

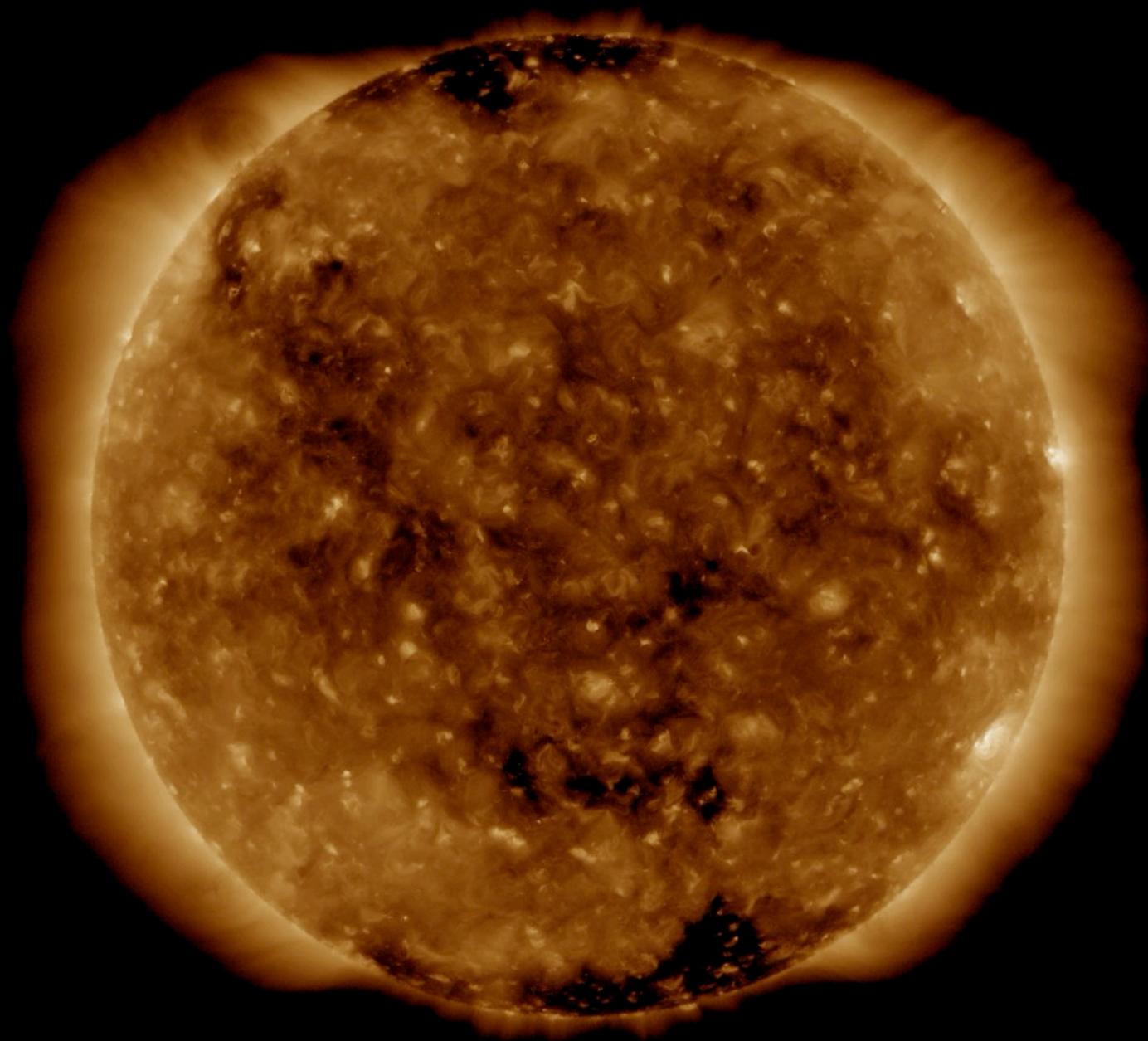
Space Weather Impacts on Society

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Dublin Institute for Advanced Studies
Ireland

Overview

- Origins of Space Weather
- Impacts on technology
- Societal impacts
- Monitoring/Emergency planning

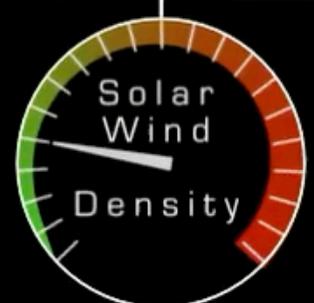
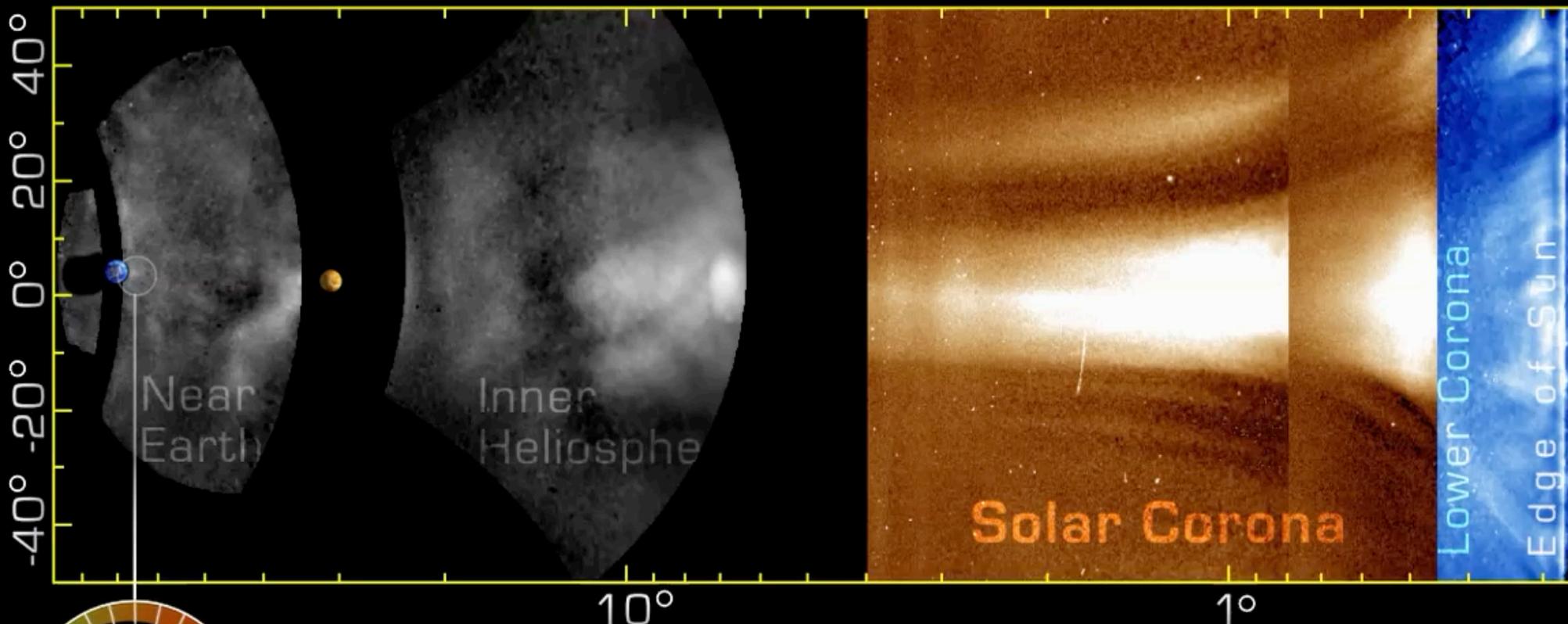
Credit: NASA/SDO



