

NOAA Space Weather Operations and Research



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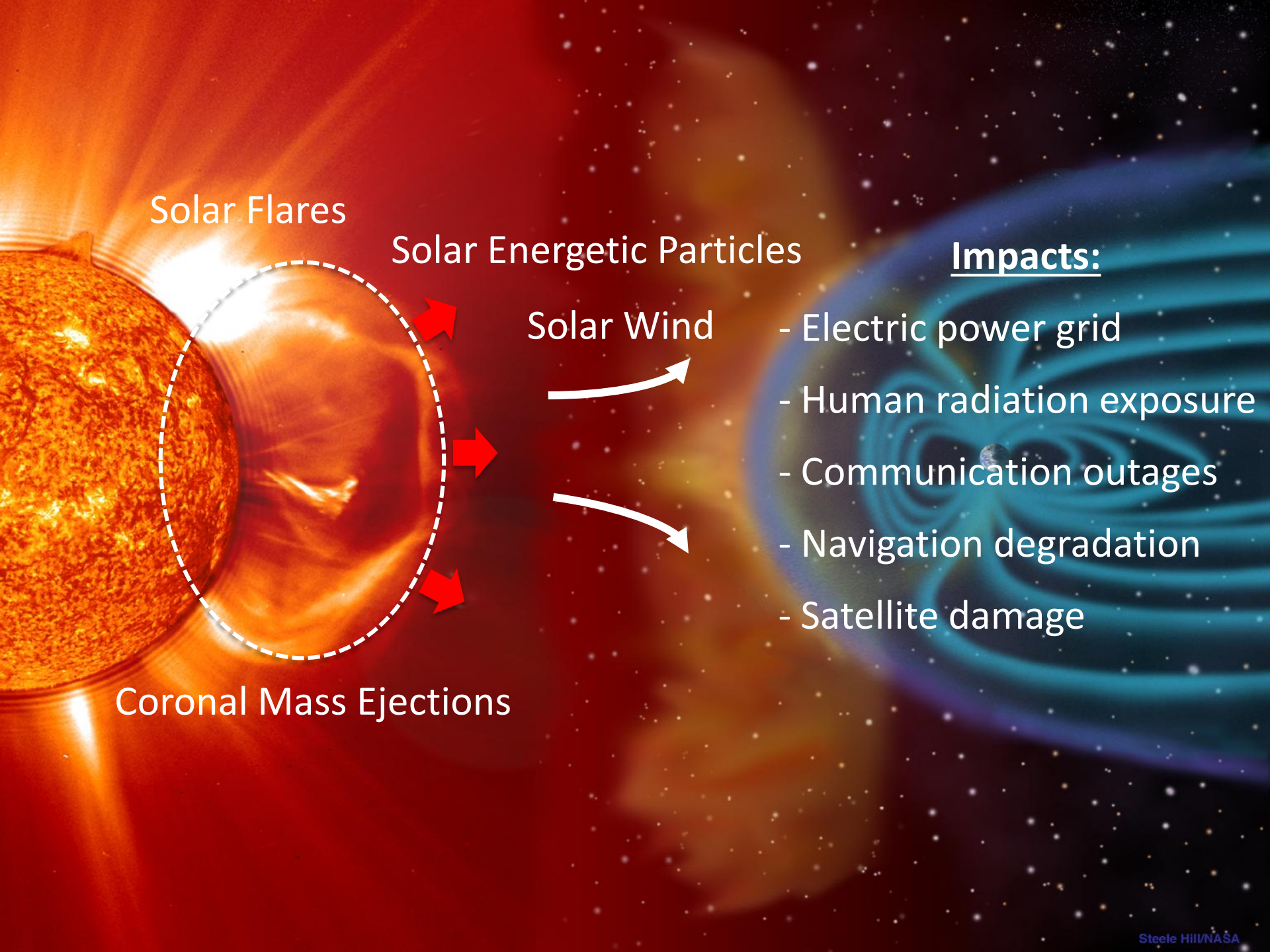
Main Points

National and international partnerships are essential for resilience to space weather



