ASGARD 2019 – Space Radiation

Earth and its neighbouring space

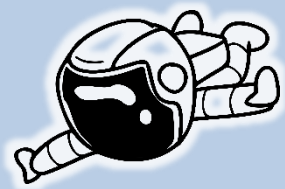
Mesosphere

80 km

Shooting stars

Stratosphere

50 km

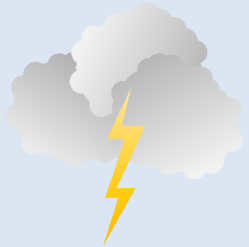


Alan Eustace, 2014 (41.425 km)

Meteorological balloon (37 km)

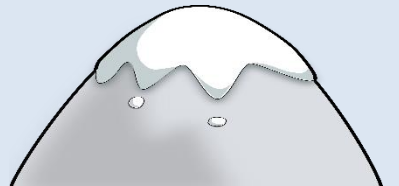
Troposphere

9-18 km



Passenger's airplane (11 km)

Mount Everest (8.848 km)



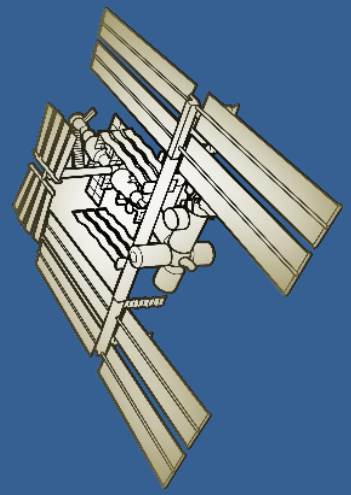
Exosphere

10000 km

Thermosphere

800 km

ISS (406 km)



Aurora

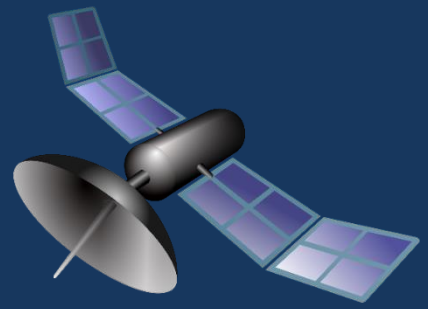
Mesosphere

80 km

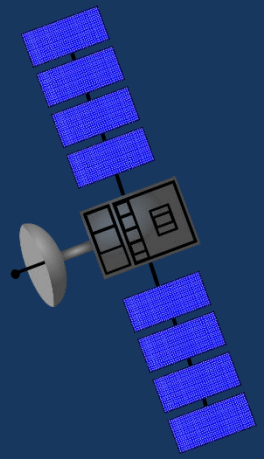
Space

Moon
(362600 km)

Geosynchronous
satellites (35786 km)



GPS satellites (20200 km)



Exosphere

10000 km

The Sun

Some characteristics of the Sun...

Age ≈ 4.6 billion years

Diameter: 1.393 million km

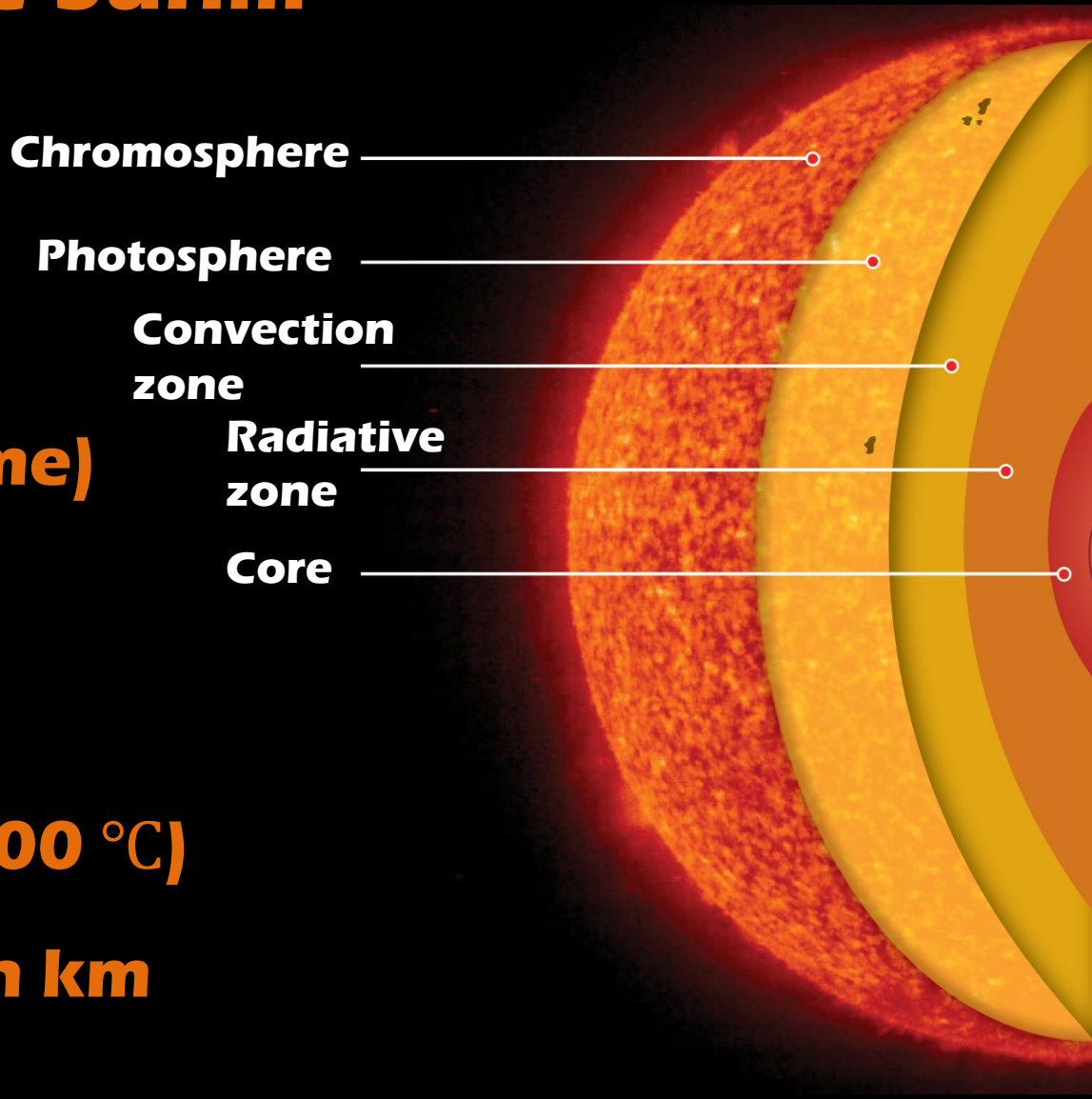
Volume: 1300000 × (Earth's volume)

Mass: 333000 × (Earth's mass)

