

# Event Week on Heatwaves and Droughts 2023

Session 4 - 1 June 2023

**Impacts on air quality**

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# Context

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1

## **Global Health Impacts of Air Pollution**

Global context

2

## **Compound Events**

Co-occurring or consecutive events

3

## **Health Impacts**

Examples: Legionella, Ophelia and Compound Hot and O3 events

**How about climate change?**

# Global Health Impacts of Air Pollution

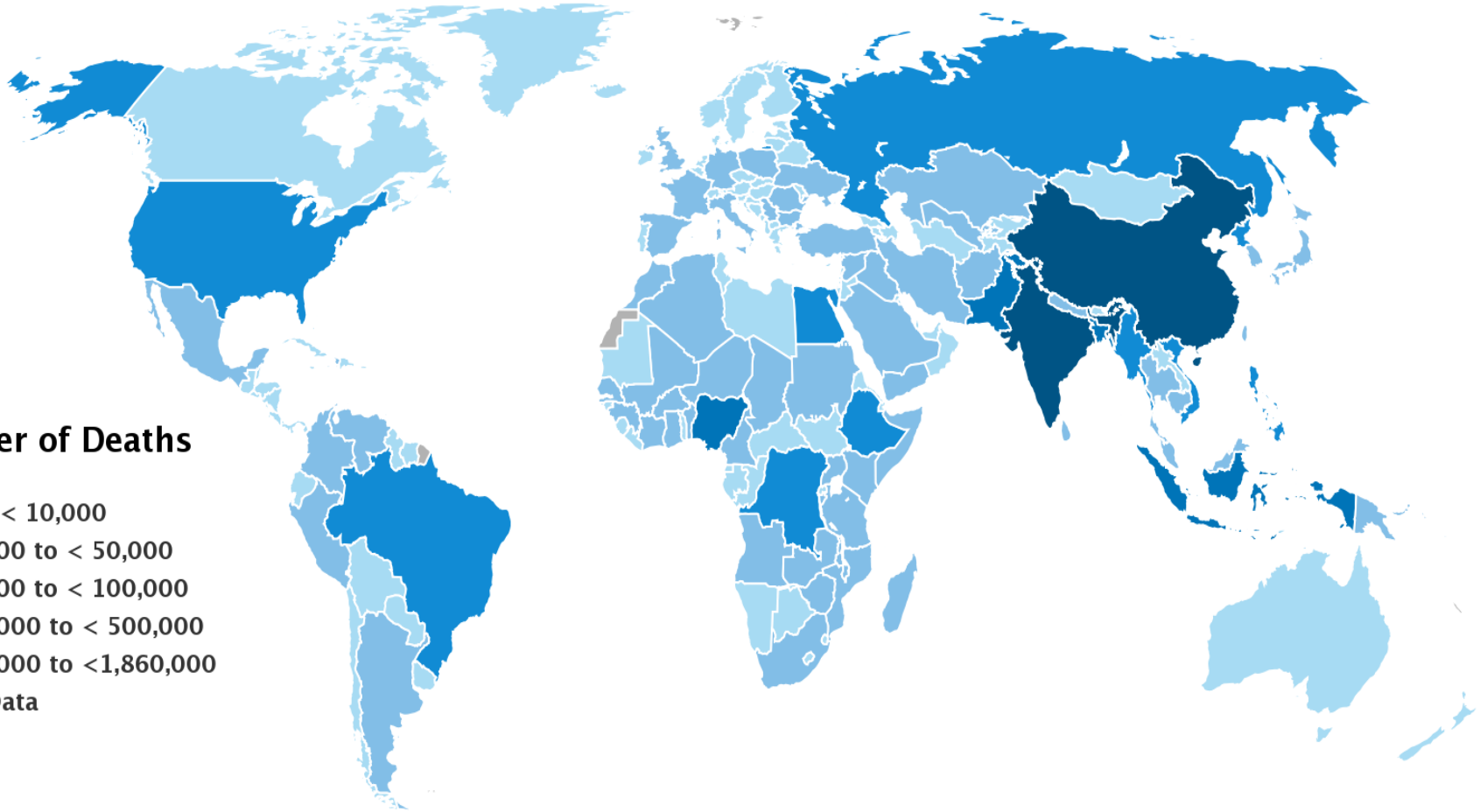
## Number of Deaths Attributable to Air Pollution in 2019

