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European cities air quality ranking: a new methodology

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Summary

The European Environment Agency publishes a European city air viewer comparing the air quality in cities across Europe on a yearly basis. The viewer provides information about air quality in over 340 cities, categorising air quality from good to very poor (five categories) and ranks the cities from the least to the most polluted, based on average levels of fine particulate matter ($PM_{2.5}$) over the last two calendar years. The levels of concentration are assessed based on observations from urban or suburban background or traffic air quality stations monitoring $PM_{2.5}$.

A new methodology for the European city viewer is proposed in this report to consider, in addition to $PM_{2.5}$, two other relevant pollutants in terms of human exposure: nitrogen dioxide (NO_2) and ozone (O_3). The methodology aligns better with the current approach for the environmental burden of disease (EBD) produced by the European Environment Agency (EEA) and the European Topic Centre (ETC) on Health and Environment (HE). The idea is to develop an indicator to communicate the mortality risk associated with pollutant exposure and evaluate air quality based on the definition of total attributable risk. The new methodology makes use of the 1*1 km^2 resolution air quality maps created by the ETC HE, a product generated by data fusion of observations, modelling and other complementary data. These air quality maps open the possibility of including more cities, as the availability of observations does not constrain the estimation of the indicator. Population-weighted averaged concentrations are used instead of concentrations, allowing for considering the concentration that the city's population is exposed to and not the average concentration for the whole city. The population-weighted average concentration is estimated based on the air quality and population density maps. The risk of mortality of the population in the city is then estimated based on the concentration-response functions describing the mortality risk associated with exposure to individual pollutants. An (arbitrary) scale to compare the different pollutants linearly to their risk is then defined, assuming that the same value in the scale corresponds to exposure to pollutants with the same risk level.

The proposed methodology seems to be a promising way to rank the air quality levels across European cities. In summary, having a methodology based on mapping allows broader coverage of the European territory. Using population-weighted concentration also seems to allow consistency in estimating the risk across the cities, and concentrations will reflect the concentration to which a city's population is exposed. Moreover, using the mortality risk approach allows cities to be ranked based on air pollutant levels for three different pollutants instead of the current methodology that penalises cities with higher $PM_{2.5}$ levels independently of the ambient NO_2 or O_3 concentration levels.

1 Introduction

In 1999, the US Environmental Protection Agency proposed the first air quality index (AQI) for reporting the pollution level and its daily impact on health (*https://www.airnow.gov*). Similar indexes have been adopted globally to evaluate air quality and communicate risk. However, the methods used to estimate the AQIs differ among countries (Plaia et al., 2011). The classification is mostly done per air pollutant or reflects only the level of the individual pollutant with the highest sub-index rather than a multi-pollutant approach. Moreover, most AQIs do not reflect the possible synergistic effects of simultaneous exposure to multiple pollutants (Plaia & Ruggieri, 2011) and do not reflect the no-threshold dose-response relationship between air pollutants and health risks (Stieb et al., 2008).

The European Environment Agency (EEA) has created a dashboard, the European city air quality viewer([1]), to categorise the air quality in European cities over the last two years and compare it among the cities. The viewer provides information about how good the air quality is in over 340 cities, categorising air quality from good to very poor (five categories). The cities are ranked from the least to the most polluted based on average levels of fine particulate matter ($PM_{2.5}$). The levels of concentration are assessed based on observations from urban or suburban background or traffic air quality monitoring stations for $PM_{2.5}$. However, looking at $PM_{2.5}$ stations only gives a partial picture of the air quality status in different cities because air quality depends on a mixture of air pollutants, different sources (local and long-range transport) and macro- and micro-meteorology. The current product does not allow ranking all the European cities, as it is currently based on monitoring data. Therefore, a city is not featured in this EEA product if it does not have any urban or suburban background or traffic([2]) air quality stations that monitor $PM_{2.5}$. Furthermore, it is not included if not in the database of cities Urban Audit([3]).

This report proposes a new methodology for the European city viewer. The idea is to develop an indicator to communicate the mortality risk associated with pollutant exposure based on the definition of total attributable risk for cities across Europe. The indicator considers the three most relevant pollutants in terms of human exposure: $PM_{2.5}$ (considered in the current methodology), nitrogen dioxide (NO_2), and ozone (O_3) and aligns better with the current approach for estimating the environmental burden of disease (EBD) related to the exposure to these three pollutants (ETC HE, 2023a) produced by the European Environment Agency (EEA) and the European Topic Centre on Health and Environment (ETC HE), hereafter referred as EEA/ETC-HE EBD. The new methodology also suggests using the air quality maps created by the ETC HE (e.g., ETC/ATNI, 2022) instead of observations. These air quality maps have a spatial resolution of 1*1 km^2 (and might also be potentially downscaled to 100 m resolution), opening the possibility of including more cities, as the availability of observations does not constrain the proposed methodology. ETC/ATNI (2022) proposes using population-weighted concentrations for more consistent information on concentrations for all the cities. Using population-weighted concentrations also allows for evaluating the concentration that an average city's inhabitant is exposed to and not the average concentration for the whole city. Table 1.1 summarises the main features of the current and proposed methodology for ranking cities across Europe.

This report describes the methodology proposed, including the rationale behind the methodology and the needed input data, in Section 2. Section 0 provides the implementation of the methodology reproducing the same temporal description as the current EEA methodology (average of the two years 2019 and 2020), but also other configurations (individual years and average of three years) and a comparison between the current and the proposed methodology based on all the considered scenarios. The ranking of the cities based on the proposed methodology and considering the latest

([1]) https://www.eea.europa.eu/themes/air/urban-air-quality/european-city-air-quality-viewer
([2]) Nevertheless, if the city has only traffic stations, the concentrations are calculated but the city is not ranked
([3]) https://ec.europa.eu/eurostat/web/cities/spatial-units

validated (2021) and UTD (2022) data is presented in Section 4. The discussion and conclusions are presented in Section 5.

Table 1.1 An overview of the current and proposed methodology for the city ranking

	Current	Proposed
Pollutants	$PM_{2.5}$	$PM_{2.5}$, NO_2, O_3
Input data	Observations from background (urban or suburban) or traffic(4) air quality monitoring stations	Air Quality maps
Year	YY-2 (validated) and YY-1 (UTD)	YY-2, (validated) and YY-1 (interim)
Metric	Annual average concentration	Annual population-weighted concentration
Ranking	The highest ranked city = lowest $PM_{2.5}$ concentration	The highest ranked city = lowest total mortality risk associated to $PM_{2.5}$, NO_2 and O_3
Cities	Urban Audit 2020, constrained by the observation's requirement (344 cities)	Urban Audit 2020 (761 cities)

Notes: YY is the current year, and validated and up-to-date (UTD) data is the data submitted by the Member States to the EEA on a yearly and hourly basis, respectively. The validated and interim maps are the maps based on the validated and UTD data, respectively.

2 Constructing a new ranking methodology

2.1 Groundwork

To overcome the shortcomings of the AQIs based on individual pollutants, Cairncross et al. (2007) proposed and developed the first Canadian air quality health index, which is used to estimate the combined health effects of multiple air pollutants and evaluate air quality. Cairncross *et al*. (2007) suggested a so-called air pollution index (API) to communicate the total mortality risk associated with air pollution and evaluate air quality based on the definition of total attributable risk. The study also intended to include different health endpoints and have different exposure-response relationships as long as the effects are not "double-counted".

The API considers:

- Relevant pollutants and their ambient concentration averaging period.
- The availability of exposure-response relationships concerning the same health outcome (e.g., mortality) and exposure metric (e.g., annual mean) for the selected pollutants.
- Standardised data to establish a relative scale to determine the equivalence of harm for the selected pollutants for summing up the risk of individual pollutants.

In general terms, the risk of mortality or morbidity in a population due to exposure to air pollution is represented by the concentration-response function (CRF), which is based on Relative Risk (RR) estimates derived from epidemiological studies. The RR_i relates the concentration of pollutant i in ambient air to the mortality risk or other adverse health effects during a given time (exposure metric), and $(RR - 1)$ is defined as the total attributable risk. The RR_i in a population whose exposure is estimated by an average concentration C can be described as a log-linear function relating concentrations and mortality (Ostro, 2004; WHO, 2013), as specified below:

(4) Only to estimate the concentrations, not for ranking the city

$$RR_i = \exp\left[\,\beta\ \ (C - C_0)\,\right] \quad (1)$$

where *C* is the concentration level the population is exposed to, C_0 can either be the background concentration (i.e., the level that would exist without any human-made pollution), a concentration below which no health effects are expected, or a counterfactual concentration level, and β is based on the *CRF* and can be estimated as follows:

$$\beta = \frac{\ln(CRF)}{UC} \qquad (2)$$

where *UC* is the unit of concentration, and *CRF is* the increase in the risk of mortality of x % for a y μg/m^3 increase in concentration.

Assuming that the total attributable risk for multi-pollutant exposure is the sum of the attributable risk values due to exposure to individual pollutants (Eq. 3), Cairncross et al. (2007) defined the API as the sum of the sub-index for each pollutant to reflect the contribution of individual pollutants to the total risk (Eq. 4).

$$(RR - 1)_{Total} = \sum_{i=1}^{n}[(RR_i - 1)] \quad (3)$$

where $(RR - 1)_{Total}$ is the total attributable risk for multi-pollutant exposure, $(RR_i - 1)$ is the individual attributable risk value to exposure to pollutant *i*, and *n* is the number of individual pollutants included in the assessment.

$$API = \sum_i PSI_i \quad (4)$$

where PSI_i is the pollutant-specific index, that is, the contribution of individual pollutants to total risk, that can be estimated as follows:

$$PSI_i = a_i * \ ExposureMetric_i \quad (5)$$

where coefficient a_i is proportional to the attributable risk $(RR_i - 1)$, and $ExposureMetric_i$ is the time-based exposure metric defined for each pollutant, i.e. the concentration averaged over the period defined by the RR_i.

Cairncross et al. (2007) applied the methodology to six pollutants: particulate matter (PM_{10} and $PM_{2.5}$), sulphur dioxide (SO_2), O_3, NO_2, and carbon monoxide (CO). Eleven sub-indexes were defined based on the RR values and the corresponding concentrations for each pollutant to provide health messages associated with a certain risk for acute exposure (daily), see Table 2.1. The risk is defined as follows: low risk of increased mortality: 1.5-6.0 % (PSI_i 1-3), moderate risk of increased mortality: 6.1 -10.6 % (PSI_i 4-6), high risk of increased mortality: 10.7 -15.3 % (PSI_i 7-9) and very high risk of increased mortality: more than 15.3 % (PSI_i 10).

Table 2.1 Pollutant sub-indexes for the air pollution index system by Cairncross et al. (2007). The CRFs to estimate the relative risk (RRi) are based on the WHO (2001) for acute exposure

		Concentration corresponding to the relative risk value						
PSI_i	**RRi**	PM10, 24-h average (mgm3)	PM2.5, 24-h average (mgm3)	SO2, 24-h average (mgm3)	O3, 8-h maximum (mgm3)	O3, 1-h maximum (mgm3)	NO2, 1-h maximum (mgm3)	CO, 8-h rolling average (mgm3)
0	1	0	0	0	0	0	0	0
1	1.015	21	10	38	30	33	51	3.9
2	1.031	41	20	77	60	67	102	7.9
3	1.046	62	30	115	90	100	153	11.8
4	1.061	83	40	153	120	133	204	15.7
5	1.077	104	50	192	150	167	256	19.7
6	1.092	124	60	230	180	200	307	23.6
7	1.107	145	70	268	210	233	358	27.5
8	1.123	166	80	307	241	267	409	31.5
9	1.138	186	90	345	271	300	460	35.4
10	> 1.153	> 207	> 100	> 383	> 301	> 333	> 511	> 39.3

2.2 Methodology for ranking the cities across Europe based on their air quality levels

Here, we propose that the concept described in Cairncross et al. (2007) and briefly in Section 2.1 can be applied to ranking the cities while considering the same pollutants and risk functions for all-cause mortality- included in the EEA/ETC-HE EBD. Cairncross et al. (2007) methodology is adapted to rank the cities based on the population's exposure to three pollutants. This methodology is not an air quality index per se, although "index" and "subindexes" are terminologies used throughout this report. In this section, we describe the implementation of the methodology of Cairncross et al. (2007) to rank European cities considering $PM_{2.5}$, NO_2, and O_3.

2.2.1 Terminology and important considerations

Three concepts are important to be defined for the ranking methodology:

Pollutant sub-index (PSI): a number defining a pollutant-specific concentration level corresponding to a relative risk value. The PSI is estimated based on Eq. 5, using the current EEA/ETC-HE EBD methodology as a basis to define the risk and exposure. Exposure to individual pollutants with the same associated risk will be assigned the same PSI. This type of assignment offers an (arbitrary) scale that can be used to compare the different pollutants linearly to their risk. Taking the Cairncross et al. (2007) example shown in Table 2.1, the daily averages of PM_{10}, $PM_{2.5}$ and SO_2 of 21, 10, and 38 µg/m^3, respectively, correspond to a maximum 1.5 % increase in the risk of mortality. A PSI equal to 1 is attributed to such a level of increase.

- **Index:** a number estimated by summing the pollutant-specific risk indexes (PSIs) for the individual cities (equivalent to what is described as API (Eq. 4) in Cairncross et al. (2007).
- **Rank:** a number that rates the cities from best to worst in terms of risk of air quality exposure to human health. The top-ranked city has the lowest index, and the bottom-ranked city has the highest index. The overall ranking is assessed based on the ascending sorting of the index estimated for the individual cities.

It is important to consider the following for the current proposal:

- The **exposure** is based on the population-weighted concentration estimated using the ambient air concentration maps and population density as used in the EEA/ETC-HE EBD.

- The **risk** is associated with long-term exposure to $PM_{2.5}$ and NO_2 and short-term exposure to O_3 concentration levels. Thus, the same exposure-response relationships (CRF) and exposure metrics in EEA/ETC-HE EBD are used: annual average for $PM_{2.5}$ and NO_2 and SOMO35 for O_3. SOMO35 is the annual sum of daily maximum running 8-hour average concentrations above 35 ppb. However, we are aware that the short-term exposure to O_3 concentration levels is inadequate for estimating an equivalent rank between the individual pollutants. Here, the WHO (2021) recommendations for long-term exposure should have been used instead. However, the peak-season average of daily maximum 8-hour mean O_3 concentrations was not available for estimating the long-term risk associated with O_3, as it has not been used for the EEA/ETC-HE EBD. With this caveat in mind, we proceed with applying the methodology based on short-term CRF for O_3 to demonstrate its usability, bearing in mind that adding PSIs reflecting different temporal aggregations is incorrect, and this will be solved when applying the methodology for the calculations to be shown in the updated EEA's city viewer.

2.2.2 Concentration-response functions, counterfactual concentrations, and exposure

Table 2.2 describes the CRFs and counterfactual concentration levels used to assess mortality in the EEA/ETC-HE EBD (ETC HE, 2023a) and to estimate the PSIs based on Equations 1, 2, and 5 presented in Section 2.1. The CRFs and the counterfactual concentrations for $PM_{2.5}$ and NO_2 are based on the recommendations from the latest WHO Guidelines (WHO, 2021). The counterfactual concentrations are the same as the air quality guideline levels, which are the values established by the guidelines as the lowest concentration from which a «minimal relevant amount» of a health outcome will result from long-term exposure. For O_3, Table 2.2 shows the CRF for short- (acute) and long-term exposure, as recommended by the latest WHO Guidelines (2021). The short-term exposure to O_3 levels is estimated in the EEA/ETC-HE EBD, as the peak season is not yet systematically calculated in the ETC HE maps, but it is planned to be in production in 2024.

Table 2.2 Concentration-response functions (as RR) linking long-term exposure to PM2.5, NO2, and long- and short-term exposure to O3 and mortality and the counterfactual concentration level used for estimating mortality risk

Pollutant	RR per 10 µg/m³	Metric	C_0
$PM_{2.5}$	1.08	Annual average	5 µg/m³
NO_2	1.02	Annual average	10 µg/m³
O_3 (short-term)	1.0043	Annual sum of the daily maximum of the 8-hr moving average over 35 ppb	70 µg/m³
O_3 (long-term)	1.01	Peak-season average of daily maximum 8-hour mean concentrations	60 µg/m³

Note: Peak season is the six consecutive months of the year with the highest six-month running-average ozone concentration.

We make use of the population-weighted concentrations estimated based on air quality and population density maps. An evaluation of the mapping methodology at the city level and NUTS3 units (ETC/ATNI, 2022) shows that the population-weighted concentration represents the whole city adequately, albeit with some smoothing. The advantage of the population-weighted concentration is the consistency of information across the cities, especially for the ones without any measurement data available. However, using the maps to estimate the index is not advantageous for the ultramarine territories of France, Portugal, and Spain, as the maps do not cover these territories (EEA, 2021). With this in mind, we make use of the population-weighted concentration instead of concentrations for estimating the time-averaged concentration (C) needed in Eq. 1.

The population-weighted concentration is the average concentration-weighted with the population living in a 1x1 km^2 grid cell and is estimated as follows:

$$\hat{c} = \frac{\sum_{i=1}^{N} c_i p_i}{\sum_{i=1}^{N} p_i} \qquad (6)$$

where $\hat{c}$ is the population-weighted average concentration for $PM_{2.5}$ and NO_2, and SOMO35 for O_3 within city boundaries defined by the Urban Atlas 2020, p_i is the population in the i^{th} grid cell, c_i is the concentration in the i^{th} grid cell, and N is the number of grid cells in the city. The population data is based on the Geostat 2011 grid dataset (Eurostat, 2014).

The ETC HE produces air quality maps to assess the concentration levels the population is exposed to. The maps are a product of data fusion combining monitoring data from rural and urban background stations for $PM_{2.5}$, O_3, and NO_2 and urban traffic station data for NO_2 and $PM_{2.5}$, with results from the atmospheric transport models (namely EMEP or CAMS Ensemble Forecast) and other supplementary data, such as altitude, meteorology, and population density. The ETC HE Report 2023/3 (ETC HE, 2023) includes the analysis of the latest maps available, including the associated uncertainties. Both concentrations and population density data are mapped to the EEA reference grid with a resolution of 1*1 km^2. Note that the overseas territories such as Madeira, Azores, Canary Islands, French Guiana, Guadeloupe, Martinique, Mayotte, and Réunion are not included in the concentration maps and, therefore, excluded from the EEA/ETC-HE EBD and the city ranking calculations.

2.2.3 Define the pollutant-specific concentration level corresponding to a relative risk value (pollutant sub-index)

Like the example shown by Cairncross et al. (2007) in Table 2.1, here we propose that the lowest PSI be defined as zero and the highest be equivalent to the number of cities included in the ranking. The total number of cities is chosen to reduce the attribution of the same index to several cities. As in Cairncross et al. (2007), the lowest PSI (0) has an associated risk of 1, where it is assumed that there is no risk of mortality associated with $PM_{2.5}$, NO_2 or O_3 ambient concentrations, i.e., all concentrations are below the counterfactual concentration assumed for the estimation of RR (see Table 2.2). Here, we propose the highest PSI to be associated with the relative risk assessed based on the highest $PM_{2.5}$ population-weighted concentration estimated across the cities, i.e., the concentration level associated with the highest mortality.

The risk associated with the remaining levels of the index is incremental. The increment is estimated based on the maximum relative risk and the number of cities. The relative risk of mortality due to exposure to air pollution for each PSI, RR_{PSI}, is estimated as follows:

$$RR_{PSI} = 1 + \frac{RR_{maxPM_{2.5}} - 1}{number\ of\ cities} \times PSI \qquad (7)$$

where $RR_{maxPM_{2.5}}$ is the risk estimated for the highest $PM_{2.5}$ population-weighted concentration estimated across the cities, using Eq. 1 and 2, and *PSI* goes from 0 to the total number of cities included in the ranking.

The maximum concentration for an individual *pollutant p* associated with the RR_{PSI}, $C_{PSI,p}$, is determined as follows:

$$C_{PSI,p} = \frac{\ln(RR_{PSI}) + \beta C_0}{\beta} \quad (8)$$

where β is calculated for each pollutant *p* from Eq. 2, and C_0 is the counterfactual concentration for pollutant *p*. Both β *and* C_0 are estimated based on the parameters described in Table 2.2.

3 Implementation and sensitivity analysis

To test the implementation of the methodology described in Section 2, we consider the average population-weighted concentrations for the cities included in the EC's Urban Audit 2020. This single value is based on the spatially and temporally (if more than one year was considered) averaged population-weighted concentration for the grid cells within the city boundaries (also defined by the Urban Audit). The data is available for 761 cities. Different scenarios were considered for estimating the city ranking:

- The population-weighted concentrations for 2018, 2019, and 2020, individually, are used to assess the impact of year-to-year variation on the ranking.
- The population-weighted concentrations include 2019 and 2020 (2yr_avg). The values are averaged to reduce year-to-year variation. This estimation is the closest to the current methodology.
- The population-weighted concentrations include 2018, 2019, and 2020 (3yr_avg). The values are averaged to reduce year-to-year variation. This estimation is the closest to the estimation of the Average Exposure Indicator (AEI).
- The population-weighted concentrations for 2020, where the maps are based on a methodological adaptation proposed by the ETC/ATNI (2022) (2020a). This scenario assesses the impact of the smoothing effect of applying the kriging interpolation.

3.1 Example of implementation

In this section, we show an example of implementing the methodology, using the averaged population-weighted concentrations for 2019 and 2020 (2yr_avg) for ranking the cities, bearing in mind the caveat explained in Section 2.2.1 about the incorrect use of short-term exposure for O_3.

3.1.1 Steps to define the pollutant sub-indexes

Here, we outline six steps to define the PSIs, the respective (maximum) concentration levels, and the associated risk. The steps are described in Table 3.1, together with the outcome based on the 2yr_avg scenario. A subset of the PSIs and respective (maximum) concentration levels for $PM_{2.5}$, NO_2, and SOMO35 for O_3 and associated risk (with four decimals) is shown in Table 3.2 (see Table A1.1, Annex 1, for all the PSI values, with different decimal numbers for the associated risks and the concentrations).

Table 3.1 Steps to define the pollutant sub-index and the respective (maximum) concentration levels and associated risk

#	Steps	Outcome (based on the example)
1	Establish the maximum number of PSIs = the number of cities included in the assessment	761
2	Find the maximum population-weighted averaged concentration for $PM_{2.5}$ across all cities	26.42 µg/m3
3	Estimate the risk associated with the maximum population-weighted averaged concentration for $PM_{2.5}$ found in step 2 using Eq. 1 and 2, i.e., define RR_{PSI} for the highest PSI	RR_{761} = 1.1792 (RR_0 = 1)
4	List the PSIs for the assessment: from 0 to the number of cities	PSI ranges from 0 to 761 See Table 3.2, column 1
5	Define the RR levels for each PSI using Eq. 7	See Table 3.2, column 2
6	Estimate the concentration levels per pollutant corresponding to the relative risk value defined for each PSI using Eq. 8	See Table 3.2, column 3 for $PM_{2.5}$, column 4 for NO_2 and column 5 for O_3

Table 3.2 Subset of pollutant sub-index (PSI), associated risk (RR) and respective (maximum) concentration levels for $PM_{2.5}$, NO_2, and SOMO35 for O_3, based on the mean of the population-weighted concentration for 2019 and 2020

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
0	1.0000	5.00	10.00	70.00
1	1.0002	5.03	10.12	70.24
2	1.0005	5.06	10.24	70.47
3	1.0007	5.09	10.36	70.71
4	1.0009	5.12	10.48	70.95
5	1.0012	5.15	10.59	71.18
6	1.0014	5.18	10.71	71.42
7	1.0016	5.21	10.83	71.66
8	1.0019	5.24	10.95	71.89
9	1.0021	5.28	11.07	72.13
10	1.0024	5.31	11.19	72.36
...	...	...	...	...
752	1.1771	26.18	92.33	233.86
753	1.1773	26.21	92.43	234.06
754	1.1776	26.24	92.54	234.26
755	1.1778	26.26	92.64	234.46
756	1.1780	26.29	92.74	234.66
757	1.1783	26.31	92.84	234.86
758	1.1785	26.34	92.94	235.06
759	1.1787	26.37	93.04	235.26
760	1.1790	26.39	93.14	235.46
761	1.1792	26.42	93.24	235.66

3.1.2 Estimate the ranking of the cities based on the population-weighted concentrations.

The final index value will be the sum of the pollutant-specific PSIs, and the cities will be ranked according to the decreasing attributed index. However, since some cities may have the same index value, the final ranking for those cities will be decided depending on the PSIs for the individual pollutants. Out of the cities with the same index values, the city with the lowest PSI for $PM_{2.5}$ will be ranked higher. If the cities still have the same PSI for $PM_{2.5}$, the city with the lowest PSI for NO_2 will be ranked higher, and if both PSI for $PM_{2.5}$ and NO_2 are the same, the city with the lowest for O3 will be ranked higher.

Table 3.3 shows a subset of the ranking of the cities based on the risk of mortality related to $PM_{2.5,}$ $NO_{2,}$ and O_3 pollution levels estimated based on the 2yr_avg scenario. The table shows the population-weighted concentrations for $PM_{2.5,}$ $NO_{2,}$ and O_3 (columns 3 to 5, respectively), the pollutant-specific PSIs (columns 6 to 8 for $PM_{2.5,}$ $NO_{2,}$ O_3, respectively), the index (column 9), and the rank (column 10). The full table is presented in Annex 1, Table A1.2.

Table 3.3 A subset of the ranking based on the mean of the population-weighted concentration for PM2.5, NO2, and O3 for 2019 and 2020 (PSI)

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
FI	Oulu	4.74	6.71	73.51	0	0	15	15	1
SE	Umeå	3.24	4.51	74.27	0	0	19	19	2
FI	Kuopio	4.43	6.90	74.55	0	0	20	20	3
FI	Tampere	4.86	9.65	75.23	0	0	23	23	4
NO	Tromsø	4.63	6.73	75.61	0	0	24	24	5
IS	Reykjavík	4.68	10.74	73.90	0	7	17	24	6
FI	Jyväskylä	5.09	7.48	74.71	4	0	20	24	7
SE	Uppsala	4.65	7.06	76.35	0	0	27	27	8
SE	Örebro	4.23	7.29	76.90	0	0	30	30	9
SE	Västerås	4.46	8.70	76.98	0	0	30	30	10
SE	Norrköping	4.81	9.04	77.50	0	0	32	32	11
FI	Lahti	5.25	8.47	75.28	9	0	23	32	12
SE	Linköping	4.89	8.50	77.69	0	0	33	33	13
SE	Södertälje	4.30	7.60	77.72	0	0	33	33	14
SE	Stockholm	5.20	9.89	76.77	7	0	29	36	15
...	...	...	...	...	...	...	...	...	...
BG	Sofia	22.89	26.76	76.62	627	144	29	800	747
PL	Ruda ÅšlÄska	23.67	20.90	81.60	657	93	50	800	748
PL	Bytom	24.09	21.57	81.72	673	99	50	822	749
PL	Katowice	24.34	22.66	81.29	682	108	48	838	750
PL	Sosnowiec	24.37	22.67	81.05	683	108	47	838	751
IT	Padova	22.62	27.18	88.46	617	147	79	843	752
PL	Chorzów	24.26	23.61	81.61	679	117	50	846	753
IT	Cremona	22.98	24.68	91.10	631	126	91	848	754
IT	Monza	20.61	36.96	91.31	542	233	92	867	755
HR	Slavonski Brod	26.42	16.31	83.64	761	54	59	874	756
IT	Milano	20.72	39.50	90.77	547	256	89	892	757
IT	Vicenza	24.16	25.93	89.37	675	137	83	895	758
IT	Torino	22.42	33.71	89.73	610	205	85	900	759
PL	Kraków	25.94	24.25	80.54	743	122	45	910	760
IT	Brescia	24.07	29.29	91.16	672	166	91	929	761

Note: The table shows the country's ISO code, city name, population-weighted concentration for the three pollutants, the associated PSI, the total index, and the ranking.

To explain in detail the establishment of the ranking, we take Oulu, a city in Finland, as an example. Oulu's index is 15, with individual pollutant-specific PSI for $PM_{2.5}$, NO_2, and O_3 being 0, 0 and 15, respectively. The PSIs and the index were estimated as follows:

- The $PM_{2.5}$ population-weighted concentration is 4.74 µg/m^3, below the maximum concentration attributed to PSI = 0 (5 µg /m^3, see Table 3.2). Hence, Oulu's PSI for $PM_{2.5}$ is 0.
- The NO_2 population-weighted concentration is 6.71 µg/m^3, below the maximum concentration for PSI = 0 (10 µg/m^3, see Table 3.2). Thus, Oulu's PSI for NO_2 is 0.
- The O_3 population-weighted concentration is 73.51 µg/m^3.day , below the maximum concentration for PSI = 15 (73.54 µg/m^3.day, see Table A1.1, Annex 1). Thus, Oulu's PSI for O_3 is 15.
- The index is the sum of the three pollutant-specific PSIs, hence the index being 15.

- Oulu has the lowest sum of the pollutant-specific PSIs and thus is ranked at the top.

In the case of cities with the same index, such as Reykjavík and Jyväskylä, Reykjavík has been ranked higher because the PSI for $PM_{2.5}$ is lower for Reykjavík.

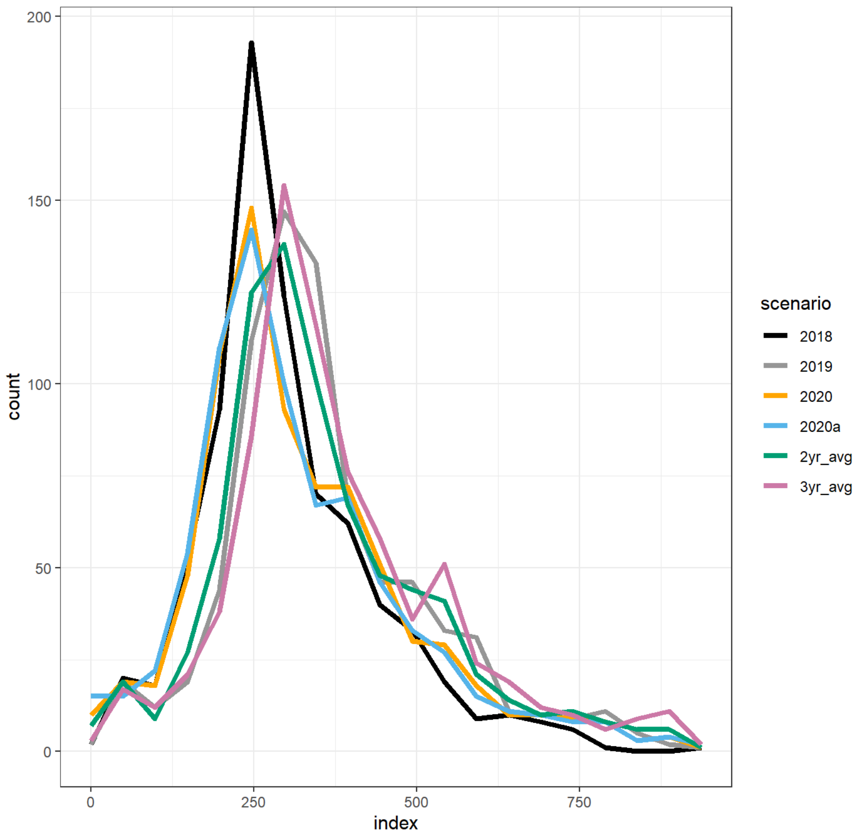
3.2 Sensitivity analysis

The cities were ranked based on the scenarios described above. Figure 3.1 shows the frequency distribution of the index values based on different individual years (2018, 2019, 2020, 2020a) and the average of two (2019 and 2020) and three years (2018, 2019 and 2020). The index is distributed equally over 20 bins.

These results show how sensitive the estimation is to the baseline data. On the one hand, it shows that at least 55% of the cities are indexed with values between 200 and 500, independently of the scenario chosen. This represents a population-weighted concentration of 13.05 ± 5.59 µg m^3, 20.86 ± 11.96 µg/m^3, and 83.45 ± 9.84 µg/m^3.day, for $PM_{2.5}$, NO_2, and O_3, respectively. It is in this range that the index changes the most scenario-wise. On the other hand, Figure 3.1 shows the differences between the scenarios, particularly if the index is based on individual years or averaged values for two or three years, reflecting on the final ranking of the cities. The difference between the index based on individual years is expected due to the interannual variability in air quality. From this evaluation, the mapping using an extra step to reduce smoothing, as described and analysed in Annex 2(2020a scenario), does not result in substantial differences from the original data (2020 scenario) in terms of index values, as the distribution looks very similar. However, this step does seem to change the final ranking substantially for some cities, as shown in the following demonstration.

With this simple exercise, it is possible to say that averaging can be beneficial to avoid outliers related to meteorology, particularly for the top and bottom-ranked cities. There will be less fluctuation in the ranking when considering more than one year.

Figure 3.1 Frequency distribution of the index values based on different years



To further demonstrate the index's variability depending on the baseline data, we take the 50 cities ranked at the top and the bottom based on the 2yr_scenario and compare their rankings based on the possible scenarios. Figure 3.2 and Figure 3.3 show the ranking of the top and bottom 50, respectively.

Both figures show once again that using individual years would increase the year-to-year variability of the ranking. However, it is for the bottom 50 that the spread of the index values for individual years is the largest. A city such as Brescia can see its index value ranging from 668 to 896, or 912 if the extra step to assess the population-averaged concentration is applied (2020a). Figure A1.1 in Annex 1 shows the results for all the cities, following the same format as Figure 3.2 and Figure 3.3. The results clearly show a larger spread on the attributed index values for individual years, as expected.

