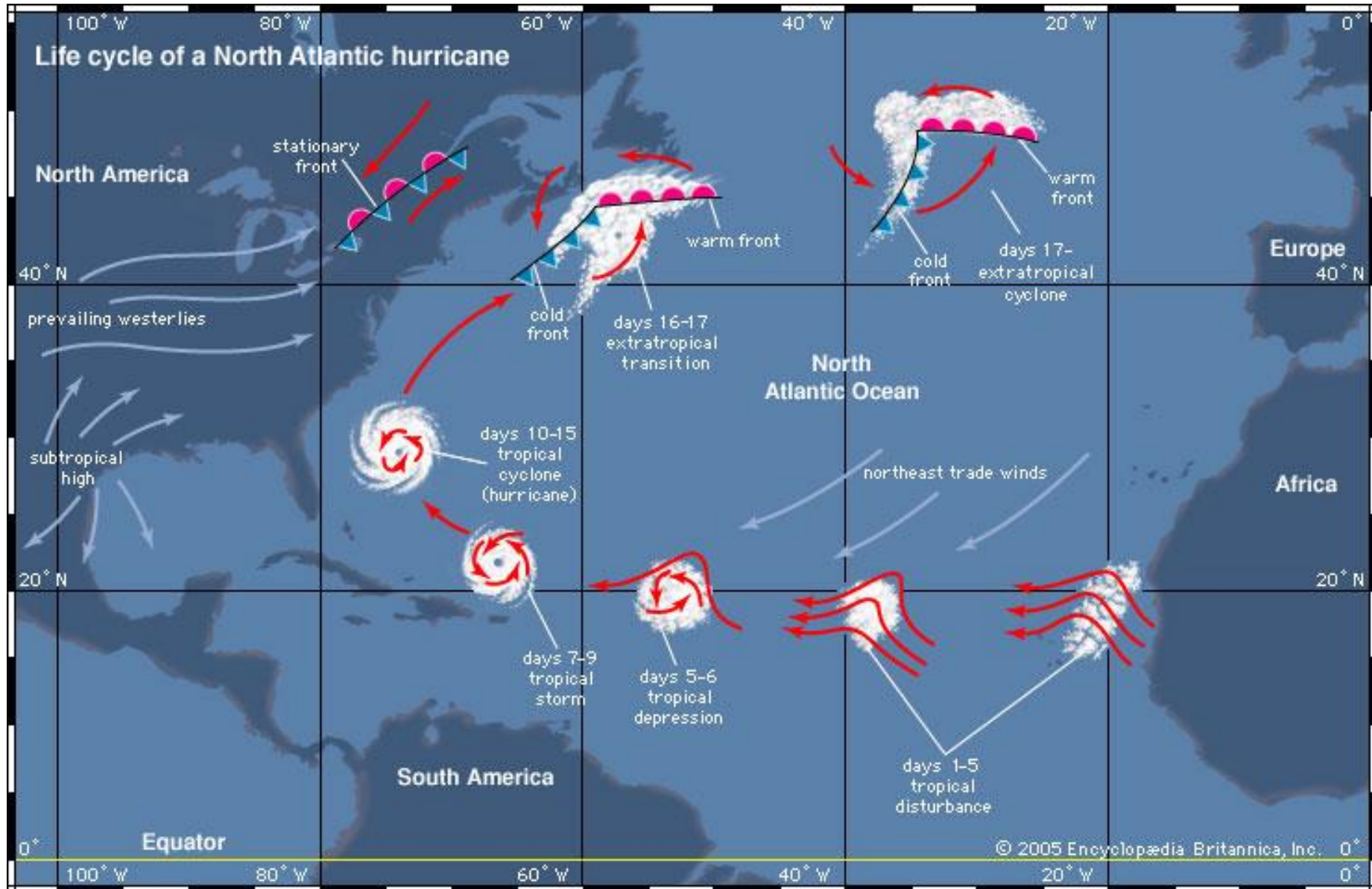


North Atlantic Hurricane Lifecycle

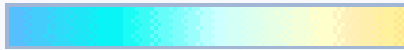


SANDY 2012

VS

IRENE 2011

WIND: 155kph



SIZE: approx 1,500km wide

Extremely large

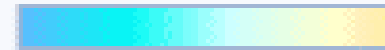
Post-Tropical Cyclone at landfall

Storm Surge up to 4 m



October 30, 2012

WIND: 140kph



Category 1 Hurricane at landfall

SIZE: 965km wide (max)