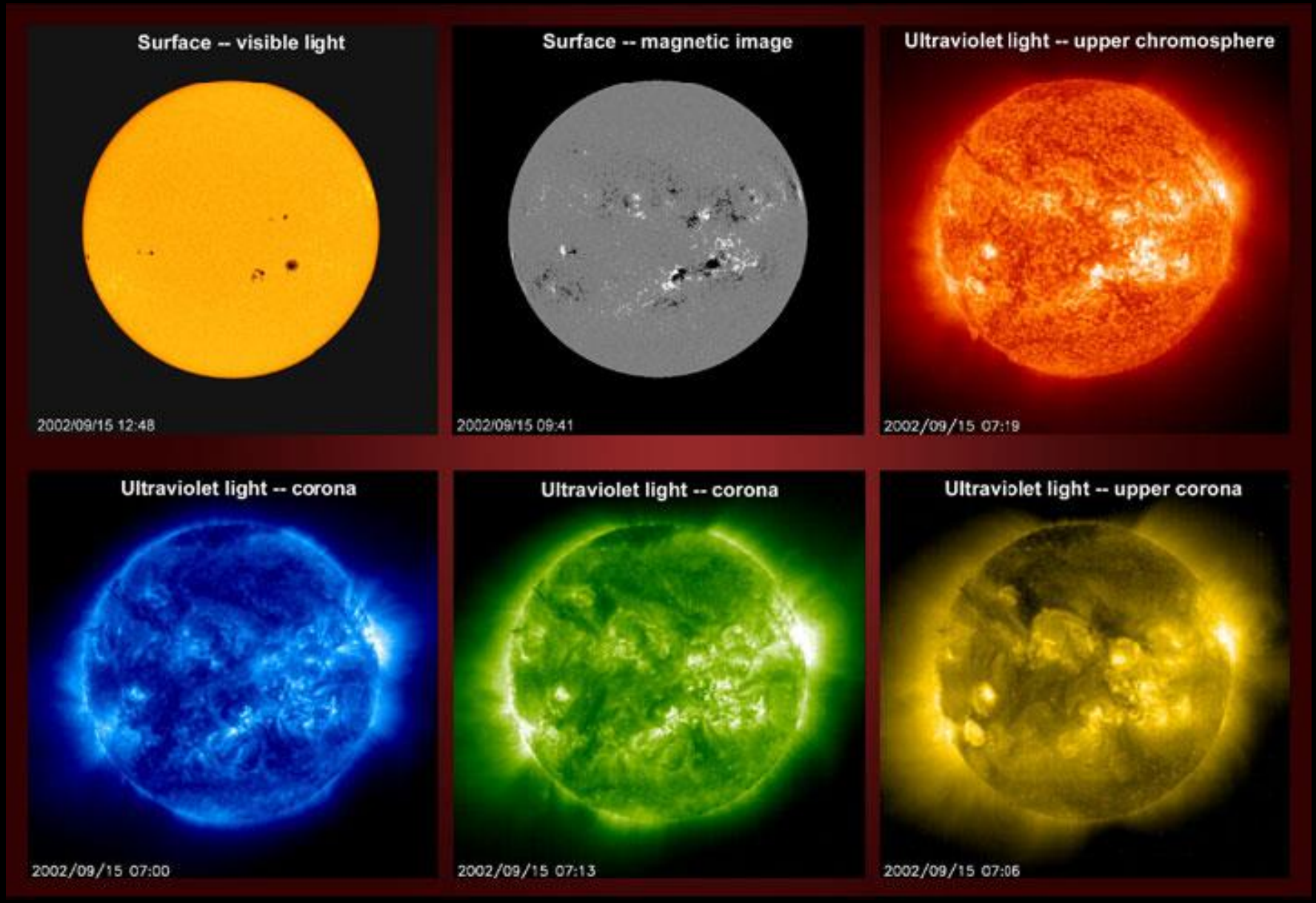
(1.989×10^{30} kg)

Surface temperature: 5780 K (≈ 5500 ℃)

