ASSESING PRECISION AND ACCURACY OF ATMOSPHERIC EMISSION INVENTORIES

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INTRODUCTION

The present work proposes a backward air quality simulation approach to assess the accuracy of emission inventories for these applications, with the goal of identifying sources that are over or underestimated. This approach consists of finding constants of the linear combination of the estimated emission that maximize R^2 and make the slope equal to one in the linear correlation analysis when the results from the air quality model are compared to the experimental measurements of air quality. This methodology was applied to the case of the mining region in northern Colombia. As one of the largest open pit coal mining regions in the world, this region consists of seven independent mines with no relevant additional sources of emission. Use of the proposed methodology allowed quantification of the amount by which companies over or underestimated their emission, as well as quantification of uncertainties due to sources not considered in the model but that locally affect each monitoring station.

Geography

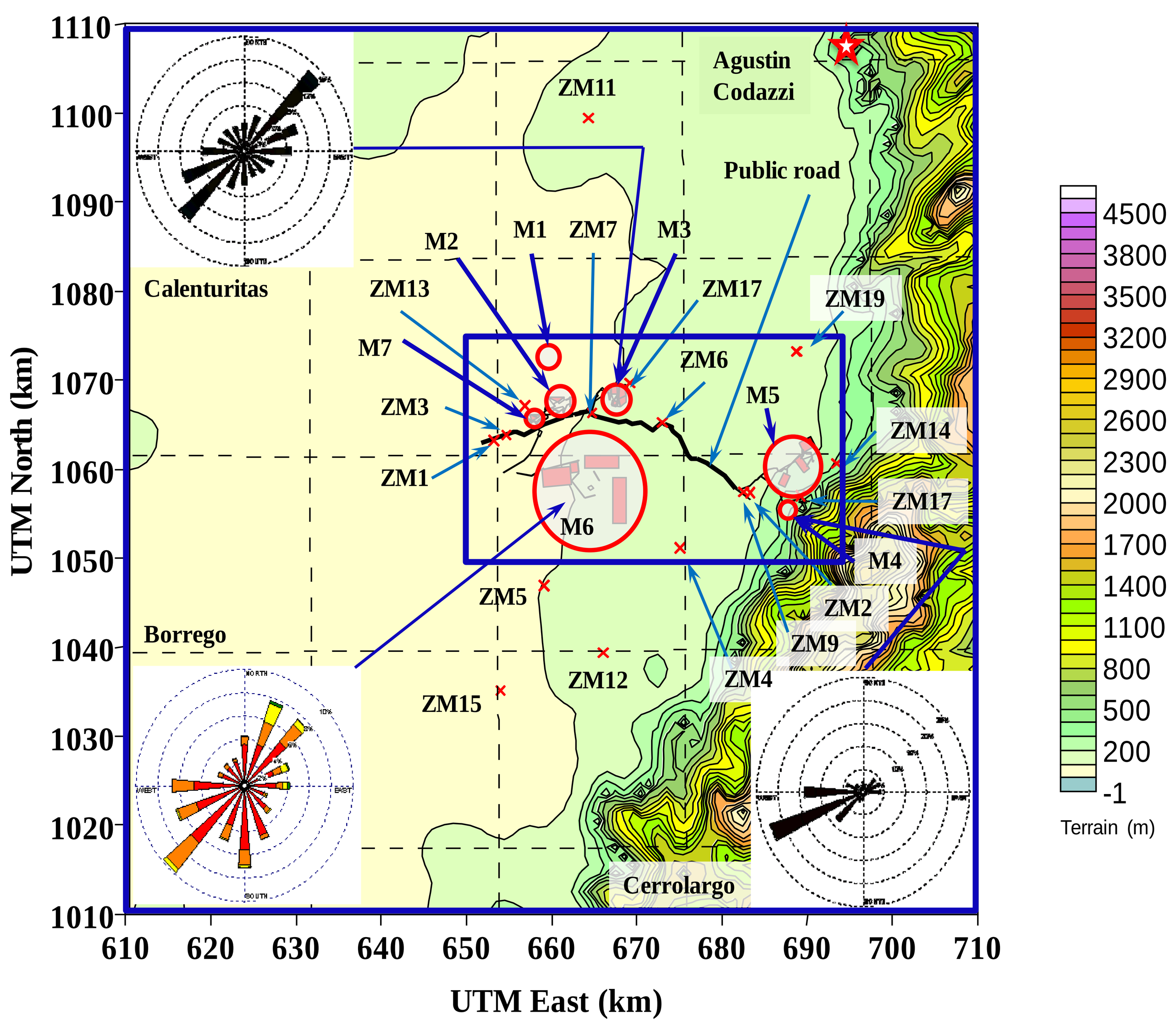

Figure 1. Location of emission sources (M s), air quality monitoring stations (ZM's) and meteorological stations used for the modeling process. Altimetry is also shown.

