AIR QUALITY IN PARIS REGION

Summary 2016

June 2017

Paris regional air observatory

AIR PARIF

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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 2016.

The complete report in French can be downloaded on the AIRPARIF website:
http://www.airparif.asso.fr/_pdf/publications/bilan-2016.pdf

Air quality complete data in the Paris region can be downloaded at:
http://www.airparif.asso.fr/telechargement/telechargement-statistique

Annual air pollution maps are available at *http://www.airparif.asso.fr/etat-air/bilan-annuel-cartes*

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 2016 (Airparif – Google Earth & Landsat data)

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1. KEY FACTS FOR 2016

In 2016, particulate matter (PM) and nitrogen dioxide (NO_2) levels within the Paris region remain a problematic issue due to the substantial exceedances of EU limit values. Despite an important pollution episode occurring in December, a decrease of chronic pollution levels for these pollutants is still confirmed this year. Concerning ozone (O_3), quality objectives thresholds are still exceeded in spite of gloomy spring weather and normal summer conditions.

In terms of meteorological conditions, 2016 was characterised by two well-contrasted half-years. The first half of the year 2016 (from January to June) brought ambient temperatures above normal (especially in winter), excess rainfall and relatively low sunshine hours (mainly in May and June). During the second half of 2016 (from July to December), air temperatures were comparable to standard values (but with a heat wave in late August). Very low and irregular rainfall and a record number of sunshine hours were also observed. In December, strong anticyclonic conditions over the Paris region led to an exceptional air pollution episode of particles. These particular weather conditions have hugely impacted the Paris region air quality (reduction of pollutant emissions in January/February but increased emissions due to heating in December; presence of photochemistry in summer).

On a trend line basis, mean pollution levels in 2016 were slightly lower than those in 2015.

→ Despite an improvement, daily and annual limit values for **PM_{10} particles** are still exceeded at roadside sites. In total, **more than 200 000 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 per year) **in 2016.** Despite an important pollution episode occurring in December, this was slightly less than in 2015. This is related to favorable meteorological conditions for pollution dispersion over a large part of the year.

For **fine particles ($PM_{2.5}$)**, **11 million inhabitants of the Paris region were potentially affected in 2016 by air quality objective exceedance** (10 µg/m³ in annual mean). Background levels away from road traffic were, on average, 1.4 times higher than the quality objective and up to 2 higher in roadside situation. In 2016, the annual limit value (25 µg/m³) is met, for the second time, everywhere in the Paris region.

→ **The slight decrease of nitrogen dioxide (NO_2) levels is still confirmed** in the greater Paris urban agglomeration in 2016. This observation is consistent with the known decrease of nitrogen oxide emissions in the region from road traffic, industries and heating.

Along the main roads, average NO_2 levels remain twice the annual limit value (40 µg/m³). However, they are slightly below 2015 levels at most measurement sites. In total, **1.4 million inhabitants of the Paris region (representing 10 % of the region's population, or almost one Parisian out of two) are still potentially exposed to NO_2 levels exceeding the annual limit value.**

→ Regarding **ozone (O_3) levels**, **the quality objective is exceeded every year in the whole Île-de-France 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 on the whole region, and especially near traffic. However, **less than 100 000 inhabitants living in the agglomeration and in roadside conditions are still potentially exposed to an exceedance of the annual quality objective for benzene** (2 µg/m³).

→ **Regarding pollution episodes, the information and warning procedure was triggered 18 days in 2016.** This is two more days than in 2015. **Almost all of these episodes are due to PM_{10}:** 11 days of exceedance of the information warning threshold and 4 days for the alert threshold. The alert threshold was overpassed during 4 days between the 1st and 7th December 2016. At the same time, an exceedance of the information warning threshold for nitrogen dioxide was observed. Due to a favorable summerly weather in August, 3 days of exceedance of the information warning threshold were also registered for ozone.

The following table provides a summary of the global trend and the situation of 2016 relating to air pollution standards:

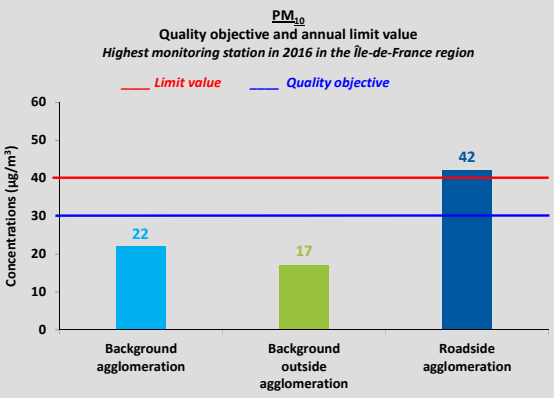
	Standards to be met	Non-binding standards		Trend
	Limit value	Target value	Quality objective	2006-2016
PM_{10}	Exceeded		Exceeded	↘
$PM_{2.5}$	Met	Exceeded	Exceeded	↘
NO_2	Exceeded		Exceeded	↘
O_3		Met	Exceeded	→
Benzene	Met		Exceeded	↘

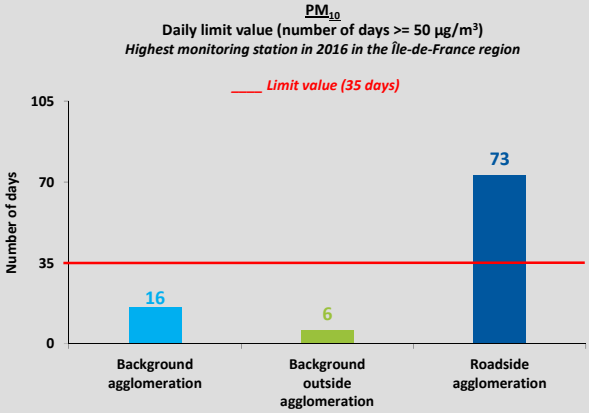
2. POLLUTANTS EXCEEDING AIR QUALITY STANDARDS

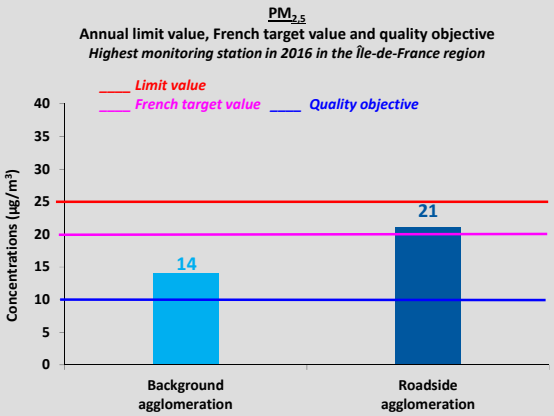
Particulate Matter (PM) in brief

Recurrent and severe exceedances of PM_{10} EU limit values are still observed near traffic
More than 200 000 inhabitants are potentially exposed to an exceedance of the PM_{10} EU daily limit value
Less than 100 000 inhabitants are potentially exposed to an exceedance of the PM_{10} quality objective

$PM_{2.5}$ levels are 1.3 to 1.4 times higher than the quality objective threshold in background situation and more than twice higher near traffic. Almost 95 % inhabitants living in the Paris region (or 11 million people) are still exposed to an exceedance of this threshold. Nonetheless, a decreasing trend occurred in particular near traffic, where the EU annual limit has not been exceeded for the third year running.







exceedance intensity	
very important	> + 50 %
important	+ 30 à + 50 %
moderate	+ 10 à + 30 %
light	0 à + 10 %

no exceedance

Particulate Matter (PM_{10})	2016			2007-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Annual quality objective exceedance						
Annual limit value exceedance						
Daily limit value exceedance				2007 2009 : station max = threshold		

Particulate Matter ($PM_{2.5}$)	2016			2007-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Quality objective exceedance					measured since 2013	
French target value exceedance				2007, 2009		
Limit value exceedance						every year since 2014

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

2.1 PM_{10} particles

SITUATION OF 2016 RELATED TO AIR POLLUTION STANDARDS

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

The maps in Figure 1 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 2016.

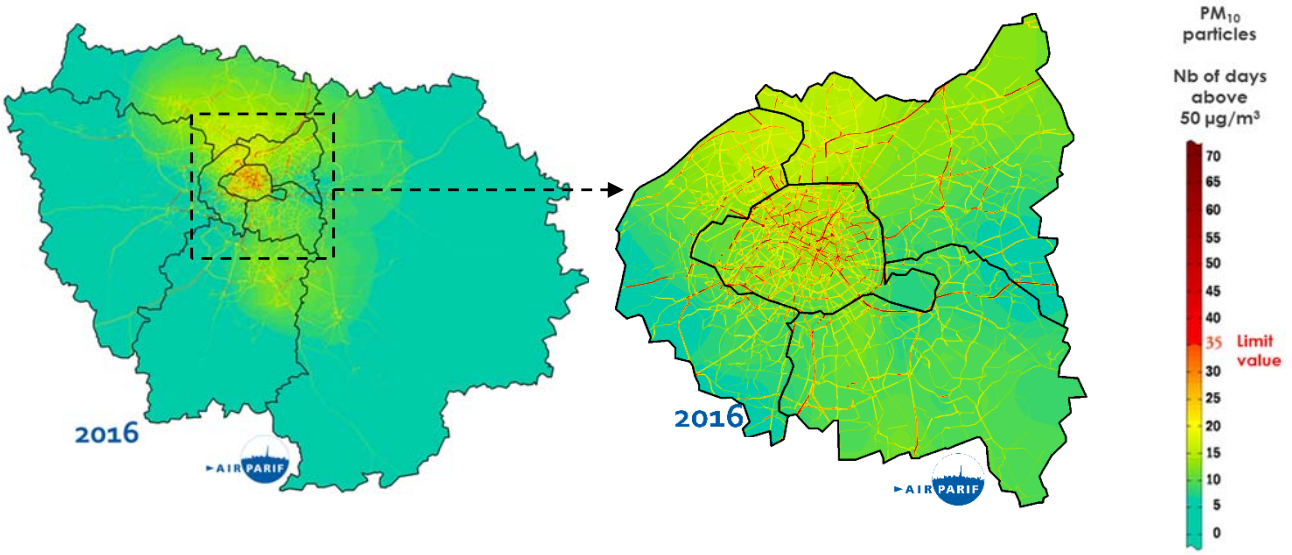


Figure 1 : PM_{10} annual number of days exceeding the 50 µg/m³ EU threshold within the Paris region (background and roadside situations) with a focus on Paris and surrounding suburbs in 2016

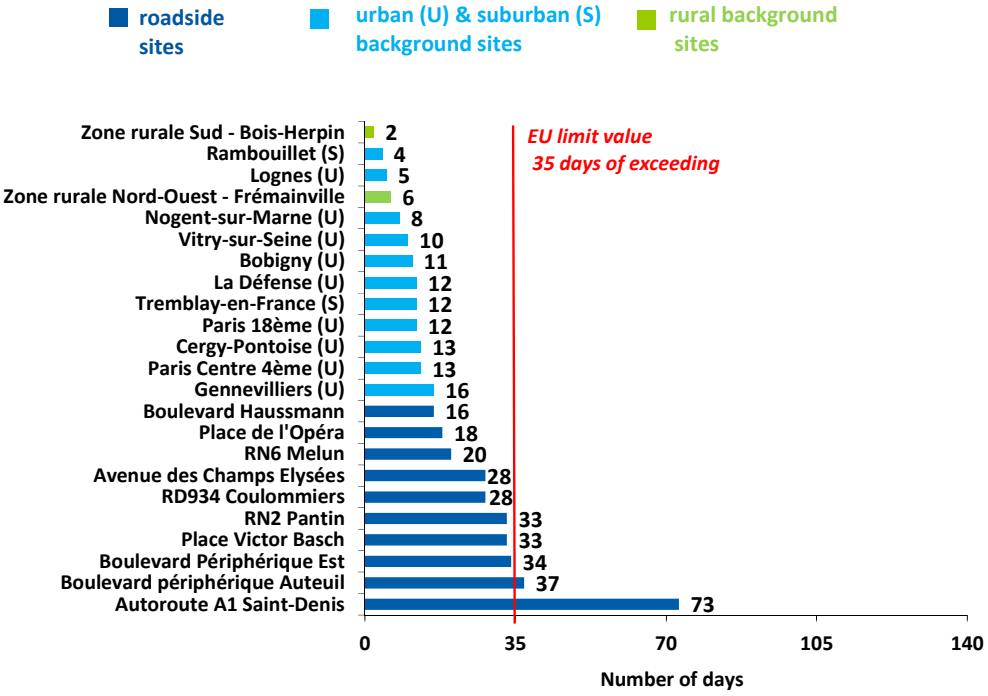


Figure 2 : PM_{10} annual number of days exceeding the 50 µg/m³ EU threshold for all continuous monitoring sites within the Paris region in 2016

In 2016, the EU daily limit value is met in background situation (Figure 2). However, the PM_{10} annual number of days exceeding this threshold is 2 to 3 times higher than in 2015. This observation can be partially explained by enhanced background levels in December 2016 (during which several air pollution episodes of particles have occurred).

Despite an improvement between 2015 and 2016, **the EU daily limit value for PM_{10} particles is still exceeded at roadside sites** (Figure 2). In 2016, 37 and 73 days of exceedance of the PM_{10} daily threshold were observed for two out of ten traffic stations (Ring road BP Auteuil and Highway A1 Saint-Denis, respectively). For the highest traffic site (A1 Saint-Denis), this threshold is exceeded every five days. The number of days exceeding the PM_{10} daily value dropped sharply on all the traffic stations compared to 2015. This can be explained by high dispersion conditions during the first half of the year.

The threshold exceedance has been confirmed in 2016 for approximately 150 kilometres of roads and highway connections (Figure 3).

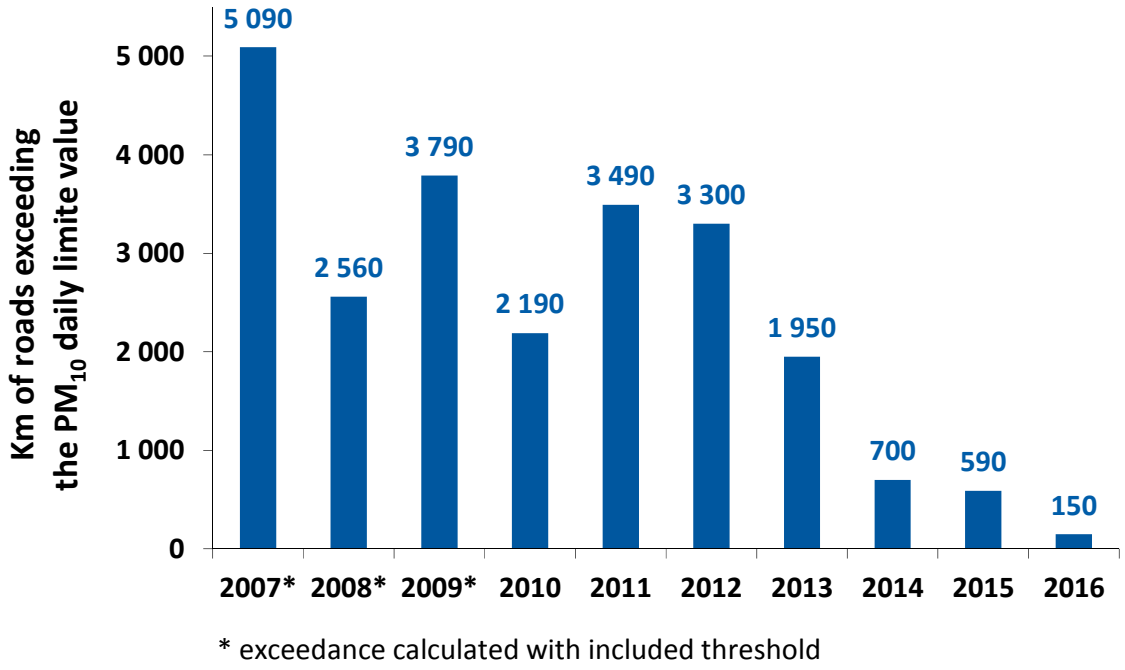


Figure 3 : kilometres of roads exceeding the PM_{10} daily limit value in the Paris region from 2007 to 2016

The surface area potentially exposed to an exceedance of the PM_{10} EU daily limit value is estimated at **approximately 30 square kilometres** (or less than 1 % of the total regional area) (Figure 4).

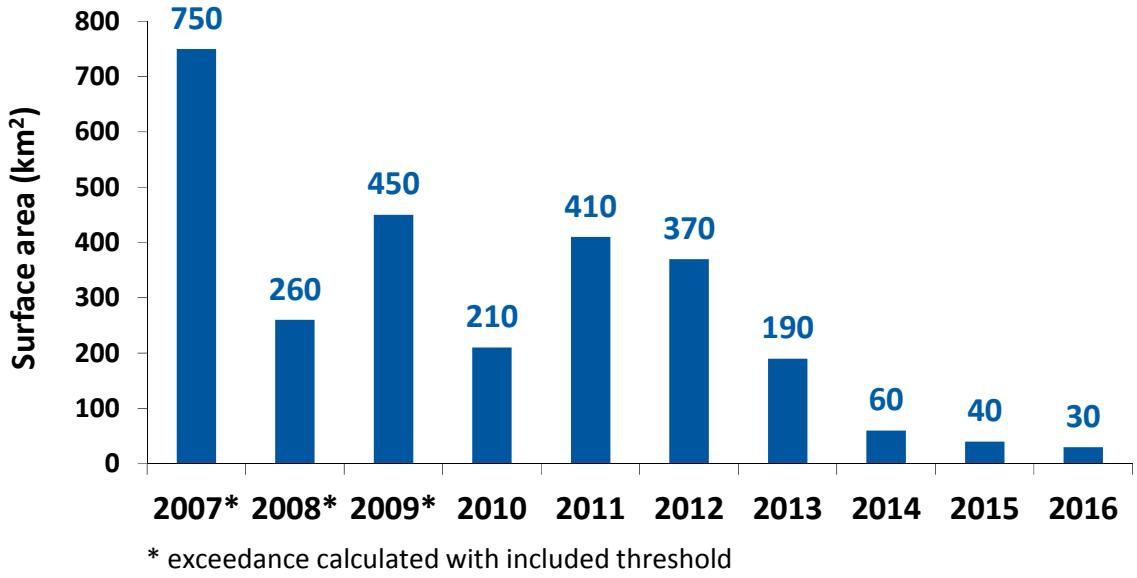


Figure 4 : trend in surface area exceeding the PM_{10} EU daily limit value within the Paris region from 2007 to 2016

In 2016, **more than 200 000 inhabitants are potentially exposed to an exceedance of the PM_{10} EU daily limit value (representing approximately 2 % of the region's population)** (Figure 5).

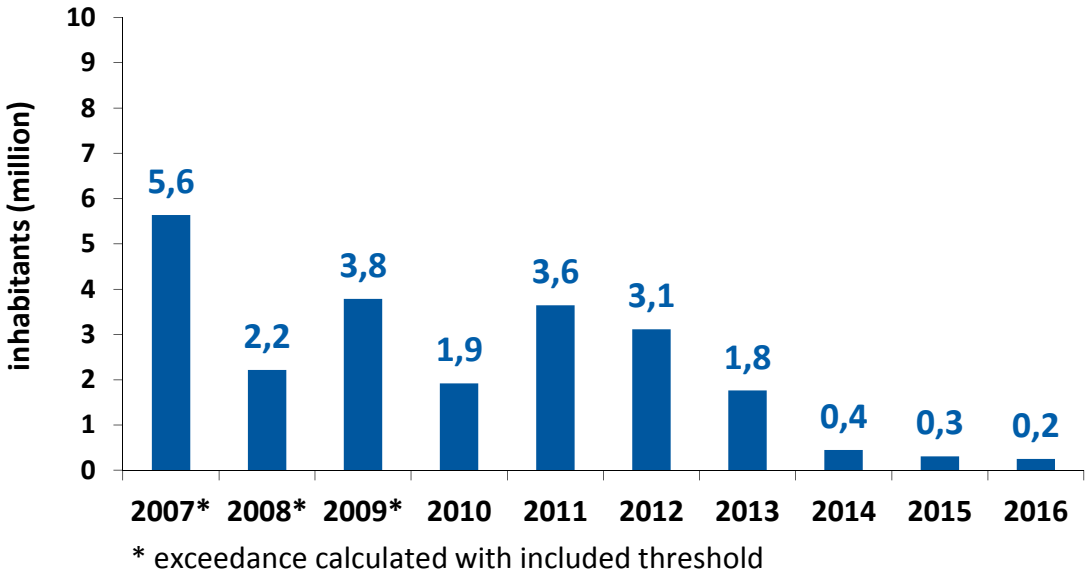


Figure 5 : million of inhabitants potentially exposed to a PM_{10} level exceeding the EU daily limit value within the Paris region from 2007 to 2016

These values should be regarded as orders of magnitude because particles have multiple origins of formation: local emissions, resuspending process, atmospheric chemistry, long-range transport and the accuracy level associated with some modeling parameters.

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

The maps in Figure 6 show the annual mean PM_{10} concentration within the Paris region, with a focus on Paris and surrounding subsurbs in 2016.