Distance from Earth: 149.6 million km

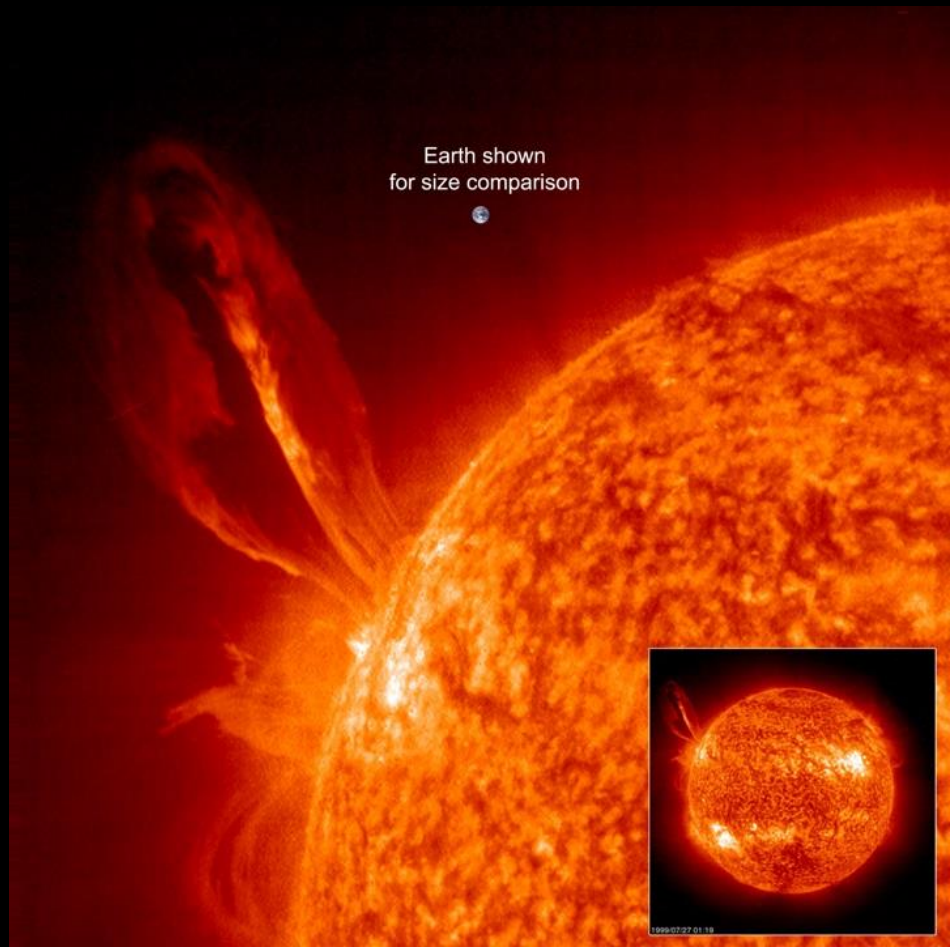


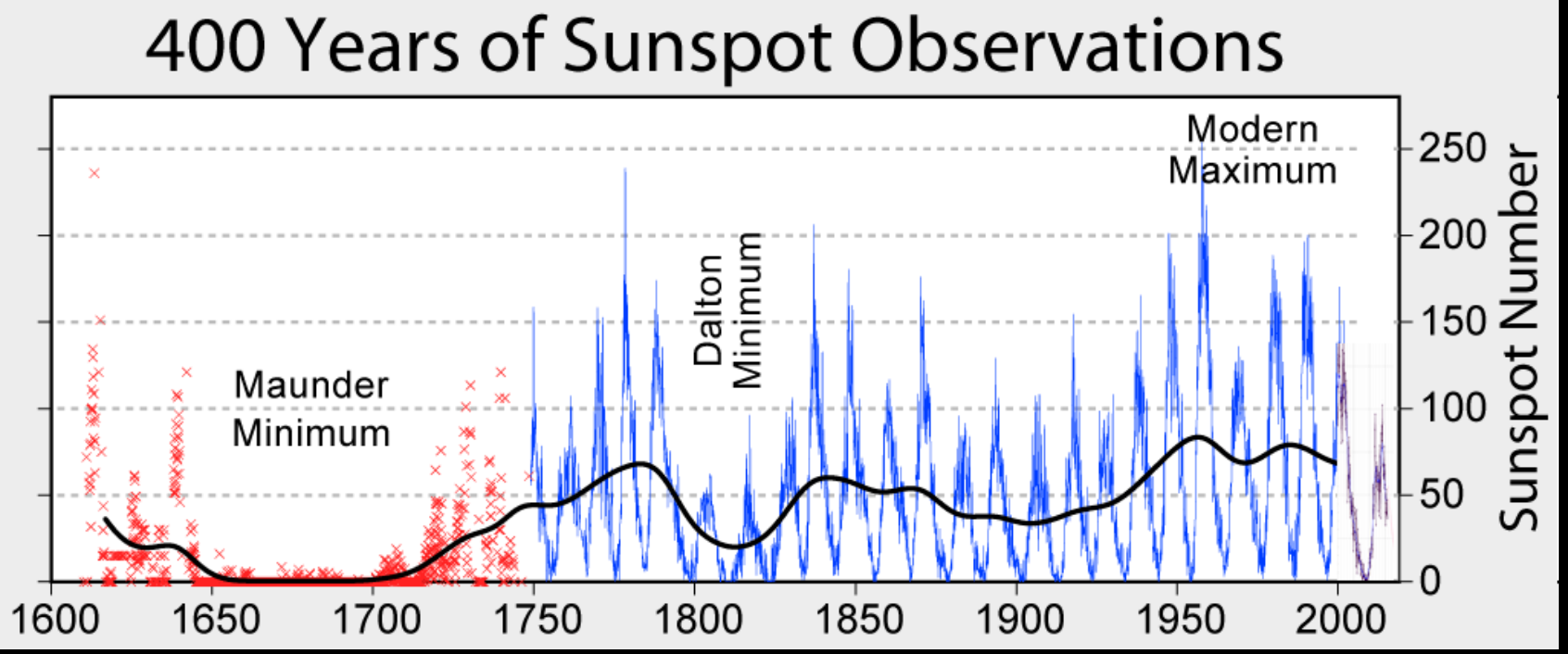
The many faces of the Sun!



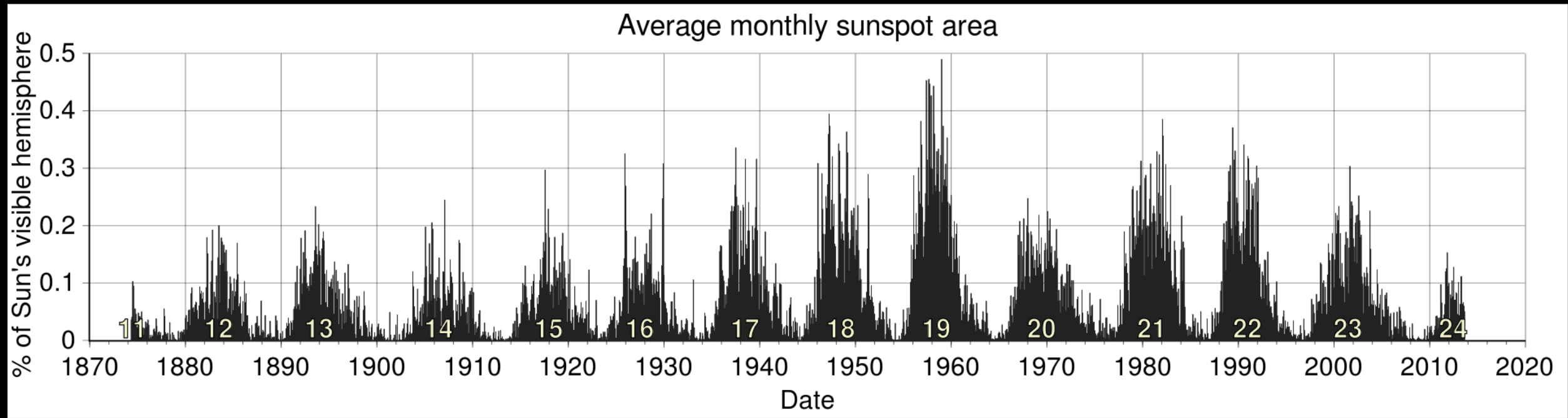
The Sun is an active star…

- **Solar wind: Constant stream of charged particles escaping the Sun's atmosphere (corona)**
- **Flares: Sudden flash of increased brightness on the Sun**
- **Corona mass ejections (CMEs): Release of large amount of matter & EM radiation into space above the Sun's surface**

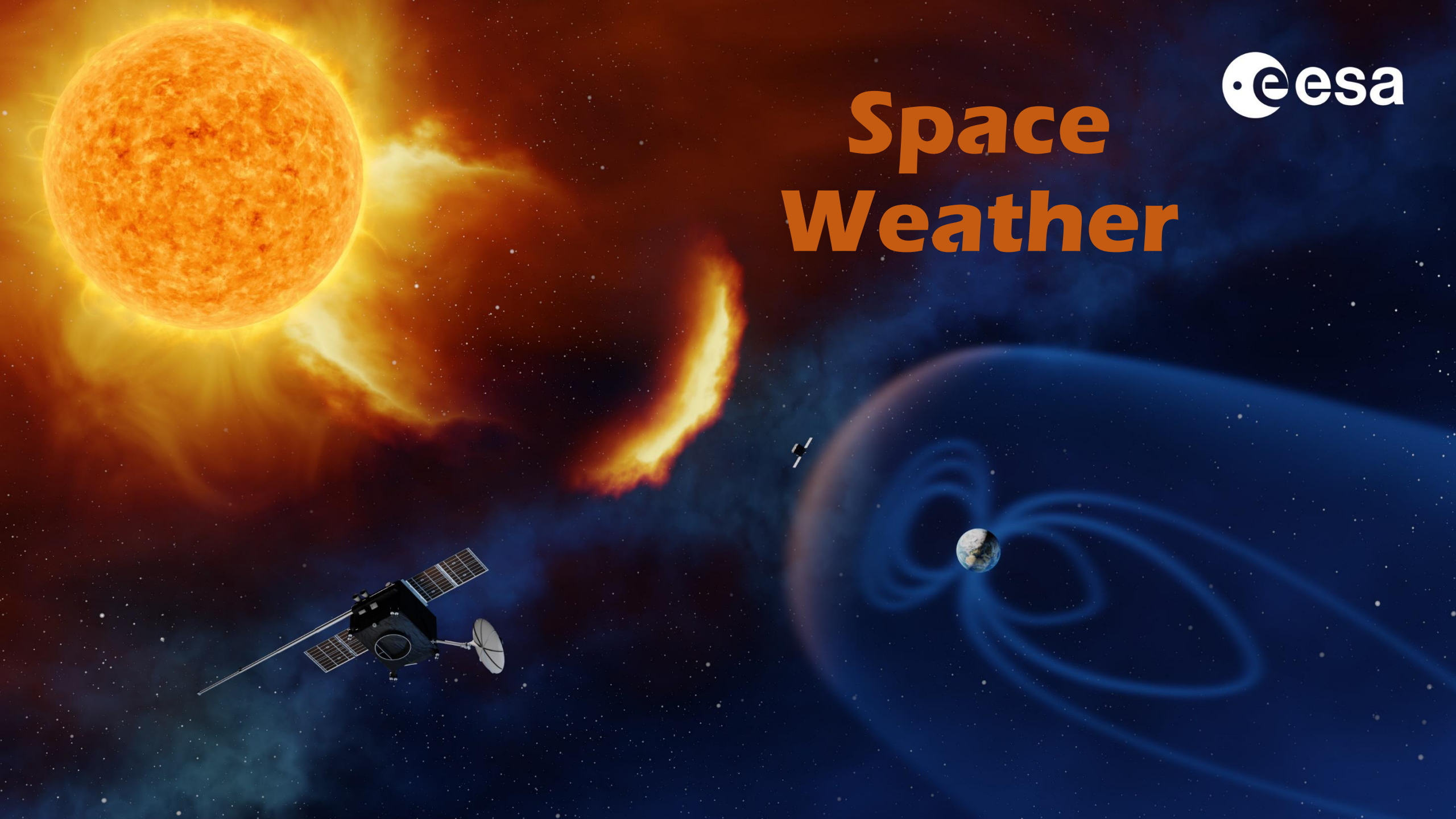




Solar cycles have an average duration of about 11 years!

