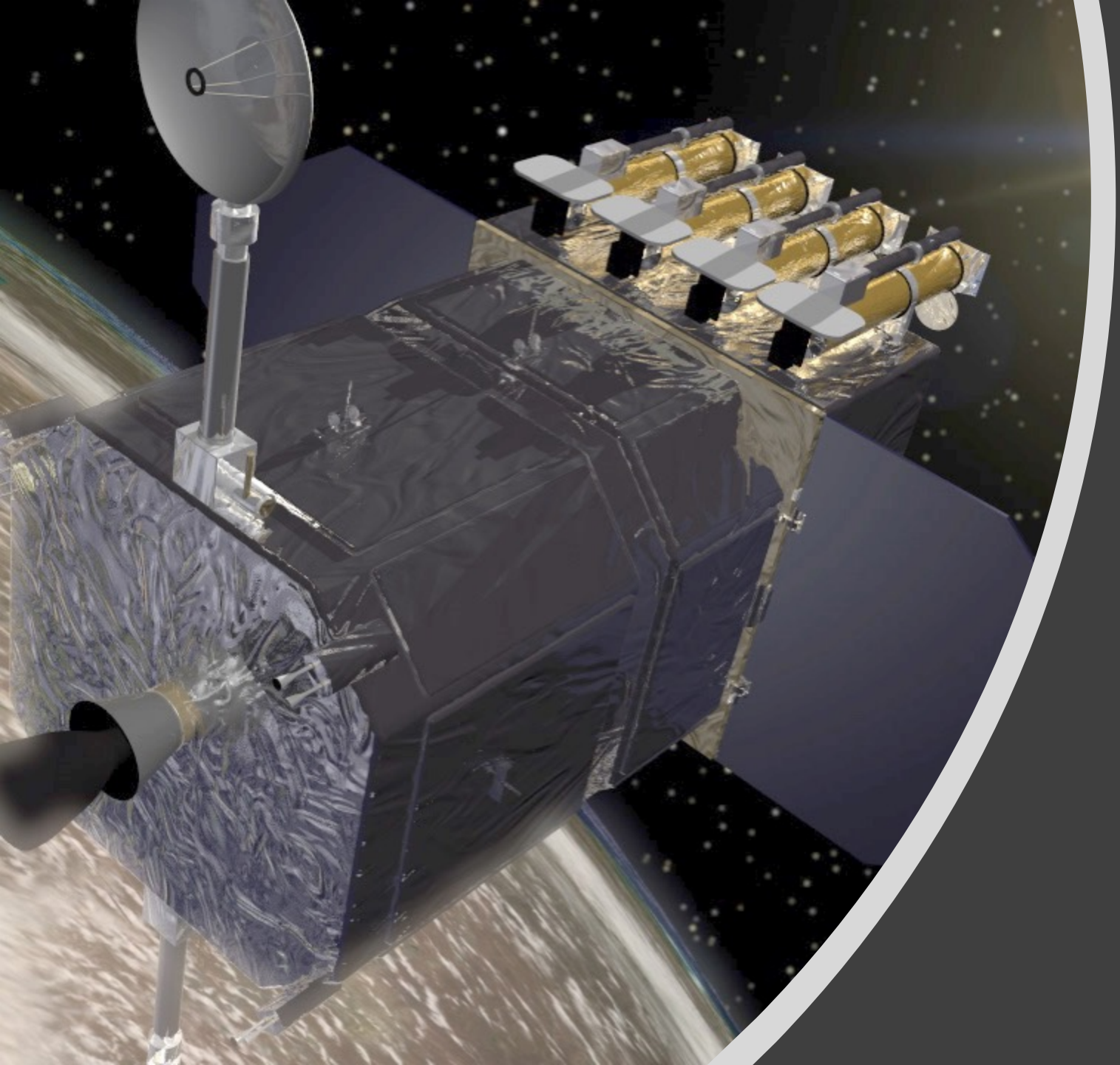


Space-Faring Nations and Space Weather Monitoring

Michael Brini

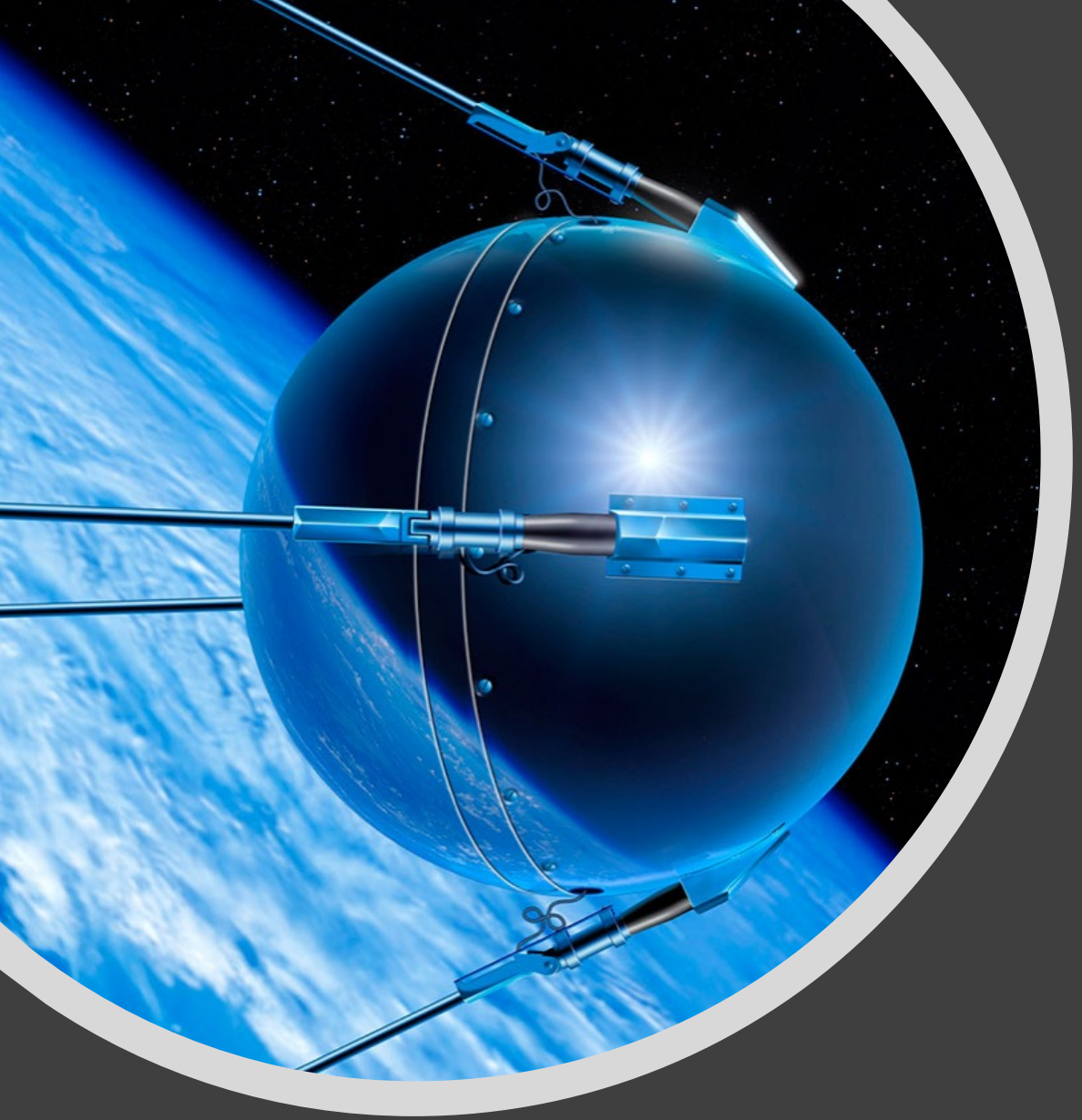


Figure 1. Sputnik 1

SPACE-FARING NATIONS

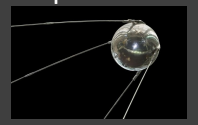
The Space Race

- A competition between the Soviet Union and United States to achieve superior capabilities and accomplishments in spaceflight
- Made possible by launch vehicles derived from intercontinental ballistic missiles (ICBMs)
- Sputnik 1, first artificial satellite, launched in 1957 by the Soviet Union
- United States feared falling behind with a widening technological gap

