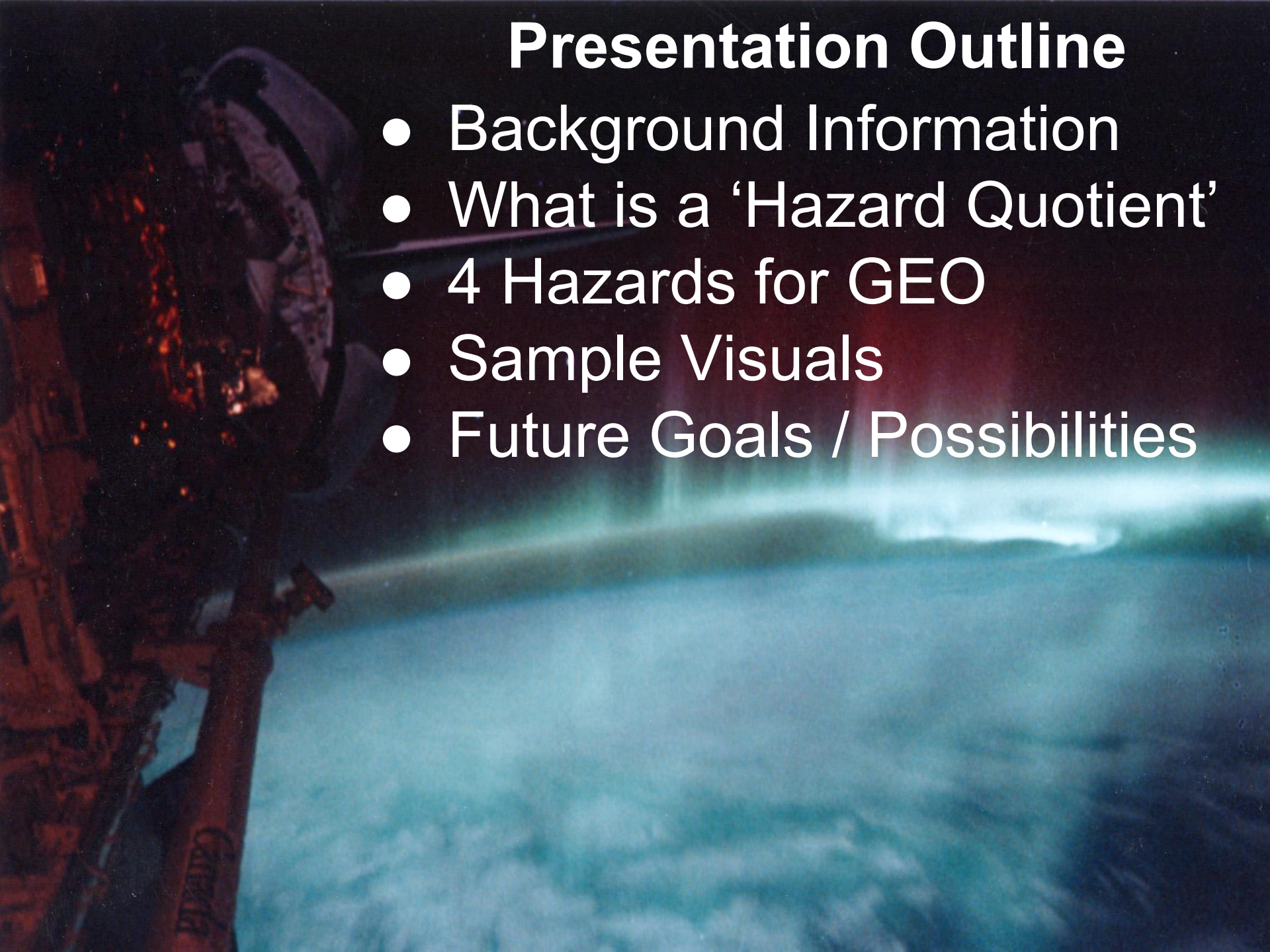
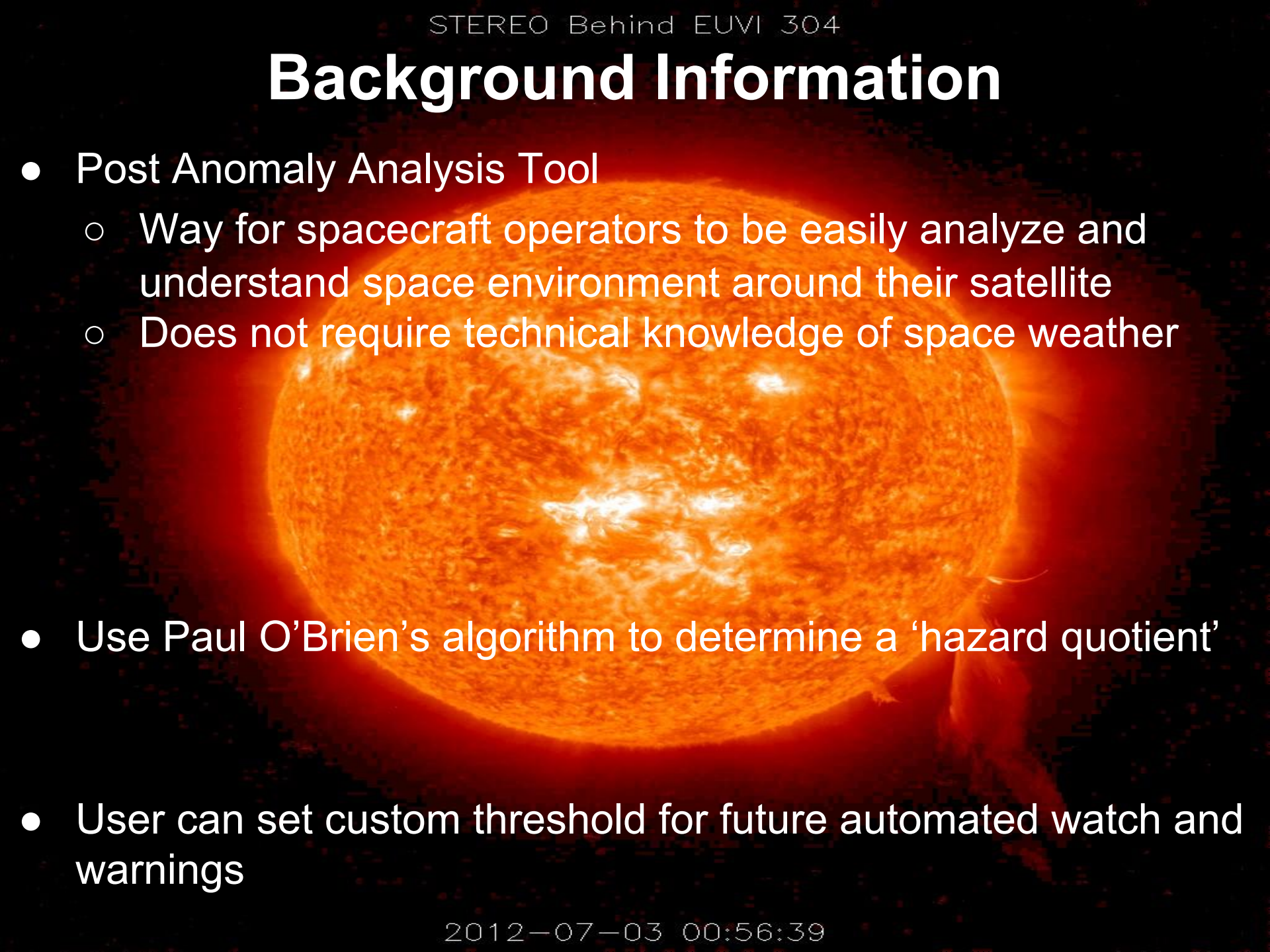
Development of Spacecraft Environmental Anomalies Expert System (SEAES) at NASA