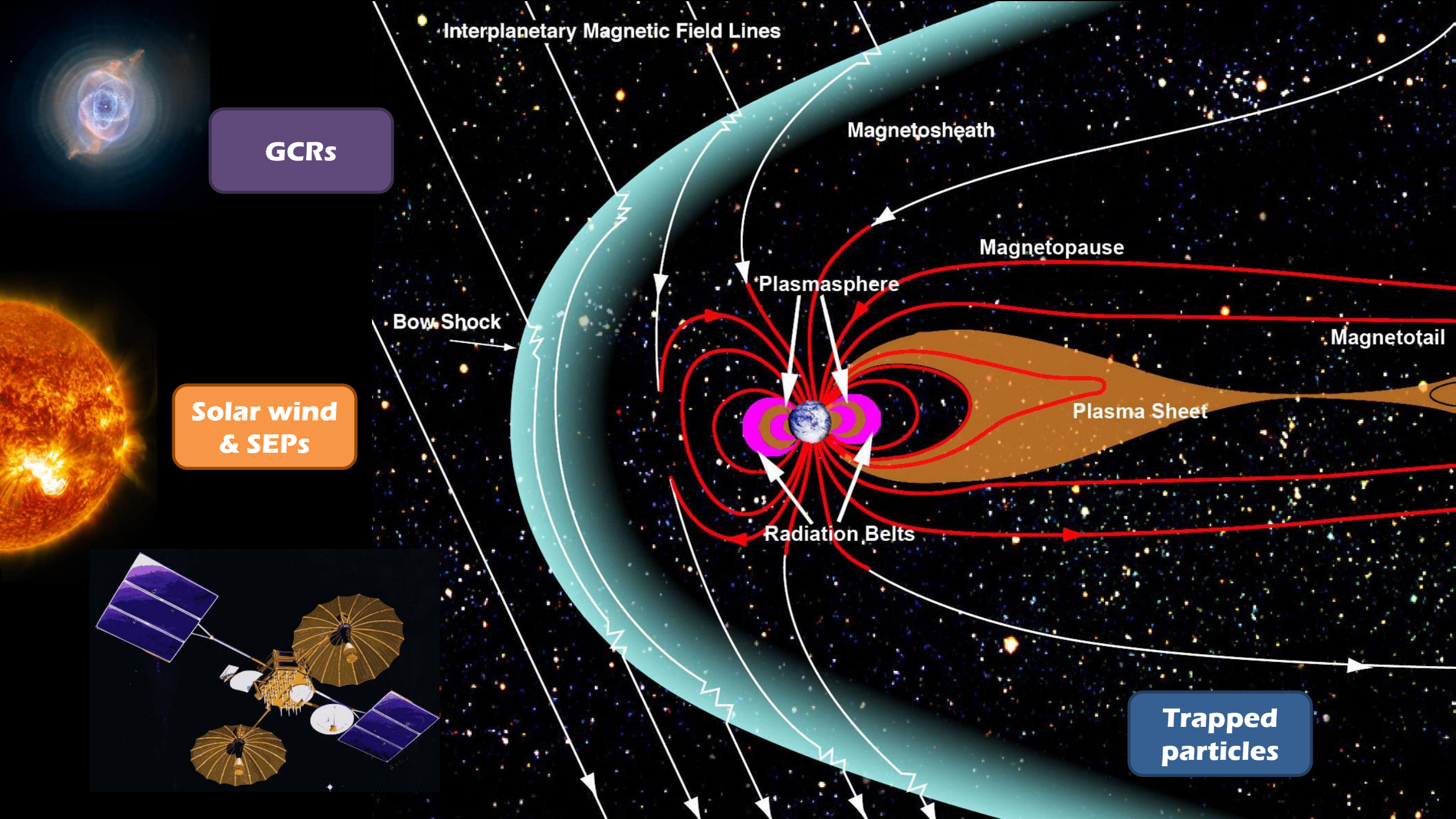


Space Weather

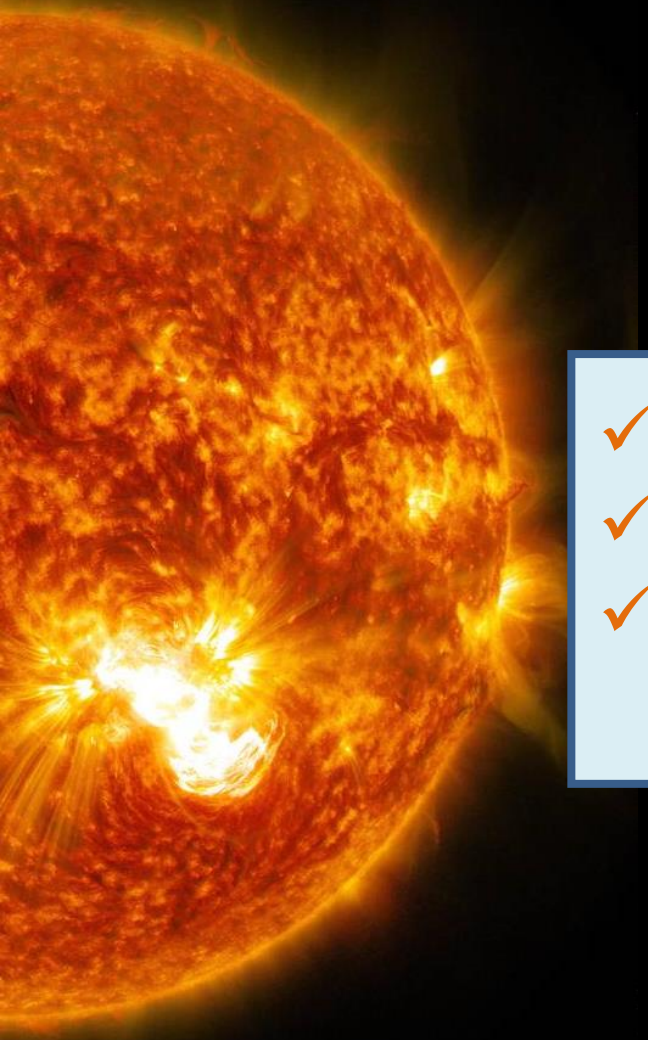


SPACE WEATHER

“Ever changing conditions in space driven by physical processes taking place in the Sun and also influenced by energetic particles arriving from outside our solar system (cosmic radiation)”.


