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Interest of a Network of Air Monitoring Micro - Stations to Visualize Air Quality at a Regional Level and at Discrete Locations

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Abstract: ***Background**: Air quality in cities is an important health factor. Several studies have shown that poor outdoor air quality is related to a wide range of discomforts and health problems. Cities in France are used to measuring air quality through a small number of fixed air monitoring stations provided by reference local organizations such as ATMO and virtual modelling. An alternative is to densify the air sensor network, thus dispatching the air monitoring micro - stations in the territory to obtain a finer mesh and a better view of air quality at a regional or local level. **Methods**: A network of thirty - four air monitoring micro - stations was installed in Annecy agglomeration community in France. These air monitoring micro - stations were lightweight and mobile to be easily hung on poles or other city infrastructures. Air quality data was retrieved and compared in order to detect any event or phenomena that would affect air quality and that would not be detected by local fixed air monitoring ATMO stations, which are reference stations. The air micro - station network granted permission to install a fine mesh in the city, in relation to air quality. Data was compared between each air monitoring micro - station in order to highlight local phenomenon (when only a few numbers of air micro - stations detected it) or global phenomenon (when every air micro - station detected it). **Results & conclusions**: This study highlighted and brought an understanding of the impact of several events and habits of the air quality in the agglomeration community. For example, the impact of a local fire in the town hall or the impact of traffic near a school.***

Highlights

- A network of thirty - four air monitoring stations was installed in the agglomeration community of Annecy.
- The distribution of the air monitoring stations permitted to get a fine mesh for evaluation of air quality in the community agglomeration.
- Similar air data given by the air monitoring stations indicated macro - effects, i. e. general air quality trends territory - wide.
- Singular air data given by one or a group of air monitoring stations indicated micro - effects, i. e. punctual and/or local pollution phenomena.

Keywords: Outdoor Air Quality, pollution, air monitoring micro - stations, sensor network, real - time monitoring

1. Introduction

Outdoor air pollution is a major worldwide health challenge (Cohen et al., 2017; Da Silva Júnior et al., 2020). Several serious adverse human health effects have been reported, due to exposition to emissions from industry, transportation and domestic burning (Kim et al., 2015). The World Health Organization's health - based - air - quality guidelines (WHO 2021) are very often exceeded, despite the fact that several reports clearly demonstrate the causal link between outdoor air pollution and human health outcomes, such as allergies, cancers (Turner et al., 2019) and various other health issues (Sun et al, 2019). To alert people of and/or detect and/or possibly stop the pollution from the source, there is a huge interest for real time air pollution monitoring in cities. This certainly explains the fast development of smart cities concept (Siregar et al., 2019; Duangsuwan et al., 2018; Kaginalkar et al., 2021) and urban computing in air quality management (Haseb et al., 2021; Rodrigues et al., 2020), as well as the development of several low - cost air quality sensors used to generate potential networks of sensors (Kadri et al., 2013; Hu et al., 2016; Munir et al., 2019; Blaawn et al., 2022). These low - cost sensors are mainly located on fixed micro - stations, however some mobile stations can be found on city buses or other vehicles (Kaivonen et al., 2020; Rafael et al., 2020; Sun et al., 2022). Studies based on these low - cost sensors are mainly based on the design, energy management, laboratory validation, data base quality and management or visual interface. However, studies based on real application and correlations between outdoor air quality and meteorological variations, human behaviors or activities, are not largely reported. This paper focuses on the interest of a dense mesh of micro - station networks to detect pollution events in real time, at a regional level and at a very localized level. The complementary aspect in combination with reference stations will be discussed.

2. Materials and Methods

2.1 Air sensors

2.1.1 Description

A network of air monitoring micro - stations was installed in the agglomeration community of Annecy in France. The objective was to create a high - density mesh of the air quality micro - stations across the agglomeration community. The micro - stations each incorporated an air monitoring device containing nine sensors to monitor various parameters**:** carbon dioxide **(**CO_2**),** fine particle matter with aerodynamic diameter ≤**2.5** µm **(**PM2, 5**),** temperature**,** humidity**,** pressure**,** Volatil Organic Compounds **(**VOC**),** carbon monoxide **(**CO**),** nitrogen dioxide **(**NO_2**),** ozone **(**O_3**).**

They provided real - time analysis, 7days/24hrs, taking one measurement every minute.

Sensors in the device were calibrated according to certified calibration gas, to measure these parameters within a specific detectable range. This has been presented in the following table.

Table 1: Detectable range for sensors and ideal range of parameters

Sensor/parameter	Detectable range	Ideal range
CO_2	400 – 10000 ppm	< 1000 ppm
PM2, 5	0 – 200 µg/m^3	< 15 µg/m^3 (24h)
Temperature	- 40° – 85°C	19 – 24 °C
Humidity	0 – 100 %	40 – 60 %
Pressure	300 – 1100 hpa	-
VOC	0 –30000 ppb	*Case by case*
CO	0 – 1000 ppm	< 4 mg/m^3 (24h)
NO_2	0 – 1000 ppb	< 25 µg/m^3 (24h)
O_3	0 – 1000 ppb	< 100 µg/m^3 (8h)

The ideal range corresponds to the limit values recommended by World Health Organization (WHO) (WHO, 2021) for PM2, 5, CO, NO_2 andO_3. For CO_2, temperature and humidity, it is solely a recommended guide and not absolute.

The air monitoring micro - stations were designed to be light, mobile and easily manipulated in order to be placed on urban infrastructures such as street lamps, power grid poles, etc.

They were built with a hollow structure designed to receive the air monitoring device, a 3G key that allow the stations to send the data and a fan to distribute incoming air to the air monitoring device. They were also fitted with several air vents and a wide, hat - like cover to protect from rain.

2.1.2 Settings

The calibration of sensors in a laboratory with certified reference gas is mandatory to validate sensors before use. However, this step does not take into account the outdoor environmental variations such as temperature, humidity or wind variation. In addition, the variation of target parameters in real outdoor conditions are clearly not in a linear progression of concentration like in laboratory conditions. ATMO is a non - profit organization in charge of following air quality of French cities. As a result, ATMO stations are calibrated following very strict and regular processes according to the European community rules and methods. This means that the results coming from ATMO stations could be used as safe reference. In order to check the dynamic of sensor responses with respect to fast variations, we decided to place micro - stations on the roof of ATMO stations in order to compare results in real time and in real outdoor conditions. Each of the 36 micro - stations were checked and compared with the ATMO stations for a minimum of two weeks. We observed a very good correlation between the results from the different micro - stations and ATMO, as recorded in the figures 1a and 1b. It is interesting to note that micro - stations give the same periodical variation according to the night and day evolution, obtained only in periods without significant wind (between 11 and 18 September 2019). With the presence of a strong wind (between 03 and 10 September 2019) the local concentration for both O3 and NO2 are diluted by the windy conditions.

This step was essential for us to safely compare future results between the different micro - stations and to be sure that any differences between these micro - stations are really coming from local air quality variations and not from potential electronic or sensitivity differences between micro - stations in outdoor conditions.

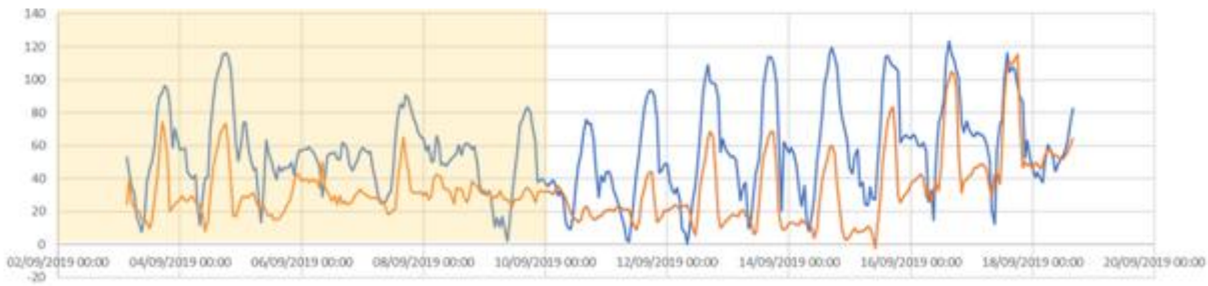

Figure 1 (a): NO_2 level measured by an air monitoring station situated near a road material storage area (based on daily averages). In yellow, the windy period.

Figure 1 (b): O_3 level measured by an air monitoring station situated near a road material storage area (based on daily averages). In yellow, the windy period.

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2.1.3 Positioning

Thirty - four air monitoring micro - stations were thus installed within different communes of the agglomeration community of Annecy, as shown on the following map.

This community agglomeration of thirty - four communes is organized around a lake. Most of the stations were installed on the north of the lake in Annecy. the other stations were distributed around the lake, in more distant communes with a specific interest.

