In order to assess the **local air quality** within the **streets** of a **city**, several factors have to be taken into account : local **sources** (fixed and mobile source), local **dispersion** (pollutant transport by the way of wind, dispersion by turbulence, chemical transformation of pollutants) and local **background** (pollution coming from the upstream quarters). It is quite difficult to determine the **real emissions** from **vehicles**. Many factors have to be studied : the composition of the real car fleet of the considered area, the working order of the engines, the traffic speed. Comprehension of **transport** and **pollutant transformation** emitted by vehicles is complex too. The pollutant **residence time** within an atmospheric layer is a major factor to identify the relative importance of the chemical reactions that take place in the urban area. In a single street the residence time of the air mass can be as short as a few seconds in windy conditions ; then only very fast chemical reactions have time to take place, and the mechanisms may be simplified considerably and still describe well the governing processes. On the other hand, during pollution episodes in anticyclonic weather with very **low winds**, the pollutant residence time within the canopy is at least of the order of several minutes to hours. In these cases, a larger number of chemical reactions play a significant role. Moreover, a large number of species is **chemically reactive** in the lower atmosphere and can form secondary substances, especially during **day time**.

Nantes'99 experiment constitutes a preliminary phase of the European project URBCAP. This program aims to assess the ability of canopy accounting models to determine local air quality and spatial and time distribution of pollutants in the different quarters of an urban area
Nantes'99 has four main objectives :

1. To determine the production of turbulent kinetic energy due to vehicles motion.
2. To measure the influence of temperature distribution of the wall surface on the flow structure in the street and on the pollutant dispersion.
3. To study wind fields in the street.
4. To validate models developed by teams which have taken part in Nantes'99 and concerning thermo-radiative budget, the model SOLENE (CERMA), the turbulence due to vehicles and the flow and the pollutants dispersion in the street, the models CHENSI (ECN) and PHOENICS (CSTB).

NANTES'99 : THE EXPERIMENT

The Nantes'99 experiment took place in a street of the Nantes city-centre (France) during June 1999. This street, 'Rue de Strasbourg' can be considered as a street canyon.

<u>Experimental strategy</u>

The gas chosen to be representative of the pollutant emissions is the **carbon monoxide**, **CO**. This gas is a great indicator of pollutant dispersion and dilution in the street since its chemical time residence is rather long (several weeks) compared to others chemical substances. In order to evaluate the emission of CO, we need to count the vehicles and their speed in the street 'Rue de Strasbourg' and in the streets in the vicinity of the 'Rue de Strasbourg'. In order to measure the carbon monoxide emitted in the street by vehicles, several CO sensors are installed at the low level of the street (at 1.50 m). To evaluate the residence time of CO in the street, others sensors are fixed at the high level of the street. A time correlation method is used for this evaluation. This method compares the time variation of the emission rate and the time variation of the flux at the canopy-atmosphere interface, during the whole diurnal cycle.
We aim to qualify the **validity of the models** in relation to the values of turbulent kinetic energy and its dissipation rate (CHENSI) and the three shear components (PHOENICS). Therefore, we used fast acquisition sensors in the low level of the street : sonic anemometers and hot wires anemometers.
With regard to the documentation of the **thermal field** in the street, several thermocouples had to be placed along the walls, close to the walls and across the street. The temperature data will be used as data input for the two models SOLENE and CHENSI.
3D propeller anemometers installed at the high level of the street complete the measurements of the low level and allow to identify **wind fields** and **ventilation regimes**.
To validate models and in particular SOLENE, data input concerning **radiation** are required. Three radiometers are placed on a roof, close to the street, and they measure global, Infra-Red and diffuse radiation. Additional measurements of radiation in the street are carried out during punctual campaigns.
In order to get the wind and temperature references above the roofs, a reference mast is erected on the roof and equipped with a 3D propeller anemometer and thermocouples. A CO intake is installed too on this roof.
(*Cf. figure 1 : sketch of the experimental site*).

Feature of the street 'rue de Strasbourg'

The 'rue de Strasbourg' is located in the city-centre of Nantes (France) and it is approximately oriented North-South (with a deviation of –28° from the North). It is straight with a great homogeneity in building shapes on both sides. Vehicles move in a single direction, **on three lanes** and with a normal urban speed. The street is approximately 15 m wide, the buildings are 22 m high and the study section is 58 m long.

Required conditions

In order to obtain important thermal effects, the required conditions are :

- Reference wind speed, at 30 m above the road, less than 3 m/s.
- Sunny weather to obtain a great solar radiation.
- High traffic.

