

Increasing likelihood of heat-related mortality events with global warming: a continental epidemiological extreme event attribution study

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Supplementary Material

Table S1: *Medians of return periods of the hottest week and deadliest week in 2022 at 1.2 °C and pre-industrial, and the resulting probability ratios for Catalonia, Spain. Values in brackets are the 95% confidence obtained by bootstrapping and Monte Carlo simulations.*

| | Return Period 1.2°C (2022) | Return Period pre-industrial | Probability Ratio |
|-------------|-------------------------------|---------------------------------|-------------------------|
| Temperature | 7.4 (3.8 – 25.4) | 33,832 (333.1 – Inf) | 4,219.7 (30.7 – Inf) |
| Mortality | 15.2 (6.9 – 46.5) | 434.8 (61.0 – 53,578) | 28.5 (3.8 – 2,647.3) |

Table S2: *Population-weighted medians of return periods of the hottest week and deadliest week in 2022 at 1.2 °C and pre-industrial, and the resulting probability ratios. Values in brackets are the 95% confidence obtained by bootstrapping and Monte Carlo simulations. Southern Europe comprises Albania, Cyprus, Greece, Spain, Croatia, Italy, Montenegro, Malta, Portugal, Serbia and Slovenia.*

| | Return Period 1.2°C (2022) | Return Period pre-industrial | Probability Ratio |
|-------------------------------|-----------------------------------|---------------------------------------|-------------------------------------|
| Temperature | 4.5 (2.5 – 18.8) | 56.8 (9.2 – 1,791.1) | 12.7 (3.6 - 157.3) |
| Temperature – Southern Europe | 7.5 (3.8 – 102.6) | 1,292.4 (26.5 – Inf) | 92.1 (7.3 – Inf) |
| Mortality | 8.0 (3.6 – 20.8) | 21.6 (9.7 – 140) | 3.0 (1.02 – 18.6) |
| Mortality – Southern Europe | 10.7 (5.2 – 34.2) | 371.8 (62.48 – 49,216.2) | 27.5 (3.8-2,354.3) |
| Mortality – Italy | 6.0 (3.1- 27.5) | 1,292.5 (131.8 – Inf) | 59.9 (7.0 – 70,307.6) |

| | | | |
|----------------------|---------------------|--------------------------|-----------------------|
| Mortality - Lombardy | 9.4 (4.7 – 33.2) | 6,356.7 (349.1 – Inf) | 677.4 (33.0 – Inf) |
| Mortality - Calabria | 8.3 (3.7 – 23.1) | 21.8 (21.8 – Inf) | 3.8 (2.4 – Inf) |

Table S3: Population-weighted medians of return periods of the deadliest week in 2022 for different population groups, and the resulting probability ratios. The last column reports the heat-related mortality rate in deaths per million for the deadliest week of the 2022 summer. Values in brackets are the 95% confidence intervals obtained by bootstrapping and Monte Carlo simulations.

| | Return Period 1.2 °C (2022) | Return Period pre-industrial | Probability Ratio | Heat-related mortality 2022 |
|--------------|--------------------------------|---------------------------------|----------------------|--------------------------------|
| Women | 6.0 (2.8 – 13.9) | 22.4 (9.3 -136.9) | 5.0 (1.3 – 22.2) | 23.3 (9.1 – 34.2) |
| Men | 6.6 (3.2 – 13.8) | 18.1 (9.1 – 99.8) | 3.5 (1.3 – 18.4) | 19.1 (10.9 – 26.8) |
| | | | | |
| Ages < 65 | 7.2 (2.5 – 23.6) | 59.7 (10.5 – 3,049.8) | 7.5 (1.4 – 227.6) | 3.5 (0.2 – 6.1) |
| Ages 65 - 79 | 7.3 (3.2 – 20.3) | 54.9 (11.9 – 741.2) | 7.5 (1.1- 69.3) | 39.7 (11.9 – 65.3) |
| Ages > 80 | 8.8 (4.2 – 19.0) | 29.6 (10.9 – 242.6) | 4.0 (1.1 – 24.5) | 293.1 (101.2 – 483.9) |

Table S4: Population-weighted medians of return periods for the deadliest week in 2022 at pre-industrial, 1.2 °C, 1.5 °C, and 2°C, and the resulting probability ratios. Values in brackets are the 95% confidence obtained by bootstrapping and Monte Carlo simulations.