Interplanetary Magnetic Field Lines
Magnetosheath
Magnetopause
Plasmasphere
Bow Shock
Magnetotail
Plasma Sheet
Radiation Belts
GCRs
Solar wind & SEPs
Trapped particles

Solar activity and space weather on Earth

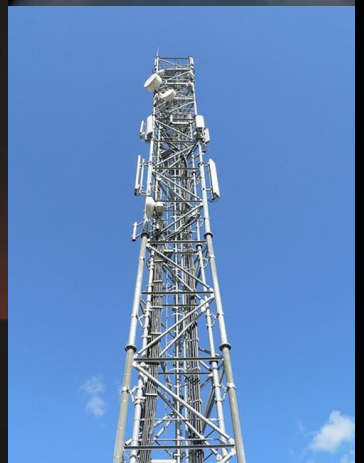


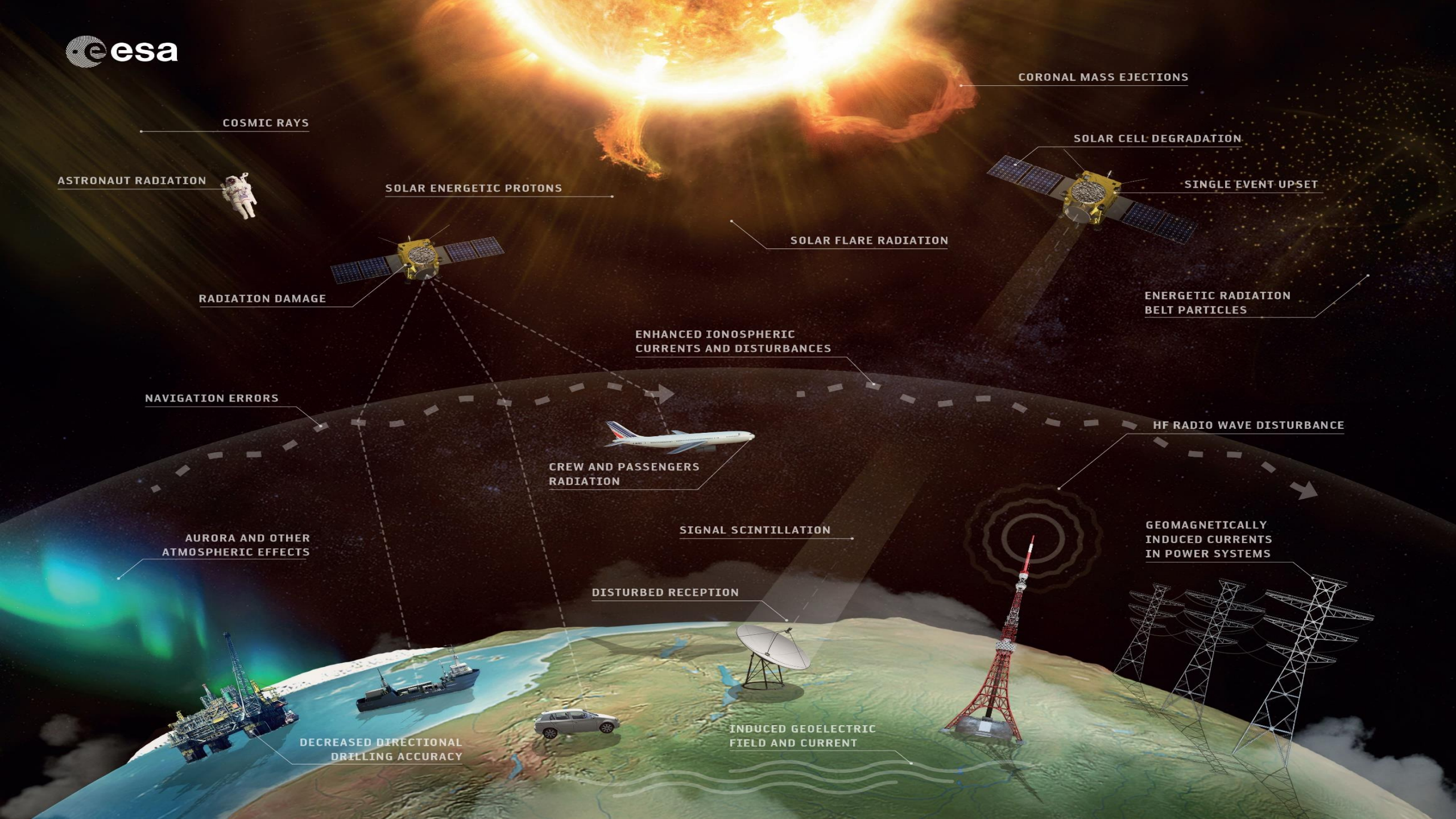
- ✓ **Solar wind:** 13 hrs. to up to 4 days
- ✓ **X rays, EUV, radio waves:** 8 minutes
- ✓ **High energy particles:** 20 minutes to up to few hours





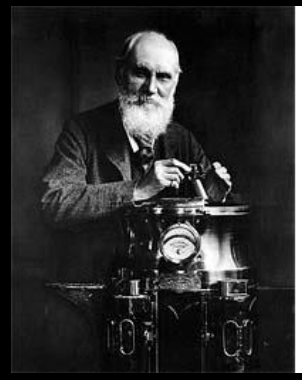

Space weather and its impact on our lives

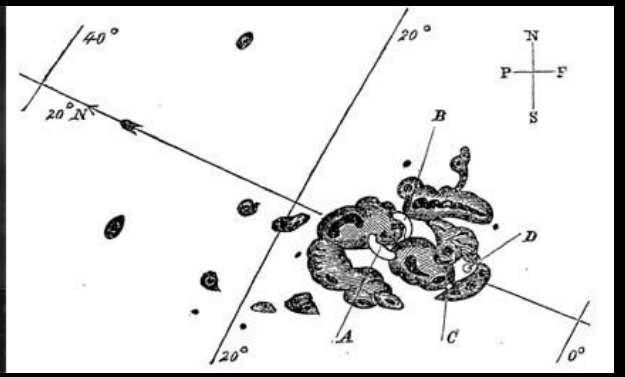




esa
CORONAL MASS EJECTIONS
COSMIC RAYS
SOLAR CELL DEGRADATION
ASTRONAUT RADIATION
SINGLE EVENT UPSET
SOLAR ENERGETIC PROTONS
SOLAR FLARE RADIATION
RADIATION DAMAGE
ENERGETIC RADIATION BELT PARTICLES
ENHANCED IONOSPHERIC CURRENTS AND DISTURBANCES
NAVIGATION ERRORS
HF RADIO WAVE DISTURBANCE
CREW AND PASSENGERS RADIATION
SIGNAL SCINTILLATION
GEOMAGNETICALLY INDUCED CURRENTS IN POWER SYSTEMS
AURORA AND OTHER ATMOSPHERIC EFFECTS
DISTURBED RECEPTION
DECREASED DIRECTIONAL DRILLING ACCURACY
INDUCED GEOELECTRIC FIELD AND CURRENT

