UK SPACE AGENCY

Space Weather Effects

Prof Richard Crowther

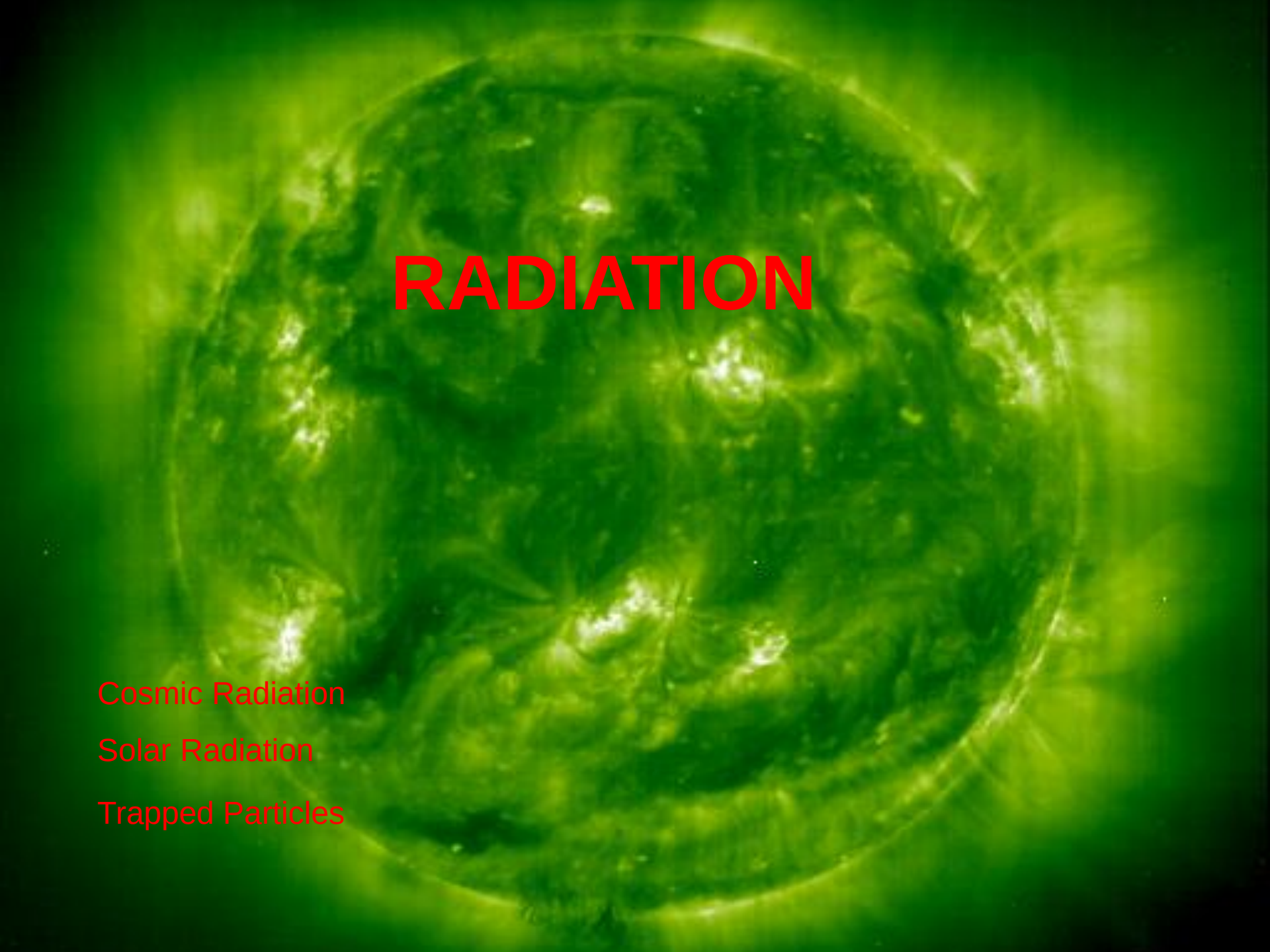
ISPL Space Policy and Law Workshop 2018

Outline

- Background
- Aviation
- Power
- Ground Transport
- Communications
- Pipelines
- Oil and Mineral Industries
- Finance

