



ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



Introduction to Space Weather

Mpho Tshisaphungo

Space Weather Practitioner

AFI Workshop on Space Weather
28 to 29 July 2021





ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



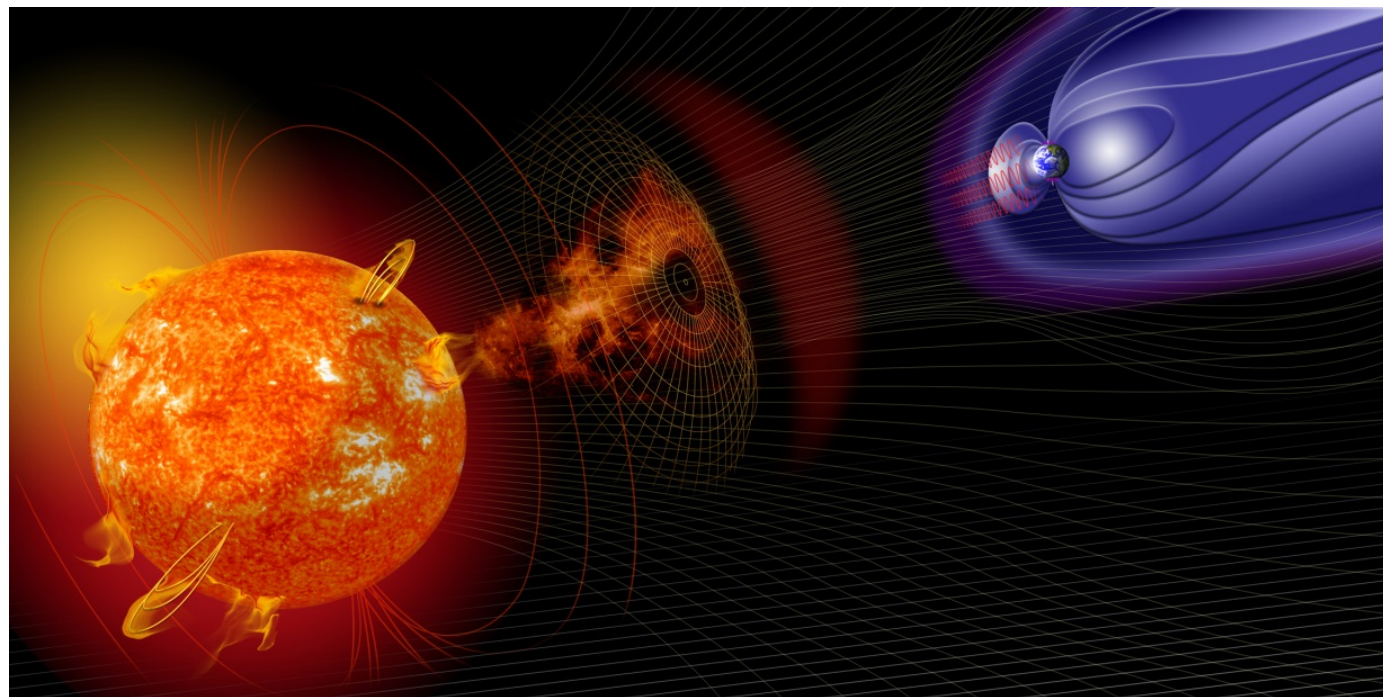
CONTENT

- What is Space Weather?
- Impact on Technology
- Space Weather Activities
- Importance of Monitoring Space Weather
- Space Weather Drivers
- International Collaboration
- Conclusion



WHAT IS SPACE WEATHER?

Space Weather refers to **conditions on the Sun** and in the solar wind, magnetosphere, ionosphere, and thermosphere that can **influence the performance and reliability** of space-borne and ground-based **technological systems**.



Space weather is a consequence of the behaviour of the sun, the nature of Earth's magnetic field and atmosphere, and our location in the solar system



ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



IMPACT ON TECHNOLOGY

In the 4IR technology continues to play an ever-increasing role in our society and the potential for space weather storms to impact our daily lives is also growing. Technological infrastructure, including the power grid, GPS and satellites used for communication and navigation, are vulnerable to space weather effects.





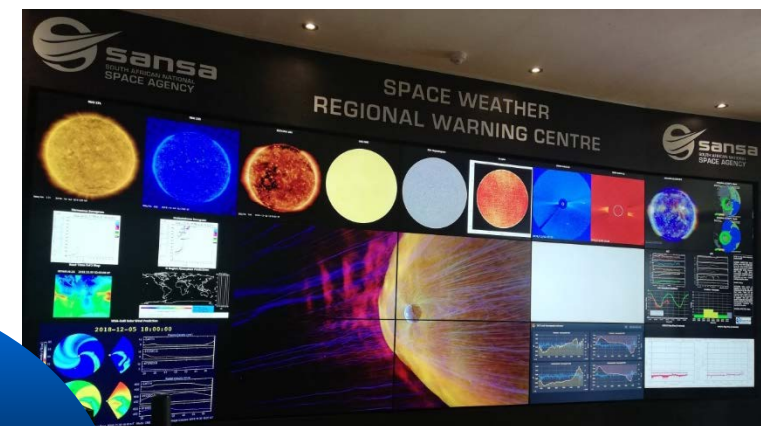
SPACE WEATHER ACTIVITIES

Space weather
research
Model
developments

SW Forecast
HF predictions
Warning/Alert
Bulletins

Weekly tours
Information days
Training

Expansion and
usage of data
network





IMPORTANCE OF MONITORING SPACE WEATHER

Space weather
monitoring, forecasting
and predictions.

Disseminate SW
information to clients and
public via website, emails,
sms and fax

Space weather analysis and
verifications of forecasts and
predictions



HALLOWEEN STORM: OCTOBER 2003

Solar Flare

Coronal Mass Ejection

11:12 UT

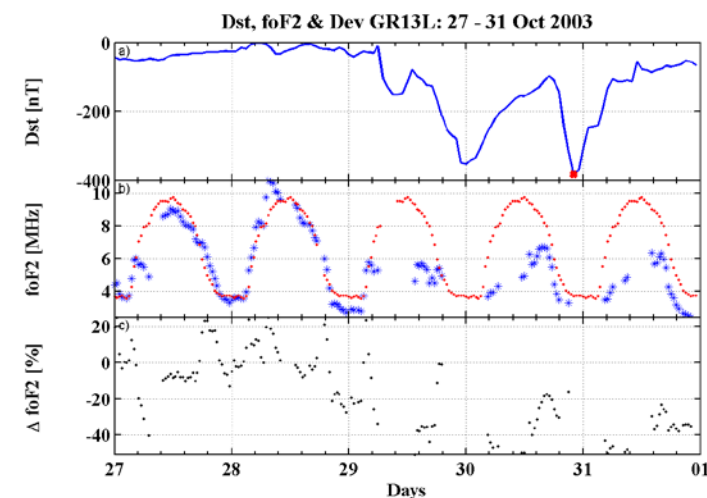
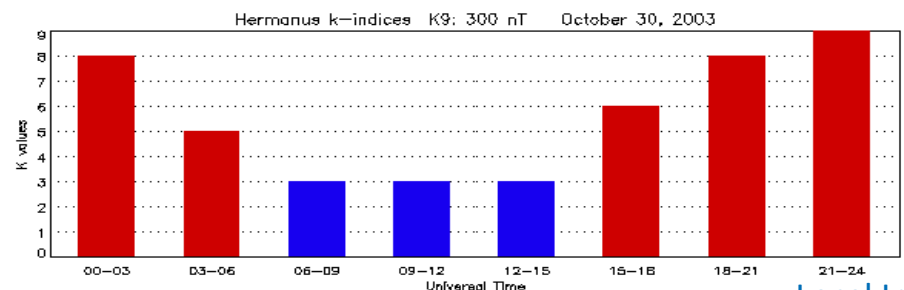
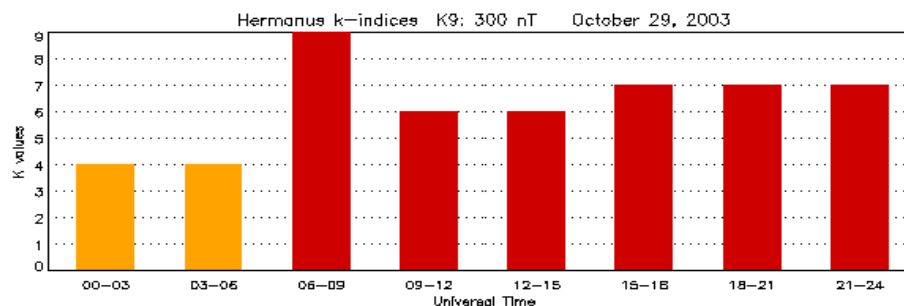
11:30 UT

Solar energetic particles

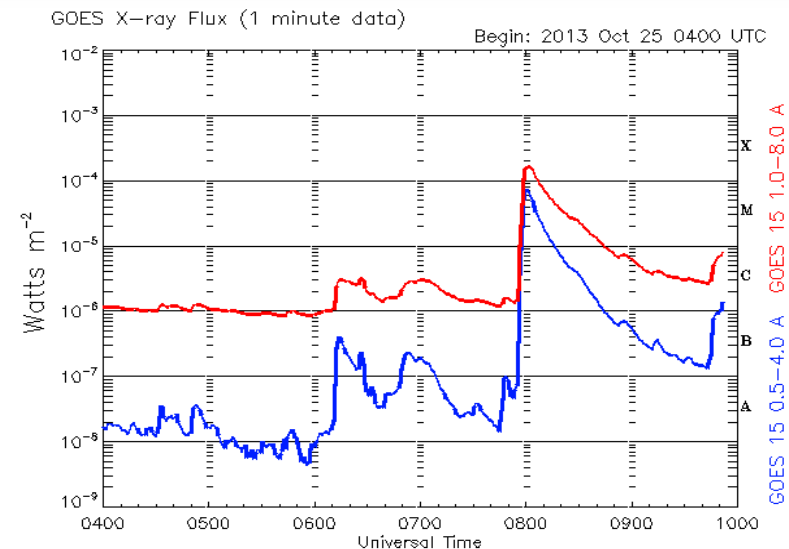
14:35 UT

16:16 UT

Solar flare, coronal mass ejection and solar energetic particles observed on October 28, 2003.