Figure 3.2 Index values for the top 50 ranked cities considering different scenarios. A higher index value corresponds to a more harmful air quality to human health

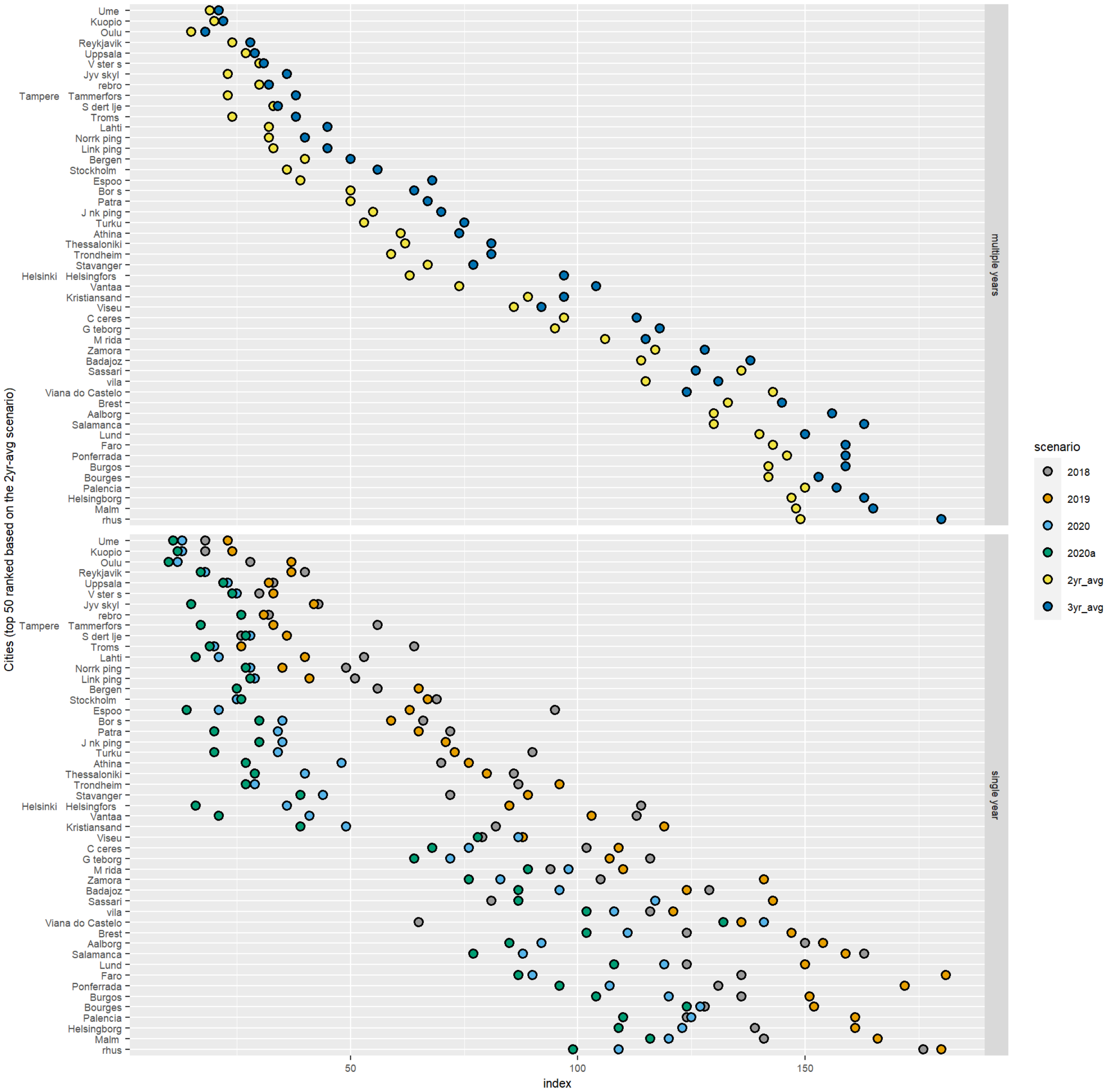
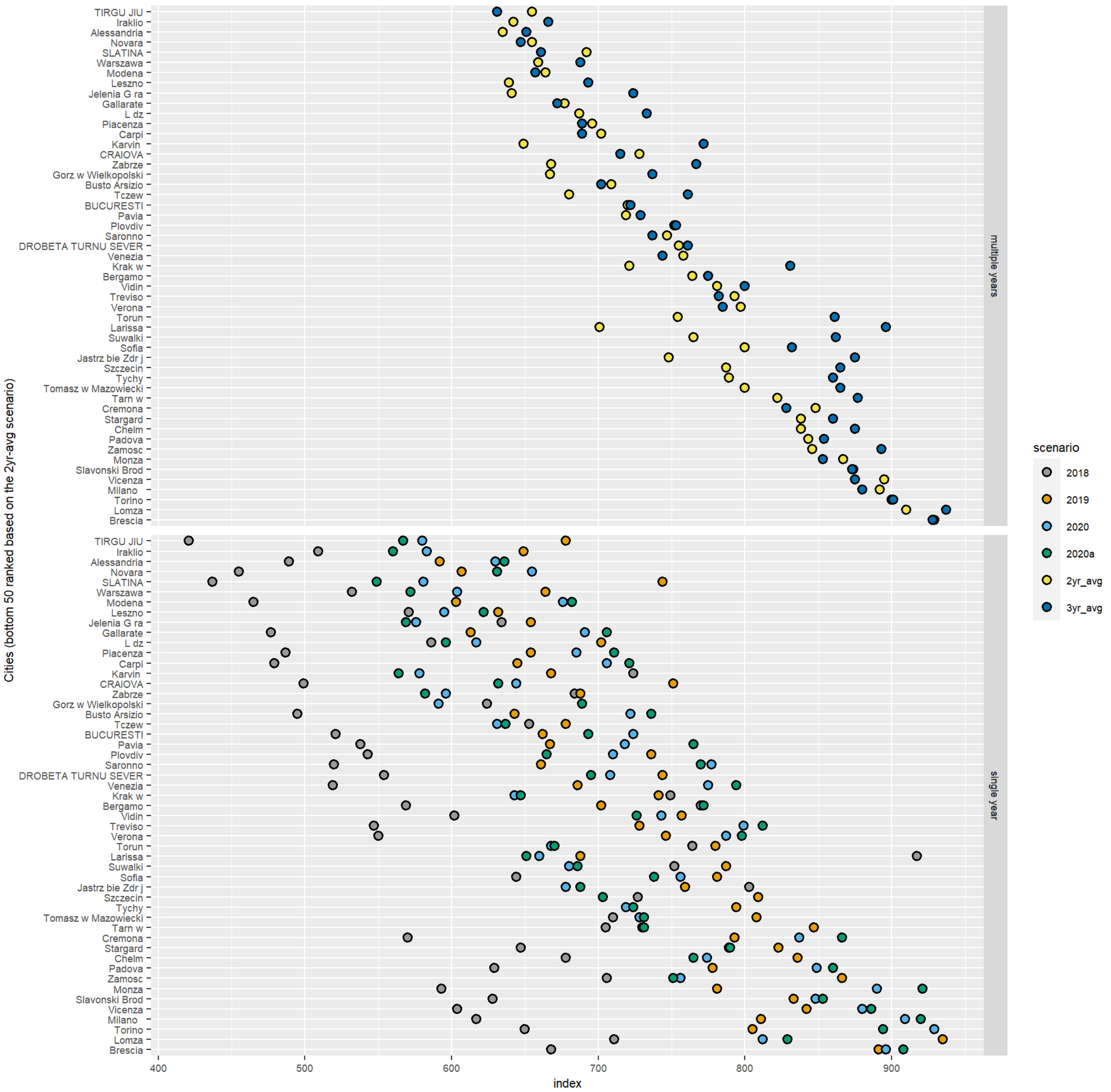


Figure 3.3 Index for the bottom 50 ranked cities considering different scenarios. A higher index corresponds to a more harmful air quality to human health



3.3 Comparison with the current EEA methodology

This section compares the ranking based on the current and proposed methodology. The ranking presented in the EEA viewer([5]) is based on $PM_{2.5}$ observations reported by the Member States via e-Reporting: validated data for 2019 and UTD data for 2020. In contrast with the proposed methodology, only 344 cities across Europe are included. The current EEA viewer presents cities as defined by the European Commission's Urban Audit 2020([6]). In order to be ranked, the cities must have $PM_{2.5}$ data from urban or suburban background monitoring stations.

Only the cities available in the current EEA methodology were selected for the analysis to make the comparison analogous, i.e., 344 cities. These cities were then "re-ranked" from 1 to 344, according to the order they were ranked based on the proposed methodology. Figure 3.4 and Figure 3.5 show the ranking of 100 cities based on the current EEA ranking and based on the proposed methodology considering all the scenarios available. The 100 cities correspond to the top 50 and the bottom 50 cities based on the current EEA ranking of the cities. The full comparison can be found in Table A1.3 in Annex 1. Note that the ranking based on the proposed methodology does not include six of the 344 cities, as seen on the top of the y-axis of Figure 3.4. As mentioned before, cities in French, Portuguese and Spanish overseas territories are not included because they fall outside EEA mapping boundaries (EEA, 2021).

The Figures show how much the current ranking presented at the EEA viewer would change if the new methodology was applied. It seems that the smallest change would be for cities at the very top or the very bottom of the ranking. For the cities at the very top of the ranking, this is because the levels of air pollution are relatively low, independent of the pollutants, and the $PM_{2.5}$ air pollution level is still the driving factor for the low-ranked cities. The figures also show that some cities radically changed their ranking when considering pollutants other than $PM_{2.5}$. Good examples of this change are Stavanger (NO), Faro (PT), and Pau (FR) (Figure 3.4). Faro has high O_3 levels, and Stavanger has relatively low levels of O_3, but both have low NO_2 concentrations. In the case of Pau, there are high levels of NO_2.

([5]) https://www.eea.europa.eu/themes/air/urban-air-quality/european-city-air-quality-viewer

([6]) https://ec.europa.eu/eurostat/web/cities/spatial-units

Figure 3.4 Ranking of the top 50 cities (based on the EEA's current ranking) based on the current and proposed methodology. The highest ranking corresponds to the city with the least harmful air quality to human health. The top panel includes the rank for the current EEA methodology (EEArank) and the rank based on the proposed methodology using two (2yr_avg) and three (3yr_avg) years average; the bottom panel includes the rank based on the proposed methodology using data for a single year

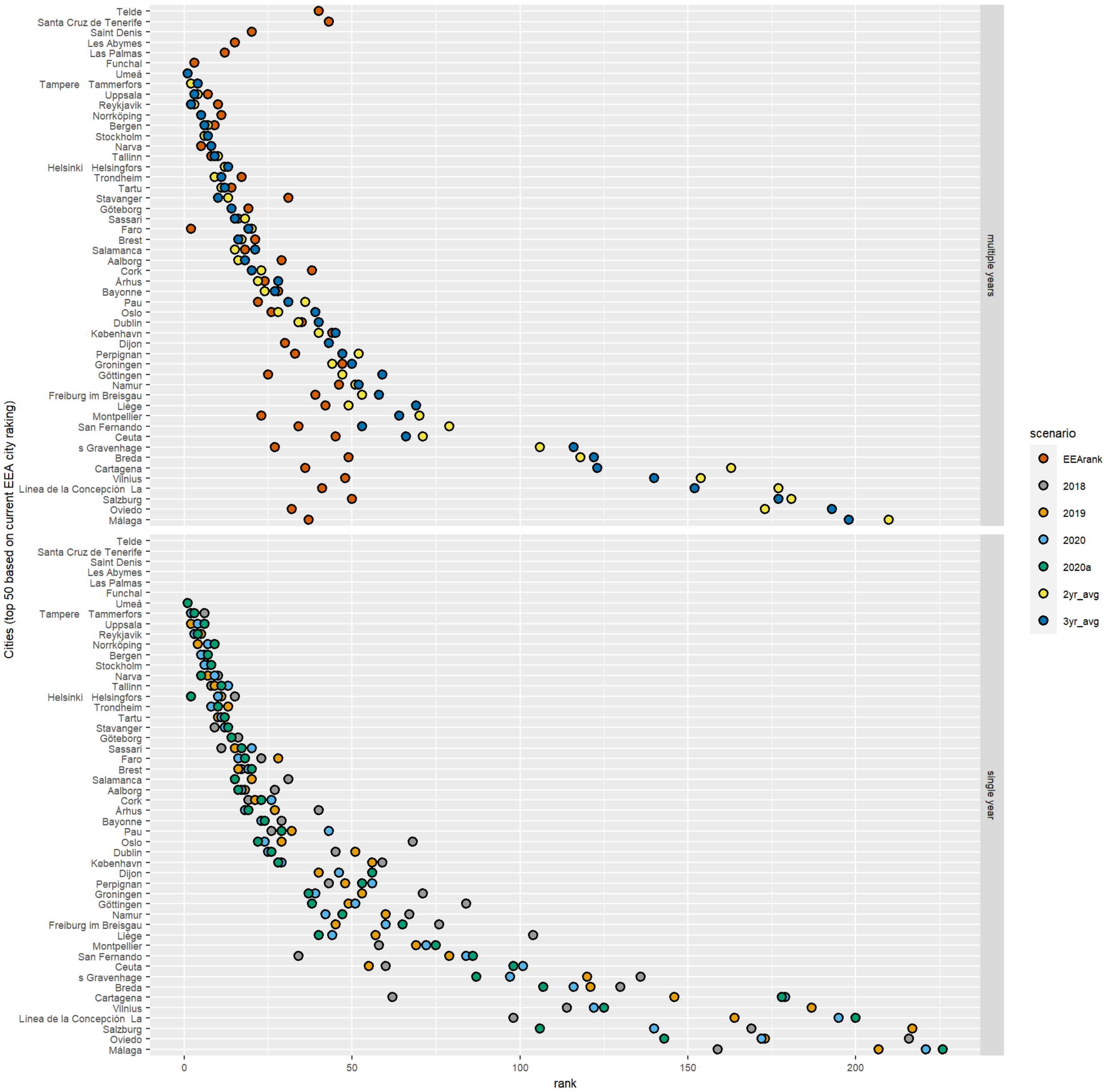
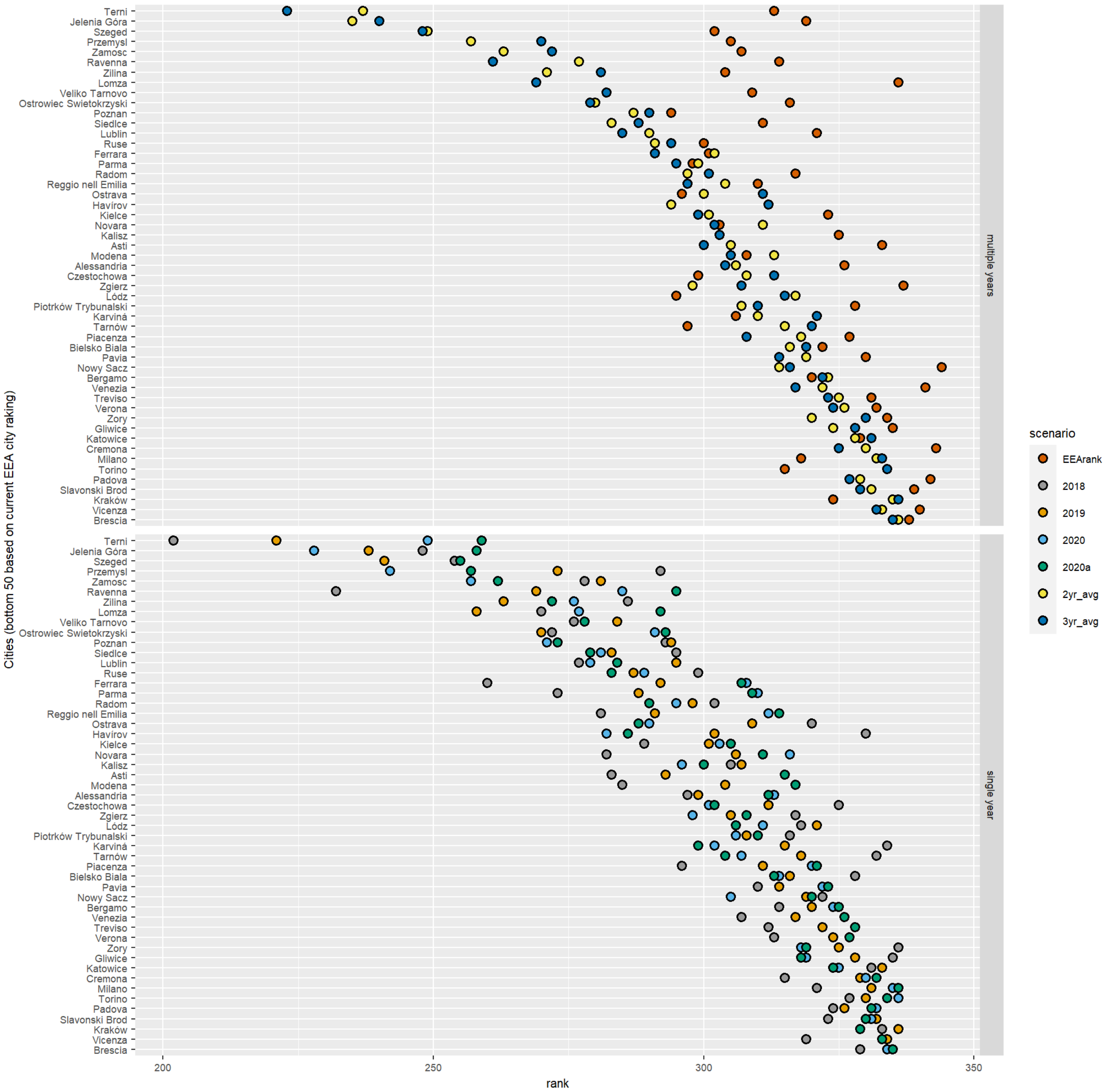


Figure 3.5 Ranking of the bottom 50 cities (based on the EEA's current ranking) based on the current and proposed methodology. The lowest ranking corresponds to the city with the most harmful air quality to human health. The top panel includes the rank for the current EEA methodology (EEArank) and the rank based on the proposed methodology using two (2yr_avg) and three (3yr_avg) years average; the bottom panel includes the rank based on the proposed methodology using data for a single year



4 Ranking of cities based on the latest maps available (2021 validated and 2022 UTD data).

Maps produced based on validated data for 2021 and UTD data for 2022 were used to estimate the latest ranking of the cities across Europe based on the methodology proposed here (since those were the most updated validated data available in the EEA e-reporting database). The population-weighted concentrations for the cities in 2021 and 2022 were estimated and averaged over the two years.

The ranking of the cities was done following the same steps as presented in Section 3.1.1. Table 4.1. and Table 4.2 show a subset of the PSIs, RRs and respective maximum levels of concentration used to rank the cities (Table 4.1) and the 15 top- and 15 bottom-ranked cities (Table 4.2). The correspondent rank based on the 2019 and 2020 average of the population-weighted average is added in Table 4.2 for the sake of comparison and to assess how much the ranking changes depending on the period analysed. See Table A1.4 for all the PSI values, with different decimal numbers for the associated risks and the concentrations, and A1.5 for the full ranking in Annex 1.

Table 4.1 Subset of pollutant sub-index (PSI), associated risk (RR) and respective (maximum) concentration levels for $PM_{2.5}$, NO_2, and SOMO35 for O_3, based on the mean of the population-weighted concentration for 2021 and 2022

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
0	1.0000	5.00	10.00	70.00
1	1.0002	5.03	10.11	70.23
2	1.0005	5.06	10.23	70.45
3	1.0007	5.09	10.34	70.68
4	1.0009	5.12	10.46	70.91
5	1.0011	5.15	10.57	71.13
6	1.0014	5.18	10.68	71.36
7	1.0016	5.21	10.80	71.59
8	1.0018	5.23	10.91	71.81
9	1.0020	5.26	11.03	72.04
10	1.0023	5.29	11.14	72.27
…	…	…	…	…
751	1.1696	25.35	89.10	227.41
752	1.1698	25.38	89.19	227.61
753	1.1700	25.40	89.29	227.80
754	1.1702	25.43	89.39	227.99
755	1.1705	25.45	89.49	228.19
756	1.1707	25.48	89.58	228.38
757	1.1709	25.50	89.68	228.58
758	1.1711	25.53	89.78	228.77
759	1.1714	25.55	89.88	228.96
760	1.1716	25.58	89.97	229.16
761	1.1718	25.60	90.07	229.35

Table 4.2 A subset of the ranking based on the 2021 and 2022 mean of the population-weighted concentration for PM2.5, NO2, and O3, including the respective pollutant-specific index (PSI), the index, the rank based on the 2021 and 2022 mean of the population-weighted concentration, and the rank based on 2019 and 2020

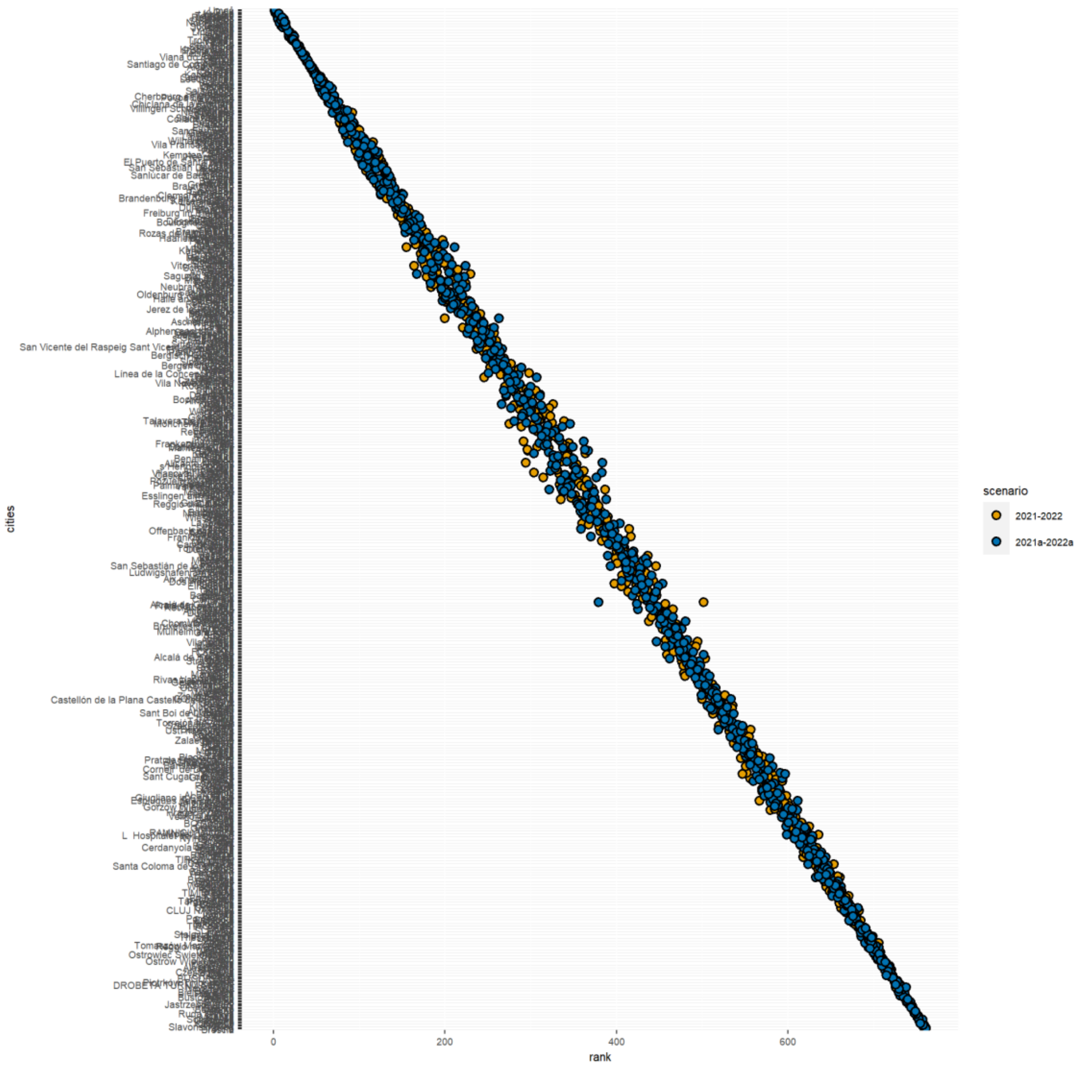
		2021-2022								2019-2020
Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	PSI $PM_{2.5}$	PSI NO_2	PSI O_3	index	rank	rank
SE	Umeå	3.81	3.6	73.43	0	0	16	16	1	2
FI	Kuopio	4.42	7.02	74.22	0	0	19	19	2	3
FI	Oulu	5.19	6.24	73.03	7	0	14	21	3	1
SE	Uppsala	4.58	6.49	75.02	0	0	23	23	4	8
SE	Västerås	4.74	7.77	75.12	0	0	23	23	5	10
IS	Reykjavík	4.38	8.24	75.36	0	0	24	24	6	6
FI	Tampere	4.86	10.48	74.48	0	5	20	25	7	4
SE	Norrköping	4.92	6.82	75.66	0	0	26	26	8	11
SE	Södertälje	4.49	7.12	75.93	0	0	27	27	9	14
SE	Stockholm	5.11	9.38	75.12	4	0	23	27	10	15
SE	Örebro	5.19	6.45	74.66	7	0	21	28	11	9
FI	Espoo	5.3	8.49	74.37	11	0	20	31	12	17
FI	Jyväskylä	5.33	7.75	74.52	12	0	20	32	13	7
FI	Lahti	5.3	8.5	74.93	11	0	22	33	14	12
NO	Tromsø	5.33	6.42	75.5	12	0	25	37	15	5
...	...	...	...	...	...	...	...	...		...
IT	Verona	20.42	23.82	93.69	559	123	106	788	747	746
PL	M. Tychy	22.73	20.18	82.18	648	91	54	793	748	744
PL	M. Ruda Śląska	22.88	19.85	82.08	654	88	54	796	749	748
PL	M. Bytom	22.93	20.51	82.1	656	94	54	804	750	749
IT	Monza	19.08	32.52	94.19	508	203	108	819	751	755

Country (ISO2 code)	City	2021-2022 $PM_{2.5}$	NO_2	O_3	PSI $PM_{2.5}$	PSI NO_2	PSI O_3	index	rank	2019-2020 rank
IT	Vicenza	21.23	23.87	93.33	590	124	105	819	752	758
IT	Cremona	21.82	22.34	91.9	613	110	98	821	753	754
PL	M. Sosnowiec	23.53	21.34	81.23	679	101	50	830	754	751
IT	Milano	19.34	34.21	92.82	517	218	102	837	755	757
PL	M. Chorzów	23.49	22.16	81.97	678	108	54	840	756	753
PL	M. Katowice	23.72	21.43	81.93	687	102	53	842	757	750
HR	Slavonski Brod	25.6	15.14	84.44	761	46	65	872	758	756
PL	M. Kraków	24.62	22.64	81.28	722	113	50	885	759	760
IT	Brescia	22.21	27.16	94.95	628	154	112	894	760	761
IT	Torino	21.99	31.1	95.38	619	189	114	922	761	759

The 2021 and 2022 mapping have also been recalculated by applying an extra step to the RIMM output to reduce the smoothing effect inherent in the original methodology. Figure 4.1 shows the ranking considering the values from the mapping resulting from the RIMM with no extra step to reduce smoothing (2021-2022) and with the extra step (2021a-2022a) for all the cities, see Table A1.5, in Annex 1, for the complete ranking. The Figure shows that the implementation of an extra step to reduce the smoothing impacts the outcome of the ranking. The outcome changes less for the top and bottom 50 cities but can make a big difference for cities between the top and bottom 50. Some changes can be as large as increasing 90 positions for Alicante in Spain and dropping 123 positions for Ełk in Poland, see Table A1.4, in Annex 1.

Annex 2 describes the mapping methodology and compares the two estimations. The analysis indicates that the adapted mapping method (i.e., with the extra step) reduces the smoothing effect of the map results and improves the agreement of the population-weighted concentration with the averages of the concentration values measured at the stations. The uncertainty of the whole map is slightly poorer in the adapted method compared to the current one. However, the benefits justify this adaptation to the original mapping methodology. Note that the comparison in areas further from the measurement stations is limited.

Figure 4.1 Ranking of all cities based on the 2021 and 2022 mean of the population-weighted concentration for $PM_{2.5}$, NO_2, and O_3, with (2021a-2022a) and without (2021-2020) extra step. The highest ranking corresponds to the city with the least harmful air quality to human health



5 Discussion and conclusions

The proposed methodology brings together a panoply of information into a system capable of communicating as simply and as accurately as possible the health risks associated with a given level of exposure to multiple pollutants in a given city. Estimating an air pollution ranking based on exposure metrics has the advantage of self-consistency, i.e., a subindex value for any pollutant included in the ranking reflects the same increment in relative risk. This methodology is a compromise between simplicity and accuracy, where we need to acknowledge several uncertainties inherent to these estimations, such as the one related to the air quality mapping and the population concentration-response functions.

The proposed methodology is a promising way to rank European cities better based on their air quality levels compared to the current EEA methodology. A methodology based on spatially continuous air quality maps instead of point-based observations allows broader coverage of the European territory, albeit missing the overseas territories of France, Portugal, and Spain. Using population-weighted concentration also seems to allow consistency in estimating the risk across the cities, and concentrations will reflect the concentration to which an average city's inhabitant is exposed. Moreover, using the risk approach allows ranking the cities based on air pollutant levels for three different pollutants instead of the current methodology that only considers $PM_{2.5}$ levels independently of the ambient NO_2 or O_3 concentration levels. On the use of individual years or an average of two or three years, the analysis shows that the use of average years will result in less fluctuation year by year in the ranking. In the proposed methodology, the extra step in the mapping of the urban background areas is included, which reduces the smoothing effect of the map results and improves the agreement of the population-weighted concentration with the values measured at the stations (albeit slightly higher mapping uncertainty in areas outside the measurement stations). Adding an extra step to reduce smoothing from the data fusion regression method to estimate the final maps may not add a significant change for the top and bottom-ranked stations. Still, it may substantially change how the cities in the middle of the raking are positioned.

Finally, there is a significant caveat to be considered in the current report: the ranking is based on different temporal exposures, short-term exposure for O_3 and long-term exposure for NO_2 and $PM_{2.5}$. The rank must be calculated based on concentration-response functions representing the same temporal description for summing the risk associated with the three individual pollutants. The comparison between EEA's current methodology and the one proposed in this report and presented in Annex 1 will be modified once the long-term exposure for O_3 can be estimated.

References

Cairncross, E., John, J., Zunckel, M., 2007, *A novel air pollution index based on the relative risk of daily mortality associated with short-term exposure to common air pollutants*, Atmospheric Environment, 41, 38, 8442-8454, https://doi.org/10.1016/j.atmosenv.2007.07.003.

EEA, 2021, *Guide for EEA map layout. EEa Operational Guidelines*, https://www.eionet.europa.eu/workspace/docs/eea-layout-guide-for-map-production-eea-gis-guide.pdf accessed June 8th 2023

ETC/HE, 2022, *Health Risk Assessment of Air Pollution and the Impact of the New WHO Guidelines*, ETC HE Report 2022/10, European Topic Centre on Human Health and Environment, Kjeller.

ETC/HE, 2022b, *European-wide city level air quality mapping. Evaluation of the current mapping methodology with respect to the level of cities and NUTS3 units and suggestions for future*, ETC/ATNI Report 20/2021, European Topic Centre on Air Pollution, transport, noise and industrial pollution, Kjeller, ISBN 978-82-93752-50-9

ETC/HE, 2023a, *Air quality maps of EEA member and cooperating countries for 2021 — PM10, PM2.5, ozone, NO2, NOx and benzo(a)pyrene spatial estimates and their uncertainties*, ETC/HE Report 2023/3, European Topic Centre on Human Health and Environment, Kjeller.

ETC/ATNI, 2022, *European-wide city level air quality mapping. Evaluation of the current mapping methodology with respect to the level of cities and NUTS3 units and suggestions for future*, ETC/ATNI Report 20/2021, European Topic Centre on Air Pollution, transport, noise and industrial pollution, Kjeller, ISBN 978-82-93752-50-9

Ostro, B., 2004, *Outdoor air pollution: Assessing the environmental burden of disease at national and local levels*, WHO Environmental Burden of Disease Series no. 5, Geneva, World Health Organization.

Plaia, A.; Ruggieri, M, 2011, *Air quality indices: A review*. Rev. Environ. Sci. Bio/Technol., 10, 165–179.

Stieb, D.M., Burnett, R.T., Smith-Doiron, M., Brion, O., Shin, H.H., Economou, V., 2008, *A new multipollutant, no-threshold air quality health index based on short-term associations observed in daily time-series analyses*, J. Air Waste Manag. Assoc. 58, 435–450.

WHO, 2021, *WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide: executive summary*. World Health Organisation, Geneva

WHO, 2013, *Health risks of air pollution in Europe – EBDPIE project Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*, World Health Organization, Regional Office for Europe, Copenhagen.

WHO, 2001, *Health impact assessment of air pollution in the WHO European Region. World Health Organization*, Regional Office for Europe, Copenhagen.

