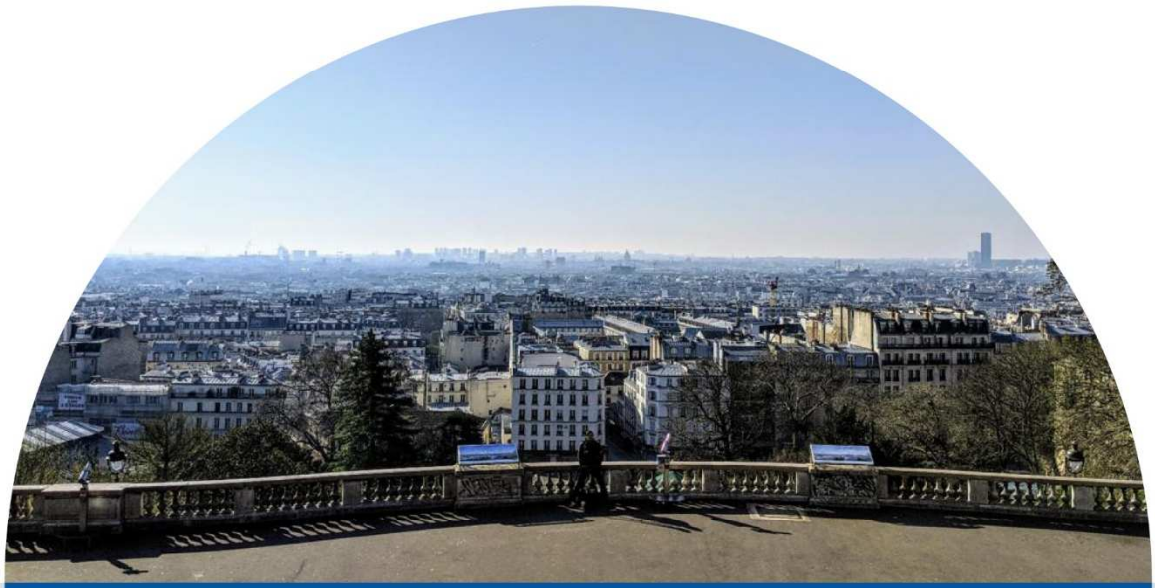
#AirQuality2020

October 2021



Air quality in the Paris region

SUMMARY 2020

AIR PARIF

AIR QUALITY IN THE PARIS REGION

Summary 2020

October 2021

This report is an English summary of the annual report on ambient air quality in the Paris region.
It gives an overview of the concentrations for the European Union regulated pollutants during the year 2020.

The complete report in French can be downloaded on the AIRPARIF website:
https://www.airparif.asso.fr/dossiers-fiches-thematiques/2021/bilan-2020-de-la-qualite-de-lair-en-ile-de-france

Air quality complete data in the Paris region can be downloaded at:
https://data-airparif-asso.opendata.arcgis.com/

Annual air pollution maps are available at *https://www.airparif.asso.fr/surveiller-la-pollution/bilan-et-cartes-annuels-de-pollution*

All data, reports and studies performed by AIRPARIF are publicly available.
Full and free access is granted on the AIRPARIF website.

Any use of part of this report should mention "AIRPARIF, the Observatory of Air Quality in the Paris Region".

Cover illustration: map of the annual NO_2 concentration in 2020 (Airparif – Google Earth & Landsat data)

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1. KEY FACTS FOR 2020

2020 has been a very special year, due to the health crisis of the Covid-19 and the government measures adopted to deal with it. These various measures have led to a significant reduction in pollutant emissions, in particular those from road and air traffic, and especially during the strict lockdown of the spring. In 2020, a decrease in pollution was observed compared to 2019. It is linked to various parameters: both a downward trend for several years due to reduction measures undertaken locally and at national and European level, to which is added a cyclical impact of the measures to restrict some activities put in place because of the pandemic, and the dispersive role of the weather conditions.

The decrease of the nitrogen dioxide (NO_2) concentrations in the Paris agglomeration continues in 2020. This is consistent with the decline of nitrogen oxides emissions (road traffic, industries, heating) in the Paris region. Near road traffic and on the busiest axes (Boulevard Périphérique, A1 Highway, etc.) the average NO_2 levels are always way higher than the annual limit value (set at 40 µg/m³), but some roads have passed below this threshold. **In 2020, less than 100 000 inhabitants of the Paris Region are potentially exposed to the exceeding of the annual NO2 limit value.**

→ Despite an improvement, daily and annual limit values for **PM_{10} particles** are still exceeded at some roadside sites. In 2020, **less than 1% of the inhabitants living in the Paris area and close to main roads were potentially affected by the PM_{10} exceedance of the daily limit value** (50 µg/m³ not to be exceeded more than 35 days a year)**.** However, approximatively 50% of the inhabitants of the Paris Region are exposed to an exceedance of the WHO recommendations (50 µg/m³ not to be exceeded more than 3 days a year).

For **fine particles ($PM_{2.5}$)**, the annual mean concentrations are still above the French quality objective (also corresponding to the World Health Organization recommended value of 10 µg/m³). **In 2020, almost every inhabitant of the Paris region were affected by an exceedance of these air quality objectives**.

→ Regarding **ozone (O_3) levels**, **the quality objective is exceeded every year in the whole Paris region, and especially in sub-urban and rural areas.**

→ After a long period of sharp decrease which began at the end of the 1990's, **benzene (C_6H_6)** levels continue to slightly decline and tend to stabilize (both near traffic and in background situation). The annual limite value (5 µg/m³) is widely complied on the whole region. However, there is a low risk to locally exceed the annual quality objective (2 µg/m³). However, **no inhabitants living in the agglomeration and in roadside conditions are exposed to an exceedance of this threshold**.

→ **Regarding pollution episodes, the information and warning procedure was triggered 14 days in 2020.** This is 3 days less than in 2019. **These episodes are due to O_3 (9 days) and PM_{10}(5 days)**.

SITUATION OF THE PARIS REGION IN RELATION TO AIR QUALITY STANDARDS FOR DIFFERENT REGULATED POLLUTANTS

Figure 1 shows whether, in 2020, air quality standards (limit value, target value and quality objective) are met or exceeded in the Paris region for the regulated pollutants.

Figure 1: situation in 2020 of the Paris region in relation to air quality standards for different regulated pollutants (Glossary at the end of this document)

2. POLLUTANTS EXCEEDING AIR QUALITY STANDARDS

2.1 Nitrogen dioxide (NO_2)

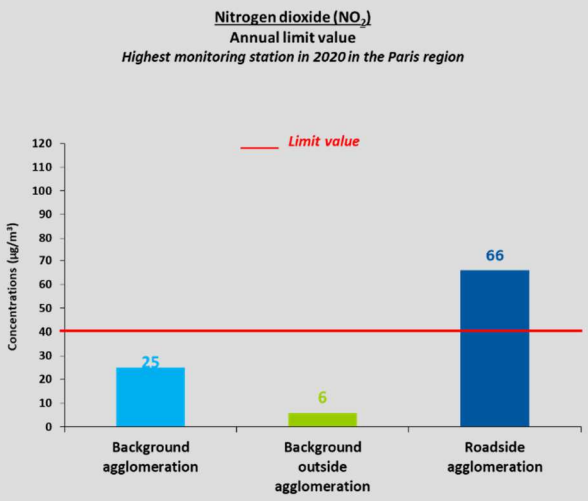
Nitrogen dioxide (NO_2) in brief

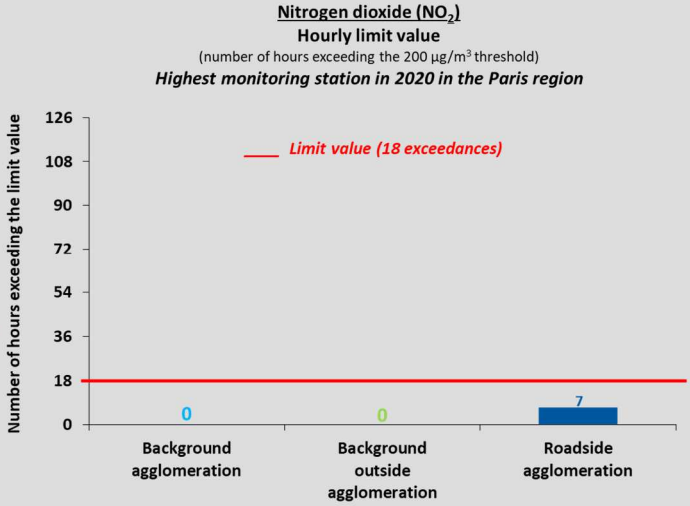
Nitrogen dioxide remains an important issue in the Paris region.

The main source of NO_2 is road traffic.
Although a decrease in annual average levels in NO_2 is confirmed both in background situation and near road traffic, levels along major roads are still much higher than the EU annual limit value.

For the second year in a row, some road traffic sites register average annual concentrations lower than the annual limit value, resulting in a significant decrease of the inhabitants potentially exposed to an exceedance of this limit.

In 2020, less than 100 000 inhabitants (less than 1 % of the regional population) living in the centre of the agglomeration are potentially exposed to an exceedance of the EU annual limit value.





Summary of air quality standards exceedances for nitrogen dioxide (NO_2) in the Paris region

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 2 show the annual mean NO_2 concentrations within the Paris region, with a focus on Paris and surrounding subsurbs in 2020.

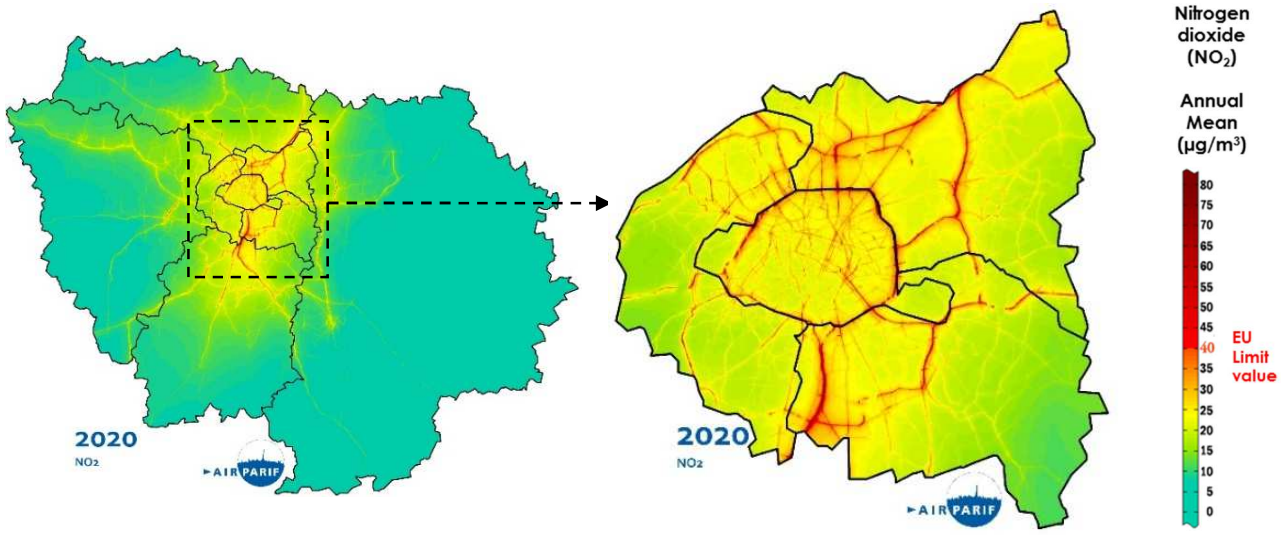


Figure 2: nitrogen dioxide (NO_2) annual mean concentration within the Paris region, with a focus on Paris and surrounding suburbs in 2020

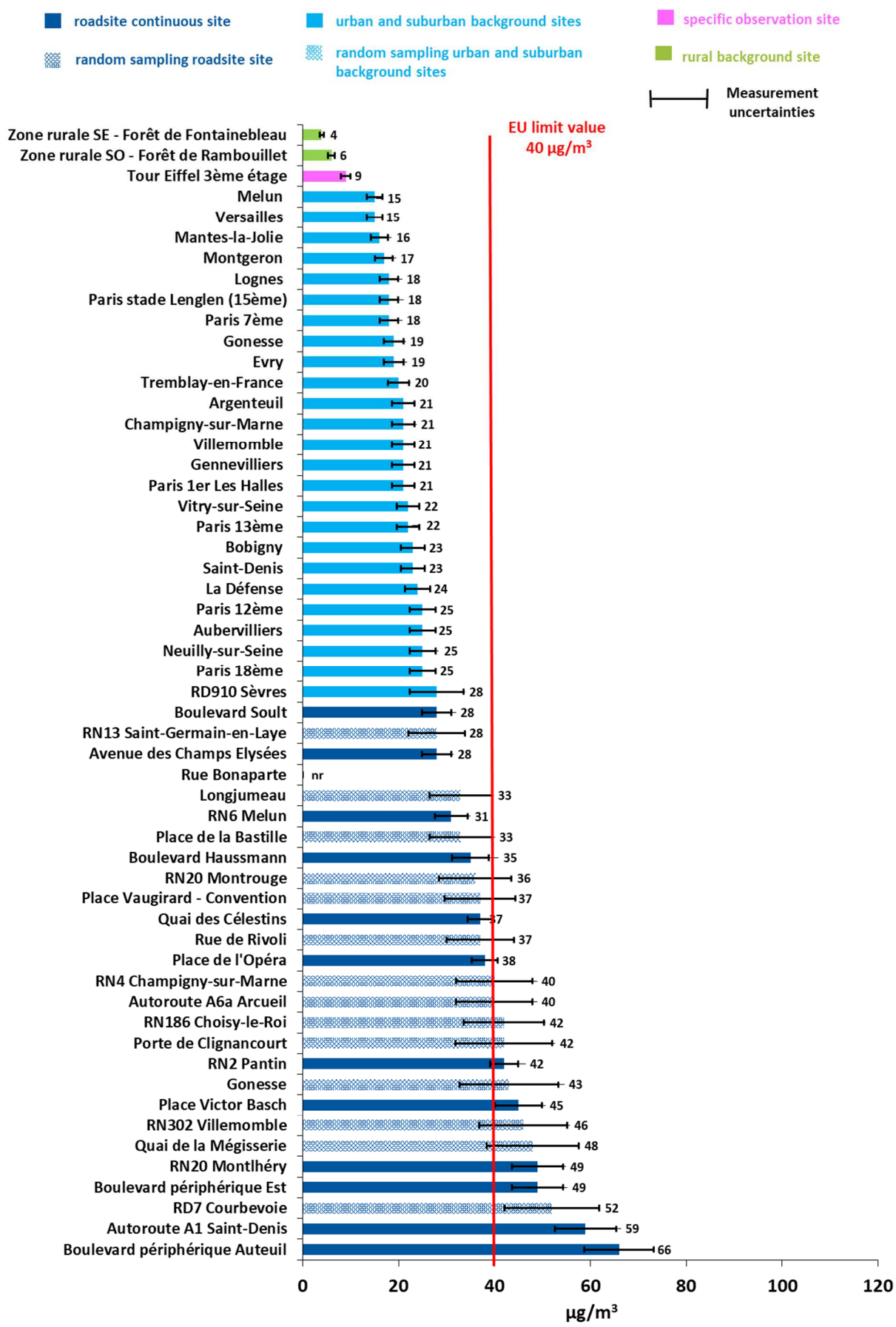
There is a **strong NO_2 background concentrations gradient** between rural areas and the centre of the Parisian agglomeration. Thus, annual mean levels measured within the agglomeration reach 25 µg/m³ (Figure 3) and the mean regional background level of NO_2 is between 4 and 6 µg/m³ in 2020.

Highest NO_2 mean concentrations are measured within the Paris agglomeration, near major traffic roads (motorways and national highway)**.** In Paris, the right bank of the Seine River is broadly more polluted than the left bank because of higher roads density.

Since 2015, the EU limit value for nitrogen dioxide (40 µg/m³) has been met at all the monitoring stations in background situation. In 2020, background mean concentrations are lower than those measured in the previous years.

NO_2 levels along major roads are more than twice those in background situation. In some cases, they are much higher than the EU annual limit value. The threshold exceedance has been confirmed in 2020 for approximately 500 kilometres of roads and highway connections. This corresponds to approximately 5 % of the main road network modeled by Airparif. These road axes are mainly located in the urban area of Paris.

Between 2019 and 2020, a significant drop in NO_2 levels is observed, both in the background and near road traffic. In Paris, the annual mean concentrations of NO_2 in a background situation have decreased by around 30%, of which 20% are attributable to the drop in emissions linked to the health crisis, and 10% are due to trend changes (renewal of the rolling stock and decrease in road traffic) and the influence of dispersive meteorological conditions, particularly in winter, when NO_2 concentrations are usually maximum. In the inner suburbs, the annual average concentrations have fallen by around 20%, of which 10% are attributable to the drop in emissions linked to the health crisis and 10% to trends and the influence of weather conditions. In the outer suburbs, the impact of COVID is negligible.



In addition to continuous measurements of NO_2, discontinuous measurements are performed by AIRPARIF since 2007. These measurements are carried out using passive diffusion tubes during 12 uncontinuous weeks evenly distributed over the year. For these sampling sites, the results reported in this figure represent the average of twelve weeks measurements.

Figure 3: nitrogen dioxide (NO_2) annual mean concentration for all monitoring sites in the Paris region in 2020

NO_2 mean concentrations are highly variable from one traffic site to another. It reflects a wide range of concentrations measured near major traffic roads and are due to **differences in traffic conditions** (traffic flow, speed, vehicle fleet) **and topography** that are more or less favorable to the pollutants dispersion.

In 2020, **less than 100 000 inhabitants (less than 1 % of the regional population) are potentially exposed to an exceedance of the NO_2 EU annual limit value (Figure 4)**. They are mainly living within the Parisian agglomeration.
The number of people potentially exposed is way lower in 2020 compared to 2019 (nearly 500 000 inhabitants in 2019 and less than 100 000 in 2020). This is explained by the fact that the annual average concentrations recorded on many axes have fallen below the threshold of the limit value (40 µg/m^3). This phenomenon would also have been observed if it had not been for the activity restrictions linked to the health crisis, due to the trend change and the effect of particularly dispersive meteorology, and has been accentuated by the measures restrictions on activities related to the pandemic.

