The Aerospace Corporation
Space Sciences Department
January 2003

Energetic Particle Requirements Workshop (2 of 3)

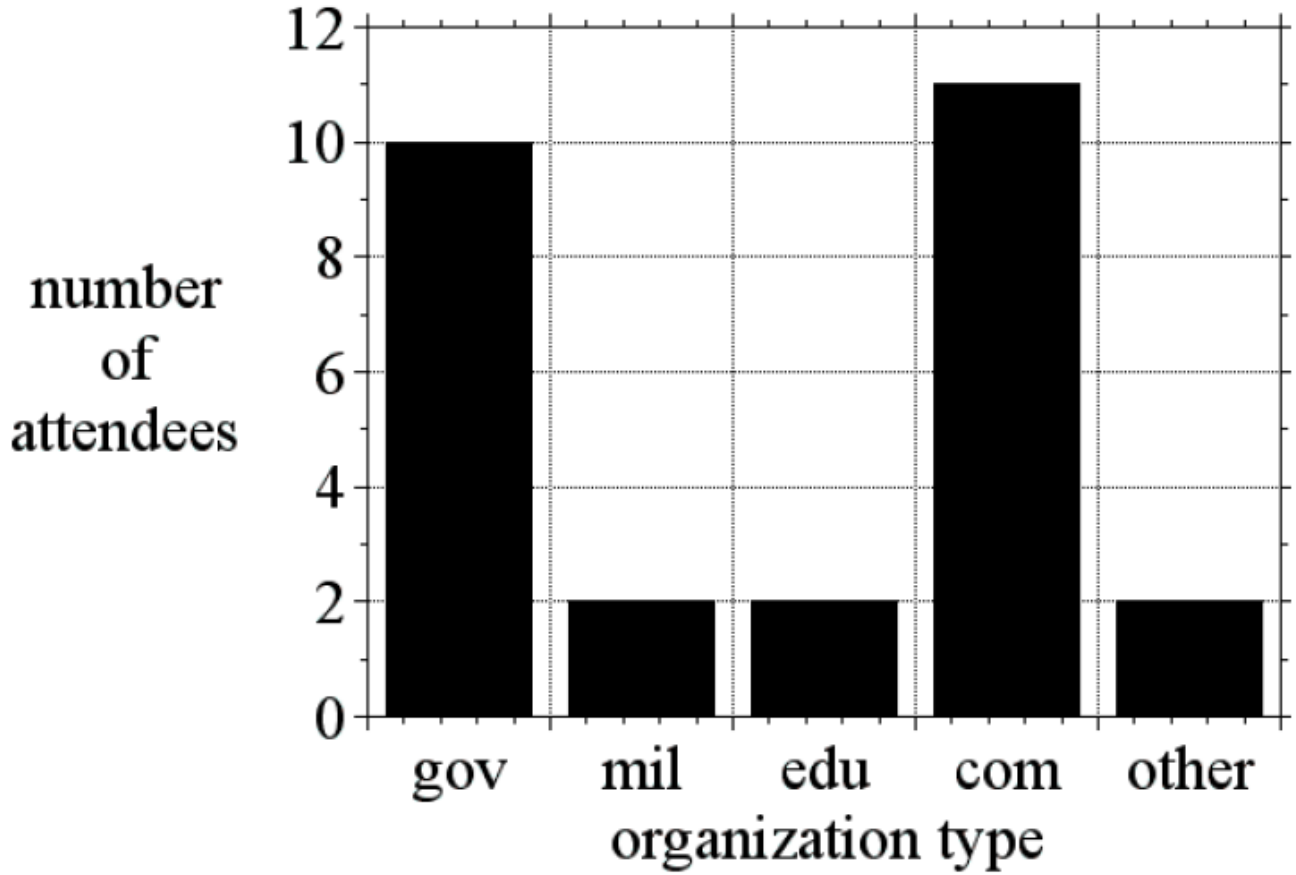


Figure A1. Representation of different institutions at the workshop: gov = US government, mil = US military, edu = educational, com = commercial.

Energetic Particle Requirements Workshop (3 of 3)

Summary findings:

- 83% of respondents wanted pitch angle resolution for both ions and electrons
- 75% of respondents saw a need for heavy ion measurements ($Z \geq 2$)
- 58% of respondents wanted to extend GOES capabilities to below 30 KeV for both electrons and ions
- >50% of respondents thought there are limitations in GOES energy range, resolution, ion composition, and pitch angle coverage. Time resolution was not a significant limitation
- Roughly equal mix of respondents were satisfied, indifferent, or dissatisfied with the current (2002) GOES particle measurements

Questions

- Forecasts (solar energetic protons) and Alerts (>10 MeV p+, >100 MeV p+, >2 MeV e-)

  Are these sufficient? Are other forecasts/alerts needed?

- GOES-16 and subsequent satellites have new capabilities

  Are we making the right measurements? LEO/MEO needs?

- Radiation belt electron models are improving, and data assimilation capabilities are maturing.

  Would real-time operational models (MEO-GEO) be valuable? Would retrospective capabilities be valuable?

- Public-private partnerships are being supported

  How can these relationships be strengthened?