Some historical examples…

- 1859 Carrington event



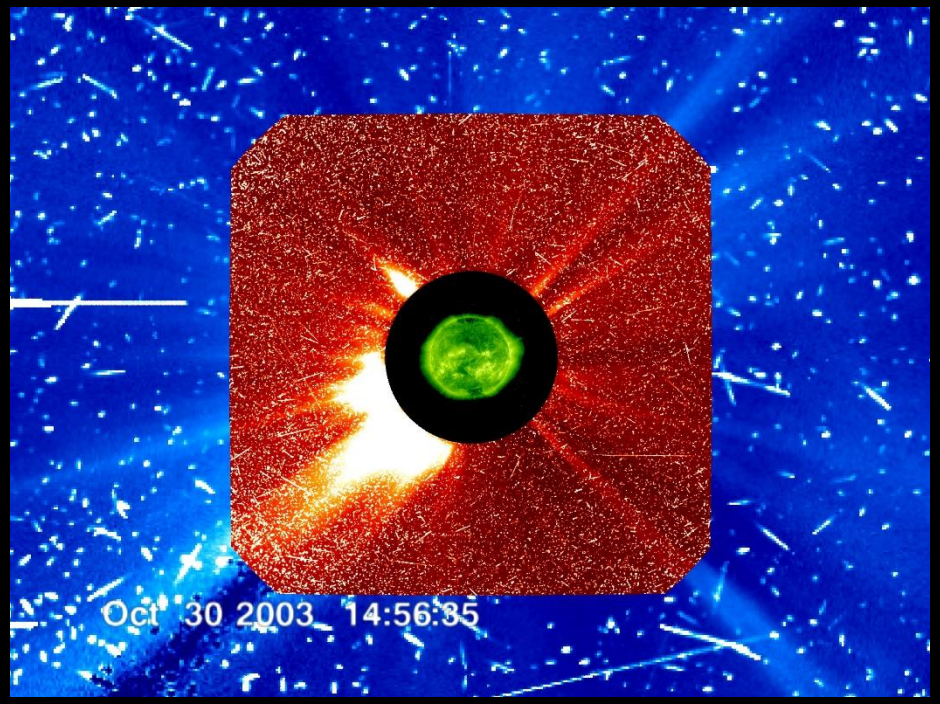


- 1967 Close to nuclear war between US and USSR

- 1979: NASA's Skylab (430 km) launched in 1973

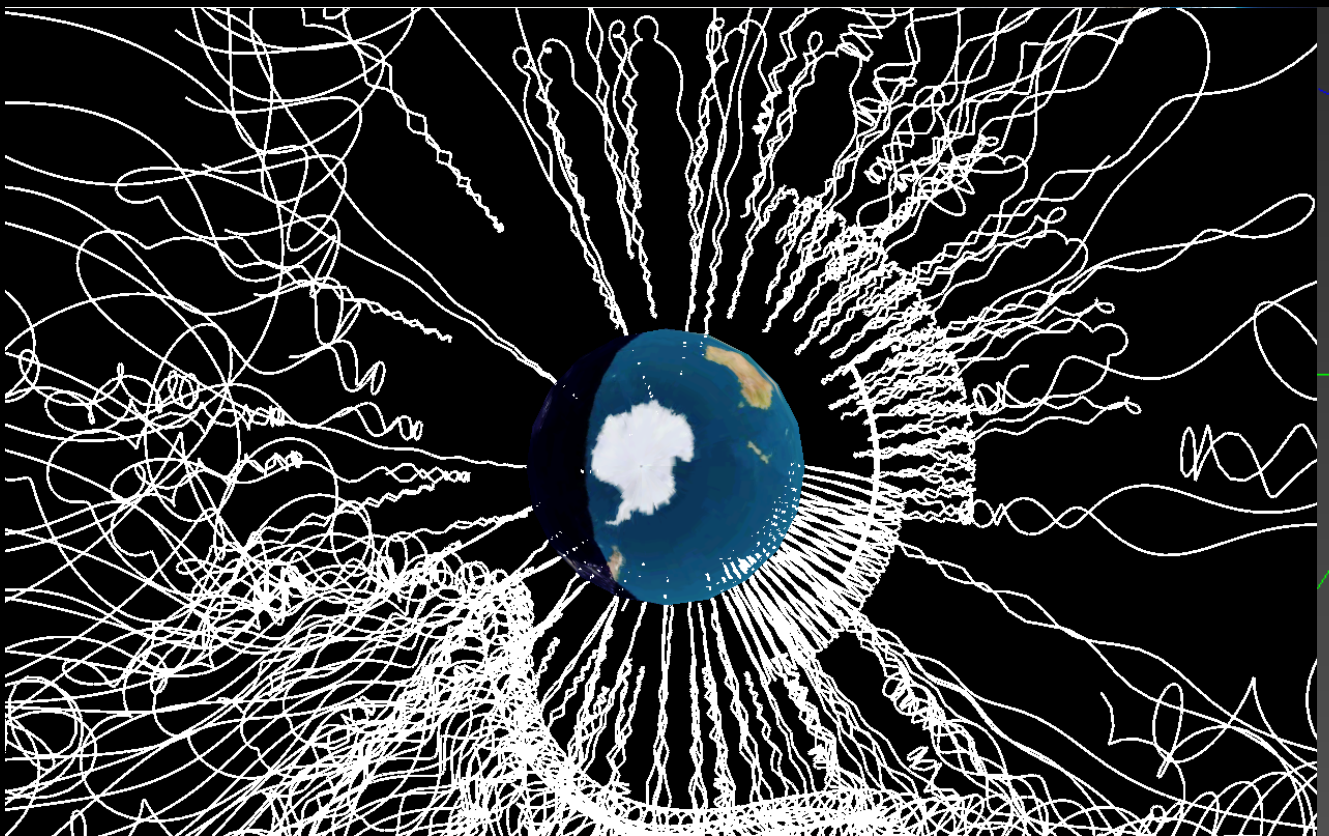
Some historical examples…

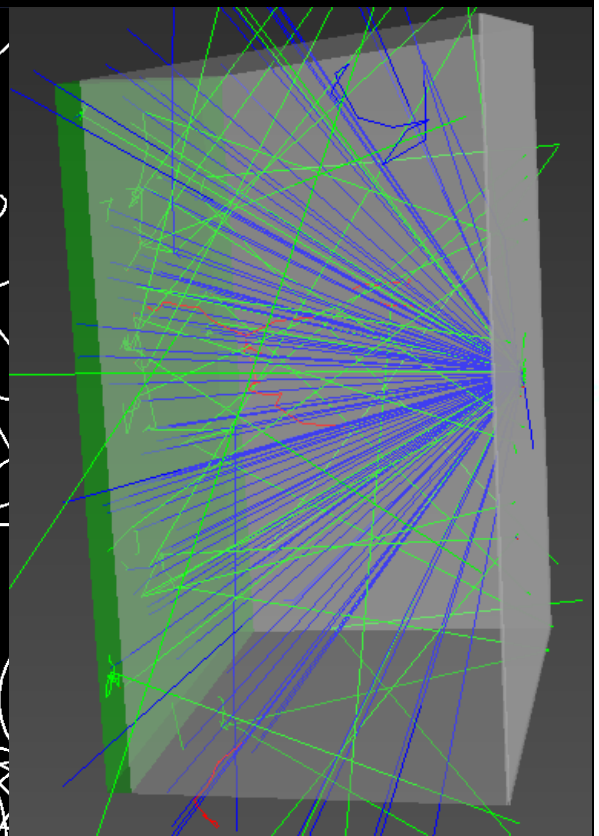
- **13 March 1989: Black outs in Quebec and North America**