| | 0 °C | 1.2 °C | 1.5 °C | 2.0 °C |
|------------------------------|----------------------------|-------------------------|--------------------------|----------------------------|
| Return Period | 21.6 (9.7 – 140.0) | 8.0 (3.6 – 20.8) | 4.9 (2.0 – 12.7) | 2.5 (1.1 – 9.5) |
| Probability Ratio | | 3.0 (1.02 – 18.7) | 4.8 (1.16 – 38.7) | 8.1 (1.24 – 77.2) |
| Return Period – Spain | 422.5 (71.2 – 49,544.5) | 13.2 (6.1 – 40.6) | 6.2 (2.4 – 21.6) | 2.1 (1.1 – 7.7) |
| Probability Ratio - Spain | | 29.0 (3.3 – 2,354.2) | 59.1 (5.4 – 10,272.3) | 141.6 (12.2 – 15,487.7) |

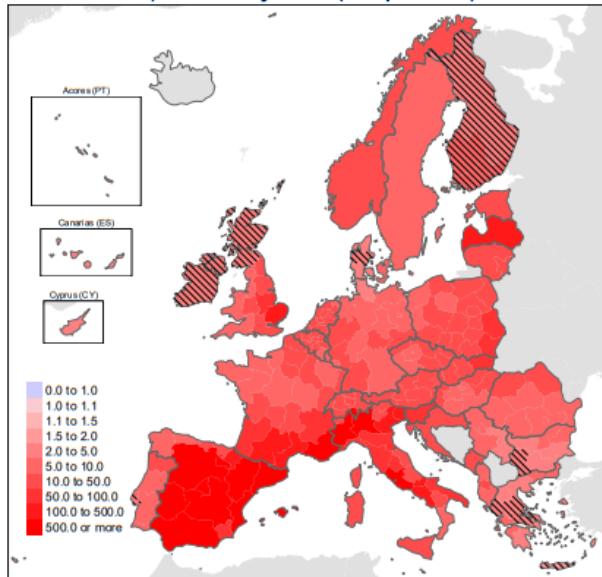
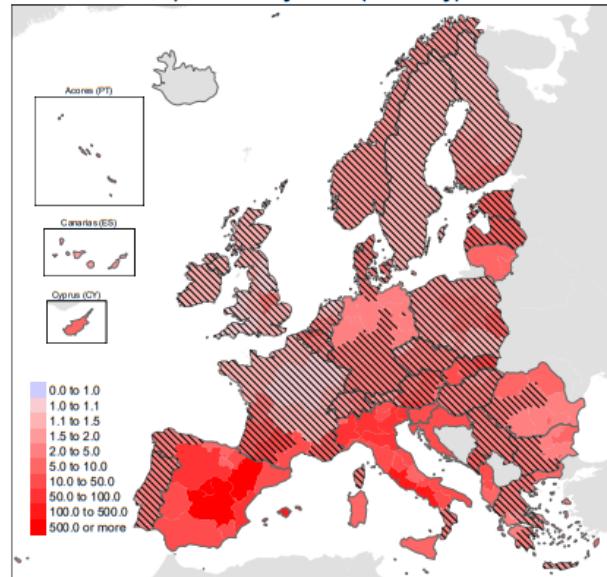
