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Numerical Simulation of Effect of Urban Geometry Layouts on the Wind in Outdoor Spaces under Mediterranean Climate

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Abstract-The use of the method "simulation" of the microclimate for an urban site presents much of interest; because this can serve as us observation and analysis of the consequences of various scenarios relating to the existence and the importance of the constituent elements in urban space. Wind in outdoor urban space is among the most difficult parameters to identify and control field given its instability. Currently, in the field of the ventilation, there are some outdoor spaces simulation tools, used to assess the flow of the wind at different spatial scales. The aim of this research is to demonstrate the effect of the urban geometry of the layout on the wind movement and the outdoor natural ventilation. However, this study investigated the effect on outdoor thermal comfort of a building layouts in a planned residential area situated in the city of Jijel humid Mediterranean region of Algeria. In order to improve outside comfort in this open space, a 3D numerical simulation tool ENVI-met 3.1 beta 4 was used to simulate the urban thermal climate taking into account various scenarios. Thus, simulation's results are discussed in this paper.

Keywords- *Urban Outdoor Spaces, Wind, ENVI-Met3.1Beta4*

I. INTRODUCTION

Wind is the phenomenon of great complexity. It is the clearest manifestation of the atmospheric circulation. Therefore, know and understand the wind is an important issue. However, various experimental and theoretical analyses have been performed in order to study wind flow. This leads us to make a state of the art for presenting the variables and their interactions in different facets. The research review was conducted to evaluate the effect of the wind, taking into account several parameters, namely the orientation, shape of buildings, their spatial arrangement, the angle of incidence of the wind, vegetation.

(Zhang A. et al., 2005) studied by simulating, the effect of the arrangement of buildings on the wind flow for different configurations in southern China. By comparing different building schemes, it is found that the wind field depends strongly on the building layout and the wind direction. The influence of the arrangement of buildings on increasing the speed of the wind and its effect on pedestrian comfort has been examined by (Katarzym K.et al., 2004) in Warsaw region. A numerical study of the wind speed conditions in passages between parallel buildings has been conducted for a wide range of passage widths with CFD code Fluent 6.1.22 by (Bocken B. et al., 2007). The results indicate that, at least for the cases studied, the increase of wind speed in passages is only pronounced at the pedestrian level and that the flow rate through the passage is at most only 8% higher than the free-field flow rate, indicating that the so-called Venturi-effect is rather weak. (Gomes et al., 2006) examines the effects of wind on and around buildings with irregular shapes, in particular L-form and U, by using experimental and numerical data. It was found that the pressure distribution can change substantially with the shape of the building and the angle of incidence of wind. A study that concerning the effect of a group of building on wind flow and pedestrian comfort in outdoor spaces was conducted by (Mazouz et al., 2008) in arid and semi-arid areas. A numerical evaluation of the wind in hot and humid climates has been realized by (Bonneaud and al., 2001), examining how urban morphology and urban geometry influence ventilation. In order to determinate the optimal design of complex buildings, for better thermal and aerodynamic comfort in China, (Chen Q., 2007) proposes a numerical simulation with CFD.

Different studies results' showed that natural ventilation in a humid urban city depends on good organization of the layout to create air movement, open spaces, permeable to wind during the warm season, and also to protect it from strong winds in winter.

The aim of this research is to demonstrate the effect of the urban geometry of the layout on the wind movement and the outdoor natural ventilation, under Mediterranean climate.

II. CASE STUDY

A. *Presentation of JijeL*

Jijel, a coastal city, located in the north-east of Algeria, between the meridians 5° and 6° 25 East Greenwich, and between 10 and 36° 50, North Hemisphere (Figure 1). This region is characterized by Mediterranean maritime climate. It is considered one of the most humid and rainy town of Algeria. It belongs to the Mediterranean climate, rainy and mild in winter, hot and humid in summer.