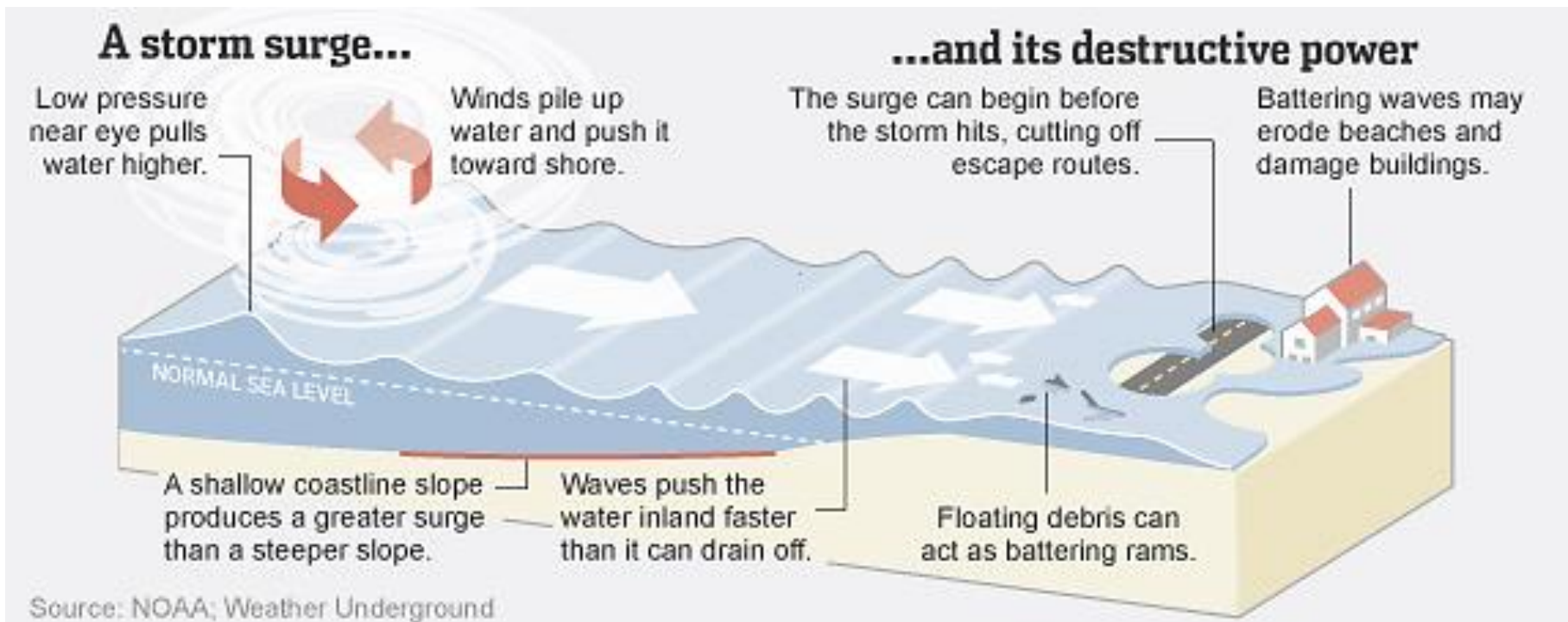
Storm Surge up to 1.5 m



August 28, 2011

What is Storm Surge?

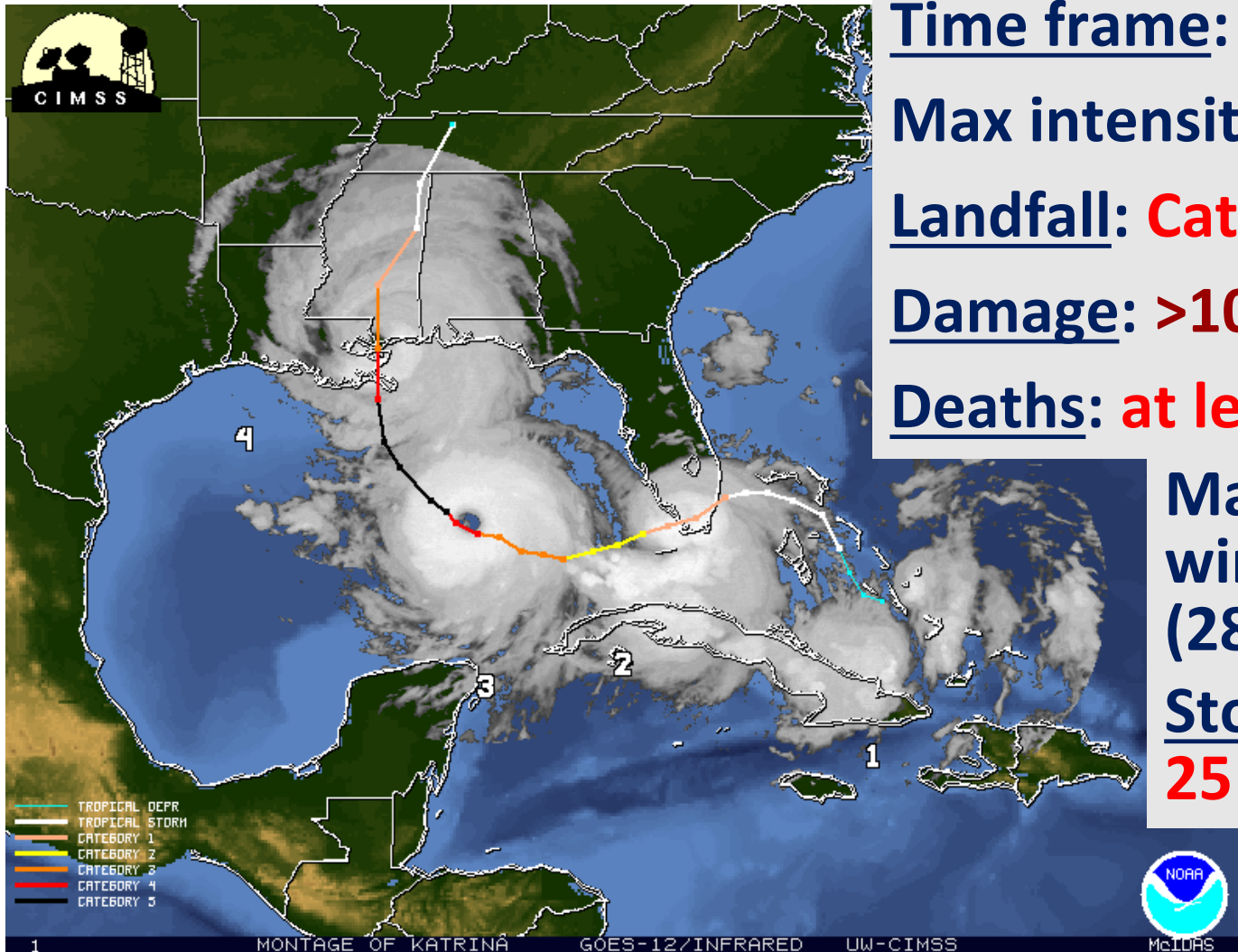
Storm surge is an abnormal rise of water generated by a storm, **over and above** the predicted **astronomical tides**.



Important factors: storm **intensity** (wind speed) and size, **forward speed**, **angle of approach** to the coast, central pressure (minimal contribution in comparison to the wind), the **coastline shape and bathymetry**.

