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Methodology for analyzing the risk of disruption of overhead power lines in Portugal

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MOTIVATION

- **Power systems**, such as power transmission infrastructure - **overhead power lines (OPL)**, and **consumers** have been heavily affected by **extreme weather events (EWEs)**, which are becoming more intense and more frequent.

- The main objective of this work is to present the **methodology of the risk analysis of the EWEs** on **OPL** in Portugal.

- The **level of risk** associated with each of the identified events was classified by:
  - **cause-and-effect diagram**
  - **risk matrix** (probability/consequences);

- **Measures** and **recommendations** for risk management are also suggested.

Figure 1. Impacts of Emma storm on February 2018 in North Portugal.

DATA AND METHODS

❖ **Case studies – Extratropical cyclones**

- **29 high impact storms** with **serious impacts over mainland Portugal** in the **four extended winters (2017-2021)**.

❖ **Meteorological data**

- ERA5 Reanalysis meteorological parameters: **wind at 250hPa and 900hPa**, **MSLP**, **TCWV,** and **IVT**;
- **Weather charts, satellite images,** and the **climatological bulletins** of the IPMA;

❖ **Impacts**

- **News of media** and **visits to places**;
- **EDP reports** (power infrastructures and OPL).

❖ **Risk assessment**

- Several tools and techniques are identified in **NP 31010:2016**, **IEC/ISO 31010:2009**, and **NP ISO 31000:2018.**