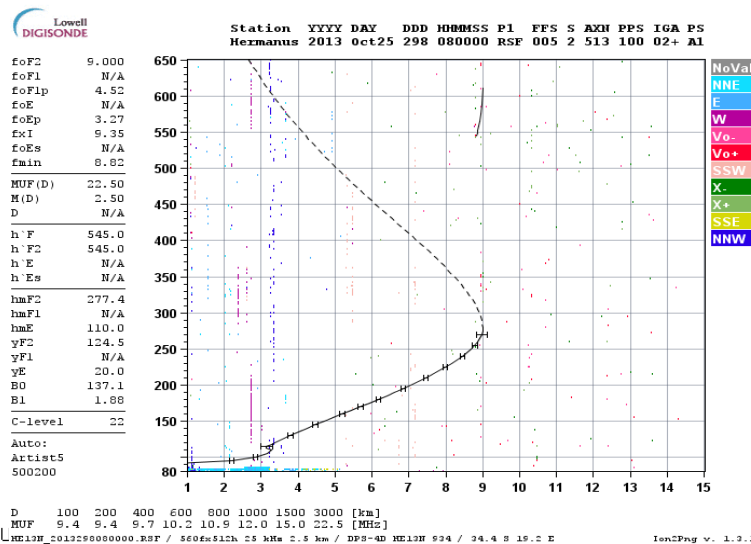


Local Impact on Magnetosphere and Ionosphere

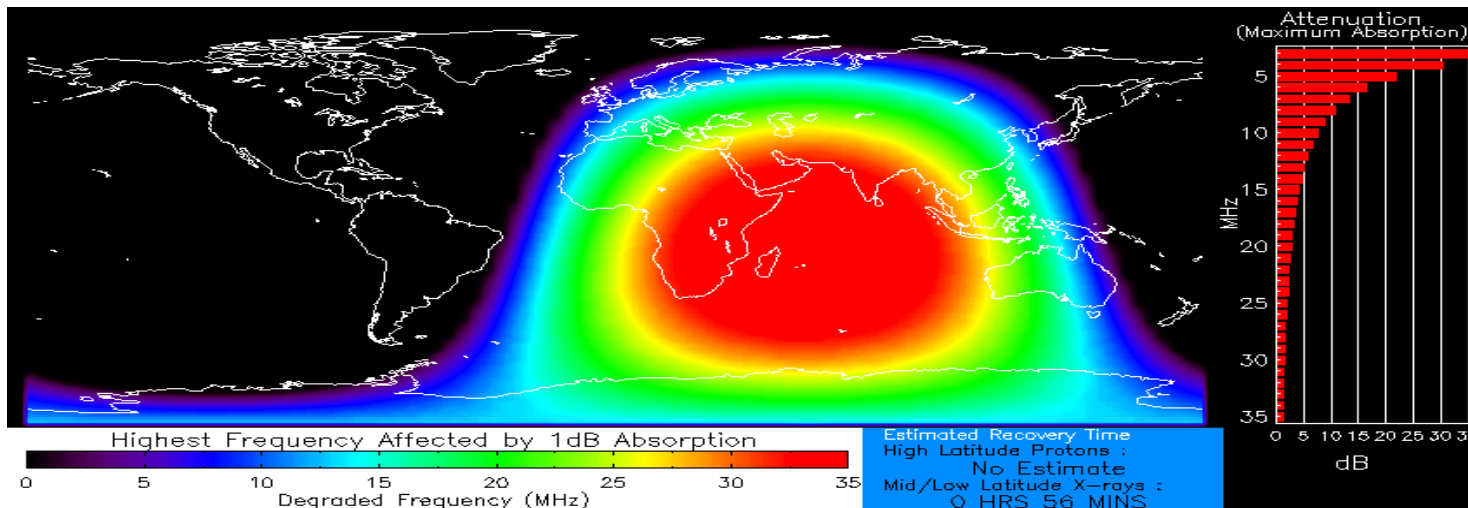
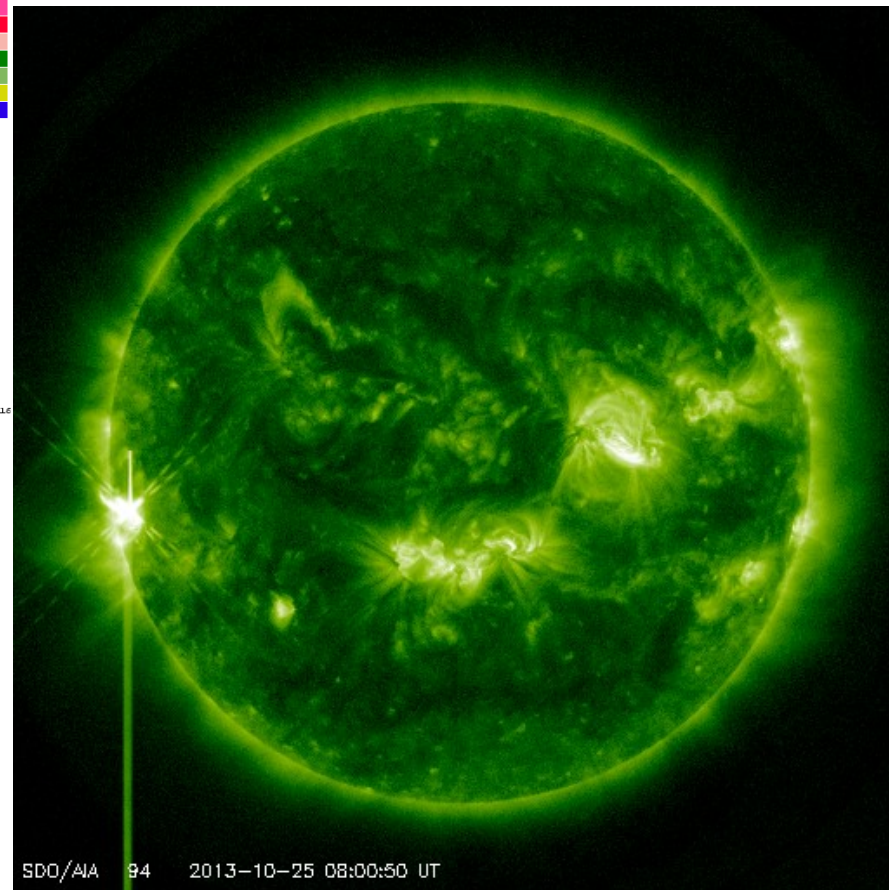


