The air quality during the confinement and coronavirus 2020-2021 period: The case of Tunisia

Abderrazak Arif, Ph.D.
Institut National de la Météorologie,
B.P. 156, 2035 Tunis-Carthage, Tunisia
abderrazak.001@gmail.com, abderrazak.arif@meteo.tn

Abstract:

At the end of 2019, the first case of coronavirus (COVID-19) was reported in Wuhan, China. A month later, that epidemic turned into a national crisis, with infected individuals diagnosed all over China. In early March 2020, the World Health Organization (WHO) declared that the Wuhan epidemic has turned into a global pandemic. Many European countries have started to know several cases affected by this coronavirus, which is known to be highly contagious. The WHO has launched several recommendations to curb the spread of this virus and to call the general confinement establishment in the affected countries. Tunisia quickly took this step on March 22, 2020 and announced immediately general confinement for two weeks, renewable according to the tests results. Factories have been closed to limit human damage. International flights have been halted and the majority of government and private services have been halted except minimum and emergency services. Following these successive events, the air quality has improved markedly during the confinement period. NASA scientists say the reduction in NO_2 pollution first appeared near Wuhan, Northern Italy and France experienced a reduction of nearly 50% of their NO_2 emissions during this first confinement period (March-April, 2020) and been reduced by almost 30% in China. In Tunisia, Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2) and Carbon monoxide (CO) showed a remarkable decrease in the North and the Center of Tunisia of more than 40% during this period mainly linked to the reduction in emission from road traffic and industries. Also these pollutant gases concentrations have knew a nearly 50% reduction during the 3rd pandemic wave during the period of January-April 2021. Consequently, the air quality has improved significantly in Tunisia and around the world.

Keywords: COVID-19; Pandemic; activities; Coronavirus; Meteorological; Tunisia; Pollution; Air; health; Pollutant.

1. Introduction

Air quality improved significantly during the first confinement that lasted almost a month and a half (March and April 2020) in Tunisia. This period is characterized by the first wave of the new epidemic that its history began in Wuhan, China at the end of 2019 where the first case of coronavirus (COVID-19) were reported [14]. Later, this epidemic turned into a national crisis, with infected individuals diagnosed across the country [4,21]. Transportation and travel to and from Wuhan have been halted. Then, they closed schools and universities to reduce the spread of the disease and established numerous quarantines [20]. In early March 2020, the World Health Organization (WHO) declared that the epidemic in Wuhan has turned into a global pandemic as several countries in North America and Europe have been affected by this COVID-19 coronavirus [19]. Italy, France, Spain and other European countries have started to know several cases affected by this coronavirus, known to be very contagious. The WHO has launched several recommendations to curb the spread of this virus and to call for the establishment of general confinement in the affected countries. Tunisia quickly took this step on March 22 and announced immediately general confinement for two weeks, renewable according to the results of the tests. Travel between towns was banned. Factories have been closed to limit human damage.

The WHO has launched several recommendations to curb the virus spread and to call a general confinement establishment in the affected countries. International flights have been halted and the majority of government and private services have been halted except minimum and emergency services. A dramatic decrease in Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2) and Carbon monoxide (CO), which are polluting gases caused mainly by human activities, was observed during the confinement period in several Tunisian cities and in particular in the North and in the Center, using satellite measurements of the European center with the European Earth monitoring program – COPERNICUS. The data was analyzed and developed at the National Institute of Meteorology, Tunisia. Following these successive events, the air quality improved markedly during this confinement period of March and April 2020; known by the COVID-19 first wave [1]. A spectacular fall in Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2) and Carbon monoxide (CO) produced mainly by human activities, was observed during this period in several Tunisian regions and in particular in the North and at the Center, using satellite measurements of Sentinel-5P. As NO_2 is a common tracer of air pollution linked to human activity, associated with morbidity and mortality [8,11, 12,15], NASA scientists said that the reduction in this pollutant (NO_2) appeared first near Wuhan, but spread to the rest of the country, and eventually worldwide [15,17]. Also, Northern Italy and France saw a reduction of nearly 50% of their NO_2 emissions during this confinement period.

