UMONS
Université de Mons

Validation of a geostatistic method

Measurement campaign vs. interpolation method

1 – Goal

Aim : validate a mathematical interpolation model (Geostatistic approach : Kriging) by a measurement campaign.

A telemetric network, consisting in **fixed measurement stations** (■) is used to control the quality of the air.

→ 14 fixed stations in Wallonia, continuously measure, with a laser diffraction technology, the particles concentrations (PM10* and PM2,5*) in the air and integrated every 30 minutes

Based on these fixed stations data, the geostatistic interpolation model is applied to estimate the concentration all over Wallonia.

2 – Methodology

A second network consisting in 6 additional **mobile measurement stations** (●) was installed during 3 months to measure the concentrations of particulate matter for 6 strategic locations.

Validation steps:

1. Measurement of particulate matter concentrations at fixed stations of the telemetric network (■)
2. Interpolation of these measures to estimate the concentration for the 6 strategic positions
3. Measurement of particulate matter concentrations on the 6 strategic positions by using the 6 mobiles stations (●)
4. Comparison of the interpolated values (2.) to the one given by the mobile measurement stations (3.)
5. Analysis of the error variance of the geostatistic method compared to results of point 4

3 – Geostatistic method

In the geostatistic approach, what differs from a statistics approach is that the spatial auto-correlation between two neighboring values is taken into account.

Variogram

The aim of the variogram is to weight the measures according to the distance between two stations locations.

- First an experimental variogram is computed. Variogram of the variable z :

$$\gamma(\boldsymbol{h}) = \frac{1}{2N_h}\sum_{i=1}^{N_h}\left(\boldsymbol{z}(\boldsymbol{x_i}) - \boldsymbol{z}(\boldsymbol{x_i}+\boldsymbol{h})\right)^2$$

x_i : location of the measurement station i

$h = |x_i - x_j|$: distance between the two stations i and j

N_h : number of pairs of stations spaced of a given distance h

- Then a theoretical variogram is modeled using defined types (linear, spherical, etc.) to be the closest to the experimental one.

In our case, the linear type is chosen.

- Finally the variance of the error is minimized

$m_z = E[z]$: Expectation

$\sigma_z^2 = E[(z_i - m_z)^2]$: Variance

4 – Measurement locations

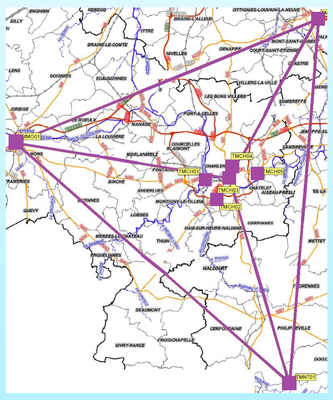


Figure 1a : Only fixed network

Fixed telemetric network (■)

The Charleroi area is geometrically interesting for the measurement campaign:

- 1 station in the town center
- 4 stations around this first one at a distance of 4km
- 3 stations forming a triangle around the town center at a distance of 35km

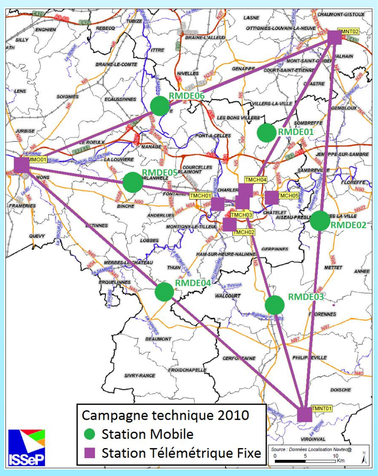
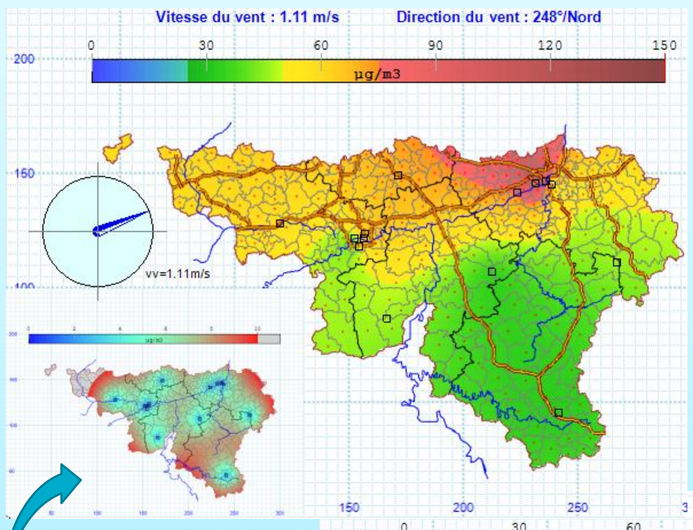


Figure 1b : Locations of the fixed and mobile stations around Charleroi

Mobile network (●)

The six **mobile stations are installed where the error of interpolation is maximal (5 $\mu g/m^3$),** i.e. halfway to fixed stations

5 – Results



Concentration of PM10 in the air in $\mu g/m^3$ on January 1st 2011 at 1AM

Figure 2a : Only fixed network (■)