Main IOP (Intense Observation Periods)

These are the days during which the required conditions are obtained. A day of IOP begins at 8h a.m. and finishes at 8h p.m., all the sensors are kept operational.

<u>Temporary assessment of the experiment Nantes'99</u>

The conditions which were required for this experiment have been present : 11 days of main IOP have been obtained. Table 1 groups together the sensors which were used, the available values and their sampling rate, the use of these data as well as some comments concerning their running during the experiment.
Figure 2 indicates the number of vehicles running in the street between 8h a.m. and 8h p.m. as well as the number of vehicles during the rush hours (during 15 minutes). Figure 3 represents the mean values of global and diffuse radiation between 8h a.m. and 8h p.m., for each days of measurements (measurements on the roof). Figures 4 and 5 give the mean values of wind speed and direction between 8h a.m. and 8h p.m. measured on the reference mast (close to the radiometers). The values of IOP days are coloured in red in the figures 2, 4 and 5.

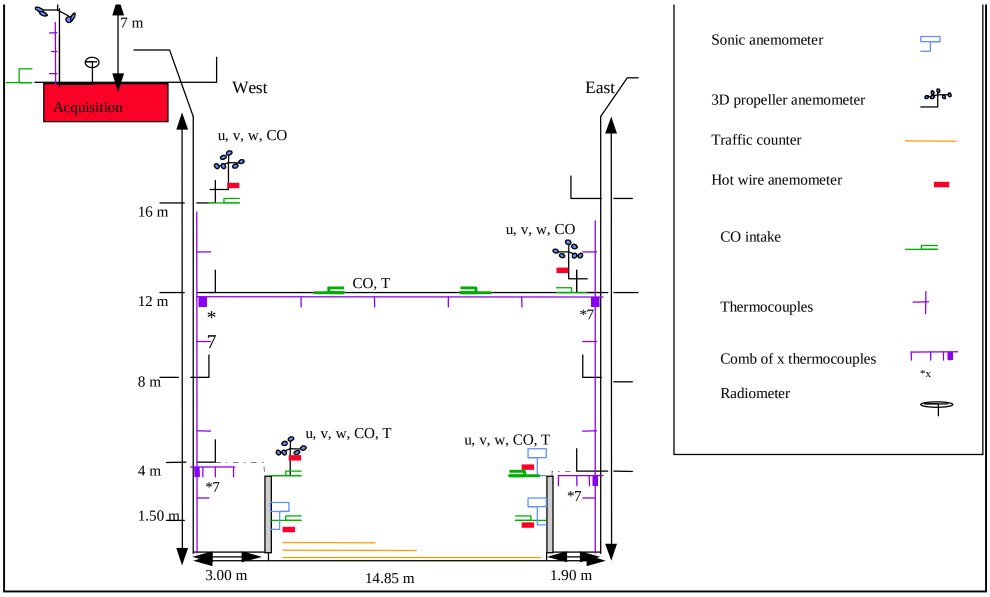

Figure 1 : *Sketch of the experimental site*

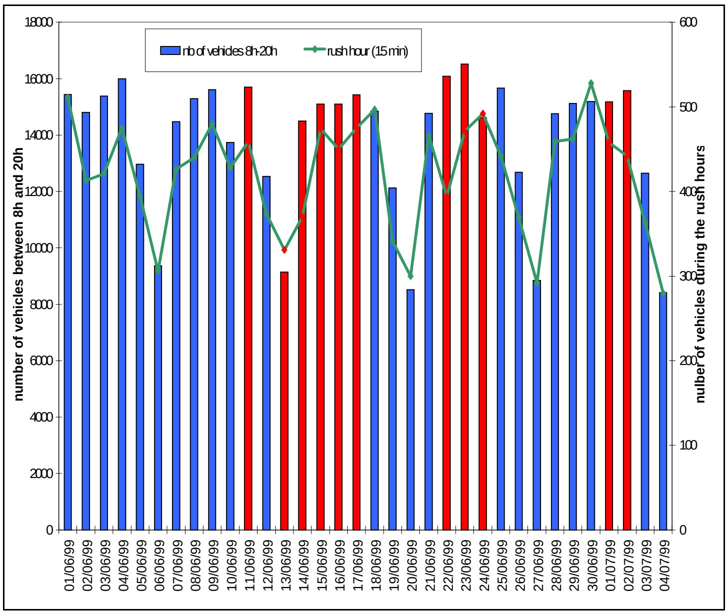

Figure 2 : *number of vehicles between 8h a.m. and 8h p.m.*

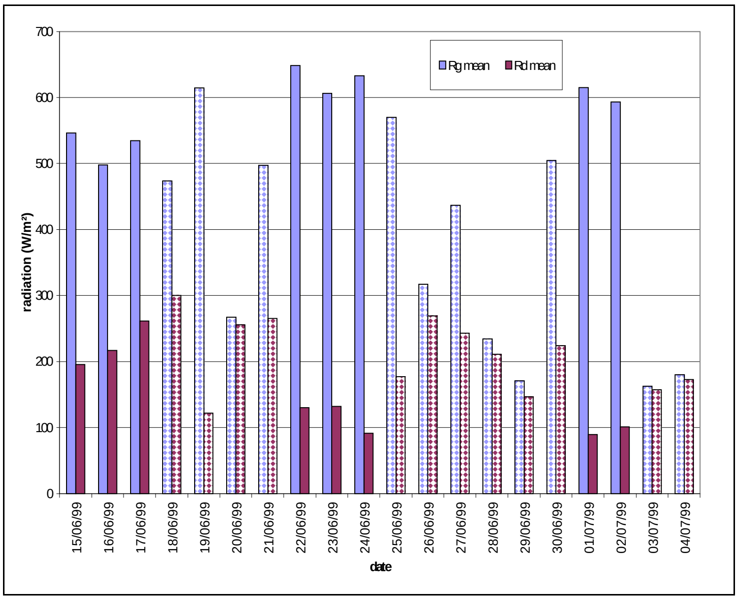

Figure 3 : *Mean global and diffuse radiation between 8h a.m. and 8h p.m.*

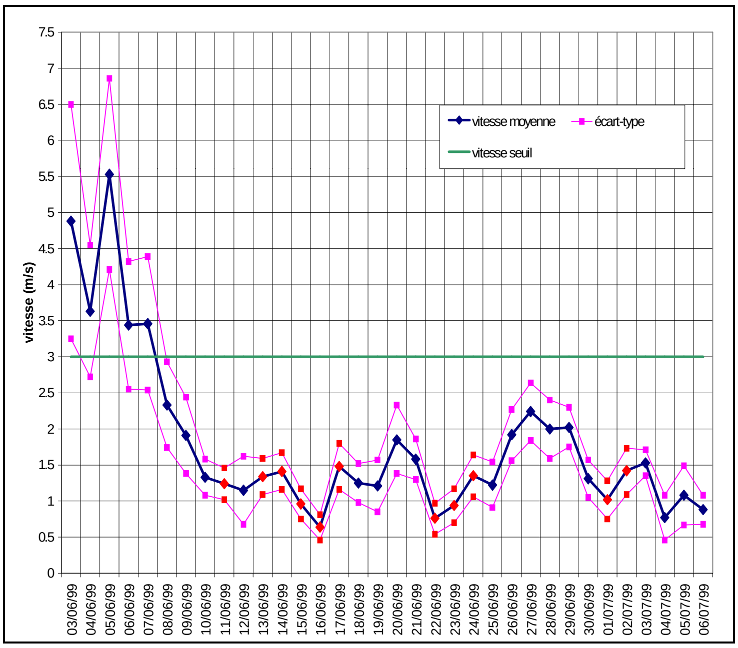

Figure 3 : *Mean reference wind speed between 8h a.m. and 8h p.m.*

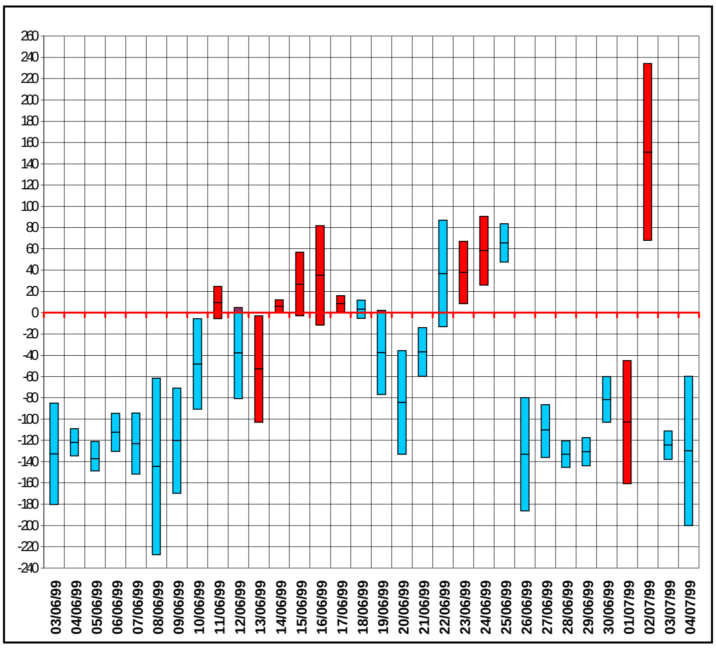

Figure 4 : *Mean reference wind direction between 8h a.m. and 8h p.m.*

SENSORS	AVAILABILITY OF THE DATA	SAMPLING RATE	DATA RUNS	COMMENTS	MEASURED DATA	USE OF THE DATA
