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URBAN FABRIC AND MEASURES OF VARIABILITY: NEIGHBORHOOD EFFECTS ON PROXIMITY POLLUTION

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1.INTRODUCTION

This paper reflects the work achieved for demonstrating the potential influences of geometric features on atmospheric pollutant distribution over metropolitan's areas. Actual methods seldom take into account morphological aspects and structural characteristics of city of interest. Hence, influences of urban forms on pollutant distribution are presently investigated in urban atmospheric pollution researches at various scales, from local to global urban area.

In fact this multi-scale problem is generally studied on a single scale (local, meso or global) but the total effect of streets network and urban units together are rarely mixed. The interaction of several scales of pollutant observations (points-measurements, close surrounding area, streets and global urban area) is a particularity of the present work. This project is applied to the city of Strasbourg, France. Its objectives are to:

- precisely define the morphological elements which influence the pollutant distribution;
- spatialize the measurements with the help of satellite data, taking benefits from previous results.

Therefore this research project explores:

- the combination of different scales (from points-measurements to the complete urban community of Strasbourg);
- different methods (mathematical morphology, spatial analysis, interpolation, extrapolation, ...);
- different modeling approaches (from a single street to the total urban area);
- and different geographical and pollutants data sources (points-measurements, geographical databases, remotely sensed data).

The benefits of the decreasing SO^2 and NO^2 values since several years in European cities are erased by an overpass of the general norms fixed by the EU15. 37 millions of inhabitants are daily exposed to high pollutants values in European cities (among those which are equipped with measurement network) [1]. Such situations are not only representative of European countries, developing countries are also facing this problem. The climatic urban profile must be more analyzed than previously, in order to get not only a precise but located understanding over time but also to define complementary spatialized measurements campaign events. The collected data would enrich the knowledge gathered over different observation scales: local to global. Urban pollutant distribution needs rather adapted observation scales allowing studying internal variability. Most of the transportation and distribution pollutant models are developed according a 1*1km grid, so it seems to be worthwhile to precise explanation elements (land cover, built density, etc.) at a rather large scale to enhance these results.

This research program deals with a better understanding of pollutants distribution processes at different scales. The design of some quantitative indicators on measurements spots network is presented. They are developed for comparison purpose and variability assessments in urban transportation pollutant studies. Thus, they are exploited for the extraction of parameter inputs in the models of pollutant distribution, the spatialization of collected data using remotely sensed data and the representation of pollution events according to public and legal obligations

2.AIR QUALITY ASSUMPTION AND STRASBOURG CASE STUDY

Several studies propose to analyze transportation and pollutants distribution processes in a global understanding rather than to consider only pollution heights [2]. It implies to observe the daily exposure to pollution through a set of indicators allowing to enhance knowledge and estimation of urban pollution level and to disseminate results throughout populations and politic decision-makers. This study deals with such goals, observing air quality through the interactions between distribution processes and urban forms.

The new European directive on Air quality promotes control and management of crisis situation in case of overlapping values of pollutants (30/12/1996) regarding European norms. Information has to be dispatched to alert the population in case of such situation and to stop or to push off course traffic transportation. To handle this situation, two objectives must be followed: the pollutant measurements must be defined at different scales and the pollutant distribution has to be the spatialized. It means that over the urban area, we might be in position to locate pollution peaks, and also to represent areas that are exposed to a too high level of pollutant particles. Such delimitation of urban area is uneasy and rather delicate toward public authorities.

Complementarity of embedded scales of observation is obvious from the measurement spot to the global urban area, but the relationships between these levels are complex and insufficiently understood. Several problems rise up when dealing such questions, such as the measurements spots network. The representativity of these measurement spots (urban, industrial, rural, traffic one, etc.) needs to be assessed according national or international typologies. It has to be noticed that such typologies change over time, over countries and even over region of the same country. The relationships between the measurement spots (its characteristics), and the interpretation accorded to the measurement values collected, may change if some variability is introduced. In this study, we cope with the observation of this representativity and we try to gather qualitative and quantitative indicators able to describe the measurement spots.

In order to spatialize the values collected through the irregular measurement network, it is necessary to perform a spatial representation of the collected values. To cope with this task, remotely sensed data are used in order to guide this realization. Based on the relationships between pollutant and dust particles and the spectral values of satellite images, previous studies [3] [4] [5] [6], have demonstrated that pollutants spatialization might be approached by this way. This solution needs several indicators to perform the relationships study, for instance collected values of course and also quantitative indicators on the close surrounding area of the different measurement spots. In fact it is necessary to get a maximum of information on this area in order to match with the spatial resolution of the satellite image used (Landsat TM, 30m*30m). Thus the more information collected around measure locations, the more the possibility to understand these specific relationships.