Background (Environment)

- Magnetic Storms
- Solar Radiation Storms
- Solar Radio Bursts
- Galactic Cosmic Rays
- High Speed Solar Wind
- Solar Flares

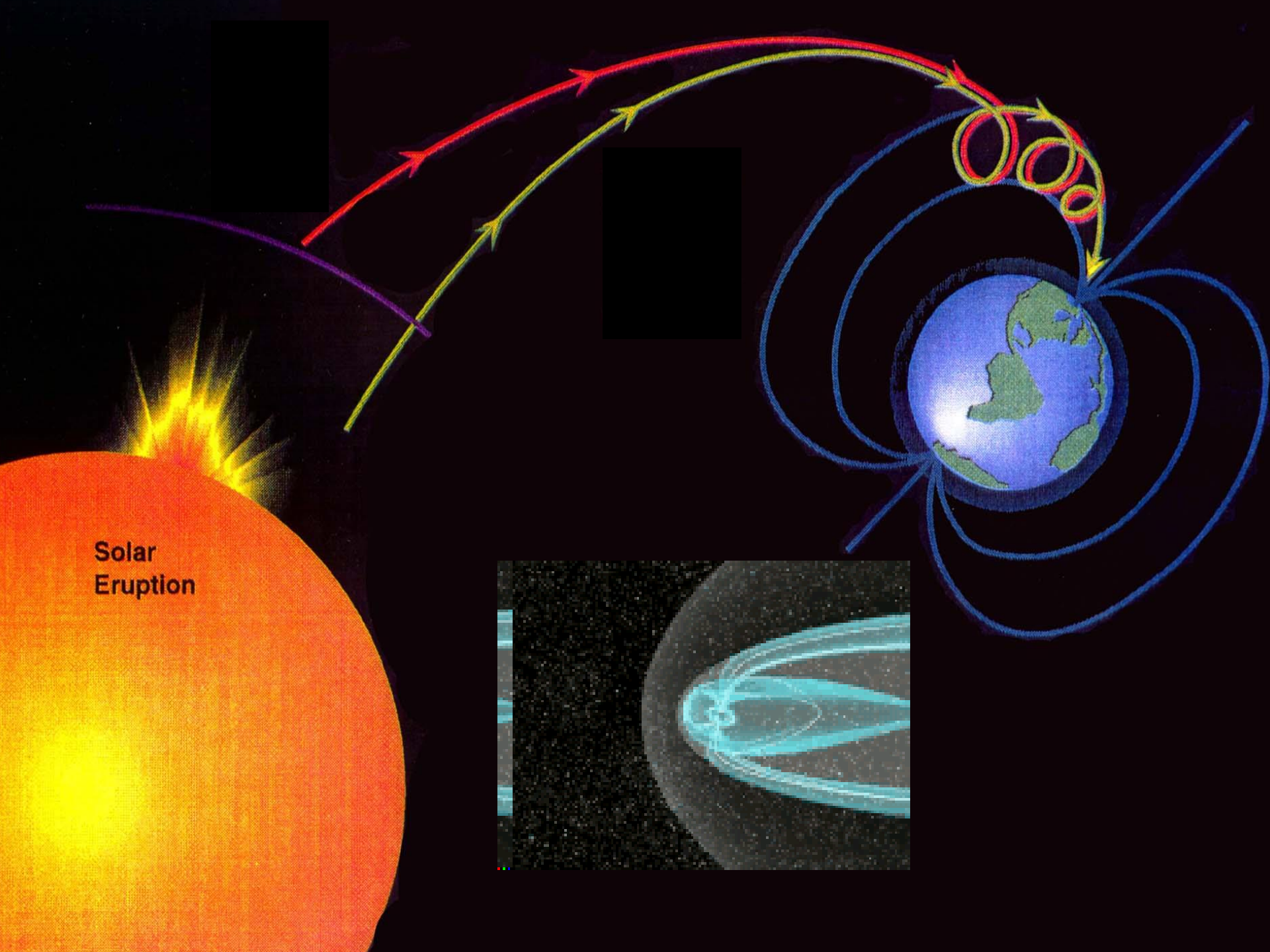


