# Università Politecnica Della Marche

## Faculty of Engineering

## Environmental Engineering Department

## Subject: Geomatics Engineering

# Final Report

# (Air Quality Analysis)

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**INDEX**

# Air Quality Analysis of Milan City (Comune)-Italy Via Remote Sensing and Machine Learning Technics.

KEWORDS

[a] Remote Sensing
[b] Air Pollution
[c] Google Earth Engine
[d] $SO_2$, CO, $O_3$
[e] AOD

ABSTRACT

Air pollution is one of the vital problems for the sustainability of cities and public health. enabling to investigate the impact of human/industrial activities on the air pollution. In this study we investigated the spatio-temporal density of TROPOMI based ozone (O3), sulphur dioxide (SO2), CO products, and MODIS-derived Aerosol Optical Depth (AOD) in three different years (2019, 2020, 2023) and in three different months, January, May, November 2019, January, May and November 2020 and the same date for 2023. over Milan City (Comune)- Italy using Google Earth Engine (GEE). So, the results showed a significant decrease in CO from January 2019 (0.037 mole / m2) to January 2023(0.033 mole/ m2), and if consider monthly data, cold seasons exhibit higher concentration of CO, such as January 2020 (0.036 mole / m2), and in the summer we can see the CO decreased May 2020 (0.034 mole / m2).

SO2 didn't decrease and had slightly higher concentrations in February 2023 (0.00066 mole / m2). compared to February 2019 (0.00064 mole / m2), and with higher concentration in February 2020 (0.0013 mole / m2), but monthly SO2 is same as CO, in the summer such as May 2023 (0.00005 mole / m2) the concentration of SO2 decreased but during the cold season increase again. Ozone (O3) as we can see on the graph level of O3 reach their peak concentration, and compared to November, it remains relatively in high level. It means that during the summer months with increasing the sunlight and warmer temperatures O3 increases too. It should be because of chemical reactions involving pollutants like nitrogen oxides and volatile organic compounds. Aerosol Optical Depth (AOD) which is a measure of how much light is absorbed or scattered by aerosol particles in the atmosphere. A higher AOD indicates more aerosol particles present in the atmosphere that have a big effect on atmospheric conditions.

Our analysis shows that during the summer months (May 2019), AOD increase to 343 PPM and decreased to 147 PPM in cold weather or in the winter (January 2019).

## 1. Introduction:

One of the biggest and the most challenging issues facing all nations especially in developing countries is air pollution, Rapid increase in population and demand for energy have resulted in emission of toxic air pollutants that affect the surrounding environment as well as human health. (Naik, 2018)

At the national, regional, and worldwide levels, pollution and environmental degradation have emerged as major issues in recent decades. When significant amounts of dangerous chemicals, particulate matter, and biological molecules enter the Earth's atmosphere, air pollution results. Additionally, it may exacerbate the effects of global warming or diseases that affect people, including heart attacks, pneumonia, asthma, and a variety of respiratory allergies. The most dangerous air pollutants in global urban areas are among the gases that pollute the air. (Program, 2021)

The most critical and hardness pollutant all over the world and metropolitan areas are ozone (O3), sulphur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), Particulate Matters (PM2.5 and $PM_{10}$). All these pollutants typically emitted form a variety of stationary and mobile resources. Stationary sources encompass domestic, residential, and industrial activities. (European Environment Agency) (WHO, september 2021)

Air pollution from mobile sources stems from vehicles and transport, emitting these with exhaust fumes and particulate matter. Except SO2 that emitted from residential and industrial sources and the other pollutants are generally emitted generally by the vehicles. (Roy M. Harrison a i, October 2021)

For the purpose of this study, we used remote sensing and machine learning technology or satellite based remote sensing technology which provides a valuable approach to continuous monitoring air quality in different periods and diverse scales.

Some satellites which use for air quality analysis are, European Remote sensing satellite-2(ERS-2), Environmental Satellite (ENVISAT), Meteorological Operational Satellite (MetOP), and Sentinel-5 (Sentinel-5P) which use for analysing air quality.

The Sentinel- 5 precursor mission is the first Copernicus mission dedicated to monitoring our atmosphere. Copernicus sentinel-5 is the result of close collaboration between ESA and the European commission, the Netherlands space office, data users and scientists( Copernicus sentinel-5 Precursor). (agency, 2017)

Additionally, aerosol optical depth is another general term which is very important in terms of climate change and global warming. In fact, AOD is comprising solid or liquid particles suspended in gas. AOD particle sizes range from $10^{-3}$ and $10^{2}$ µm. AOD serving as fundamental optical characteristic, quantifies the extinction influence exerted by atmospheric aerosols and serves as a pivotal metric for evaluating the extent of atmospheric pollution(Aerosol Optical Depth). (Shuang Zhang a, 2020)

The primary aim of this study is to observe and analyse the spatial and temporal trends of air pollutions, including carbon monoxide (CO), ozone(O3), and sulphur dioxide (SO2) derived from sentinel-5 data, alongside Aerosol Optical Depth(AOD) derived from MODIS data sense 2019 data has been collected over three years and in various or three different months such as ( January or February, May, October or November).

These three months were chosen to comprehend and understand the pollution concentration across seasons and to determine periods of a year when emissions of more pollution concentration are highest. The table below related to 2019 Lombardy, and it correctly shows which factors are related to the source of pollution in municipality of Milan city or generally in the whole part of Lombardy. As we consider about SO2 and CO you can see the sources which these contaminants spread from. As seen in the table 1.1. below the sources of sulphur dioxide (SO2) emissions is more from combustion in industry, energy production and transformation fuels, production processes, waste treatment and disposal and non-industrial combustion.

The sources of CO are more from non-industrial combustion, road transport, production processes, combustion in industry, and other mobile sources and machinery (ARPA) (Agency, 1999)

| Emissioni in Lombardia nel 2019 ripartite per macrosettore - public review (Fonte: INEMAR ARPA LOMBARDIA) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $SO_2$ | NOx | COV | $CH_4$ | CO | $CO_2$ | $N_2O$ | $NH_3$ | PM2.5 | PM10 | PTS | $CO_2$eq | Precurs. $O_3$ | Tot. acidif. (H+) |
| | t/anno | t/anno | t/anno | t/anno | t/anno | kt/anno | t/anno | t/anno | t/anno | t/anno | t/anno | kt/anno | t/anno | kt/anno |
| 1-Produzione energia e trasform. combustibili | 2,612 | 7,852 | 758 | 1,489 | 5,667 | 14,322 | 346 | 10 | 159 | 162 | 167 | 14,463 | 10,981 | 253 |
| 2-Combustione non industriale | 592 | 10,172 | 6,390 | 3,553 | 50,402 | 13,637 | 531 | 625 | 5,962 | 6,108 | 6,446 | 13,884 | 24,394 | 276 |
| 3-Combustione nell'industria | 3,640 | 16,471 | 3,299 | 720 | 10,934 | 11,920 | 297 | 455 | 953 | 1,144 | 1,366 | 12,026 | 24,607 | 499 |
| 4-Processi produttivi | 2,241 | 1,582 | 8,825 | 163 | 31,153 | 3,454 | 57 | 78 | 350 | 597 | 869 | 3,475 | 14,184 | 109 |
| 5-Estrazione e distribuzione combustibili | | | 8,649 | 44,113 | | | | | | | | 1,103 | 9,266 | |
| 6-Uso di solventi | 0 | 80 | 81,015 | 0 | 33 | 0 | | 23 | 653 | 747 | 1,093 | 4,108 | 81,116 | 3 |
| 7-Trasporto su strada | 34 | 46,467 | 10,010 | 850 | 50,414 | 15,072 | 526 | 807 | 2,199 | 3,208 | 4,413 | 15,250 | 72,257 | 1,059 |
| 8-Altre sorgenti mobili e macchinari | 197 | 12,707 | 1,242 | 27 | 4,837 | 1,433 | 45 | 2 | 579 | 580 | 581 | 1,447 | 17,276 | 283 |
| 9-Trattamento e smaltimento rifiuti | 1,080 | 2,904 | 721 | 62,964 | 1,219 | 1,939 | 457 | 546 | 43 | 44 | 48 | 3,649 | 5,279 | 129 |
| 10-Agricoltura | 41 | 817 | 61,836 | 223,618 | 2,114 | | 5,158 | 88,093 | 503 | 979 | 2,008 | 7,128 | 66,196 | 5,201 |
| 11-Altre sorgenti e assorbimenti | 38 | 183 | 64,883 | 4,979 | 5,250 | -3,153 | 2 | 87 | 722 | 926 | 1,109 | -3,028 | 65,754 | 10 |
| **Totale** | **10,476** | **99,234** | **247,628** | **342,476** | **162,022** | **58,625** | **7,419** | **90,727** | **12,122** | **14,496** | **18,101** | **73,507** | **391,310** | **7,821** |