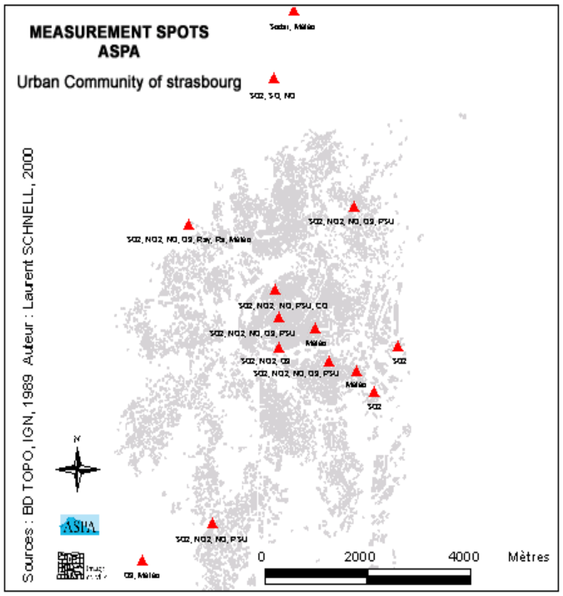
Several questions appear when dealing with those goals:

- Could some indicators be attached to measurement spots in order to get comparison values in a quantitative format?
- Could we observe specific behavior among the different spots?
- Are they some impacts of the geometry of the measurement areas on the collected values?

Such results assume to provide some information on feasible urban variability at a large scale. The relationships between spots, streets and general area might be more understandable with such explanatory elements. Different types of indicators might be listed for instance: the class of measurement spot, the surface of the surrounding area, its land-cover characterization, the volume of the spot according to the heights around, the number of streets linked with the spot, the density of built surfaces, the density of population concerned by the spot and consequently by the pollutant values collected...

The city of Strasbourg is located in Eastern France at the border of Germany. L'Association pour la Surveillance et l'étude de la Pollution Atmosphérique en Alsace (ASPA) is the local organization in charge of the air quality measuring network in the city of Strasbourg and vicinity. The case of Strasbourg-France ($306 km^2$) is interesting because a large set of measurement spots is spread over the area. 14 spots are listed. The measurement network is rather old and provides time series data since about 1980 according to national typology requirements (figure 1). All the spots collect large or peculiar data sets.

Figure 1: Typology of the Pollutants and particles collected by the measurement spots



▲ Localization of the measurements spots

Measured paramaters

CO	Monoxyde de carbone
NO2	Dioxyde d'azote
NO	Monoxyde d'azote
O3	Ozone
PSU	Poussières
SO2	Dioxyde de soufre
SO	Monoxyde de soufre
Ra	Radioactivité

Ray	Rayonnement global, diffus, infrarouge, ultraviolet A, direct et insolation
Sodar	Profileur de vent accoustique mesurant la composante des vents de 100 à 1200 m (Profil de vitesse horizontale, de direction, de turbulence et de température)
Météo	Direction et force du vent, température, humidité

3. STEPS OF STUDY AND COLLECTED DATA

The different steps developed in this study are complementary. The general process articulates observation and spatialization and anticipates the inputs/outputs the results might provide.

These steps focuse mainly on the measurement spots description liable to allow comparisons. The use of the third dimension to characterize built area and design geometric indicators introduces urban forms in the approach. The hypothesis here, is that at a micro scale, forms have some influence on urban climatic profiles. Data sets collected (table 1) are numerous describing measurement spots, buildings and streets, socio-economic data (population, density of population), relations with streets (removal of traffic source). It has to be noticed that the streets have been studied also, but the results will not be developed here. Each building is described by the location coordinates (x, y) and the z value (height) in a geographical database (BD TOPO© IGN). The points-measurements sites were qualified according to morphological indicators and a representativity indicator of the sites defined. The geographical database was also exploited for the extraction of parameters as inputs of the models of pollutants transport [7].

The capacities of the GIS software (Arcview© 3D analyst) allow the obtaining of a 3D representation of the measurement areas and also performing of several spatial analyses over buildings or heights for instance. This is obtained by extrusion of the volumes through a hybrid process able to dissociate two buildings placed side by side.

Table 1 - Measurement spots indicators

Measurement data	**Close surrounding area**	**Buildings**	**Socio-economic data**	**Street data**
Meteorological	Surface	Coordinates	Population	Distance to
Pollutant data	Volume	Height	Density	Traffic
	Land-cover			Orientation

4.RESULTS

Performing GIS analyses provide different indicators about measurement spots. These indicators will be used for two purposes: (1) the study of the representativity of measurement spots and its close surrounding area; (2) the extraction of parameters for “ virtual station ”[8] in relation with the satellite data in order to describe as precisely as feasible the location and the associate spectral values. They have to be defined according comparison criteria among the spots of the same city but also regarding networks of other cities.

4.1Spot measurements definitions

Two main types have been developed relying on usual collected values and geometry of urban forms over three “ urban measurement spots ”. The first is associated to the general behavior of the collected date, meteorological data and pollutant information. They provide an idea of the variability of the spots values. The second deals more with geometric information due to urban forms and heights use. The three urban spots (Kleber, STG centre, STG est) have been chosen for the characteristics of the location (near the center of the city) and the specificities of the urban forms of the close surrounding area.