Hurricane Katrina, 2005

the **costliest** hurricane ever recorded in the Atlantic



Time frame: **August 23-31**

Max intensity: **Category 5**

Landfall: **Category 3**

Damage: **>100 billion USD**

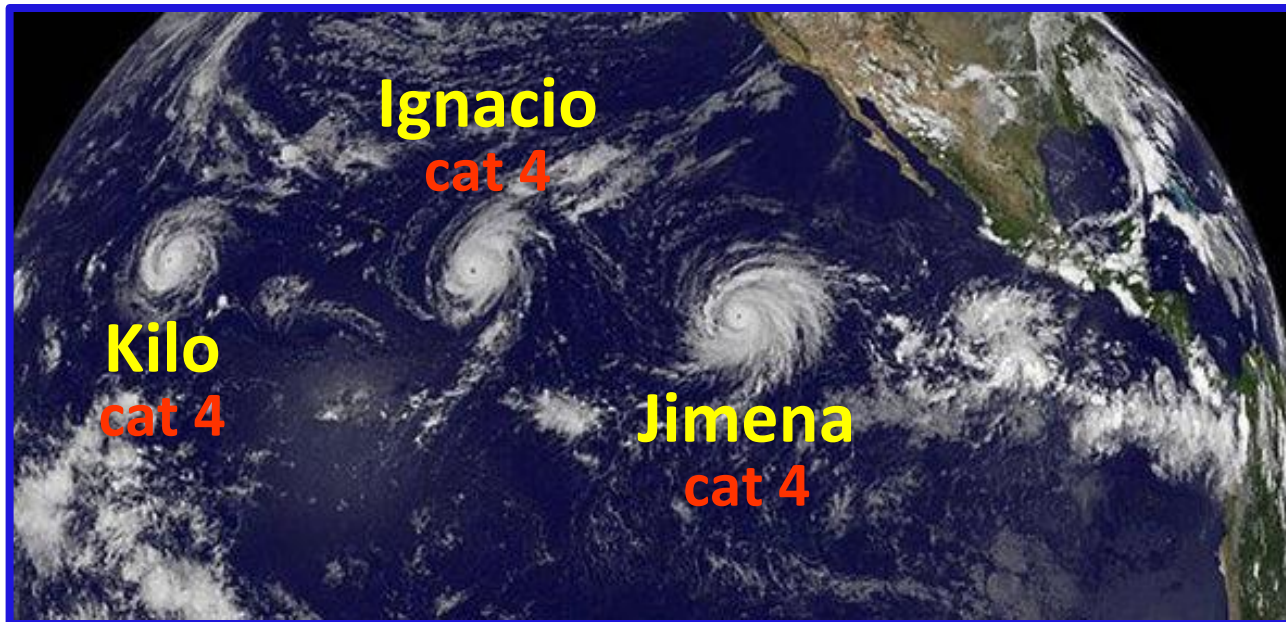
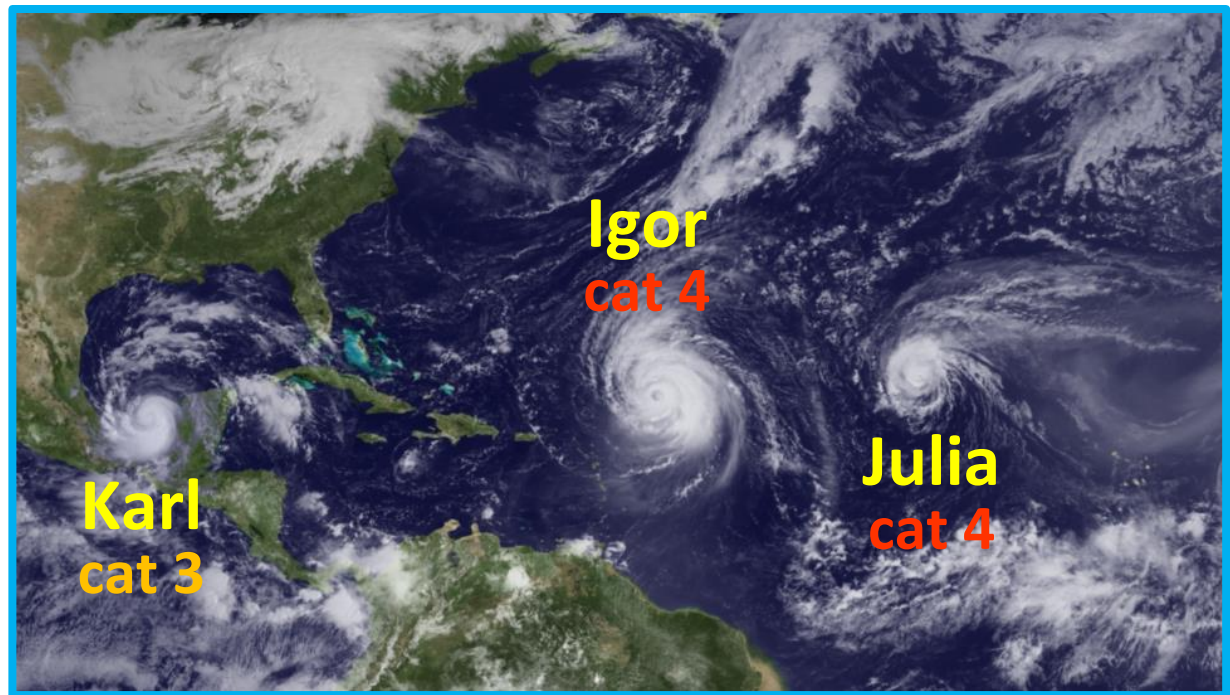
Deaths: **at least 1,833**

