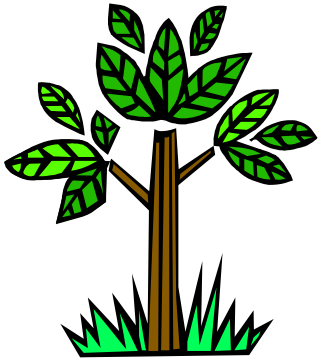
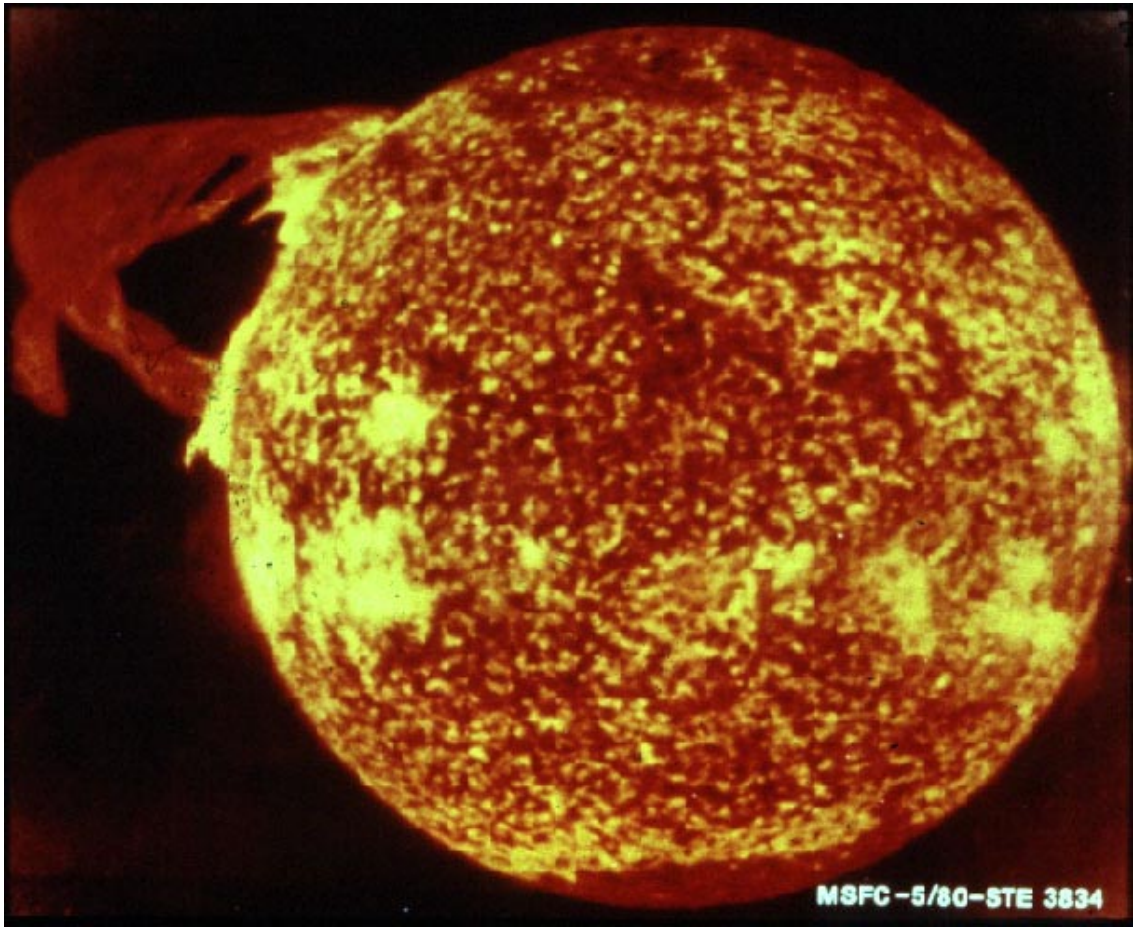
Solar Emission



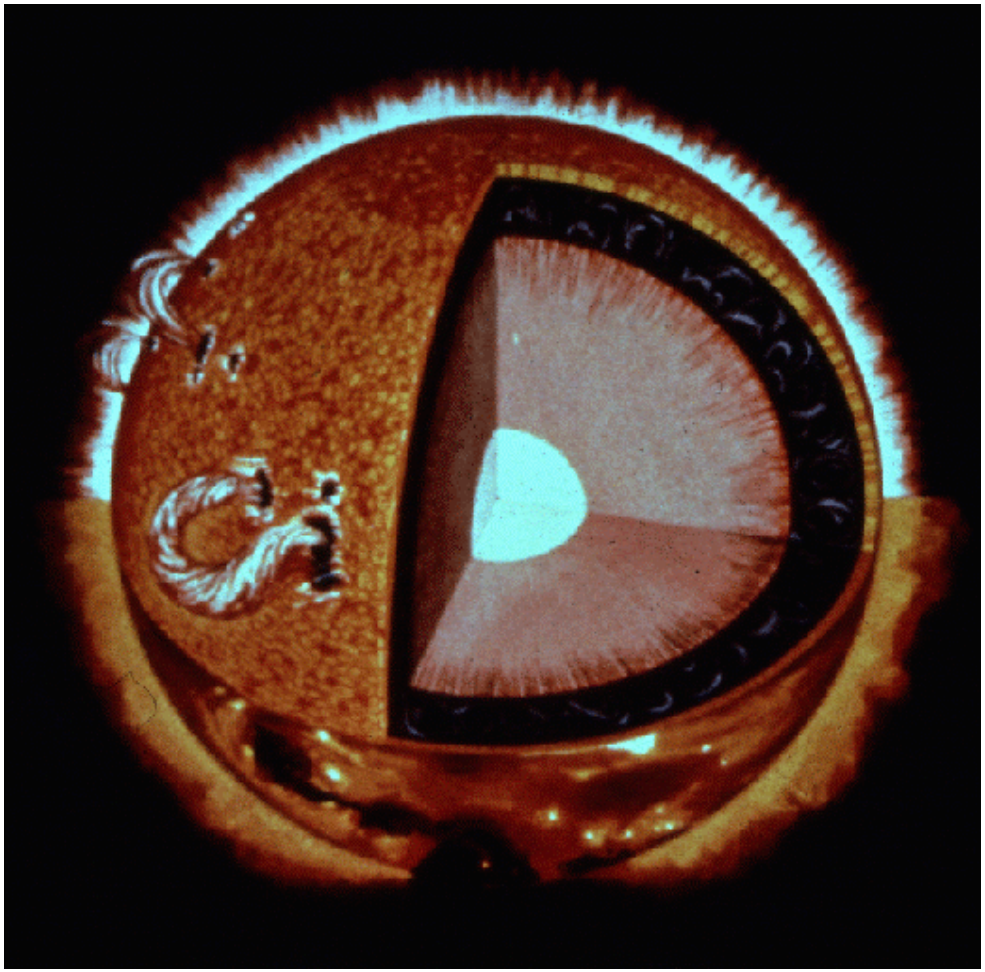
- 95% of the Sun's energy reaches us as "sunshine," that is, light and heat
- Photosynthesis (how plants grow), sunburn, weather are all attributed to this energy
- The last 5% of the energy determines space weather

The Sun



- At 5 billion years old, our sun is an energy machine
- The sun's energy released in 1 sec, could power the U.S. for 9 million years