In central China, NO_2 emissions have been reduced by almost 25% [19]. SO_2 emissions, another common marker of air pollution, have fallen by over 60% in northern Tunisia [1], Mumbai, New York and Los Angeles nearly 33%, Madrid 50%, Seoul 50% and Wuhan 42% [10]. Air pollution is responsible for many deaths and an increased incidence of respiratory illnesses [3]. According to the World Health Organization (WHO), nearly 4.6 million people die each year from diseases related to poor air quality [5,7], responsible for more deaths each year than motor vehicle accidents [9]. Deaths associated with air pollution include, but are not limited to, aggravated asthma, bronchitis, emphysema, lung and heart disease, and respiratory allergies [3]. China, where the COVID-19 epidemic began, is also a country severely affected by air pollution [11, 12] Air pollution in China is responsible for 4,000 deaths every day, or 1, 6 million deaths in 2016 [16,18]. Scientific studies have mentioned that mortality due to air pollution represents a rate of 0.13% per day [11,12] to 2% for 10 $\mu g / m^3$ of NO_2 over a period of 5 days [6,13]. Considering the huge decrease in air pollution following quarantine around the world, the COVID-19 pandemic paradoxically could have reduced the total number of deaths during this period, by drastically reducing the number of deaths due to air pollution. Moreover, in addition to the reduced deaths number from air pollution, the reduction in this last itself, could also have positive benefits in reducing preventable non transmissible diseases.

2. Methods :

To study the air pollution in Tunisia during the COVID-19 period, we collected satellite measurements (Sentinel-5P satellite) before and after this pandemic. Tunisia is the northernmost country in Africa covering nearly 164 000 km^2 and had a population of nearly 12 million with 4 million inhabitants live in Grand-Tunis, located in the North of the country (Ariana, Ben Arous, Manouba and Tunis). These four governorates are found on the Capital outskirts; Tunis. This large agglomeration represents an important concentration of the Tunisian population; region most affected by COVID-19 since the start of this pandemic, characterized by considerable industrial activity.

As the Tunisian cities majority have been infected by this new coronavirus since the appearance of this COVID-19 pandemic, we have selected the air pollution data from 2019 year (one year before this pandemic) until to date (May, 2021) in order to analyze the trends of pollutants before and after this phenomenon. We used data collected daily from 00h TU to calculate the monthly concentrations mean of the four air pollutants; namely Carbon monoxide CO, Sulfur dioxide SO_2, Nitrogen dioxide NO_2 and ozone (O_3). We have monitored the monthly trends of these pollutants from this pandemic onset (beginning December 2019 and January 2020) in order to compare them with previous periods. The appearance of the first COVID-19 wave which began in March-April 2020, the air quality has been changed mainly due, on the one hand, by the country actions to contain the COVID-19 spread and on the other hand, by the general atmospheric circulation. We looked the air pollution during the first four months of 2020 and assessed whether there were linear trends in pollutant concentrations due to the protection and confinement measures imposed by the government due to this pandemic. We then compared these concentrations before and after COVID-19 for the majority of the affected cities.

3. Results and discussion:

To study the air quality during the COVID-19 pandemic apparition in Tunisia, we will use the four pollutants daily data; Carbon monoxide CO, Sulfur dioxide SO_2, Nitrogen dioxide NO_2 and Ozone (O_3), collected from COPERNICUS program satellite measurements. The mean monthly data treatment of these pollutants showed remarkable changes mainly during the first period of confinement 2020 and after linked to the decrease in road traffic emissions and industries influenced by the general atmospheric circulation on a regional and global scale. The Ozone pollutant at surface level showed a slight growth due mainly to a combination of oxygen and nitrogen gazes, which occurs most often in the context of high temperature combustion phenomena in the excess oxygen presence. This type of combustion can occur in the context of natural phenomena such as in the thunderstorms presence, a high temperature prevailing in the lightning vicinity or around forest fires and results as a result of human activities [2]. Monthly graphics have also been produced for the majority of Tunisian regions, making it possible to visualize the effects of confinement on air quality. It is interested in the Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Carbon monoxide (CO) and Ozone (O_3) concentrations, pollutants known to have deleterious effects on human health. Here, we compare a normal situation (from the previous year, 2019) to the observed situation since the first COVID-19 wave of 2020 and the third COVID-19 wave beginning in January, 2021. This generalized decrease in pollution observed having an impact on health and climate. According to the data collected, all of Europe, North America and China have seen this decrease. The monthly graphics show remarkable differences of these pollutant concentrations in Tunisia for April 2020 and 2021 compared to the previous April (Figures 5 to 8). The Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2) and Carbon monoxide (CO) showed an important decrease in the North and the Center with more than 40% during the confinement periods of 2020 and 2021 linked mainly to the emissions decreasing from road traffic and industries [1]. Conversely, Ozone (O_3) showed growth of nearly 20% in the Center-West of Tunisia and a slight decrease of 10% in the North-West and South [1]. Ozone's average growth was between 1% and 23% during the COVID-19 coronavirus first wave and declined in summer 2020; period of returning to normal life and has continued with this rhythm to the present day.