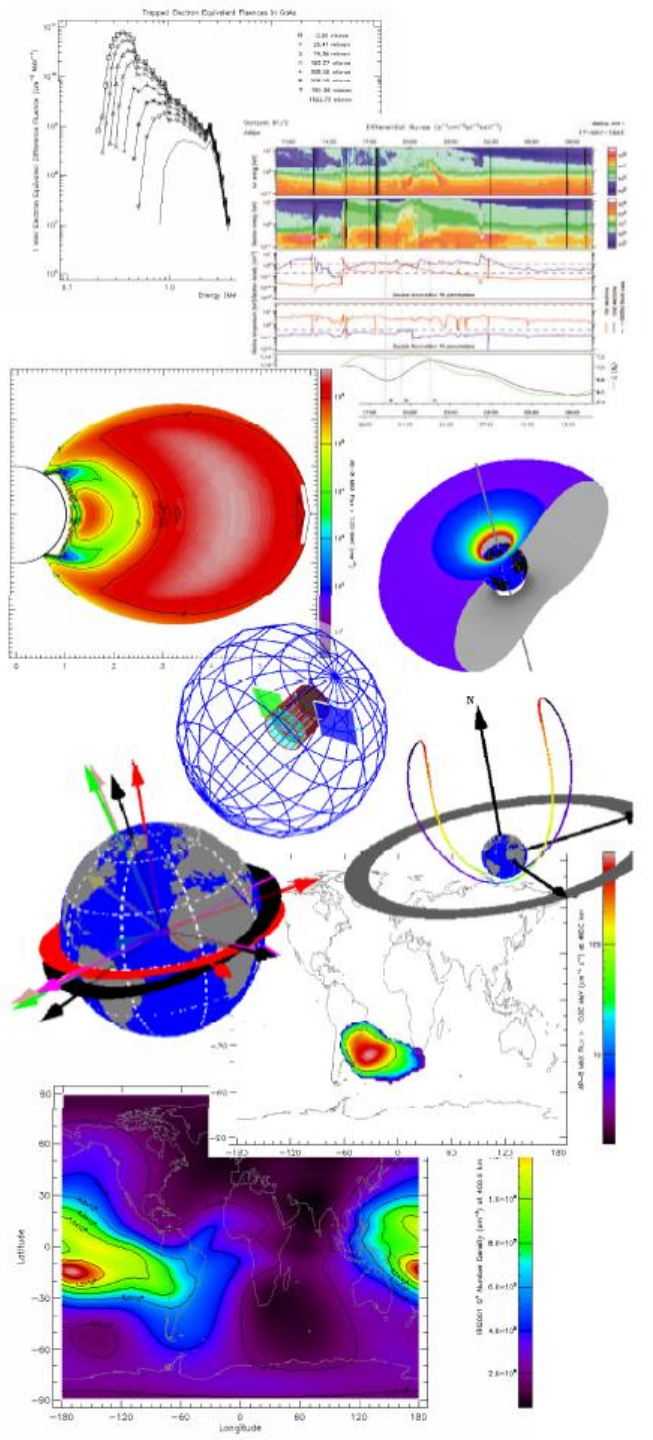


- **29 Oct. 2003: Halloween storms – communication disruptions and damaging satellites**

The SPace ENVironment Information System (SPENVIS)





