UMONS Université de Mons

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Validation of a geostatistical interpolation model using measurement of particulate matter concentration

1 – Goal

Aim : Validate a mathematical interpolation model (Kriging – geostatistic approach) using measurement.

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

→ 23 fixed stations in Wallonia continuously measure the particles concentrations (PM10* and PM2.5*) in the air with a laser diffraction technology (GRIMM), and integrate every 30 minutes.

Based on these fixed stations data, a geostatistic interpolation model is applied to evaluate the concentrations of pollutant in the whole of Wallonia.

2 – Methodology

A second network consisting of 6 **additional measurement stations** (■), using same instruments (GRIMM), was installed during 3 months to measure the concentrations of particulate matter (PM) in 6 strategic locations.

Validation steps:

1. Measurement of PM concentrations at fixed stations (■)
2. Interpolation of these measures to estimate the concentration for the 6 strategic positions
3. Measurement of PM concentrations on these positions by using additional stations (■)
4. Comparison of the interpolated values to the ones given by the additional measurement stations

3 – Geostatistic method

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

The measures are weighted according to the distance between to measurement stations using a variogram.

This variogram is computed from the covariance of stations locations.

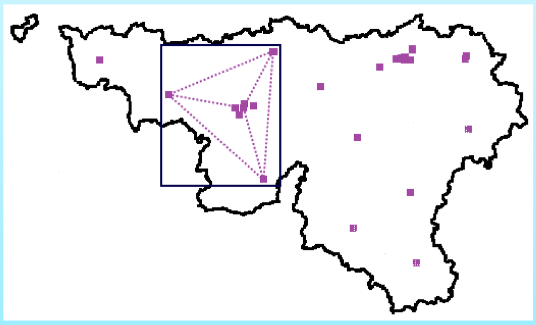

Figure 1: Localisation of measurement stations

4 – Application: pollution episodes

Daily mean of PM_{10} concentration limit value	Area where this value is exceeded	Such values forecast	episode
70 µg.m^{-3}	Whole of Wallonia	for two days	global
100 µg.m^{-3} AND 70 µg.m^{-3}	Where heavy industry is installed / North part of Wallonia	for two days	local

Table 1: Alert episode conditions

When	Alert condition	Action
J-2	Forecast	• Protagonist warned • Communication chain tested
J-1	If confirmed	• Alert becomes public • Actions are performed
From J+1	Evaluated	• Alert is confirmed OR • Alert is ended

Table 2: Alert stages

5 – Measurement locations

Fixed telemetric network (■)

The Charleroi area has interesting particular aspects for a measurement campaign and a model validation:

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

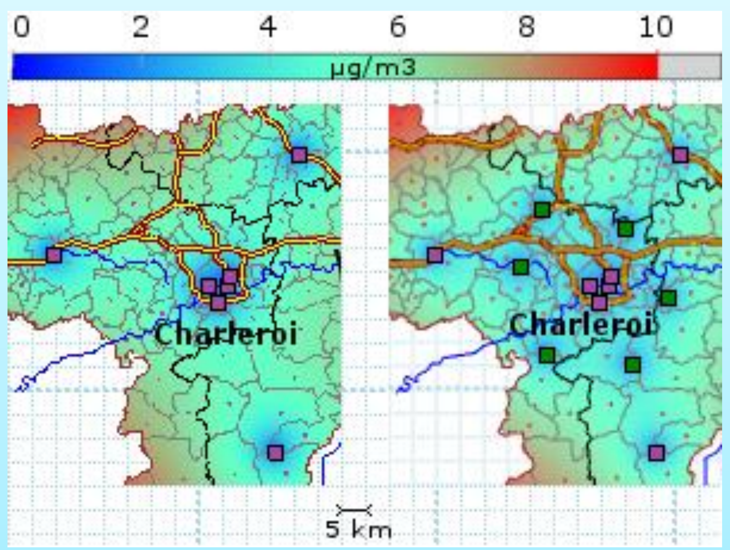

Figure 2: Error of interpolation in the Charleroi area

Additional network (■)

