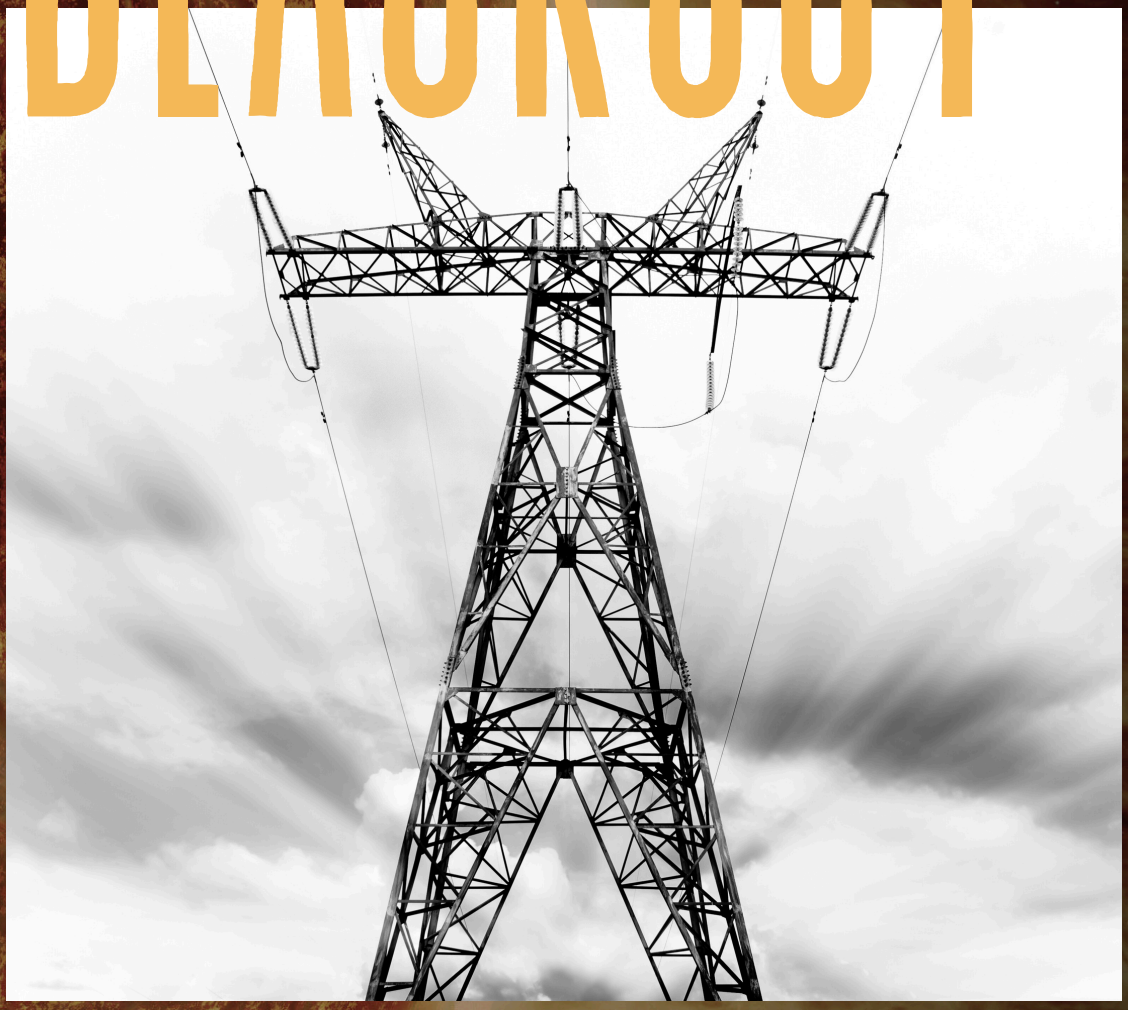
CAN I EXPERIENCE POWER BLACKOUT DUE TO SOLAR STORMS?



