Four top tier Challenges for Space Weather Research for the Next Decade

National Aeronautics and Space Administration

James Spann
Chief Scientist, NASA/MSFC
Science & Technology Office
jim.spann@nasa.gov

14th Conference on Space Weather
American Meteorological Society
23 January, 2017
Seattle, Washington

MARSHALL
SPACE FLIGHT CENTER

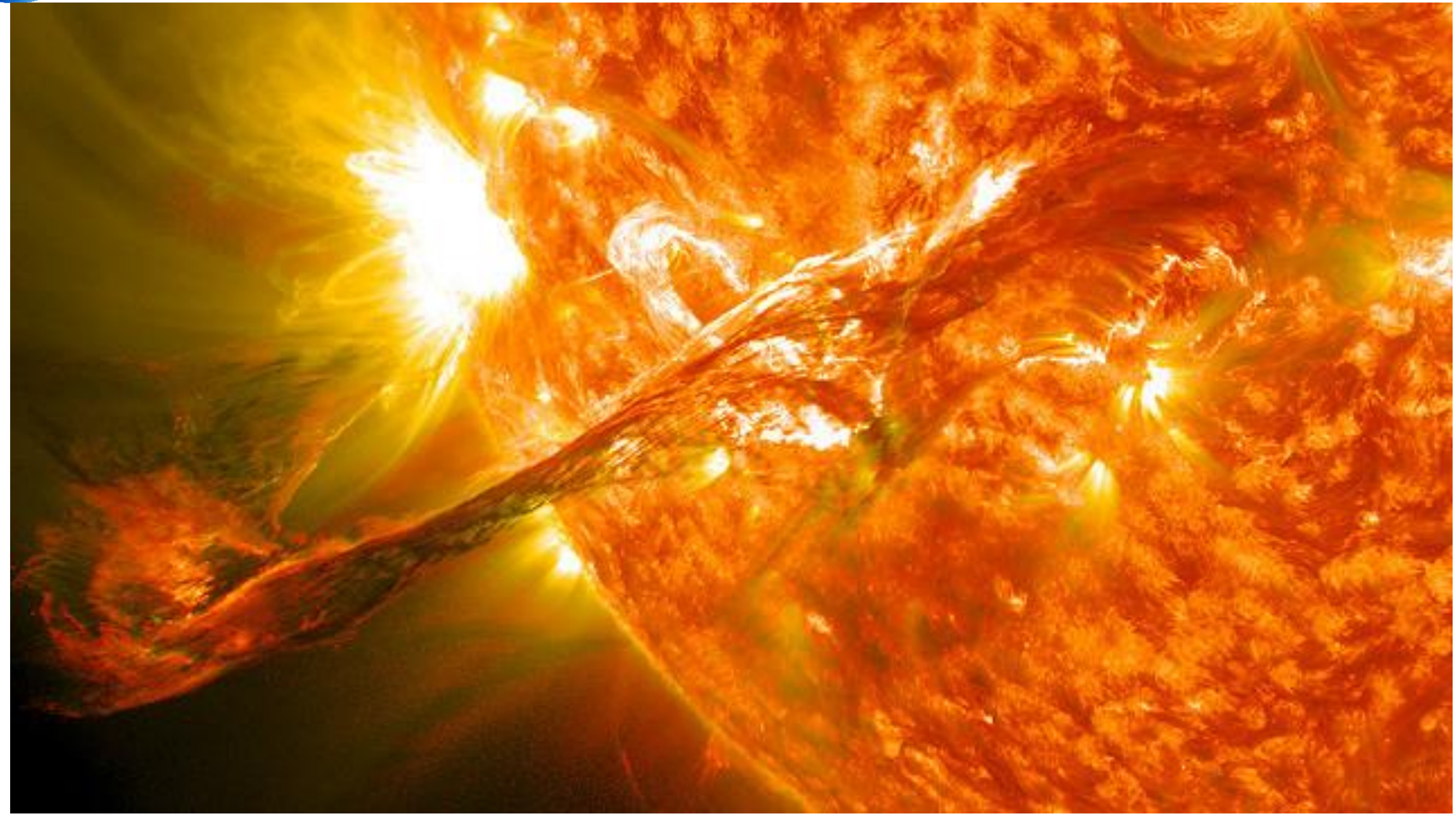
outline

- Context
- Challenges
  - Trigger of Solar Variability
  - Acceleration of Mass and Energy
  - Geoeffectiveness
  - Ionospheric Variability
- Conclusion
- Summary Remarks

Context

- Space Weather Enterprise
- Space Weather Action Plan (tomorrow at 8:30)
- NOAA – SWPC, DSCOVR, GOES
- NASA – Heliophysics Great Observatory, LWS TR&T, CCMC
- NSF – Models, Ground Observatories & Networks
- Academia, Commercial, Government, National/International