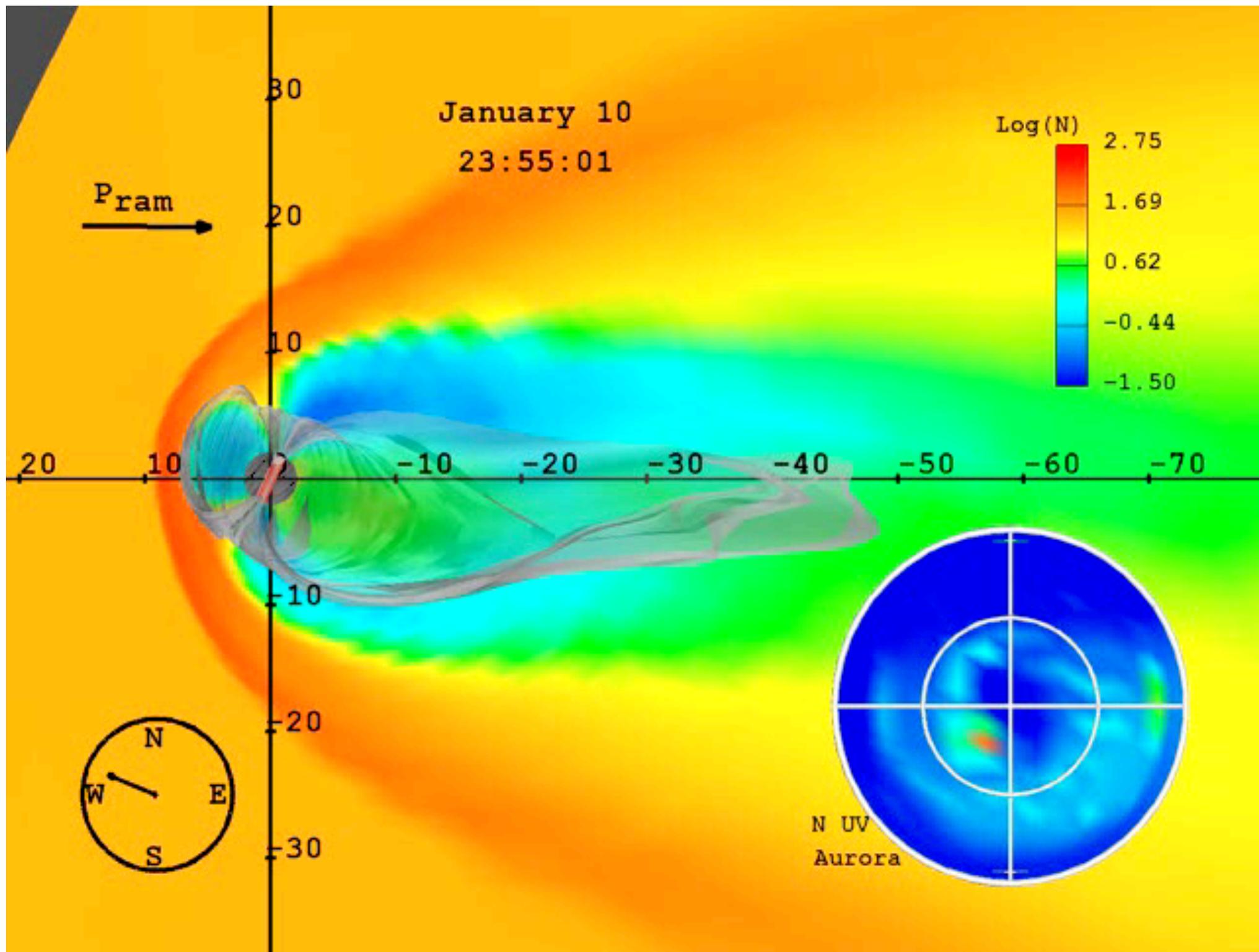
SDO/AIA 193 2020-06-28 00:08:29 UT



Apr 17 2002 23:59:32

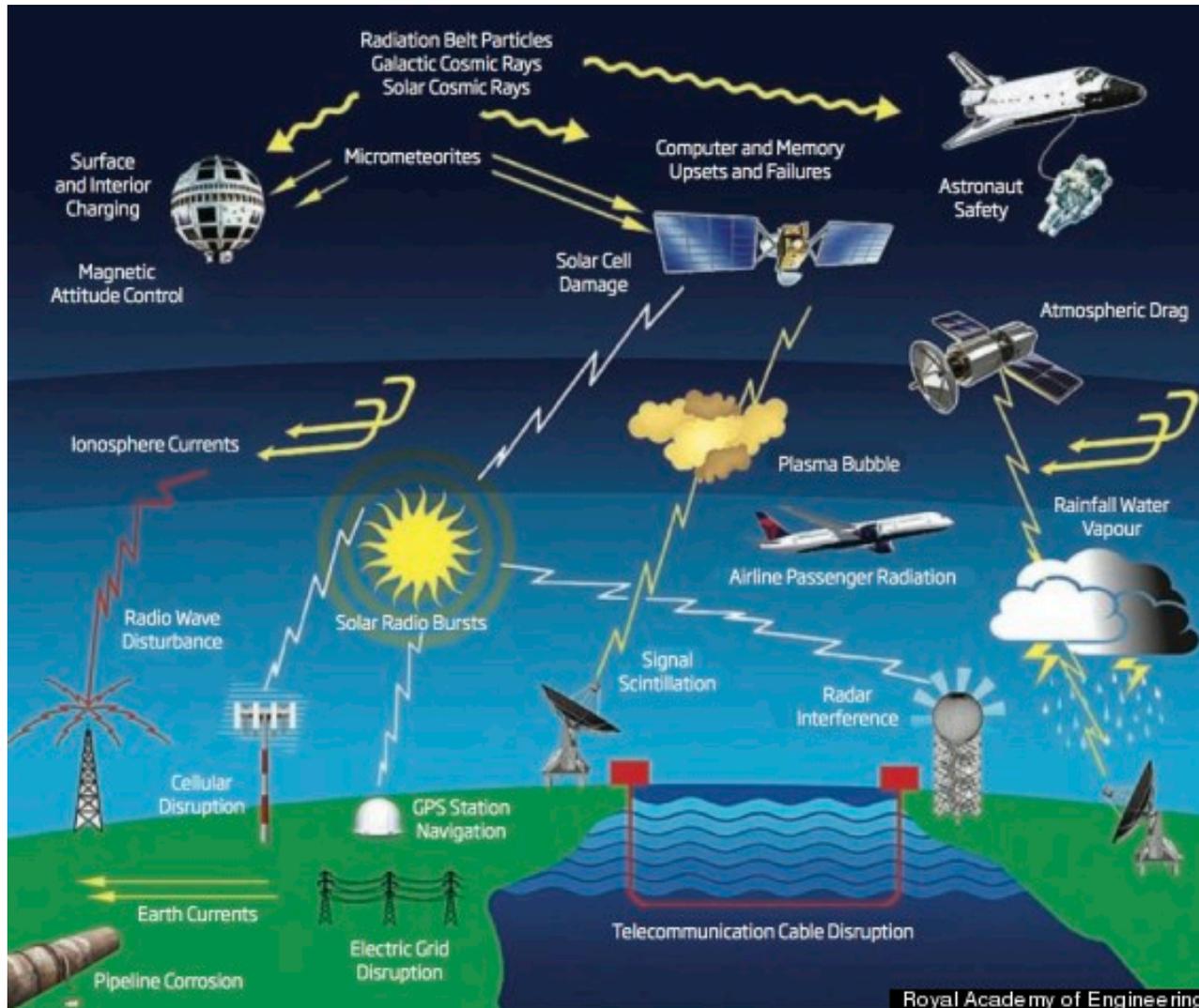


STEREO-A:12/11/08 12:40:00 AM



Technological Impacts of Space Weather

Royal Academy of Engineering Extreme Space Weather Study



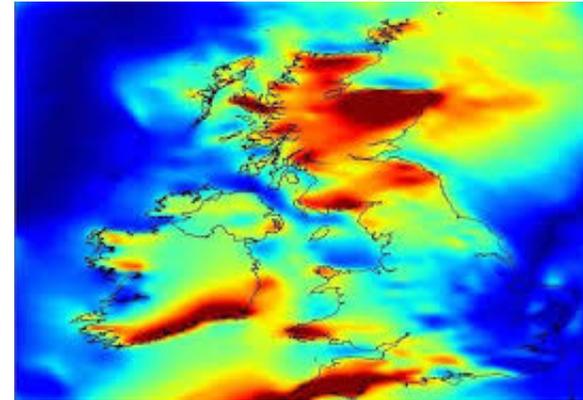
Main Impacts of Concern

- Power grid outages, surveying and directional drilling
- Communications outages
- Aviation and Air Traffic Control disruptions
- Global Navigation Satellite Systems (GNSS) disruptions

Power Grids, Surveying and Drilling

Geomagnetic Effects

- **Cause:** Geomagnetic storm cause currents in power grid and errors in magnetic positioning.
- **Impact:** Power blackouts and damage to infrastructure and positioning errors.
- **Example:** Quebec, Canada, 1989 and Malmo, Sweden, 2003.
- **100 year Event:** Could cause loss of power for hours-days and serious long-term damage.



