

# An Agent-Based Model for a participatory network of air quality sensors on bicycles

N. Coisne<sup>1,3</sup>, J.-F. Léon<sup>3</sup>, N. Verstaevel<sup>1</sup>, B. Gaudou<sup>1</sup>, E. Kaddoum<sup>2</sup>

<sup>1</sup>UMR 5505 IRIT, Université Toulouse 1 Capitole, France

<sup>2</sup>UMR 5505 IRIT, Université Toulouse 2 Jean-Jaurès, France

<sup>3</sup>Laboratoire d'Aérologie, Université Paul Sabatier, CNRS, Toulouse, France.

nathan.coisne@irit.fr

## Keywords

Bicycle traffic, Urban mobility, Air quality, Urban pollution, Agent based simulation, Synthetic population

## Abstract

Excessive concentrations of pollutants in the urban air are regularly observed, posing a long-term danger to the health of inhabitants. Monitoring the quality of urban air is therefore a very important issue to help stakeholders to take appropriate measures (reduction of road traffic...). The urban spatial distribution of air pollution is very heterogeneous and evolves rapidly over time. It is therefore important to develop reliable, fast, and spatially spread measurement methods. This last criterion is often hard to implement. For example, air quality measuring stations are very accurate, but their measurements are too local to obtain information on areas with no station.

In this work, we propose to study the usage of residents' daily bicycle traffic as a participatory network of air quality sensors, providing volunteer cyclists with an air quality sensor to use during their daily commute. To evaluate the effectiveness of such a network, we choose to build a multi-agent simulation based on the GAMA development environment that models a group of bicycle-mounted sensors mapping urban air quality. Traces of urban air quality collected by the sensors are then used to infer air quality at the city level. Results are compared with actual data from public air administration.

The model simulates the daily mobility of a synthetic population of cyclists in the city. The population (with age, activity, location) is created from census data provided by the INSEE French institute, trips data coming from House trip surveys of Mobiliscope (<https://mobiliscope.cnrs.fr>), and from geolocalized, time-stamped and anonymized travel data from private companies. The simulated daily routes of the bicycles are associated with pollution levels (NO<sub>2</sub> and particulate matter PM<sub>10</sub>) provided by a state-of-the art urban air quality model. The synthetic observations recorded along the bike trips are complemented by geographical information (height of buildings, natural areas, distance to highway, ...) that are obtained through Geographical information systems (GIS) and further used as predictor variables in a land use regression (LUR) model.

The dataset of synthetic information is used to infer a critical number of bicycles that would be required for an optimal assessment of the intra-urban air quality. To this end, we process the collected pollution data, for each time step, with extrapolation algorithms (eg. LUR) of the measured pollution concentrations and the city environment. For example, the distance of a point to primary roads is a relevant indicator for determining NO<sub>2</sub> concentration. Thus, by performing a regression to estimate the relationship between the distance to the main roads and NO<sub>2</sub> concentration, we can predict the NO<sub>2</sub> concentration at unmeasured points. Moreover, the impact of the cyclists' circadian rhythm on the monitoring of the daily cycle of pollutants is investigated. We also evaluate the opportunity for cross-calibrating the mobile sensors during the biker's Rendez-vous based on the daily agenda of the different biker categories.

## Additional material

All the models code is publicly available on : <https://github.com/Nathancoisne/participatory-bicycle-network>

## Acknowledgments

This work has been partially funded by the University Paul Sabatier in the frame of the neOCampus program.