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# AIR CONCENTRATIONS OF $SO_2$ AND WIND TURBULENCE NEAR *LA PLATA* PETROCHEMICAL POLE (ARGENTINA)

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*Abstract*–– **The aim of the present work is to show the correlation of the $SO_2$ atmospheric concentration, taken in the surroundings of La Plata city, and the characteristics of the wind turbulence in such area. The first results indicate that there are a reasonable agreement between them.**

*Keywords*–– **atmosphere, pollutant, sulphur dioxide, wind, turbulence.**

## I. INTRODUCTION

The atmospheric pollution can be understood as the presence in air of one or more pollutant gases and / or particulate matter (or a combination of both), in an amount and time duration such that may affect the ecosystem.

This problem can be addressed in different steps, i.e.: to detect and measure the concentration of pollutant gases in the studied region, to process the data and correlate it with other atmospheric parameters, in order to act toward the solution of the problem.

The $SO_2$ is a pollutant gas that is currently taken as pollution indicator of urban and industrial areas, which can severely affect the human health if its concentration is large. It is usually emitted by fixed and mobile sources (mainly fosil-fuel based machines), and in presence of water vapor it is the main component of the acid rain. More details about this subject can be found in Del Giorgio (1977), Morettón (1996) and Sigrist (1994).

The meteorological parameters of the studied region play and important role in the behaviour of the local pollutants ( Del Giorgio, 1977).

Some results about relationships between atmospheric concentrations of $SO_2$, and the characteristics of the wind turbulence in the region near La Plata's Petrochemical Pole, are presented in this work.

## II. METHODS

### A. For the determination of *$SO_2$* concentrations

To obtain the Sulphur Dioxide concentration values, a commercial equipment Lear Siegler, model ML 9850, was used ( Siegler, 1992). The equipment was placed in a laboratory at the Facultad Regional La Plata (F.R.L.P.), U.T.N. This type of analyzer, that uses an optical emission spectroscopy method, is an ultraviolet (UV) fluorescence spectrometer designed to continuously measure low concentrations of $SO_2$ in ambient air. Sulphur Dioxide exhibits a strong ultraviolet absorption spectrum between 200 and 240 nm. Absorption of radiation at these wavelengths results in the emission of fluorescence radiation at wavelengths between approximately 300 and 400 nm. The amount of fluorescence emitted is directly proportional to the $SO_2$ concentration.

UV radiation at 213.9 nm from a zinc discharge lamp is separated from the other wavelengths in the zinc spectrum by an optical band-pass filter. The 213.9 nm radiation is focused into the fluorescence cell where it interacts with $SO_2$ molecules in the beam path. A certain amount of the fluorescence, i.e., that emitted perpendicularly to the excitation beam, is collected and focused onto a photomultiplier tube, through a 350 nm filter. A reference detector monitors the emission from the zinc lamp and is used in order to correct for temporal lamp fluctuations.

The precision in the $SO_2$ measurements is 0,5 ppm or 1% of reading, whichever is greater, working between 5 to 40 ºC (USEPA Designated Range: 15 to 35 ºC). The $SO_2$ data was continuously stored in a floppy disk.

The equipment was calibrated using standard $SO_2$ concentrations. Adequate chemical methods, and biological indicators (Rosato, 1999), were also used.

A 7440 CSEU model, Davis Meteorological Station, placed at the same point as the $SO_2$ analyzer, was used to obtain the meteorological data.

The installation, first operation and calibration of the $SO_2$ equipment were performed in March 1995. Preliminary concentration values have been obtained since June of that year. In the present work, $SO_2$ data since 1996 are considered

**B. For the determination of the turbulence characteristics**

In order to complete the meteorological data acquired with the Davis meteorological station, we carried out turbulence measurements in the same place at different times of the year, with the aid of a Dantec Constant Temperature Anemometry equipment. Instantaneous velocity components can be determined with high precision at every point of the flow field. The statistical analysis of the acquired data allows to determinate the wind turbulence characteristics in the area, as well as the scale of the turbulent structures embedded in the incident wind.