List of abbreviations

Abbreviation	Name	Reference
AQG	Air quality guidelines	
BoD	burden of disease	
CI	Confidence interval	
CRF	Concentration response function	
EEA	European Environment Agency	www.eea.europa.eu
ETC/ATNI	European Topic Centre on Air pollution, Transport, Noise and Industrial pollution	
ETC HE	European Topic Centre on Human Health and the Environment	
m^3	Cubic meter	
NO_2	Nitrogen dioxide	
O_3	Ozone	
$PM_{2.5}$	Fine particulate matter (diameter below 2.5 µm)	
ppb	Parts per billion	
RR	Relative risk	
SOMO35	annual sum of daily maximum running 8-h average concentrations above 35 ppb	
WHO	World Health Organization	www.who.int
µg	Microgram	

Annex 1 Ranking based on the current EEA and proposed methodology

Table A1.1 Pollutant sub-index (PSI), associated risk (RR) and respective (maximum) concentration levels for $PM_{2.5}$, NO_2, and SOMO35 for O_3 based on population-weighted concentrations for 2019 and 2020

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
0	1	5	10	70
1	1.000235	5.030594	10.1189	70.23663
2	1.000471	5.061182	10.23778	70.47321
3	1.000706	5.091762	10.35662	70.70973
4	1.000942	5.122335	10.47544	70.9462
5	1.001177	5.1529	10.59423	71.18261
6	1.001413	5.183459	10.713	71.41897
7	1.001648	5.21401	10.83173	71.65527
8	1.001884	5.244554	10.95044	71.89151
9	1.002119	5.275091	11.06912	72.1277
10	1.002355	5.305621	11.18777	72.36383
11	1.00259	5.336144	11.30639	72.59991
12	1.002826	5.366659	11.42499	72.83593
13	1.003061	5.397167	11.54355	73.0719
14	1.003297	5.427668	11.66209	73.30781
15	1.003532	5.458162	11.7806	73.54367
16	1.003768	5.488649	11.89909	73.77947
17	1.004003	5.519129	12.01755	74.01521
18	1.004239	5.549601	12.13597	74.2509
19	1.004474	5.580067	12.25437	74.48654
20	1.00471	5.610525	12.37275	74.72212
21	1.004945	5.640976	12.49109	74.95764
22	1.005181	5.67142	12.60941	75.19311
23	1.005416	5.701857	12.7277	75.42853
24	1.005652	5.732286	12.84596	75.66388
25	1.005887	5.762709	12.9642	75.89919
26	1.006123	5.793124	13.0824	76.13444
27	1.006358	5.823533	13.20058	76.36963
28	1.006594	5.853934	13.31873	76.60477
29	1.006829	5.884328	13.43686	76.83985
30	1.007065	5.914715	13.55495	77.07488
31	1.0073	5.945095	13.67302	77.30986
32	1.007536	5.975468	13.79106	77.54477
33	1.007771	6.005833	13.90908	77.77964
34	1.008007	6.036192	14.02706	78.01445
35	1.008242	6.066543	14.14502	78.2492
36	1.008477	6.096888	14.26295	78.4839
37	1.008713	6.127225	14.38085	78.71855
38	1.008948	6.157555	14.49873	78.95314
39	1.009184	6.187878	14.61658	79.18767

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
40	1.009419	6.218195	14.7344	79.42215
41	1.009655	6.248504	14.85219	79.65658
42	1.00989	6.278805	14.96996	79.89095
43	1.010126	6.3091	15.08769	80.12526
44	1.010361	6.339388	15.20541	80.35953
45	1.010597	6.369669	15.32309	80.59373
46	1.010832	6.399943	15.44074	80.82789
47	1.011068	6.430209	15.55837	81.06198
48	1.011303	6.460469	15.67597	81.29603
49	1.011539	6.490721	15.79355	81.53002
50	1.011774	6.520967	15.91109	81.76395
51	1.01201	6.551205	16.02861	81.99783
52	1.012245	6.581437	16.14611	82.23166
53	1.012481	6.611661	16.26357	82.46543
54	1.012716	6.641879	16.38101	82.69914
55	1.012952	6.672089	16.49842	82.93281
56	1.013187	6.702292	16.6158	83.16642
57	1.013423	6.732489	16.73315	83.39997
58	1.013658	6.762678	16.85048	83.63347
59	1.013894	6.79286	16.96778	83.86691
60	1.014129	6.823036	17.08506	84.10031
61	1.014365	6.853204	17.2023	84.33364
62	1.0146	6.883365	17.31952	84.56693
63	1.014836	6.913519	17.43671	84.80015
64	1.015071	6.943667	17.55388	85.03333
65	1.015307	6.973807	17.67101	85.26645
66	1.015542	7.00394	17.78812	85.49952
67	1.015778	7.034066	17.90521	85.73253
68	1.016013	7.064186	18.02226	85.96549
69	1.016249	7.094298	18.13929	86.19839
70	1.016484	7.124403	18.25629	86.43124
71	1.01672	7.154502	18.37327	86.66404
72	1.016955	7.184593	18.49022	86.89678
73	1.01719	7.214678	18.60714	87.12947
74	1.017426	7.244755	18.72403	87.36211
75	1.017661	7.274826	18.8409	87.59469
76	1.017897	7.304889	18.95773	87.82721
77	1.018132	7.334946	19.07455	88.05969
78	1.018368	7.364996	19.19133	88.29211
79	1.018603	7.395038	19.30809	88.52447
80	1.018839	7.425074	19.42482	88.75679
81	1.019074	7.455103	19.54153	88.98904
82	1.01931	7.485125	19.6582	89.22125
83	1.019545	7.51514	19.77485	89.4534

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
84	1.019781	7.545148	19.89148	89.6855
85	1.020016	7.575149	20.00807	89.91754
86	1.020252	7.605143	20.12464	90.14953
87	1.020487	7.63513	20.24118	90.38147
88	1.020723	7.665111	20.3577	90.61335
89	1.020958	7.695084	20.47419	90.84518
90	1.021194	7.72505	20.59065	91.07696
91	1.021429	7.75501	20.70709	91.30868
92	1.021665	7.784963	20.82349	91.54035
93	1.0219	7.814909	20.93988	91.77197
94	1.022136	7.844847	21.05623	92.00353
95	1.022371	7.874779	21.17256	92.23504
96	1.022607	7.904704	21.28886	92.4665
97	1.022842	7.934623	21.40513	92.6979
98	1.023078	7.964534	21.52138	92.92925
99	1.023313	7.994438	21.6376	93.16055
100	1.023549	8.024336	21.7538	93.39179
101	1.023784	8.054227	21.86996	93.62298
102	1.02402	8.08411	21.9861	93.85412
103	1.024255	8.113987	22.10222	94.0852
104	1.024491	8.143857	22.21831	94.31623
105	1.024726	8.173721	22.33437	94.54721
106	1.024962	8.203577	22.4504	94.77813
107	1.025197	8.233426	22.56641	95.009
108	1.025432	8.263269	22.68239	95.23982
109	1.025668	8.293105	22.79834	95.47059
110	1.025903	8.322934	22.91427	95.7013
111	1.026139	8.352756	23.03017	95.93196
112	1.026374	8.382571	23.14604	96.16257
113	1.02661	8.412379	23.26189	96.39312
114	1.026845	8.442181	23.37771	96.62362
115	1.027081	8.471976	23.49351	96.85407
116	1.027316	8.501764	23.60927	97.08446
117	1.027552	8.531545	23.72501	97.31481
118	1.027787	8.561319	23.84073	97.54509
119	1.028023	8.591086	23.95642	97.77533
120	1.028258	8.620847	24.07208	98.00552
121	1.028494	8.650601	24.18771	98.23565
122	1.028729	8.680348	24.30332	98.46572
123	1.028965	8.710088	24.41891	98.69575
124	1.0292	8.739821	24.53446	98.92572
125	1.029436	8.769548	24.64999	99.15564
126	1.029671	8.799267	24.76549	99.38551
127	1.029907	8.82898	24.88097	99.61533

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
128	1.030142	8.858686	24.99642	99.84509
129	1.030378	8.888386	25.11184	100.0748
130	1.030613	8.918078	25.22724	100.3045
131	1.030849	8.947764	25.34261	100.5341
132	1.031084	8.977443	25.45796	100.7636
133	1.03132	9.007116	25.57328	100.9931
134	1.031555	9.036781	25.68857	101.2226
135	1.031791	9.06644	25.80383	101.452
136	1.032026	9.096092	25.91907	101.6813
137	1.032262	9.125737	26.03429	101.9106
138	1.032497	9.155375	26.14947	102.1398
139	1.032733	9.185007	26.26463	102.369
140	1.032968	9.214632	26.37977	102.5982
141	1.033204	9.24425	26.49488	102.8272
142	1.033439	9.273861	26.60996	103.0563
143	1.033674	9.303466	26.72501	103.2852
144	1.03391	9.333064	26.84004	103.5142
145	1.034145	9.362655	26.95505	103.743
146	1.034381	9.392239	27.07002	103.9719
147	1.034616	9.421817	27.18497	104.2006
148	1.034852	9.451388	27.2999	104.4294
149	1.035087	9.480952	27.4148	104.658
150	1.035323	9.51051	27.52967	104.8866
151	1.035558	9.54006	27.64452	105.1152
152	1.035794	9.569604	27.75934	105.3437
153	1.036029	9.599142	27.87413	105.5722
154	1.036265	9.628672	27.9889	105.8006
155	1.0365	9.658196	28.10364	106.0289
156	1.036736	9.687714	28.21836	106.2572
157	1.036971	9.717224	28.33305	106.4855
158	1.037207	9.746728	28.44771	106.7137
159	1.037442	9.776225	28.56235	106.9418
160	1.037678	9.805715	28.67696	107.1699
161	1.037913	9.835199	28.79154	107.3979
162	1.038149	9.864676	28.9061	107.6259
163	1.038384	9.894147	29.02064	107.8539
164	1.03862	9.92361	29.13515	108.0818
165	1.038855	9.953067	29.24963	108.3096
166	1.039091	9.982517	29.36408	108.5374
167	1.039326	10.01196	29.47851	108.7651
168	1.039562	10.0414	29.59292	108.9928
169	1.039797	10.07083	29.7073	109.2204
170	1.040033	10.10025	29.82165	109.448
171	1.040268	10.12967	29.93597	109.6755

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
172	1.040504	10.15908	30.05027	109.903
173	1.040739	10.18848	30.16455	110.1304
174	1.040975	10.21788	30.2788	110.3578
175	1.04121	10.24727	30.39302	110.5851
176	1.041446	10.27665	30.50722	110.8124
177	1.041681	10.30603	30.62139	111.0396
178	1.041916	10.3354	30.73553	111.2668
179	1.042152	10.36477	30.84965	111.4939
180	1.042387	10.39412	30.96375	111.721
181	1.042623	10.42347	31.07782	111.948
182	1.042858	10.45282	31.19186	112.1749
183	1.043094	10.48215	31.30587	112.4018
184	1.043329	10.51148	31.41987	112.6287
185	1.043565	10.54081	31.53383	112.8555
186	1.0438	10.57013	31.64777	113.0823
187	1.044036	10.59944	31.76168	113.309
188	1.044271	10.62874	31.87557	113.5356
189	1.044507	10.65804	31.98943	113.7622
190	1.044742	10.68733	32.10327	113.9888
191	1.044978	10.71661	32.21708	114.2153
192	1.045213	10.74589	32.33087	114.4417
193	1.045449	10.77516	32.44463	114.6681
194	1.045684	10.80443	32.55836	114.8945
195	1.04592	10.83369	32.67207	115.1208
196	1.046155	10.86294	32.78575	115.347
197	1.046391	10.89218	32.89941	115.5732
198	1.046626	10.92142	33.01304	115.7993
199	1.046862	10.95065	33.12665	116.0254
200	1.047097	10.97988	33.24023	116.2515
201	1.047333	11.0091	33.35378	116.4775
202	1.047568	11.03831	33.46731	116.7034
203	1.047804	11.06751	33.58082	116.9293
204	1.048039	11.09671	33.69429	117.1551
205	1.048275	11.1259	33.80775	117.3809
206	1.04851	11.15509	33.92117	117.6067
207	1.048746	11.18427	34.03458	117.8324
208	1.048981	11.21344	34.14795	118.058
209	1.049217	11.24261	34.2613	118.2836
210	1.049452	11.27177	34.37463	118.5091
211	1.049688	11.30092	34.48793	118.7346
212	1.049923	11.33007	34.6012	118.96
213	1.050159	11.35921	34.71445	119.1854
214	1.050394	11.38834	34.82768	119.4107
215	1.050629	11.41747	34.94088	119.636

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
216	1.050865	11.44659	35.05405	119.8613
217	1.0511	11.4757	35.1672	120.0864
218	1.051336	11.50481	35.28032	120.3116
219	1.051571	11.53391	35.39342	120.5367
220	1.051807	11.563	35.50649	120.7617
221	1.052042	11.59209	35.61954	120.9867
222	1.052278	11.62117	35.73256	121.2116
223	1.052513	11.65025	35.84555	121.4365
224	1.052749	11.67931	35.95852	121.6613
225	1.052984	11.70838	36.07147	121.8861
226	1.05322	11.73743	36.18439	122.1108
227	1.053455	11.76648	36.29729	122.3355
228	1.053691	11.79552	36.41016	122.5601
229	1.053926	11.82456	36.523	122.7847
230	1.054162	11.85359	36.63582	123.0092
231	1.054397	11.88261	36.74861	123.2337
232	1.054633	11.91163	36.86138	123.4581
233	1.054868	11.94064	36.97413	123.6825
234	1.055104	11.96964	37.08684	123.9068
235	1.055339	11.99864	37.19954	124.1311
236	1.055575	12.02763	37.31221	124.3553
237	1.05581	12.05661	37.42485	124.5795
238	1.056046	12.08559	37.53747	124.8036
239	1.056281	12.11456	37.65006	125.0277
240	1.056517	12.14352	37.76263	125.2517
241	1.056752	12.17248	37.87517	125.4757
242	1.056988	12.20143	37.98769	125.6996
243	1.057223	12.23038	38.10018	125.9235
244	1.057459	12.25932	38.21265	126.1473
245	1.057694	12.28825	38.32509	126.3711
246	1.05793	12.31717	38.43751	126.5948
247	1.058165	12.34609	38.5499	126.8185
248	1.058401	12.37501	38.66227	127.0421
249	1.058636	12.40391	38.77461	127.2657
250	1.058871	12.43281	38.88693	127.4893
251	1.059107	12.46171	38.99922	127.7127
252	1.059342	12.49059	39.11149	127.9362
253	1.059578	12.51948	39.22373	128.1595
254	1.059813	12.54835	39.33595	128.3829
255	1.060049	12.57722	39.44814	128.6061
256	1.060284	12.60608	39.56031	128.8294
257	1.06052	12.63493	39.67245	129.0526
258	1.060755	12.66378	39.78457	129.2757
259	1.060991	12.69263	39.89666	129.4988

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
260	1.061226	12.72146	40.00873	129.7218
261	1.061462	12.75029	40.12077	129.9448
262	1.061697	12.77911	40.23279	130.1677
263	1.061933	12.80793	40.34479	130.3906
264	1.062168	12.83674	40.45676	130.6134
265	1.062404	12.86555	40.5687	130.8362
266	1.062639	12.89434	40.68062	131.059
267	1.062875	12.92313	40.79251	131.2816
268	1.06311	12.95192	40.90438	131.5043
269	1.063346	12.9807	41.01623	131.7269
270	1.063581	13.00947	41.12805	131.9494
271	1.063817	13.03824	41.23984	132.1719
272	1.064052	13.06699	41.35161	132.3943
273	1.064288	13.09575	41.46336	132.6167
274	1.064523	13.12449	41.57508	132.8391
275	1.064759	13.15323	41.68678	133.0614
276	1.064994	13.18197	41.79845	133.2836
277	1.06523	13.2107	41.91009	133.5058
278	1.065465	13.23942	42.02172	133.7279
279	1.065701	13.26813	42.13331	133.95
280	1.065936	13.29684	42.24489	134.1721
281	1.066172	13.32554	42.35644	134.3941
282	1.066407	13.35424	42.46796	134.616
283	1.066643	13.38293	42.57946	134.8379
284	1.066878	13.41161	42.69093	135.0598
285	1.067113	13.44029	42.80238	135.2816
286	1.067349	13.46896	42.91381	135.5033
287	1.067584	13.49762	43.02521	135.725
288	1.06782	13.52628	43.13659	135.9467
289	1.068055	13.55493	43.24794	136.1683
290	1.068291	13.58358	43.35926	136.3899
291	1.068526	13.61222	43.47057	136.6114
292	1.068762	13.64085	43.58184	136.8328
293	1.068997	13.66948	43.6931	137.0542
294	1.069233	13.6981	43.80433	137.2756
295	1.069468	13.72671	43.91553	137.4969
296	1.069704	13.75532	44.02671	137.7182
297	1.069939	13.78392	44.13787	137.9394
298	1.070175	13.81251	44.249	138.1606
299	1.07041	13.8411	44.3601	138.3817
300	1.070646	13.86968	44.47119	138.6027
301	1.070881	13.89826	44.58224	138.8238
302	1.071117	13.92683	44.69328	139.0447
303	1.071352	13.95539	44.80429	139.2657

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
304	1.071588	13.98395	44.91527	139.4865
305	1.071823	14.0125	45.02623	139.7074
306	1.072059	14.04104	45.13717	139.9281
307	1.072294	14.06958	45.24808	140.1489
308	1.07253	14.09811	45.35896	140.3696
309	1.072765	14.12664	45.46983	140.5902
310	1.073001	14.15516	45.58067	140.8108
311	1.073236	14.18367	45.69148	141.0313
312	1.073472	14.21218	45.80227	141.2518
313	1.073707	14.24068	45.91303	141.4722
314	1.073943	14.26918	46.02378	141.6926
315	1.074178	14.29766	46.13449	141.913
316	1.074414	14.32615	46.24518	142.1333
317	1.074649	14.35462	46.35585	142.3535
318	1.074885	14.38309	46.4665	142.5737
319	1.07512	14.41155	46.57712	142.7939
320	1.075356	14.44001	46.68771	143.014
321	1.075591	14.46846	46.79828	143.234
322	1.075826	14.49691	46.90883	143.454
323	1.076062	14.52534	47.01935	143.674
324	1.076297	14.55378	47.12985	143.8939
325	1.076533	14.5822	47.24033	144.1137
326	1.076768	14.61062	47.35078	144.3336
327	1.077004	14.63904	47.4612	144.5533
328	1.077239	14.66744	47.57161	144.773
329	1.077475	14.69584	47.68198	144.9927
330	1.07771	14.72424	47.79234	145.2123
331	1.077946	14.75263	47.90267	145.4319
332	1.078181	14.78101	48.01297	145.6514
333	1.078417	14.80939	48.12325	145.8709
334	1.078652	14.83776	48.23351	146.0903
335	1.078888	14.86612	48.34375	146.3097
336	1.079123	14.89448	48.45396	146.529
337	1.079359	14.92283	48.56414	146.7483
338	1.079594	14.95117	48.6743	146.9676
339	1.07983	14.97951	48.78444	147.1868
340	1.080065	15.00785	48.89455	147.4059
341	1.080301	15.03617	49.00464	147.625
342	1.080536	15.06449	49.11471	147.844
343	1.080772	15.09281	49.22475	148.063
344	1.081007	15.12112	49.33477	148.282
345	1.081243	15.14942	49.44476	148.5009
346	1.081478	15.17771	49.55473	148.7197
347	1.081714	15.206	49.66467	148.9386

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
348	1.081949	15.23429	49.77459	149.1573
349	1.082185	15.26257	49.88449	149.376
350	1.08242	15.29084	49.99437	149.5947
351	1.082656	15.3191	50.10422	149.8133
352	1.082891	15.34736	50.21404	150.0319
353	1.083127	15.37561	50.32384	150.2504
354	1.083362	15.40386	50.43362	150.4689
355	1.083598	15.4321	50.54338	150.6873
356	1.083833	15.46034	50.65311	150.9057
357	1.084068	15.48856	50.76281	151.124
358	1.084304	15.51679	50.8725	151.3423
359	1.084539	15.545	50.98215	151.5605
360	1.084775	15.57321	51.09179	151.7787
361	1.08501	15.60142	51.2014	151.9969
362	1.085246	15.62961	51.31099	152.215
363	1.085481	15.6578	51.42055	152.433
364	1.085717	15.68599	51.53009	152.651
365	1.085952	15.71417	51.63961	152.869
366	1.086188	15.74234	51.7491	153.0869
367	1.086423	15.77051	51.85857	153.3047
368	1.086659	15.79867	51.96801	153.5225
369	1.086894	15.82683	52.07744	153.7403
370	1.08713	15.85497	52.18683	153.958
371	1.087365	15.88312	52.29621	154.1757
372	1.087601	15.91125	52.40556	154.3933
373	1.087836	15.93938	52.51488	154.6109
374	1.088072	15.96751	52.62419	154.8284
375	1.088307	15.99563	52.73347	155.0459
376	1.088543	16.02374	52.84272	155.2633
377	1.088778	16.05185	52.95195	155.4807
378	1.089014	16.07995	53.06116	155.6981
379	1.089249	16.10804	53.17035	155.9154
380	1.089485	16.13613	53.27951	156.1326
381	1.08972	16.16421	53.38865	156.3498
382	1.089956	16.19229	53.49776	156.567
383	1.090191	16.22036	53.60685	156.7841
384	1.090427	16.24842	53.71592	157.0011
385	1.090662	16.27648	53.82496	157.2181
386	1.090898	16.30453	53.93398	157.4351
387	1.091133	16.33257	54.04298	157.652
388	1.091369	16.36061	54.15195	157.8689
389	1.091604	16.38865	54.2609	158.0857
390	1.09184	16.41667	54.36982	158.3025
391	1.092075	16.44469	54.47873	158.5192

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
392	1.09231	16.47271	54.5876	158.7359
393	1.092546	16.50072	54.69646	158.9526
394	1.092781	16.52872	54.80529	159.1691
395	1.093017	16.55672	54.9141	159.3857
396	1.093252	16.58471	55.02288	159.6022
397	1.093488	16.6127	55.13165	159.8186
398	1.093723	16.64068	55.24038	160.035
399	1.093959	16.66865	55.3491	160.2514
400	1.094194	16.69662	55.45779	160.4677
401	1.09443	16.72458	55.56646	160.684
402	1.094665	16.75253	55.6751	160.9002
403	1.094901	16.78048	55.78372	161.1164
404	1.095136	16.80842	55.89232	161.3325
405	1.095372	16.83636	56.0009	161.5486
406	1.095607	16.86429	56.10945	161.7646
407	1.095843	16.89222	56.21797	161.9806
408	1.096078	16.92013	56.32648	162.1965
409	1.096314	16.94805	56.43496	162.4124
410	1.096549	16.97595	56.54342	162.6283
411	1.096785	17.00386	56.65185	162.8441
412	1.09702	17.03175	56.76026	163.0598
413	1.097256	17.05964	56.86865	163.2755
414	1.097491	17.08752	56.97702	163.4912
415	1.097727	17.1154	57.08536	163.7068
416	1.097962	17.14327	57.19368	163.9224
417	1.098198	17.17114	57.30197	164.1379
418	1.098433	17.199	57.41024	164.3534
419	1.098669	17.22685	57.51849	164.5688
420	1.098904	17.2547	57.62672	164.7842
421	1.09914	17.28254	57.73492	164.9995
422	1.099375	17.31037	57.8431	165.2148
423	1.099611	17.3382	57.95125	165.4301
424	1.099846	17.36602	58.05939	165.6453
425	1.100082	17.39384	58.1675	165.8604
426	1.100317	17.42165	58.27558	166.0755
427	1.100553	17.44946	58.38364	166.2906
428	1.100788	17.47726	58.49168	166.5056
429	1.101023	17.50505	58.5997	166.7206
430	1.101259	17.53284	58.7077	166.9355
431	1.101494	17.56062	58.81567	167.1504
432	1.10173	17.5884	58.92361	167.3652
433	1.101965	17.61617	59.03154	167.58
434	1.102201	17.64393	59.13944	167.7947
435	1.102436	17.67169	59.24732	168.0094

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
436	1.102672	17.69944	59.35517	168.2241
437	1.102907	17.72719	59.46301	168.4387
438	1.103143	17.75493	59.57082	168.6532
439	1.103378	17.78266	59.6786	168.8678
440	1.103614	17.81039	59.78637	169.0822
441	1.103849	17.83811	59.89411	169.2966
442	1.104085	17.86583	60.00182	169.511
443	1.10432	17.89354	60.10952	169.7253
444	1.104556	17.92124	60.21719	169.9396
445	1.104791	17.94894	60.32484	170.1539
446	1.105027	17.97663	60.43246	170.368
447	1.105262	18.00432	60.54007	170.5822
448	1.105498	18.032	60.64765	170.7963
449	1.105733	18.05968	60.7552	171.0103
450	1.105969	18.08735	60.86274	171.2244
451	1.106204	18.11501	60.97025	171.4383
452	1.10644	18.14267	61.07774	171.6522
453	1.106675	18.17032	61.1852	171.8661
454	1.106911	18.19796	61.29264	172.0799
455	1.107146	18.2256	61.40006	172.2937
456	1.107382	18.25324	61.50746	172.5075
457	1.107617	18.28087	61.61483	172.7211
458	1.107853	18.30849	61.72219	172.9348
459	1.108088	18.33611	61.82951	173.1484
460	1.108324	18.36372	61.93682	173.3619
461	1.108559	18.39132	62.0441	173.5754
462	1.108795	18.41892	62.15136	173.7889
463	1.10903	18.44651	62.2586	174.0023
464	1.109265	18.4741	62.36581	174.2157
465	1.109501	18.50168	62.47301	174.429
466	1.109736	18.52926	62.58017	174.6423
467	1.109972	18.55682	62.68732	174.8555
468	1.110207	18.58439	62.79444	175.0687
469	1.110443	18.61195	62.90154	175.2819
470	1.110678	18.6395	63.00862	175.495
471	1.110914	18.66704	63.11568	175.708
472	1.111149	18.69458	63.22271	175.921
473	1.111385	18.72212	63.32972	176.134
474	1.11162	18.74965	63.43671	176.3469
475	1.111856	18.77717	63.54367	176.5598
476	1.112091	18.80469	63.65061	176.7726
477	1.112327	18.8322	63.75753	176.9854
478	1.112562	18.8597	63.86443	177.1982
479	1.112798	18.8872	63.9713	177.4109

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
480	1.113033	18.9147	64.07815	177.6235
481	1.113269	18.94218	64.18498	177.8361
482	1.113504	18.96967	64.29179	178.0487
483	1.11374	18.99714	64.39857	178.2612
484	1.113975	19.02461	64.50533	178.4737
485	1.114211	19.05208	64.61207	178.6861
486	1.114446	19.07954	64.71879	178.8985
487	1.114682	19.10699	64.82548	179.1108
488	1.114917	19.13444	64.93215	179.3231
489	1.115153	19.16188	65.0388	179.5353
490	1.115388	19.18931	65.14543	179.7475
491	1.115624	19.21674	65.25203	179.9597
492	1.115859	19.24417	65.35861	180.1718
493	1.116095	19.27159	65.46517	180.3839
494	1.11633	19.299	65.5717	180.5959
495	1.116566	19.3264	65.67822	180.8079
496	1.116801	19.35381	65.78471	181.0198
497	1.117037	19.3812	65.89118	181.2317
498	1.117272	19.40859	65.99762	181.4435
499	1.117507	19.43597	66.10405	181.6553
500	1.117743	19.46335	66.21045	181.8671
501	1.117978	19.49072	66.31683	182.0788
502	1.118214	19.51809	66.42318	182.2905
503	1.118449	19.54545	66.52952	182.5021
504	1.118685	19.5728	66.63583	182.7137
505	1.11892	19.60015	66.74212	182.9252
506	1.119156	19.6275	66.84838	183.1367
507	1.119391	19.65483	66.95463	183.3481
508	1.119627	19.68217	67.06085	183.5595
509	1.119862	19.70949	67.16705	183.7709
510	1.120098	19.73681	67.27323	183.9822
511	1.120333	19.76413	67.37938	184.1934
512	1.120569	19.79143	67.48551	184.4047
513	1.120804	19.81874	67.59162	184.6158
514	1.12104	19.84603	67.69771	184.827
515	1.121275	19.87333	67.80378	185.0381
516	1.121511	19.90061	67.90982	185.2491
517	1.121746	19.92789	68.01584	185.4601
518	1.121982	19.95517	68.12184	185.671
519	1.122217	19.98244	68.22782	185.882
520	1.122453	20.0097	68.33377	186.0928
521	1.122688	20.03696	68.43971	186.3036
522	1.122924	20.06421	68.54562	186.5144
523	1.123159	20.09145	68.6515	186.7252

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
524	1.123395	20.11869	68.75737	186.9358
525	1.12363	20.14593	68.86321	187.1465
526	1.123866	20.17316	68.96903	187.3571
527	1.124101	20.20038	69.07483	187.5676
528	1.124337	20.2276	69.18061	187.7782
529	1.124572	20.25481	69.28637	187.9886
530	1.124808	20.28201	69.3921	188.199
531	1.125043	20.30921	69.49781	188.4094
532	1.125279	20.33641	69.6035	188.6198
533	1.125514	20.3636	69.70916	188.8301
534	1.125749	20.39078	69.81481	189.0403
535	1.125985	20.41796	69.92043	189.2505
536	1.12622	20.44513	70.02603	189.4607
537	1.126456	20.47229	70.13161	189.6708
538	1.126691	20.49945	70.23716	189.8808
539	1.126927	20.52661	70.3427	190.0909
540	1.127162	20.55376	70.44821	190.3009
541	1.127398	20.5809	70.5537	190.5108
542	1.127633	20.60804	70.65917	190.7207
543	1.127869	20.63517	70.76461	190.9306
544	1.128104	20.6623	70.87004	191.1404
545	1.12834	20.68942	70.97544	191.3501
546	1.128575	20.71653	71.08082	191.5598
547	1.128811	20.74364	71.18618	191.7695
548	1.129046	20.77075	71.29151	191.9792
549	1.129282	20.79784	71.39683	192.1887
550	1.129517	20.82494	71.50212	192.3983
551	1.129753	20.85202	71.60739	192.6078
552	1.129988	20.8791	71.71264	192.8173
553	1.130224	20.90618	71.81786	193.0267
554	1.130459	20.93325	71.92307	193.236
555	1.130695	20.96031	72.02825	193.4454
556	1.13093	20.98737	72.13341	193.6547
557	1.131166	21.01442	72.23855	193.8639
558	1.131401	21.04147	72.34366	194.0731
559	1.131637	21.06851	72.44876	194.2822
560	1.131872	21.09555	72.55383	194.4914
561	1.132108	21.12258	72.65888	194.7004
562	1.132343	21.1496	72.76391	194.9094
563	1.132579	21.17662	72.86892	195.1184
564	1.132814	21.20364	72.9739	195.3274
565	1.13305	21.23064	73.07887	195.5363
566	1.133285	21.25765	73.18381	195.7451
567	1.133521	21.28464	73.28873	195.9539

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
568	1.133756	21.31163	73.39363	196.1627
569	1.133992	21.33862	73.4985	196.3714
570	1.134227	21.3656	73.60336	196.5801
571	1.134462	21.39257	73.70819	196.7887
572	1.134698	21.41954	73.813	196.9973
573	1.134933	21.44651	73.91779	197.2058
574	1.135169	21.47346	74.02256	197.4143
575	1.135404	21.50041	74.1273	197.6228
576	1.13564	21.52736	74.23203	197.8312
577	1.135875	21.5543	74.33673	198.0396
578	1.136111	21.58124	74.44141	198.2479
579	1.136346	21.60817	74.54607	198.4562
580	1.136582	21.63509	74.65071	198.6644
581	1.136817	21.66201	74.75532	198.8726
582	1.137053	21.68892	74.85992	199.0808
583	1.137288	21.71583	74.96449	199.2889
584	1.137524	21.74273	75.06904	199.497
585	1.137759	21.76963	75.17357	199.705
586	1.137995	21.79652	75.27807	199.913
587	1.13823	21.8234	75.38256	200.1209
588	1.138466	21.85028	75.48702	200.3288
589	1.138701	21.87715	75.59147	200.5367
590	1.138937	21.90402	75.69589	200.7445
591	1.139172	21.93089	75.80029	200.9523
592	1.139408	21.95774	75.90467	201.16
593	1.139643	21.98459	76.00902	201.3677
594	1.139879	22.01144	76.11336	201.5753
595	1.140114	22.03828	76.21767	201.7829
596	1.14035	22.06512	76.32196	201.9905
597	1.140585	22.09195	76.42623	202.198
598	1.140821	22.11877	76.53048	202.4055
599	1.141056	22.14559	76.63471	202.6129
600	1.141292	22.1724	76.73891	202.8203
601	1.141527	22.19921	76.8431	203.0276
602	1.141763	22.22601	76.94726	203.2349
603	1.141998	22.25281	77.0514	203.4422
604	1.142234	22.2796	77.15552	203.6494
605	1.142469	22.30638	77.25962	203.8566
606	1.142704	22.33316	77.36369	204.0637
607	1.14294	22.35993	77.46775	204.2708
608	1.143175	22.3867	77.57178	204.4778
609	1.143411	22.41347	77.67579	204.6848
610	1.143646	22.44022	77.77978	204.8918
611	1.143882	22.46698	77.88375	205.0987

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
612	1.144117	22.49372	77.9877	205.3056
613	1.144353	22.52046	78.09163	205.5124
614	1.144588	22.5472	78.19553	205.7192
615	1.144824	22.57393	78.29942	205.9259
616	1.145059	22.60065	78.40328	206.1326
617	1.145295	22.62737	78.50712	206.3393
618	1.14553	22.65409	78.61094	206.5459
619	1.145766	22.68079	78.71474	206.7525
620	1.146001	22.7075	78.81852	206.959
621	1.146237	22.73419	78.92227	207.1655
622	1.146472	22.76089	79.02601	207.3719
623	1.146708	22.78757	79.12972	207.5783
624	1.146943	22.81425	79.23341	207.7847
625	1.147179	22.84093	79.33708	207.991
626	1.147414	22.8676	79.44073	208.1973
627	1.14765	22.89426	79.54436	208.4035
628	1.147885	22.92092	79.64797	208.6097
629	1.148121	22.94757	79.75155	208.8159
630	1.148356	22.97422	79.85512	209.022
631	1.148592	23.00086	79.95866	209.2281
632	1.148827	23.0275	80.06218	209.4341
633	1.149063	23.05413	80.16568	209.6401
634	1.149298	23.08076	80.26916	209.846
635	1.149534	23.10738	80.37262	210.0519
636	1.149769	23.13399	80.47606	210.2578
637	1.150005	23.1606	80.57947	210.4636
638	1.15024	23.18721	80.68287	210.6693
639	1.150476	23.21381	80.78624	210.8751
640	1.150711	23.2404	80.88959	211.0808
641	1.150946	23.26699	80.99293	211.2864
642	1.151182	23.29357	81.09624	211.492
643	1.151417	23.32015	81.19952	211.6976
644	1.151653	23.34672	81.30279	211.9031
645	1.151888	23.37329	81.40604	212.1086
646	1.152124	23.39985	81.50926	212.314
647	1.152359	23.4264	81.61247	212.5194
648	1.152595	23.45295	81.71565	212.7247
649	1.15283	23.4795	81.81881	212.93
650	1.153066	23.50603	81.92196	213.1353
651	1.153301	23.53257	82.02508	213.3405
652	1.153537	23.5591	82.12818	213.5457
653	1.153772	23.58562	82.23125	213.7509
654	1.154008	23.61214	82.33431	213.956
655	1.154243	23.63865	82.43735	214.161

