Supplementary material for *RHITA: a web tool for real-time detection of extreme weather events*

Greta Cazzaniga[1], Anastasia Akakpo-Numado[1], Patrick Brockmann[1], Adrien Burq[1], Mathieu Vrac[1], and Davide Faranda[1,2,3]

[1]Laboratoire des Sciences du Climat et de l'Environnement, UMR 8212 CEA-CNRS-UVSQ, Université Paris-Saclay, IPSL, 91191 Gif-sur-Yvette, France
[2]London Mathematical Laboratory, 8 Margravine Gardens, London, W6 8RH, UK
[3]Laboratoire de Météorologie Dynamique/IPSL, École Normale Supérieure, PSL Research University, Sorbonne Université, École Polytechnique, IP Paris, CNRS, Paris, 75005, France

Correspondence: Davide Faranda (davide.faranda@lsce.ipsl.fr)

Contents of the supplementary material

This supplementary document provides additional methodological details, parameter optimization results, regional classifications, and extended trend figures supporting the main manuscript.

- Section 1: Detailed results of the parameter optimization for heatwaves, cold spells, and heavy precipitation events.
- Section 2: EuroVoc-based classification of European subregions and corresponding country lists.
- Section 3: Extended trend analyses for heatwaves, cold spells, heavy precipitation, and strong wind events, including all event metrics.

1 Parameters optimization results

Here we report the quantitative results from the optimization of the RHITA algorithm parameters for the detection of heatwaves, cold spells, and heavy precipitation events.

1.1 Heatwaves and cold spells

As stated in the main article, the parameters for cold spells and heatwaves are optimized jointly. Cold spells are identified by values below the 0.01 quantile of daily values over the 1950–2023 period, while heatwaves correspond to values above the 0.99 quantile. For both hazards, a minimum duration of three consecutive days is imposed.

The parameters selected for optimization, based on physical considerations and targeted spatial and temporal scales, are:

- A_{min} (km^2): $\{25\,000$, $50\,000$, $75\,000$, $100\,000\}$.
- d (km): $\{50$, 100, 150, 200, $250\}$.
- d_c (km): $\{50$, 100, 150, 200, $250\}$.

Figure S1 shows the sensitivity obtained across all parameter combinations. The optimal parameter triplet is $A_{\text{min}} = 25\,000$ km^2, $d = 50$ km, and $d_c = 250$ km. This solution lies at the boundary of the explored parameter space. While this could suggest that extending the parameter ranges might yield alternative optima, we retain the predefined ranges to focus on large-scale events relevant at the European scale.

In this optimization, a single optimal solution is identified, making further minimization of the cost function unnecessary. The sensitivity for the combined cold spell and heatwave dataset is 0.59. When considered separately, the sensitivity is 0.45 for cold spells and 0.87 for heatwaves, indicating higher detection performance for heatwaves.

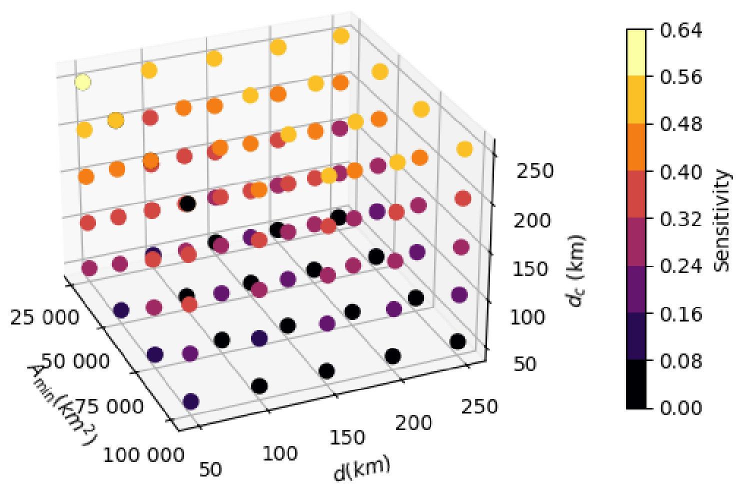

Figure S1. Grid search results for the optimization of RHITA parameters for cold spells and heatwaves. Lighter colors indicate higher sensitivity.

1.2 Heavy precipitation

The optimization for heavy precipitation events is conducted using parameter ranges reflecting their distinct spatial and temporal characteristics. Heavy precipitation events tend to be more localized in space and more dynamically evolving than temperature extremes.

