Presentation for Student Scientists March 22, 2017

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How is Science Done?

The Scientific Method, Basic Problem Solving

Make an Observation: - An astronomer notices that the number of sunspots changes in a cyclical way (over about 11 years, duration between minima or maxima).
- A marine ecologist notices bleaching of coral reefs.
- A ham radio operator notices that she can communicate over longer distances at night.

Form a hypothesis: - The Sun's magnetic field creates these changes.
- Seawater is becoming more acidic.
- Recombination of ions in the atmosphere allow radio waves to go higher before being reflected back to Earth.

Make a Prediction: - With a mathematical model, the Sun's magnetic field can be "turned off". If this happens, sunspots will go away.
- Coral in a more alkaline or neutral pH will not bleach.
- Radio waves will travel farther at midnight than at dusk or dawn.

Test!
Iterate!

What Does a Scientist Do?
Research

- Pick a topic
- Review the literature
- Collect data
- Analyze the data
- Form a hypothesis
- Write papers describing the research
- Submit papers for peer review
- Revise papers for publication
- Publish

What Does a Scientist Do?
Proposals

- From previous research, propose new research
- Review the literature
- Collect data
- Analyze the data
- Form a hypothesis
- Write a proposal describing the new research
- Consider how the research will advance the field
- Submit proposal
- Wait for panel review
- Deal with the rejection, but learn from comments of panel

The Sun and an Eclipse Overview

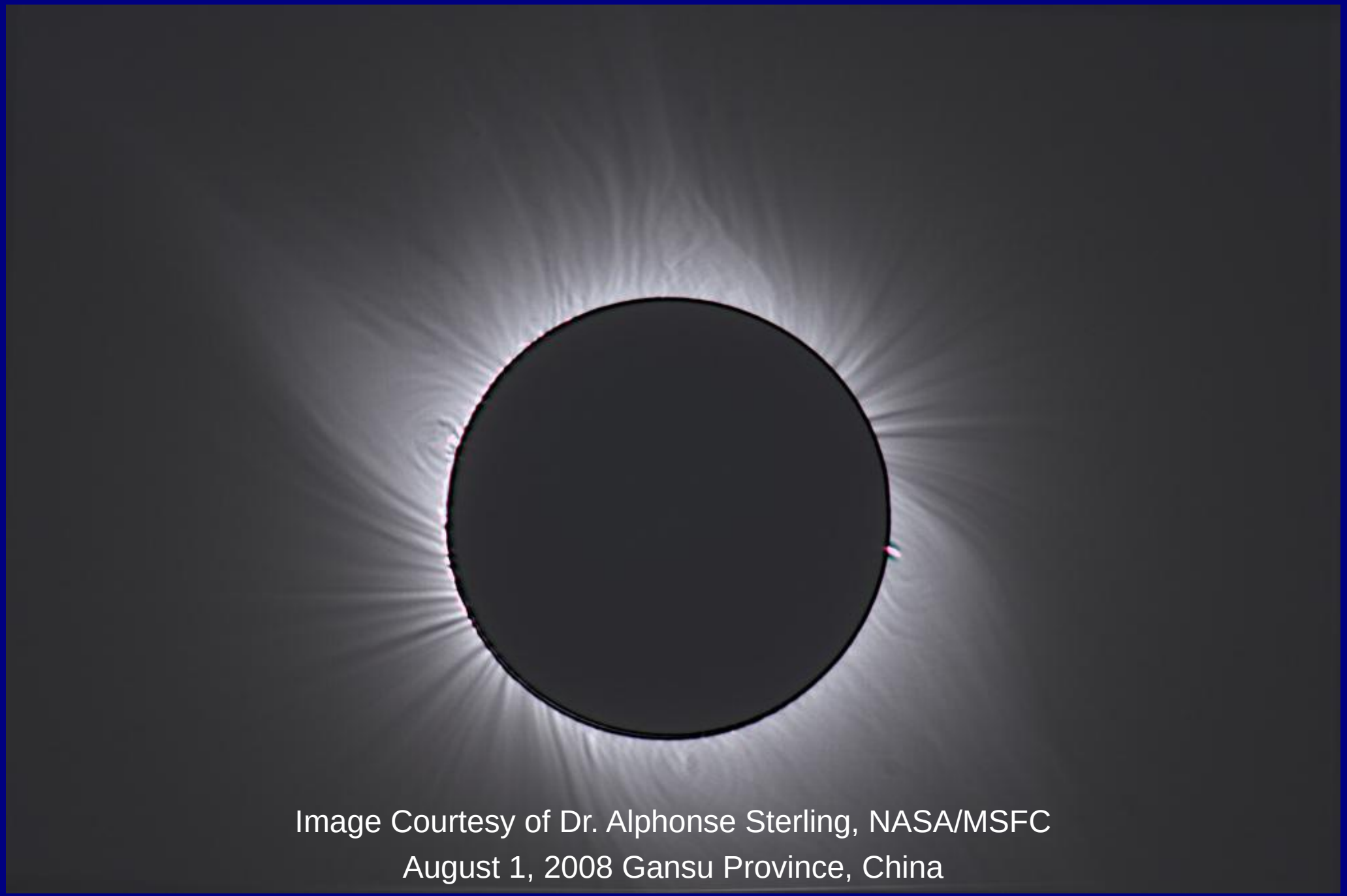
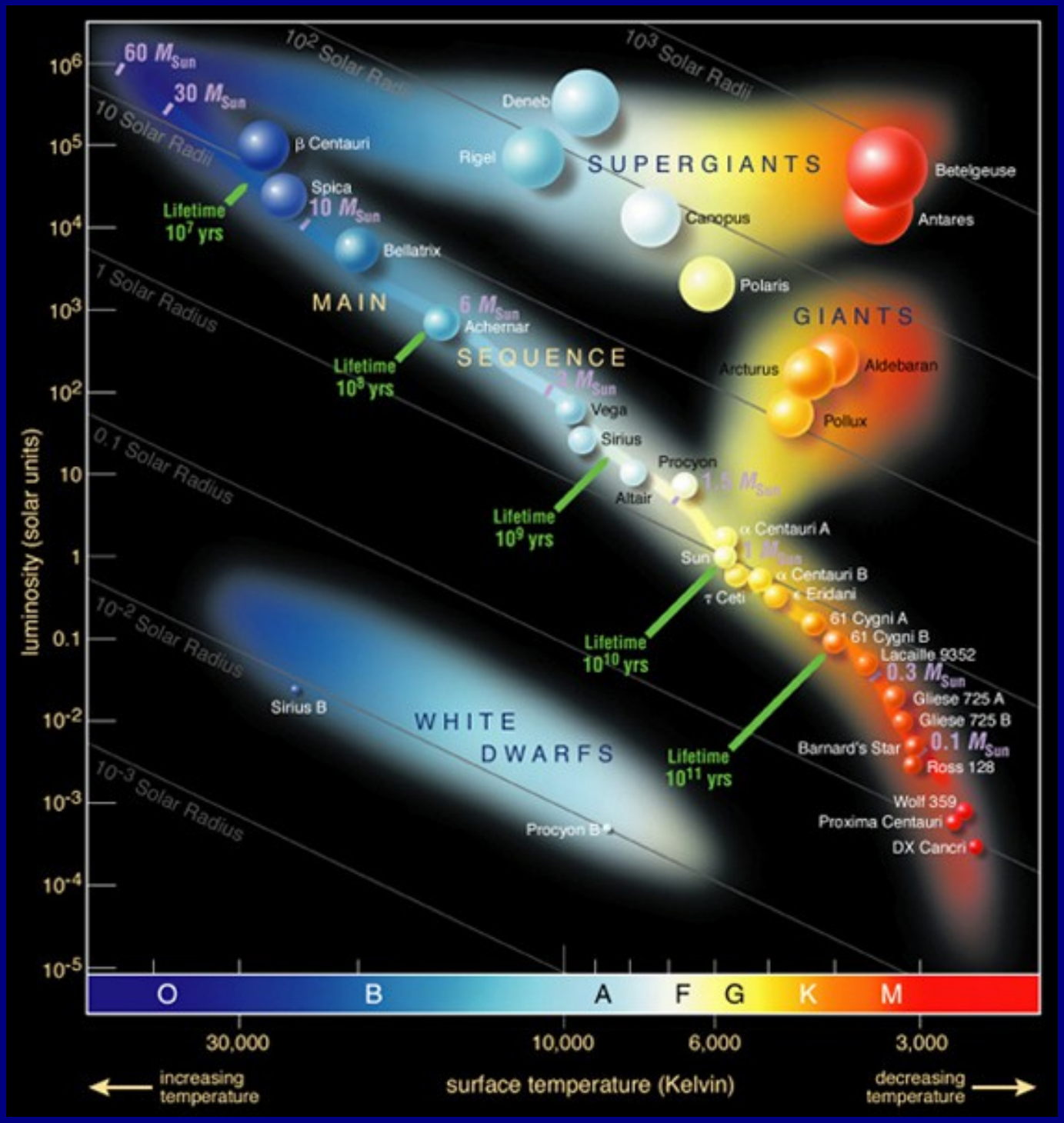


Image Courtesy of Dr. Alphonse Sterling, NASA/MSFC

August 1, 2008 Gansu Province, China

What IS the Sun?



