



Earth's Magnetic $F(\text{Sh})$ ield

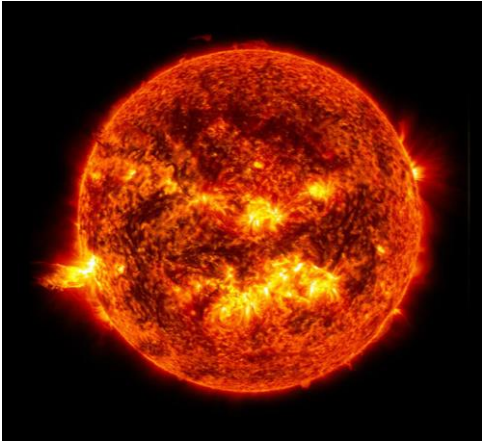
Cristian Ferradas

*NASA Goddard Space Flight Center
Catholic University of America*

NASA@ My Library
November 20, 2024

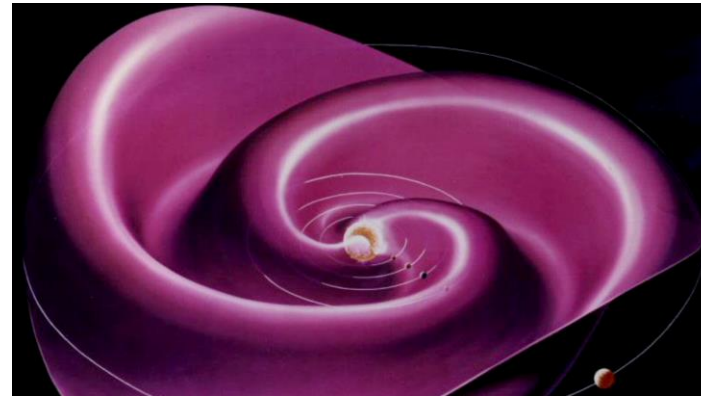
Which fact about space is your favorite?

1. Sun's State



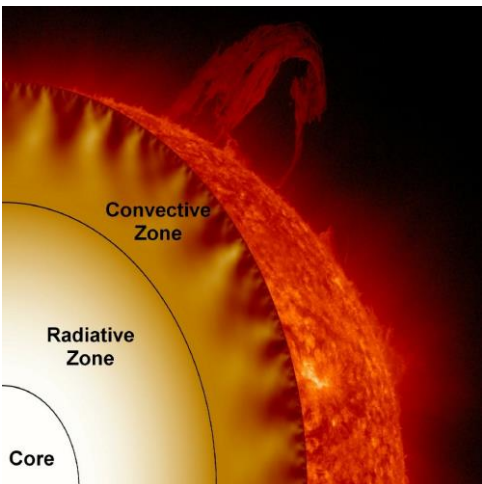
Even though we usually learn that there are 3 states of matter: solid, liquid, and gas, **99.9% of the observable universe** is in the fourth state: plasma (the Sun's state).

2. Sun's Magnetic Field



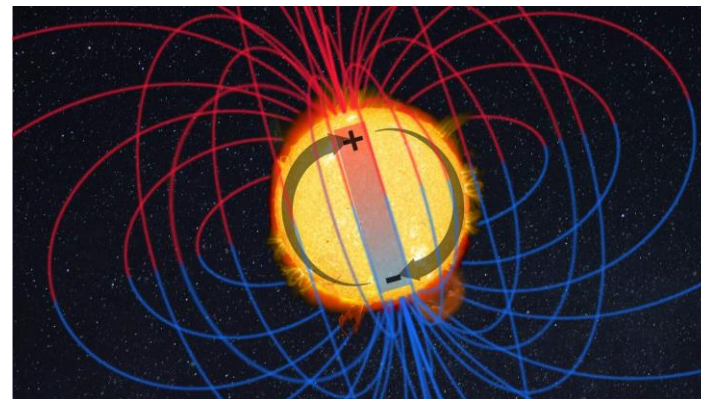
The Sun's magnetic field, which fills the entire solar system, **looks like a spiral**. This is due to the rotation of the Sun.

3. Sun's Core



The Sun's core is the only place in our solar system where temperature and density conditions are high enough for **nuclear fusion to occur naturally**.

4. Sun's Magnetic Poles



The Sun's magnetic field goes through an 11-year solar cycle, during which its magnetic field **completely flips**—the Sun's north and south poles switch places.

A bit about me



I was born and raised in Lima, Peru.


I moved to the US to study in graduate school at the University of New Hampshire in Durham, NH.

My first job was at the Los Alamos National Laboratory in Los Alamos, NM.

Now, I work at NASA Goddard Space Flight Center, and I love doing outreach sharing the science that I study!



Discussion Question



In what ways are you incorporating Heliophysics content into your library programs?

Earth's Magnetic F(Sh)ield

Its Shape

What defines it?

As a Shield

Shield from what?

Its Effects

Are they good or bad?

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Shield from what?