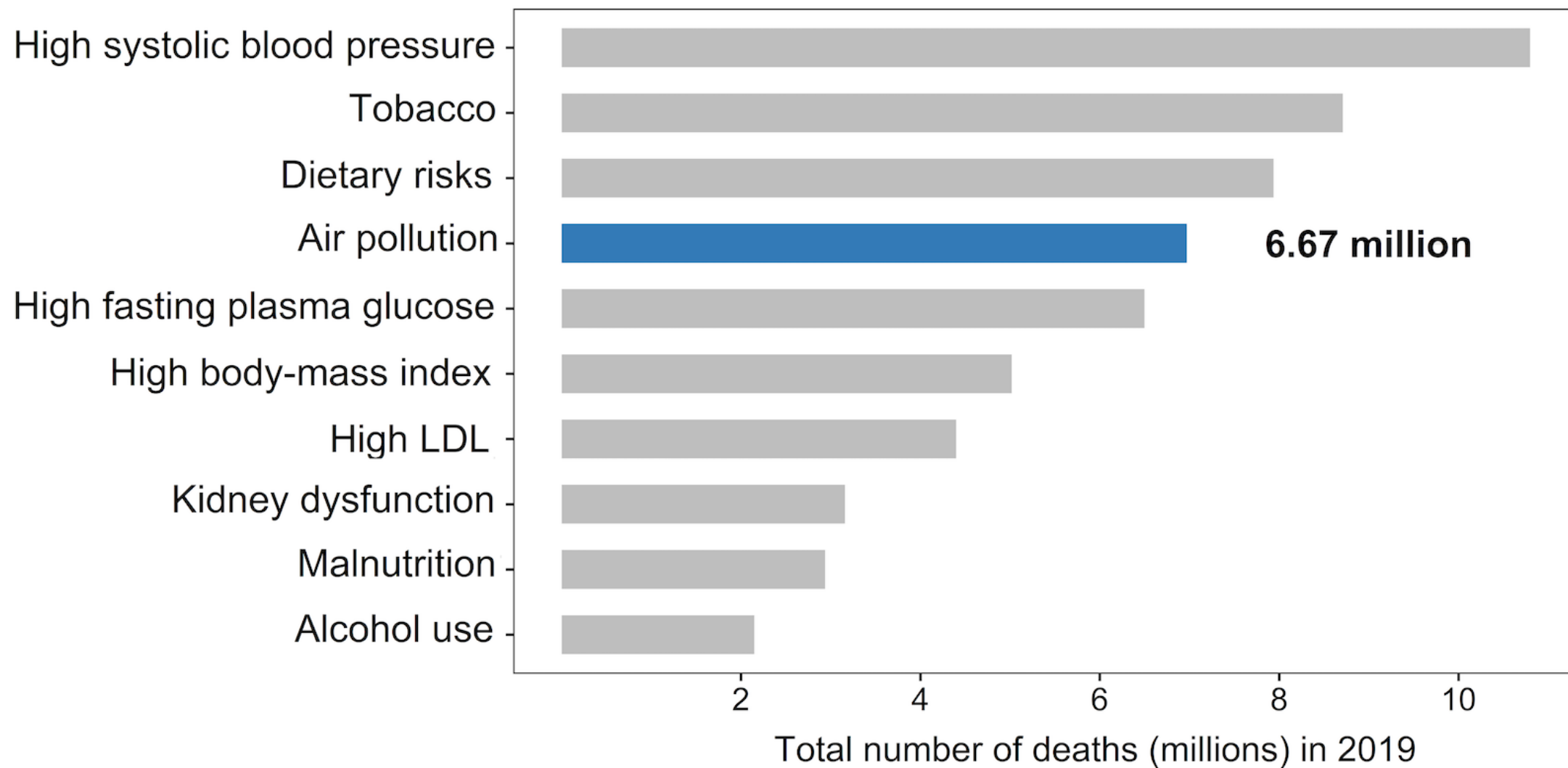
This world map displays the number of deaths attributable to air pollution in 2019, categorized by country. The map uses a color scale from light yellow to dark red to represent the magnitude of deaths. China and India are shown in dark red, indicating the highest number of deaths. Other countries in red include the United States, Brazil, and several nations in Africa and Southeast Asia. Most countries in Europe, North America, and South America are colored in shades of yellow and orange, indicating lower death tolls. The map also includes a legend on the left side, a title at the top, and a data source note at the bottom.


**Number of Deaths**

- 0 to < 10,000
- 10,000 to < 50,000
- 50,000 to < 100,000
- 100,000 to < 500,000
- 500,000 to < 1,860,000

Data source: [WHO, 2020](#)





A photograph of a dark bowl filled with bright red cherries, some of which have spilled out onto a light-colored, weathered wooden surface. The cherries are glossy and have green stems. The background is dark and out of focus.

Conversations  
are like cherries;  
we never pick  
just one!

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Wildfires, heatwaves and droughts often result from a combination of interacting physical processes across multiple spatial and temporal scales, leading to significantly higher impacts