The Sun is a Star
Stars are Mostly Hydrogen Gas

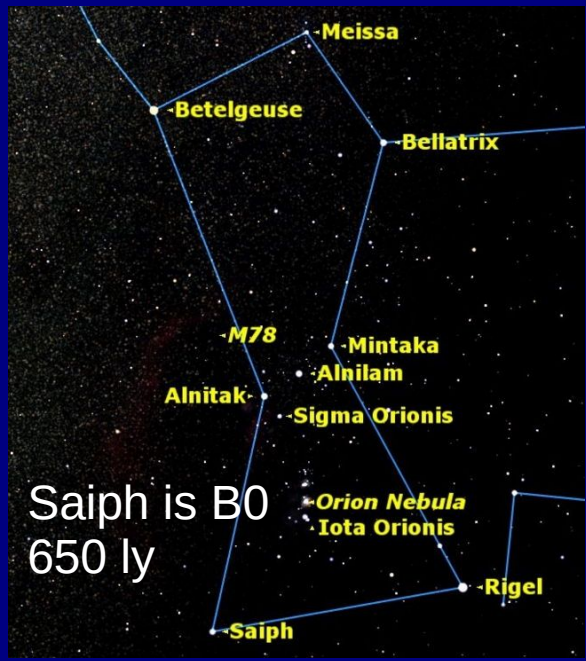
α-Cen-A is G2,
α-Cen-B is K1,
Proxima (α-Cen-C) is M6,