Max sustained winds: **175 mph (280 km/h)**

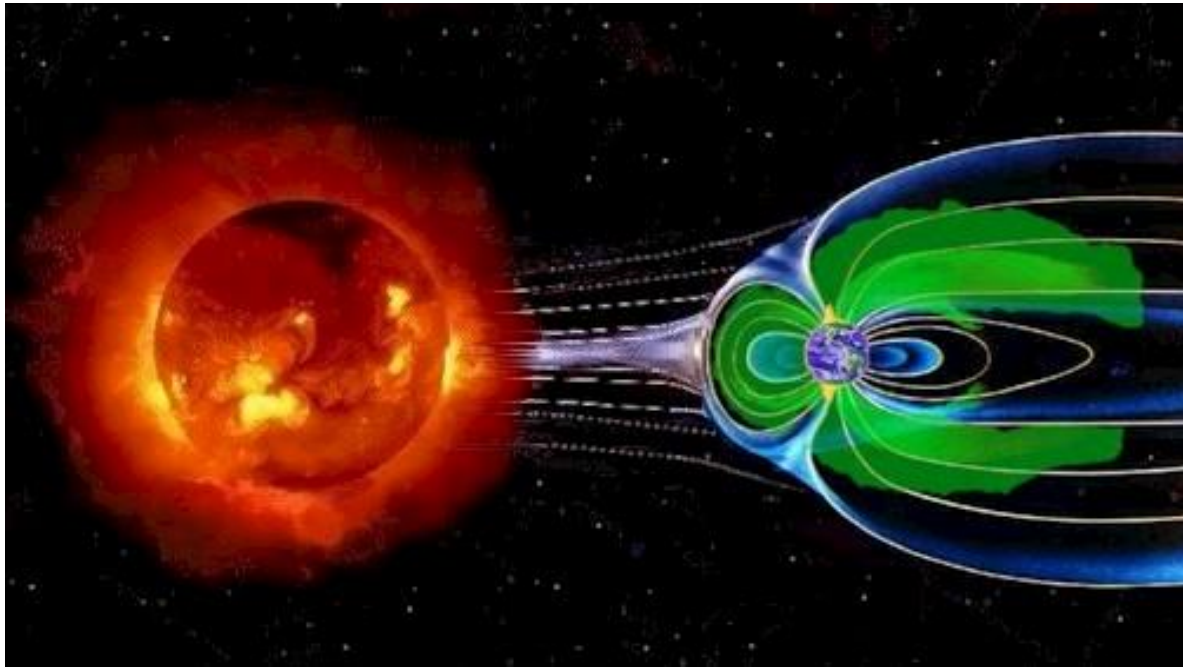
Storm surge: **25 to 28 feet**

At Once...