The explored parameter ranges are:

- A_{min} (km^2): {25 000, 50 000, 75 000, 100 000}.
- d (km): {50, 100, 150, 200}.
- d_c (km): {300, 350, 400, 450, 500, 550}.

Multiple parameter triplets yield the same maximum sensitivity (0.80):

- (25 000, 200, 300)
- (25 000, 200, 350)
- (25 000, 200, 400)
- (25 000, 200, 450)
- (25 000, 200, 550)

To select a unique solution, the cost function defined in the main manuscript is evaluated. Figure S2 shows the cost function as a function of d_c, with A_{min} and d fixed. The minimum cost corresponds to $d_c = 550$ km, leading to the final selected parameter triplet.

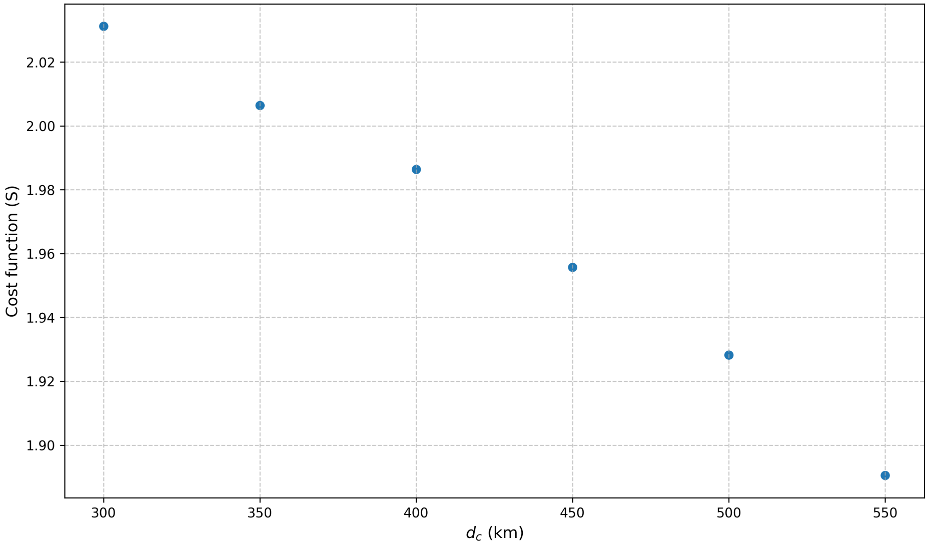

Figure S2. Cost function S as a function of d_c for heavy precipitation events, with $A_{\min} = 25\,000$ km^2 and $d = 200$ km.

2 EuroVoc classification of European subregions

Table S1. European subregions and associated countries according to the EuroVoc classification (Publications Office of the European Union).

Subregion	Countries
Northern Europe	Estonia, Latvia, Lithuania, Denmark, Finland, Iceland, Norway, Sweden
Western Europe	Andorra, Austria, Belgium, France, Germany, Ireland, Liechtenstein, Luxembourg, Monaco, Netherlands, Switzerland, United Kingdom
Southern Europe	Cyprus, Greece, Holy See, Italy, Malta, Portugal, San Marino, Spain, Turkey
Central and Eastern Europe	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Kosovo, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia