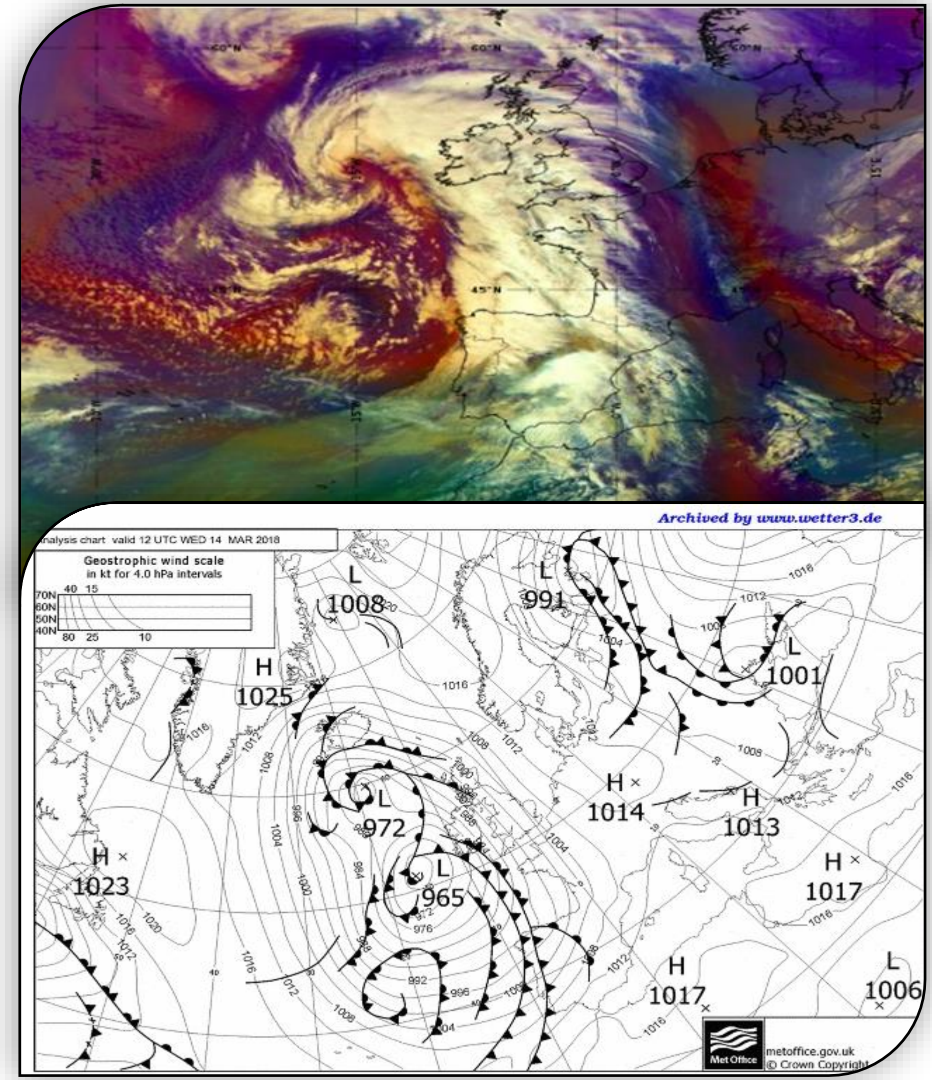

Figure 2. Top: Weather chart (available in http://www1.wetter3.de/archiv_ukmet_dt.html); **Bottom:** Satellite "air mass RGB" composite image from Gisele Storm on 14 March 2018 at 12UTC (available in http://www.eumetrain.org).

RESULTS AND DISCUSSION

❖ Synoptic condition and large-scale dynamics of the 9 storms

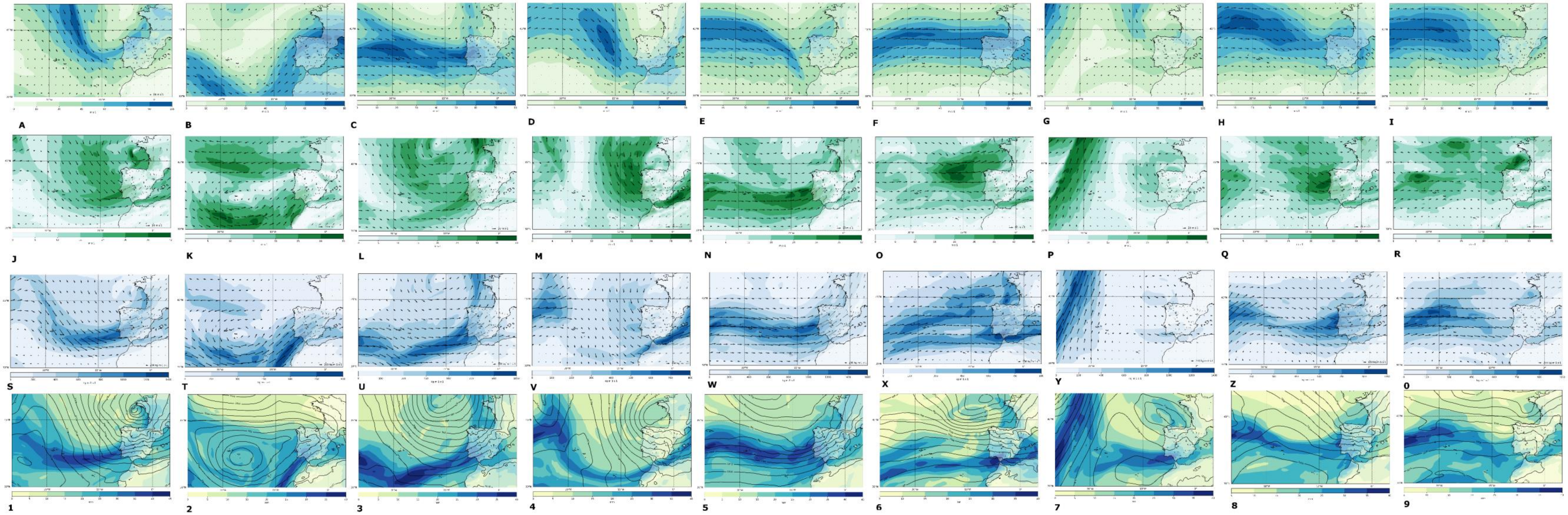

Figure 3. Composites of the 9 storms, in the instant with more impact in mainland Portugal, that caused damage to overhead power lines: **A-I)** Wind speed (shaded; ms^{-1}) and the vector wind at 250hPa; **J-R)** Wind speed (shaded; ms^{-1}) and the vector wind at 900hPa; **S-0)** Integrated Vapour Transport (shaded; IVT; kg m^{-1} s^{-1}) and the vector IVT; **1-9)** Total Column Water Vapour (shaded; mm) and MSLP field (contour interval 4 hPa).