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
656	1.154479	23.66515	82.54036	214.366
657	1.154714	23.69166	82.64336	214.571
658	1.15495	23.71815	82.74633	214.7759
659	1.155185	23.74464	82.84928	214.9808
660	1.155421	23.77113	82.95221	215.1857
661	1.155656	23.79761	83.05512	215.3905
662	1.155892	23.82408	83.15801	215.5952
663	1.156127	23.85055	83.26088	215.8
664	1.156363	23.87701	83.36373	216.0046
665	1.156598	23.90347	83.46655	216.2093
666	1.156834	23.92992	83.56936	216.4139
667	1.157069	23.95637	83.67214	216.6184
668	1.157305	23.98281	83.77491	216.823
669	1.15754	24.00925	83.87765	217.0274
670	1.157776	24.03568	83.98037	217.2319
671	1.158011	24.0621	84.08307	217.4362
672	1.158247	24.08853	84.18575	217.6406
673	1.158482	24.11494	84.28841	217.8449
674	1.158718	24.14135	84.39105	218.0492
675	1.158953	24.16775	84.49366	218.2534
676	1.159189	24.19415	84.59626	218.4576
677	1.159424	24.22055	84.69884	218.6617
678	1.159659	24.24693	84.80139	218.8658
679	1.159895	24.27332	84.90393	219.0699
680	1.16013	24.29969	85.00644	219.2739
681	1.160366	24.32607	85.10893	219.4779
682	1.160601	24.35243	85.2114	219.6818
683	1.160837	24.37879	85.31385	219.8857
684	1.161072	24.40515	85.41628	220.0895
685	1.161308	24.4315	85.51869	220.2933
686	1.161543	24.45785	85.62108	220.4971
687	1.161779	24.48419	85.72345	220.7008
688	1.162014	24.51052	85.82579	220.9045
689	1.16225	24.53685	85.92812	221.1082
690	1.162485	24.56317	86.03043	221.3118
691	1.162721	24.58949	86.13271	221.5153
692	1.162956	24.61581	86.23498	221.7189
693	1.163192	24.64211	86.33722	221.9223
694	1.163427	24.66842	86.43944	222.1258
695	1.163663	24.69471	86.54164	222.3292
696	1.163898	24.72101	86.64382	222.5325
697	1.164134	24.74729	86.74598	222.7358
698	1.164369	24.77357	86.84812	222.9391
699	1.164605	24.79985	86.95024	223.1423

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
700	1.16484	24.82612	87.05234	223.3455
701	1.165076	24.85239	87.15442	223.5487
702	1.165311	24.87865	87.25648	223.7518
703	1.165547	24.9049	87.35851	223.9549
704	1.165782	24.93115	87.46053	224.1579
705	1.166018	24.95739	87.56253	224.3609
706	1.166253	24.98363	87.6645	224.5638
707	1.166489	25.00987	87.76646	224.7667
708	1.166724	25.03609	87.86839	224.9696
709	1.16696	25.06232	87.9703	225.1724
710	1.167195	25.08854	88.07219	225.3752
711	1.167431	25.11475	88.17407	225.5779
712	1.167666	25.14095	88.27592	225.7806
713	1.167901	25.16716	88.37775	225.9833
714	1.168137	25.19335	88.47956	226.1859
715	1.168372	25.21954	88.58135	226.3885
716	1.168608	25.24573	88.68312	226.591
717	1.168843	25.27191	88.78487	226.7935
718	1.169079	25.29809	88.8866	226.996
719	1.169314	25.32426	88.9883	227.1984
720	1.16955	25.35042	89.08999	227.4008
721	1.169785	25.37658	89.19166	227.6031
722	1.170021	25.40274	89.2933	227.8054
723	1.170256	25.42888	89.39493	228.0076
724	1.170492	25.45503	89.49654	228.2098
725	1.170727	25.48117	89.59812	228.412
726	1.170963	25.5073	89.69969	228.6141
727	1.171198	25.53343	89.80123	228.8162
728	1.171434	25.55955	89.90275	229.0183
729	1.171669	25.58567	90.00426	229.2203
730	1.171905	25.61178	90.10574	229.4222
731	1.17214	25.63789	90.2072	229.6242
732	1.172376	25.66399	90.30865	229.8261
733	1.172611	25.69009	90.41007	230.0279
734	1.172847	25.71618	90.51147	230.2297
735	1.173082	25.74226	90.61285	230.4315
736	1.173318	25.76834	90.71421	230.6332
737	1.173553	25.79442	90.81555	230.8349
738	1.173789	25.82049	90.91687	231.0365
739	1.174024	25.84656	91.01817	231.2381
740	1.17426	25.87262	91.11945	231.4397
741	1.174495	25.89867	91.22071	231.6412
742	1.174731	25.92472	91.32195	231.8427
743	1.174966	25.95076	91.42317	232.0441

PSI	RR	PM2.5 (µg/m3)	NO2 (µg/m3)	O3 (µg/m3.day)
744	1.175202	25.9768	91.52437	232.2455
745	1.175437	26.00284	91.62554	232.4469
746	1.175673	26.02887	91.7267	232.6482
747	1.175908	26.05489	91.82784	232.8495
748	1.176143	26.08091	91.92896	233.0507
749	1.176379	26.10692	92.03005	233.2519
750	1.176614	26.13293	92.13113	233.4531
751	1.17685	26.15893	92.23219	233.6542
752	1.177085	26.18493	92.33322	233.8553
753	1.177321	26.21092	92.43424	234.0563
754	1.177556	26.23691	92.53524	234.2573
755	1.177792	26.26289	92.63621	234.4583
756	1.178027	26.28887	92.73717	234.6592
757	1.178263	26.31484	92.8381	234.8601
758	1.178498	26.3408	92.93902	235.0609
759	1.178734	26.36676	93.03991	235.2617
760	1.178969	26.39272	93.14079	235.4624
761	1.179205	26.41867	93.24164	235.6632

Table A1.2 Ranking based on the mean of the population-weighted concentration for PM2.5, NO2, and O3 for 2019 and 2020 (PSI)

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
FI	Oulu	4.74	6.71	73.51	0	0	15	15	1
SE	Umeå	3.24	4.51	74.27	0	0	19	19	2
FI	Kuopio	4.43	6.90	74.55	0	0	20	20	3
FI	Tampere	4.86	9.65	75.23	0	0	23	23	4
NO	Tromsø	4.63	6.73	75.61	0	0	24	24	5
IS	Reykjavík	4.68	10.74	73.90	0	7	17	24	6
FI	Jyväskylä	5.09	7.48	74.71	4	0	20	24	7
SE	Uppsala	4.65	7.06	76.35	0	0	27	27	8
SE	Örebro	4.23	7.29	76.90	0	0	30	30	9
SE	Västerås	4.46	8.70	76.98	0	0	30	30	10
SE	Norrköping	4.81	9.04	77.50	0	0	32	32	11
FI	Lahti	5.25	8.47	75.28	9	0	23	32	12
SE	Linköping	4.89	8.50	77.69	0	0	33	33	13
SE	Södertälje	4.30	7.60	77.72	0	0	33	33	14
SE	Stockholm	5.20	9.89	76.77	7	0	29	36	15
NO	Bergen	4.89	11.34	76.41	0	12	28	40	16
FI	Espoo	5.58	9.26	74.60	20	0	20	40	17
SE	Borås	5.40	8.62	78.27	14	0	36	50	18
EE	Narva linn	5.76	8.71	75.80	25	0	25	50	19
FI	Turku	5.80	9.51	75.91	27	0	26	53	20
SE	Jönköping	5.58	7.82	78.36	20	0	36	56	21
NO	Trondheim	5.38	12.33	76.02	13	20	26	59	22
EE	Tallinn	6.15	9.64	75.30	38	0	23	61	23
EE	Tartu linn	6.11	8.81	75.73	37	0	25	62	24
FI	Helsinki	5.82	11.97	74.47	27	17	19	63	25
NO	Stavanger	6.33	8.76	75.24	44	0	23	67	26
FI	Vantaa	6.27	11.40	74.58	42	12	20	74	27
PT	Viseu	6.25	9.63	80.46	41	0	45	86	28
NO	Kristiansand	6.71	8.07	77.33	57	0	32	89	29
SE	Greater Göteborg	6.32	12.15	77.34	44	19	32	95	30
ES	Cáceres	5.51	11.61	85.37	17	14	66	97	31
ES	Mérida	6.04	10.37	85.52	35	4	67	106	32
ES	Badajoz	6.00	12.20	84.51	33	19	62	114	33
ES	Ávila	6.27	10.19	86.62	42	2	71	115	34
ES	Zamora	6.46	11.95	82.00	48	17	52	117	35
ES	Salamanca	6.28	13.33	83.52	43	29	58	130	36
DK	Aalborg	7.91	8.45	77.56	97	0	33	130	37
FR	City of Brest	7.80	9.31	79.26	93	0	40	133	38
IT	Sassari	7.88	9.43	79.19	96	0	40	136	39
SE	Lund	8.13	8.78	78.39	104	0	36	140	40
ES	Burgos	7.04	13.28	80.67	68	28	46	142	41
FR	City of Bourges	7.71	9.64	82.03	90	0	52	142	42

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
PT	Faro	7.26	7.45	85.79	75	0	68	143	43
PT	Viana do Castelo	8.33	9.96	77.32	111	0	32	143	44
ES	Ponferrada	7.43	13.13	79.08	81	27	39	147	45
SE	Helsingborg	8.22	10.40	78.36	107	4	36	147	46
SE	Malmö	8.16	10.64	78.57	105	6	37	148	47
DK	Århus	8.49	9.52	77.67	116	0	33	149	48
ES	Palencia	7.50	11.49	82.51	83	13	54	150	49
IE	Cork	8.61	10.62	76.00	120	6	26	152	50
IE	Galway	8.73	9.73	76.40	124	0	28	152	51
BE	Verviers (greater city)	7.24	14.10	80.93	74	35	47	156	52
FR	City of Bayonne	8.04	11.79	79.78	101	16	42	159	53
FR	City of Saint-Nazaire	8.35	8.85	81.27	112	0	48	160	54
FR	City of Saint-Brieuc	8.67	9.52	78.99	122	0	39	161	55
FR	City of Lorient	8.68	9.27	79.41	122	0	40	162	56
FR	City of Chartres	8.00	11.60	81.53	100	14	49	163	57
ES	Irun	8.27	12.26	78.43	109	20	36	165	58
NO	Oslo	7.37	17.46	75.65	79	64	24	167	59
ES	Ourense	8.20	14.32	76.46	106	37	28	171	60
ES	Alcoy/Alcoi	7.75	11.27	86.28	91	11	70	172	61
ES	Santiago de Compostela	8.94	11.59	76.27	131	14	27	172	62
DK	Odense	9.22	9.59	77.76	141	0	33	174	63
FR	City of Cherbourg-en-Cotentin	9.07	9.45	79.05	136	0	39	175	64
ES	Collado Villalba	7.37	12.89	86.70	79	25	72	176	65
FR	City of Béziers	7.83	13.18	83.55	94	27	58	179	66
DE	Villingen-Schwenningen	7.49	13.92	84.91	83	34	64	181	67
FR	City of Limoges	8.35	12.84	80.72	111	24	46	181	68
PT	Coimbra	8.44	13.57	78.27	114	31	36	181	69
FR	City of La Rochelle	8.85	10.59	81.21	128	5	48	181	70
NL	Leeuwarden	8.56	13.02	79.03	119	26	39	184	71
FR	City of Orléans	8.44	12.15	82.41	114	19	53	186	72
ES	Pontevedra	8.97	12.99	76.44	132	26	28	186	73
ES	Lugo	9.28	11.72	76.60	143	15	28	186	74
DE	Stralsund	9.48	10.16	78.68	149	2	37	188	75
IE	Dublin	8.28	17.61	73.38	109	65	15	189	76
IE	Waterford	9.98	8.02	75.41	166	0	23	189	77
PT	Sintra	8.02	15.35	80.34	100	46	44	190	78
DE	Aachen	7.80	15.69	81.30	93	49	49	191	79
FR	City of Pau	8.44	14.05	79.81	115	35	42	192	80
FR	City of Le Mans	9.03	11.27	80.89	134	11	47	192	81
FR	City of Poitiers	8.81	12.41	80.81	127	21	46	194	82

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
PT	Setúbal	8.54	13.14	81.66	118	27	50	195	83
ES	San Sebastián Donostia	8.69	14.08	78.80	123	35	38	196	84
DE	Salzgitter	8.93	12.07	80.87	131	18	47	196	85
DK	København	8.92	14.31	77.38	130	37	32	199	86
PT	Póvoa de Varzim	9.01	14.39	76.15	134	38	27	199	87
ES	León	8.31	15.05	81.08	110	43	48	201	88
ES	Eivissa	8.66	10.90	86.44	122	8	71	201	89
FR	City of Nantes	9.24	11.91	80.20	141	17	44	202	90
ES	Valladolid	7.94	15.54	83.55	98	47	58	203	91
FR	City of Angers	9.39	11.15	80.87	146	10	47	203	92
FR	City of Dijon	7.93	15.62	83.94	97	48	60	205	93
DE	Greifswald	9.77	10.79	78.99	159	7	39	205	94
DE	Celle	8.81	13.56	81.23	127	31	48	206	95
DE	Schwerin	9.61	11.15	79.81	154	10	42	206	96
DE	Hildesheim	8.82	14.03	80.76	127	34	46	207	97
NL	Groningen	8.88	14.85	78.76	129	41	38	208	98
IT	Cagliari	9.85	12.04	76.59	162	18	28	208	99
DE	Wolfsburg	9.07	12.94	81.26	136	25	48	209	100
FR	City of Tours	9.27	12.01	81.75	142	17	50	209	101
NL	Assen	9.08	13.80	79.62	136	33	41	210	102
FR	City of Clermont-Ferrand	7.93	16.64	83.36	97	57	57	211	103
PT	Vila Franca de Xira	8.16	17.25	80.30	105	62	44	211	104
ES	Benidorm	8.70	11.57	87.23	123	14	74	211	105
DE	Lüneburg	9.19	13.13	80.32	140	27	44	211	106
DE	Göttingen	8.95	13.99	80.93	131	34	47	212	107
FR	City of Caen	9.33	13.66	78.42	145	31	36	212	108
DE	Trier	7.90	17.73	82.00	96	66	52	214	109
BE	Liège (greater city)	8.14	17.77	80.41	104	66	45	215	110
DE	Düren, Stadt	8.16	17.48	81.06	105	64	47	216	111
ES	Pamplona/Iruña	8.54	17.23	78.49	118	62	37	217	112
DE	Weimar	9.20	13.06	81.87	140	26	51	217	113
BE	Namur	8.41	16.96	80.45	114	59	45	218	114
FR	City of Perpignan	8.48	15.24	83.19	116	45	57	218	115
DE	Freiburg im Breisgau	7.93	16.53	85.42	97	56	66	219	116
PT	Guimarães	9.27	15.90	76.20	142	50	27	219	117
FR	City of Rennes	9.40	13.97	78.78	147	34	38	219	118
NL	Greater Alkmaar	9.18	15.05	78.75	139	43	38	220	119
DE	Flensburg	9.66	13.14	78.53	156	27	37	220	120
FR	City of Troyes	9.11	13.83	82.10	137	33	52	222	121
PT	Paredes	9.47	15.74	75.64	149	49	24	222	122
DE	Neubrandenburg	10.14	10.83	79.86	172	8	42	222	123
NL	Greater Heerlen	8.66	16.19	81.13	122	53	48	223	124

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
ES	Vigo	9.13	17.06	75.70	138	60	25	223	125
PT	Aveiro	10.21	11.90	77.74	174	17	33	224	126
FR	City of Roanne	8.52	15.63	84.00	117	48	60	225	127
FR	City of Besançon	8.57	14.69	85.49	119	40	66	225	128
ES	Gandia	9.10	12.58	85.49	137	22	66	225	129
DE	Rostock	9.95	12.81	78.35	165	24	36	225	130
DE	Iserlohn	8.88	15.53	81.71	129	47	50	226	131
ES	Rozas de Madrid, Las	7.94	16.50	87.05	98	56	73	227	132
ES	Huelva	8.32	15.99	85.49	110	51	66	227	133
CH	Thun	8.26	16.46	85.18	108	55	65	228	134
DE	Paderborn	9.02	15.50	81.11	134	47	48	229	135
DE	Braunschweig	9.19	14.99	80.72	140	43	46	229	136
DE	Plauen	9.51	13.47	81.76	150	30	50	230	137
DE	Lübeck	9.77	13.94	78.79	159	34	38	231	138
DE	Kiel	9.75	14.43	77.86	159	38	34	231	139
DE	Kempten (Allgäu)	8.27	17.77	83.26	109	66	57	232	140
DE	Jena	9.40	13.87	82.00	147	33	52	232	141
LV	Liepāja	10.89	8.40	78.13	197	0	35	232	142
FR	City of Le Havre	9.76	14.16	78.92	159	36	38	233	143
CH	Biel/Bienne	8.46	16.48	84.88	115	55	64	234	144
DE	Erfurt	9.26	14.95	81.58	142	42	50	234	145
ES	Chiclana de la Frontera	9.82	10.25	86.34	161	3	70	234	146
DE	Brandenburg an der Havel	9.98	11.74	82.36	166	15	53	234	147
DE	Wilhelmshaven	9.62	15.18	78.66	154	44	37	235	148
IE	Limerick	10.63	12.50	75.45	189	22	24	235	149
CH	Winterthur	8.56	16.40	84.80	118	55	63	236	150
ES	Sanlúcar de Barrameda	9.12	13.33	86.34	137	29	70	236	151
NL	Hoorn	9.15	16.76	79.25	138	58	40	236	152
PT	Barreiro	9.08	16.73	80.57	136	57	45	238	153
CH	Zug	8.62	16.17	85.44	120	53	66	239	154
ES	Zaragoza	8.17	20.16	81.25	105	87	48	240	155
DE	Kaiserslautern	8.81	16.49	83.60	127	55	58	240	156
DE	Gera	9.64	13.86	82.14	155	33	52	240	157
NL	Lelystad	9.30	16.32	80.29	143	54	44	241	158
FR	City of Boulogne-sur-Mer	10.28	13.10	78.50	177	27	37	241	159
DE	Remscheid	9.13	16.34	81.54	138	54	50	242	160
DE	Hannover	9.23	16.69	80.29	141	57	44	242	161
DE	Zwickau	9.57	14.27	82.22	153	37	52	242	162
FR	City of Bordeaux	9.66	14.60	81.01	156	39	47	242	163
PT	Amadora	8.29	20.61	79.92	109	91	43	243	164

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
CH	St. Gallen	8.60	17.20	84.35	120	61	62	243	165
DE	Neumünster	9.89	15.06	78.60	163	43	37	243	166
DE	Bielefeld	9.27	16.43	80.93	142	55	47	244	167
PT	Seixal	9.42	16.31	80.07	147	54	43	244	168
LU	Luxembourg	8.01	21.91	80.09	100	102	43	245	169
FR	City of Montpellier	8.03	18.77	85.98	101	75	69	245	170
NL	Greater Heemskerk	9.51	16.97	78.08	150	60	35	245	171
ES	Ferrol	10.99	11.31	77.37	201	12	32	245	172
NL	Maastricht	9.00	17.74	80.92	133	66	47	246	173
DE	Dessau-Roßlau	10.12	12.45	82.62	171	21	54	246	174
ES	Ceuta	8.67	16.68	85.75	122	57	68	247	175
ES	Majadahonda	8.28	18.06	86.43	109	69	70	248	176
BE	La Louvière (greater city)	9.43	16.85	79.66	148	58	42	248	177
ES	Elda	9.30	13.70	87.36	143	32	74	249	178
DE	Chemnitz	9.37	15.98	82.22	146	51	52	249	179
NL	Greater Soest	9.94	15.08	79.55	165	43	41	249	180
LT	Klaipėda	11.08	11.33	77.65	204	12	33	249	181
FR	City of Saint-Etienne	8.85	16.85	85.01	128	58	64	250	182
IT	Grosseto	9.60	13.68	84.96	154	32	64	250	183
ES	Sagunto/Sagunt	9.52	13.91	85.71	151	33	67	251	184
DE	Osnabrück	9.52	16.20	81.11	151	53	48	252	185
FR	City of Toulouse	9.40	16.13	82.50	147	52	54	253	186
ES	El Puerto de Santa María	9.71	12.57	87.33	157	22	74	253	187
DE	Siegen	9.00	17.82	82.60	133	67	54	254	188
FR	City of Metz	9.29	16.73	82.30	143	58	53	254	189
NL	Greater Middelburg	10.23	14.90	78.57	175	42	37	254	190
BE	Charleroi (greater city)	9.08	19.07	79.91	136	77	43	256	191
ES	San Fernando	9.61	12.81	88.21	154	24	78	256	192
NL	Purmerend	9.65	17.55	78.70	155	64	37	256	193
DE	Saarbrücken	9.13	17.24	83.21	138	62	57	257	194
NL	Greater Haarlem	9.75	17.56	77.95	158	65	34	257	195
PT	Braga	10.01	17.64	75.81	167	65	25	257	196
DE	Offenburg	8.97	17.41	84.74	132	63	63	258	197
DE	Tübingen	8.98	17.31	84.72	133	62	63	258	198
DE	Hagen	9.32	17.66	81.43	144	65	49	258	199
DE	Magdeburg	10.06	14.49	81.78	169	38	51	258	200
PT	Almada	9.41	18.24	79.77	147	70	42	259	201
NL	Greater Sittard-Geleen	9.45	17.51	81.04	148	64	47	259	202

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
FR	City of Mantes-la-Jolie	9.74	16.18	81.12	158	53	48	259	203
CZ	Karlovy Vary	10.23	13.70	82.23	175	32	52	259	204
DE	Konstanz	8.99	17.35	84.96	133	63	64	260	205
ES	Logroño	9.97	16.11	79.75	166	52	42	260	206
ES	Getxo	10.10	16.65	77.46	171	57	32	260	207
FR	City of Saint-Quentin	10.24	14.85	79.96	175	42	43	260	208
FR	City of Amiens	10.35	14.69	79.46	179	40	41	260	209
FR	City of Calais	10.84	13.89	77.23	196	33	31	260	210
DE	Pforzheim	8.43	19.97	84.55	114	85	62	261	211
FR	City of Nîmes	9.14	16.10	86.66	138	52	71	261	212
DE	Bergisch Gladbach	9.24	18.45	81.16	141	72	48	261	213
ES	Vitoria-Gasteiz	9.55	18.21	79.07	152	70	39	261	214
DE	Bremerhaven	9.98	16.86	78.40	166	59	36	261	215
DE	Oldenburg (Oldenburg)	9.95	16.62	79.34	165	57	40	262	216
DE	Kassel	9.54	17.32	81.11	152	63	48	263	217
ES	Cádiz	9.63	13.61	87.87	155	31	77	263	218
FR	City of Belfort	9.68	15.00	85.02	156	43	64	263	219
NL	Almere	9.67	17.28	80.44	156	62	45	263	220
NL	Zwolle	9.86	16.76	80.04	162	58	43	263	221
NL	Hilversum	10.01	16.48	79.47	167	55	41	263	222
CH	Lausanne	8.74	18.70	85.14	125	74	65	264	223
BE	Oostende	10.94	13.37	78.48	199	29	36	264	224
NL	Apeldoorn	9.86	16.71	80.81	162	57	46	265	225
PL	M. Koszalin	11.62	10.94	78.23	222	8	35	265	226
FR	City of Nancy	9.68	16.43	82.83	156	55	55	266	227
NL	Haarlemmermeer	9.77	18.64	77.57	159	74	33	266	228
BE	Mons (greater city)	10.04	16.63	79.47	168	57	41	266	229
FR	City of Arras	10.75	13.76	79.45	193	32	41	266	230
CH	Bern	9.08	18.04	84.47	136	69	62	267	231
NL	Greater Leiden	9.54	19.34	78.34	151	80	36	267	232
DE	Fulda	9.60	17.13	82.09	154	61	52	267	233
ES	Santurtzi	9.95	18.49	76.92	165	72	30	267	234
NL	Almelo	10.00	16.41	80.82	167	55	46	268	235
LV	Daugavpils	11.93	10.87	76.36	233	8	27	268	236
ES	Talavera de la Reina	9.14	16.92	86.75	138	59	72	269	237
DE	Halle an der Saale	10.17	15.10	82.01	173	44	52	269	238
DE	Reutlingen	8.82	19.32	84.72	127	80	63	270	239
DE	Hamm	9.70	17.74	81.05	157	66	47	270	240
FR	City of Melun	9.74	17.05	82.08	158	60	52	270	241
IT	Catanzaro	10.54	11.67	86.32	185	15	70	270	242

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
DE	Solingen	9.46	18.72	81.24	149	74	48	271	243
FR	City of Meaux	9.87	16.77	81.68	163	58	50	271	244
DE	Potsdam	10.47	14.13	82.41	183	35	53	271	245
DE	Friedrichshafen	9.32	17.62	84.61	144	65	63	272	246
ES	Jerez de la Frontera	10.01	14.21	86.15	167	36	69	272	247
LV	Jelgava	11.90	11.63	76.05	232	14	26	272	248
DE	Wuppertal	9.47	18.73	81.38	149	75	49	273	249
NL	Zaanstad	10.06	18.45	77.64	169	72	33	274	250
NL	Deventer	10.19	16.63	80.33	173	57	44	274	251
NL	Enschede	9.87	17.48	81.28	163	64	48	275	252
NL	Alphen aan den Rijn	9.94	18.75	78.14	165	75	35	275	253
DE	Marburg	9.63	18.12	82.19	155	69	52	276	254
ES	Palma de Mallorca	9.72	16.73	84.39	157	57	62	276	255
NL	Hengelo	9.99	17.30	80.99	167	62	47	276	256
ES	San Vicente del Raspeig/Sant Vicent del Raspeig	9.97	14.92	86.07	166	42	69	277	257
PL	M. Słupsk	12.03	10.93	77.38	237	8	32	277	258
CH	Lucerne	9.14	18.95	84.92	138	76	64	278	259
ES	Marbella	9.83	14.44	88.33	161	38	79	278	260
DE	Münster	10.10	16.94	81.38	170	59	49	278	261
DE	Leipzig	10.32	15.76	81.93	178	49	51	278	262
DE	Witten	9.75	18.42	81.23	159	72	48	279	263
IT	Potenza	10.03	14.06	87.69	168	35	76	279	264
BE	Leuven	10.13	17.65	79.92	171	65	43	279	265
ES	Pozuelo de Alarcón	8.60	20.84	85.60	120	93	67	280	266
DE	Rosenheim	9.61	18.66	82.07	154	74	52	280	267
ES	Albacete	9.81	16.15	85.37	161	53	66	280	268
DE	Bayreuth	10.11	16.72	82.01	171	57	52	280	269
NL	Amersfoort	10.26	17.41	79.61	176	63	41	280	270
IT	Bagheria	10.69	11.58	87.52	191	14	75	280	271
ES	Santander	11.11	15.06	77.36	205	43	32	280	272
PT	Valongo	10.25	20.18	74.09	176	87	18	281	273
NL	Greater Ede	10.46	16.43	79.97	183	55	43	281	274
PT	Odivelas	9.80	19.95	78.65	160	85	37	282	275
NL	Bergen op Zoom	10.22	18.26	78.61	174	71	37	282	276
LT	Šiauliai	11.78	13.00	76.60	228	26	28	282	277
FR	City of Valence	9.98	15.52	86.29	166	47	70	283	278
FR	City of Douai	11.21	13.97	79.57	208	34	41	283	279
DE	Sindelfingen	9.26	19.48	84.11	142	81	61	284	280
HU	Sopron	10.84	12.78	85.13	196	24	65	285	281

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
NL	Greater 's-Gravenhage	9.57	21.51	78.11	153	98	35	286	282
FR	City of Rouen	10.66	16.57	79.39	190	56	40	286	283
PT	Vila Nova de Gaia	10.34	19.88	75.59	179	84	24	287	284
DE	Cottbus	11.11	13.05	83.03	205	26	56	287	285
FR	City of Reims	10.60	16.09	81.37	187	52	49	288	286
IT	Trapani	10.74	12.82	86.85	192	24	72	288	287
IT	Ragusa	11.21	10.49	87.30	209	5	74	288	288
LT	Alytus	11.89	12.64	77.65	232	23	33	288	289
PL	M. Gdynia	12.17	12.06	76.68	241	18	29	288	290
FR	City of Annecy	9.85	17.89	84.10	162	67	60	289	291
FR	City of Toulon	9.57	17.20	87.90	152	61	77	290	292
DE	Sankt Augustin	9.54	20.39	81.43	152	89	49	290	293
FR	City of Creil	10.52	16.51	81.30	185	56	49	290	294
FR	City of Lens	11.41	14.14	79.34	215	35	40	290	295
ES	Avilés	11.68	14.80	75.86	224	41	25	290	296
NL	Veenendaal	10.58	17.25	79.66	187	62	42	291	297
DE	Bamberg	10.06	18.24	82.39	169	70	53	292	298
HR	Rijeka	10.40	15.35	85.18	181	46	65	292	299
DE	Bonn	9.38	21.34	81.61	146	97	50	293	300
DE	Leverkusen	9.69	20.55	80.83	156	90	47	293	301
NL	Gouda	10.02	20.42	78.26	168	89	36	293	302
DE	Schweinfurt	10.08	18.17	82.39	170	70	53	293	303
NL	Greater Utrecht	10.24	19.59	78.42	175	82	36	293	304
DE	Bremen	10.28	19.01	78.99	177	77	39	293	305
NL	Roosendaal	10.36	18.91	78.78	179	76	38	293	306
NL	Oss	10.66	17.12	79.74	190	61	42	293	307
ES	A Coruña	11.71	14.47	76.81	226	38	29	293	308
NL	Breda	10.15	19.58	79.28	172	82	40	294	309
ES	Torrevieja	10.56	13.29	88.60	186	28	80	294	310
BE	Brugge	11.50	14.69	78.25	218	40	36	294	311
CH	Zürich	9.44	20.00	84.47	148	85	62	295	312
DE	Aschaffenburg	9.69	19.59	83.10	157	82	56	295	313
DE	Würzburg	9.76	19.35	82.96	159	80	56	295	314
NL	Zoetermeer	9.90	21.36	77.83	164	97	34	295	315
DE	Dresden	10.51	16.40	82.97	184	55	56	295	316
FR	City of Valenciennes	11.24	15.34	79.55	209	46	41	296	317
DE	Bocholt, Stadt	10.51	17.58	81.22	184	65	48	297	318
PT	Gondomar	10.51	20.85	74.31	185	93	19	297	319
IT	L'Aquila	10.83	14.44	84.99	195	38	64	297	320
DE	Heidelberg	9.61	20.07	83.62	154	86	58	298	321
ES	Toledo	10.46	14.68	87.39	183	40	75	298	322
ES	Reus	10.46	16.81	83.38	183	58	57	298	323

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
NL	Greater Arnhem	10.50	18.31	80.10	184	71	43	298	324
FR	City of Fréjus	10.52	13.62	89.04	185	31	82	298	325
DE	Landshut	10.15	18.32	82.97	172	71	56	299	326
DE	Hamburg	10.38	19.73	78.53	180	83	37	300	327
PL	M. Suwałki	12.61	11.41	77.46	256	12	32	300	328
CH	Basel	9.36	20.63	84.87	146	91	64	301	329
ES	Alicante/Alacant	10.14	16.53	87.00	172	56	73	301	330
DE	Mönchengladbach	9.82	20.80	81.36	161	92	49	302	331
ES	Dos Hermanas	10.38	15.79	87.29	180	49	74	303	332
FR	City of Dunkerque	11.52	15.75	78.06	219	49	35	303	333
CZ	České Budějovice	11.54	13.75	81.85	220	32	51	303	334
DE	Dortmund	9.96	20.69	81.06	166	91	47	304	335
IT	Reggio di Calabria	11.68	11.28	86.16	225	11	69	305	336
ES	Paterna	10.42	17.78	83.48	182	66	58	306	337
NL	Nijmegen	10.63	18.81	79.83	189	75	42	306	338
DE	Frankfurt (Oder)	11.87	12.62	82.08	231	23	52	306	339
FR	City of Annemasse	10.19	18.71	84.01	173	74	60	307	340
ES	Elche/Elx	10.55	15.99	86.41	186	51	70	307	341
NL	's-Hertogenbosch	10.57	19.27	79.65	187	79	41	307	342
IT	La Spezia	10.72	15.08	86.87	192	43	72	307	343
MT	Valletta (greater)	11.29	13.03	86.31	211	26	70	307	344
DE	Darmstadt	9.67	21.09	83.30	156	95	57	308	345
ES	Alcalá de Guadaíra	10.64	15.32	87.26	189	45	74	308	346
ES	Torrent	10.78	16.12	84.42	194	52	62	308	347
NL	Greater Amsterdam	10.30	21.71	77.51	177	100	32	309	348
DE	Erlangen	10.42	18.73	82.38	181	75	53	309	349
NL	Greater Nissewaard	10.44	21.00	77.69	182	94	33	309	350
ES	Torrelavega	12.57	13.16	76.15	255	27	27	309	351
ES	Lorca	11.30	12.38	88.01	212	21	77	310	352
BE	Mouscron	11.63	15.49	79.42	223	47	40	310	353
FR	City of Avignon	10.41	16.32	87.65	181	54	76	311	354
ES	Guadalajara	10.84	15.18	86.62	196	44	71	311	355
ES	Tarragona	11.04	15.82	83.42	203	50	58	311	356
DE	Augsburg	9.96	20.30	83.50	166	88	58	312	357
NL	Tilburg	10.49	19.97	79.97	184	85	43	312	358
LV	Riga	12.14	16.04	74.51	240	52	20	312	359
DE	Neu-Ulm	9.96	20.46	83.54	166	89	58	313	360
DE	Bochum	10.10	21.07	81.19	170	95	48	313	361
CZ	Jihlava	12.04	12.45	82.73	237	21	55	313	362
ES	Vilanova i la Geltrú	11.20	15.41	83.97	208	46	60	314	363
DE	Ulm	9.84	21.05	83.71	162	94	59	315	364
FR	City of Martigues	10.45	16.51	88.15	182	56	78	316	365