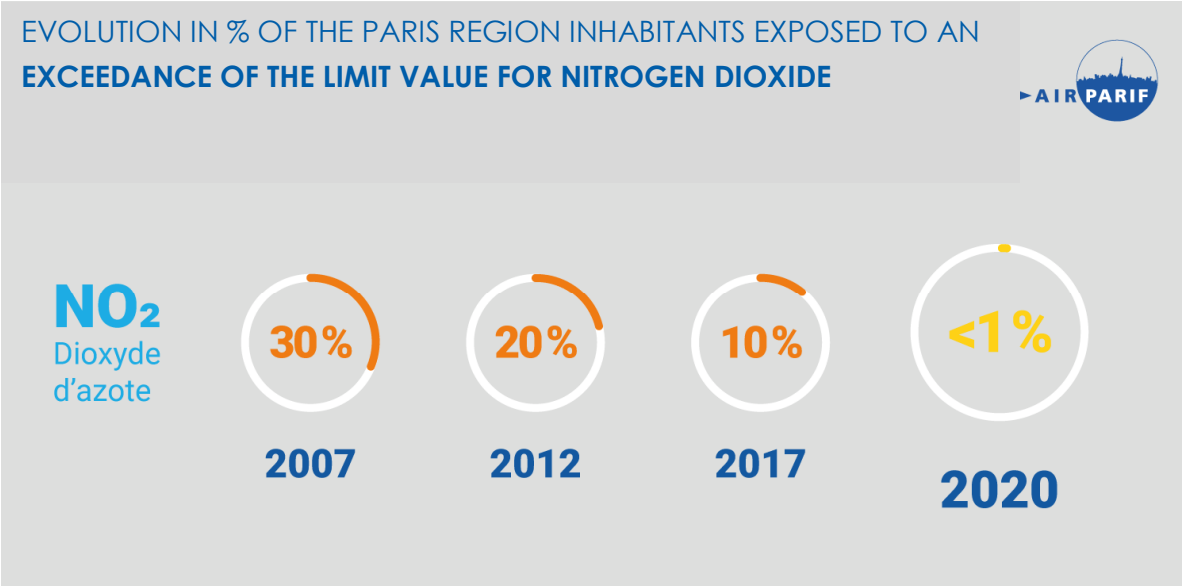


Figure 4: million of inhabitants potentially exposed to a nitrogen dioxide (NO_2) level exceeding the EU annual limit value in the Paris region from 2007 to 2020

LONG-TERM TRENDS

As the year 2020 is particularly atypical, the trends presented in this report are based on the concentrations for the period 2009-2019.

The maps in Figure 5 show a similar pollution pattern illustrating **a downward trend of NO_2 annual mean concentrations between 2007 and 2019 within the Paris region.**

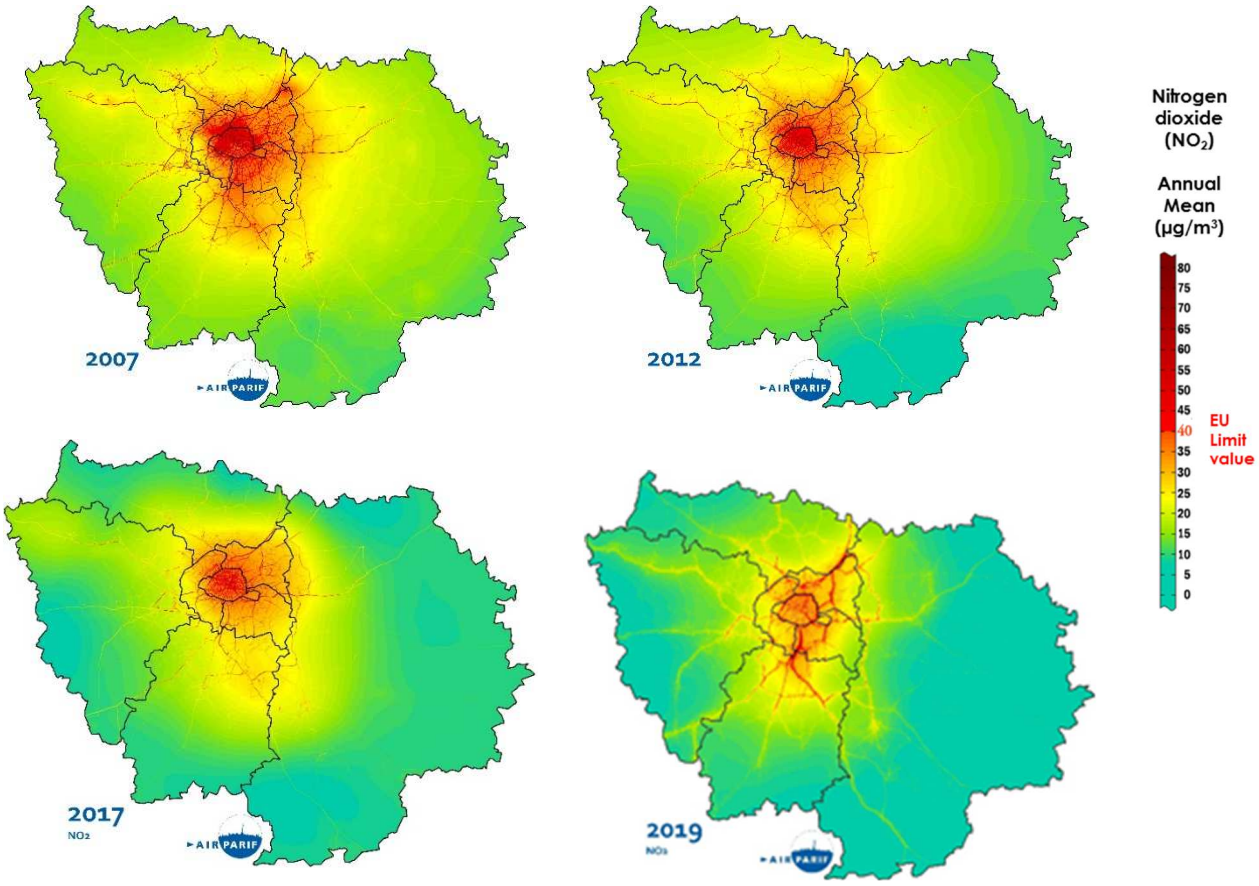


Figure 5: annual mean concentrations of nitrogen dioxide (NO_2) from 2007 to 2019 in the Paris region

A downward trend of NO_2 tri-annual mean levels is observed since the end of the 1990's on background sites (Figure 6). Technological improvements of emission sources (road traffic, heating, industry) can explain reduced NO_2 levels, especially due to **the progressive expansion of catalytic converters on gasoline and diesel vehicles.** NO_2 tri-annual mean concentrations are broadly stable from 1992-1994 to 1999-2001. The average annual decrease of about -3 % from 2000 to 2006. It is slower since then (with an annual average of around -2 %). Between 1992 and 2019, the annual background concentrations decreased by around 40 %.

The trend in NO_2 tri-annual mean concentrations is quite different in roadside situation. **NO_2 levels based on a permanent sample of traffic stations are broadly constant between 1998 and 2012. A downward trend of NO_2 concentrations is observed since the 2011-2013 period**. From 2011 to 2019, annual concentrations in proximity to road traffic decreased by around 30%. Over this period, the average annual decrease is 3%. The year 2020 is presented for information but is not included in a tri-annual mean.

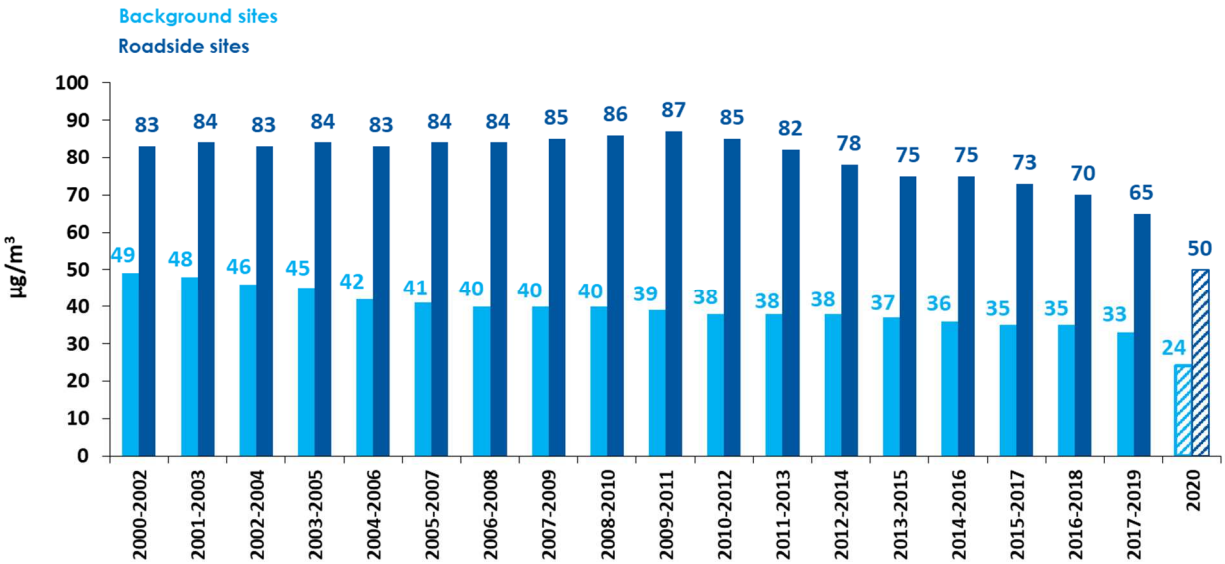


Figure 6: trend in the NO_2 tri-annual mean concentration (based on a sample of the same 6 urban background sites and 5 roadside sites) within the Paris agglomeration from 1996-1998 to 2020

Nitrogen dioxide (NO_2) is a complex pollutant related to direct emissions (from transport, heating and industry sectors) and chemical reactions with other atmospheric pollutants, especially ozone (O_3).

A study on the specific impact of traffic measures to improve air quality in Paris and London has been conducted by the King's College and Airparif (Font et al., 2019). This study focuses specifically on the share of pollution related to road traffic. It enables to highlight the influence of the evolution of the road fleet, in connection with the implementation of the euro standards and the local measures aiming at reducing traffic emissions.

Over the 2005-2009 period, the overall stability of NO_2 levels close to traffic is mainly due to the dieselisation of the road fleet. Indeed, numerous studies show that the treatment carried out to reduce particulate emissions has led to an increase in primary NO_2 emissions since the introduction of Euro 3 diesels (Grice et al., 2009, Weiss et al., 2012; et al., 2016).

The decrease of NO_2 levels near traffic is related to the introduction of the Euro 5 standard, especially for heavy vehicles. However, the Euro 5 standard on light diesel vehicles did not lead to a significant decrease in actual emissions. Indeed, the emissions of this pollutant in real traffic conditions are way higher than the standards corresponding to this standard.

One of the major reasons to the changes of nitrogen dioxide levels, both in terms of background and proximity to road traffic situations, is linked to the renewal of the road fleet and the evolution of NO_2 primary emissions by diesel vehicles.

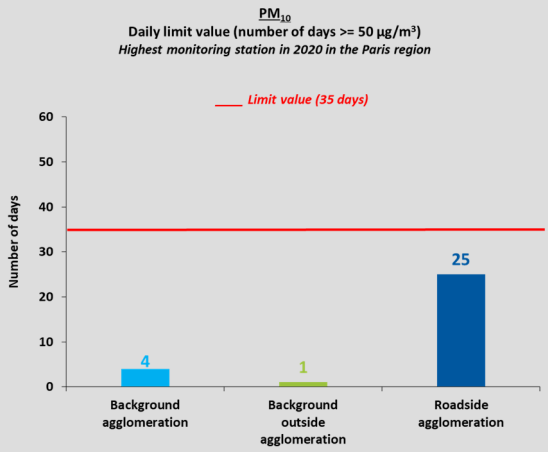
2.2 PM_{10} particles

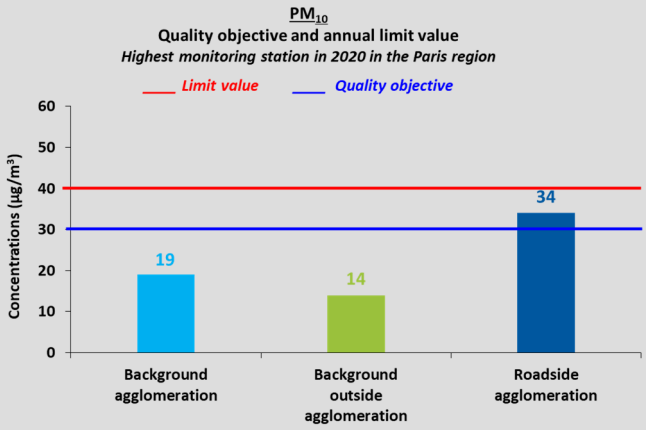
Particulate Matter (PM) in brief

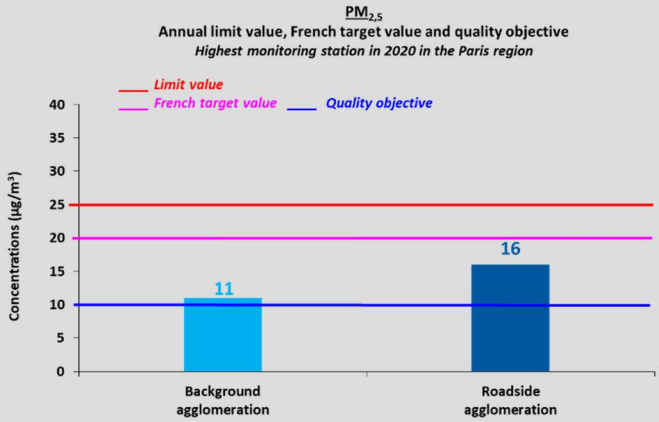
A decreasing trend of the PM is observed, in both background and near traffic situations. Nonetheless, recurrent exceedances of PM_{10} EU limit values are still observed near traffic

Less than 1% of the population is potentially exposed to an exceedance of the PM_{10} EU daily limit value
Less than 1% of the population is potentially exposed to an exceedance of the PM_{10} quality objective
More than 75% of the population is potentially exposed to an exceedance of the WHO recommendations

$PM_{2.5}$ levels complies with the annual limit value (25 µg/m³) and with the target value (20 µg/m³). However, they are still much higher than the French quality objective (10 µg/m³). Approximatively 20 % of the inhabitants living in the Paris region are still exposed to an exceedance of this threshold. Moreover, almost every inhabitant of the Paris Region is exposed to an exceedance of the WHO recommendations.







Summary of air quality standards exceedances for Particulate Matter (PM_{10} and $PM_{2.5}$) within the Paris region

EU daily limit value (50 µg/m³ not to be exceeded more than 35 days a year)

The maps in Figure 7 show the PM_{10} annual number of days exceeding the EU daily limit value within the Paris region, with a focus on Paris and surrounding subsurbs in 2020.

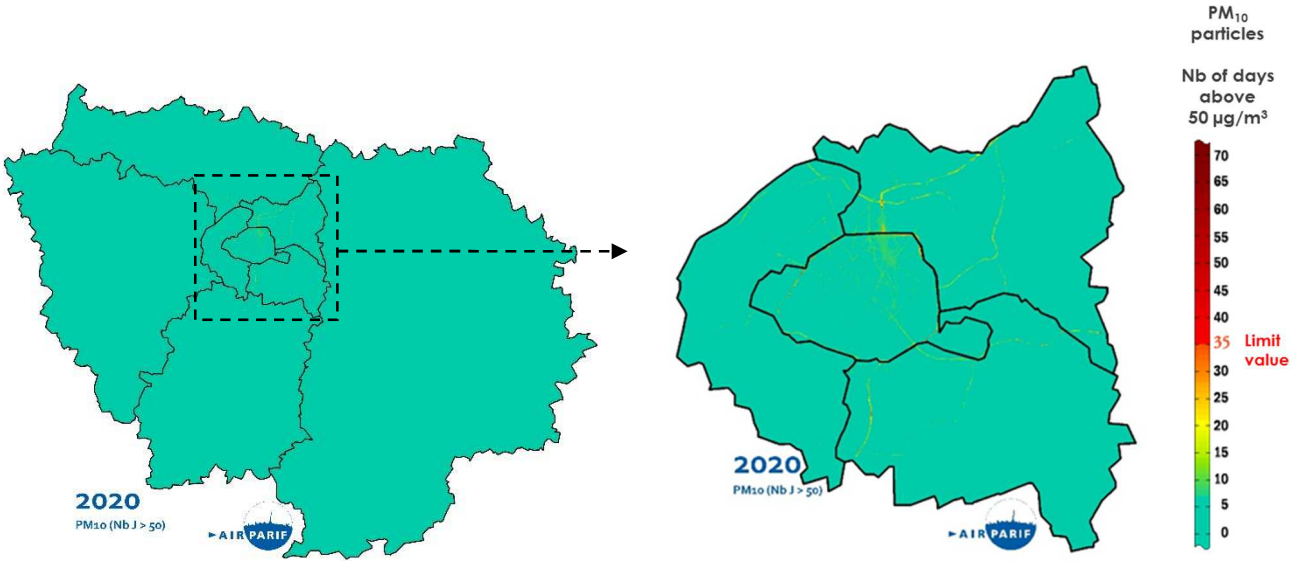


Figure 7: PM_{10} annual number of days exceeding the 50 µg/m³ EU threshold within the Paris region with a focus on Paris and surrounding suburbs in 2020

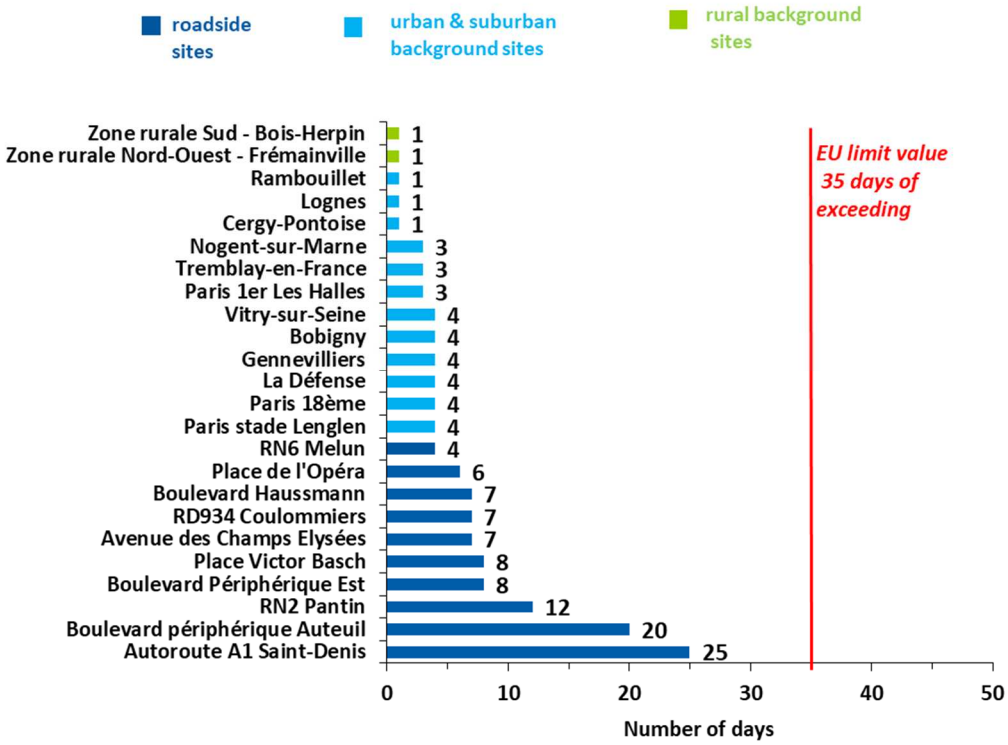


Figure 8: PM_{10} annual number of days exceeding the 50 µg/m³ EU threshold for all continuous monitoring sites within the Paris region in 2020

In 2020, the EU daily limit value is met in background situation (Figure 8). In 2020, the PM_{10} annual number of days exceeding the 50 µg/m³ is lower (1 to 4 days) than in 2019 (1 to 10 days). However, the EU daily limit value is still exceeded near traffic. This exceedance was observed in 2020 on less than 1% of the Paris region roads.