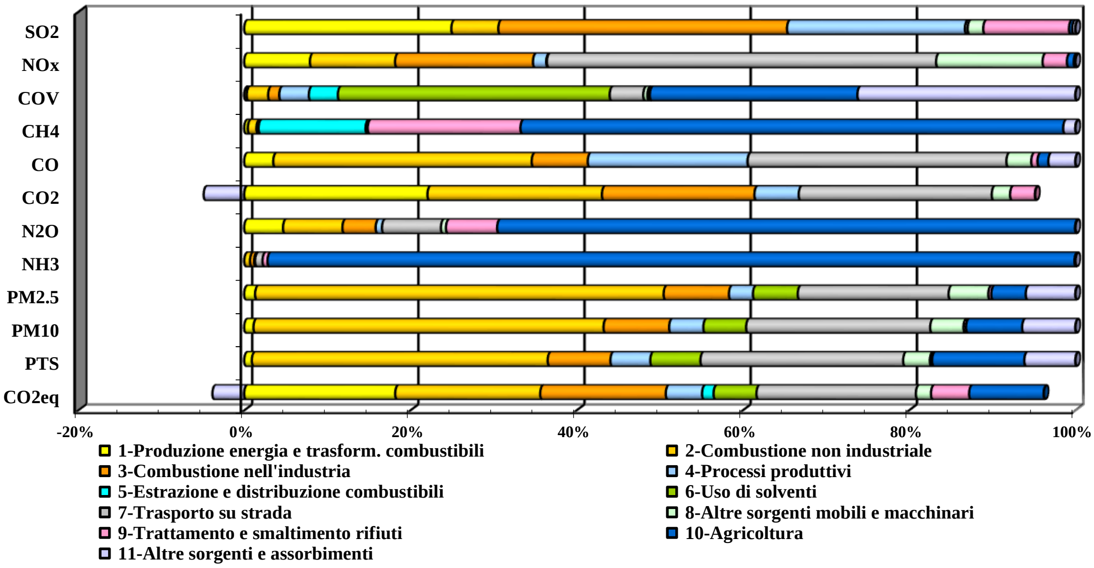



**Fig. 1.** Emissions in Lambordia in 2019 which indicates the sources of different emissions such as (SO2, O3, CO and CO2).

**Fig.1** shows the number of emissions and their sources in Lambordia in 2019. The number of emissions are presented as percentage in the graph, the amount SO2 emitted in 2019 was 10.476 tone/year. the main sources of SO2 emissions were energy production and transformation from fuels (2,612 tone), combustion in industry (3,640 tone), fuel extraction and distribution (2,241 tone), and waste treatment and disposal (1,080 tone).

The total amount of CO emitted in 2019 was 162,022 tone/ year. The main sources of CO emissions were non-industrial combustion (50,402 tone), combustion in industry (10,934 tone), production process (31,153 tone), road transport (50,414 tone).

The total amount of O3 emitted in 2019 was 391,310 tone/year. The main sources of O3 emission were energy production and transformation fuels (10,981 tone), non-industrial combustion (24,394 tone), combustion in industrial (24,607 tone), production process (14,184 tone), use of solvents (81,116 tone), road transportation (72,257 tone), other mobile sources and machinery (17,276 tone), agriculture (66,196 tone), other sources and absorption (65,754 tone).

The **Fig.1** and image have taken from ARPA LOMBARDIA site ([Results – regional summary tables (arpalombardia.it)](Results – regional summary tables (arpalombardia.it)))

## 2. Study area:

Milan city, capital of Lombardy province which located in to north of Italy, a city 122 meters above sea level and which surrounded by Po Basin. Milan is one the most industrious and vital city in the world with 3.1 to 3.2 million population and area city is 182 square km.

Due to its high amount of population, industries, traffic, and location this city is one of the polluted cities in Italy. In contemporary times, traffic accounts for approximately 50% of nitrogen dioxide emissions (NOx) in the atmosphere, while it contributes only 20% to the presence of fine particulate matter. Heating contributes to 9 percent of the production of nitrogen oxides (NOx) and for 56 percent on the diffusion of fine particles. Agriculture that is responsible for 97 percent of ammonia (NH3) emissions. (Air quality in Milan).

Look at the sources, in recent decades the air quality of Millan city in improved, the amount of SO2 and CO go from an average concentration of 55 µg / m3 in 2005 to 35 35 µg / m3 in 2019.

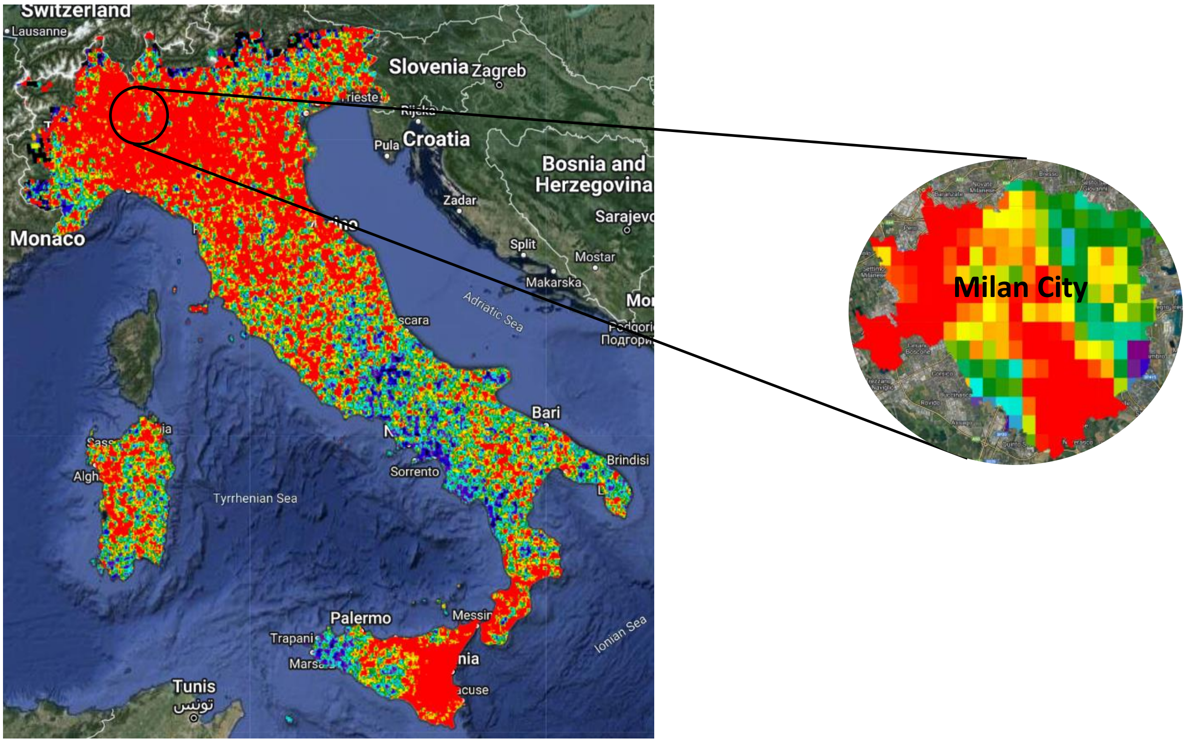



**Fig. 2.** Indicate the study area (Milan-City Italy)

## 3. Data:

The data we utilized include, daily satellite imagery from the sentinel-5P, capturing sulphur dioxide (SO2), carbon monoxide (CO), and ozone (O3) products, is accessible via the google earth engine (GEE). Daily satellite images of MODIS Aerosol Optical Depth (AOD) product are available on the GEE platform (AOD). And important information from ARPA (Agenzia Regionale per la Protezione Ambientale), also known as the Regional Environmental Protection Agency, is an Italian agency responsible for monitoring the environmental and air quality in various region of Italy. Each region has its own ARPA agency, with responsibilities, including monitoring air quality, water quality, soil contamination, and other environmental factors.

### 3.1. Sentinel–5Ps TROPOMI data.

The sentinel-5 initiative is an integral part of the European Earth Observation Program known as 'Copernicus', overseen by the European Commission (EC).

The sentinel-5 precursor mission dedicated to monitoring our atmosphere, consist of one satellite carrying the TROPOsheric Monitoring Instrument (TROPOMI) instrument. The main purpose of this sentinel are to provide daily global observations at a spatial resolution of 3.5× 7 km of key atmospheric constituents related to air quality, climate change monitoring and ozone layer. Level 2 data provide total columns of ozone, sulphur dioxide, carbon monoxide, nitrogen dioxide, vertical profile of ozone and cloud information. This level data are available since the end of 2018. The TROPOMI instrument has four separate sepectrometers, which cover spectral range in the ultraviolet and near-infrared (0.27–0.5 μm and 0.675–0.775 μm) and the shortwave infra-red (2.305–2.385 μm).