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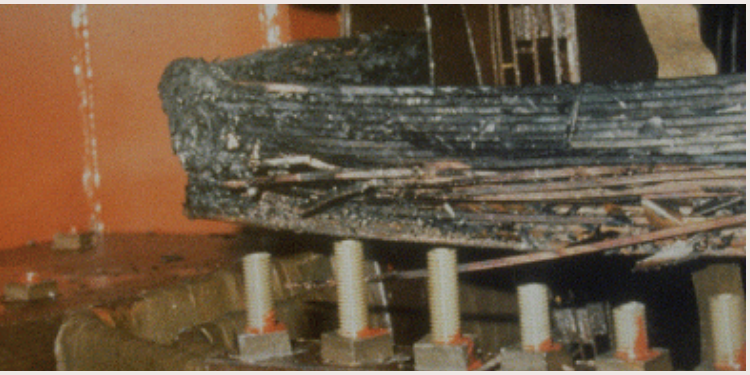
ONE FREEZING MORNING

The Quebec power blackout in 1989

Quebec from ISS, NASA

On March 13, 1989, an event no one expected unfolded in Canada. The entire population of Quebec, numbering approximately six million, awoke to a cold morning devoid of electricity. The absence of light, electric heating, radio, television, telephones, and even traffic signals created a challenging situation. The blackout, which lasted for nine hours, left residents in a state of uncertainty and confusion. Essential services such as the Montreal Metro and the airport were forced to cease operations. Numerous businesses and schools had to close their doors for the day.

One can wonder what caused such a severe event? We need to look at the day sky, particularly at our most important source of light and warmth - the Sun. The Sun is very active, and the way it influences its environment, including Earth's, is called space weather. That day, the space weather was very stormy, causing power blackouts.



Damage to a power transformer in Salem, New Jersey, USA, J.G. Kappenman

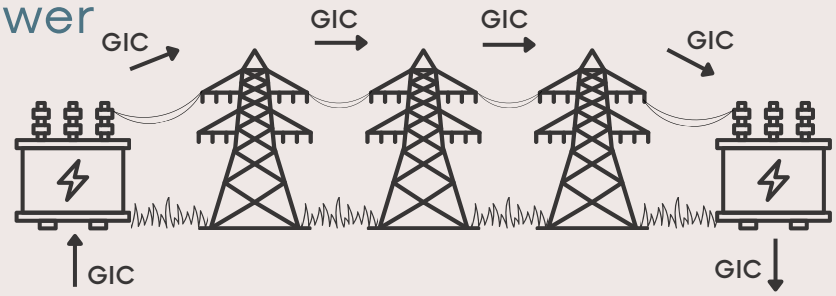
This event also led to the display of spectacular aurorae, visible as far south as Cuba and Florida. Unfortunately, it caused the entire power grid of Quebec to collapse.

There have been several instances where space weather events have led to power disruptions. For instance, on October 29th and 30th, 2003, a severe space weather storm, known as the Halloween storm, caused simultaneous blackouts in different parts of the world. In Malmö, Sweden, approximately 50,000 residents lost electrical power for 50 minutes due to space weather causing transformer saturation. Concurrently, in South Africa, a dozen transformers were damaged and had to be replaced.

This confirms that it is indeed possible to experience power blackouts due to solar storms. The probability of experiencing a blackout due to a solar storm depends on several factors, including the intensity of the storm, the resilience of the local power grid, and geographical location. Although these events are relatively rare, power blackouts due to space weather pose a genuine risk that utilities worldwide must prepare for.

THE POWER BEHIND

How powerful solar storms can turn off the power



Coronal Mass Ejections

So, how can our Sun plunge entire cities into darkness? Our Sun is quite active, and at times, it can become stormy. Events, in which chunks of solar plasma are ejected from the Sun to the outer space, are called coronal mass ejections (CMEs), and they look truly impressive in pictures. If you saw how big a CME can appear in a photo, you might be amazed and concerned about how much material could potentially reach Earth. However, even though it seems remarkable, the chunk of plasma released during a CME is actually much thinner than what we can create as a vacuum on Earth.

SOHO/NASA

The crucial thing to note about CMEs is that they carry the part of the magnetic field released and frozen with the ejected solar plasma. Earth has its own magnetic field, a defense against speedy particles cruising through space. The magnetic field of the CME interacts with Earth's geomagnetic field, causing it to waver, or in scientific terms, creating disturbances.

Geomagnetically Induced Currents

These disturbances trigger a chain reaction that leads to the generation of additional electrical currents in our power grids, called geomagnetically induced currents (GICs). The power grids themselves might not be directly harmed by these additional currents, but the transformers connected to the affected grids are at severe risk. This risk ranges from damaging the protective layers of the transformers to saturating their cores, potentially causing complete damage.

WHAT CAN WE DO?

Mitigation Strategies

"Allo Lucia ? Here is Jan, from the Belgian space weather forecasting center. Do you hear me well?"

"Hello Jan! What's going on?"

"Our SWAP instrument onboard the PROBA2 satellite detected a strong event on the Sun. Looking at other data, we have calculated that a CME should be effective at Earth within the next 20 hours. We are seeking confirmation."

