

Data Processes Project

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Abstract

Introduction and related work

Exploratory data analysis

Dataset description

Before exposing the results of the exploratory data analysis carried the data, important information and background about the dataset is introduced below:

The dataset used for this work was obtained from Kaggle's website. In this page, we can find a lot of information and datasets about the air quality in Madrid.

The data in this data set has been collected from the original files provided by Madrid Open Data. Decide soluciones organization processed them and uploaded to the Kaggle's website.

Originally, Madrid Open Data get the data from 24 automatic stations around Madrid. Those stations, which are set around all the districts of the city, record information about pollution in the area. The data was generated from those stations whose pollution sensors measure air quality in Madrid city.

Regarding the observations, all csv files include twelve month data, except the last one that only has data until May. According to this, we have the followings rows:

CSV	Observations
Stations.csv	24 rows

CSV	Observations
Madrid2001.csv	217872 rows
Madrid2002.csv	217296 rows
Madrid2003.csv	243984 rows
Madrid2004.csv	245496 rows
Madrid2005.csv	237000 rows
Madrid2006.csv	230568 rows
Madrid2007.csv	225120 rows
Madrid2008.csv	226392 rows
Madrid2009.csv	215688 rows
Madrid2010.csv	209448 rows
Madrid2011.csv	209928 rows
Madrid2012.csv	210720 rows
Madrid2013.csv	209880 rows
Madrid2014.csv	210024 rows
Madrid2015.csv	210096 rows
Madrid2016.csv	209496 rows
Madrid2017.csv	210120 rows
Madrid2018.csv	69096 rows

We can also differentiate two domains whose columns represent different data:

On the one hand, we have Stations.csv with six columns, which contains information about the stations previously mentioned, in which the data about the pollution levels of the air is collected. On the other hand, we have Madrid20xx.csv, which contain the data about Madrid’s air pollution itself. Some of these csv files have 14 columns, others 16 and others 17. We have the following columns in the csv files:

CSV	Features
Stations.csv	6 columns
Madrid2001.csv	16 columns
Madrid2002.csv	16 columns
Madrid2003.csv	16 columns
Madrid2004.csv	17 columns
Madrid2005.csv	17 columns
Madrid2006.csv	17 columns
Madrid2007.csv	17 columns
Madrid2008.csv	17 columns
Madrid2009.csv	17 columns
Madrid2010.csv	17 columns
Madrid2011.csv	14 columns
Madrid2012.csv	14 columns
Madrid2013.csv	14 columns
Madrid2014.csv	14 columns
Madrid2015.csv	14 columns
Madrid2016.csv	14 columns
Madrid2017.csv	16 columns
Madrid2018.csv	16 columns

Data wrangling

Before getting to work with the previously described data, some steps were performed in order to make the data more manageable:

Selected Features

In order to perform both the exploratory data analysis and the prediction methods, we will focus on the five gases that harm humans the most when they are present, and that relate the most to pollution:

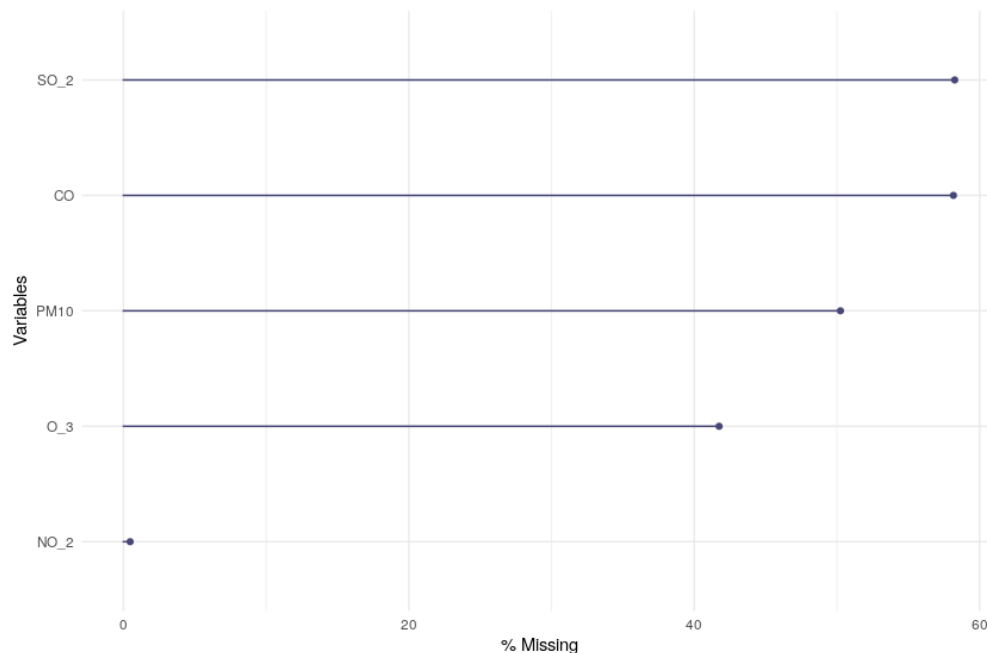
1. CO
2. O3
3. SO2
4. PMH10
5. NO2

Datasets unification

In order to work with the data, all the yearly datasets were unified in a single one, adding one additional feature to the existing date column that all of the datasets present: the year. Thus, after this transformation, a single dataset contained all the information about Madrid's air pollution in the last 17 years, instead of 17 different datasets (one per year). Two additional columns were added: the *only_month* and *only_year* columns, which stand for the month and the year in which the observation was recorded, respectively.

Missing values treatment

As we can observe in the plot below, there is a high amount of missing values in the variables that we concern about:



Thus, in order to deal with missing values, the mean of each one of the variables for each year, month and station is computed, so that all the missing values for each one of the columns in that same year, month and station are imputed with the corresponding mean.

Descriptive statistics analysis

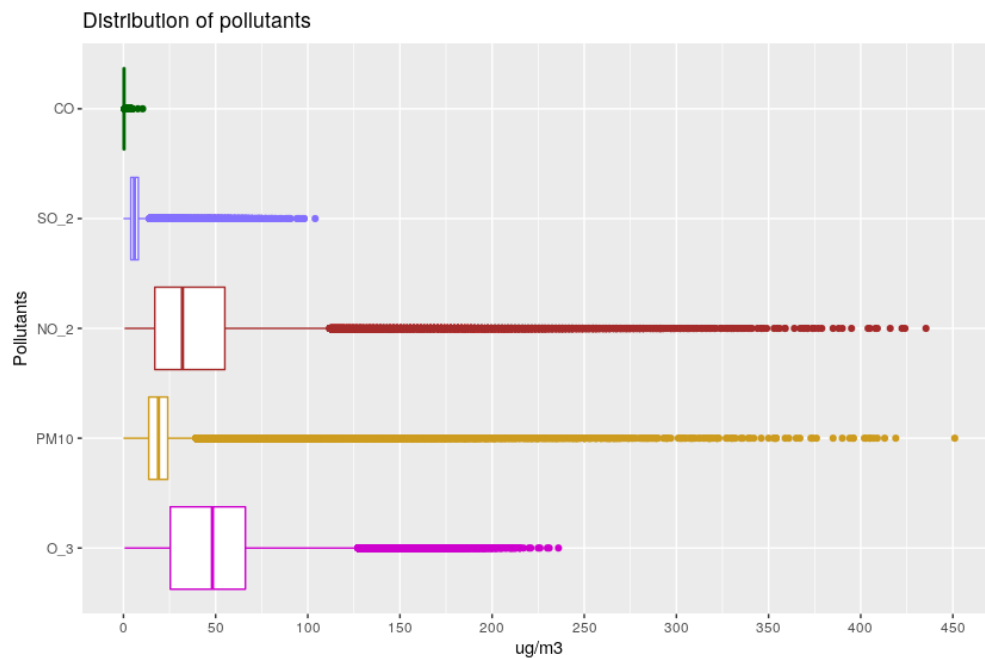
After the data wrangling step, we are ready to perform the exploratory data analysis.

To start the analysis, the distribution of the variables in our dataset in terms of center, dispersion and distribution descriptive measures, is analysed below.

After that, the linear relationships of the five variables are analysed, to determine the relations among them, if any.