Updated 2013 Oct 25 0953 UTC

NOAA/SWPC Boulder, CO



SOLAR FLARE EVENT

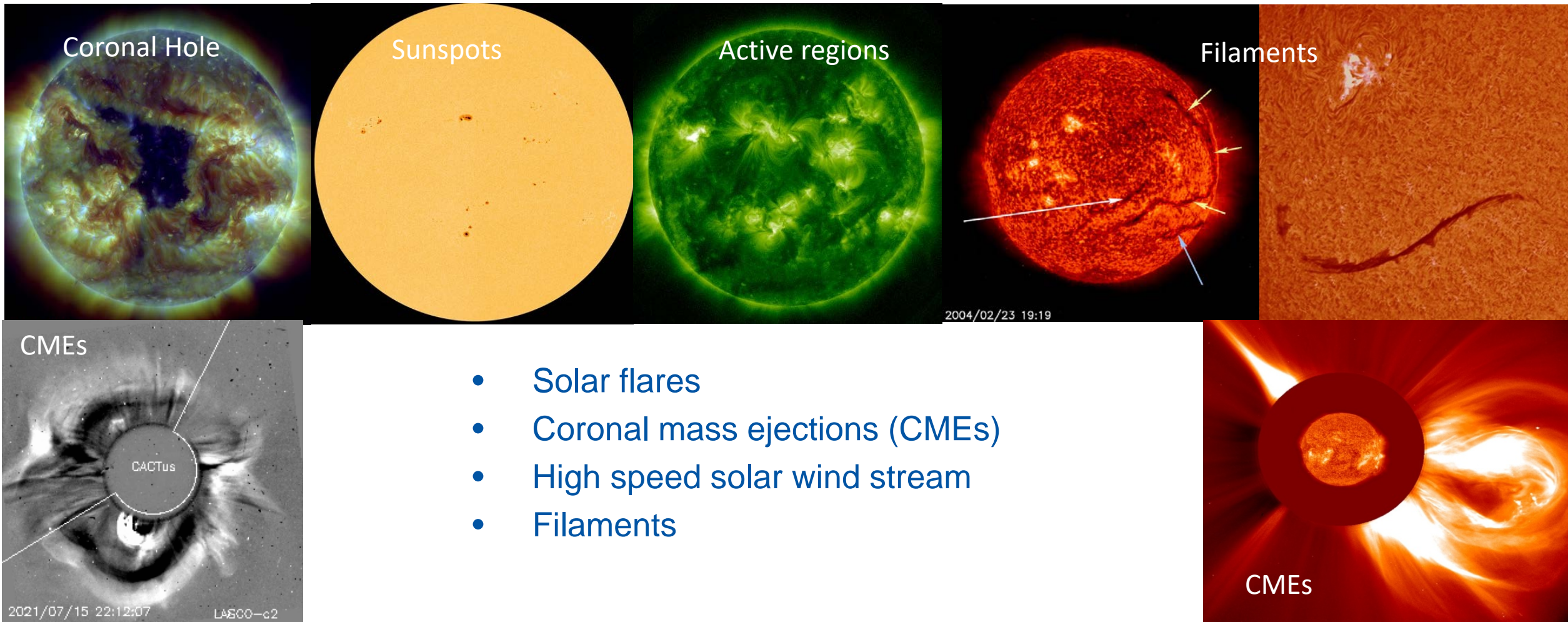


Moderate X-ray flux
Product Valid At : 2013-10-25 08:09 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA



SPACE WEATHER DRIVERS





ICAO UNITING AVIATION

NO COUNTRY LEFT BEHIND



SANSA SPACE WEATHER INFORMATION



[Home](#) [Products and Services](#) [Space Weather Information](#) [Contact Us](#) [Clients](#)

Daily Forecast

DATE: 19 Jul 2021, composed at 08:57 SAST

CURRENT CONDITIONS: Solar activity is low with background X-ray flux at B-class levels. The solar wind speed is at background levels with speeds ranging between 350 - 380 km/s. Geomagnetic conditions are at unsettled levels. Local HF working frequencies are near monthly average predicted values.

EVENTS: None.

OUTLOOK: Solar activity is expected to be low with background X-ray flux at B-class levels. There are a couple of active regions visible on the solar disk with simple magnetic configurations and no major flaring activity is expected. The solar wind speed is expected to be at background levels during the next 24 hours. Geomagnetic conditions are expected to be quiet to unsettled.

SYSTEMS AFFECTED: None. <https://spaceweather.sansa.org.za/>

Current Conditions

2021-07-19 12:42

Solar wind speed: N/A km/s

IMF Bz: -4.7 nT

Hermanus T-index: 7

Hermanus K-index: 3

Hermanus hmF2: 193.502 km

Hermanus foF2: 5.500 MHz

Dst Index: 29 nT

Dcx Index: 4.4 nT

Space Weather Bulletin

19 July 2021

SANSA Space Weather Centre Information

S SANSA Space Weather Centre <spaceweather@sansa.org.za>
Wed 9/6/2017 2:18 PM
To: Mpho Tshisaphungo

Space Weather Bulletin

06 Sept 2017, composed at 14:15 SAST

WARNING/ALERT;

An X-class X-ray solar flare is in progress. Degraded frequency up to 35 MHz. Estimate recovery time is 1 hour and 40 minutes. HF signal absorption is possible during this time.

Prepared by M. Tshisaphungo

Website Info
Email and SMS Bulletin
Alert and warning messages



INTERNATIONAL COLLABORATION

- One of the 22 member of ISES (International Space Environment Service) as a Regional Warning Centres for Space Weather.
- Representation on WMO, UNCOPUOS and ICAO expert groups on Space Weather.
- African Instrumentation Network partners (e.g. Kenya, Zambia)
- High quality regional data is benchmarked with international databases to deliver accurate well researched information.
- Regional designation by ICAO as Space Weather Information Provider for international air navigation.
- SANSa is leading the ICAO Met Project 3 entitled “Implementation of Annex 3 provisions relating to Space Weather requirements within the AFI Region”.



ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



CONCLUSION

- Space Weather events can create vulnerabilities within our technology dependencies and is a risk to the 4IR.
- Space Weather affects safety of live principles for aviation operations, and compliance with ICAO is now a requirement.
- SANSa is addressing operational capability for Space Weather information provision as a service to the African region.
- SANSa will continue to utilize its existing capability and global networks to ensure that the most optimum solution for dealing with the threat of Space Weather is developed for the continent.
- SANSa will continue to partner with the various role players to ensure an adequate readiness level on both sides (provider & user) for space weather information.



ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



ICAO

North American
Central American
and Caribbean
(NACC) Office
Mexico City

South American
(SAM) Office
Lima

ICAO
Headquarters
Montréal

Western and
Central African
(WACAF) Office
Dakar

European and
North Atlantic
(EUR/NAT) Office
Paris

Middle East
(MID) Office
Cairo

Eastern and
Southern African
(ESAF) Office
Nairobi

Asia and Pacific
(APAC) Sub-office
Beijing

Asia and Pacific
(APAC) Office
Bangkok



THANK YOU



ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



The origin of space weather

Martin Snow

Research Chair in Space Weather

AFI Workshop on SWx





solar system.

nuclear fusion turns hydrogen
y to the surface over thousands

d by convective overturning.
magnetic field.





ICAO UNITING AVIATION

NO COUNTRY LEFT BEHIND



Close up of the surface: constant motion

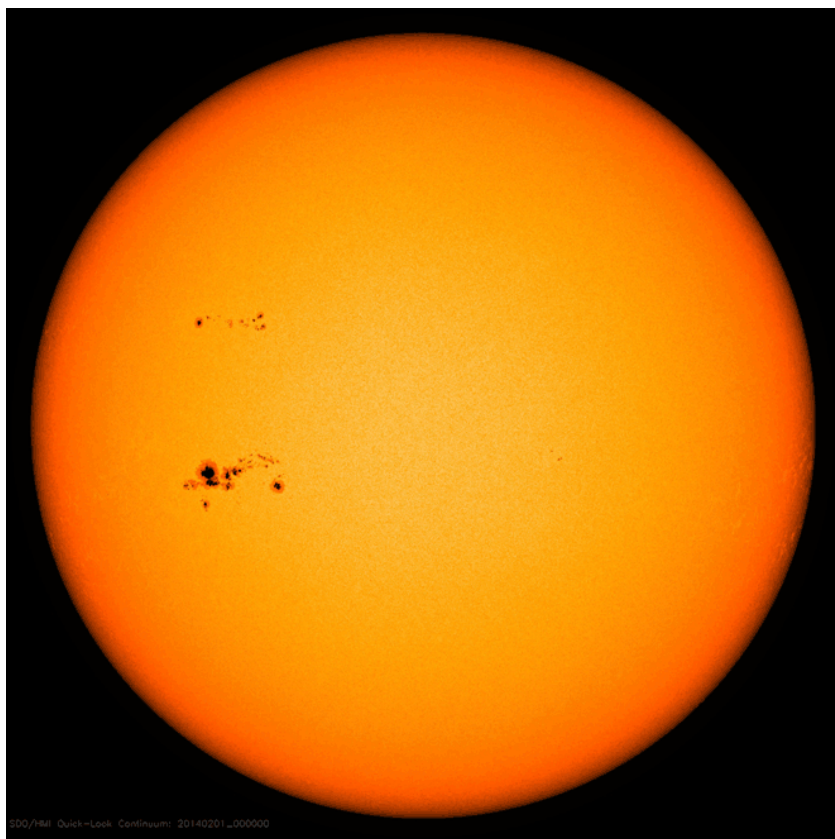


Cat not to scale.





Sun in visible light



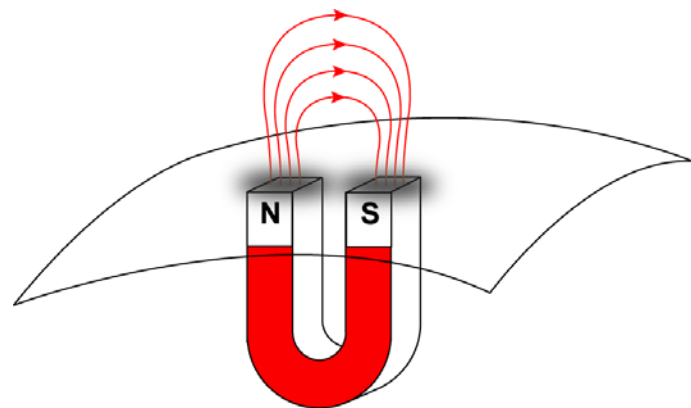
The Sun rotates with a period of about 27 days.

Unlike the Earth, there are no permanent features on the Sun. There are magnetic structures that emerge and last for a few months, then dissipate.