### 3.2. Aerosol Optical Depth (AOD), MODIS Data.

Aerosol Robotic Network (AERONET) is a ground-based network of sun photometers that measure the Sun's radiation as it passes through Earth atmosphere and this technology. These instruments are strategically settled by NASA around the world and analyse and provide measurements of aerosol optical properties such as aerosol optical depth, size distribution and absorption characteristics. For more than 25 years the AERONET has been using the Cimel Electronique sun/sky radiometers to prepare extremely accurate ground truth measurement. We have used the version 3 level 2 data with a high-quality ground-based assurance for validation of MODIS AOD products which provides AOD estimates at 1 km spatial resolution covering and area 1200 by 1200 km. This is a combined Level-2 gridded daily product of Terra and Aqua with Mult Angle Implementation of Atmospheric Correction (MAIAC). Aerosol Optical Depth (nasa.gov)

## 4. methods:

The method shows how we analysed pollutant concentration that includes different resources and involves three different sources, namely, Sentinel-5P TROPOMI-based SO2, O3 and CO products, and MODIS-based AERONET AOD data, and also CO from ground station January 2019, 2020, 2021, 2022, and 2023. TROPOMI which is stand for Tropospheric Monitoring Instrument, is a satellite instrument onboard the European Space Agency Sentinel-5 Precursor satellite launched in 2017 and designed to monitor earth surface atmosphere. Specially focusing on trace gases that effect air quality and climate.

So for the analysis we used the Google Earth Engin platform. GEE is one of the open sources geospatial analysis platform which is possible for users globally or locally analyse changes, visualization, quantity differences and map trends on the earth surface. In this platform JavaScript program was developed to analyse, correct and visualize the data from imaged collections.

In this study, our attention was directed towards the following analysis:

- Sense 2019 we analysed CO, SO2, O3 emissions concentration (µ mol/m2) and Aerosol Optical Depth (AOD) which includes the types of Particulate Matters (PM) in three different years (2019, 2020, and 2023) for months January, May and November. But the data for SO2 is not available in January and for this reason we analysed the month February for SO2.
- SO2 emissions concentration analysed in 2019 (February, May and November), the same date is considered for 2020, and 2023 as well.
- CO emissions concentration analysed in 2019 (January, May and November), the same date is considered for 2020, and 2023 as well.
- O3 emissions concentration analysed in 2019 (January, May and November), the same date is considered for 2020, and 2023 as well.
- AOD emissions concentration like CO and O3 analysed in 2019 (January, May and November), the same date is considered for 2020, and 2023 as well.
- The data which got it from ARPA site, is analysed also for the same year and date.

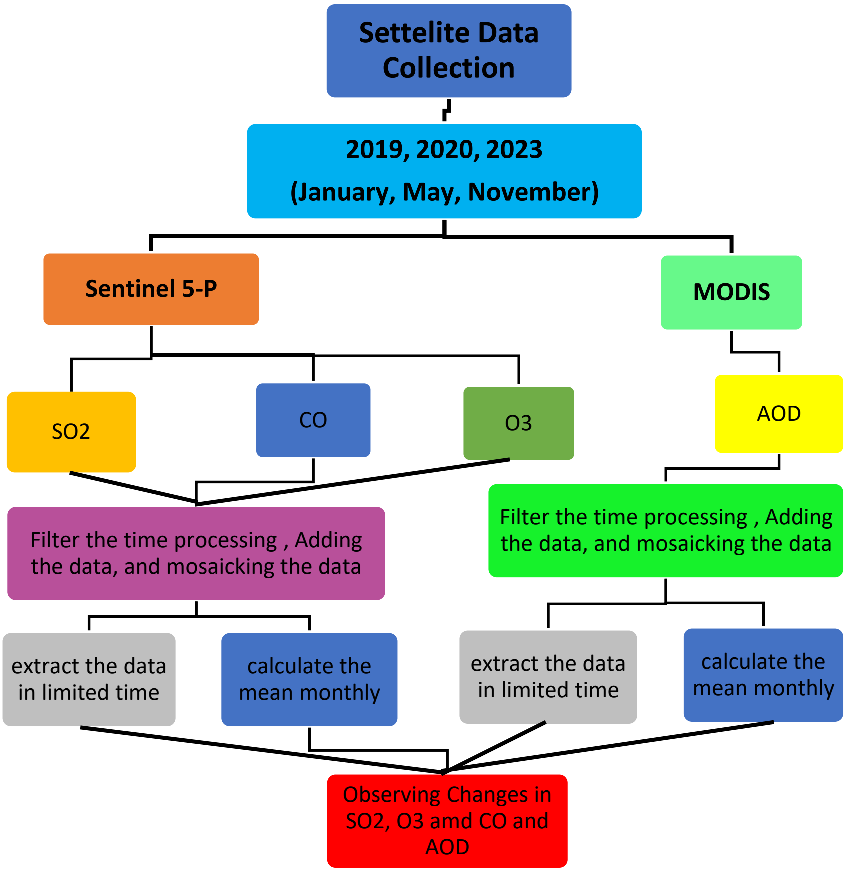



**Fig. 3.** Workflow indicates the operations and methodology during this study. Started from data collection Sentinel 5-p, MODIS to analysis in GEE and conclusion.

For instance we explain the method of just one of the pollutants ($O_3$), and the rest of pollutants analyse the same way, just AOD is with a different data source which the data we download from MODS.

1- **Upload the Shapefile of Comune di Milano.**

Here we downloaded the shapefile of comune di Milano which is our study area from geoportal of the municipality of Milan ([Open data | SIT Geoportal (comune.milano.it)]) and uploaded to google earth engine platform.

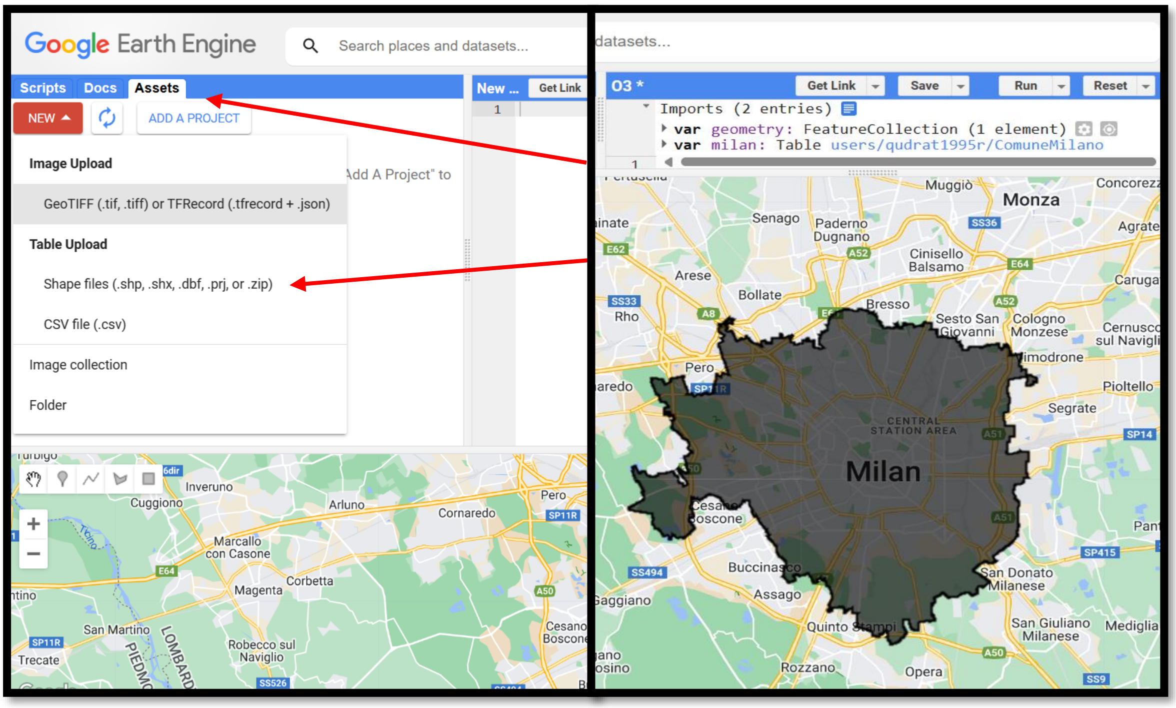



**Fig.4**. Upload the shapefile of study area.

2- **Collect the Image**

Second step is to add the satellite image to google earth engine platform. Here we collect the data from the Copernicus program which is the European Union's Eerth observation program.