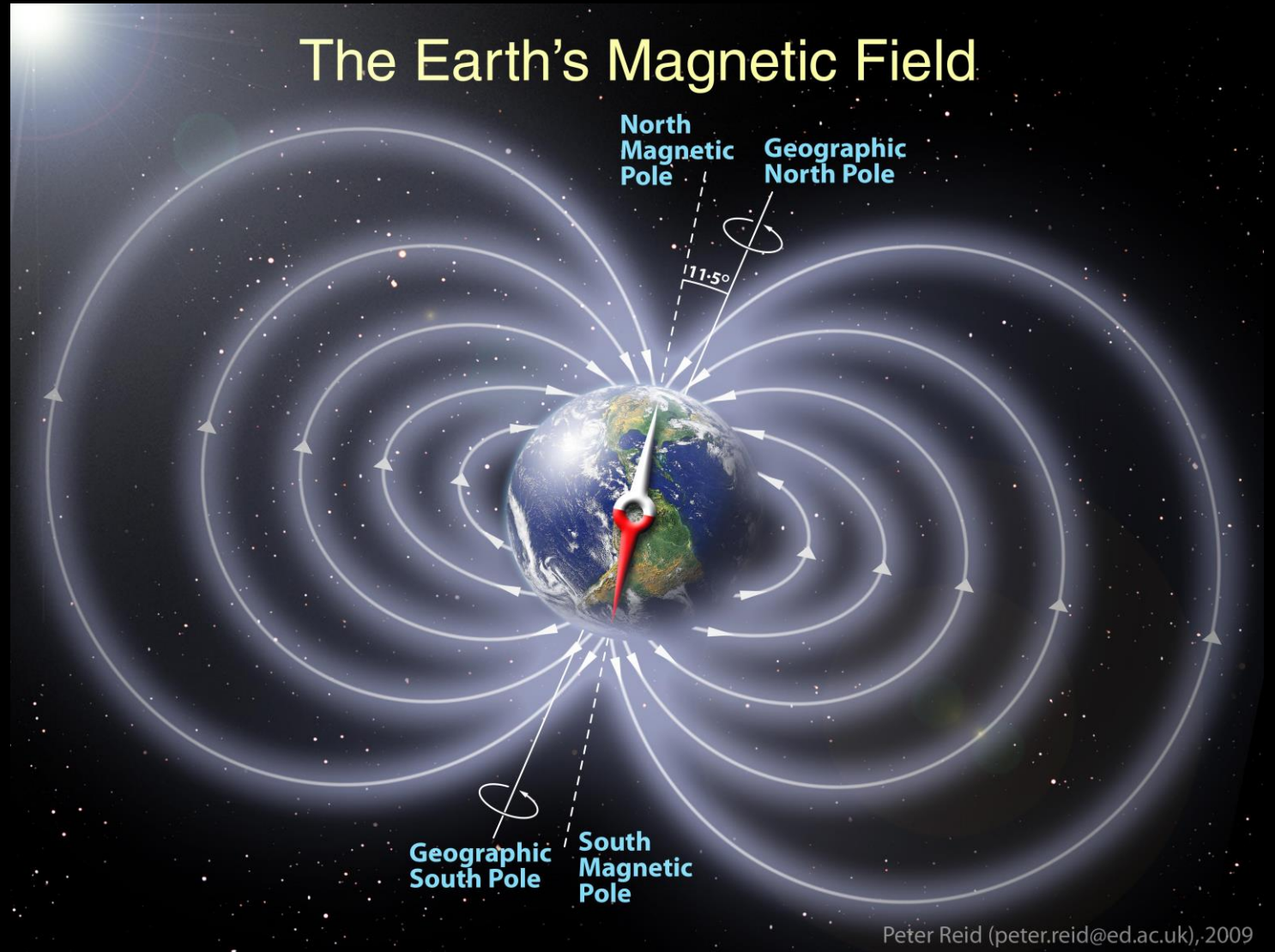
Its Effects

Are they good or bad?

Its Shape

The Earth is a giant magnet.