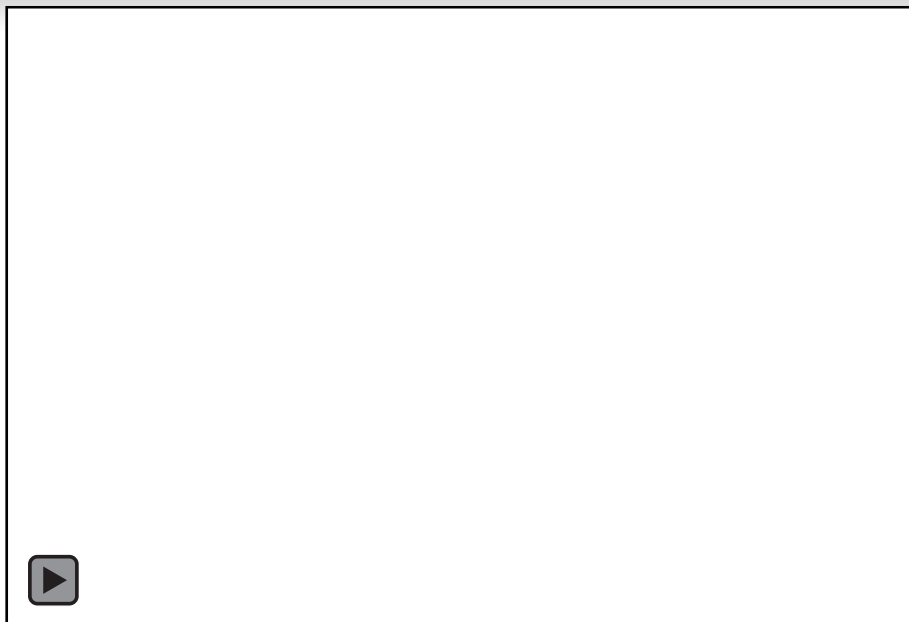
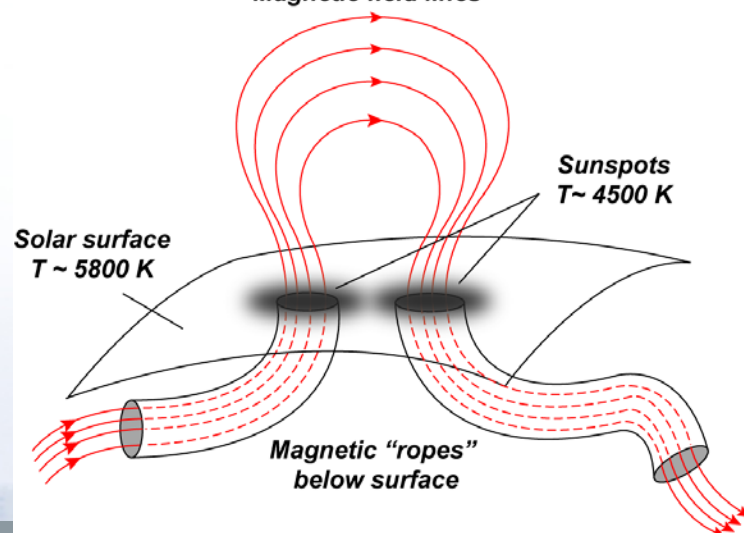




The formation of sunspots



Magnetic field lines





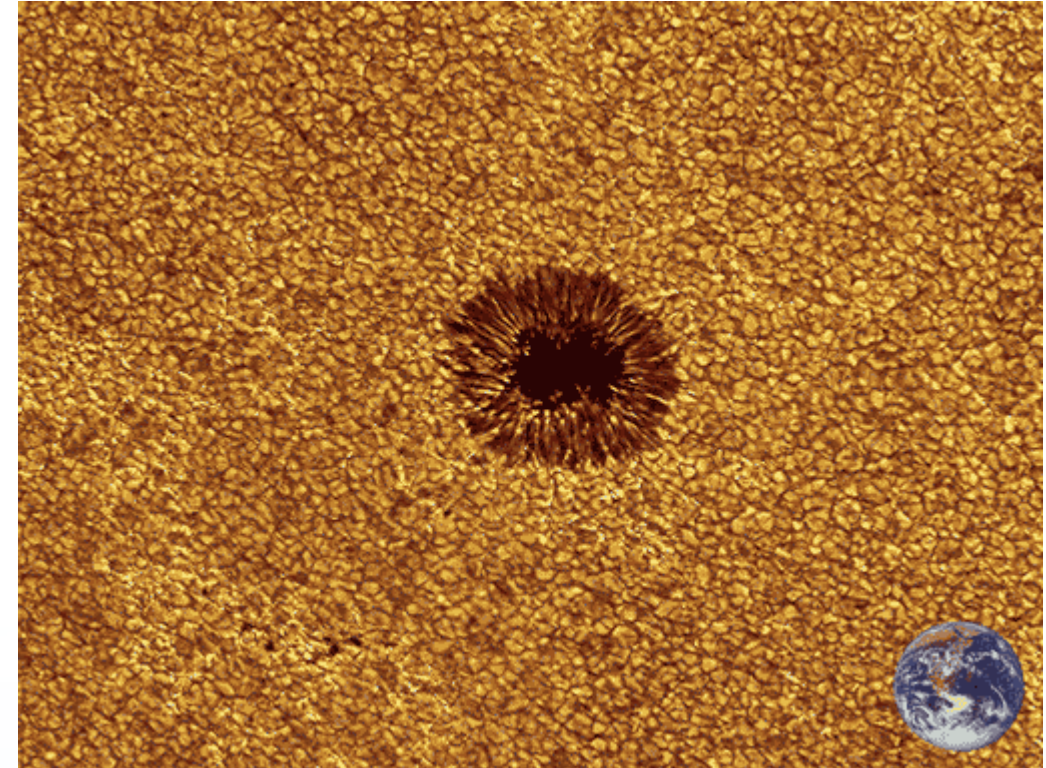
Sunspot

A sunspot is part of a larger structure known as an Active Region.

Sunspots are dark, but only last about one rotation.

The bright region surrounding a sunspot is known as “facula” and can last for several rotations.

The interplay between bright faculae and dark sunspots causes variations in solar irradiance.





Sunspots usually come in pairs, connected by magnetic field.

Charged particles (plasma) stay trapped in the magnetic field.

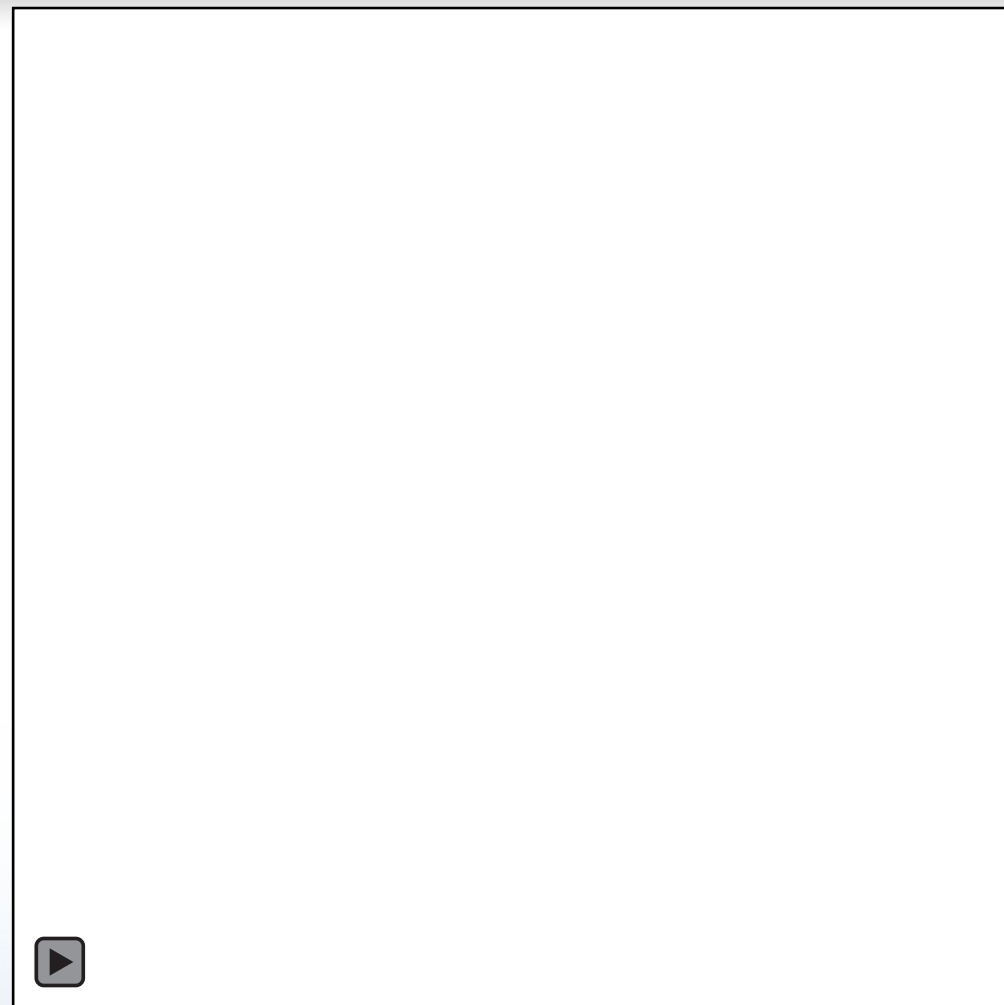
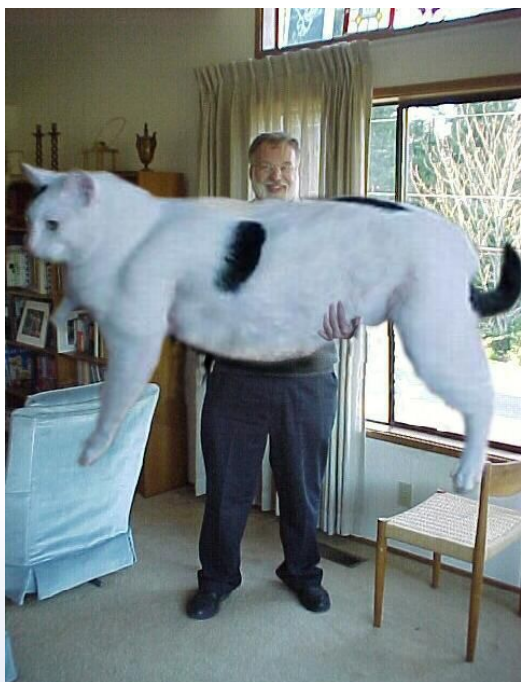
The plasma illuminates the magnetic structures.