Dhanesh Krishnarao



Presentation Outline

- Background Information
- What is a ‘Hazard Quotient’
- 4 Hazards for GEO
- Sample Visuals
- Future Goals / Possibilities



Background Information

- Post Anomaly Analysis Tool
  - Way for spacecraft operators to be easily analyze and understand space environment around their satellite
  - Does not require technical knowledge of space weather
- Use Paul O'Brien's algorithm to determine a 'hazard quotient'
- User can set custom threshold for future automated watch and warnings

What is a ‘Hazard Quotient’

- **Hazard Quotient:** The ratio of instantaneous to mission averaged likelihood of an anomaly for a specific space weather effect

Surface Charging

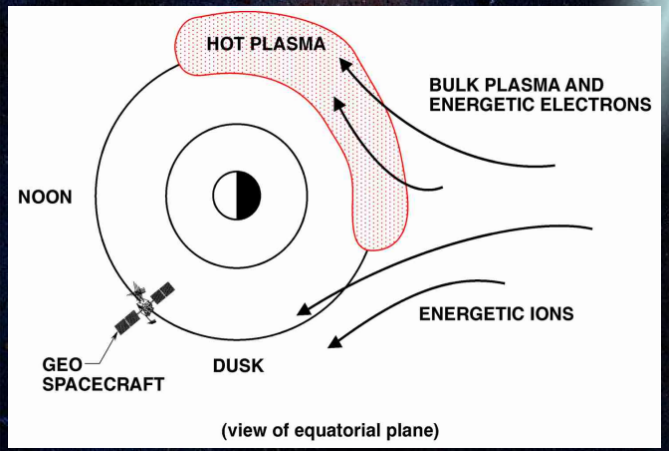
Single Event Effects

Internal Charging

Total Dose

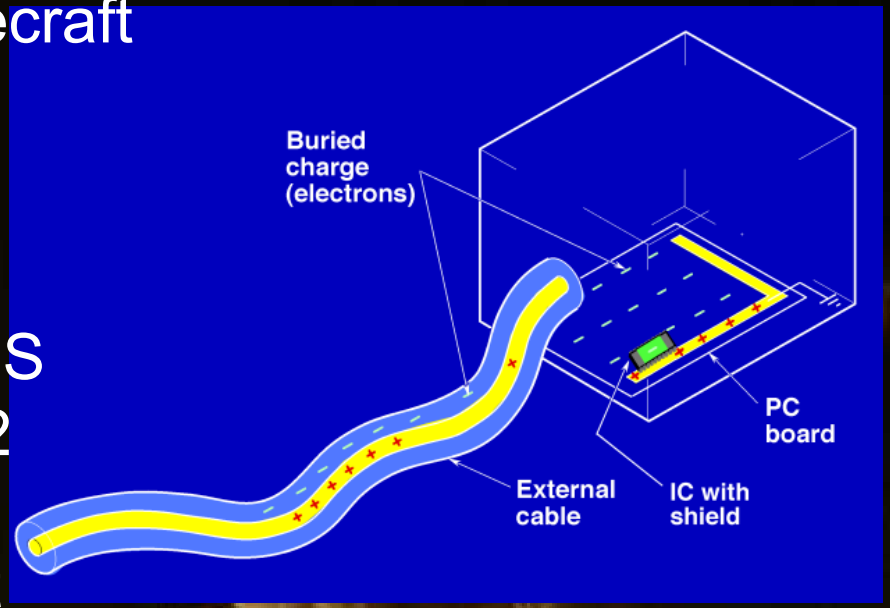
Surface Charging

- **<u>Surface Charging:</u>** Buildup of electric charge on the surface of a spacecraft structure
  - Large Currents of Low Energy (~10 KeV)
  - Using O'Brien's table of values
    - Based on historical analysis of Surface Charging in relation to Kp and MLT of spacecraft.