3 Extended trend analyses

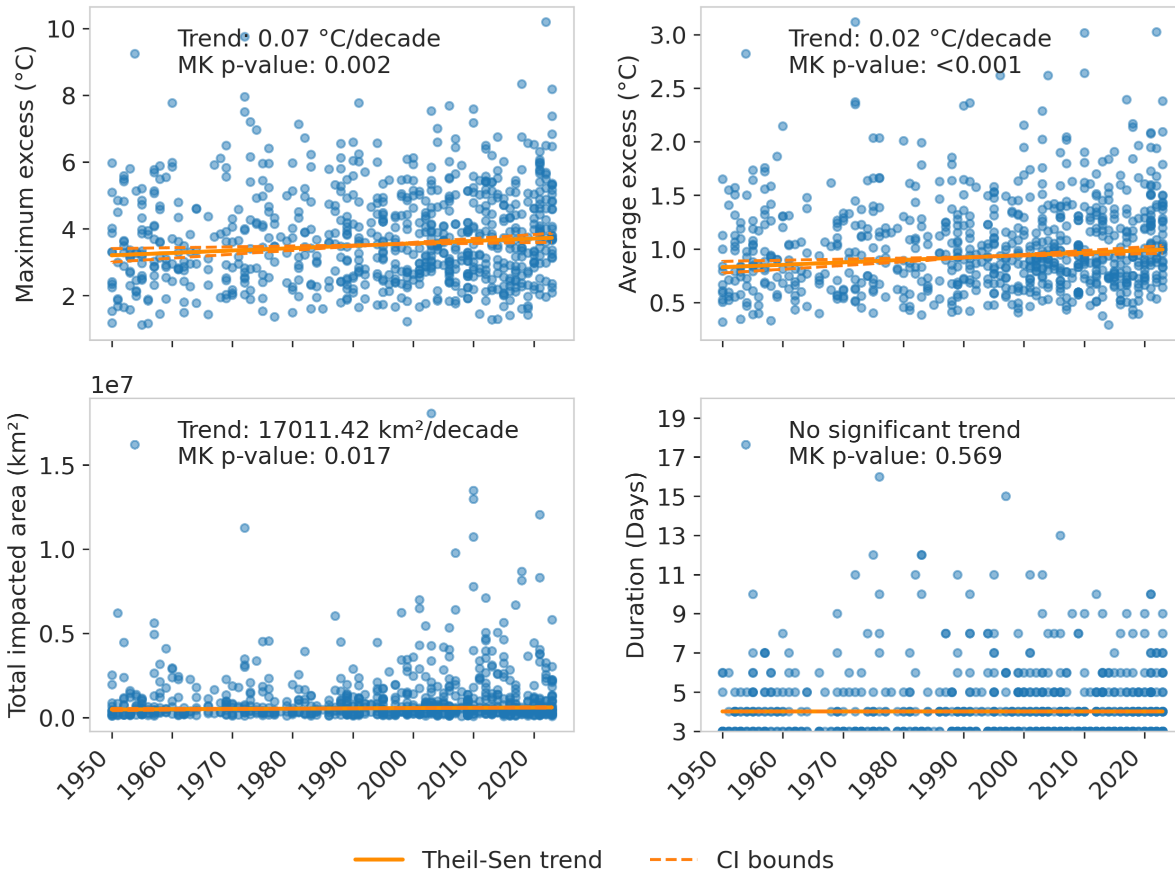

Figure S3. Trends in maximum excess, mean excess, total impacted area, and duration for heatwaves detected over Europe from 1950 to 2024.