- Drivers of Space Weather
- Growing Space Weather Product Demand
- NOAA Observations and Research
- International Partnerships





Solar Flares

Solar Energetic Particles

Solar Wind

Impacts:

- Electric power grid
- Human radiation exposure
- Communication outages
- Navigation degradation
- Satellite damage

Coronal Mass Ejections



Major Forecast Center Products

Daily Forecasts (1-3 day):

- Solar flares
- Solar energetic particles
- Geomagnetic activity
- 10.7 cm radio flux

Event-Driven Warnings and Alerts:

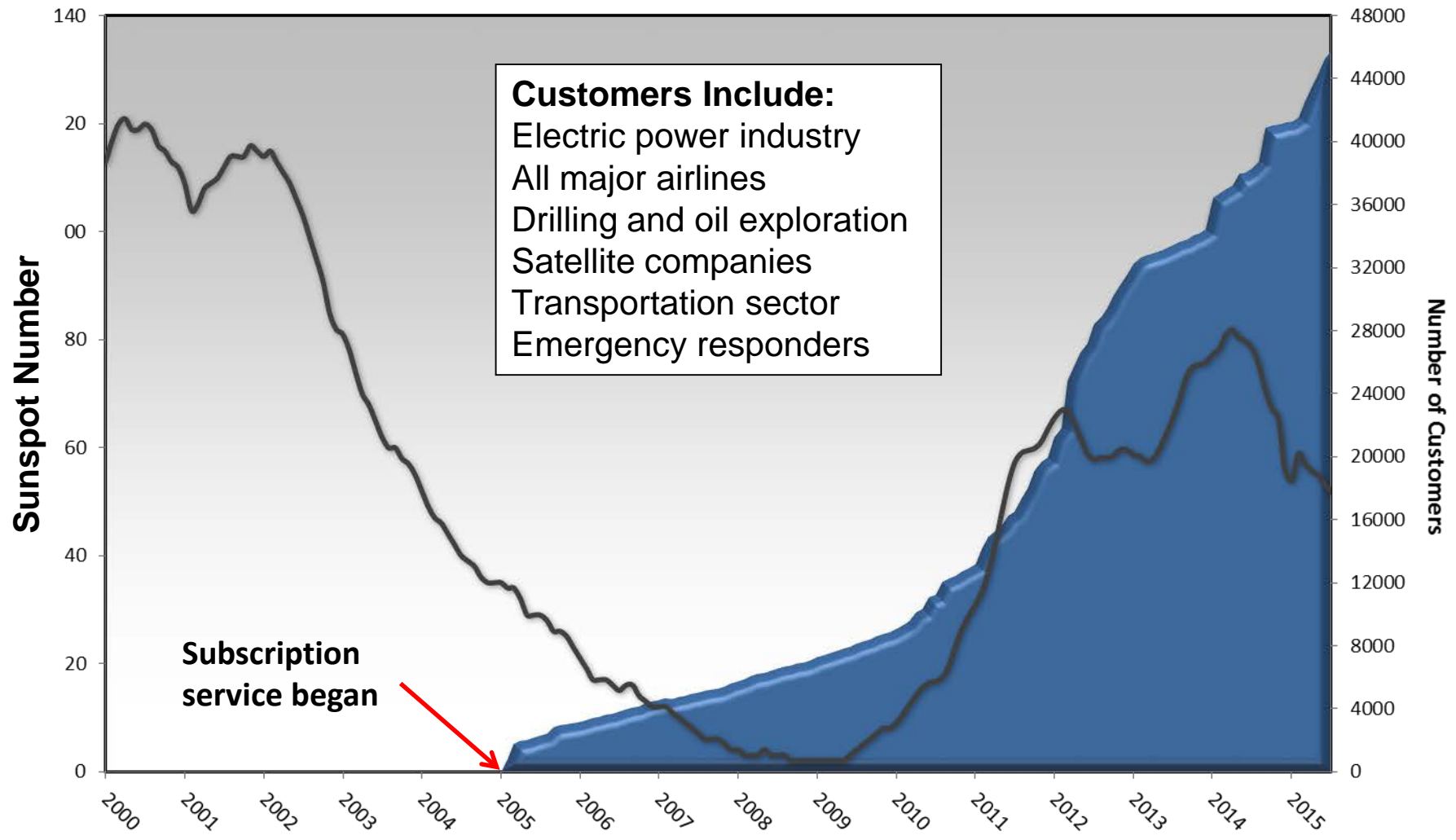
- Warnings: geomagnetic storms, proton events
- Alerts: solar flare, proton event, geomagnetic storm, electron event, solar radio burst