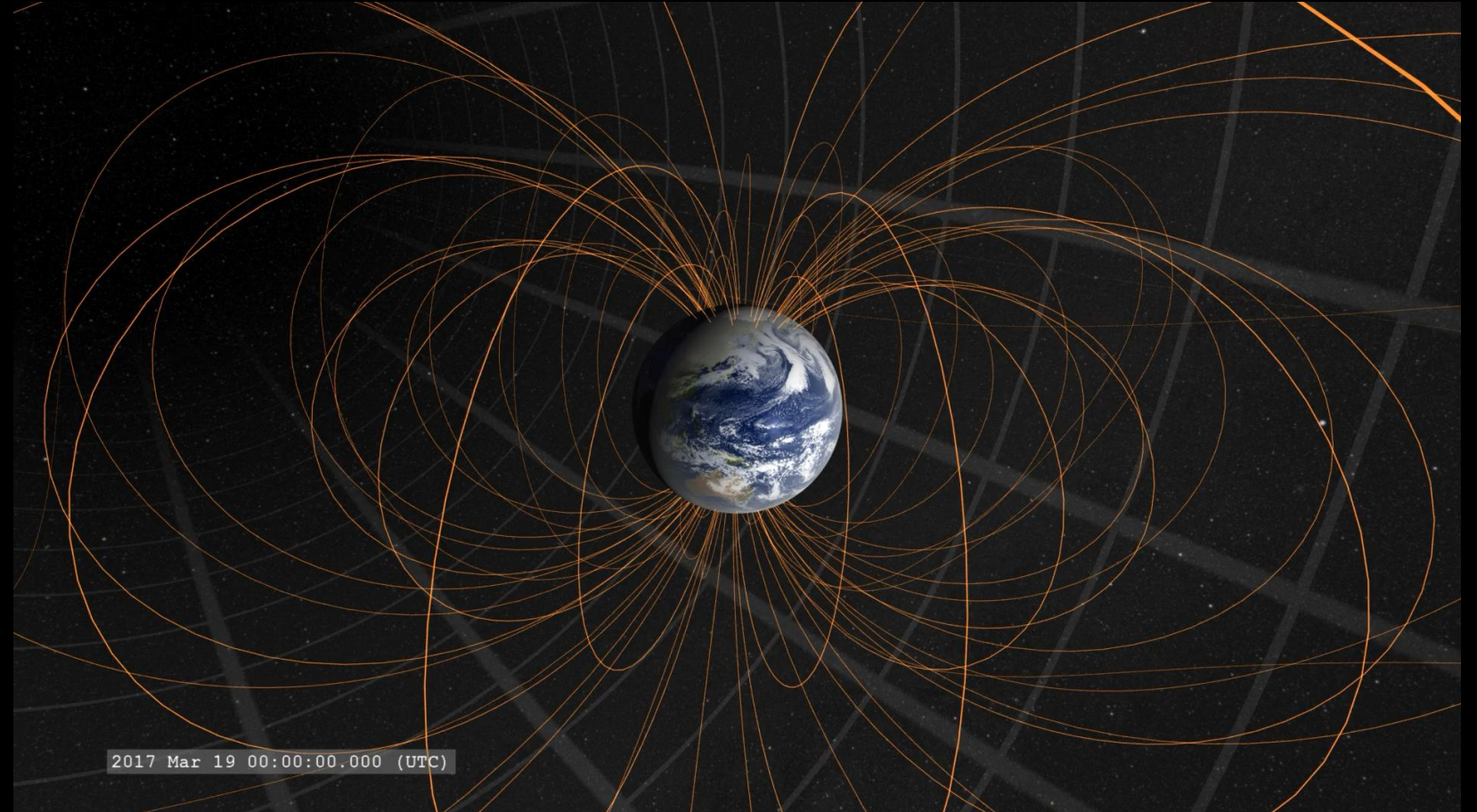
Magnetic field lines in 2D



Its Shape

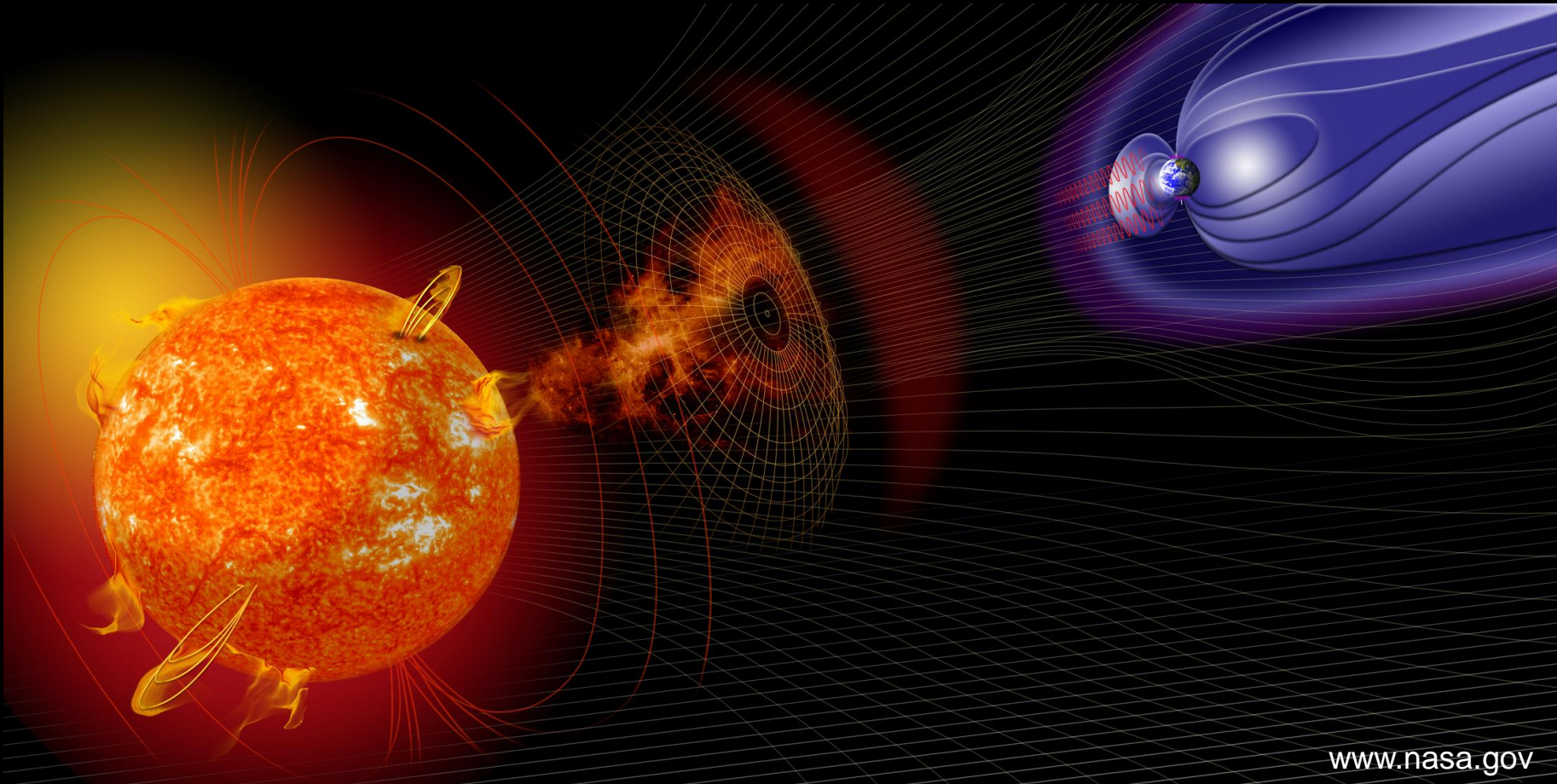
The Earth is a giant magnet.

Magnetic field lines in 3D... if space were empty.



Its Shape

But space is not empty! A “wind” from the sun called the “solar wind” is constantly blowing and shaping the Earth’s magnetic field.



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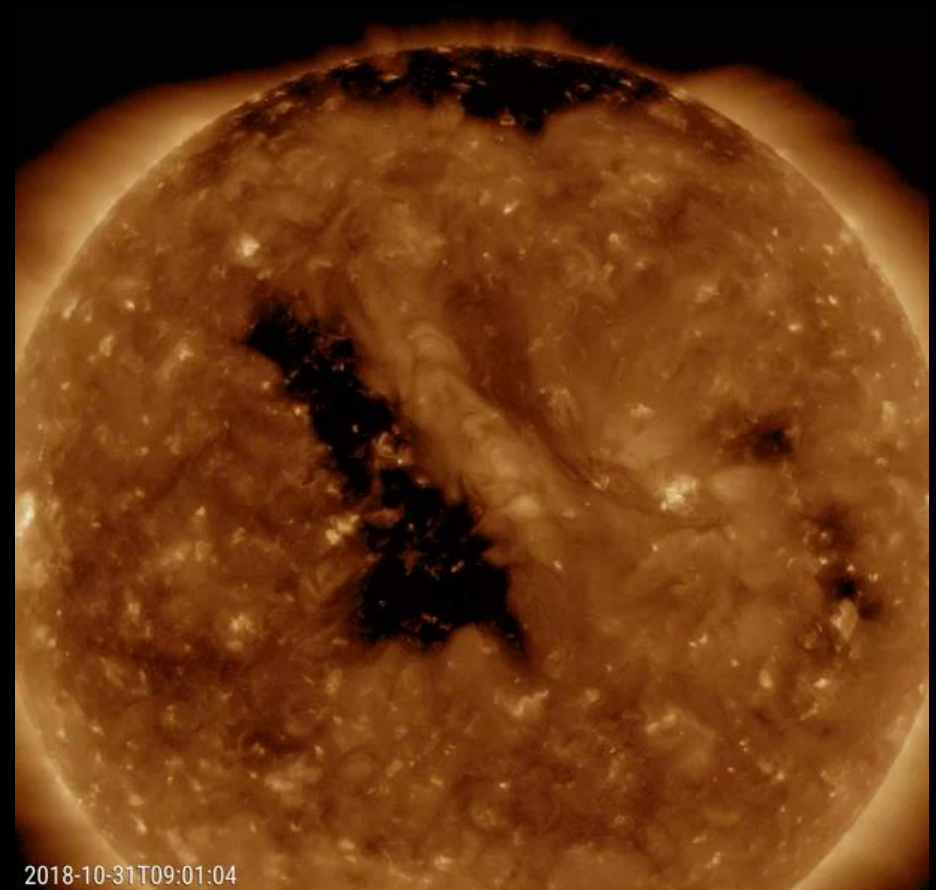
Are they good or bad?

As a Shield

Two predominant features of solar activity:

Active Regions

Coronal Holes



As a Shield

Two predominant features of solar activity:

Active Regions

Places where the Sun's magnetic field is disturbed.

Bright regions in EUV images.

- *Solar Flares*
- *Coronal Mass Ejections (CMEs)*
- *Visible light/UV/EUV/FUV/X-ray*

Can lead to CME-driven geomagnetic storms.

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Coronal Holes

Regions of cooler, less dense plasma than the surrounding plasma and of open, unipolar magnetic fields.

Dark regions in EUV images.