It is widely known the fact that the mixture properties and dispersion of polluting agents of the atmosphere are direct function, among other parameters, of the scales of the turbulent structures (eddies) of the wind. Large structures promote a better mixing than those of smaller size. The experimental data has been processed in order to obtain autocorrelation functions; power density spectra; and Reynolds stresses.

Wavelets analysis, has been performed giving a description of aspects of the structure of the turbulence, closely related with the mixing processes

The turbulent wind data were acquired at the same place as the $SO_2$ measurements, on May 7$^{th}$ 2001, August 23$^{rd}$ 2001 and April 29$^{th}$ 2002. Wind measurements were performed at 9 points, with vertical separations of 0.1 m. The lowest point was located at a height of 6.1 m, 2.1 m over the building's roof. The anemometric probe was an X-wire Dantec 55R51. Data were acquired at a sampling rate of 500 Hz per channel (16384 samples per channel), for each point. The measurements of May and August were obtained for winds blowing from the N-E, which is the prevailing wind direction in the region. Nevertheless during the record of April 2002, the wind direction was N-W.

## III. RESULTS

Figure 1 shows the vertical distribution of turbulence intensity for the three days of measurements. Despite the different mean wind directions, the curves evidence similar characteristics. The measurements performed “in situ” indicate that the turbulence has similar properties in such period, regardless the mean wind directions.

Figure 2 shows the evolution of monthly averages of $SO_2$ concentration in 1998, 1999 and 2000. The values are similar until August 2000. In September 2000 the $SO_2$ concentration reached an unusual high peak, and

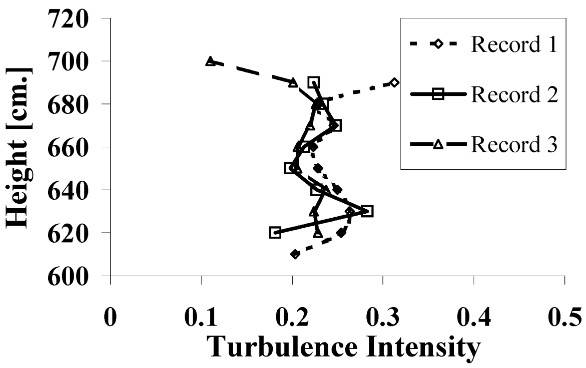


Figure 1 Vertical distribution of Turbulence Intensity

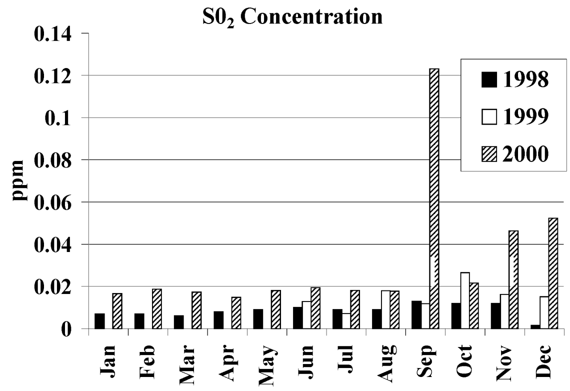


Figure 2 Mean distribution of $S0_2$ concentration

attenuates slowly. This behavior may be attributed to an unusual high contaminated emission.

In order to obtain more realistic information about the scale of the turbulent structures which appear intermittently in the flow, a wavelet analysis was performed. This procedure retains information in time domain as well as in the frequency domain. The wavelet analysis of the velocity data allows the identification of aspects of turbulent structures which can be connected to transport events.

The continuous wavelet transform used in this paper, is known to be appropriate for analyzing turbulent flow data (Farge, 1990 and 1992). Our aim was to compare time scales and intensities of the turbulent structures in the wavelet map.