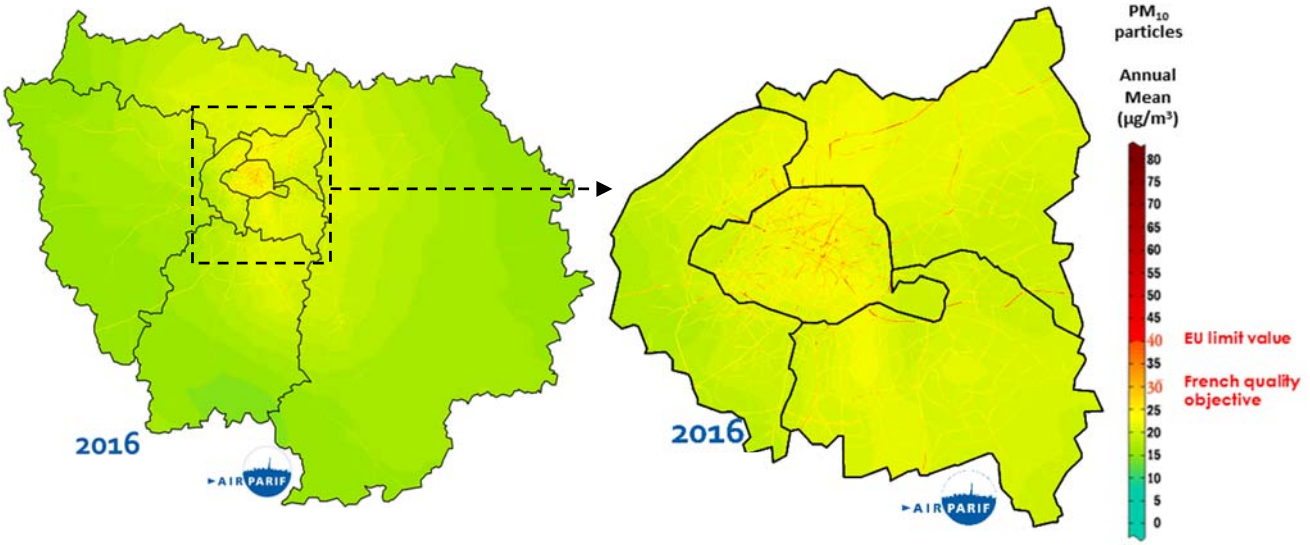


Figure 6 : PM_{10} annual mean concentration within the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

As in 2015, PM_{10} background levels measured within the Paris conurbation are fairly homogeneous in 2016 (20-22 µg/m³). A slight decline in PM_{10} concentrations from the Paris conurbation (Paris, Vitry-sur-Seine, Gennevilliers, Bobigny, La Défense cities) to the periphery of the region (Cergy-Pontoise, Lognes, Rambouillet cities) was observed (Figure 7). In general, **background annual mean levels are broadly constant in 2016 compared to 2015.**

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

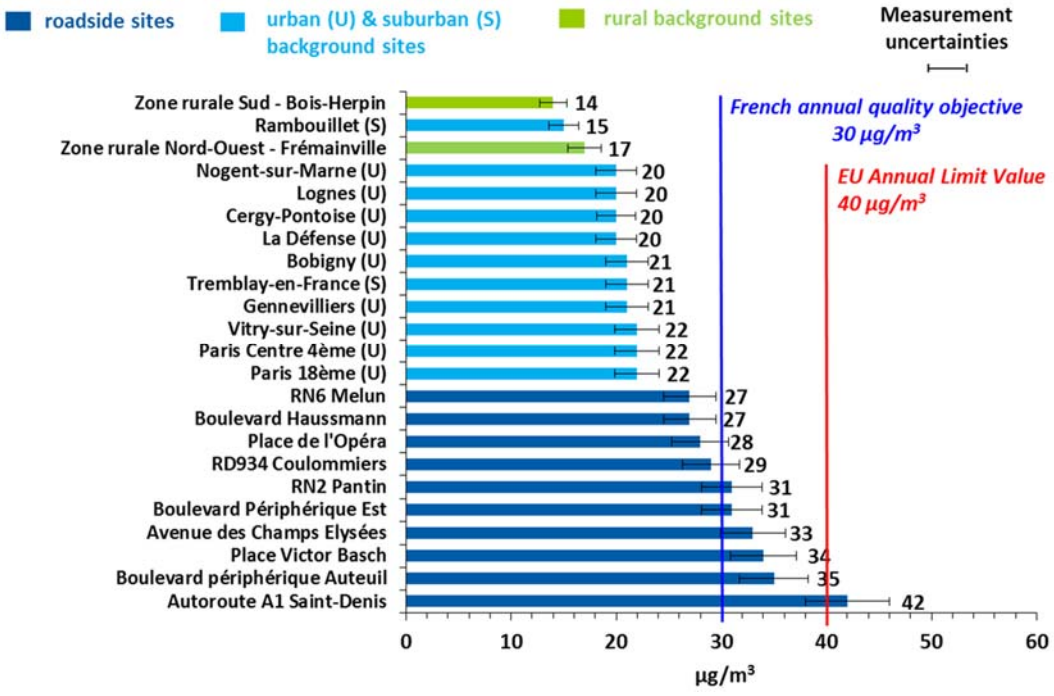


Figure 7 : PM_{10} annual mean concentrations for all continuous monitoring sites in the Paris region in 2016

Highest PM_{10} mean concentrations were measured near main roads and highway connections in 2016. PM_{10} levels near traffic can be at least **twice higher** than those measured in background situation (27-42 µg/m³). However, **PM_{10} concentrations slightly decline between 2015 and 2016 at roadside sites.** In 2016, **the French annual quality objective for PM_{10} particles is exceeded for most of the main roads located in the Parisian conurbation.** As in 2015, the EU annual limit value (40 µg/m³) is exceeded in 2016 at the traffic monitoring station Highway A1 Saint-Denis. This regulating threshold is met at other monitoring stations.

In 2016, some 100 000 inhabitants (or less than 1 % of the region's population) are potentially exposed to an exceedance of the PM_{10} quality objective (Figure 8). This value is lower than in the preceding year. **The number of inhabitants potentially exposed to an exceedance of the EU annual limit value is very low.** Due to the uncertainties relating to the estimation method, these values are not meaningful.

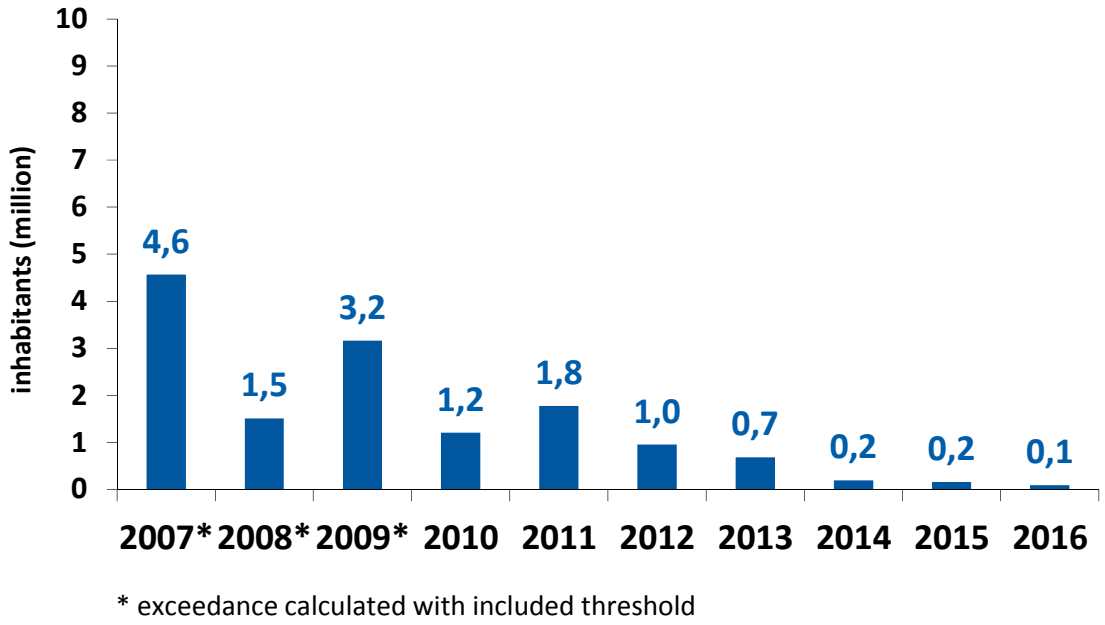


Figure 8 : million of inhabitants potentially exposed to a PM_{10} level exceeding the French quality objective in the Paris region from 2007 to 2016

LONG-TERM TRENDS

Besides the amount of pollutants released to the atmosphere, PM_{10} levels are strongly impacted by meteorological conditions from one year to the next. The years 2010 and 2015 were characterised by weather conditions that were conductive to good air quality, resulting in few high-intensity particle episodes. Conversely, unfavourable weather conditions associated with higher PM_{10} emissions (especially due to wood burning combustion during wintertime episodes) led to high PM_{10} levels in winter and spring. As in the previous two years, **2016 is a year with favorable meteorological conditions for pollution dispersion. However, this year there are two well-contrasted half-years.** Although the early months of the year were mild months (involving a reduced usage of heating and thus, lower emissions related to this source), **December 2016 has been significantly affected by the month's adverse meteorological conditions.** Strong anticyclonic conditions (no wind, temperature inversion) over the Paris region led to a significant increase in PM_{10} concentrations. This impact is of particular importance in terms of daily concentrations. These differences were reflected on the maps illustrating the number of days exceeding the EU daily limit value from 2007 to 2016 in the Paris region (Figure 9).

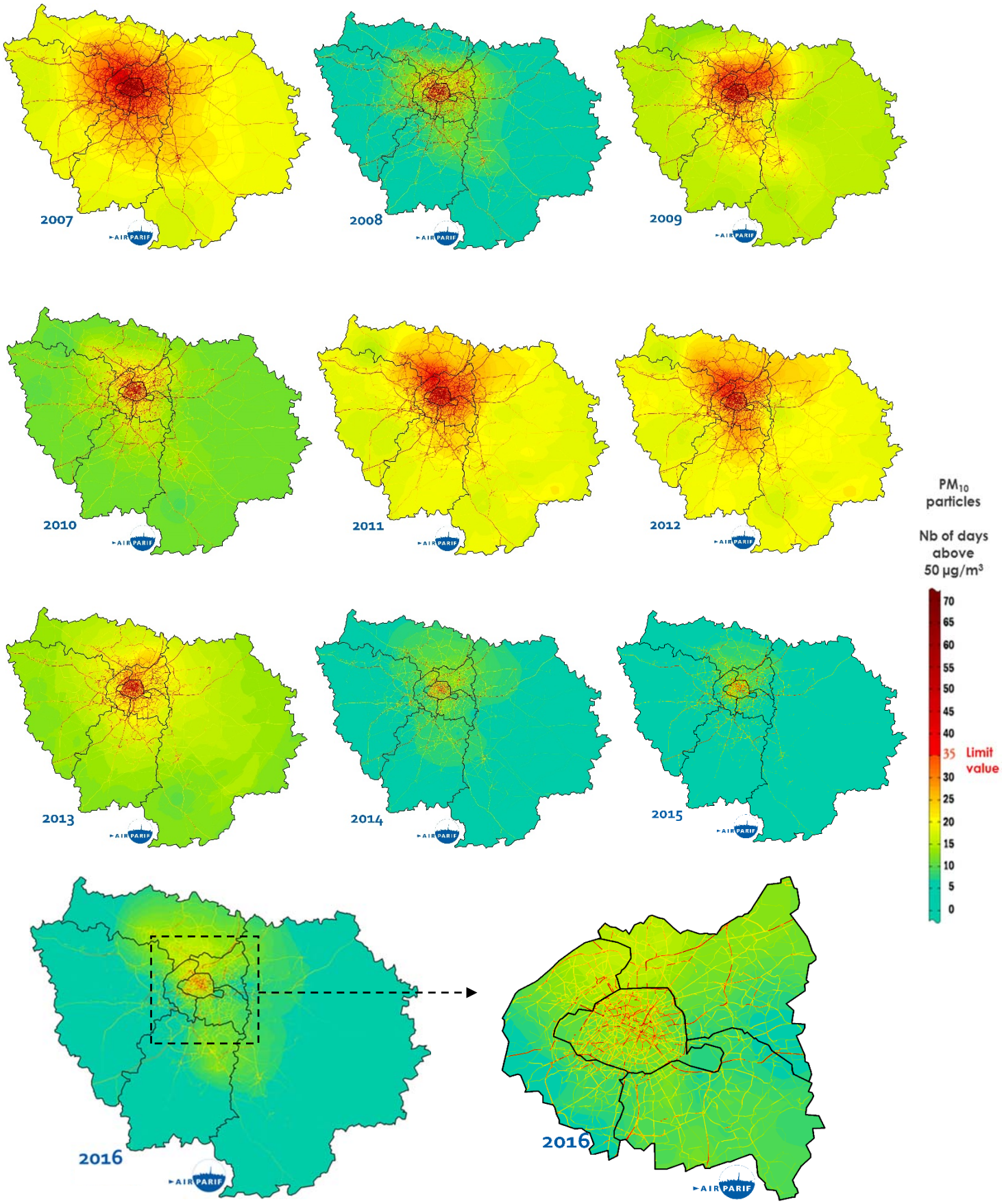


Figure 9 : number of days exceeding the EU daily limit value in PM_{10} in the Paris region (background and roadside situations) from 2007 to 2016

Besides these seasonal changes, **the number of days exceeding the 50 µg/m³ EU limit value is decreasing since 2007, especially near main roads and highway connections.**

AVERAGE ANNUAL TRENDS

In order to take into account semi-volatile particles and comply with the specifications of the EU directives, the PM measuring method has changed from January 1st 2007. This evolution of the measuring method led to an increase of the PM concentrations ranging from +30 % in background situation and +20 % in roadside condition. Annual mean concentrations of particles from 1999 to 2007 were reevaluated through different statistical works.

The Figure 10 shows **a downward trend of PM_{10} mean concentrations in background agglomeration**. **These PM_{10} levels decreased by about 30 % from 1999-2001 to 2014-2016**. This is related to the PM_{10} regional emission reductions, accounting for almost -50 % between 2000 and 2012. **This decline is particularly acute over the past three years in background situation.**

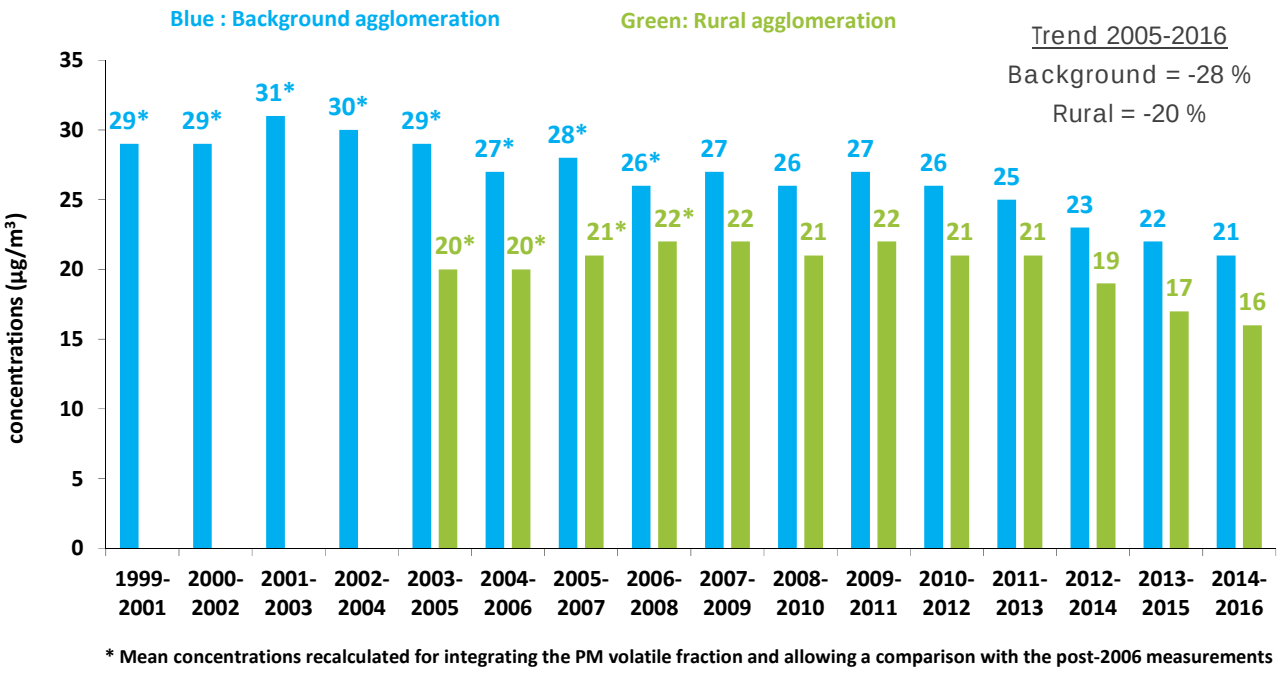


Figure 10 : trend in the PM_{10} tri-annual mean concentration (based on a scalable sample of background sites located within and out the Paris agglomeration) from 1999-2001 to 2014-2016

The traffic monitoring station Ring road BP Porte d'Auteuil is providing PM_{10} measurements since 1998 and Place Victor Basch since 2003. The Figure 11 shows **a downward trend of PM_{10} mean concentrations** of -30 % for Place Victor Basch and -25 % for BP Porte d'Auteuil. For the traffic site BP Porte d'Auteuil, this reduction is roughly 35 % from 1998-2000 to 2014-2016. This trend can be explained by a greater decline in particle emissions from road traffic (around -55 % between 2000 and 2012), especially due to **the progressive introduction of diesel particulate filters**.

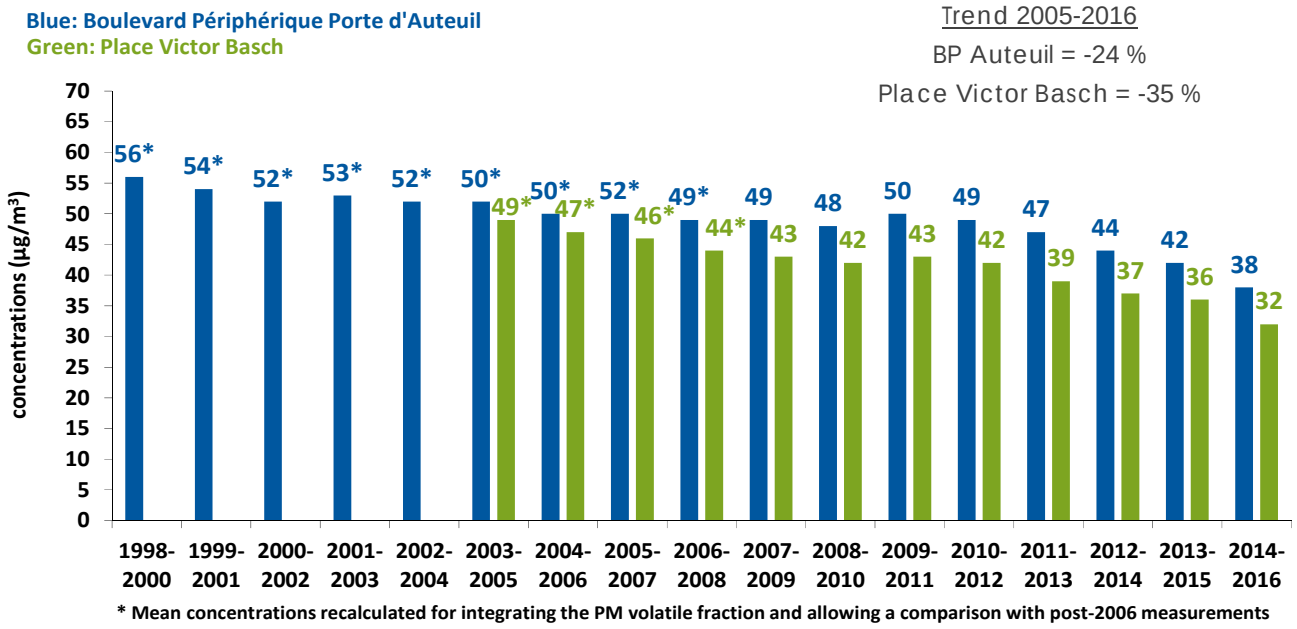


Figure 11 : trend in the PM_{10} tri-annual mean concentration for two traffic sites in Paris from 1998-2000 to 2014-2016

2.2 $PM_{2.5}$ particles

SITUATION OF 2016 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 12 show the annual mean $PM_{2.5}$ concentration within the Paris region, with a focus on Paris and surrounding subsurbs in 2016.

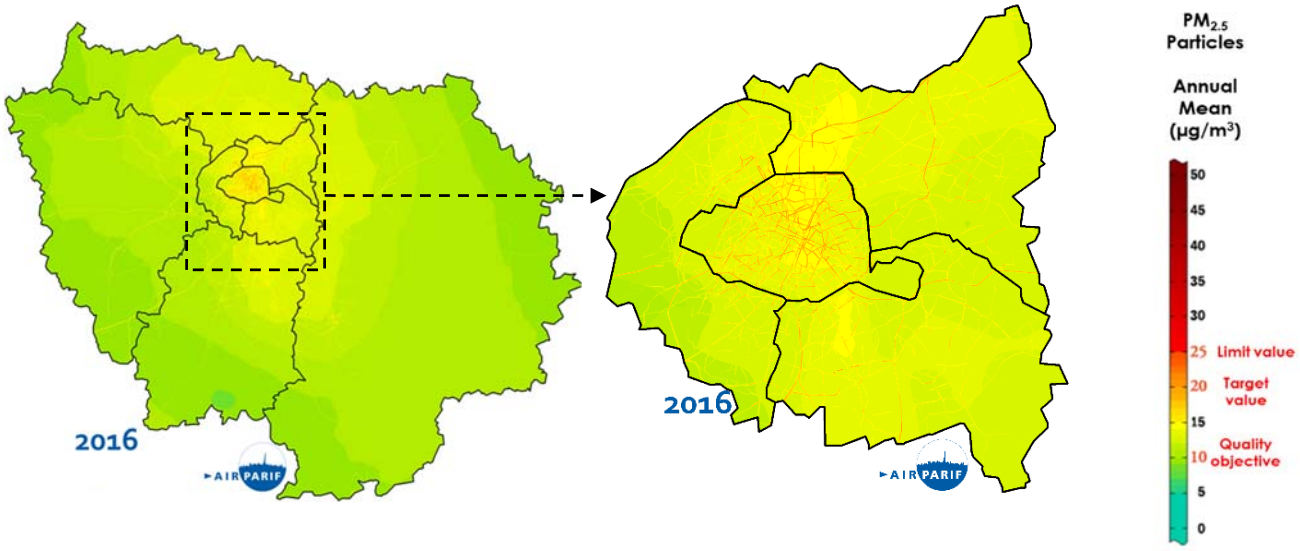


Figure 12 : annual mean concentration of fine particles $PM_{2.5}$ in the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

As in 2015, there is a small difference in $PM_{2.5}$ concentrations between (sub)-urban and rural areas in 2016. $PM_{2.5}$ annual mean concentrations range from 9 to 12 µg/m³ in rural situation and from 10 to 14 µg/m³ for urban and suburban background sites (Figure 13).