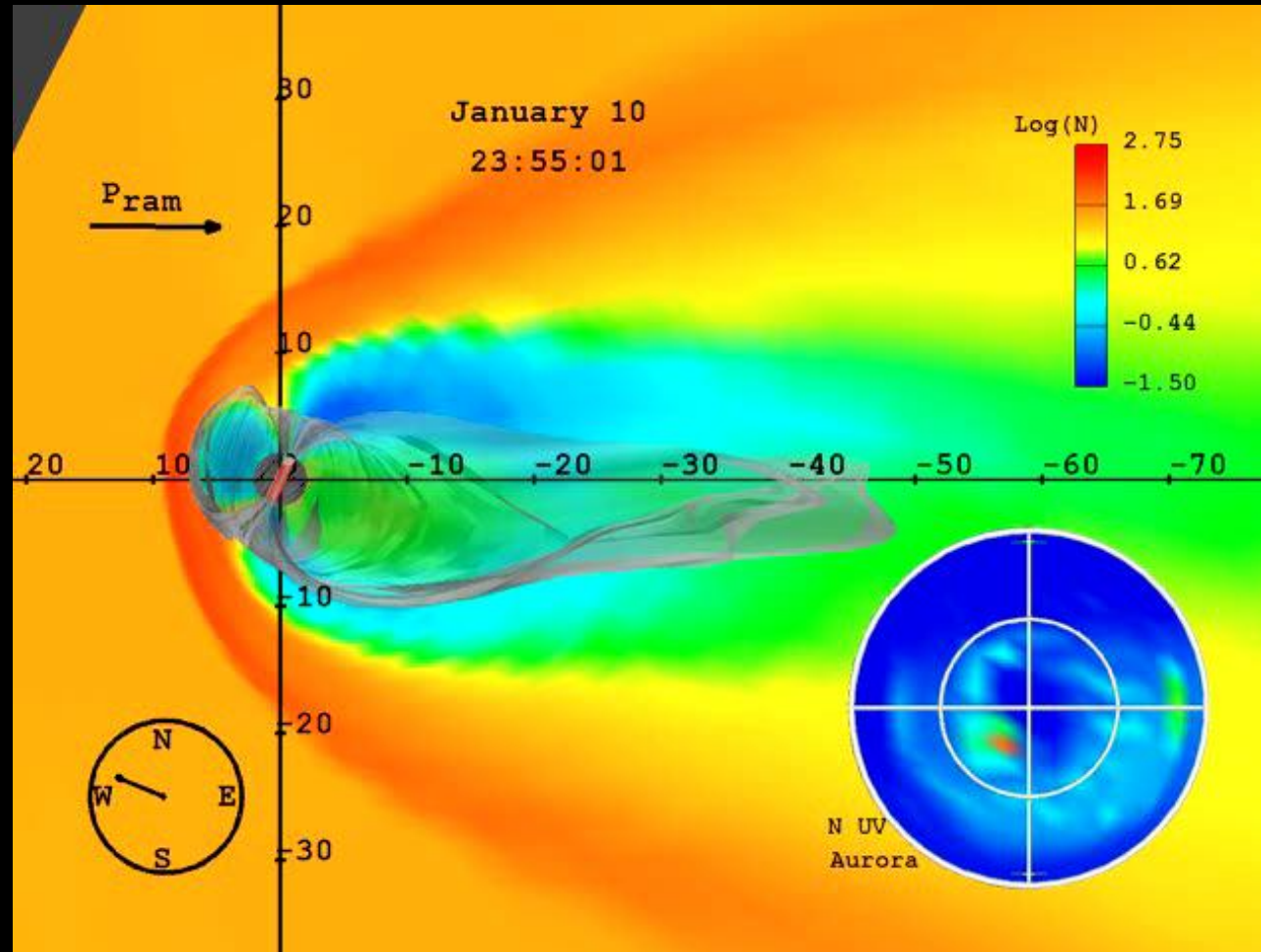
- *High Speed Streams (HSSs)*

Can lead to CIR-driven geomagnetic storms.

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As a Shield

A geomagnetic storm is a temporary disturbance of the Earth's magnetic field caused by a solar wind shock.

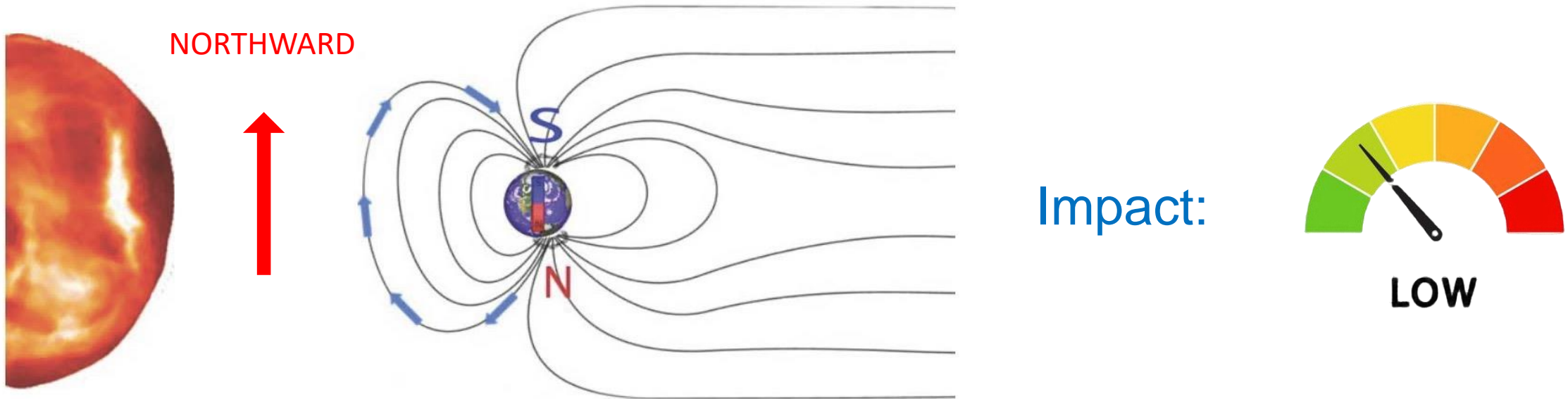


Charles C. Goodrich
University of Maryland,
Space and Plasma Physics Group

As a Shield

The magnitude of a geomagnetic storm is in part determined by the **strength** and **direction** of the solar wind's magnetic field:

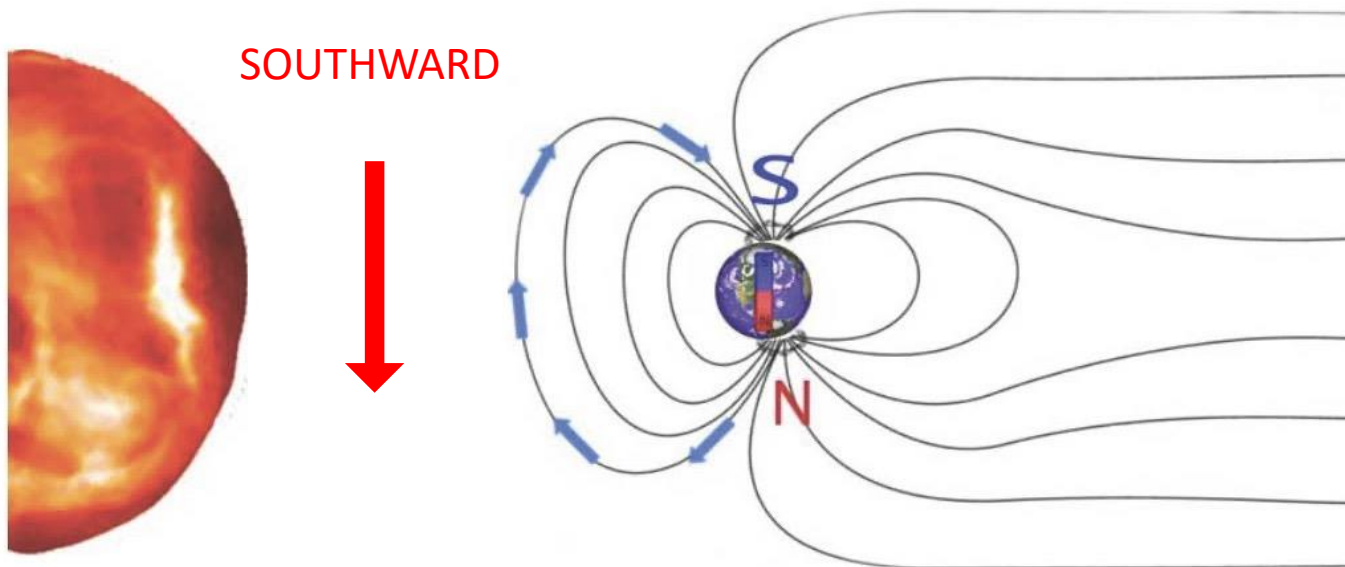
A **northward** solar wind magnetic field does not interact or “reconnect” with the Earth's magnetic field.