**= *Compound Events* =**



# Strong evidence that droughts and heatwaves are at times synergetic – with subsequent impacts on fires

# COMPOUND FRAMEWORK

## Hot days induced by precipitation deficits at the global scale

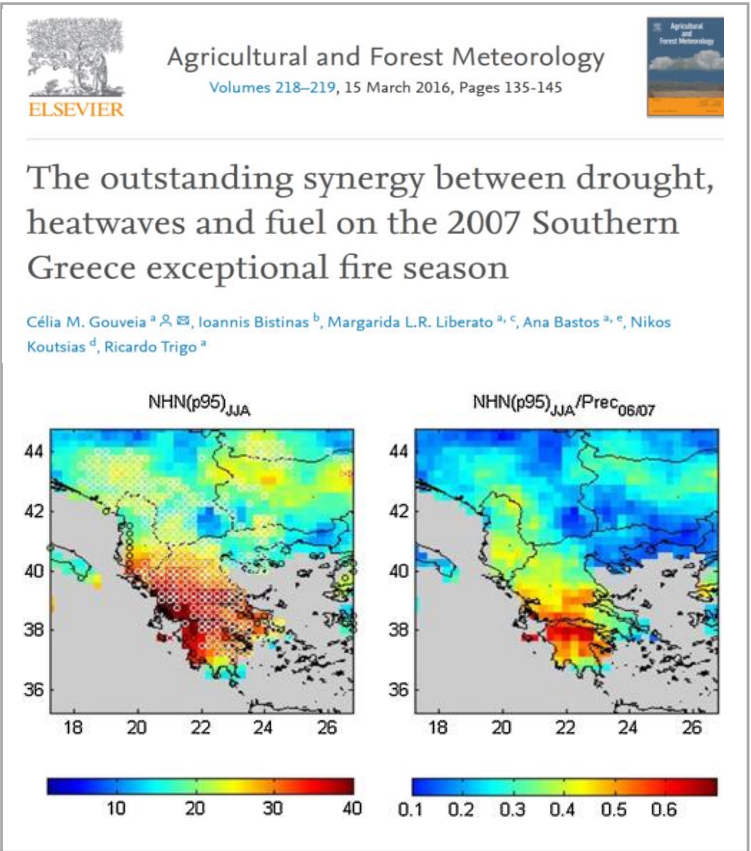
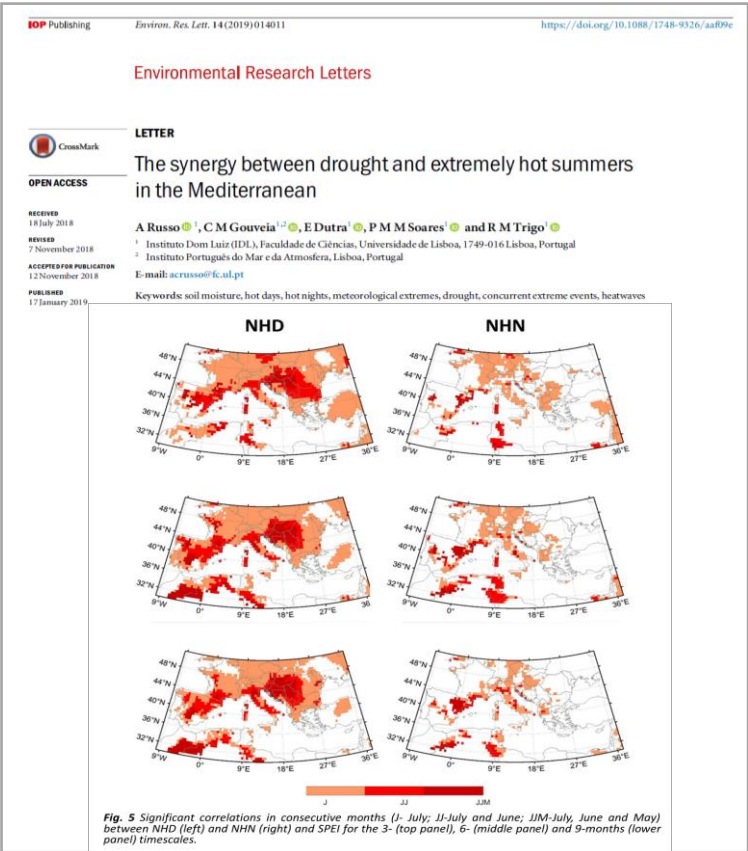
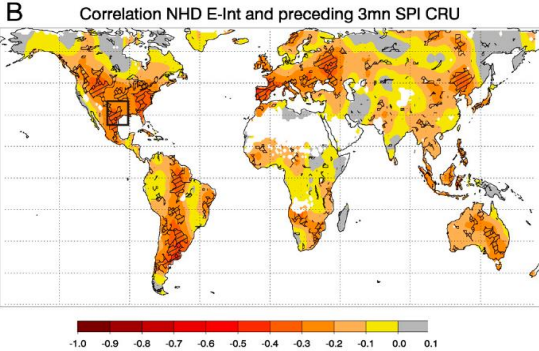
Brigitte Mueller<sup>1</sup> and Sonia I. Seneviratne<sup>1</sup>

Institute for Atmospheric and Climate Science, Eidgenössische Technische Hochschule (ETH) Zurich, 8092 Zurich, Switzerland  
Edited by Mark H. Thieme, University of California San Diego, La Jolla, CA, and approved June 18, 2012 (received for review March 16, 2012)

Global warming increases the occurrence probability of hot extremes, and improving the predictability of such events is thus becoming of critical importance. Hot extremes have been shown to be induced by surface moisture deficits in some regions. In this study, we assess whether such a relationship holds at the global scale. We find that wide areas of the world display a strong relationship between the number of hot days in the regions' hottest month and preceding precipitation deficits. The occurrence probability of an above-average number of hot days is over 70% after precipitation deficits in most parts of South America as well as the Iberian Peninsula and Eastern Australia, and over 60% in most of North America and Eastern Europe, while it is below 30–40% after wet conditions in these regions. Using quantile regression analyses, we show that the impact of precipitation deficits on the number of hot days is asymmetric, i.e. extreme high numbers of hot days are most strongly influenced. This relationship also applies to the 2011 extreme event in Texas. These findings suggest that effects of soil moisture-temperature coupling are geographically more widespread than commonly assumed.