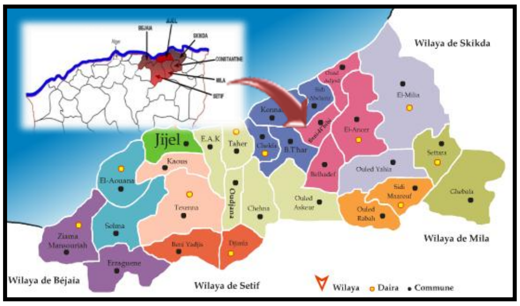

Figure 1. Location of Jijel and limits

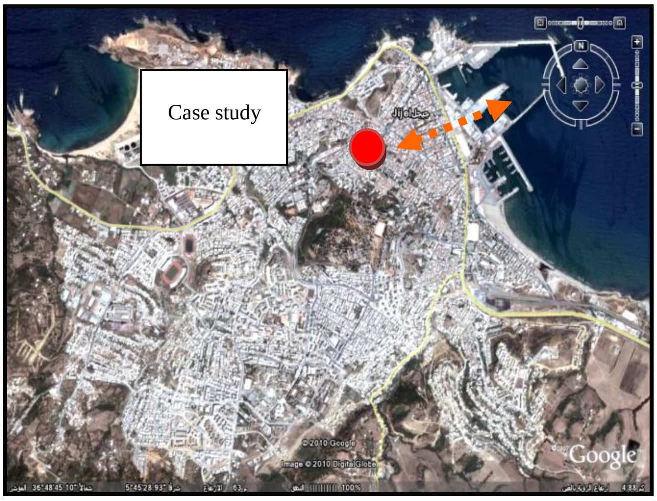

Figure 2. Location of the case study

Figure 3. Layout of case study; plan, sections and views

The maximum wind speed is between 3.20 m/s in the month of December and 17.8 m/s in March. For the summer season, the maximum wind speed varies between 14.9 m/s in the month of August and 18.2 m/s in September. According to the compass rose made by the specialized services of the meteorological station of Jijel during the period of January 1rst 1999 to December 31th, 2008, we can deduce:

- The prevailing winds of winter are direction N to O.
- The frequency of wind speeds is divided by classes as follows:

  - 1 to 3 m / s: 11.1 %.

  - 3-6 m / s: 30.5 %.

  - 6 to 10 m / s: 11.6 %.

  - 10 to 16 m/s: 1.4 %. To the north class 3-6 m/s

  the frequency is 4.76 %.

- The frequency of calm winds is 45.45 %.
- The frequency of strong winds is 1.4 %.

B. Case study:

This study investigated the effect on outdoor thermal comfort of a building layout in a planned residential area (Figure 2.) situated in the city of Jijel, humid Mediterranean region of Algeria (Table 1).

TABLE I. FEATURES OF CASE STUDY

Case study Localisation	Features
City center (colonial core) Altitude = 16m (Figure2.1)	-Ratio H/W= 0.44 (clear form) - Walkways holes in buildings - Central area cleared. - Presence of dense vegetation. - Near the sea (700m)

III. METHODOLOGY AND NUMERICAL SIMULATION:

A. Choice of simulation software ENVI-met

ENVI-met is a free software developed as a research project in 1998 by Dr. Michael Bruse from the Institute of Geography at the University of Bochum in Germany. It is a three-dimensional non-hydrostatic model used for a dynamic time, and is designed including analysis by simulation the interactions between the elements of design urban (buildings, surfaces and plants) and microclimates on a small scale that which concerns the fragments of a city. The function of the software is done by solving the basic equations for the physical power of wind, thermodynamics and equilibrium radiation surfaces. This freeware whose name is derived from the term "Environmental Meteorology" for various application areas: Geography and Spatial Dynamics, Economics and Management Urban, Urban Morphology and Urban Physics (Figure 4).