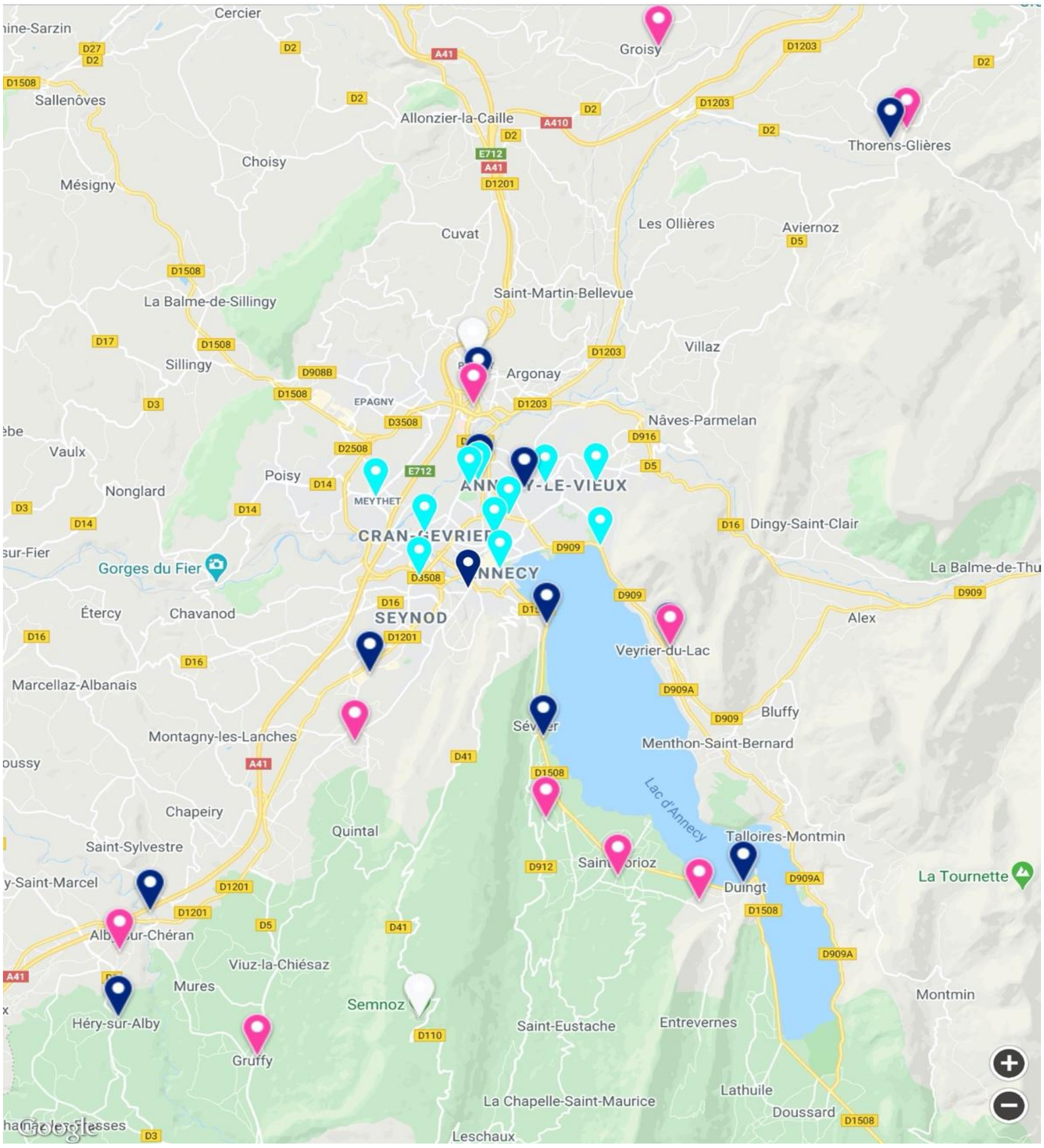

Figure 2: Map of the distribution of the air monitoring micro - stations across the community agglomeration.

The following maps show the distribution of the air monitoring stations in Annecy downtown (figure 3), and the distribution of the three reference ATMO fixed air monitoring stations (figure 4).

Figure 3: Map of the distribution of the air monitoring micro - stations within Annecy downtown.

Figure 4: Map of the three fixed ATMO reference stations (source: ATMO Auvergne Rhone Alpes)

The distribution of the air monitoring stations provided a fine mesh for the air quality monitoring in the agglomeration community and highlighted general air quality trends and local and/or specific/ accurate results in relation with some pollution events. This mesh, in particular in Annecy downtown, was complementary to the three fixed ATMO stations already installed

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Air monitoring micro - stations were left in operation for several months, from 2019 to 2021, allowing for a large sample of data to be recovered

Figure 5 shows the topography of Annecy community agglomeration. This map is important to study, to be able to understand the innate territorial conditions that have a huge impact on air quality in the area.

Several high mountains can be observed on the east side of the lake: they form a barrier to the air mass and consequently to the pollution. Lower mountains are located on the west side of the lake: they also represent a brake on the dissipation of the pollutants.

A busy highway is located on the west, on the other side of the west mountains: this configuration results in a high concentration of pollutants on either side of the road. The pollution that descends on Annecy can not escape to the east nor to the south because of the mountains. If there is no wind, pollution is blocked above/ in Annecy downtown.

The pollution can only exit via the small corridor created by the lake and only if there is a northernly wind, moving towards the south.

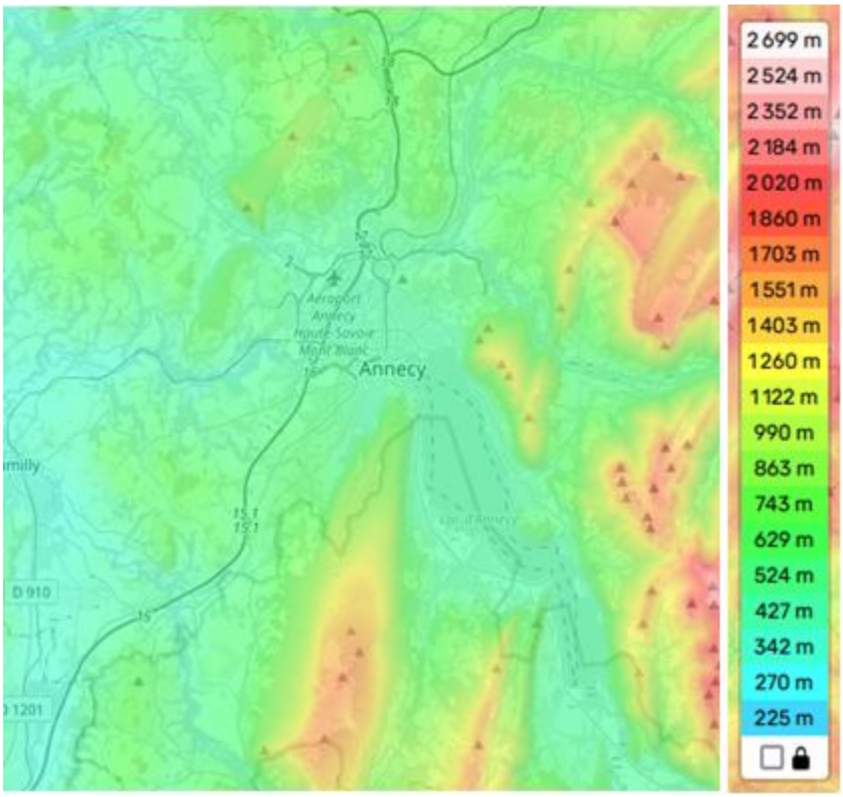


Figure 5: Topography of the community agglomeration (source: topographic - map. com).

The prevailing winds are another parameter to consider when studying the behaviour of pollution. The following figure 6 shows the prevailing winds in the region: they are mostly oriented from north to south, or on the contrary, from south to north in this area because of the presence of mountains framing a north - south facing plane.

When there is wind, the pollution above/ in Annecy can escape along the mountains and towards the lake.

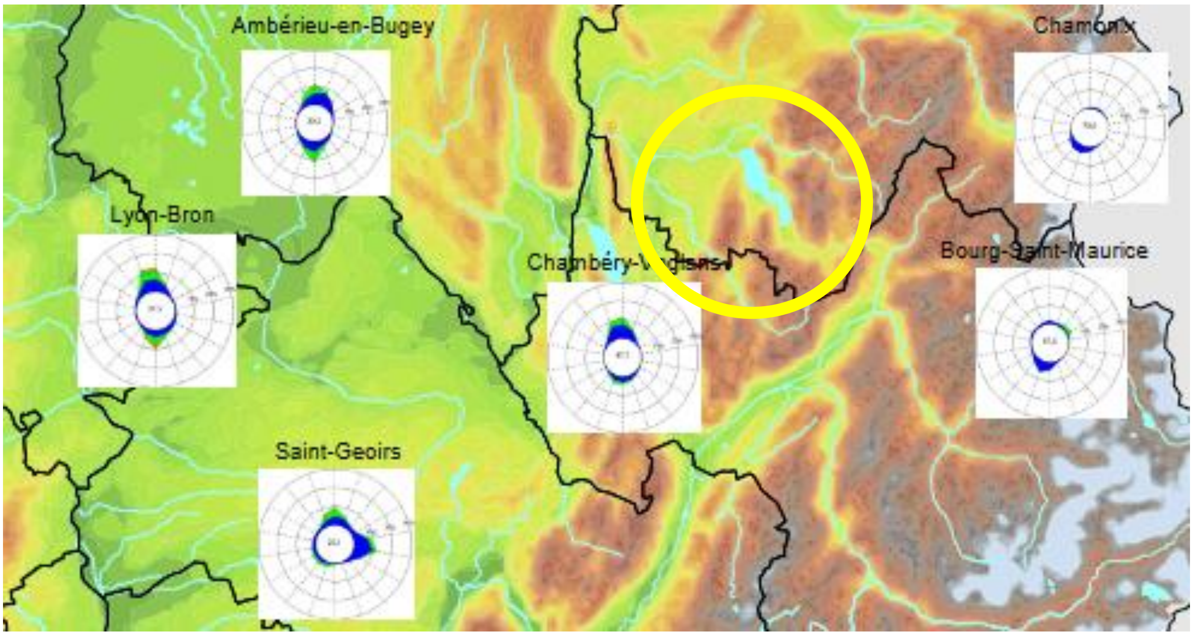


Figure 6: Map of prevailing winds in the region (source: DREAL Auvergne Rhone Alpes): the yellow circle indicates the location of the agglomeration community.