Numerical Models:

- WSA-Enlil – background solar wind and CMEs
- Relativistic Electron Forecast Model
- D-Region Absorption Product
- U.S. Total Electron Content
- Ovation Aurora Model

Customer Growth

NOAA Space Weather Prediction Center – Product Subscription Service





Electric Power Impacts – October, 2003

Sweden:

- Power outage
- Transformer heating in nuclear plant



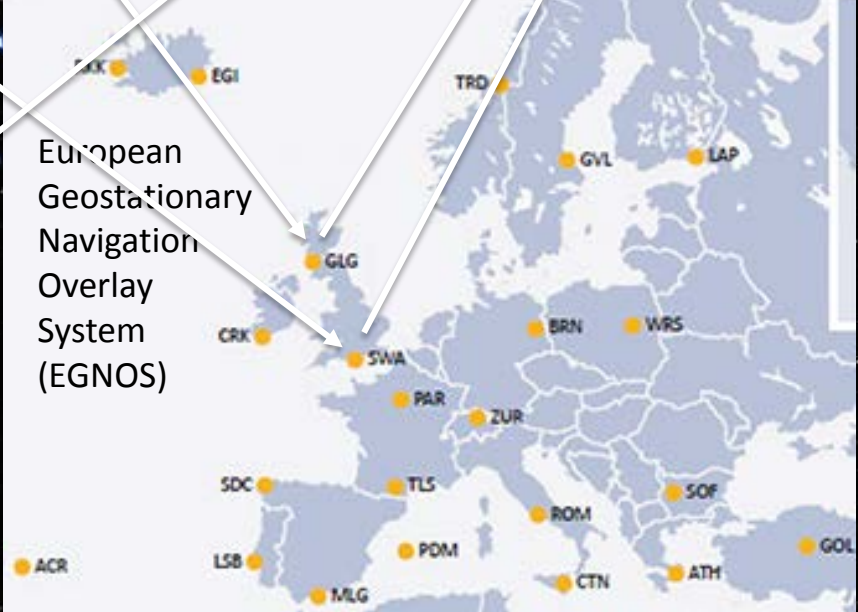
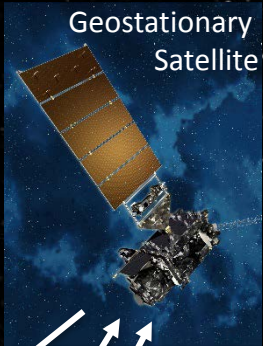
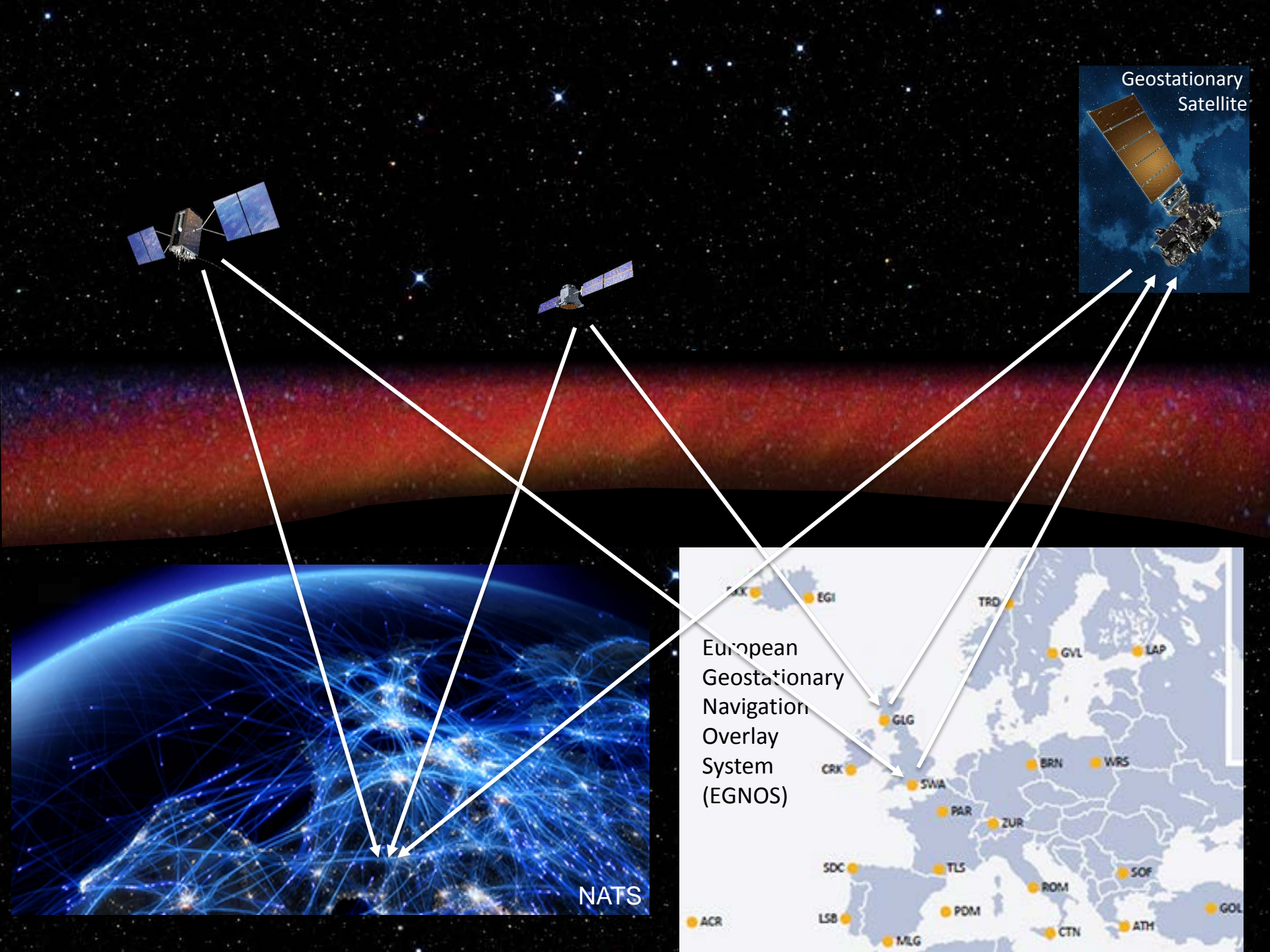
United States:

- Power reduced to mitigate impact on generation facilities



South Africa:

- 14 transformers damaged
- \$60 million impact
- Basic commerce and security impaired

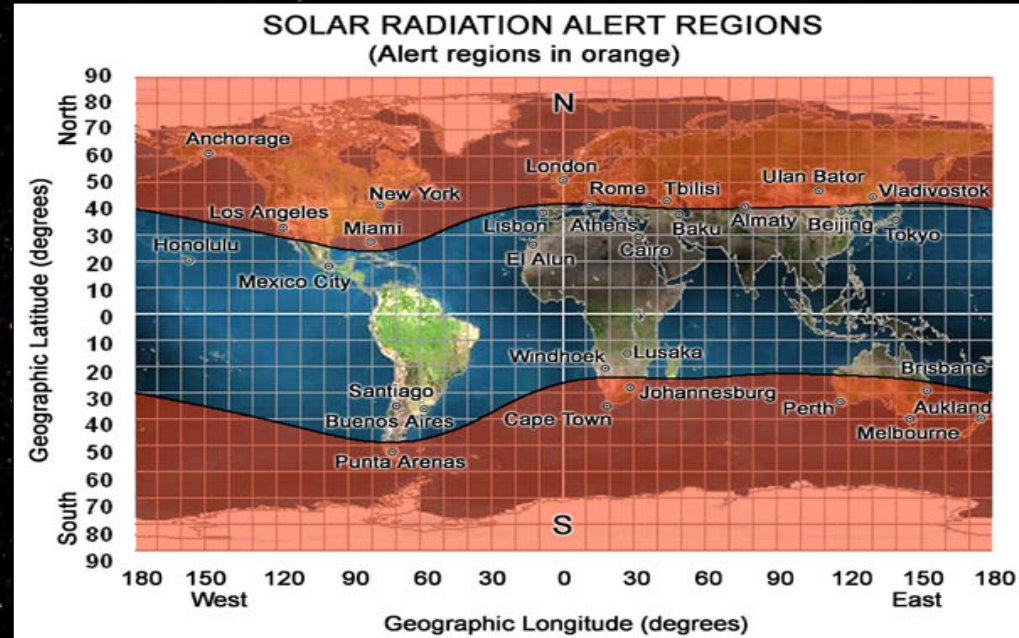


Alert Issued for Airline Radiation

ALERT: Solar Radiation Alert at Flight Altitudes Conditions Began: 2003 Oct 28 2113 UTC

Comment: Satellite measurements indicate unusually high levels of ionizing radiation, coming from the sun. This may lead to excessive radiation doses to air travelers at Corrected Geomagnetic Latitudes above 35 degrees north, or south.

(Federal Aviation Administration)



RESEARCH ARTICLE

OPEN ACCESS

Economic impact and effectiveness of radiation protection measures in aviation during a ground level enhancement

Daniel Matthiä^{1,*}, Martin Schaefer², and Matthias M. Meier¹

2015



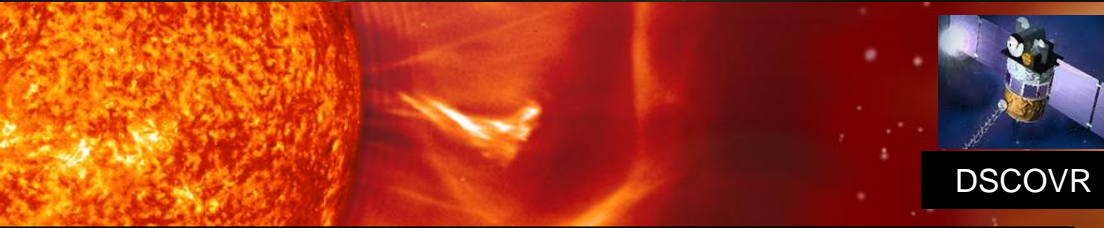
- Radiation dose reduced by 42% with 5% fuel increase and 30 min flight delay
- Prompt changes in altitude and velocity not compliant with Air Traffic Mgmt System



Overarching Goal: Strengthen Resilience Through Improved Services

Four elements needed to improve space weather capabilities:

1. User Needs: Understand the risks and the actions that need to be taken
2. Targeted Services: Develop useable capabilities from basic science knowledge
3. Observing Infrastructure: Shared approach for long-term continuity
4. Global Coordination: Consistent, accurate message