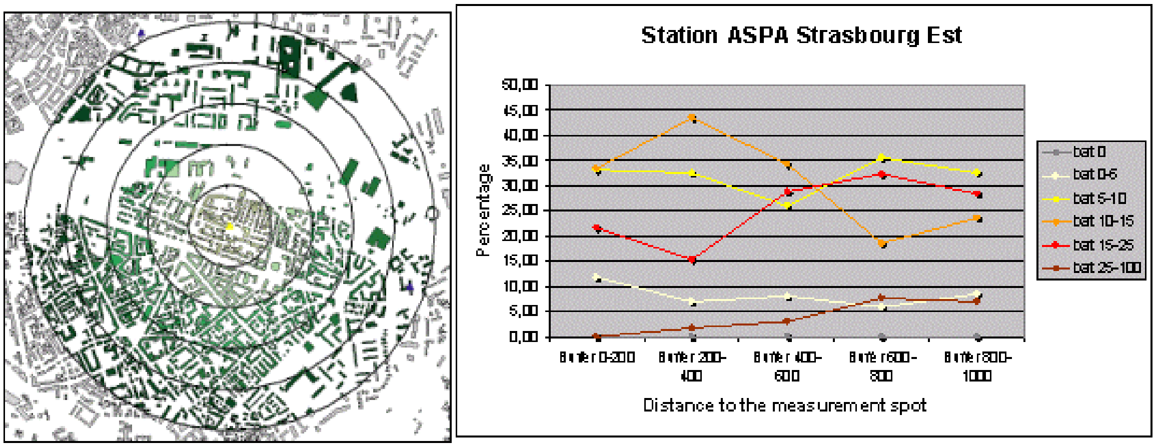
4.1.1 Urban spots descriptors

The meteorological trends provide general behavior of the measurements spots, their nycthemeral and seasonal rhythms. The land-cover data extracted from remote sensing data processing give information on the land-cover/use types associated with the measures location and allow considering the associate spectral values.

4.1.2 Geometric descriptors

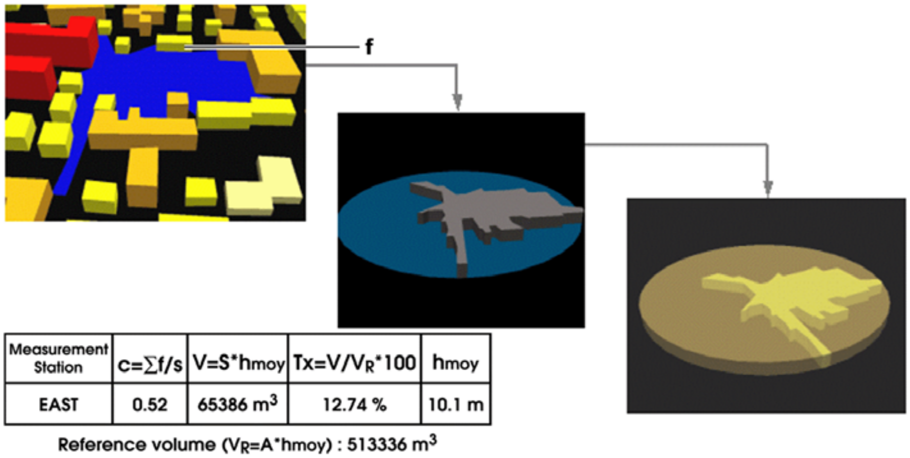
In order to describe the close surrounding area and the possible relationships between forms and measured values, we have defined a peculiar surface (S) corresponding to the “ visible ” area from the measurement location and the total surfaces of the houses’ fronts (f) concerned by the surface (Σf) [9]. Other information are collected like the number of streets connected and type of street. This type depends on the number of lanes, the height of buildings related to the width of the street, the type of buildings, etc. Another area has been taken into account, defined as the exposed population density inside a 1km radius around the location (A). This area have been divided into five embedded circles, each of them being able to allow extraction of data on building densities per distance, heights of buildings per distance and sectoral information (figure 2).

Figure 2: Geometric information on close surrounding area



Volumes have been also used to describe the measurement spots. In particular they allow extraction of comparison features enabling to look at the difference between a stuffy volume or on the contrary an open one. Using a reference volume (V_R) = (Hmoy*A) where Hmoy is the mean height of the surrounding buildings) it is possible to obtain several indicators linked to urban forms (figure 3), like:
(V) related to S (Hmoy*S) and the form rate (T_V = V/V_R*100). These descriptors provide quantitative features that complete the observations on measurement spots.

Figure 3: Volumetric descriptors



Measurement Station	$c=\Sigma f/s$	$V=S^*hmoy$	$Tx=V/V_R^*100$	hmoy
EAST	0.52	65386 m^3	12.74 %	10.1 m

Reference volume (V_R=A*hmoy) : 513336 m^3

5.DISCUSSION AND CONCLUSION

This study is still on going and must be developed on various directions: the interactions between measure location, surrounding area, street and global urban area. We have set down that some relationships might be identified and described in order to improve our knowledge on pollutant transportation and distribution. We have extracted several indicators that can be used to characterize measurement spots and the close surrounding area, in different ways. This approach has to be developed to assess measurement spots representativity inside a network but also through different networks. These indicators are also useful to reinforce the relationships between locations and spectral values due remotely sensed data.

6. ACKNOWLEDGEMENTS

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