ARPALData: retrieving and analyzing air quality and weather data of Lombardy (Italy)

Example for GRASPA 2023 annual meeting, Palermo 10-11 July 2023

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Abstract

Code for the example at Section 4 ‘Case study: air quality during COVID-19 pandemic in Lombardy’ of Maranzano P. & Algieri A. “ARPALData: retrieving and analyzing air quality and weather data of Lombardy (Italy)”. Presented at GRASPA 2023 annual meeting, Palermo (Italy) 10-11 July 2023.

Example: AQ during COVID-19 lockdown at municipal level

Step 0: Libraries

```r
library(ARPALData)
library(tidyverse)
library(ggplot2)
library(ggpubr)
```

Step 1: Download daily NO2 concentrations at municipal level from 2018 to 2021

```r
data <- get_ARPA_Lombardia_AQ_municipal_data(
  Year = 2018:2021,
  Frequency = "daily",
  Var_vec = c("NO2_mean"),
  Fns_vec = c("mean"),
  verbose = T,
  parallel = T
)
```

```
## Parallel ( 4 cores) download, import and process of ARPA Lombardia data: started at
## 2023-04-05 14:40:07
## Parallel download, import and process of ARPA Lombardia data: ended at
## 2023-04-05 14:40:34
## Regularizing ARPA Lombardia data: started started at 2023-04-05 14:40:34
## Processing ARPA Lombardia data: ended at 2023-04-05 14:40:35
```

```r
### Show the first 10 observations of the panel data
head(data, n = 10)
```

```
## # A tibble: 10 x 4
```

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```
##    Date                IDStation NameStation           NO2_mean
##    <dttm>                  <int> <chr>                    <dbl>
##  1 2018-01-01 00:00:00    101429 Abbadia Cerreto           32.1
##  2 2018-01-01 00:00:00    101339 Abbadia Lariana           17
##  3 2018-01-01 00:00:00    100380 Abbiategrasso             34.5
##  4 2018-01-01 00:00:00    100758 Acquafredda               35.7
##  5 2018-01-01 00:00:00    101154 Acquanegra Cremonese      24.5
##  6 2018-01-01 00:00:00    101269 Acquanegra Sul Chiese     28.3
##  7 2018-01-01 00:00:00    100514 Adrara San Martino        33
##  8 2018-01-01 00:00:00    100515 Adrara San Rocco          27.7
##  9 2018-01-01 00:00:00    100759 Adro                      52.4
## 10 2018-01-01 00:00:00    101155 Agnadello                 18.8
```

Step 2: Computing period averages (3rd March - 8th May) of NO2 concentrations from 2018 to 2021

```
### Filter obserations between 3rd March and 8th May of each year
data_spring <- data %>%
  filter(Date >= "2021-03-08" & Date <= "2021-05-18" |
           Date >= "2020-03-08" & Date <= "2020-05-18" |
           Date >= "2019-03-08" & Date <= "2019-05-18" |
           Date >= "2018-03-08" & Date <= "2018-05-18")

### Aggregate to yearly averages per municipality
data_y <- Time_aggregate(
  Dataset = data_spring,
  Frequency = "yearly"
)

### Show the first 10 observations of the aggregated dataset
head(data_y, n = 10)
```

```
## # A tibble: 10 x 4
##    Date                IDStation NameStation           NO2_mean
##    <dttm>                  <int> <chr>                    <dbl>
##  1 2018-01-01 00:00:00    101429 Abbadia Cerreto           19.9
##  2 2018-01-01 00:00:00    101339 Abbadia Lariana           12.2
##  3 2018-01-01 00:00:00    100380 Abbiategrasso             25.5
##  4 2018-01-01 00:00:00    100758 Acquafredda               15.4
##  5 2018-01-01 00:00:00    101154 Acquanegra Cremonese      14.0
##  6 2018-01-01 00:00:00    101269 Acquanegra Sul Chiese     13.1
##  7 2018-01-01 00:00:00    100514 Adrara San Martino        15.8
##  8 2018-01-01 00:00:00    100515 Adrara San Rocco          16.5
##  9 2018-01-01 00:00:00    100759 Adro                      24.9
## 10 2018-01-01 00:00:00    101155 Agnadello                 28.4
```

Step 3: Compute the reference value (middle) of the maps as the average NO2 concentrations in 2018 throughout the whole region

1. Observations for 2018 are filtered using *filter*
2. We compute the average of 2018 fro the whole region using *summarise*
3. We extract the value using *pull*

```r
### Compute reference value for the mean: average NO2 concentrations in 2018
mid_conc_2018 <- data_y %>%
  filter(lubridate::year(Date) == 2018) %>%
  summarise(mean(NO2_mean,na.rm = T)) %>%
  pull()
mid_conc_2018
```