Power Grids, Surveying and Drilling

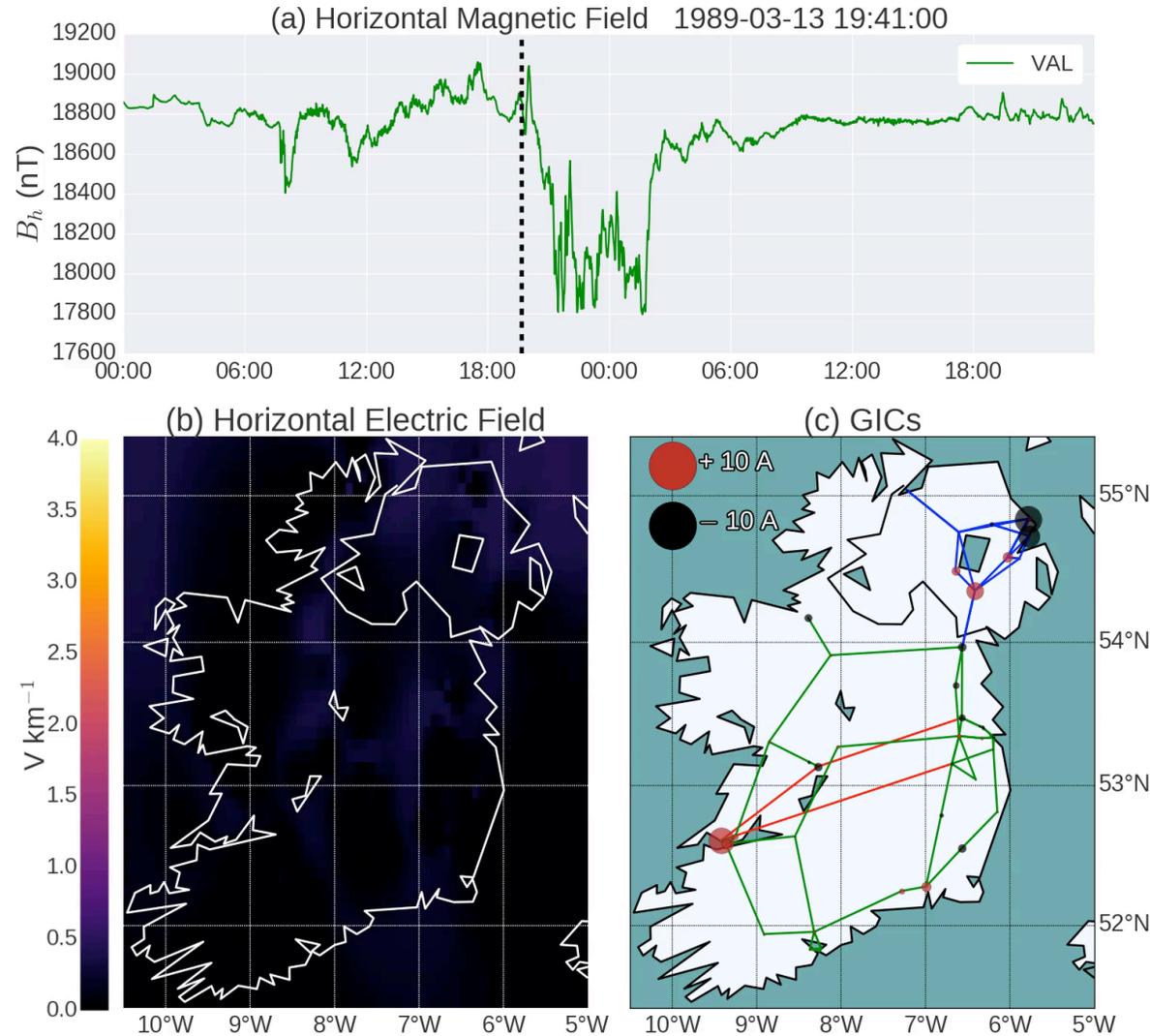
Examples of Extreme Events

- **Solar Storm of March 1989**
 - Electrical blackout in Canada affecting millions of people for 9 hours. Cost: CA\$2 billion.
 - Damage to Jew Jersey transformer cost \$10 million and 6 weeks to repair.
- **Halloween Storms of October/November 2003**
 - Hour-long power outage in Sweden.
 - In UK, compass north changed temporarily by five degrees in just six minutes.



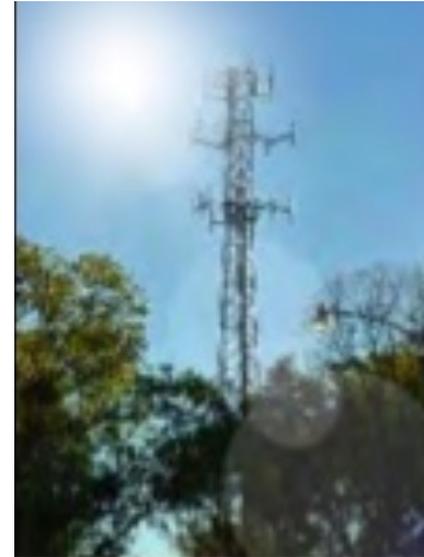
Power Grids, Surveying and Drilling

Irish power-grid simulation (Blake, Gallagher, et al., Space Weather, 2016)