Connection between active regions can extend very far.

Remember how large the Sun is compared to the Earth!





ICAO UNITING AVIATION

NO COUNTRY LEFT BEHIND



Earth to scale

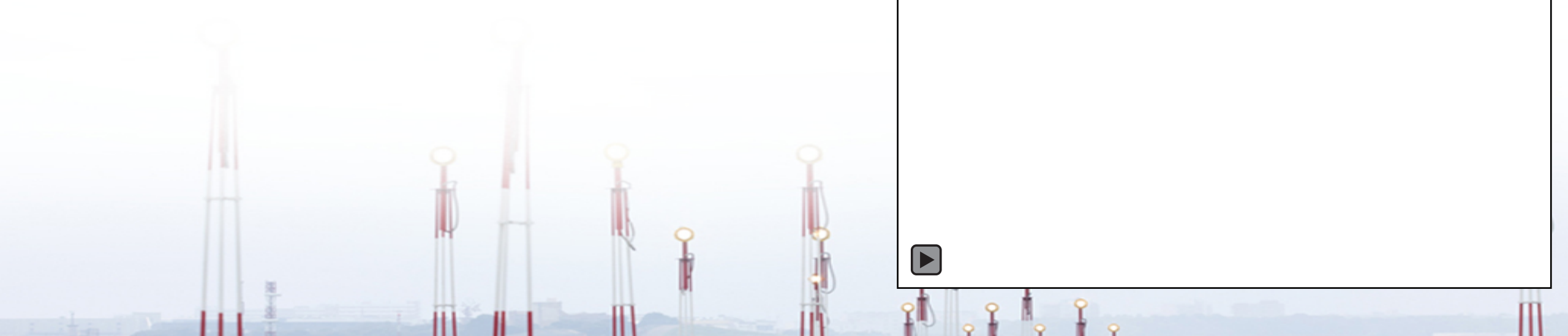
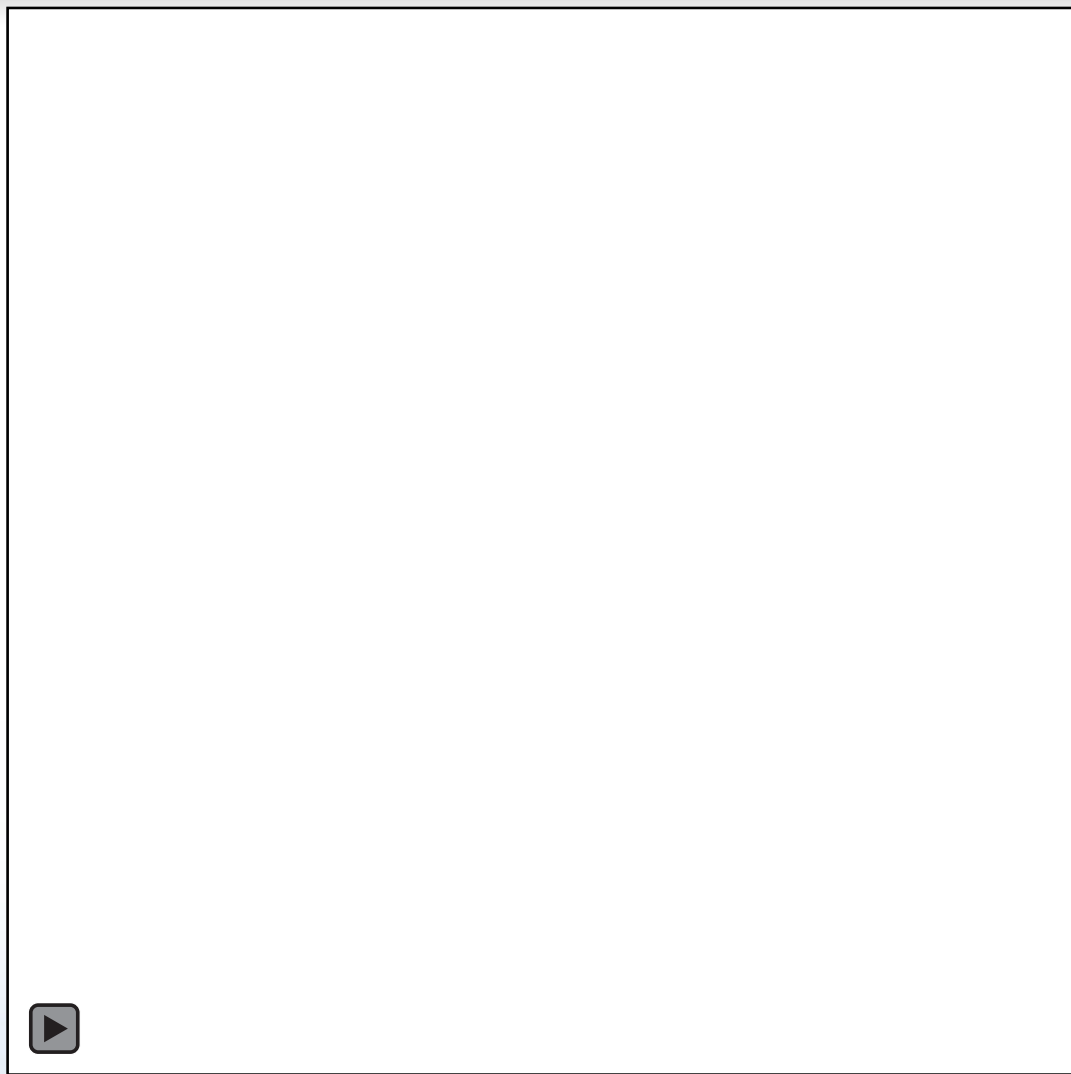




Motion on the surface can twist the magnetic field like a spring.

The magnetic field can reconnect to a simpler geometry, which can release enormous amounts of energy.

These events are known as flares.





Sizes of flares:

Much like storms on Earth, flares are classified according to strength. A hurricane's strength is related to wind speed. A solar flare's strength is defined by the amount X-rays it emits.