Figures 1 to 4 show the temporal distribution of the monthly concentration mean of these pollutants at ground level for all Tunisian regions for the years 2019, 2020 and 2021. These show us that the month's majority of the year 2020 and 2021 showed a decrease in the 3 pollutants concentration compared to the previous year; namely Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2) and Carbon monoxide

(CO) and a slight rise in Ozone (O_3). A comparison between the first period of COVID-19 of 2020 and the same period of the previous year (2019), the Sulfur dioxide (SO_2) concentration shows us a sharp decrease in most Tunisian regions with a decrease between 50% and 74 % for 2020 and between 46% and 80% for 2021 (Figure 1). The mean monthly concentration of this gas for April 2020; the month characterized by total confinement in Tunisia, being 3.85μg/m^3 and was 1.35μg/m^3 for 2021. The maximum was in Grand-Tunis; region with a mean of 28.84μg/m^3 and 3.66μg/m^3 for April 2020 and 2021 respectively. The minimum was in Seliana region with a mean of 1.48μg/m^3 and 0.58μg/m^3 at Kasserine and Thala regions for April 2020 and 2021 respectively. Also, all Tunisian regions were characterized by a Nitrogen dioxide (NO_2) decreases from January to April 2020 compared to the same period of the previous year showing a decrease between 24% and 61% for 2020 and between 27 % and 52% for 2021 (Figure 2). The monthly mean concentration of this gas for April 2020 was 4.69μg/m^3 and 2.49μg/m^3 for April 2021. The maximum was in Grand-Tunis region with a mean of 22.49μg/m^3 and 11.1μg/m^3 for April 2020 and 2021 respectively. The minimum was at Kebili region with a mean of 0.44μg/m^3 and 0.61μg/m^3 for April 2020 and 2021 respectively. On the other hand, the Tunisian regions recorded a slight increase in the Ozone concentration (O_3) from January to April 2020 compared to the same period of the previous year showing a growth between 1% and 23% for 2020 and between 4% and 6% for 2021 except for the March month 2021 where it presented a decrease of 2% (Figure 3). The values of the monthly mean concentration of this gas were 59.26µg/m^3 for April 2020 and 62.77µg/m^3 for the same month in 2021. The maximum was in Djerba Ile region with a mean of 80.42µg/m^3 and 80.74µg/m^3 in Kelibia region for April 2020 and 2021 respectively. The minimum was in Grand-Tunis region with a mean of 33.50µg/m^3 and 42µg/m^3 in Jendouba region for April 2020 and 2021 respectively. Finally, the Tunisian regions have recorded a decrease in the Carbon monoxide concentration (CO) from January to April 2020 compared to the same period of the previous year showing a decrease between 11% and 35% for 2020 and between 1% and 21% for 2021 except for the February month 2021 where it presented a small rise of 3% (Figure 4). The mean of the monthly concentration of this gas were 164.86µg/m^3 for April 2020 and 145.94µg/m^3 for the same month in 2021. The maximum was in Grand-Tunis region with a mean of 446,4µg/m^3 and 265.43µg/m^3 for April 2020 and 2021 respectively. The minimum was at El Borma region with a mean of 129.45µg/m^3 and 120.57µg/m^3 for April 2020 and 2021 respectively.

Thus, Figures 5 to 8 present the regional distribution of the monthly concentration means of the all pollutants for the April month 2019, 2020 and 2021, month reference as a period of total or partial confinement for the years 2020 and 2021 where low and high concentrations regions of these pollutants appear at ground level. The pollutants are mainly related to many environmental and meteorological factors where the general atmospheric circulation affects them. These regional distributions show a remarkable decrease in Sulfur dioxide (SO_2) for the years 2020 and 2021; years referenced for COVID-19 occurrence compared to the previous year. For all Tunisian regions, this decrease was 62% and 65% for April 2020 and 2021 respectively (Figure 5). The maximum of this decrease occurs more in the West of the Country mainly caused by high industries concentration in coastal regions. For the Nitrogen dioxide (NO_2), its decrease was 48% and 47% for April 2020 and 2021 respectively (Figure 6). The maximum of this decrease occurs more in the North and the Center of the country than in the South. Thus, the regional distributions for the Ozone concentration (O_3) show a slight increase for the years 2020 and 2021 compared to the previous year. This growth was 1% and 6% for April 2020 and 2021 respectively (Figure 7). The maximum of this increase occurs more in the North than in the Center and the South. Finally, the regional distributions of the Carbon monoxide (CO) also show a decrease for the years 2020 and 2021 compared to the previous year. This decrease was 22% and 11% for April 2020 and 2021 respectively (Figure 8). The maximum of this decrease occurs more in the North of all Tunisian regions than in the Center and the South.