2.2 Traffic sensors

In addition to the already installed air monitoring micro - stations, several traffic sensors in the form of pneumatic tubes were used in order to correlate air quality and traffic data.

More specifically, they were used within the context of one of the specific studies concerning the opening of a bypass in a small commune. Air quality and traffic were simultaneously studied in order to reveal any correlations and to gather more data about bypass efficacy.

They were installed across several strategic roads of the commune, where air quality micro - stations were also installed.
Their purpose was to calculate the quantity and type of vehicles using the roads. The traffic sensors were able to detect light vehicles (cars), small trucks (double axle), and two - wheeled vehicles.

3. Results and Discussion

Comparing the results of the different micro - stations made it possible to highlight both macro - effects indicated by similar air data in several air monitoring stations and micro - effects indicated by differing air data between air monitoring micro - stations.

3.1 Macro - effects

When the whole fleet of micro - stations - or several close air monitoring stations – indicate same air quality data, it means that a pollution event affected the entire area: a macro - effect.

For example, almost all air monitoring stations detected a cloud of sand from the Sahara, called Sirocco, resulting in an orange sky that covered France at the end of February 2021 and made the fine particle (PM) amount rise enormously during several days.

The following figure 7 shows several curves of the particle (PM) levels measured by several air monitoring micro - stations situated remote from each other: a huge peak of PM is actually detected around the 23rd of February 2021 by every air monitoring station, reaching a maximum of 70µg/m^3.

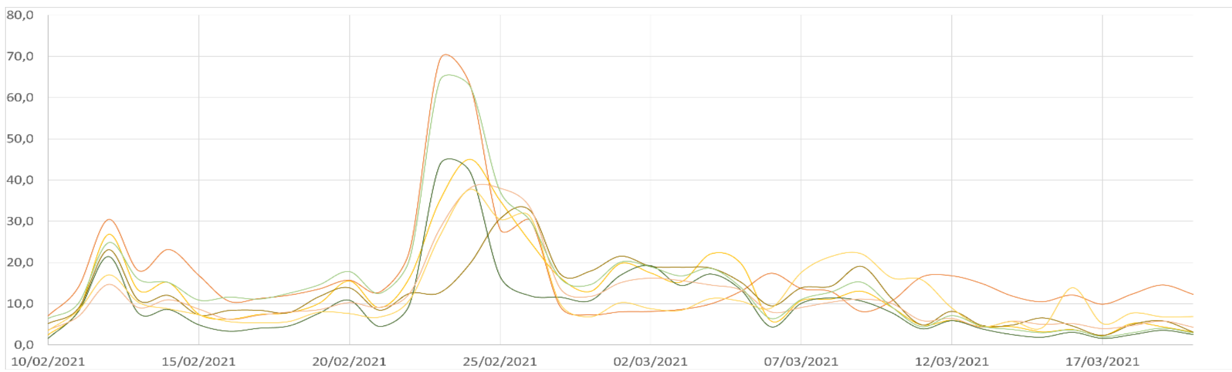


Figure 7: Several remote air monitoring micro - stations measuring the same peak of PM at the end of February 2021 (based on daily averages)

These results can be confirmed by the PM levels measured by reference ATMO air monitoring stations, that rose to 80µg/m^3 around the same date, as shown below on the graphic.

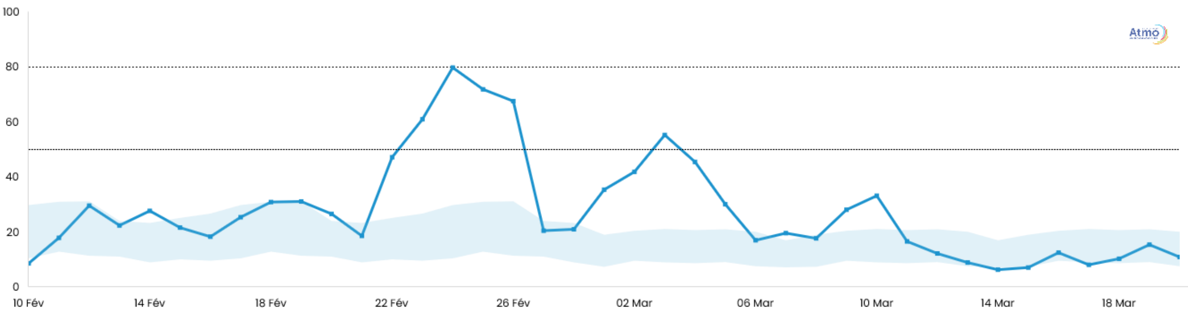


Figure 8: Reference ATMO air monitoring station measuring a peak of PM at the end of February 2021 (based on daily averages).

3.2 Micro - effects

When close air monitoring micro - stations indicate differing air data – for example if just one micro - station shows different readings - it demonstrates a big rise in particles or ozone, meaning that a pollution event only affected a specific area located around a reduced number of air monitoring stations. It is then a local and specific/ accurate? phenomenon.

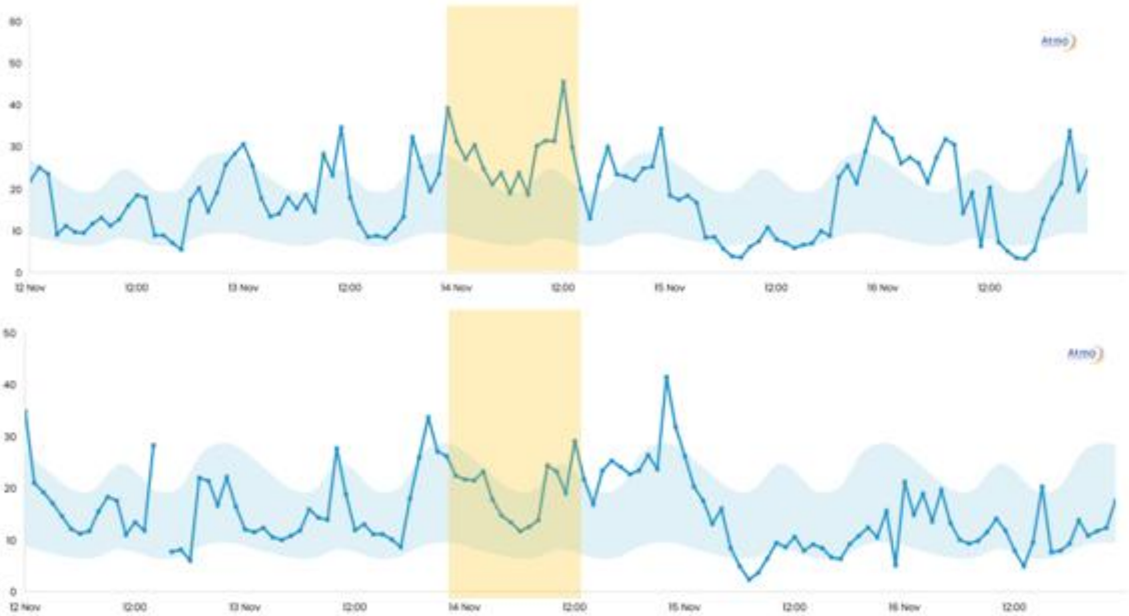
A plurality of examples of micro - effects that have been identified in the study thanks to the air monitoring micro - stations network, are described in the following cases.

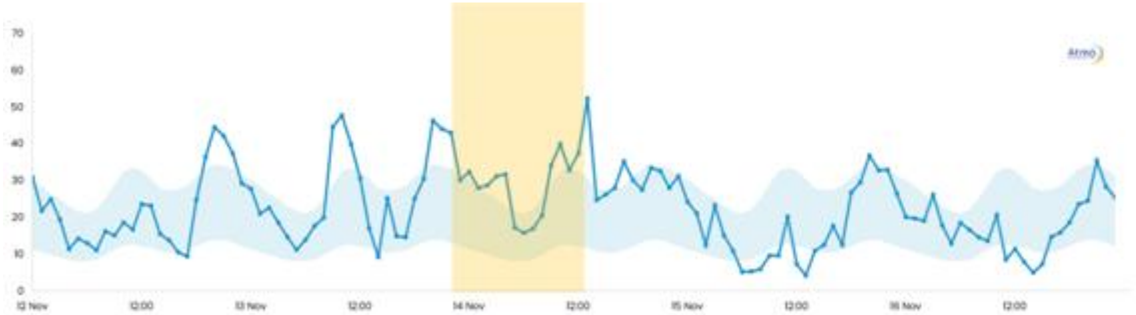
3.2.1 Case 1: Fire impact on air quality

An initial example of the usefulness of the air monitoring micro - stations network, concerns a fire case in Annecy downtown: the fire broke out in the town hall of Annecy, on the 14th of November 2019, midday and was detected by the air monitoring stations network but not those of ATMO.