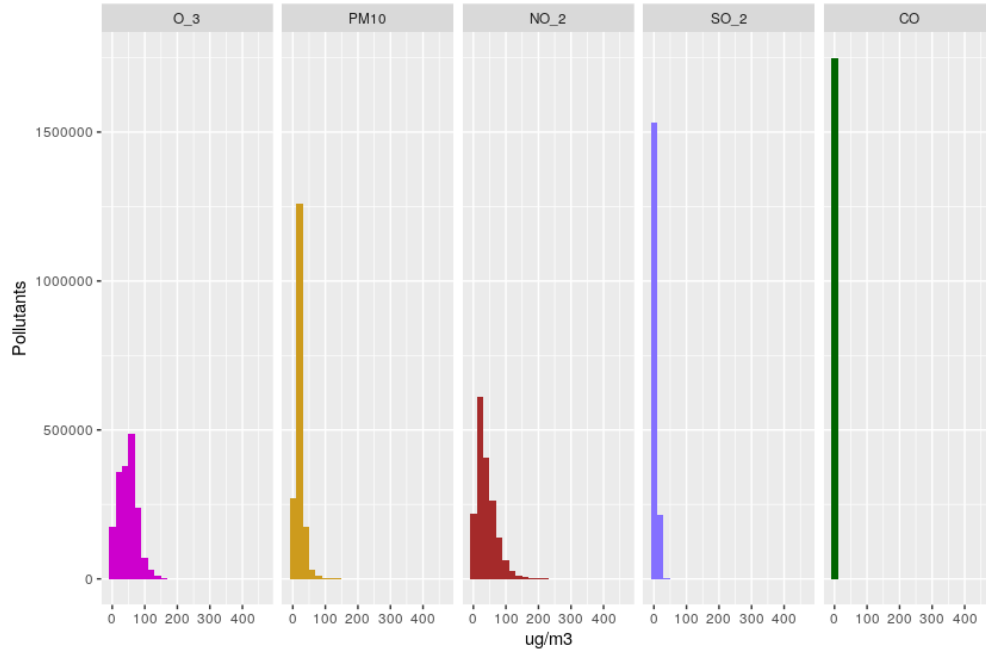
Center, dispersion and distribution measures

The plot below is useful to visualize the center measures of the five selected variables:



As we can see, variables NO₂, O₃ and PM₁₀ spread along wide ranges, while variables SO₂ and CO spread along narrower ranges. A characteristic that they all share is that all of them have many outliers or highly unexpected values.

The histograms below show a better insight of the shape of the distribution of the variables: as we can see, all of them are highly skewed to the right, so they don't follow a normal distribution.



In the plot above, we can also observe a phenomenon that leads us to the conclusion that, depending on what we want to do with the data in upcoming sections, it may be a good approach to normalize it: variables SO2 and CO always take values that are very close to 0, while the other variables can reach much higher values.

Linear relationships analysis

As our intention is to make predictions using our data, it is convenient to analyse the linear relationships among the features, if any. In order to do so, the correlation matrix is represented in the plot below:



In the plot, we can observe that the most correlated pair of variables is CO and NO₂, which are positively related with a value of 0.57. They are followed by O₃ and NO₂, which are negatively correlated with a value of -0.53.

In order to have an overall insight on whether there are high correlations among the five variables or not, we are going to calculate the determinant of the correlation matrix:

```
> det(r)
[1] 0.3320525
```

The value obtained is close to 0, but not small enough to conclude the existence of variables that are linearly dependent on others. There are correlations among the variables, but they are not high enough.

This result is coherent, as the variables recorded in our data seem to be the outcome of some other predictors which are not included in our dataset. For instance, a high number of manufacturing plants in the city, or high traffic levels, could be a direct cause of a high level of some of the gases that our five variables stand for, like SO₂.

