# Extreme Space Weather: Risk Assessment and Mitigation

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# Defining The Problem

Eruption on the Sun’s surface

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Interaction between a CME and the Earth’s magnetosphere

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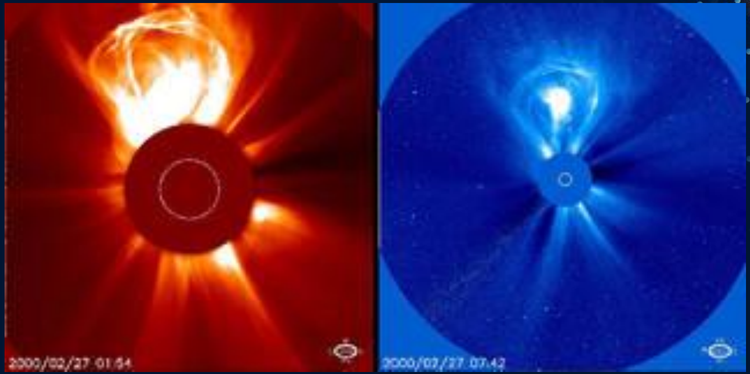
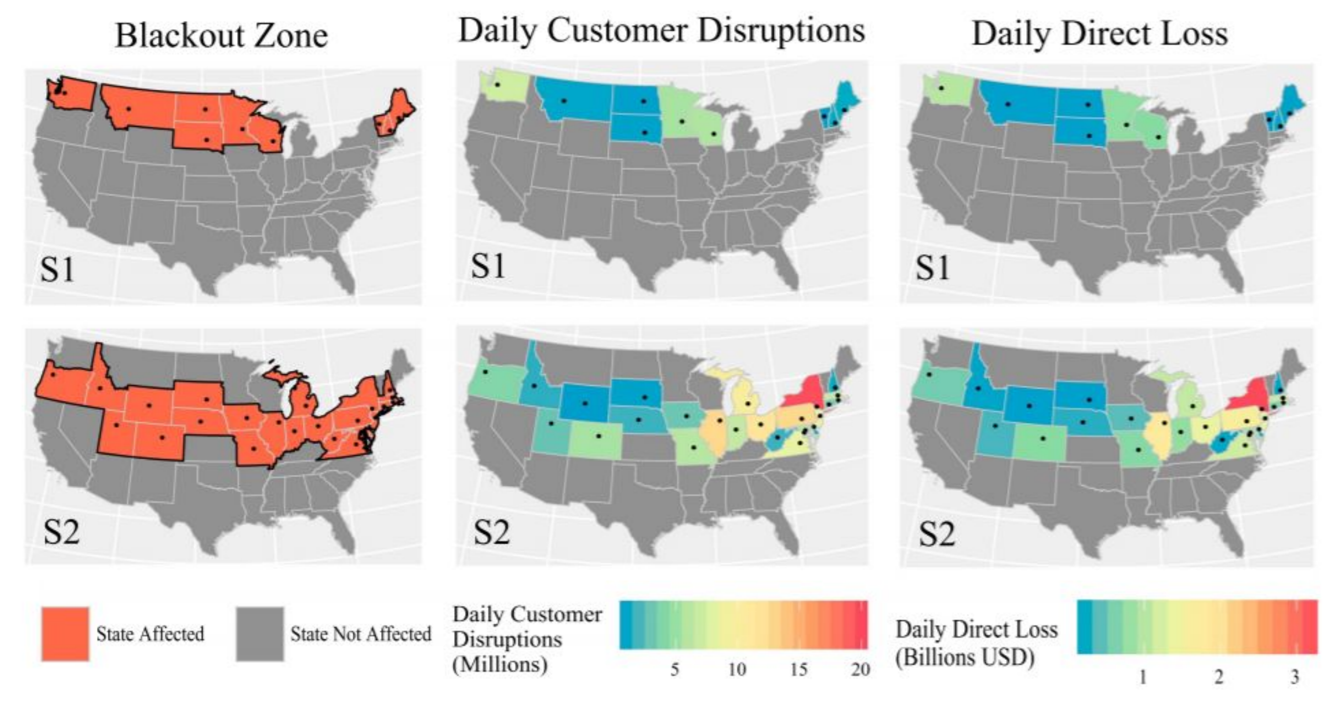
Disturbances and damage to essential technology and infrastructure on Earth



# Defining the Problem




Source: Oughton et al. (2017)

# Scenarios

- What could happen?
  - Electric grid operated by ConEd seriously damaged
  - Partial blackout of New York City

# Historical Context: the Carrington Event of 1859

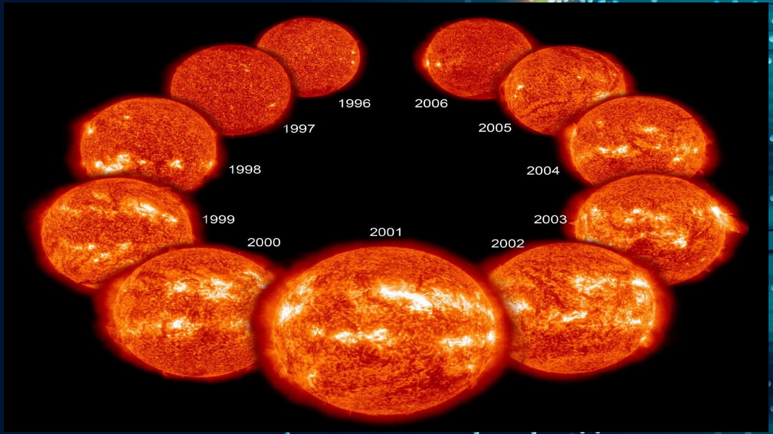
*From the New York Sun.*

A splendid exhibition of the Aurora Borealis, or "Northern Lights," took place on Sunday evening. They were so brilliant that they gave rise to the rumor of a large fire. The air became affected by them, being made very cool, and singularly enough the telegraph wires were also acted upon so much as to be almost useless.