Emissions

Table 1.
Open pit coal mine emissions for 2009

Sources	TSP emission intensities g/(m² s)						
	M1	M2	M3	M4	M5	M6	M7
Pit	5.0681E−05	3.4910E−06	1.1912E−05	9.1367E−04	9.8477E−06	2.6908E−05	1.2887E−05
Dump	8.6049E−06	5.4693E−06	5.8058E−06	4.3629E−04	1.0434E−05	6.6505E−06	7.0641E−06
Stock	3.5024E−05	2.0435E−04	1.3037E−03	2.0729E−03	2.9833E−03	1.4394E−04	5.3191E−05
Pit-dump via	2.1887E−04	5.5485E−06	1.4318E−04	2.1503E−04	3.5172E−05	7.2359E−05	2.6565E−05
Pit-stock via	4.3951E−05	1.0493E−07	1.4638E−05	2.3989E−07	1.1574E−06	8.8889E−04	9.9652E−06
Beltway	5.4694E−05	1.4430E−07	0.0000E + 00	9.3328E−07	3.1034E−06	4.3277E−05	3.8399E−06
Total TSP emissions g/(m² −s)	3.5713E−04	2.1911E−04	1.4792E−03	3.6390E−03	3.0430E−03	1.1820E−03	1.1351E−04
Total TSP emissions kg/year	3.9276E+06	7.4812E+05	2.3139E+06	1.6727E+06	3.0230E+06	1.4819E+07	9.0708E+05
Total coal production ton/year	1.8148E+06	1.038E+06	5.984E+06	6.000E+05	4.730E+06	1.840E+07	1.600E+06

Pit, dump, stock and pit-dump via, pit-stock via and beltway are the area sources considered within mine (M's)

METHODOLOGY

The proposed methodology to assess the accuracy of emission inventories of a given pollutant compares experimental data of pollutant concentration with concentrations obtained through an air quality model that use emissions inventory in a backward modeling approach.

Let n be the number of emission sources in the region of interest. This method consists on affecting the estimated emission of each source *Ei* by a constant *Ai*, where *Ai* > 0. The resulting emission inventory $(E=\sum_i^n A_i E_i)$ is used as data input of a well-established air quality model to obtain the pollutant concentration at the j points where that pollutant has been measured for a long period of time. Then, the correlation between the numerical results ($P_{t,j}$) and experimental values ($M_{t,j}$) was statistically evaluated in terms of long-term averages (M_j vs. P_j). The sets of constants {*Ai*} are changed systematically to obtain the set of constants $\{Ai\}_{max}$ that maximizes R^2 and simultaneously makes the slope = 1.

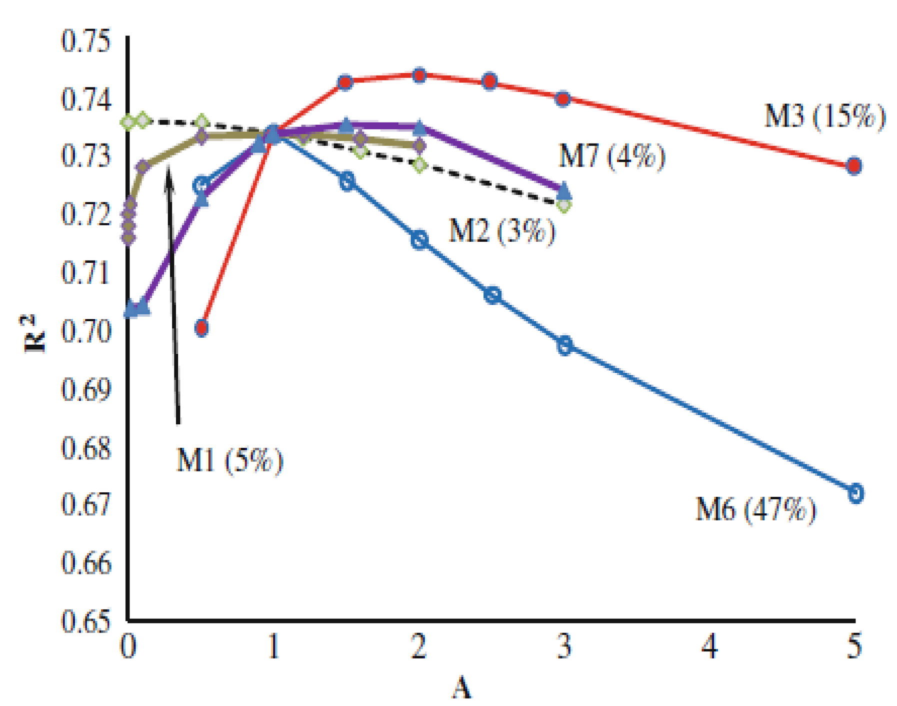

Figure 2. Variation of the metrics of correlation as funtion of Ai

RESULTS

Figure 3. Linear correlation of measured verus estimated annual mean geometric TSP comcemtratopm for the base case and optimized scenarios