Highest $PM_{2.5}$ mean concentrations were measured within the Paris conurbation and also near main roads and highway connections. In roadside situation, annual mean $PM_{2.5}$ concentrations range from 16 to 21 µg/m³. They are slightly lower than those measured in 2015.

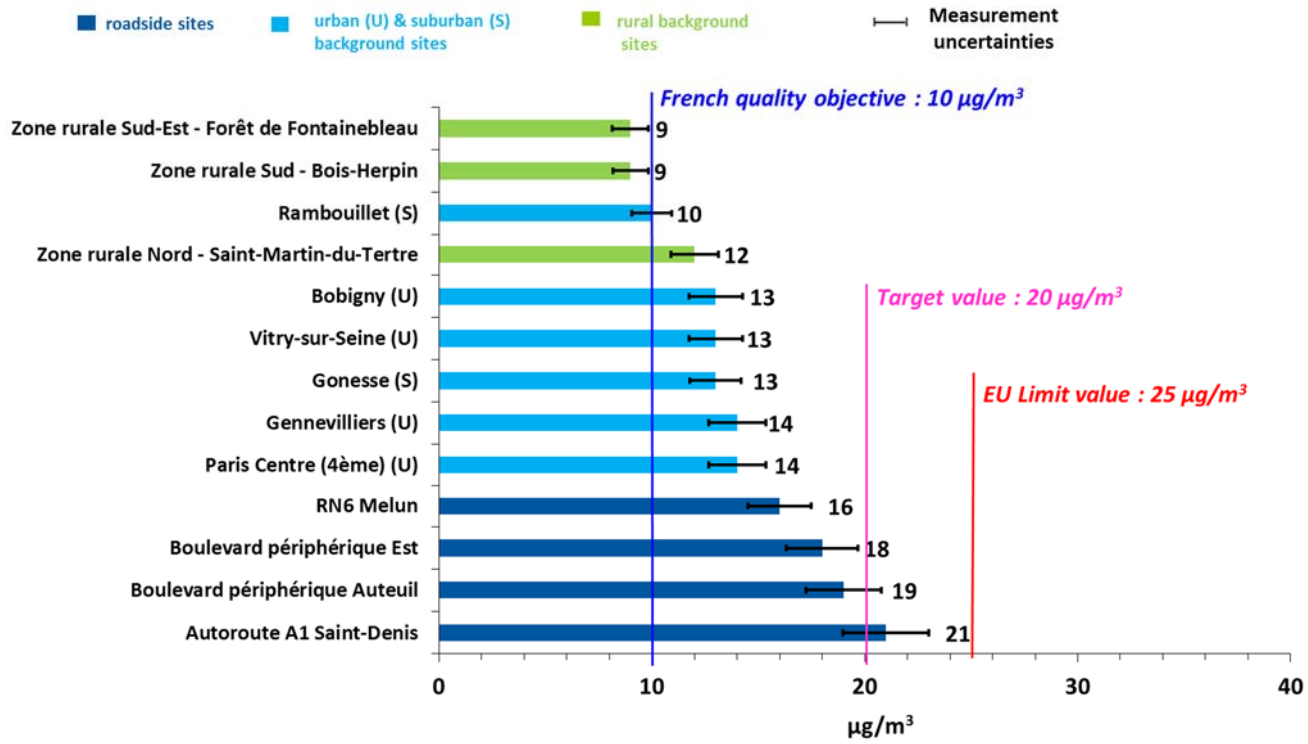


Figure 13 : $PM_{2.5}$ annual mean concentration for all continuous monitoring sites in the Paris region in 2016

For the third year running, the EU limit value for fine particles $PM_{2.5}$ (25 µg/m³) is met at all the monitoring stations. The number of inhabitants potentially exposed to an exceedance of this regulating threshold is very low in 2016. Due to the uncertainties relating to the estimation method, these values are not meaningful.

As in 2015, **the $PM_{2.5}$ target value (20 µg/m³) is exceeded in 2016** at the traffic monitoring station Highway A1 Saint-Denis. This regulating threshold is met at other monitoring stations. **Less than 100 000 inhabitants (or < 1% of the region's population) are potentially exposed to an exceedance of the annual target value.** They are mainly living within the Parisian conurbation (e.g. Paris, Hauts-de-Seine, Seine-Saint-Denis departments).

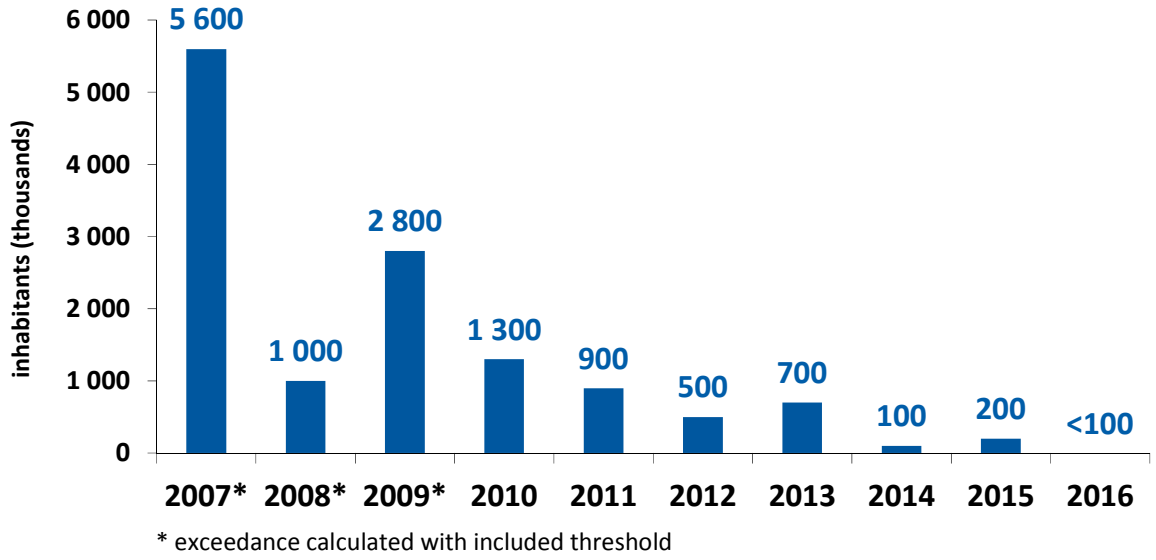


Figure 14 : thousands of inhabitants potentially exposed to an exceedance of the annual target value for fine particles $PM_{2.5}$ (20 µg/m³) in the Paris region from 2007 to 2016

The French quality objective for fine particles $PM_{2.5}$ (10 µg/m³) is exceeded on more than three quarters of the Île-de-France region. $PM_{2.5}$ mean levels are 1.3 to 1.4 times higher above this threshold in background situation and more than twice higher near traffic. **Almost 95 % inhabitants living in the Paris region (or 11 million people) would be exposed to an exceedance of this French $PM_{2.5}$ quality objective.**

LONG-TERM TRENDS

Similar to 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 15.

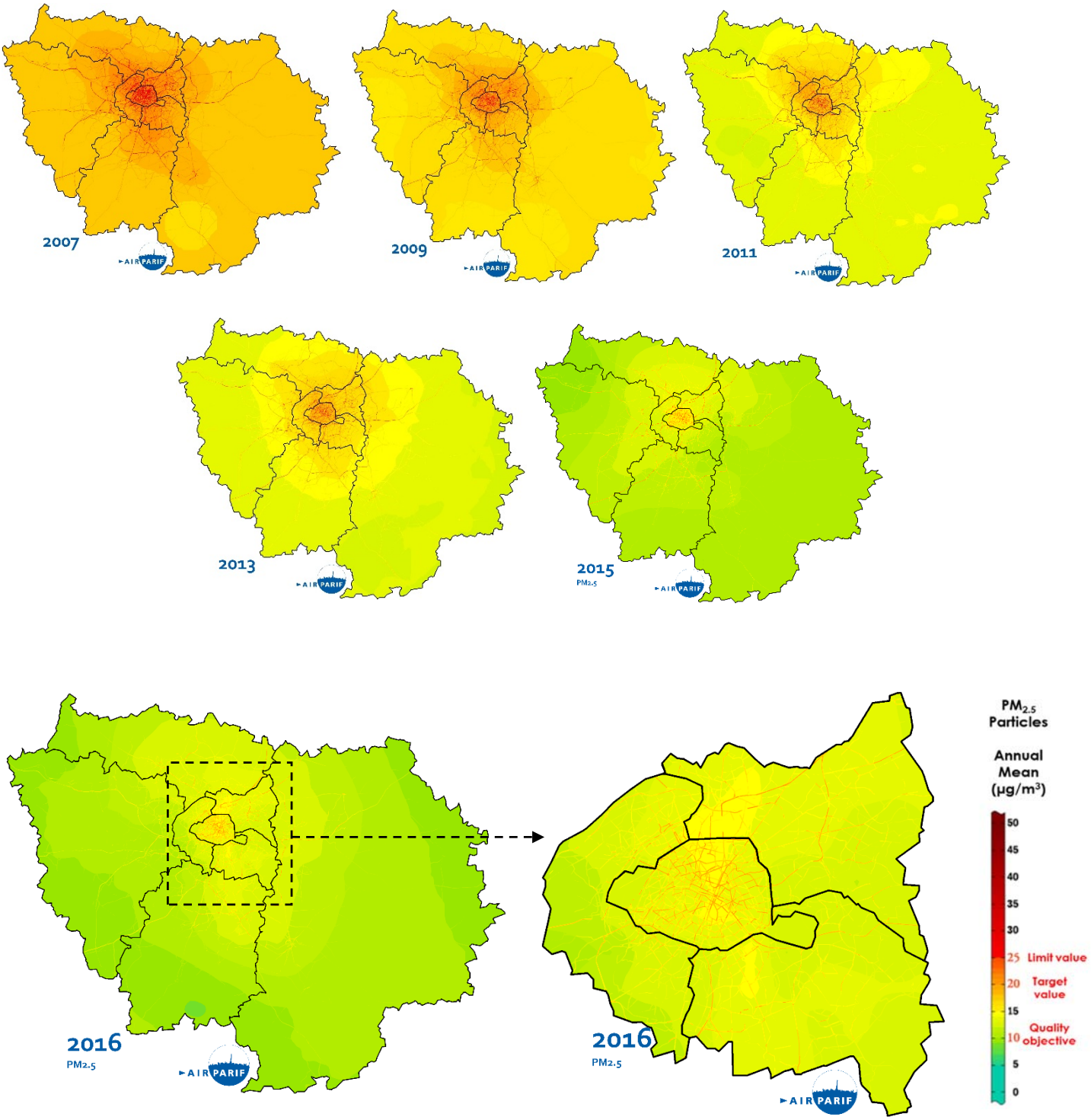


Figure 15 : annual mean concentration of fine particules $PM_{2.5}$ from 2007 to 2016 in the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

$PM_{2.5}$ tri-annual mean levels reflect a significant decline of 35 % from 2000-2002 to 2014-2016 in background situation (Figure 16).

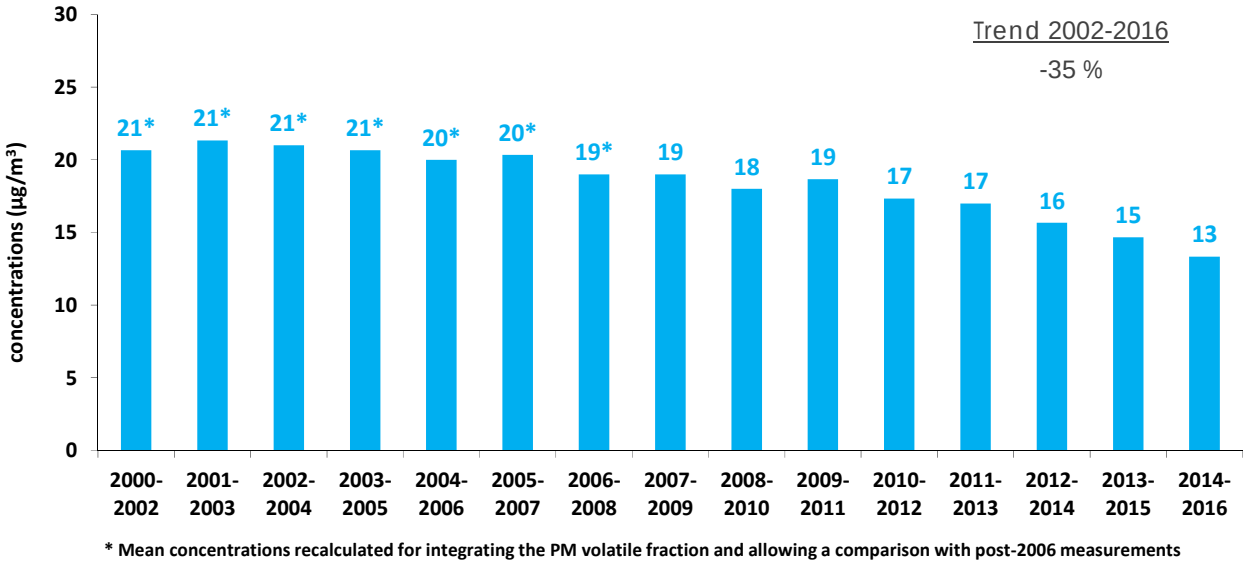


Figure 16 : trend in the $PM_{2.5}$ tri-annual mean concentration (based on a scalable sample of urban background sites) within the Paris agglomeration from 2000-2002 to 2014-2016

The decline of $PM_{2.5}$ concentrations is particularly acute for the traffic monitoring station Ring road BP Porte d'Auteuil (Figure 17). A significant reduction in $PM_{2.5}$ levels of 50 % is observed from 1999-2001 to 2014-2016. As for PM_{10}, this decrease is related to the reduction of primary particle emissions from diesel exhaust (approximately -60 % between 2000 and 2012). **The decrease is greater for $PM_{2.5}$ than for PM_{10} particles because most of $PM_{2.5}$ particles are issued from exhaust emissions.** PM_{10} particles include a significant fraction related to tyre-wear, brake-wear, road abrasion and dust suspension.

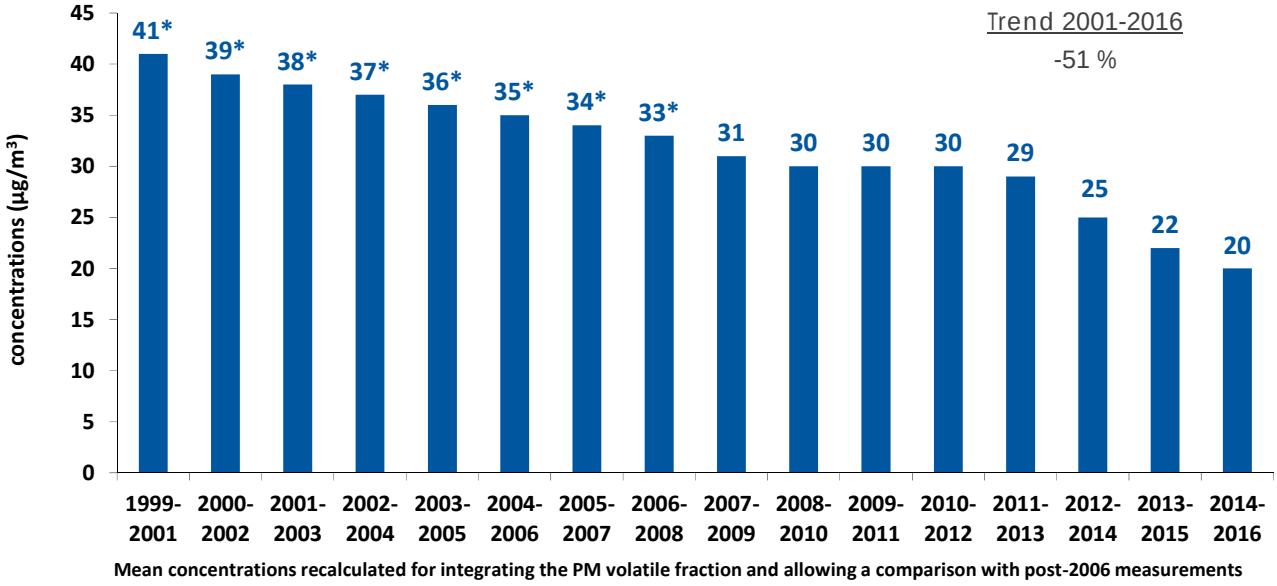


Figure 17 : trend in the $PM_{2.5}$ tri-annual mean concentration for the traffic monitoring station Ring road BP Porte d'Auteuil from 1999-2001 to 2014-2016

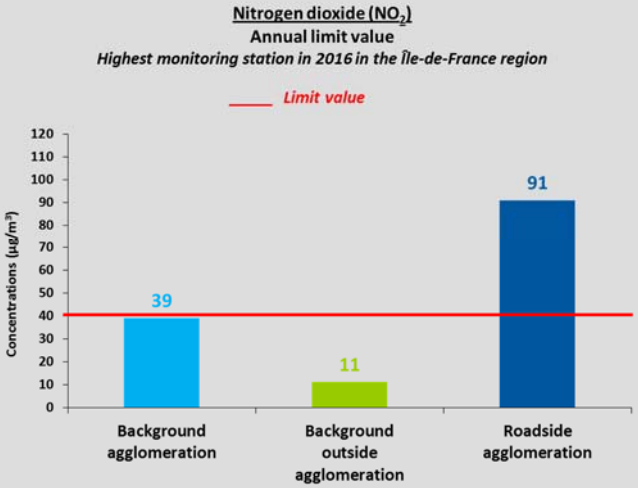
Nitrogen dioxide (NO_2) in brief

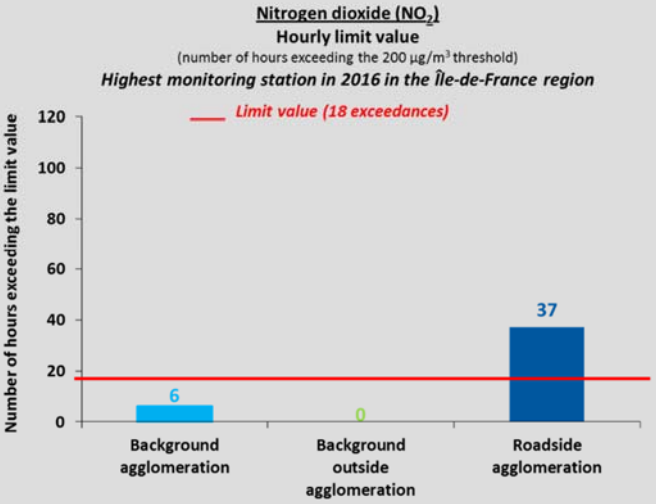
Nitrogen dioxide remains an important issue in the Paris region

The main source of NO_2 is road traffic
Levels along major roads can be twice higher than the EU annual limit value

Around 1.4 million inhabitants (or more than 10 % of the region's population) living in the centre of the agglomeration are potentially exposed to an exceedance of the EU annual limit value

The decreasing trend of background levels observed within the agglomeration since the beginning of the 2000's goes on between 2015 and 2016





exceedance intensity	
very important	> + 50 %
important	+ 30 à + 50 %
moderate	+ 10 à + 30 %
light	0 à + 10 %

no exceedance

Nitrogen dioxide (NO_2)	2016			2005-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Annual limit value exceedance *				2003, 2007, 2009, 2010, 2011, 2012, 2013, 2014		every year
Hourly limit value exceedance *						since 2006

* considering margins of tolerance decreasing from year to year

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

2.3 Nitrogen dioxide (NO_2)

SITUATION OF 2016 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 18 show the annual mean NO_2 concentrations within the Paris region, with a focus on Paris and surrounding subsurbs in 2016.