the Sun is G2
8.5 light minutes away

Betelgeuse is M2
643 ly

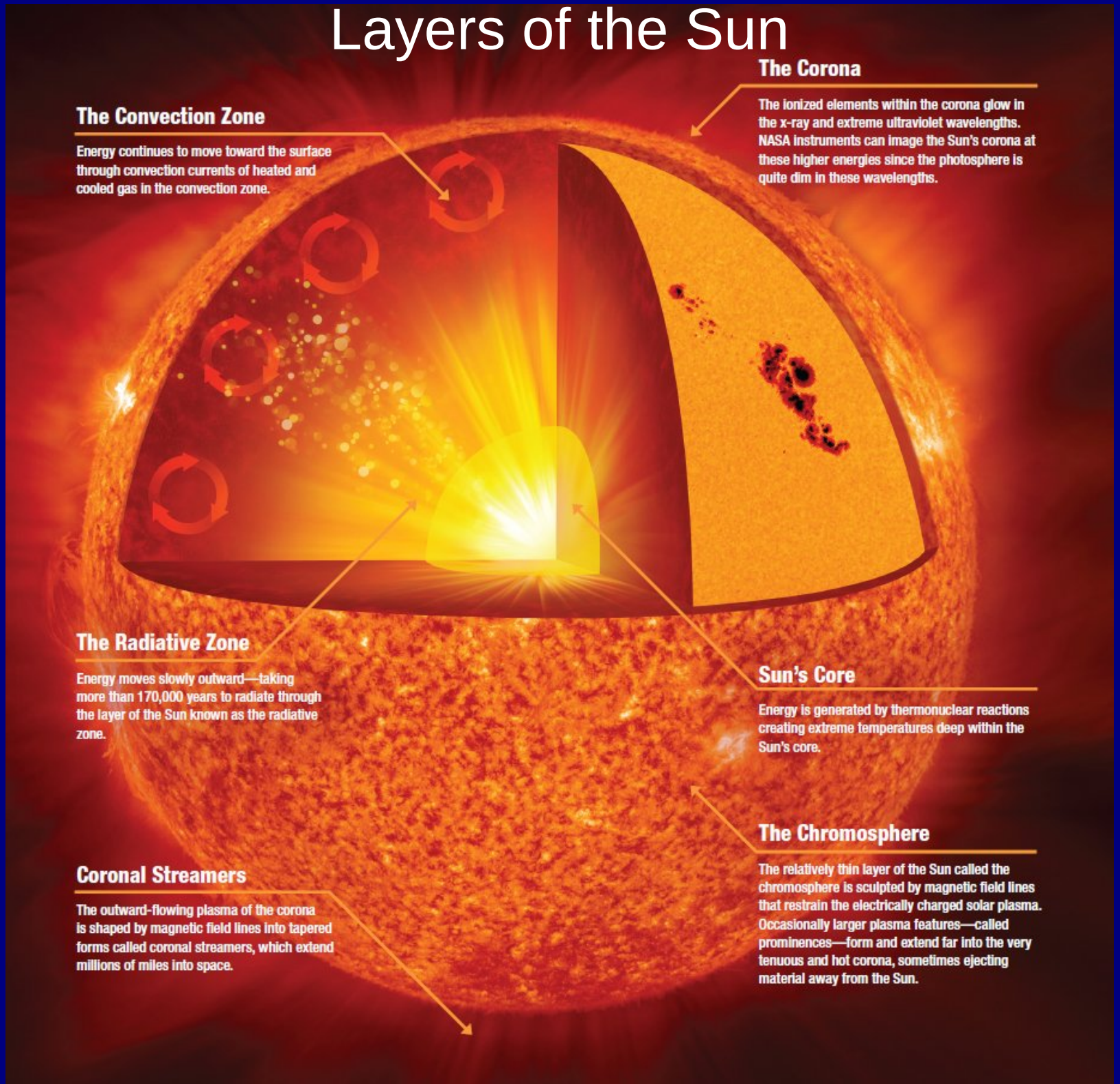
Bellatrix is B2
250 ly

Rigel is B8
860 ly

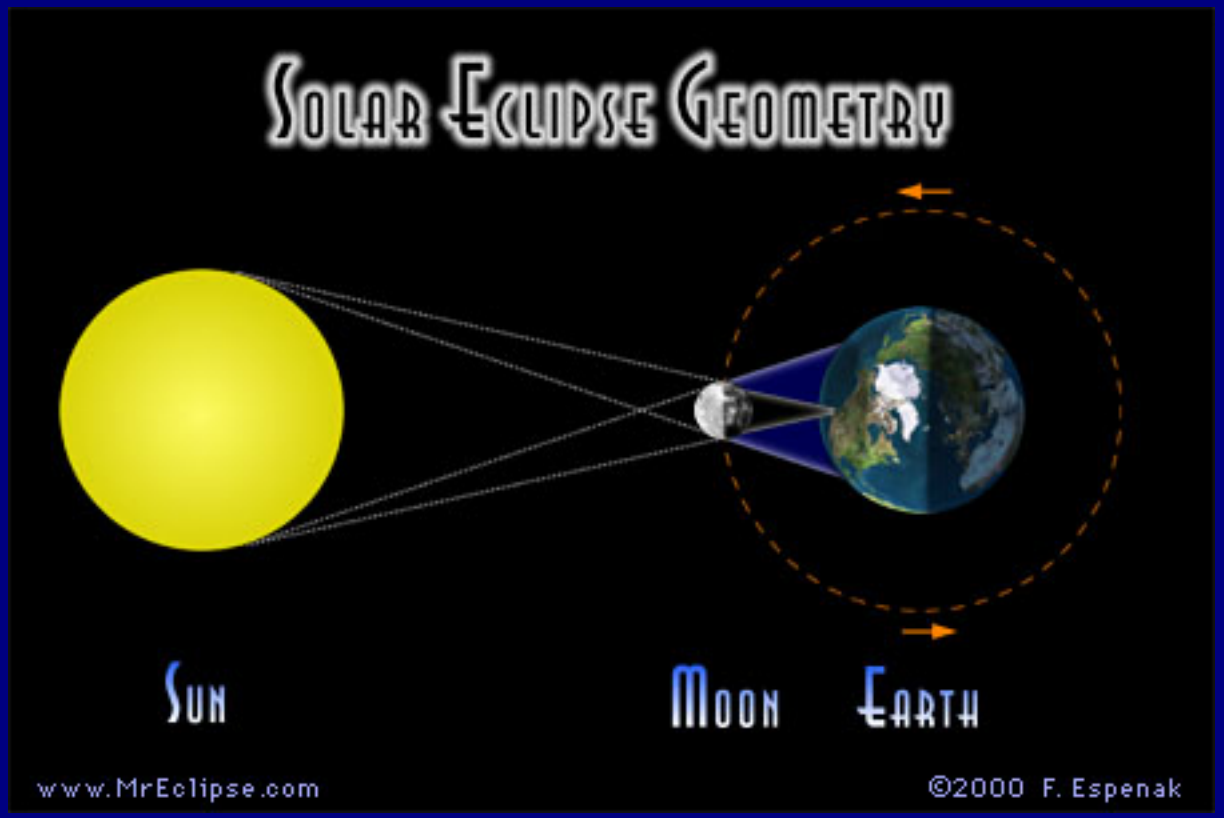


Saiph is B0
650 ly

Layers of the Sun

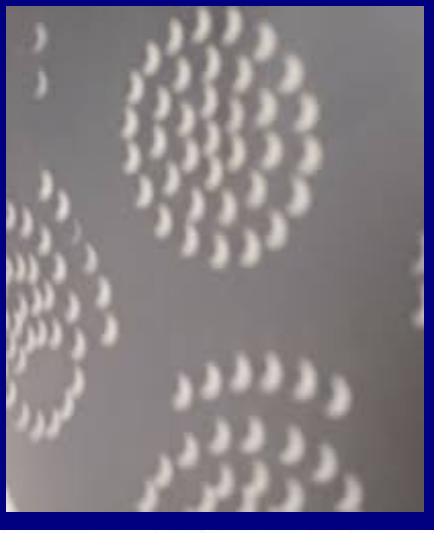


Solar Eclipses

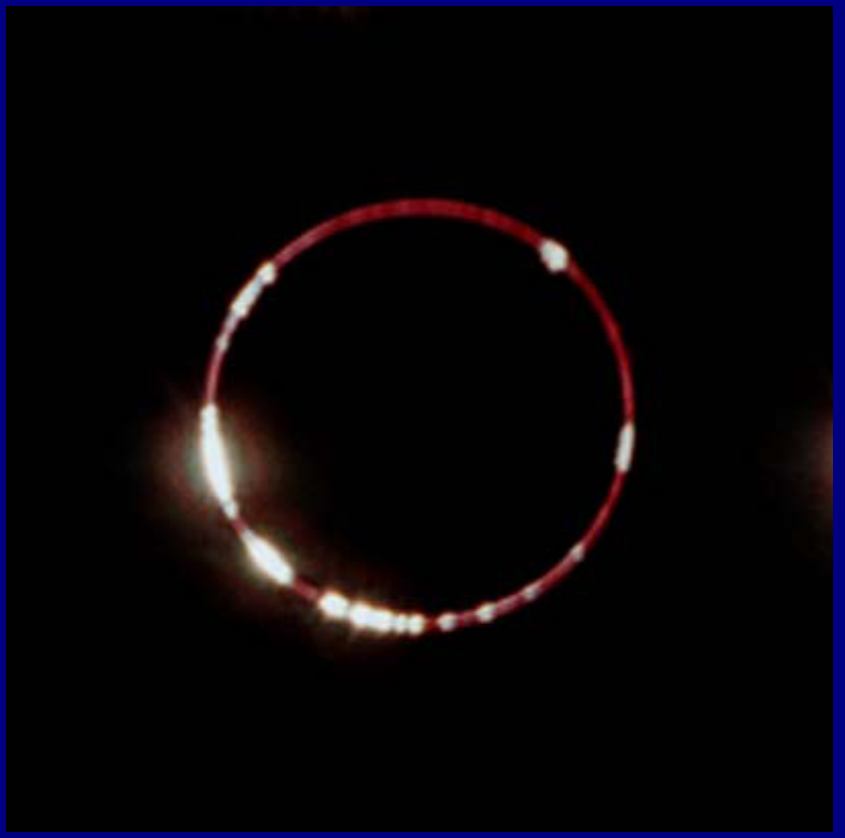


Images Used With Permission

Use a Kitchen Colander or Trees For Partial Phases



Total Eclipse: Diamond Ring and Bailey's Beads



What You Can See: Total Eclipse

Image Used With Permission

Zophia Edwards wide-angle view, from Jay Pasachoff's Eclipse 2013 page

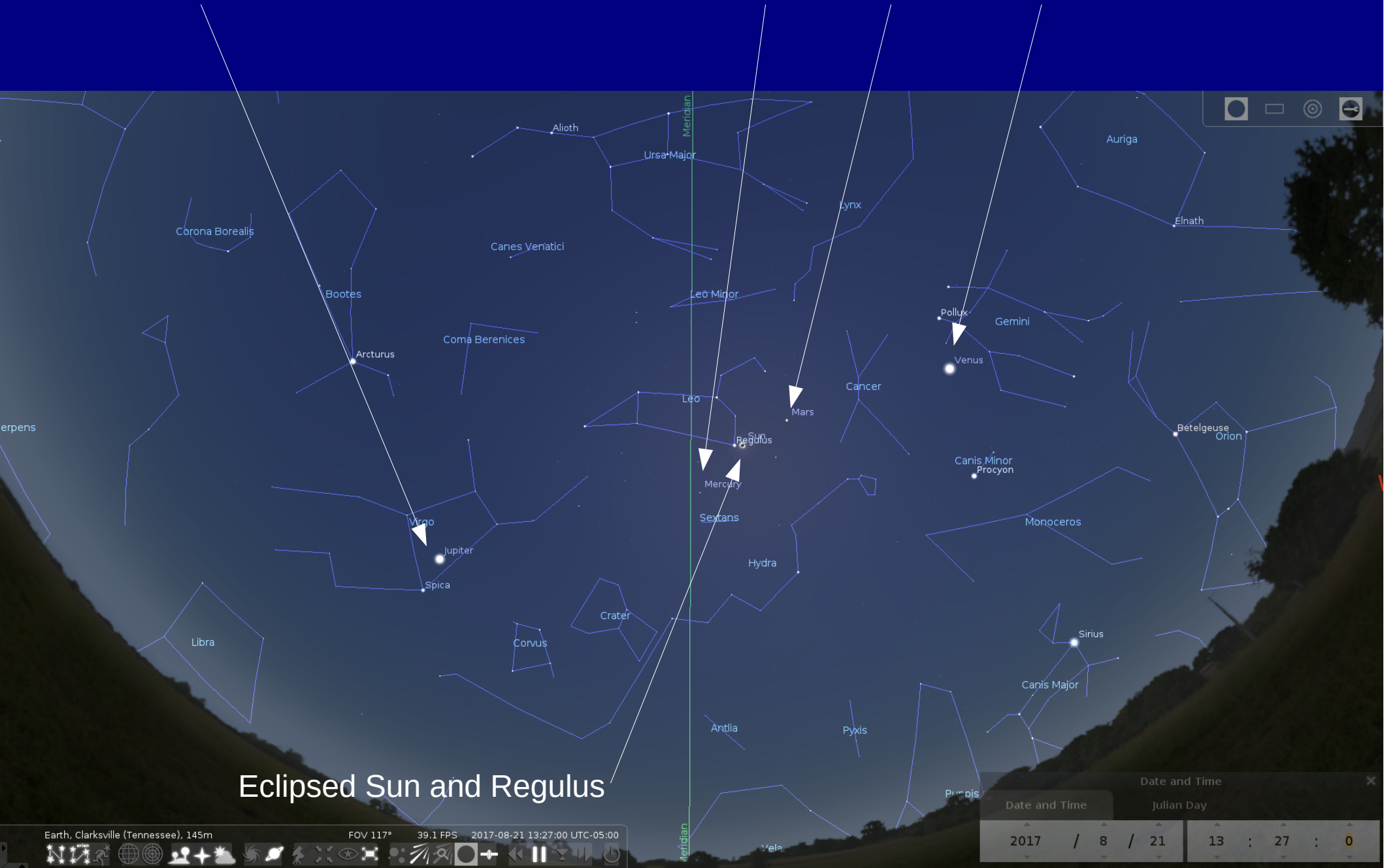
The Corona and Prominences

Rob Lucas, with Jay Pasachoff's 2013 Eclipse Expedition

Image Used With Permission