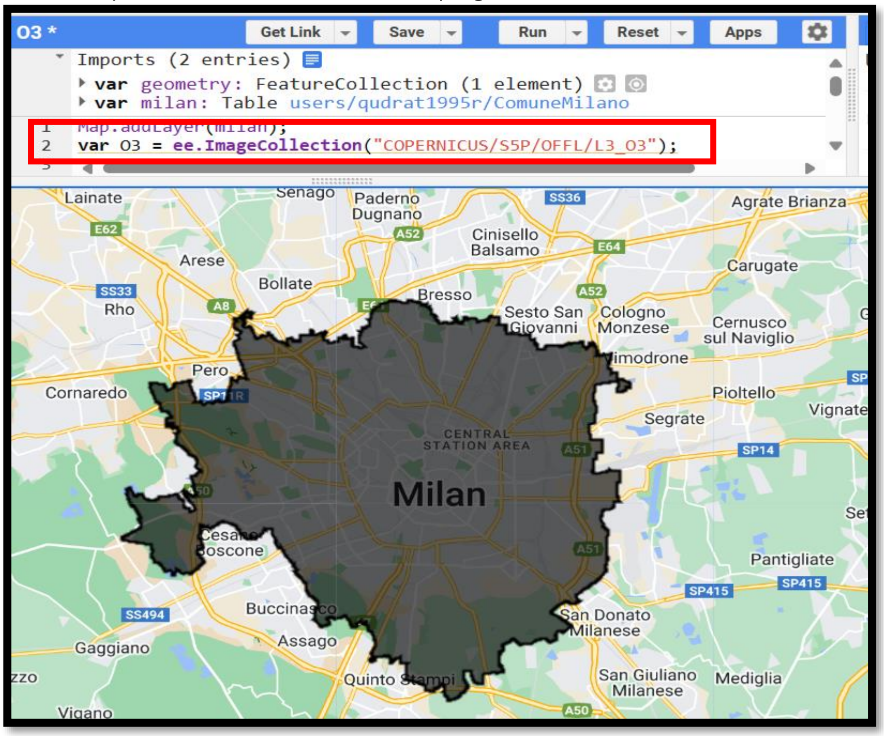



**Fig.5.** Image collection

### 3- Filter the Collected Images and Set the Date

In this part we filter the image collection and based on our specified area as uploaded the geographical boundary, and set the specific date range and time, so for example here we captured the images from 2020-06-01 to 2020-06-01.


**Fig.6.** Filter collected images and determined date range.

#### 4- Visualization

Here we used colour palate range from black to read, and other intermediate colour like, blue, cyan, green and yellow. And the data values started from 0.12 to 0.15 that will be mapped in this colour palette.

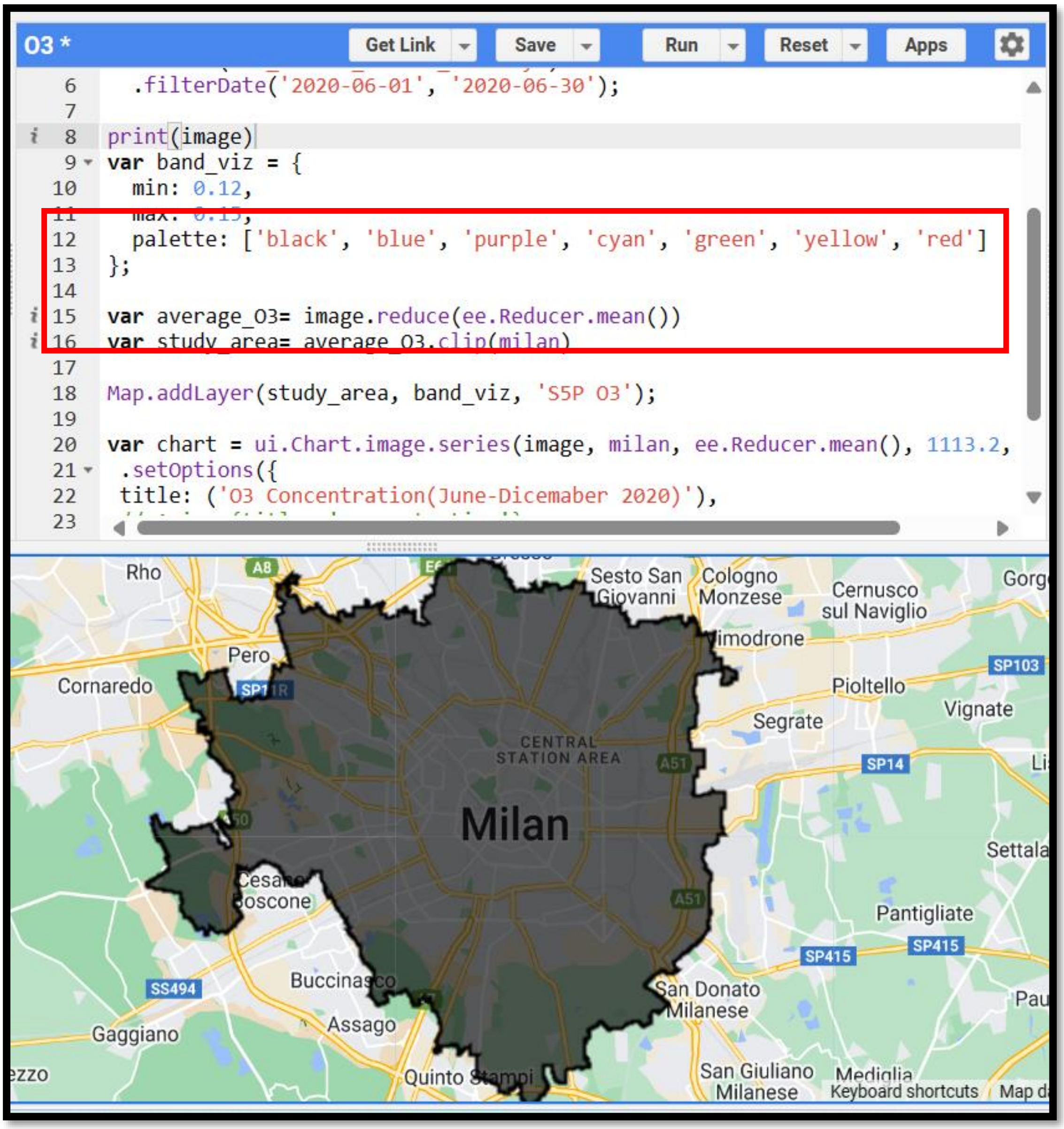



**Fig.7.** visualization

**5- Average Concentration, Time Series and print the results.**

In this step we compute the mean value of concentration of pixels in each band of the image across all the image collection. Then we generated a time series chart showing the mean Ozone concentration over time for the area of Comune di Milano.