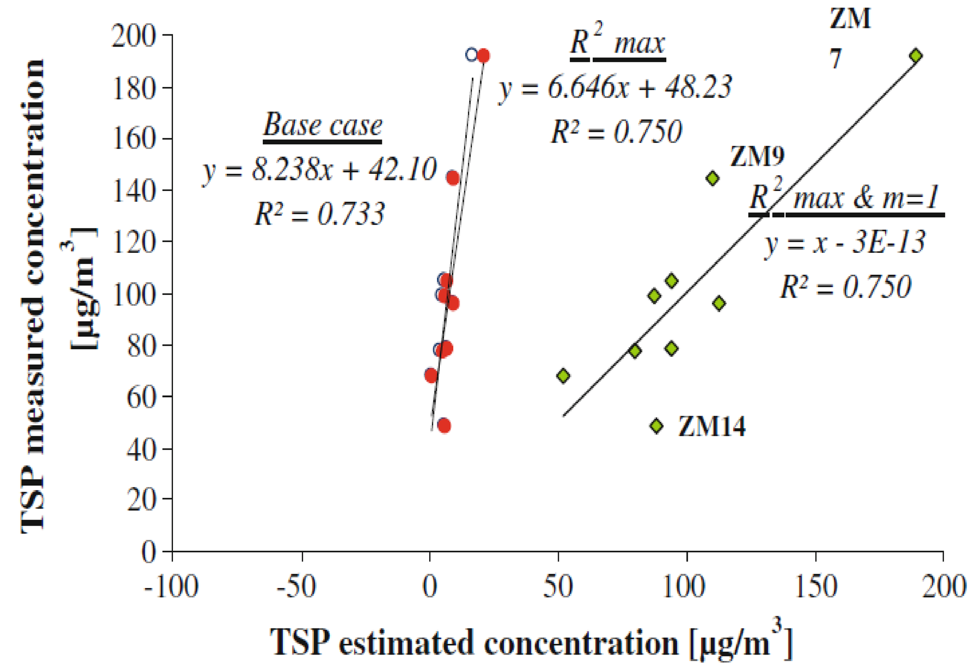

Table 2. Results of the metrics to evaluate the accuracy of air quality model. Results expressed as annual mean geometric TSP concentration

	Base	M1	M2	M3	M6	M7	R^2 max	R^2 max and $m = 1$
A	N/A	6.65	0.66	13.29	6.65	9.97	N/A	N/A
1 − *p*	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7
m	8.24	1.24	1.29	0.99	1.24	1.20	6.65	1.00
b	42.10	−17.68	−19.60	0.98	−17.68	−16.66	48.23	0.00
R^2	0.7336	0.7336	0.7357	0.7437	0.7336	0.7352	0.7501	0.7501
r	0.8565	0.8565	0.8577	0.8624	0.8565	0.8574	0.8661	0.8661
d	0.26	0.87	0.86	0.91	0.87	0.88	0.26	0.92
Bias	−93.79	−5.24	−7.20	−0.17	−5.24	−3.25	−93.00	0.00
FB	−1.74	−0.05	−0.07	0.00	−0.05	−0.03	−1.71	0.00
MG	0.06	0.98	0.96	1.02	0.98	1.00	0.06	1.02
NMSE	14.15	0.05	0.06	0.04	0.05	0.05	12.47	0.04
RMSE	100.97	22.82	23.60	20.75	22.82	22.15	99.89	20.49
FAC2 (%)	0	100	100	100	100	100	0	100

- Mine 2 was found to overestimate its emission by 1/0.66, and the other mines underestimated their emissions by a factor between 6.65 and 13.29. The result of 1 - R^2 = 25.0% indicated that there were relevant circumstances that locally affected each monitoring station and were not included in the air quality model.
- Stations ZM9 and ZM14 exhibited the largest dispersion.

CONCLUSIONS

- The methodology was applied to the case of the mining region in northern Colombia, R^2 was determined to be an n-dimensional convex function with respect to the set of n constants that affect each emission source; thus, there existed a unique set of constants for which R^2 was a global maximum. R^2 moved from 0.73 in the base case scenario to 0.75 in the optimum scenario

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