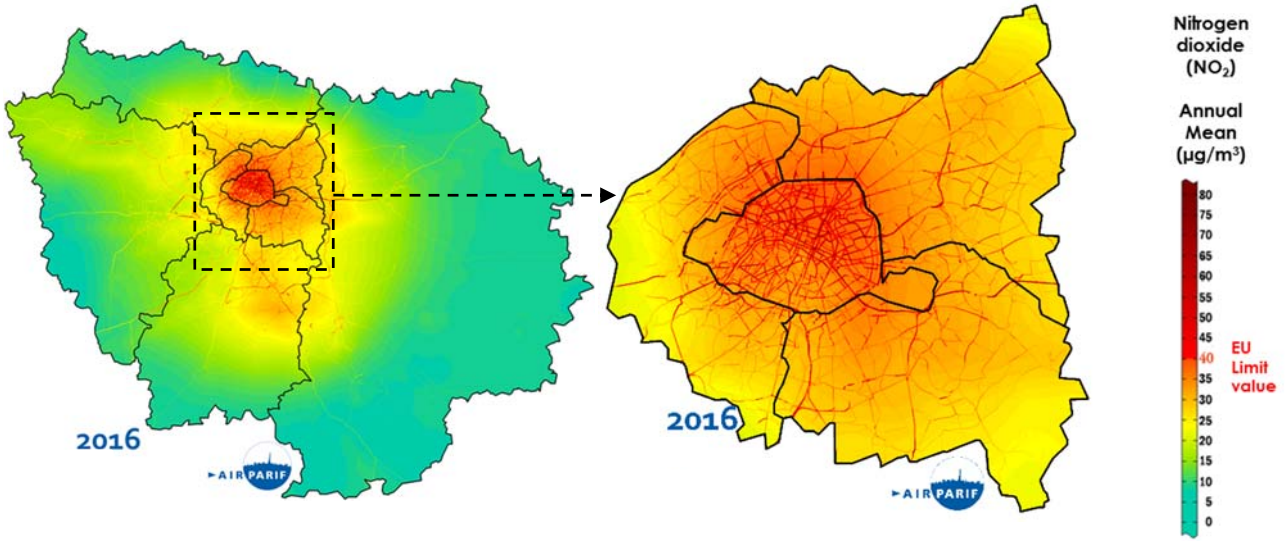


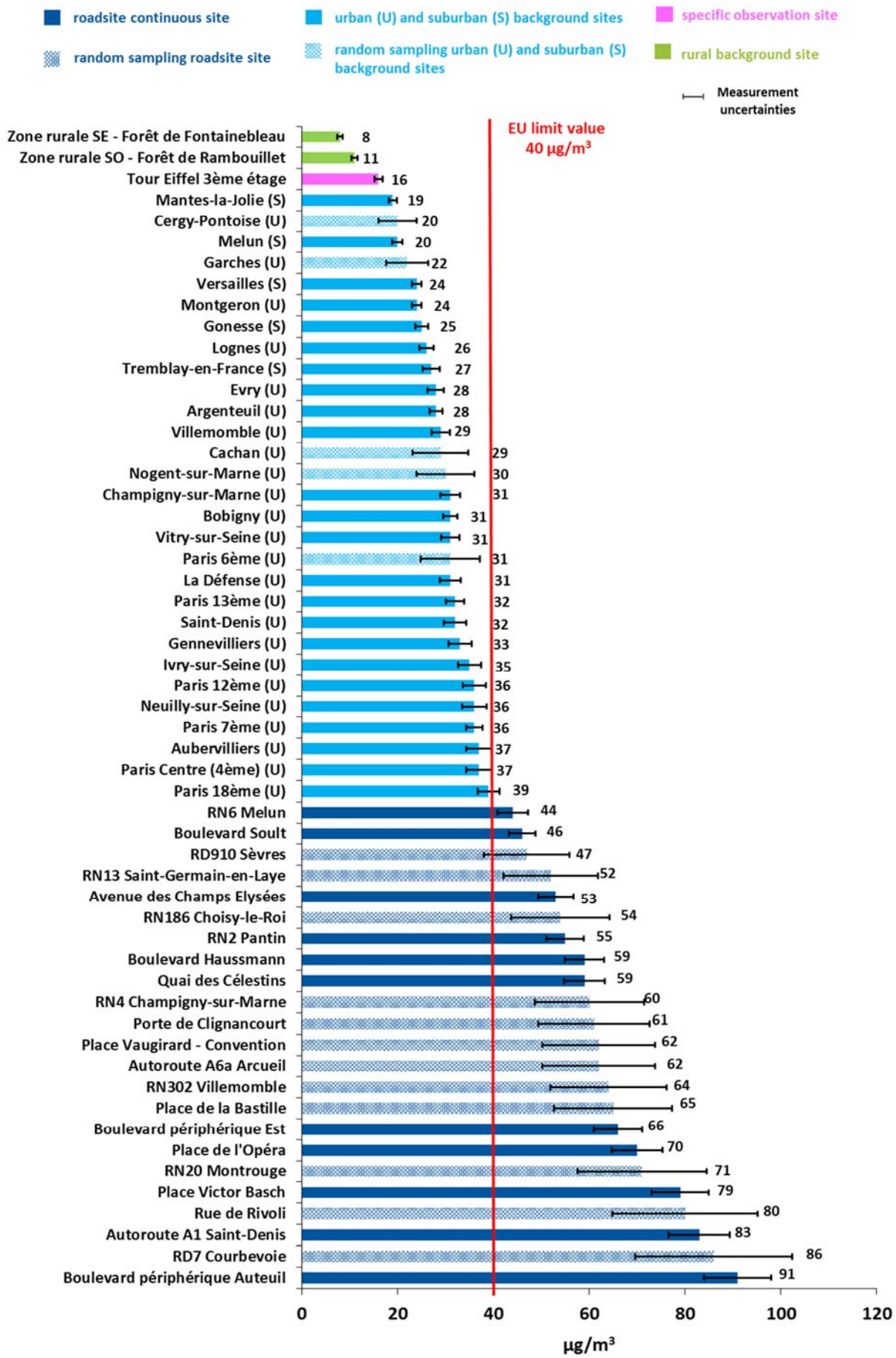
Figure 18 : nitrogen dioxide (NO_2) annual mean concentration within the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

There is a **strong NO_2 concentration gradient** between rural areas and the centre of the Parisian conurbation in background situation. Although annual mean levels measured within the agglomeration may reach 39 µg/m³ (Figure 19), the mean regional background level of NO_2 is close to 10 µg/m³ in 2016.

Highest NO_2 mean concentrations were measured within the Paris conurbation, near major traffic roads (motorways and national highways)**, in the northern part of the Parisian agglomeration and in the north-east part of the Essonne department.** In Paris, the right bank of the Seine River is more severely polluted than the left bank because of higher roads density.

For the second year running, the EU limit value for nitrogen dioxide (40 µg/m³) is met at all the monitoring stations in background situation. Background mean concentrations are similar to those measured in 2014 and 2015.

NO_2 levels along major roads are twice those in background situation. They also can be up to two times higher than the EU annual limit value. The threshold exceedance has been confirmed in 2016 for approximately 990 kilometres of roads and highway connections (Figure 20). This corresponds to approximately 10 % of the main road network modeled by Airparif. These road axes are mainly located in the urban area of Paris.



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 random sampling sites, the results reported in this figure represent the average of twelve-weeks measurements.

Figure 19 : nitrogen dioxide (NO_2) annual mean concentration for all monitoring sites in the Paris region in 2016

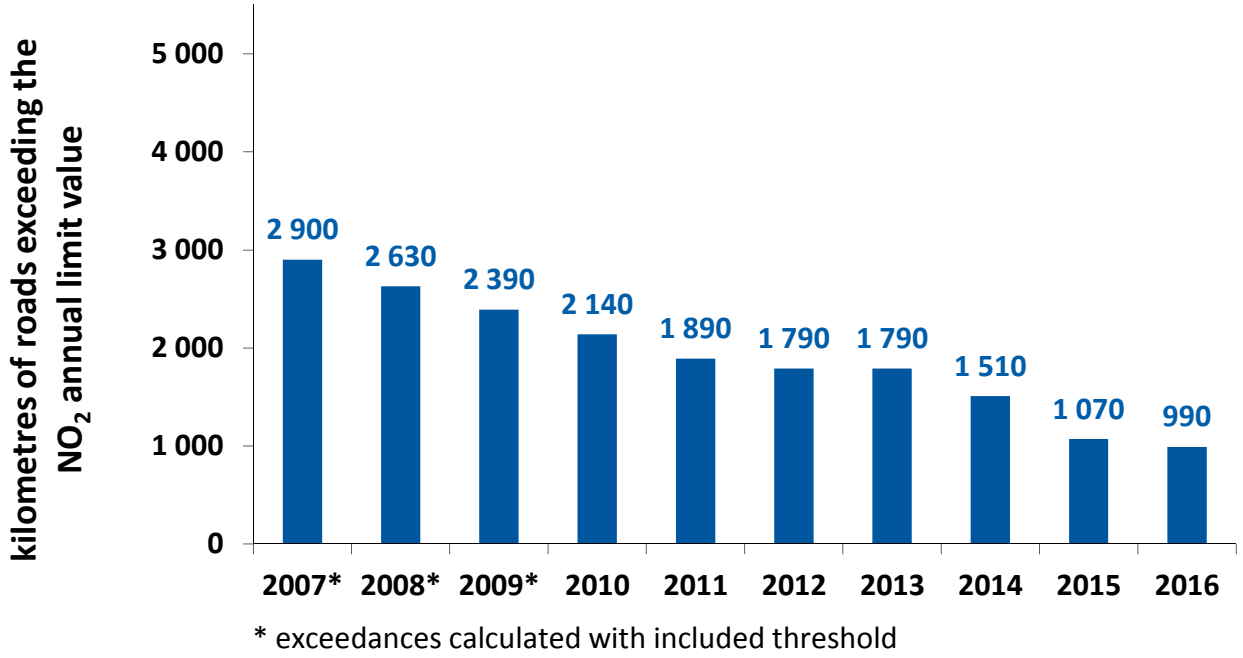


Figure 20 : kilometres of roads exceeding the nitrogen dioxide (NO_2) EU annual limit value in the Paris region from 2007 to 2016

NO_2 mean concentrations are highly variable from one traffic site to another. They reflect a wide concentration range measured near major traffic roads. They are due to **differences in traffic conditions** (traffic flow, speed, vehicle fleet) **and topography** that are able to disperse emitted pollutants (with varying degrees of ease). They also explain differences in NO_2 concentrations in background situation.

The surface area potentially exposed to an exceedance of the NO_2 EU annual limit value is estimated at **approximately 80 square kilometres** (or less than 1 % of the total regional area) (Figure 21).

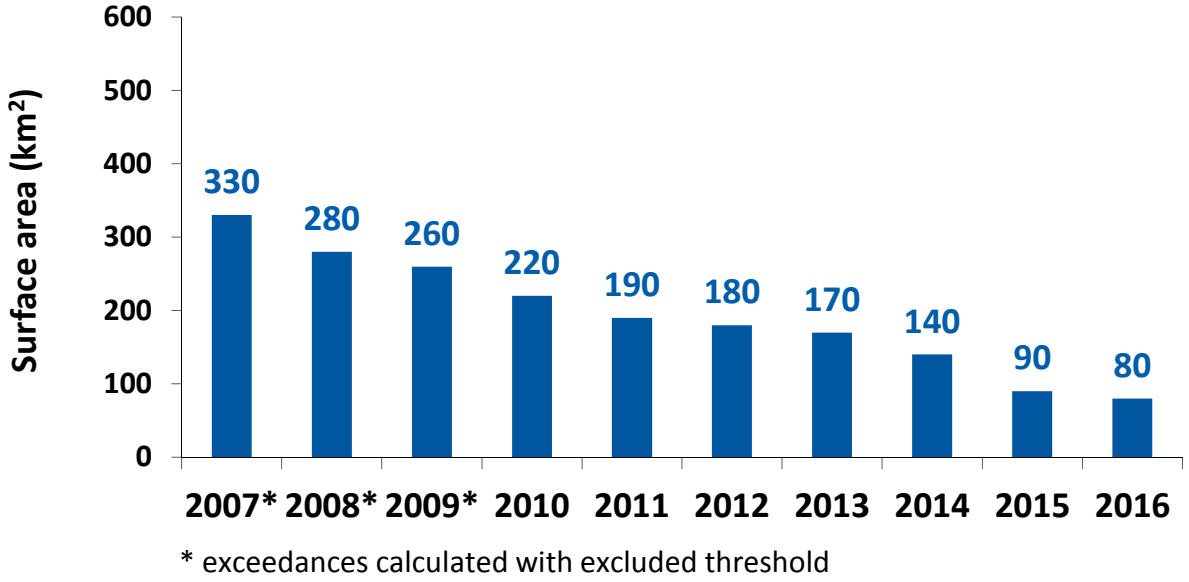


Figure 21 : trend in surface area exceeding the annual limit value (40 µg/m³) in nitrogen dioxide (NO_2) in the Paris region from 2007 to 2016

In 2016, **around 1.4 million inhabitants (or more than 10 % of the region's population) are potentially exposed to an exceedance of the NO_2 EU annual limit value** (Figure 22). They are mainly living within the Parisian conurbation. **Nearly half of all Paris inhabitants** are concerned by the exceedance of the NO_2 annual limit value. A slight decrease in the number of inhabitants exposed to the EU annual limit value was observed between 2015 and 2016.

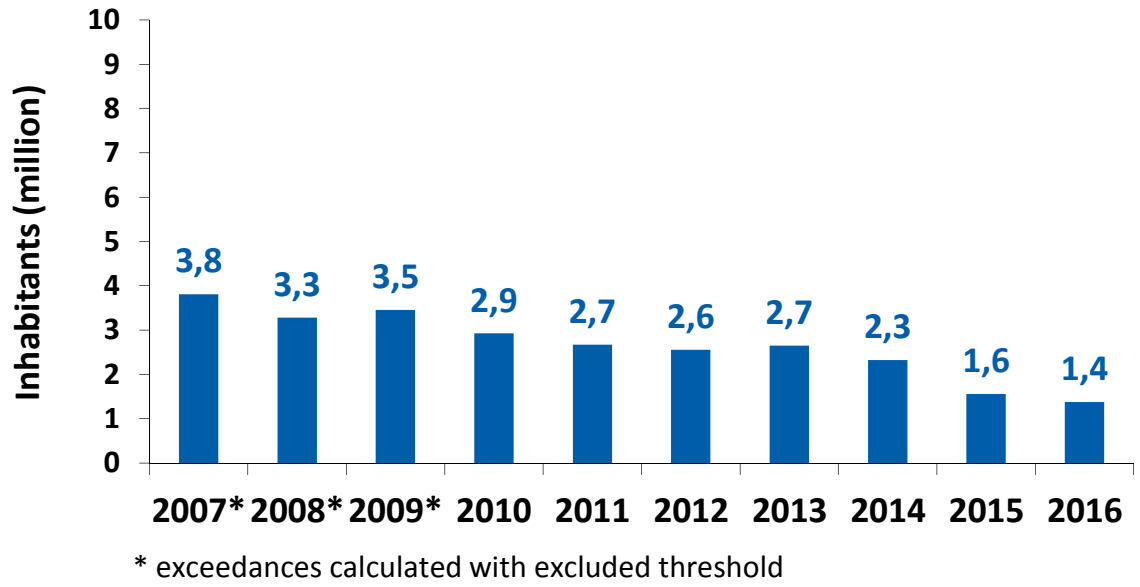


Figure 22 : million of inhabitants potentially exposed to a nitrogen dioxide (NO_2) level exceeding the EU annual limit value in the Paris region from 2007 to 2016

Due to the high road density within the Paris region, modelling tools do not currently allow any estimation of the number of hours exceeding the NO_2 hourly threshold (200 µg/m³) throughout the regional road network. Developments are ongoing to estimate kilometres of roads, surface areas and the number of inhabitants exposed to an exceedance of this NO_2 hourly limit value (200 µg/m³ not to be exceeded more than 18 times per year).

In 2016, **the NO_2 hourly limit value is exceeded** at three traffic monitoring stations (37 exceedances for the Ring road BP Auteuil site, 22 exceedances for the Place Victor Basch site and 19 exceedances for the Ring road BP Est site). **The number of monitoring stations prone to an exceedance of the hourly limit value is consistent with the prior year.** The exceedance hours of this regulating threshold have decreased for the BP Porte d'Auteuil and Place Victor Basch traffic stations, with a gain of respectively 14 and 35 hours for the two traffic sites between 2015 and 2016. However, the number of exceedance hours for the traffic station BP Est has increased in 2016 (+13 hours). In 2014, only one site exceeded the hourly limit value (considering the lowest exceedance number for over 10 years).

The NO_2 hourly limit value is met at all the background stations. In 2016, some urban background stations registered from 1 to 6 exceedance hours of the hourly threshold.

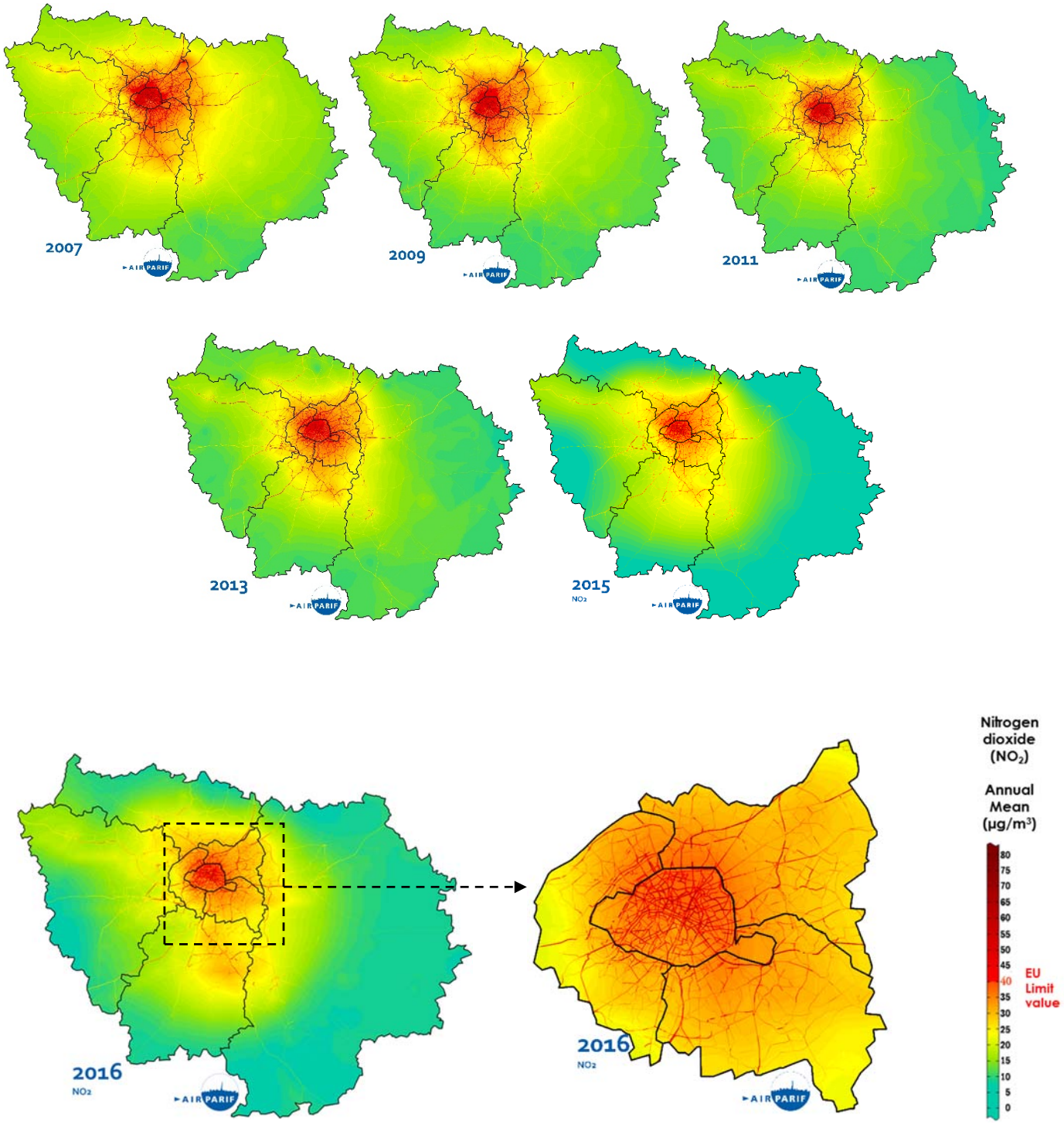


Figure 23 : annual mean concentration of nitrogen dioxide (NO_2) from 2007 to 2016 in the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

The maps in Figure 23 show a similar pollution pattern illustrating **a downward trend of NO_2 annual mean concentrations between 2007 and 2016 within the Paris region.**

A downward trend of NO_2 tri-annual mean levels is observed since the end of the 1990's (Figure 24). Technological improvements focused on different emissioneers (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 is a range of -4 % from 2000 to 2006. It is much slower since then (with an annual average of around -1 %).

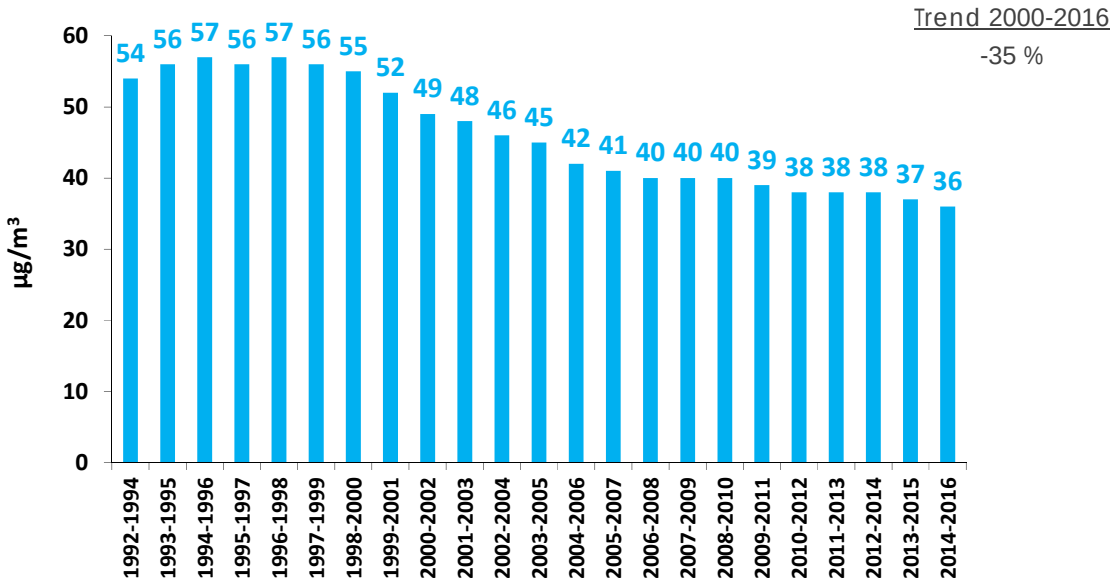


Figure 24 : trend in the NO_2 tri-annual mean concentration (based on a sample of the same six urban background sites) within the Paris agglomeration from 1992-1994 to 2014-2016

In contrast, 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** (Figure 25). NO_2 tri-annual mean concentrations decreased in the range of 10 % in roadside situation from 2011-2013 to 2014-2016.