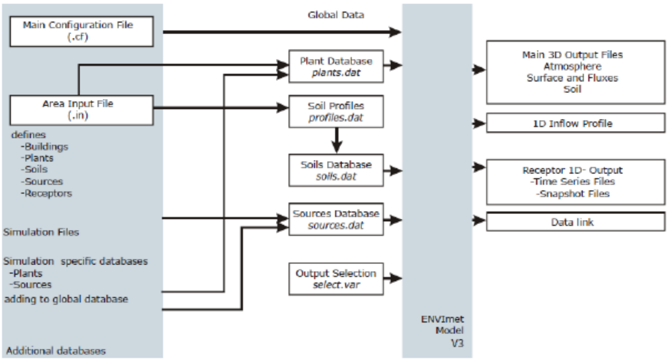

Figure 4. Structure of the software

B. Numerical simulation

This simulation was performed using the software ENVI - met 3.1 Beta 4 in order to improve the conditions of the external ventilation of case study - which was based on the investigation - the most efficient. It covers both winter and summer periods chosen for the investigation. The physical parameters studied are the air temperature, relative humidity and wind speed. In this presentation we will show last parameter results. Three (03) scenarios were simulated taking into account arrangement of buildings on the layout.

IV. Results and Discussion

Using the freeware ENVI-met, we were able to assess the effect of geometry layout on wind and natural ventilation. It retained that the arrangement of buildings on ground plane has an influence on wind flow. It is said our assumptions, where the geometry of buildings and their provisions on the ground plane affects the wind flow in humid climates. In this aspect, our results are consistent with several studies such as that of Zhang. L, al., (2005), Katarzym. K and al.(2005), Blocken B., and al. (2004), which showed by simulation that the wind field is highly dependent on the arrangement of buildings on the ground plane.

In addition, the influence of the arrangement of buildings on the increase in wind speed and comfort on the outside has been demonstrated in their research. Also, it can be concluded, according to the specific context of the study, a ground plane exploded like this case can be generated for a location on a low altitude in a humid climate, introducing changes vis-à-vis external works to improve the microclimate.