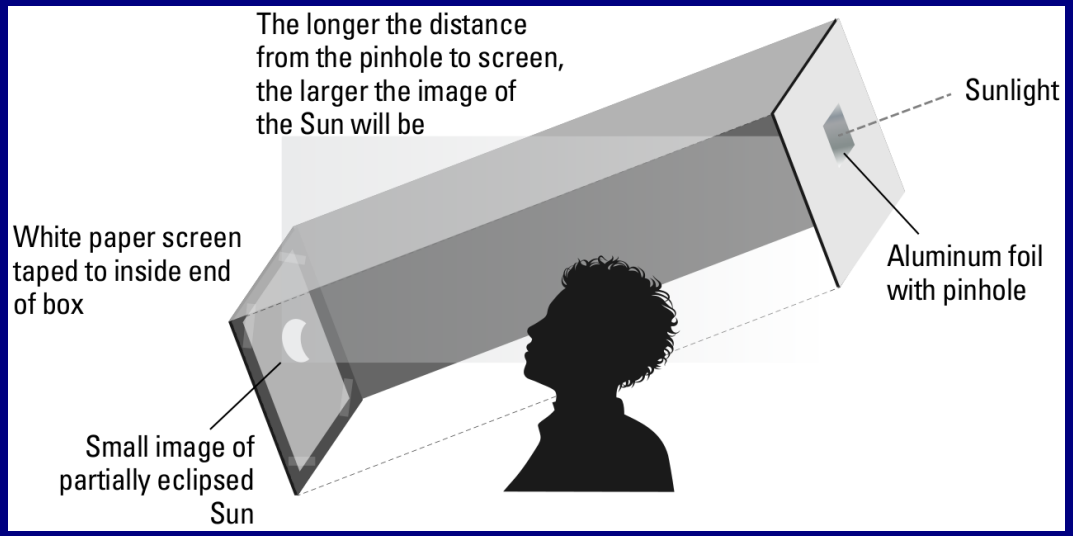
The Sky During Totality

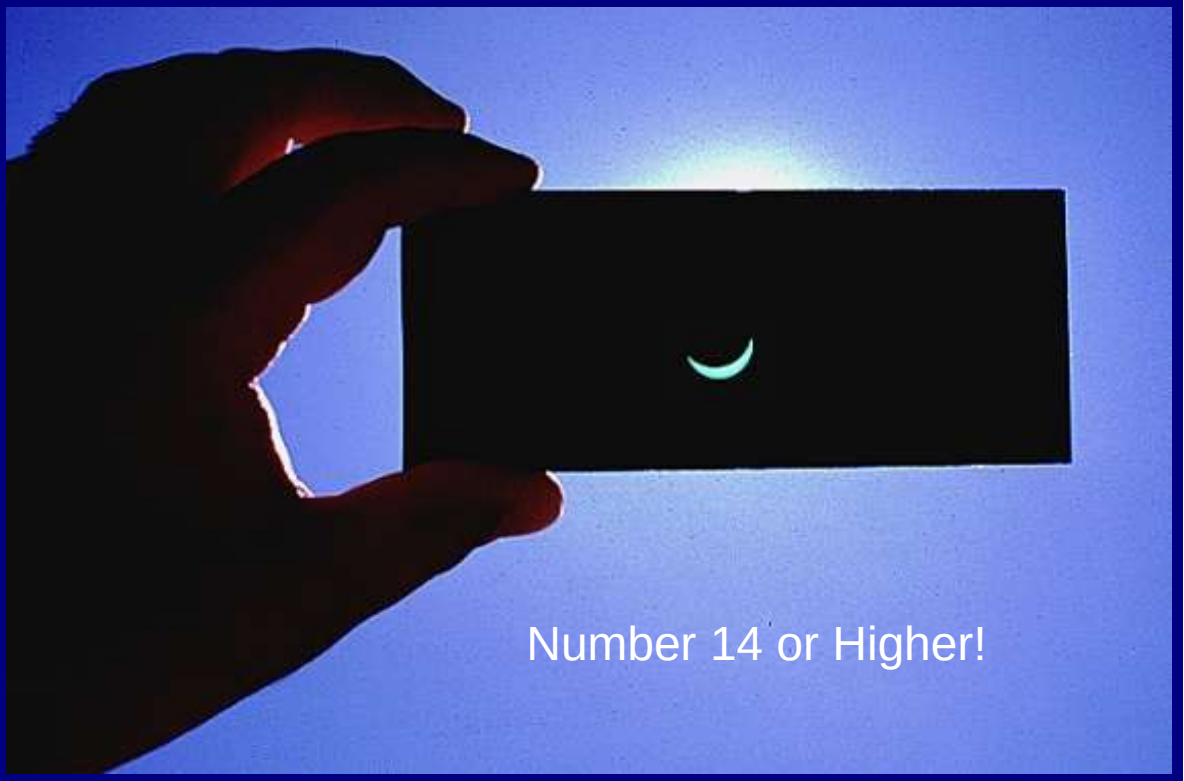
Jupiter is to the east of the Meridian (left), Mercury, Mars, and Venus to the west.



Safely Viewing an Eclipse

Projection, Special Telescope Filters, Eclipse Glasses, Number 14 Welder's Glass





More Information

http://www.astrosociety.org/tov/Build_a_Sun_Funnel2.pdf

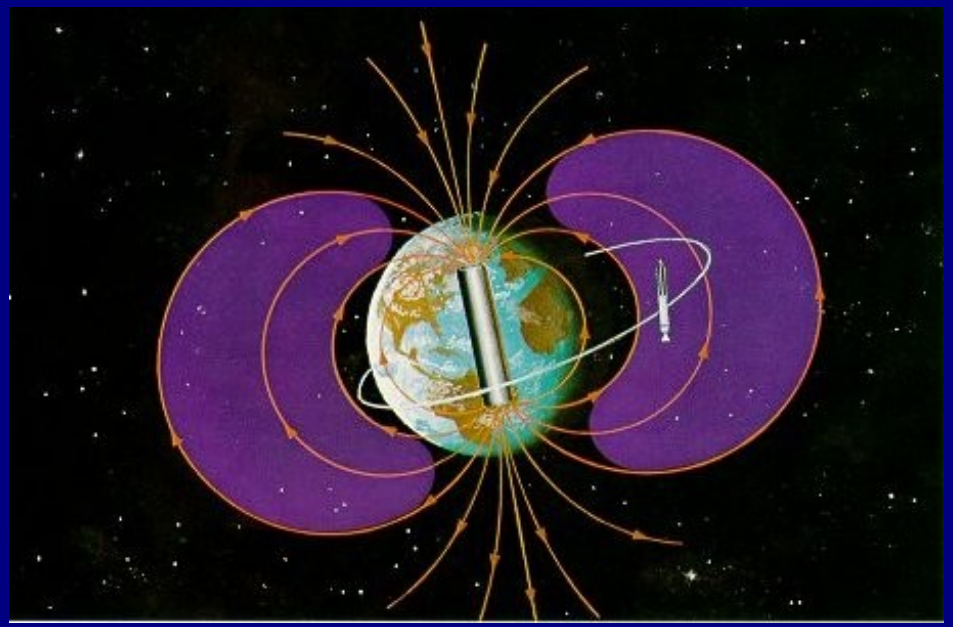
http://www.nasa.gov/offices/education/about/index.html

http://www.greatamericaneclipse.com/

http://eclipse.gsfc.nasa.gov/SEgoogle/SEgoogle2001/SE2017Aug21Tgoogle.html

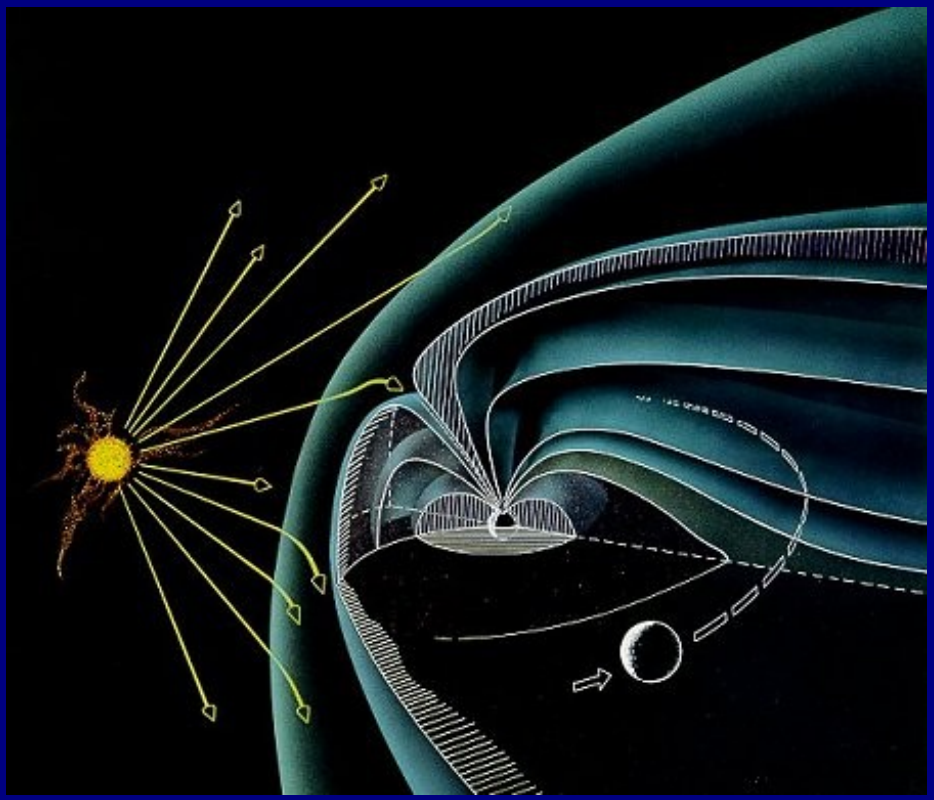
The Magnetosphere

From NASA's History Office
(https://history.nasa.gov/EP-177/ch3-4.html)