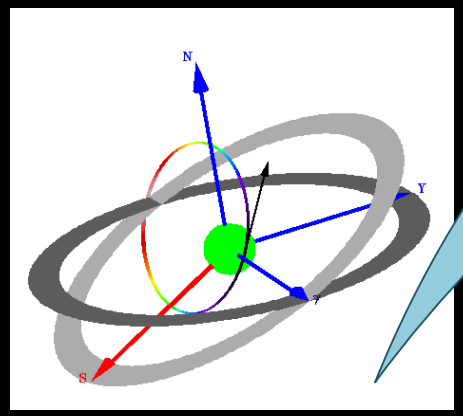


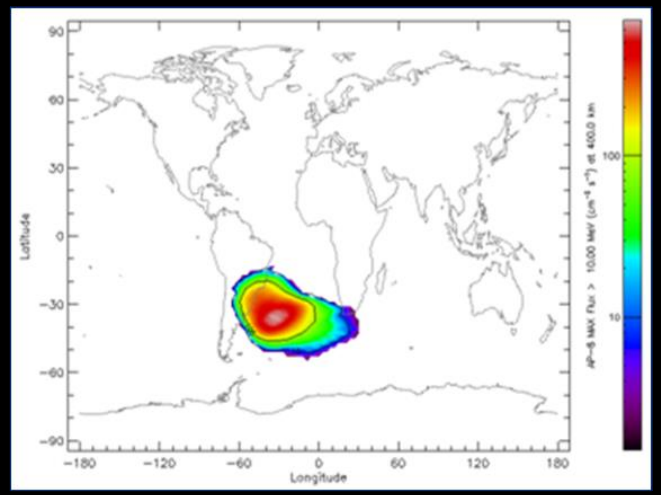
Radiation analysis with SPENVIS…

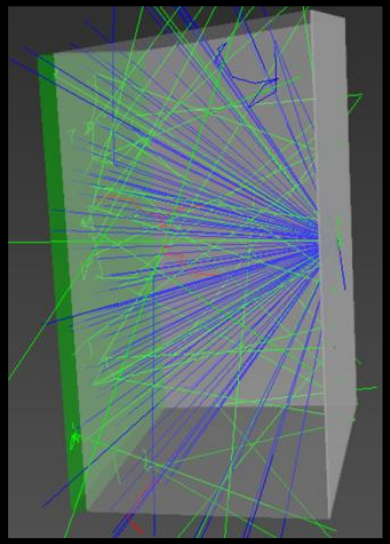
Mission

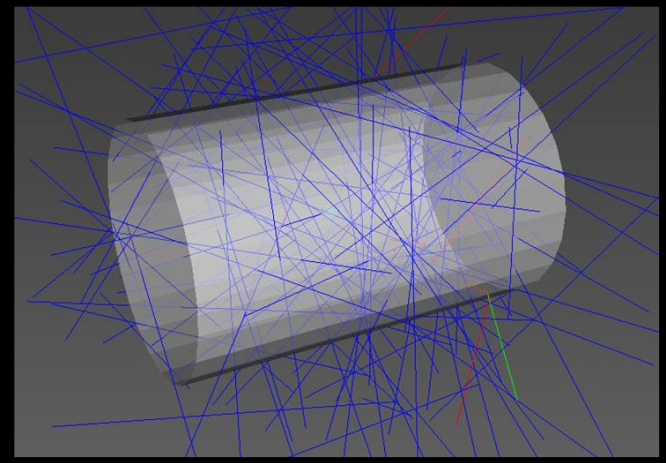
Environment

Effects

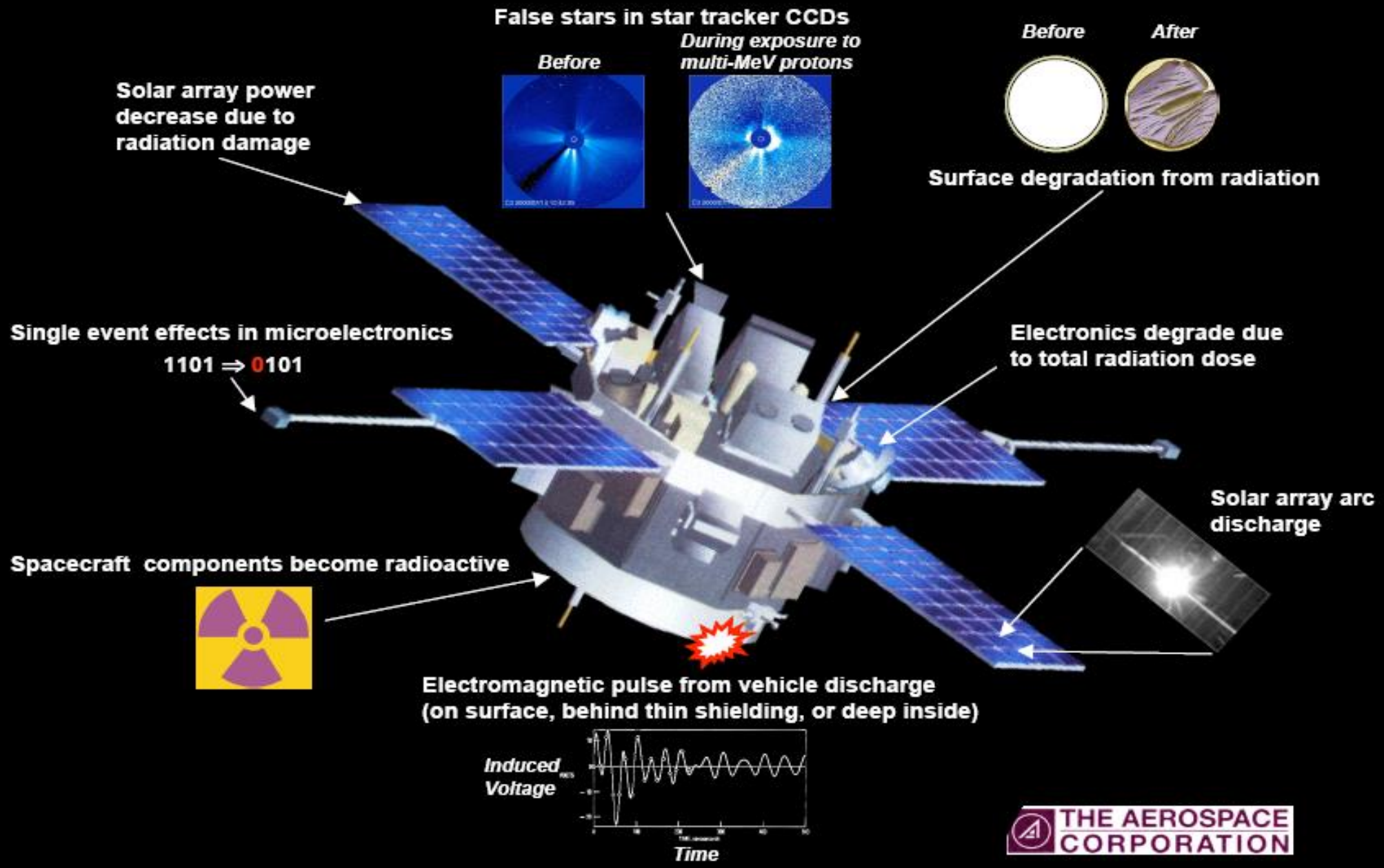








Major Space Environment Hazards



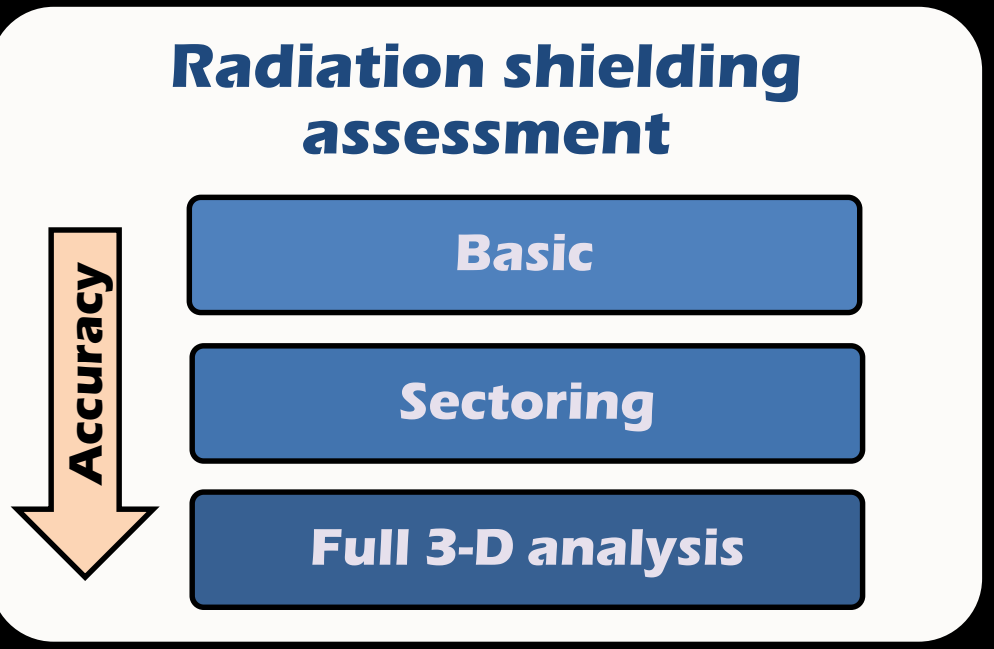
THE AEROSPACE CORPORATION

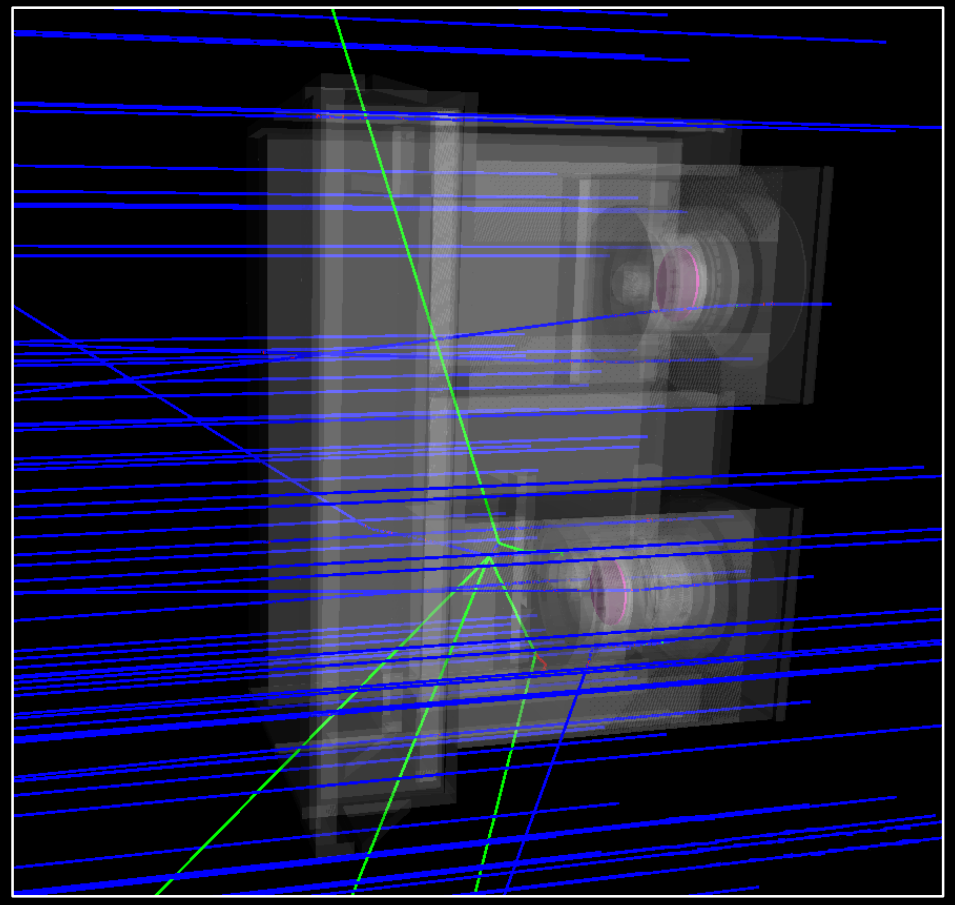
Performing radiation analysis

Requires accurate knowledge of

a. external space environment

b. shielding effect of material





Next you will use SPENVIS to …

- Define your mission & orbit (e.g. Sun-synchronous, Medium Earth or Geosynchronous orbit)
  - Characterise the space environment (e.g. trapped & solar particles)
    - Radiation dose to component near the surface of a spacecraft