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
NL	Venlo	10.47	20.03	80.97	183	86	47	316	366
NL	Helmond	10.84	18.61	80.90	196	73	47	316	367
ES	Gijón	10.97	20.09	76.98	200	86	30	316	368
ES	Barakaldo	11.08	19.68	76.61	204	83	29	316	369
ES	San Sebastián de los Reyes	9.06	22.91	86.78	135	110	72	317	370
DE	Koblenz	9.74	22.43	82.35	158	106	53	317	371
DE	Wetzlar	10.07	20.74	82.72	170	92	55	317	372
ES	Valdemoro	10.12	18.78	86.47	171	75	71	317	373
BE	Mechelen	11.13	18.36	79.24	206	71	40	317	374
FR	City of Colmar	10.23	19.47	84.50	175	81	62	318	375
ES	Castellón de la Plana/Castelló de la Plana	10.38	18.56	85.10	180	73	65	318	376
FR	City of Chambéry	10.90	17.01	84.05	198	60	60	318	377
ES	Cuenca	10.25	19.55	84.32	176	82	61	319	378
BE	Kortrijk	11.76	16.09	79.42	227	52	40	319	379
FR	City of Aix-en-Provence	9.87	19.30	88.18	163	79	78	320	380
ES	Melilla	11.20	14.69	86.86	208	40	72	320	381
HR	Pula	11.27	14.23	87.30	210	36	74	320	382
IT	Messina	12.16	11.22	85.81	241	11	68	320	383
DE	Ingolstadt	10.52	19.38	83.16	185	80	56	321	384
DE	Regensburg	10.67	19.18	82.36	190	78	53	321	385
PT	Matosinhos	10.73	22.59	74.81	192	108	21	321	386
DE	Recklinghausen	10.49	20.82	80.89	184	92	47	323	387
ES	Bilbao	11.16	20.31	76.52	207	88	28	323	388
DE	Frankenthal (Pfalz)	10.12	21.83	82.17	171	101	52	324	389
ES	Algeciras	10.89	18.58	82.59	198	73	54	325	390
LT	Vilnius	12.67	14.33	76.72	259	37	29	325	391
DE	Karlsruhe	10.14	21.16	83.81	172	95	59	326	392
ES	Alcobendas	8.91	24.72	86.59	130	126	71	327	393
DE	Heilbronn	9.89	22.07	83.95	164	103	60	327	394
DE	Ludwigsburg	9.97	21.74	84.15	166	100	61	327	395
NL	Greater Rotterdam	10.22	23.85	77.69	175	119	33	327	396
DE	Passau	10.99	18.57	82.50	201	73	54	328	397
IT	Siracusa	11.58	13.28	88.40	221	28	79	328	398
DE	Esslingen am Neckar	10.02	21.75	84.11	168	100	61	329	399
IT	Gela	12.04	10.73	89.74	237	7	85	329	400
LT	Kaunas	12.72	14.43	77.25	260	38	31	329	401
DE	Neuss	10.11	23.36	80.42	171	114	45	330	402
DE	Speyer	10.20	21.54	83.30	174	99	57	330	403
NL	Greater Eindhoven	10.95	19.91	80.53	200	85	45	330	404

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
ES	Igualada	11.23	17.34	83.73	209	63	59	331	405
DE	Hanau	10.17	22.11	82.72	173	104	55	332	406
DE	Gießen	10.34	21.68	82.38	179	100	53	332	407
IT	Campobasso	11.27	16.21	85.88	211	53	68	332	408
ES	Cartagena	12.13	12.48	86.89	240	21	72	333	409
DE	Mainz	10.05	23.10	82.48	169	112	54	335	410
DE	Fürth	10.53	21.34	82.43	185	97	53	335	411
ES	Móstoles	9.44	23.89	86.01	148	119	69	336	412
FR	City of Mulhouse	10.78	19.14	85.09	194	78	65	337	413
PL	Stargard	13.20	12.56	78.77	277	22	38	337	414
DE	Wiesbaden	10.10	23.28	82.36	171	114	53	338	415
ES	Sevilla	10.35	19.90	87.16	179	85	74	338	416
BE	Bruxelles / Brussel (greater city)	10.59	23.42	78.38	187	115	36	338	417
IT	Savona	11.25	15.17	89.47	210	44	84	338	418
DE	Krefeld	10.51	22.85	80.74	184	110	46	340	419
IT	Massa	11.42	16.00	87.07	216	51	73	340	420
CZ	Plzeň	12.21	15.51	81.74	243	47	50	340	421
IT	Battipaglia	10.90	18.38	86.64	198	72	71	341	422
ES	Fuengirola	11.18	16.35	88.60	207	54	80	341	423
ES	Castelldefels	11.39	17.60	84.36	214	65	62	341	424
DE	Köln	9.95	25.34	80.46	166	131	45	342	425
CH	Geneva	10.13	23.16	83.45	171	113	58	342	426
DE	Herne	10.57	22.78	80.75	187	109	46	342	427
RO	MUNICIPIUL BISTRITA	12.07	18.90	76.39	238	76	28	342	428
ES	Córdoba	11.41	15.33	89.01	215	46	82	343	429
ES	Benalmádena	11.43	15.06	89.65	216	43	84	343	430
ES	Oviedo	12.23	18.45	76.21	244	72	27	343	431
ES	Rivas-Vaciamadrid	10.47	21.21	85.24	183	96	65	344	432
IT	Cosenza	11.66	16.59	85.24	224	56	65	345	433
GR	Kalamata	11.90	12.48	91.49	232	21	92	345	434
FR	City of Lille	12.02	18.39	78.66	236	72	37	345	435
ES	Alcorcón	9.29	25.73	85.92	143	135	68	346	436
PT	Porto	10.58	26.10	74.89	187	138	21	346	437
IT	Acireale	12.02	14.12	87.49	236	35	75	346	438
DE	Essen	10.53	23.39	80.89	185	115	47	347	439
ES	Línea de la Concepción, La	11.37	19.49	82.08	214	81	52	347	440
IT	Arezzo	12.38	14.01	84.82	249	34	64	347	441
HU	Zalaegerszeg	12.82	12.99	83.50	264	26	58	348	442
HR	Zadar	12.46	13.11	86.53	251	27	71	349	443
DE	München	10.09	24.64	82.82	170	125	55	350	444
DE	Stuttgart	10.11	23.96	83.86	171	120	59	350	445

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
AT	Salzburg	11.99	17.88	81.26	235	67	48	350	446
ES	Girona	11.25	19.15	84.68	210	78	63	351	447
HU	Szombathely	12.61	13.99	83.95	257	34	60	351	448
CZ	Kladno	12.36	15.34	83.54	248	46	58	352	449
PL	Tczew	13.48	13.99	77.09	287	34	31	352	450
PL	M. Elbląg	13.87	11.97	77.84	301	17	34	352	451
ES	Lleida	12.06	17.10	82.53	238	61	54	353	452
PL	Ełk	14.24	10.50	78.02	313	5	35	353	453
ES	Fuenlabrada	9.78	24.62	86.05	160	125	69	354	454
DE	Mülheim a.d.Ruhr	10.86	23.15	80.44	196	113	45	354	455
LT	Panevėžys	13.45	14.67	76.45	286	40	28	354	456
BE	Gent	11.98	19.58	78.94	235	82	38	355	457
DE	Düsseldorf	10.42	25.35	79.93	181	132	43	356	458
DE	Moers	10.96	23.03	80.43	200	111	45	356	459
HU	Veszprém	12.65	15.11	82.64	258	44	54	356	460
DE	Offenbach am Main	10.29	24.97	82.43	177	128	53	358	461
FR	City of Marseille	10.03	23.66	87.36	168	117	74	359	462
DE	Mannheim	10.37	24.76	82.40	180	126	53	359	463
FR	City of Lyon	10.45	23.69	84.01	182	117	60	359	464
ES	Alcalá de Henares	10.64	21.74	86.38	189	100	70	359	465
IT	Palermo	11.46	18.79	85.54	217	75	67	359	466
IT	Matera	12.22	14.64	87.60	243	40	76	359	467
RO	MUNICIPIUL PIATRA NEAMT	13.06	17.29	75.81	272	62	25	359	468
DE	Nürnberg	10.75	23.31	82.43	193	114	53	360	469
IT	Livorno	11.04	19.21	88.37	203	79	79	361	470
FR	City of Grenoble	11.20	20.83	83.99	208	93	60	361	471
CZ	Liberec	13.30	12.70	83.32	281	23	57	361	472
DE	Gelsenkirchen	10.95	23.50	80.60	200	116	46	362	473
DE	Berlin	11.79	20.03	81.27	228	86	48	362	474
IT	Altamura	12.03	16.06	87.30	236	52	74	362	475
ES	Parla	10.49	23.18	85.73	184	113	67	364	476
ES	Ciudad Real	12.37	14.79	87.55	248	41	75	364	477
DE	Ludwigshafen am Rhein	10.41	25.36	82.23	181	132	53	366	478
CZ	Chomutov-Jirkov	12.22	17.71	83.24	243	66	57	366	479
PT	Lisboa	11.27	24.04	78.60	210	120	37	367	480
ES	Murcia	12.21	16.03	86.75	243	52	72	367	481
PL	M. Gdańsk	13.80	14.93	76.33	298	42	27	367	482
IT	Brindisi	12.89	12.75	88.23	266	24	78	368	483
IT	Perugia	13.06	13.81	84.66	272	33	63	368	484
AT	Innsbruck	10.67	24.81	82.32	190	127	53	370	485
ES	Mislata	10.92	23.53	83.06	198	116	56	370	486
IT	Cerignola	11.93	17.06	88.03	233	60	77	370	487

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
IT	Genova	10.98	21.06	87.91	201	94	77	372	488
IT	Bisceglie	12.61	15.17	86.94	257	44	73	374	489
ES	Torremolinos	11.93	16.52	90.27	233	56	87	376	490
ES	Leganés	9.94	27.36	84.67	165	149	63	377	491
IT	Anzio	12.52	17.06	84.57	254	60	63	377	492
DE	Bottrop	11.39	23.77	80.46	215	118	45	378	493
IT	Trani	12.53	15.51	87.92	254	47	77	378	494
IT	Lecce	13.23	12.76	87.68	278	24	76	378	495
DE	Görlitz	13.75	13.18	82.74	296	27	55	378	496
ES	Torrejón de Ardoz	10.75	24.03	85.30	193	120	66	379	497
PL	M. Szczecin	13.93	14.14	79.50	303	35	41	379	498
IT	Trieste	11.57	20.50	85.99	221	90	69	380	499
IT	Bitonto	12.89	14.71	87.19	266	40	74	380	500
SK	Banská Bystrica	14.19	12.87	80.14	312	25	44	381	501
HU	Tatabánya	13.63	14.42	82.09	292	38	52	382	502
DE	Oberhausen	11.24	24.92	80.36	210	128	45	383	503
FR	City of Strasbourg	11.78	21.33	83.59	228	97	58	383	504
HU	Kaposvár	13.68	14.05	82.57	294	35	54	383	505
ES	Getafe	10.14	27.05	85.52	172	146	67	385	506
SK	Trnava	13.88	13.67	82.75	301	31	55	387	507
IT	Andria	12.25	18.33	86.94	244	71	73	388	508
IT	Taranto	12.76	15.78	87.96	262	49	77	388	509
DE	Frankfurt am Main	10.64	27.41	81.70	189	150	50	389	510
IT	Molfetta	12.77	15.94	87.90	262	51	77	390	511
SK	Bratislava	13.24	16.37	83.53	278	54	58	390	512
ES	Málaga	11.55	20.62	88.53	220	91	80	391	513
IT	Barletta	12.31	18.40	87.10	246	72	73	391	514
IT	Foggia	12.09	19.03	87.63	239	77	76	392	515
CH	Lugano	11.51	20.21	90.18	219	87	87	393	516
ES	Valencia	11.86	22.44	83.14	231	106	56	393	517
BE	Antwerpen	11.97	24.41	78.03	235	123	35	393	518
ES	Jaén	12.56	16.29	89.65	255	54	84	393	519
ES	Coslada	10.52	27.04	84.65	185	146	63	394	520
HU	Kecskemét	14.00	14.95	80.95	305	42	47	394	521
PL	M. Zielona Góra	14.31	12.67	82.75	316	23	55	394	522
HU	Győr	13.88	14.65	82.72	301	40	55	396	523
RO	MUNICIPIUL SATU MARE	14.15	15.68	78.58	310	49	37	396	524
CZ	Pardubice	13.94	14.47	83.08	303	38	56	397	525
IT	Avellino	12.27	19.01	87.76	245	77	76	398	526
DE	Duisburg	11.83	24.79	79.71	230	127	42	399	527
SK	Nitra	14.26	13.71	82.27	314	32	53	399	528
ES	Madrid	9.54	31.56	84.62	151	186	63	400	529
FR	City of Paris	11.08	28.04	79.44	204	155	41	400	530

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
AT	Klagenfurt	13.25	18.02	82.16	279	69	52	400	531
PL	M. Olsztyn	15.18	12.05	78.30	346	18	36	400	532
AT	Wien	12.12	21.96	83.90	240	102	60	402	533
HU	Székesfehérvár	13.80	16.31	81.95	298	54	51	403	534
BG	Sliven	13.98	17.28	78.60	304	62	37	403	535
CZ	Hradec Králové	14.28	13.70	83.13	315	32	56	403	536
ES	Manresa	12.89	19.37	84.21	266	80	61	407	537
ES	Linares	13.30	14.86	89.48	281	42	84	407	538
RO	MUNICIPIUL TULCEA	13.82	18.53	78.42	299	73	36	408	539
IT	Salerno	11.71	23.08	86.51	226	112	71	409	540
FR	City of Nice	11.74	22.46	87.98	226	107	77	410	541
IT	Catania	12.57	19.48	87.36	255	81	74	410	542
IT	Ancona	13.02	18.26	85.95	271	71	68	410	543
SK	Trenčín	14.51	14.31	81.88	323	37	51	411	544
CZ	Ústí nad Labem	13.81	16.68	83.94	298	57	60	415	545
PL	Piła	15.29	13.18	79.25	350	27	40	417	546
AT	Linz	12.98	21.34	81.80	270	97	51	418	547
CZ	Praha	13.29	19.66	83.21	280	82	57	419	548
IT	Latina	13.56	18.46	83.32	290	72	57	419	549
RO	MUNICIPIUL BIRLAD	14.44	17.81	77.50	320	67	32	419	550
HU	Szolnok	14.63	15.26	80.90	327	45	47	419	551
HU	Békéscsaba	14.60	15.81	80.27	326	50	44	420	552
SI	Maribor	14.02	17.06	83.06	306	60	56	422	553
PL	M. Jelenia Góra	14.99	12.93	83.28	340	25	57	422	554
IT	Pescara	13.24	18.93	86.09	279	76	69	424	555
ES	Mataró	12.87	21.58	84.00	266	99	60	425	556
IT	Terni	13.94	16.87	85.02	303	59	64	426	557
PL	M. Gorzów Wielkopolski	14.99	15.13	80.00	340	44	43	427	558
ES	Viladecans	13.19	21.15	83.05	277	95	56	428	559
CZ	Most	13.64	19.15	83.36	293	78	57	428	560
HU	Pécs	15.11	13.87	81.85	344	33	51	428	561
IT	Bari	13.59	17.54	87.36	291	64	74	429	562
PL	M. Toruń	15.58	13.67	78.89	361	31	38	430	563
RO	MUNICIPIUL Suceava	15.09	16.94	76.66	344	59	29	432	564
PL	M. Białystok	15.65	13.95	78.10	363	34	35	432	565
HU	Eger	15.10	15.11	80.43	344	44	45	433	566
IT	Pesaro	13.84	18.47	85.30	300	72	66	438	567
HU	Dunaújváros	14.82	16.31	81.57	334	54	50	438	568
PL	M. Grudziądź	16.03	13.24	77.76	377	28	33	438	569
RO	MUNICIPIUL FOCSANI	14.63	19.68	77.06	327	83	30	440	570

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
BG	Yambol	14.76	18.53	78.16	332	73	35	440	571
CZ	Zlín	15.44	13.46	82.64	356	30	54	440	572
ES	Granollers	12.88	24.01	82.93	266	120	55	441	573
GR	Patra	13.72	17.40	89.66	295	63	84	442	574
IT	Udine	14.07	18.24	85.69	308	70	67	445	575
CZ	Brno	14.66	17.14	83.13	328	61	56	445	576
HU	Szeged	15.23	16.13	80.59	349	52	45	446	577
IT	Firenze	13.00	23.11	85.25	270	112	65	447	578
ES	Sant Boi de Llobregat	13.46	23.25	81.18	286	113	48	447	579
IT	Pisa	13.74	19.63	86.08	296	82	69	447	580
IT	Giugliano in Campania	13.46	21.66	84.67	286	100	63	449	581
GR	Volos	14.19	18.83	84.66	312	75	63	450	582
GR	Katerini	14.64	17.18	84.46	327	61	62	450	583
PL	M. Wałbrzych	15.92	12.74	82.72	373	24	55	452	584
RO	MUNICIPIUL BRAILA	15.08	18.67	78.36	343	74	36	453	585
RO	MUNICIPIUL Baia Mare	15.61	17.20	77.04	362	61	30	453	586
GR	Trikala	14.64	16.53	86.34	328	56	70	454	587
RO	MUNICIPIUL BUZAU	14.99	19.74	77.37	340	83	32	455	588
ES	Sant Cugat del Vallès	14.09	21.31	81.98	308	97	51	456	589
GR	Chania	14.86	13.08	92.02	335	26	95	456	590
PL	M. Włocławek	16.26	13.86	79.56	385	33	41	459	591
PL	Inowrocław	16.30	14.22	78.69	386	36	37	459	592
RO	MUNICIPIUL SIBIU	14.74	21.89	76.28	331	102	27	460	593
RO	MUNICIPIUL CLUJ-NAPOCA	14.47	23.32	76.15	321	114	27	462	594
ES	Terrassa	13.40	24.52	82.73	284	124	55	463	595
IT	Rimini	14.67	17.74	86.12	329	66	69	464	596
RO	MUNICIPIUL ARAD	15.38	18.13	79.57	354	69	41	464	597
HU	Nyíregyháza	15.91	15.41	80.52	373	46	45	464	598
RO	MUNICIPIUL GALATI	15.00	20.46	78.56	340	89	37	466	599
ES	Rubí	13.94	23.32	82.03	303	114	52	469	600
IT	Forlì	15.05	16.62	86.33	342	57	70	469	601
ES	Prat de Llobregat, El	13.70	24.39	82.51	294	123	54	471	602
HR	Split	15.15	15.83	87.86	345	50	77	472	603
PL	Lubin	15.91	15.24	82.69	373	45	54	472	604
BG	Burgas	16.21	16.69	77.79	383	57	34	474	605
PL	M. Przemyśl	16.76	13.22	80.27	403	28	44	475	606
RO	MUNICIPIUL CONSTANTA	15.88	19.35	77.06	371	80	30	481	607

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
PL	Gniezno	16.71	14.77	79.32	401	41	40	482	608
PL	Świdnica	16.38	14.76	82.36	389	41	53	483	609
PL	M. Bydgoszcz	16.44	16.37	78.74	391	54	38	483	610
ES	Cornellà de Llobregat	13.64	26.71	81.18	293	143	48	484	611
GR	Ioannina	15.27	17.34	86.65	350	63	71	484	612
RO	MUNICIPIUL Târgu Mures	15.60	21.30	76.63	361	97	29	487	613
IT	Napoli	13.28	27.54	83.79	280	151	59	490	614
ES	Esplugues de Llobregat	13.71	27.17	81.18	295	147	48	490	615
AT	Graz	14.79	22.00	82.89	333	103	55	491	616
RO	MUNICIPIUL ALBA IULIA	15.95	20.21	76.89	374	87	30	491	617
CZ	Olomouc	16.08	16.89	82.60	379	59	54	492	618
RO	MUNICIPIUL CALARASI	16.30	18.07	78.54	386	69	37	492	619
BG	Dobrich	16.38	17.89	78.43	389	67	36	492	620
ES	Sabadell	14.00	25.88	82.27	305	136	53	494	621
PL	M. Konin	17.18	13.81	80.25	418	33	44	495	622
PL	M. Zamość	17.25	14.34	79.73	420	37	42	499	623
IT	Caserta	14.72	22.59	84.55	330	108	62	500	624
HU	Debrecen	16.35	17.88	80.53	388	67	45	500	625
CY	Lemesos	14.54	23.50	84.15	324	116	61	501	626
ES	Cerdanyola del Vallès	14.46	25.28	81.65	321	131	50	502	627
PL	M. Chełm	17.27	14.60	79.73	421	39	42	502	628
SK	Prešov	17.07	14.76	81.20	414	41	48	503	629
IT	Bolzano	13.96	25.62	85.41	304	134	66	504	630
BG	Stara Zagora	16.70	17.59	79.09	401	65	39	505	631
PL	M. Płock	17.59	13.90	79.17	433	33	39	505	632
PL	M. Łomża	17.74	13.82	78.45	438	33	36	507	633
RO	MUNICIPIUL TIRGOVISTE	16.16	21.11	77.43	381	95	32	508	634
PL	Głogów	16.92	15.64	82.22	408	48	52	508	635
HU	Miskolc	17.32	14.50	80.84	423	39	47	509	636
ES	Mollet del Vallès	14.78	24.56	82.37	332	125	53	510	637
RO	MUNICIPIUL ORADEA	16.23	20.34	78.95	384	88	38	510	638
RO	MUNICIPIUL ROMAN	16.86	18.81	76.63	406	75	29	510	639
ES	Almería	16.11	14.77	90.94	380	41	90	511	640
ES	Badalona	13.86	28.75	83.15	300	161	56	517	641
IT	Prato	15.32	21.54	85.64	351	99	67	517	642
SK	Žilina	17.13	16.85	80.02	416	58	43	517	643
BG	Shumen	17.38	16.38	78.84	425	54	38	517	644
GR	Kavala	17.15	14.92	83.75	417	42	59	518	645

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
GR	Iraklio	15.24	18.56	92.69	349	73	97	519	646
RO	MUNICIPIUL BRASOV	15.82	24.79	75.78	369	127	25	521	647
RO	MUNICIPIUL BOTOSANI	16.76	20.55	77.06	403	90	30	523	648
PL	M. Leszno	17.59	14.84	81.71	432	41	50	523	649
BG	Haskovo	17.42	16.34	80.25	427	54	44	525	650
SK	Košice	17.46	16.44	80.31	428	55	44	527	651
PL	M. Legnica	17.16	16.74	82.34	417	58	53	528	652
IT	Roma	14.32	28.66	82.25	316	160	53	529	653
BG	Varna	16.67	20.66	78.74	400	91	38	529	654
CY	Lefkosia	14.73	25.55	85.41	331	133	66	530	655
IT	Ravenna	16.92	16.00	86.66	409	51	71	531	656
ES	Santa Coloma de Gramenet	13.87	31.19	81.64	300	182	50	532	657
IT	Lecco	15.06	20.77	92.88	342	92	98	532	658
PL	M. Rzeszów	18.16	14.19	80.07	453	36	43	532	659
PL	Stalowa Wola	17.91	15.09	80.86	444	44	47	535	660
PL	Ostrowiec Świętokrzyski	17.91	15.66	80.36	444	48	44	536	661
IT	Bologna	15.64	21.83	87.71	363	101	76	540	662
BG	Veliko Tarnovo	17.97	17.30	77.66	446	62	33	541	663
GR	Larissa	15.95	20.84	87.43	374	93	75	542	664
PL	M. Siedlce	18.34	15.03	79.06	460	43	39	542	665
BG	Blagoevgrad	17.60	18.36	78.99	433	71	39	543	666
IT	Sassuolo	16.11	20.18	88.52	380	87	80	547	667
HU	Budapest	15.58	26.26	81.15	361	139	48	548	668
IT	Varese	15.67	20.65	91.75	364	91	93	548	669
GR	Serres	16.87	20.15	82.49	407	87	54	548	670
RO	MUNICIPIUL RAMNICU VALCEA	17.20	21.43	77.39	418	98	32	548	671
GR	Xanthi	17.83	16.78	81.58	441	58	50	549	672
CY	Greater Larnaka	15.50	24.22	86.22	358	122	70	550	673
ES	Granada	15.67	22.65	88.86	364	108	81	553	674
PL	M. Poznań	17.49	19.70	79.52	429	83	41	553	675
ES	L' Hospitalet de Llobregat	14.40	31.79	81.35	319	188	49	556	676
IT	Trento	15.31	25.33	87.35	351	131	74	556	677
RO	MUNICIPIUL GIURGIU	17.72	20.22	77.60	437	87	33	557	678
RO	MUNICIPIUL TIMISOARA	16.98	23.04	78.25	411	112	35	558	679
PL	M. Wrocław	17.60	19.22	81.87	433	79	51	563	680
PL	M. Lublin	18.38	17.15	79.58	461	61	41	563	681
BG	Ruse	17.88	20.41	77.65	443	89	33	565	682
IT	Como	15.81	21.75	92.49	369	100	97	566	683

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
RO	MUNICIPIUL BACAU	18.03	20.62	76.28	448	91	27	566	684
ES	Barcelona	14.51	32.71	81.69	323	196	50	569	685
SI	Ljubljana	17.60	19.55	82.73	433	82	55	570	686
BG	Vratsa	18.99	16.91	77.10	483	59	31	573	687
RO	MUNICIPIUL PITESTI	18.32	20.07	77.52	459	86	32	577	688
CZ	Havířov	18.58	17.19	81.34	468	61	49	578	689
PL	M. Opole	18.80	15.91	82.39	476	51	53	580	690
IT	Pordenone	17.09	21.29	86.05	415	97	69	581	691
BG	Pernik	18.90	17.42	79.06	480	63	39	582	692
PL	Ostrów Wielkopolski	19.12	15.13	81.71	488	44	50	582	693
HR	Zagreb	17.55	21.32	84.22	431	97	61	589	694
RO	MUNICIPIUL IASI	18.19	22.85	76.60	454	110	28	592	695
PL	M. Radom	18.73	18.88	80.02	474	76	43	593	696
RO	MUNICIPIUL PLOIESTI	18.31	22.47	76.57	459	107	28	594	697
PL	Tomaszów Mazowiecki	19.38	16.15	80.73	497	52	46	595	698
PL	Pabianice	19.39	16.95	80.76	498	59	46	603	699
PL	Zgierz	19.97	14.85	80.61	519	41	46	606	700
IT	Parma	17.88	19.93	88.96	443	85	81	609	701
CZ	Ostrava	19.35	17.21	81.77	496	62	51	609	702
PL	M. Kielce	19.18	18.59	81.10	490	73	48	611	703
IT	Ferrara	18.16	19.25	88.99	453	79	81	613	704
PL	M. Kalisz	19.87	16.10	81.14	516	52	48	616	705
IT	Reggio nell'Emilia	18.21	20.23	88.65	455	87	80	622	706
BG	Pleven	20.53	16.64	76.71	539	57	29	625	707
BG	Pazardzhik	19.82	18.87	78.66	514	76	37	627	708
IT	Asti	18.52	19.28	89.48	466	79	84	629	709
HR	Osijek	20.05	16.62	82.69	522	57	54	633	710
IT	Alessandria	18.01	21.96	89.84	448	102	85	635	711
PL	M. Piotrków Trybunalski	20.09	18.21	80.61	523	70	46	639	712
PL	M. Częstochowa	20.10	18.00	81.36	524	68	49	641	713
GR	Athina	17.13	27.14	88.37	416	147	79	642	714
CZ	Karviná	20.40	17.47	81.68	535	64	50	649	715
IT	Novara	18.49	22.12	90.02	465	104	86	655	716
RO	MUNICIPIUL TIRGU JIU	19.90	22.40	77.74	517	106	33	656	717
PL	M. Warszawa	19.74	22.96	78.95	510	111	38	659	718
IT	Modena	18.81	22.38	88.77	477	106	81	664	719
PL	M. Nowy Sącz	21.00	17.43	80.91	557	63	47	667	720
PL	M. Tarnów	21.10	17.63	80.07	560	65	43	668	721
IT	Gallarate	18.11	25.73	91.22	451	135	91	677	722

Country (ISO2 code)	City	$PM_{2.5}$	NO_2	O_3	$PSI_{PM2.5}$	PSI_{NO2}	PSI_{O3}	index	rank
PL	M. Bielsko-Biała	21.23	17.89	81.27	565	67	48	680	723
PL	M. Łódź	21.38	18.35	80.53	571	71	45	687	724
RO	MUNICIPIUL SLATINA	21.29	20.69	77.62	568	91	33	692	725
IT	Piacenza	18.97	24.42	90.85	483	123	90	696	726
GR	Thessaloniki	19.52	27.48	81.27	502	150	48	700	727
IT	Carpi	19.71	22.57	89.74	510	108	85	703	728
IT	Busto Arsizio	18.70	26.53	91.90	473	142	94	709	729
IT	Pavia	19.62	23.85	91.96	506	119	94	719	730
RO	MUNICIPIUL BUCURESTI	19.18	32.80	77.76	490	197	33	720	731
PL	M. Jastrzębie-Zdrój	22.25	18.10	81.38	603	69	49	721	732
RO	MUNICIPIUL CRAIOVA	21.94	22.14	77.43	592	104	32	728	733
IT	Saronno	18.98	29.30	92.71	483	166	98	747	734
PL	M. Żory	22.70	19.22	81.48	620	79	49	748	735
BG	Plovdiv	22.08	24.12	77.94	597	121	34	752	736
PL	M. Rybnik	23.08	18.18	81.69	634	70	50	754	737
RO	MUNICIPIUL DROBETA-TURNU SEVER	23.20	19.98	77.28	639	85	31	755	738
IT	Venezia	20.76	26.22	86.54	548	139	71	758	739
IT	Bergamo	20.12	27.21	91.50	524	148	92	764	740
PL	M. Gliwice	22.85	20.40	81.60	626	89	50	765	741
BG	Vidin	24.71	15.92	77.88	696	51	34	781	742
PL	M. Zabrze	23.36	20.93	81.45	645	93	49	787	743
PL	M. Tychy	23.35	21.00	81.57	645	94	50	789	744
IT	Treviso	22.16	23.85	87.30	600	119	74	793	745
IT	Verona	21.45	25.62	90.76	574	134	89	797	746
BG	Sofia	22.89	26.76	76.62	627	144	29	800	747
PL	M. Ruda Śląska	23.67	20.90	81.60	657	93	50	800	748
PL	M. Bytom	24.09	21.57	81.72	673	99	50	822	749
PL	M. Katowice	24.34	22.66	81.29	682	108	48	838	750
PL	M. Sosnowiec	24.37	22.67	81.05	683	108	47	838	751
IT	Padova	22.62	27.18	88.46	617	147	79	843	752
PL	M. Chorzów	24.26	23.61	81.61	679	117	50	846	753
IT	Cremona	22.98	24.68	91.10	631	126	91	848	754
IT	Monza	20.61	36.96	91.31	542	233	92	867	755
HR	Slavonski Brod	26.42	16.31	83.64	761	54	59	874	756
IT	Milano	20.72	39.50	90.77	547	256	89	892	757
IT	Vicenza	24.16	25.93	89.37	675	137	83	895	758
IT	Torino	22.42	33.71	89.73	610	205	85	900	759
PL	M. Kraków	25.94	24.25	80.54	743	122	45	910	760
IT	Brescia	24.07	29.29	91.16	672	166	91	929	761

Table A1.3 Ranking based on the current EEA and proposed methodology based on 2019 and 2020 data (validated interpolated maps)

Country	City	Ranking	
		EEA's current method	Proposed methodology
Sweden	Umeå	1	1
Portugal	Faro	2	20
Portugal	Funchal	3	NA
Finland	Tampere / Tammerfors	4	2
Estonia	Narva	5	8
Sweden	Stockholm (greater city)	6	6
Sweden	Uppsala	7	4
Estonia	Tallinn	8	10
Norway	Bergen	9	7
Iceland	Reykjavik	10	3
Sweden	Norrköping	11	5
Spain	Las Palmas	12	NA
Finland	Helsinki / Helsingfors (greater city)	13	12
Estonia	Tartu	14	11
France	Les Abymes	15	NA
Italy	Sassari	16	18
Norway	Trondheim	17	9
Spain	Salamanca	18	15
Sweden	Göteborg	19	14
France	Saint Denis	20	NA
France	Brest	21	17
France	Pau	22	36
France	Montpellier	23	70
Denmark	Århus	24	22
Germany	Göttingen	25	47
Norway	Oslo	26	28
Netherlands	Greater 's-Gravenhage	27	106
France	Bayonne	28	24
Denmark	Aalborg	29	16
France	Dijon	30	43
Norway	Stavanger	31	13
Spain	Oviedo	32	173
France	Perpignan	33	52
Spain	San Fernando	34	79
Ireland	Dublin	35	34
Spain	Cartagena	36	163
Spain	Málaga	37	210
Ireland	Cork	38	23
Germany	Freiburg im Breisgau	39	53
Spain	Telde	40	NA
Spain	Línea de la Concepción, La	41	177

Country	City	Ranking	
		EEA's current method	Proposed methodology
Belgium	Liège	42	49
Spain	Santa Cruz de Tenerife	43	NA
Denmark	København	44	40
Spain	Ceuta	45	71
Belgium	Namur	46	51
Netherlands	Groningen	47	44
Lithuania	Vilnius	48	154
Netherlands	Breda	49	118
Austria	Salzburg	50	181
Netherlands	Greater Heerlen	51	56
France	Calais	52	85
Germany	Villingen-Schwenningen	53	30
France	Saint-Etienne	54	73
Spain	Santiago de Compostela	55	29
Germany	Hannover	56	67
Germany	Kaiserslautern	56	66
Netherlands	Enschede	58	100
Sweden	Malmö	59	21
Germany	Leipzig	60	102
France	Clermont-Ferrand	61	46
France	Limoges	62	31
France	Toulon	63	111
Germany	Kassel	64	89
Spain	San Sebastián/Donostia	65	39
Germany	Osnabrück	66	75
Italy	Livorno	67	192
Germany	Darmstadt	68	141
France	Nîmes	69	87
Germany	Mönchengladbach	70	132
Belgium	Charleroi	71	78
France	Saint-Nazaire	72	25
Ireland	Limerick	73	64
Germany	Kempten (Allgäu)	74	60
Switzerland	Zürich (greater city)	75	120
Italy	Catanzaro	76	95
France	La Rochelle	77	32
Germany	Reutlingen	78	94
France	Besançon	79	57
Austria	Innsbruck	80	201
France	Annecy	81	110
Portugal	Lisboa (greater city)	82	197
France	Aix-en-Provence	83	152
Italy	Battipaglia	84	171