Some wavelet interpretation criteria used by Mahrt (1991), were qualitatively followed, estimating the time extent of a particular detected structure directly from its wavelet graph scale. The velocity-time records were explored in order to detect features related to the second derivative of a Gaussian g2 (usually called the ‘Mexican hat’ wavelet).

The wavelet transformations were calculated from three different day records. In two of them the wind direction was similar, heading from the northwest, and in the other one was blown from the northeast. These particular records were extracted from the whole measurements because they showed the characteristic behaviour of the turbulent wind in the location.

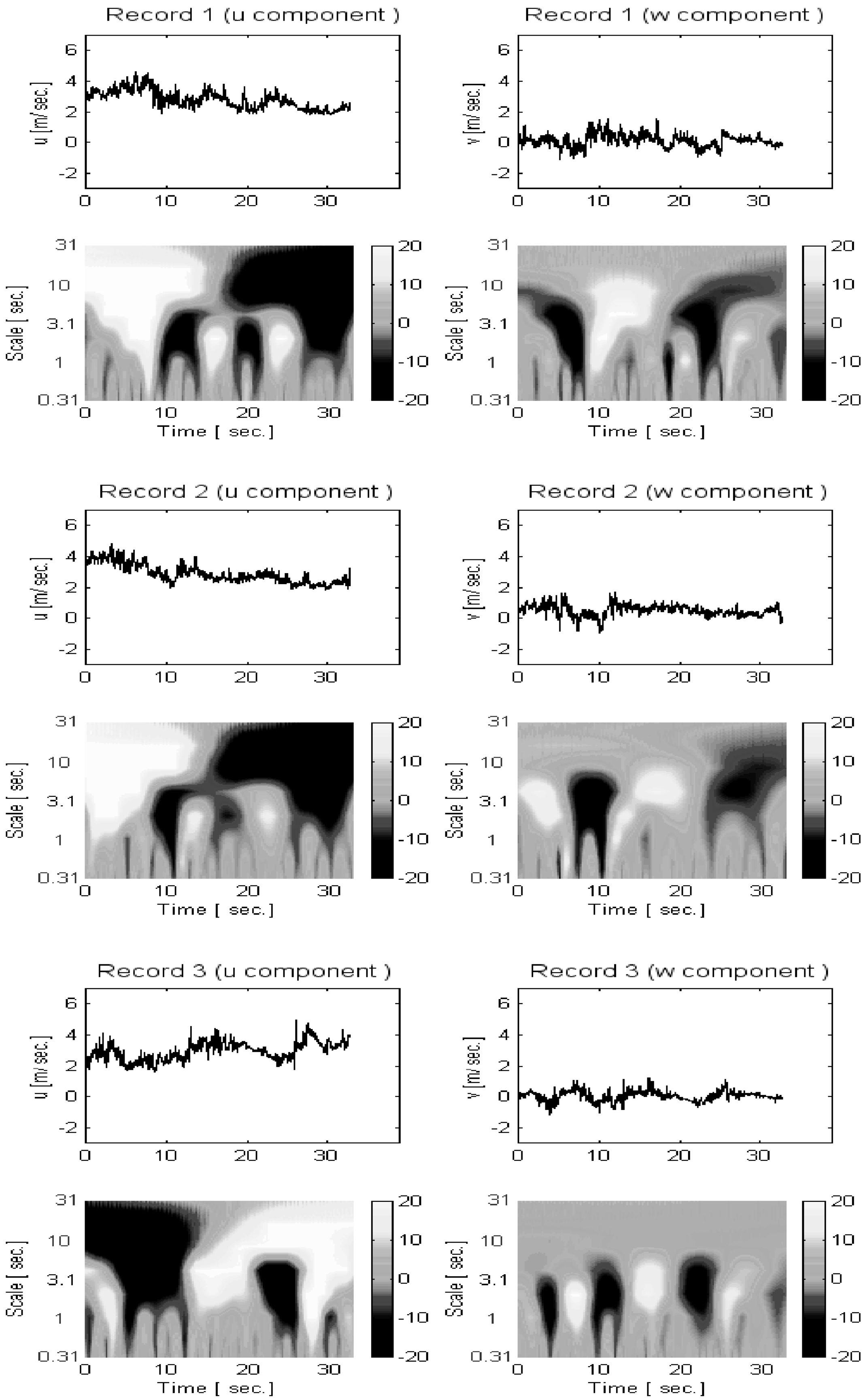


Figure 3. Wavelets coefficient representation.