4. Conclusions:

Since the first coronavirus case appearance (COVID-19), reported in Wuhan, China, the Tunisian government has taken a protective measures series to limit its spread at national scale. Travel between cities is prohibited. Factories have been closed to limit human damage. International flights have been halted and the government and private services majority have been halted except minimum and emergency services. These unique circumstances are perfect for study the human behaviour impact on air pollution in Tunisia. We conducted this research to study the possible impacts of human behaviour following COVID-19 pandemic about the air pollution in Tunisia. We used hourly atmospheric pollutant concentrations collected from Sentinel-5P satellite data from the European COPERNICUS program. The mean monthly concentrations tendency analysis of air pollutants during the end March and April 2020; period of total confinement in Tunisia, showed significant reductions of SO_2, NO_2 and CO. This reduction is mentioned in the North and the Center of Tunisia. A comparison of these pollutants revealed that the concentrations of almost all pollutants have decreased compared to the same period of the previous year. The concentration of Sulfur dioxide (SO_2) was lowered in the majority of Tunisian cities mainly in April 2020 except the Tunisian South regions and which has not known a remarkable change in this concentration. This decrease at ground level was visibly remarkable at the 2021 begin year, especially during the third COVID-19 pandemic wave (January to April 2021). In reality, this decrease depends mainly with several environmental and meteorological factors. For example, the atmospheric general circulation affects directly the pollutant concentration. There are several factors that can affect this air pollutant concentration. Local meteorological parameters such as temperatures, thunderstorms occurrence with high air temperatures or forest fires occurrences, the atmosphere stability and in presence of high atmospheric pressure could influence these concentrations. We have also noted Nitrogen dioxide (NO_2) and Carbon monoxide (CO) concentrations decreases in the majority of Tunisian regions. The largest decrease was observed in Grand-Tunis region. So, notable increases in O_3 were observed in the majority of Tunisian regions. The air quality appears to be improved in almost all regions following the government COVID-19 pandemic protective measures introduction. Thus, this study shows that the gradual limitation of industrial activity and automobile traffic in Tunisia caused by COVID-19 pandemic protective measures have been accompanied by an apparent decrease of air pollution and air quality index in Tunisian regions. In other words, the effect of this horrible virus has brought us back to cleaner air.

5. References:

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Figure 1: Monthly mean of the surface Sulfur dioxide concentration, SO_2 ($\mu g/m^3$) before and after the confinement 2019-2021 period: Tunisia, 00h UTC.

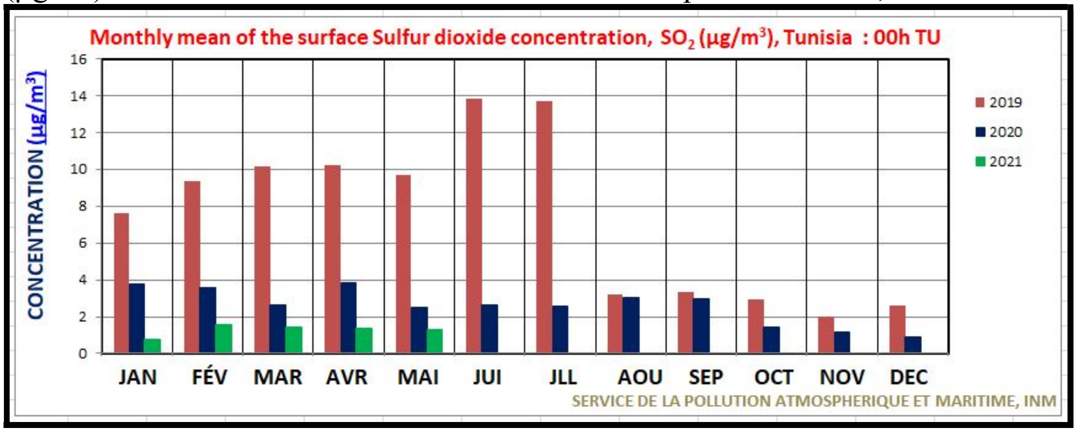

Figure 2: Monthly mean of the surface Nitrogen dioxide concentration, NO_2 ($\mu g/m^3$) before and after the confinement 2019-2021 period: Tunisia, 00h UTC.