Error of interpolation between 0 and 10 $\mu g/m^3$

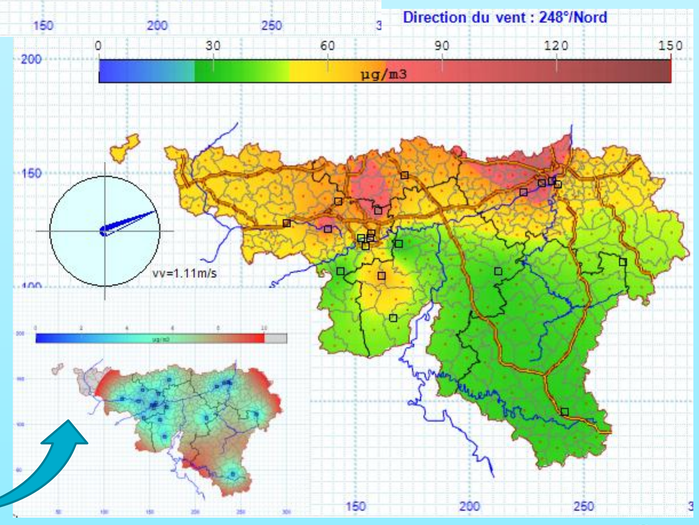
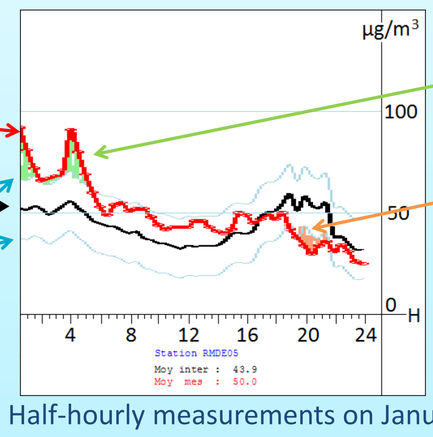


Figure 2b : Both fixed (■) and mobile networks (●)

6 – Comparisons

Comparisons between interpolated and measured concentrations of PM10 in the air in $\mu g/m^3$ at Morlanwelz

- Measurement at mobile station (3.)
- Interpolation of data given by the fixed stations (2.)
- Interpolation ± confidence interval (CI = 99%)



Measure > interpolation + confidence interval

Measure < interpolation - confidence interval

Figure 3 : Half-hourly measurements on January 1st 2011

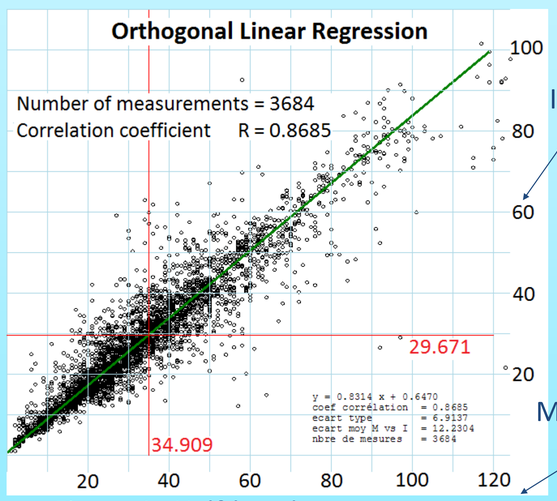


Figure 4 : Half-hourly measurements

Interpolated values

Measurements

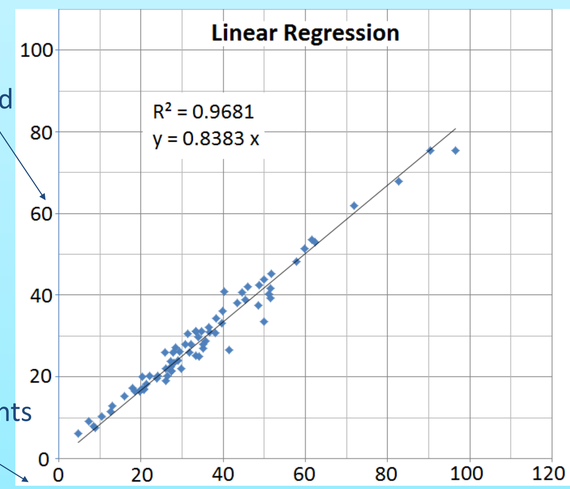


Figure 5 : Daily means

Comparison period from November 16th 2010 to January 31st 2011

7 – Conclusions

→ Geostatistic model **successfully** validated by orthogonal linear regression → correlation coefficient ≈ 1

→ Working with half-hourly measurement includes spots → correlation even better when comparing the daily means

→ European regulations about air quality given for daily means

8 – Comments

Stations location

- 5 stations in Charleroi center giving almost the same measurements → some of them could be moved to more strategic places
- Mobile stations shows local phenomenon not noticed with the fixed stations → necessity to add fixed measurement stations

Discussions

- Concentrations in Charleroi center lower than the one measured by the mobile stations → environmental reality or metrological issue?
- Same comparisons could be done on gas such as NO2 and O3 but to do this measurements during summer are needed → new campaign?

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Definitions

*PM2,5: also named “fine particles” diameter < 2,5µm
*PM10: diameter < 10µm

Partners

AWAC : Agence Wallonne de l'Air et du Climat
ISSeP : Institut Scientifique de Service Public

Website http://airquality.issep.be

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