Journal of Earth Sciences and Geotechnical Engineering, vol.6, no. 4, 2016, 245-254
ISSN: 1792-9040 (print version), 1792-9660 (online)
Scienpress Ltd, 2016

Air-noise observatory: regional and local scale exposure to air and noise pollution in Rhône-Alpes

Philippe Olivier[1], Didier Chapuis[1], Bruno Vincent[2], Sebastien Carra[2], Xavier Olny[3] and Bernard Miege[3]

Abstract

Air Rhône-Alpes, Acoucité and the Technical French State Services (CEREMA) have developed an environmental platform combining air quality and noise pollution on the Rhône-Alpes region. This platform, named ORHANE (Observatoire RHônalpin des Nuisances Environnementales - Rhône-Alpes region's Observatory of Environmental Nuisances) has been developed to identify and prioritize areas of overexposure to air and noise pollution. The information is delivered to the public as well as the decision makers who need reliable diagnoses in order to implement action plans.

Transport activity is the major source of nuisance for both air and noise pollution. Therefore, a very precise work was conducted on atmospheric and acoustic emissions of transport and on their dispersion modeling. Thus the result is a regional map of air quality and noise pollution. Thanks to the combination of models at different scales, this map is consistent and precise for both regional and local scale.

Currently, work is in progress to extend this platform to the larger territory of the new region Auvergne Rhône-Alpes and to update the current database. Moreover, this platform will be opened to the public in 2016 and its current results will be promoted to the local authorities in order to identify the overexposed areas and gradually lower them.

Keywords: air pollution, noise pollution, numerical modeling, observatory, environmental nuisances

[1] Air-Rhône-Alpes, Air Quality Monitoring Network, Bron, Rhône-Alpes, 69500, France
[2] Acoucité, Environmental Noise Observatory of Greater Lyon, Lyon, Rhône-Alpes, 69003, France
[3] CEREMA, L'Isle d'Abeau, Rhône-Alpes, 38080, France

1 Introduction

The approach of environmental diagnosis at European level is nowadays strongly oriented and encouraged by the European policy, through scientific and technical-oriented directive. Member States are often faced with a three-part issue consisting in:

- Harmonizing the European regulatory requirements with the pre-existing national regulatory procedures,
- Consolidating the link between the different environmental crossed diagnoses, both in terms of territory and in terms of kind of sources (air, noise…),
- Ensuring the consistency of approaches mostly delegated to the local authorities as regions or urban community.

This article offers to describe from an experimentation conducted on a 44 000 km2 territory and 6 million inhabitants, Rhône-Alpes, with an approach among the different stakeholders for a crossed diagnosis with themes such as noise and air quality. This approach steps forward a future information portal oriented towards the general public and decision makers. Furthermore, it intends to offer a methodology mainly aiming at minimizing the uncertainty related to the input data quality of the calculation methods.

The European directives in matters of noise and air impose a detailed knowledge of the impact of human activity on territories. The National Environmental Health Plans (PNSE) 2 and 3, declined in regional plans as PRSE, have placed the resorption of environmental black spots as a national priority. Simultaneously, the European regulation is being reinforced and calls for the implementation of perspectives and action plans evaluations.

For nearly 10 years, ACOUCITE and AIR Rhône-Alpes have been cross-cooperating and cross-intervening on the main tools acting at the local and regional levels in matters of transport policies and environmental impacts: Urban Transports Plan (PDU), Territorial COherence Strategy (SCOT), Plan for the Prevention of Noise in the Environment (PPBE), Atmosphere Protection Plan (PPA), Climate Air Energy Regional Strategy (SRCAE), etc. Both are more and more commonly solicited on the impact of road projects (Rocade Est, Aménagement Mermoz in Lyon …).

Rhône-Alpes is a pioneer region with effective expertise poles on noise (ACOUCITE) and air quality (AIR Rhône-Alpes). Through partnership with CEREMA (the Technical French State Services), these three structures have engaged into innovative works, which aim at providing local decision-makers with cartography on Air and Noise fragile points, by developing an index integrating

data on air (PM_{10} particles and nitrogen dioxide) and noise condition, revealing a co-exposure to both of these environmental nuisances. A web platform, named ORHANE (http://orhane.fr), will make these results public. The Rhône-Alpes DREAL and the Auvergne Rhône-Alpes Region financially support these works.