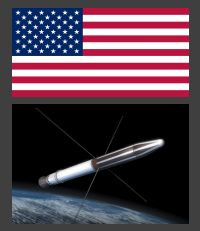
SPACE-FARING NATIONS

Timeline – First Launches

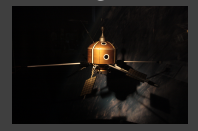
1957 – Sputnik 1



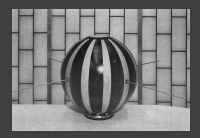
1958 – Explorer 1



1962 – Ariel 1



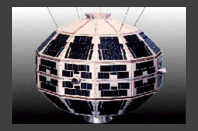
1964 – San Marco 1



1965 – Astérix 1

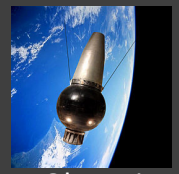
1967 – WRESAT

1969 – Alouette 1



1970 – Azur

Ohsumi



Dongfanghong I

- First individual launches
- ESRO 2B designed by a consortium of 10 European countries
- Canada first non-superpower to develop and manufacturer satellite (Ariel 1 manufactured by NASA)

SPACE-FARING NATIONS

Missions

- Space-faring nations posses launch capabilities
  - Manned missions
  - Unmanned missions
- Manned Missions: 
- Unmanned Missions: 
- USA has 1300 satellites in orbit. Most of any nation
- First Earth-observing satellite: Television Infrared Observation Satellite 1 (TIROS 1)
  - Launched by NASA in April 1960

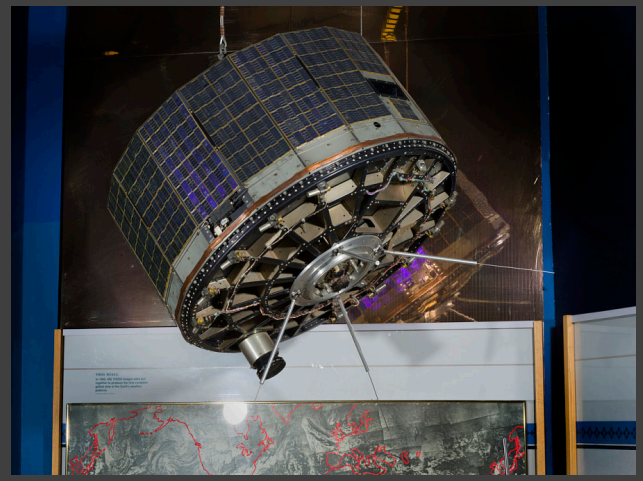


Figure 2. TIROS 1

SPACE-FARING NATIONS

Weather Satellite Platforms

- Non-standard platforms, specific to each mission
- High costs, millions of $/unit
- High launch mass, tonnes/unit

