

Why we need methane regulation for tropospheric ozone reduction

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OZONE IN THE LOW ZONE

STRATOSPHERE

PROTECTIVE OZONE LAYER

TROPOSPHERE

DANGEROUS GROUND-LEVEL OZONE

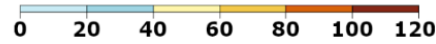
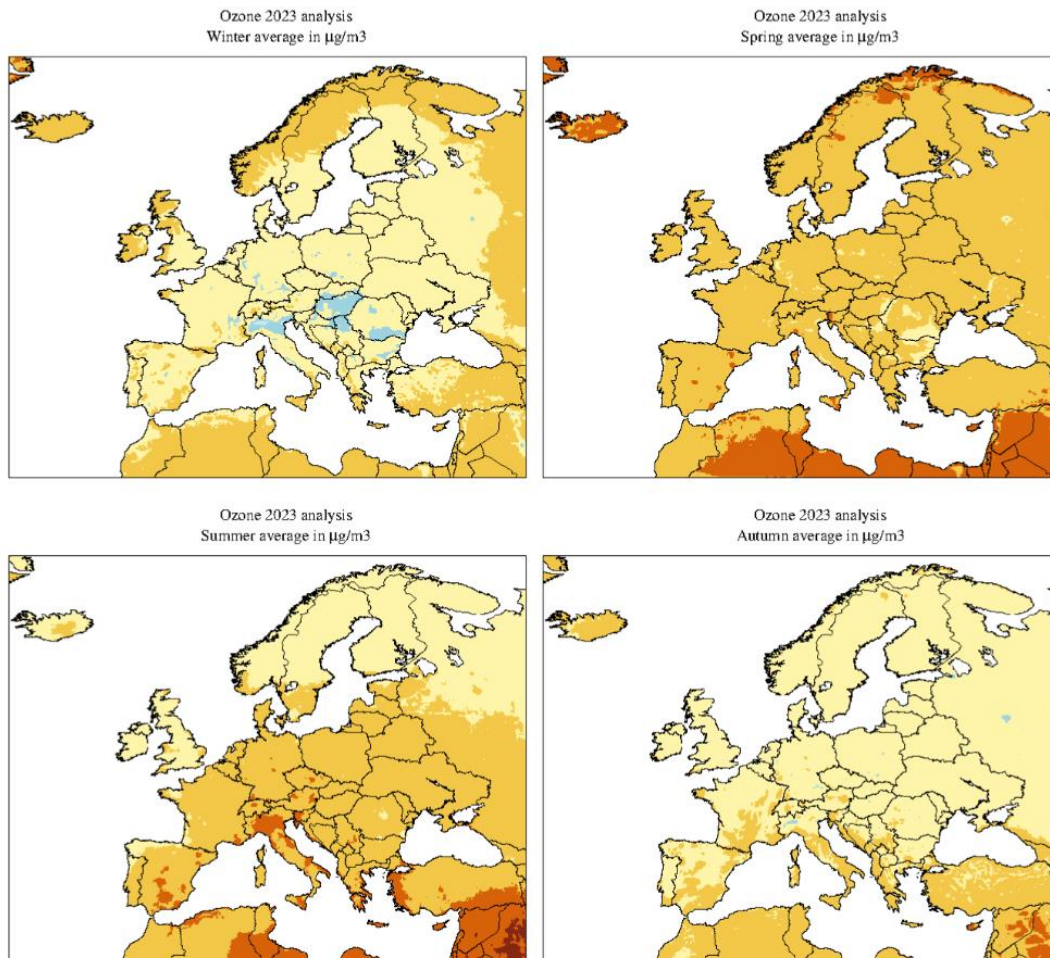