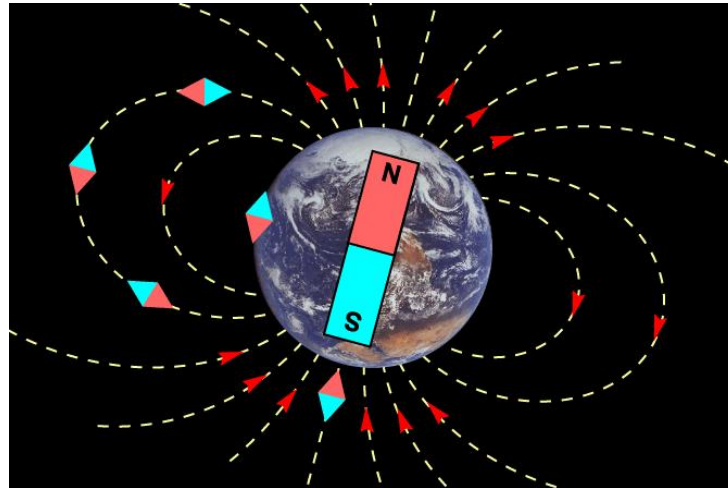
North
Atlantic
Basin,
09/19/10



Pacific
Basin,
08/31/15

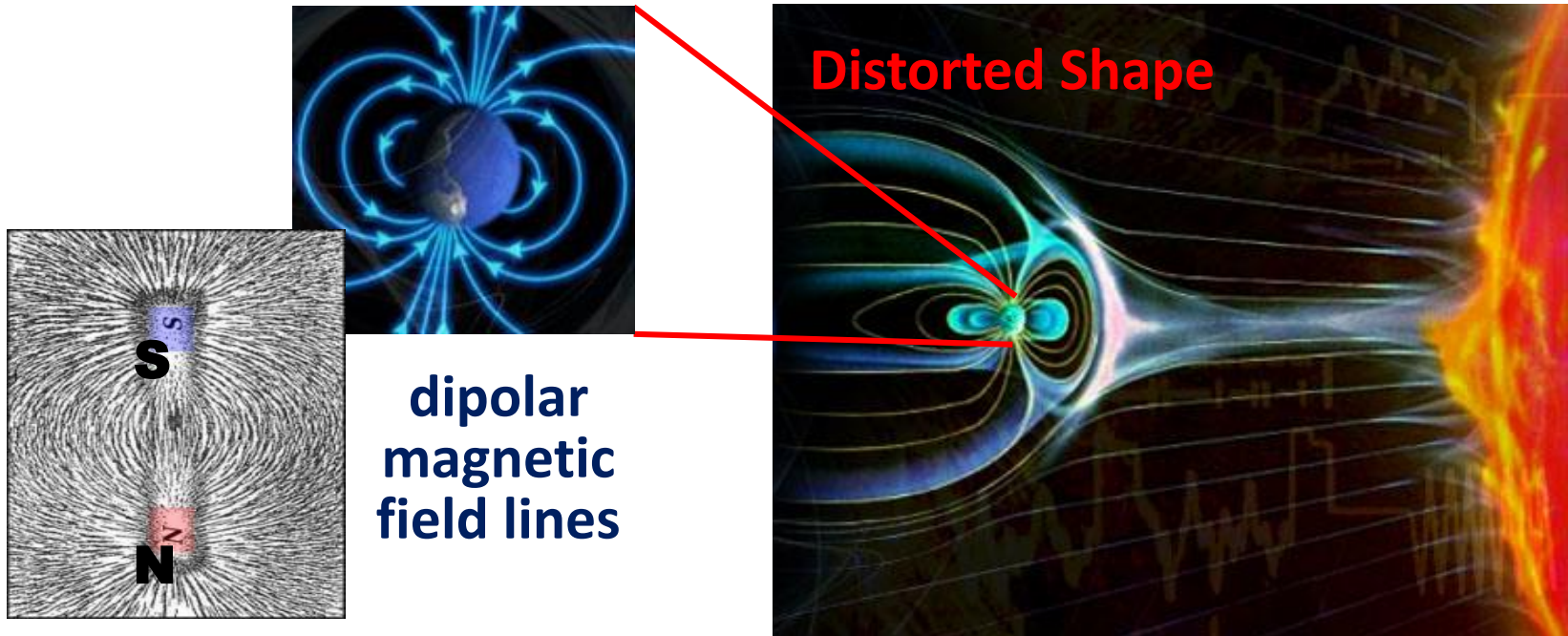


Magnetosphere



Earth's Magnetic Field

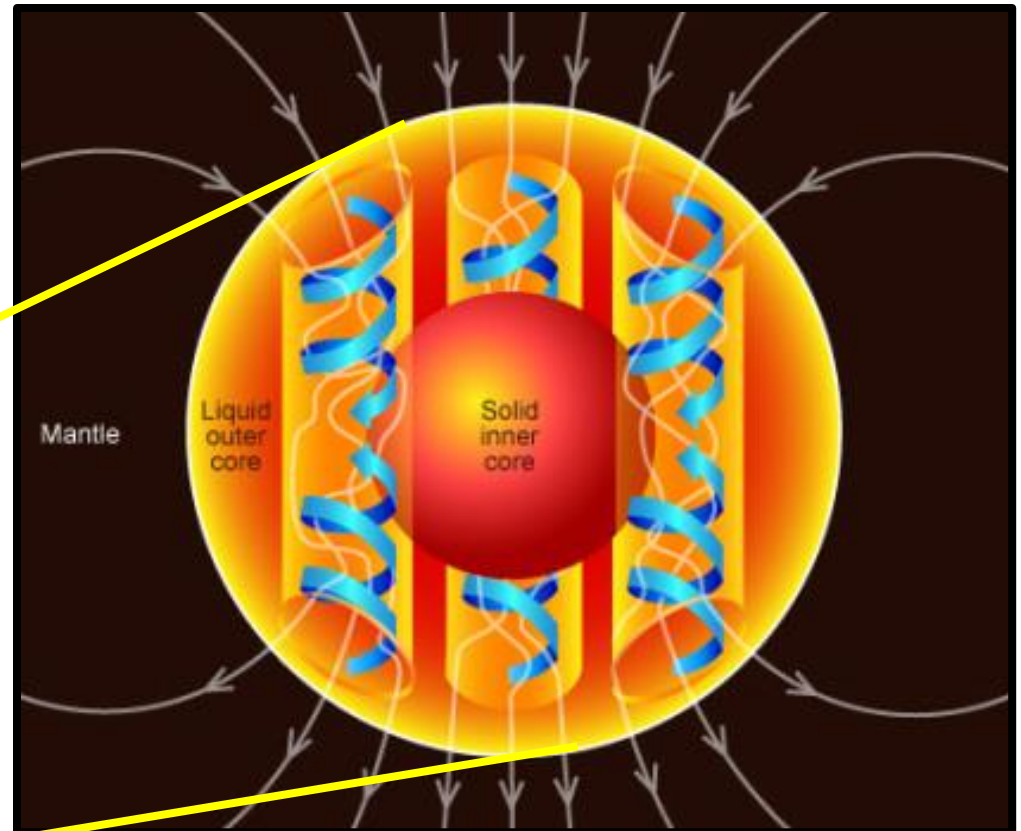
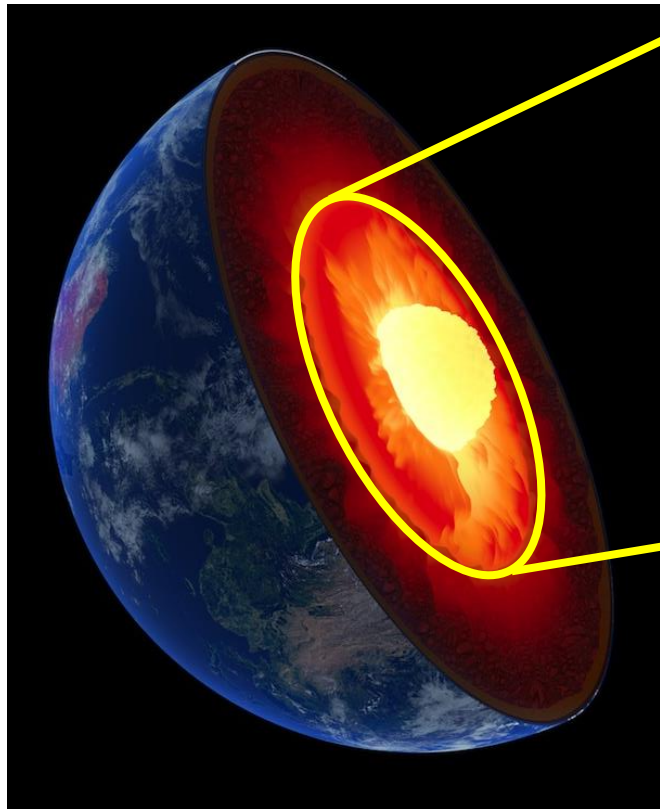
- At the Earth's surface, the Earth's magnetic field is **dipolar** - similar to that of a **bar magnet**.
- Further out, the Earth's magnetic field is **distorted by Solar Wind**.



- Magnetosphere is **asymmetric**: the *sunward side* is about 10 Earth radii out but the other side stretches out in a *magnetotail* that extends beyond 200 Earth radii.

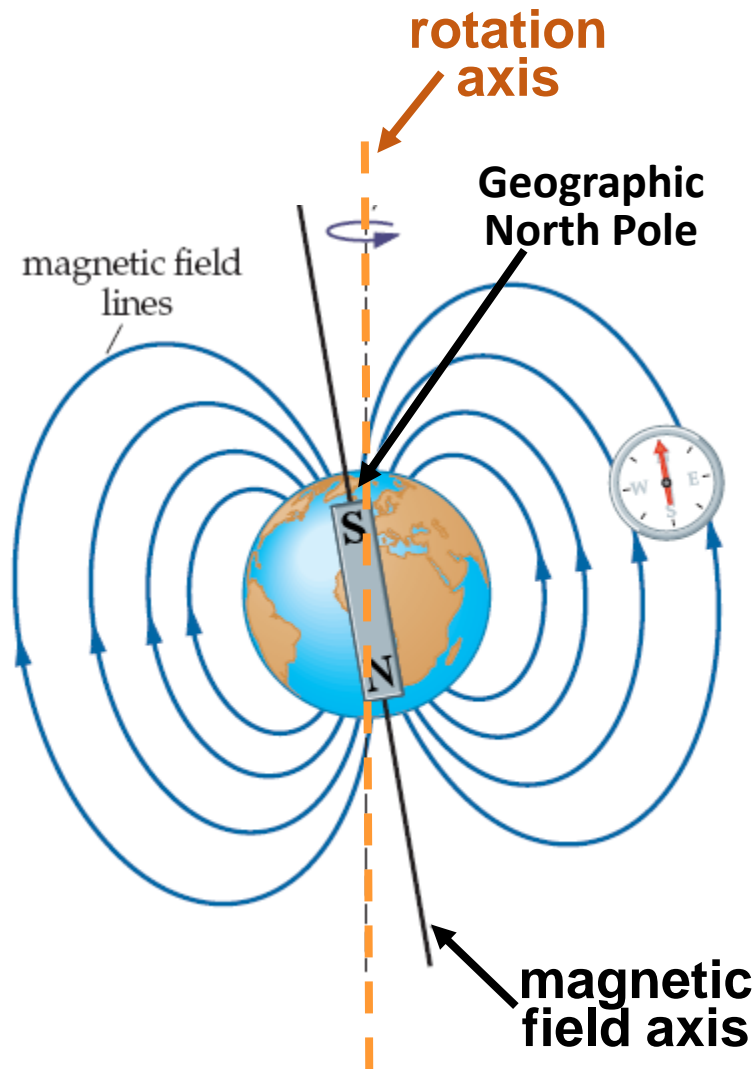
What creates Earth's Magnetic Field?