2 The method

The determination of fine scale cartography on the co-exposure to air and noise nuisances is based on a four-step methodology:

- Development of a regional basis of common sources of noise and atmospheric pollution;
- Development of an annual map of atmospheric pollution and of noise levels, in high spatial resolution (10m);
- Cross-referencing both maps in order to establish a unique map with an air and noise co-nuisance index;
- Cross-referencing the air-noise map with the population to establish a spatial diagnosis on exposition.

2.1. Regional basis of common sources of air-noise nuisances

The regional common database gathers all of the useful data to estimate the impacts of air quality and noise pollution associated to road, rail and air transport.

The work on road transport is greater, in terms of impact on cartographies and of the complexity of implementation. It consists in collecting all characteristics data on traffic travelling on major public roads of the study area (average flow of vehicles, ratio of heavy good vehicles, circulation speed of each type of vehicle…). This data is essentially generated from the results of traffic count and traffic modelling in agglomerations. Concerning noise pollution calculations, additional information on the topography of traffic lanes and noise protection devices should be gathered.

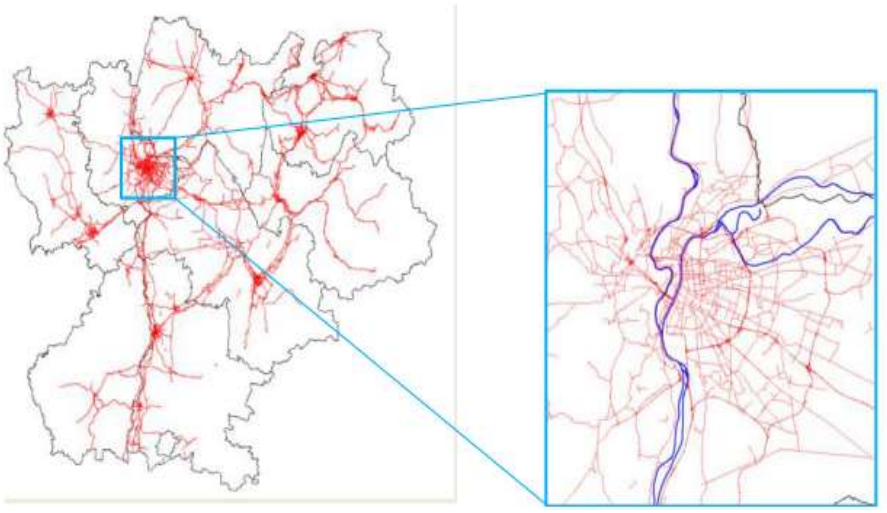

Figure 1. Harmonised regional traffic overview with a zoom on Lyon

In the same manner, a regional rail network was build, and each section of this network was documented in terms of traffic volumes, distinction of its activities (freight, major lines/TGV and TER), and proportion of diesel and electric locomotives by section. The tunnels were also identified, so that entry and exits could be treated as punctual sources for concentrations calculations, and hence ignored for the noise.

The work on air transport takes into consideration a dozen of airports, for which data on activities (number of commercial and non-commercial flights, type of airplanes) is gathered. A particular focus was brought on the location of airstrips and take-off and landing tracks.

2.2. Elaboration of annual maps of atmospheric pollution and noise levels

2.2.1. Air emissions calculations

The elaboration of an annual fine-scale map of atmospheric pollution first requires measuring emissions. The pollutants taken into consideration for this project are nitrogen oxide and PM10 particles.

The calculation of road transport pollutant emissions is based on a tool developed by Air Rhône-Alpes, which relies on the COPERT European methodology (Computer Programme to Estimate Emissions from Road Transport).

The calculation of rail transport emissions takes into account its diverse origins: combustion for diesel locomotives, which are mainly circulating on non-electrified railways, the wear of wheels, rails and breaks, and of catenaries for electrified

railways at the origin of particles emission.

The emissions of air transport also have various origins (taxiing and take-off, climbing or approaching phases, abrasion…), which match diverse spatial representations.

In the context of this project, work has also been led to represent on a fine-scale the contribution of the most important industrial emitters. Thus, the 100 emitting sites of nitrogen oxides and PM_{10} particles have been specifically treated.

Finally, all of the other emitting activities, especially in residential, service and agriculture sectors are quantified in order to be taken into consideration on a surface-based approach.

2.2.2. Elaboration of cartographies on atmospheric pollutants concentrations

The cartographies of atmospheric pollutants produced by Air Rhône-Alpes are generated from a modelling chain commonly used for the production of annual cartographies on air quality, thus beneficiating from validation and feedback for over ten years. The main principle of this chain resides in the combination of two concentration cartographies, each related to a specific treatment scale, regional and proximity.