Figure 3. NOAA-18

National Oceanic and Atmospheric Administration 18

Launch Weight: 2232 kg
Cost: $141 million

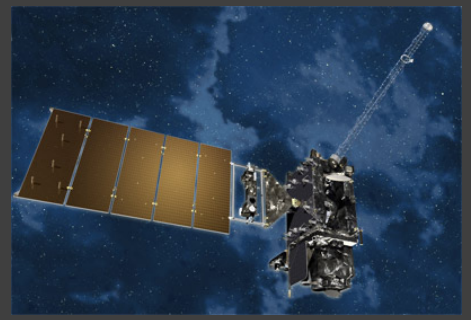


Figure 4. GOES-18

Geostationary Operational Environmental Satellite 18

Launch Weight: 5192 kg
Cost: $165.7 million

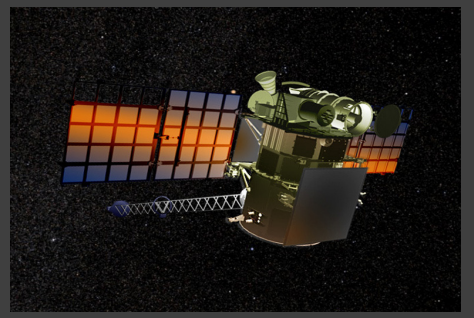


Figure 5. DSCOVR

Deep Space Climate Observatory

Launch Weight: 570 kg
Cost: $150 million

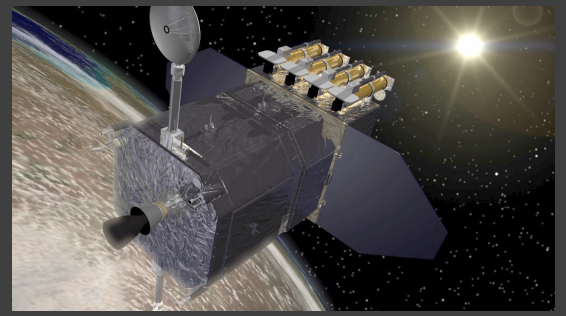
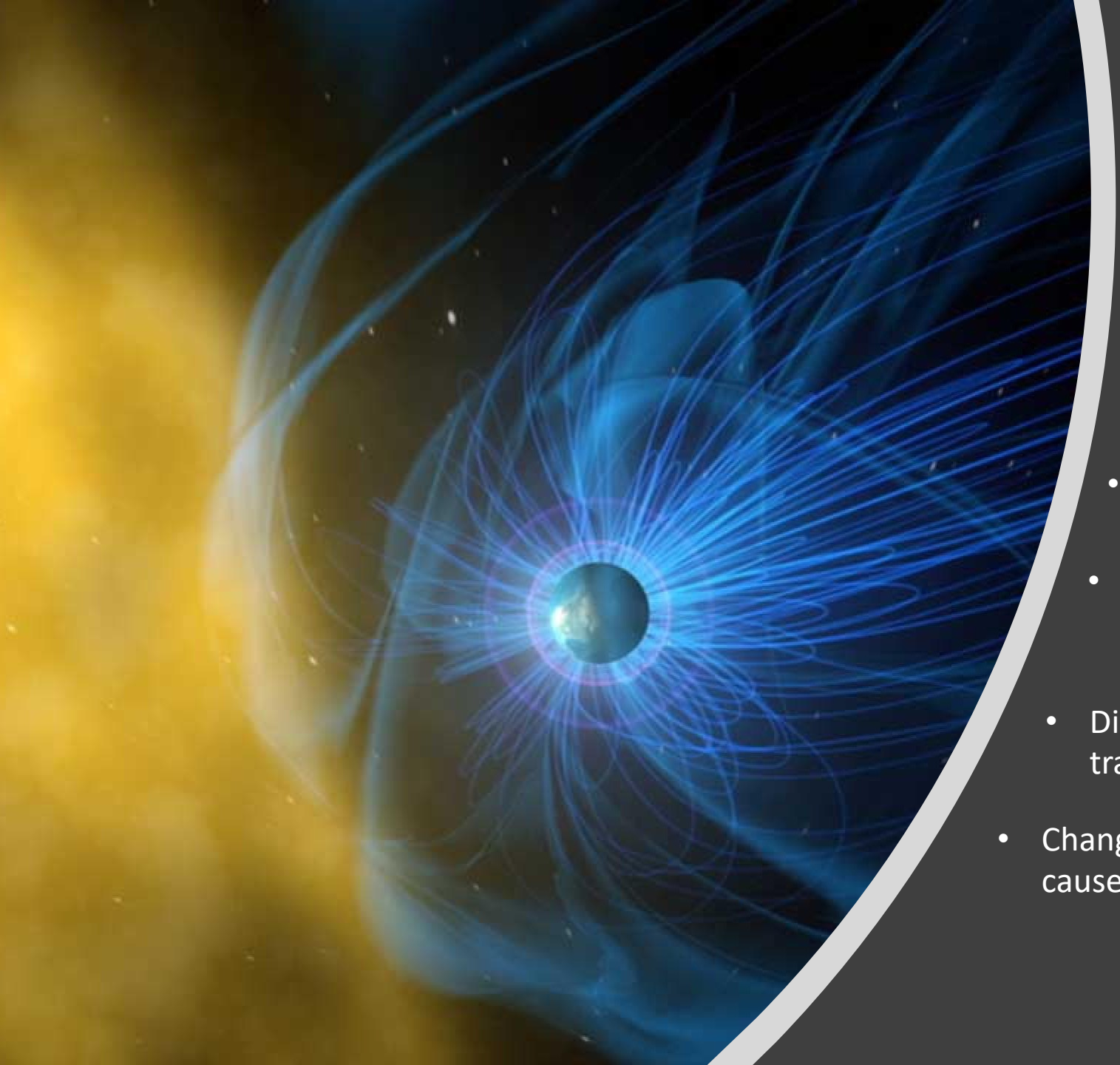