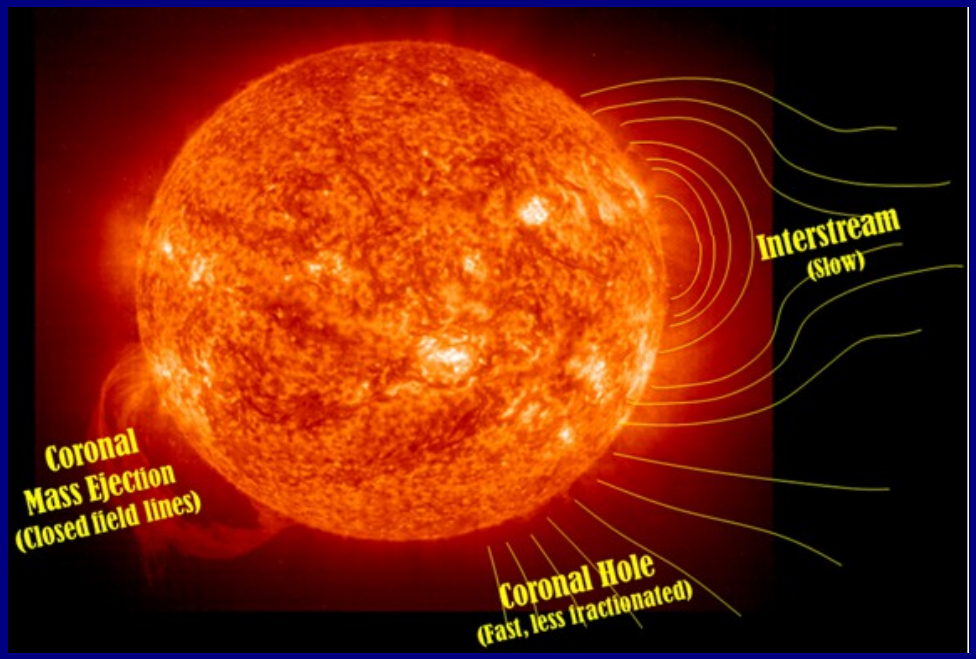


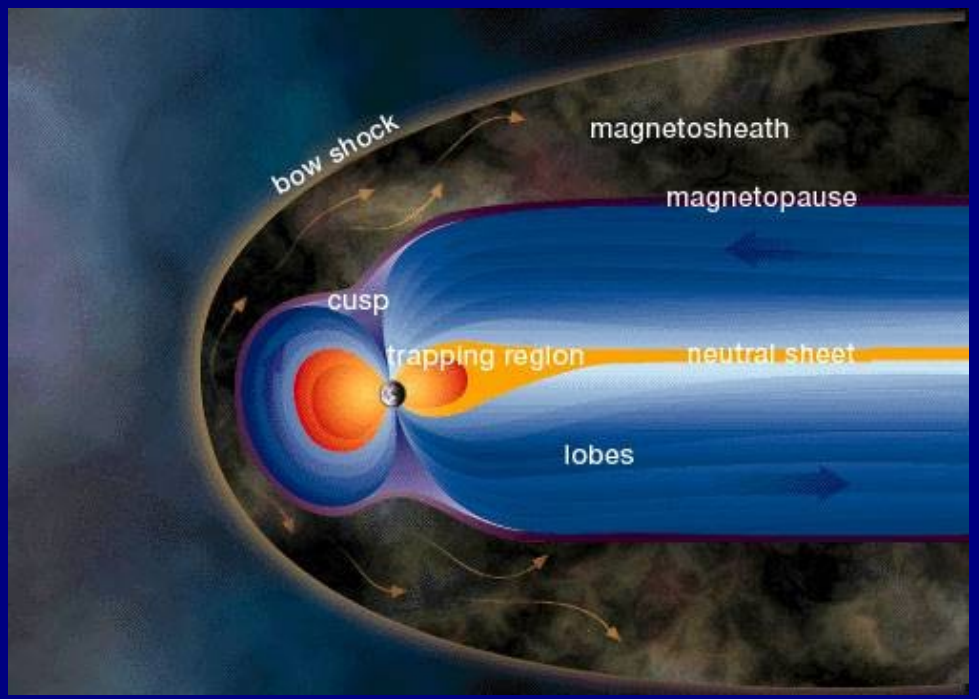
Explorer I (1958) discovered radiation belts, named for James Van Allen

Magnetosphere and Magnetotail

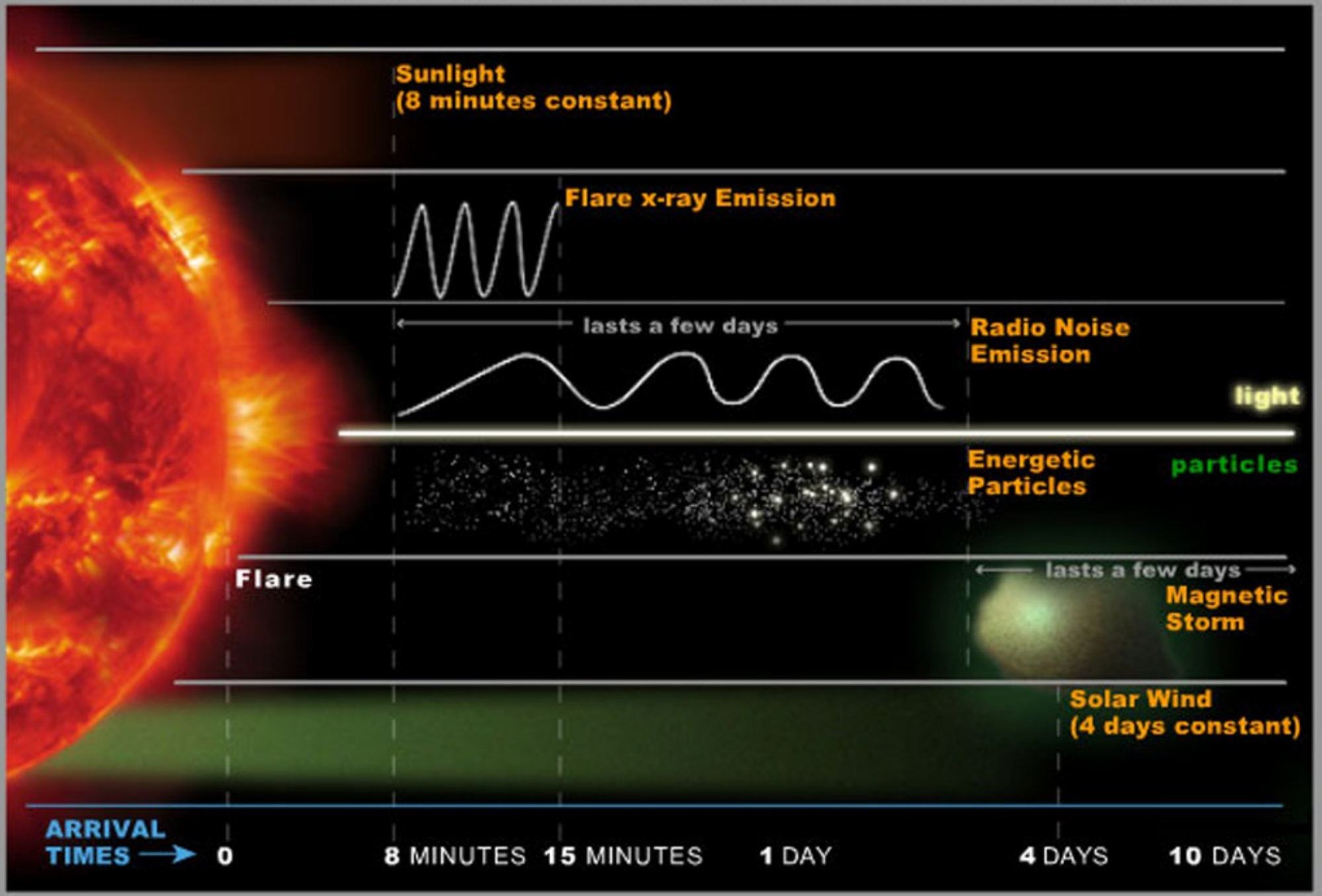


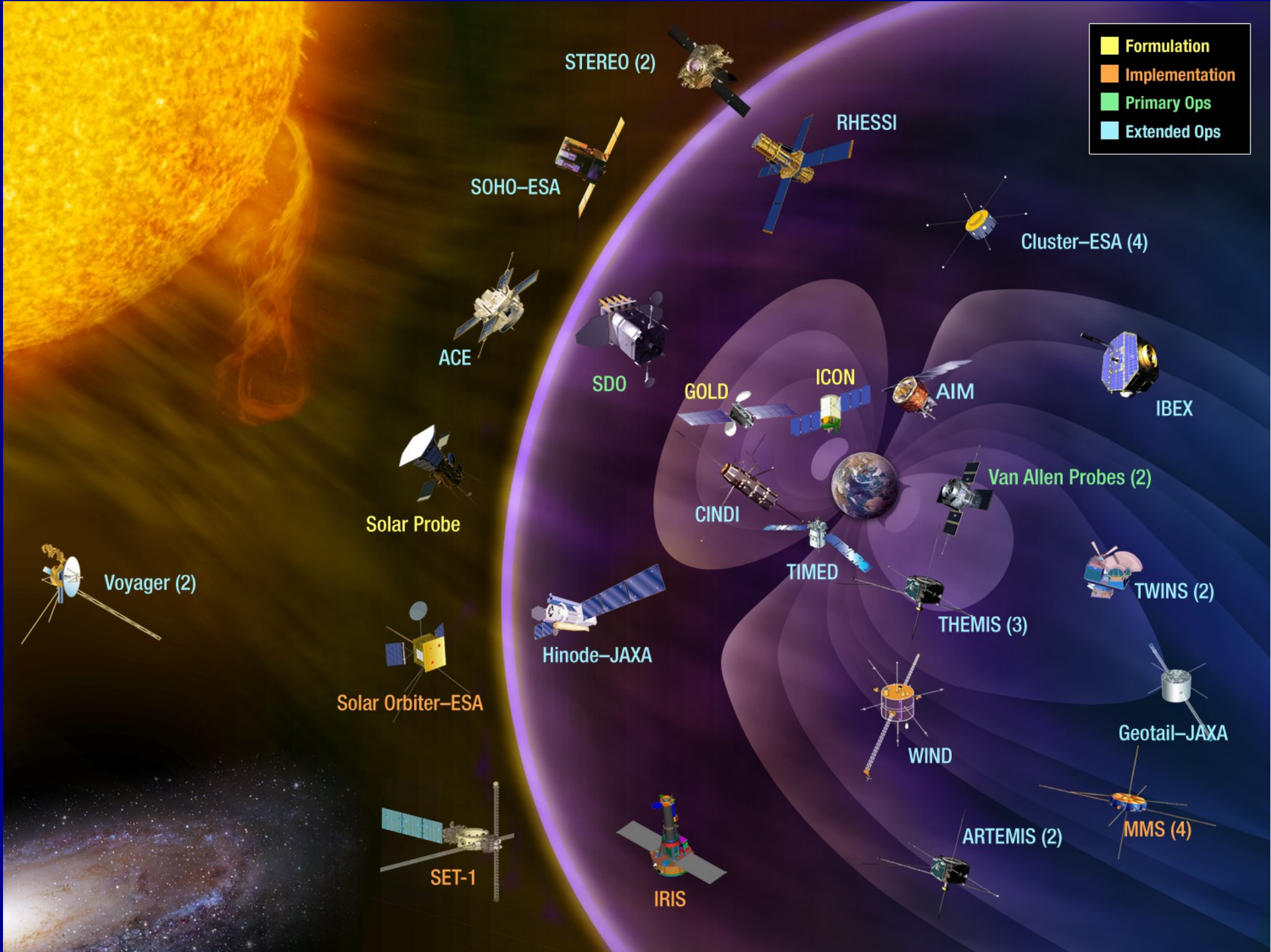
The Solar Wind Interacts with Earth's Magnetosphere