Internal Charging

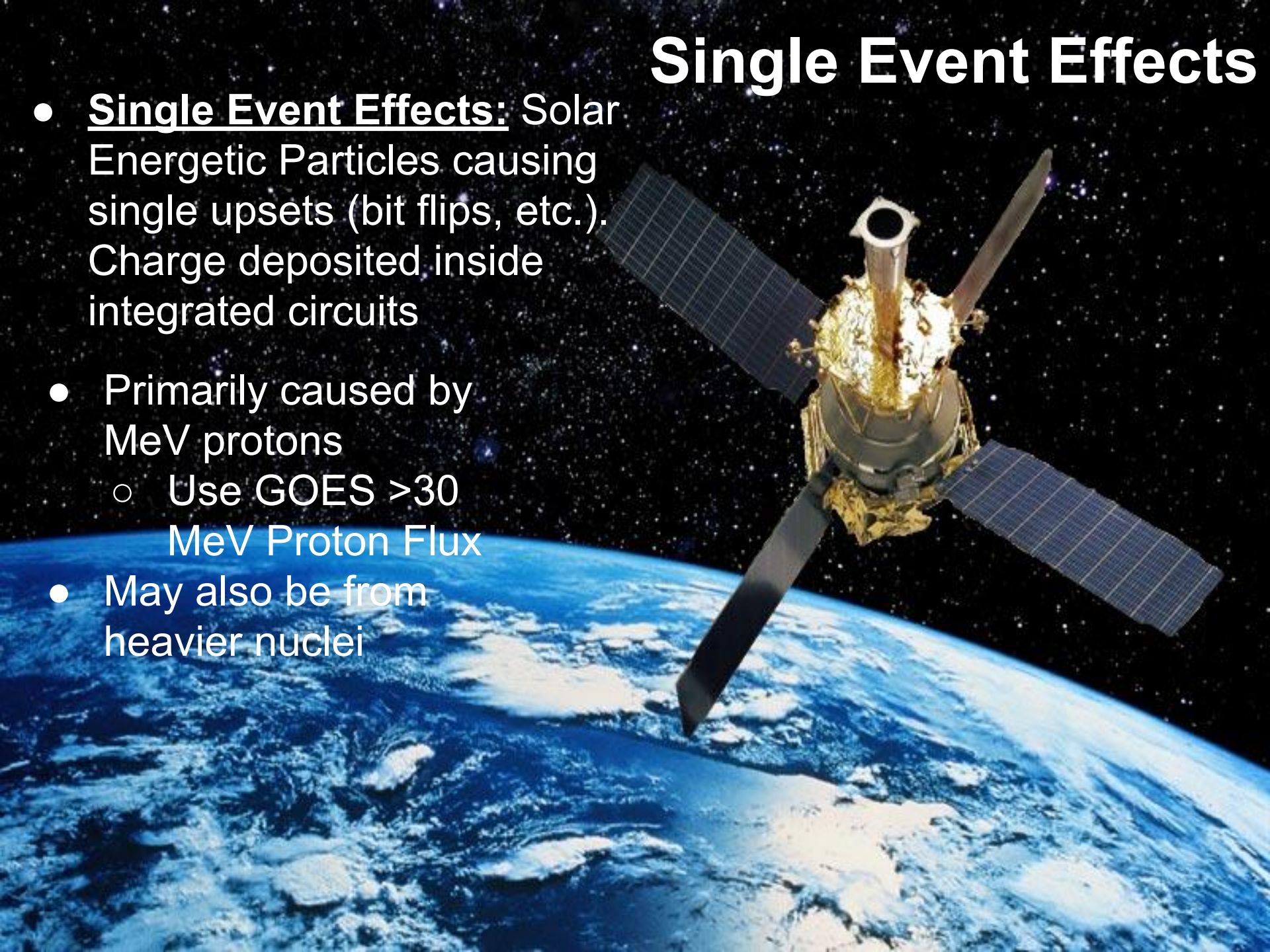
- **Internal Charging:** Buildup of electric charge anywhere within a spacecraft structure
- Small currents of high energy electrons
  - >2 MeV Electron Flux at GOES
    - averaged over previous 12 hours
  - Local Time (LT) at Spacecraft



- Asymmetric electron radiation bel
  - Use two different methods to approximate the Flux at different longitudes.
    - O'Brien (2009)
    - Yi-Jiun Su (2014)

Single Event Effects

- **<u>Single Event Effects:</u>** Solar Energetic Particles causing single upsets (bit flips, etc.). Charge deposited inside integrated circuits
- Primarily caused by MeV protons
  - Use GOES >30 MeV Proton Flux
- May also be from heavier nuclei



- **Total Dose:** Coming from SEP events, a large amount of energy can build up on solar arrays
  - Susceptible to protons with Energy ~5 MeV
    - Use GOES >5 MeV Proton Flux
      - averaged over previous 24 hours