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

6 – Results

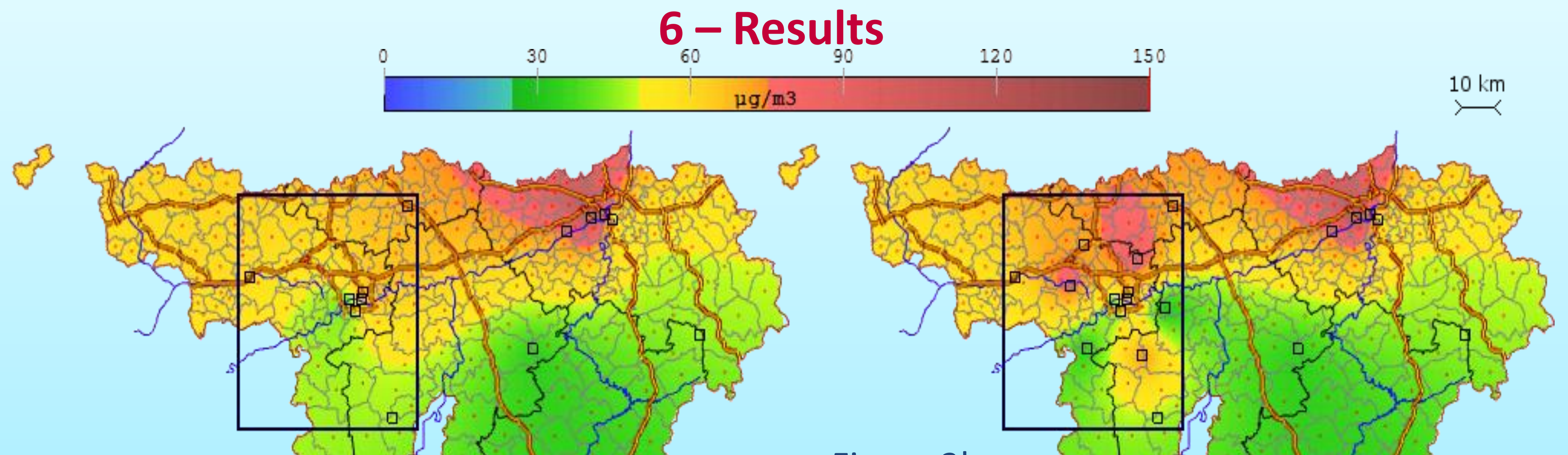

Figure 3a : Only fixed network (■)

Figure 3b : Both fixed (■) and additional networks (■)

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

7 – Comparisons

Comparisons between interpolated and measured concentrations of PM10 and PM2.5 in the air in $\mu g.m^{-3}$ according to 3 criteria:

- Orthogonal linear regression
- Between sampler uncertainty $u_{bs} < 2.5\ \mu g.m^{-3}$: criteria defined by Europe to compare and validate data supplied by two measurement instruments

$$u_{bs}^2 = \frac{\sum_{i=1}^{n}\left(z_{i,meas} - z_{i,\text{int}}\right)^2}{2n}$$

$z_{i,meas}$: daily mean of measured concentrations for day i
$z_{i,int}$: daily mean of interpolated concentrations for day i
n: number of days