Sonic anemometers (3)	10 June to 4 July	4 Hz, 1 anemometer : 24h/24 2 anemometers : 8h30 a.m. to 7h30 p.m. during the IOP days	1 run every fifteen minutes	Logging anemometers	. Three components of wind speed	. Value of turbulent kinetic energy (production of turbulent kinetic energy due to the vehicles)
3D propeller anemometers (4)	2 June to 4 July	4 Hz 24h/24	1 run every fifteen minutes		. Three components of wind speed	. Study of wind fields
Thermocouples (43)	4 June to 4 July	1 Hz (10 acquisitions every minute) 24h/24	1 run every fifteen minutes	Some disable data from thermocouples located on the roof	. Temperature	. Documentation of the thermal field in the street . Temperature horizontal profiles in the layer adjacent to the wall . Data input for the models SOLENE and CHENSI
Hot wire anemometers (5)	13 June to 2 July	1000Hz 8h30 a.m. to 7h30 p.m. during the IOP days	1 run every fifteen minutes	Many problems during the whole experiment due to the sensitivity of the hot wires.	. Wind speed measured at high frequency	. Evaluation of the dissipation rate of the turbulent kinetic energy
Radiometers (3)	15 June to 5 July	24h/24	1 run every fifteen minutes		. Global radiation . Diffuse radiation . Infra-Red radiation	. Validation of models, in particular : SOLENE
Gill anemometer bivane (1)	8 June to 2 July	1Hz 8h30 a.m. to 7h30 p.m. during the IOP days	1 run every fifteen minutes		. Three wind speed components	. Documentation of the flow in the cross road near the study section
Tracers gas (propylene)	8 June to 16 June	50 Hz		. .6 successful days . 80 puff releases . 4 continuous releases	. Rate of propylene	• Pollutant time transfer between two levels • Vertical transfers in the layers adjacent to the building wall
Balloons releases	15, 16, 23, 24, 30 June, 1 July			. 21 releases, from 4 to 15 balloons each release		• Visualisation of the flow in the street . Evaluation of the residence time of a fluid particle in the street
Sodar	13 June, 1 July			High noise pollution generated by the SODAR	. Wind components in the low atmospheric layer	• Documentation of the low atmospheric layer