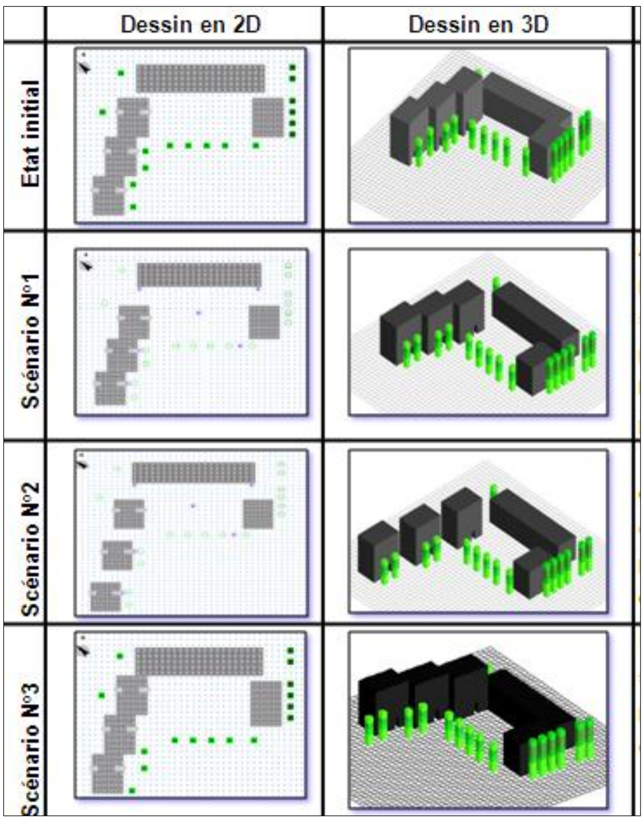

Figure 5. Layout of case study and proposed scenario

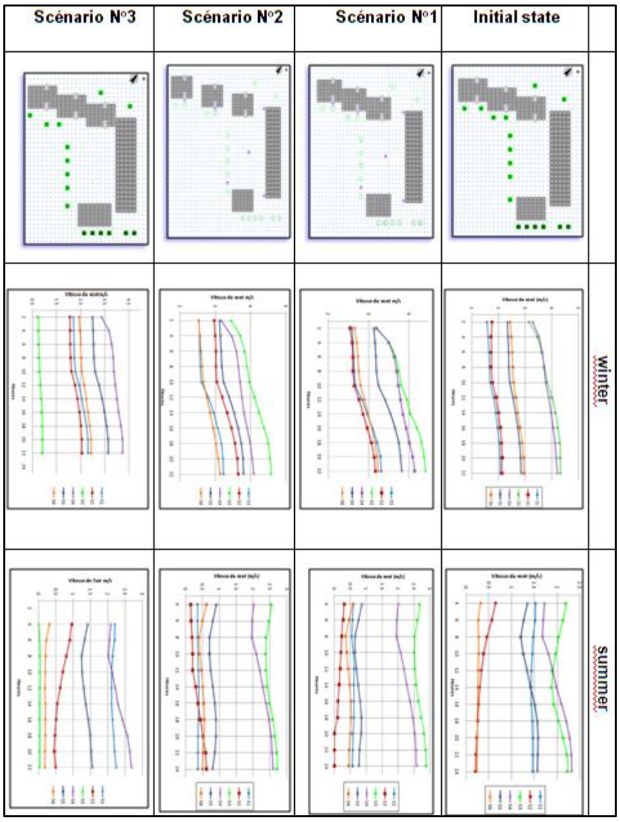

Figure 6. Graphic wind results

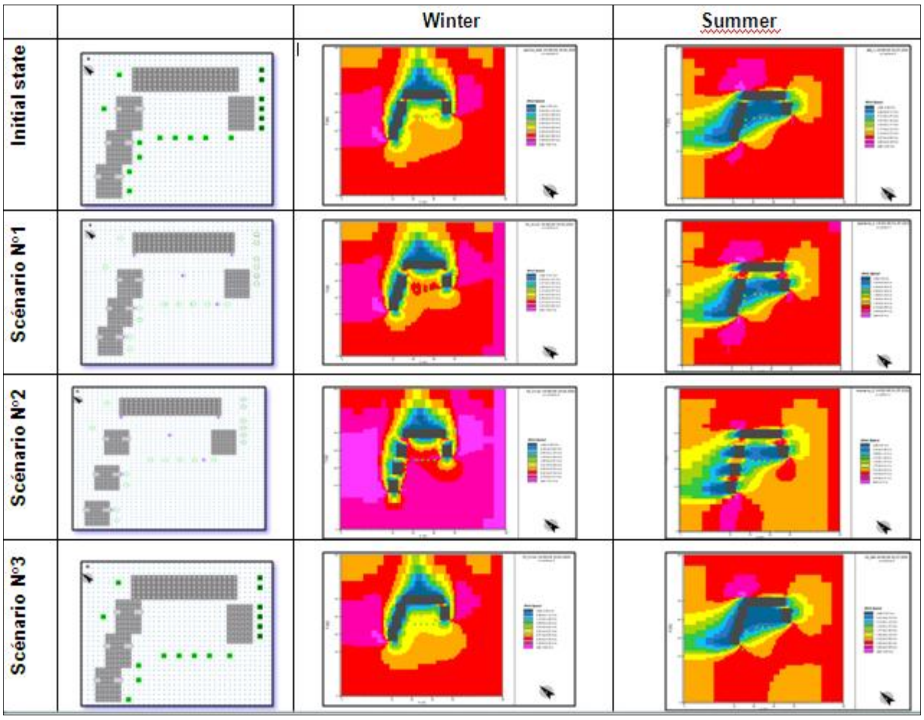

Figure 7. Data wind results

V. ACKNOWLEDGEMENTS

We conducted several simulation tests, and during this experience, we identified some constraints to the model Envi-met, which could limit our work, namely:

The software considers a single wind direction for the duration of the simulation, when in fact; the wind direction is constantly changing, even if there is a dominant direction especially in coastal areas. The simulation speed at a location becomes difficult when the wind is strongly influenced by local climate: a coastal area, for example, is strongly influenced by sea breezes that result in significant changes in speed and direction. It does not take into account the effect of altitude; our case studies have different altitudes. Jijel's coastal humidity is greatly influenced by the proximity of the sea; this factor of "local weather" is not at all taken into account by envi -met.

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