Figure 3 shows the wavelet coefficients, for the horizontal and vertical velocity components: u and w.

The turbulent behaviour, for the northeast wind, seems to be similar in the two different days, the time scale were approximately 2 seconds for the u component and 4 seconds for the w component. In the third record, which corresponds to the northwest heading, the graphics show a slightly different behaviour in the two components, about 2.5 and 2 seconds, respectively, for u and w components. Assuming frozen flow theory, one can deduce that the Turbulent Spatial Scale for the u component is for the first case about 6 m. and, for the northwest wind, it is about 7.5 m.

The statistical analysis of the meteorological data shows also similar results. For example, Fig. 4 represents the daily autocorrelation functions for the meteorological recorded data (wind) and $SO_2$ concentration, for the August 26$^{th}$' 01. The curves are very similar suggesting that the $SO_2$ concentration distribution is basically dependent on the turbulent structure of the oncoming wind.

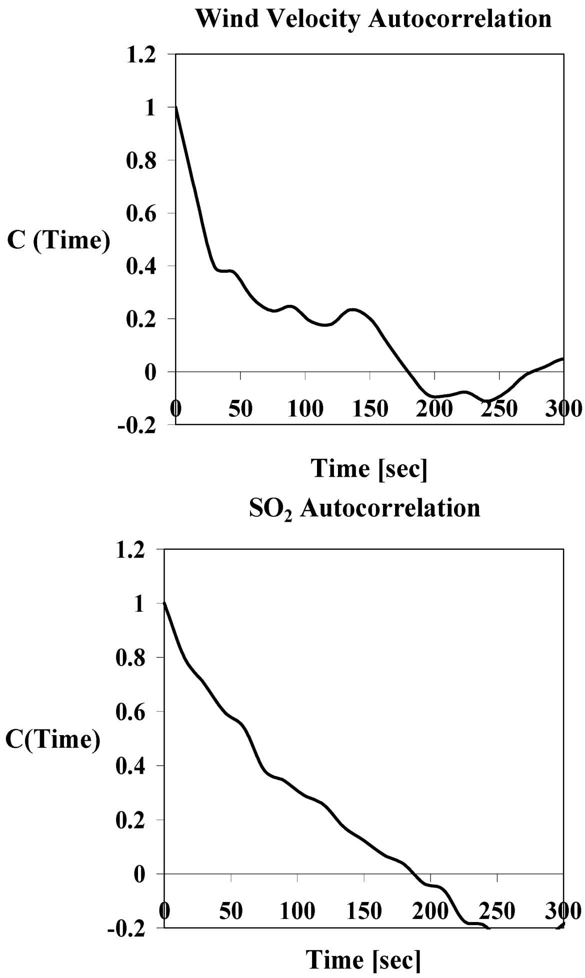


Figure 4 Daily Autocorrelation Functions

## IV. CONCLUSIONS

It was interesting to find that the turbulent scales associated to the main turbulent structures detected in the flow at different times were approximately the same, independent of the mean wind direction. This reveals that the measuring site was immersed in an homogeneous atmospheric surface layer generated by the aerodynamic roughness of the urban environment.

During windy days the $SO_2$ concentration variations were mainly linked to the characteristics of the oncoming turbulent structures.

It seems important to perform turbulence and $SO_2$ measurements over an extended area in order to improve the description of the local atmospheric layer.

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