Country	City	Ranking	
		EEA's current method	Proposed methodology
France	Troyes	85	55
Germany	Wiesbaden	86	166
France	Poitiers	87	38
Germany	Marburg	88	101
Germany	Tübingen	89	81
Spain	Albacete	90	103
Germany	München	91	179
Bulgaria	Sofia	92	327
Germany	Pforzheim	93	86
Luxembourg	Luxembourg	94	69
Switzerland	Basel (greater city)	95	130
France	Lorient	96	26
Germany	Karlsruhe	97	155
Spain	Elda	98	72
Germany	Konstanz	99	83
France	Tours	100	45
France	Le Mans	101	37
France	Bourges	102	19
France	Metz	103	77
France	Chartres	104	27
Germany	Bremerhaven	105	88
Italy	Grosseto	106	74
Austria	Klagenfurt	107	223
France	Annemasse	108	139
Germany	Würzburg	109	122
Germany	Saarbrücken	110	80
Belgium	Mons	111	92
Germany	Heidelberg	112	125
Germany	Dresden	113	123
Germany	Rostock	114	58
Croatia	Rijeka	115	114
Germany	Erfurt	116	62
France	Angers	117	42
Germany	Wuppertal	118	98
Italy	Genova	119	202
France	Orléans	120	33
Spain	Madrid	121	221
Germany	Heilbronn	122	156
Netherlands	Greater Rotterdam	123	158
Germany	Potsdam	124	96
Germany	Ludwigsburg	125	157
Germany	Frankfurt am Main	126	208
France	Dunkerque	127	133

Country	City	Ranking	
		EEA's current method	Proposed methodology
Italy	Salerno	128	227
France	Caen	129	48
Ireland	Waterford	130	35
France	Nice	131	228
Germany	Brandenburg an der Havel	132	63
Germany	Augsburg	133	144
Germany	Stuttgart	134	180
France	Toulouse	135	76
France	Nantes	136	41
France	Marseille	137	188
Italy	Campobasso	138	162
France	Fort-de-France	139	NA
France	Chambéry	140	151
Netherlands	Greater Amsterdam	141	142
Germany	Lübeck	142	59
France	Le Havre	143	61
France	Rennes	144	54
Germany	Ulm	145	148
Italy	Savona	146	169
Germany	Bremen	147	116
Spain	Sevilla	148	167
Germany	Halle an der Saale	149	93
France	Cayenne	150	NA
Spain	Jaén	151	216
Netherlands	Zaanstad	152	99
Germany	Magdeburg	153	82
Germany	Aschaffenburg	154	121
Spain	Gijón	155	149
Germany	Hamburg	156	128
France	Bordeaux	157	68
Belgium	Bruxelles / Brussel	158	168
Germany	Neu-Ulm	159	146
Germany	Mainz	160	164
France	Nancy	161	91
Germany	Düsseldorf	162	186
Spain	Valencia	163	214
Germany	Weimar	164	50
France	Valence	165	104
Italy	L'Aquila	166	124
Germany	Dortmund	167	135
France	Avignon	168	143
Germany	Essen	169	176
France	Grenoble	170	193

Country	City	Ranking	
		EEA's current method	Proposed methodology
Netherlands	Greater Utrecht	171	115
Belgium	Brugge	172	119
France	Creil	173	112
France	Reims	174	109
Germany	Friedrichshafen	175	97
Spain	Zaragoza	176	65
France	Strasbourg	177	207
Germany	Bamberg	178	113
Czechia	Kladno	179	182
France	Rouen	180	107
France	Paris (greater city)	181	222
Italy	Reggio di Calabria	182	136
Czechia	Plzen	183	170
Germany	Frankfurt (Oder)	184	138
Czechia	Ústí nad Labem	185	230
Italy	La Spezia	186	140
Netherlands	Nijmegen	187	137
Germany	Mülheim a.d.Ruhr	188	184
Germany	Cottbus	189	108
Poland	Koszalin	190	90
Germany	Speyer	191	160
Austria	Wien	192	225
Latvia	Riga	193	145
France	Douai	194	105
Italy	Perugia	195	200
Netherlands	Greater Eindhoven	196	161
Germany	Gelsenkirchen	197	195
France	Lyon	198	189
Switzerland	Lugano (greater city)	199	213
Spain	Bilbao	200	153
Czechia	Ceské Budejovice	201	134
France	Fréjus	202	127
France	Amiens	203	84
Germany	Passau	204	159
Italy	Palermo	205	190
Poland	Zielona Góra	206	217
Slovenia	Maribor	207	234
Italy	Brindisi	208	199
Germany	Nürnberg	209	191
Italy	Latina	210	233
France	Mulhouse	211	165
Spain	Valdemoro	212	150
Germany	Berlin	213	196

Country	City	Ranking	
		EEA's current method	Proposed methodology
Austria	Linz	214	231
Spain	Toledo	215	126
Italy	Cosenza	216	174
Belgium	Gent	217	185
Czechia	Liberec	218	194
Italy	Foggia	219	212
Belgium	Antwerpen	220	215
Czechia	Praha	221	232
Poland	Suwalki	222	129
Spain	Córdoba	223	172
Spain	Alicante/Alacant	224	131
Italy	Trieste	225	205
France	Lille	226	175
Greece	Athina	227	309
Hungary	Veszprém	228	187
Poland	Szczecin	229	204
Spain	Torrejón de Ardoz	230	203
Romania	Baia Mare	231	253
Cyprus	Lemesos	232	265
Italy	Caserta	233	264
Italy	Firenze	234	250
Italy	Barletta	235	211
Czechia	Jihlava	236	147
Italy	Pesaro	237	244
Hungary	Pécs	238	240
Czechia	EBDdec Králové	239	226
Slovakia	Bratislava	240	209
Italy	Napoli (greater city)	241	260
Italy	Roma	242	274
Italy	Arezzo	243	178
Spain	Barcelona	244	292
Poland	Walbrzych	245	252
Italy	Trento	246	288
Italy	Ancona	247	229
Poland	Torun	248	241
Romania	Târgu Mures	249	259
Italy	Pisa	250	251
Czechia	Pardubice	251	219
Cyprus	Lefkosia	252	276
Spain	Granada	253	286
Poland	Rzeszów	254	279
Italy	Forlì	255	256
Czechia	Brno	256	248

Country	City	Ranking	
		EEA's current method	Proposed methodology
Bulgaria	Varna	257	275
Poland	Olsztyn	258	224
Spain	A Coruña	259	117
Austria	Graz	260	261
Italy	Lecco	261	278
Italy	Pescara	262	236
Italy	Udine	263	247
Slovakia	Banská Bystrica	264	206
Poland	Bydgoszcz	265	258
Czechia	Most	266	239
Slovakia	Nitra	267	220
Hungary	Budapest	268	285
Poland	Elblag	269	183
Romania	Suceava	270	242
Poland	Gdansk	271	198
Hungary	Gyõr	272	218
Poland	Bialystok	273	243
Italy	Bologna	274	281
Czechia	Zlín	275	246
Poland	Gorzów Wielkopolski	276	238
Bulgaria	Plovdiv	277	321
Italy	Prato	278	270
Slovenia	Ljubljana	279	293
Czechia	Olomouc	280	262
Poland	Grudziadz	281	245
Croatia	Zagreb	282	296
Poland	Legnica	283	273
Poland	Plock	284	268
Poland	Opole	285	295
Slovakia	Kosice	286	272
Poland	Wroclaw	287	289
Poland	Warszawa	288	312
Italy	Rimini	289	255
Poland	Wloclawek	290	254
Italy	Sassuolo	291	284
Poland	Chelm	292	266
Bulgaria	Stara Zagora	293	267
Poland	Poznan	294	287
Poland	Lódz	295	317
Czechia	Ostrava	296	300
Poland	Tarnów	297	315
Italy	Parma	298	299
Poland	Czestochowa	299	308

Country	City	Ranking	
		EEA's current method	Proposed methodology
Bulgaria	Ruse	300	291
Italy	Ferrara	301	302
Hungary	Szeged	302	249
Italy	Novara	303	311
Slovakia	Zilina	304	271
Poland	Przemysl	305	257
Czechia	Karviná	306	310
Poland	Zamosc	307	263
Italy	Modena	308	313
Bulgaria	Veliko Tarnovo	309	282
Italy	Reggio nell'Emilia	310	304
Poland	Siedlce	311	283
Czechia	Havírov	312	294
Italy	Terni	313	237
Italy	Ravenna	314	277
Italy	Torino	315	334
Poland	Ostrowiec Swietokrzyski	316	280
Poland	Radom	317	297
Italy	Milano (greater city)	318	332
Poland	Jelenia Góra	319	235
Italy	Bergamo	320	323
Poland	Lublin	321	290
Poland	Bielsko-Biala	322	316
Poland	Kielce	323	301
Poland	Kraków	324	335
Poland	Kalisz	325	303
Italy	Alessandria	326	306
Italy	Piacenza	327	318
Poland	Piotrków Trybunalski	328	307
Poland	Katowice	329	328
Italy	Pavia	330	319
Italy	Treviso	331	325
Italy	Verona	332	326
Italy	Asti	333	305
Poland	Zory	334	320
Poland	Gliwice	335	324
Poland	Lomza	336	269
Poland	Zgierz	337	298
Italy	Brescia	338	336
Croatia	Slavonski Brod	339	331
Italy	Vicenza	340	333
Italy	Venezia	341	322
Italy	Padova	342	329

Country	City	Ranking	
		EEA's current method	Proposed methodology
Italy	Cremona	343	330
Poland	Nowy Sacz	344	314

Table A1.4 Pollutant sub-index (PSI), associated risk (RR) and respective (maximum) concentration levels for $PM_{2.5}$, NO_2, and SOMO35 for O_3 based on population-weighted concentrations for 2021 and 2022

PSI	RR	PM2.5	NO2	O3
0	1.0000	5.00	10.00	70.00
1	1.0002	5.03	10.11	70.23
2	1.0005	5.06	10.23	70.45
3	1.0007	5.09	10.34	70.68
4	1.0009	5.12	10.46	70.91
5	1.0011	5.15	10.57	71.13
6	1.0014	5.18	10.68	71.36
7	1.0016	5.21	10.80	71.59
8	1.0018	5.23	10.91	71.81
9	1.0020	5.26	11.03	72.04
10	1.0023	5.29	11.14	72.27
11	1.0025	5.32	11.25	72.49
12	1.0027	5.35	11.37	72.72
13	1.0029	5.38	11.48	72.95
14	1.0032	5.41	11.59	73.17
15	1.0034	5.44	11.71	73.40
16	1.0036	5.47	11.82	73.62
17	1.0038	5.50	11.93	73.85
18	1.0041	5.53	12.05	74.08
19	1.0043	5.56	12.16	74.30
20	1.0045	5.59	12.28	74.53
21	1.0047	5.61	12.39	74.75
22	1.0050	5.64	12.50	74.98
23	1.0052	5.67	12.62	75.21
24	1.0054	5.70	12.73	75.43
25	1.0056	5.73	12.84	75.66
26	1.0059	5.76	12.96	75.88
27	1.0061	5.79	13.07	76.11
28	1.0063	5.82	13.18	76.33
29	1.0065	5.85	13.30	76.56
30	1.0068	5.88	13.41	76.78
31	1.0070	5.91	13.52	77.01
32	1.0072	5.94	13.64	77.24
33	1.0075	5.96	13.75	77.46
34	1.0077	5.99	13.86	77.69

PSI	RR	PM2.5	NO2	O3
35	1.0079	6.02	13.97	77.91
36	1.0081	6.05	14.09	78.14
37	1.0084	6.08	14.20	78.36
38	1.0086	6.11	14.31	78.59
39	1.0088	6.14	14.43	78.81
40	1.0090	6.17	14.54	79.04
41	1.0093	6.20	14.65	79.26
42	1.0095	6.23	14.77	79.49
43	1.0097	6.26	14.88	79.71
44	1.0099	6.28	14.99	79.93
45	1.0102	6.31	15.10	80.16
46	1.0104	6.34	15.22	80.38
47	1.0106	6.37	15.33	80.61
48	1.0108	6.40	15.44	80.83
49	1.0111	6.43	15.56	81.06
50	1.0113	6.46	15.67	81.28
51	1.0115	6.49	15.78	81.51
52	1.0117	6.52	15.89	81.73
53	1.0120	6.55	16.01	81.95
54	1.0122	6.57	16.12	82.18
55	1.0124	6.60	16.23	82.40
56	1.0126	6.63	16.34	82.63
57	1.0129	6.66	16.46	82.85
58	1.0131	6.69	16.57	83.08
59	1.0133	6.72	16.68	83.30
60	1.0135	6.75	16.80	83.52
61	1.0138	6.78	16.91	83.75
62	1.0140	6.81	17.02	83.97
63	1.0142	6.84	17.13	84.19
64	1.0145	6.86	17.24	84.42
65	1.0147	6.89	17.36	84.64
66	1.0149	6.92	17.47	84.87
67	1.0151	6.95	17.58	85.09
68	1.0154	6.98	17.69	85.31
69	1.0156	7.01	17.81	85.54
70	1.0158	7.04	17.92	85.76
71	1.0160	7.07	18.03	85.98
72	1.0163	7.10	18.14	86.21
73	1.0165	7.12	18.26	86.43
74	1.0167	7.15	18.37	86.65
75	1.0169	7.18	18.48	86.88
76	1.0172	7.21	18.59	87.10
77	1.0174	7.24	18.70	87.32
78	1.0176	7.27	18.82	87.54

PSI	RR	PM2.5	NO2	O3
79	1.0178	7.30	18.93	87.77
80	1.0181	7.33	19.04	87.99
81	1.0183	7.35	19.15	88.21
82	1.0185	7.38	19.26	88.44
83	1.0187	7.41	19.38	88.66
84	1.0190	7.44	19.49	88.88
85	1.0192	7.47	19.60	89.10
86	1.0194	7.50	19.71	89.33
87	1.0196	7.53	19.82	89.55
88	1.0199	7.56	19.94	89.77
89	1.0201	7.59	20.05	89.99
90	1.0203	7.61	20.16	90.22
91	1.0205	7.64	20.27	90.44
92	1.0208	7.67	20.38	90.66
93	1.0210	7.70	20.49	90.88
94	1.0212	7.73	20.61	91.11
95	1.0214	7.76	20.72	91.33
96	1.0217	7.79	20.83	91.55
97	1.0219	7.82	20.94	91.77
98	1.0221	7.84	21.05	91.99
99	1.0224	7.87	21.16	92.22
100	1.0226	7.90	21.27	92.44
101	1.0228	7.93	21.39	92.66
102	1.0230	7.96	21.50	92.88
103	1.0233	7.99	21.61	93.10
104	1.0235	8.02	21.72	93.33
105	1.0237	8.04	21.83	93.55
106	1.0239	8.07	21.94	93.77
107	1.0242	8.10	22.05	93.99
108	1.0244	8.13	22.17	94.21
109	1.0246	8.16	22.28	94.43
110	1.0248	8.19	22.39	94.66
111	1.0251	8.22	22.50	94.88
112	1.0253	8.24	22.61	95.10
113	1.0255	8.27	22.72	95.32
114	1.0257	8.30	22.83	95.54
115	1.0260	8.33	22.94	95.76
116	1.0262	8.36	23.06	95.98
117	1.0264	8.39	23.17	96.20
118	1.0266	8.42	23.28	96.43
119	1.0269	8.45	23.39	96.65
120	1.0271	8.47	23.50	96.87
121	1.0273	8.50	23.61	97.09
122	1.0275	8.53	23.72	97.31

PSI	RR	PM2.5	NO2	O3
123	1.0278	8.56	23.83	97.53
124	1.0280	8.59	23.94	97.75
125	1.0282	8.62	24.05	97.97
126	1.0284	8.64	24.17	98.19
127	1.0287	8.67	24.28	98.41
128	1.0289	8.70	24.39	98.63
129	1.0291	8.73	24.50	98.85
130	1.0294	8.76	24.61	99.07
131	1.0296	8.79	24.72	99.29
132	1.0298	8.82	24.83	99.51
133	1.0300	8.84	24.94	99.73
134	1.0303	8.87	25.05	99.96
135	1.0305	8.90	25.16	100.18
136	1.0307	8.93	25.27	100.40
137	1.0309	8.96	25.38	100.62
138	1.0312	8.99	25.49	100.84
139	1.0314	9.02	25.60	101.06
140	1.0316	9.04	25.72	101.28
141	1.0318	9.07	25.83	101.50
142	1.0321	9.10	25.94	101.72
143	1.0323	9.13	26.05	101.94
144	1.0325	9.16	26.16	102.16
145	1.0327	9.19	26.27	102.37
146	1.0330	9.21	26.38	102.59
147	1.0332	9.24	26.49	102.81
148	1.0334	9.27	26.60	103.03
149	1.0336	9.30	26.71	103.25
150	1.0339	9.33	26.82	103.47
151	1.0341	9.36	26.93	103.69
152	1.0343	9.38	27.04	103.91
153	1.0345	9.41	27.15	104.13
154	1.0348	9.44	27.26	104.35
155	1.0350	9.47	27.37	104.57
156	1.0352	9.50	27.48	104.79
157	1.0354	9.53	27.59	105.01
158	1.0357	9.55	27.70	105.23
159	1.0359	9.58	27.81	105.45
160	1.0361	9.61	27.92	105.67
161	1.0364	9.64	28.03	105.88
162	1.0366	9.67	28.14	106.10
163	1.0368	9.70	28.25	106.32
164	1.0370	9.72	28.36	106.54
165	1.0373	9.75	28.47	106.76
166	1.0375	9.78	28.58	106.98

PSI	RR	PM2.5	NO2	O3
167	1.0377	9.81	28.69	107.20
168	1.0379	9.84	28.80	107.42
169	1.0382	9.87	28.91	107.63
170	1.0384	9.89	29.02	107.85
171	1.0386	9.92	29.13	108.07
172	1.0388	9.95	29.24	108.29
173	1.0391	9.98	29.35	108.51
174	1.0393	10.01	29.46	108.73
175	1.0395	10.04	29.57	108.94
176	1.0397	10.06	29.68	109.16
177	1.0400	10.09	29.79	109.38
178	1.0402	10.12	29.90	109.60
179	1.0404	10.15	30.01	109.82
180	1.0406	10.18	30.12	110.04
181	1.0409	10.20	30.23	110.25
182	1.0411	10.23	30.34	110.47
183	1.0413	10.26	30.45	110.69
184	1.0415	10.29	30.56	110.91
185	1.0418	10.32	30.66	111.13
186	1.0420	10.35	30.77	111.34
187	1.0422	10.37	30.88	111.56
188	1.0424	10.40	30.99	111.78
189	1.0427	10.43	31.10	112.00
190	1.0429	10.46	31.21	112.21
191	1.0431	10.49	31.32	112.43
192	1.0434	10.51	31.43	112.65
193	1.0436	10.54	31.54	112.87
194	1.0438	10.57	31.65	113.08
195	1.0440	10.60	31.76	113.30
196	1.0443	10.63	31.87	113.52
197	1.0445	10.65	31.98	113.74
198	1.0447	10.68	32.09	113.95
199	1.0449	10.71	32.19	114.17
200	1.0452	10.74	32.30	114.39
201	1.0454	10.77	32.41	114.60
202	1.0456	10.79	32.52	114.82
203	1.0458	10.82	32.63	115.04
204	1.0461	10.85	32.74	115.26
205	1.0463	10.88	32.85	115.47
206	1.0465	10.91	32.96	115.69
207	1.0467	10.94	33.07	115.91
208	1.0470	10.96	33.18	116.12
209	1.0472	10.99	33.28	116.34
210	1.0474	11.02	33.39	116.56

PSI	RR	PM2.5	NO2	O3
211	1.0476	11.05	33.50	116.77
212	1.0479	11.08	33.61	116.99
213	1.0481	11.10	33.72	117.21
214	1.0483	11.13	33.83	117.42
215	1.0485	11.16	33.94	117.64
216	1.0488	11.19	34.05	117.86
217	1.0490	11.22	34.15	118.07
218	1.0492	11.24	34.26	118.29
219	1.0494	11.27	34.37	118.50
220	1.0497	11.30	34.48	118.72
221	1.0499	11.33	34.59	118.94
222	1.0501	11.35	34.70	119.15
223	1.0503	11.38	34.81	119.37
224	1.0506	11.41	34.91	119.58
225	1.0508	11.44	35.02	119.80
226	1.0510	11.47	35.13	120.02
227	1.0513	11.49	35.24	120.23
228	1.0515	11.52	35.35	120.45
229	1.0517	11.55	35.46	120.66
230	1.0519	11.58	35.57	120.88
231	1.0522	11.61	35.67	121.10
232	1.0524	11.63	35.78	121.31
233	1.0526	11.66	35.89	121.53
234	1.0528	11.69	36.00	121.74
235	1.0531	11.72	36.11	121.96
236	1.0533	11.75	36.22	122.17
237	1.0535	11.77	36.32	122.39
238	1.0537	11.80	36.43	122.60
239	1.0540	11.83	36.54	122.82
240	1.0542	11.86	36.65	123.03
241	1.0544	11.88	36.76	123.25
242	1.0546	11.91	36.86	123.46
243	1.0549	11.94	36.97	123.68
244	1.0551	11.97	37.08	123.89
245	1.0553	12.00	37.19	124.11
246	1.0555	12.02	37.30	124.32
247	1.0558	12.05	37.40	124.54
248	1.0560	12.08	37.51	124.75
249	1.0562	12.11	37.62	124.97
250	1.0564	12.13	37.73	125.18
251	1.0567	12.16	37.84	125.40
252	1.0569	12.19	37.94	125.61
253	1.0571	12.22	38.05	125.83
254	1.0573	12.25	38.16	126.04

PSI	RR	PM2.5	NO2	O3
255	1.0576	12.27	38.27	126.26
256	1.0578	12.30	38.38	126.47
257	1.0580	12.33	38.48	126.69
258	1.0583	12.36	38.59	126.90
259	1.0585	12.38	38.70	127.12
260	1.0587	12.41	38.81	127.33
261	1.0589	12.44	38.91	127.54
262	1.0592	12.47	39.02	127.76
263	1.0594	12.50	39.13	127.97
264	1.0596	12.52	39.24	128.19
265	1.0598	12.55	39.35	128.40
266	1.0601	12.58	39.45	128.62
267	1.0603	12.61	39.56	128.83
268	1.0605	12.63	39.67	129.04
269	1.0607	12.66	39.78	129.26
270	1.0610	12.69	39.88	129.47
271	1.0612	12.72	39.99	129.68
272	1.0614	12.74	40.10	129.90
273	1.0616	12.77	40.21	130.11
274	1.0619	12.80	40.31	130.33
275	1.0621	12.83	40.42	130.54
276	1.0623	12.85	40.53	130.75
277	1.0625	12.88	40.63	130.97
278	1.0628	12.91	40.74	131.18
279	1.0630	12.94	40.85	131.39
280	1.0632	12.97	40.96	131.61
281	1.0634	12.99	41.06	131.82
282	1.0637	13.02	41.17	132.03
283	1.0639	13.05	41.28	132.25
284	1.0641	13.08	41.39	132.46
285	1.0643	13.10	41.49	132.67
286	1.0646	13.13	41.60	132.89
287	1.0648	13.16	41.71	133.10
288	1.0650	13.19	41.81	133.31
289	1.0653	13.21	41.92	133.53
290	1.0655	13.24	42.03	133.74
291	1.0657	13.27	42.13	133.95
292	1.0659	13.30	42.24	134.17
293	1.0662	13.32	42.35	134.38
294	1.0664	13.35	42.46	134.59
295	1.0666	13.38	42.56	134.80
296	1.0668	13.41	42.67	135.02
297	1.0671	13.43	42.78	135.23
298	1.0673	13.46	42.88	135.44

PSI	RR	PM2.5	NO2	O3
299	1.0675	13.49	42.99	135.65
300	1.0677	13.52	43.10	135.87
301	1.0680	13.54	43.20	136.08
302	1.0682	13.57	43.31	136.29
303	1.0684	13.60	43.42	136.50
304	1.0686	13.63	43.52	136.72
305	1.0689	13.65	43.63	136.93
306	1.0691	13.68	43.74	137.14
307	1.0693	13.71	43.84	137.35
308	1.0695	13.74	43.95	137.57
309	1.0698	13.76	44.06	137.78
310	1.0700	13.79	44.16	137.99
311	1.0702	13.82	44.27	138.20
312	1.0704	13.85	44.38	138.41
313	1.0707	13.87	44.48	138.63
314	1.0709	13.90	44.59	138.84
315	1.0711	13.93	44.70	139.05
316	1.0713	13.95	44.80	139.26
317	1.0716	13.98	44.91	139.47
318	1.0718	14.01	45.01	139.68
319	1.0720	14.04	45.12	139.90
320	1.0723	14.06	45.23	140.11
321	1.0725	14.09	45.33	140.32
322	1.0727	14.12	45.44	140.53
323	1.0729	14.15	45.55	140.74
324	1.0732	14.17	45.65	140.95
325	1.0734	14.20	45.76	141.17
326	1.0736	14.23	45.87	141.38
327	1.0738	14.26	45.97	141.59
328	1.0741	14.28	46.08	141.80
329	1.0743	14.31	46.18	142.01
330	1.0745	14.34	46.29	142.22
331	1.0747	14.36	46.40	142.43
332	1.0750	14.39	46.50	142.64
333	1.0752	14.42	46.61	142.86
334	1.0754	14.45	46.71	143.07
335	1.0756	14.47	46.82	143.28
336	1.0759	14.50	46.93	143.49
337	1.0761	14.53	47.03	143.70
338	1.0763	14.56	47.14	143.91
339	1.0765	14.58	47.24	144.12
340	1.0768	14.61	47.35	144.33
341	1.0770	14.64	47.46	144.54
342	1.0772	14.66	47.56	144.75

PSI	RR	PM2.5	NO2	O3
343	1.0774	14.69	47.67	144.96
344	1.0777	14.72	47.77	145.17
345	1.0779	14.75	47.88	145.38
346	1.0781	14.77	47.98	145.60
347	1.0783	14.80	48.09	145.81
348	1.0786	14.83	48.20	146.02
349	1.0788	14.86	48.30	146.23
350	1.0790	14.88	48.41	146.44
351	1.0793	14.91	48.51	146.65
352	1.0795	14.94	48.62	146.86
353	1.0797	14.96	48.72	147.07
354	1.0799	14.99	48.83	147.28
355	1.0802	15.02	48.94	147.49
356	1.0804	15.05	49.04	147.70
357	1.0806	15.07	49.15	147.91
358	1.0808	15.10	49.25	148.12
359	1.0811	15.13	49.36	148.33
360	1.0813	15.15	49.46	148.54
361	1.0815	15.18	49.57	148.75
362	1.0817	15.21	49.67	148.96
363	1.0820	15.24	49.78	149.17
364	1.0822	15.26	49.88	149.38
365	1.0824	15.29	49.99	149.59
366	1.0826	15.32	50.10	149.80
367	1.0829	15.34	50.20	150.01
368	1.0831	15.37	50.31	150.22
369	1.0833	15.40	50.41	150.42
370	1.0835	15.43	50.52	150.63
371	1.0838	15.45	50.62	150.84
372	1.0840	15.48	50.73	151.05
373	1.0842	15.51	50.83	151.26
374	1.0844	15.53	50.94	151.47
375	1.0847	15.56	51.04	151.68
376	1.0849	15.59	51.15	151.89
377	1.0851	15.61	51.25	152.10
378	1.0853	15.64	51.36	152.31
379	1.0856	15.67	51.46	152.52
380	1.0858	15.70	51.57	152.73
381	1.0860	15.72	51.67	152.93
382	1.0862	15.75	51.78	153.14
383	1.0865	15.78	51.88	153.35
384	1.0867	15.80	51.99	153.56
385	1.0869	15.83	52.09	153.77
386	1.0872	15.86	52.20	153.98

PSI	RR	PM2.5	NO2	O3
387	1.0874	15.88	52.30	154.19
388	1.0876	15.91	52.41	154.40
389	1.0878	15.94	52.51	154.60
390	1.0881	15.97	52.62	154.81
391	1.0883	15.99	52.72	155.02
392	1.0885	16.02	52.83	155.23
393	1.0887	16.05	52.93	155.44
394	1.0890	16.07	53.04	155.65
395	1.0892	16.10	53.14	155.86
396	1.0894	16.13	53.25	156.06
397	1.0896	16.15	53.35	156.27
398	1.0899	16.18	53.45	156.48
399	1.0901	16.21	53.56	156.69
400	1.0903	16.23	53.66	156.90
401	1.0905	16.26	53.77	157.10
402	1.0908	16.29	53.87	157.31
403	1.0910	16.32	53.98	157.52
404	1.0912	16.34	54.08	157.73
405	1.0914	16.37	54.19	157.94
406	1.0917	16.40	54.29	158.14
407	1.0919	16.42	54.40	158.35
408	1.0921	16.45	54.50	158.56
409	1.0923	16.48	54.60	158.77
410	1.0926	16.50	54.71	158.98
411	1.0928	16.53	54.81	159.18
412	1.0930	16.56	54.92	159.39
413	1.0932	16.58	55.02	159.60
414	1.0935	16.61	55.13	159.81
415	1.0937	16.64	55.23	160.01
416	1.0939	16.66	55.33	160.22
417	1.0942	16.69	55.44	160.43
418	1.0944	16.72	55.54	160.64
419	1.0946	16.75	55.65	160.84
420	1.0948	16.77	55.75	161.05
421	1.0951	16.80	55.85	161.26
422	1.0953	16.83	55.96	161.47
423	1.0955	16.85	56.06	161.67
424	1.0957	16.88	56.17	161.88
425	1.0960	16.91	56.27	162.09
426	1.0962	16.93	56.38	162.29
427	1.0964	16.96	56.48	162.50
428	1.0966	16.99	56.58	162.71
429	1.0969	17.01	56.69	162.91
430	1.0971	17.04	56.79	163.12

PSI	RR	PM2.5	NO2	O3
431	1.0973	17.07	56.89	163.33
432	1.0975	17.09	57.00	163.53
433	1.0978	17.12	57.10	163.74
434	1.0980	17.15	57.21	163.95
435	1.0982	17.17	57.31	164.15
436	1.0984	17.20	57.41	164.36
437	1.0987	17.23	57.52	164.57
438	1.0989	17.25	57.62	164.77
439	1.0991	17.28	57.73	164.98
440	1.0993	17.31	57.83	165.19
441	1.0996	17.33	57.93	165.39
442	1.0998	17.36	58.04	165.60
443	1.1000	17.39	58.14	165.81
444	1.1002	17.41	58.24	166.01
445	1.1005	17.44	58.35	166.22
446	1.1007	17.47	58.45	166.42
447	1.1009	17.49	58.55	166.63
448	1.1012	17.52	58.66	166.84
449	1.1014	17.55	58.76	167.04
450	1.1016	17.57	58.87	167.25
451	1.1018	17.60	58.97	167.46
452	1.1021	17.63	59.07	167.66
453	1.1023	17.65	59.18	167.87
454	1.1025	17.68	59.28	168.07
455	1.1027	17.71	59.38	168.28
456	1.1030	17.73	59.49	168.48
457	1.1032	17.76	59.59	168.69
458	1.1034	17.79	59.69	168.90
459	1.1036	17.81	59.80	169.10
460	1.1039	17.84	59.90	169.31
461	1.1041	17.87	60.00	169.51
462	1.1043	17.89	60.11	169.72
463	1.1045	17.92	60.21	169.92
464	1.1048	17.95	60.31	170.13
465	1.1050	17.97	60.42	170.33
466	1.1052	18.00	60.52	170.54
467	1.1054	18.03	60.62	170.74
468	1.1057	18.05	60.72	170.95
469	1.1059	18.08	60.83	171.16
470	1.1061	18.10	60.93	171.36
471	1.1063	18.13	61.03	171.57
472	1.1066	18.16	61.14	171.77
473	1.1068	18.18	61.24	171.98
474	1.1070	18.21	61.34	172.18

PSI	RR	PM2.5	NO2	O3
475	1.1072	18.24	61.45	172.39
476	1.1075	18.26	61.55	172.59
477	1.1077	18.29	61.65	172.80
478	1.1079	18.32	61.76	173.00
479	1.1082	18.34	61.86	173.20
480	1.1084	18.37	61.96	173.41
481	1.1086	18.40	62.06	173.61
482	1.1088	18.42	62.17	173.82
483	1.1091	18.45	62.27	174.02
484	1.1093	18.48	62.37	174.23
485	1.1095	18.50	62.47	174.43
486	1.1097	18.53	62.58	174.64
487	1.1100	18.56	62.68	174.84
488	1.1102	18.58	62.78	175.05
489	1.1104	18.61	62.89	175.25
490	1.1106	18.63	62.99	175.45
491	1.1109	18.66	63.09	175.66
492	1.1111	18.69	63.19	175.86
493	1.1113	18.71	63.30	176.07
494	1.1115	18.74	63.40	176.27
495	1.1118	18.77	63.50	176.48
496	1.1120	18.79	63.60	176.68
497	1.1122	18.82	63.71	176.88
498	1.1124	18.85	63.81	177.09
499	1.1127	18.87	63.91	177.29
500	1.1129	18.90	64.01	177.50
501	1.1131	18.92	64.12	177.70
502	1.1133	18.95	64.22	177.90
503	1.1136	18.98	64.32	178.11
504	1.1138	19.00	64.42	178.31
505	1.1140	19.03	64.53	178.51
506	1.1142	19.06	64.63	178.72
507	1.1145	19.08	64.73	178.92
508	1.1147	19.11	64.83	179.13
509	1.1149	19.14	64.94	179.33
510	1.1151	19.16	65.04	179.53
511	1.1154	19.19	65.14	179.74
512	1.1156	19.21	65.24	179.94
513	1.1158	19.24	65.34	180.14
514	1.1161	19.27	65.45	180.35
515	1.1163	19.29	65.55	180.55
516	1.1165	19.32	65.65	180.75
517	1.1167	19.35	65.75	180.96
518	1.1170	19.37	65.85	181.16