Near traffic, in 2020, less than 1 % of the population is potentially exposed to an exceedance of the PM_{10} EU daily limit value (Figure 9).

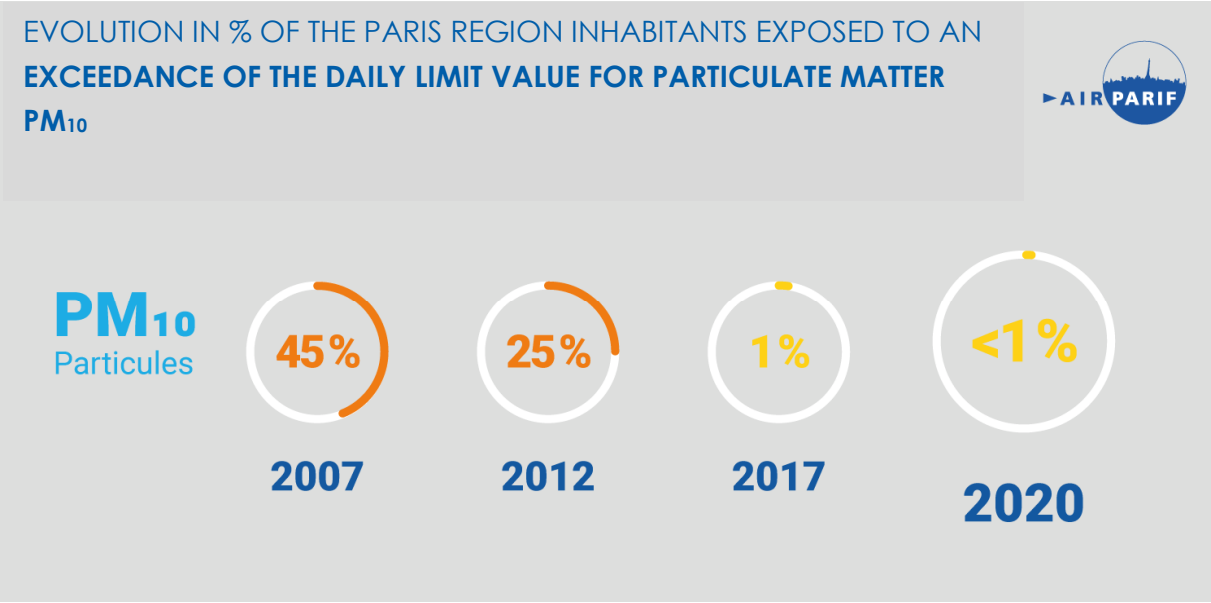


Figure 9: million of inhabitants potentially exposed to a PM_{10} level exceeding the EU daily limit value within the Paris region from 2007 to 2020

EU annual limit value (40 µg/m³ on average)

The maps in Figure 10 show the annual mean PM_{10} concentration within the Paris region, with a focus on Paris and surrounding subsurbs in 2020.

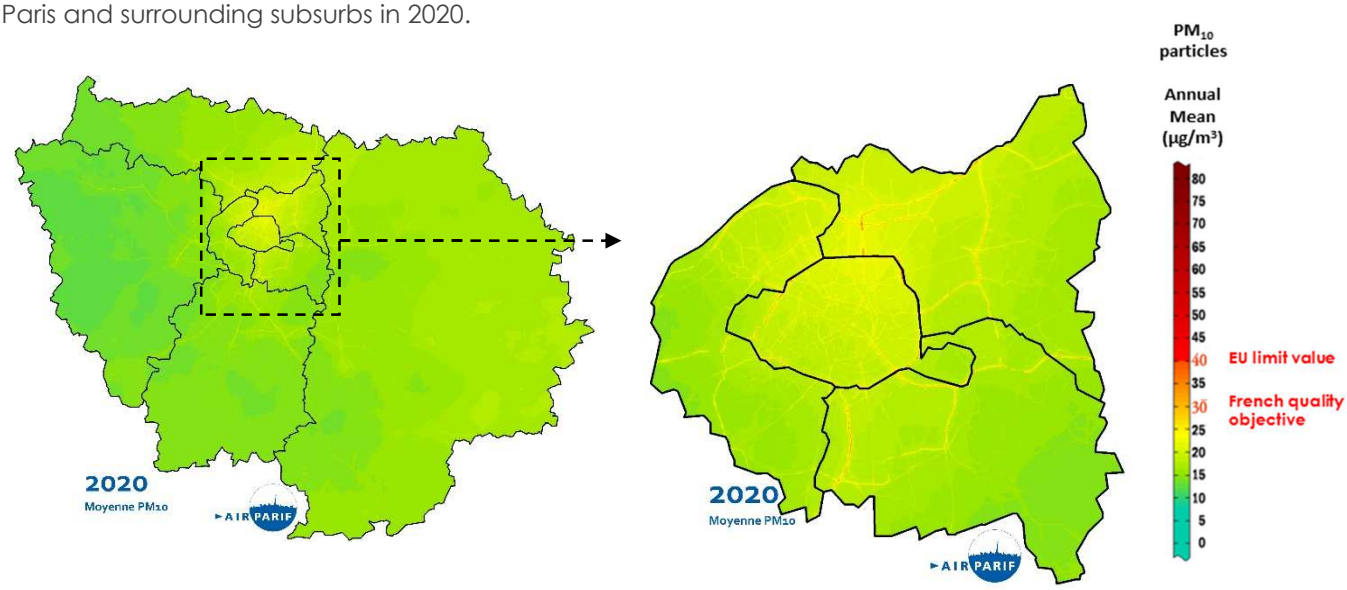


Figure 10: PM_{10} annual mean concentration within the Paris region with a focus on Paris and surrounding suburbs in 2020

As in the last years, PM_{10} background levels measured in the Paris agglomeration are fairly homogeneous in 2020 (between 14 and 19 µg/m³). A slight decline in PM_{10} concentrations from the Paris agglomeration to the periphery of the region is observed (Figure 11). In general, **background annual mean levels are slightly lower in 2020 than in 2019.**

PM_{10} standard annual values (EU annual limit value and French annual quality objective) are widely met in background and rural situations.

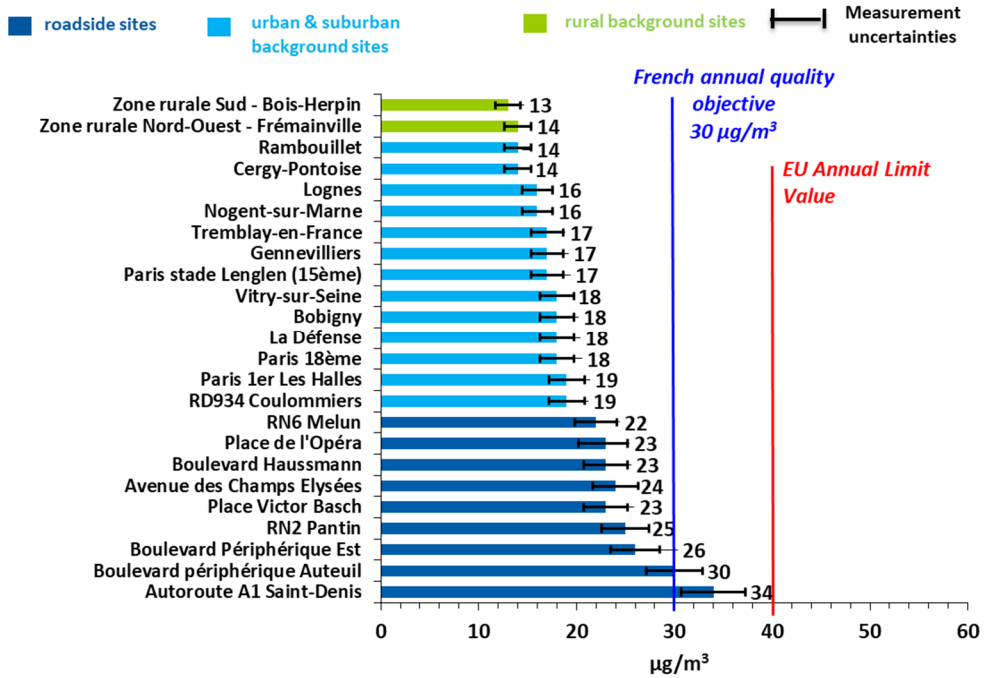


Figure 11: PM_{10} annual mean concentrations for all continuous monitoring sites in the Paris region in 2020

Highest PM_{10} mean concentrations were measured near main roads in 2020. PM_{10} levels near traffic (19-39 µg/m³) can be up to twice higher than those measured in background situation. However, PM_{10} concentrations slightly decline between 2019 and 2020 at roadside sites.

For the first time, the EU annual limit value (40 µg/m³) is met at all the traffic monitoring station. This decrease follows the trend of recent years and is accentuated in 2020 by the weather, which offered very dispersive winter conditions and very rainy months (February, October, December), as well as by the situation linked to the Covid. On the other hand, the quality objective is still exceeded on this site, as well as the WHO recommendation of 20 µg/m³, while all the traffic stations of Airparif's permanent network comply with it.

In 2020, approximatively 10 % of the regional population are potentially exposed to an exceedance of the PM_{10} quality objective (Figure 12). This value is way lower than in 2019 where almost 30 % of the regional population were concerned by this exceedance.

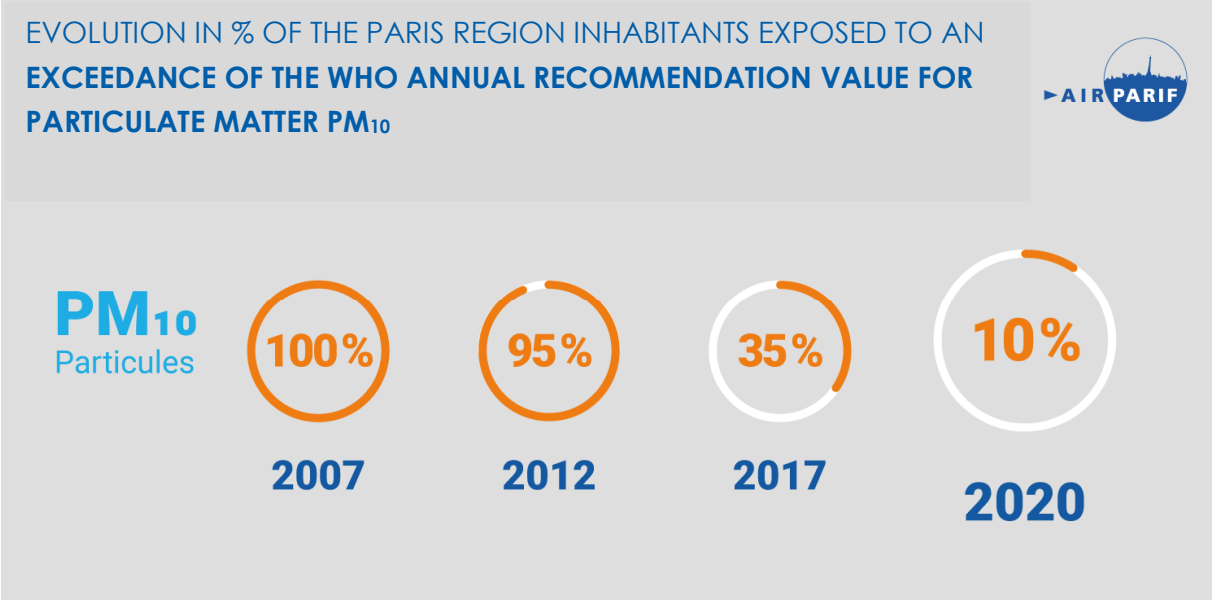


Figure 12: million of inhabitants potentially exposed to a PM_{10} level exceeding the WHO recommendations in the Paris region from 2007 to 2020

LONG-TERM TRENDS

As the year 2020 is particularly atypical, the trends presented in this report are based on the concentrations for the period 2009-2019.

PM_{10} show an overall downward trend between 2007 and 2019, as illustrated by the maps in Figure 13, particularly in the heart of the Paris agglomeration.

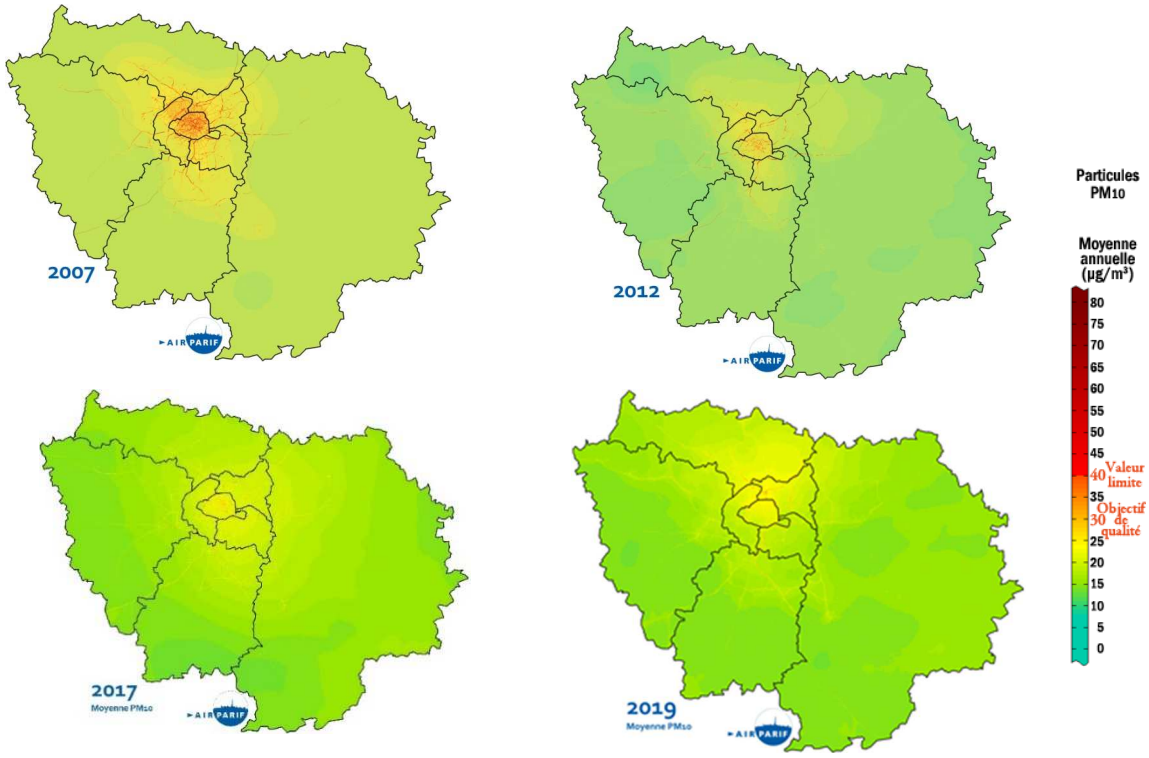


Figure 13: number of days exceeding the EU daily limit value in PM_{10} in the Paris region from 2007 to 2019

AVERAGE ANNUAL TRENDS

The Figure 14 shows **a downward trend of PM_{10} mean concentrations in background agglomeration**. **These PM_{10} levels decreased by about 35 % from 1999 to 2019**. This is related to the PM_{10} regional emissions reduction for almost -30 % between 2005 and 2015. **This decline is particularly strong over the last years in background situation. This decrease is also observed in rural agglomeration.** The year 2020, atypical, is presented for information but is not included in a tri-annual mean.