"Yes, I can confirm a CME is on the way. Our Spanish space weather center made the same observation from the SOHO instruments and from the Solar Dynamics Observatory. Our ground-based radars were also strongly affected. We think it is time to start the alert procedure."

During that night, Lucia and Jan are the forecasters on duty for the European Union. They immediately contact their two colleagues staffing the on-call service in the Czech Republic and in the UK. Both confirm the observation. All four forecasters then run their computer models; three out of the four countries expect that a major magnetic storm will impact Earth within the next 24 hours.

Following standard procedures, they subsequently warn the International Space Environment Service to issue a first alert. In parallel, they contact the space weather warning centers in China, Japan, Australia, South Africa and the US, which have seen the solar phenomena and have also issued alerts. They use dedicated ground instruments, radars and optical instruments to monitor the coming storm.

Silhouette of electric post during sunsett, Andrey Metelev

WHAT CAN WE DO?

Mitigation Strategies

Two hours later, the fleet of spacecraft from ESA and NASA that operate on each side of the Sun confirm that a major plasma cloud was ejected. It takes only one hour to confirm that its velocity is almost 9 million kilometers per hour, and that it will intersect the Earth on its trajectory. A first public alert is launched.

"Jan? Do you hear me?"

"Yes Lucia ! This promises to be a severe storm, doesn't it?"

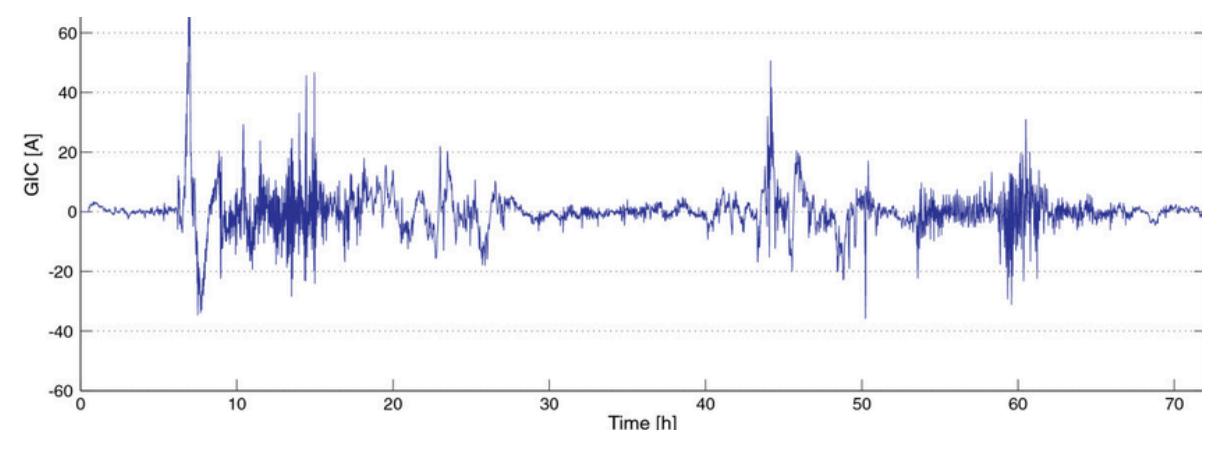
"Indeed. Any reason to worry?"

"Probably not. Several hours ago, I already issued warnings to power transmission operators throughout Europe on behalf of our international warning network."

"Very well, and timely too: the DSCOVR spacecraft ahead of the Earth has just detected the first signs of the approaching plasma cloud in the solar wind data. I can confirm that there may be a significant impact on some power networks. Level two of the protection plan must be activated."

About 19 hours following the solar eruption, the CME arrives at Earth and severely disturbs the Earth's magnetic field. Shorthly after, ground sensors in Canada, Scandinavia and Argentina start to monitor enhanced flows of electricity in the ground and significant enhancements of currents are observed within the Austrian power grid. National agencies issue warnings to their industries and to the general public. Anytime a geomagnetically induced current poses a threat to a power plant, especially a nuclear one, the voltage is lowered to prevent overheating. In less than 24 hours, the danger has been averted, thanks to international collaboration and the responsiveness of our space weather forecasters.

GICs during the Halloween storm in 2003, southern Spain, Torta, J. & Marsal, S. & Quintana, Marta. (2014)



What is E-SWAN?

The European Space Weather and Space Climate Association (E-SWAN), founded in 2022, is a non-profit organization working to unite and develop European activities in space weather and space climate. E-SWAN aims to achieve this through various means, including organizing conferences, supporting early career scientists, promoting education, and fostering collaboration between scientists, engineers, and stakeholders. Their focus is on Europe, but they also collaborate internationally and aim to raise awareness of space weather's impact.