**POLLUTION + HEAT & SUNLIGHT
= OZONE**

Source: EPA

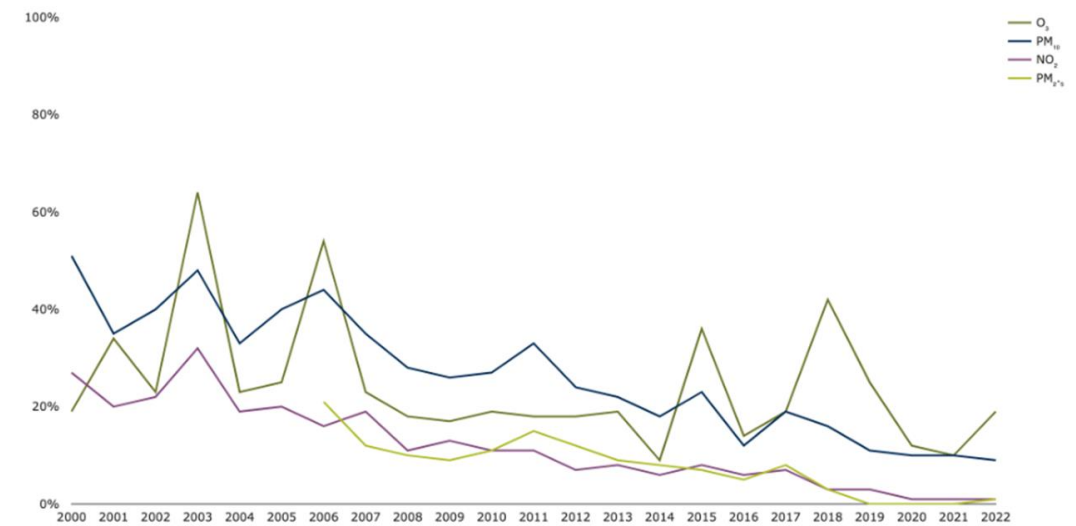
CLIMATE  CENTRAL

Image from Climate central

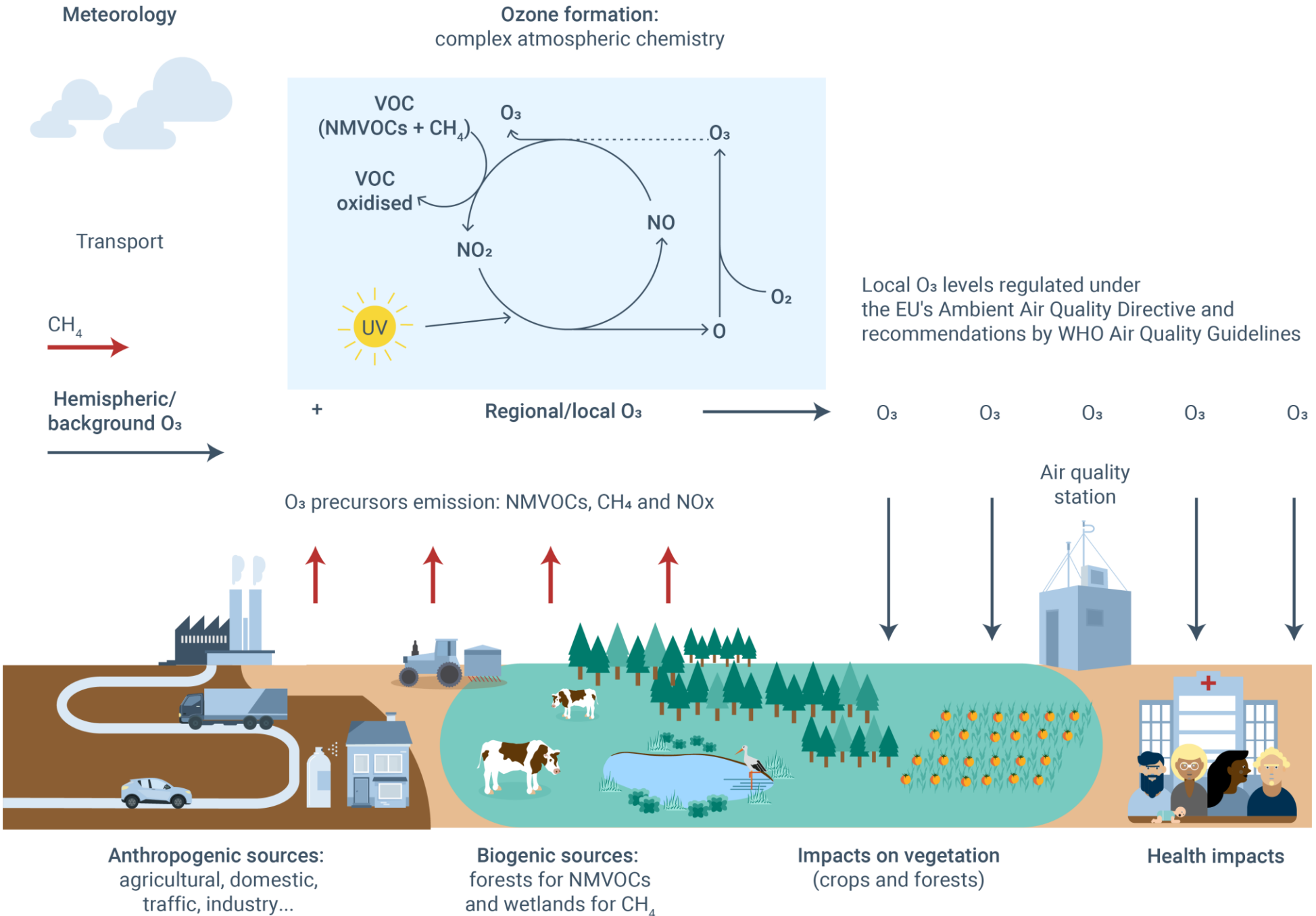


Seasonal average of daily mean ozone concentrations for 2023. For winter (upper left); spring (upper right); summer (lower left) and autumn (lower right). Units: $[\mu\text{g}\cdot\text{m}^{-3}]$.