Trigger of solar variability

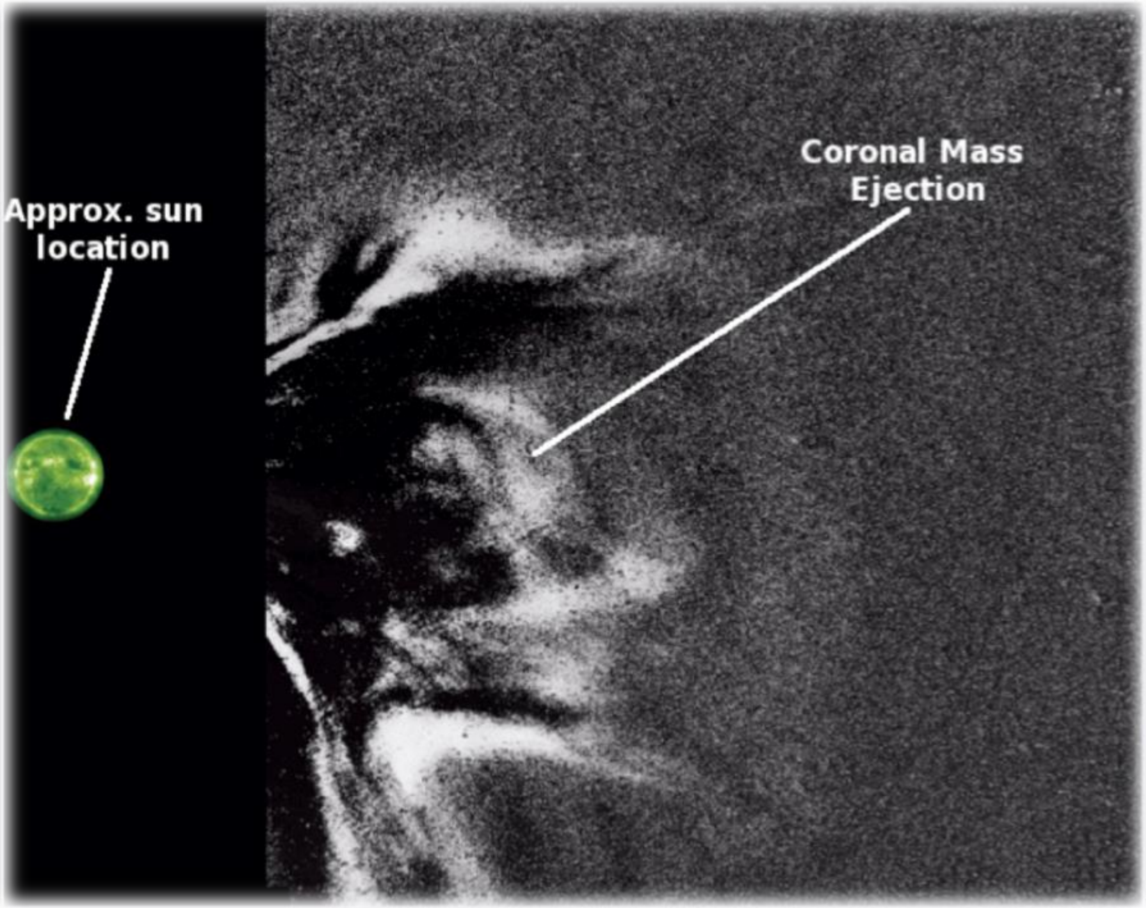


On August 31, 2012 a long filament of solar material that had been hovering in the sun's atmosphere, the corona, erupted out into space at 4:36 p.m. EDT. The coronal mass ejection, or CME, traveled at over 900 miles per second. The CME did not travel directly toward Earth, but did connect with Earth's magnetic environment, or magnetosphere, causing aurora to appear on the night of Monday, September 3.
Pictured here is a lighten blended version of the 304 and 171 angstrom wavelengths. Cropped
Credit: NASA/GSFC/SDO

Trigger of solar variability

- Understanding the underlying mechanisms
  - Interior
  - Magnetic atmosphere
- High resolution observations, models,
- Prediction of solar eruptive events, their magnitude, content, direction . . .
- Coupling of surface to the extended solar atmosphere

Acceleration of Mass and Energy



SECCHI Heliospheric Imager

Conceived, developed, and operated at NRL, SECCHI's Heliospheric Imager (HI) instrument on NASA's STEREO spacecraft is a new remote sensing tool that tracks, for the first time, Coronal Mass Ejections (CMEs) as they pass through the volume of space between the Sun and the Earth. Images from HI show continuous solar wind outflow from the Sun and are applied to detect significant changes in solar outflow (often resulting from CMEs that are headed to Earth and arrive within 24 to 72 hours). Data from HI is useful towards validating HPC models of heliospace dynamics.

Acceleration of Mass and Energy

- The temporal evolution of the magnetic content of the interplanetary solar wind
- Time, energy, mass, space, velocity, polarity
- What observations needed to drive and constrain models?
- Spaceborne assets impacted
- Coupling of solar wind to geospace

The concept to measure IMF

- Zodiacal light is scattered sunlight off interplanetary dust grains
- Dust grains rotate when illuminated, and become charged when exposed to UV and charged particles
- A rotating grain will align itself with mag field
- Alignment of a cloud of dust grains will produce polarized scattered light when illuminated
- Using polarimetry measurements and knowledge of dust grain optical extinction coefficient, the mag field direction can be inferred