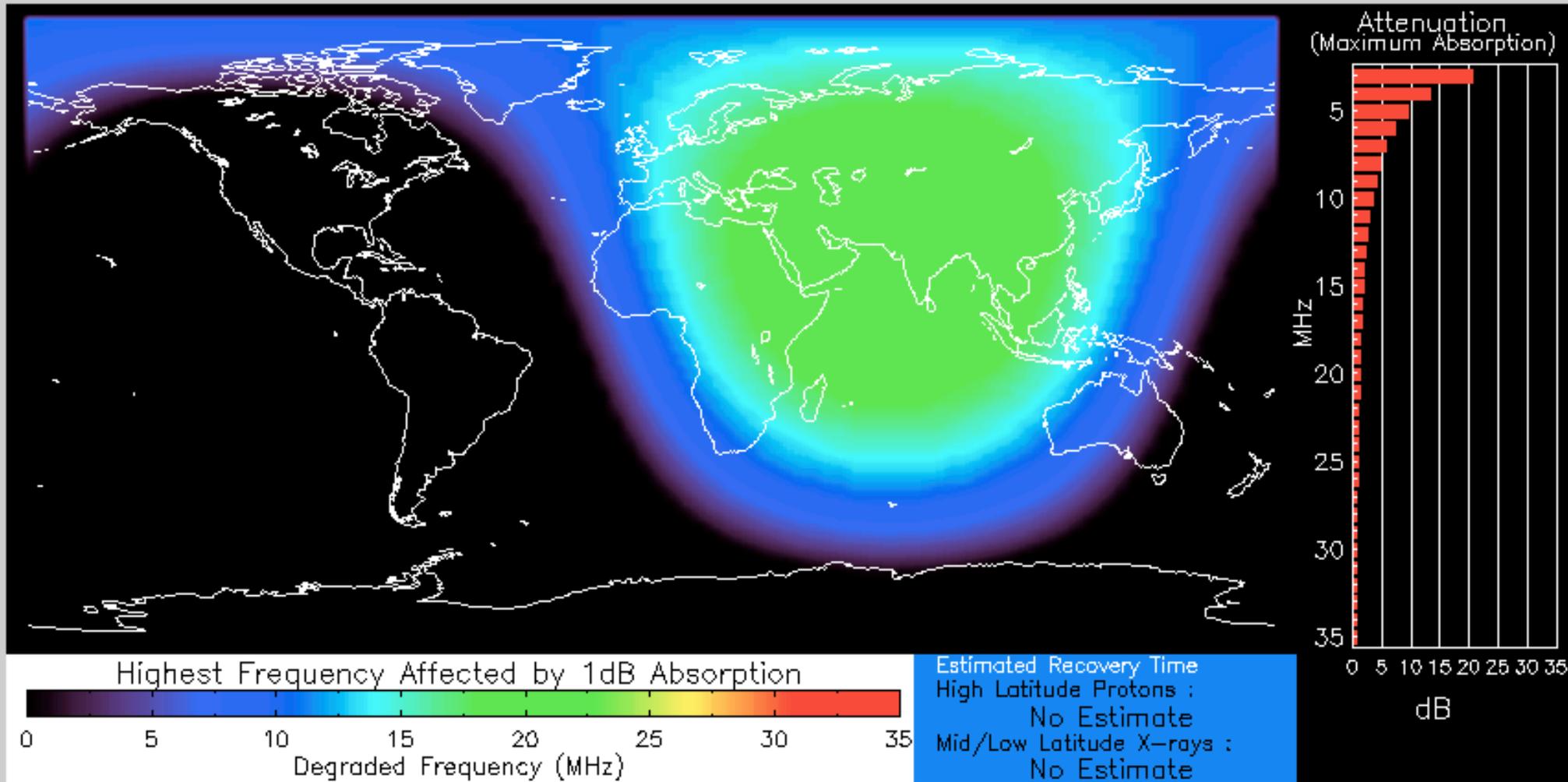
Communications

- **Cause:** Solar flare radiation interferes with the ionosphere.
- **Impact:** HF, VHF, UHF blackouts. Mobile phone call drops.
- **Example:** Many disruptions per month.