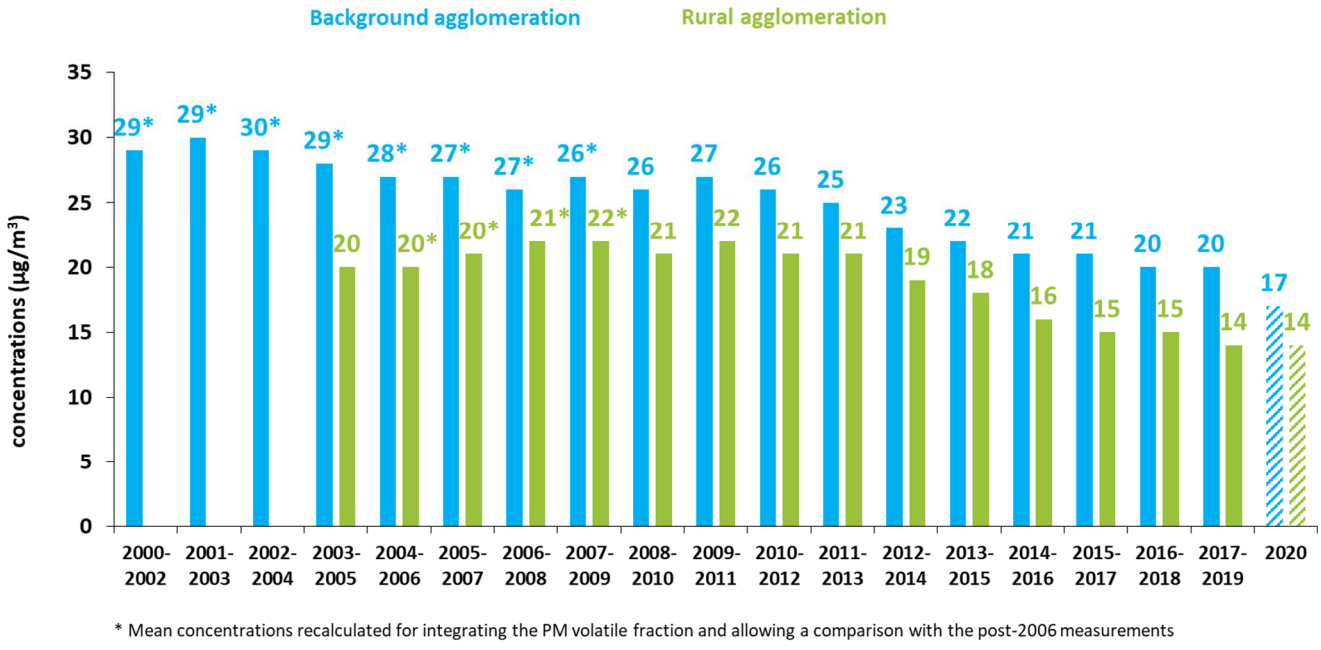


Figure 14: trend in the PM_{10} tri-annual mean concentration (based on a scalable sample of background sites located within and out of the Paris agglomeration) from 2000-2002 to 2000

The Ring road "Boulevard Périphérique (BP) Porte d'Auteuil" traffic monitoring station is providing PM_{10} measurements since 1998 and Place Victor Basch since 2003. The Figure 15 shows **a downward trend of PM_{10} mean concentrations** of around -35 % for BP Porte d'Auteuil between 1998 and 2019. This trend can be explained by a greater decline in particle emissions from road traffic (around -30 % between 2000 and 2015), especially due to **the progressive introduction of diesel particulate filters**. The year 2020 is presented for information but is not included in a tri-annual mean.

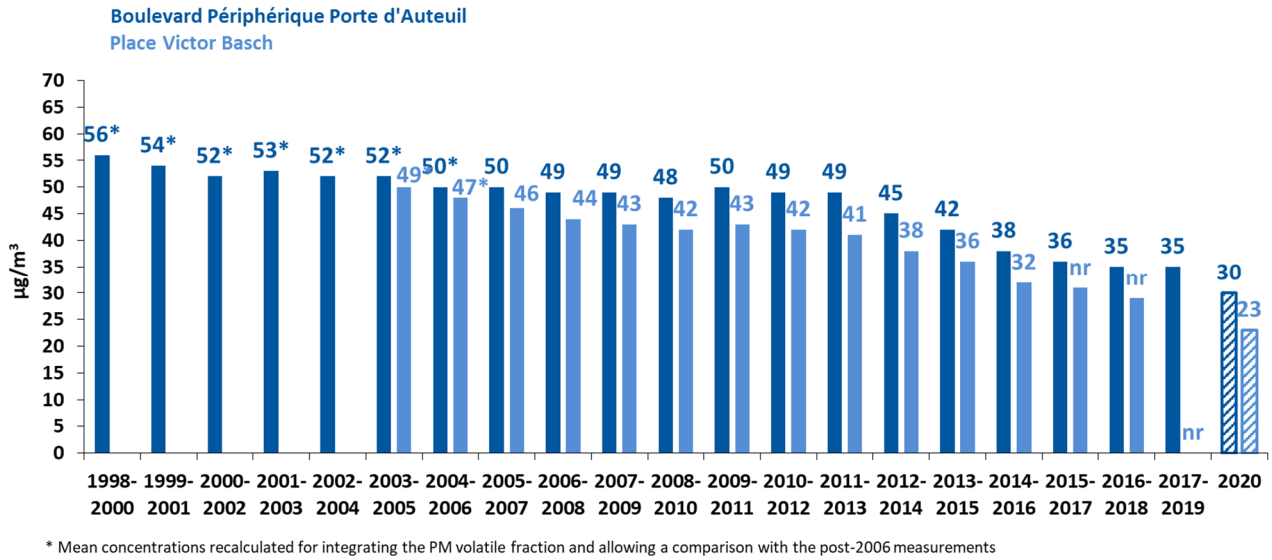


Figure 15: trend in the PM_{10} tri-annual mean concentration at the Place Victor Basch and BP Porte d'Auteuil stations from 1998-2000 to 2020
nr : not representative

Regardless of the reductions in road traffic and economic activities linked to the COVID-19 pandemic, 2020 pursued the downward trend. The reduction in activities had little impact on PM_{10} concentrations. This is explained by the sources diversity of particulate matter, including residential heating, construction sites and agriculture, with less traffic responsibility than for NO_2. As a result, the impact of strong reductions in emissions from road traffic is less noticeable than on nitrogen oxides. It is partially offset by increases in emissions from the residential sector (in particular wood heating during the first lockdown in spring 2020) compared to a baseline situation, with Ile-de-France residents having spent more time at home. This increase was however limited by the very mild winter temperatures.

2.2 $PM_{2.5}$ particles

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 16 show the annual mean $PM_{2.5}$ concentration within the Paris region, with a focus on Paris and surrounding subsurbs in 2020.

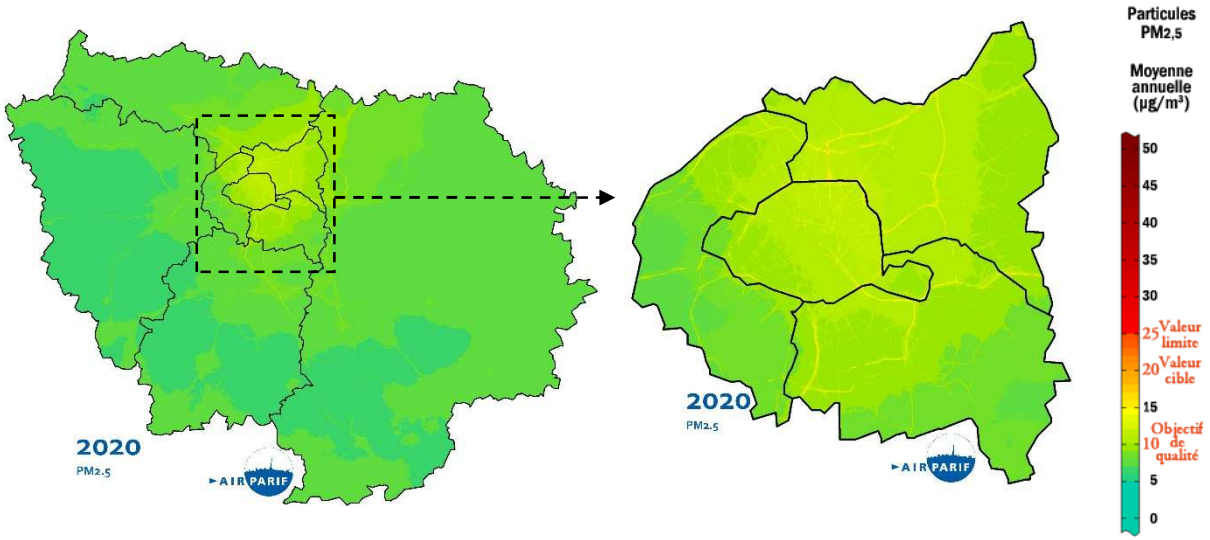


Figure 16: annual mean concentration of fine particles $PM_{2.5}$ in the Paris region, with a focus on Paris and surrounding suburbs in 2020

There is a small difference in $PM_{2.5}$ concentrations between urban and rural areas in 2020. $PM_{2.5}$ annual mean concentrations range from 5 to 8 µg/m³ in rural situation and from 9 to 11 µg/m³ for urban and suburban background sites (Figure 17).

Highest $PM_{2.5}$ mean concentrations are measured within the Paris agglomeration and also near main roads and highway connections. In roadside situation, annual mean $PM_{2.5}$ concentrations range from 11 to 16 µg/m³.

Both in a background situation and near road traffic, the annual mean concentrations of $PM_{2.5}$ recorded in 2020 are lower than those measured in 2019.

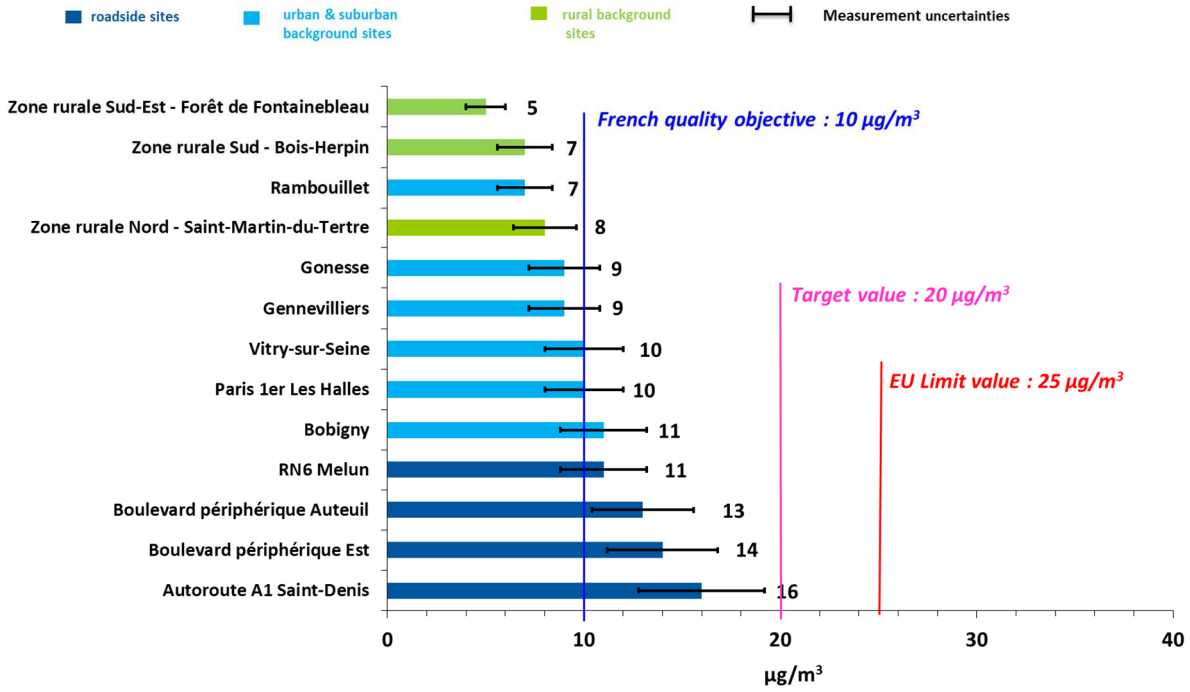


Figure 17: $PM_{2.5}$ annual mean concentration for all continuous monitoring sites in the Paris region in 2020

The EU limit value for fine particles $PM_{2.5}$ (25 µg/m³) ant the $PM_{2.5}$ target value (20 µg/m³) are met at all the monitoring stations.

$PM_{2.5}$ mean levels are above the WHO recommendations and **the French quality objective for fine particles $PM_{2.5}$ (10 µg/m³). Around 20 % of the inhabitants living in the Paris region (or around 2.5 million people) are potentially exposed to an exceedance of this French $PM_{2.5}$ quality objective.** In line with the decrease observed over the past two years, this number is way lower compared to 2019, when this exceedance concerned around 6.5 million people (or nearly 50%).
The daily WHO recommendation (25 µg/m³ not to be exceeded more than 3 days per year) is still exceeded in almost all of the Paris region in 2020 (Figure 18).

Figure 18: Evolution in percentage of the number of inhabitants of the Paris region concerned by an exceedance of the daily WHO recommandation for fine particles $PM_{2.5}$ (25 µg/m³ not to be exceeded more than 3 days per year) from 2007 to 2020

LONG-TERM TRENDS

As the year 2020 is particularly atypical, the trends presented in this report are based on the concentrations for the period 2009-2019.

As for PM_{10} particles, significant changes related to the occurrence of air pollution episodes are observed for fine particules $PM_{2.5}$, as illustrated in Figure 19.

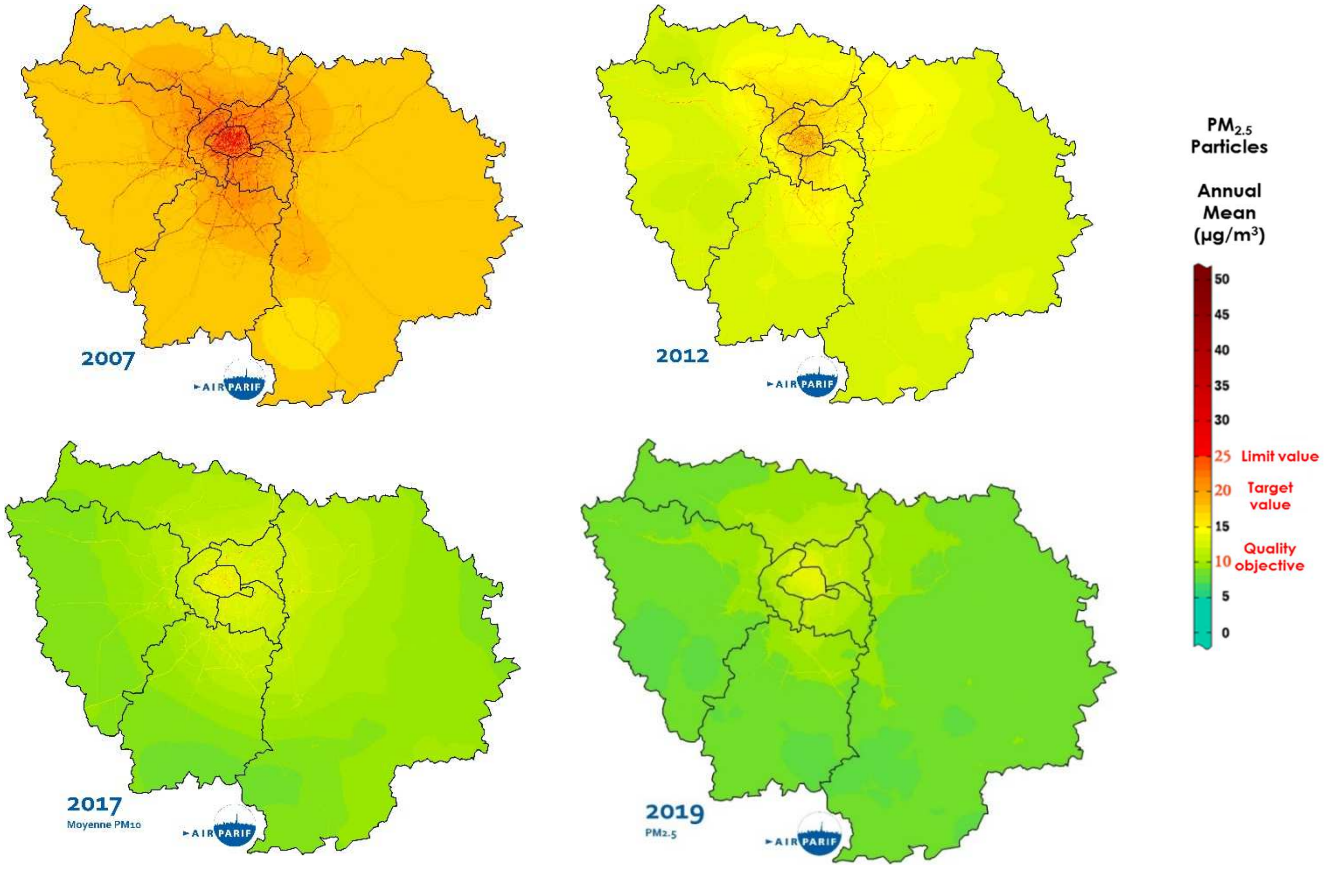


Figure 19: annual mean concentrations of fine particles $PM_{2.5}$ from 2007 to 2019 in the Paris region

$PM_{2.5}$ tri-annual mean levels reflect a significant decline of 45 % from 2000-2002 to 2017-2019 in background situation (Figure 20). The year 2020 is presented for information but is not included in a tri-annual mean.