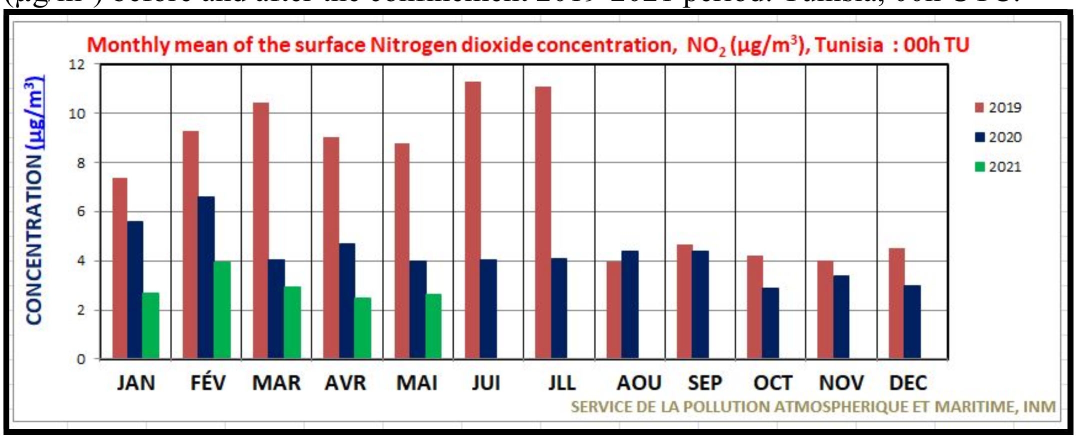

Figure 3: Monthly mean of the surface Ozone concentration, O_3 ($\mu g/m^3$) before and after the confinement 2019-2021 period: Tunisia, 00h UTC.

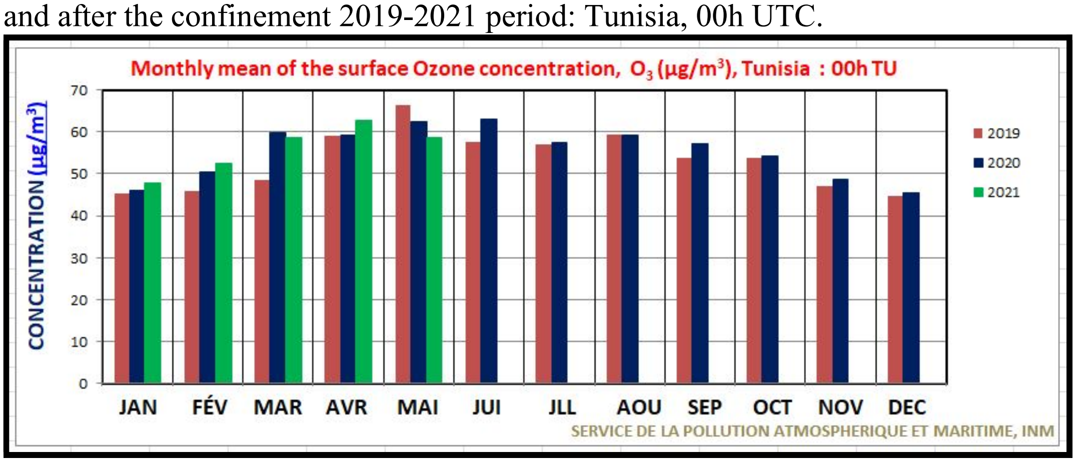

Figure 4: Monthly mean of the surface Carbon monoxide concentration, CO (μg/m^3) before and after the confinement 2019-2021 period: Tunisia, 00h UTC.