Geodynamo Theory



Rotating, convecting, and electrically conducting **liquid outer core** acts to induce and constantly maintain Earth's magnetic field.

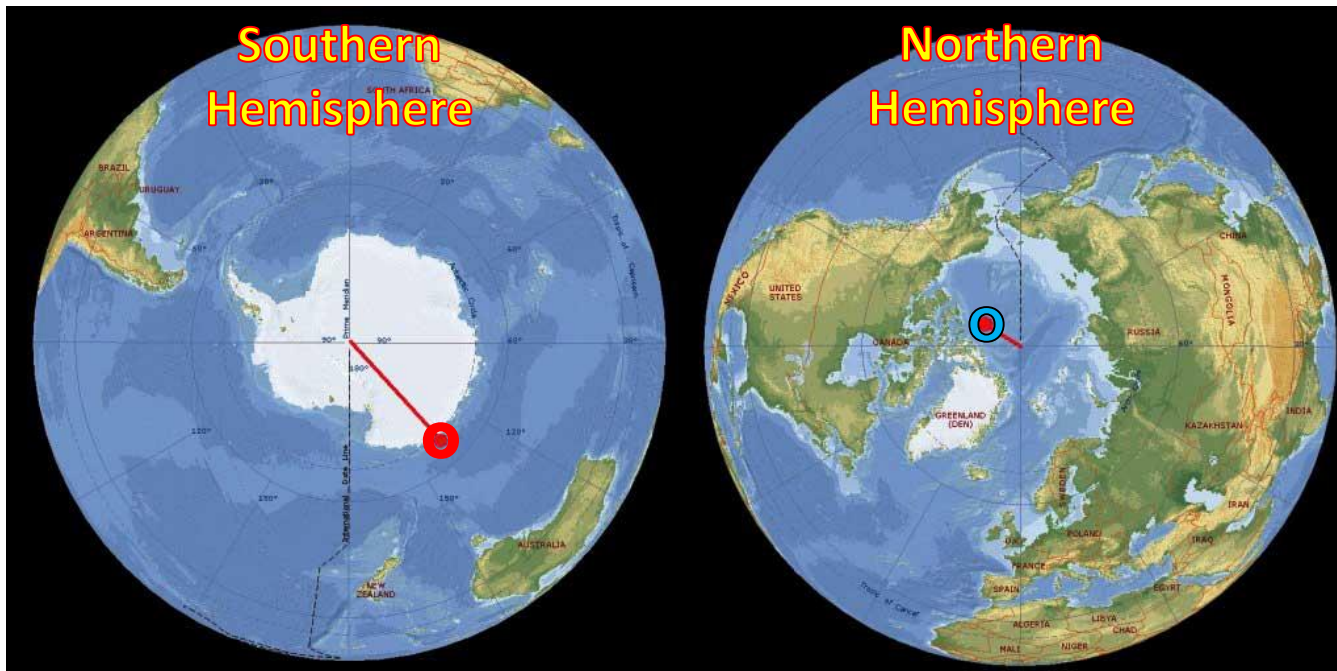
Magnetic Field Axis



- The axis of Earth's magnet and the geographical (rotation) axis **do not coincide**.
- The magnetic field axis is **tilted at 11.5°** to the axis of rotation of the Earth.
- The magnetic field axis **does not pass through the center of the Earth**.
- The magnetic poles and geographic poles are **not the same**.

Magnetic Poles

- The Earth's North and South Magnetic Poles are also known as **Magnetic Dip Poles**, with reference to the vertical "dip" of the magnetic field lines at those points.