```
## [1] 18.89532
```

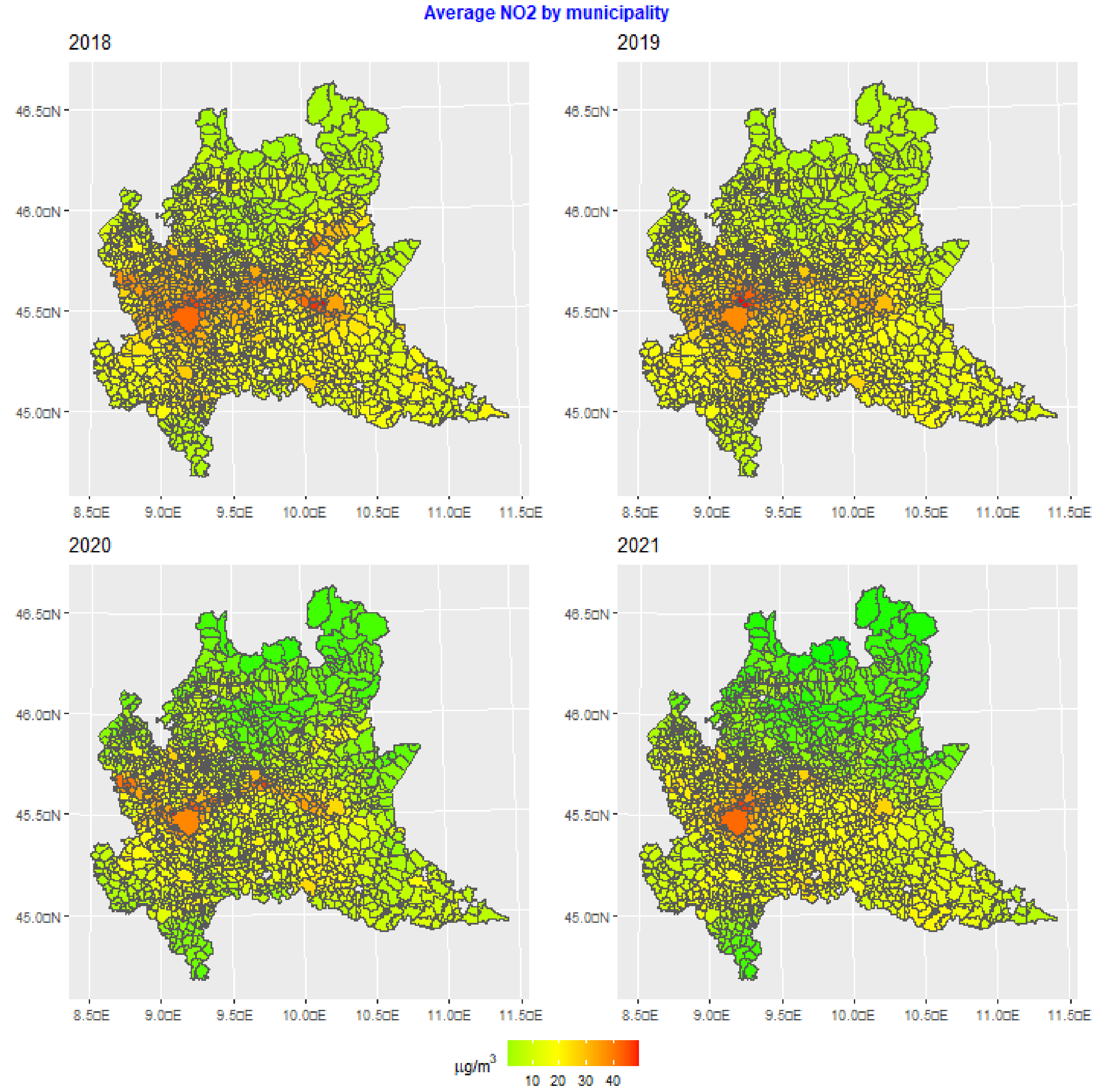
Step 4: Generate maps of average NO2 concentrations during the subperiod (3rd March - 8th May) from 2018 to 2021

```r
### Map for 2018
map_18 <- ARPALdf_Summary_map(
  Data = data_y %>% filter(lubridate::year(Date) == 2018),
  Title_main = "2018",
  Variable = "NO2_mean",
  val_midpoint = mid_conc_2018,
  Title_legend = expression(mu*"g/m"^"3")
)

### Map for 2019
map_19 <- ARPALdf_Summary_map(
  Data = data_y %>% filter(lubridate::year(Date) == 2019),
  Title_main = "2019",
  Variable = "NO2_mean",
  val_midpoint = mid_conc_2018,
  Title_legend = expression(mu*"g/m"^"3")
)

### Map for 2020
map_20 <- ARPALdf_Summary_map(
  Data = data_y %>% filter(lubridate::year(Date) == 2020),
  Title_main = "2020",
  Variable = "NO2_mean",
  val_midpoint = mid_conc_2018,
  Title_legend = expression(mu*"g/m"^"3")
)

### Map for 2021
map_21 <- ARPALdf_Summary_map(
  Data = data_y %>% filter(lubridate::year(Date) == 2021),
  Title_main = "2021",
  Variable = "NO2_mean",
  val_midpoint = mid_conc_2018,
  Title_legend = expression(mu*"g/m"^"3")
)
```

Step 5: Plot combined maps

During Spring 2020 Lombardy region shifted from a yellow-orange color (concentrations above the 2018 average) to more green-like colors (concentrations below the 2018 average). In particular, it can be seen that the alpine belt at North and the Apennini chain at South-West have experienced remarkable improvements. The situation in the highly industrialized and urbanized central belt still remains critical. Indeed, it should be noted that the four main cities in the region (Milan, Monza, Bergamo and Brescia) are connected by an orange stripe, perfectly overlapping with the route of the main highway in Northern Italy, i.e. the A4 Turin-Trieste highway.

```
### Combine maps: common legend and title
fig_comb <- ggarrange(map_18,map_19,map_20,map_21,
                      ncol = 2, nrow = 2, common.legend = T, legend = "bottom")
annotate_figure(p = fig_comb, top = text_grob("Average NO2 by municipality",col="blue",
        face = "bold"))
```



Step 6: Export maps to .png file

```
### Export maps
png(file="ARPALData_example_municipalities.png",width=1800, height=600,res = 100)
print(fig_comb)
dev.off()
```