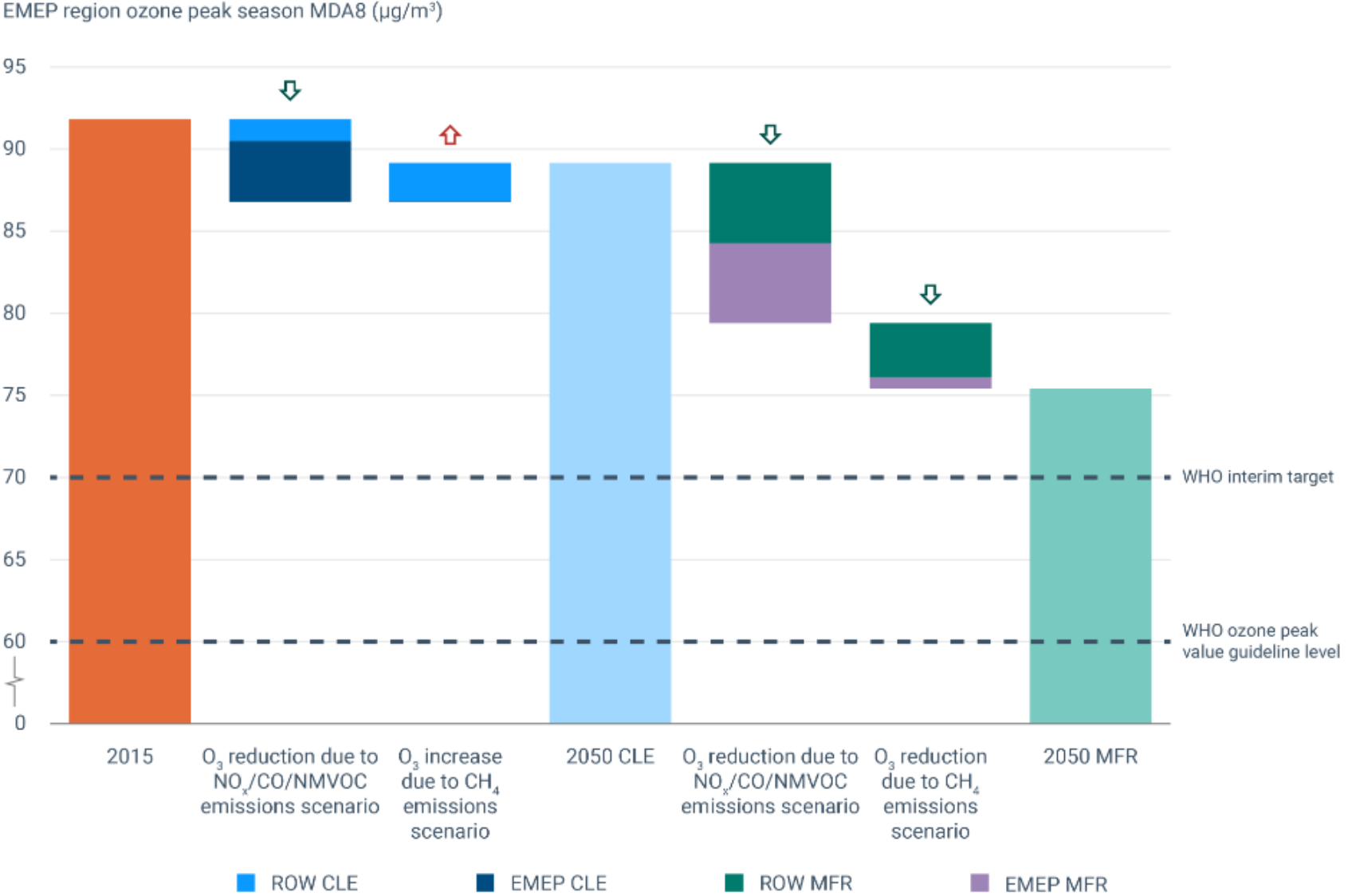
While [according to the European Environmental Agency \(EEA\)](#) the exposure of the urban population to air pollutants above the EU standards has decreased over the years, ozone exposure is clearly more difficult to curb, and subject to important seasonal peaks.