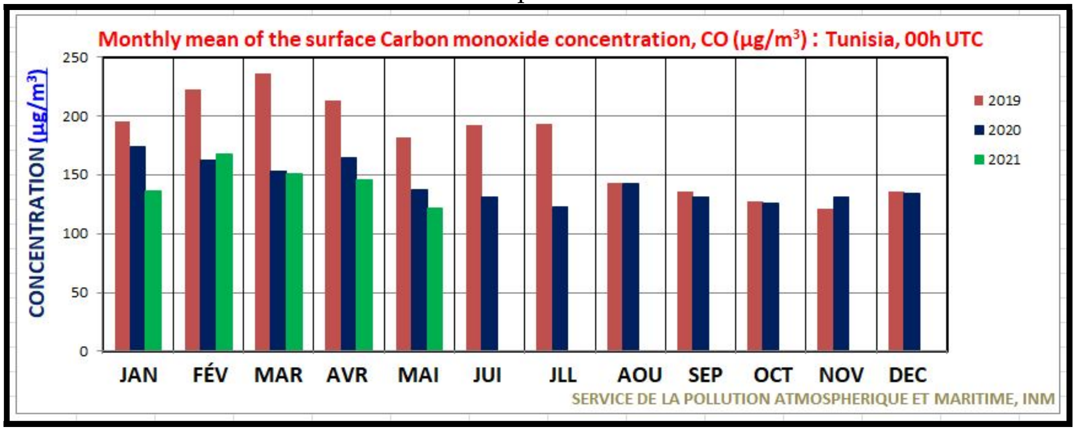

Figure 5: Regional distribution of the monthly mean Sulfur dioxide concentration (SO_2) at ground level for April, 2019, 2020 and 2021 (unit µg/m^3).