PSI	RR	PM2.5	NO2	O3
519	1.1172	19.40	65.96	181.36
520	1.1174	19.42	66.06	181.57
521	1.1176	19.45	66.16	181.77
522	1.1179	19.48	66.26	181.97
523	1.1181	19.50	66.36	182.17
524	1.1183	19.53	66.47	182.38
525	1.1185	19.56	66.57	182.58
526	1.1188	19.58	66.67	182.78
527	1.1190	19.61	66.77	182.99
528	1.1192	19.63	66.87	183.19
529	1.1194	19.66	66.98	183.39
530	1.1197	19.69	67.08	183.59
531	1.1199	19.71	67.18	183.80
532	1.1201	19.74	67.28	184.00
533	1.1203	19.77	67.38	184.20
534	1.1206	19.79	67.49	184.40
535	1.1208	19.82	67.59	184.61
536	1.1210	19.84	67.69	184.81
537	1.1212	19.87	67.79	185.01
538	1.1215	19.90	67.89	185.21
539	1.1217	19.92	67.99	185.42
540	1.1219	19.95	68.10	185.62
541	1.1221	19.97	68.20	185.82
542	1.1224	20.00	68.30	186.02
543	1.1226	20.03	68.40	186.23
544	1.1228	20.05	68.50	186.43
545	1.1231	20.08	68.60	186.63
546	1.1233	20.11	68.70	186.83
547	1.1235	20.13	68.81	187.03
548	1.1237	20.16	68.91	187.24
549	1.1240	20.18	69.01	187.44
550	1.1242	20.21	69.11	187.64
551	1.1244	20.24	69.21	187.84
552	1.1246	20.26	69.31	188.04
553	1.1249	20.29	69.41	188.24
554	1.1251	20.31	69.52	188.45
555	1.1253	20.34	69.62	188.65
556	1.1255	20.37	69.72	188.85
557	1.1258	20.39	69.82	189.05
558	1.1260	20.42	69.92	189.25
559	1.1262	20.44	70.02	189.45
560	1.1264	20.47	70.12	189.66
561	1.1267	20.50	70.23	189.86
562	1.1269	20.52	70.33	190.06

PSI	RR	PM2.5	NO2	O3
563	1.1271	20.55	70.43	190.26
564	1.1273	20.57	70.53	190.46
565	1.1276	20.60	70.63	190.66
566	1.1278	20.63	70.73	190.86
567	1.1280	20.65	70.83	191.06
568	1.1282	20.68	70.93	191.27
569	1.1285	20.70	71.03	191.47
570	1.1287	20.73	71.14	191.67
571	1.1289	20.76	71.24	191.87
572	1.1291	20.78	71.34	192.07
573	1.1294	20.81	71.44	192.27
574	1.1296	20.83	71.54	192.47
575	1.1298	20.86	71.64	192.67
576	1.1301	20.89	71.74	192.87
577	1.1303	20.91	71.84	193.07
578	1.1305	20.94	71.94	193.27
579	1.1307	20.96	72.04	193.48
580	1.1310	20.99	72.14	193.68
581	1.1312	21.02	72.25	193.88
582	1.1314	21.04	72.35	194.08
583	1.1316	21.07	72.45	194.28
584	1.1319	21.09	72.55	194.48
585	1.1321	21.12	72.65	194.68
586	1.1323	21.15	72.75	194.88
587	1.1325	21.17	72.85	195.08
588	1.1328	21.20	72.95	195.28
589	1.1330	21.22	73.05	195.48
590	1.1332	21.25	73.15	195.68
591	1.1334	21.28	73.25	195.88
592	1.1337	21.30	73.35	196.08
593	1.1339	21.33	73.45	196.28
594	1.1341	21.35	73.55	196.48
595	1.1343	21.38	73.65	196.68
596	1.1346	21.40	73.75	196.88
597	1.1348	21.43	73.86	197.08
598	1.1350	21.46	73.96	197.28
599	1.1352	21.48	74.06	197.48
600	1.1355	21.51	74.16	197.68
601	1.1357	21.53	74.26	197.88
602	1.1359	21.56	74.36	198.08
603	1.1361	21.59	74.46	198.28
604	1.1364	21.61	74.56	198.48
605	1.1366	21.64	74.66	198.68
606	1.1368	21.66	74.76	198.88

PSI	RR	PM2.5	NO2	O3
607	1.1371	21.69	74.86	199.08
608	1.1373	21.71	74.96	199.28
609	1.1375	21.74	75.06	199.48
610	1.1377	21.77	75.16	199.68
611	1.1380	21.79	75.26	199.88
612	1.1382	21.82	75.36	200.08
613	1.1384	21.84	75.46	200.28
614	1.1386	21.87	75.56	200.47
615	1.1389	21.89	75.66	200.67
616	1.1391	21.92	75.76	200.87
617	1.1393	21.95	75.86	201.07
618	1.1395	21.97	75.96	201.27
619	1.1398	22.00	76.06	201.47
620	1.1400	22.02	76.16	201.67
621	1.1402	22.05	76.26	201.87
622	1.1404	22.08	76.36	202.07
623	1.1407	22.10	76.46	202.27
624	1.1409	22.13	76.56	202.47
625	1.1411	22.15	76.66	202.66
626	1.1413	22.18	76.76	202.86
627	1.1416	22.20	76.86	203.06
628	1.1418	22.23	76.96	203.26
629	1.1420	22.26	77.06	203.46
630	1.1422	22.28	77.16	203.66
631	1.1425	22.31	77.26	203.86
632	1.1427	22.33	77.36	204.06
633	1.1429	22.36	77.46	204.25
634	1.1431	22.38	77.56	204.45
635	1.1434	22.41	77.66	204.65
636	1.1436	22.43	77.76	204.85
637	1.1438	22.46	77.86	205.05
638	1.1441	22.49	77.96	205.25
639	1.1443	22.51	78.06	205.44
640	1.1445	22.54	78.16	205.64
641	1.1447	22.56	78.26	205.84
642	1.1450	22.59	78.36	206.04
643	1.1452	22.61	78.46	206.24
644	1.1454	22.64	78.56	206.44
645	1.1456	22.67	78.66	206.63
646	1.1459	22.69	78.75	206.83
647	1.1461	22.72	78.85	207.03
648	1.1463	22.74	78.95	207.23
649	1.1465	22.77	79.05	207.43
650	1.1468	22.79	79.15	207.62

PSI	RR	PM2.5	NO2	O3
651	1.1470	22.82	79.25	207.82
652	1.1472	22.84	79.35	208.02
653	1.1474	22.87	79.45	208.22
654	1.1477	22.90	79.55	208.41
655	1.1479	22.92	79.65	208.61
656	1.1481	22.95	79.75	208.81
657	1.1483	22.97	79.85	209.01
658	1.1486	23.00	79.95	209.21
659	1.1488	23.02	80.05	209.40
660	1.1490	23.05	80.15	209.60
661	1.1492	23.07	80.24	209.80
662	1.1495	23.10	80.34	210.00
663	1.1497	23.13	80.44	210.19
664	1.1499	23.15	80.54	210.39
665	1.1501	23.18	80.64	210.59
666	1.1504	23.20	80.74	210.78
667	1.1506	23.23	80.84	210.98
668	1.1508	23.25	80.94	211.18
669	1.1510	23.28	81.04	211.38
670	1.1513	23.30	81.14	211.57
671	1.1515	23.33	81.24	211.77
672	1.1517	23.36	81.34	211.97
673	1.1520	23.38	81.43	212.16
674	1.1522	23.41	81.53	212.36
675	1.1524	23.43	81.63	212.56
676	1.1526	23.46	81.73	212.76
677	1.1529	23.48	81.83	212.95
678	1.1531	23.51	81.93	213.15
679	1.1533	23.53	82.03	213.35
680	1.1535	23.56	82.13	213.54
681	1.1538	23.58	82.23	213.74
682	1.1540	23.61	82.32	213.94
683	1.1542	23.63	82.42	214.13
684	1.1544	23.66	82.52	214.33
685	1.1547	23.69	82.62	214.53
686	1.1549	23.71	82.72	214.72
687	1.1551	23.74	82.82	214.92
688	1.1553	23.76	82.92	215.11
689	1.1556	23.79	83.02	215.31
690	1.1558	23.81	83.11	215.51
691	1.1560	23.84	83.21	215.70
692	1.1562	23.86	83.31	215.90
693	1.1565	23.89	83.41	216.10
694	1.1567	23.91	83.51	216.29

PSI	RR	PM2.5	NO2	O3
695	1.1569	23.94	83.61	216.49
696	1.1571	23.96	83.71	216.68
697	1.1574	23.99	83.80	216.88
698	1.1576	24.02	83.90	217.08
699	1.1578	24.04	84.00	217.27
700	1.1580	24.07	84.10	217.47
701	1.1583	24.09	84.20	217.66
702	1.1585	24.12	84.30	217.86
703	1.1587	24.14	84.39	218.06
704	1.1590	24.17	84.49	218.25
705	1.1592	24.19	84.59	218.45
706	1.1594	24.22	84.69	218.64
707	1.1596	24.24	84.79	218.84
708	1.1599	24.27	84.89	219.04
709	1.1601	24.29	84.98	219.23
710	1.1603	24.32	85.08	219.43
711	1.1605	24.34	85.18	219.62
712	1.1608	24.37	85.28	219.82
713	1.1610	24.40	85.38	220.01
714	1.1612	24.42	85.48	220.21
715	1.1614	24.45	85.57	220.40
716	1.1617	24.47	85.67	220.60
717	1.1619	24.50	85.77	220.79
718	1.1621	24.52	85.87	220.99
719	1.1623	24.55	85.97	221.18
720	1.1626	24.57	86.06	221.38
721	1.1628	24.60	86.16	221.58
722	1.1630	24.62	86.26	221.77
723	1.1632	24.65	86.36	221.97
724	1.1635	24.67	86.46	222.16
725	1.1637	24.70	86.55	222.36
726	1.1639	24.72	86.65	222.55
727	1.1641	24.75	86.75	222.75
728	1.1644	24.77	86.85	222.94
729	1.1646	24.80	86.95	223.14
730	1.1648	24.82	87.04	223.33
731	1.1650	24.85	87.14	223.52
732	1.1653	24.87	87.24	223.72
733	1.1655	24.90	87.34	223.91
734	1.1657	24.92	87.44	224.11
735	1.1660	24.95	87.53	224.30
736	1.1662	24.98	87.63	224.50
737	1.1664	25.00	87.73	224.69
738	1.1666	25.03	87.83	224.89

PSI	RR	PM2.5	NO2	O3
739	1.1669	25.05	87.92	225.08
740	1.1671	25.08	88.02	225.28
741	1.1673	25.10	88.12	225.47
742	1.1675	25.13	88.22	225.66
743	1.1678	25.15	88.32	225.86
744	1.1680	25.18	88.41	226.05
745	1.1682	25.20	88.51	226.25
746	1.1684	25.23	88.61	226.44
747	1.1687	25.25	88.71	226.64
748	1.1689	25.28	88.80	226.83
749	1.1691	25.30	88.90	227.02
750	1.1693	25.33	89.00	227.22
751	1.1696	25.35	89.10	227.41
752	1.1698	25.38	89.19	227.61
753	1.1700	25.40	89.29	227.80
754	1.1702	25.43	89.39	227.99
755	1.1705	25.45	89.49	228.19
756	1.1707	25.48	89.58	228.38
757	1.1709	25.50	89.68	228.58
758	1.1711	25.53	89.78	228.77
759	1.1714	25.55	89.88	228.96
760	1.1716	25.58	89.97	229.16
761	1.1718	25.60	90.07	229.35

Table A1.5 Ranking based on the proposed methodology based on 2021 (validated maps) and 2022 (interim maps) data, with (2021a-2022a) and without (2021-2022) an extra step in calculations to avoid smoothing, and based on 2019 and 2020 validated maps (2019-2020)

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
SE	Umeå	1	2	2
FI	Kuopio	2	3	3
FI	Oulu	3	1	1
SE	Uppsala	4	6	8
SE	Västerås	5	10	10
IS	Reykjavík	6	8	6
FI	Tampere	7	4	4
SE	Norrköping	8	13	11
SE	Södertälje	9	14	14
SE	Stockholm	10	9	15
SE	Örebro	11	12	9
FI	Espoo	12	5	17
FI	Jyväskylä	13	11	7
FI	Lahti	14	7	12
NO	Troms	15	15	5
PT	Faro	16	16	43
SE	Linköping	17	17	13
NO	Bergen	18	24	16
FI	Turku	19	19	20
FI	Helsinki	20	20	25
NO	Trondheim	21	23	22
EE	Tallinn	22	21	23
EE	Narva	23	18	19
FI	Vantaa	24	22	27
EE	Tartu	25	25	24
SE	Jönköping	26	26	21
SE	Bor s	27	27	18
NO	Stavanger	28	30	26
NO	Kristiansand	29	29	29
SE	Lund	30	28	40
SE	Malmö	31	32	47
ES	Pontevedra	32	31	73
SE	Helsingborg	33	33	46
DK	Aalborg	34	37	37
ES	Ávila	35	34	34
ES	Burgos	36	36	41
PT	Viana do Castelo	37	35	44
FR	Brest	38	40	38
DK	Århus	39	38	48

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
ES	Palencia	40	39	49
ES	Santiago de Compostela	41	41	62
ES	Alcoy Alcoi	42	43	61
SE	Göteborg	43	42	30
IE	Cork	44	45	50
PT	Viseu	45	44	28
DK	Odense	46	47	63
DK	København	47	50	86
ES	Cáceres	48	46	31
ES	Zamora	49	48	35
FR	Saint Brieuc	50	55	55
NL	Leeuwarden	51	54	71
ES	Mérida	52	49	32
IE	Galway	53	65	51
IE	Dublin	54	68	76
ES	Vigo	55	52	125
ES	Lugo	56	56	74
BE	Verviers	57	58	52
IT	Sassari	58	51	39
FR	Cherbourg en Cotentin	59	71	64
DE	Kiel	60	60	139
ES	Salamanca	61	62	36
ES	Badajoz	62	53	33
DE	Flensburg	63	63	120
IE	Waterford	64	76	77
PT	Setúbal	65	59	83
NO	Oslo	66	67	59
DE	Lübeck	67	57	138
NL	Alkmaar	68	70	119
ES	Ourense	69	64	60
FR	Bourges	70	86	42
PT	Póvoa de Varzim	71	61	87
DE	Villingen Schwenningen	72	77	67
FR	Bayonne	73	73	53
PT	Sintra	74	72	78
ES	Chiclana de la Frontera	75	66	146
FR	Saint Nazaire	76	90	54
ES	Gandia	77	93	129
DE	Stralsund	78	94	75
DE	Neumünster	79	79	166
ES	Ponferrada	80	74	45
ES	Benidorm	81	88	105
ES	Irun	82	92	58

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
NL	Assen	83	83	102
FR	La Rochelle	84	102	70
DE	Schwerin	85	80	96
FR	Limoges	86	101	68
DE	Salzgitter	87	75	85
ES	Collado Villalba	88	78	65
FR	Béziers	89	96	66
NL	Hoorn	90	89	152
NL	Groningen	91	91	98
ES	Logro o	92	69	206
DE	Lüneburg	93	85	106
FR	Lorient	94	114	56
FR	Chartres	95	107	57
FR	Poitiers	96	118	82
FR	Dijon	97	122	93
DE	Celle	98	82	95
DE	Hildesheim	99	84	97
ES	San Fernando	100	81	192
DE	Kempten Allgäu	101	121	140
ES	Ferrol	102	108	172
NL	Lelystad	103	105	158
DE	Wilhelmshaven	104	98	148
DE	Wolfsburg	105	95	100
DE	Weimar	106	106	113
PT	Vila Franca de Xira	107	97	104
FR	Roanne	108	132	127
ES	San Sebastián Donostia	109	127	84
FR	Le Mans	110	131	81
FR	Troyes	111	119	121
NL	Heemskerk	112	110	171
FR	Nantes	113	135	90
DE	Trier	114	116	109
FR	Tours	115	130	101
DE	Göttingen	116	87	107
DE	Plauen	117	112	137
ES	León	118	111	88
DE	Rostock	119	120	130
DE	Greifswald	120	138	94
PT	Seixal	121	100	168
ES	Eivissa	122	133	89
ES	Cádiz	123	99	218
BE	Namur	124	141	114
FR	Clermont Ferrand	125	151	103

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
ES	El Puerto de Santa María	126	103	187
DE	Aachen	127	129	79
IT	Cagliari	128	104	99
ES	Huelva	129	109	133
DE	Erfurt	130	123	145
DE	Zwickau	131	134	162
FR	Angers	132	149	92
PT	Almada	133	115	201
ES	Sanlúcar de Barrameda	134	113	151
NL	Purmerend	135	136	193
DE	Braunschweig	136	124	136
PT	Barreiro	137	117	153
ES	Elda	138	142	178
LU	Luxembourg	139	145	169
DE	Jena	140	126	141
PT	Guimar es	141	128	117
DE	Kaiserslautern	142	140	156
FR	Caen	143	148	108
DE	Brandenburg an der Havel	144	137	147
ES	Ceuta	145	166	175
ES	Valladolid	146	139	91
DE	Freiburg im Breisgau	147	155	116
NL	Haarlem	148	152	195
FR	Besançon	149	170	128
PT	Amadora	150	125	164
DE	Gera	151	144	157
FR	Orléans	152	172	72
DE	Düren Stadt	153	146	111
DE	Fulda	154	147	233
FR	Le Havre	155	211	143
BE	Liège	156	157	110
DE	Hannover	157	143	161
FR	Boulogne sur Mer	158	163	159
DE	Dessau Roßlau	159	162	174
IE	Limerick	160	150	149
DE	Paderborn	161	160	135
NL	Almere	162	159	220
NL	Zwolle	163	165	221
CH	Thun	164	224	134
DE	Tübingen	165	169	198
FR	Metz	166	199	189
DE	Bremerhaven	167	161	215
CH	Winterthur	168	171	150

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
PT	Odivelas	169	156	275
NL	Heerlen	170	158	124
NL	Haarlemmermeer	171	181	228
DE	Pforzheim	172	198	211
PT	Paredes	173	153	122
DE	Rosenheim	174	168	267
DE	Reutlingen	175	203	239
ES	Vitoria Gasteiz	176	208	214
NL	Zaanstad	177	188	250
ES	Rozas de Madrid Las	178	154	132
CH	Biel Bienne	179	223	144
DE	Chemnitz	180	175	179
FR	Montpellier	181	192	170
ES	Marbella	182	179	260
DE	Siegen	183	189	188
ES	Albacete	184	225	268
NL	Middelburg	185	182	190
DE	Marburg	186	180	254
IT	Grosseto	187	221	183
FR	Belfort	188	215	219
FR	Bordeaux	189	193	163
NL	Almelo	190	177	235
NL	Leiden	191	205	232
DE	Iserlohn	192	191	131
CZ	Karlovy Vary	193	174	204
NL	Soest	194	176	180
DE	Neubrandenburg	195	214	123
LV	Liepāja	196	217	142
FR	Perpignan	197	164	115
IT	Catanzaro	198	220	242
PT	Coimbra	199	184	69
ES	A Coruña	200	263	308
CH	St Gallen	201	230	165
DE	Konstanz	202	204	205
DE	Schweinfurt	203	190	303
DE	Saarbrücken	204	212	194
NL	Enschede	205	173	252
NL	Hengelo	206	187	256
FR	Rennes	207	232	118
NL	Apeldoorn	208	185	225
NL	Deventer	209	195	251
DE	Magdeburg	210	194	200
DE	Oldenburg Oldenburg	211	206	216

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
ES	Sagunto Sagunt	212	186	184
DE	Bielefeld	213	209	167
NL	Hilversum	214	202	222
PT	Braga	215	178	196
PT	Aveiro	216	196	126
DE	Offenburg	217	227	197
DE	Osnabrück	218	201	185
DE	Halle an der Saale	219	200	238
ES	Cartagena	220	222	409
CH	Zug	221	257	154
DE	Landshut	222	218	326
DE	Remscheid	223	213	160
DE	Kassel	224	183	217
FR	Nancy	225	237	227
ES	Torrevieja	226	236	310
FR	Pau	227	210	80
BE	Oostende	228	197	224
ES	Lorca	229	245	352
FR	Calais	230	167	210
FR	Saint Etienne	231	253	182
ES	Santander	232	216	272
BE	Charleroi	233	242	191
ES	Jerez de la Frontera	234	207	247
BE	La Louvi re	235	235	177
FR	Saint Quentin	236	247	208
DE	Friedrichshafen	237	267	246
NL	Alphen aan den Rijn	238	244	253
ES	San Vicente del Raspeig Sant Vicent del Raspeig	239	262	257
DE	Würzburg	240	233	314
NL	Maastricht	241	219	173
DE	Bayreuth	242	255	269
DE	Aschaffenburg	243	229	313
DE	Leipzig	244	231	262
ES	Pamplona Iruña	245	264	112
CH	Lausanne	246	307	223
FR	Nîmes	247	252	212
NL	s Gravenhage	248	243	282
IT	Potenza	249	258	264
ES	Getxo	250	246	207
DE	Potsdam	251	265	245
DE	Sindelfingen	252	270	280
FR	Meaux	253	289	244

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
NL	Ede	254	228	274
DE	Hamburg	255	234	327
FR	Arras	256	254	230
ES	Majadahonda	257	226	176
DE	Augsburg	258	260	357
NL	Sittard Geleen	259	241	202
NL	Amersfoort	260	238	270
ES	Avilés	261	239	296
DE	Bergisch Gladbach	262	249	213
ES	Algeciras	263	240	390
DE	Heidelberg	264	250	321
DE	Neu Ulm	265	286	360
NL	Bergen op Zoom	266	268	276
DE	Hagen	267	272	199
NL	Breda	268	261	309
LT	Alytus	269	248	289
DE	Ulm	270	300	364
DE	Bamberg	271	311	298
LT	Šiauliai	272	274	277
FR	Toulouse	273	280	186
ES	Toledo	274	275	322
HR	Rijeka	275	346	299
NL	Zoetermeer	276	283	315
NL	Veenendaal	277	256	297
ES	Castelldefels	278	279	424
NL	Gouda	279	287	302
FR	Melun	280	312	241
BE	Mons	281	297	229
NL	Arnhem	282	273	324
FR	Amiens	283	298	209
PT	Vila Nova de Gaia	284	276	284
NL	Roosendaal	285	284	306
PT	Valongo	286	259	273
ES	Cuenca	287	314	378
LT	Klaipėda	288	302	181
ES	Zaragoza	289	337	155
DE	Solingen	290	282	243
DE	Bocholt Stadt	291	294	318
CH	Bern	292	362	231
NL	Amsterdam	293	292	348
ES	Alicante Alacant	294	384	330
ES	Santurtzi	295	278	234
IT	L Aquila	296	363	320

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
CH	Lucerne	297	367	259
ES	Línea de la Concepción La	298	251	440
DE	Hamm	299	288	240
IT	Trapani	300	285	287
DE	Münster	301	296	261
DE	Heilbronn	302	320	394
DE	Wuppertal	303	301	249
ES	Vilanova i la Geltrú	304	383	363
FR	Douai	305	299	279
PT	Lisboa	306	269	480
DE	Regensburg	307	328	385
FR	Mantes la Jolie	308	349	203
LV	Jelgava	309	305	248
ES	Talavera de la Reina	310	308	237
DE	Darmstadt	311	271	345
DE	Wetzlar	312	306	372
ES	Elche Elx	313	324	341
PL	Koszalin	314	333	226
FR	Valence	315	377	278
DE	Dresden	316	293	316
ES	Paterna	317	318	337
NL	Oss	318	291	307
DE	Ingolstadt	319	334	384
BE	Brugge	320	309	311
BE	Leuven	321	338	265
HU	Sopron	322	277	281
PT	Gondomar	323	290	319
DE	München	324	315	444
DE	Mönchengladbach	325	295	331
ES	Torrent	326	266	347
ES	Gijón	327	350	368
FR	Lens	328	313	295
FR	Toulon	329	352	292
DE	Bonn	330	303	300
FR	Annemasse	331	353	340
DE	Witten	332	317	263
FR	Reims	333	356	286
ES	Palma de Mallorca	334	368	255
HR	Pula	335	388	382
NL	Utrecht	336	342	304
LV	Daugavpils	337	319	236
FR	Colmar	338	374	375
ES	Torrelavega	339	281	351

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
DE	Ludwigsburg	340	351	395
DE	Sankt Augustin	341	316	293
NL	Tilburg	342	332	358
DE	Karlsruhe	343	321	392
DE	Hanau	344	326	406
DE	Frankenthal Pfalz	345	310	389
DE	Gießen	346	331	407
FR	Fréjus	347	375	325
ES	Benalmádena	348	327	430
DE	Erlangen	349	372	349
NL	s Hertogenbosch	350	330	342
CZ	České Budějovice	351	340	334
DE	Esslingen am Neckar	352	366	399
ES	Melilla	353	329	381
DE	Cottbus	354	325	285
DE	Leverkusen	355	345	301
ES	Ciudad Real	356	344	477
FR	Rouen	357	373	283
CH	Basel	358	341	329
FR	Valenciennes	359	347	317
FR	Annecy	360	404	291
DE	Passau	361	387	397
DE	Bremen	362	323	305
NL	Nijmegen	363	343	338
IT	Bagheria	364	304	271
ES	Pozuelo de Alarcón	365	335	266
ES	Fuengirola	366	348	423
RO	TULCEA	367	371	539
FR	Creil	368	397	294
CZ	Jihlava	369	382	362
NL	Nissewaard	370	376	350
IT	Reggio di Calabria	371	360	336
DE	Koblenz	372	336	371
PT	Matosinhos	373	339	386
CH	Zürich	374	365	312
DE	Speyer	375	381	403
ES	Guadalajara	376	354	355
NL	Venlo	377	355	366
LT	Vilnius	378	361	391
NL	Helmond	379	357	367
MT	Valletta	380	392	344
FR	Chambéry	381	398	377
IT	Battipaglia	382	358	422

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
FR	Mulhouse	383	410	413
DE	Mainz	384	380	410
IT	Siracusa	385	389	398
IT	La Spezia	386	378	343
AT	Salzburg	387	322	446
IT	Messina	388	402	383
LV	Riga	389	369	359
DE	Wiesbaden	390	364	415
NL	Rotterdam	391	395	396
DE	Neuss	392	394	402
DE	Stuttgart	393	408	445
DE	Offenbach am Main	394	385	461
DE	Dortmund	395	399	335
ES	Tarragona	396	386	356
ES	Reus	397	396	323
CH	Geneva	398	454	426
IT	Arezzo	399	434	441
DE	Fürth	400	420	411
IT	Ragusa	401	436	288
LT	Kaunas	402	400	401
IT	Livorno	403	431	470
ES	Valencia	404	418	517
IT	Campobasso	405	391	408
IT	Massa	406	449	420
IT	Perugia	407	441	484
FR	Dunkerque	408	403	333
ES	Torremolinos	409	401	490
ES	Jaén	410	405	519
AT	Innsbruck	411	428	485
ES	Igualada	412	438	405
BE	Mechelen	413	421	374
PL	Słupsk	414	446	258
IT	Savona	415	359	418
DE	Bochum	416	409	361
DE	Frankfurt Oder	417	370	339
ES	Barakaldo	418	445	369
FR	Aix en Provence	419	429	380
IT	Acireale	420	407	438
CZ	Plzeň	421	427	421
ES	San Sebastián de los Reyes	422	417	370
NL	Eindhoven	423	430	404
RO	BIRLAD	424	411	550
ES	Murcia	425	433	481

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
BE	Mouscron	426	423	353
LT	Panev žys	427	416	456
DE	Krefeld	428	432	419
PT	Porto	429	412	437
BG	Sliven	430	426	535
IT	Cerignola	431	444	487
DE	Ludwigshafen am Rhein	432	414	478
DE	Mannheim	433	415	463
ES	Linares	434	413	538
BE	Kortrijk	435	442	379
RO	GALATI	436	422	599
ES	Málaga	437	390	513
ES	Valdemoro	438	481	373
RO	BRAILA	439	435	585
DE	Recklinghausen	440	448	387
IT	Altamura	441	466	475
DE	Köln	442	437	425
ES	Dos Hermanas	443	406	332
DE	Frankfurt am Main	444	440	510
IT	Matera	445	459	467
ES	Oviedo	446	393	431
PL	Suwałki	447	419	328
DE	Düsseldorf	448	450	458
ES	Mislata	449	439	486
ES	Alcobendas	450	443	393
FR	Avignon	451	455	354
GR	Kalamata	452	465	434
DE	Moers	453	453	459
FR	Lyon	454	476	464
DE	Nürnberg	455	470	469
IT	Bisceglie	456	452	489
ES	Alcalá de Guadaíra	457	424	346
ES	Bilbao	458	483	388
HR	Zadar	459	502	443
IT	Brindisi	460	469	483
FR	Grenoble	461	471	471
BE	Bruxelles Brussel	462	460	417
IT	Trani	463	472	494
CZ	Chomutov Jirkov	464	456	479
IT	Bitonto	465	468	500
CZ	Kladno	466	425	449
IT	Cosenza	467	490	433
IT	Andria	468	479	508

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
DE	Berlin	469	484	474
AT	Wien	470	451	533
ES	Almería	471	467	640
IT	Gela	472	461	400
DE	Essen	473	464	439
DE	Mülheim a d Ruhr	474	458	455
DE	Herne	475	473	427
DE	Görlitz	476	497	496
IT	Foggia	477	478	515
IT	Lecce	478	498	495
FR	Martigues	479	505	365
IT	Anzio	480	509	492
RO	FOCSANI	481	474	570
IT	Molfetta	482	480	511
FR	Lille	483	477	435
FR	Strasbourg	484	489	504
IT	Barletta	485	495	514
ES	Alcalá de Henares	486	475	465
ES	Móstoles	487	463	412
PL	Stargard	488	487	414
BE	Gent	489	488	457
FR	Nice	490	493	541
ES	Córdoba	491	485	429
CZ	Liberec	492	482	472
ES	Alcorcón	493	457	436
ES	Rivas Vaciamadrid	494	500	432
ES	Viladecans	495	447	559
IT	Salerno	496	491	540
IT	Avellino	497	486	526
DE	Gelsenkirchen	498	507	473
SK	Bratislava	499	492	512
ES	Castellón de la Plana Castelló de la Plana	500	534	376
ES	Lleida	501	516	452
PL	Ełk	502	379	453
ES	Fuenlabrada	503	494	454
ES	Sevilla	504	462	416
FR	Marseille	505	514	462
BG	Yambol	506	501	571
SK	Trnava	507	504	507
PL	Elbląg	508	517	451
DE	Oberhausen	509	503	503
DE	Bottrop	510	508	493
HU	Veszprém	511	512	460

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
HU	Szombathely	512	496	448
PL	Gdynia	513	537	290
IT	Bari	514	529	562
RO	CONSTANTA	515	518	607
DE	Duisburg	516	511	527
AT	Linz	517	521	547
IT	Genova	518	520	488
GR	Chania	519	522	590
PL	Tczew	520	547	450
BE	Antwerpen	521	525	518
BG	Pernik	522	530	692
IT	Palermo	523	515	466
HU	Székesfehérvár	524	542	534
ES	Torrejón de Ardoz	525	535	497
ES	Sant Boi de Llobregat	526	524	579
PL	Zielona Góra	527	499	522
HU	Tatabánya	528	531	502
BG	Haskovo	529	523	650
ES	Parla	530	528	476
SK	Nitra	531	527	528
IT	Pisa	532	545	580
ES	Mataró	533	513	556
HU	Győr	534	526	523
RO	SIBIU	535	510	593
AT	Klagenfurt	536	506	531
RO	BUZAU	537	559	588
IT	Catania	538	540	542
HU	Békéscsaba	539	536	552
IT	Taranto	540	550	509
HU	Kaposvár	541	543	505
ES	Leganés	542	532	491
IT	Trieste	543	553	499
IT	Latina	544	554	549
IT	Terni	545	579	557
HU	Zalaegerszeg	546	544	442
IT	Pesaro	547	597	567
ES	Coslada	548	539	520
ES	Manresa	549	558	537
ES	Madrid	550	538	529
IT	Pescara	551	582	555
IT	Ancona	552	591	543
ES	Getafe	553	546	506
FR	Paris	554	548	530

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
RO	ORADEA	555	533	638
IT	Firenze	556	594	578
CZ	Ústí nad Labem	557	519	545
ES	Girona	558	552	447
PL	Szczecin	559	557	498
PL	Olsztyn	560	541	532
HU	Kecskemét	561	568	521
RO	PIATRA NEAMT	562	566	468
ES	Prat de Llobregat El	563	562	602
CZ	Praha	564	549	548
PL	Gdańsk	565	577	482
HU	Pécs	566	555	561
PL	Jelenia Góra	567	612	554
BG	Stara Zagora	568	561	631
CZ	Pardubice	569	569	525
CH	Lugano	570	590	516
BG	Blagoevgrad	571	551	666
HU	Szolnok	572	584	551
SK	Trenčín	573	588	544
SK	Banská Bystrica	574	556	501
ES	Cornell de Llobregat	575	563	611
PL	Przemyśl	576	581	606
ES	Granollers	577	572	573
GR	Patra	578	565	574
IT	Giugliano in Campania	579	592	581
IT	Rimini	580	611	596
BG	Burgas	581	574	605
CZ	Most	582	575	560
RO	Suceava	583	576	564
ES	Sant Cugat del Vall s	584	564	589
IT	Forlì	585	605	601
SI	Maribor	586	567	553
BG	Vratsa	587	587	687
HU	Dunaújváros	588	600	568
GR	Katerini	589	571	583
RO	ALBA IULIA	590	578	617
GR	Volos	591	570	582
CZ	Hradec Králové	592	604	536
ES	Esplugues de Llobregat	593	583	615
BG	Varna	594	560	654
BG	Dobrich	595	589	620
BG	Veliko Tarnovo	596	606	663
HU	Debrecen	597	586	625