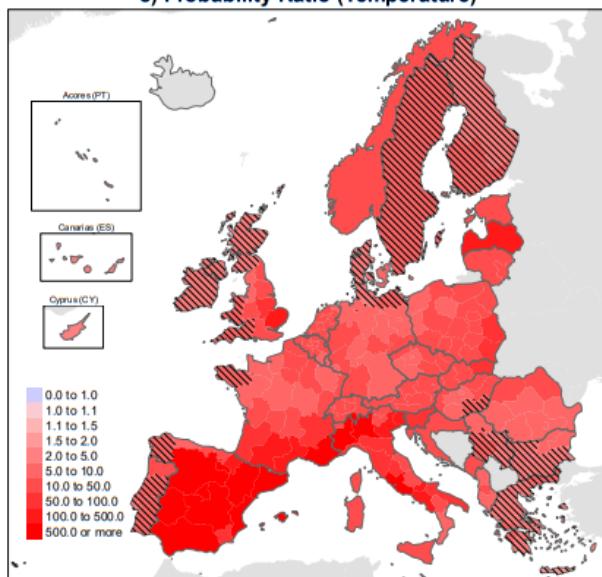
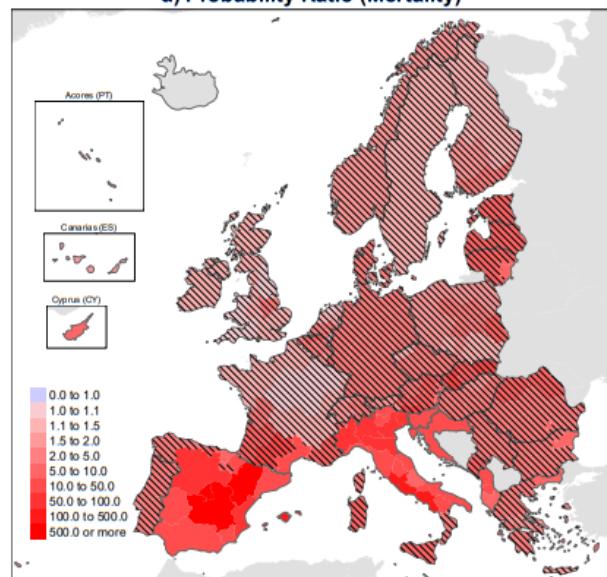
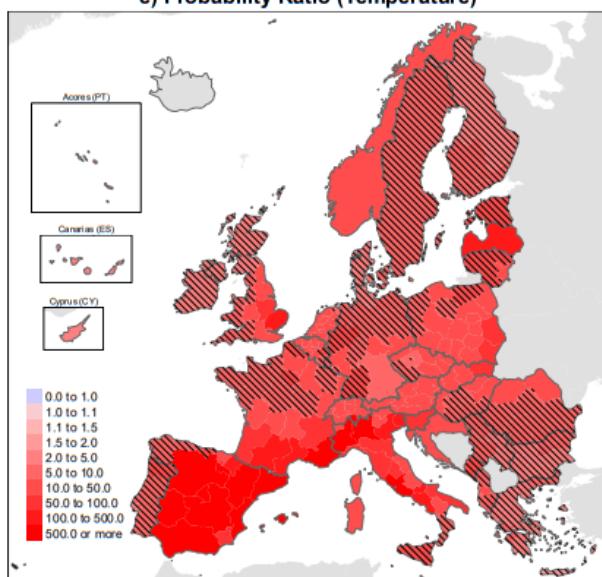
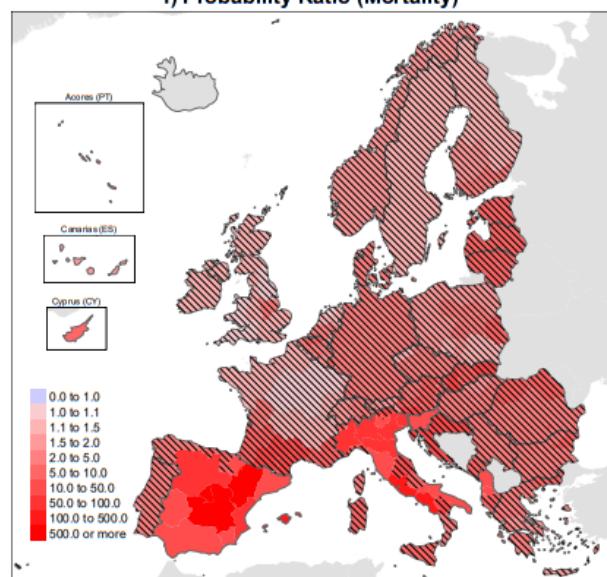
a) Probability Ratio (Temperature)**b) Probability Ratio (Mortality)****c) Probability Ratio (Temperature)****d) Probability Ratio (Mortality)****e) Probability Ratio (Temperature)****f) Probability Ratio (Mortality)**

Figure S1 depicts the median regional probability ratios between 1.2°C and pre-industrial climatic conditions. Hatched areas illustrate regions where the probability ratio is not significantly greater than two (Panels a + b), three (Panels c + d), and five (Panels e + f) at the 0.1 significance level.