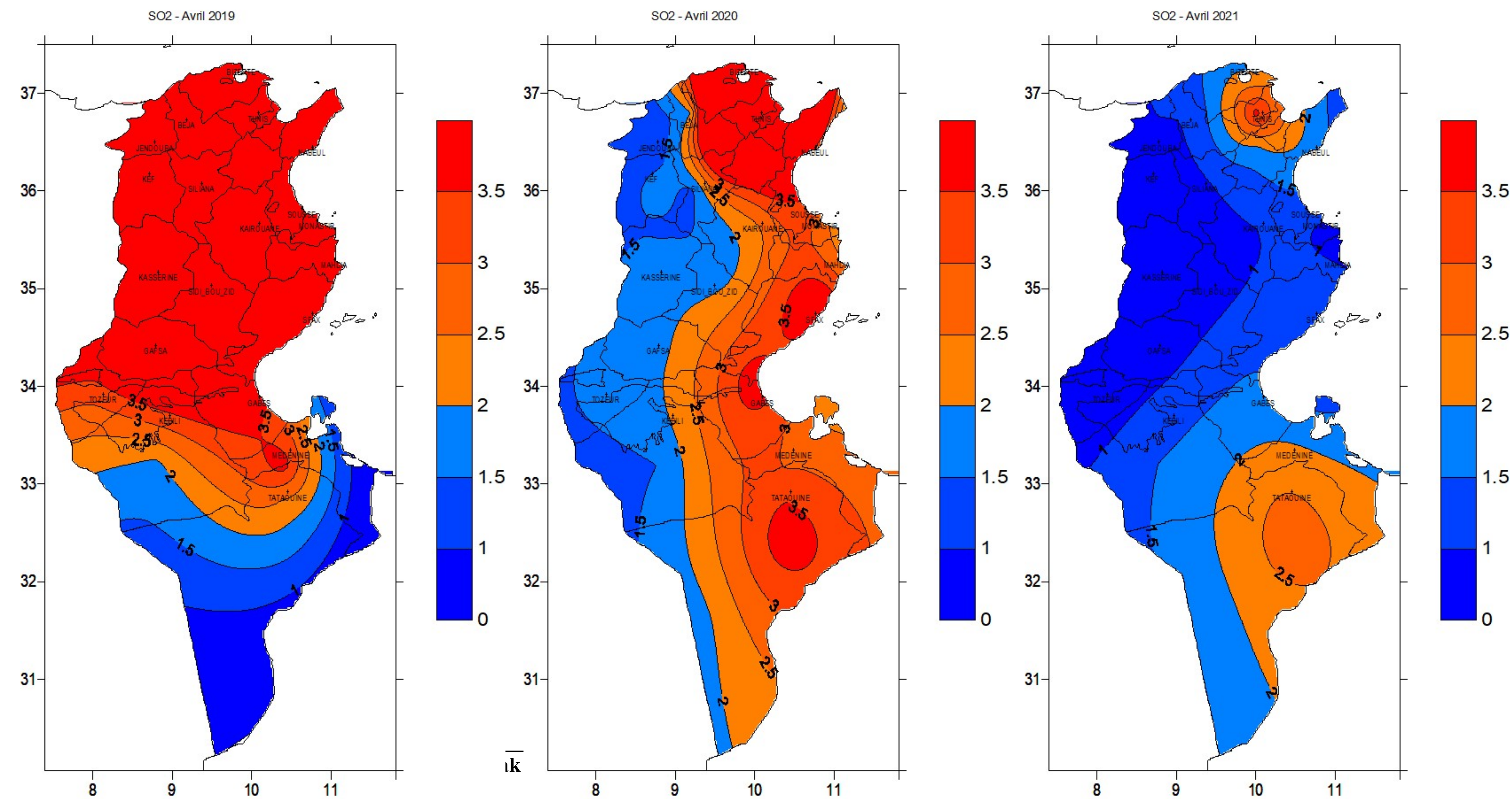

Figure 6: Regional distribution of the monthly mean Nitrogen dioxide concentration (NO_2) at ground level for April, 2019, 2020 and 2021 (unit µg/m^3).

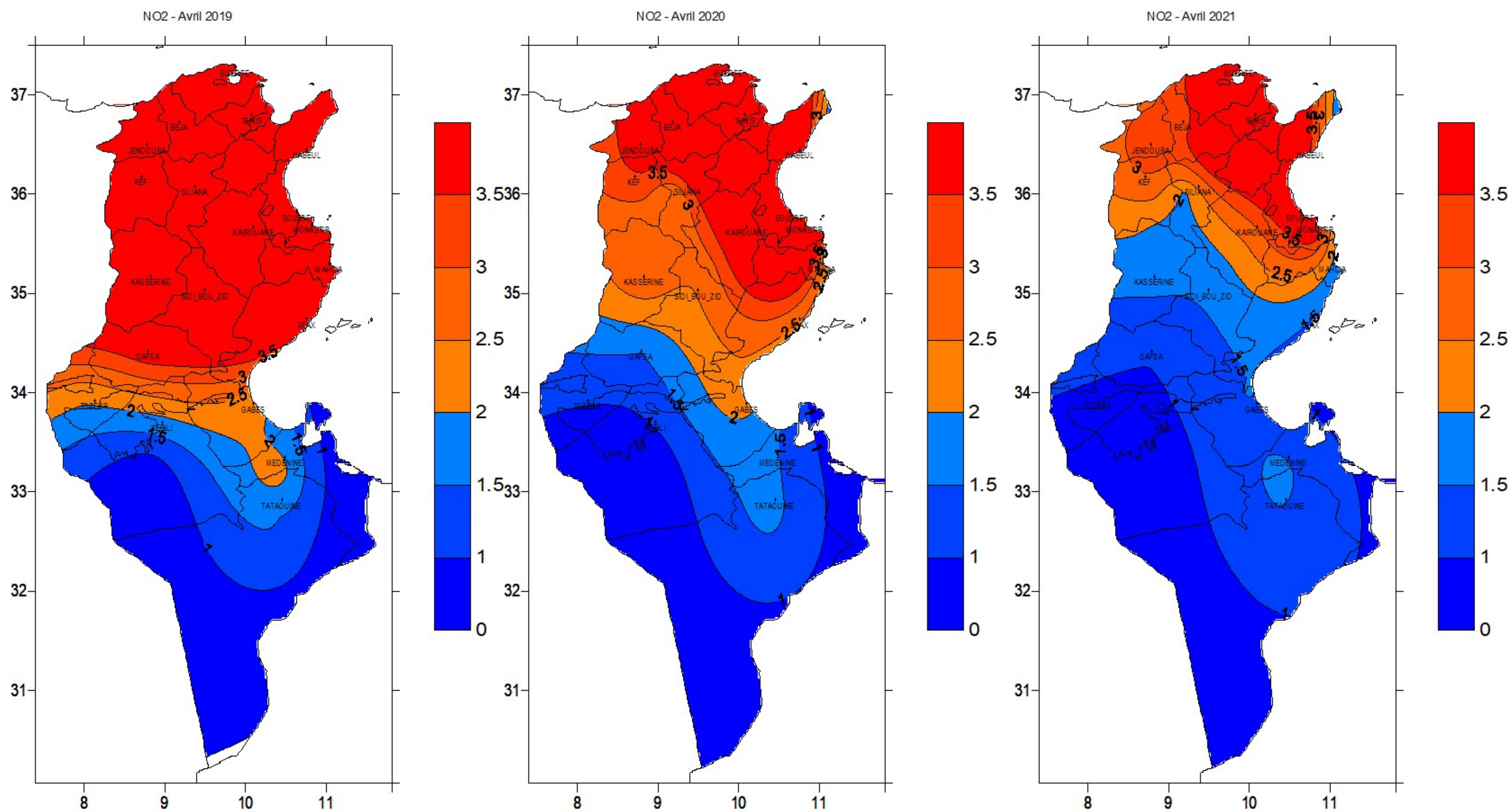

Figure 7: Regional distribution of the monthly mean Ozone concentration (O_3) at ground level for April, 2019, 2020 and 2021 (unit µg/m^3).