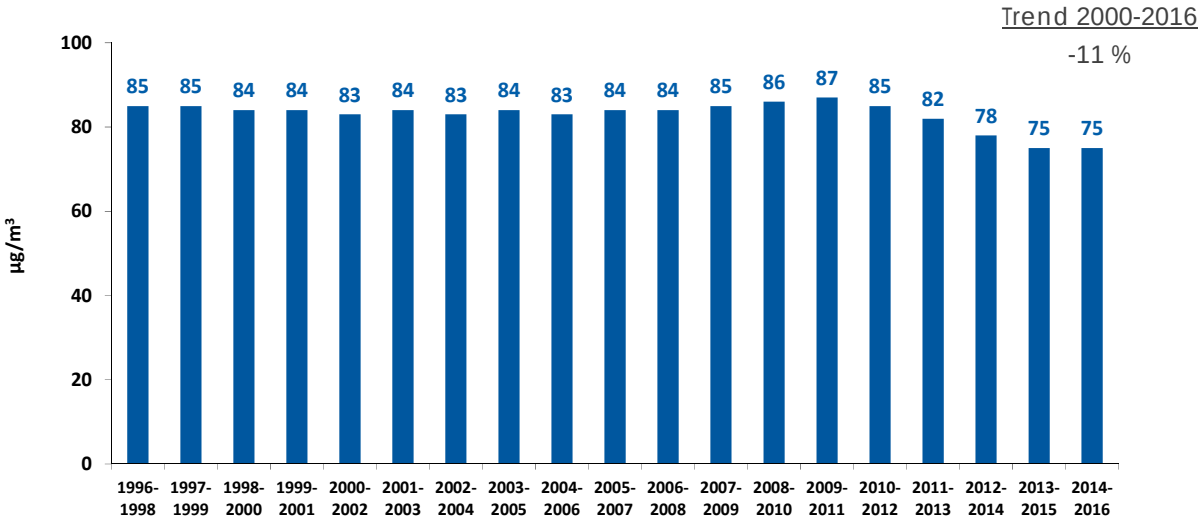


Figure 25 : trend in NO_2 tri-annual mean concentration (based on a sample of the same five roadside sites) within the Paris agglomeration from 1996-1998 to 2014-2016

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). The global stability of NO_2 levels in roadside situation before 2011 can be explained by high nitrogen oxides concentrations (NO_x – pollutants from vehicles) associated with high background levels of ozone. Moreover, the spread of diesel-engined vehicles is an adverse factor for NO_2 concentrations along roads. Although catalysed particulate filters provided on the new diesel vehicles reduce particulate emissions, those using oxidation catalysis increase the proportion of nitrogen dioxide within the NO_x emissions.

The trend in NO_2/NO_x tri-annual mean concentration ratio at all the Parisian roadside stations is shown in Figure 26. NO_2 background levels were subtracted in order to obtain an optimal NO_2/NO_x emission ratio (also considered to evaluate the impact of road traffic emissions). While the NO_2 impact near traffic roads would represent less than 10 % in 1998, it has more than doubled in ten years (24 % in 2011). However, a downward trend of the NO_2/NO_x ratio is observed since 2012. Nonetheless, there was a stagnation of this indicator between 2007 and 2012 at all the traffic monitoring stations. The NO_2/NO_x ratio has steadily increased for the traffic station BP Porte d'Auteuil until 2011. It decreased more slowly thereafter. For the site Highway A1 Saint-Denis, this ratio remains constant after a significant increase. These variations are related to the evolution of the vehicle fleet composition (with differences in the rate of two wheels and diesel vehicles). Over the past decade, the proportion of two wheels increased on traffic roads located in the Paris Intra-muros area (+13 % from 2003 to 2012). There are more diesel vehicles than two wheels on the major highways. It may be noted that the NO_2/NO_x ratio is lower for two wheels. Further investigation about the vehicle fleet composition would underline these hypotheses.

Apart from the declining NO_x emissions, **one of the most important reasons for this trend in NO_2 levels (background and roadside situations) is related to NO_2 primary emissions from diesel vehicles.**

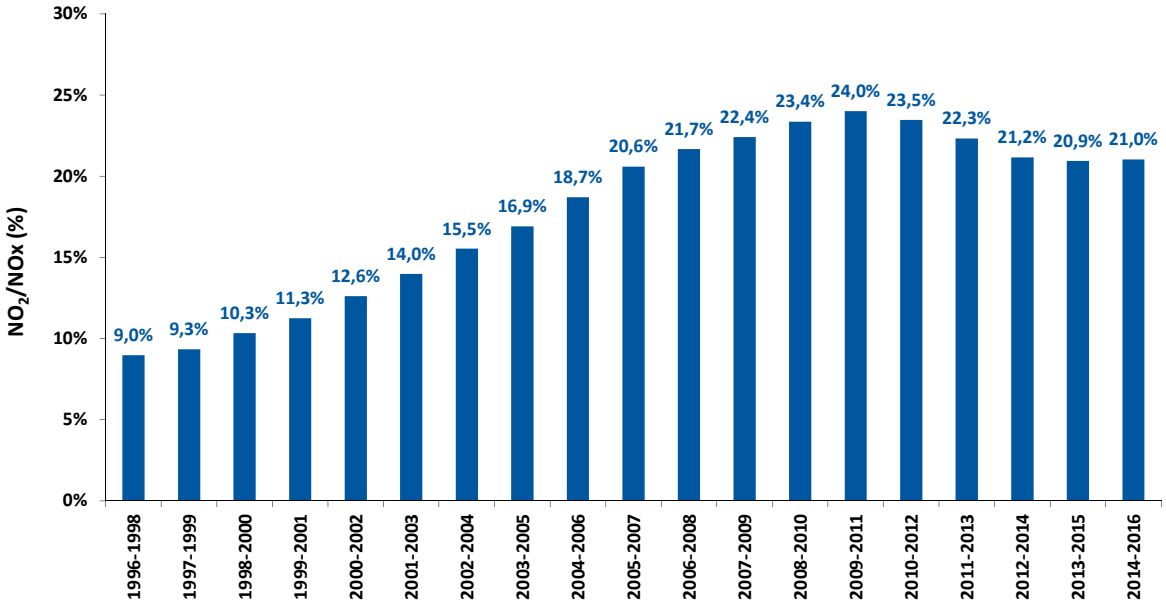


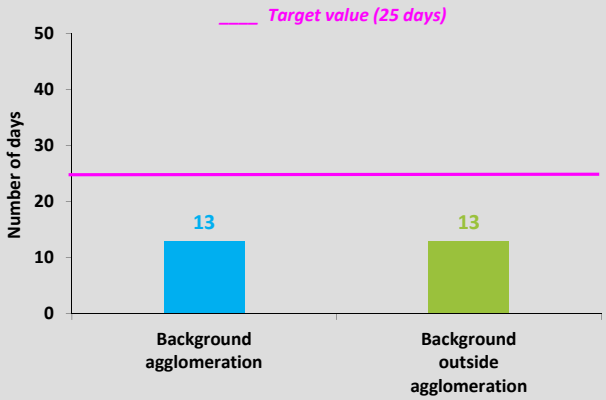
Figure 26 : trend in [NO_2] / [NO_x] tri-annual mean ratio at all the roadside sites in the Paris agglomeration (background level subtracted) from 1998 to 2016

Ozone (O_3) in brief

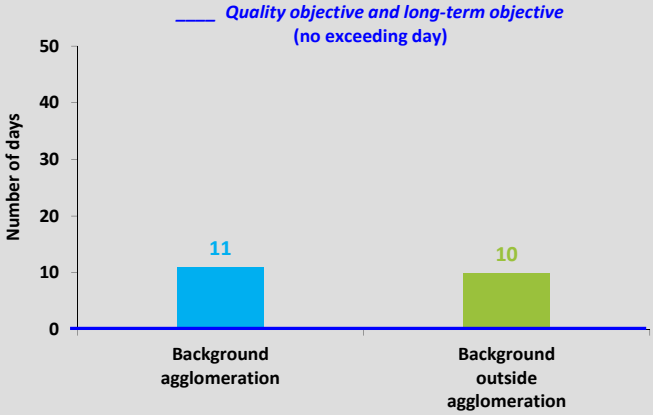
Stabilization of O_3 mean levels since 2003
Target values for the protection of Human Health and vegetation met
The French quality objectives are still exceeded in 2016
in spite of gloomy spring weather and normal summer conditions

Ozone remains an important issue in the Paris region

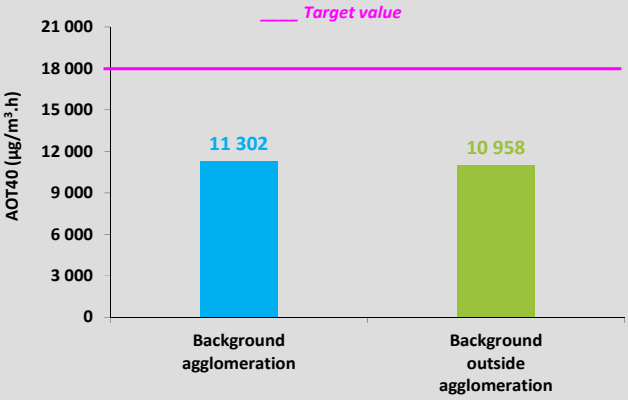
Ozone (O_3) Human Health
Target value
Highest monitoring station in 2016 in the Île-de-France region



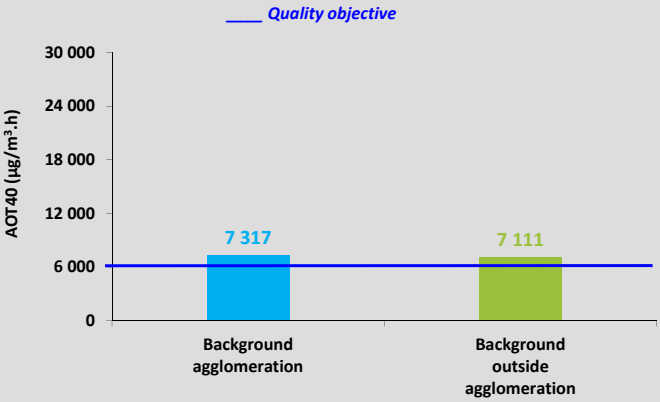
Ozone (O_3) Human Health
Quality objective and long-term objective
Highest monitoring station in 2016 in the Île-de-France region



Ozone (O_3) vegetation
Target value
Highest monitoring station in 2016 in the Île-de-France region



Ozone (O_3) vegetation
Quality objective and long-term objective
Highest monitoring station in 2016 in the Île-de-France region



exceedance intensity	
very important	> + 50 %
important	+ 30 à + 50 %
moderate	+ 10 à + 30 %
light	0 à + 10 %

no exceedance

Ozone (O_3)	2016			2005-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Quality objective exceedance (health) Long term objective applicable in 2020 (health)			*no measurement*	every year	every year	*no measurement*
Target value exceedance (health)			*no measurement*	every year until 2006	every year until 2006	*no measurement*
Quality objective exceedance (vegetation) Long term objective applicable in 2020 (vegetation)			*no measurement*	every year	every year	*no measurement*
Target value exceedance (vegetation)			*no measurement*			*no measurement*

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

2.4 Ozone (O_3)

SITUATION OF 2016 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. In contrast with spring/summer 2015 (that were globally warm and sunny seasons), **the spring 2016 was very cold and rainy. The summer 2016 was characterised by an alternation of heat and cold periods. A heat wave also occurred in late August 2016.** As a result, ozone concentrations were significantly lower than in 2015. This particularly concerns exceedances of the 120 µg/m³ threshold (on a maximum daily 8-hour mean).

Protection of Human Health

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

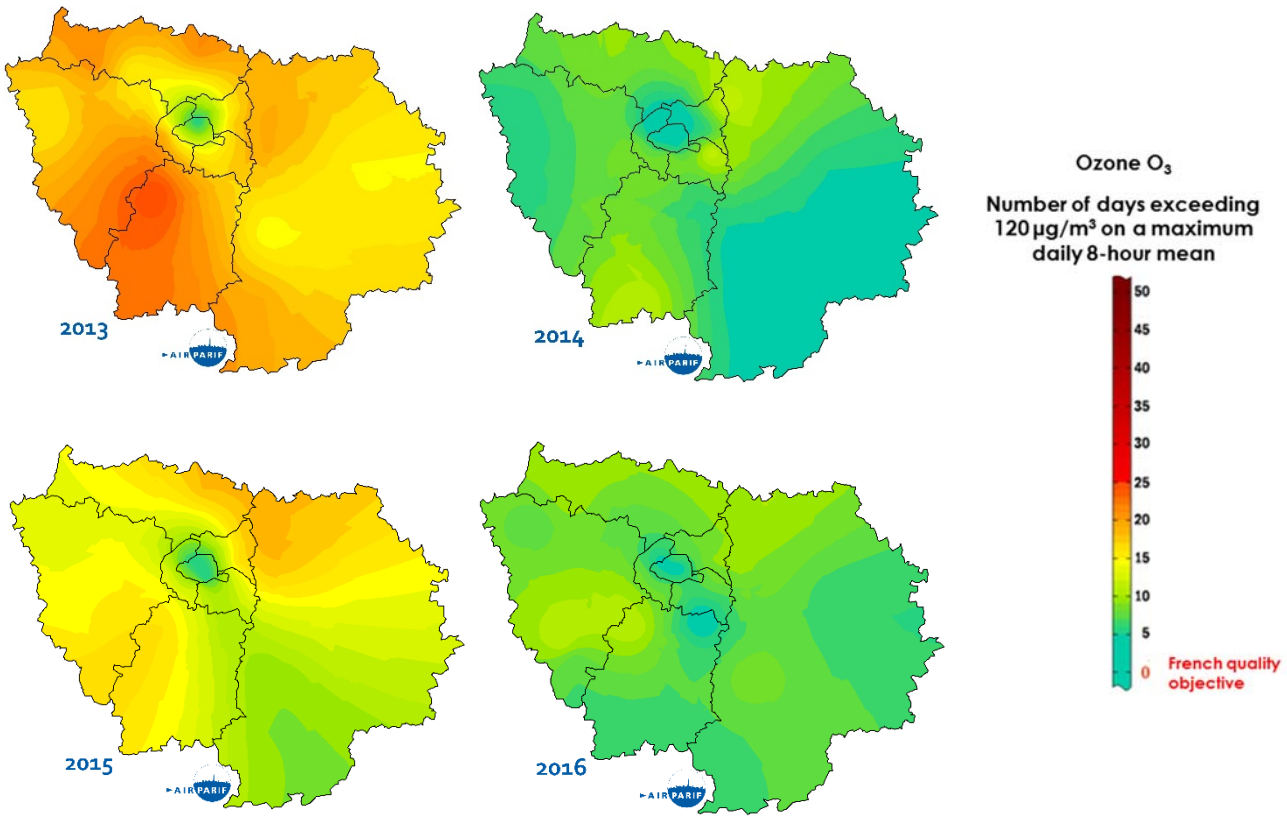


Figure 27 : number of days exceeding the French quality objective (=EU long-term objective) threshold of 120 µg/m³ on a maximum daily 8-hour mean (objective = no exceedance) for ozone (O_3) in the Paris region from 2013 to 2016

Due to contrasting meteorological conditions (with an alternation of freshness/rainfull and sunlight/warm temperatures periods) from May to June, **Airparif has observed in 2016 approximately two times less days of the quality objective exceedances than in 2015** (2016 accounting the lowest number of days over the last ten years).

The **target value for the protection of human health** (calculated on a 3-year average) was exceeded until 2007 within southwest rural areas and in the north of the Paris region. **This regulating threshold is no longer exceeded in the Île-de-France region since the 2006-2008 period.** This observation is confirmed for the 2014-2016 period (Figure 28).

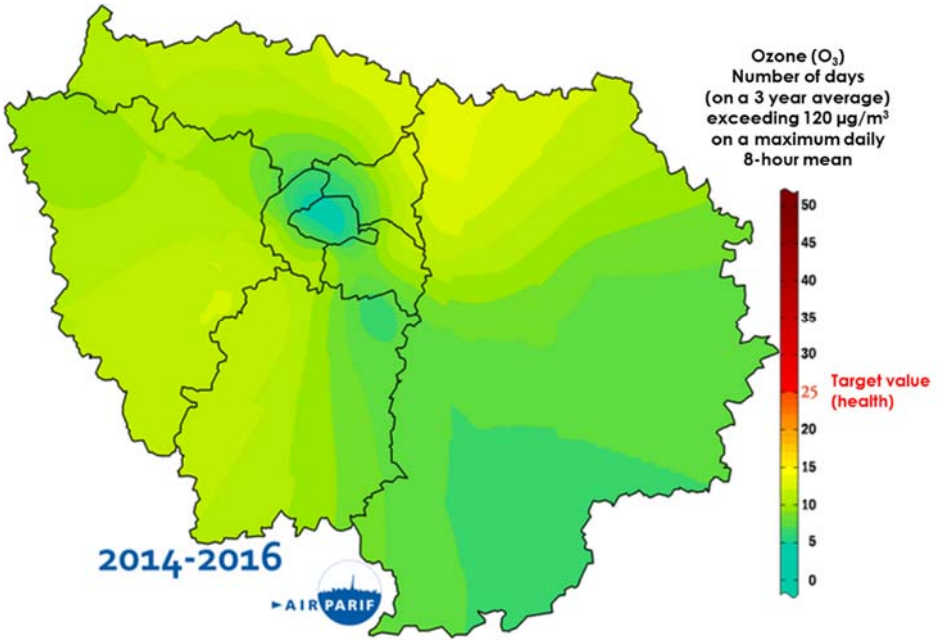


Figure 28 : number of days exceeding the O_3 target value for the protection of human health (120 µg/m³ for the daily maximum on a 8-hour average not to be exceeded more than 25 days per calendar year calculated on a 3-year average) within the Paris region for the 2014-2016 period

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

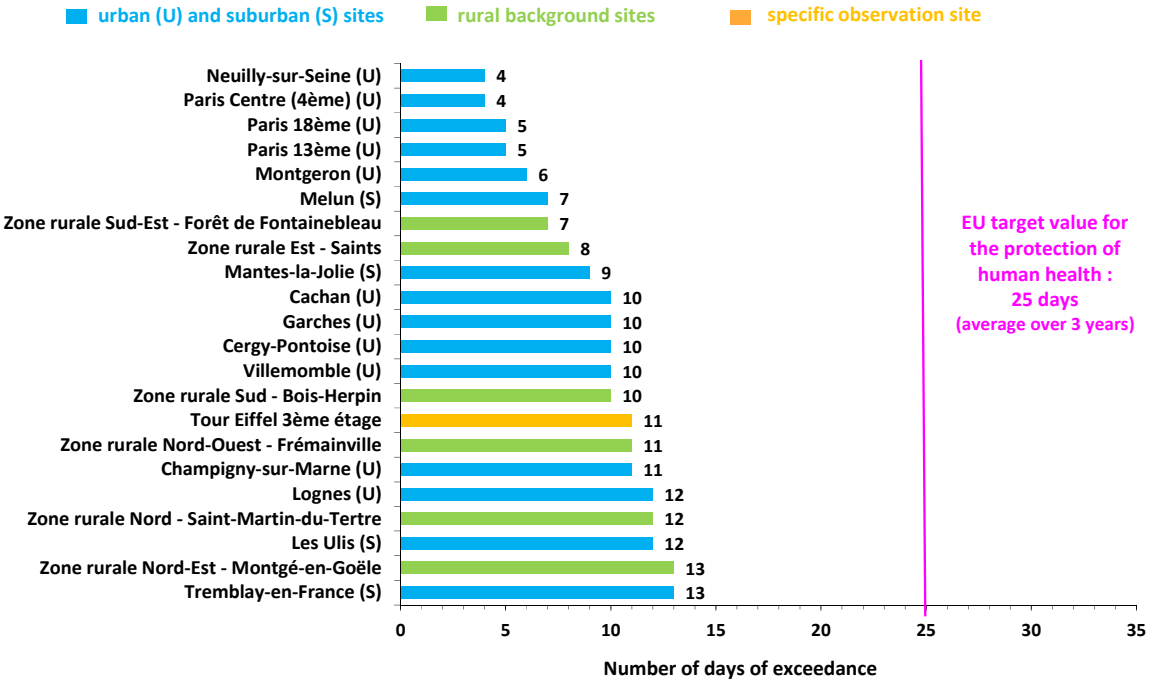


Figure 29 : number of days exceeding the O_3 EU target value for the protection of human health (120 µg/m³ 8-hour average) in the Paris region (average 2014-2016)

Protection of vegetation

Many scientific studies have revealed the negative effects of ozone on the vegetation (forests, ecologically or biologically significant areas and cereal/wheat crops) due to its strong oxidizing action. Consequently, European regulations consider **quality objectives and target values for the protection of vegetation set to growing vegetation and crops periods occurring 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 (=40 ppb) 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}.