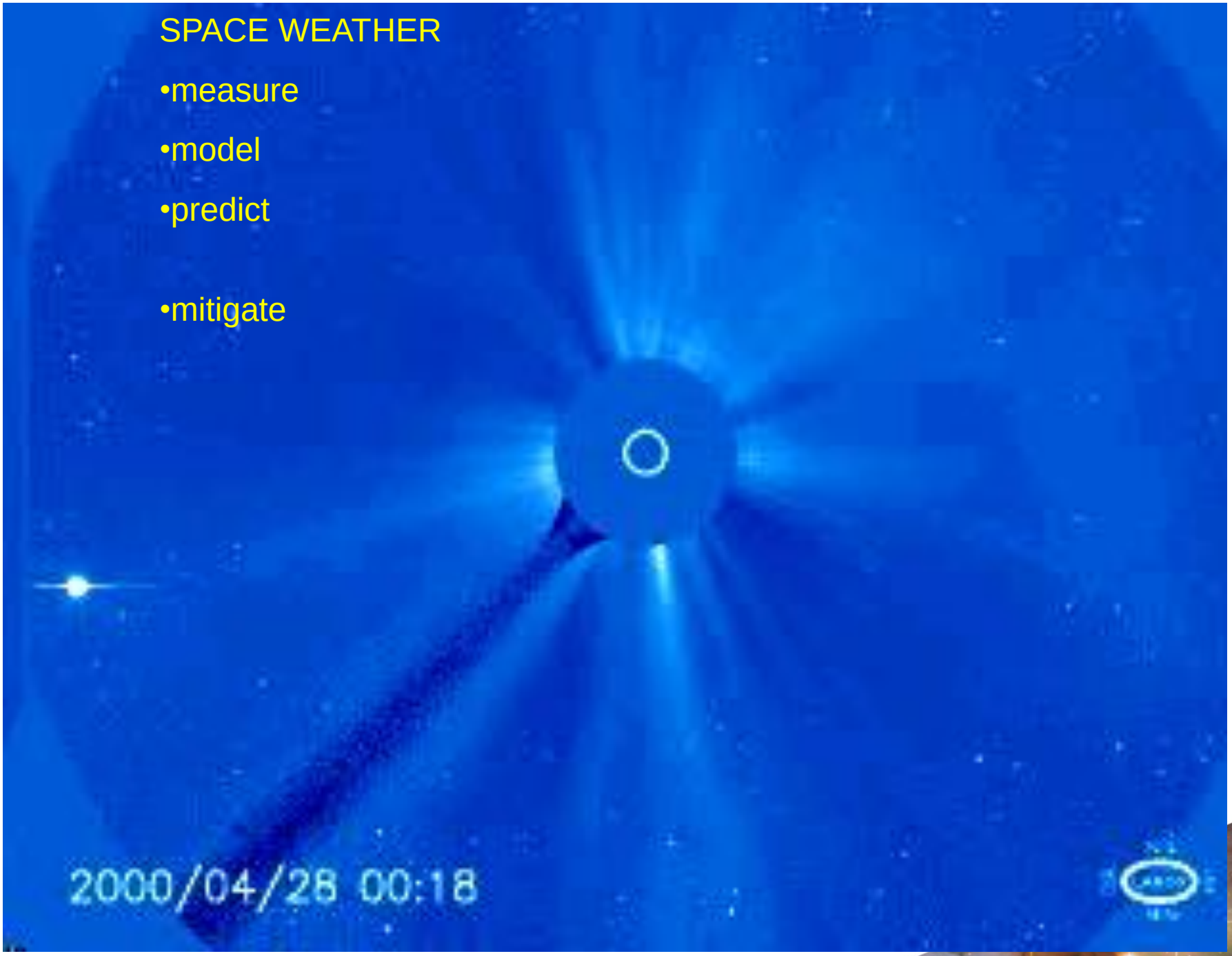
RADIATION

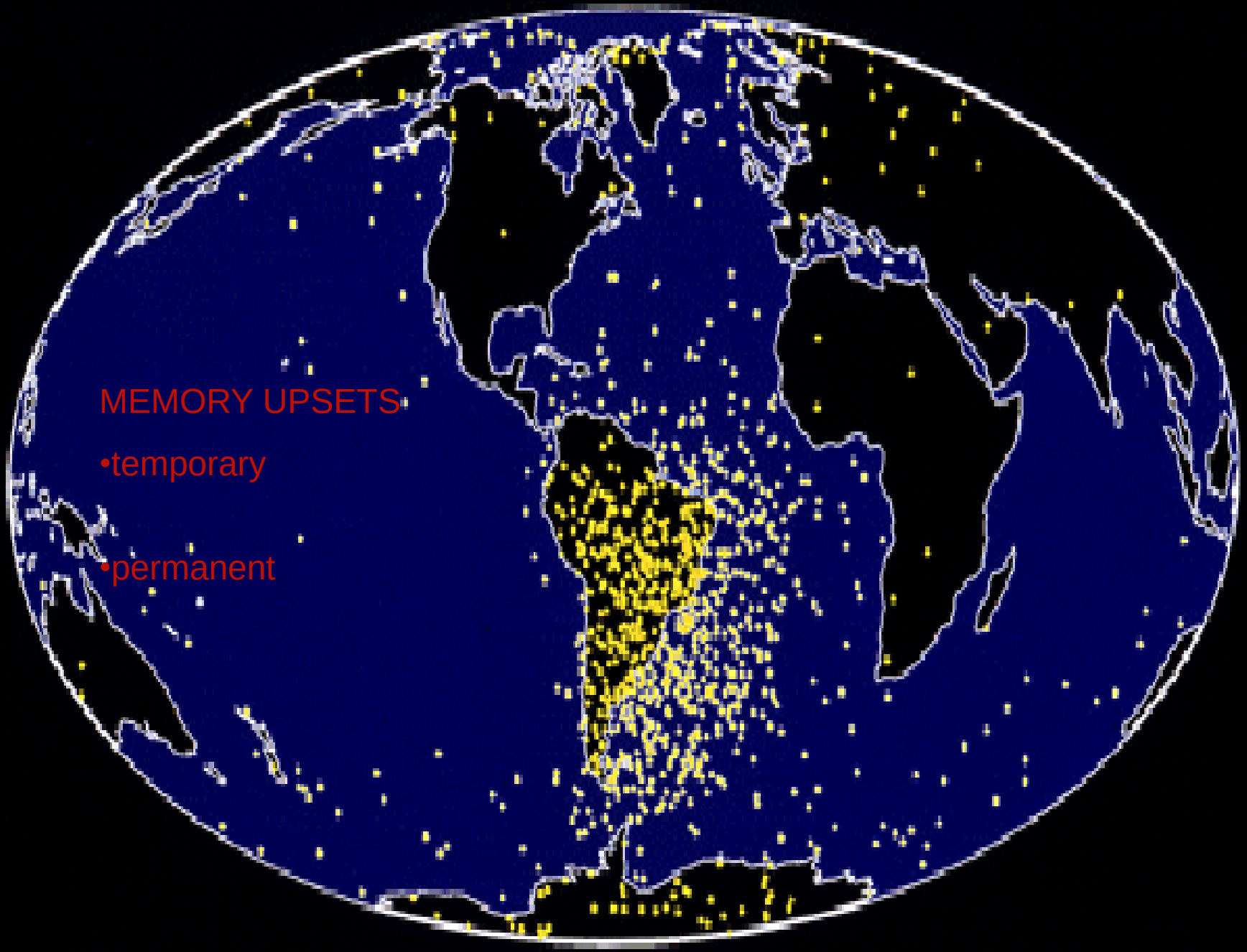
Cosmic Radiation

Solar Radiation

Trapped Particles


Solar
Eruption


SPACE WEATHER
•measure
•model
•predict
•mitigate
2000/04/28 00:18


MEMORY UPSETS
•temporary
•permanent

RADIATION DAMAGE

- astronauts
  - tissue damage
- spacecraft systems
  - degradation in performance
  - malfunction