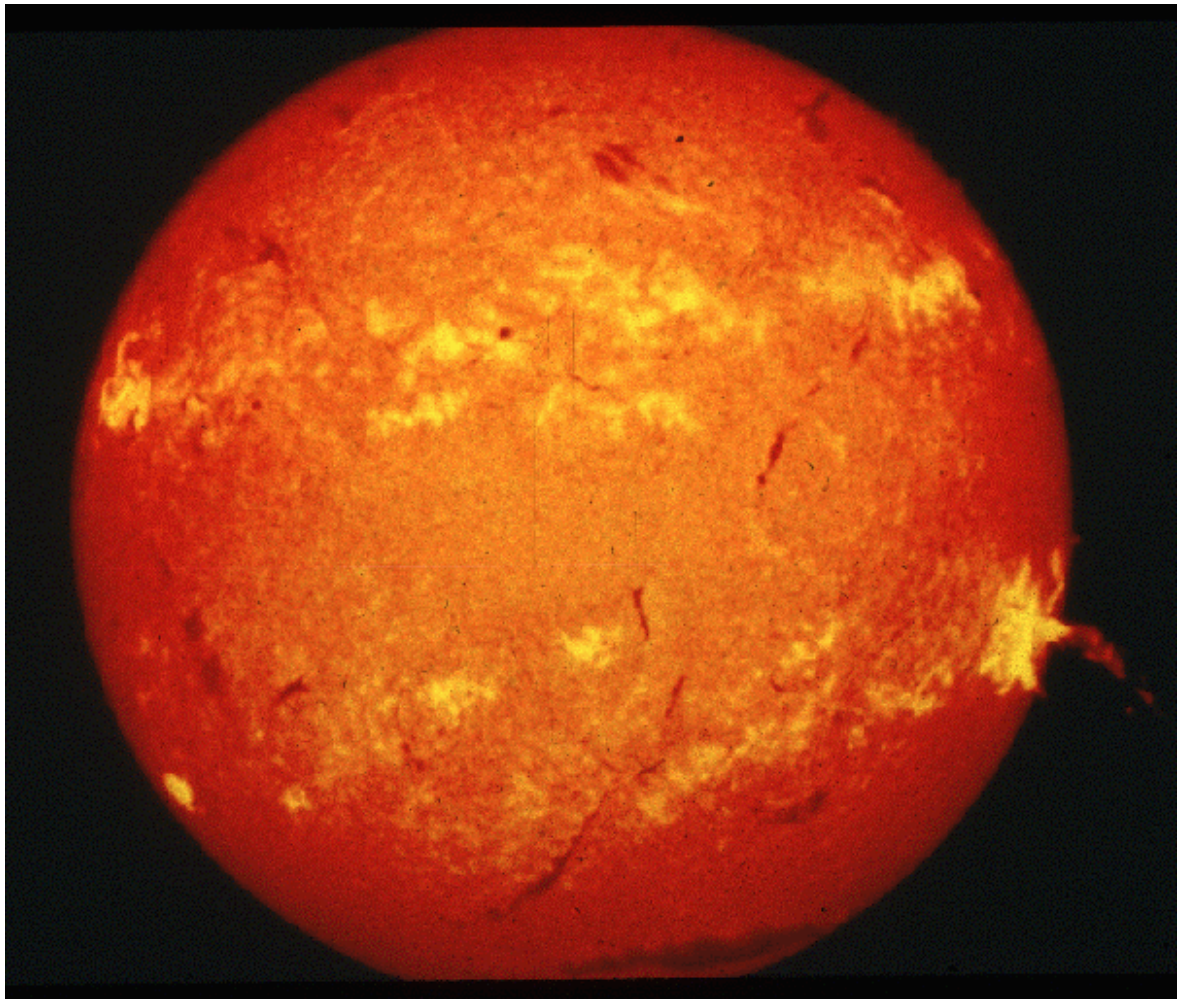
Parts of the Sun



The sun is a gas ball with various temperatures and densities

- Core: millions of degrees
- Surface: thousands of degrees
- Corona: millions of degrees

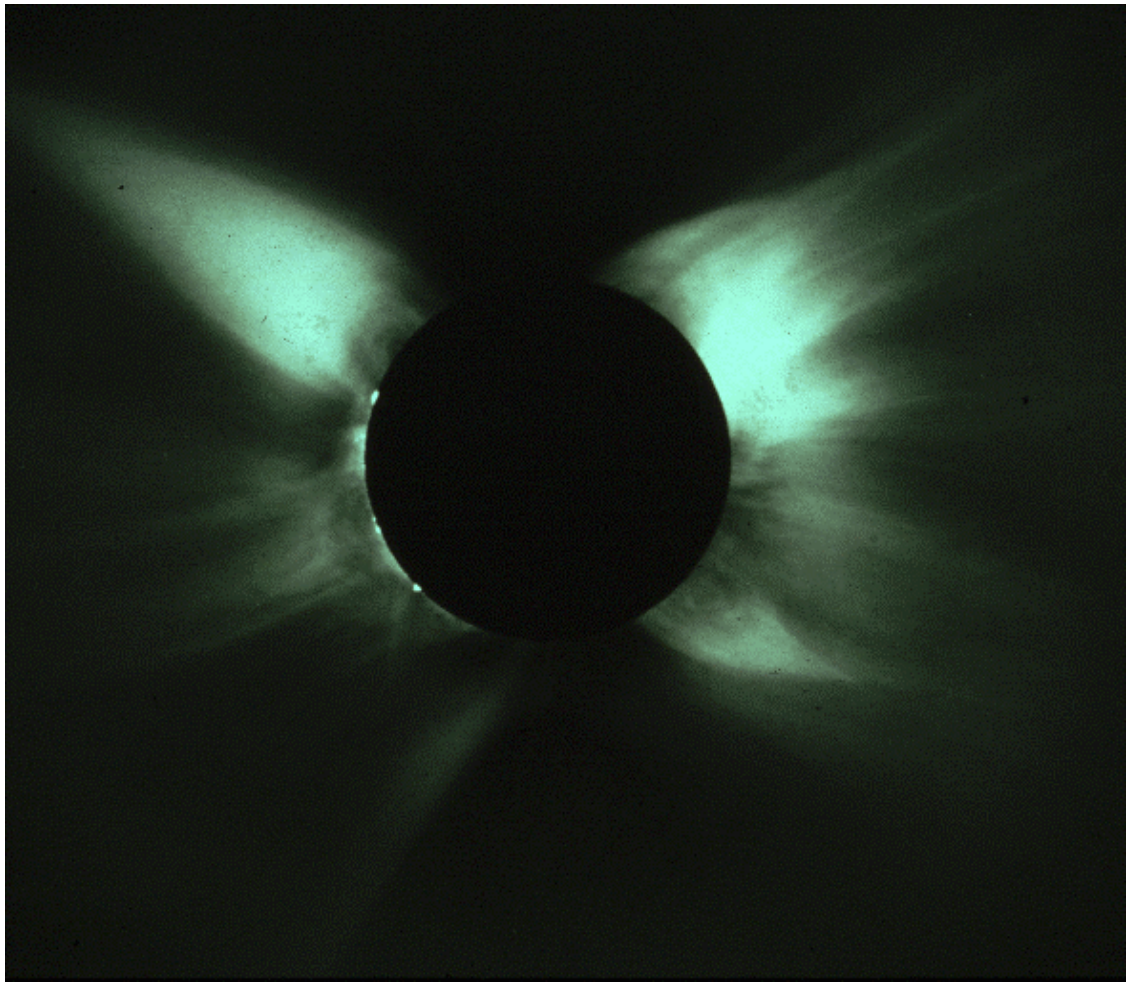
The Surface We See



Photosphere

- "Surface" of the sun
- You couldn't stand on surface
- Constantly bubbling
- 6000 K