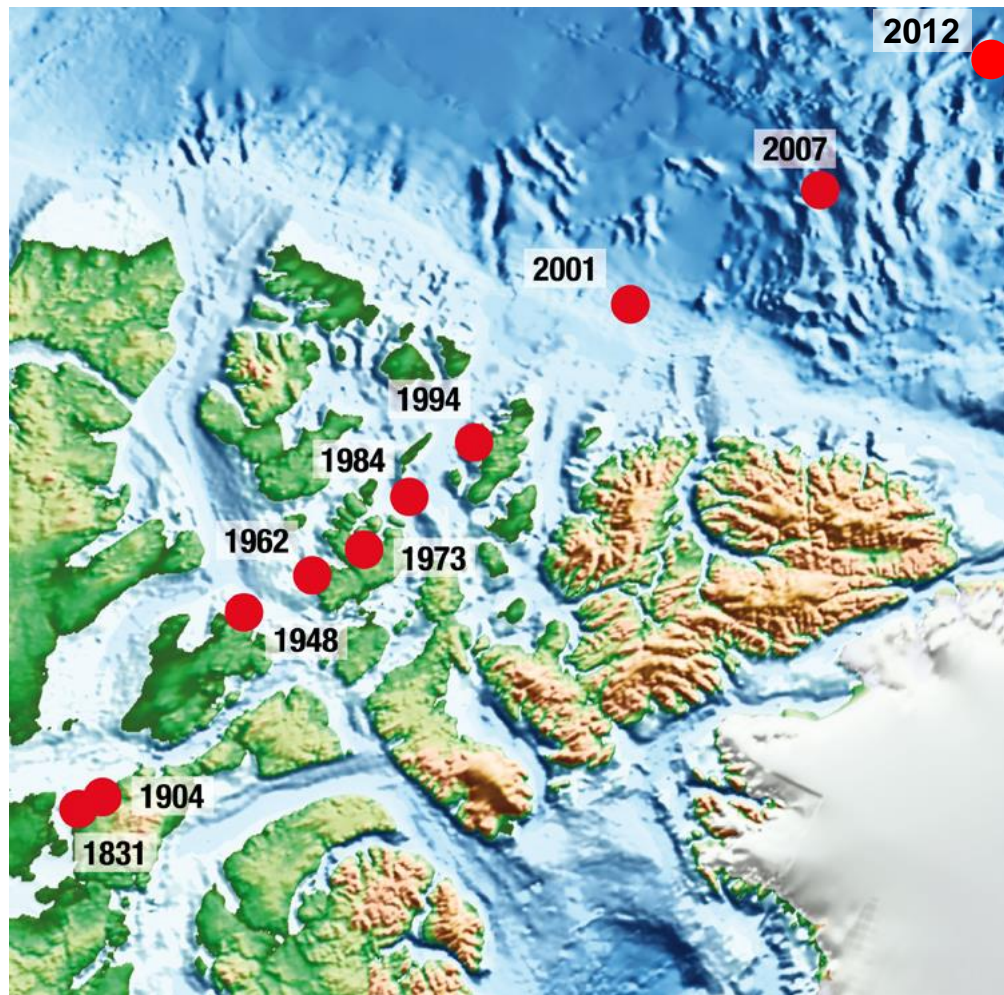
**Magnetic
Dip
Poles
Location
(2010)**

1800 mi from True South

380 mi from True North

- The **positions** of the Earth's magnetic poles are **not very well defined**: they are spread over an area, wandering ~50 km (~30 mi) back and forth every day.

Magnetic Poles Are Constantly Moving



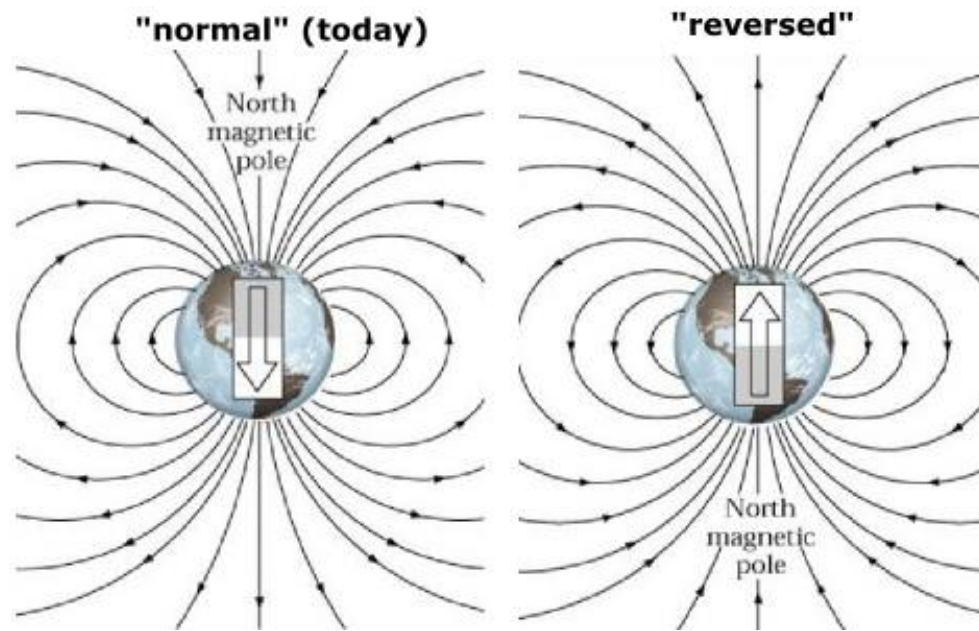
Tracking North Magnetic Pole

- The location of the **magnetic north pole** has been recorded for over 180 years: it has been **steadily moving north** by an average 10 km per year, lately accelerating to 40-50 km per year.
- The global magnetic field strength has also **weakened** by about **10%** since the 19th century.

**Are we due
for another
*field reversal?***

Magnetic Field Reversal

- Careful study of the magnetic structure of ancient rocks suggests that the Earth's magnetic field has **reversed its direction many times** over the Earth's history.

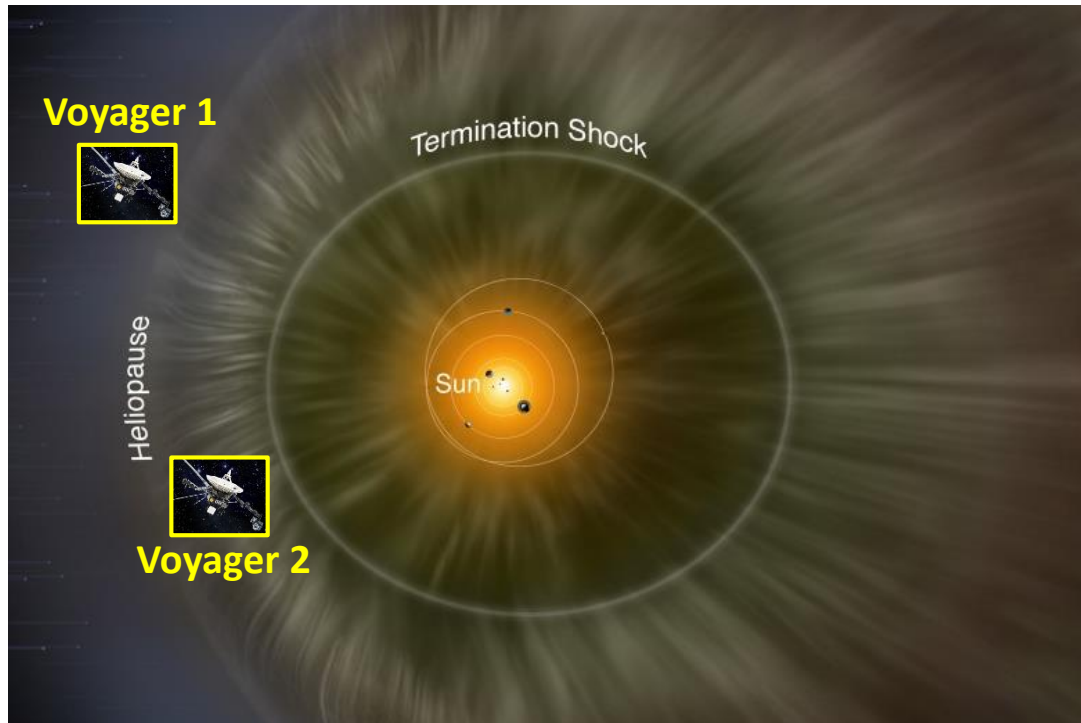


How exactly this reversal mechanism works is still not completely understood...

- Field reverses **once every 400,000 years** on average.
 - Reversal takes about 10,000 years to happen.
 - **Last reversal** was ~780,000 years ago.