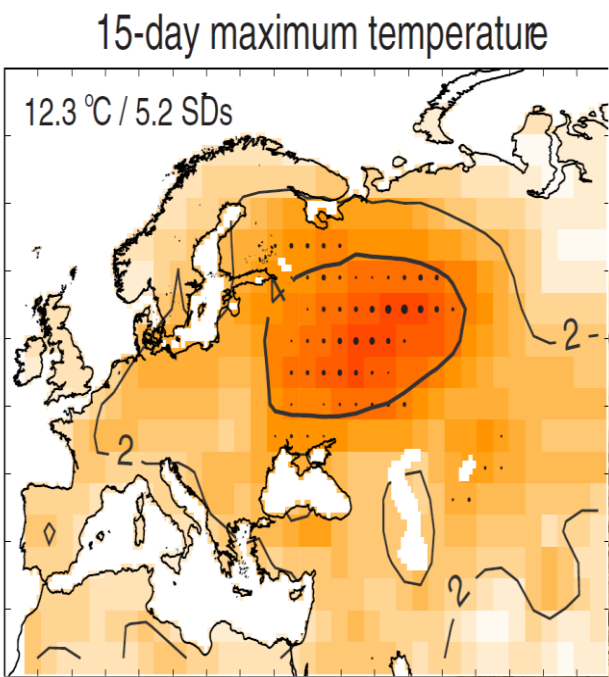
Building upon a recently published study (14), we use here the Standardized Precipitation Index (SPI) (22) as proxy for surface moisture deficits, and we globally assess the impact of these deficits on the occurrence of subsequent hot days in the respective hottest month of each particular year and at each location (see Fig. 1A) using correlation analysis and quantile regression (23, 24). While correlation analyses are suitable to study the relationship between two variables' mean states, quantile regression allows to estimate the impact of one variable on the tails of the distribution of another. It should be noted that statistical relationships do not necessarily imply causality, but can be used to assess the coupling between two variables if plausible mechanisms exist (10).

The SPI is the standard deviation of observed precipitation values from the long-term mean after a normalization with the gamma distribution. SPI values lower than −0.8 are usually referred to as moderately to extremely dry, and values higher than 0.8 as moderately to extremely wet. The SPI is calculated from precipitation deficits over a given time period. We consider here

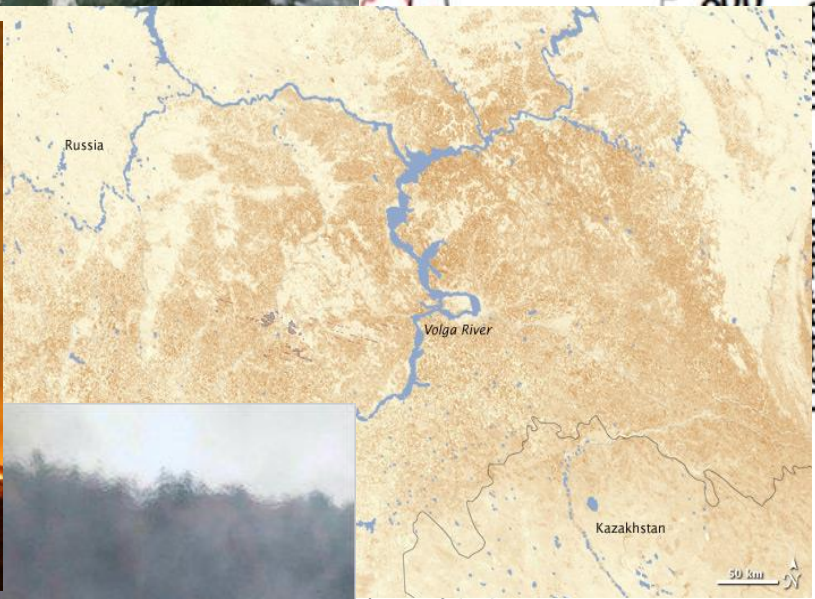
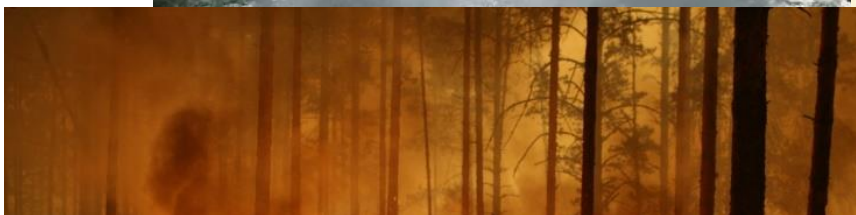




# 2010 Extreme Heatwave



Barriopedro et al. (2011) *Science*



# Health Impacts

## 1) Legionnaire Disease

How the weather can negatively affect air pollution and consequently our health

How were the recirculation and the synoptic conditions?