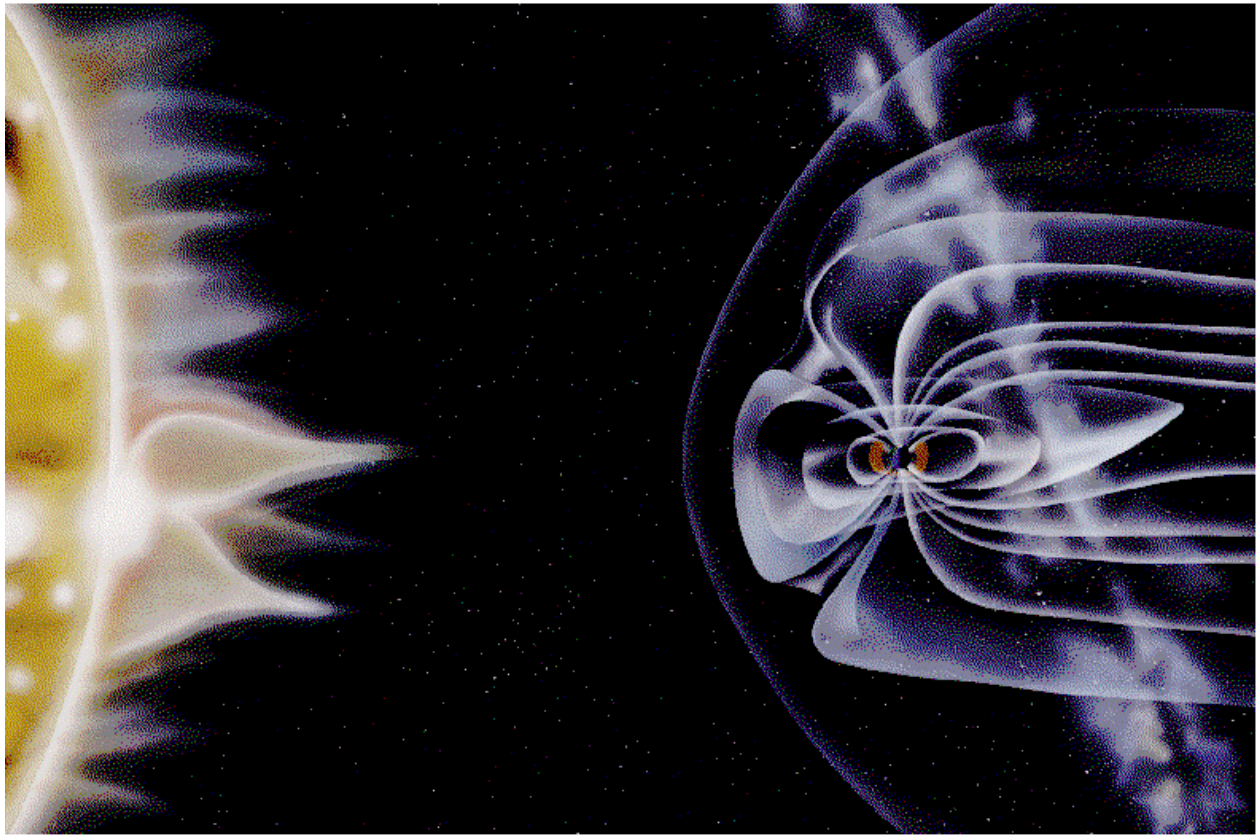
Faint Upper Atmosphere



Corona

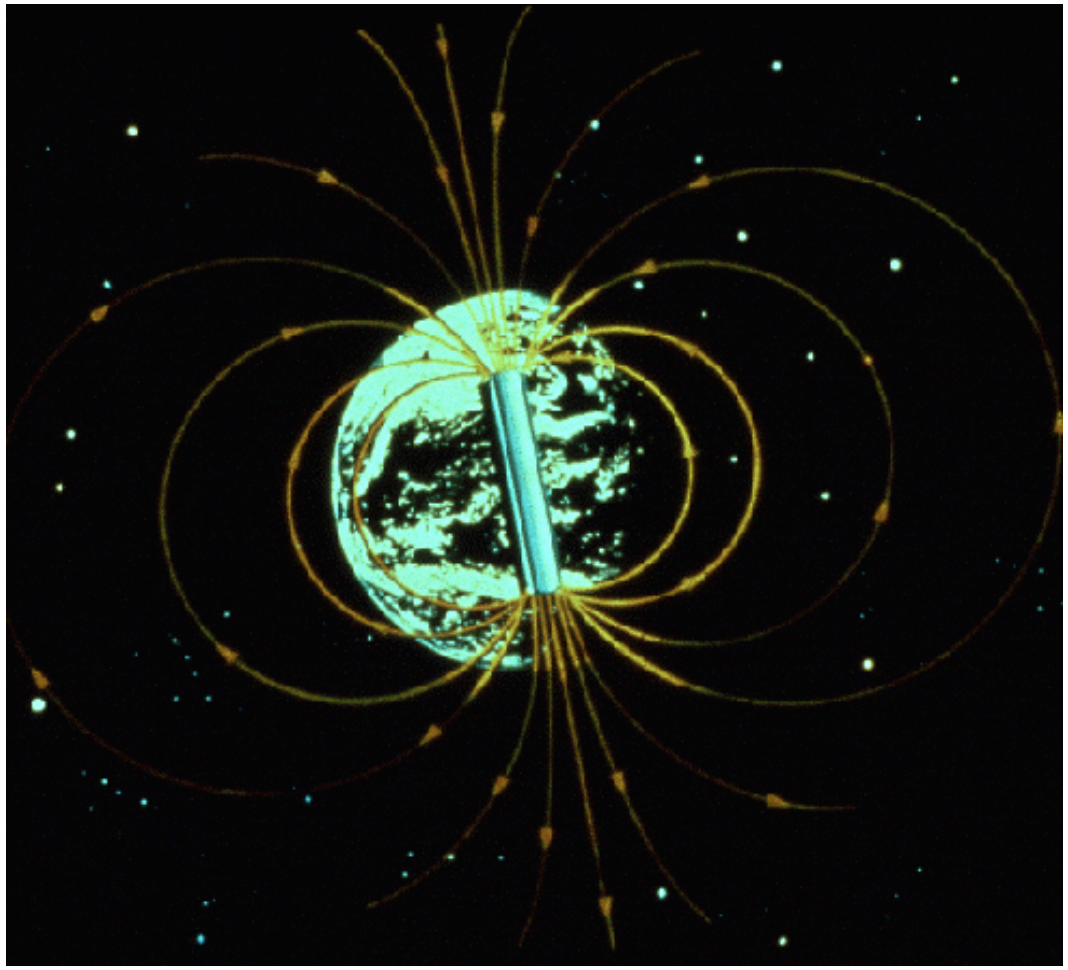
- Visible during an eclipse
- This outer layer extends millions of miles
- Earth is immersed in this

Between Sun and Earth



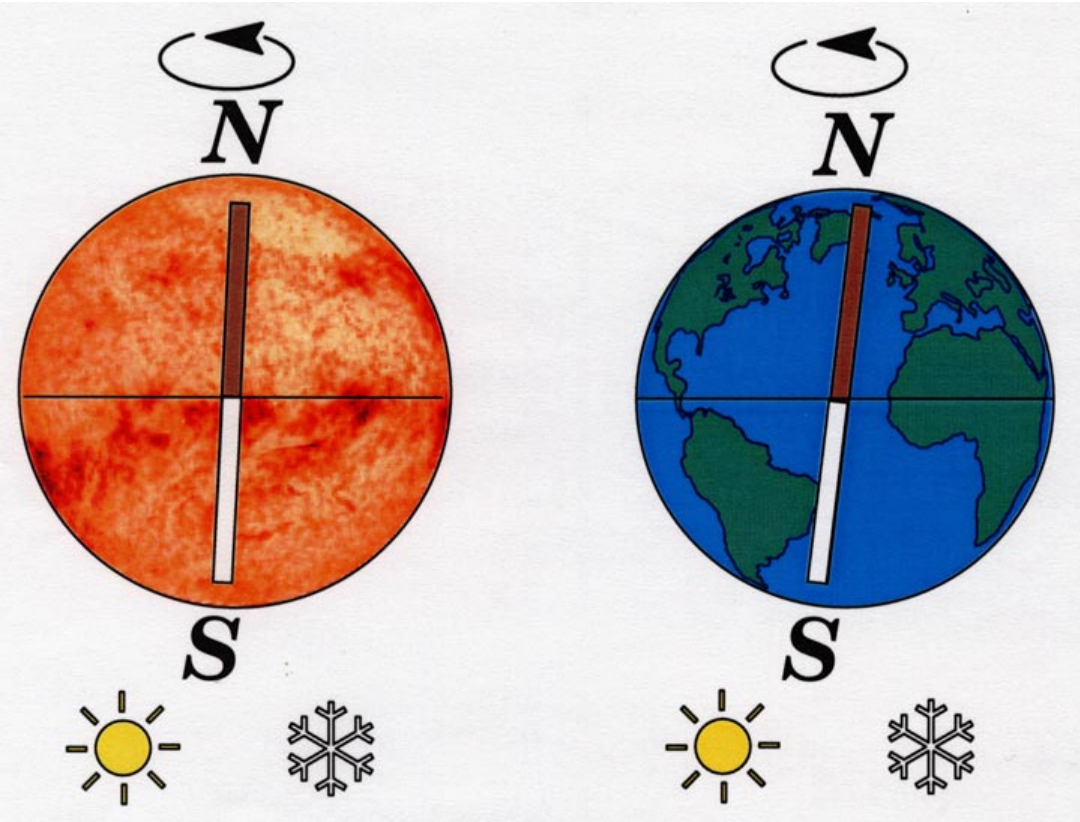
- Called solar-terrestrial environment
- Solar wind, blows 1 million miles/hr,
- Shapes Earth's magneto-sphere