- **100 year event:** Could cause many hours of communications blackout across day side of Earth.



Radio communications impact (29 May 2020)

GLOBAL (1 DB ABS)

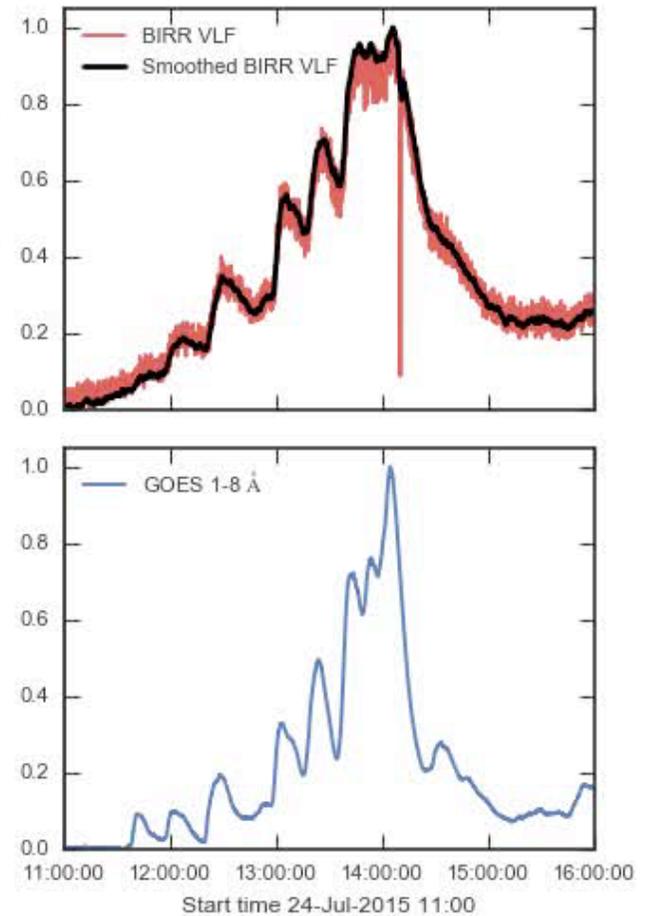
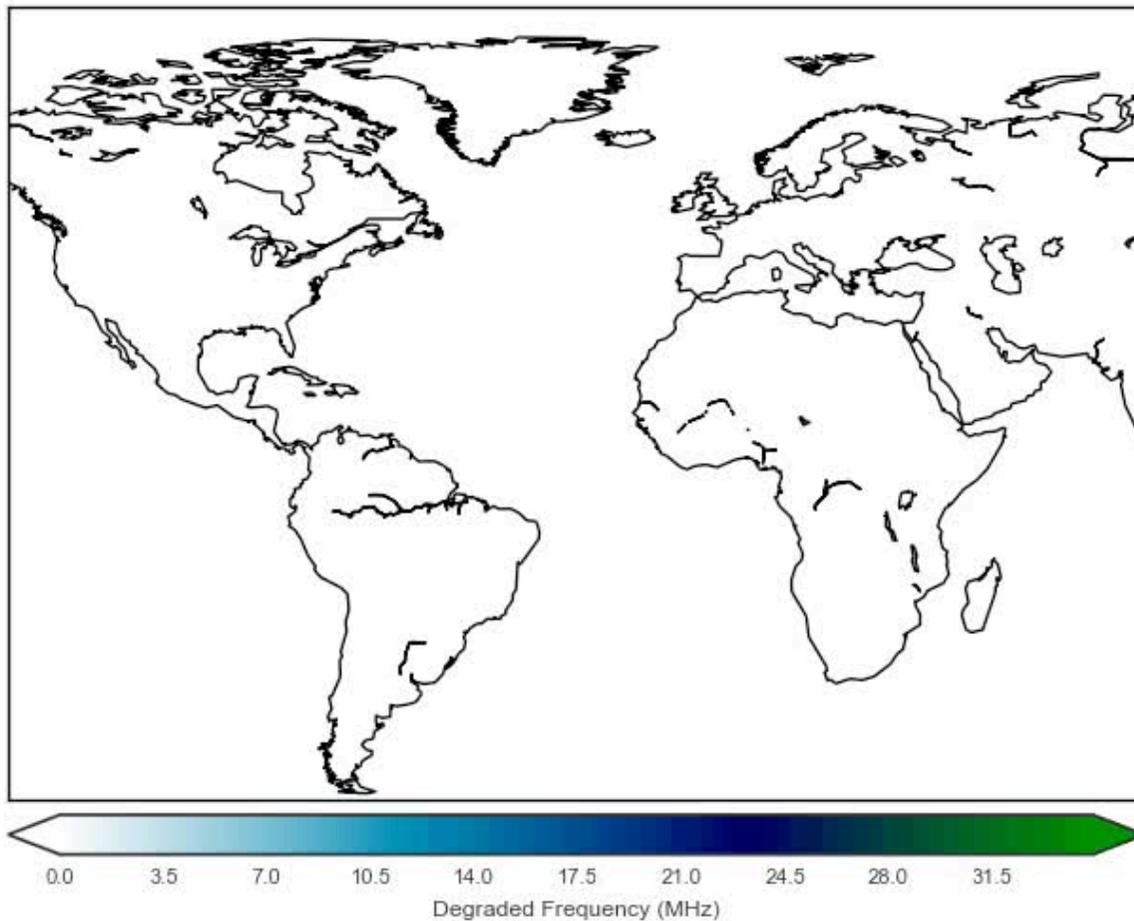