DYNAMIC AND CONSTANT SOLAR EFFECTS ON EARTH



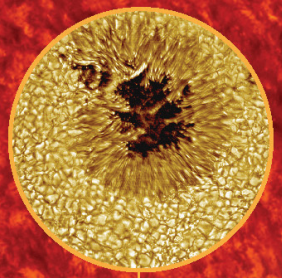

Formulation
Implementation
Primary Ops
Extended Ops
STEREO (2)
RHESSI
SOHO–ESA
Cluster–ESA (4)
ACE
SDO
GOLD
ICON
AIM
IBEX
Van Allen Probes (2)
CINDI
Solar Probe
TIMED
Voyager (2)
TWINS (2)
THEMIS (3)
Hinode–JAXA
Solar Orbiter–ESA
Geotail–JAXA
WIND
MMS (4)
ARTEMIS (2)
SET-1
IRIS

Space Weather

Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space-based and ground-based technological systems, as well as endanger life or health. Just like weather on Earth, space weather has its seasons, with solar activity rising and falling over an approximate 11 year cycle.

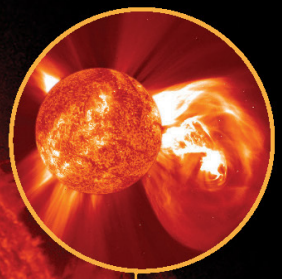
Sunspots

Sunspots are comparatively cool areas at up to 7,700° F and show the location of strong magnetic fields protruding through what we would see as the Sun's surface. Large, complex sunspot groups are generally the source of significant space weather.



Coronal Mass Ejections (CMEs)

Large portions of the corona, or outer atmosphere of the Sun, can be explosively blown into space, sending billions of tons of plasma, or superheated gas, Earth's direction. These CMEs have their own magnetic field and can slam into and interact with Earth's magnetic field, resulting in geomagnetic storms. The fastest of these CMEs can reach Earth in under a day, with the slowest taking 4 or 5 days to reach Earth.



Solar Wind

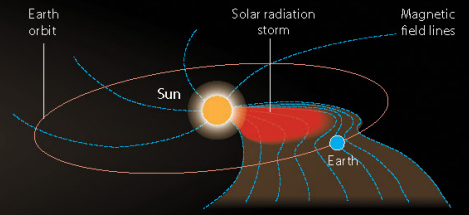
The solar wind is a constant outflow of electrons and protons from the Sun, always present and buffeting Earth's magnetic field. The background solar wind flows at approximately one million miles per hour!

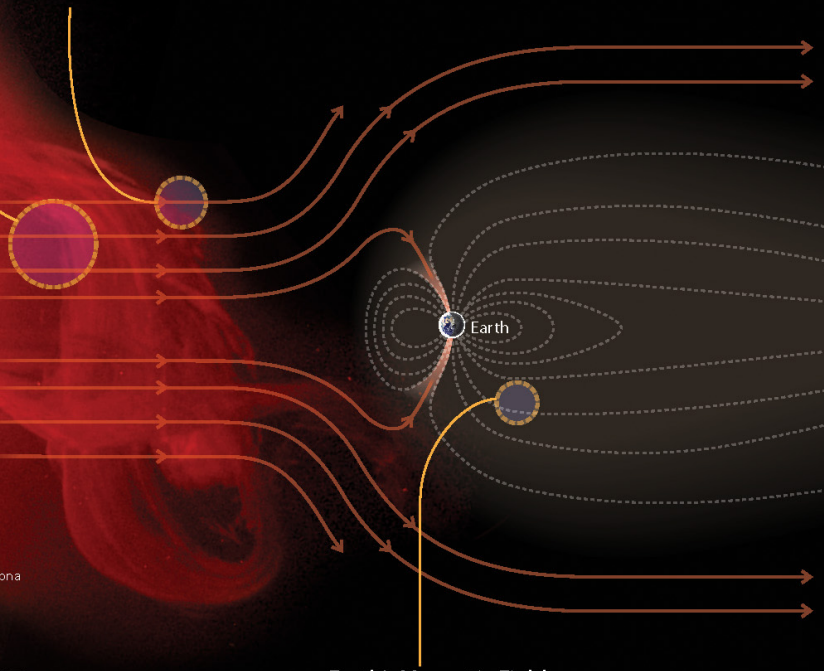
Sun's Magnetic Field

Strong and ever-changing magnetic fields drive the life of the Sun and underlie sunspots. These strong magnetic fields are the energy source for space weather and their twisting, shearing, and reconnection lead to solar flares.

Solar Radiation Storms

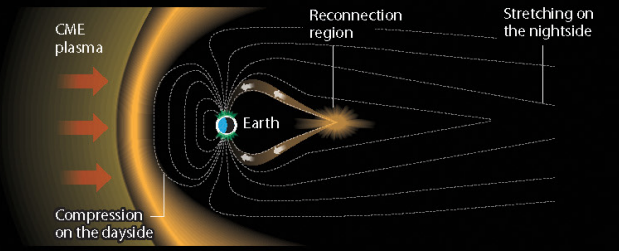
Charged particles, including electrons and protons, can be accelerated by coronal mass ejections and solar flares. These particles bounce and gyrate their way through space, roughly following the magnetic field lines and ultimately bombarding Earth from every direction. The fastest of these particles can affect Earth tens of minutes after a solar flare.





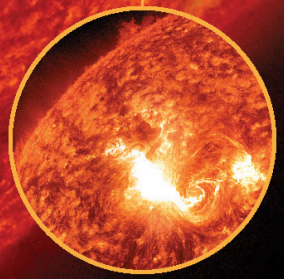
Geomagnetic Storms

A geomagnetic storm is a temporary disturbance of Earth's magnetic field typically associated with enhancements in the solar wind. These storms are created when the solar wind and its magnetic field interacts with Earth's magnetic field. The primary source of geomagnetic storms is CMEs which stretch the magnetosphere on the nightside causing it to release energy through magnetic reconnection. Disturbances in the ionosphere (a region of Earth's upper atomosphere) are usually associated with geomagnetic storms.



Solar Flares

Reconnection of the magnetic fields on the surface of the Sun drive the biggest explosions in our solar system. These solar flares release immense amounts of energy and result in electromagnetic emissions spanning the spectrum from gamma rays to radio waves. Traveling at the speed of light, these emissions make the 93 million mile trip to Earth in just 8 minutes.