Earth's Magnetic Field



- Earth's magnetic field, without solar wind distortion
- Magnetic field lines channel charged particles

Sun and Earth are Alike

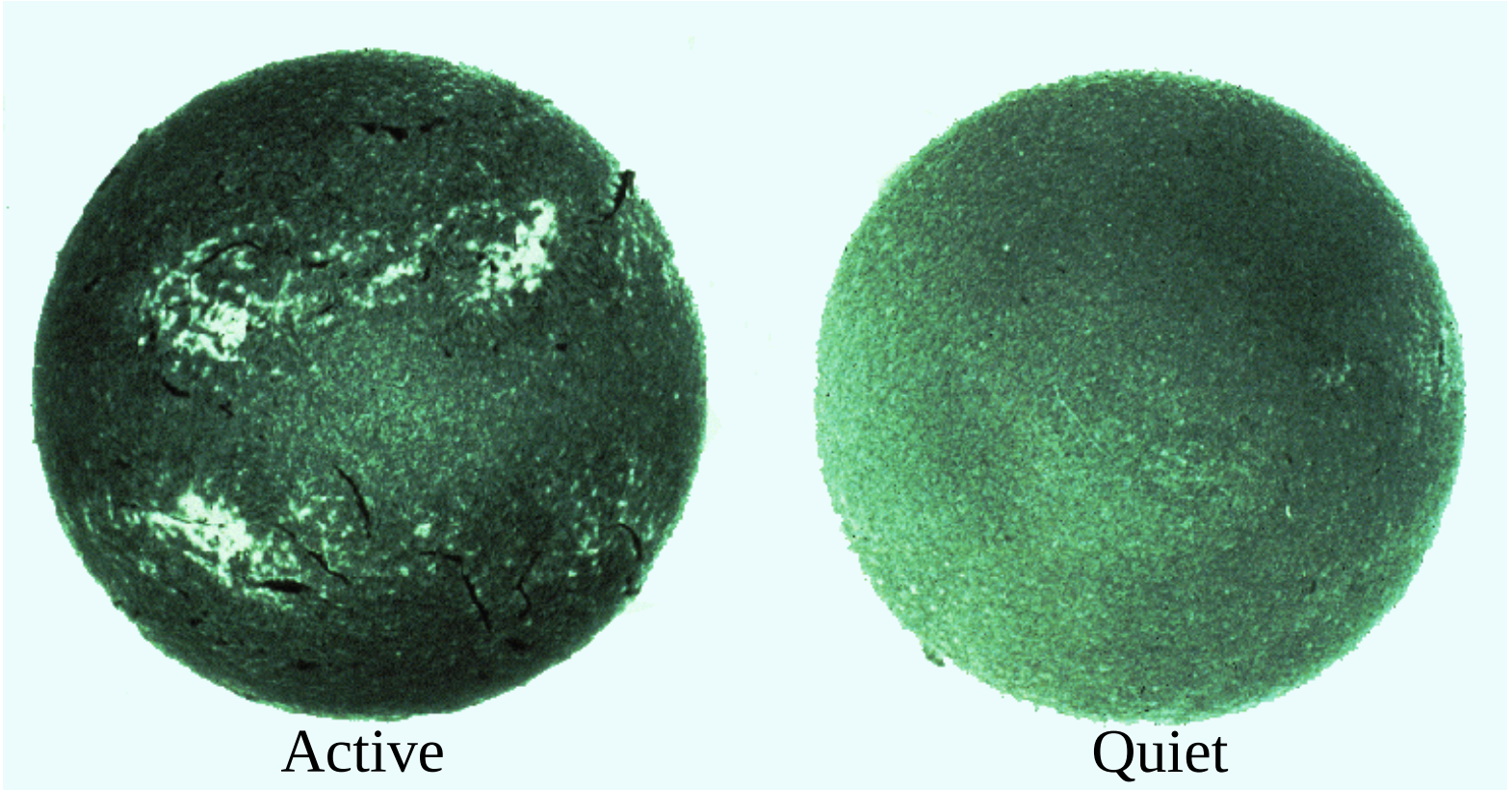


Active Quiet Summer Winter

Each have:

- Equator
- Magnetic field, N and S poles
- Rotation ("day")
- Seasons
- Atmospheric Weather