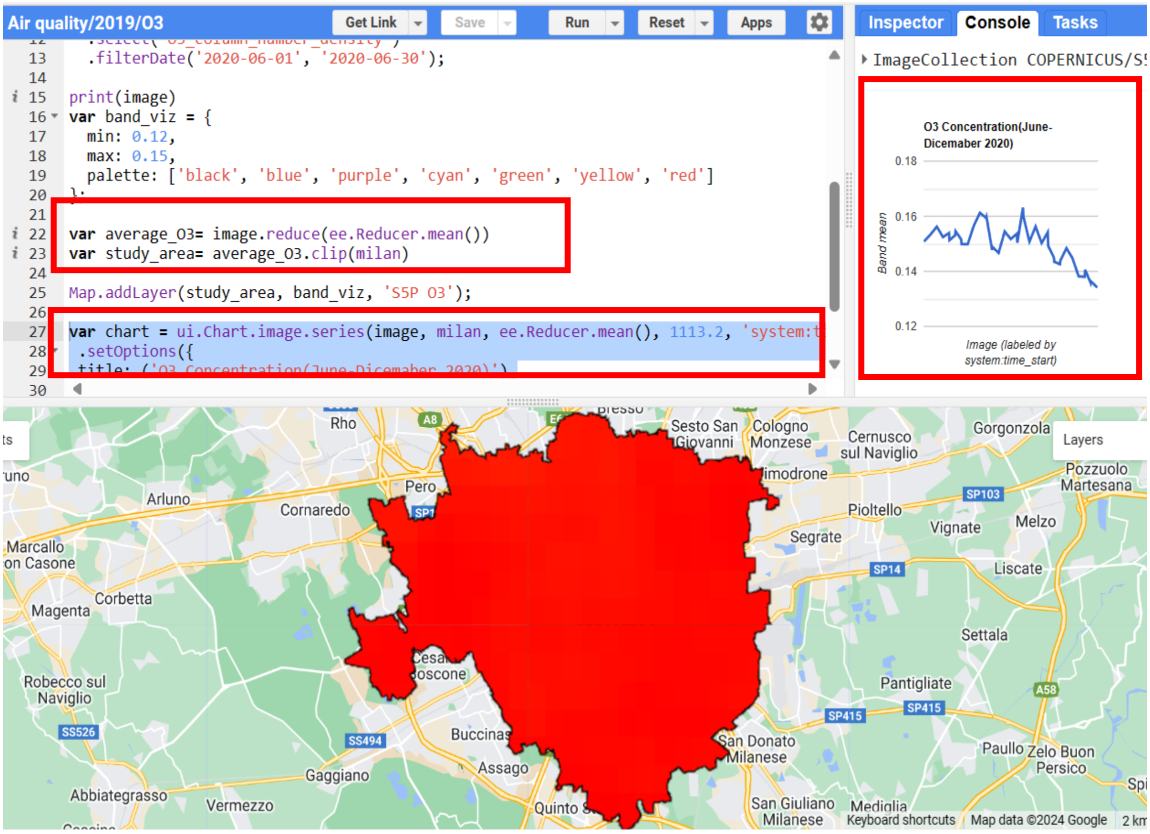


**Fig.8.** time series chart, average concentration and print the results.

## 5- Result and discussion

### 5.1. Sulphur Dioxide

As shown in the **Fig.9**, SO2 concentration across different years have changed. The highest concentrations are observed in months of February and October. In February 2019 the density in Milan city is around 0.000647 mole/ m2, by February 2020 it had risen to 0.001333 mole/ m2, but by February 2023 it had decreased again to 0.000667. Comparing these months to months May in each year reveals that during the summer months the density of SO2 is lower than in spring or winter. In May 2019 the density of SO2 was 0.0002 mole/ m2, in May 2020 decreasing to 0.00005 mole/ m2 much lower than 2019, and similar observed for 2023. The same for months October in three years which is lower than February in each year and more than May in each year.

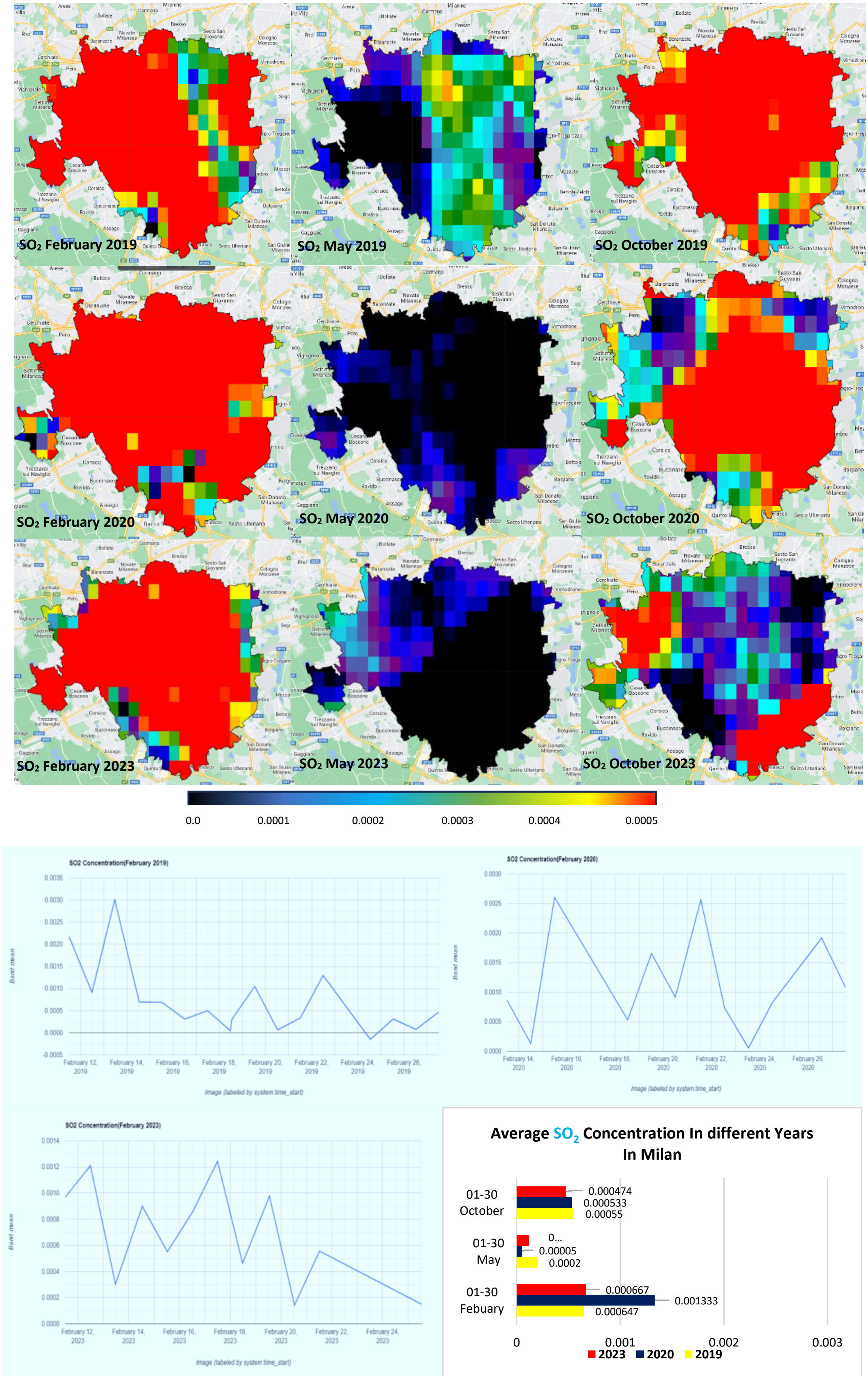



**Fig.9.** The monthly images of SO2 column density over Milan city, February 2019, May 2019, October 2019, February 2020, May 2020, October 2020, February 2023, May 2023, and October 2023.

### 5.2. Carbon Monoxide

In **Fig.10**. revealed the concentration of Carbon Monoxide during the years (2019, 2020, and 2023) and the study periods include months of January, May and November. The highest concentration observed in January 2019 which is equal to 0.037 mole/ m2 , it then decreased to 0.036 mole/ m2 in January 2020 and further decreased to 0.033 mole/ m2 by January 2023.

By comparing these concentration numbers in January across three years with May in the same years, it shows a decrease in concentrations, the concentration observed was 0.0347 mole/ m2 for May 2019, 0.0346 mole/ m2 for May 2020 and 0.032 mole/ m2 for May 2023.

In addition in November 2019, the concentration is 0.031 mole/ m2 still lower compare to May 2019, for November and May 2020 the concentration are almost the same, but in November 2023 observed increase in concentrations again to 0.034 mole/ m2 compared to May 2023.

So the reason why the concentration of Carbon Monoxide decreased in all three year during the months May should be several reasons. Fist decreasing the heating needs, this is clear that the heating system is one the main source of carbon monoxide emissions and generally during the summer months, there is less demand for heating in commercial or residential buildings. secondary sources should be the vehicles that during the summer months people use alternative thing for transport, by walking, bicycle or public transport. Also Industrial activities should be decrease in the summer months which contribute to decrease in concentration.