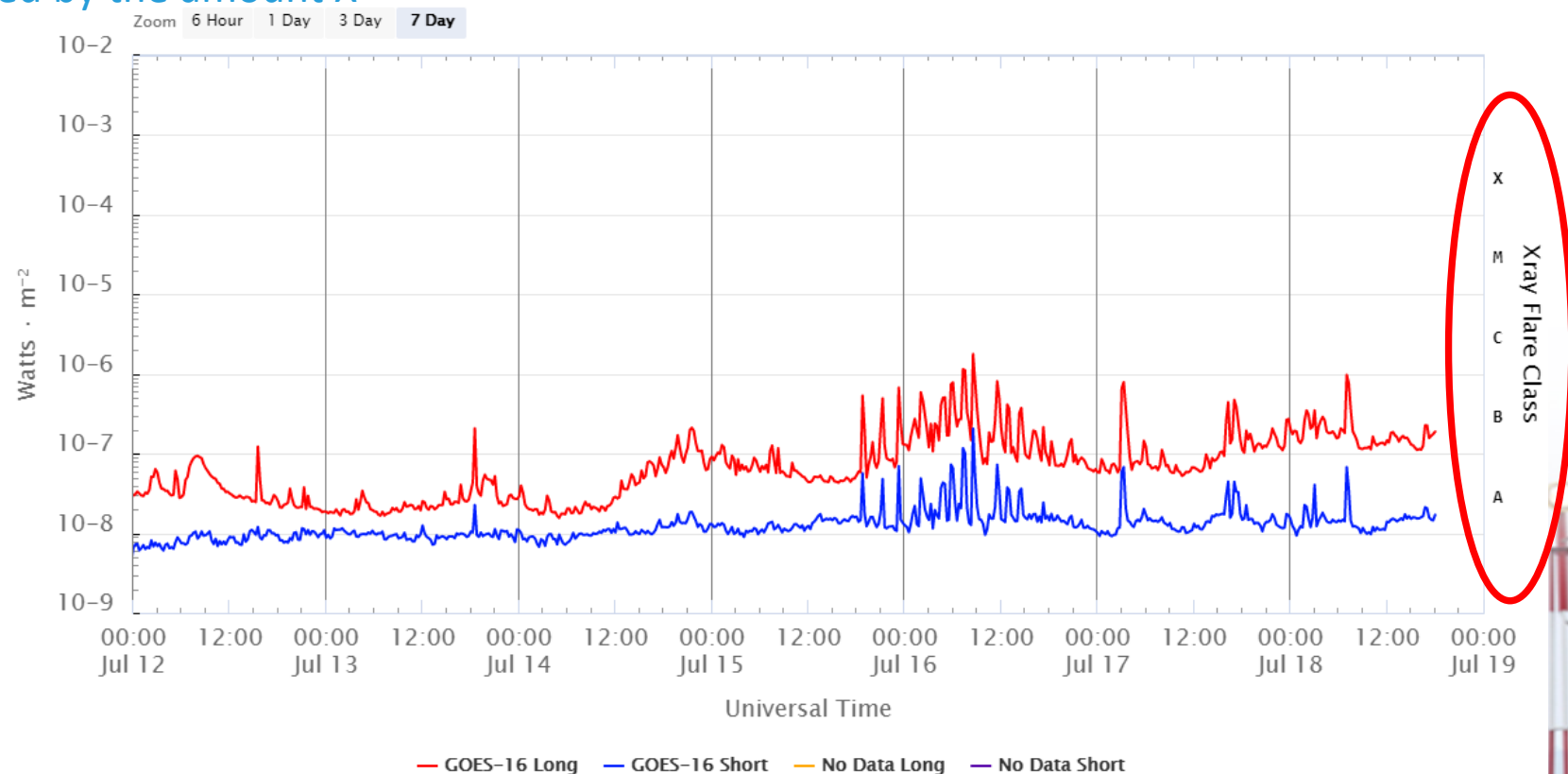
X – extreme

M – medium

A, B, C – all small



GOES X-Ray Flux (1-minute data)





Effect of solar x-rays on the atmosphere: HF radio disruption.

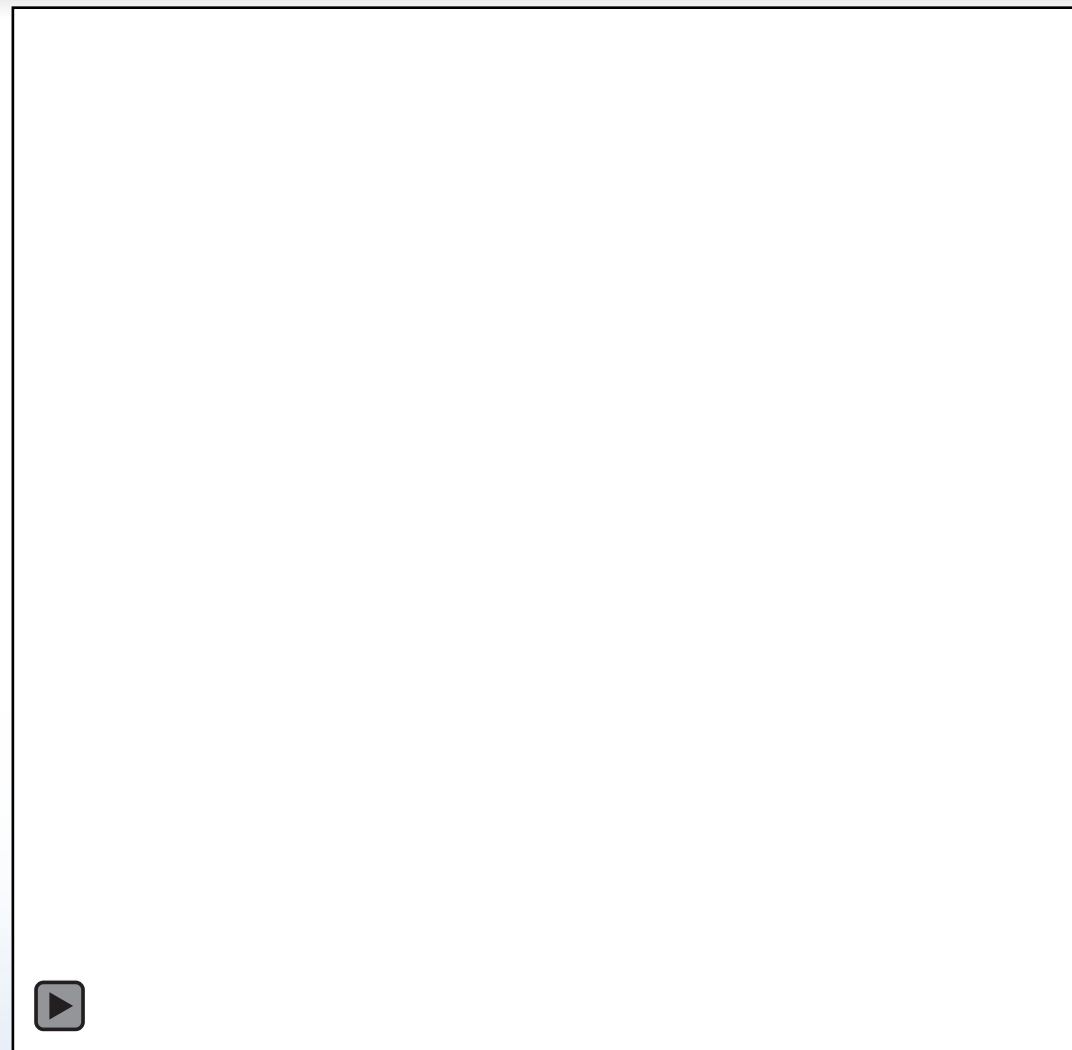
Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
R 5	Extreme	<p>HF Radio: Complete HF (high frequency) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector.</p> <p>Navigation: Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.</p>	X20 (2×10^{-3})	Less than 1 per cycle
R 4	Severe	<p>HF Radio: HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time.</p> <p>Navigation: Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.</p>	X10 (10^{-3})	8 per cycle (8 days per cycle)
R 3	Strong	<p>HF Radio: Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth.</p> <p>Navigation: Low-frequency navigation signals degraded for about an hour.</p>	X1 (10^{-4})	175 per cycle (140 days per cycle)
R 2	Moderate	<p>HF Radio: Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes.</p> <p>Navigation: Degradation of low-frequency navigation signals for tens of minutes.</p>	M5 (5×10^{-5})	350 per cycle (300 days per cycle)
R 1	Minor	<p>HF Radio: Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact.</p> <p>Navigation: Low-frequency navigation signals degraded for brief intervals.</p>	M1 (10^{-5})	2000 per cycle (950 days per cycle)



Magnetic field can become extremely twisted.

When the magnetic field tension is released, it can carry material out in to space.

This is called a Coronal Mass Ejection.





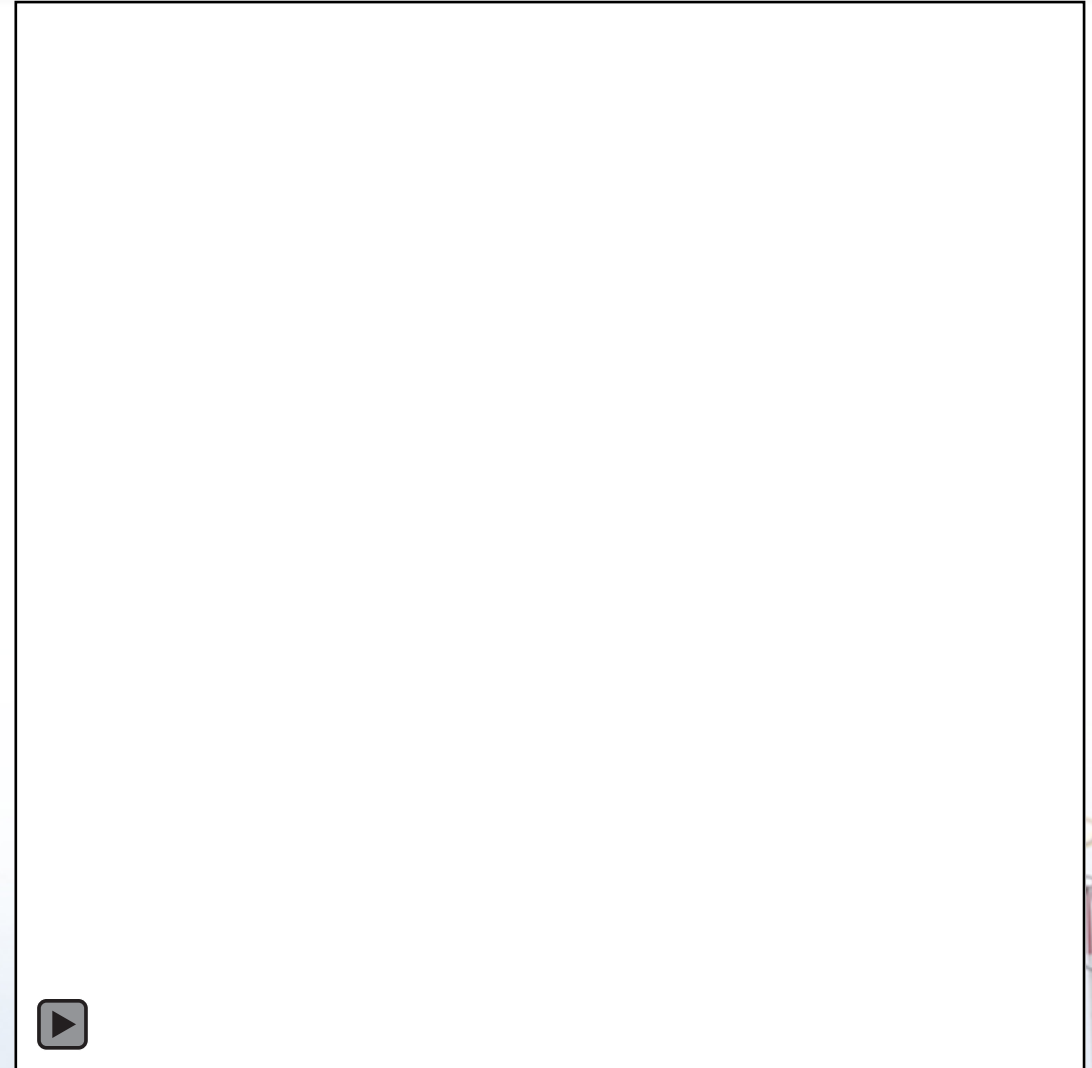
What does a CME look like from far away?