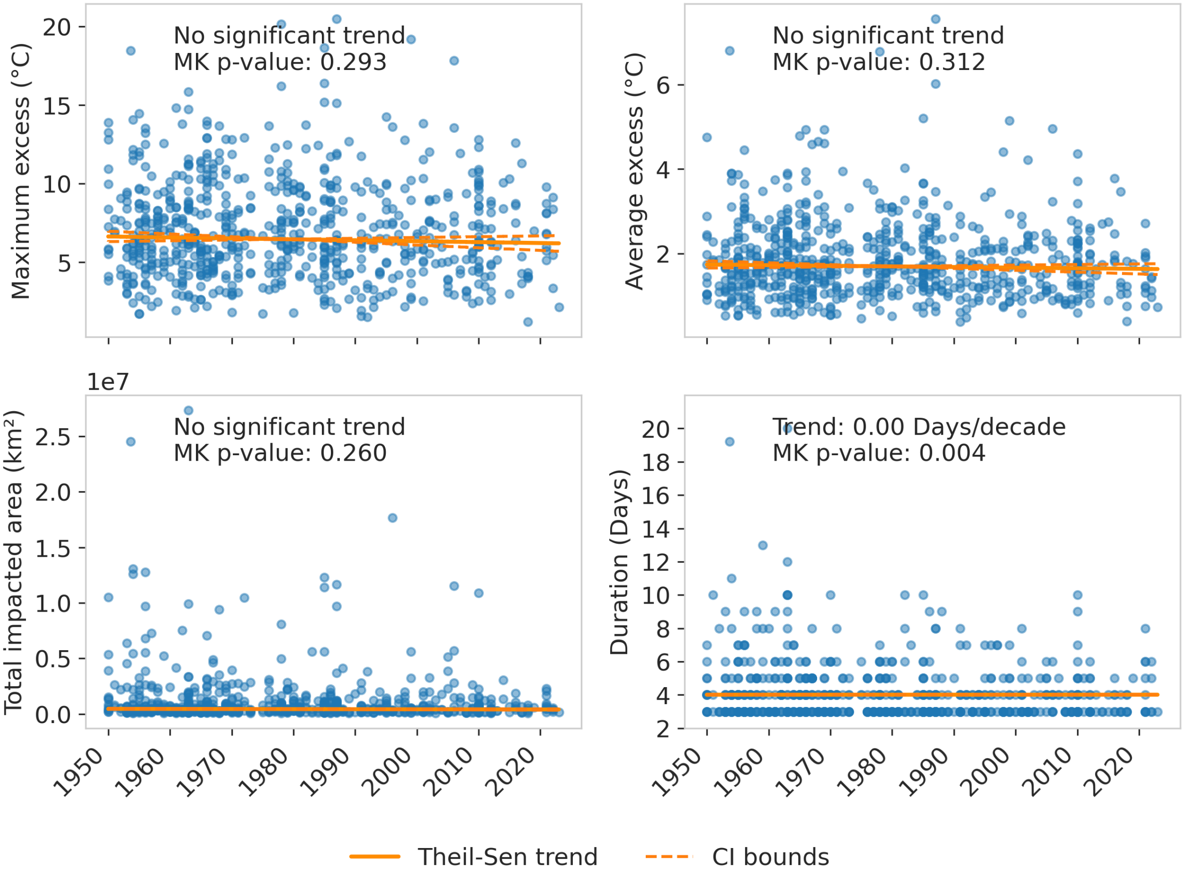

Figure S4. Trends in maximum excess, mean excess, total impacted area, and duration for cold spells detected over Europe from 1950 to 2024.