As a Shield

The magnitude of a geomagnetic storm is in part determined by the **strength** and **direction** of the solar wind's magnetic field:

A **large** and **southward** solar wind magnetic field interacts or “reconnects” with the Earth's magnetic field in such a way that produces a strong storm.



Impact:



HIGH

“Geomagnetic storm”

Earth's Magnetic F(Sh)ield

Its Shape

What defines it?

As a Shield

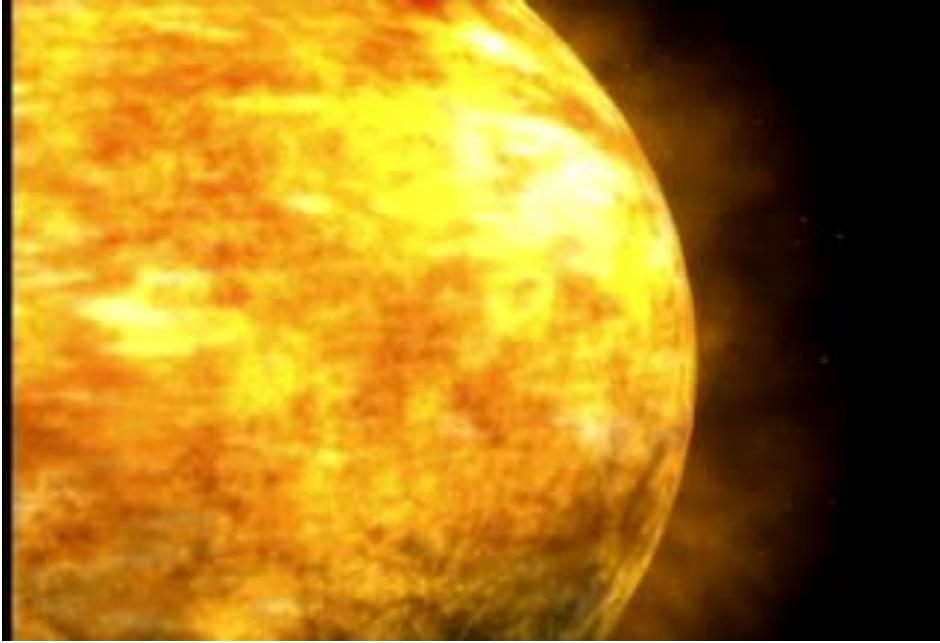
Shield from what?

Its Effects

Are they good or bad?

Its Effects

Good Space Weather: When Space Weather is Beautiful



Its Effects

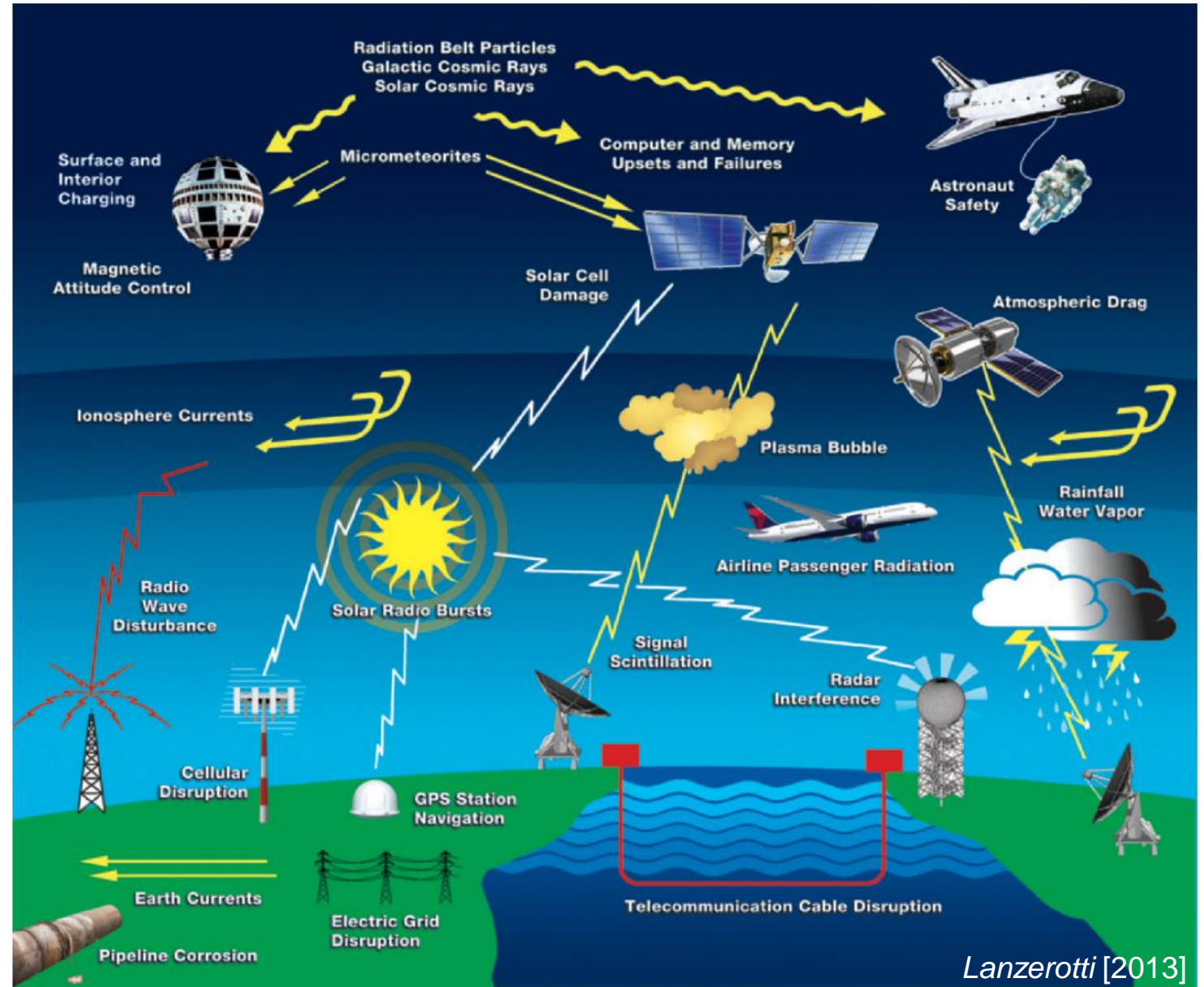
Good Space Weather: When Space Weather is Beautiful



Its Effects

Bad Space Weather: When Space Weather is Harmful

Solar activity can have significant impacts on communications, satellites, astronauts, and animals.