Elevated X-ray flux
Product Valid At : 2020-05-29 07:26 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA

Communications and Aviation

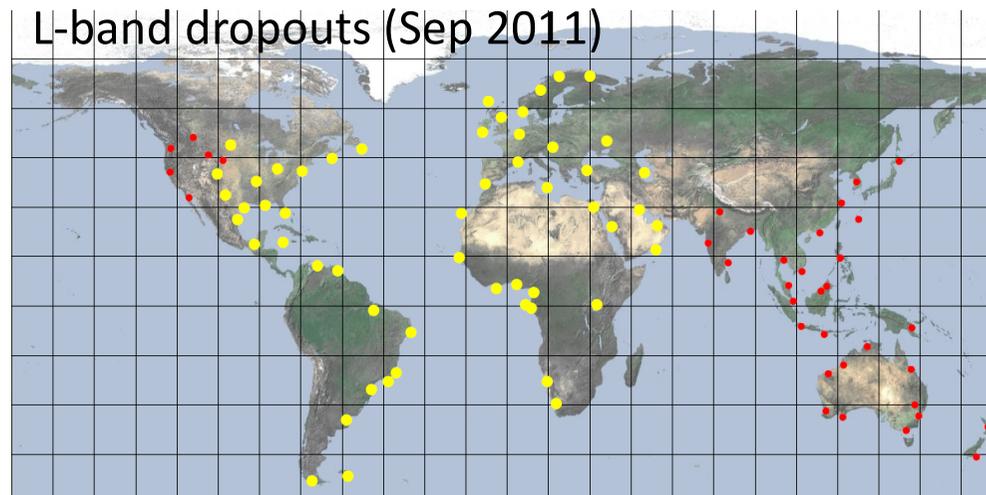
TCD monitoring of ionosphere



Communications

Examples of Extreme Events

- **Mobile phones:** 7% of mobile phone calls dropped during solar storms. Much larger during 100 year event.
- **Commercial SW radio:** Down in Netherlands and China for several hours in 2005 and 2011.



- **HF Communications:** 2005 all HF communications degraded on day side of Earth during flare.

Aviation

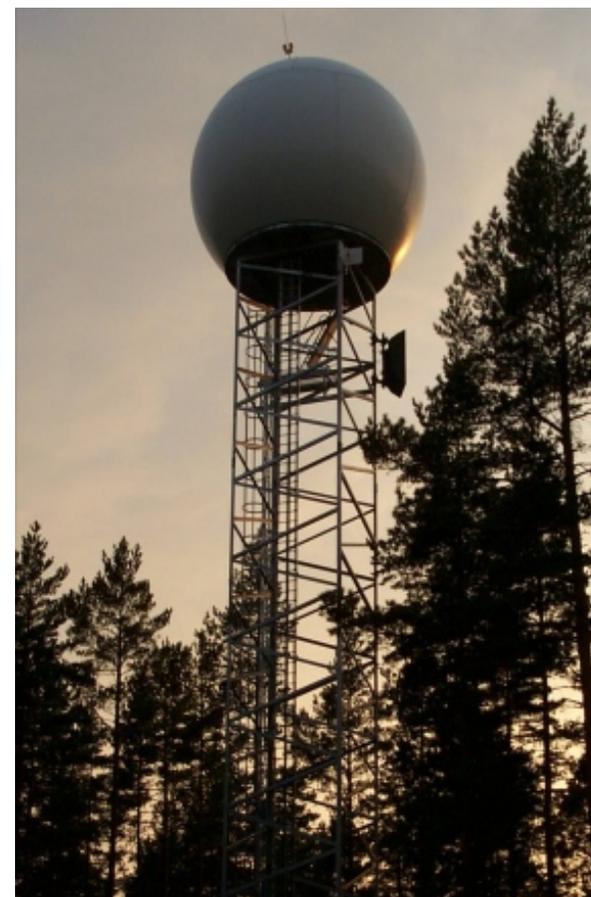
- **Cause:** Solar flares and solar storms.
- **Impact:** Radiation dose for crew and passengers and loss of communications.
- **Example:** Transatlantic planes grounded in 2003 in Greenland. Air traffic radar jammed in September 2015 in Sweden.
- **100 year event:** Could ground significant number of flights.



Aviation

Examples of Extreme Events

- **1989:** Montreal-Dorval international airport temporarily paralysed.
- **2003:** Aircraft forced to land in Greenland due to a communications blackout and excessive radiation exposure to air travellers.
- **2015:** Sweden airtraffic control radar out of operation for ~1 hour.



Global Navigation Satellite Systems (GNSS) disruptions

- **Cause:** Flare radiation and storms.
- **Impact:** Loss of timing and positioning.
- **Example:** 2006 radio burst caused GPS lock loss across entire day side of Earth.
- **100 year event:** Could cause complete loss of GNSS signal for many hours.