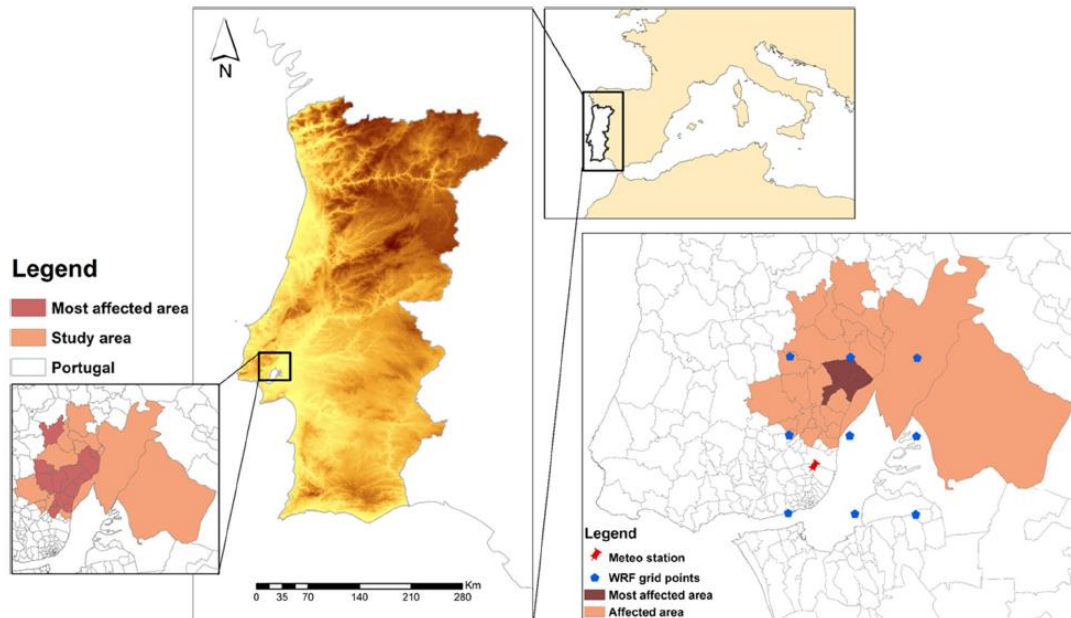
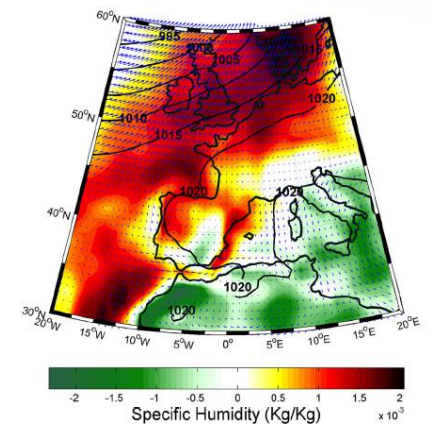
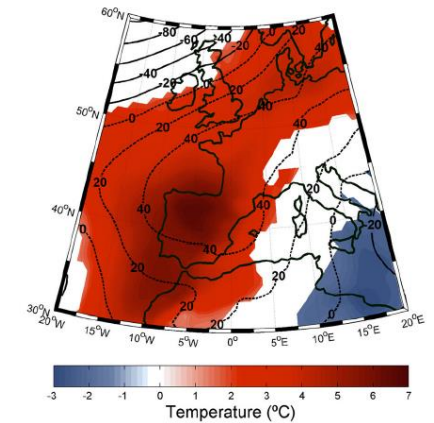
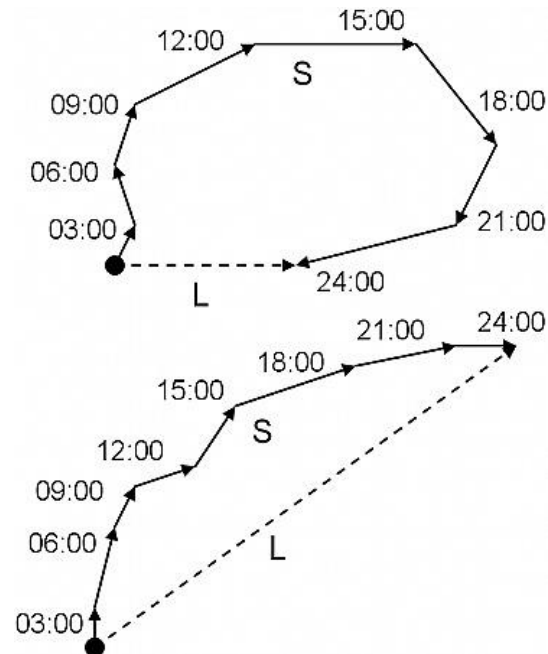


Fig. 1 Location of the affected area and of the meteorological station (red pin) and wind model output point locations (blue dots). The X-axis shows the months of the year from January to December: J-January, F-February,

M-March, A-April, M-May, J-June, J-July, A-August, S-September, O-October, N-November, D-December. For color specifications, please refer to the online version

### Recirculation Potential





# How the weather can negatively affect air pollution and consequently our health

## Health Impacts

### 1) Legionnaire Disease

Three factors essential for Legionella proliferation were present:

- (1) susceptible population;
- (2) pathogen proliferation in the cooling towers;
- (3) aerosol exposure, which was supported by the meteorological conditions (warm temperatures, low winds, and humidity values above 50%, low recirculation).