The following figures 9a - c show the levels of PM measured by the three ATMO stations between the 12th of November and the 16th of November. It can be seen no specific impact of the fire on the air quality on the 14th of November at midday (yellow mark): the fixed reference stations were not able to detect the fire case.

Please note that fine particle (PM) is one of the most representative parameters to characterize fires because of the ash and debris that disperses in the air.





Figures 9 (a – c): PM levels measured by the three reference ATMO air monitoring stations in the time window in which the fire occurred (based on daily averages).

The seven following graphs present the levels of particles in several remote locations in the community agglomeration.

Figures 10a - c show the results for the air monitoring micro - stations (n°1 to n°3) closest to the town hall, as indicated with arrows on the map on the right - hand side.

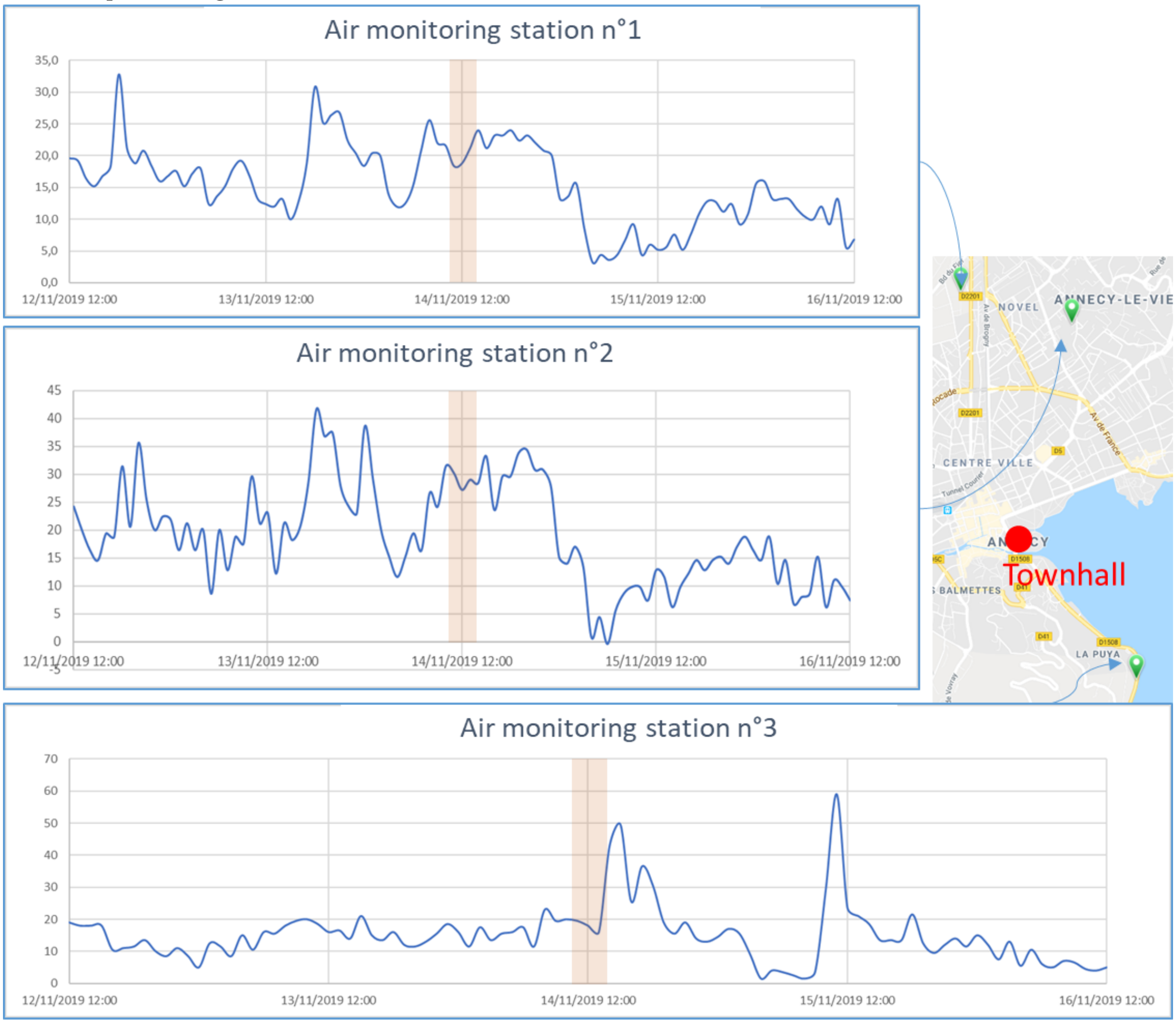


Figure 10(a – c): Particle levels measured by three air monitoring micro - stations close to Annecy town hall in November 2019 (based on daily averages).

The orange marker shows the start of the fire at midday.

Air monitoring stations n°1 and n°2 report no noticeable effect of the fire on the particle rate. However, on the graph of air monitoring station n°3, a clear rise in particle (PM) levels can be observed shortly after the fire started.

The explanation lies in the direction of the wind: air monitoring micro - stations n°1 and n°2 that are located north of the town hall, as are the three referenceATMO air monitoring stations, did not detect the particle flow because the wind was blowing from the northwest at this moment and subsequently transported particles towards the southeast.

The air monitoring station n°3, however, was the closest station, located southeast of the town hall.

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Figures 11d - g show the results for several air monitoring stations (n°4 to n°7) distributed along the lake and far from the town hall, as shown on the map to the right of the figures.

Here the effect of the fire can be clearly noticed, as big rises in fine particles (PM) occur shortly after the fire started, except for air monitoring station n°6. The most impacted air monitoring station appears to be n°7: particle levels rise to 90µg/m^3.

When studying more precisely the direction of the wind, it appears that the wind came from the west between 12h and 13h and between 15h and 18h, and from the north from 13h to 15h. Particles, smoke and ashes were then carried away from the town hall and towards air monitoring station n°7 which is the most distant station in the southeast direction. Air monitoring station n°6, however, was not in the path of the wind.