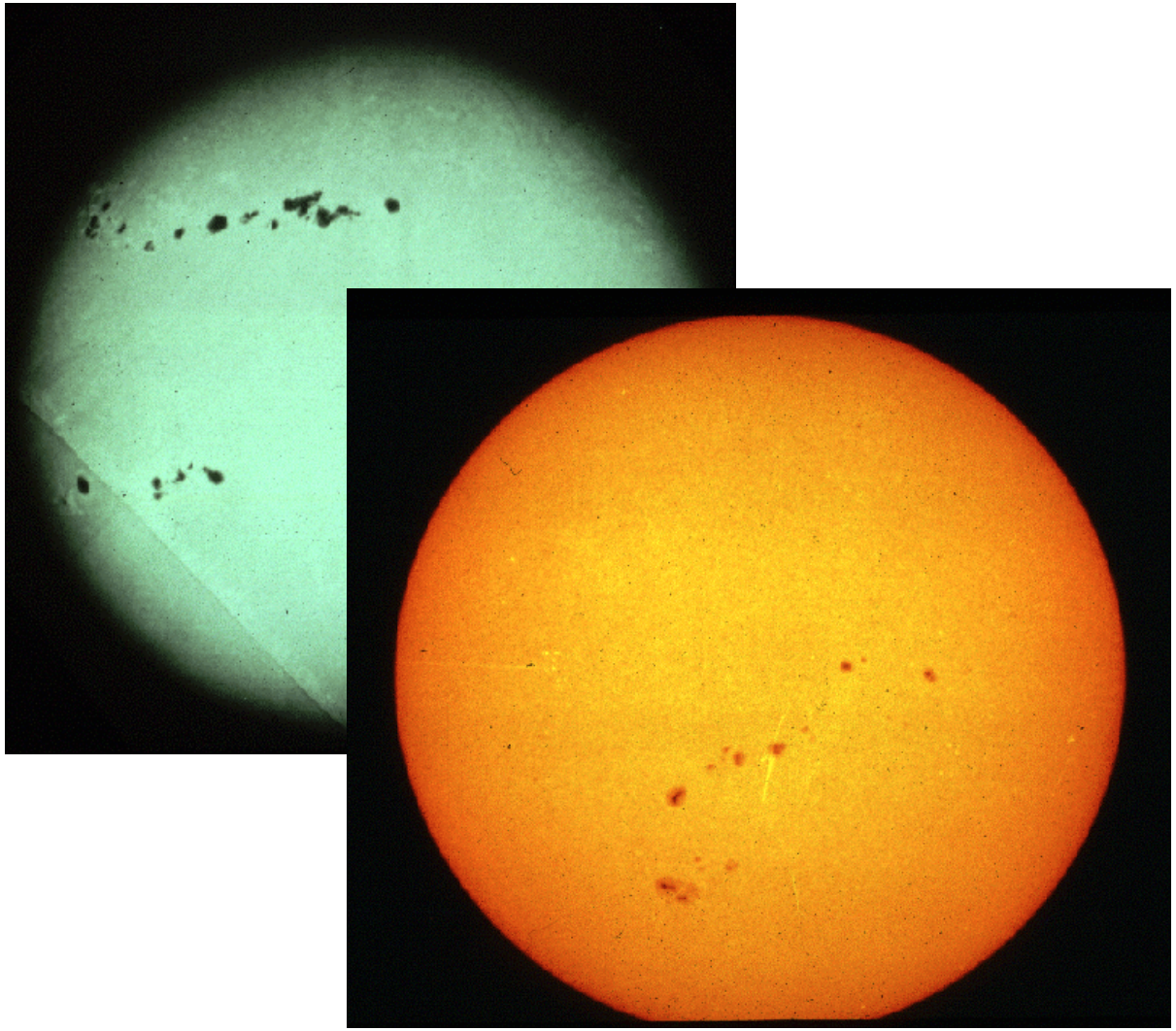
Solar Activity



Active Quiet

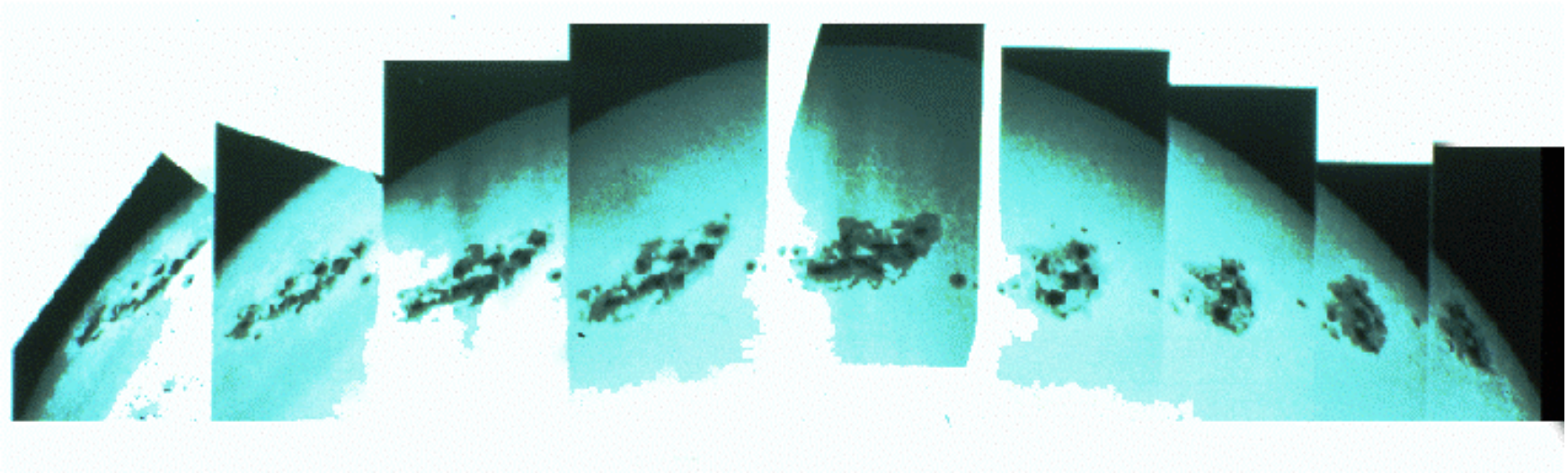
- Active and Quiet Sun look quite different
- One Solar Cycle is 11 years long.

Sunspots!



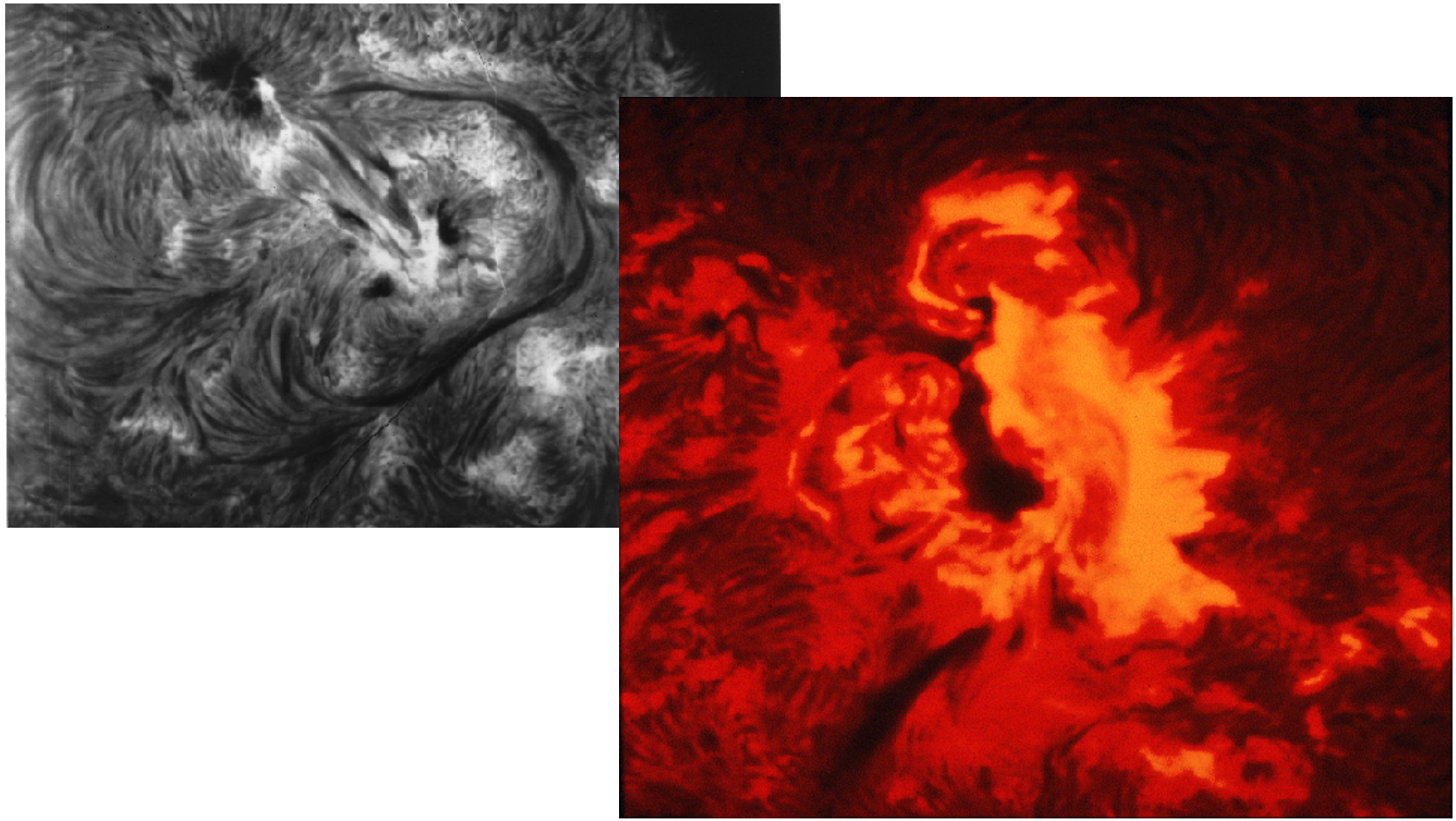
- Cooler regions 4400 Kelvin
- Appear in moments or hours, last hours, days, or weeks
- Disturbed magnetic field, is one cause for solar flares