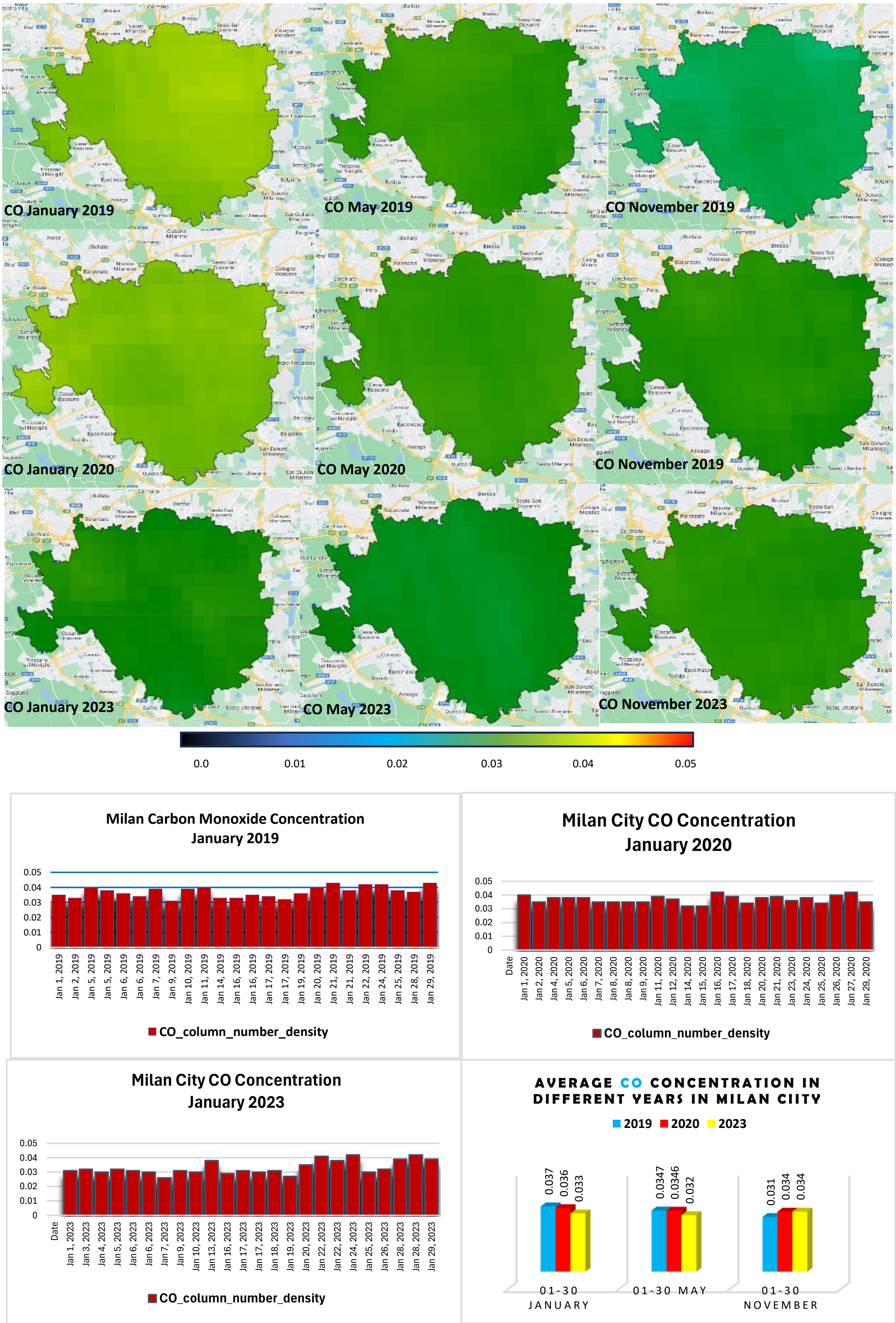



**Fig.10.** The monthly images of CO column density over Milan city, January 2019, May 2019, November 2019, January 2020, May 2020, November 2020, January 2023, May 2023, and November 2023.

### 5.3. Ozone (O3)

Our analysis indicate that the Ozone concentration in Milan city increase in months January and May, just in January 2019 is lower than January 2020 and 2023. But in all three year in November the concentration of ozone decrease.

**Fig.11**. indicates the concentration of ozone in January 2019 is 0.146 mol/ m2 , in May 2019 increase to 164 mol/ m2 but in November 2019 reduced to 0.14 mol/ m2 , in January 2020 compared to January 2019 we have higher ozone layer 0.153 mol/ m2 and slightly decreased by May 2020 which is 0.151 mol/ m2 , in November again decreased to 0.123 mol/ m2 , and similar for 2023 higher level in January and May and decreased in November.High levels of ozone near the earth's surface negative impact and risk to human health and plant life, generally Ozone is generating through the volatile organic compounds(VOCs) and nitrogen oxides(NOx) reacting in the presence of sunlight, especially on the hot days.

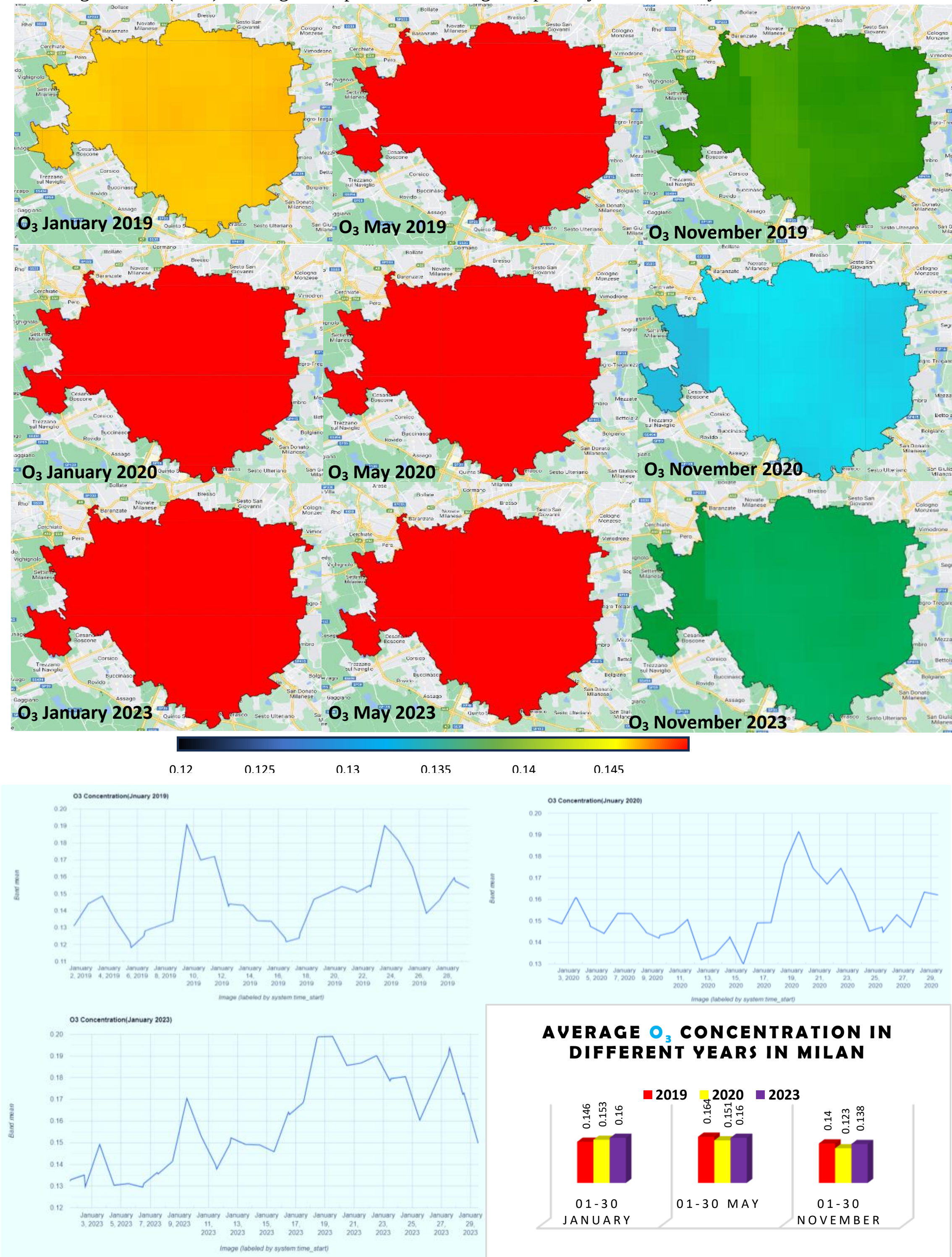
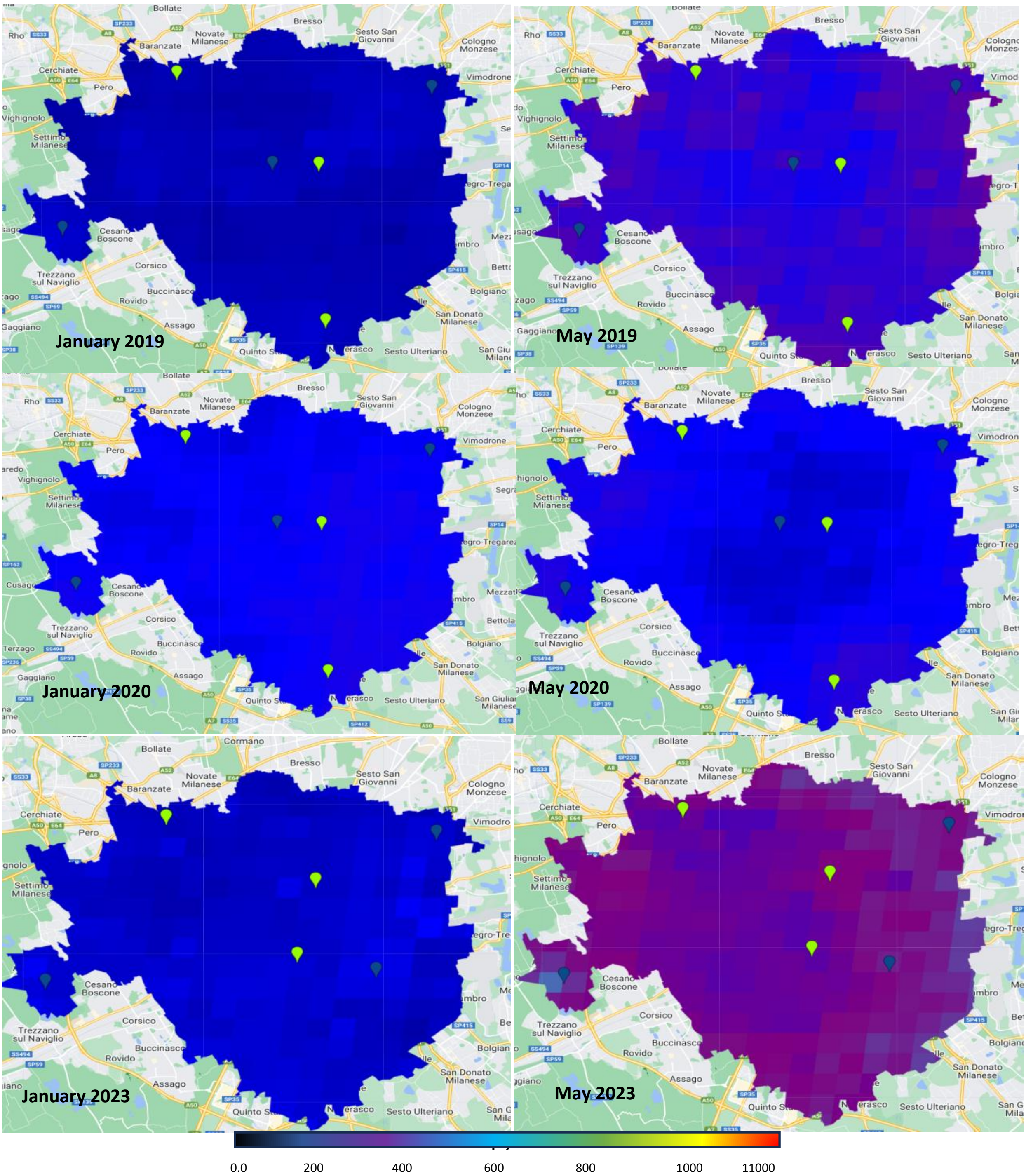