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 2016, **the EU target value is met in the whole Île-de-France region.** The highest average over the 2012-2016 period is 11 302 µg/m³.h^{-1}.

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 still exceeded in the Île-de-France region.** In 2016, 17 out of 24 monitoring stations detected ozone levels below the quality objective for the protection of vegetation (while this regulated threshold was met for one monitoring station in 2015). The threshold exceedance is especially evident in suburban and rural areas. Ozone levels are 1.2 times higher than the French quality objective at these sites (Figure 30).

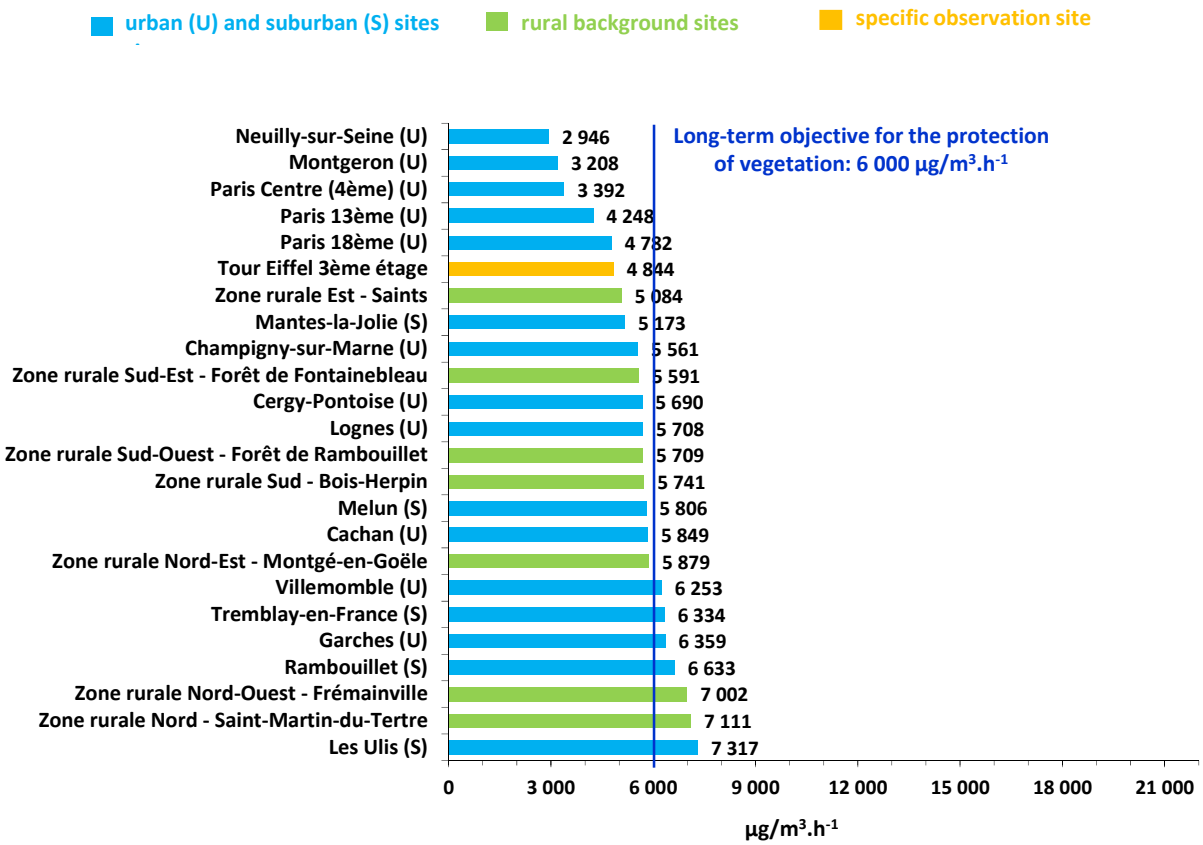


Figure 30 : long-term objective in ozone (O_3) for the protection of vegetation (AOT40, threshold of 6 000 µg/m³.h^{-1}) in the Paris region in 2016

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-hour average) can vary considerably over time. It depends on summer weather conditions, and in particular the presence of durably warm periods.

The year of 2016 is characterised by a sunshine duration and a number of hottest days (when the maximal temperature has met or exceeded 30 Celsius degrees) comparable to standard values. In 2016, the average numbers of exceedance days of the quality objective (both in the Paris agglomeration and rural areas) are quite similar to those in 2009, 2012 and 2014 (Figure 31). **There is no clear downward trend of the number of exceedance days over the 1998-2016 period**. **This number is still above the quality objective** (no exceedance day).

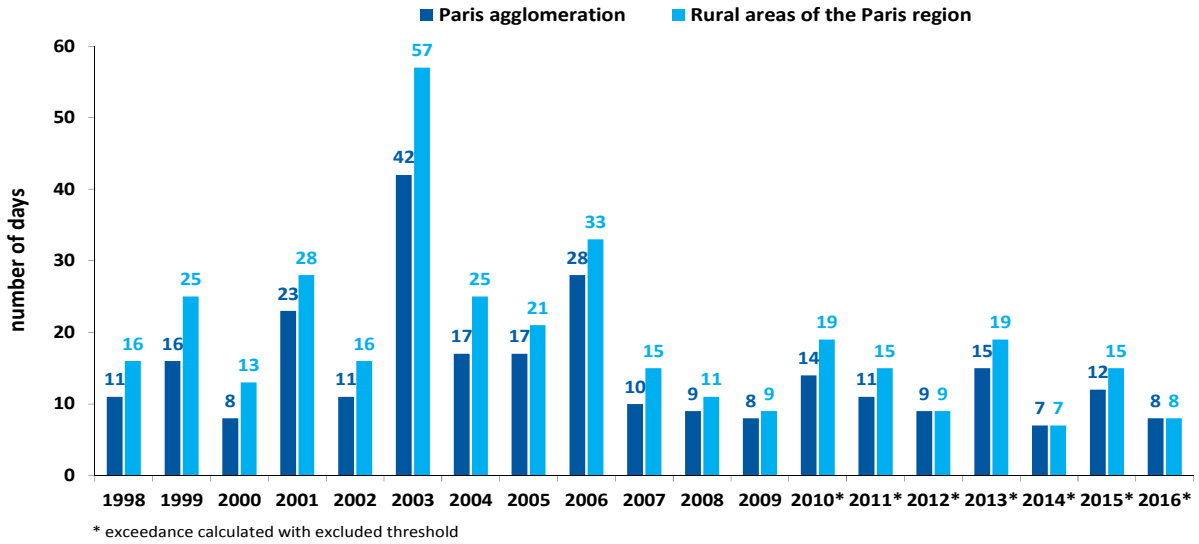


Figure 31 : average number of days exceeding the O_3 quality objective for the protection of human health (120 µg/m³ 8-hour average) in the Paris region from 1998 to 2016

Due to strong direct dependence of weather conditions, the evolution of the number of exceedance days (120 µg/m³ 8-hour average) can only be meaningfully assessed 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 32. In 2016, **this regulated threshold is met in the agglomeration and rural areas of the Paris region** for the ninth and the eighth consecutive year, respectively. **The target value exceedance does not seem to be met in the future, even in the rural and suburban areas of the Paris region.** Due to the relative stability of ozone levels since 2007**, it would be premature, however, to draw conclusion about a possible downward trend of 8-hour average O_3 levels over the long term.**

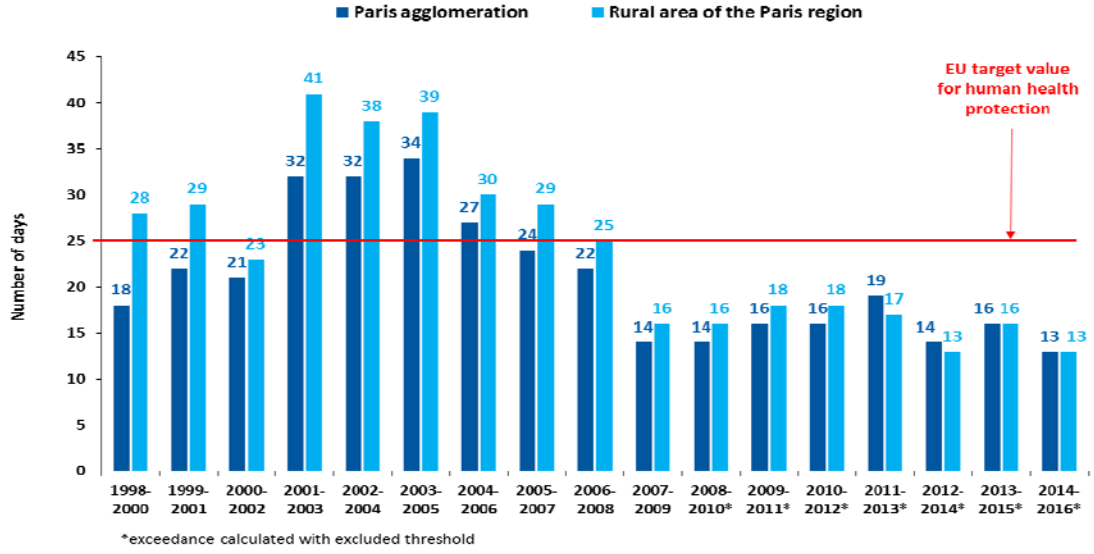


Figure 32 : number of days exceeding the EU target value for the protection of human health (120 µg/m³ 8-hour average, not over 25 days of exceedance on a 3-year period) for the highest monitoring station in the Paris region from 1998-2000 to 2014-2016

The trend of the O_3 tri-annual mean concentrations measured within the Paris agglomeration is shown in Figure 33. These O_3 levels rose by 85 % between 1994 and 2016. **The annual average rate reached 7 % per year between 1994 and 2003. Urban background ozone concentrations are statistically stable since 2003.** This increase was seen in France, but also everywhere in Europe. It is related to the overall increase in the emissions of ozone precursors and the paradoxical decrease of NO_x levels in large cities. The steady decline in NO levels (that chemically consumes ozone in urban areas) exerts an upward effect of average ozone levels.

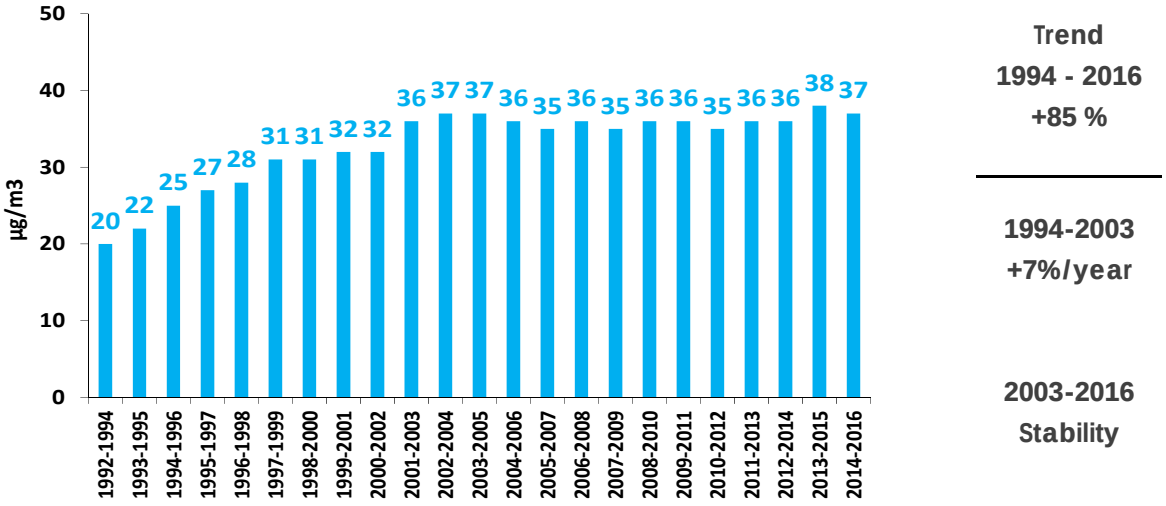


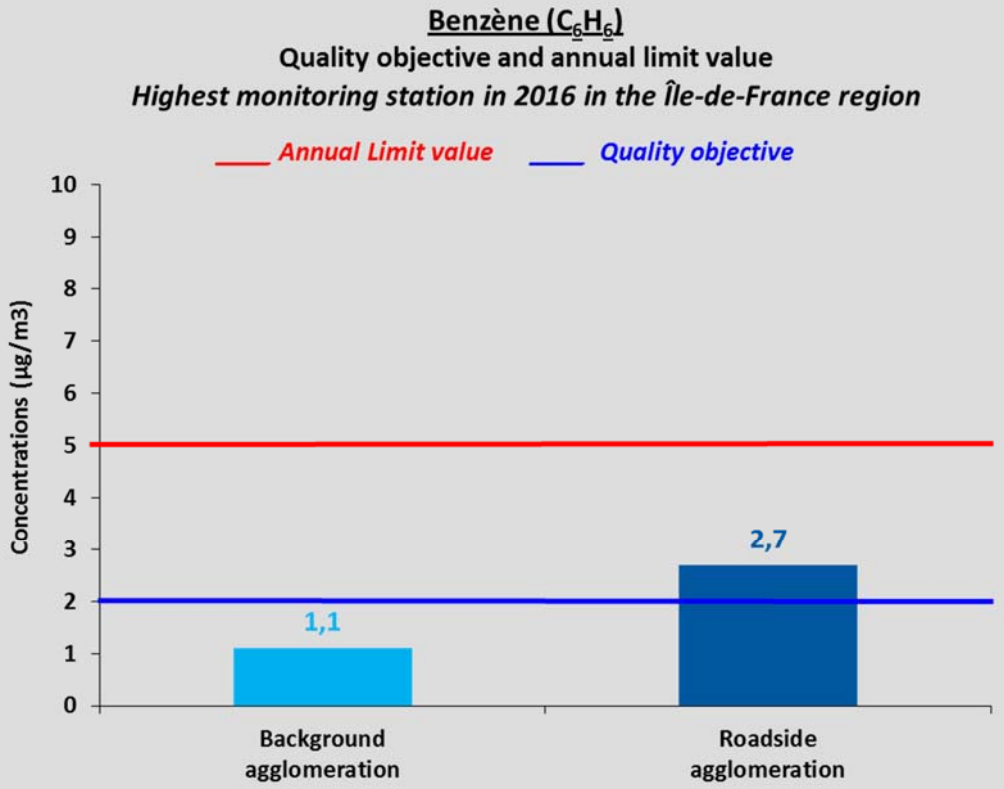
Figure 33 : trend in the O_3 tri-annual mean concentration (based on a sample of the same three urban background sites) within the Paris agglomeration from 1992-1994 to 2014-2016

Benzene (C_6H_6) in brief

Annual limit value for benzene (5 µg/m³) is met everywhere in the Paris region in 2016

Less than 100 000 inhabitants are potentially exposed to an exceedance of the annual quality objective (2 µg/m³)

The decreasing trend of benzene levels from 1994 to the beginning of the 2000's observed within the Paris region goes on between 2015 and 2016



Benzene (C_6H_6)	2016			2005-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Quality objective exceedance		no measurement			no measurement	every year
Limit value exceedance		no measurement			no measurement	

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

2.5 Benzene (C_6H_6)

SITUATION OF 2016 RELATED TO AIR POLLUTION STANDARDS

The maps in Figure 34 show the annual mean benzene concentration within the Paris region, with a focus on Paris and surrounding subsurbs in 2016.

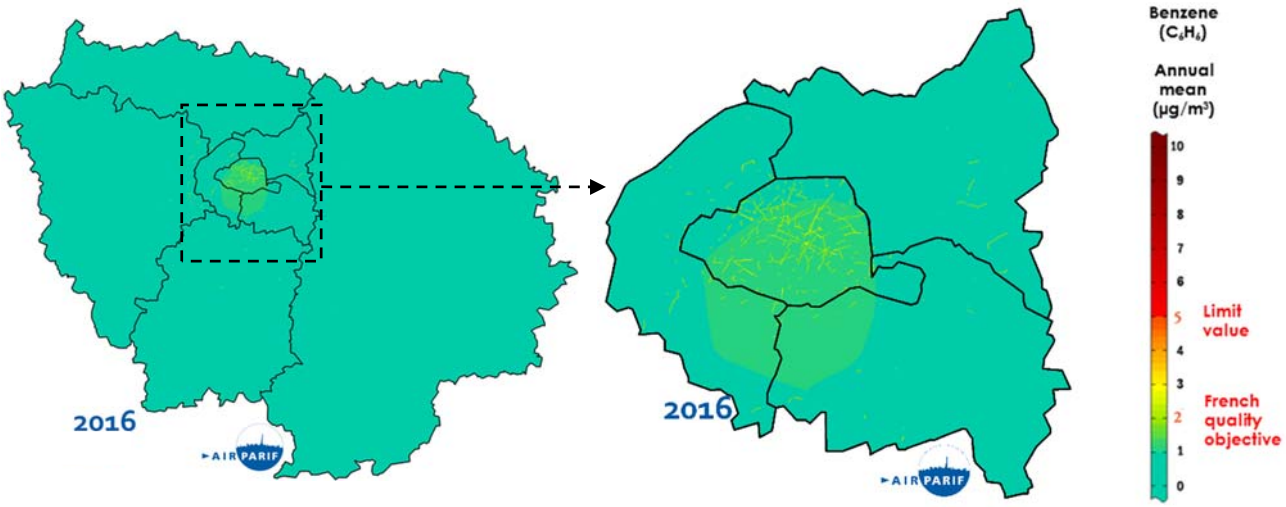


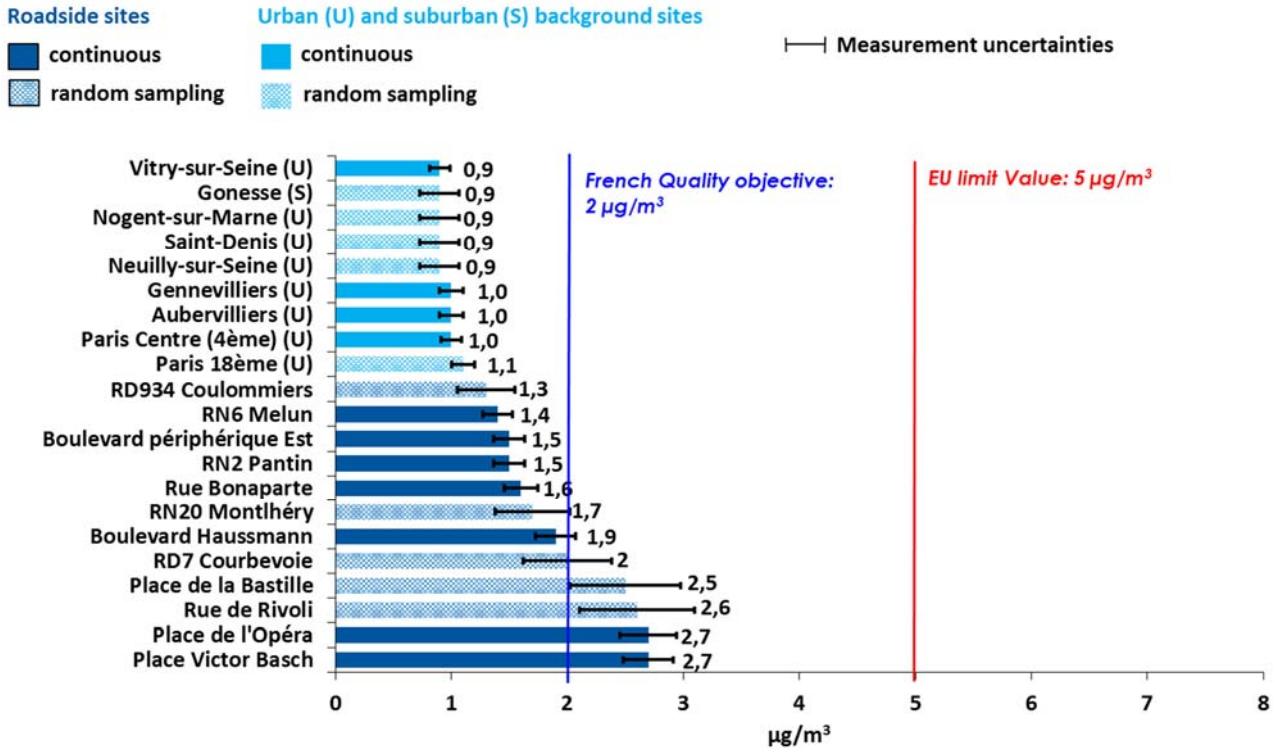
Figure 34 : annual mean concentration of benzene (C_6H_6) in the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

Annual mean concentrations of benzene are higher in the Paris agglomeration than the periphery of the region. There is a slight decline of C_6H_6 levels in accordance with the distance from the Paris centre. **Background benzene concentrations are lower than the French quality objective and the EU annual limit value** (2 and 5 µg/m³, respectively). In 2016, background benzene levels (from 0.9 to 1.1 µg/m³) are similar to those in 2015 (Figure 35).

Highest annual mean concentrations of benzene were 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 1.3 and 2.7 µg/m³ for the traffic monitoring stations. They are slightly less than those measured in 2015 (in the range of -10 %). Benzene concentrations can be high in the proximity of point sources (storage and fuel distribution areas).

For several years now, benzene levels are on a slightly downward trend, especially along traffic roads.