Sunspots Travel



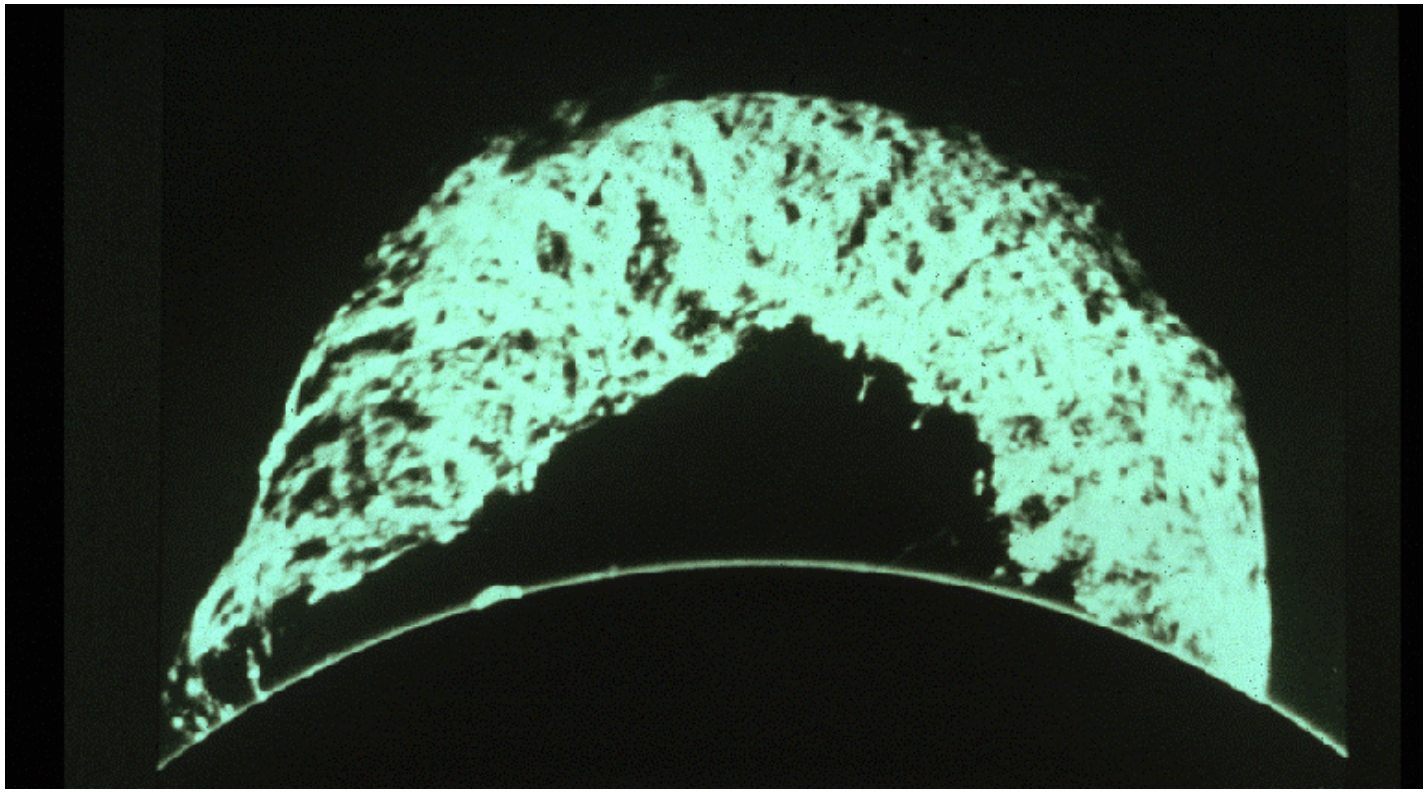
- Sunspots move across the surface of the sun as the sun rotates
- They change as they age and may produce repeated flares

Solar Flare



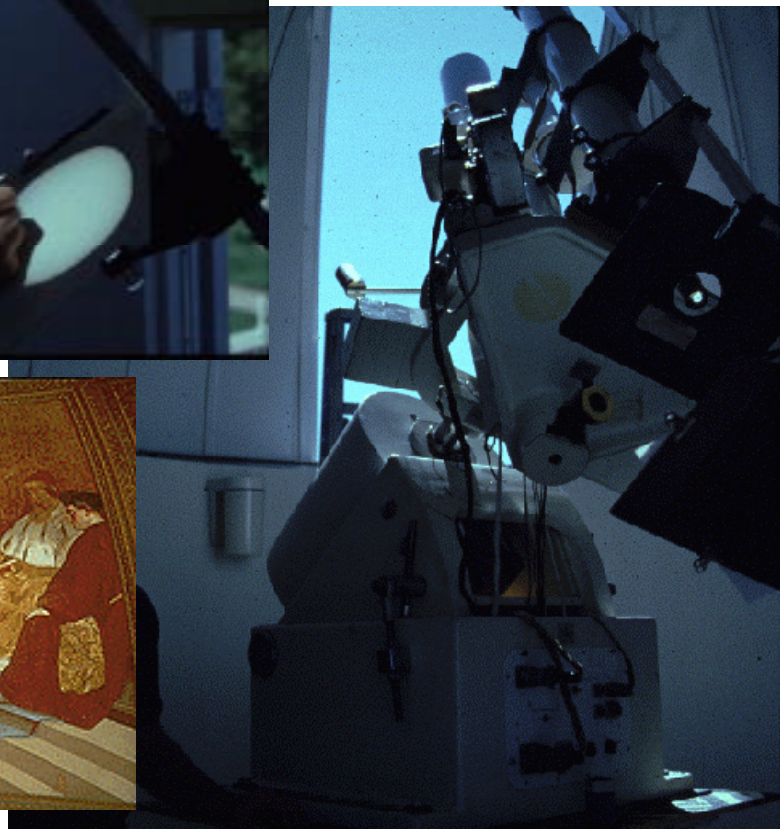
- This sunspot, 2 Earths wide, produced a bright flare

Prominence



- Magnetic fields give structure to ejecta
- When very disturbed, breaks and plasma goes shooting out into space.

Optical Telescopes



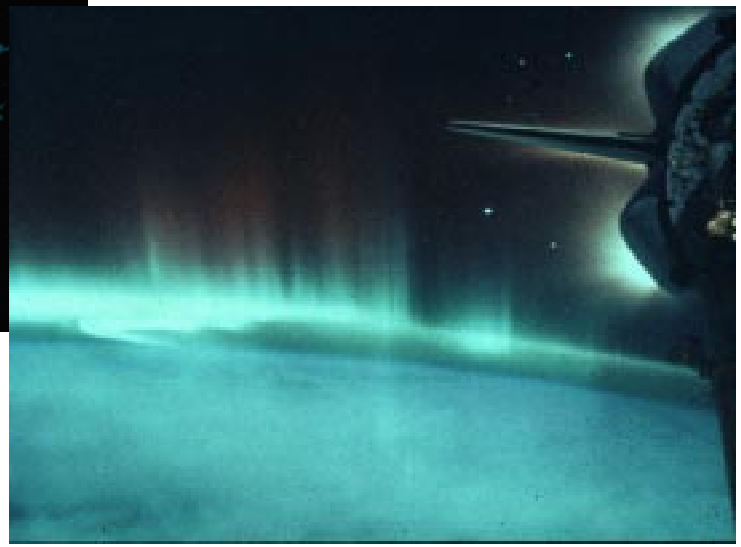
- In white light one can easily see sunspots
- Light is projected onto a sheet so the eye doesn't look directly through the telescope at the sun.
- Telescope like one Galileo might have used

Other Telescopes

- Radio telescopes and satellite imager tell us other information about the Sun

Effects: Aurora

- The aurora is directly due to the energy coming from the sun



- Aurora from space with the shuttle in foreground

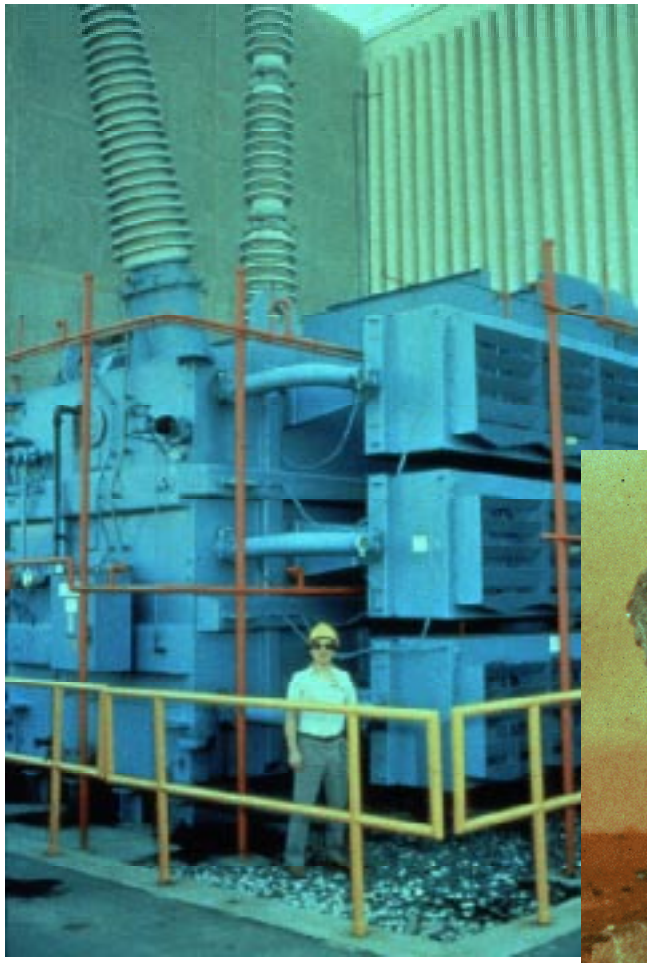
Effects: Navigation

- Ships at sea require good navigation signals
- Navigation errors can lead to wasted fuel, groundings, and spilled cargo