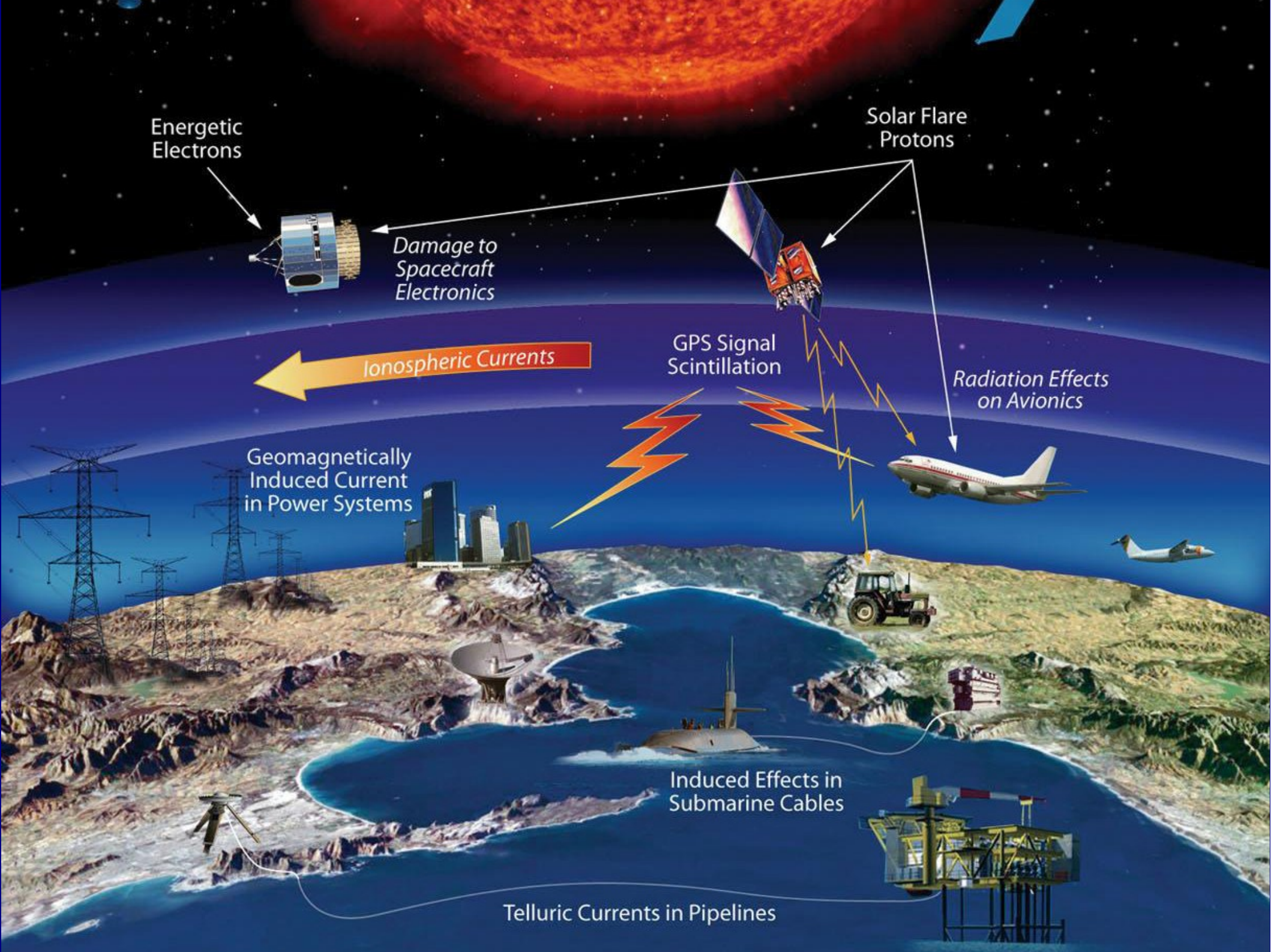


Earth's Magnetic Field

Earth's magnetic field, largely like that of a bar magnet, gives the Earth some protection from the effects of the Sun. Earth's magnetic field is constantly compressed on the day side and stretched on the night side by the ever-present solar wind. During geomagnetic storms, the disturbances to Earth's magnetic field can become extreme. In addition to some buffering by the atmosphere, this field also offers some shielding from the charged particles of a radiation storm.

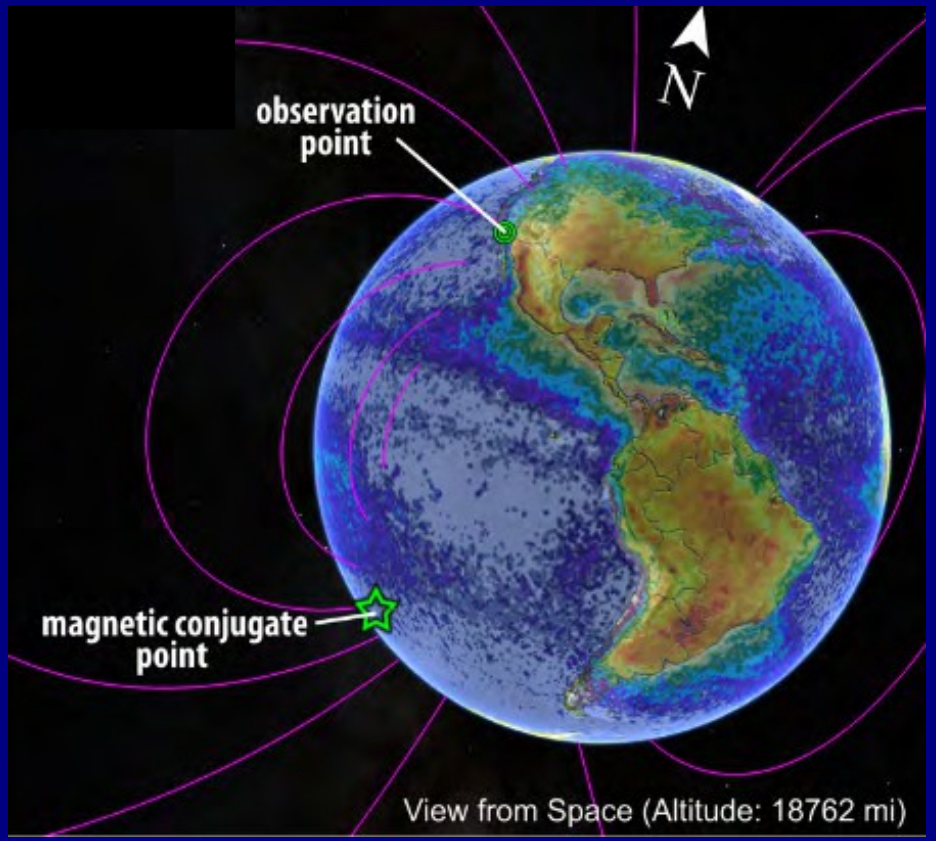
NOAA Space Weather Prediction Center – www.spaceweather.gov

Source images: NASA, NOAA.


Energetic Electrons
Solar Flare Protons
Damage to Spacecraft Electronics
Ionospheric Currents
GPS Signal Scintillation
Radiation Effects on Avionics
Geomagnetically Induced Current in Power Systems
Induced Effects in Submarine Cables
Telluric Currents in Pipelines

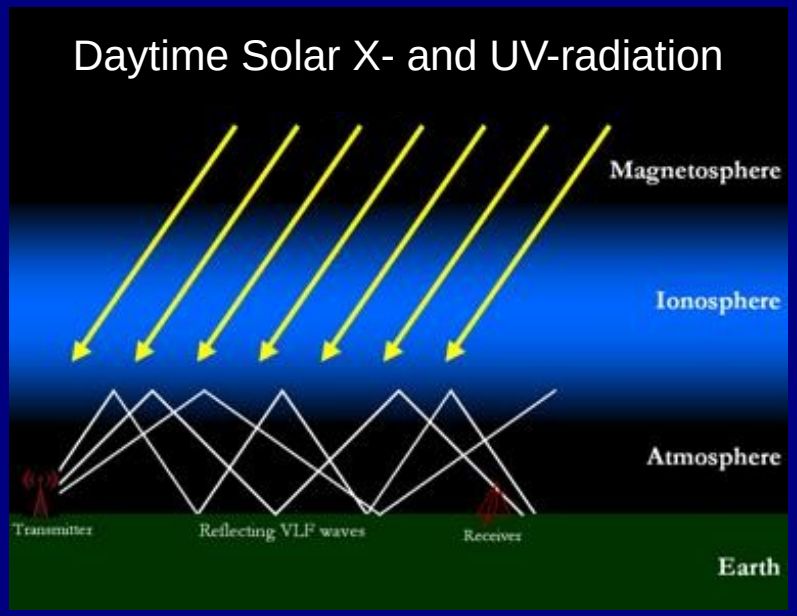
The INSPIRE Project provides creative hands-on opportunities for students of all ages to observe Very Low Frequency waves (i.e. lightning and other atmospheric sounds) by using the INSPIRE VLF-3 Natural Radio Sound Receiver.