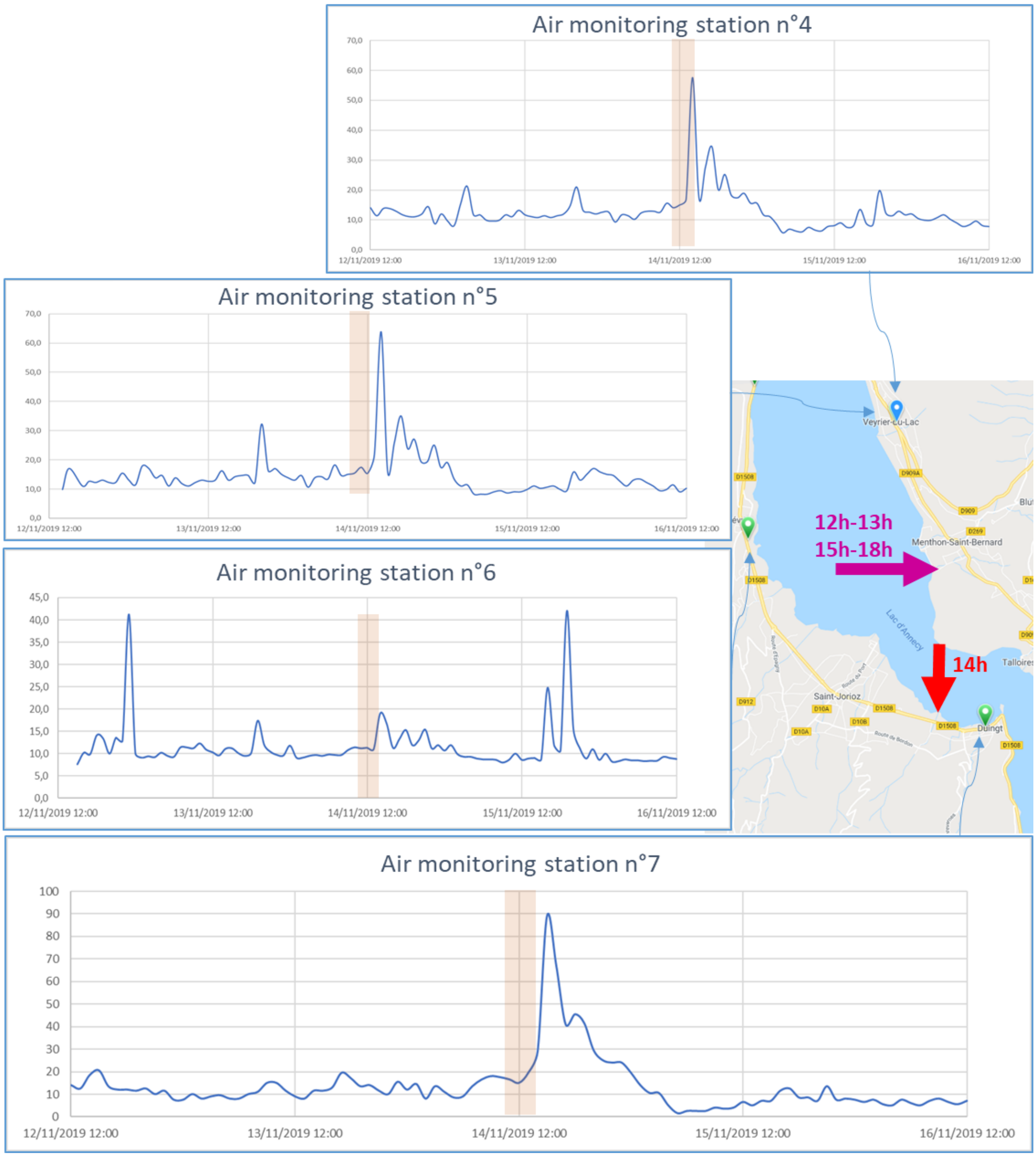

Figure 11(d – g): Particle levels measured by four air monitoring micro - stations distributed along the lake and a distance from Annecy town hall in November 2019 (based on daily averages).

Each of the seven graphs show that the particle level decreased on the following day, probably because of a strong depression and rain as confirmed by the weather stations online. This is presented in a screenshot in figure 12. It can be observed (yellow mark) that during the following day after the fire, pressure dropped (orange line) and several rain episodes were registered (blue lines). Rain brings fine particles (PM) to the ground, where they get "stuck": then, air monitoring micro - stations can only detect a low level of particles in the air.

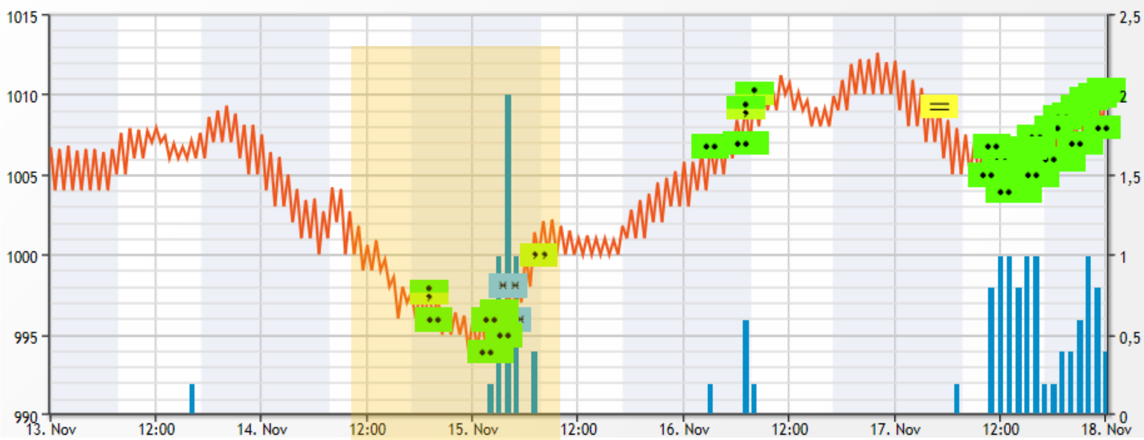

Figure 12: Weather, pressure and rain from 13 - 11 - 2019 to 18 - 11 - 2019 (source: infoclimat. fr)

3.2.2 Case 2: Bypass opening impact on air quality

A second example of the usefulness of air monitoring station networks, concerns a bypass opening case. As introduced earlier in part 2.2, a bypass was opened in May 2019 to get around one of the communes and relieve traffic congestion in the town center.

The objective was to study the impact of the bypass opening on the traffic transfer at the town center and on the air quality in the town at the exit of the bypass, which was intended to be a future residential area.

The following figures 13a - b show as an example, the particle (PM), ozone (O_3) and nitrogen dioxide (NO_2) levels, before and especially after opening the bypass. The results are recorded over two months by the air monitoring station placed in the town center.

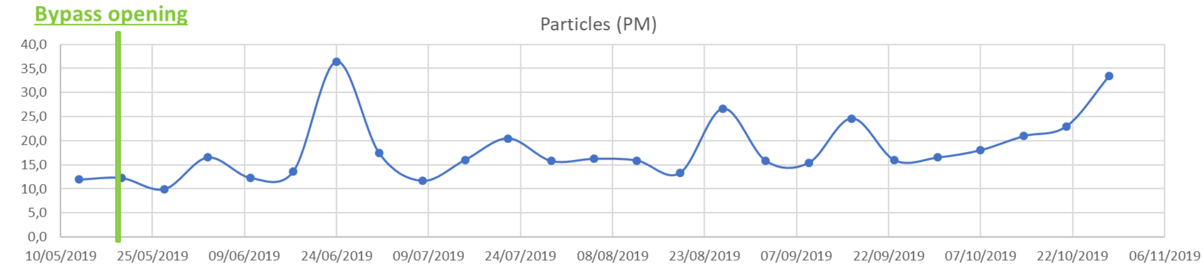

Figure 13 (a): PM level measured by the town center air monitoring micro - station before and after the bypass opening (based on weekly averages).

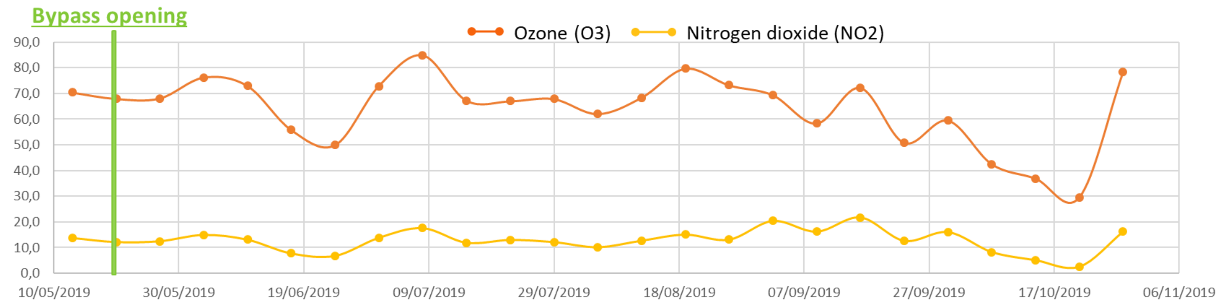

Figure 13 (b): O_3 and NO_2 levels measured by the town center air monitoring micro - station before and after the bypass opening (based on weekly averages).

Graphs show that there is no significant decrease in PM, O_3 and NO_2 values, as expected, in the town center after the opening of the bypass.

An important increase in fine particles (PM) can been seen around the end of June 2019, along with a decrease in O_3 and NO_2. It looks as though the increase is due to the combination of really dry, hot weather and the presence of street work nearby the air monitoring station. Strong winds would stir dust – i. e. particles – in the air and disperse gases such as O_3 and NO_2.

The study of the traffic data, provided by the traffic sensors installed on different strategic roads, highlight a supplementary reason to explain why there were no changes in air quality in the city center after the opening of the bypass.

Even if a slight decrease of global traffic could be noted near the town center (around - 2000 vehicles), the truck traffic kept relatively constant. The reason for this is that trucks kept taking this road to go towards the industrial area. Trucks are more pollutant than regular cars.

The following figure 14 illustrates the evolution of global traffic (in blue) and truck traffic (in orange) after the opening of the bypass.

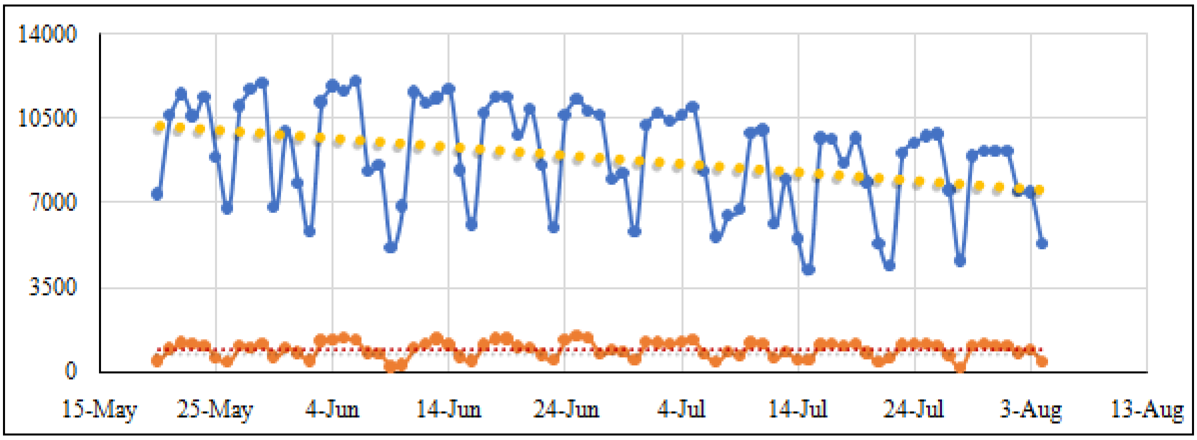

Figure 14: Evolution of the traffic in the town center between the 20th of May 2019 and the 8th of August 2019 (based on daily averages).