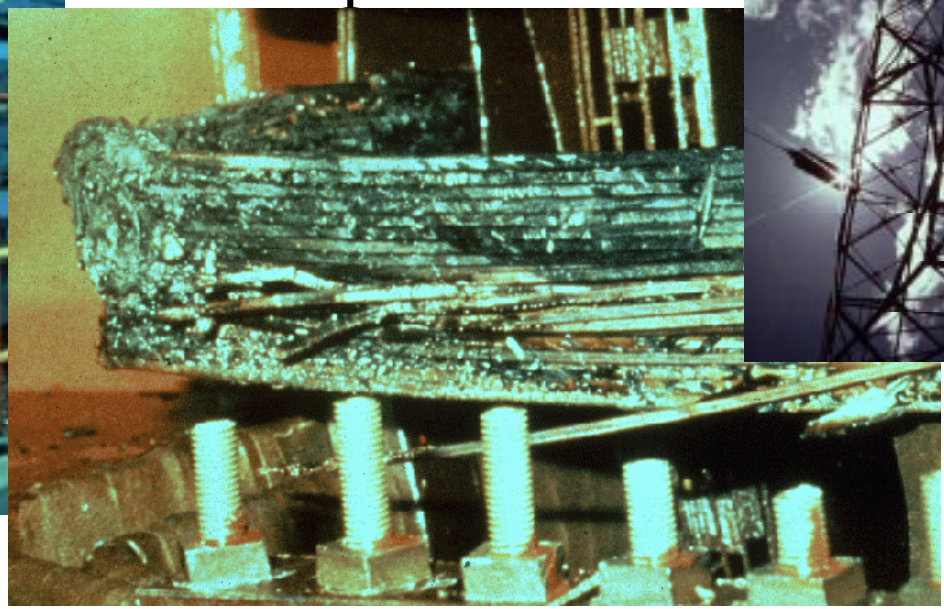
Effects: Radio

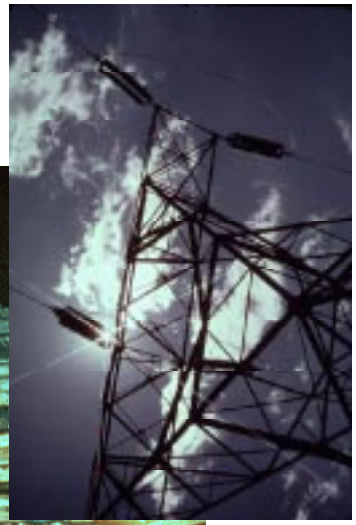
- Signals can get lost or absorbed, bounce and miss the receivers
- Communication over the poles at certain frequencies can be completely blacked out

Effects: Electric Power



- Huge transformers can be damaged by geomagnetic storms
- Blackouts can be widespread



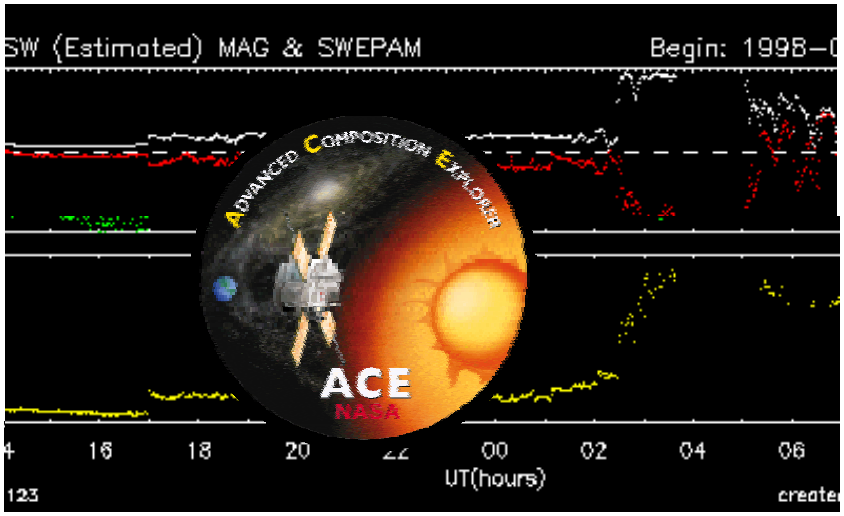


Effects: Pipelines

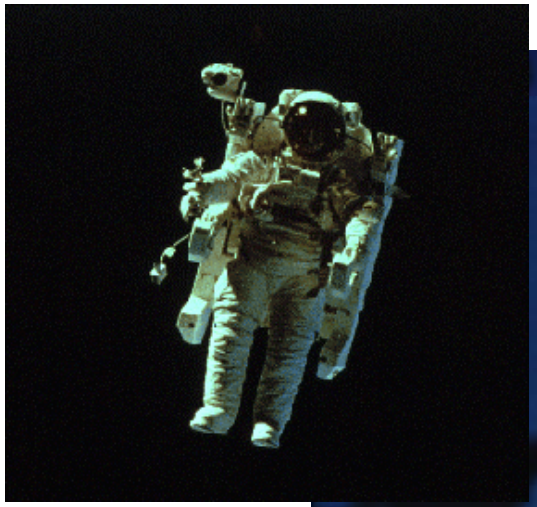
- Pipelines can corrode with geomagnetic storms
- Without mitigation, corrosion can cause severe leaks and damage the environment

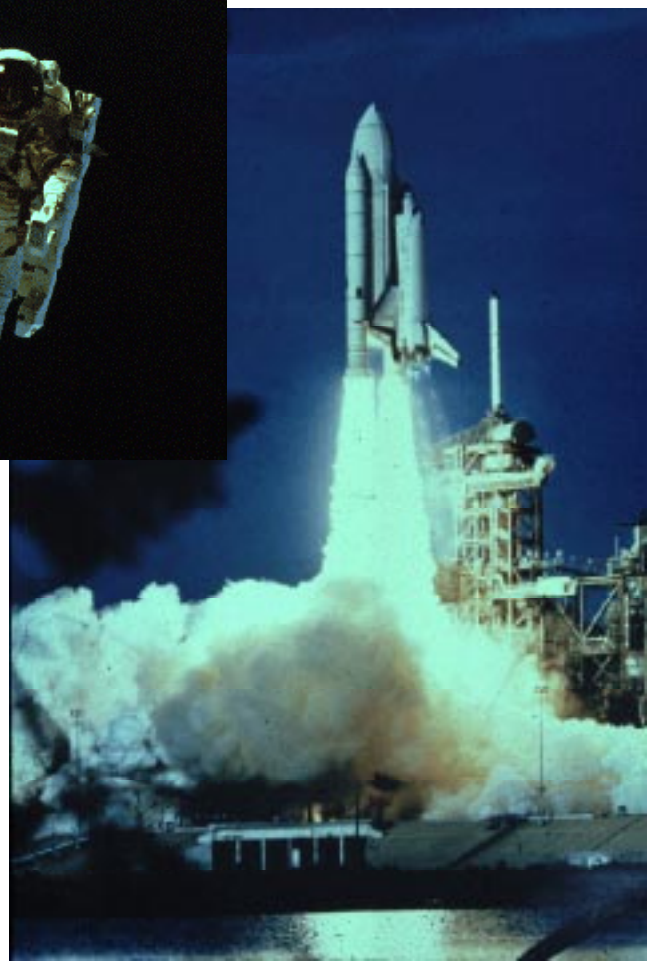
Effects: Satellites

- Satellites can be damaged, lost, returned to Earth early
- Satellites sit in the space environment and alert us