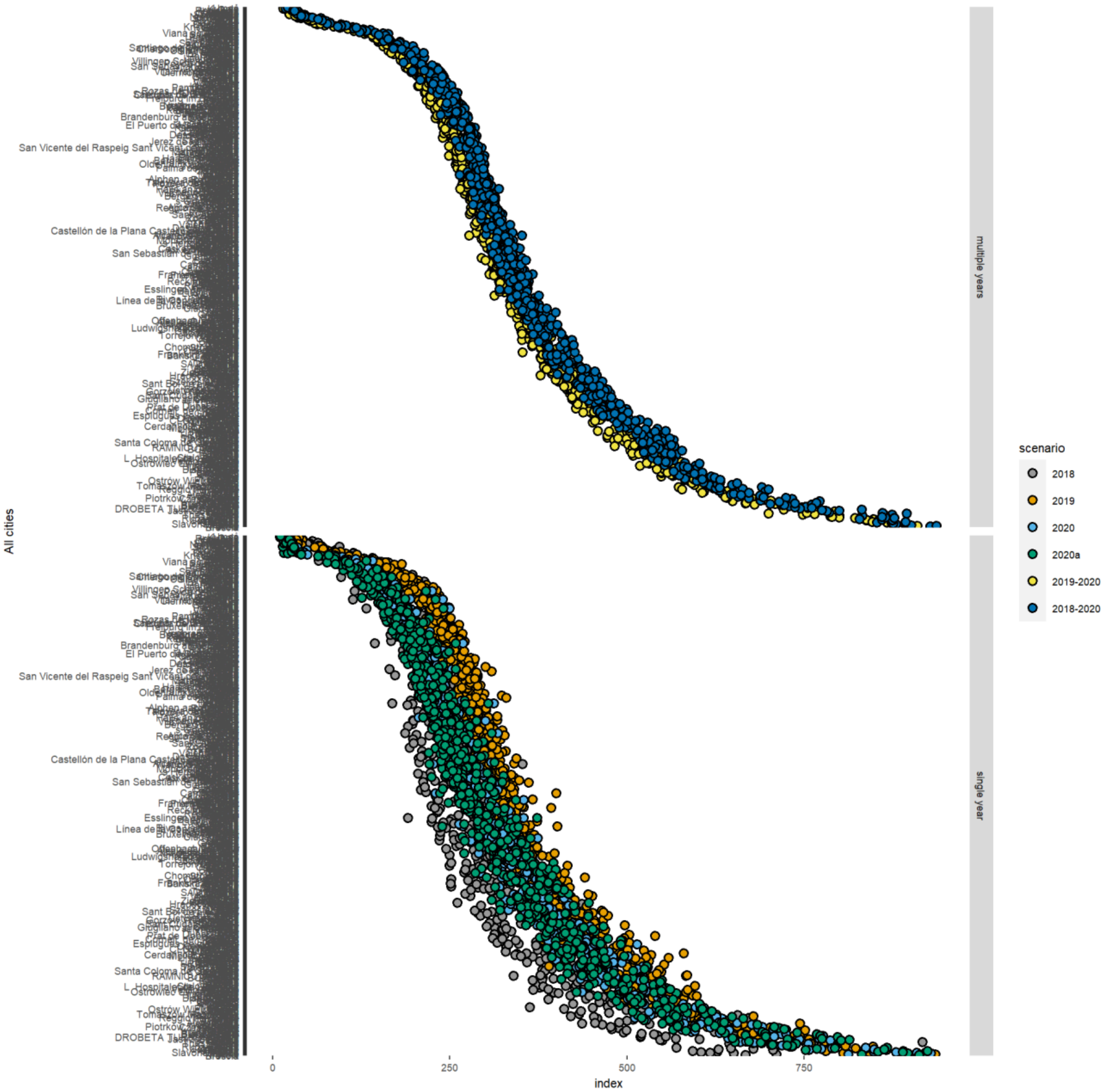
Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
ES	Rubí	598	573	600
RO	ARAD	599	607	597
GR	Trikala	600	580	587
CZ	Brno	601	596	576
PL	Gorzów Wielkopolski	602	585	558
IT	Udine	603	603	575
ES	Terrassa	604	602	595
RO	SATU MARE	605	595	524
PL	Grudziądź	606	620	569
HU	Szeged	607	629	577
PL	Piła	608	621	546
PL	Białystok	609	593	565
ES	Sabadell	610	613	621
HU	Eger	611	627	566
CZ	Zlín	612	609	572
GR	Iraklio	613	616	646
ES	Mollet del Vall s	614	618	637
ES	Badalona	615	628	641
RO	BOTOSANI	616	601	648
BG	Shumen	617	622	644
IT	Prato	618	644	642
IT	Ravenna	619	639	656
HU	Nyíregyháza	620	617	598
RO	RAMNICU VALCEA	621	610	671
RO	BISTRITA	622	638	428
IT	Roma	623	631	653
AT	Graz	624	615	616
CY	Lemesos	625	598	626
ES	Cerdanyola del Vall s	626	626	627
ES	Granada	627	614	674
IT	Napoli	628	630	614
RO	BACAU	629	608	684
PL	Inowrocław	630	642	592
RO	TIRGOVISTE	631	632	634
ES	Santa Coloma de Gramenet	632	647	657
IT	Caserta	633	623	624
GR	Ioannina	634	619	612
PL	Lubin	635	646	604
ES	L Hospitalet de Llobregat	636	599	676
RO	ROMAN	637	625	639
PL	Toruń	638	643	563
RO	CALARASI	639	635	619
RO	PITESTI	640	634	688

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
PL	Wałbrzych	641	649	584
PL	Chełm	642	650	628
PL	Gniezno	643	659	608
BG	Pleven	644	637	707
IT	Bologna	645	662	662
CZ	Olomouc	646	651	618
RO	BRASOV	647	645	647
ES	Barcelona	648	640	685
PL	Głogów	649	663	635
PL	Zamość	650	657	623
PL	Włocławek	651	656	591
RO	TIMISOARA	652	661	679
PL	Bydgoszcz	653	641	610
CY	Lefkosia	654	624	655
RO	GIURGIU	655	648	678
PL	Siedlce	656	654	665
BG	Ruse	657	653	682
PL	Płock	658	636	632
SK	Prešov	659	660	629
IT	Bolzano	660	671	630
CY	Larnaka	661	633	673
HR	Split	662	682	603
PL	Rzeszów	663	665	659
RO	Târgu Mures	664	667	613
BG	Sofia	665	655	747
PL	Świdnica	666	674	609
BG	Pazardzhik	667	664	708
RO	Baia Mare	668	658	586
PL	Legnica	669	670	652
PL	Konin	670	669	622
GR	Kavala	671	652	645
RO	CLUJ NAPOCA	672	675	594
PL	Łomża	673	678	633
PL	Leszno	674	677	649
IT	Sassuolo	675	680	667
HU	Budapest	676	681	668
SK	Žilina	677	676	643
IT	Lecco	678	679	658
IT	Ferrara	679	683	704
IT	Pordenone	680	673	691
GR	Larissa	681	668	664
HR	Osijek	682	689	710
GR	Xanthi	683	666	672

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
RO	IASI	684	691	695
SI	Ljubljana	685	672	686
RO	TIRGU JIU	686	684	717
PL	Stalowa Wola	687	693	660
RO	PLOIESTI	688	698	697
RO	SLATINA	689	687	725
IT	Trento	690	688	677
IT	Parma	691	692	701
HU	Miskolc	692	694	636
PL	Opole	693	685	690
IT	Varese	694	706	669
IT	Reggio nell Emilia	695	703	706
HR	Zagreb	696	695	694
PL	Zgierz	697	697	700
PL	Tomaszów Mazowiecki	698	699	698
GR	Thessaloniki	699	686	727
PL	Radom	700	702	696
PL	Ostrowiec Świętokrzyski	701	707	661
CZ	Havířov	702	701	689
PL	Lublin	703	708	681
SK	Košice	704	696	651
IT	Como	705	711	683
GR	Serres	706	690	670
CZ	Ostrava	707	704	702
PL	Wrocław	708	700	680
PL	Ostrów Wielkopolski	709	709	693
PL	Poznań	710	705	675
IT	Alessandria	711	718	711
IT	Asti	712	716	709
PL	Pabianice	713	714	699
IT	Modena	714	719	719
IT	Novara	715	712	716
IT	Carpi	716	721	728
PL	Kielce	717	720	703
PL	Częstochowa	718	717	713
PL	Warszawa	719	710	718
PL	Kalisz	720	722	705
BG	Plovdiv	721	713	736
RO	CRAIOVA	722	715	733
RO	BUCURESTI	723	723	731
BG	Vidin	724	725	742
PL	Piotrków Trybunalski	725	728	712
PL	Nowy Sącz	726	738	720

Country (ISO2 code)	City	2021-2022	2021a-2022a	2019-2020
CZ	Karviná	727	727	715
PL	Łódź	728	724	724
IT	Pavia	729	732	730
IT	Piacenza	730	736	726
RO	DROBETA TURNU SEVER	731	726	738
IT	Gallarate	732	733	722
IT	Venezia	733	734	739
IT	Busto Arsizio	734	735	729
PL	Tarnów	735	730	721
PL	Bielsko Biała	736	729	723
GR	Athina	737	731	714
IT	Treviso	738	737	745
IT	Saronno	739	743	734
PL	Rybnik	740	740	737
PL	Gliwice	741	739	741
PL	Jastrzębie Zdrój	742	741	732
PL	Żory	743	742	735
IT	Padova	744	745	752
IT	Bergamo	745	746	740
PL	Zabrze	746	744	743
IT	Verona	747	747	746
PL	Tychy	748	749	744
PL	Ruda Śląska	749	748	748
PL	Bytom	750	750	749
IT	Monza	751	752	755
IT	Vicenza	752	751	758
IT	Cremona	753	757	754
PL	Sosnowiec	754	753	751
IT	Milano	755	756	757
PL	Chorzów	756	755	753
PL	Katowice	757	754	750
HR	Slavonski Brod	758	760	756
PL	Kraków	759	758	760
IT	Brescia	760	761	761
IT	Torino	761	759	759

Figure A1.1 Index values for all ranked cities based on different scenarios. A higher index corresponds to a more harmful air quality to human health



Annex 2 Evaluation of potential adaptation of mapping methodology

This Annex 2 evaluates the methodological adaptation of the map creation, which was proposed by the ETC/ATNI (2022) in order to reduce the smoothing effect of applying the kriging interpolation. For all three pollutants $PM_{2.5}$, NO_2 and O_3, the mapping results based on the updated method are compared with the results based on the current method, for 2020.

A2.1 Mapping methodology and its proposed adaptation

The current mapping methodology is the Regression – Interpolation – Merging Mapping (RIMM) as routinely used in the spatial mapping under the ETC HE (ETC HE, 2023). Different map layers (rural, urban background and in the case of $PM_{2.5}$ and NO_2 also urban traffic) are calculated separately and subsequently merged into one final map. The separate map layers are calculated using the linear regression model followed by kriging of its residuals (residual kriging):

$$\hat{Z}(s_0) = c + a_1 X_1(s_0) + a_2 X_2(s_0) + \cdots + a_n X_n(s_0) + \hat{R}(s_0) \qquad \text{(A2.1)}$$

where $\hat{Z}(s_0)$ is the estimated concentration in a grid cell s_o,
$X_1(s_0), \ldots, X_n(s_0)$ are n supplementary variables (including CTM output) in a grid cell s_o,
$c, a_1, a_2, \ldots, a_n$ are the $n+1$ parameters of the linear regression model calculated based on the data at the points of measurement,
$\hat{R}(s_0)$ is the spatial interpolation of the residuals of the linear regression model in a grid cell s_o, based on the residuals at the points of measurement.

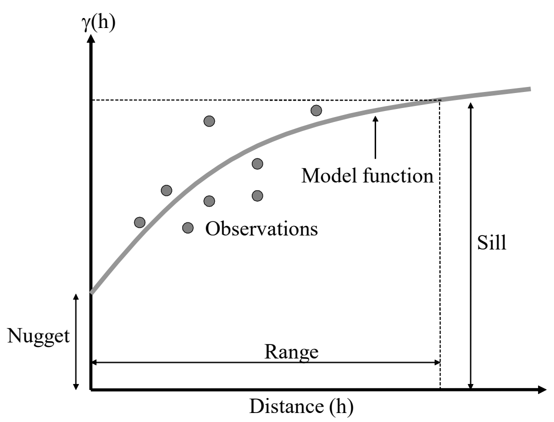
For different pollutants and map layers, different supplementary data are used, depending on their improvement to the fit of the regression. Ordinary kriging is used to interpolate the residuals:

$$\hat{R}(s_0) = \sum_{i=1}^{N} \lambda_i(s_0) R(s_i), \; \sum_{i=1}^{N} \lambda_i = 1 \qquad \text{(A2.2)}$$

where $R(s_i)$ are the residuals in the points of the measuring stations s_i,
$\lambda_1, \ldots, \lambda_N$ are the weights in a grid cell s_o estimated based on variogram,
N is the number of the stations used in the interpolation.

The variogram (as a measure of a spatial correlation) is estimated as follows: at first, the empirical variogram is calculated and then, the empirical variogram is fitted using a spherical function. Figure A2.1 shows the estimated variogram including its parameters *nugget*, *sill*, and *range*.

Figure A2.1 Diagram showing the parameters of variogram



In principle, for nugget equal to zero, the interpolation predicts values identical as the values at the measurement stations, while for nugget greater than zero, the interpolation smooths the values. It the routine mapping, the nugget is mostly greater than zero.

For $PM_{2.5}$, prior to linear regression and interpolation, a logarithmic transformation to measurements and CTM output is executed. For details, see ETC HE (2023).

The separate handling of the rural and urban background map layers is based on the assumption that the estimated rural map layer value is lower (PM and NO_2) or higher (ozone) than the estimated urban background map layer value. In areas (i.e., grid cells) where this criterion does not hold, both the rural and the urban background map layers are substituted by a joint urban/rural background map layer (created using all background stations regardless their type) and such adjusted rural and urban background map layers are further applied in the final map creation. For details, see ETC HE (2023).

In order to reduce the smoothing effect caused by the non-zero nugget (see above), ETC/ATNI (2022) recommends applying a methodological adaptation based on the kriging residuals, specifically by interpolating them by some exact interpolator. As shown in ETC/ATNI (2022), the urban background map layer has the major influence on the population-weighted concentration (and the city ranking). Thus, the methodological adaptation has been applied just on the urban background map layer. Specifically, the residuals of the urban background map layer are used, i.e.

$$\varepsilon(s_{\mathrm{i}}) = \mathrm{Z}(s_{\mathrm{i}}) - \hat{Z}_{UB}(s_{\mathrm{i}}) \qquad \text{(A2.3)}$$

where $Z(s_i)$ is the measured concentration at a point s_i, $i = 1, \ldots, N$,
$\hat{Z}_{UB}(s_{\mathrm{i}})$ is the estimated concentration of the urban map layer at a point s_o,
$\varepsilon(s_{\mathrm{i}})$ is the residual at a point s_i, $i = 1, \ldots, N$.

For the residuals ε_i, additional interpolation is applied using the exact interpolator (i.e. interpolation that predicts values identical as the values at the measurement stations). Specifically, we use ordinary kriging (like in Eq, 2.2), with a nugget effect set to zero. Thus, the urban background map layer is calculated according to

$$\hat{Z}_{UB\_A}(s_0) = \hat{Z}_{UB}(s_{\mathrm{i}}) + \hat{\varepsilon}(s_0) \qquad \text{(A2.4)}$$

where $\hat{Z}_{UB\_A}(s_0)$ is the concentration in a grid cell s_o estimated based on the adapted method,
$\hat{\varepsilon}(s_0)$ is the spatial interpolation of the residuals of the linear regression model at point s_o, based on the residuals ε_i at the N points of measurement.

Based on the separate rural, urban background and urban traffic (for $PM_{2.5}$ and NO_2 only) map layers, the final map is calculated using the population density and the buffers around the roads (for $PM_{2.5}$ and NO_2 only). For details, see ETC HE (2023). In the current methodology, the urban background layer without the adaptation is used, while in the proposed methodology, the adapted urban background layer (see Eq. A2.4) is applied.

A2.2 Uncertainty estimation and comparison of different approaches

The uncertainty estimation and the comparison of different mapping approaches is based on the leave-one-out cross-validation and the simple comparison between the measurement data in the station points and the estimated values of the 1 km grid cells. The analysis is performed based on the individual stations and based on the average of the station values in a given city of the Urban Audit.

The predicted and measurement values are compared using statistical indicators and scatter plots. The main indicators used are root mean square error (RMSE), relative root mean square error (RRMSE) and bias (mean prediction error, MPE). Other indicators are R^2 and the regression equation parameters *slope* and *intercept*, following from the scatter plot between the predicted (using cross-validation) and the observed concentrations. For details, see ETC HE (2023).

RMSE and RRMSE should be as small as possible, bias (MPE) should be as close to zero as possible, R^2 should be as close to 1 as possible, slope *a* should be as close to 1 as possible, and intercept *c* should be as close to zero as possible (in the regression equation $y = a.x + c$).

A2.3 Analysis

In this section, the comparison of the current and the proposed methodologies is shown, for all three pollutants. At first, the one-leave-out cross-validation has been executed for the urban background layers in both variants, as well as the simple comparison between the measurement data in the station points and the estimated values of the 1 km grid cells. This analysis is based on the urban and suburban background stations and based on the average of the urban and suburban background station values in a given city of the Urban Audit. The reason of this analysis is to verify the level of the smoothing in both variants and to show what the "price" for the reduction of the smoothing is. As mentioned in ETC/ATNI (2022), the reduction of the smoothing effect in the station points probably leads to some worsening of the cross-validation uncertainty for the whole interpolation.

Next to this, the population-weighted concentration based on the final concentration maps in both variants has been compared for the cities of the Urban Audit. Apart from the whole set of the cities, the subsets of the cities with and without the measurement stations have been also analysed.

$PM_{2.5}$ – annual average

For the PM_{10} annual average 2020, the comparison has been done (i) for the set of 748 urban and suburban background stations and (ii) for the set of 321 cities with at least one urban and suburban background station (based on 421 such stations located in these cities, with their values averaged per city).

Table A2.1 shows the comparison between the results of the current and the adapted method.

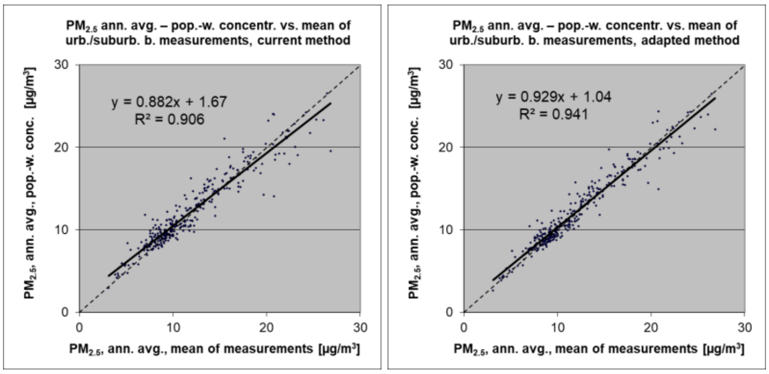
Table A2.1 Comparison of cross-validated and predicted gridded values from urban background map layer and final merged map against measurements from urban/suburban background stations taken individually (up) and in average per city of the Urban Audit (bottom) for current (left) and adapted (right) mapping method, using RMSE, RRMSE, bias, R^2 and regression equation from scatter plots for PM_{10} annual average 2020

PM_{10} – Annual Average	Current Method					Adapted Method				
	RMSE	RRMSE	Bias	R^2	Lin. r. equation	RMSE	RRMSE	Bias	R^2	Lin. r. equation
Urban background areas, entire domain (based on individual stations)										
Cross-val. prediction, urban b. map layer	2.5	20.9%	0.2	0.724	y = 0.759x + 3.06	2.6	21.4%	0.1	0.715	y = 0.779x + 2.77
Simple grid prediction, urb. b. map layer	1.8	14.9%	0.1	0.861	y = 0.824x + 2.19	0.3	2.3%	0.0	0.997	y = 0.979x + 0.26
Simple grid prediction, final merged map	2.2	18.0%	-0.1	0.795	y = 0.782x + 2.58	1.5	12.5%	-0.1	0.901	y = 0.891x + 1.20
Urban background areas, cities of Urban Audit (based on mean measured values per city)										
Cross-val. prediction, urban b. map layer	2.0	16.7%	0.5	0.834	y = 0.861x + 2.12	2.1	17.3%	0.4	0.822	y = 0.882x + 1.84
Simple grid prediction, urb. b. map layer	1.4	11.7%	0.3	0.917	y = 0.897x + 1.51	0.2	2.0%	0.0	0.998	y = 0.988x + 0.18
Simple grid prediction, final merged map	1.6	13.6%	0.3	0.886	y = 0.884x + 1.65	1.0	8.3%	0.0	0.956	y = 0.955x + 0.57

As expected, one can see much better agreement of the predicted and measured values in the points of the measurement stations for the adapted method compared to the current one, see the simple grid predictions. The cross-validation uncertainty (that estimates the uncertainty in locations without measurements) is somewhat poorer for the adapted method, as expected. Specifically, the relative cross-validation uncertainty is 16.7% for the current method, while 17.3% for the adapted method. This is supposed to be a satisfactory price for the reduction of the smoothing.

Additionally, we have compared the population-weighted concentration with the averages of the concentration values measured at the urban/suburban background stations located in the relevant cities for both the current and the adapted mapping methods. The comparison has been done using the scatterplots, see Figure A2.2. As expected, the population-weighted concentrations show better agreement with the means of the measurements for the adapted method compared to the current one.

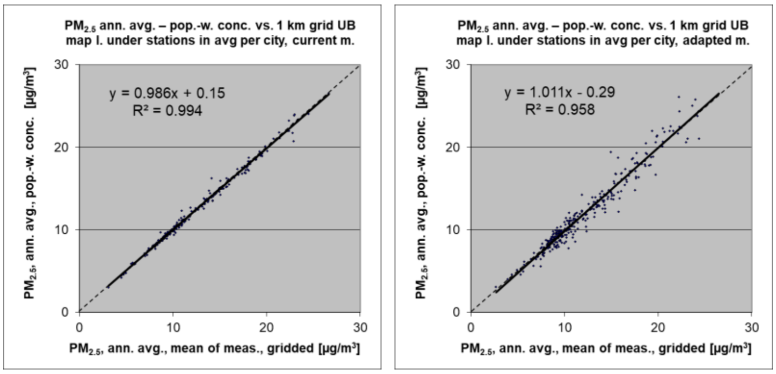
Figure A2.2 Correlation between the population-weighted concentrations (y-axis) based on current (left) and adapted (right) method and the means of measured data from urban/suburban background stations (x-axis) of relevant cities of the Urban Audit, PM_{10} annual average 2020



One can see better agreement of the population-weighted concentrations with the measurement data for the adapted method compared to the current one.

In order to examine the spatial variability within the cities (for both mapping variants), we have also compared the population-weighted concentrations with the average of the gridded mapped values in the locations of the measurement stations within the relevant cities, see Figure A2.3.

Figure A2.3 Correlation between the population-weighted concentrations (y-axis) based on current (left) and adapted (right) method and the means of predicted gridded values at urban/suburban background stations (x-axis) of relevant cities of the Urban Audit, $PM_{2.5}$ annual average 2020



One can see a strong agreement of the population-weighted concentrations and the means of the gridded mapped values in the locations of the measurement stations within the relevant cities for the current method, while somewhat poorer agreement for the adapted method. The results show that the spatial variability of the map results within the cities is quite small for the current method (indicating that the most of the variability shown in the relevant scatterplot of Figure A2.2 is attributable to the interpolation smoothing effect), while somewhat higher for the adapted method (indicating that the adaption of the method mainly influences predictions of areas around stations, not the mapping results in general).

Based on these results, it can be concluded that the adapted method reduces the smoothing effect of the map results and improves the agreement of the population-weighted concentration with the averages of the concentration values measured at the stations of the relevant cities, while its change compared to the current method in areas outside the measurement stations is limited. The uncertainty of the whole map is slightly poorer in the adapted method compared to the current one, however the benefits of the adapted method justify this slight worsening. Thus, **it is recommended to apply the adapted mapping method for the city ranking calculations**.

NO_2 – annual average

For the NO_2 annual average 2020, the comparison has been done (i) for the set of 1400 urban and suburban background stations and (ii) for the set of 476 cities with at least one urban and suburban background station (based on 704 such stations located in these cities, with their values averaged per city).

Table A2.2 shows the comparison between the results of the current and the adapted method.

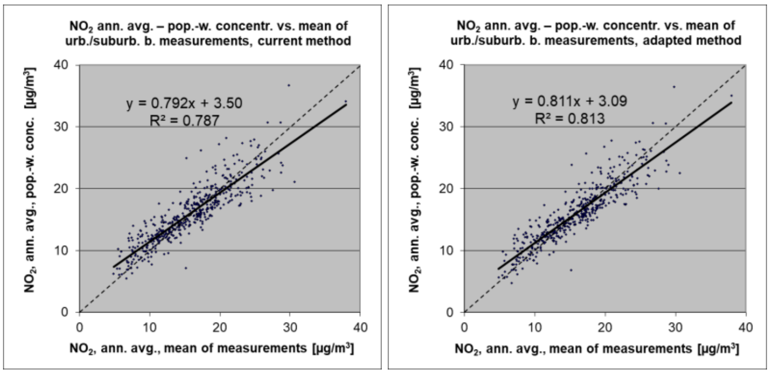
Table A2.2 Comparison of cross-validated and predicted gridded values from urban background map layer and final merged map against measurements from urban/suburban background stations taken individually (up) and in average per city of the Urban Audit (bottom) for current (left) and adapted (right) mapping method, using RMSE, RRMSE, bias, R^2 and regression equation from scatter plots for NO_2 annual average 2020

NO_2 – Annual Average	Current Method					Adapted Method				
	RMSE	RRMSE	Bias	R^2	Lin. r. equation	RMSE	RRMSE	Bias	R^2	Lin. r. equation
Urban background areas, entire domain (based on individual stations)										
Cross-val. prediction, urban b. map layer	4.2	26.5%	0.0	0.660	y = 0.696x + 4.84	4.4	27.7%	-0.1	0.635	y = 0.692x + 4.80
Simple grid prediction, urb. b. map layer	2.7	17.2%	0.1	0.858	y = 0.813x + 3.07	0.9	5.6%	0.0	0.986	y = 0.953x + 0.74
Simple grid prediction, final merged map	3.3	20.8%	0.4	0.794	y = 0.828x + 3.13	2.2	13.9%	0.3	0.905	y = 0.944x + 1.19
Urban background areas, cities of Urban Audit (based on mean measured values per city)										
Cross-val. prediction, urban b. map layer	3.1	19.7%	-0.2	0.660	y = 0.736x + 3.97	3.2	20.3%	-0.3	0.645	y = 0.736x + 3.85
Simple grid prediction, urb. b. map layer	1.9	11.9%	0.0	0.873	y = 0.853x + 2.33	0.6	3.8%	0.0	0.988	y = 0.960x + 0.61
Simple grid prediction, final merged map	2.3	14.3%	0.5	0.828	y = 0.864x + 2.69	1.5	9.4%	0.5	0.930	y = 0.954x + 1.20

Like for $PM_{2.5}$, one can see much better agreement of the predicted and measured values in the points of the measurement stations for the adapted method compared to the current one. The cross-validation uncertainty that estimates the uncertainty in locations without measurements is somewhat poorer for the adapted method, as expected. Specifically, the relative cross-validation uncertainty is 19.7% for the current method, while 20.3% for the adapted method. This is supposed to be a satisfactory price for the reduction of the smoothing.

Again, we have compared the population-weighted concentration with the average of the concentration values measured at the urban/suburban background stations located in the relevant city for both the current and the adapted mapping. The comparison has been done using the scatterplots, see Figure A2.4. As expected, the population-weighted concentrations show better agreement with the averages of the background stations for the adapted method compared to the current one.

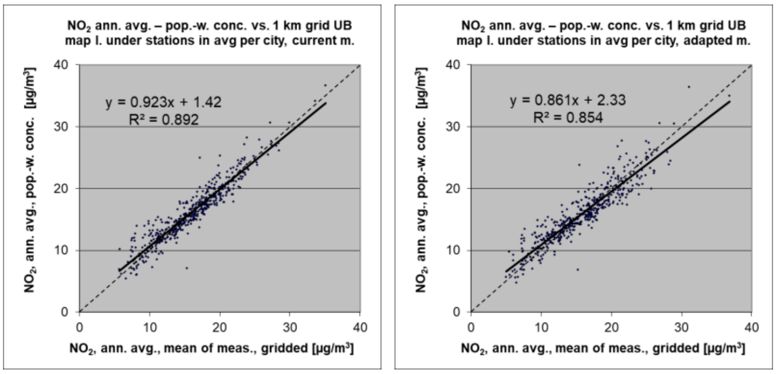
Figure A2.4 Correlation between the population-weighted concentrations (y-axis) based on current (left) and adapted (right) method and the means of measured data from urban/suburban background stations (x-axis) of relevant cities of the Urban Audit, NO_2 annual average 2020



Like for $PM_{2.5}$, the population-weighted concentrations show better correlation with the measurement data for the adapted method compared to the current one.

The comparison of the population-weighted concentrations and the means of the gridded mapped values in the locations of the measurement stations within the relevant cities for both mapping variants can be seen in Figure A2.5. Like in ETC/ATNI (2022), the spatial variability within the cities is somewhat higher for NO_2 compared to the $PM_{2.5}$. Without regard to that and similarly to the $PM_{2.5}$, the results show only limited influence of the adapted method in areas outside the measurement stations.

Figure A2.5 Correlation between the population-weighted concentrations (y-axis) based on current (left) and adapted (right) method and the means of predicted gridded values at urban/suburban background stations (x-axis) of relevant cities of the Urban Audit, NO_2 annual average 2020



Based on the analysis, it is recommended to apply the adapted mapping method for the city ranking calculations.

O_3 – SOMO35

For the ozone indicator SOMO35 for 2020, the comparison has been done (i) for the set of 1223 urban and suburban background stations and (ii) for the set of 452 cities with at least one urban and suburban background station (based on 584 such stations located in these cities, with their values averaged per city).

Table A2.3 shows the comparison between the results of the current and the adapted method.

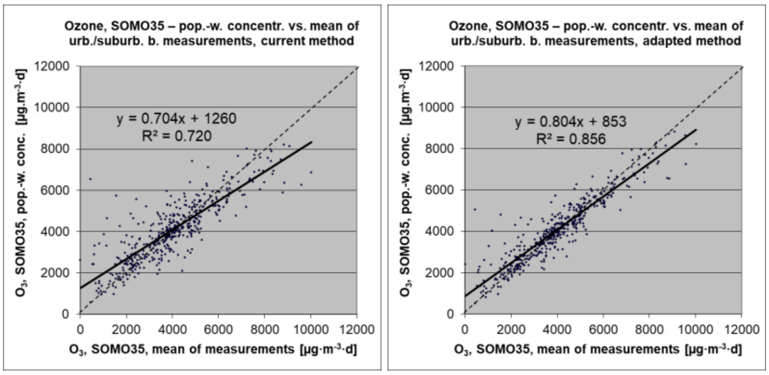
Table A2.3: Comparison of cross-validated and predicted gridded values from urban background map layer and final merged map against measurements from urban/suburban background stations taken individually (up) and in average per city of the Urban Audit (bottom) for current (left) and adapted (right) mapping method, using RMSE, RRMSE, bias, R^2 and regression equation from scatter plots for ozone indicator SOMO35 for 2020

O_3 – SOMO35	Current Method					Adapted Method				
	RMSE	RRMSE	Bias	R^2	Lin. r. equation	RMSE	RRMSE	Bias	R^2	Lin. r. equation
Urban background areas, entire domain (based on individual stations)										
Cross-val. prediction, urban b. map layer	1329	31.9%	4	0.517	y = 0.523x + 1989	1367	32.8%	15	0.493	y = 0.535x + 1952
Simple grid prediction, urb. b. map layer	1180	28.3%	-9	0.624	y = 0.572x + 1772	159	3.8%	0	0.995	y = 0.950x + 210
Simple grid prediction, final merged map	1231	29.6%	88	0.589	y = 0.578x + 1844	564	13.5%	76	0.915	y = 0.908x + 461
Urban background areas, cities of Urban Audit (based on mean measured values per city)										
Cross-val. prediction, urban b. map layer	1062	26.5%	62	0.646	y = 0.674x + 1370	1103	27.5%	83	0.624	y = 0.686x + 1344
Simple grid prediction, urb. b. map layer	939	23.4%	45	0.723	y = 0.707x + 1223	126	3.1%	7	0.996	y = 0.966x + 146
Simple grid prediction, final merged map	982	24.5%	65	0.697	y = 0.706x + 1244	375	9.3%	10	0.956	y = 0.951x + 209

Again, one can see much higher agreement of the predicted and measured values in the points of the measurement stations for the adapted method compared to the current one. The cross-validation uncertainty that estimates the uncertainty in locations without measurements is somewhat poorer for the adapted method, as expected. Specifically, the relative cross-validation uncertainty is 26.5% for the current method, while 27.5% for the adapted method. This is supposed to be a satisfactory price for the reduction of the smoothing.

Additionally, we have compared the population-weighted concentration with the average of the concentration values measured at the urban/suburban background stations located in the relevant city for both the current and the adapted mapping. The comparison has been done using the scatterplots, see Figure A2.6. As expected, the population-weighted concentrations show better agreement with the averages of the background stations for the adapted method compared to the current one.

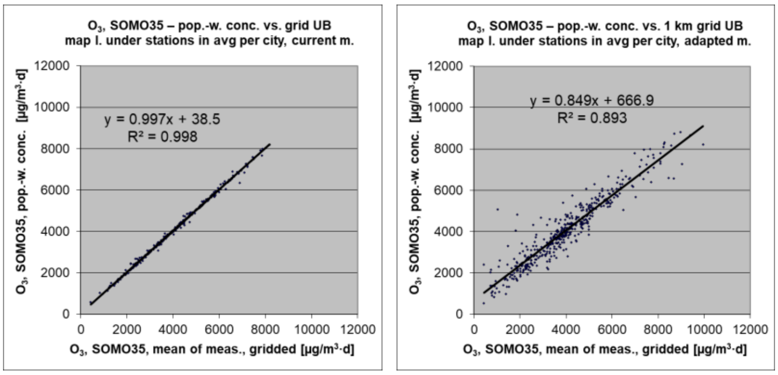
Figure A2.6 Correlation between the population-weighted concentrations (y-axis) based on current (left) and adapted (right) method and the means of measured data from urban/suburban background stations (x-axis) of relevant cities of the Urban Audit, O_3 indicator SOMO35, 2020



Again, the population-weighted concentrations show better correlation with the measurement data for the adapted method compared to the current one.

The analysis of the differences between the population-weighted concentrations and the means of the gridded mapped values in the locations of the measurement stations within the relevant cities show similar results as for $PM_{2.5}$, see Figure A2.7.

Figure A2.7 Correlation between the population-weighted concentrations (y-axis) based on current (left) and adapted (right) method and the means of predicted gridded values at urban/suburban background stations (x-axis) of relevant cities of the Urban Audit, O_3 indicator SOMO35, 2020



In total, it is recommended to apply the adapted mapping method for the city ranking calculations.

A2.4 Conclusion

The adapted method reduces the smoothing effect of the map results and improves the agreement of the population-weighted concentration with the averages of the concentration values measured at the stations of the relevant cities, while its change compared to the current method in areas outside the measurement stations is limited. The uncertainty of the whole map is slightly poorer for the adapted method compared to the current one, however the benefits of the adapted method justify this slight worsening. **It is recommended to apply the adapted mapping method for the city ranking calculations**.

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