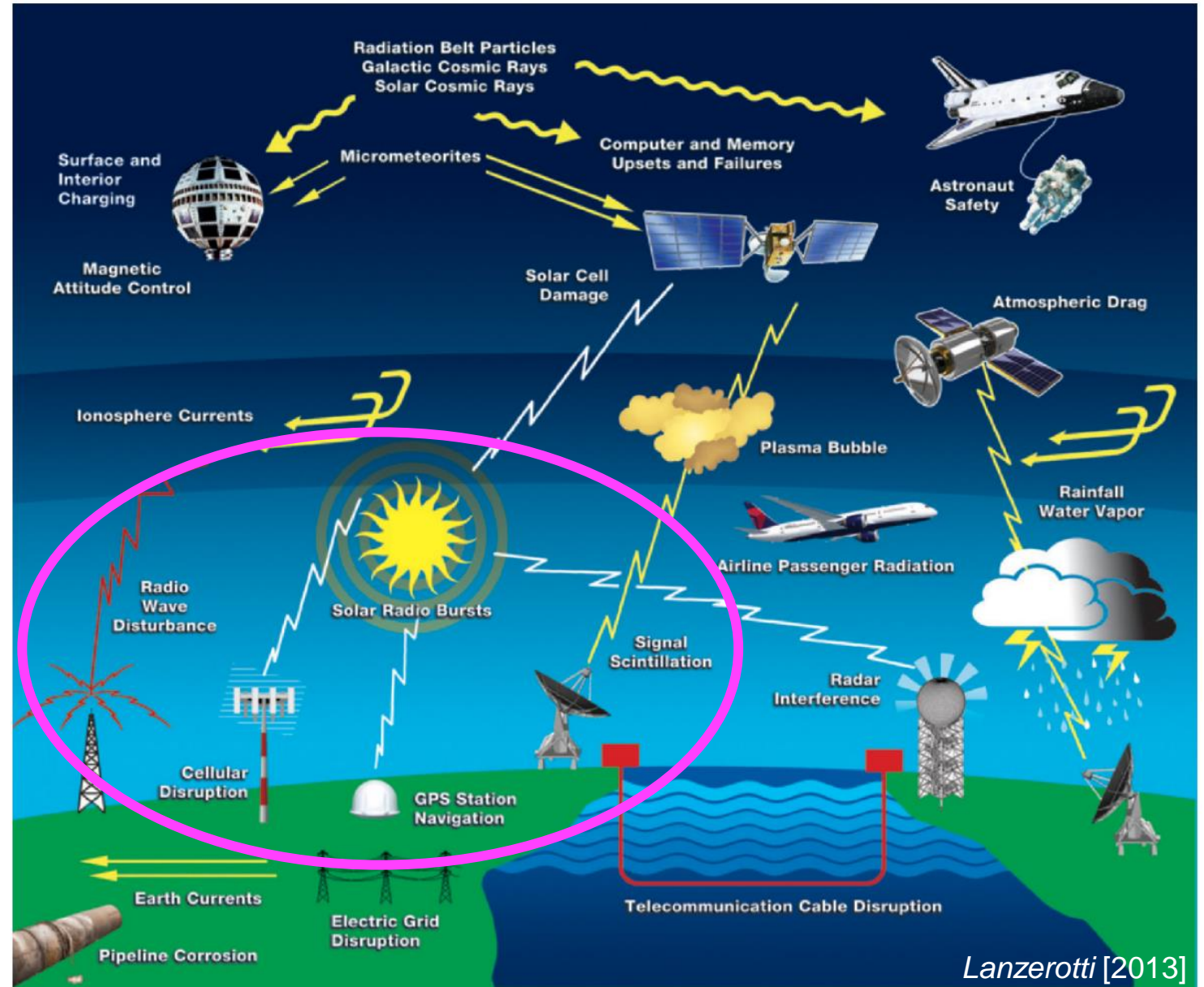
Its Effects

Bad Space Weather: When Space Weather is Harmful

Solar activity can:

- Interfere with cell phones, GPS, and other communications

Solar-Terrestrial Process:
Solar UV/FUV/EUV/soft X-ray emissions from ARs (for example, flares). These create variability in the ionosphere.