Effects: Radiation

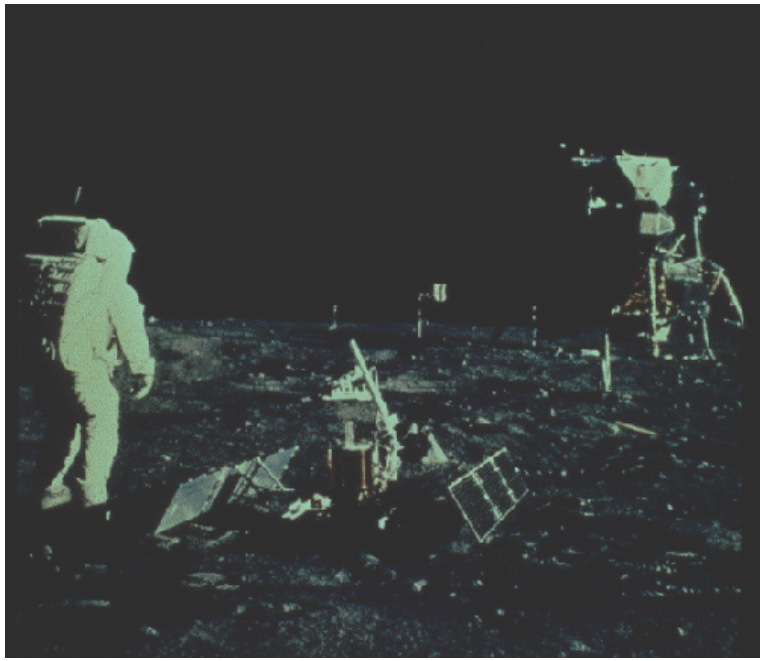




- Astronauts in space
  (EVA, Extra Vehicular Activity)
- All Space Shuttle missions
- SST (the Concorde) flying at high altitude, at high latitude

Work in Space

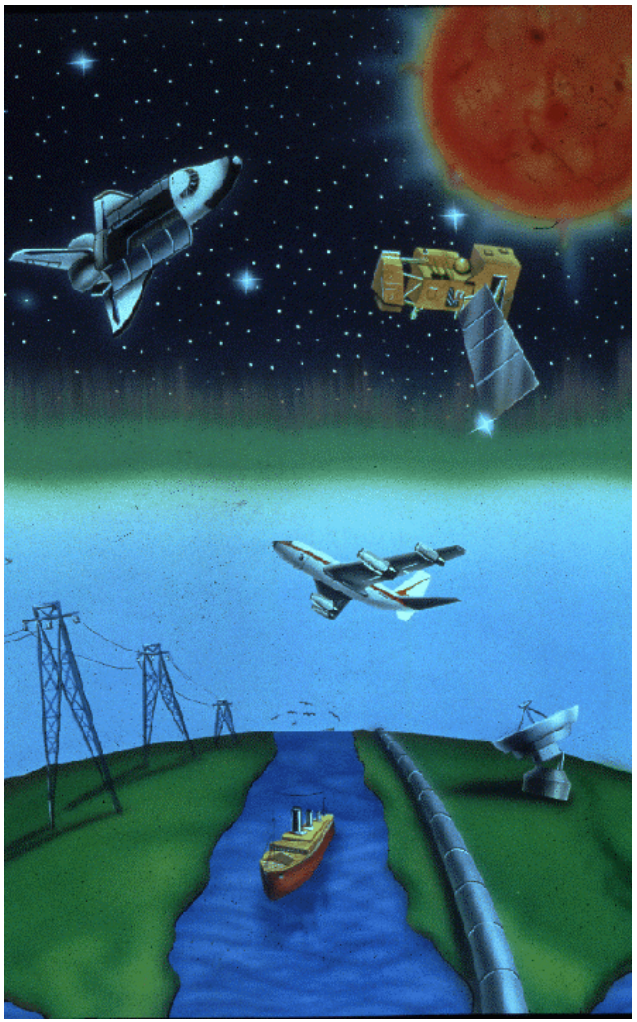
- Dangers of space travel are many
- Astronauts working on the Moon



Effects: Climate

- Is the Sun's variability tied to Earth's climate?
- Controversial correlation with droughts, ice ages, large-scale weather patterns on Earth

Summary of Effects



Space Weather effects on:

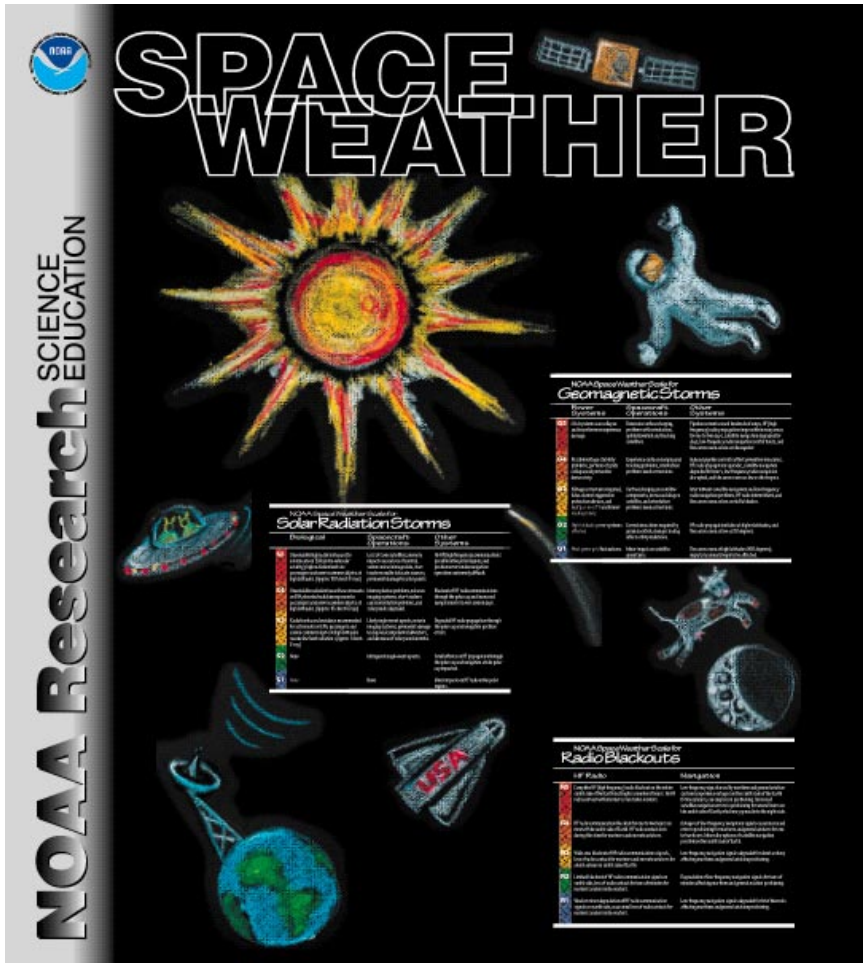
- Satellites
  - What technology is dependent on satellties?
- Navigation
  - What are the risks of lost navigation signals?
- Manned Space Flights
  - As an astronaut, would you care about this?
- Communication
  - How are communications disrupted?
- Electric Power
  - How would you know about this disruption?

NOAA Space Weather Scales

Category	Effects
Geomagnetic Storms G1-G5	Satellites, Power Grids, other
Solar Radiation Storms S1-S5	Biological, Satellites, other
Radio Blackouts R1-R5	Navigation, Radio

- Easy way to communicate conditions and forecasts
- Like the hurricane or earthquake scales
- Will be hearing these, seeing them in the news

NOAA Science Ed Poster



- Poster shows effects on different systems
- Also
  - Facts about space weather
  - Questions to answer
  - Websites

What would you like to study about Space Weather?