**Fig.11.** Ozone concentration and time series

## 5.4. Aerosol Optical Depth (AOD)

Aerosols are mixture of solid particles or liquid droplets suspended in gas, typically including substances like dust, ash, mist, and smog. Human activities often generate aerosols, particularly in densely populated areas. The telemetry parameter utilized in studying these aerosols in the optical depth of the atmosphere, the aerosol optical depth (AOD) index quantifies aerosol presence by measuring the ratio of solar waves transmitted and absorbed within the atmosphere across different wavelengths and distances. This index serves as numerical indicator of atmospheric particle density and concentration and is typically assessed along vertical paths.

Our analysis **Fig 12** shows, the AOD is increasing in the worm weather and decreasing in the cold weathers specially in the winter. In January 2019 the colour of area is darker blue which indicates lower AOD (147.6 PPM), but in May 2019 the colour is lighter blue and partly purple which indicates that the level of AOD increased to 343 PPM. Further in January 2020 AOD increased to 211 PPM compared to January 2019, but in May 2020 AOD decreased to 178 PPM and should has different reasons, for instance the amount of rainfall contribute to decrease the amount of AOD. Then in January 2023 the AOD level is 140 PPM but letter on in May 2023 it dabbled to 355 PPM. It shows AOD always increase in the summer month. So there are several reasons contribute to increase AOD concentration like the decrease in rainfall, or increase in burning of fusel fuels for power plants and industrial activities.



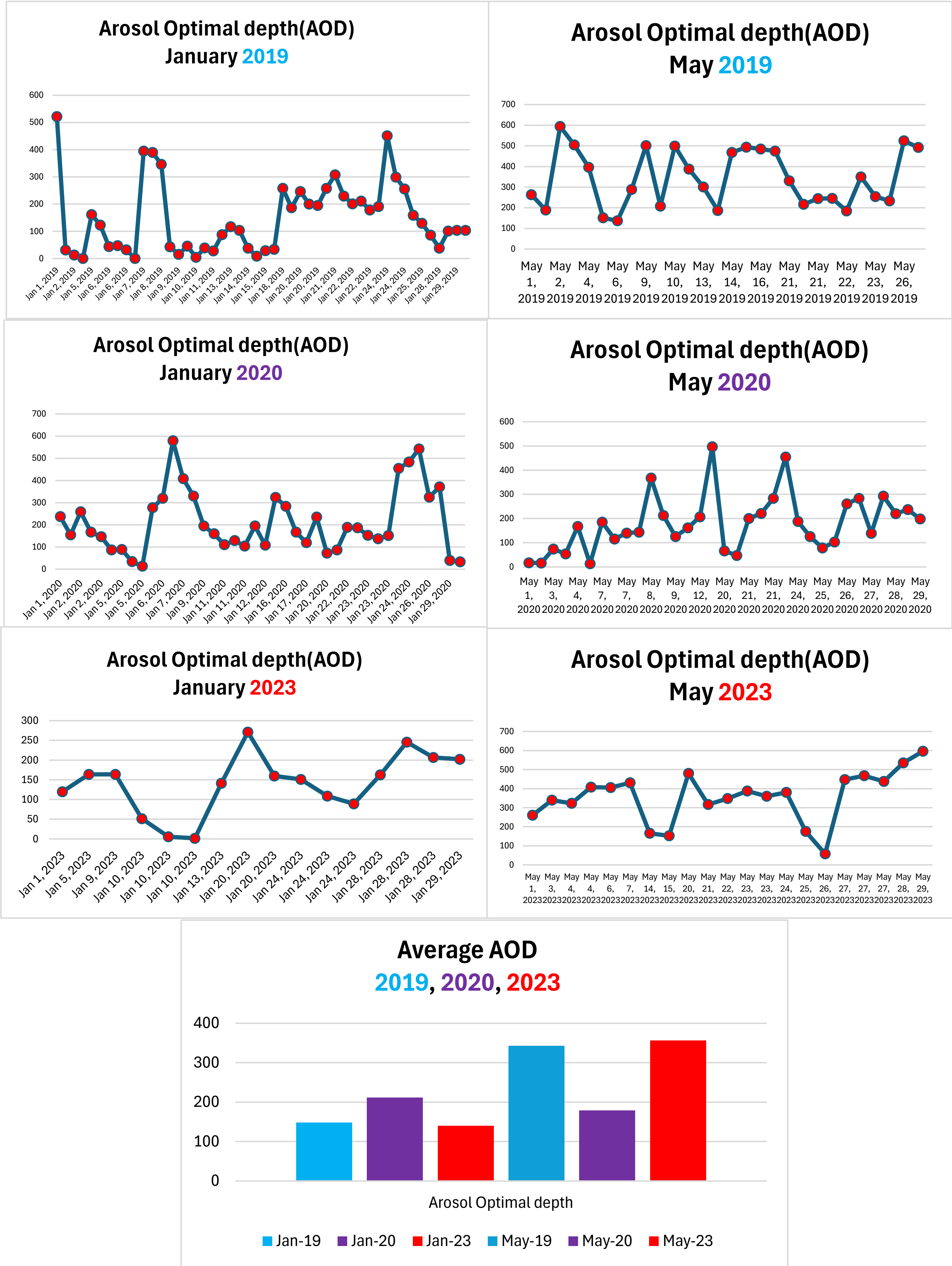



**Fig. 12.** The monthly images of MODIS AOD concentration over Milan city

## 6. Conclusion

In this study we analysed the variation and change in concentration of air pollutants, Carbon Monoxide (CO), Sulphur Dioxide ($SO_2$ ), Ozone ($O_3$) using spatial temporal of sentinel-5P TROPOMI and Aerosol Optical Depth(AOD) using MODIS in three different years 2019, 2020, 2023 in months January, May and November over comune di Milan city-Italy.

In accordance with observed and obtained results $SO_2$ in February is with high levels of concentration, then in May in the summer decreased, but in the October it increased again. If we compare year by year, $SO_2$ reach in high concentration in February 2020, but decrease again in February 2023, also in months October gradually decreased from 2019 to 2023.

Carbon Monoxide (CO) in months January is in the highest level of concentration but decreased by May in all three years. But again, in month November increased again. Yearly, if consider the month of January from 0.037 mol/ $m^2$ in 2019 to 0.033 mol/ $m^2$ 2023 gradually decreased.

Ozone reach in high value by May in 2019 and 2023, just in May 2020 decreased compare to January, and reached minimum value by November in all three years. It has gradually increased every year in January, from 0.14 mol/ $m^2$ 2019 to 0.16 mol/ $m^2$ in January 2023, but in generally in 2020 Ozone is with lower value compare to 2023 and 2019.

Aerosol Optical Depth (AOD) analysed in months January and Many in three years which shows with high concentration value in May 2023 and 2019, then a significant decrease in May 2020.

So we conclude that some emissions like $SO_2$ and CO decrease with warming of the air in summer time, which has several reasons, for instance decrease in heating, vehicles and industrial activities. But at the same time some other pollutants like $O_3$ increase in the summertime, should also have some reasons. Ozone generally forms and increase with high temperatures, that is why with high temperatures the concentration increases too.