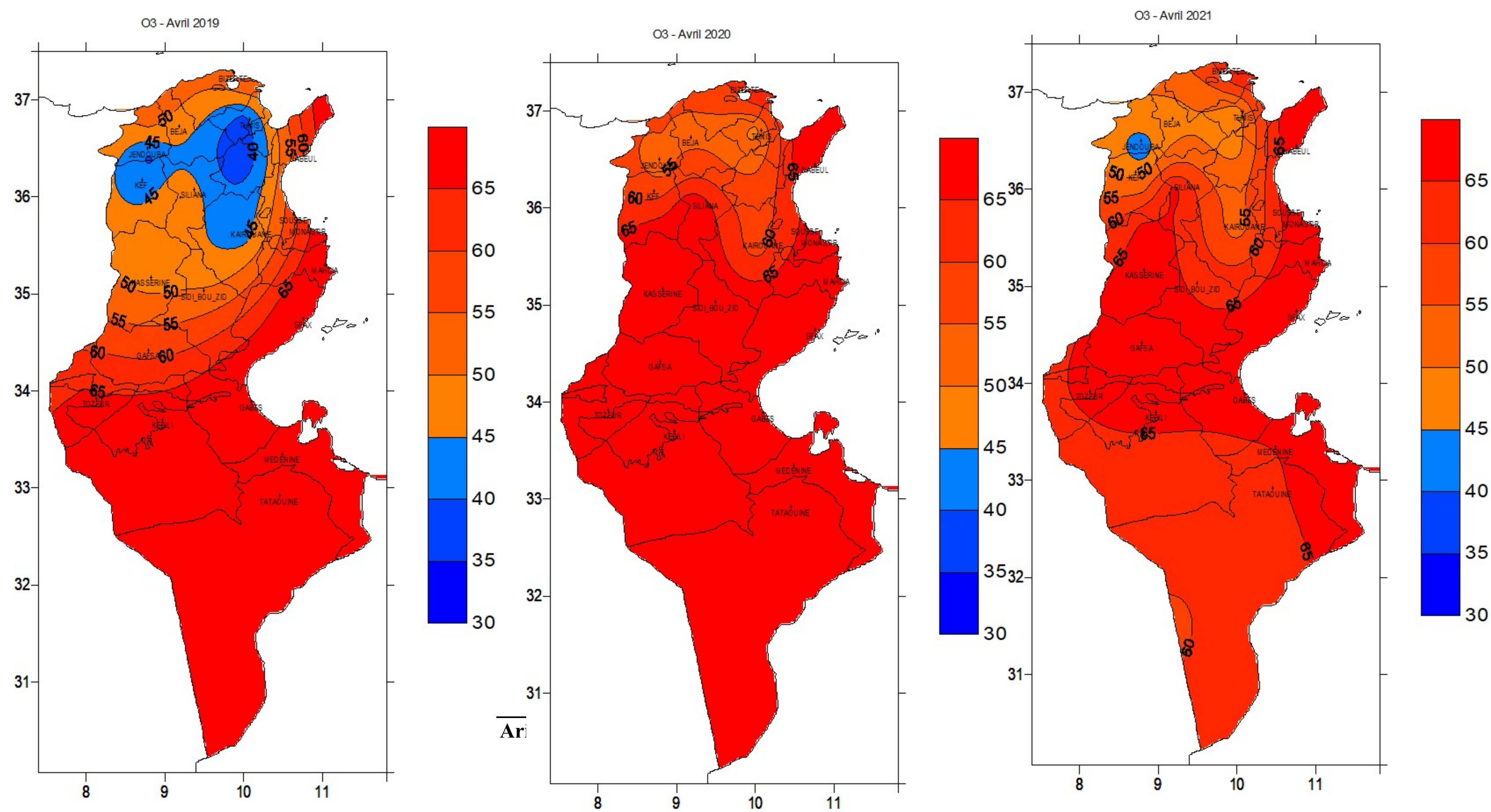

Figure 8: Regional distribution of the monthly mean Carbon Monoxide concentration (CO) at ground level for April, 2019, 2020 and 2021 (unit µg/m^3).