Similarly, a slight increase in traffic on the bypass could be noticed (around +9000 vehicles). As in the previous case, truck traffic kept globally constant and low as the trucks do not often use the bypass.

The number of vehicles taking the bypass is much more important than the number of vehicles that do not take the city center road: there may be a transfer between the highway and the bypass.

The following figure 15 shows the evolution of the traffic on the bypass, after opening of the bypass.

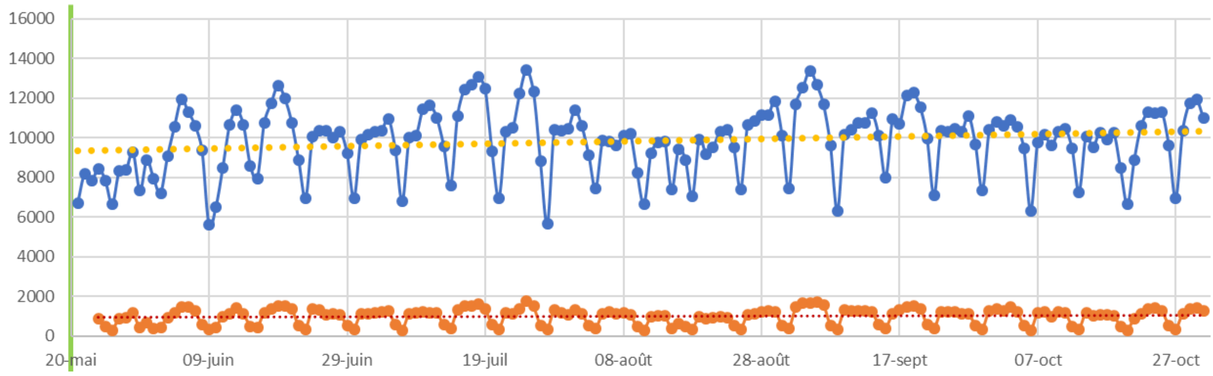

Figure 15: Evolution of the traffic at bypass exit between the 20th of May 2019 and the 27th of October 2019 (based on daily averages)

The following figures 16a - b show an example of the particle (PM) and ozone (O_3) andnitrogen dioxide (NO_2) levels over six months, after opening the bypass, registered by the air monitoring station placed at the bypass exit.

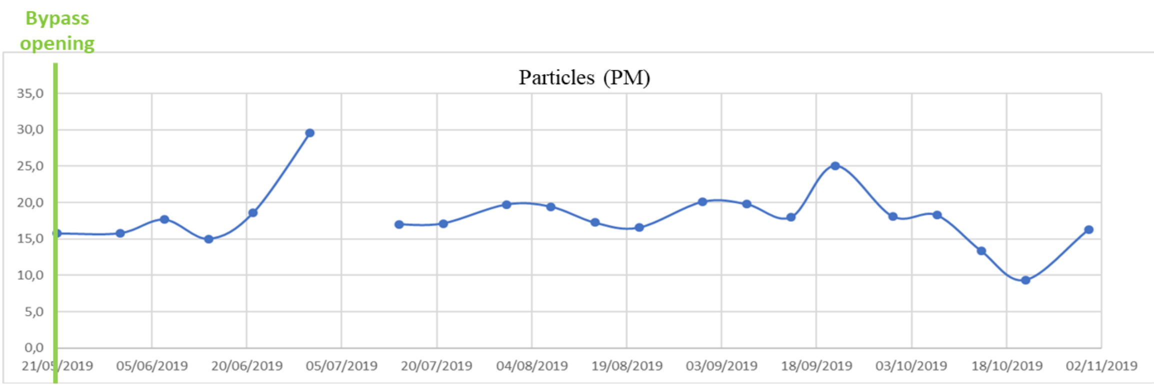

Figure 16a: PM level measured by the bypass exit air monitoring micro - station after the bypass opening (based on weekly averages).

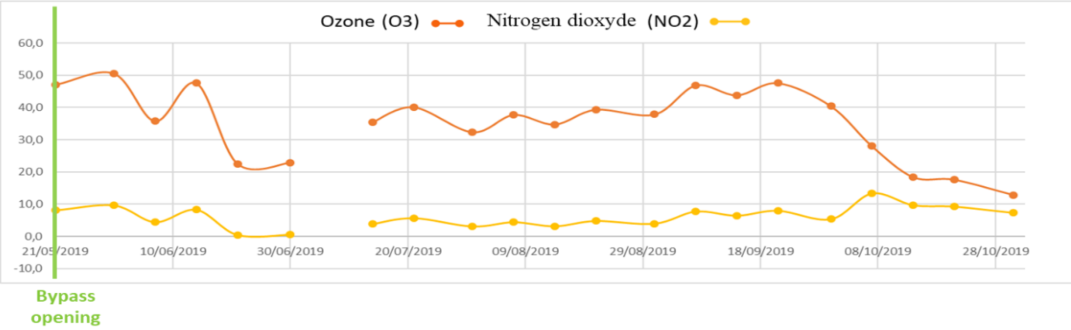

Figure 16b: O_3 and NO_2 levels measured by the bypass exit air monitoring micro - station after the bypass opening (based on weekly averages).

By observing these graphs, it can be noted that there is no air quality degradation around the bypass despite the high number of vehicles that take the new road. Alternativley phrased, the level of fine particles (PM), ozone (O_3) and nitrogen dioxide (NO_2) are similar to the levels in the town center.

The explanation may lie in the fact that the bypass area is an extremely windy area and it prevents the pollution from settling there.

At the end of the month of June, a peak of particles (PM) was detected, just like in the other air monitoring stations: it is thus a pollution event that affected the entire territory, independent of the pollution generated by the bypass use.

Therefore, this study made it possible to conclude that, on the basis of these results, the opening of the bypass seemed to have no impact on the air quality in the area, especially in terms of particle (PM), ozone (O_3) andnitrogen dioxide (NO_2).

Several particle pollution episodes have been registered around the three monitoring areas (town center, exit of the bypass, town hall area), especially around the end of June. It seems to correspond to high dryness periods (high temperatures, low humidity, high atmospheric pressure) and to the presence of dust on roads.

This study allows us to see that the area around the bypass, meant to be converted into a residential area, seems to be well exposed to wind and is consequently not subjected to high pollutant concentrations, even with the significant amount of traffic on the bypass.

3.2.3 Case 3: Traffic impact on air quality close to a school

The relation between traffic data and air quality was studied. To do this, online traffic data was extracted and compared with the air quality data obtained by the air monitoring micro - stations.

Attention has been paid to traffic variations, such as during holiday periods and abnormal traffic increase.

3.2.3.1 Case 3: Holidays

For this specific case, the air quality around a school in the agglomeration community was studied. Air quality data retrieved during the school period was compared with air quality data retrieved during the holidays. The idea was to assess if the higher concentration of cars near the school during the school period, could impact the air quality and the children’s health.

Indeed, during the school period, parents are used to dropping off and picking up their children two to four times a day, in the morning, at midday and in the evening. Because of this, many cars circulate and ‘minute - park’ around the school at these times.

An example is shown on the following figures, showing the CO_2 levels around the school (figure 17a), in a residential area (figure 17b) near the school and in a quiet area with little traffic, near a cemetery, away from the school (figure 17c). The yellow section shows the holiday periods.

CO_2 parameter is studied because it is relevant in this case: it is released by combustion of fossil fuel, especially car engines, and so really present when parents park and circulate their car around the school.

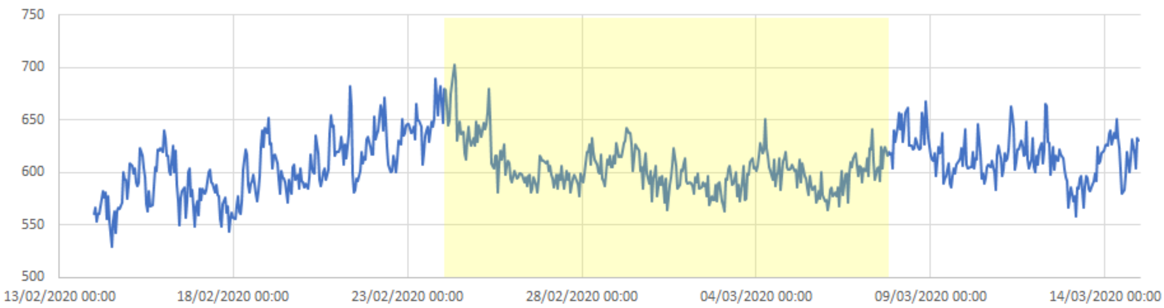

Figure 17a: CO_2 levels measured by a first air monitoring micro - station installed next to a school in Annecy, before, during and after a holiday period (based on daily averages).