In 2016, the French quality objective is exceeded at 4 out of 12 traffic monitoring stations. A slight decrease of benzene levels in roadside situation was observed between 2016 and 2015 (when benzene annual concentrations exceeded the quality objective over half of traffic sites). **Benzene annual levels are lower than the EU limit value.** This finding is based on modeling results and measurement network observations, especially onto heavily-loaded traffic roads. These results have to be considered without being directly influenced by local point sources of VOC (in particular benzene). Highest concentrations can be observed in close proximity to emission sources such as service stations or garages (for which specific measurement campaigns occurring).



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 the random sampling sites, the results reported in this figure represent the average of twelve-weeks measurements.

Figure 35 : annual mean concentration of benzene in the Paris region in 2016

The exceedance of the benzene quality objective (2 µg/m³) has been confirmed in 2016 for approximately 130 kilometres of roads and highway connections (Figure 36). This corresponds to approximately 1 % of the main road network modeled by Airparif. These threshold exceedances are mainly observed within the urban area of Paris.

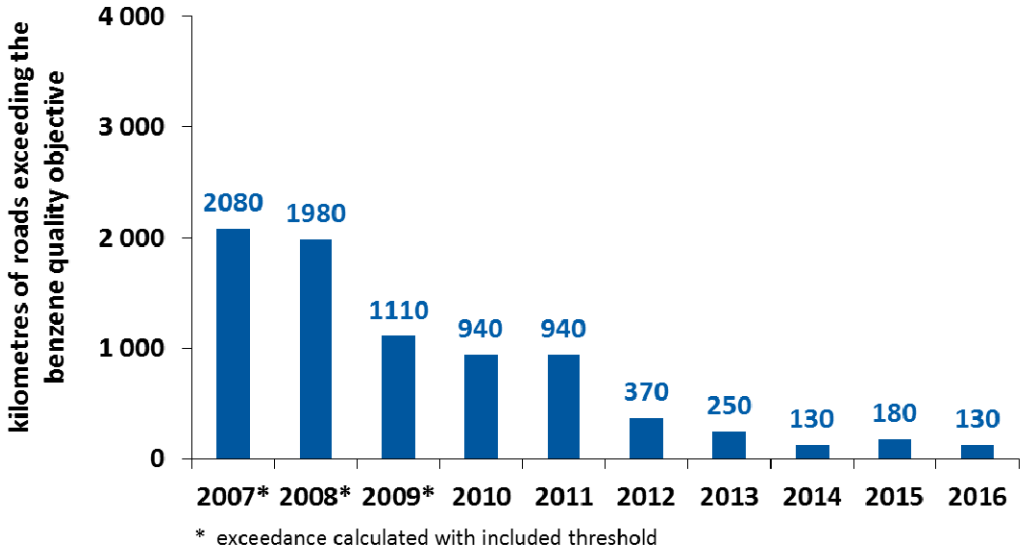


Figure 36 : kilometres of roads exceeding the benzene French quality objective (2 µg/m³) in the Paris region from 2007 to 2016

The surface area potentially exposed to an exceedance of the benzene French quality objective is very low at the scale of the Île-de-France region. Due to the uncertainties relating to the estimation method, the corresponding values are not meaningful.

In 2016, less than 100 000 inhabitants living in the agglomeration and in roadside situations are potentially exposed to an exceedance of the annual quality objective for benzene. They are mainly living within the Paris agglomeration.

The number of inhabitants potentially exposed to an exceedance of the benzene quality objective has dropped significantly since the beginning of the 2000's (Figure 37). In 2002, 3.2 million of inhabitants were potentially concerned by this threshold exceedance.

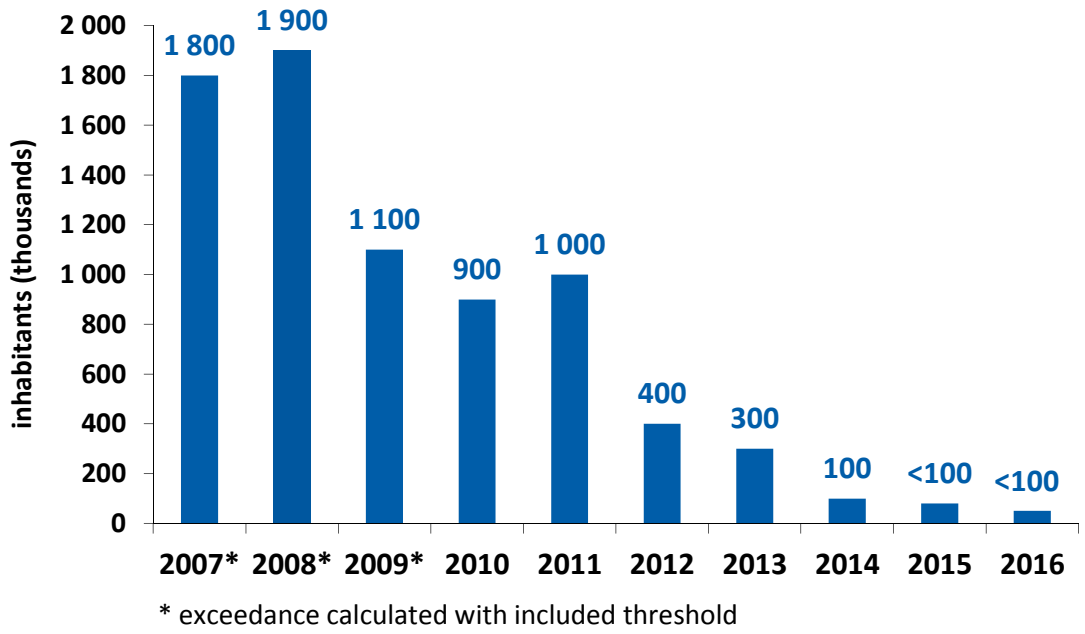


Figure 37 : thousands of inhabitants potentially exposed to an exceedance of the benzene French quality objective (2 µg/m³) in the Paris region from 2007 to 2016

AVERAGE ANNUAL TRENDS

The maps in Figure 38 show the annual mean benzene concentrations within the Paris region, with a focus on Paris and surrounding subsurbs in 2016.

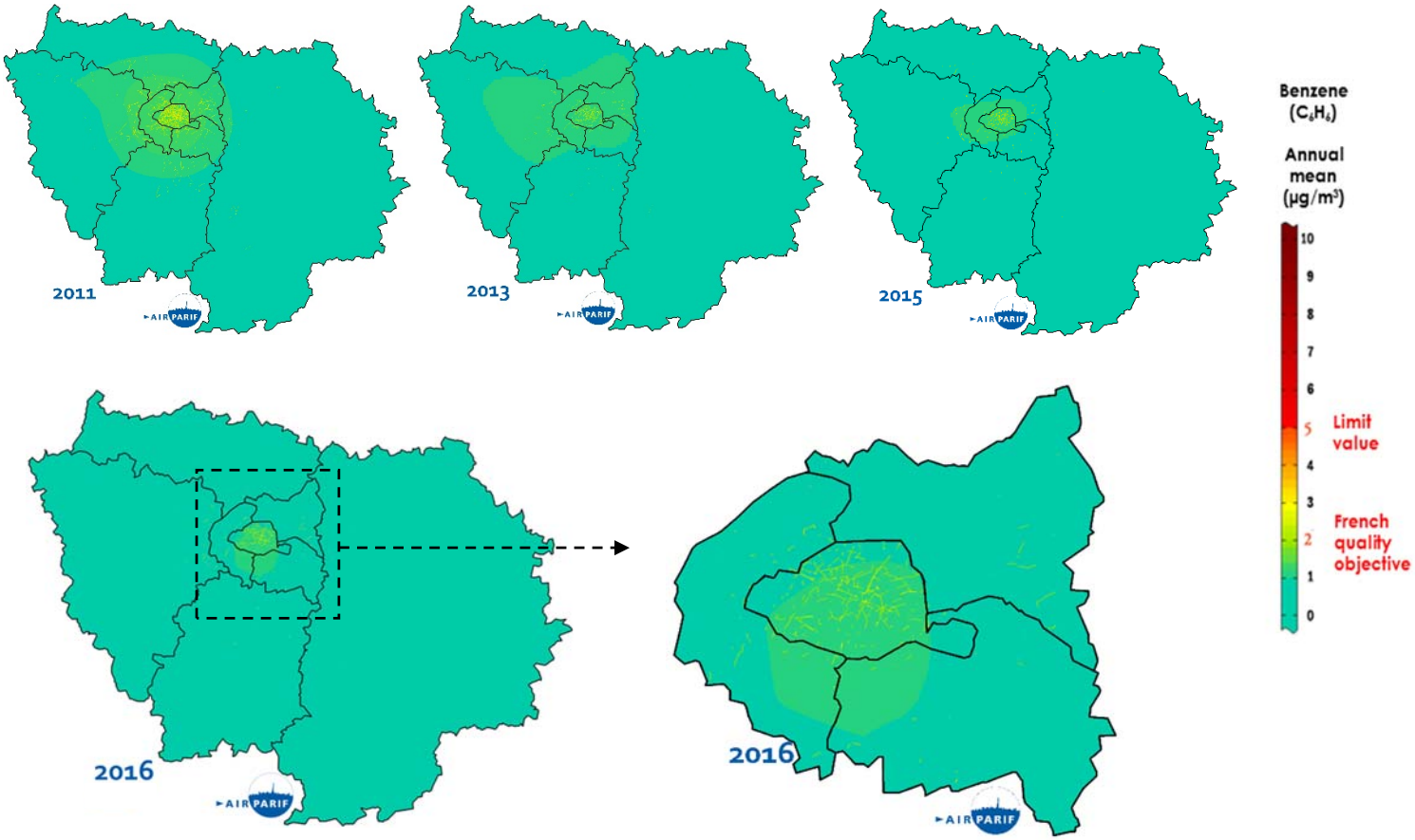


Figure 38 : annual mean concentration of benzene (C_6H_6) from 2011 to 2016 in the Paris region (background and roadside situations), with a focus on Paris and surrounding suburbs in 2016

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 show some stability during the last few years (Figure 39).

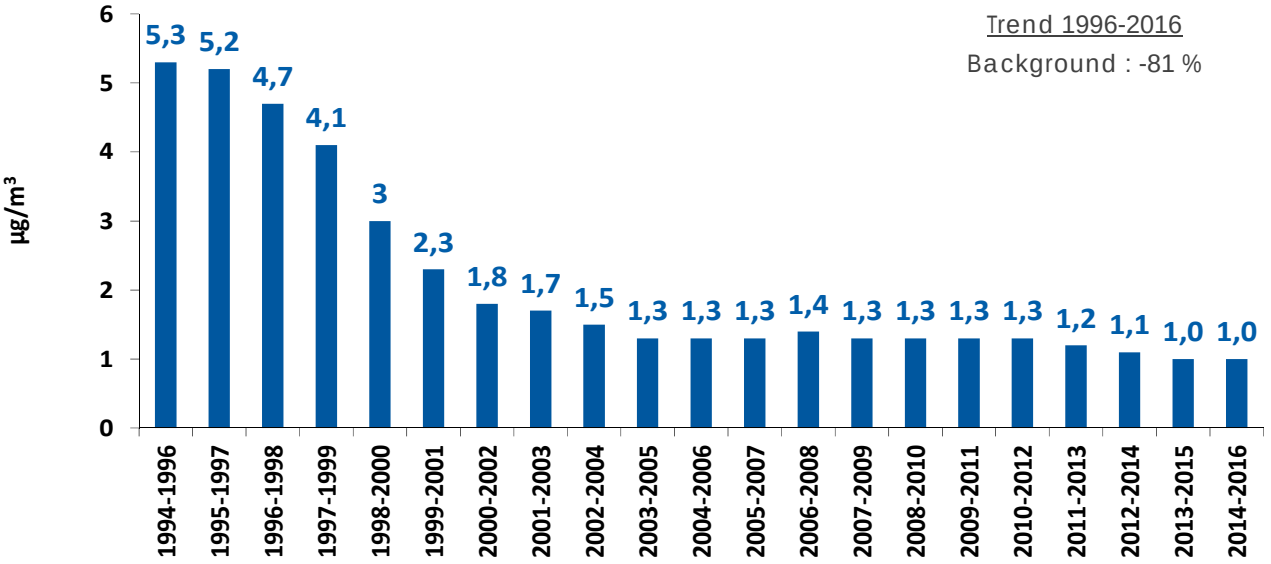


Figure 39 : trend in the benzene tri-annual mean concentration (based on a scalable sample of urban background sites) within the Paris agglomeration from 1994-1996 to 2014-2016

In roadside situation, the trend in benzene concentrations is consistent with those of other primary pollutants directly emitted from 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 40). Benzene average concentrations decreased by approximately threefold from 1994-1996 to 2000-2002. This decline has slowed down substantially since 2007 (-40 % between 2007 and 2016).

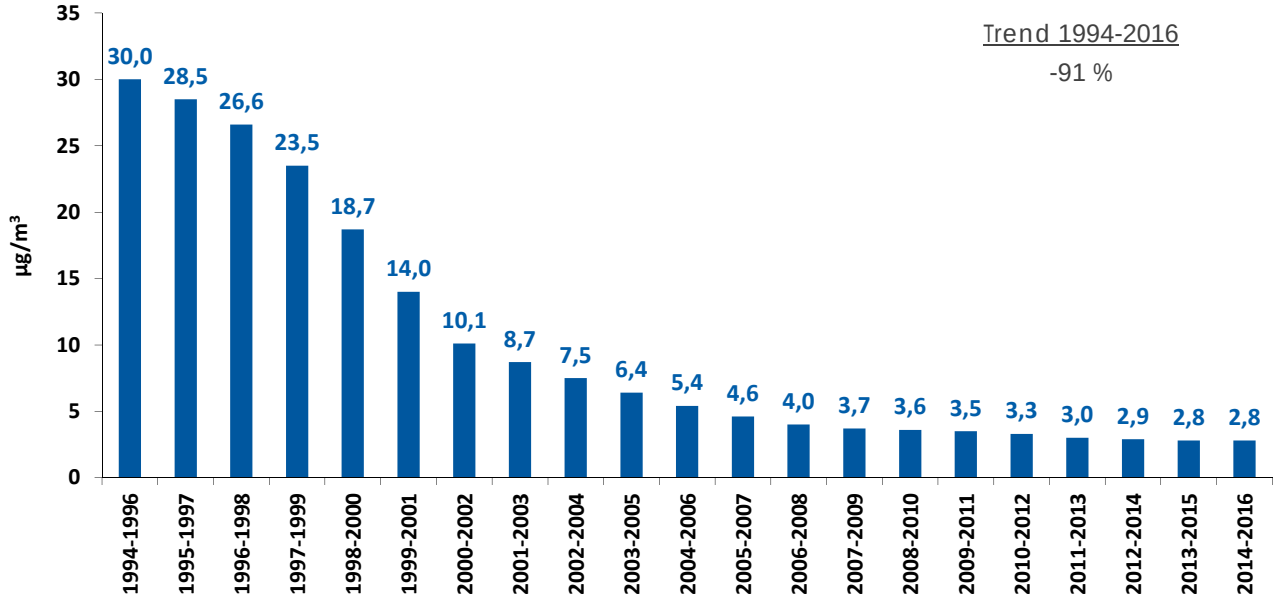


Figure 40 : trend in benzene annual mean concentration at the traffic monitoring station Place Victor Basch from 1994-1996 to 2014-2016

3. Pollutants meeting air quality standards

In brief:

Benzo(a)pyrene (BaP)

Benzo(a)pyrene (BaP)	2016			2005-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Target value exceedance		no measurement			no measurement	

Metals (Lead, Arsenic, Cadmium and Nickel)

Lead (Pb)	2016				2005-2015			
	Background agglomeration	Rural background	Roadside	Industrial situation	Background agglomeration	Rural background	Roadside	Industrial situation
Quality objective exceedance		no measurement				no measurement		measured since 2015
Limit value exceedance		no measurement				no measurement		measured since 2015

Arsenic (As) , Cadmium (Cd) , Nickel (Ni)	2016				2005-2015			
	Background agglomeration	Rural background	Roadside	Industrial situation	Background agglomeration	Rural background	Roadside	Industrial situation
Target value exceedance		no measurement	no measurement	*possible exceedance for As*		no measurement		measured since 2015

Carbon monoxide (CO)

Carbon monoxide (CO)	2016			2005-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Quality objective exceedance		no measurement			no measurement	
Limit value exceedance		no measurement			no measurement	

Sulfur dioxide (SO_2)

Sulfur dioxide (SO_2)	2016			2005-2015		
	Background agglomeration	Rural background	Roadside	Background agglomeration	Rural background	Roadside
Quality objective exceedance						
Hourly limit value exceedance						
Daily limit value exceedance						

exceedance intensity	
very important	> + 50 %
important	+ 30 à + 50 %
moderate	+ 10 à + 30 %
light	0 à + 10 %

no exceedance

Summary of air quality standards exceedances for B(a)P, metals (Pb, As, Cd, Ni), CO and SO_2 in the Paris region

3.1 Benzo(a)pyrene (BaP)

SITUATION OF 2016 RELATED TO AIR POLLUTION STANDARDS

The B(a)P EU target value (1 ng/m³) is widely met at the three urban background sites (Paris 13ème, Argenteuil, Gennevilliers) and at the roadside site BP Est (Figure 41). Differences in B(a)P levels are mainly observed in background situation. **Local emissions (related to wood burning fireplaces, open uncontrolled burning of wastes) are more significant in suburban residential areas (Gennevilliers, Argenteuil) than in Paris and its neighbouring cities.** In 2016, B(a)P levels are higher at the roadside BP Est station than at the agglomeration background sites (+30 % on average).

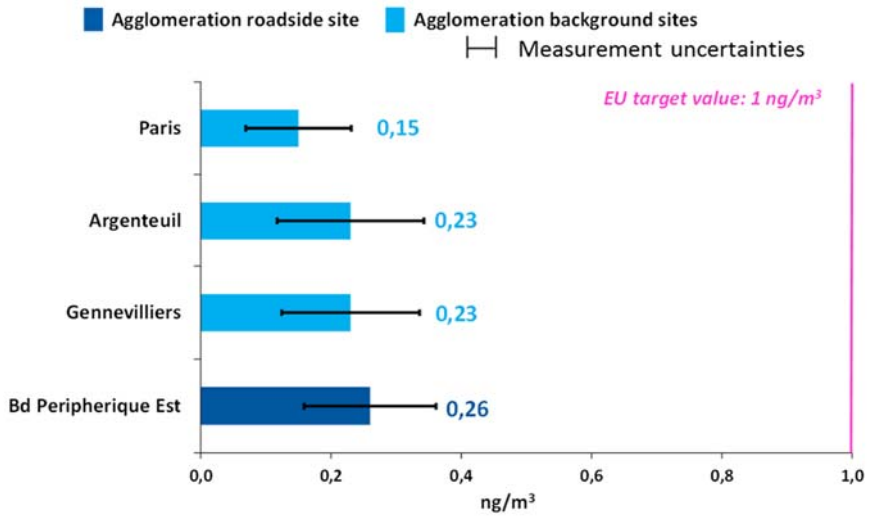


Figure 41 : benzo(a)pyrene annual mean concentrations for all monitoring sites in the Paris region in 2016

AVERAGE ANNUAL TREND

A significant decrease of B(a)P levels is observed near traffic roads (-83 %) between 1998 and 2016 (Figure 42). For several years now, it slowed down substantially. The B(a)P annual mean concentrations are, however, more stable in background situation. They are prone to fluctuations from one year to the next due to inter-annual meteorological variations.