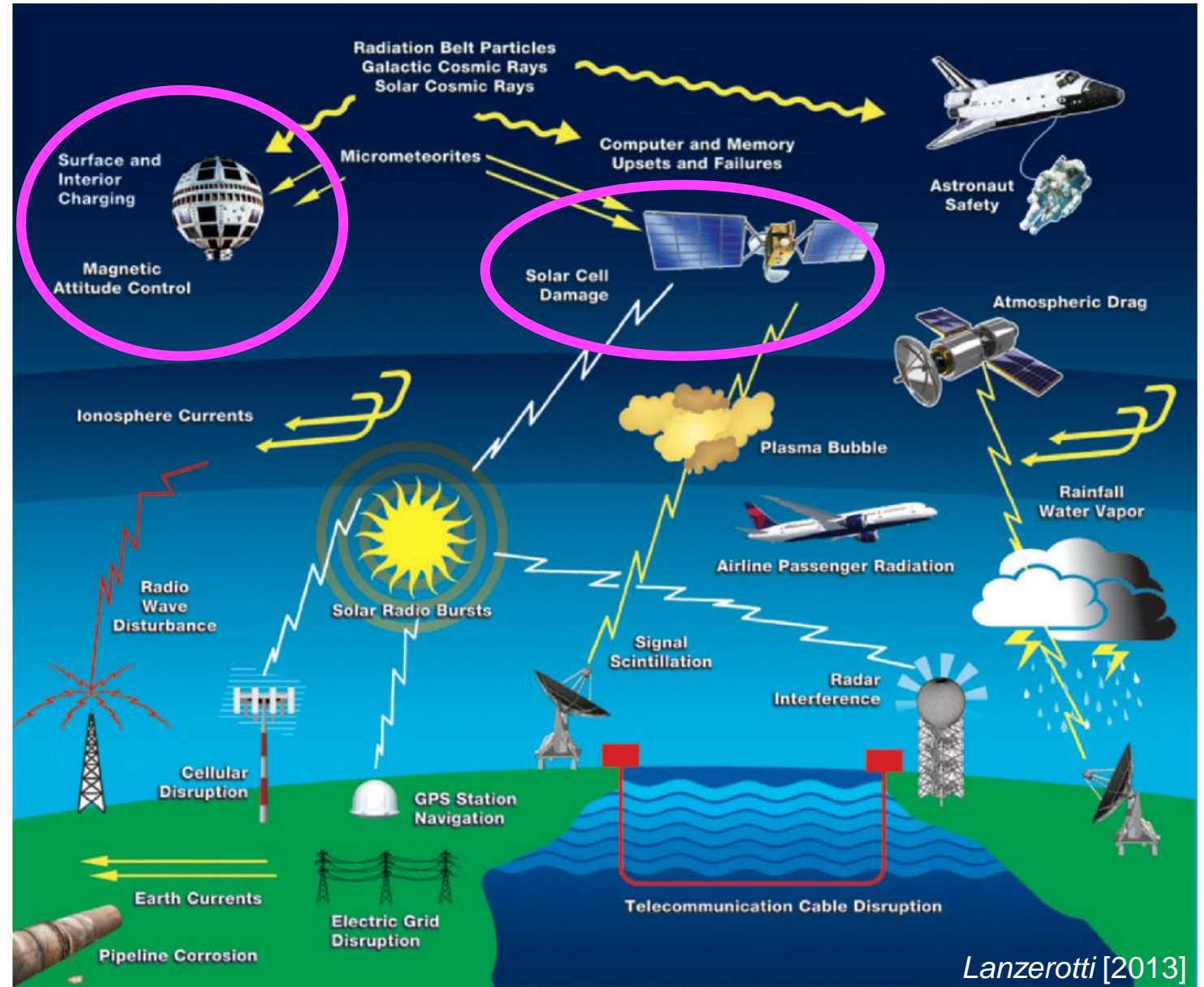
Its Effects

Bad Space Weather: When Space Weather is Harmful

Solar activity can:

- Damage or destroy satellites

Solar-Terrestrial Process:
Particle radiation from ARs or CHs. High-energy particles penetrate satellites' shielding creating charge in electronic devices.



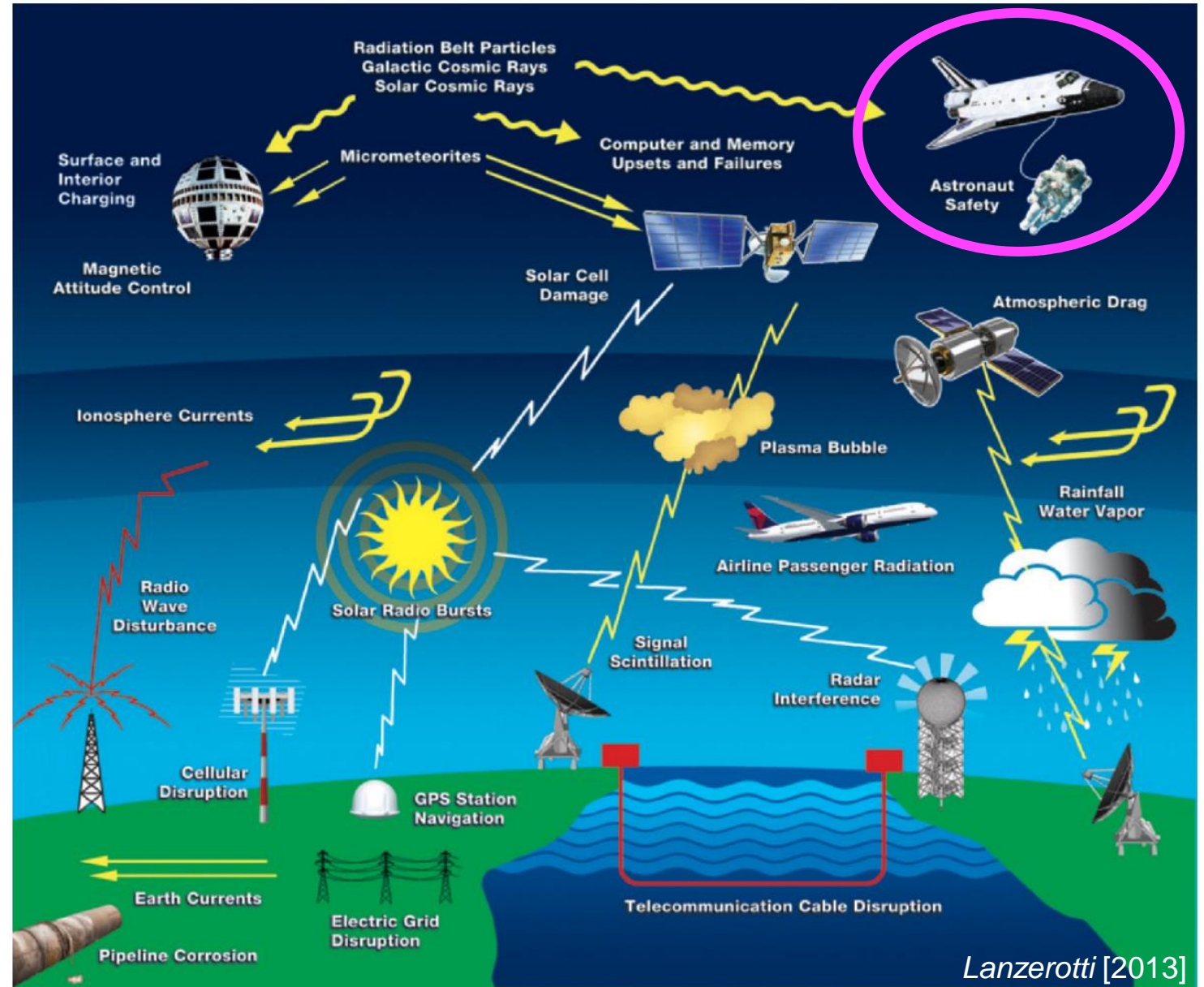
Its Effects

Bad Space Weather: When Space Weather is Harmful

Solar activity can:

- Threaten astronauts and high-flying airplanes with their radiation

Solar-Terrestrial Process:
Solar Energetic Particle (SEP) radiation from ARs.