Solar Wind

- The Solar Wind is a stream of *plasma* released from the upper atmosphere of the Sun (photosphere and corona).



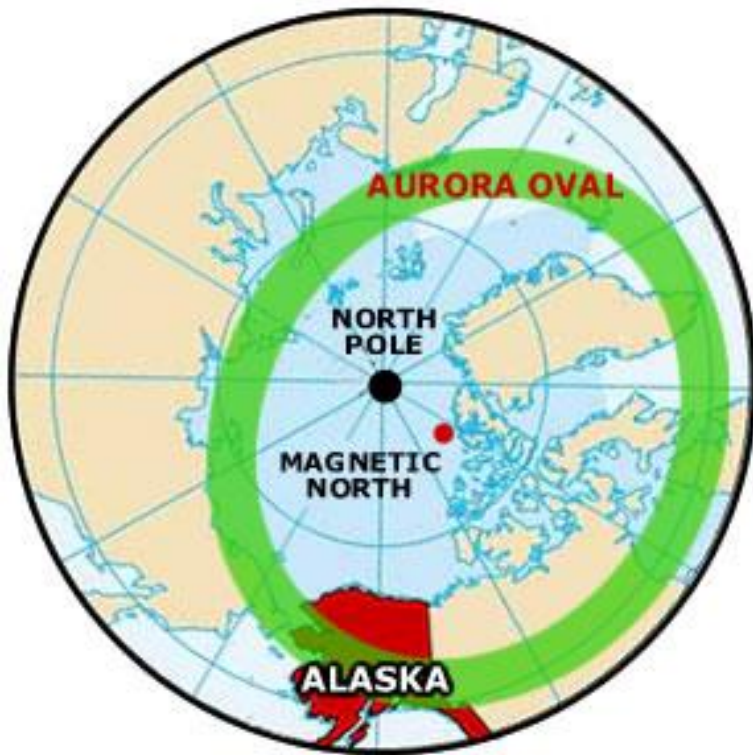
- Solar Wind consists of mostly **electrons** and **protons**.

- The stream of particles varies over time and averages **1.3×10^{36} particles per second!**

- The Earth's magnetic field deflects most of the particles away and **acts to protect life on Earth** from **Solar Wind** as well as from **cosmic ray particles** coming from deep space.

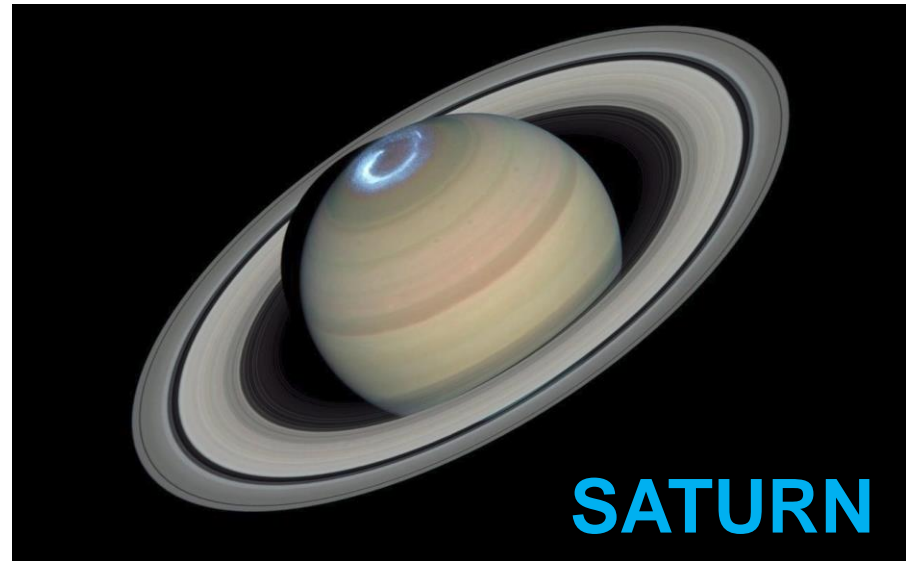
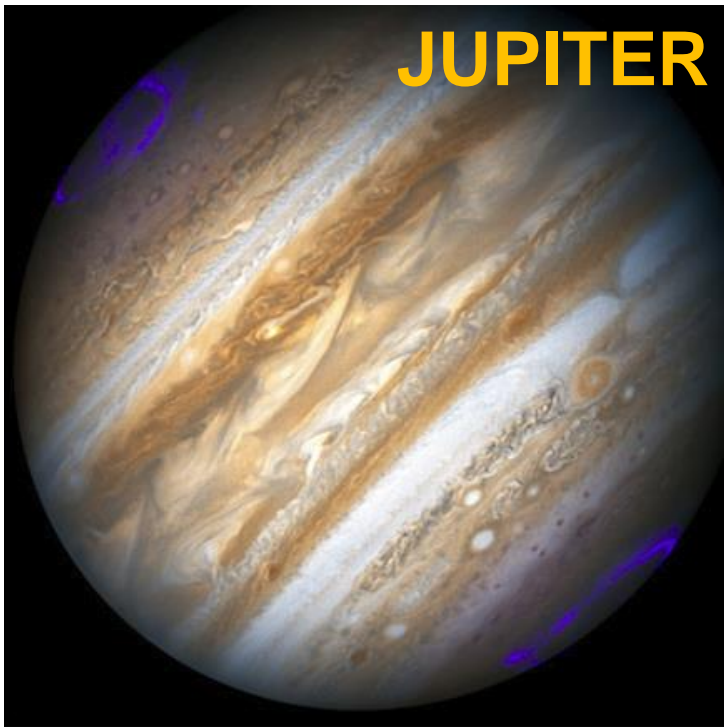
Aurora Borealis or Northern Lights

(Galileo!)



- **Generally can be observed at night in the polar regions between 60 and 72 degrees north and south latitudes, within the Arctic and Antarctic polar circles (south: *Aurora Australis*).**
- **Periods of particularly intense Solar activity, called *geomagnetic storms*, cause a lot of disturbance to the Earth's magnetic field, including auroras as far south as Hawaii (just 20°N latitude)!**

Aurora on other planets



Aurora Borealis Video

<https://www.youtube.com/watch?v=N5utQxtma2U>

<https://www.youtube.com/watch?v=fVsONlc3OUY>