Figure 17b: CO_2 levels measured by a second air monitoring micro - station installed in a residential area near the school, before, during and after a holiday period (based on daily averages).

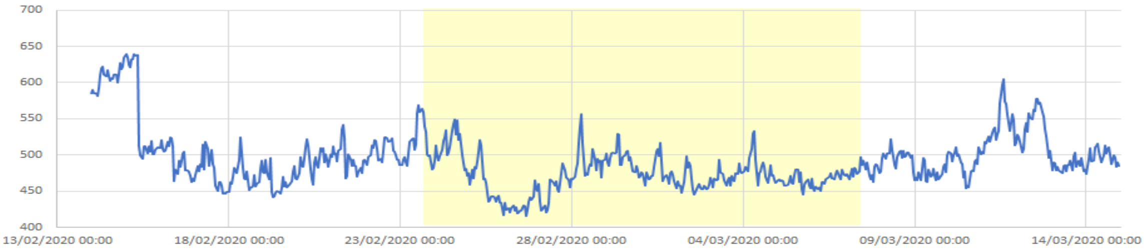

Figure 17c: CO_2 levels measured by a third air monitoring micro - station installed in a low traffic area next to a cemetery remote from the school, before, during and after a holiday period (based on daily averages).

As can be observed, there is a slight diminution of CO_2 levels during the holidays, compared to the levels during the school period, around the first and second air monitoring stations (figures 17a and b).

This trend was not measured by the third air monitoring station (figure 17c) neither by the rest of the fleet of air monitoring stations in the community agglomeration. There seems to be no impact from the holidays on CO_2 levels at the regional scale.

As a result, it is possible to make a direct relation between CO_2 levels and the vehicle traffic around the school: the circulation of parents' vehicles around the school in the morning, at midday and in the evening actually makes CO_2 levels rise.

As the second air monitoring station (figure 17b) is installed in a residential area, it may register much less movement during holiday periods, due to the absence of families or parents staying at home with their children.

Nevertheless, other parameters such as fine particles (PM) and ozone (O_3) do not seem to be impacted by the holiday period for this school specifically.

Figure 16 shows an example of fine particle (PM) levels in front of the school (first air monitoring station) before, during and after the holidays.

Fine particles (PM) are another parameter which is important to study because there is a significant release during the combustion process in car engines.

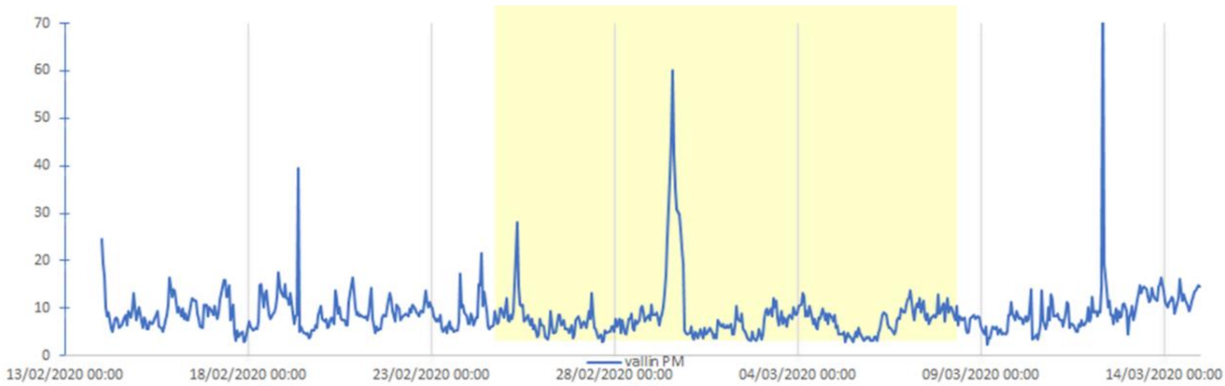

Figure 18: PM levels measured by the first air monitoring micro - station, before, during, and after a holiday period (based on daily averages).

During the school period, a peak of PM can be observed every day on the morning at school opening time, at midday break and at the end of the day before the school closes. It clearly corresponds to the already noticed increase in traffic every day.

During the holiday period (yellow), a very slight decrease in amplitude of the peaks of fine particle (PM) rate can be observed. It is important to note that during the holidays, several rainy days were registered. The rain makes the particles stick on the ground and may be the cause of the particle rate decrease. It is thus, not possible to make a direct link between the slight decrease in PM and the decrease in vehicles around the school because of the holidays.

A building was also under construction in front of the school during this period, which could explain the presence of very important dust production at some moments.

Concerning ozone (O_3) is another important parameter to consider. The following figures 19a - c show the results measured by the same three air monitoring micro - stations.

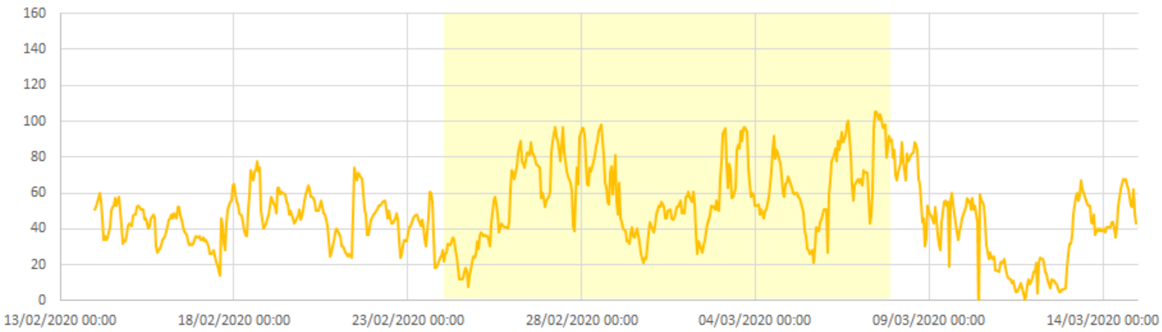

Figure 19a: O_3 levels measured by the first air monitoring micro - station, before, during and after a holiday period (based on daily averages).

Figure 19b: O_3 levels measured by the second air monitoring micro - station, before, during and after a holiday period (based on daily averages).

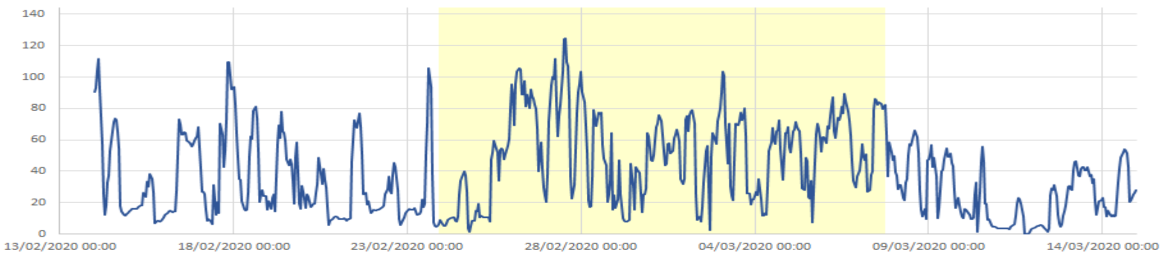

Figure 19c: O_3 levels measured by the third air monitoring micro - station, before, during and after a holiday period (based on daily averages).

The graphs show that the air monitoring station registered no decrease in ozone (O_3) during the holidays, contrary to the previous parameters (PM, CO_2). Instead, a slight augmentation in O_3 can be observed, passing from 40 to 60 µg/m^3. This slight augmentation could be due to a global augmentation in ozone throughout the whole region, which has been observed in any vacation period in a touristic city.

3.2.3.2 Case 3: Abnormal increase in traffic

Another example of the useful functionality of the air monitoring micro - stations network is demonstrated in this case. The data of two air monitoring stations situated close to each other were compared. The first air monitoring station (figure 20a) was installed on a small traffic road serving a campsite. An abnormal increase in PM was detected from the beginning of November to the beginning of April (yellow marking), on the small road serving the campsite, as shown on this figure:

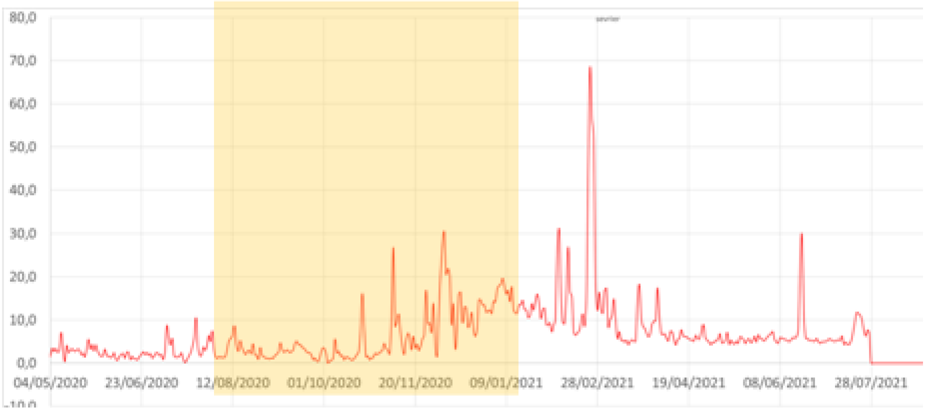

Figure 20a: PM level measured by a first air monitoring micro - station situated on a low traffic road, serving a campsite (based on daily averages).