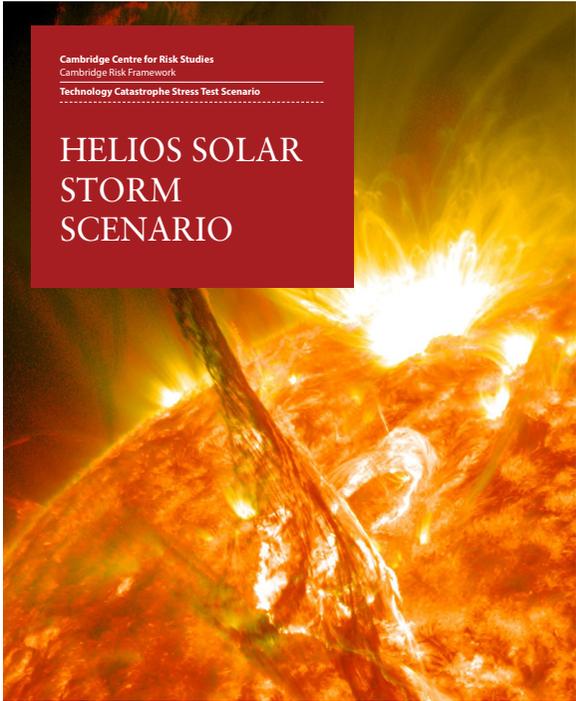
Space Weather Risk and Insurance



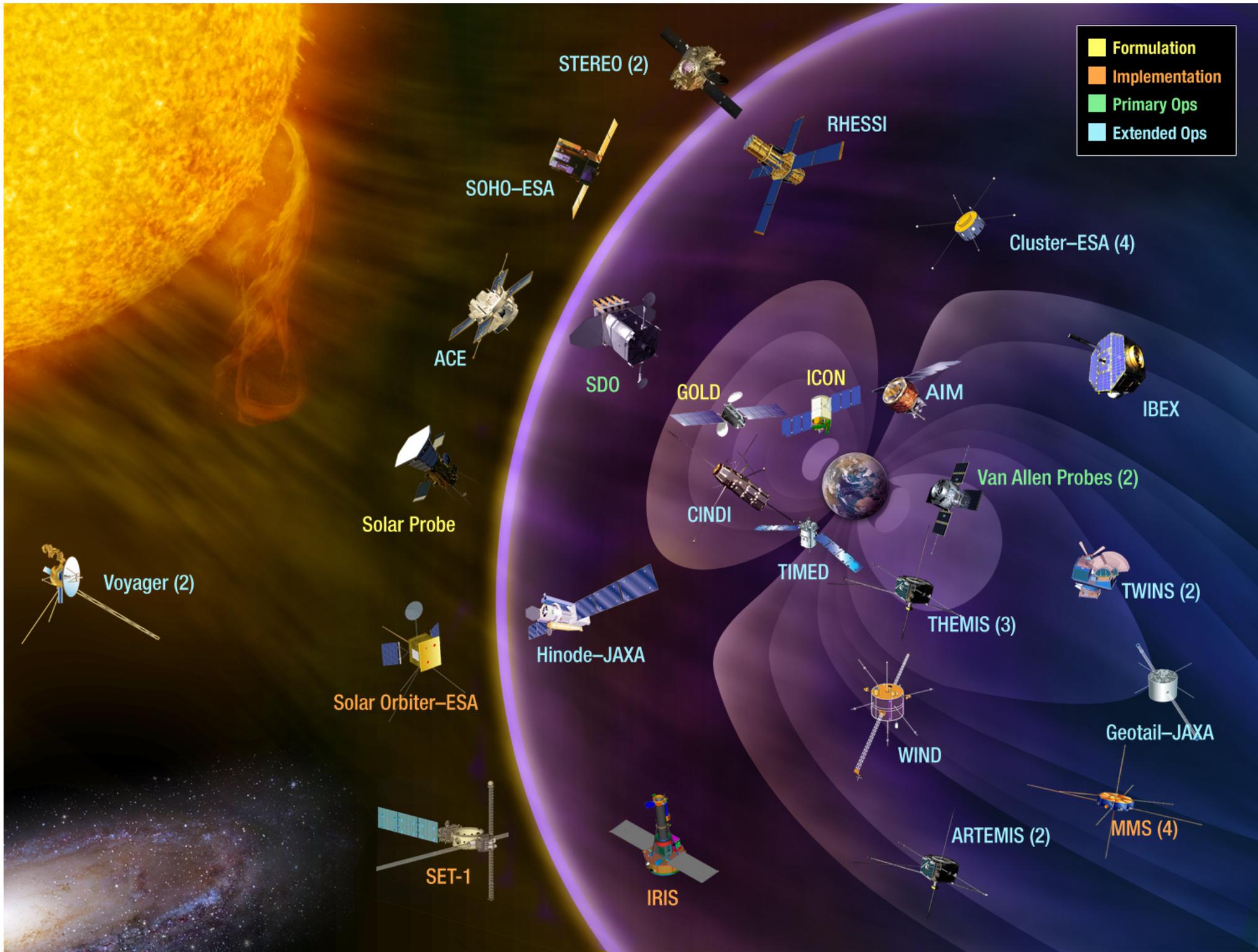
Allianz 2009



Lloyds 2011



Cambridge/AIG 2016



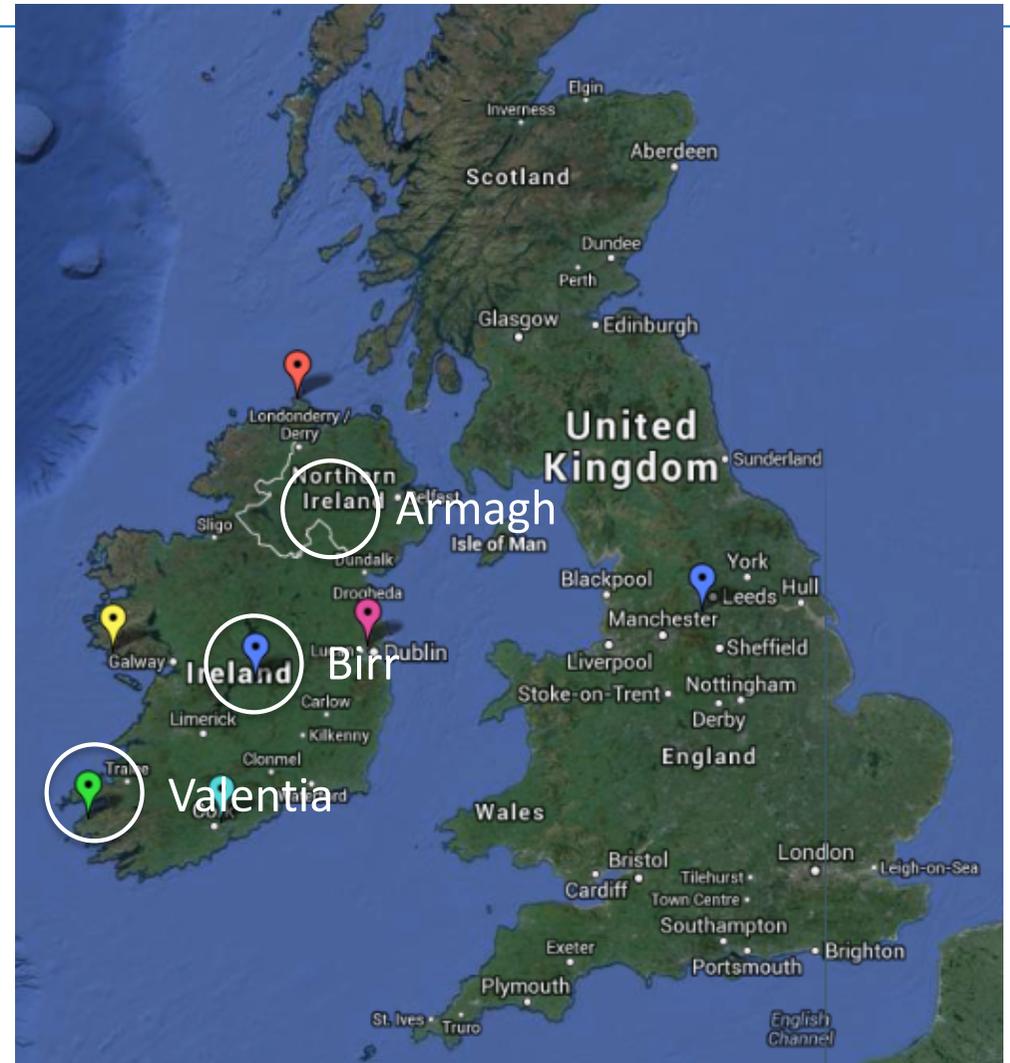
Space Weather Monitoring in Ireland

- **Solar Radio Burst Monitoring**
 - LOFAR and eCallisto
- **VLF Ionosphere Monitors**
 - Stanford, Russian Academy
- **Geomagnetic Monitors**
 - Birr/Valentia/Armagh



MagIE: Magnetometer Network of Ireland

- Met Eireann Valentia Observatory: Magnetic fields since 1888.
- Valentia magnetometer data on INTERMAGNET.
- Magnetometers now at Birr and Armagh.
- Data at www.magie.ie



Date Search

4 June 2020

NOAA Search

← 20200603 ← Week ← Rotation

Today

Rotation → Week → 20200605 →

Main

Far-side

SDO short-wave

SDO long-wave

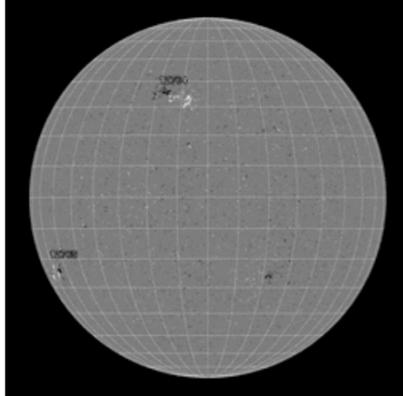