Source: *New York Sun*(

# Characterizing The Uncertainty

- Identifying the **peak** of the 11-year solar cycle
- **Extreme** storms occur during the descending phase
- Probability of an **extreme geomagnetic storm** with 95% confidence: (0.0046, 0.0188)*

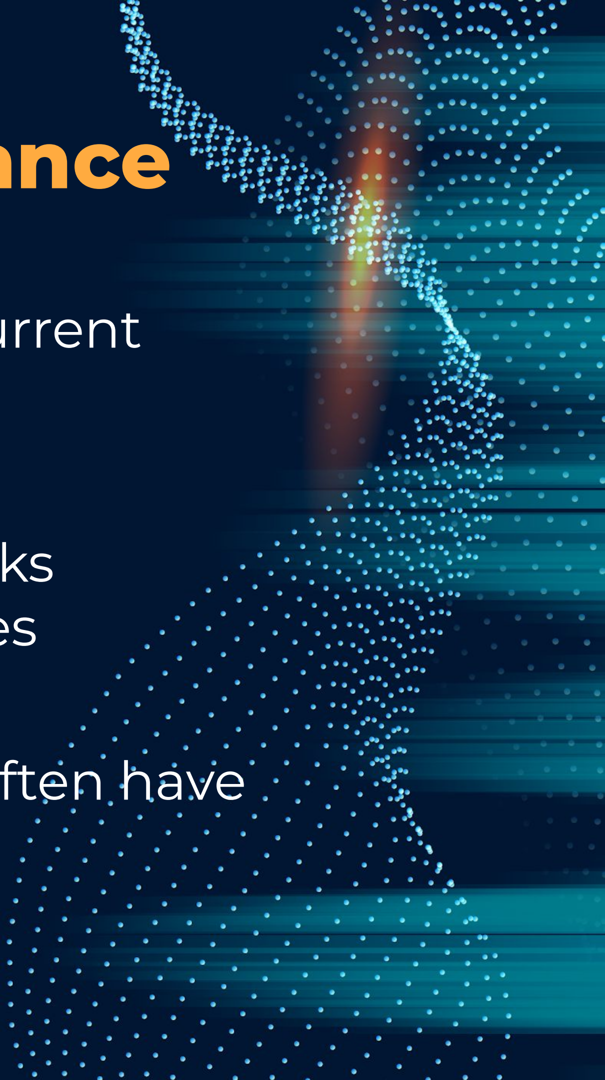



*(Moriña et al., 2019)

# Narratives and Risk Tolerance

Evaluating the narratives surrounding current practices and risk tolerance levels:

- Anthropocentrism
  - Perception around addressing risks
  - Western, first-world country biases
- Risk Tolerance
  - Stakeholders (private vs. public) often have different risk-awareness levels



# Expected Utility Maximization

EU = VoLL * Expected offline time * Electricity demand * Probability estimate

| Metric | Value |
|---|---|
| Value of Lost Load (VoLL) | $12.70 per unserved kWh |
| Expected offline time | 120 hours |
| Electricity demand | 29.2 kW * (8,336,817 + 1,050,911) |
| 95% CI (probability) | (0.0046, 0.0188) |
| **Budget** | **$1.9B - $7.9B** |

# Recommendations

Implementing safeguards to regulate power flow and protect transformers

Increasing reserves of both active and reactive power*

Funding geophysics, transmission network, & transformer modeling research*

*(Royal Academy of Engineering, 2013)

# Risk Outreach

- Increasing public awareness of and preparation for geomagnetic storms
  - Various channels: email, phone, social media
  - Emergency plans (“good” vs. “bad” examples)

- Avoiding outrage
  - Contextualize the probability estimate
  - Neutral wording

# Remaining Questions & Challenges

- Science and Technology
  - Will scientists ever be able to accurately forecast a geomagnetic storm?
  - Which future technological advances might help mitigate the damage potential of geomagnetic storms?
- Policy Implementation
  - How do we create meaningful policy solutions that address the needs of the public and private sector?

# References


Moriña, D., Serra, I., Puig, P., & Corral, Á. (2019). Probability estimation of a Carrington-like geomagnetic storm. *Scientific Reports*, *9*(1). doi: 10.1038/s41598-019-38918-8

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# References


Oughton, E. J., Skelton, A., Horne, R. B., Thomson, A. W., & Gaunt, C. T. (2017). Quantifying the daily economic impact of extreme space weather due to failure in electricity transmission infrastructure. *Space Weather*, *15*(1), 65–83. doi: 10.1002/2016sw001491