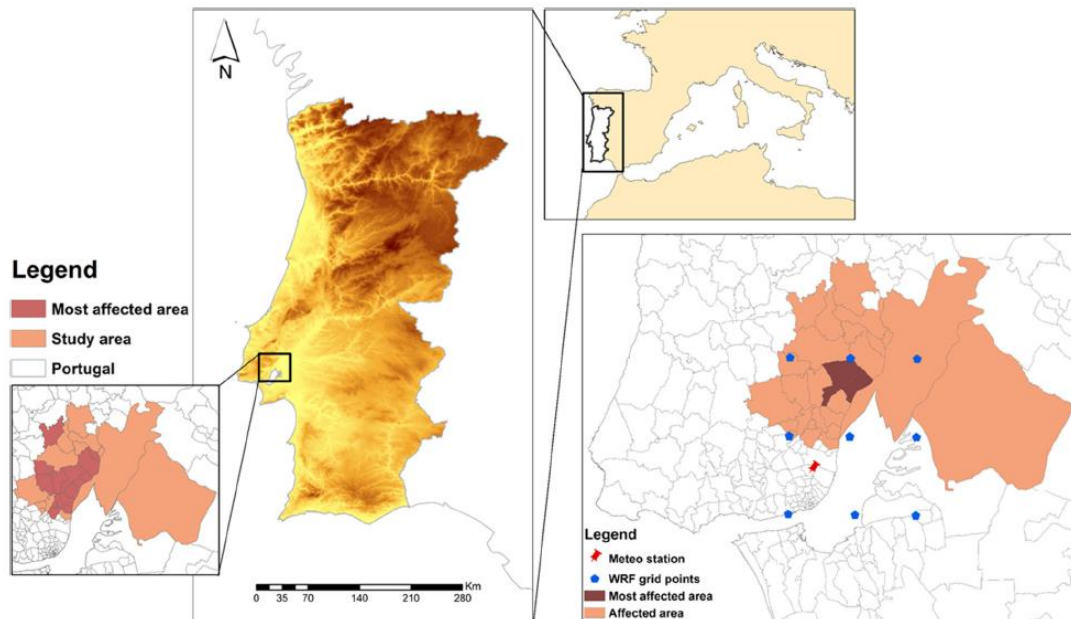


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# Health Impacts

## 2) Wildfire-pollution From Storm Ophelia

- (1) Storm Ophelia dragged up smoke from Portuguese wildfires into Western Europe
- (2) Storm Ophelia picked up dust from North Africa and added it to the wildfire smoke
- (3) Smoke and dust caused increases in PM levels in Portugal and in the UK
- (4) PM10 had a significant effect on the same day natural and cardiorespiratory mortalities

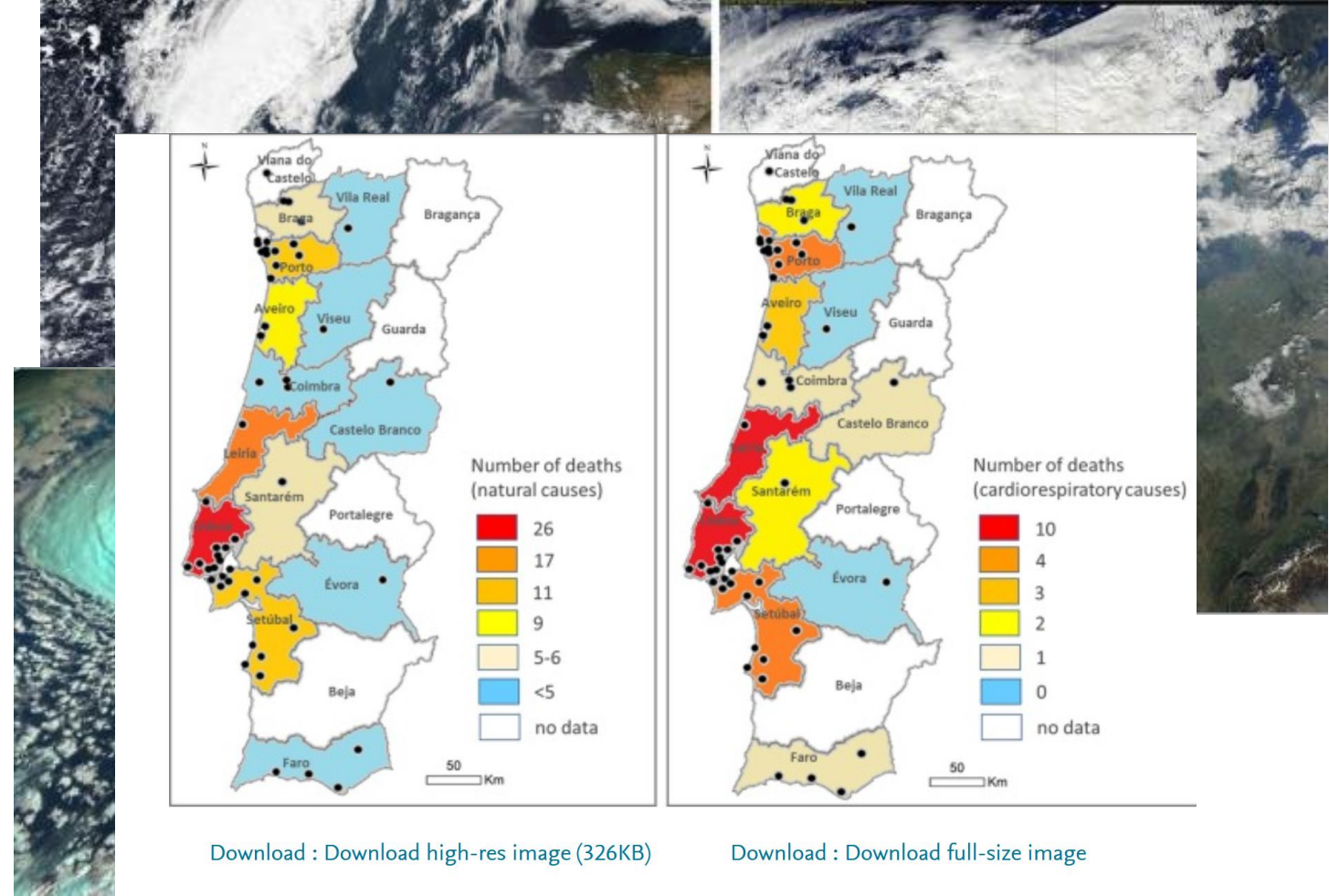


Fig. 7. (Left) Number of natural deaths attributable to PM<sub>10</sub> from the wildfires of October 2017 in Portugal; additional information in SM1. (Right) Number of cardiorespiratory deaths attributable to PM<sub>10</sub> from the wildfires of October 2017 in Portugal; additional information in SM2.