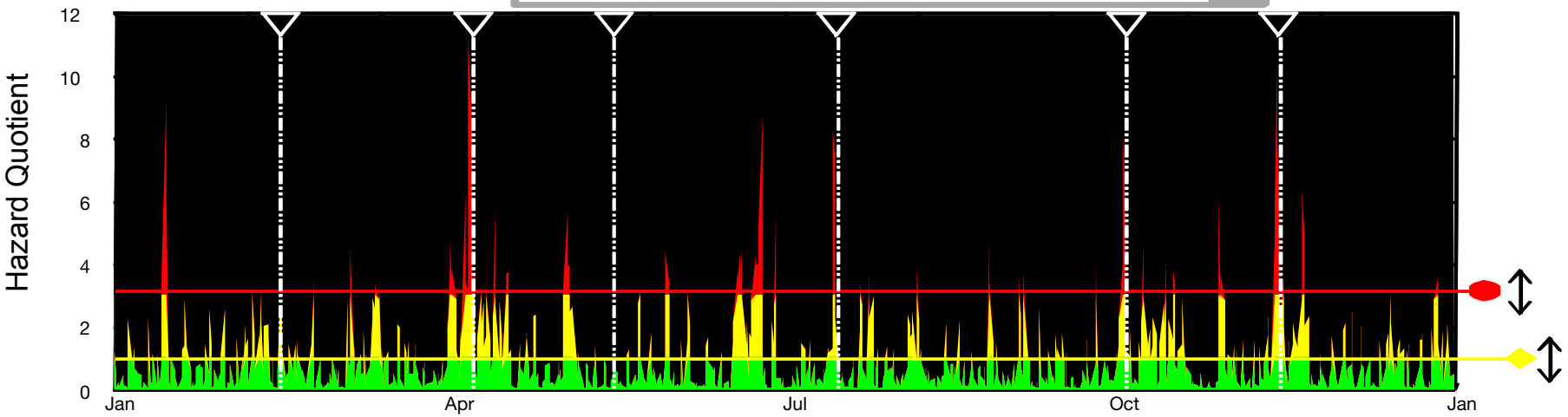
Total Dose

Vehicle: GEO SDO

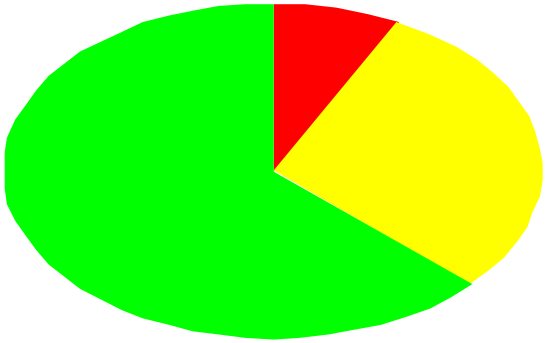
Anomaly Type: VTCW RESET

NEW

Hazard Indicator: GOES >2MeV Electron Flux



% Time



8.4%

31.6%

68.4%

% Anomalies

66.7%

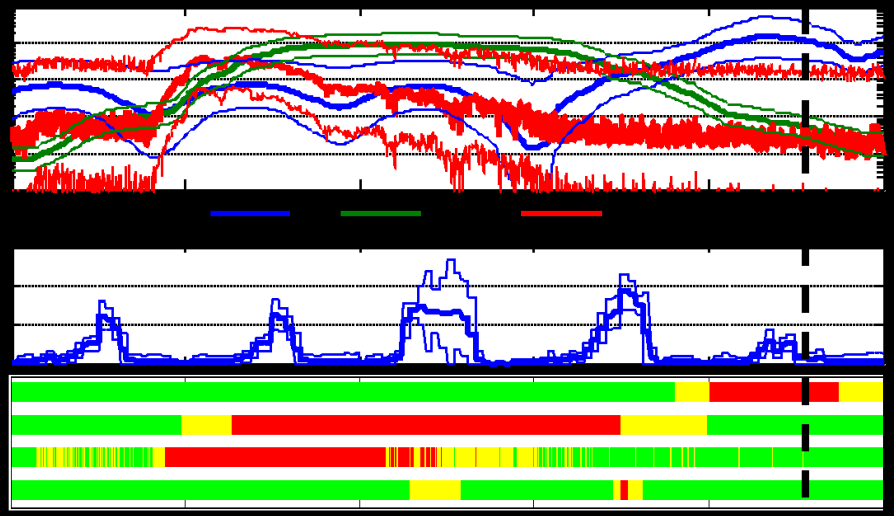
16.7%

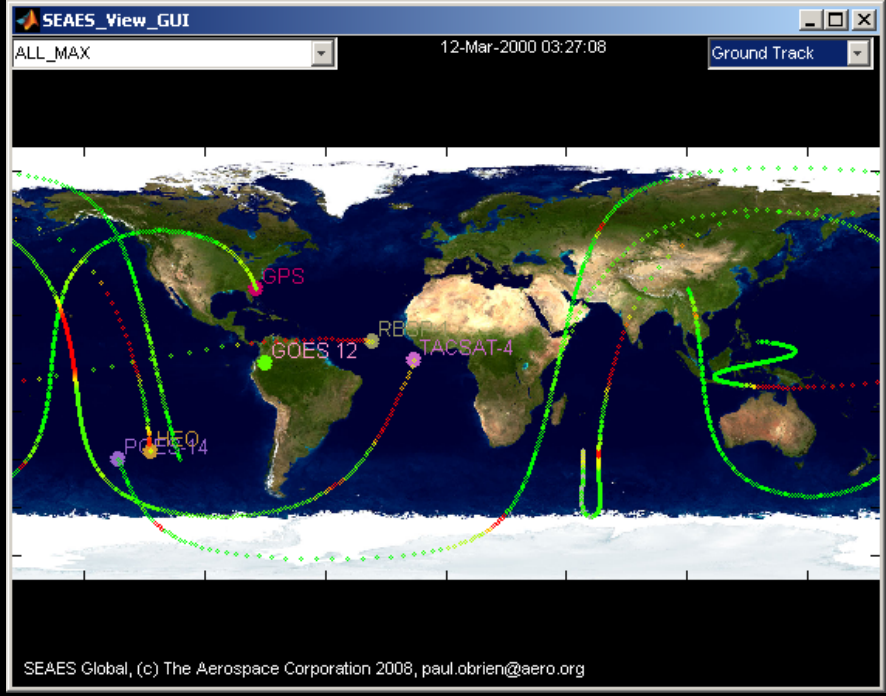
16.7%

Expected anomalies per year for selected Hazard Indicator: 1