Figure 6. SDO

Solar Dynamics Observatory

Launch Weight: 3100 kg
Cost: $150 million



SPACE WEATHER MONITORING

Geomagnetic Storms

- Coronal mass ejections (CME) inject high-energy protons and electrons into the ring current
- Ring current magnetic field felt globally
- Changes to ring current magnetic field induce currents in electrical equipment
- Disruptions to power generation and transmission stations
- Changes to ionosphere critical frequency causes communications disruptions

SPACE WEATHER MONITORING

Storm Consequences

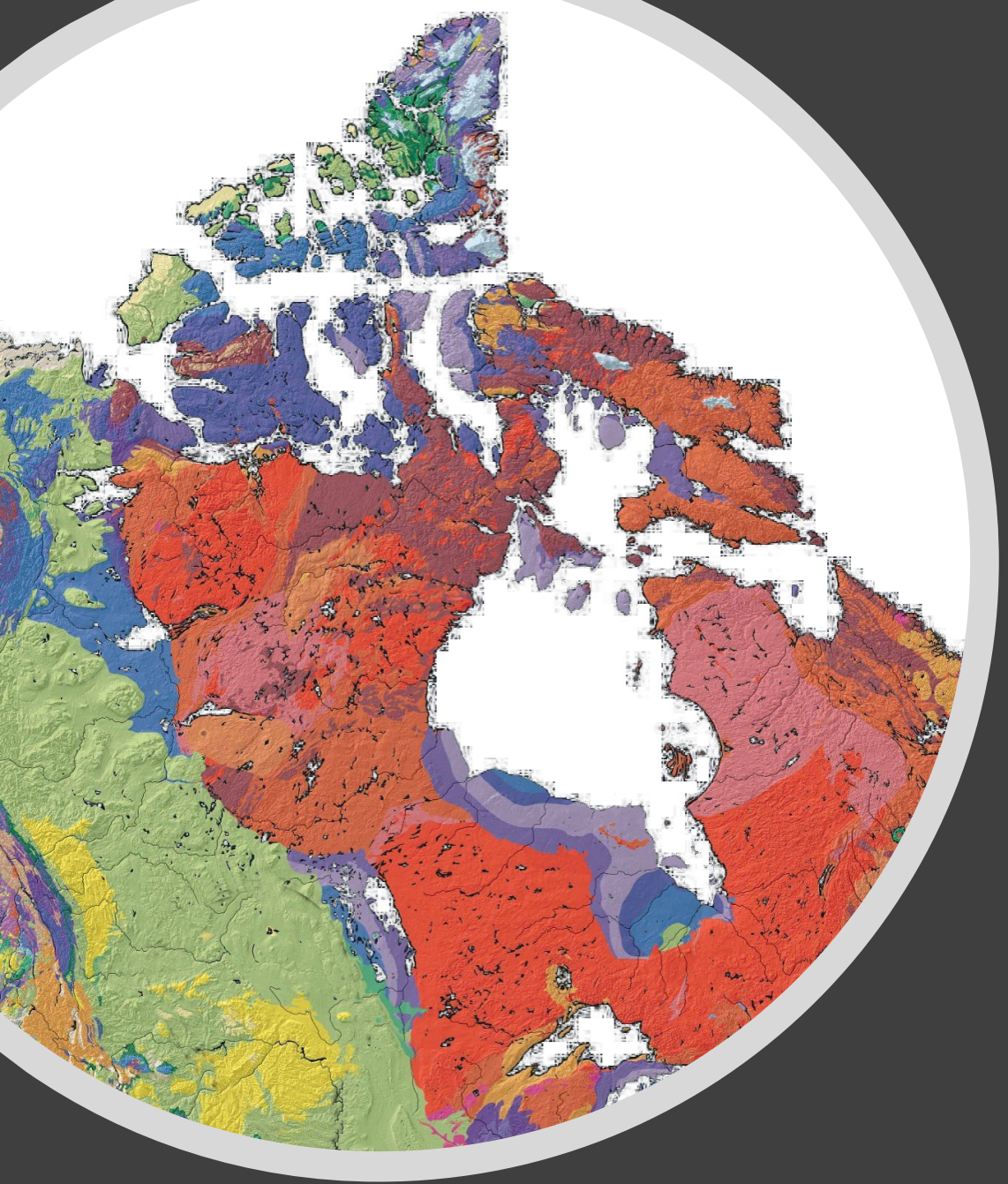
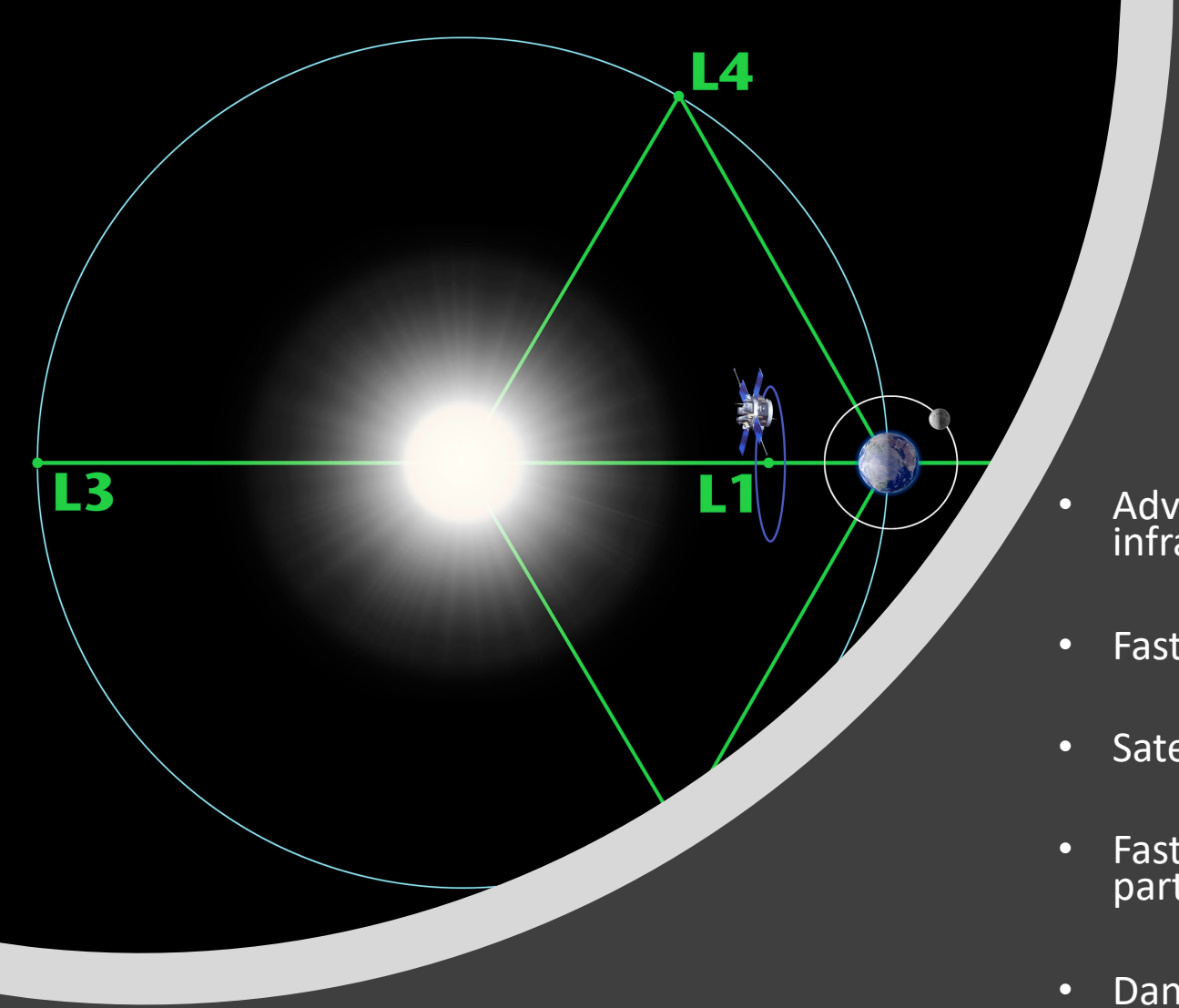


