

# Using systematic diffusive sampling campaigns and geostatistics to map air pollution in Portugal

## Abstract

In the context of the European Framework Directive (96/62/EC) preliminary assessment and the definition of zones, diffusive sampling campaigns applied for the first time at a country level were performed with the main objective to evaluate background concentrations throughout the country aiming both to complement monitoring stations results and to analyze spatial distribution patterns of sulphur dioxide, nitrogen dioxide, and ozone under different meteorological conditions. ESRI Geographic Information System software ArcGIS and the extension Geostatistical Analyst was used to obtain distribution maps. Several interpolation methods available were tested. The selected method was the geostatistical interpolation method – kriging. The produced maps showed that the levels were low for both nitrogen dioxide and sulphur dioxide but high for ozone especially in inland areas, where currently no monitoring stations exist.

## Introduction

The interpolation methods which rely on the similarity of nearby sample points to create a surface, combined with indicative measurements campaigns using diffusive sampling can be a very useful tool for supplementary assessment of air quality in obtaining spatial concentration distribution in large zones where no continuous monitoring exists.

In the context of the European Framework Directive (96/62/EC) two diffusive sampling campaigns aiming the measurement of background levels, for SO<sub>2</sub>, NO<sub>2</sub>, and O<sub>3</sub> were performed in:

- Summer 2000 - July, 17<sup>th</sup> to July, 31<sup>st</sup>
- Spring 2001 - May, 7<sup>th</sup> to May, 21<sup>st</sup>

The purpose was:

- Preliminary classification of zones - defining areas with similar air quality
- Evaluating in a preliminary way the distribution of background levels throughout the country

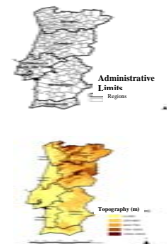
## Results and Discussion

A systematic sampling grid of 20 x 20 Km<sup>2</sup> was used, 236 sampling points were

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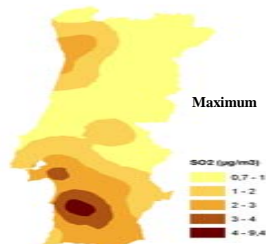
### Delimitation of zones

Making use of administrative limits, pollutant background levels distribution, topography, climate and meteorological patterns, population density and land use maps, 10 zones were delimited for Portuguese Continental Regions



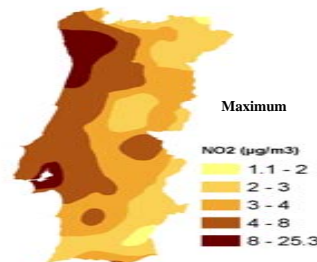
### SO<sub>2</sub>

Sulphur dioxide background levels are also low; the pattern of concentrations, can be explained looking to the location of the main sources of SO<sub>2</sub> and the wind regime in both campaigns.



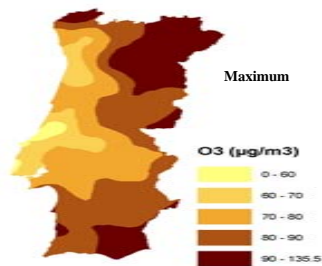
### NO<sub>2</sub>

Nitrogen dioxide background results are generally low but are higher closer to urban areas (high population density) caused by high road traffic levels.



### O<sub>3</sub>

Finally, the concentration values found for O<sub>3</sub> are, in absolute values, very high; Topography, wind direction, and the location of the main sources of ozone precursors (NOx and VOC's) were the most relevant factors.



## Conclusions

- The use of diffusive sampling method within a systematic grid (20x20 Km<sup>2</sup>) combined with the geostatistical interpolation method - Kriging as proved to be a low-cost and efficient way for mapping of SO<sub>2</sub>, NO<sub>2</sub> and O<sub>3</sub> background levels in a country like Portugal;
- The geostatistical interpolation method - Kriging provides the possibility of obtaining probability and error maps which are very useful on the perception of patterns and the interpretation of data;
- Making maps of the potential factors that influence air quality such as wind roses of both campaigns, population density, major point industrial sources and topography was also helpful in the interpretation of campaign results;
- The pollutant distribution maps produced were fundamental in the delimitation of the 10 zones for Portuguese Continental Regions. Also important were the administrative limits, topography, climate and meteorological patterns, population density, and land use maps.

## Authors

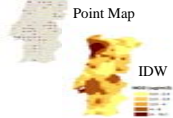
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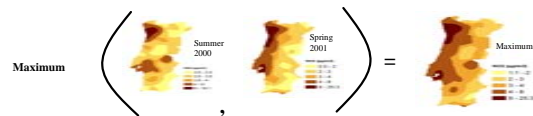
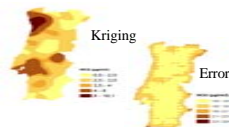
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## Methodology



The results of the campaigns were introduced in the ESRI Geographic Information System software ArcGIS and the extension Geostatistical Analyst was used to obtain distribution maps. Several interpolation methods available such as IDW were tested.

The selected method was the geostatistical interpolation method – kriging, because it relies on both statistical and deterministic methods to create a surface and assesses the uncertainty of the predictions. Both prediction and error maps were performed for the Summer and Spring campaigns.



The final distribution map produced for each pollutant uses the maximum value between campaigns. These maps represent the maximum probable value for each location.

Maps representing the factors that influence air quality patterns were also produced for discussion purposes

- Type and location of the major air pollution stationary sources;
- Population density and major agglomerations.
- Topography
- Meteorological conditions

Zones were delimited based on administrative regions, pollutant background levels distribution maps, topography, climate and meteorological patterns, population density and land use.