EXHAUSTION

White Paper
January 2024

The duration and magnitude of heatwaves are projected to increase in Europe under all emission scenarios, while the level of air pollutants will decrease under most emission scenarios.

In a climate with increasingly frequent and extended heatwaves, mitigation of ozone and particulate matter will benefit health

- Heatwaves are projected to increase faster in duration and in magnitude by mid-century than in the past, even under the Sustainability scenario (SSP1). Southern Europe is projected to experience the most intense heatwaves and to encounter the largest increases.
- A decrease in surface ozone concentrations of up to 20% is projected in 2050 compared to the levels in 2015, assuming Middle of the road and Sustainability scenarios. The least ambitious mitigation scenario leads to a slight increase of 3% by mid-century.
- Substantial increases are expected in the emission and pollution hotspots like the Po Valley in Italy, Ruhr industrial belt in Germany, the Benelux region (Belgium and the Netherlands) and over major cities under the Middle of the road and Regional rivalry scenarios.
- Surface $PM_{2.5}$ concentrations are projected to decrease across Europe, in particular over central and eastern Europe, under all the scenarios by up to 55%, however with a slower rate as compared to the near past (1981-2010).

Factory in the Netherlands
Photo: Istockphoto / AlbertPego

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The EXHAUSTION Project estimates the change in cardiopulmonary mortality and morbidity due to extreme heat and air pollution (including from wildfires) under selected climate scenarios, calculates the associated costs, and identifies effective strategies for minimizing adverse impacts.

Research findings

The increase in heatwave duration and magnitude until mid-century are projected to be significantly higher compared to that in the past. The projected future trends are very heterogeneous across Europe, with the largest increase in trend over southern Europe and much smaller increases in northern and western Europe.

The majority of southern Europe will experience an increase of 5 to 11 days per decade in heatwave duration, which is 2 to 3 times larger than in the past.

If we take Italy as an example, even under the Sustainability scenario (SSP1), heatwave duration will increase by around 15 days per decade, which is substantially larger than the heatwave duration of 1.2 days per decade during 1981-2010.

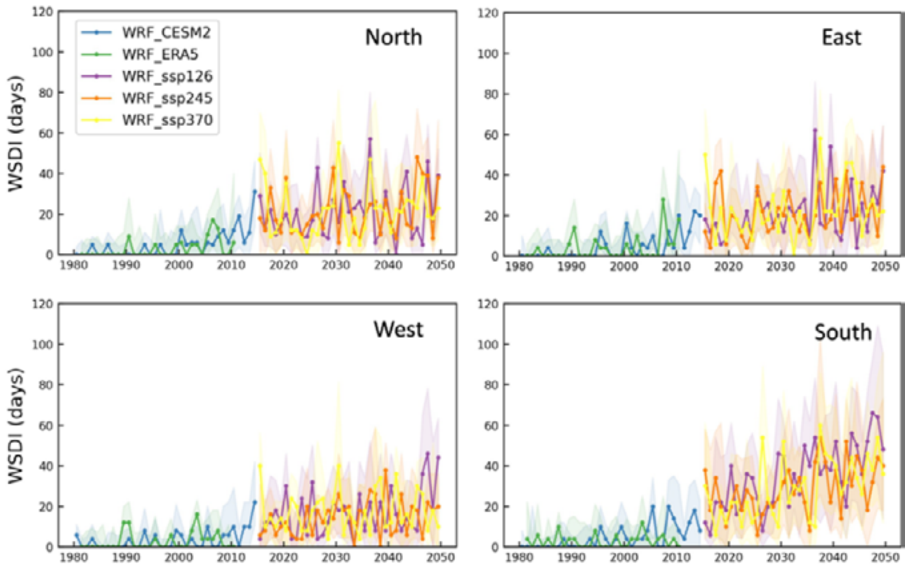

Figure 1: Heatwave duration and magnitude over different regions in Europe in near past (1990-2014) and between 2015 and 2050 under the Sustainability scenario (SSP1-2.6), Middle of the road scenario (SSP2-4.5) and Regional rivalry scenario (SSP3-7.0).

Mitigation scenarios

In EXHAUSTION, we have adopted the Shared Socioeconomic Pathways (SSP) used in the 6th Assessment Report (AR6) from the Intergovernmental Panel on Climate Change (IPCC). We have used SSP1, SSP2, and SSP3 scenarios, where SSP1 and SSP3 define various combinations of high or low socio-economic challenges to climate change adaptation and mitigation, while SSP2 describes medium challenges of both kinds and is intended to represent a future in which development trends are not extreme but rather follow middle-of-the-road pathways.