Traffic counters (flow, car speed and light-weight and heavy-weight vehicles)	1 June to 5 July	24h/24	1 data every fifteen minutes or every hour.	In the street 'Rue de Strasbourg' and in the streets which run across the 'Rue de Strasbourg'.	. Flow . Car speed . Light-weight and heavy-weight vehicles	

CO MEASUREMENTS	AVAILABILITY OF THE DATA	SAMPLING RATE	DATA RUNS	COMMENTS	MEASURED DATA	USE OF THE DATA
in the study section (6 sensors inlet)	3 June to 5 July	1 value every 3 minutes 24h/24	1 run every fifteen minutes	Three configurations of 6 CO intakes in the study section are used (8 CO intakes are available)	. Rate of CO in the study section	• Emissions of CO (with data measured by the traffic counters) • Residence time of CO in the street • Concentration fields of CO in the street
on the roof (1 sensor)	3 June to 5 July	24h/24	1 data every fifteen minutes or every hour	3rd of June : no measurements	. Rate of CO in the roof, close to the reference mast	. Background pollution
downstream of the study section (laboratory-van)	2 June to 27 June	24h/24	1 data every fifteen minutes		. Rate of different pollutants : CO, NO_x, SO_2, dusts, O_3 (and wind speed and direction, temperature of the air, humidity)	• Pollution close to the main point of the measurements
north of the study section, on the town-hall garden (laboratory-van)	28 June to 30 June	24h/24	1 data every fifteen minutes		. Rate of different pollutants : CO, NO_x, SO_2, dusts, O_3 (and wind speed and direction, temperature of the air, humidity)	• Local background pollution
north of the study section on the same street (monitoring network of Nantes)	1 June to 30 June	24h/24	1 data every fifteen minutes	No CO measurements on the 2, 19, 20, 25, 26 of June	. Rate of CO, NO_2, NO	• Pollution close to the main point of the measurements