Coronagraph blocks out light from the Sun, allowing us to see faint gas expelled from the Sun.

An image of the Sun has been superimposed on the occulted region.

Eruptions do not always move with the same apparent speed.

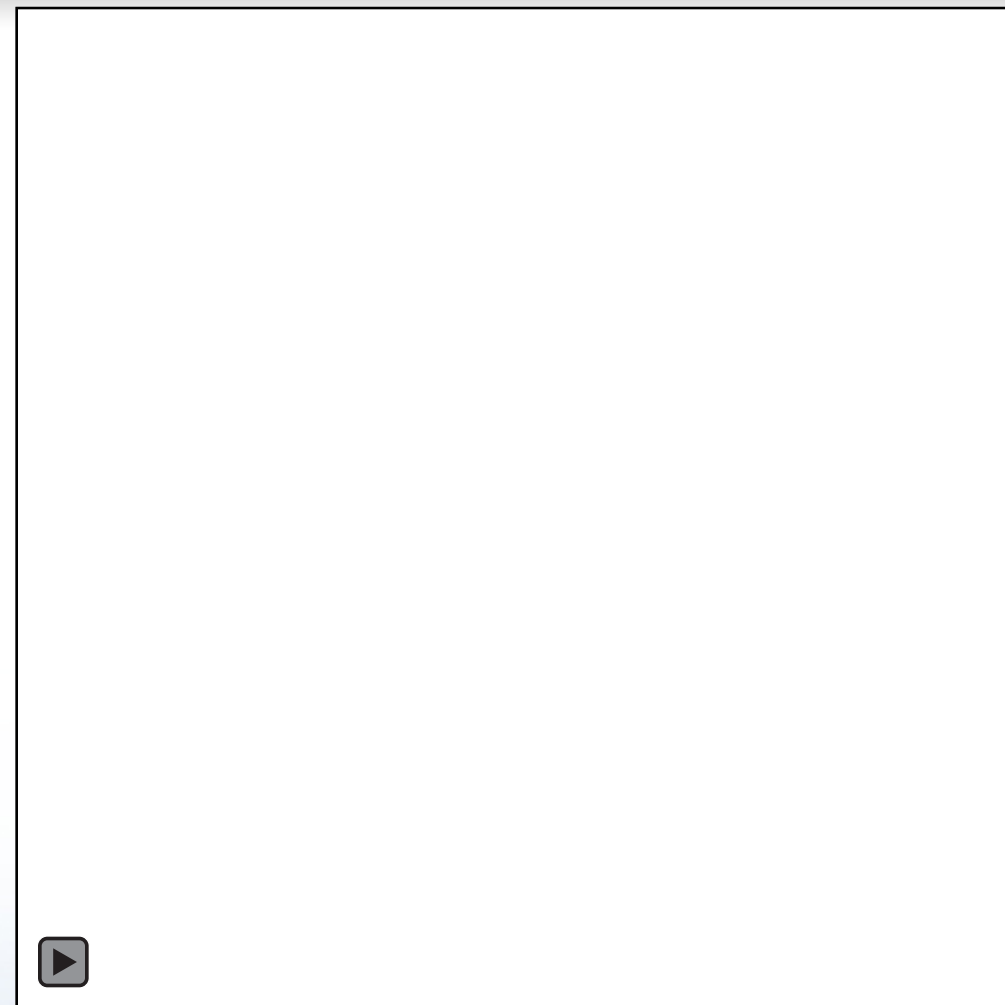
Is the eruption at the top moving slower, or is it coming straight at us?





How do we know if the ejected material will hit the Earth?

We shall see....

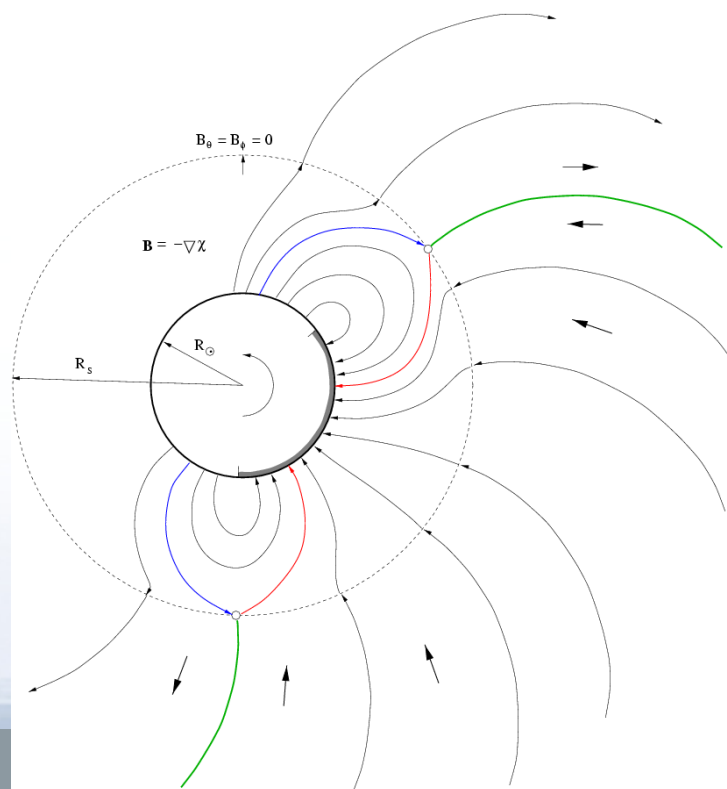




Magnetic structures connect one area on the Sun to another.

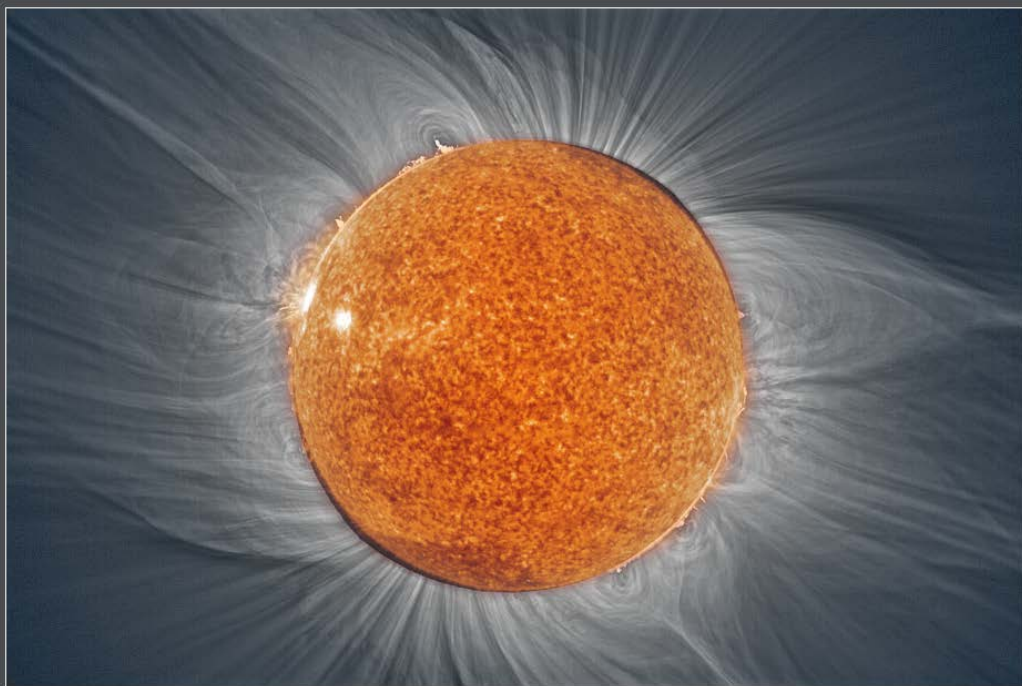
Spaces in between are known as Coronal Holes.