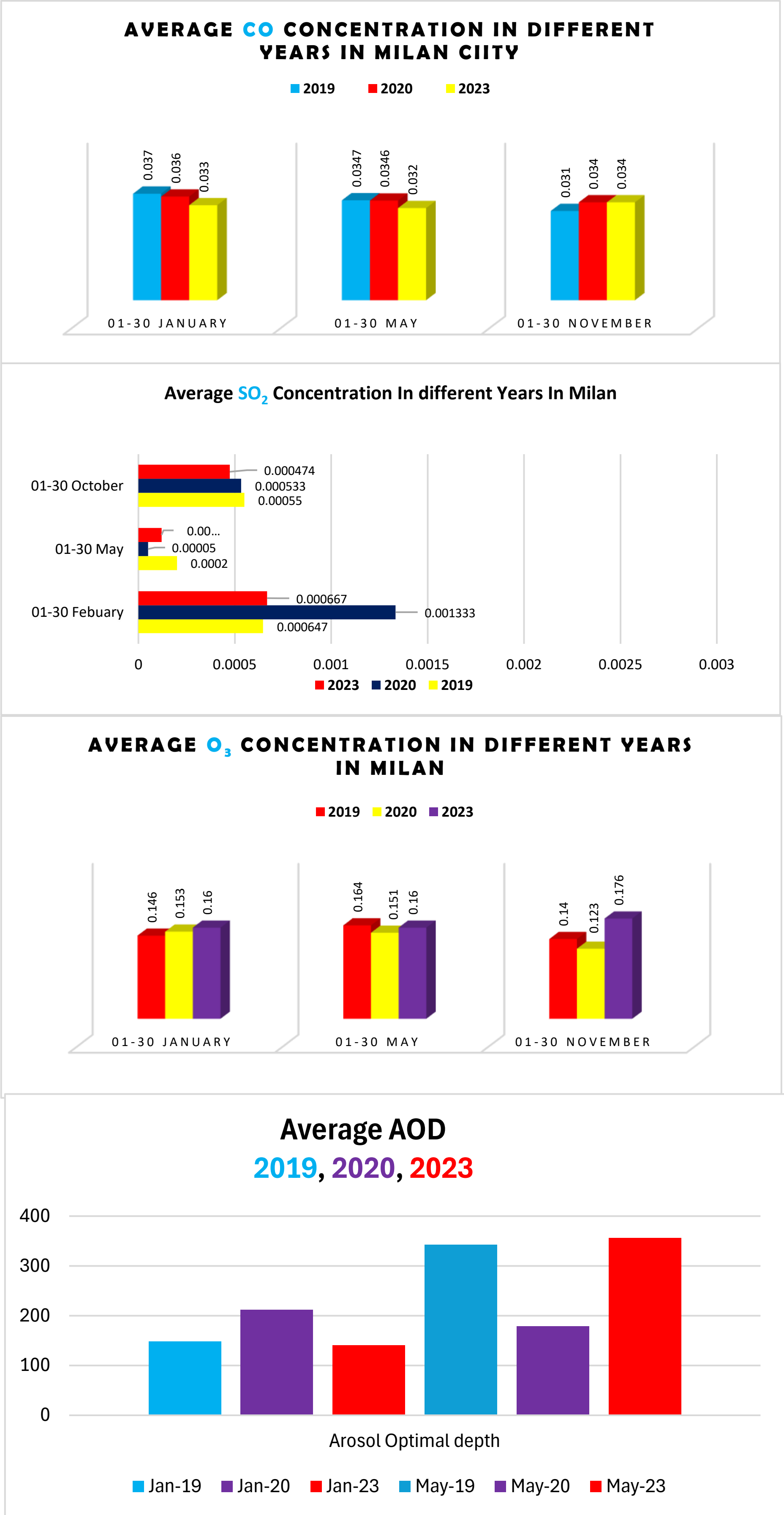



**Fig.13**. graphical chart (concentration) of pollutants results

# 7. Appendix

**Google Earth Engine (GEE) Code**

**Ozone($O_3$):**

```
var collection= ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_SO2')
    .filterBounds(milan)
    .filterDate('2021-02-01','2021-02-28')
    .select('SO2_column_number_density');
print(collection)

var average_SO2= collection.reduce(ee.Reducer.mean())
var study_area= average_SO2.clip(table)
var band_viz = {
    min: 0.0,
    max: 0.0005,
    palette: ['black', 'blue', 'purple', 'cyan', 'green', 'yellow', 'red']};

Map.addLayer(collection.mean().clip(table), band_viz, 'S5P SO2');
Export.image.toDrive({
image: study_area,
description: 'SO2 2019 January ',
region:milan,
fileFormat:'GeoTIFF',
});

var chart = ui.Chart.image.series(collection, table, ee.Reducer.mean(), 1113.2, 'system:time_start')
     .setOptions({
     title: ('SO2 Concentration (May 2023)'),
     vAxis: {title: 'concentration'},
     hAxis: {title: 'month'},
});
print(chart);
```

**Sulphur Dioxide ($SO_2$):**

```
var collection= ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_SO2')
  .filterBounds(milan)
  .filterDate('2020-02-01','2020-02-28')
  .select('SO2_column_number_density');
print(collection)

var average_SO2= collection.reduce(ee.Reducer.mean())
var study_area= average_SO2.clip(table)
var band_viz = {
  min: 0.0,
  max: 0.0005,
  palette: ['black', 'blue', 'purple', 'cyan', 'green', 'yellow', 'red']
};

Map.addLayer(collection.mean().clip(table), band_viz, 'S5P SO2');
  Export.image.toDrive({
  image: study_area,
  description: 'SO2 2019 January ',
  region:milan,
  fileFormat:'GeoTIFF',
  });

var chart = ui.Chart.image.series(collection, table, ee.Reducer.mean(), 1113.2, 'system:time_start')
 .setOptions({
 title: ('SO2 Concentration(May 2023)'),
 vAxis: {title: 'concentration'},
 hAxis: {title: 'month'},
 });
print(chart);
```

### Carbone Monoxide (CO):

```
var collection= ee.ImageCollection("COPERNICUS/S5P/OFFL/L3_CO")
  .filterBounds(milan)
  .filterDate('2023-01-01','2023-01-30')
  .select('CO_column_number_density');
print(collection)

var average_CO= collection.reduce(ee.Reducer.mean())
var study_area= average_CO.clip(milan)
var band_viz = {
  min: 0,
  max: 0.05,
  palette: ['black', 'blue', 'purple', 'cyan', 'green', 'yellow', 'red']
};
Map.addLayer(study_area, band_viz, 'S5P CO');

var chart = ui.Chart.image.series(collection, geometry, ee.Reducer.mean(), 1113.2, 'system:time_start')
 .setOptions({
 title: ('CO Concentration'),
 //vAxis: {title: 'concentration'},
 //hAxis: {title: 'month'},
 });
print(chart);
```

### Aerosol Optical Depth (AOD) code:

```
var collection = ee.ImageCollection('MODIS/061/MCD19A2_GRANULES')
                  .select('Optical_Depth_047')
                  .filterDate('2023-01-01', '2023-01-30');
var band_viz = {
  min: 0,
  max: 1100,
  palette: ['black', 'blue', 'purple', 'cyan', 'green', 'yellow', 'red']
};

var AODAvg= collection.reduce(ee.Reducer.mean());

var Clip= AODAvg.clip(milan)
Map.addLayer(AODAvg.clip(milan), band_viz, 'Optical Depth 047');
Map.centerObject(milan, 11);

var chart = ui.Chart.image.series({imageCollection: collection, region: milan, reducer: ee.Reducer.mean(),
          scale: 500,
          xProperty: 'system:time_start'
         });
         .setSeriesNames(['Arosol Optical Depth'])
         .setOptions({
          title: 'Average',
          hAxis: {title: 'Date', titleTextStyle: {italic: false, bold: true}},
          vAxis: {
          title: 'AOD',
          titleTextStyle: {italic: false, bold: true}},
         lineWidth: 5,
         colors: ['e37d05'],
         curveType: 'function'
        });
print(chart);
```

**References**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ARPA Lombordia – Regional Agency*, which stablished for the protection of the environmental of Lombardy deals with the prevention in multiple activities.*
ARPA Lombardia | About us - ARPA Lombardia.

IQAir, Air quality in Milan. Milano Air Quality Index (AQI) and Italy Air Pollution | IQAir

EnviSat(Environmental Satellite), was a satellite mission monitoring Eearth's environment.

EnviSat (Environmental Satellite) - eoPortal

NASA, Aerosol Optical Depth(AOD). Aerosol Optical Depth (nasa.gov)

## FIGURES INDEX