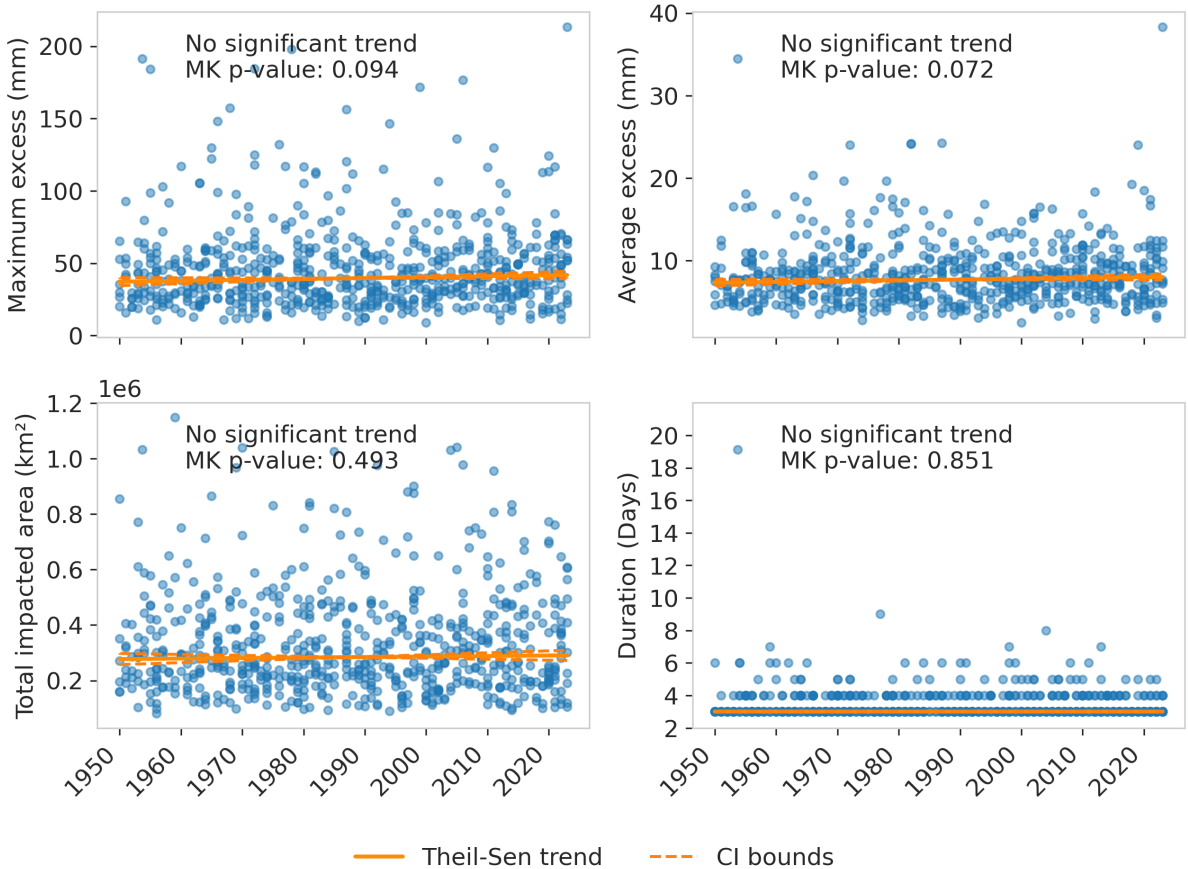

Figure S5. Trends in maximum excess, mean excess, total impacted area, and duration for heavy precipitation events detected over Europe from 1950 to 2024.

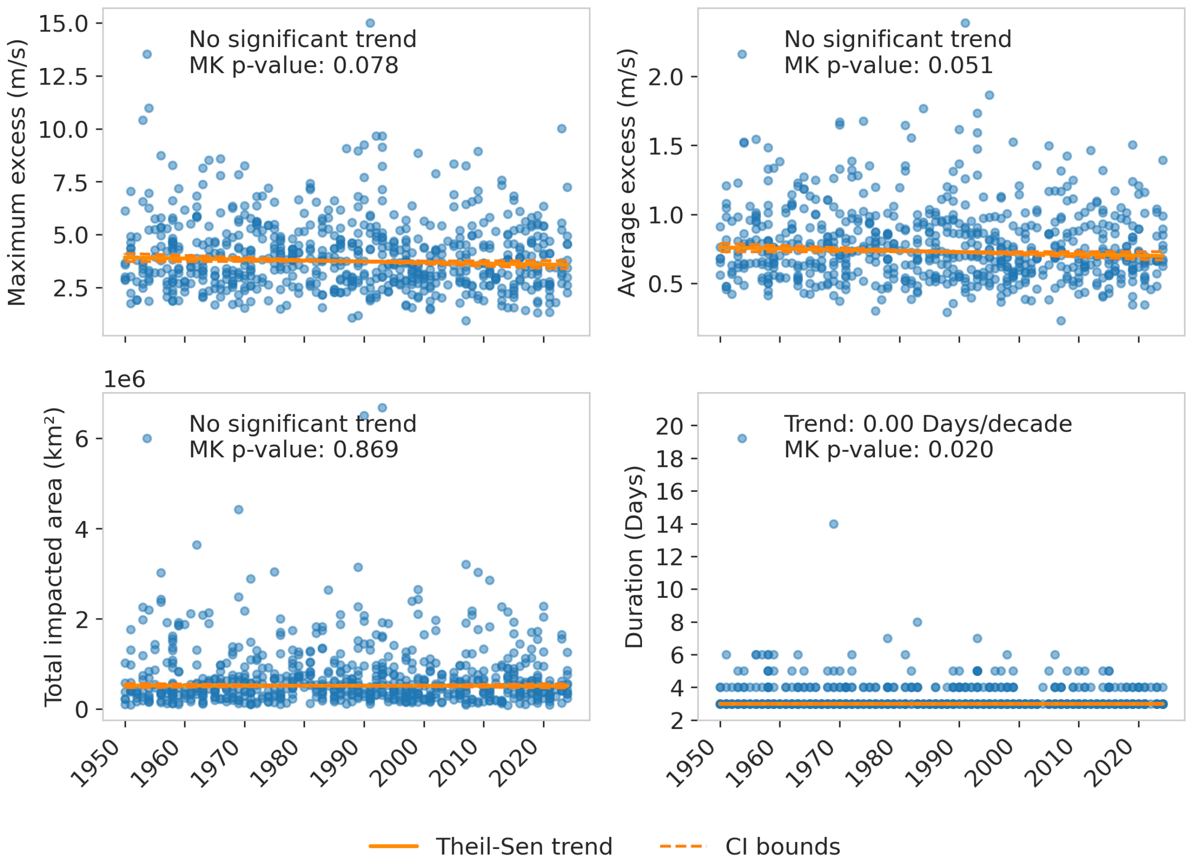

Figure S6. Trends in selected metrics for extreme wind events detected over Europe.

References

Publications Office of the European Union: EuroVoc, https://eur-lex.europa.eu/browse/eurovoc.html?params=72,7206,914#arrow_914.