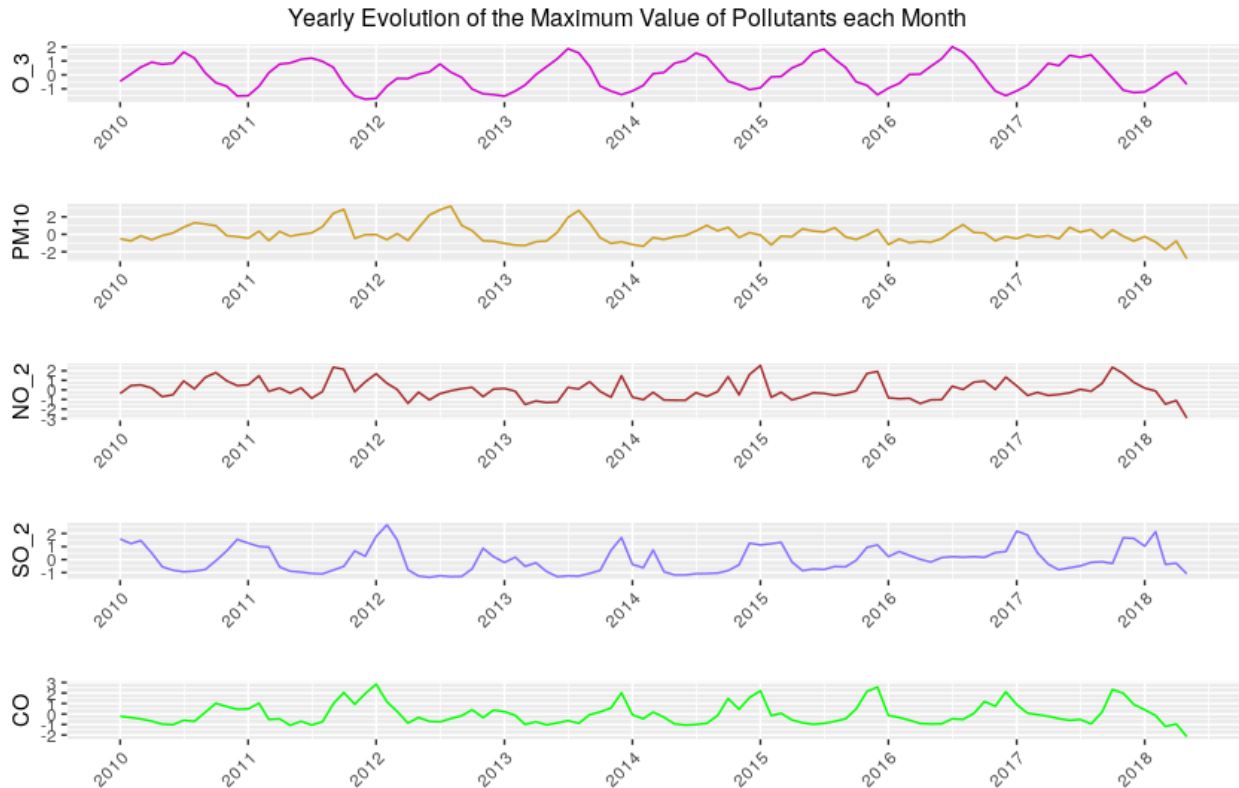
Due to these findings, in upcoming steps of this project we will not be trying to predict any of the five variables as an outcome of the others.

Data insights

It is interesting to answer some questions related to our data, in order to acquire some previous knowledge on how pollution behaves in Madrid's air, taking into account factors like year month and hour in the day, before proceeding to further steps in the project.

It is important to highlight that the questions that we intend to answer in this section are merely exploratory. We are still not trying to predict any phenomenon, but it may be interesting to find out some patterns in the temporal evolution of the five pollutants.

At first, it is interesting for us to observe the *yearly evolution of the maximum value that each pollutant reaches each month*. In order to do so, first the maximum value for each day on each month and year is computed. Then, the average value for each month per year is obtained. Note that the values have been normalized to be on the same scale. The resulting plot, looks as follows:



From the plot above we can see some curious information:

- the clear patterns followed by **O₃** and **SO₂** are the opposite: while the levels of O₃ reach their yearly maximum during the months in the middle of the year (summer months) and decrease towards the end of the year, we observe the opposite trend for SO₂, that reaches its yearly minimum values towards the middle of the year, and its maximum towards the end.
- **PM₁₀** levels have reached a more regular trend since year 2014. The trend of this variable is very irregular. This also happens with variable **NO₂**, which has an irregular trend aswell, but this variable seems to reach the yearly maximum value towards the end of the year, even though the maximum value can change a lot from one year to another.
- The temporal evolution of variable **CO** is more irregular than the one for SO₂ and O₃, but a pattern is also appreciated: the yearly maximum value is reached mostly towards the end of the current year and the beginning of the next one, in the coolest months.

Strength of relationships

Prediction

Results

Discussion and future work