# Predicting Air Quality

Smart Cities need to be capable to control the Air Quality. The European Air Quality Directive has set reference standard levels for PM2.5, PM10, O3, NO2, in some cases defining limits on the number of times a certain threshold can be exceeded as measured by the official sensors in the city, in the area; while in others cases the limits posed are with respect to average values in the year, measured by the same sensors. For example:

| | | Air Quality Directive | | WHO guidelines | |
|---|---|---|---|---|---|
| **Pollutant** | **Averaging period** | **Objective and legal nature and concentration** | **Comments** | **Concentration** | **Comments** |
| $PM_{2.5}$ | One day | | | 25 µg/m³ (*) | 99th percentile (3 days/year) |
| $PM_{2.5}$ | Calendar year | Target value, 25 µg/m³ | The target value has become a limit value since 1 January 2015 | 10 µg/m³ | |
| $PM_{10}$ | One day | Limit value, 50 µg/m³ | Not to be exceeded on more than 35 days per year. | 50 µg/m³ (*) | 99th percentile (3 days/year) |
| $PM_{10}$ | Calendar year | Limit value, 40 µg/m³ (*) | | 20 µg/m³ | |
| $O_3$ | Maximum daily 8-hour mean | Target value, 120 µg/m³ | Not to be exceeded on more than 25 days per year, averaged over three years | 100 µg/m³ | |
| $NO_2$ | One hour | Limit value, 200 µg/m³ (*) | Not to be exceeded more than 18 times a calendar year | 200 µg/m³ (*) | |
| $NO_2$ | Calendar year | Limit value, 40 µg/m³ | | 40 µg/m³ | |

For this reason, it becomes relevant to be capable to predict the Air Quality Indexes hours, days, weeks, months in advances. The predictions can be densely computed in the city as in the TRAFAIR project and Snap4City tools: https://www.snap4city.org/530 in which the predictions have been computed for NOX 24/48 hours in advance, every hour. The same approach can be used for predicting the diffusion of particles as performed in Helsinki by Snap4City: https://www.snap4city.org/528

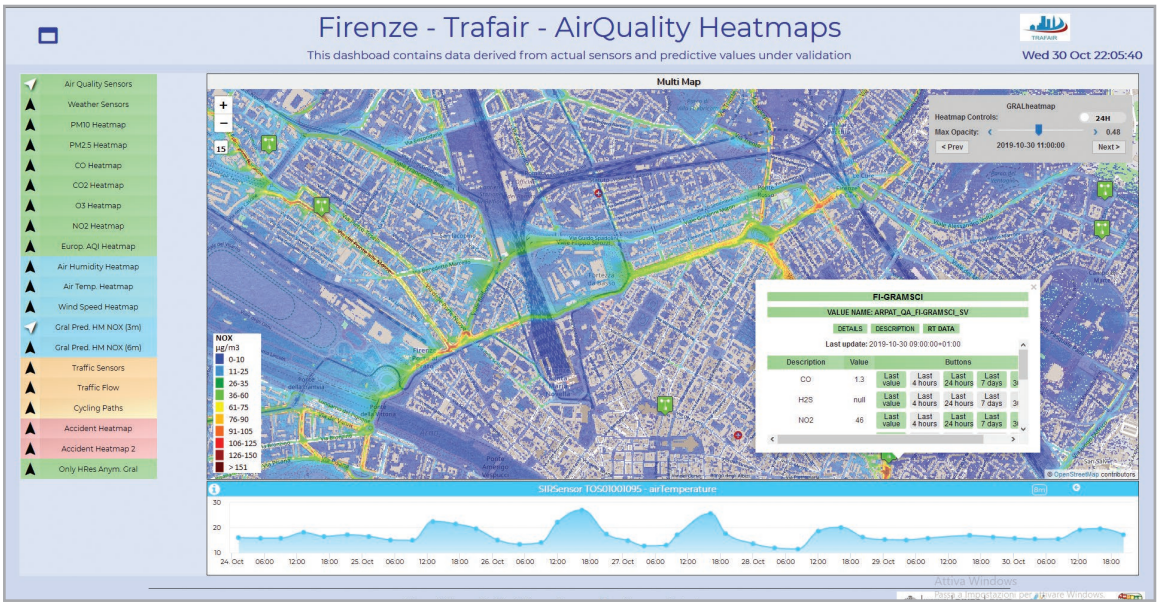
In this note, the approach to predictions Air Quality is punctual. Predicting when the measures PM2.5, PM10, NO2, etc., reference values will exceeded in the area so that one could prevent the exceeding changing the causes of emissions: works in the city, emissions for combustion, industrial emission, heating, etc. Most of the trends can be predicted on the basis of: historical data of the measures, environmental data (temperature, humidity, wind, ...), traffic, events, etc. Specific measures may depend on the sensor position and location context, on calibration, on the time of the measure, season, etc. A measure performed along a primary street in terms of traffic may strongly differ with respect to the actual values just in the garden of the house behind the primary street. To this end, mathematical methods have been set up to perform predictions of pollution diffusion and deductions. To this end, specific sensors and solutions become fundamental, such as: traffic flow sensors for monitoring urban mobility, traffic flow reconstruction, sensors for assessing air quality parameters, parking, traffic and RTZ sensors, weather forecasts, etc., together with the knowledge of the city structure, prediction model for environmental variables.

## Analysis of Pollutant in the city

## Predicting Days with Exceedance of Pollution

Big Data Analytic and machine learning may help in this sense. The idea of predicting the days in which the acceptable values are going to exceed is an anomaly detection problem.
In Snap4City environment the Hackathon team Greenifiers has demonstrated that is possible to predicting critical days for:

- PM10 with an accuracy of more than 90% and precision of 85%;
- PM2.5 with an accuracy of 90% and precision greater than the 95%.




https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTUzMg==

A further analysis can lead to identify what has to be suggested in terms of directive and limitations to avoid the exceeding of the limits. The city operators may regulate urban mobility, thus **providing the evidence** at citizens that they are living in a city sensitive to the quality of life, **predicting the overruns of law limits**.

Snap4City can collect data, manage processes for prediction, compute data analytics for data prediction, computing of limits, predicting the exceedances, detecting and predicting anomalies, etc. Heatmaps and Dashboards with predictions of environmental parameters in cities can be easily produced, to create early warning, and also supporting what-if analysis in the wide areas.

For example, the air quality regarding NOX (NO and NO2) is primarily related to the production of pollution from the vehicles running in the city. The computation of the traffic flow in all primary and secondary streets of the city is used to estimate the number of vehicles passing and producing pollutant in each road segment of the urban graph. The production of pollution is an input data for the predictive model to determine the air quality state in a given city using the GRAL model. Other sources of pollutant can be taken into account, and the diffusion in the model depend on the size and kind of particles and gasses. The GRAL model is based on modelling the flow of particles in the 3D shape of the city, taking into account wind, vegetation, etc. The approach can be also used for computing prediction on other kind of particles, such as PM10, PM2.5 as performed in Helsinki.

The figure above presents a dashboard on Snap4City reporting the predicted NOx concentration map in the city of Florence, Livorno and Pisa. A similar computation has been performed also on Helsinki for predicting the PM10 24 hours in advance. On the dashboard, you can navigate on several predictions, in past and future and you can see the 24H animation of the next and past days.

**Extended version accessible from:** https://www.snap4city.org/553
**Contact**: https://www.snap4city.org
**Partners:** Snap4City, Greenifier.