A continual stream of plasma flows out of these holes, known as the solar wind.





CMEs burst out on top of the steady solar wind.



Total Solar Eclipse 2006

© 2006 Miloslav Druckmüller, Peter Aniol, ESA/NASA





ICAO UNITING AVIATION

NO COUNTRY LEFT BEHIND



Since the Sun is rotating, the solar wind looks bent in a spiral pattern.

Slow solar wind 400 km/s

Fast solar wind 800 km/s





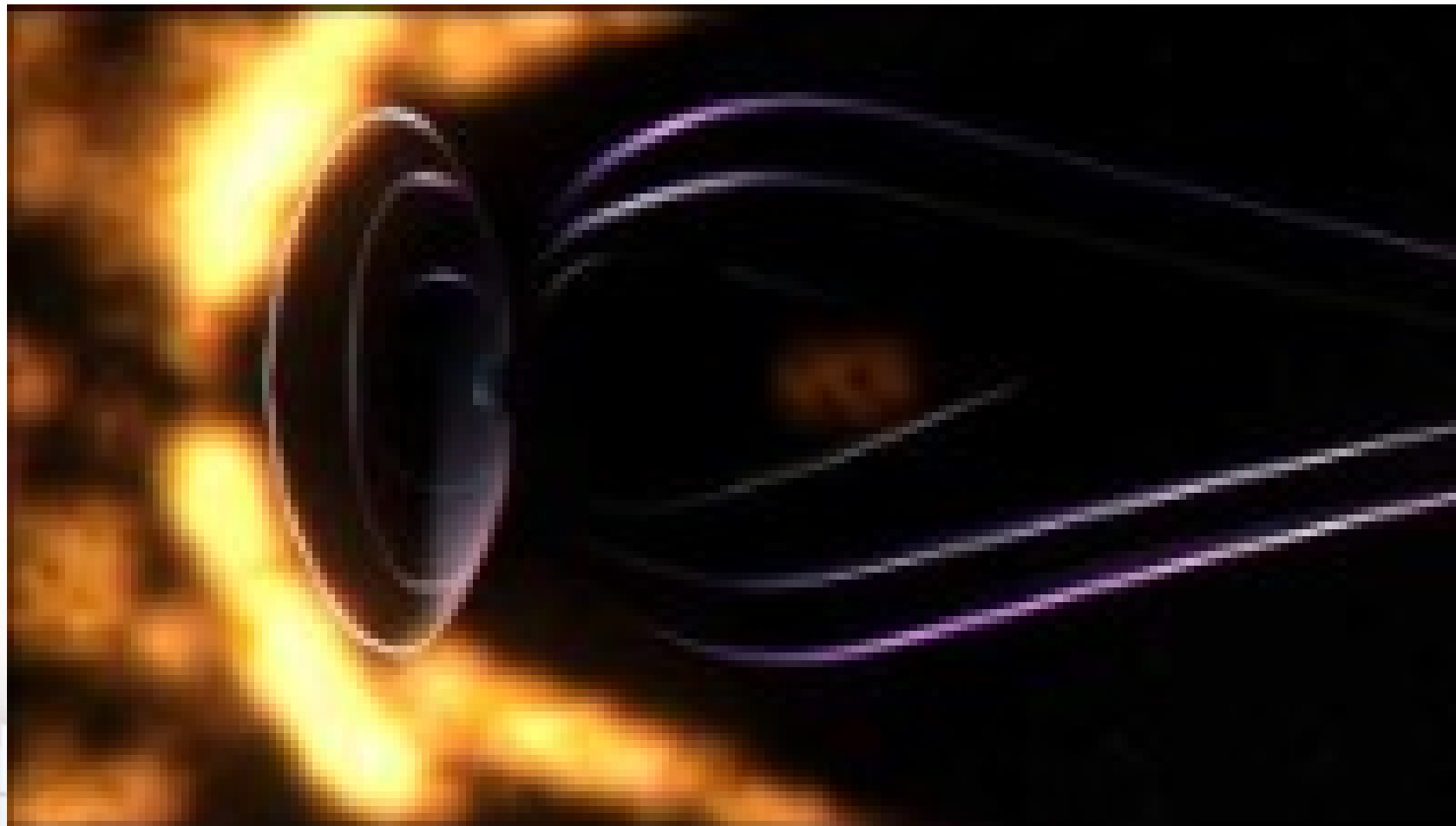
What happens when a CME hits the Earth?

Does it hit directly?

What is the magnetic field orientation of the CME?

What is the density of the CME?

Why are there so many questions?





ICAO UNITING AVIATION

NO COUNTRY LEFT BEHIND



What is coming around the corner?

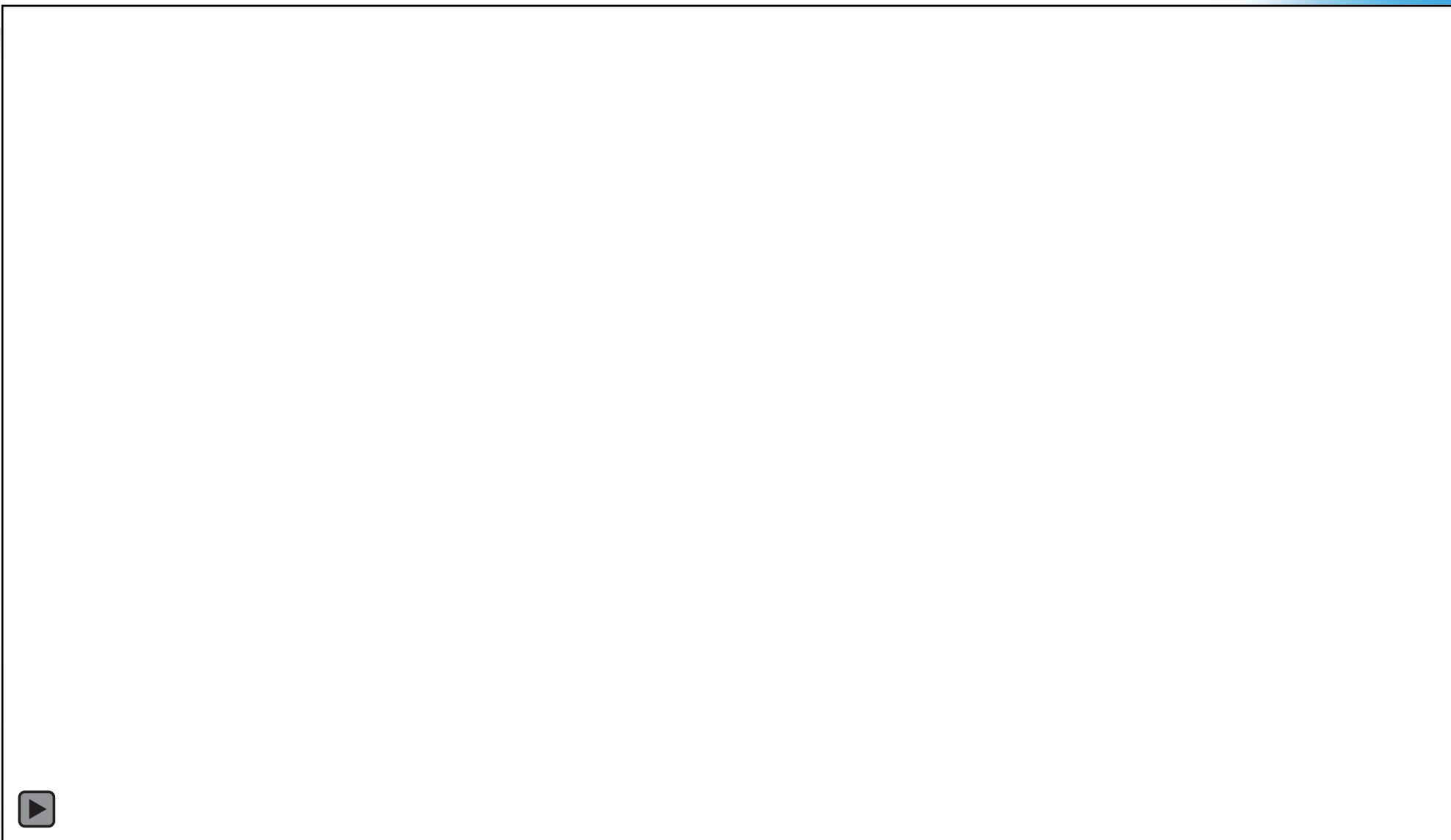
Only Space Weather Forecasters know!





ICAO UNITING AVIATION

NO COUNTRY LEFT BEHIND





ICAO

UNITING AVIATION

NO COUNTRY LEFT BEHIND



ICAO

North American
Central American
and Caribbean
(NACC) Office
Mexico City

South American
(SAM) Office
Lima

ICAO
Headquarters
Montréal

Western and
Central African
(WACAF) Office
Dakar

European and
North Atlantic
(EUR/NAT) Office
Paris

Middle East
(MID) Office
Cairo

Eastern and
Southern African
(ESAF) Office
Nairobi

Asia and Pacific
(APAC) Sub-office
Beijing

Asia and Pacific
(APAC) Office
Bangkok



THANK YOU