Ozone pollution is a butterfly effect, high concentrations resulting from a mix of local sources of precursors, and other sources that might be hundreds of kilometers away; therefore, consistent monitoring and tracking methods and international collaboration are crucial to curb it.



Given its relatively long lifetime in the context of air pollution and increasing concentration in the atmosphere, methane is a significant contributor to the ground-level ozone burden. Current global methane emissions from both natural and anthropogenic sources are estimated to be responsible for about 37% of the ozone background levels in Europe (European Commission, Joint Research Centre, 2024).



Proceedings for the Ozone Workshop US EPA 2024



Emerging research areas/findings include impact on the brain.



Increase in studies on COPD and other respiratory diseases.



In general, more linear concentration-response functions on short-term effects with no threshold.



Short-term effects of O₃ exposure, lag of one or two days for respiratory endpoints and had a lag of up to five days for cardiovascular endpoints.

Recent meta-analysis

Kasdagli et al.

Nitrogen Dioxide, Ozone and Mortality

TABLE 2 | Meta-analysis results and characteristics of studies informing the associations between long-term exposure to ozone (O₃) (per 10 µg/m³ increase) and mortality outcomes (Global, 2023-2024).

A) Annual O₃

	N	RR (95% CI)	I ² (%)	80% prediction interval	Sample size	Age (years)	Median of O ₃ (min – max)
All-cause	9	1.01 (0.96, 1.06)	92	(0.91, 1.11)	1,622,831	>30	60.6 (42.3–94.3)
Respiratory disease	6	1.05 (1.02, 1.08)	65	(1.00, 1.09)	1,544,274	>30	70.4 (50.8–94.3)
COPD	2	1.06 (1.03, 1.08)	25	-	1,217,826	>30	74.87–76.44*
ALRI	2	1.04 (0.97, 1.11)	80	-	1,217,826	>30	74.87–76.44*

B) Peak/warm season O₃

	N	RR (95% CI)	I ² (%)	80% Prediction Interval	Sample size	Age (years)	Median of O ₃ (min – max)
All-cause	12	1.01 (0.97, 1.04)	98	(0.92, 1.10)	107,896,036	>18	90.6 (74.9–106.6)
Respiratory disease	9	1.01 (0.98, 1.03)	92	(0.95, 1.06)	57,107,136	>25	85 (74.9–109.8)
COPD	7	1.00 (0.96, 1.04)	95	(0.92, 1.09)	56,668,296	>25	85 (74.9–109.8)
ALRI	4	1.02 (0.99, 1.04)	88	(0.97, 1.07)	23,702,383	>30	87.9 (74.9–109.8)

N = number of studies; min: minimum; max: maximum.