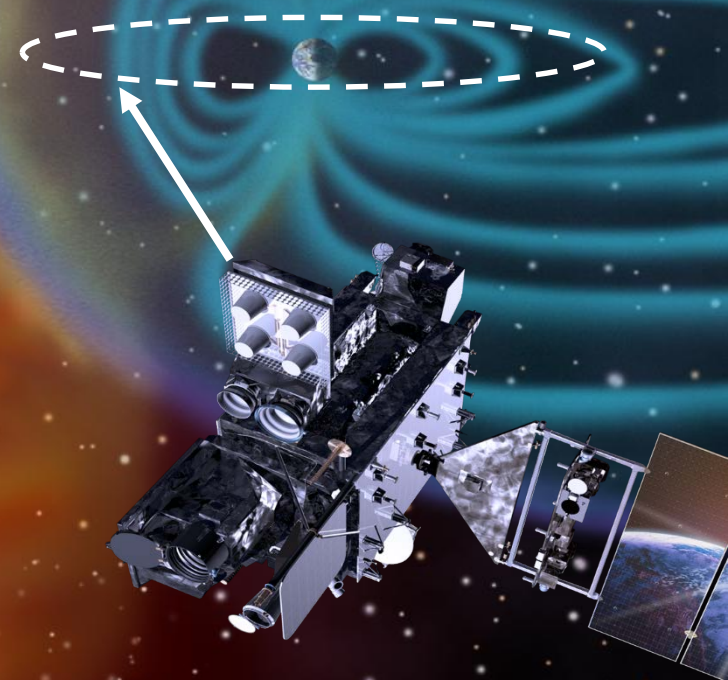
DSCOVR



- Launched: February 11, 2015
- To replace operational use of NASA ACE spacecraft
- Space weather measurements:
 - Solar wind density, velocity, temperature
 - Solar wind magnetic field
- High-reliability warnings of geomagnetic storms
- Requires international real-time data network
- Follow-on mission in planning

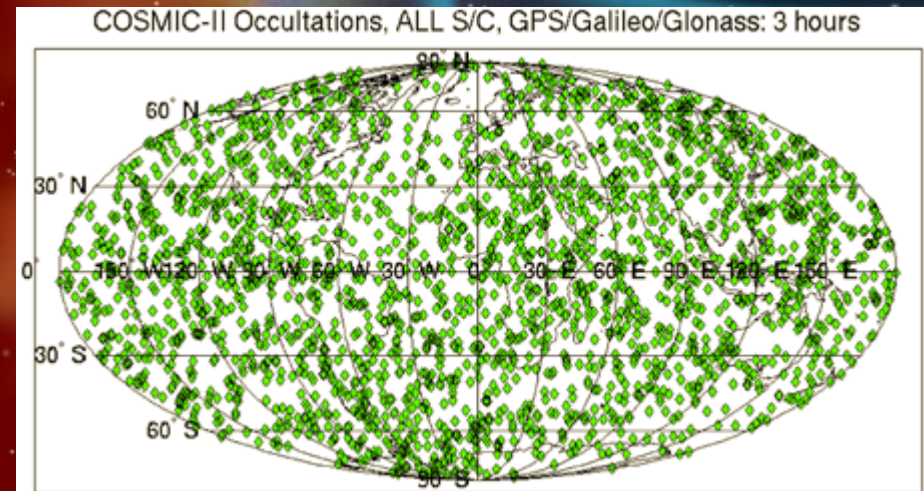
Geostationary Operational Environmental Satellite Series GOES-R

- Launched planned: October, 2016
- Space weather measurements:
 - Solar EUV
 - Solar X-rays
 - Energetic particles
 - Magnetic field



COSMIC-2

- Taiwan-U.S. 12-satellite constellation
- 6 low- and 6 high-inclination satellites
- First launch (6 low-inclination) planned for 2017
- GNSS Radio-Occultation
 - Ionospheric electron density profiles
 - Ionospheric scintillation
- Ionospheric ion velocity
- NOAA is working with international partners to host/operate data-receiving ground stations