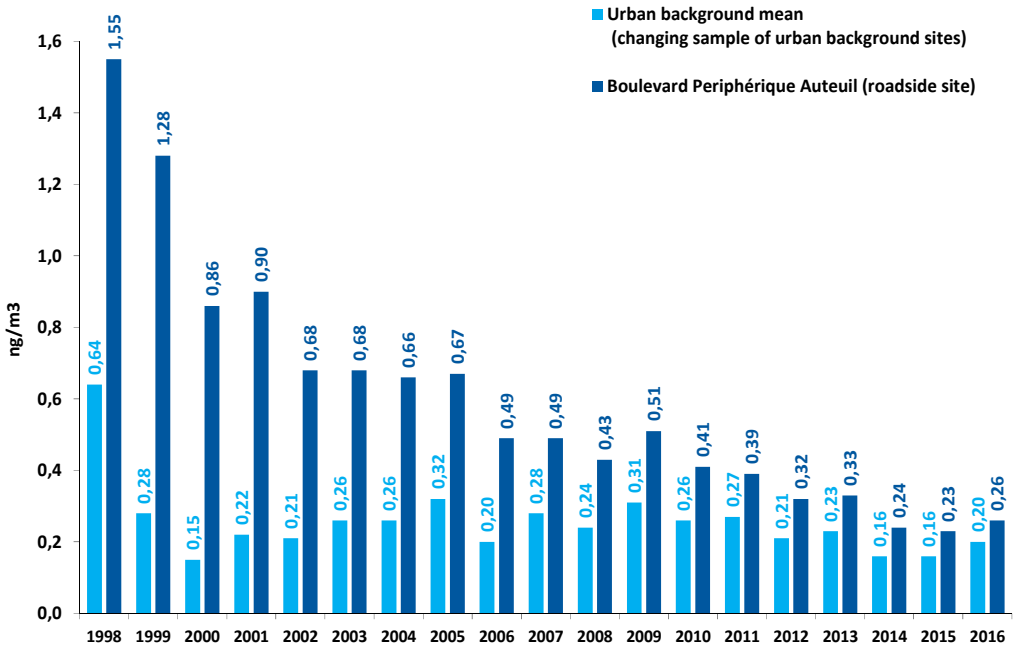


Figure 42 : trend in the benzo(a)pyrene annual mean concentration (based on the means of urban background sites and the Boulevard Périphérique site) in the Paris agglomeration from 1998 to 2016

3.2 Metals (Lead, Arsenic, Cadmium and Nickel)

SITUATION OF 2016 RELATED TO AIR POLLUTION STANDARDS AND LONG-TERM TRENDS

Lead (Pb) annual mean concentrations significantly decreased in 15 years (-91 % between 1991 and 2005), due to its gradual disappearance in fuels since 2000 (Figure 43). 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 every 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 2016 annual value being from 25 to 50 times below air quality standards).**

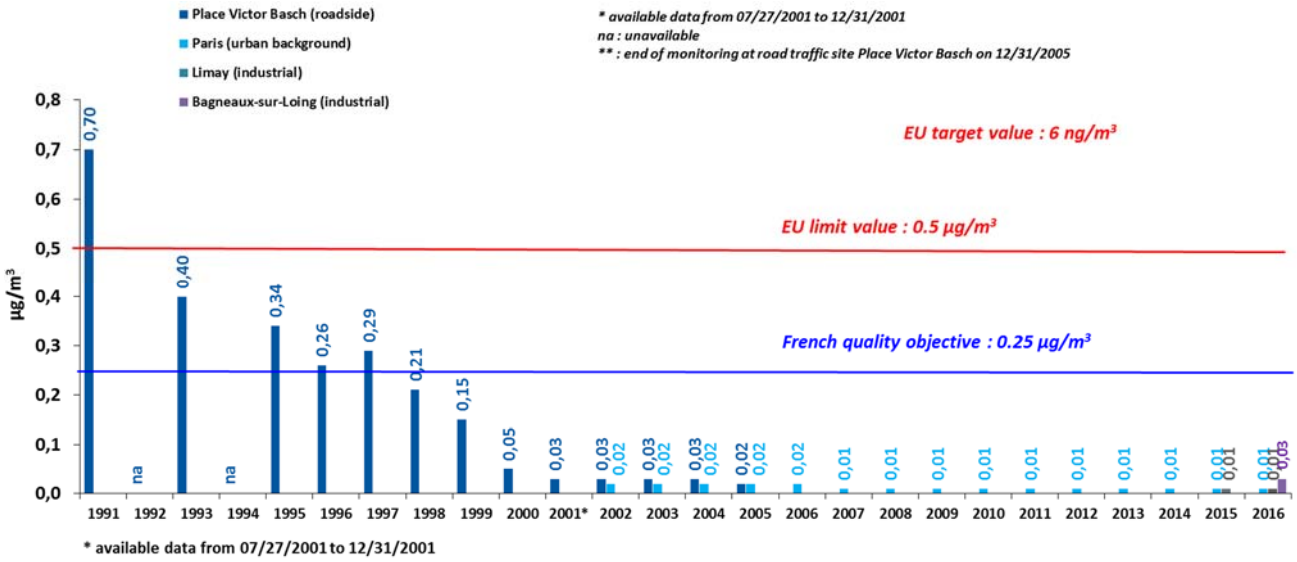


Figure 43 : trends in the lead (Pb) annual mean concentration at urban background, roadside and industrial sites within the Paris region from 1991 to 2016

After a significant decrease of **arsenic (As)** concentrations between 2007 and 2008, an increasing trend was observed from 2008 to 2011. It ended in 2012. In 2016, arsenic levels measured in background situation are similar to those in 2015 and 2014 (Figure 44). The Limay industrial station (located near a glass factory, an arsenic emitting installation) shows slightly higher levels but, however, lower than those in 2015. The Bagneaux-sur-Loing industrial site (operated by Airparif in December 2015) provides higher arsenic concentrations. Some arsenic data were invalidated following the acts of vandalism on the sampling head in the periods in which arsenic emissions may have occurred. As a consequence, it is not impossible to exclude an exceedance of the EU target value at this industrial station.

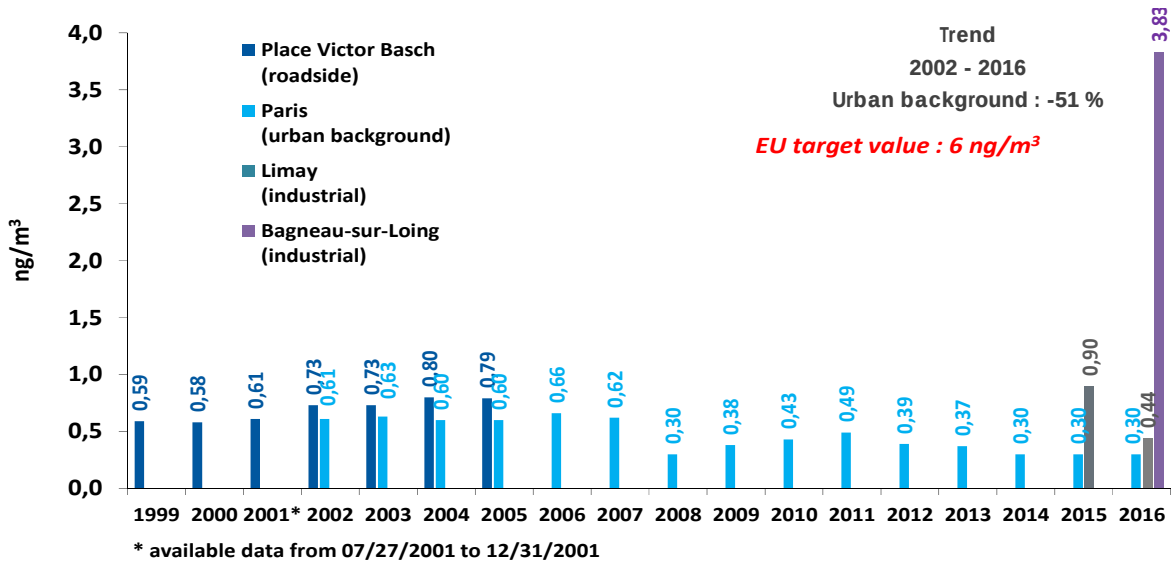


Figure 44 : trends in the arsenic (As) annual mean concentration at urban background, roadside and industrial sites within the Paris region from 1999 to 2016

For the **cadmium (Cd)**, a downward trend of annual mean levels was observed both in urban background and roadside situations between 1999 and 2005. Since 2008, there is no clear downward trend of cadmium concentrations. The annual average concentration measured in background situation in 2016 is similar to those in 2015 (Figure 45). **It is 50 times lower than the EU target value (5 ng/m³).** The Limay industrial site provides twice higher levels than in urban background situation. However, they remain low. The arsenic annuel mean level measured at the Bagneaux-sur-Loing site is comparable to those in background situation in 2016.

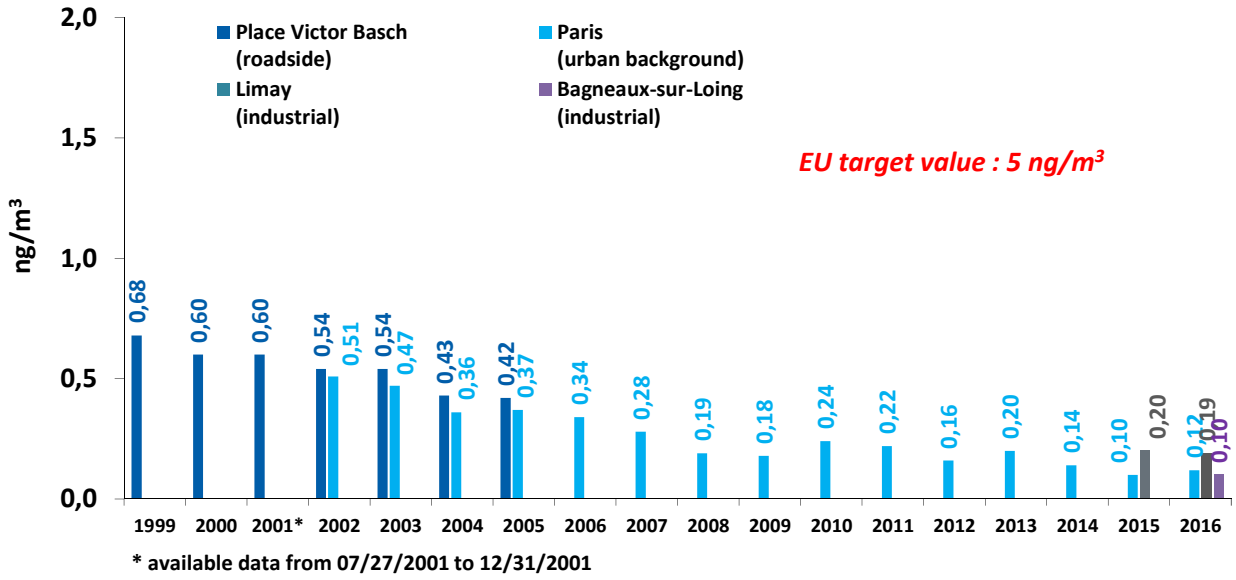


Figure 45 : trends in the cadmium annual mean concentration at urban background, roadside and industrial sites within the Paris region from 1999 to 2016

Nickel levels were measured since 2007 at the reference monitoring station Paris 1er les Halles until 2010. Due to renovation changes, nickel is measured now at the Paris 18ème station. Annual background mean concentrations are in the range from 0.9 to 2.6 ng/m³ (Figure 46). **These nickel levels are from 8 to 20 times lower than the EU target value** (20 ng/m³). Nickel background levels are one-half times lower than in 2015. Nickel levels measured at the Limay industrial station are three times lower than in 2015. They also are lower than arsenic urban background concentrations. The Bagneaux-sur-Loing industrial site provides a very low annual mean concentration, also lower than those measured in background situation.

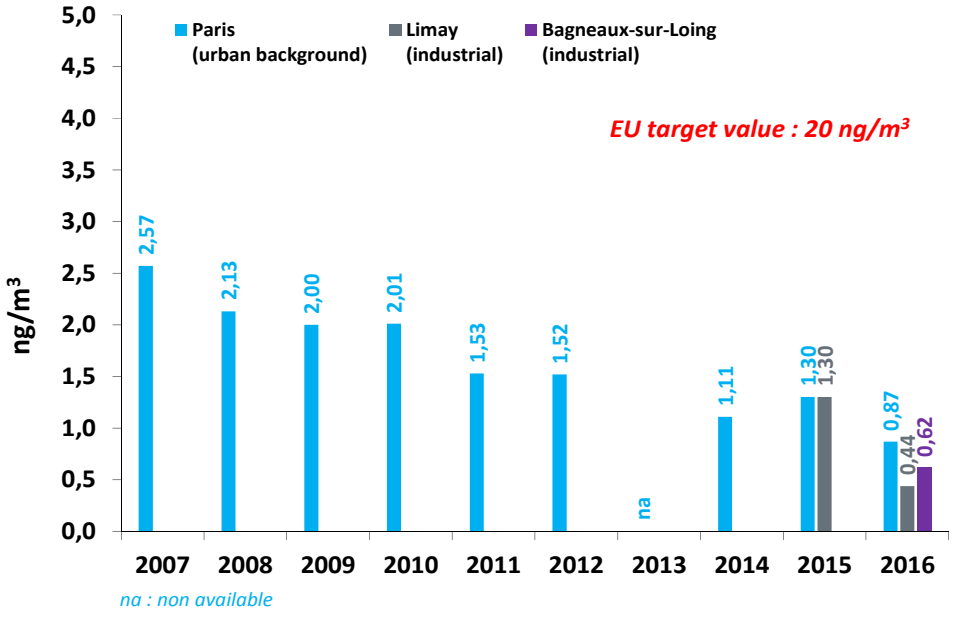


Figure 46 : trend in the nickel (Ni) annual mean concentration at urban background and industrial sites within the Paris region from 2007 to 2016

3.3 Carbon monoxide (CO)

SITUATION OF 2016 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** (max. in 2016 = 2 175 µg/m³) **and at roadside sites** (max. = 2 063 µg/m³) (Figure 47).

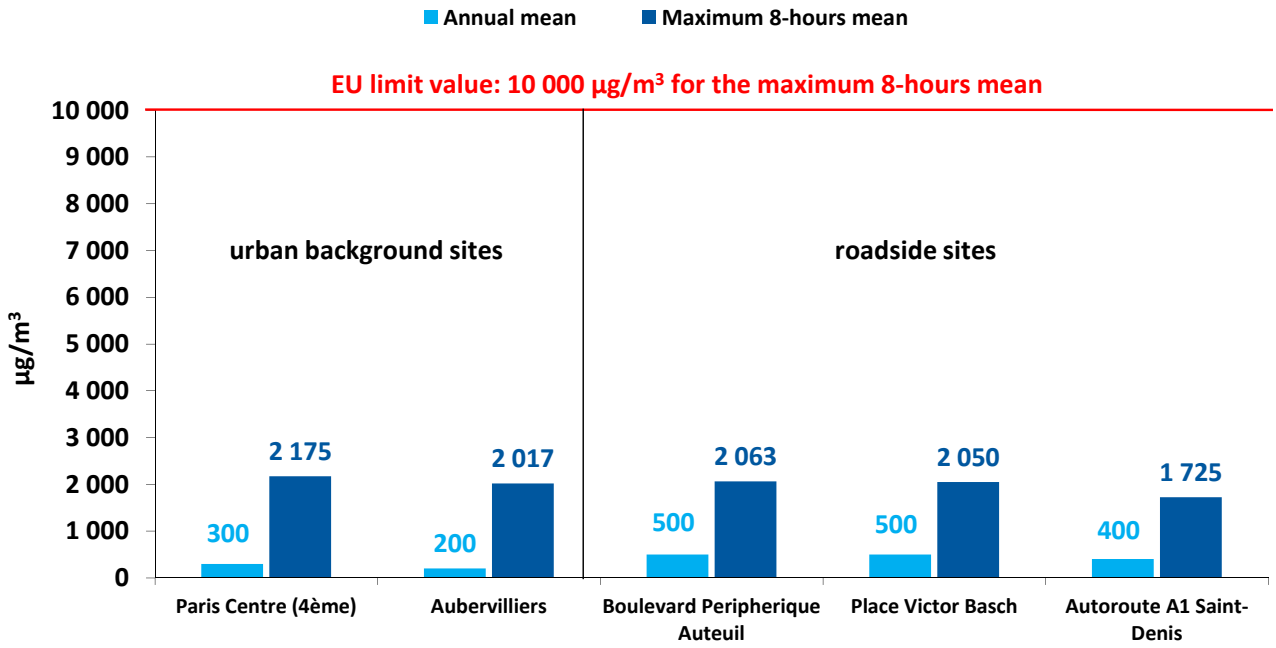


Figure 47 : carbon monoxide (CO) annual mean and annual maximum 8-hours mean concentrations for all continuous monitoring sites in the Paris region in 2016

AVERAGE ANNUAL TREND

CO annual maximum 8-hours mean concentrations have significantly decreased in 25 years (Figure 48). Maximum concentrations are 10 times lower than those at the beginning of the 1990's.

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

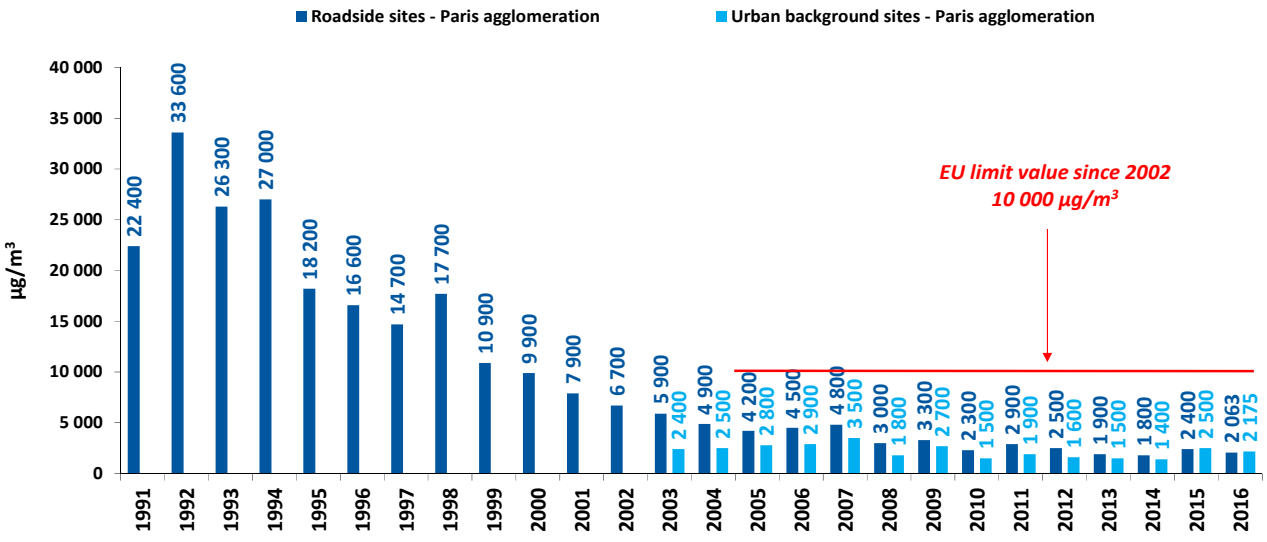


Figure 48 : trend in the carbon monoxide (CO) annual maximum 8-hours mean concentration at roadside and urban background sites within the Paris agglomeration from 1991 to 2016

3.4 Sulfur dioxide (SO_2)

SITUATION OF 2016 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 five monitoring stations and the roadside BP Porte d'Auteuil site since 2008. **For several years now, they are widely 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.

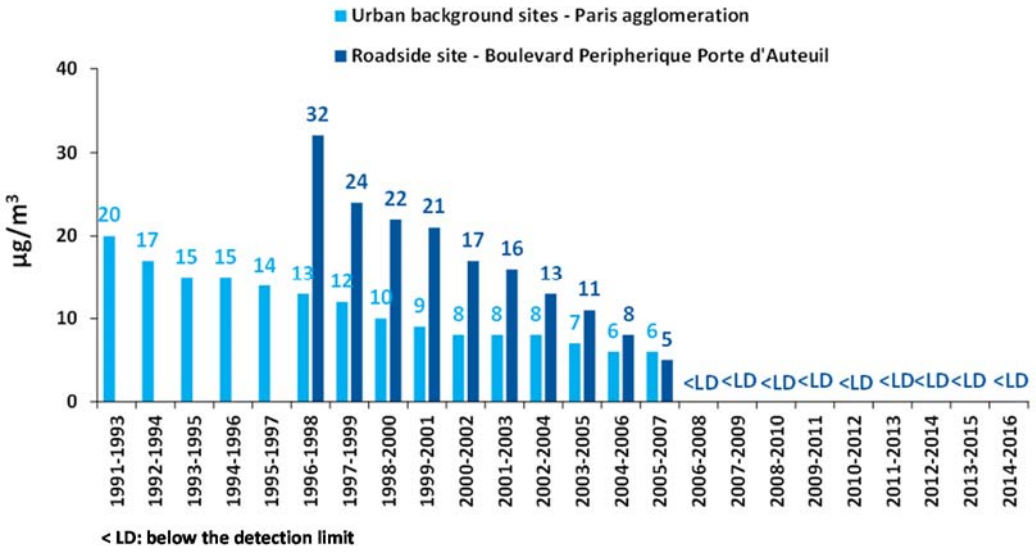


Figure 49 : trend in the sulfur dioxide (SO_2) tri-annual mean concentration (based on a scalable sample of urban background sites and one roadside station) within the Paris agglomeration from 1991-1993 to 2014-2016

AVERAGE ANNUAL TREND

A significant decrease of SO_2 levels was observed over the long-term (Figure 50). 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 40). 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 finding.

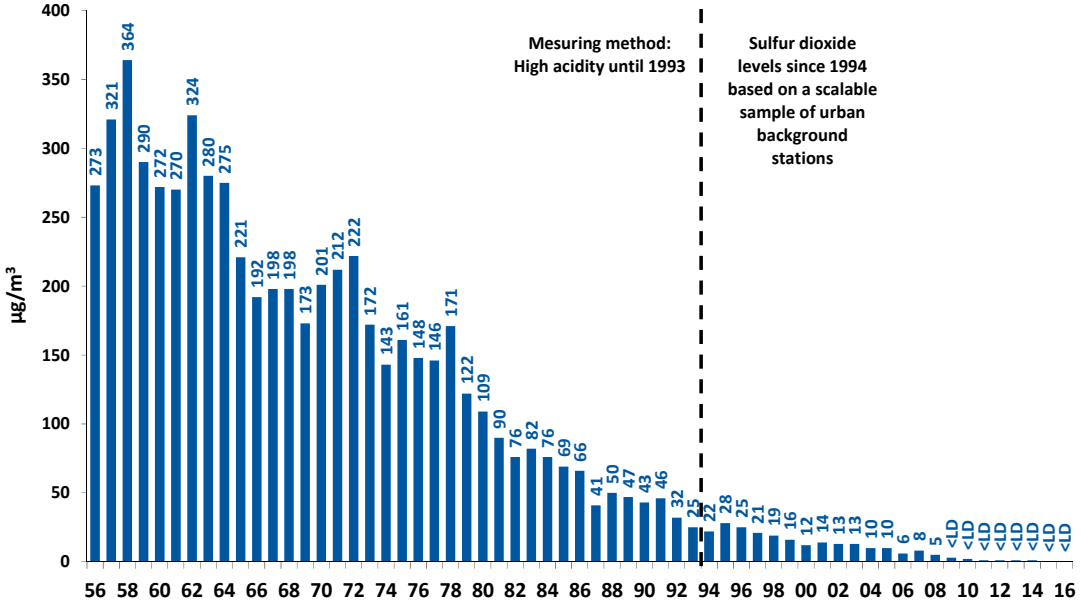


Figure 50 : trend in the sulfur dioxide (SO_2) winter mean concentrations in Paris since the end of 1950's

LIST OF FIGURES