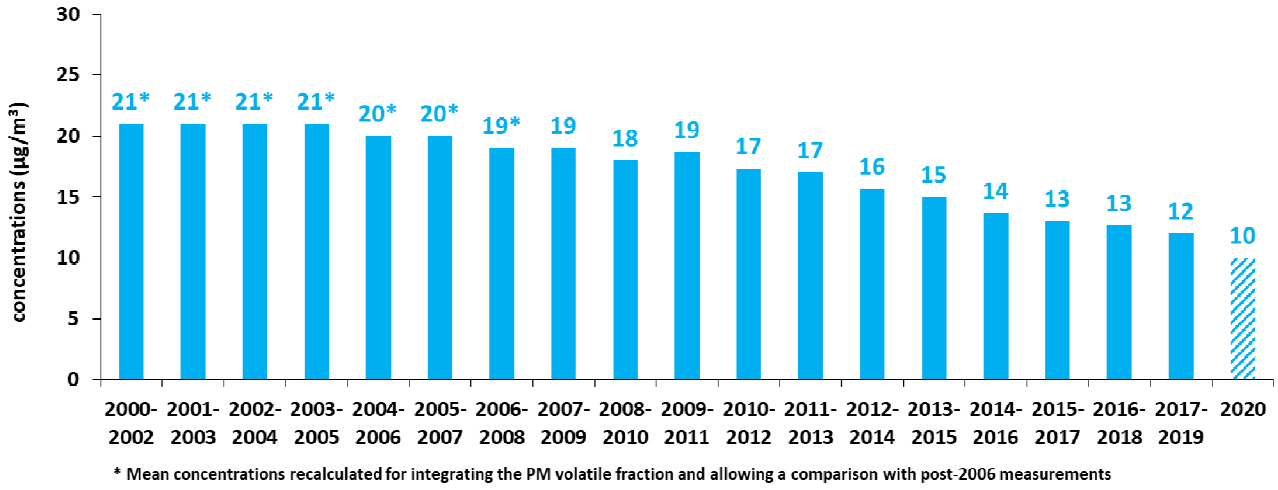


Figure 20: trend in the $PM_{2.5}$ tri-annual mean concentrations (based on a scalable sample of urban background sites) within the Paris agglomeration from 2000-2002 to 2020

The decline of $PM_{2.5}$ concentrations is particularly acute for the Ring road BP Porte d'Auteuil traffic monitoring station (Figure 21). A significant reduction in $PM_{2.5}$ levels of 60 % is observed from 1999 to 2019. As for PM_{10}, this decrease is related to the reduction of primary particles emissions from diesel exhaust (approximately -35 % between 2005 and 2015). **The decrease is greater for $PM_{2.5}$ than for PM_{10} particles as most of $PM_{2.5}$ particles are emitted in vehicles exhaust.** A large part of PM_{10} particles are emitted by tyre-wear, brake-wear, road abrasion and dust suspension. The year 2020 is presented for information but is not included in a tri-annual mean.

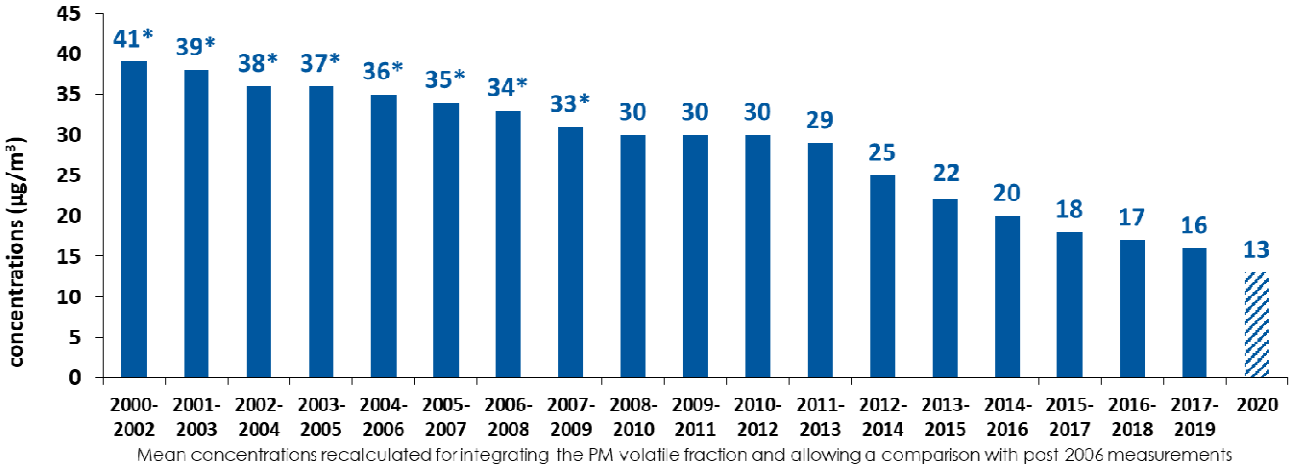


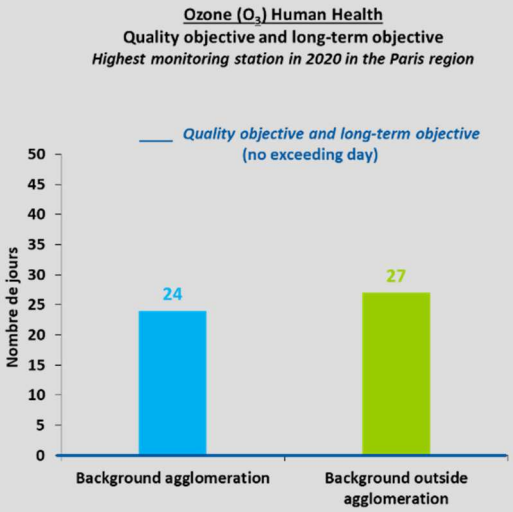
Figure 21: trend in the $PM_{2.5}$ tri-annual mean concentration for the traffic monitoring station Ring road BP Porte d'Auteuil from 1999-2001 to 2020

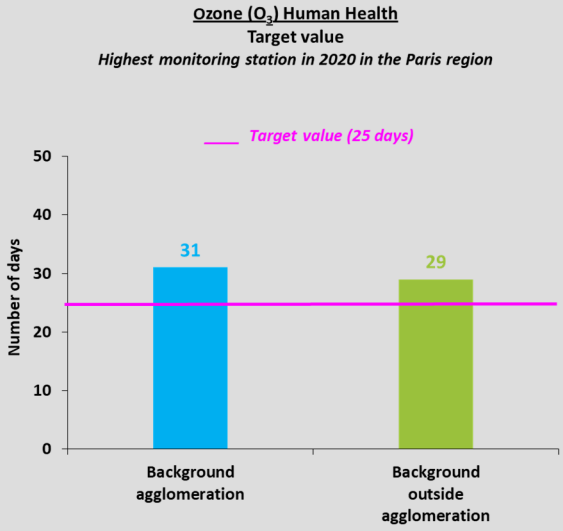
2.4 Ozone (O_3)

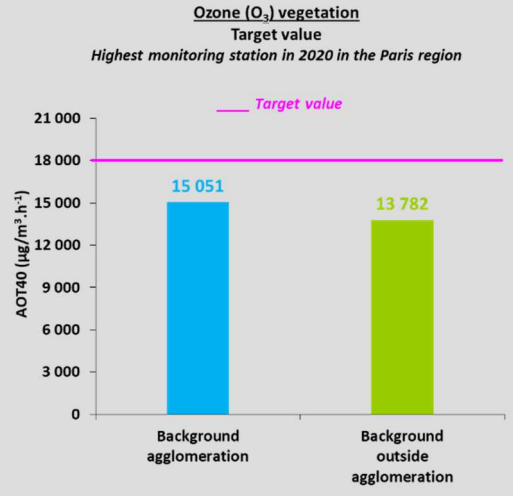
Ozone (O_3) in brief

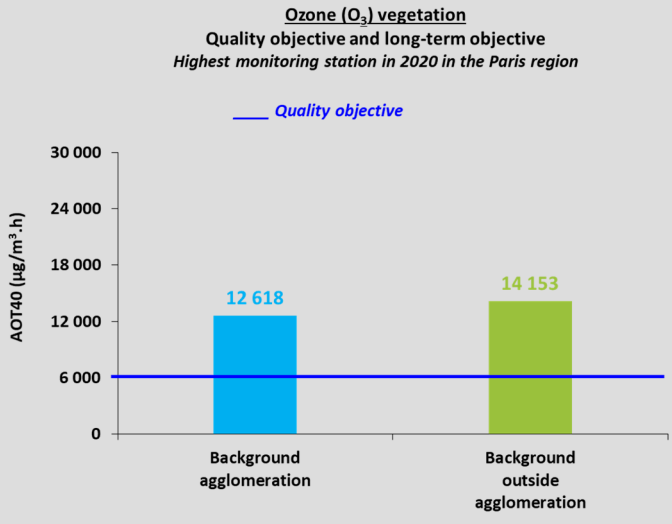
Quality objectives for the protection of health and vegetation are exceeded at any point of the region in 2020.
Target value for the protection of Human Health is exceeded, especially in some peri-urban and rural areas.
100 % of the population is affected by the exceedance of the WHO recommendation value (100 µg/m³ over 8 hours).

Ozone remains an important issue in the Paris region. It is the only pollutant with increasing annual concentrations.









Summary of air quality standards exceedances for ozone (O_3) in the Paris region

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

Ozone (O_3) is a secondary pollutant (and also a greenhouse gas) not directly emitted to the atmosphere but formed in air from complex reactions between the precursor gases (nitrogen oxides (NO_x) and volatile organic compounds (VOC)) in the presence of sunlight and high temperatures. Meteorological conditions (especially in spring and summer) influence O_3 concentrations.
Summer 2020 was hot and sunny. The anticyclonic conditions observed from June to September 2020, coupled with several heat waves and a high level of sunshine, led to a rise in summer ozone concentrations. As a result, ozone levels are higher than those recorded in 2019 but lower than those of 2018, were the summer weather conditions were even more intense.

Protection of Human Health

As in previous years, **the O_3 quality objective for the protection of human health** (120 µg/m³ on a maximum daily 8-hours mean per civil year) **is exceeded over the whole Paris region in 2020 (**
Figure 22**). Suburban and rural areas are more commonly affected than the Paris agglomeration.** Annual prevailing meteorological conditions (mainly summer conditions) have an impact on the number of threshold exceedances.

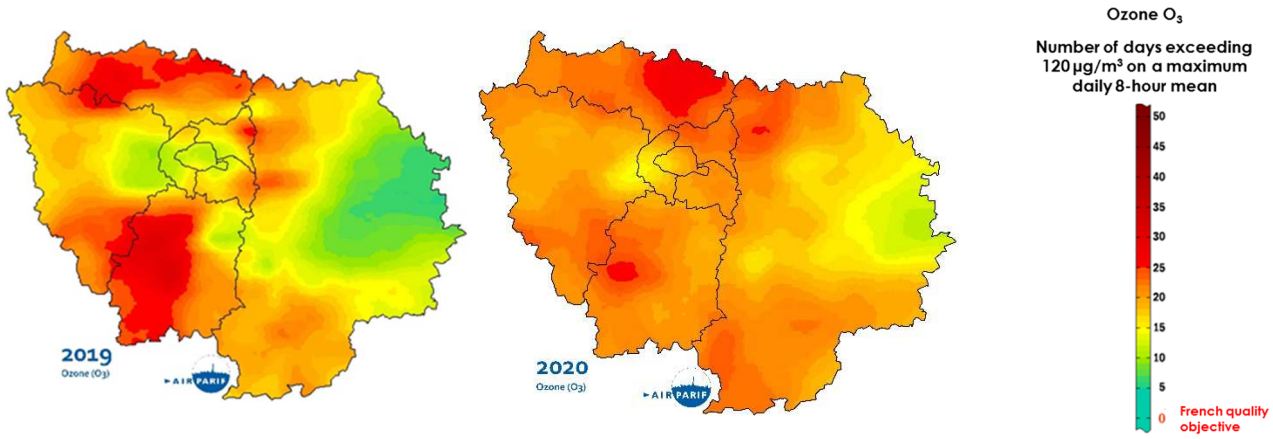


Figure 22: number of days exceeding the French quality objective (=EU long-term objective) threshold of 120 µg/m³ on a maximum daily 8-hours mean (objective = no exceedance) for ozone (O_3) in the Paris region in 2020

Due to higher sunlight and temperatures from June to September, **the year 2020 recorded a number of days of exceeding the quality objective higher than in 2019, but lower than in 2018.**

The **target value for the protection of human health** (calculated on a 3-years average) **is exceeded in the Paris region, on the 2018-2020 period, more specifically in some rural and suburban areas of the Essonne and Val d'Oise departments** (Figure 23).

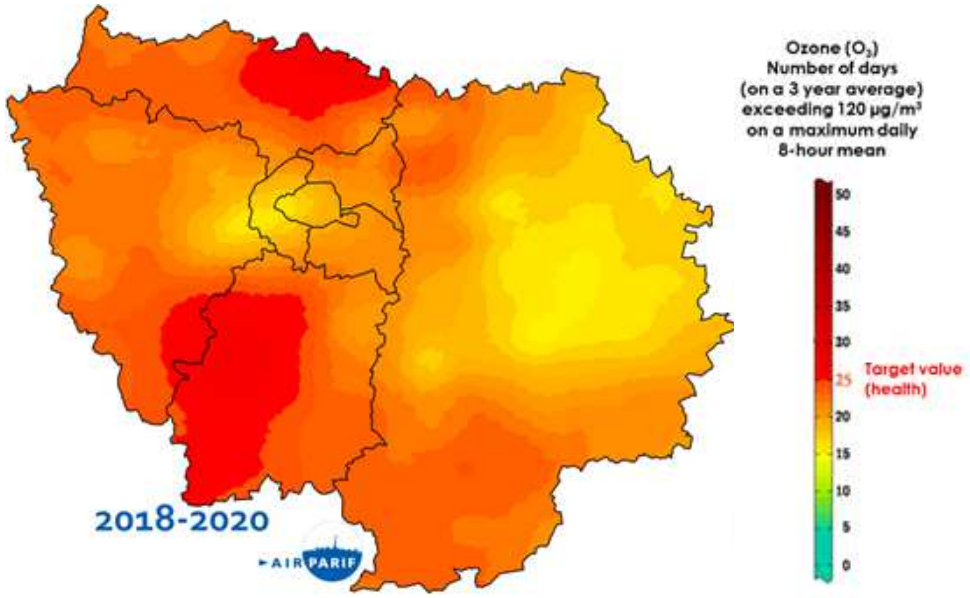


Figure 23: number of days exceeding the O_3 target value for the protection of human health (120 µg/m³ for the daily maximum on an 8-hours average not to be exceeded more than 25 days per calendar year calculated on a 3-years average) within the Paris region for the 2018-2020 period

The average number of days exceeding the O_3 target value is usually higher in rural and suburban areas than in the Paris agglomeration (Figure 24). This is due to the « ozone sinks » effect. It is specific to large metropolitan areas which concentrate NO_x sources from road traffic and residential heating. As a consequence, ozone is consumed by NO_x emissions through photochemical reactions.

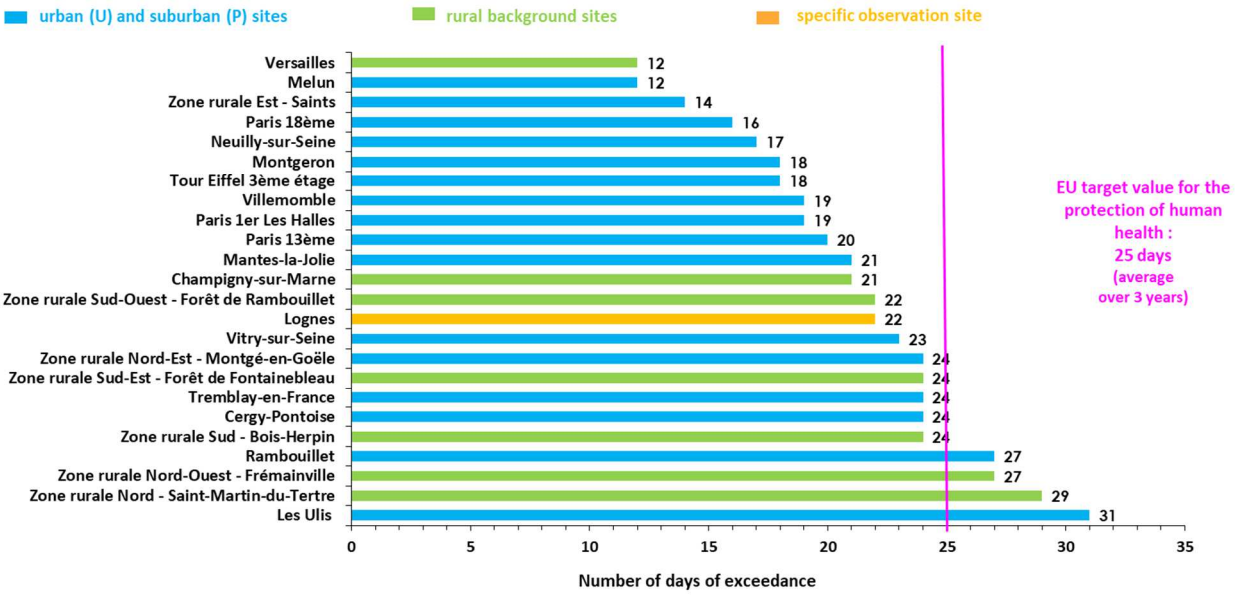


Figure 24: number of days exceeding the O_3 EU target value for the protection of human health (120 µg/m³ 8-hours) in the Paris region (2018-2020 tri-annual mean)

Protection of vegetation

Many scientific studies have revealed the ozone negative effects on the vegetation (forests, ecologically or biologically significant areas and cereal/wheat crops) due to its strong oxidizing action. Consequently, European regulations focus the quality objectives and target values for the protection of vegetation on

growing vegetation and crops periods, in the spring and early summer. AOT 40 (corresponding to '*Accumulated Ozone exposure over a Threshold of 40 parts per billion (ppb)*') means the sum of the difference between hourly concentrations greater than 80 µg/m³ and 80 µg/m³ over a given period using only the one-hour value measured between 8.00 am and 8.00 pm Central European Time (CET) each day. It is expressed in µg/m³.h⁻¹.

Lockdowns to fight Covid-19 did not concern the summer period and therefore did not have any impact on summer ozone. Unlike other pollutants, it is therefore possible to include the year 2020 for the calculation of the quality objective for the protection of vegetation.

The EU target value for the protection of vegetation (18 000 µg/m³.h⁻¹) is calculated on a 5-year average. The averaged value is less prone to fluctuations from one year to the next. In 2020, **the EU target value is met in the whole Paris region.** The highest average recorded per station over the 2016-2020 period is 15 051 µg/m³.h⁻¹ (-2 % compared to 2019).

As every year, the French quality objective for the protection of vegetation (6 000 µg/m³.h⁻¹ from May to July 8 am to 8 pm, equivalent to EU long-term objective) **is exceeded in the Paris region.** In 2020, all the stations of the Airparif network recorded levels above the quality objective for the protection of vegetation, as in 2018. Exceedance is generally pronounced in rural and peri-urban areas aimed by this protection threshold, where the levels are up to about 2 times higher than the norm (Figure 25).