In this White Paper, we use the following terminology: A Sustainability scenario (SSP1), a Middle of the road scenario (SSP2) and a Regional rivalry scenario (SSP3), the first representing the scenario with the highest emission reductions. These are coupled with Representative Concentration Pathways: RCP 2.6, RCP 4.5, RCP 7.0, and the white paper also refers to SSP1-2.6, SSP2-4.5 and SSP3-7.0

Trends of ozone concentrations depend on a particular scenario and time period

The ten-years mean population-weighted surface ozone (O_3) concentration decreases by almost 14% from 2015-2025 to 2040-2049 in the Sustainability scenario.

It decreases by 2% in the Middle of the road scenario, and increases by 3% in the Regional rivalry scenario.

For air pollution ($PM_{2.5}$) the trends are more homogeneous:

The ten-years-mean population-weighted surface $PM_{2.5}$ concentrations decrease by 48% from 2015-2025 to 2040-2049 in the Sustainability scenario. It decreases by 27% in the Middle of the road scenario and only by 16% in the Regional rivalry scenario.

In the Sustainability scenario, air pollution ($PM_{2.5}$), concentrations decrease by about 10 microgram per cubic meter (10 $\mu g/m^3$) over central and eastern Europe. Despite the decreases, however, relatively high concentrations remain.

Despite the decreases in air pollution ($PM_{2.5}$), it takes years to meet the WHO Air Quality Guidelines from 2021 (5 $\mu g/m^3$). Averaged over continental Europe, the guideline is projected to be met after 2025 under the Sustainability scenario, to be met after 2040 under the Middle of the road scenario, and to be still challenging by mid-century under the Regional rivalry scenario.

Milano, Italy

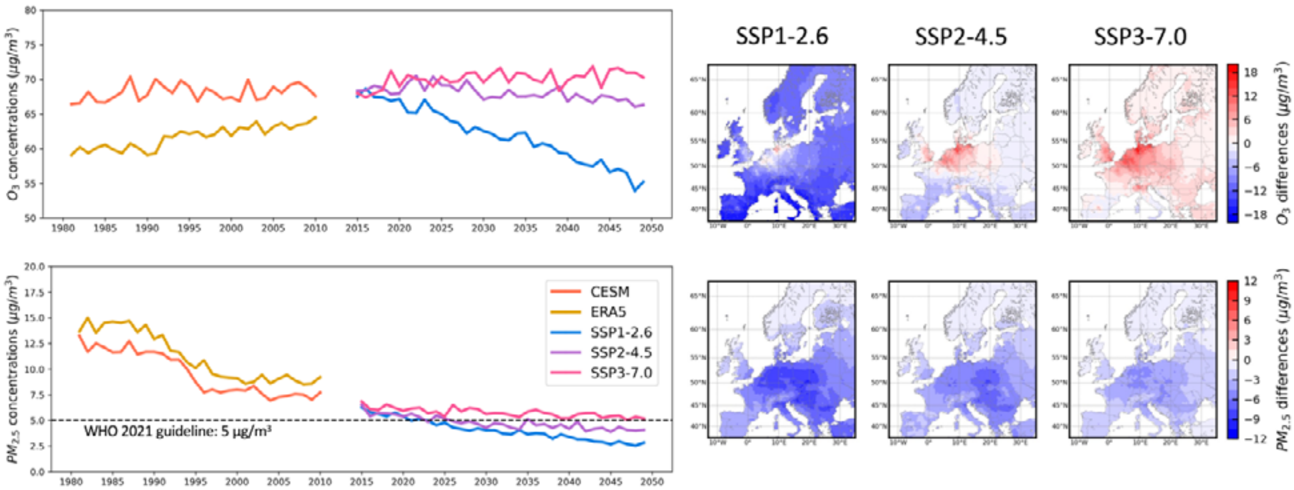

Figure 2: Timeseries of annual mean population-weighted land surface ozone (O_3) (upper panel) and air pollution ($PM_{2.5}$) (lower panel) concentrations over continental Europe (left panel), and the spatial distribution of changes in surface O_3 and $PM_{2.5}$ concentrations under the different emission scenarios.

Key policy recommendations

Due to the interactive effects of air pollution and heat documented by researchers in EXHAUSTION, policies reducing air pollution concentrations in Europe, such as the EU's revised Ambient Air Quality Directive, will not only reduce the health effects of air pollution but also prevent death and disease from heat.

Ambitious legislations to reduce the causes of climate change and promote clean air should be timely adopted to mitigate adverse health impacts.

Air pollution and climate change policies should not be two separate policy areas but need to go hand in hand to harvest the health co-benefits.

Key research recommendations

Further research is needed to improve climate and air pollution models with more accurate representation of physical and chemical governing processes of the Earth system to achieve more accurate predictions.

More research is needed to improve anthropogenic and natural emission estimates that better take into account European energy policies and population dynamics and that account for tailored adaptation to climate change.

Open data should be promoted in order to design strategies and evaluate impacts

Po valley, Italy

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