The first cartography is generated from a calculation of regional models, the WRF meteorological model and the CHIMERE chemical-transport model (Menut and al. 2013). A statistical treatment enables the application of a correction on the modelled concentration fields, by exploiting the data on the network of Air Rhône-Alpes measuring stations.

The second cartography is generated from the SIRANE model (Soulhac and al. 2011), developed by the École Centrale de Lyon, which allows for the calculation of pollutants concentrations from a network of streets, taking into consideration the existing constructions, and the modelling of spatial distribution of pollutants concentrations, on a scale of almost ten meters.

This combination of models allows the conjoint phenomena representation of dispersion and chemical transformation of pollutants on a regional scale, and very precisely on a fine-scale neighbouring the principal emitting sources, for the production of high-resolution cartographies of pollution levels of nitrogen dioxide and PM_{10} particles.

2.2.3. Elaboration of noise levels cartographies

The elaboration of a noise map at the regional scale required beforehand a modelling for each of these three sources: road, rail and air traffic. This procedure

involves the work of three partners: Acoucité, the CEREMA and the Safety Civil Aviation Centre-East Directorate (DSAC-CE):

- Acoucité, using the Mithra SIG software, and the NMPB2008 calculation standard for the calculation of acoustic emission and propagation, calculated the road noise cartography.
- The rail noise cartography was the result of the calculation undertook by the CEREMA, using the Mithra SIG software and the NMPB-Fer-2008 calculation standard.
- The DSAC-CE provided the air noise maps for airports and aerodromes near the agglomerations. These maps were calculated with INM and use data based on short or average term traffic hypothesis (Noise Exposition Plan or Noise Annoyance Plan).

For each of these three sources, a 10x10 metres matrix is produced with the global noise index L_{DEN}. A noise index is then calculated, on each geographical point, combining the 3 indexes (multi-exposure), according to the principle of accumulation of the "annoyance equivalent road noise reference", admitted by the European Union.

2.3. Elaboration of a unique cartography of an air and noise co-nuisance index

The cross-referencing of both fine-scale cartographies, respectively atmospheric and noise pollution, required the creation of a unique composite index. To this end, two specific indexes were developed, one for the air, the other for the noise, on a 6 classes scale, of which the boundaries were conditioned to the existing regulation:

- The NO_2 class refers to the average annual concentration of NO_2 projected on the 6 classes scale;
- The PM_{10} class refers to the daily threshold exceedence (daily average of 50 µg/m3) projected on the 6 classes scale;
- The Air sub-index refers to the maximum value of sub-index NO_2 and PM_{10}, rounded to a whole number;
- The level of global noise annoyance is also converted into a "noise multi-exposure" index that can vary from 1 to 6.

Lastly, the final co-nuisance index is calculated with the average of the air index and the noise index.

		index value - area	1 - Very low exposure area	2 - Low exposure area	3 - Impaired area	4 - Degraded area	5 - Priority area	6 - High-priority area
Air quality	NO_2	Air Concentrations ($\mu g/m^3$)	≤ 11	11 - 29	29 - 35	35 - 40	40 - 60	> 60
	PM_{10}	Number of days of exceedence	≤ 10	10 - 25	25 - 31	31 - 35	35 - 53	> 53
Noise	L_{DEN} ref. road	Noise multi-exposure index	≤ 55	55 - 60	60 - 65	65 - 70	70 - 75	> 75

Figure 2. Determination matrix of the air and noise co-nuisance index

2.4. Population exposure

From the exposure and co-exposure indexes, and an affectation of population in residential buildings, a statistical estimation of the number of persons affected by the noise, the air pollution or both is realised. This information is compatible to those asked by Europe in matters of reporting.

The cross-referencing of "pollution x population" is aggregated to the municipality, while retaining the distribution data by index class. This index provides a weighted vision of the issues on the territory, highlighting the coincidental situations between pollution and human presence.

3 The results

The estimation results of the index of co-exposure to the air and noise environmental nuisances, and exposure of the population, are made available to the public on a dedicated website, which is expected to be operating in 2016.