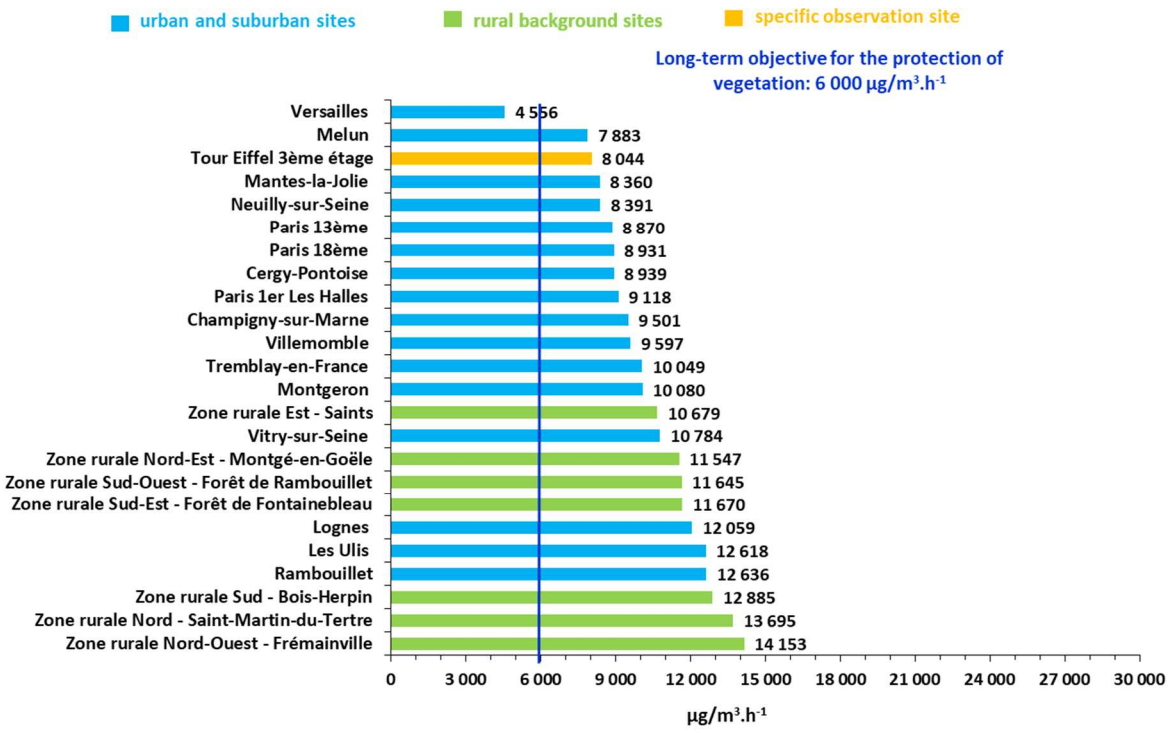


Figure 25: long-term objective in ozone (O_3) for the protection of vegetation (AOT40, threshold of 6 000 µg/m³.h⁻¹) in the Paris region in 2020

AVERAGE ANNUAL TRENDS FOR THE PROTECTION OF HUMAN HEALTH

Due to strong interannual fluctuations related to meteorological conditions, **the average number of exceedance days of the quality objective for the protection of human health (120 µg/m³ 8-hours average) can vary considerably over time.** It depends on summer weather conditions, and in particular the presence of durably warm periods.
Containment to fight Covid-19 did not concern the summer period and therefore did not have any impact on summer ozone. Unlike other pollutants, it is therefore possible to include the year 2020 for the calculation of the quality objective for the protection of human health.

The year 2020 is characterized by an average insulation and a number of days of high heat above average. The number of days exceeding the quality objective in the agglomeration and in rural areas in 2020 are higher than those of the last twelve years (Figure 26) except for 2018.
This number of days exceeding the quality objective is lower than to those of 2018 and way below the year 2003 which had experienced a very intense heat wave.

Over the period 1998-2020, **the number of exceedance days does not show a clear downward trend. It still exceeds the quality objective** (no exceedance allowed).

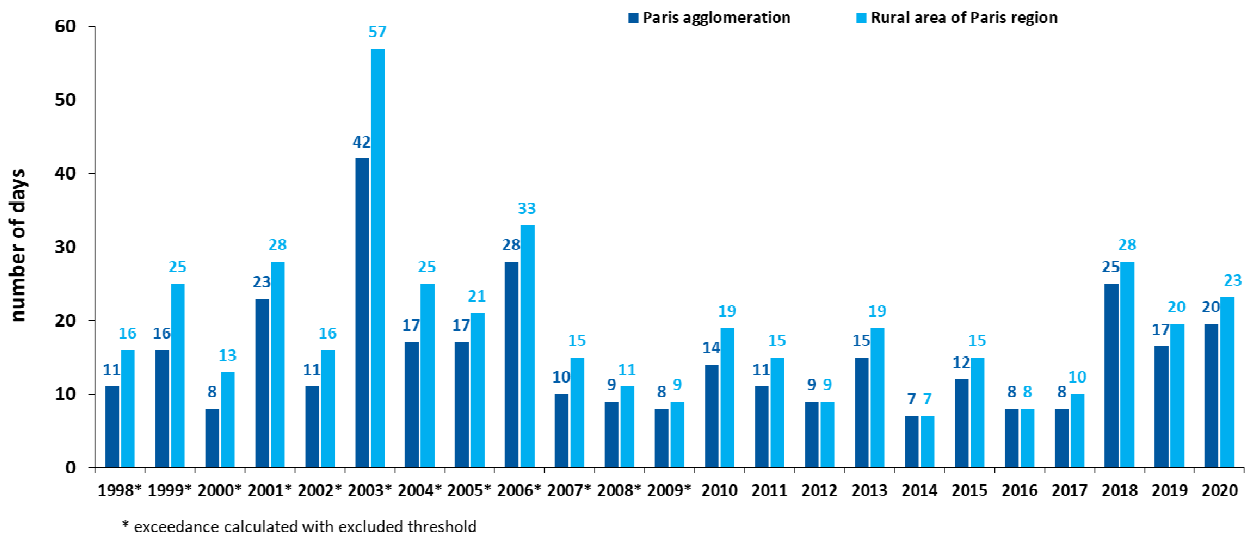


Figure 26: average number of days exceeding the O_3 french quality objective for the protection of human health (120 µg/m³ 8-hours average) in the Paris region from 1998 to 2020

Due to the strong dependence to weather conditions, the evolution of the number of days exceeding the threshold of 120 µg/m³ over 8 hours can only be meaningful in the medium term. The number of days exceeding the EU target value for the protection of human health on a 3-year period is shown in Figure 27.

From 2006-2008 to 2016-2018, this regulated threshold has been met in the agglomeration and rural areas of the Paris region. The period from 2007-2009 to 2015-2017 has the lowest number of exceeding days of the entire history.
The number of days exceeding the target value is increasing since the 2016-2018 period (Figure 27). **For the second year in a row, the target value is exceeded**. This increase is due to the 2018, 2019 and 2020 exceptional summer weather conditions, with high temperature and sunshine, leading to high ozone concentrations.

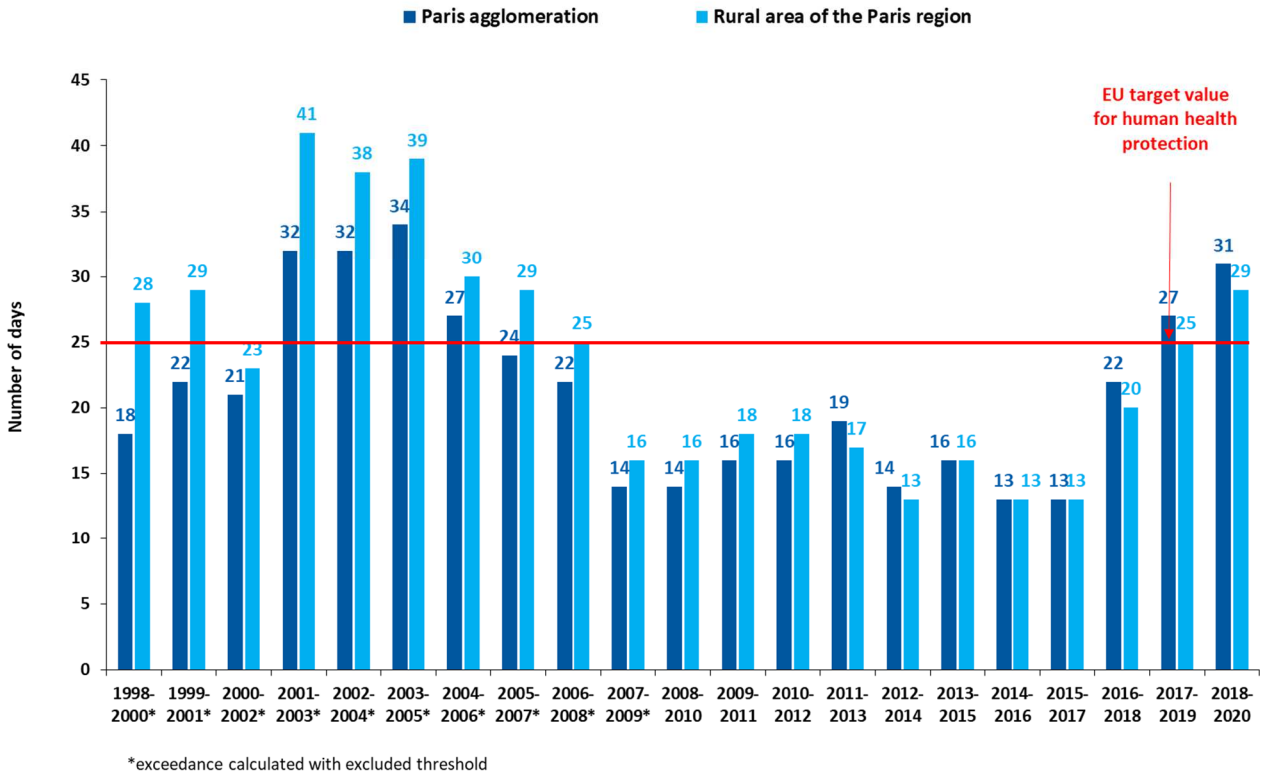


Figure 27: number of days exceeding the EU target value for the protection of human health (120 µg/m³ 8-hour average, not over 25 days of exceedance on a 3-year period) for the highest monitoring station in the Paris region from 1998-2000 to 2018-2020

Unlike other values measured during the summer period, the annual mean takes into account the entire year. Mean nitrogen dioxide levels were strongly impacted by activity restrictions linked to the health crisis (-20% in Paris and -10% in the inner suburbs). As nitrogen oxides react with ozone, these decreases have resulted in a slight increase in ozone mean concentrations, mainly in Paris. This is why the year 2020, due to its atypical nature, was not taken into account in the calculation of the long-term trends presented below not to bias them.

The trend of the O_3 tri-annual mean concentrations measured within the Paris agglomeration is shown in Figure 28. These O_3 levels have risen by 96 % between 1994 and 2019. **The annual average rate reached 7 % per year between 1994 and 2003. Between the 2001-2003 and 2015-2017 periods, urban background ozone concentrations were statistically stable.** The 2017-2019 period has the highest average ozone concentrations of the entire history. The year 2020 is presented for information but is not included in a tri-annual mean.

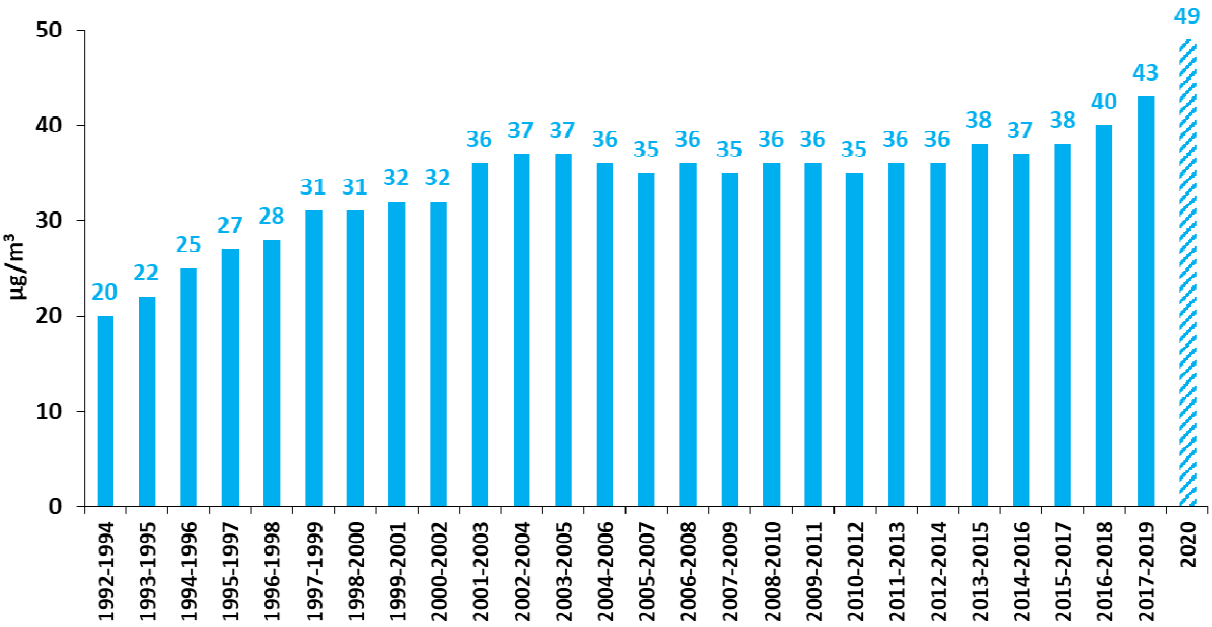


Figure 28: trend in the O_3 tri-annual mean concentrations (based on a sample of the same three urban background sites) within the Paris agglomeration from 1992-1994 to 2020

2.5 Benzene (C_6H_6)

Benzene (C_6H_6) in brief

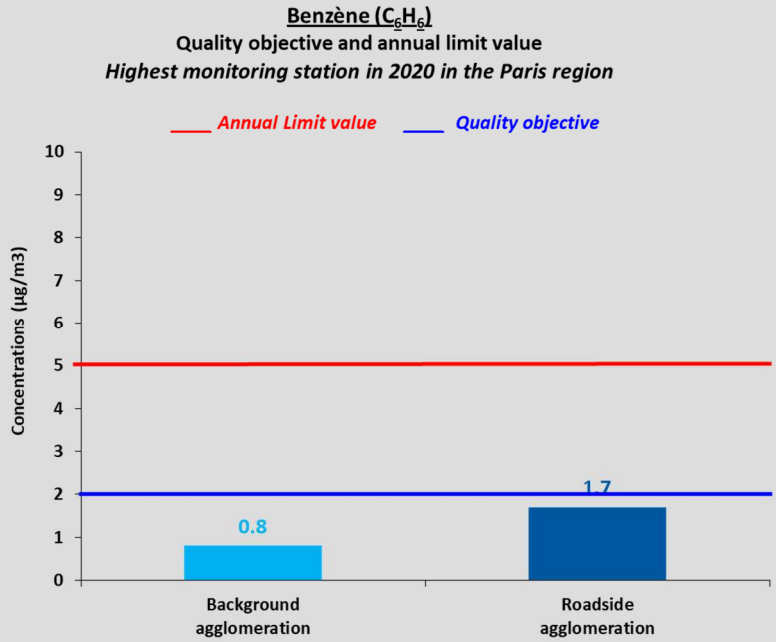
Besides the downward trend in recent years, activity restrictions linked to the health crisis, and in particular lockdowns with a drop in traffic, have had an impact on benzene concentrations

Annual limit value for benzene (5 µg/m³) has been met everywhere in the Paris region since 2006. Complied in background situation, the quality objective (2 µg/m³) can be very locally exceeded near some Parisian roads.

No inhabitant of the Paris region is exposed to an exceedance of the annual quality objective (2 µg/m³).

Since 2010, the decresase has been constant.

Both in a background situation and near road traffic, benzene levels dropped slightly between 2019 and 2020.



Summary of air quality standards exceedances for benzene (C_6H_6) in the Paris region

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 29 show the annual mean benzene concentrations within the Paris region, with a focus on Paris and surrounding subsurbs in 2020.