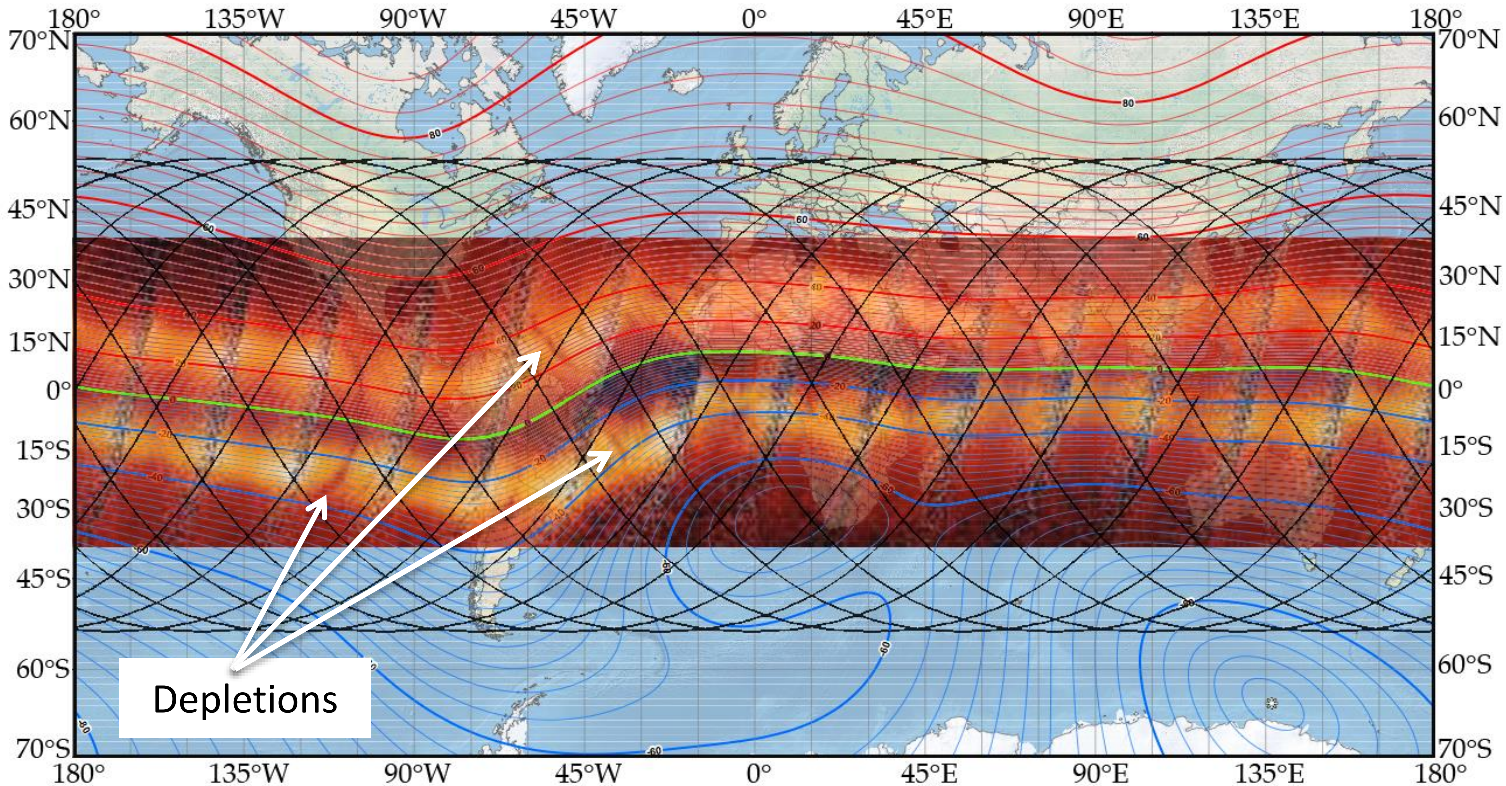
Geoeffectiveness

Orange outlines highlight the areas in the U.S. that are most vulnerable to electrical outages due to a severe geomagnetic storm, according to a 2008 report from the National Research Council.
Credit: Kathleen Cantner, AGI

Geoeffectiveness

- Geospace does not always respond as we understand it should
- More than solar wind IMF and momentum
- Large dynamic range of scales in space, time, mass, and energy
- Passive Recipient vs Active Participant
- Understanding our planet is just as important and understanding our space

Ionospheric variability



UV Airglow images from TIMED GUVI clearly showing the equatorial anomaly with embedded depletions that have penetrated through the F peak. Green, Red and Blue traces show the magnetic equator and positive and negative dip angles. 52° inclination ground tracks are superimposed as black traces.

Ionospheric variability

- Solar driver vs upper atmospheric driver?
- On a day-to-day basis, this unresolved challenge impacts the greatest number of assets

Conclusions

- SWx Science challenges require observations, models, and monitoring
- SWx Science challenges will not be resolved overnight
- Humanity's dependence on evolved technology continues to drive SWx science challenges

Summary Remarks

- SWx Science extends beyond understanding how nature works.
- SWx Science also includes understanding how technology responds to natural variability – e.g. surface charging, deep dielectric energy deposition, organic radiation damage
- Effective SWx Science must be intentional, and is separate from the pursuit of natural science understanding
- SWx Science has a tremendous potential over the next decade