



## 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 PM<sub>2.5</sub>, PM<sub>10</sub>, O<sub>3</sub>, NO<sub>2</sub>, 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 <sub>2.5</sub>	One day			25 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 µg/m <sup>3</sup>	The target value has become a limit value since 1 January 2015	10 µg/m <sup>3</sup>	
PM <sub>10</sub>	One day	Limit value, 50 µg/m <sup>3</sup>	Not to be exceeded on more than 35 days per year.	50 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup> (*)		20 µg/m <sup>3</sup>	
O <sub>3</sub>	Maximum daily 8-hour mean	Target value, 120 µg/m <sup>3</sup>	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m <sup>3</sup>	
NO <sub>2</sub>	One hour	Limit value, 200 µg/m <sup>3</sup> (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m <sup>3</sup> (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup>		40 µg/m <sup>3</sup>	

For this reason, it is 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 and Snap4City tools: <https://www.snap4city.org/530> in which the predictions have been computed for NO<sub>x</sub> 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 PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>2</sub>, etc., reference values will be 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.

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.

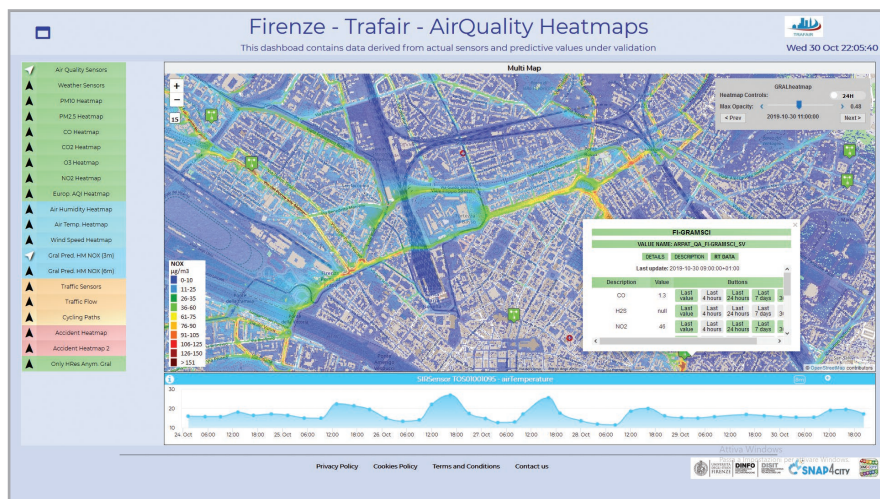
In Snap4City environment we demonstrated that it is possible to predict critical days for:

- PM<sub>10</sub> with an accuracy of more than 90% and precision of 85%;
- PM<sub>2.5</sub> with an accuracy of 90% and precision greater than the 95%.

Analysis of  
Pollutant in  
the city

Predicting  
Days with  
Exceedance of  
Pollution

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**.



## Long Terms predictions and Simulations

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,

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

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.

Other examples and connected scenarios:

- Air Quality Standards: <https://www.eea.europa.eu/themes/air/air-quality-standards>
- Directive: <https://www.eea.europa.eu/data-and-maps/figures/air-quality-standards-under-the>
- Air quality standards under the Air Quality Directive, and WHO air quality guidelines: [https://environment.ec.europa.eu/topics/air\\_en](https://environment.ec.europa.eu/topics/air_en)
- Scenario: High Resolution Prediction of Environmental Data: <https://www.snap4city.org/530>
- Scenario: Antwerp Pilot on Environmental Data: <https://www.snap4city.org/526>
- Scenario: Helsinki Pilot on Environmental Data: <https://www.snap4city.org/528>
- Trafair project: example of GRAL estimation: <https://www.snap4city.org/500>
- Traffic Flow reconstructions: <https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==>
- What If analysis dashboard online help: <https://www.snap4city.org/521>
- Environmental Data Definitions, and Predictive Models <https://www.snap4city.org/435>
- Air Quality Indexes <https://www.snap4city.org/413>
- Data Analytics: the cases of Antwerp and Helsinki, and general views <https://www.snap4city.org/524>
- Balancing of traffic in Florence, ingoing and outgoing flows: <https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc2MQ==>
- Dashboard on mobility on Florence: <https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=OTA5>
- Dashboard on mobility Pisa: <https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjUy>
- Dashboard with GRAL on Helsinki: <https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTQwNg==>
- Comparison Actual FMI, GRAL on Helsinki PM10: <https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTczMg==>

**Extended version accessible from:** <https://www.snap4city.org/553>

**Contact:** <https://www.snap4city.org>

**Partners:** Snap4City, Greenifier.