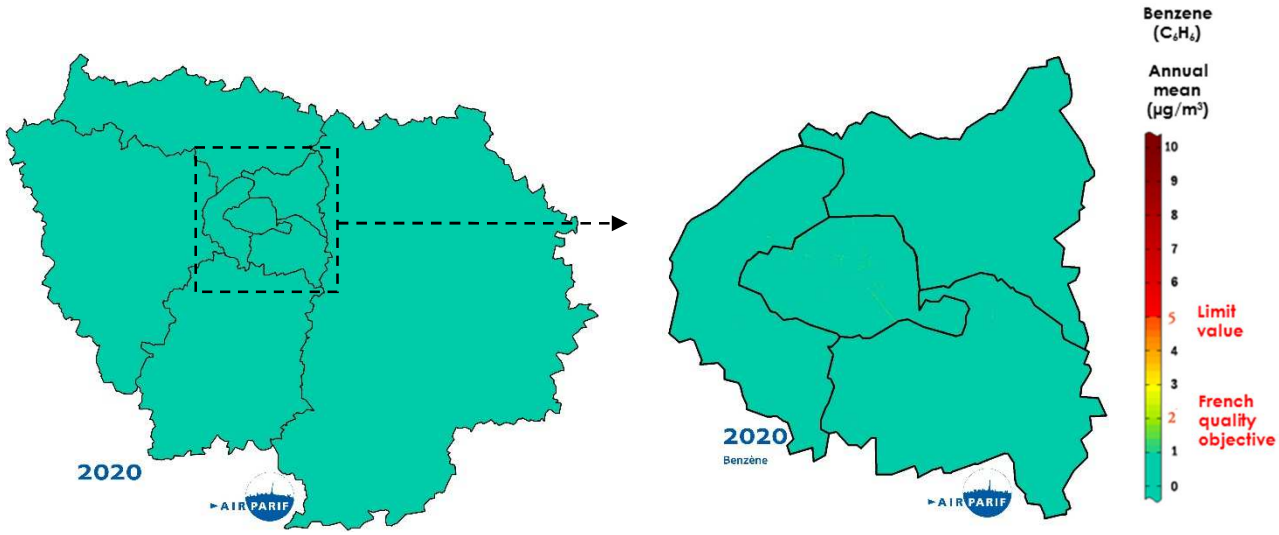
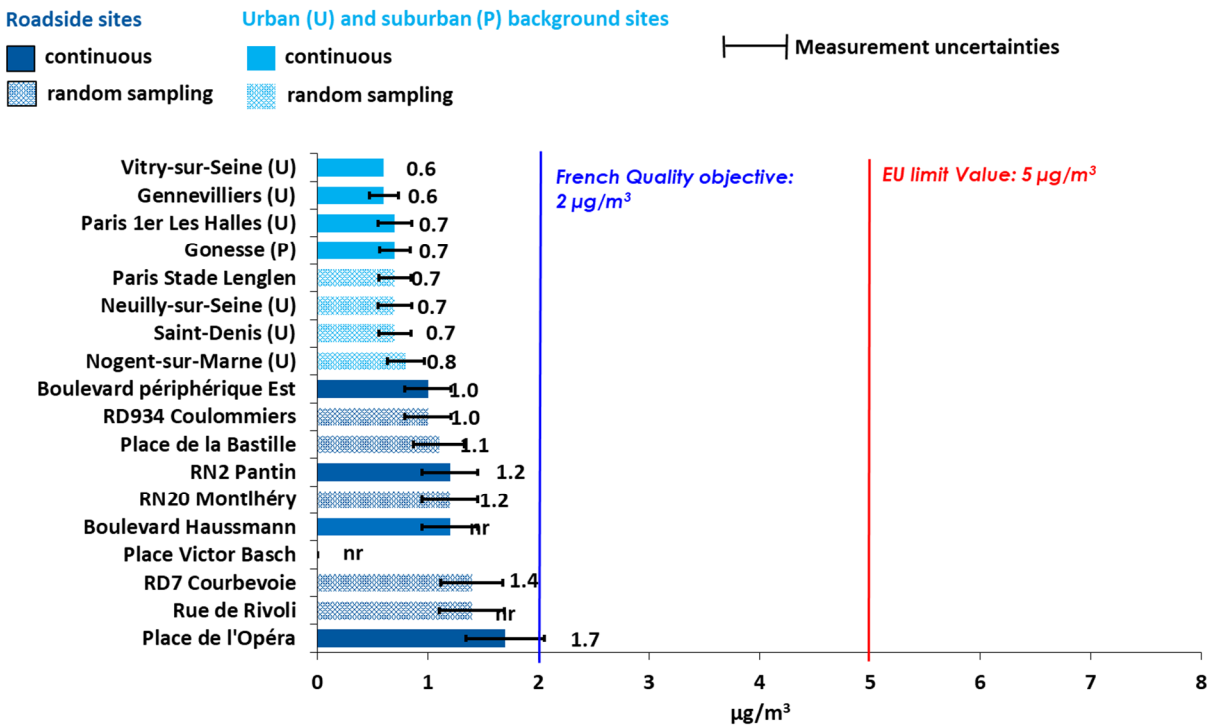


Figure 29: annual mean concentration of benzene (C_6H_6) in the Paris region, with a focus on Paris and surrounding suburbs in 2020

Every year, annual mean concentrations of benzene are slightly higher in the centre of the Paris agglomeration than in the periphery of the region. Background benzene concentrations are lower than the French quality objective and the EU annual limit value (2 and 5 µg/m³, respectively). In 2020, background benzene levels (from 0.6 to 0.8 µg/m³) are the lowest of historical data (Figure 30).

Highest annual mean concentrations of benzene are measured near main roads located in the Paris agglomeration, due to traffic-clogged conditions associated with unfavourable conditions for pollution dispersion (major traffic roads contained in the urban fabric like street canyons). These concentrations are between 1.0 and 1.7 µg/m³ for the traffic monitoring stations. They are the lowest of the historical data as well.
The difference between the concentrations measured on background stations and stations near traffic has never been so small, which is explained by the sharp drop in road traffic during lockdowns.

In 2020, the French quality objective (2 µg/m³) is met on every monitoring station. Benzene annual levels are way lower than the EU limit value (5 µg/m³). For the first time, no inhabitant of the Paris region is exposed to an exceedance of the French quality objective. However, it cannot be ruled out that this value may be exceeded very occasionally on certain Parisian and regional roads.



In addition to continuous measurements of benzene, discontinuous measurements are performed by AIRPARIF since 2007. These measurements are carried out using passive diffusion tubes during 12 uncontinuous weeks evenly distributed over the year. All these sites are characterised by a high pedestrian density and the presence of residences near road axes. For these sampling sites, the results reported in this figure represent the average of twelve weeks measurements.

Figure 30: annual mean concentration of benzene in the Paris region in 2020

AVERAGE ANNUAL TREND

As the year 2020 is particularly atypical, the trends presented in this report are based on the concentrations for the period 2009-2019.

After a significant decrease of benzene concentrations since the beginning of the 2000's (-66 % between 1994-1996 and 2000-2002, due to the decline in the benzene content of petrol), levels are rather stable in the recent years (Figure 31).

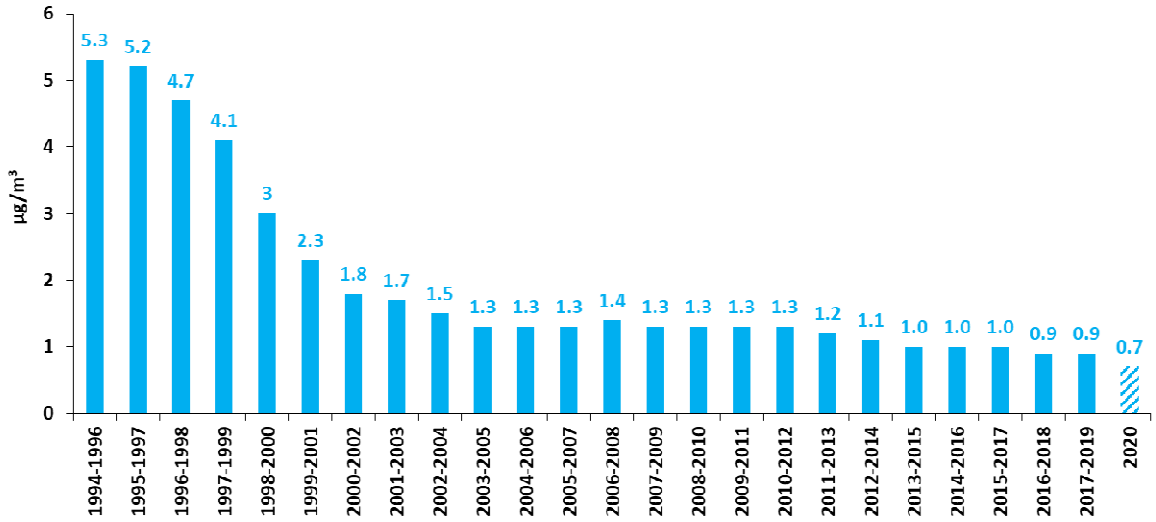


Figure 31: trend in the benzene tri-annual mean concentrations (based on a scalable sample of urban background sites) within the Paris agglomeration from 1994-1996 to 2020

In roadside situation, the trend in benzene concentrations is consistent with those of other primary pollutants directly emitted by road traffic (particles, NO_2). However, a decline in benzene levels is more marked since 2000 (date on which an EU regulation limiting the benzene content in petrol is implemented) (Figure 32). Benzene average concentrations decreased by approximately threefold from 1994-1996 to 2000-2002. This decline has slowed down substantially since 2007 (-50 % between 2009 and 2019).

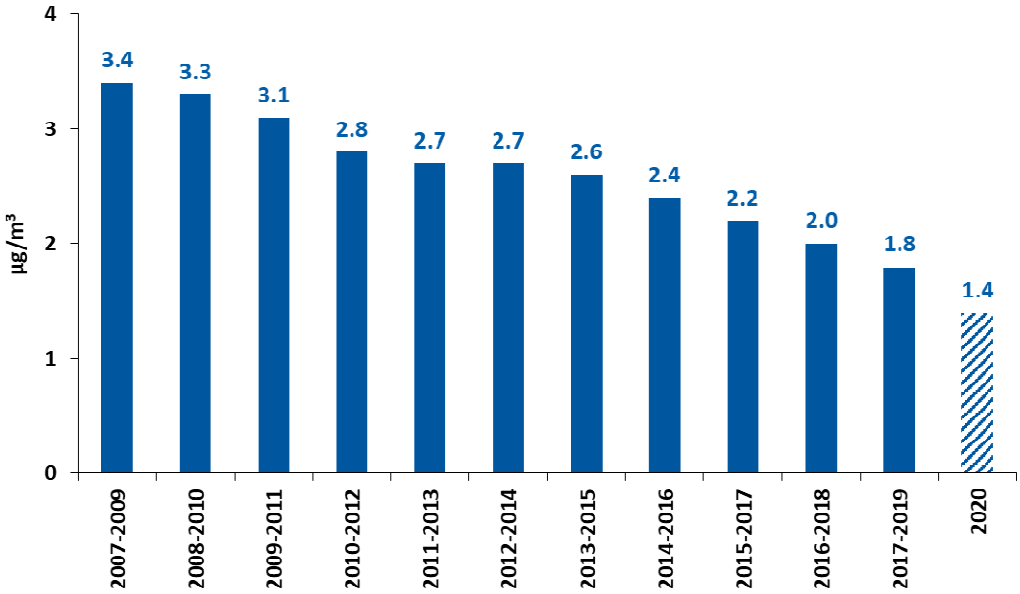


Figure 32: evolution of the mean benzene concentrations over 3 years for 5 traffic stations (Place Victor Basch, Place de l'Opéra, Boulevard Haussmann, RN2 Pantin, RD7 Courbevoie) from 2007-2009 to 2020

3. Pollutants meeting air quality standards

3.1 Benzo(a)pyrene (BaP)

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

The BaP EU target value (1 ng/m³) is widely met on the five Airparif monitoring sites (Figure 33).

Differences in benzo(a)pyrene concentrations can be observed between background sites. **Local emissions (related to wood burning fireplaces, open uncontrolled burning of wastes) are more significant in suburban residential areas (Gennevilliers, Tremblay), even in the greater Paris area (Pommeuse), than in Paris and its neighbouring cities.**

The Pommeuse site (77), representative of a residential area consuming firewood in the outer suburbs [Airparif, 2015], records the highest concentrations of BaP of the monitoring network (between 2 and 3.5 times greater than those of the other stations of the network).

In 2020, BaP levels were all lower than those of 2019, principally due to dispersive weather conditions and a mild winter.

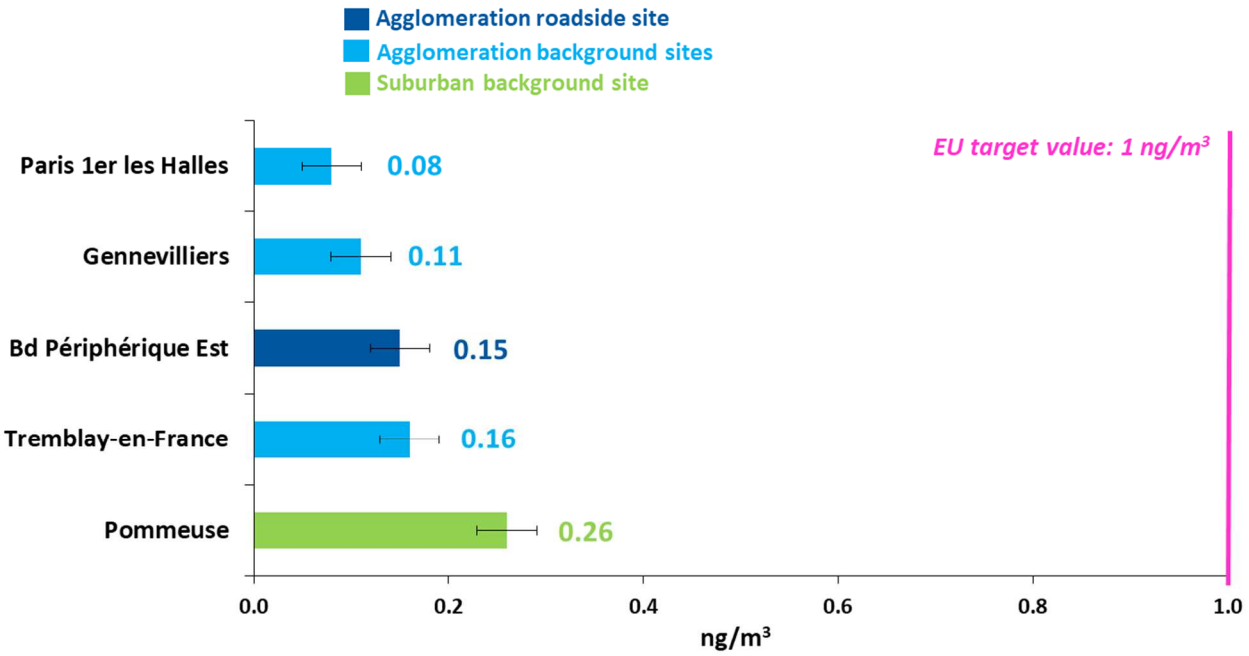


Figure 33: benzo(a)pyrene annual mean concentrations for all monitoring sites in the Paris region in 2020

AVERAGE ANNUAL TREND

Due to its atypical nature, the year 2020 was not taken into account in the calculation of the trends presented below not to bias them.

A significant decrease of BaP levels is observed near traffic roads (-87 %) between 1998 and 2019 (Figure 34), through the gradual renewal of the fleet. However, there is no clear trend in background situation. The year 2020 is presented for information but is not included in a tri-annual mean.

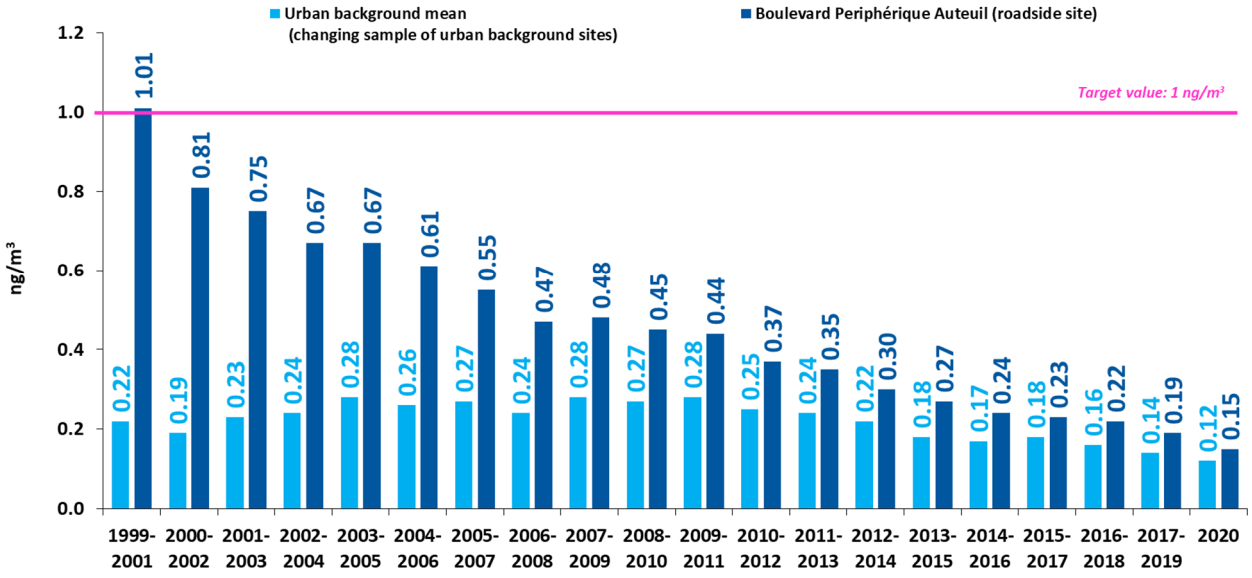


Figure 34: evolution of the benzo(a)pyrene 3-years mean concentrations (based on the means of urban background sites and the Boulevard Périphérique site) in the Paris agglomeration from 1999-2001 to 2020

3.2 Metals (Lead, Arsenic, Cadmium and Nickel)

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS AND LONG-TERM TRENDS

Lead (Pb) annual mean concentrations significantly decreased in 15 years (-97 % between 1991 and 2005), due to its gradual disappearance in fuels since 2000 (Figure 35). Lead no longer represents a relevant indicator of road traffic. As a consequence, lead measurements at the Place Victor Basch site were stopped at the end of 2005. Each year, lead concentrations are very low and close to the limits of quantification in background and industrial situations. **The EU limit value and the French quality objective for lead are widely met (the 2019 annual value being from 25 to 50 times below air quality standards).** The same observation is also observed in the vicinity of the industrial sites of Limay and Bagneaux-sur-Loing.

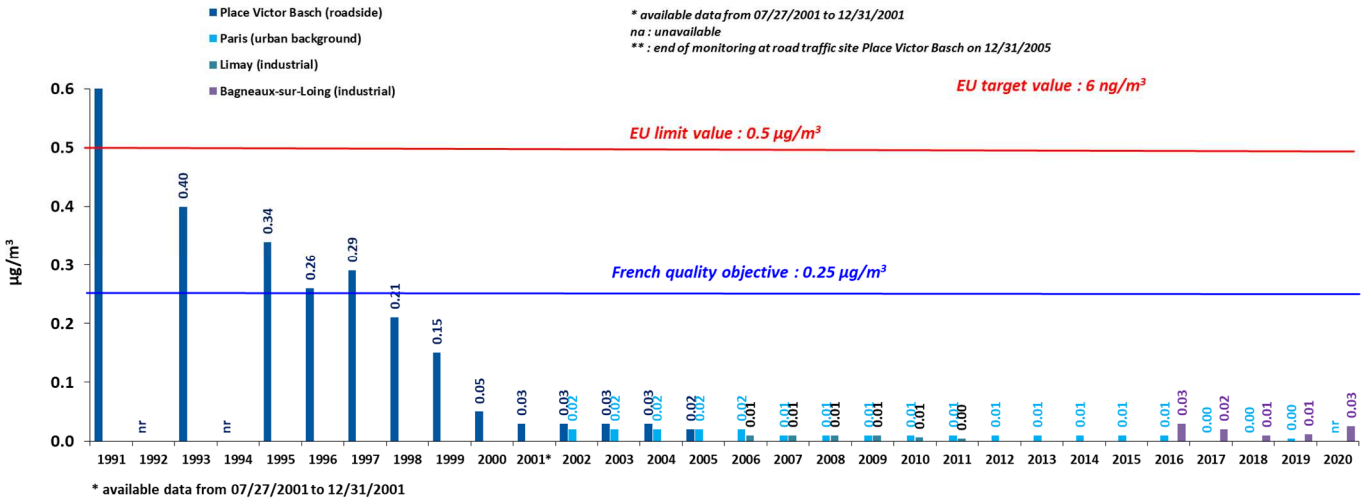


Figure 35: trends in the lead (Pb) annual mean concentration at urban background, roadside and industrial sites within the Paris region from 1991 to 2020

After a significant decrease of **arsenic (As)** concentrations between 2007 and 2008 (around -50 %), an increasing trend was observed from 2008 to 2011 in background situation. It ended in 2012. In 2019, arsenic levels measured in background situation (0.22 ng/m³) is the lowest of the historical data whereas the 2020 mean is not representative due to a lack of data (Figure 36). The Limay industrial station (located near a glass factory, an arsenic emitting installation) shows similar levels compared to the previous years.