Aviation

- Space weather has significant impact on Aviation, esp. trans-polar routes
- Communications
  - HF radio links can be degraded (2003, blackout)
  - GEO satcom not accessible above 82 degrees)
- Navigation
  - Accuracy can be degraded & signal lost
- Radiation Hazards
  - Compromise operation (Single Event Effects)
  - Health of aircrew and passengers

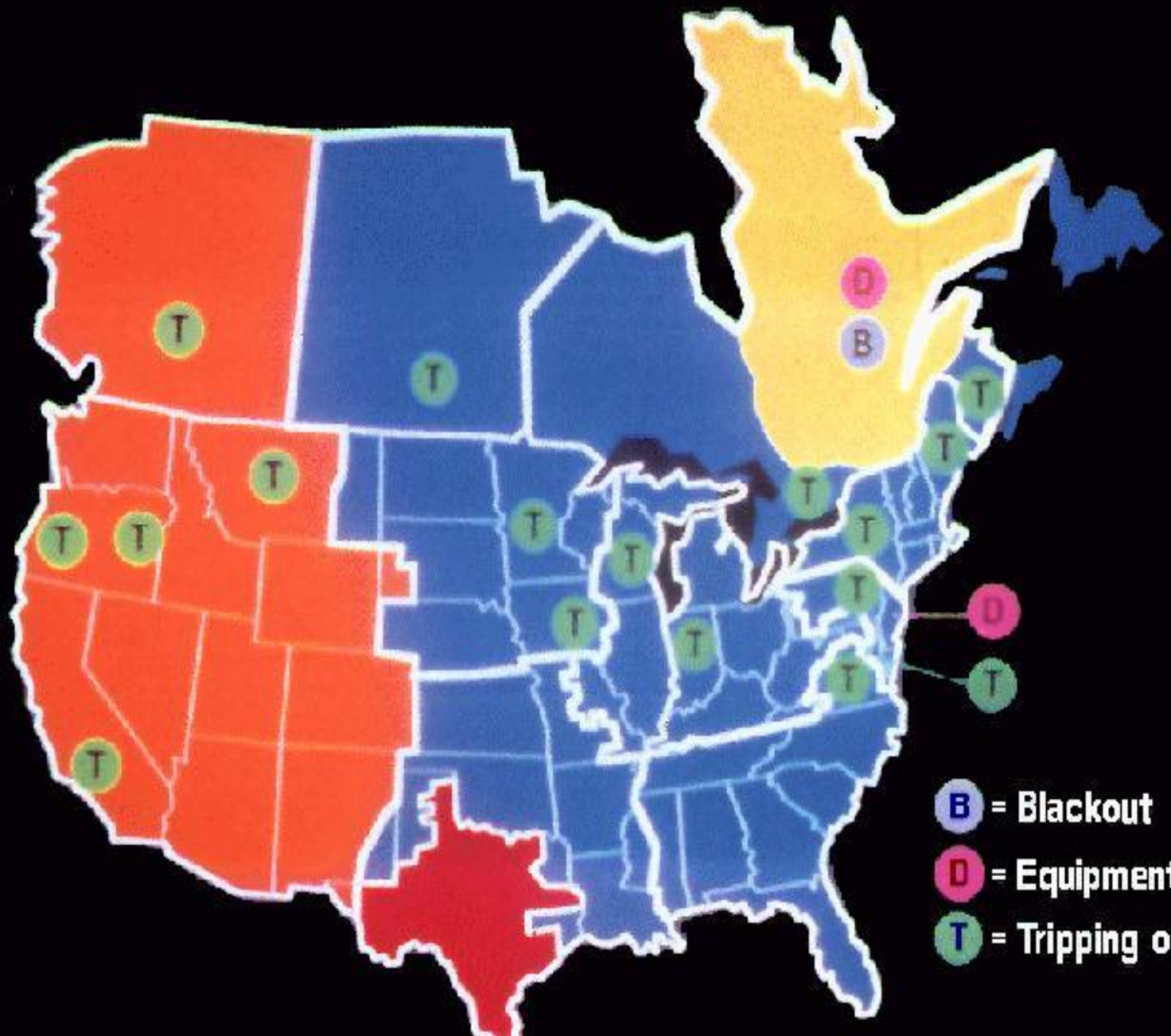
CHARGING

- Surface
- Internal

Power

- During magnetic storms, changes in Earth's magnetic field can generate sub-surface electric fields
  - Damaging currents in power grids (1989, Quebec C$2bn, New Jersey, UK)
  - Permanent damage requiring replacement
  - Cascade failure & need to restore
- Implications for "renewables" which have long transmission lines?
- Indirect consequences for fuel, food, sanitation, finance, …

POWER SYSTEM EVENTS DUE TO SMD MARCH 13, 1989



Transport

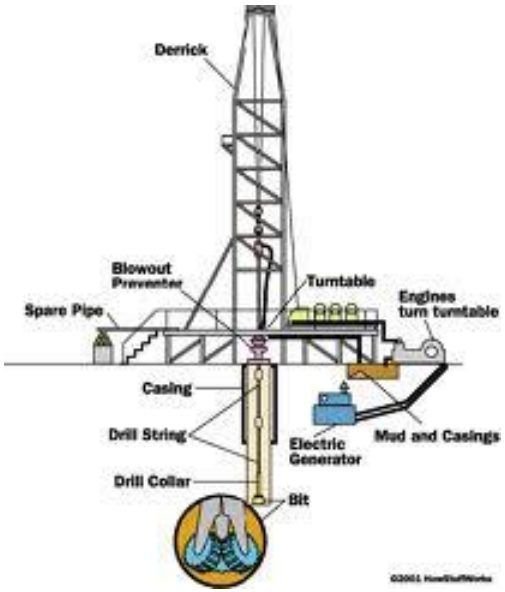
- Road and Maritime transport which use GPS less susceptible to space weather effects
  - New electronic controls may be vulnerable to SEE
- Rail traffic
  - Electric power networks (direct/indirect)
  - Currents in signalling systems
  - Control/communication technologies susceptible

Communications

- Telephones:
  - Historic risk for:
  - Long distance systems & calls routed via comsat
  - Mobile phone links vulnerable to solar radio bursts
  - Mobile phone networks use GPS timing
- Internet is relatively robust as most traffic carried by optical fibre
- Low power wireless vulnerable to interference from solar radio bursts

Oil and Mineral Industries

- Magnetic measurements used to search for natural resources and guide drilling
- Surveys are scheduled during quiet magnetic storm conditions
- Drilling suspended during severe events to avoid misdirection ($O(10^0)$)
- Miniature magnetic sensors are reaching the consumer market



Finance

- Time stamping of financial transactions is critical to operation of markets
  - Time stamps tend to be derived from satellite navigation or internet
  - Automated trading could also be affected
  - Power and communications outages could have indirect impact

Pipelines

- Space weather can induce electrical currents (up to 1000 amps) in long metal pipelines
  - Effect is accentuated in auroral zones
  - Australian study indicates effects at moderate latitudes
- This can lead to increased corrosion rate and associated ageing & decreased lifetime

Summary

- Growth of technologies has left society more at risk from space weather
- Space weather could create major disturbances in the transport, aviation and power sectors
- GPS signals are vulnerable to space weather
- Severe space weather event could create risk to society