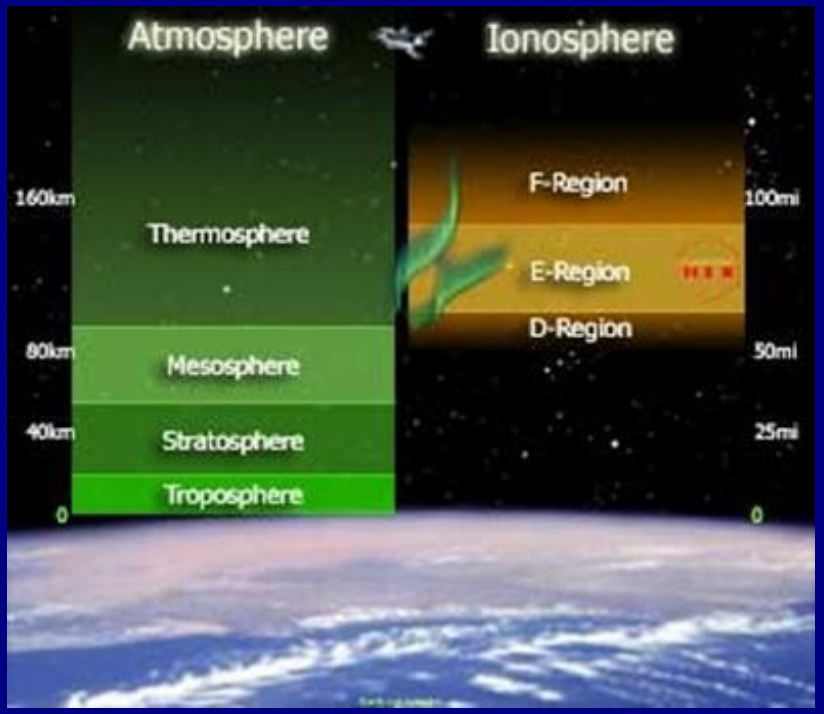
INSPIRE
INTERACTIVE NASA SPACE PHYSICS IONOSPHERE RADIO EXPERIMENTS

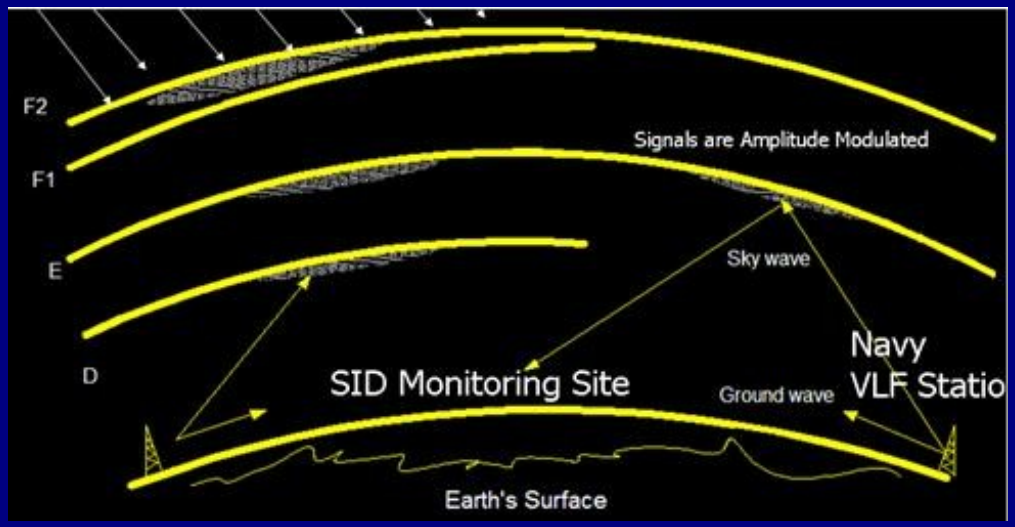


WAV File!

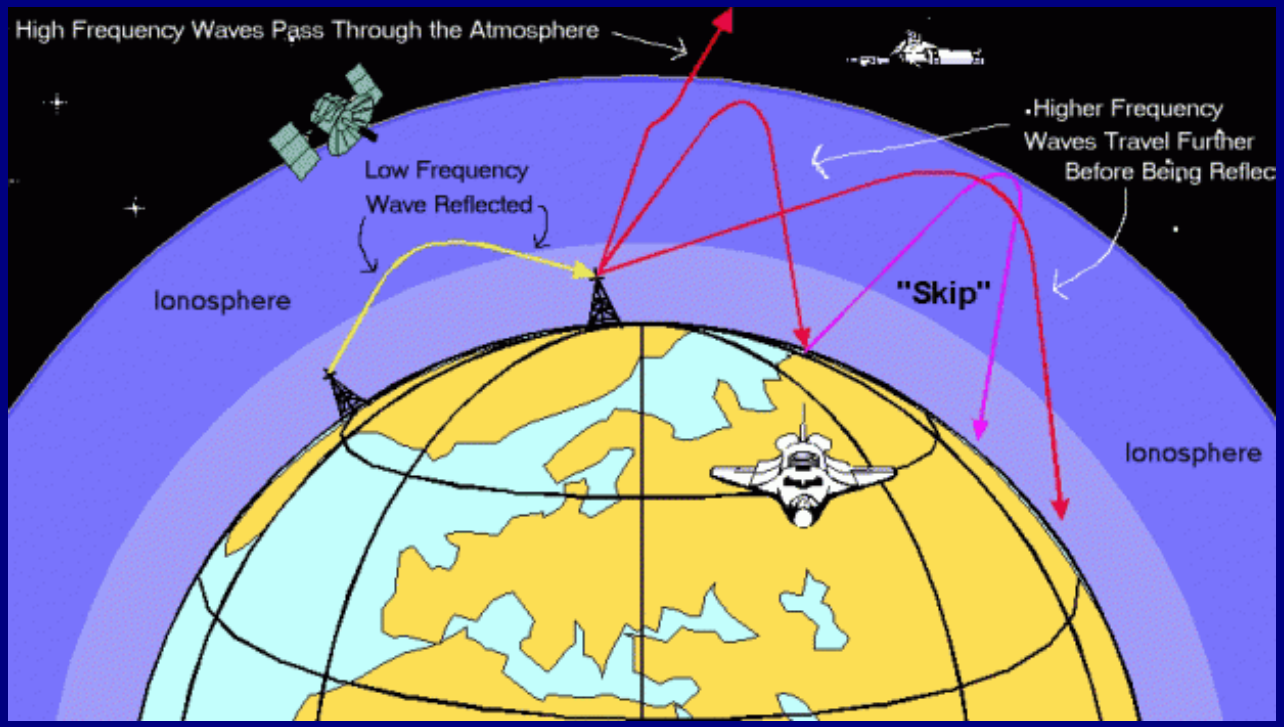
The Ionosphere

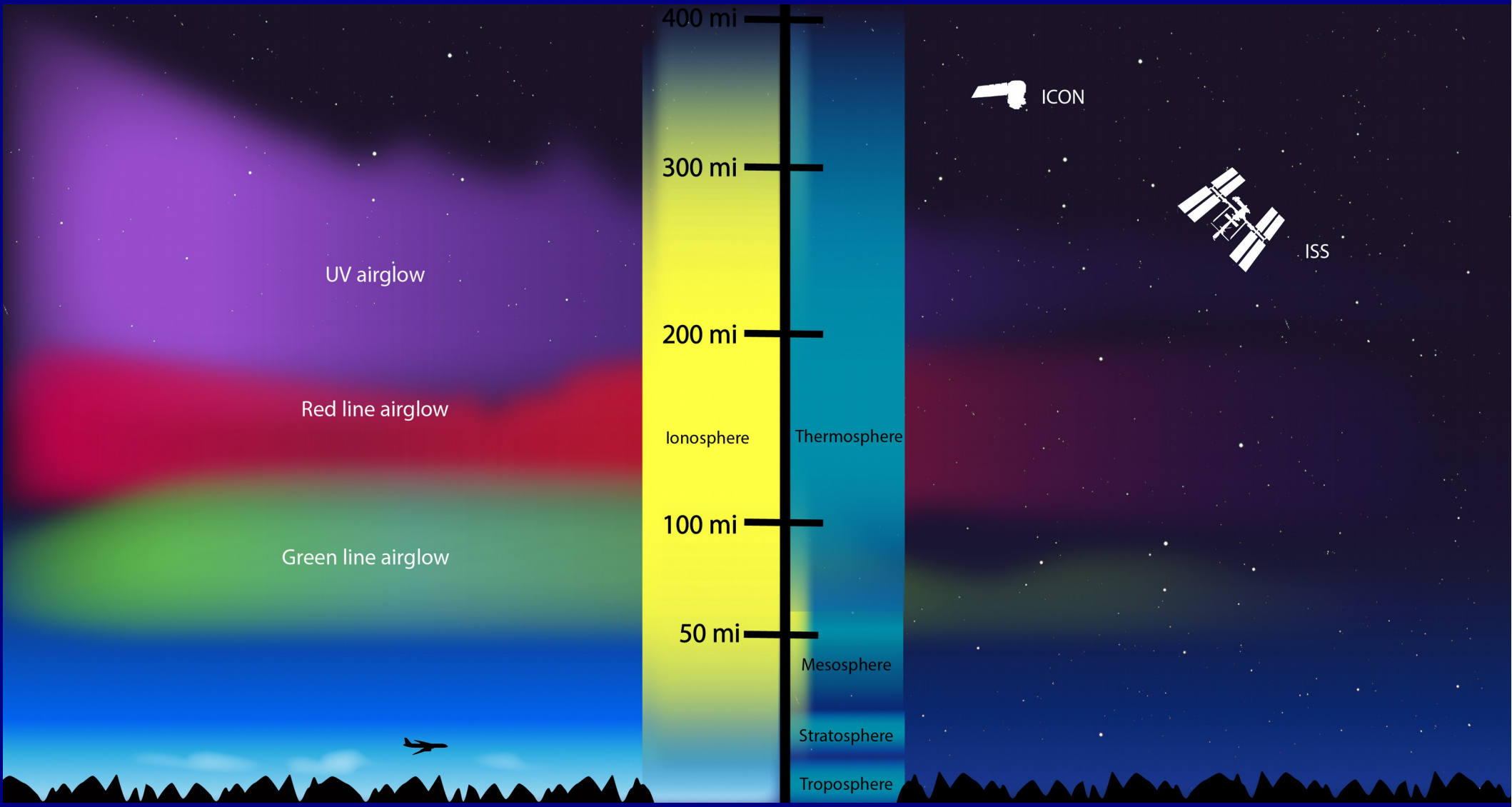






At night (on right), ions recombine, ionosphere has only F and E layers, transmitted radio signals travel higher before bouncing, so can be received at larger distances.


High Frequency Waves Pass Through the Atmosphere
Higher Frequency
Waves Travel Further
Before Being Reflec
Low Frequency
Wave Reflected
Ionosphere
"Skip"
Ionosphere


400 mi
300 mi
200 mi
100 mi
50 mi
ICON
ISS
UV airglow
Red line airglow
Green line airglow
Ionosphere
Thermosphere
Mesosphere
Stratosphere
Troposphere