This website offers a cartographic interface allowing the visualisation of the Air-Noise index at different scales, throughout the Rhône-Alpes region, up to a 10 meter resolution through successive zooms. The cartographies proposed here provide a very detailed geographical delimitation of the areas exposed to the different classes of the index. An example of the visualisation is presented on the following figure:

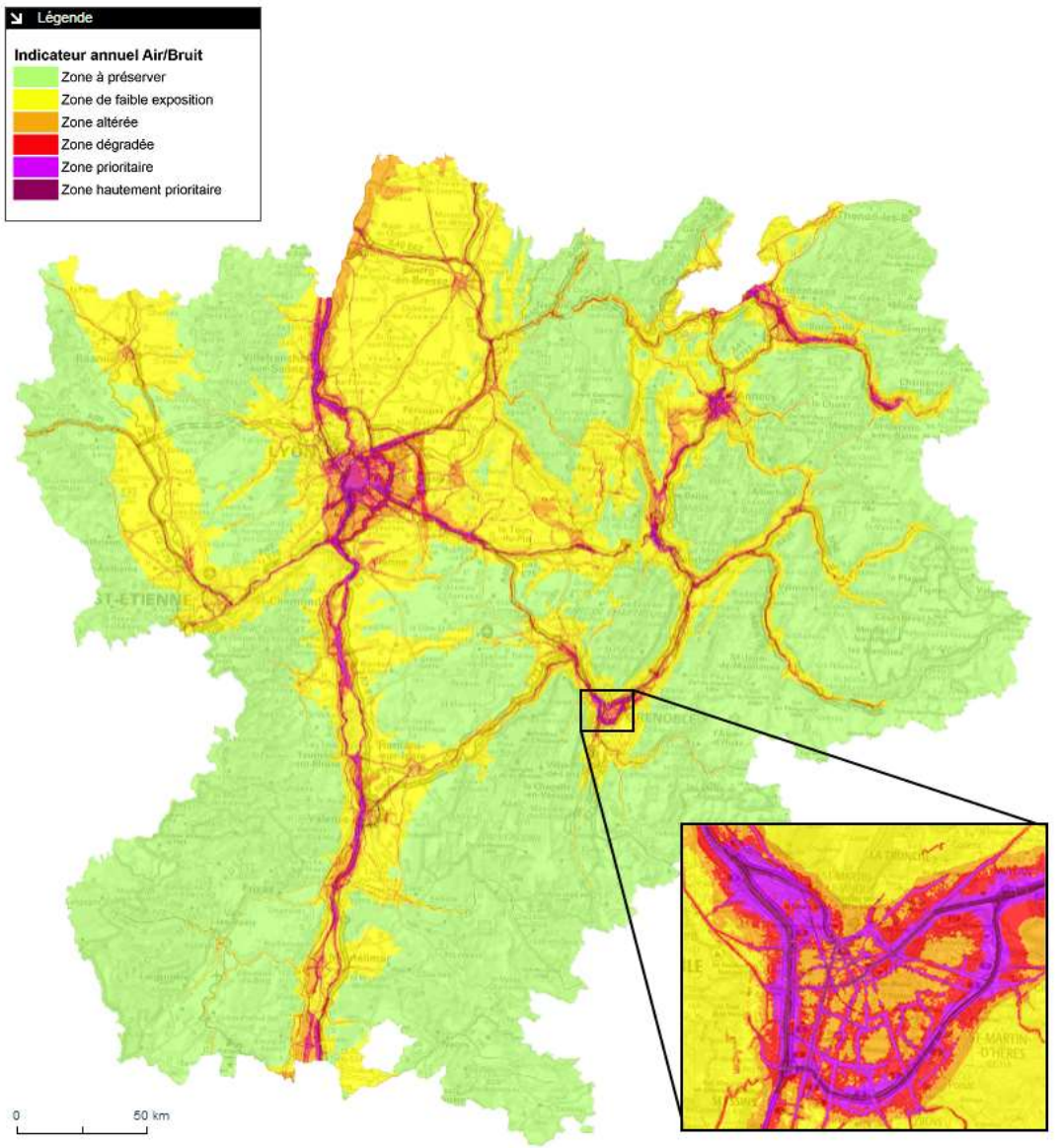

Figure 3. Example of the Air-Noise index cartographies: Rhône-Alpes region and zoom on the Grenoble agglomeration

The maps of the population co-exposure to the air and noise nuisances are presented on the website on a municipality scale, in the form of histograms of population distribution according to the 6 classes of the Air-Noise index (portion of the municipality population exposed to each class of the index). An example of the visualisation is presented in the following figure:

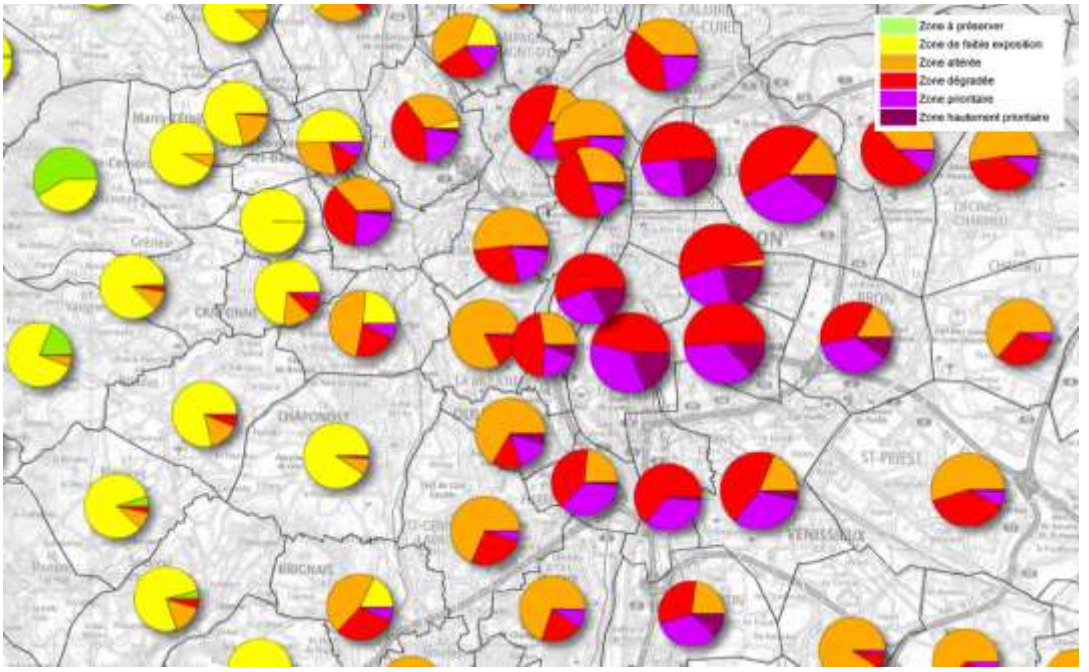

Figure 4. Example of cartographies of co-exposure of population to the air and noise nuisances

4 Perspectives

This first work fuels a thematic to which the interest, in terms of environmental health and territorial socio-environmental inequalities, is growing.

A first challenge is located at a technical level:

- The law n° 2015-991 of August 7th, 2015, based on a new territorial organisation of the Republic, effectively merges the Auvergne and Rhône-Alpes regions. In this context, the works and the platform will be extended to the Auvergne territory, as of 2017, following the same methodology, involving an update of data on road traffic (traffic counting), pollutants emissions, population data, etc.
- The tool created may allow the integration of other parameters

describing environmental nuisances. It is a perspective that will be carefully studied, for example in the context of the National Environmental Health Plan 3 (PRSE3).

A second challenge lies on a rather political and strategic level. It aims at promoting this diagnosis tool towards the territorial communities, city and urban planners, in order to reduce the exposition of populations to nuisances in areas identified as overexposed or to not degrade this exposition in preserved areas.

Acknowledgments

The stakeholders of this project thank the Auvergne Rhône-Alpes region and the DREAL Rhône-Alpes for their financial support, as part of the PRSE2.

References

[1] Ben Salem N., Garbero V., Salizzoni P., Lamaison G., Soulhac L. (2015): Modelling Pollutant Dispersion in a Street Network, Bound.-Layer Meteorol. vol 155, p 157–187

[2] Miedema (2002), Position paper on dose response relationships between transportation noise and annoyance

[3] Soulhac L., Salizzoni P., Cierco F.-X., Perkins R. J., (2011). The model SIRANE for atmospheric urban pollutant dispersion: PART I: Presentation of the model. Atmospheric Environment. vol 45, p 7379-7395

[4] Menut L., Bessagnet B., Khvorostyanov D., Beekmann M., Blond N., Colette A., Coll I., Curci G., Foret G., Hodzic A., Mailler S., Meleux F., Monge J.-L., Pison I., Siour G., Turquety S., Valari M., Vautard R., and Vivanco M. G. (2013): CHIMERE 2013: a model for regional atmospheric composition modelling, Geosci. Model Dev., vol 6, p 981-1028