RESULTS AND DISCUSSION

❖ **Cause-and-effect analysis**

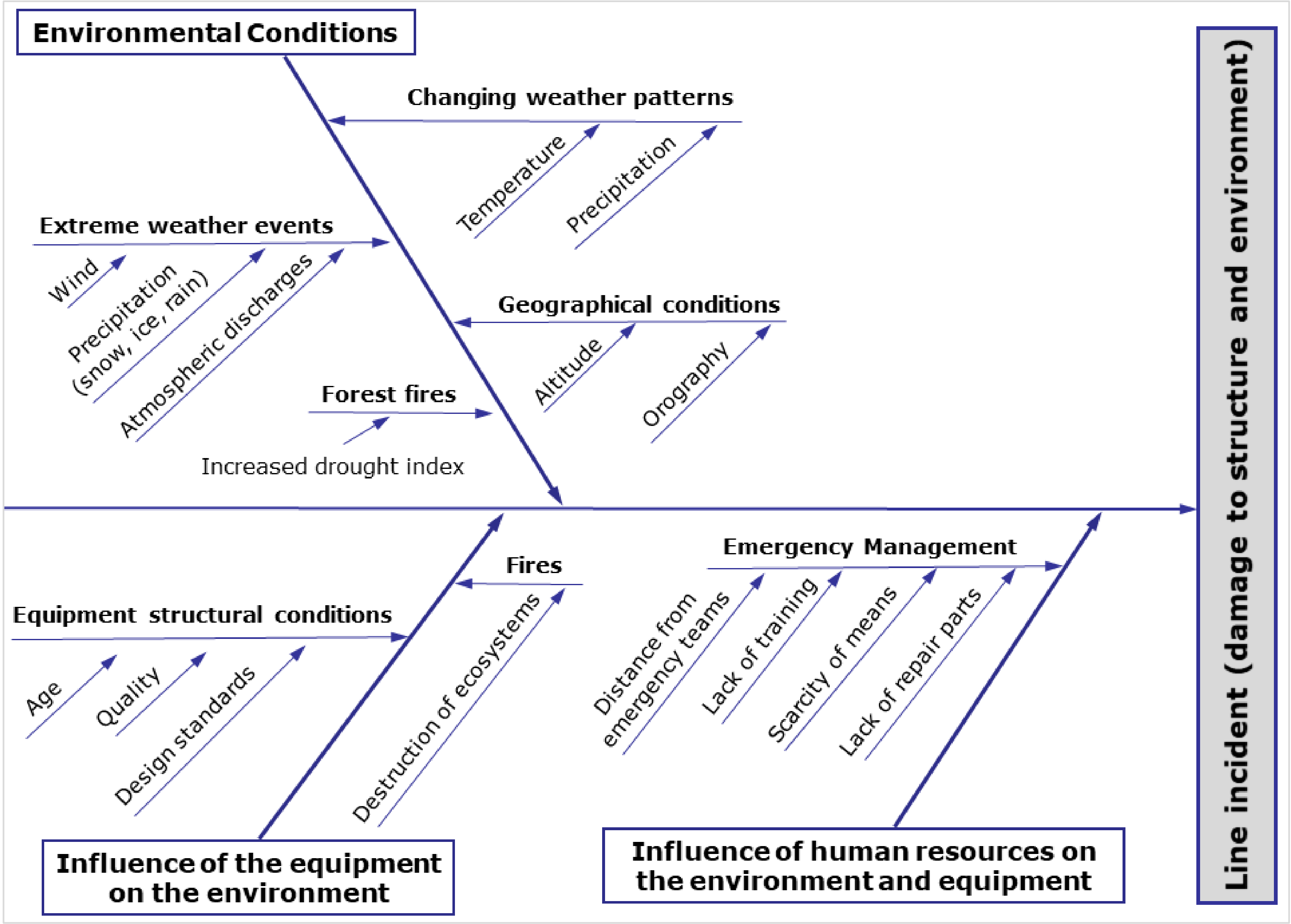

Figure 4. Ishikawa diagram relating to the risk analysis understudy.