What is EOCOM?

EOCOM, the Education and Outreach Committee of E-SWAN, works to bridge the gap between the Space Weather and Space Climate (SWSC) community and the general public. Their activities include creating a social media presence, running SWSC courses and webinars, publishing an SWSC book, and enriching the E-SWAN website. These efforts aim to raise public awareness of SWSC's impact in Europe, distribute scientific knowledge, and promote educational opportunities within the field.

About this booklet

This informative booklet, "Can I experience power blackout due to solar storms?", was co-authored by Sophie Chabanski, Jean Lilensten, Lisa Nelson and Lenka Zychová, all members of the ESWAN EOCOM. Lenka Zychová is also credited for the booklet's design.

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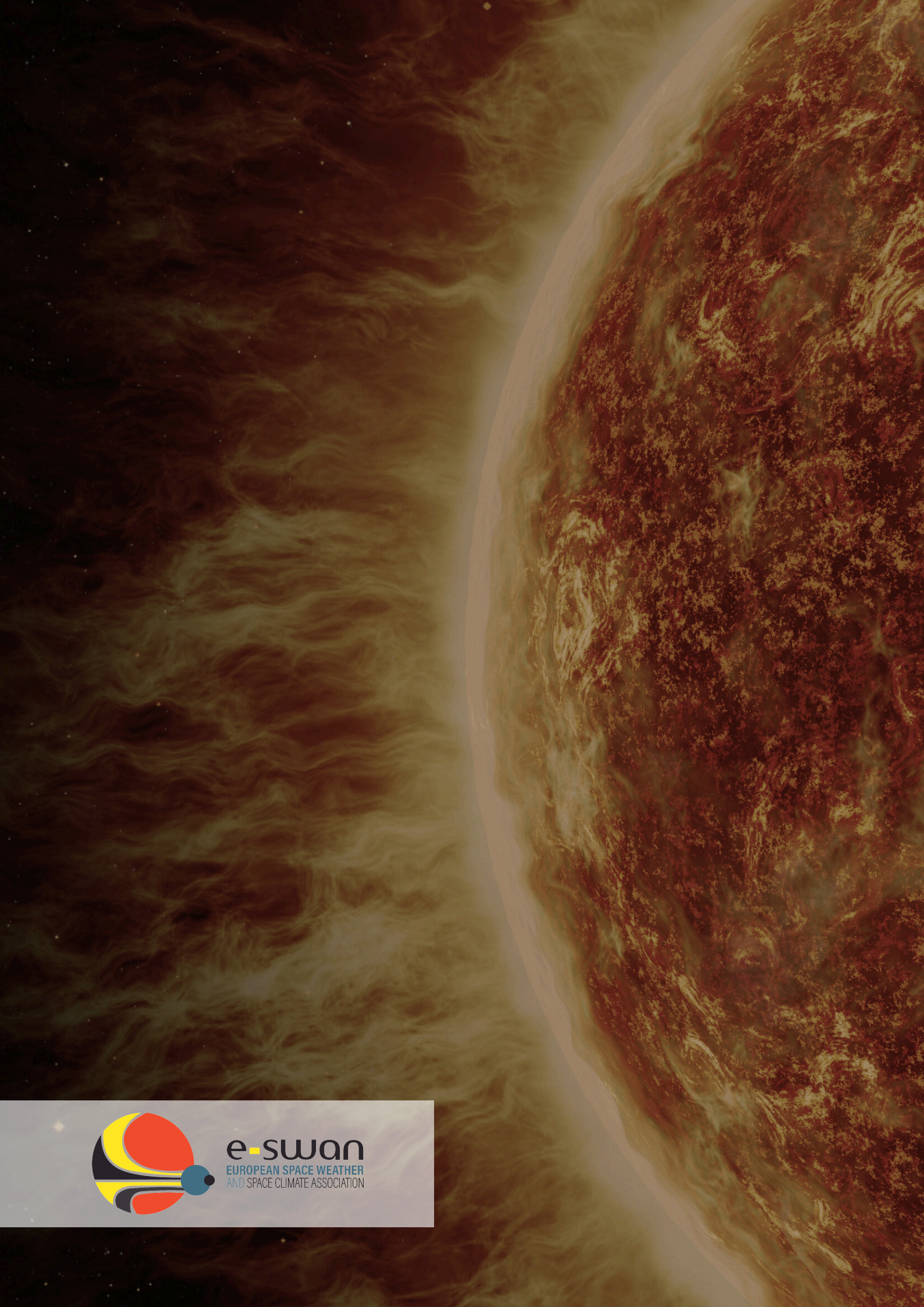
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