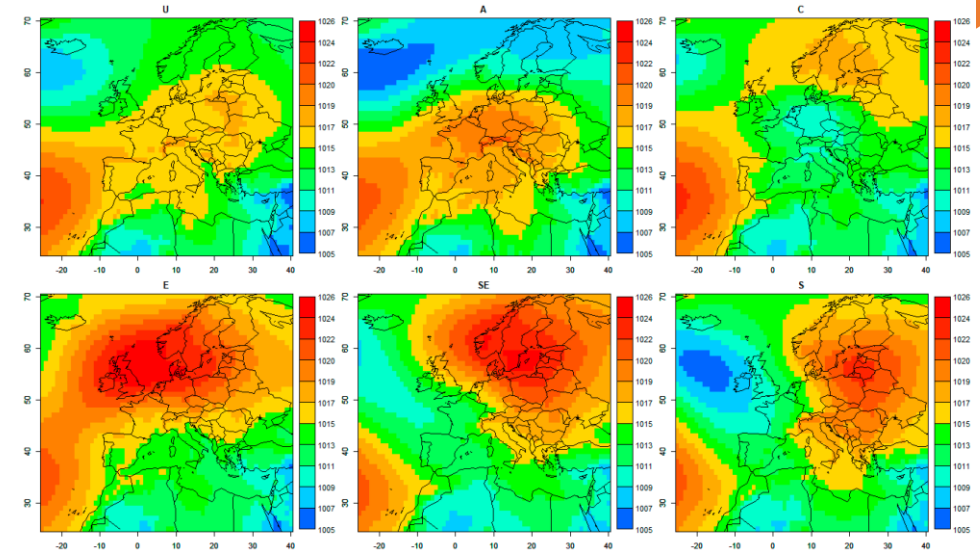
# How the weather can negatively affect air pollution and consequently our health

## Health Impacts

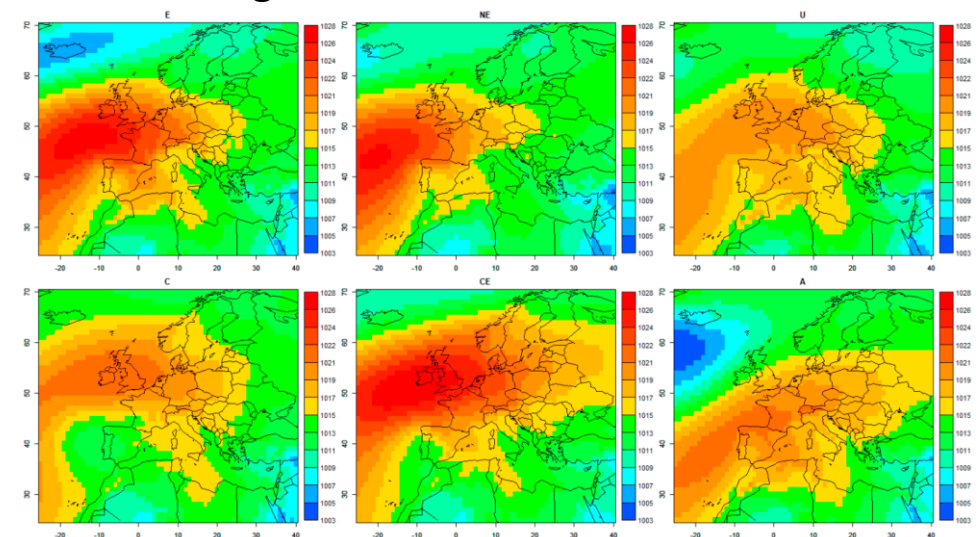
### 3) Compound O3 and Heatwave

- (1) Heat waves were identified as the most frequent wave type
- (2) Comparable exposure to heat and ozone waves was found in Central and South Europe
- (3) Bavaria waves showed the strongest connection with autochthonous weather conditions
- (4) Portugal showed the strongest relationship appeared for eastern and north-eastern inflow
- (5) The most severe events, as measured by excess mortality, were always associated to compound heat-ozone waves