Kasdagli et al,
2024

Table A2.4. Detailed EMAPEC classification criteria for long-term exposure to O₃ with mortality outcomes

Pollutant	Outcome	Causality	List	RR (95% CI) per 10 µg/m ³	Criterion						
					1i	1ii	2i	2ii	2iii	2iv, I ² , 80% PI	2v
O ₃ annual	Natural	Suggestive	B-	1.01 (0.96–1.06)	9	X	✓	✓	1000%	92%, 0.91–1.11	✓
	Respiratory (non-malignant)	Likely	B+	1.05 (1.02–1.08)	6	✓	✓	X	120%	65%, 1.00–1.09	NA
	COPD ^a	NA	NA	NA	2	NA	NA	NA	NA	NA	NA
	ALRI ^a	NA	NA	NA	2	NA	NA	NA	NA	NA	NA
O ₃ warm/ peak season	Natural	Suggestive	B-	1.01 (0.97–1.04)	12	X	✓	✓	700%	98%, 0.92–1.10	✓
	Respiratory (non-malignant)	Likely	B-	1.01 (0.98–1.03)	9	X	✓	✓	500%	92%, 0.95–1.06	NA
	COPD	NA	B-	1.00 (0.96–1.04)	7	X	✓	✓	> 1000%	95%, 0.92–1.09	NA
	ALRI	NA	B-	1.02 (0.99–1.04)	4	X	✓	✓	250%	80%, 0.97–1.07	NA

✓: fulfilled; X: not fulfilled; ALRI: acute lower respiratory infection; CI: confidence interval; COPD: chronic obstructive pulmonary disease; PI: prediction interval; RR: relative risk; NA: not assessed or not applicable.

^a Outcome omitted because of inadequate number of studies.

Source: data are taken from Forastiere et al. (2024), Kasdagli et al. (2024) and US EPA (2020).