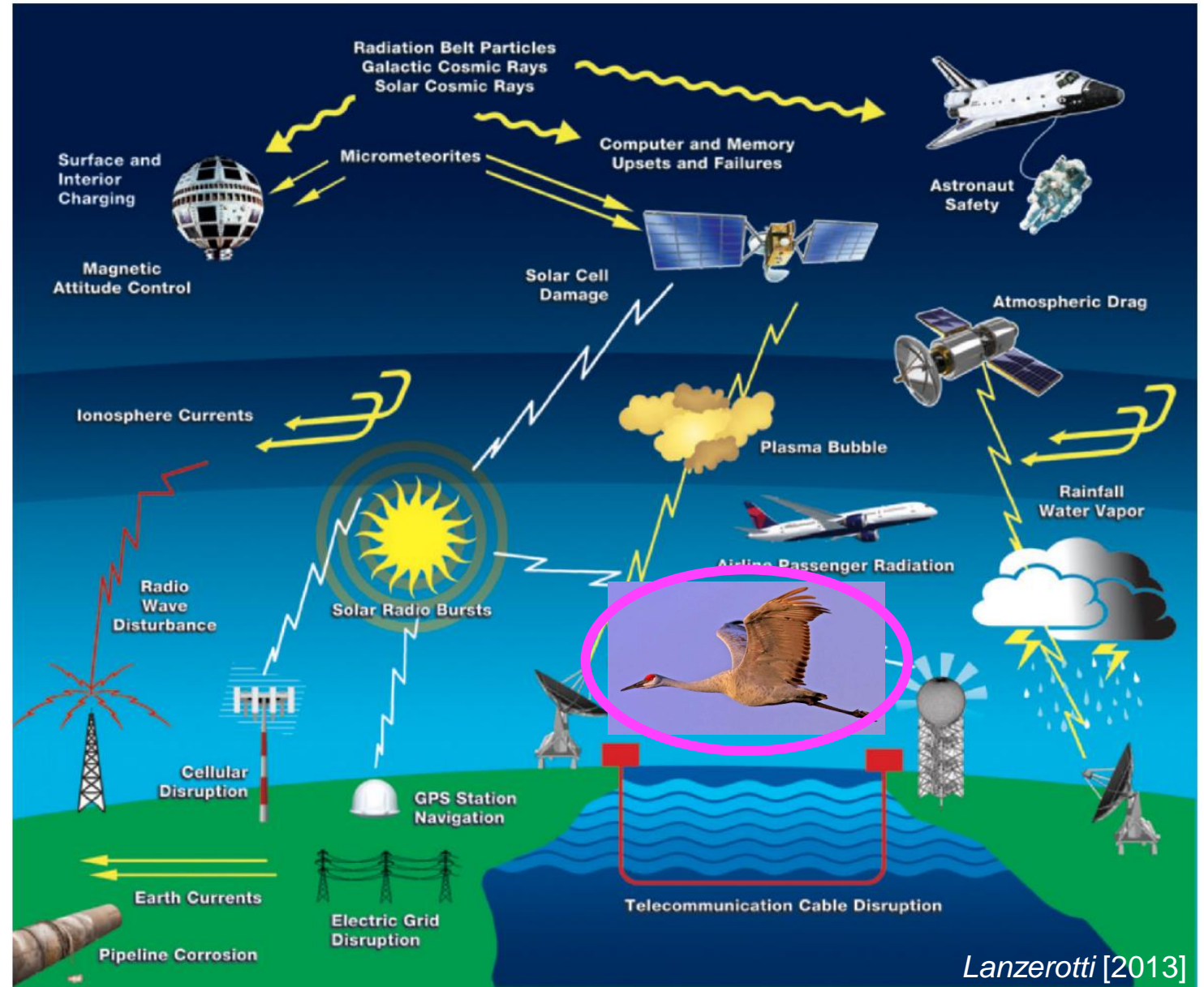
Its Effects

Bad Space Weather: When Space Weather is Harmful

Solar activity can:

- Disrupt animal movements and migrations (pigeons, bats, sea turtles, dolphins & whales, etc.)

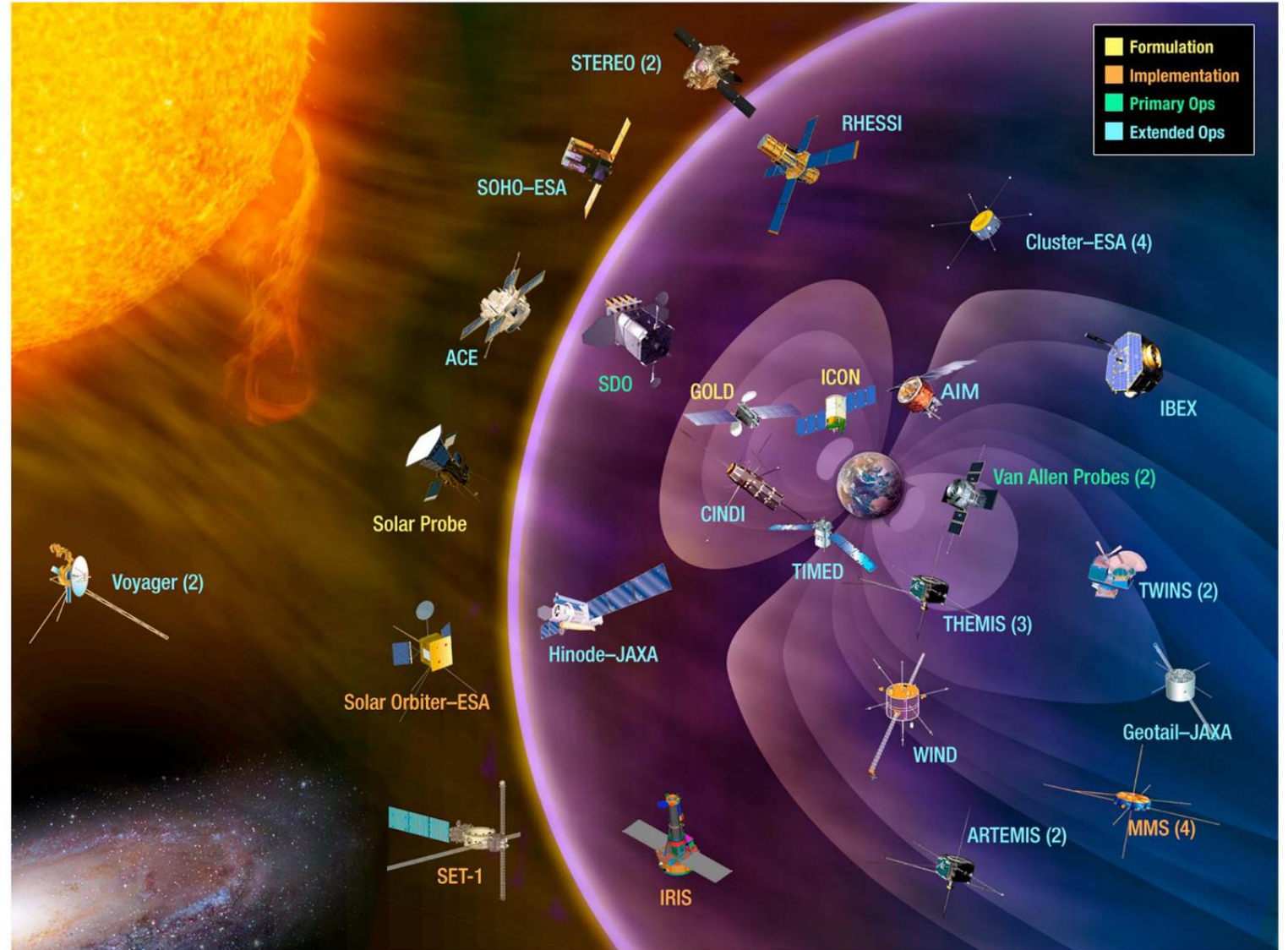
Solar-Terrestrial Process:
Geomagnetic storms that produce significant magnetic field variations (typically from CMEs associated with ARs).



Its Effects

The Near-Earth Space is Being Monitored

NASA's Heliophysics System Observatory (HSO)



Cassak et al. [2017]

More Resources:

- [Sun|trek](#)
- [NASA's Heliophysics](#)
- [NASA's Heliophysics Big Year](#)

Find this presentation at:

- www.cristianferradas.com

Thank you!