CWT Bavaria



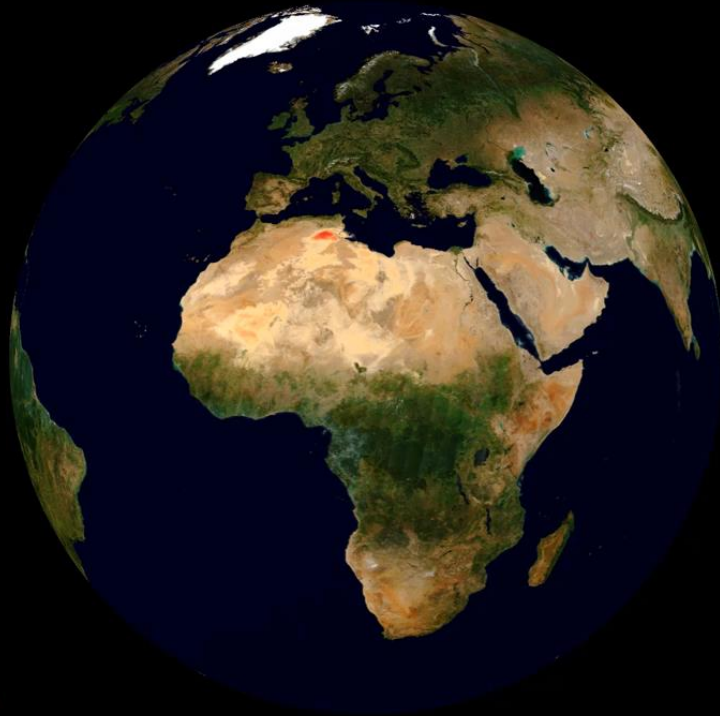
CWT Portugal





# Take Home Messages

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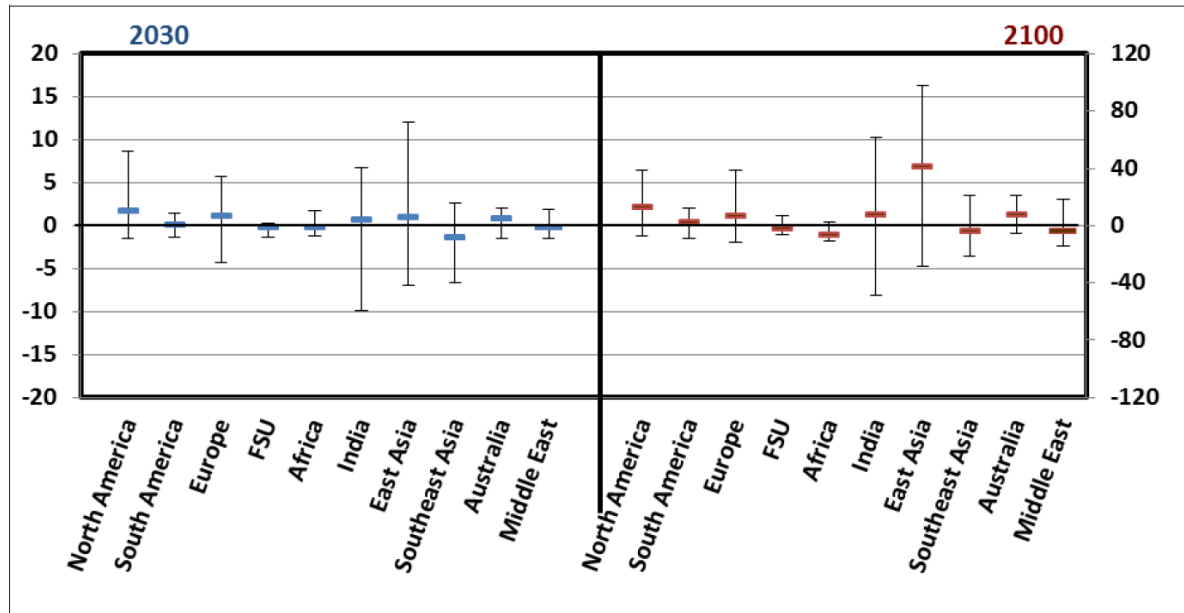


- Overall, pollutants have different influences on mortality and morbidity depending on the location and season
  - The elderly, children and people with previous illness are more susceptible
  - In some places, and for some types of pathologies, there is greater gender susceptibility
  - High heat and air pollution are even deadlier combined
-

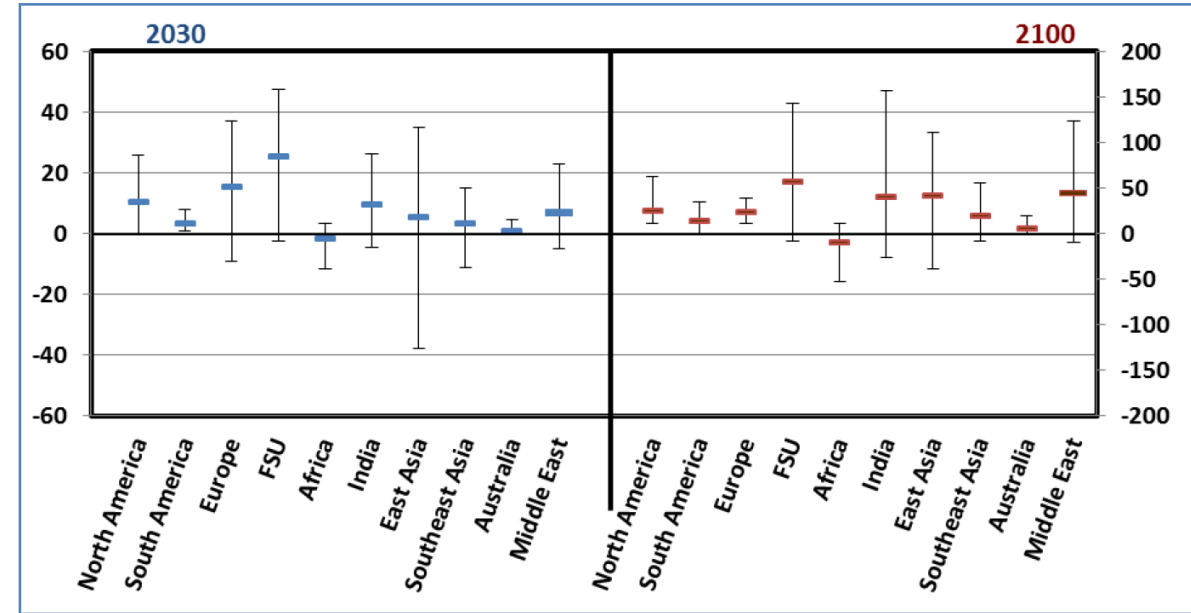
# Climate change

Silva, R., West, J., Lamarque, JF. *et al.* **Future global mortality from changes in air pollution attributable to climate change.** *Nature Clim Change* **7**, 647–651 (2017).  
<https://doi.org/10.1038/nclimate3354>

a. Ozone mortality



b. PM<sub>2.5</sub> mortality



Million Inhabitants

Premature mortality attributable to climate change is expected to be positive in all regions, except for Africa, being higher in India and eastern Asia.

slido



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# Thank you for your attention



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