NOAA
2 Active
Regions

Flare
Forecast

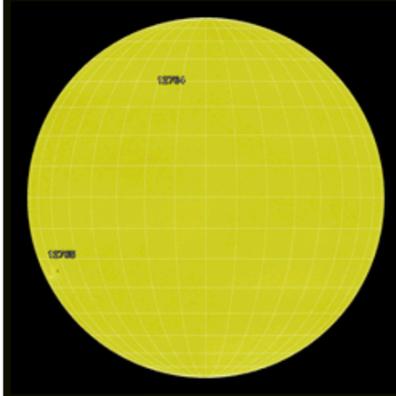
Coronal
Holes

GOES
ACE
SDO/EVE
Events

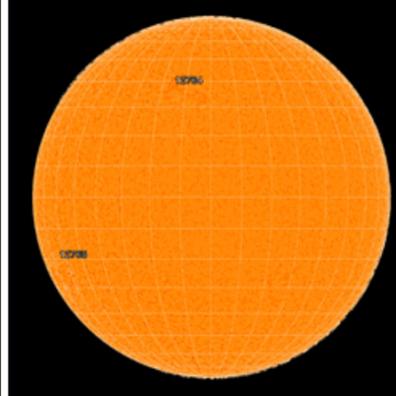
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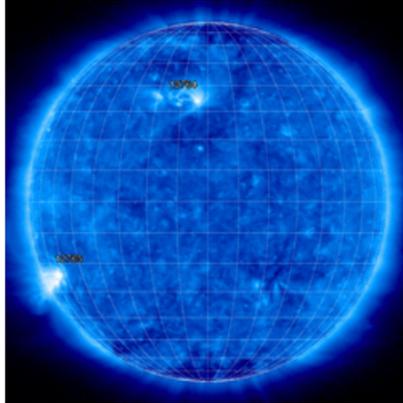
HMI 6173Å 20200604 10:10



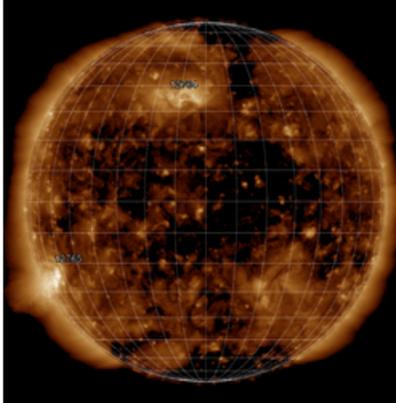
GHN Ha 20200604 18:44



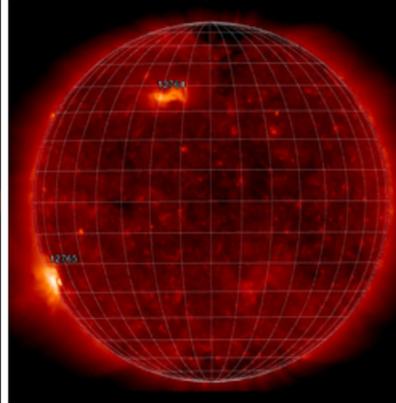
SWAP 174Å 20200604 16:41



AIA 193Å 20200604 18:54



XRT 20200604 05:56



Today's/Yesterday's NOAA Active Regions

NOAA Number	Latest Position	Hale Class	McIntosh Class	Sunspot Area [millionths]	Number of Spots	Recent Flares
12765	S24E60 (-749", -383")	α/-	Hsx/---	0070/----	02/--	-
12764	N34E10 (-136", 532")	/	/	/	/	-



ISES
International Space
Environment Service

International Space Environment Service