RESULTS AND DISCUSSION

❖ Risk matrix analysis

Risk level	
1-4	Low
5-9	Med Low
10-14	Medium
15-19	High
20-25	Extreme

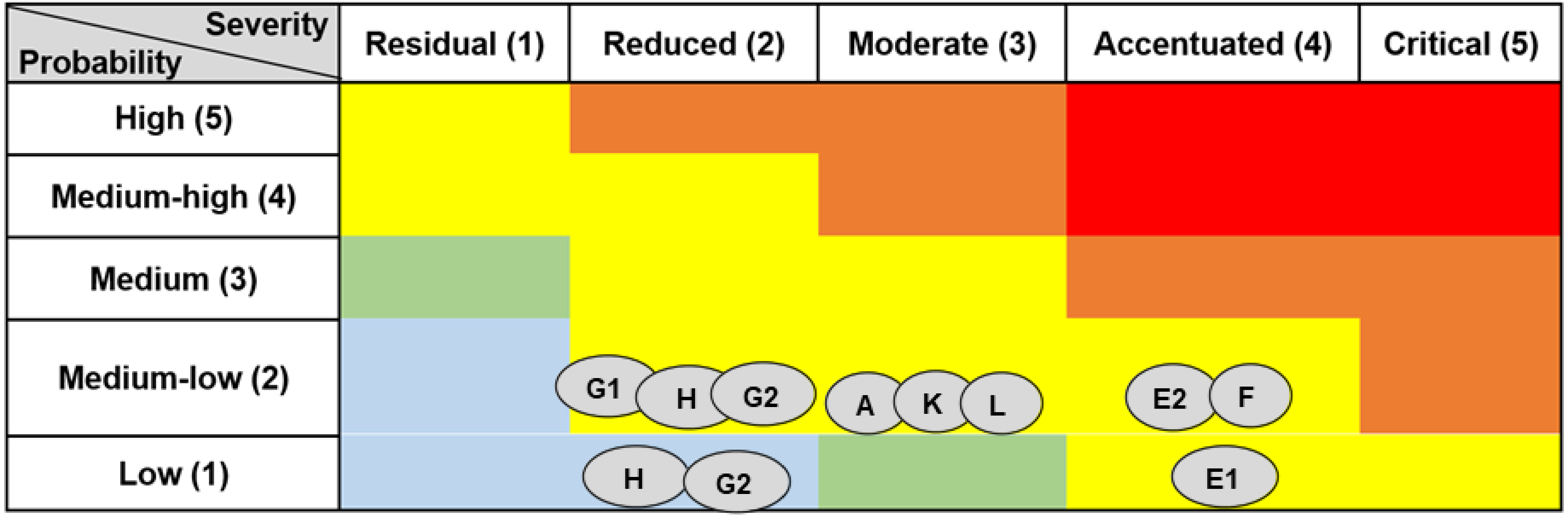

Figure 5. Risk matrix of high-impact storms analyzed in the study. The risk level caption is shown in the box above. E1 corresponds to the only snowstorm considered.

Ana (A)
Emma (E1)
Gisele (G1)
Helena (H)
Elsa (E2)
Fabien (F)
Gloria (G2)
Karine (K)
Leon (L)

RESULTS AND DISCUSSION

❖ **Adaptation strategy and recommendations for risk management**

Table 1. Strategies for improving network resilience.

Type of training	Improvement strategy
Physical robustness	▪ Vegetation management ▪ Partial burial ▪ Revitalization and physical update ▪ Substation replacement and line rerouting
Operational capacity	▪ Emergency generators and mobile substations ▪ Repair parts and restoration teams' management ▪ Network monitoring system ▪ Regulation and update of regulated design standards

CONCLUSIONS

- EWEs, such as **high-impact storms** studied in this work, are associated with **numerous socioeconomic impacts** caused by **strong winds** and **heavy precipitation**.

- Of the **29 events** that affected mainland Portugal, **31%** disrupted the overhead power lines (OPL).

- The **wind is the main factor** that provoked the disruption of the OPL (**28%** windstorms), followed by compound events (**wind and rain**) with **21%** and **3%** for a **snowstorm**.

- It is important to **minimize the impacts of these EWEs on the energy sector** and to adapt and **implement strategies** that may be adequate for each situation (power systems, **overhead power lines**, and infrastructures associated).

Figure 6. Impacts of Emma storm on February 2018 in North Portugal.

THANK YOU FOR YOUR ATTENTION!

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