- Difference of the mean of moving-average 24 hours

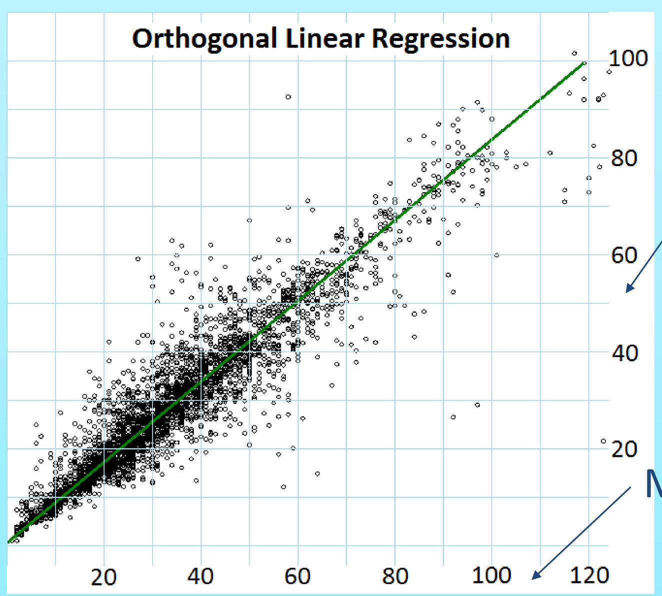

Figure 4: Half-hourly measurements

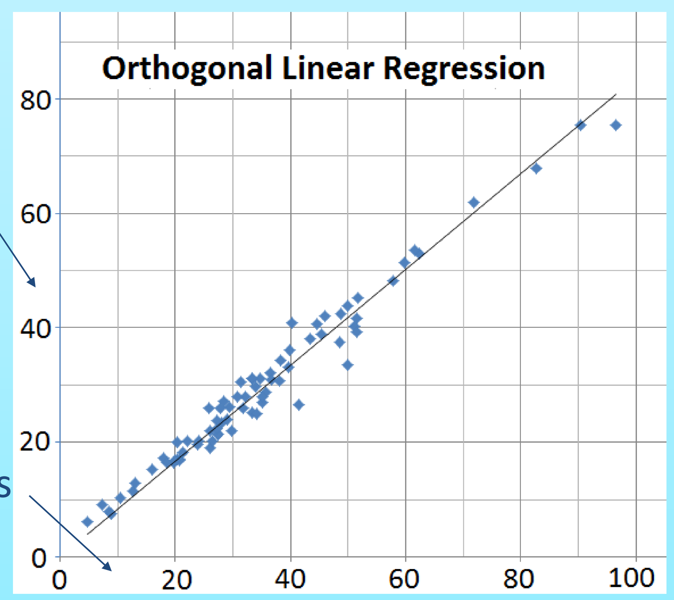

Figure 5: Daily means

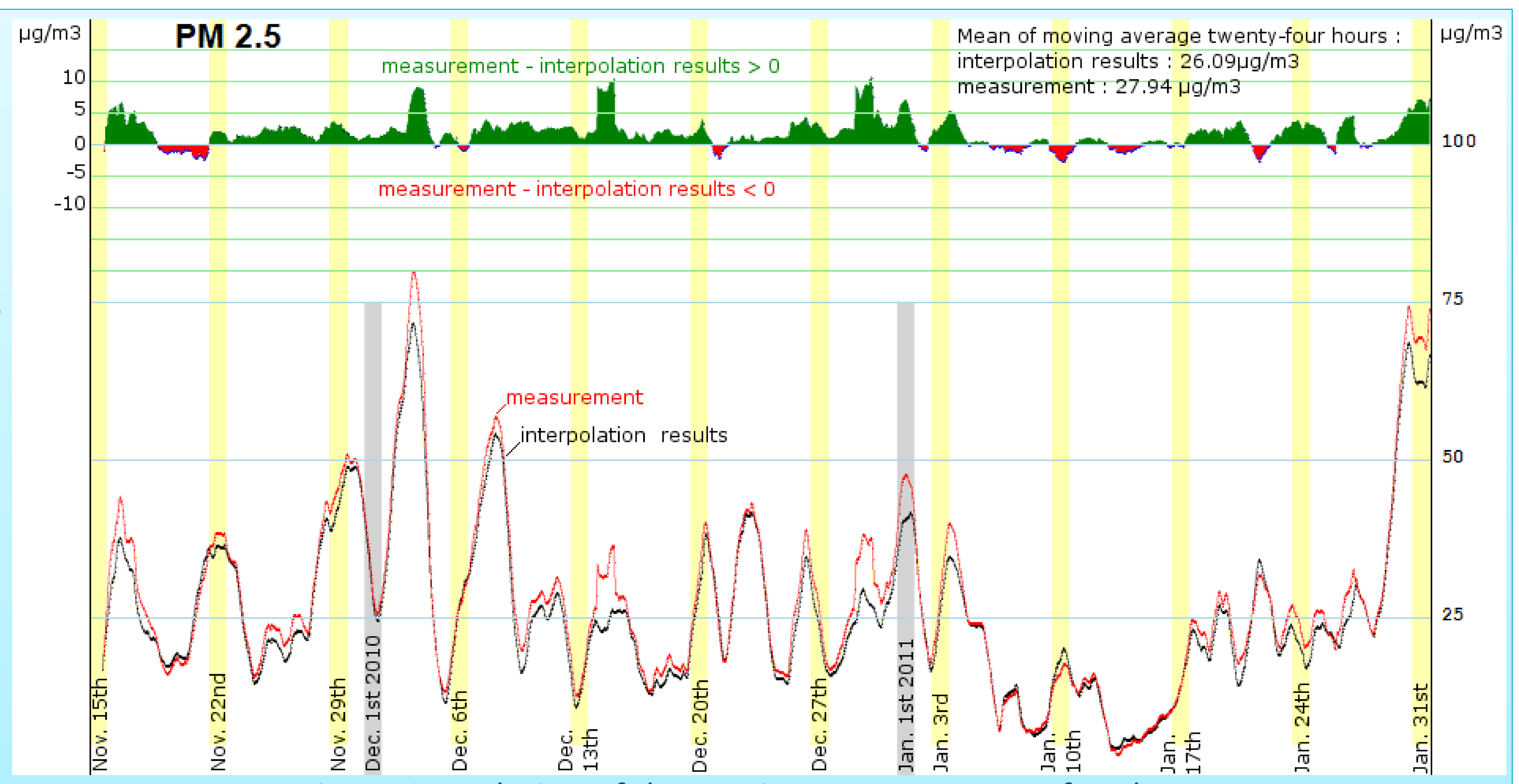

Figure 6: evolution of the moving average twenty-four hours

Stations		S1	S2	S4	S5	S6
Number of days		71	70	78	78	59
Correlation coefficient	PM_{10}	0.9773	0.9684	0.9745	0.9851	0.9573
	$PM_{2.5}$	0.9878	0.9862	0.9839	0.9920	0.9767
u_{bs}	PM_{10}	2.77	3.13	2.41	2.19	2.32
	$PM_{2.5}$	1.95	1.71	1.67	1.99	1.58

Table 3: Orthogonal linear regression and between sampler uncertainty

→ 3 reasons to compare results on **daily averages**:

- Working with half-hourly measurement includes spots
- European regulations about air quality given for daily averages
- As the transport and diffusion phenomena have a certain duration, the longer the period of comparison, the better the correlation

→ Globally interpolation results **underestimated** the measurement

8 – Comments and conclusions

→ Geostatistic model **successfully** validated according to 3 criteria

- Orthogonal linear regression : correlation coefficient > 0.95
- Between-sampler uncertainty < 2.0 µg.m^{-3} for PM2.5 and < 3.20 µg.m^{-3} for PM10
- Difference of means of moving-average 24 hours < 1.9 µg.m^{-3}

Stations location

- 5 stations in Charleroi centre giving almost the same measurements → some of them could be moved to more strategic places
- Mobile stations show local phenomena which are not noticed with the fixed stations → necessity to add fixed measurement stations

Discussions

- Concentrations in Charleroi centre lower than the ones measured by the mobile stations → metrological issue

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Definitions

*PM2.5: also named "fine particles", diameter < 2.5µm
*PM10: diameter < 10µm

Partners

AWAC : Walloon air and climate agency
ISSeP : Scientific institute of public services

Contacts

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