For the Bagneaux-sur-Loing station, which recorded levels above the target value in 2019, arsenic concentrations fell by more than half, dropping way below the target value in 2020.
Installed on the municipal territory of Bagneaux-sur-Loing (77), the Keraglass and Corning SAS factories are specialized in the manufacture of glasses special items (glass-ceramic glass, eyeglasses and optical glasses, respectively). This industrial production emits heavy metals, and more particularly lead and arsenic. In the vicinity of Keraglass, significant arsenic emissions were occasionally measured in ambient air. This industrial site is the leading arsenic emitter in the Paris region and the fifth largest national emitter. It should be noted that these emissions can vary greatly from one year to another depending on the productions [Airparif, 2014].

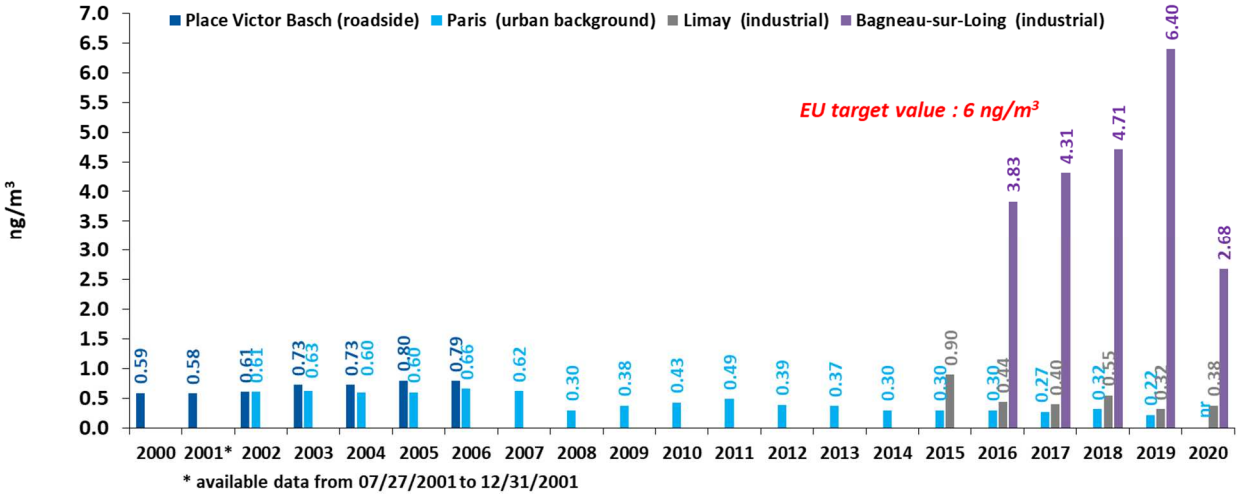


Figure 36: trends in the arsenic (As) annual mean concentrations at urban background, roadside and industrial sites within the Paris region from 1999 to 2020

For **cadmium (Cd)**, a downward trend of annual mean levels was observed both in urban background and roadside situations between 1999 and 2005 (Figure 37). Over the period 2008-2014, cadmium levels do not show a clear trend. Since 2015, background concentrations of cadmium are rather stable. The annual average recorded in background situation in 2019 is 25 times lower than the European target value set at 5 ng/m³ (the 2020 data are not representative due to an insufficient number of measurements on this station). The Limay site (industrial) records an increase, while remaining more than 15 times below the target value. The site of Bagneaux-sur-Loing (industrial) records an average annual level in cadmium rather stable since 2016.

These values are way lower than the target value of 5 ng/m³.

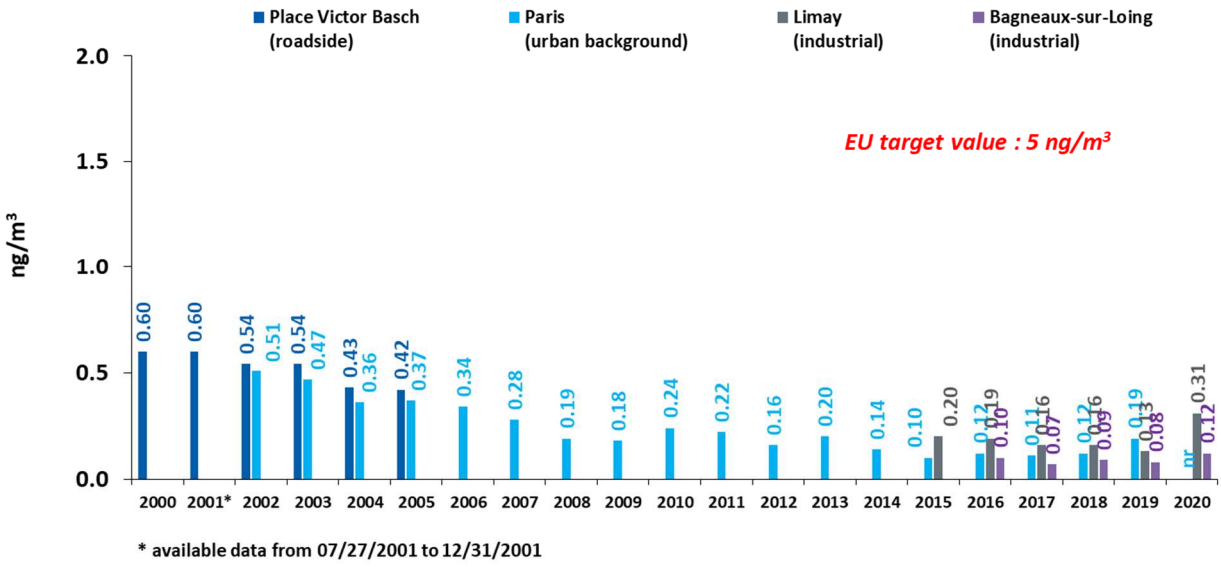


Figure 37: trends in the cadmium annual mean concentrations at urban background, roadside and industrial sites within the Paris region from 1999 to 2020

Regarding **nickel (Ni)**, background concentrations have been gradually decreasing since 2011. Since 2011, annual average background concentrations have been between 1.53 and 0.88 ng/m³, corresponding to levels 13 to more than 20 times lower than the target value (set at 20 ng/m³) (Figure 38). In 2020, the nickel annual mean concentrations at the Limay and Bagneaux-sur-Loing sites are similar to those of 2019. The 2020 data for the Paris 18ème site are not representative due to an insufficient number of measurements on this station.

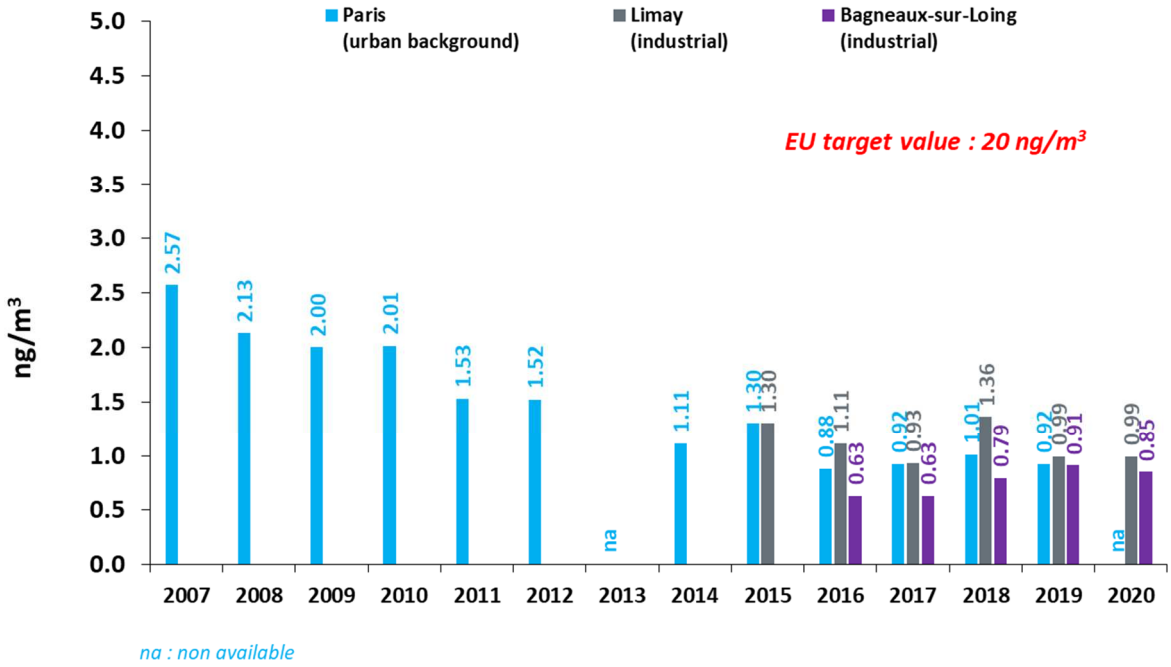


Figure 38: trend in the nickel (Ni) annual mean concentrations at urban background and industrial sites within the Paris region from 2007 to 2020

3.3 Carbon monoxide (CO)

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

The carbon monoxide EU limit value for the protection of human health (10 000 µg/m³ for the maximum 8-hours mean) **is widely met at urban background sites and at roadside sites** (Figure 39). In 2020, mean CO levels are slightly lower than to those measured in 2019.

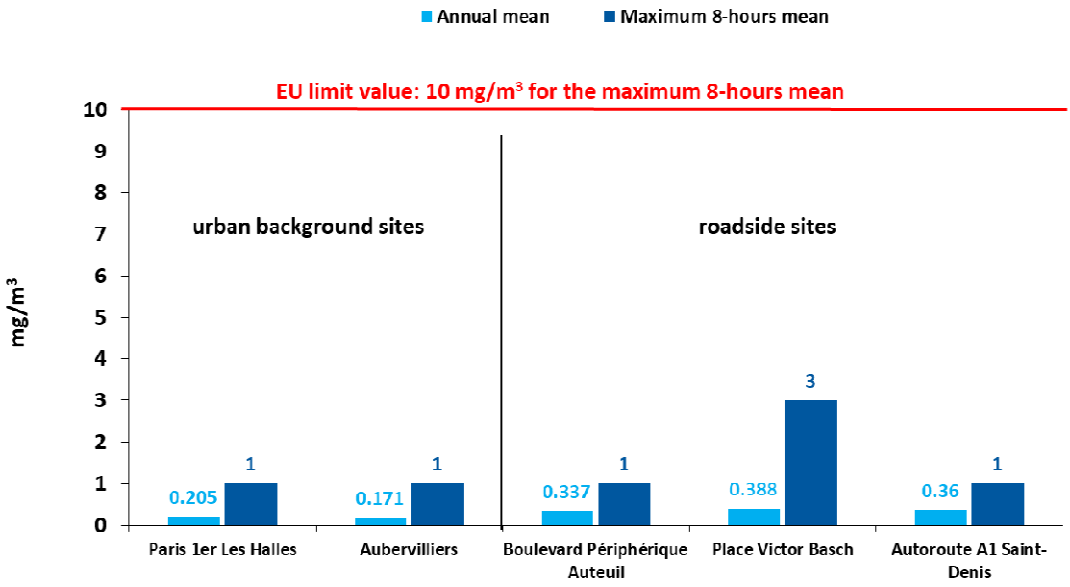


Figure 39: carbon monoxide (CO) annual mean and annual maximum 8-hours mean concentrations for all continuous monitoring sites in the Paris region in 2020

AVERAGE ANNUAL TREND

CO annual maximum 8-hours mean concentrations have significantly decreased between 1994 and 2019 (-88 %) (Figure 40). Due to its atypical nature, the year 2020 was not taken into account in the calculation of the trends presented below not to bias them.

Average concentrations over 3 years tend to stabilize since 2010. CO levels are, as for other primary pollutants from road traffic, lower in background conditions than in the immediate vicinity of roads. However, the gap tends to stabilize from year to year.

Major technological improvements in emissions from on-road vehicles explain this long-term trend.

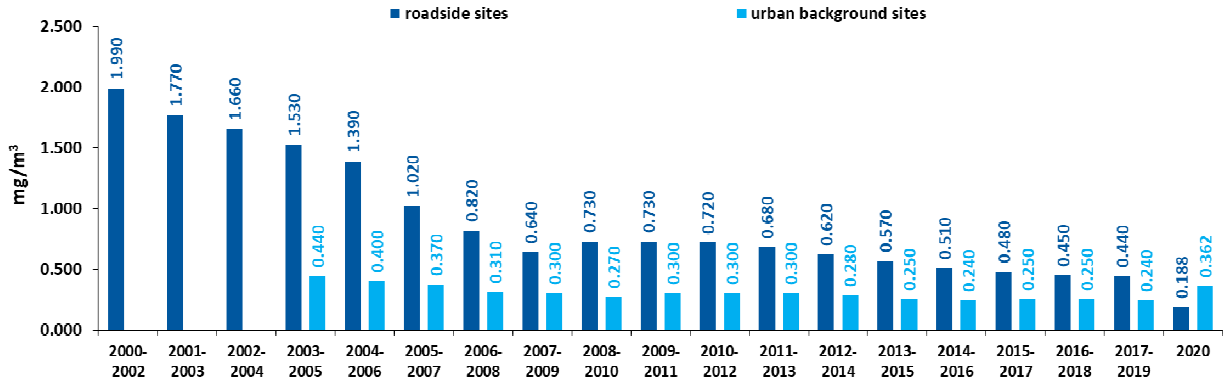


Figure 40: trend in the carbon monoxide (CO) tri-annual mean concentrations at roadside and urban background sites within the Paris agglomeration from 2000-2002 to 2020

3.4 Sulfur dioxide (SO_2)

SITUATION IN 2020 RELATED TO AIR POLLUTION STANDARDS

The sulfur dioxide (SO_2) tri-annual mean concentrations are lower than the detection limit (5 µg/m³) at all the monitoring stations, even on the Ringroad BP Auteuil site. **They are way lower than the French quality objective** (50 µg/m³).

SO_2 limit values are also widely met over the whole monitoring stations in the Paris region. No exceedance of the 125 µg/m³ daily threshold and the 350 µg/m³ hourly threshold was observed in 2020.

AVERAGE ANNUAL TREND

A significant decrease of SO_2 levels was observed over the long-term (Figure 41). Considered as a relevant pollution indicator related to heating and electricity generation activities, the trend in SO_2 concentrations spectacularly dropped since the 1950's (SO_2 levels divided by 100). It is related to the decrease of the number of industrial sites in the Paris region since the 1950's. The sharp decrease in the use of some fuels (such as coal) and the decline of sulphur content in fuels also explain this trend.

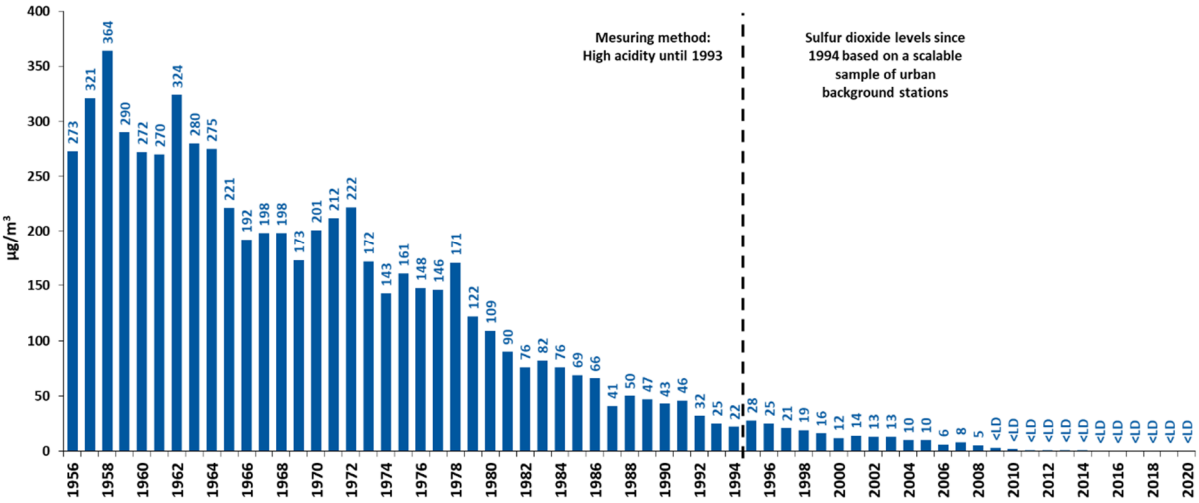


Figure 41: trend in the sulfur dioxide (SO_2) winter mean concentrations in Paris since the end of 1950's

LIST OF FIGURES

Glossary

Français	English
Particules	Particulate Matter
Dioxyde d'azote	Nitrogen dioxide
Monoxyde de carbone	Carbon monoxide
Dioxyde de soufre	Sulphur dioxide
Oxyde d'azote	Nitrogen oxide
Plomb	Lead
Autres métaux	Other metals
Normes	Standards
Normes à respecter	Standards to be respected
Normes à respecter dans la mesure du possible	Standards to be respected as much as possible
Recommandations OMS	WHO recommendations
Valeur limite	Limit value
Valeur cible	Target value
Objectif de qualité	Quality objective
Respectée	Met
Dépassée	Exceeded