It turns out, that the departmental road was subjected to roadworks during this period of time. In order to avoid the traffic jams which occurred because of the traffic slowdown, many people chose to take the small road that passed in front of the campsite. The residents in the area had never seen so many cars using that road. The second air monitoring station (figure 20b) was installed on a departmental road below the campsite. The PM data retrieved from the second air monitoring station confirms that hypothesis, as shown on the following graph. It can be clearly seen that the PM level rose during this period and particles were massively generated because of cars stopping and restarting in traffic jams.

Figure 20b: PM level measured by a second air monitoring micro - station situated on a departmental road below the campsite (based on daily averages).

To conclude, thanks to the air monitoring station network, it is possible to detect non - predicable and abnormal situations that ATMO reference fixed stations cannot detect.

3.2.4 Case 4: Impact of gravel, sand and road material storage on air quality

The air monitoring micro - station network highlights how air quality is impacted by the continuous dust generation around a storage area for gravel, sand and road material. This dust is coming from trucks (loading or unloading materials for instance) and wind as the material is not covered. An air monitoring station placed next to this area, where road material was stored, registered the levels of particles PM, NO_2 and O_3 as shown on the following graphs 21a - c (blue line). To compare the data in real time, an air monitoring station placed north and at a distance from the area of the storage material, also registered the levels of PM, NO_2 and O_3as shown on the following graphs 21a - c (orange line).

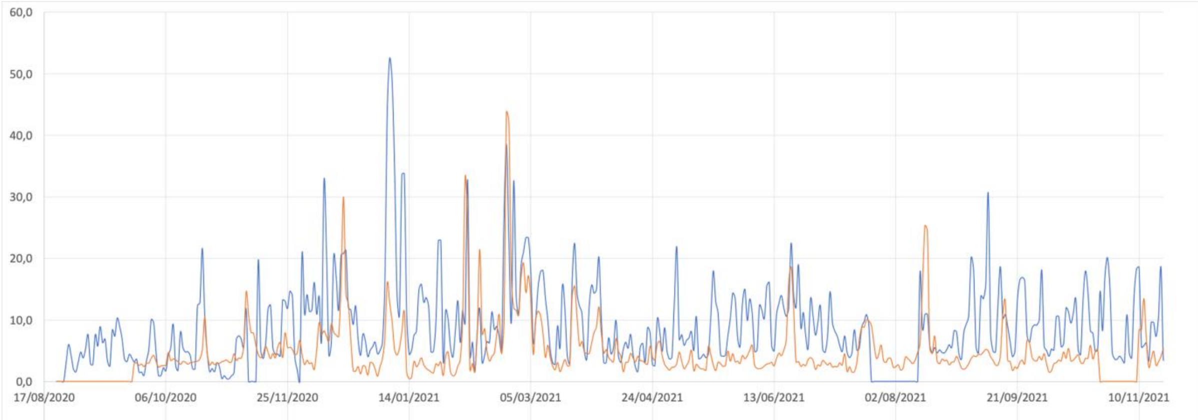

Figure 12a: PM level measured by the air monitoring station situated near material storage area (blue line) and by an air monitoring station situated north, at a distance from the first station (orange line) (based on daily averages).

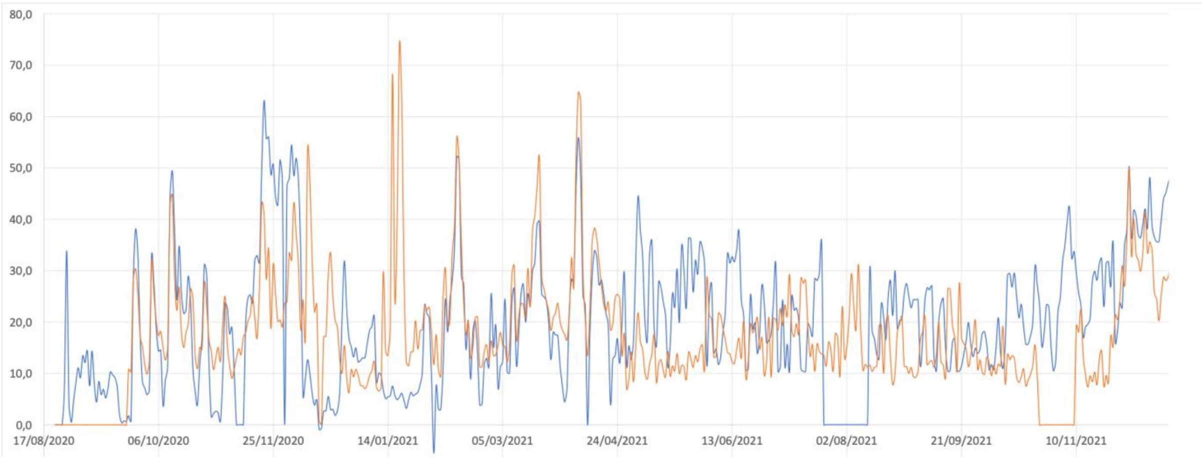

Figure 21b: NO_2 level measured by the air monitoring station situated near material storage area (blue line) and by an air monitoring station situated north, at a distance from the first station (orange line) (based on daily averages).

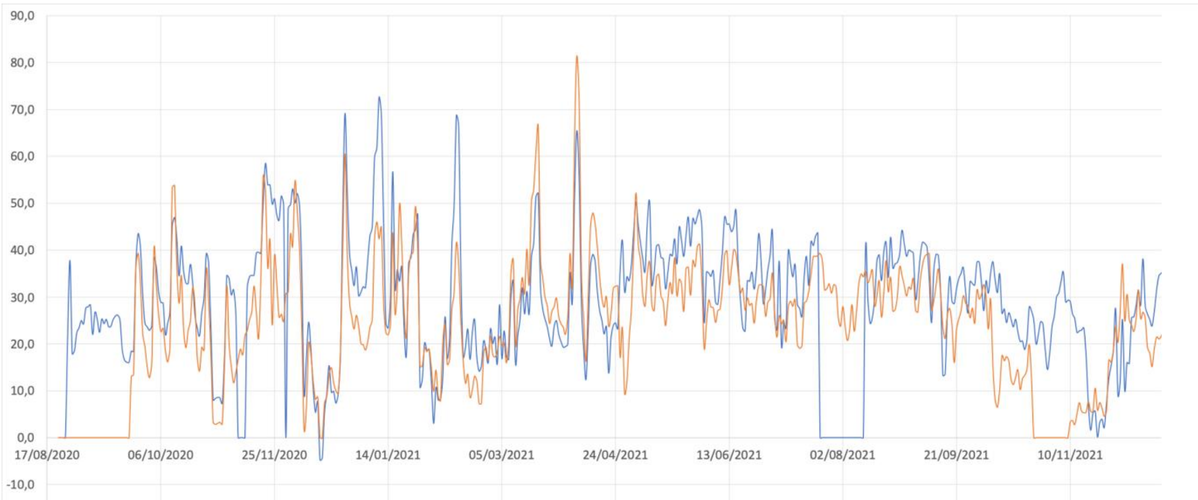

Figure 21c: O_3 level measured by the air monitoring station situated near material storage area (blue line) and by an air monitoring station situated north, at a distance from the first station (orange line) (based on daily averages).

A permanent higher level of PM is detected, as shown in figure 21a, for the micro - station close to the storage area (blue curve), in comparison with the second station (orange curve). This difference is more significant during dry periods (April to October) than during the rainy period (November to March), as the rain strongly contributes to reducing dust diffusion. In addition, the traffic of trucks using this storage area (i. e potential dust production), can be observed in the blue curve, with alternation of days and nights and is not observed for the orange curve. It should be noted that the production of dust could be really consequential even if the truck flow is low (4 to 6 movements per day). Thus, it is not surprising that this big effect observed for the PM level was not detected for NO_2 and O_3 levels, as the traffic of trucks in the storage area is much lower than the classic traffic in the downtown city. The figures 21b and 21c showed an insignificant difference for NO_2 and O_3 levels between the storage area and other places in the city, only the global pollution is detected.

4. Conclusions

Thirty - four air monitoring stations have been installed in the agglomeration community of Annecy in France in order to monitor air quality, in addition to fixed ATMO air monitoring stations already installed.

The results highlight, on the one hand, general air quality trends indicated by similar air data in several air monitoring stations and, on the other hand, local pollution events indicated by differing air data between air monitoring stations.

The air monitoring station network highlighted in particular, some events that could not be detected by ATMO fixed air monitoring stations. For example, a fire in Annecy town hall, high particle levels due to gravel, sand and road material storage, abnormal excessive traffic on a low traffic road serving a campsite, etc.

In conclusion, the implementation of a network of numerous mobile air monitoring stations across a territory, is a more effective and precise way of monitoring air quality, rather than with only ATMO air monitoring stations used to detect and understand regional or local pollution events.

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Declaration of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared toinfluence the work reported in this paper.

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