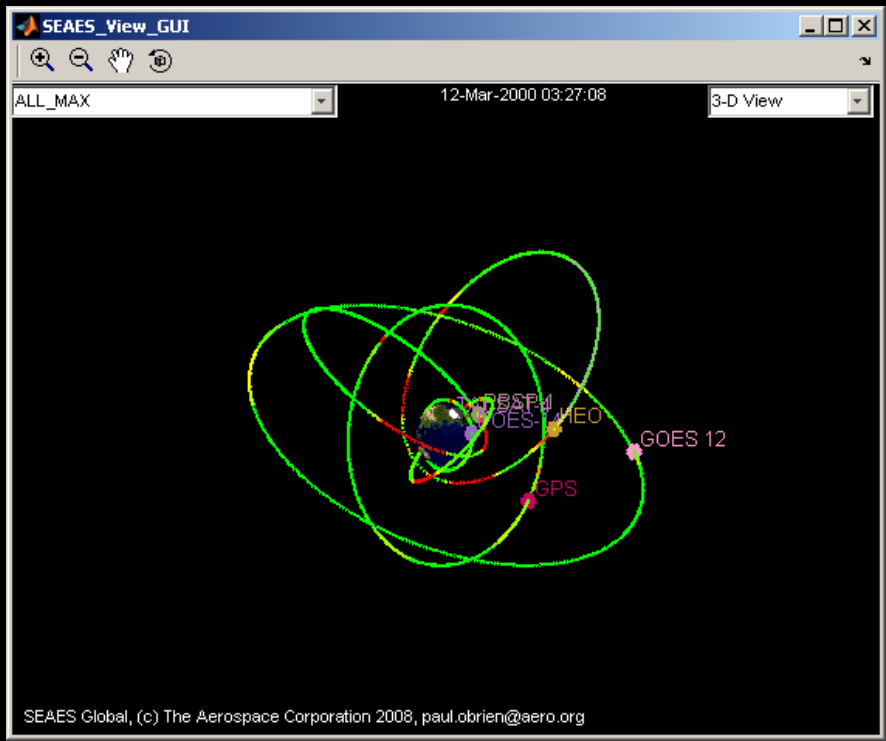
Suggested value based on selected Anomaly Type: 6

SAVE





More Sample Visuals from O' Brien



Future Goals / Possibilities

- Will be a product on Space Environment Automated Alerts & Anomaly Analysis Assistant (SEA^5)
- Should be expanded to more orbits
  - MEO
  - LEO
  - HEO
  - Interplanetary

References & Thanks

Thanks to:

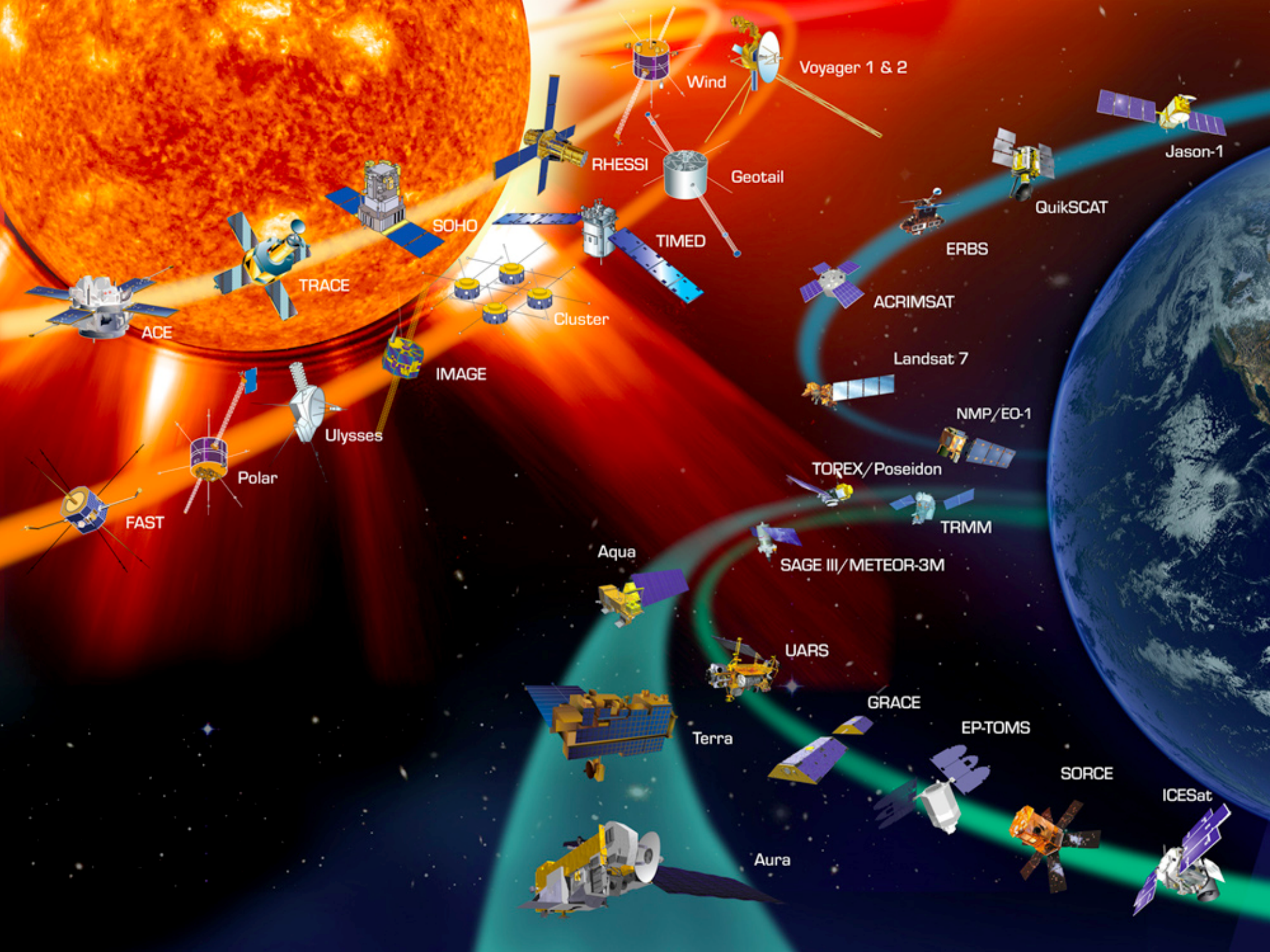
Yihua Zheng

Marlo Maddox

Tyler Schiewe

Paul O'Brien (2009)

Yi-Jiun Su (2014)


Wind
Voyager 1 & 2
RHESSI
Geotail
Jason-1
QuikSCAT
SOHO
TIMED
ERBS
TRACE
ACRIMSAT
ACE
Cluster
IMAGE
Landsat 7
NMP/EO-1
Ulysses
TOREX/Poseidon
Polar
TRMM
FAST
SAGE III/METEOR-3M
Aqua
UARS
GRACE
Terra
EP-TOMS
SORCE
ICESat
Aura