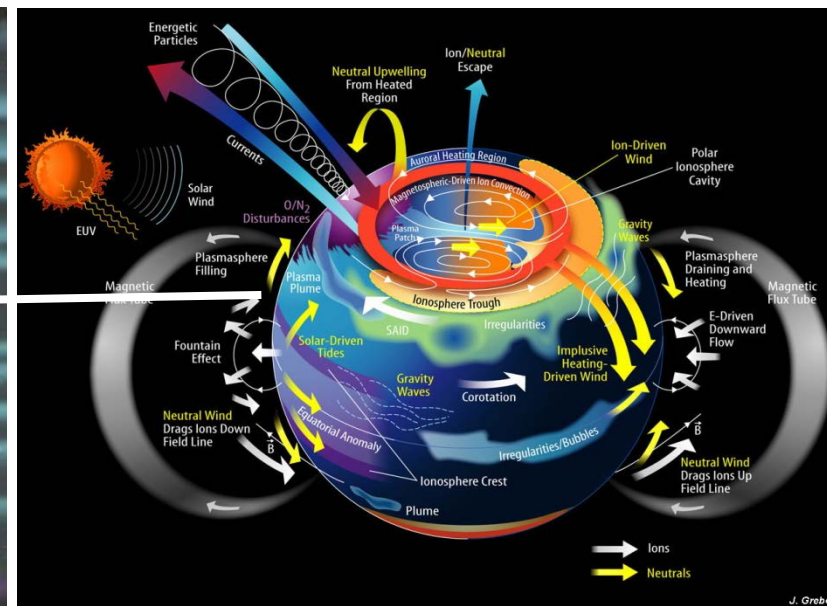
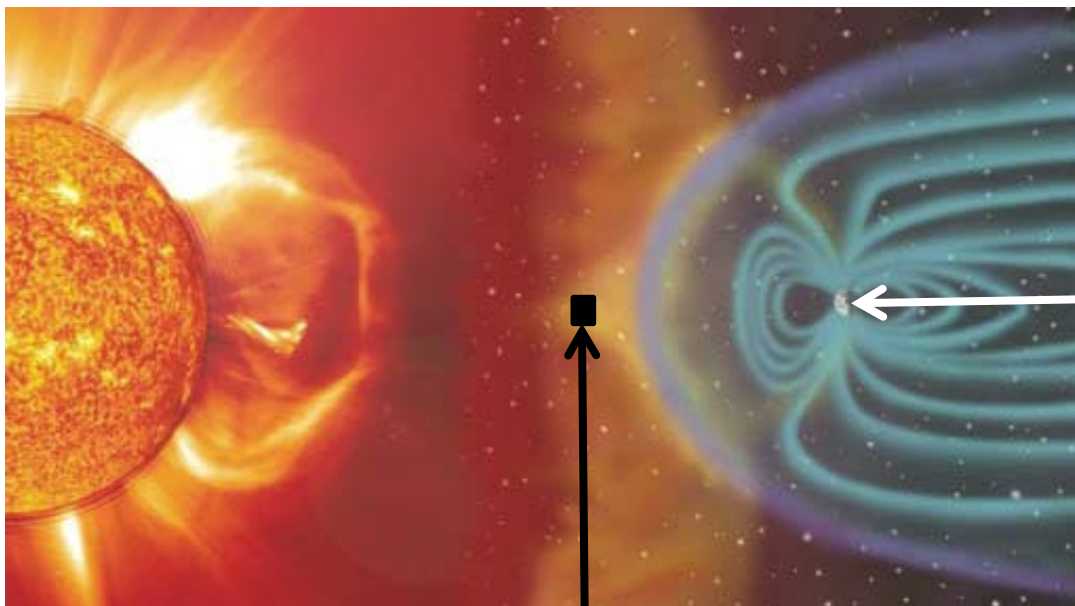


Components of NOAA's Numerical Space Weather Modeling Effort

Solar /Solar Wind

Magnetosphere/
Ionosphere

Atmosphere/
Ionosphere



L1 Satellite Location – ACE and now DSCOVR



International Organizations Involved in Space Weather Services



International Space Environment Service – Global network of space weather service providers since 1962



World Meteorological Organization – Leverage global infrastructure and membership, build capacity and increase service providers



UN Committee on Peaceful Uses of Outer Space – Promote high-level awareness of space weather



Coordination Group for Meteorological Satellites – Satellite observations, user needs, and anomaly reporting



International Civil Aviation Organization – Defining civil aviation requirements and space weather service needs



Summary

- Demand is increasing for space weather services – electric power, aviation, satellites, navigation, communication
- NOAA's role is to provide forecasts, warning, and alerts to protect critical infrastructure, society, and economic vitality
- User needs, targeted services, observations, and service coordination are essential elements
- NOAA provides key space-based observations and works with NASA and other partners to utilize space-based and global ground-based data
- Improvements to numerical models and services rely on cooperation with national (NASA, NSF, DoD, industry) and international research efforts
- National and international partnerships are essential for improving resilience to space weather