

# Space Weather

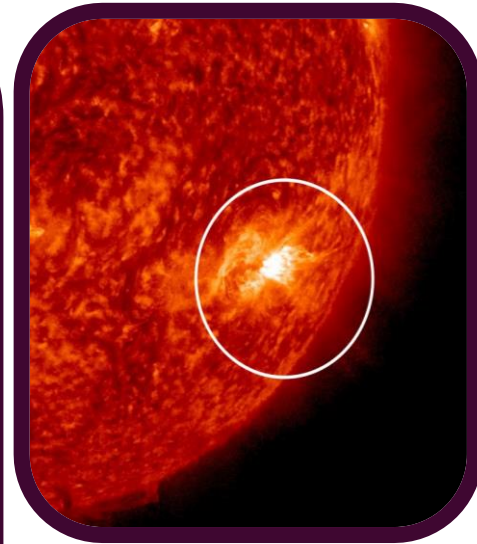
## WHAT IS SPACE WEATHER?

Environmental conditions in space influenced by the Sun and solar wind. The Sun experiences 11-year cycles of solar activity; the peak is the solar maximum. Largest events are scattered throughout the solar cycle and are not restricted to period of solar maximum.

Includes:

- ❖ Coronal Holes
- ❖ Sunspots
- ❖ Solar Flares
- ❖ Solar Eclipses
- ❖ Coronal Mass Ejections (CMEs)

CMEs are large expulsions of plasma from the Sun's corona into interplanetary space.



CME captured by  
NASA/Solar Dynamics  
Observatory –  
15<sup>th</sup> July 2023

## CARRINGTON EVENT, 1859

The most intense geomagnetic storm in recorded history occurred on 1<sup>st</sup>–2<sup>nd</sup> Sep 1859, caused by a CME travelling directly towards Earth and arriving in only 17 hours. It caused intense auroras to be seen globally, even as far as the tropics. GICs caused fires on telegraph poles, leading to telegraph systems all over Europe and North America to fail and in some cases giving the operators electric shocks. Some telegraph operators were able to continue sending and receiving messages despite disconnecting their power supplies, working solely with the current induced by the aurora.

## QUEBEC BLACKOUT, 1989

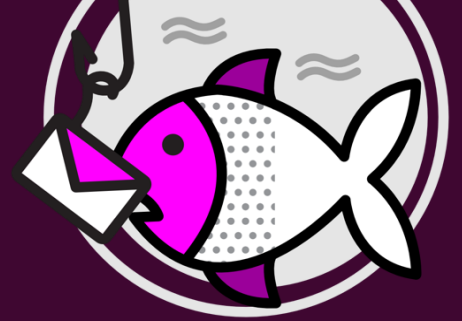
A large CME caused a 9-hour long blackout of the Quebec grid. Unusual harmonics caused transformers to overheat and circuit breakers to trip leading to the loss of 9.45GW of supply (out of a total load of 21.35GW).



Damage to Quebec transformer  
[Image from J.G. Kappenamn]



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## THE IMPACTS OF SPACE WEATHER

Plasma expelled from the Sun has a magnetic charge; when this reaches Earth it can induce an electric field in the earth's surface. This field can induce geomagnetically induced currents (GICs) in conductive structures. It is also the cause of the aurora borealis ('Northern Lights').

GICs can cause:

- Harmonics
- Part-Cycle Saturation
- Voltage Depression
- Damage to High Voltage Transformers
- Degradation of GPS Signals

The impact of GICs are amplified by:

- Geographic Location
- Higher Voltages
- Longer Transmission Lines
- Transformer Design

## PROJECT SWIFTER

*Space Weather Impact for Future Electricity System Resilience*

Aims to review the system's resilience; investigate how resilience might change in the future; assess the effectiveness of potential mitigations; & review industry contingency and response plans.

## MITIGATION

Action must be taken before the CME occurs. This is enabled by live monitoring, accurate forecasting/modelling and timely alerts, such as from the Met Office (MOSWOC). Other actions include:

- Implementing site specific switching plans to reduce the impacts of GIC on transmission.
- Consideration in design of transformers and network.
- Making extra generation, voltage support and staff available.
- Business continuity plans.

## NESO's WORK

- ✓ Collaborated with DESNZ, Met Office and Industry to better understand the effects of space weather.
- ✓ Implemented GC0183 → Obligating Generators, Interconnector Owners and Restoration Contractors to set out their anticipated availability during and after a space weather event.
- ✓ Reviewing system resilience and the effective of potential mitigations.