- EEA 2024, Ozone premature Mortality per 100, 000

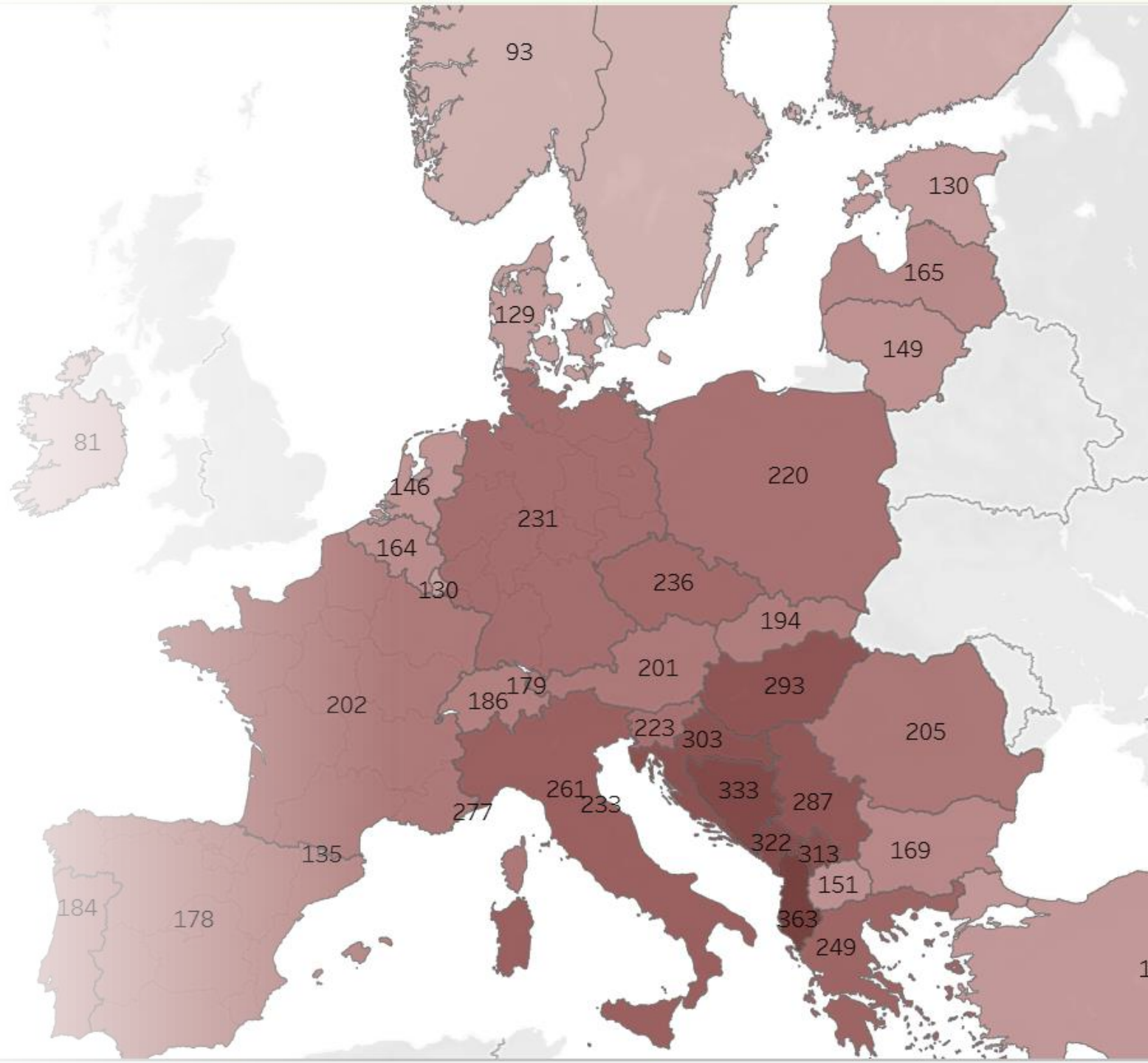


Table 1: Selection of meteorological parameters that may increase under future climate change and their impact on ozone levels

Climatic change	Consequence	Impact on ozone levels
Temperature	Faster chemistry	Increase
	Decomposition of nitrogen oxides reservoir species (PAN)	Increase
	Increased biogenic emissions (VOC, NO)	Increase
CO ₂ concentrations	Decreased biogenic emissions	Decrease
Solar radiation (e.g. decreased cloudiness, or reduced aerosol optical depth)	Faster photochemistry	Increase (high NO _x) Decrease (low NO _x)
Precipitation	Scavenging of soluble precursors (HNO ₃)	Decrease
Atmospheric humidity	Increased ozone destruction	Increase (high NO _x) Decrease (low NO _x)
Drought events	Decreased atmospheric humidity and higher temperatures	Increase
	Plant stress and reduced stomata opening reduced dry deposition on the ground	Increase
	Plant stress reduces BVOC emissions	Decrease
	Increased frequency of wild fires	Increase
Blocked weather patterns	More frequent episodes of stagnant air	Increase
	Increase in summer/dry season heat waves	Increase

Source: Adapted from Jacob and Winner (2009), The Royal Society (2008) and Lin et al. (2020)

Ozone-related acute excess mortality projected to increase in the absence of climate and air quality controls consistent with the Paris Agreement

Domingo et al. 2024

Changes in emissions and climate

+

Changes in baseline mortality rate

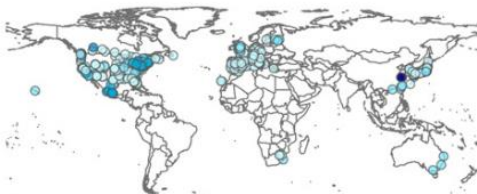
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Changes in population size

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Future changes in ozone-related deaths

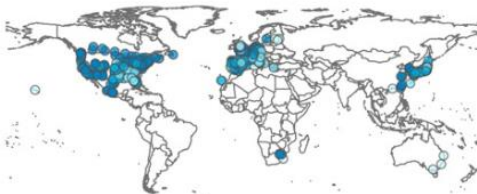
SSP 1-2.6



SSP 2-4.5



SSP 3-7.0



SSP 5-8.5



O₃-related mortality ○ -109 to -8% ○ -8 to 27% ● 27 to 56% ● 56 to 79% ● 79 to 442%

- strong climate and air pollution controls (SSP1-2.6) total ozone-related mortality is estimated to increase by 45 deaths/year
- middle-of-the-road scenario (SSP2-4.5) total ozone-related mortality is estimated to increase by 4,400 deaths/year
- regional rivalry scenario (SSP3-7.0), which has weak climate and air pollution controls total ozone-related mortality is estimated to increase by 6,200 deaths/year
- weak climate mitigation measures but strong air pollution measures (SSP5-8.5) total ozone-related mortality is estimated to increase by 3,700 deaths/year

SSP Shared socio-economic pathways