Figure 7. Canadian Shield geological formation (red)

- In 1989, Hydro Quebec experienced a blackout from a geomagnetic storm
- Ring current magnetic field induced current spikes in network
- Canadian Shield geological formation under Quebec prevents proper grounding to Earth. Safety systems triggered.
- Ionosphere changes disrupted communications an also caused power outages in Sweden
- SOHO instruments temporarily shutdown while ACE permanently lost two instruments



SPACE WEATHER MONITORING

Preparedness

- Advanced warning of CMEs allows for time to protect critical infrastructure
- Fast solar wind velocity increases current impacting space objects
- Satellite systems designed to handle nominal speed of 400 km/s
- Fast wind speed (800 km/s) generates high current of charged particles
- Danger of burnt-out systems and short circuits
- Shutdown of non-critical systems protects solar wind-induced short-circuits

SPACE WEATHER MONITORING

Space Missions

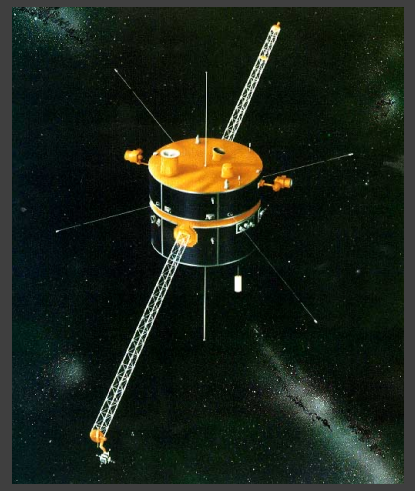


Figure 8. Wind – Launched in 1994

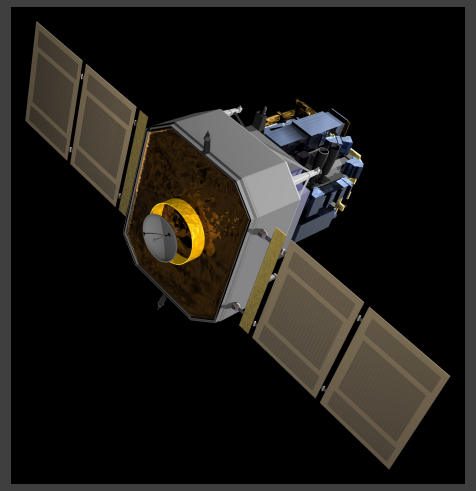


Figure 9. Solar and Heliospheric Observatory – Launched in 1995

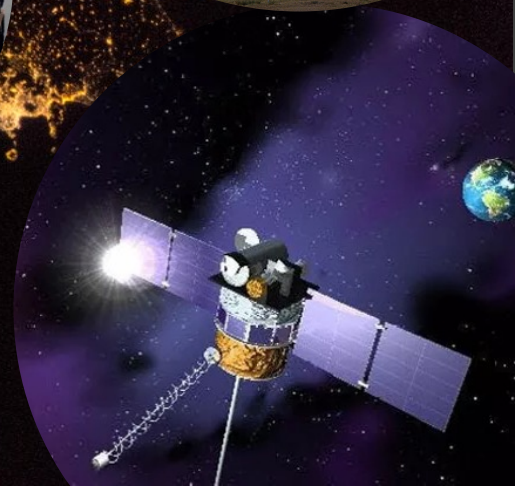
Figure 10. Advanced Composition Index – Launched in 1997

Figure 11. Deep Space Climate Observatory – Launched in 2015

- 4 current missions
  - Wind
  - ACE
  - SOHO
  - DSCOVR
- L1 Orbit between Earth and the Sun
- Near real-time solar wind information
- 1 hour warning

SUMMARY

- Development of ICBMs paved the way for launch vehicles with enough thrust to launch payloads into orbit.
- Space-faring nations posses launch capabilities, sending manned and un-manned missions into space
- Launch capabilities are expensive
- Most satellite belong to the United States including Earth and sun-facing weather missions
- Geomagnetic storms haver global effects: power blackouts and damaged satellites in the path of the coronal mass ejection
- Advanced warning from sun-observing satellites in L1 orbit provide warning to shutdown most vulnerable systems.



THANK YOU

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