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CAN PARTICULATE MATTER BE USED TO EVALUATE TRAFFIC RELATED ABATEMENT MEASURES? CONCLUSIONS OF THREE RECENT CASE STUDIES IN THE "HOT SPOT" FLANDERS, BELGIUM

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Abstract: Recently, three different scenario studies were implemented in the Flanders region to assess the impact of traffic related mitigation measures. Based on these analyses, it can be concluded that the commonly used PM_{10} and $PM_{2.5}$ pollutants are not the most appropriate to evaluate the effect of such measures. It turns out that elemental carbon is a better traffic related air quality indicator which contains a much more pronounced signal of traffic emissions. Therefore, a traffic environmental impact assessment should include elemental carbon as a relevant parameter.

Key words: *particulate matter, elemental carbon, traffic pollution*

INTRODUCTION
Member States are obliged to look for all possible measures that can be implemented to improve the ambient air quality and to meet the EU air quality limit values. In many cases, abatement measures have a focus on traffic related pollution. Since particulate matter is one of the most important air pollutants in Flanders (Northern part of Belgium), mitigation strategies are evaluated on the basis of PM concentration reductions

Very recently, three case studies were set up in Flanders. In each case, a traffic related abatement measure was evaluated. More specifically the cases consists of a low emission zone in the city centre of Antwerp, the closure of the Ring road of the city of Antwerp and a speed limit reduction from 120 to 90 km/h on several major highways during particulate matter smog episodes.

METHODOLOGY
The impact of each of those traffic related measures was evaluated by means of an air quality modelling system. The emission model MIMOSA, based on the COPERT 4 methodology, is used to model the traffic emissions (both exhaust and non-exhaust) in the different scenarios. The MIMOSA model calculates geographically and temporally (hourly) distributed emissions for Flanders. It employs detailed mobility data (traffic volumes per road segment, fleet composition, traffic speed on road segments, …) and emission factors following the COPERT methodology. MIMOSA can hence generate hourly emissions for different traffic scenarios.

The regional air quality models AURORA or BelEUROS were used to simulate the regional background concentrations. The regional air quality models are prognostic 3-dimensional Eulerian chemistry-transport models, designed to simulate urban- to regional-scale concentration fields both for gaseous pollutants and particulate matter. They take into account emissions of all air pollutants and hence can assess the change in concentration levels due to changing emission patterns.
Coupled to these regional models, the bi-Gaussian plume model IFDM was used to simulate the air quality patterns at high resolution along the highways on an hourly basis. Using this procedure, concentration maps for the Flemish region with a resolution up to 30 m for the hot spots were obtained.

CASE STUDIES
Recently, three different scenario studies were implemented in the Flanders region to assess the impact of traffic related mitigation measures.

A first case study was related to the closure of the north-western part of the Ring road of Antwerp. The closure of the Ring road of Antwerp via the so called "Oosterweelverbinding" is one of the main projects in the Master plan of Antwerp. This master plan is initiated to solve the serious traffic congestion problems which are faced today in and around the city of Antwerp. In this study, the impact assessment of the Oosterweelverbinding is tested with respect to these evolutions for PM2.5. Model calculations are preformed for two different situations: the "Oosterweel" scenario for 2015 in which the Ring is closed and an "Autonomous" scenario for 2015 in which the Ring is not closed. The model calculations pointed out (Figure 1) that the impact of traffic related measures on the local PM concentrations (PM10 and PM2.5) are rather limited and of the order of a few percent level.

In a second case, the implementation of a low emission zone (LEZ) for the city centre of Antwerp is examined. The LEZ is defined as a restriction for heavy duty vehicles and busses with a Euro label lower than EURO IV. The measure is intended to be in force in the year 2015. EURO IV vehicles will be older than 10 years at that time. In combination with the LEZ, a reorganisation of the local traffic flows in the city centre is implemented as well. Local traffic circulation plans are developed by the city authorities and are designed to discourage people entering the city centre by cars.

A third case study is related to a short term emission reduction strategy taken by the Flemish government which decided to introduce speed reducing measures (maximum 90 km/h instead of 120 km/h on certain sections of motorways) during PM10 smog episodes. Since May 2006, the measure has been put into force a couple of times during predicted smog episodes.

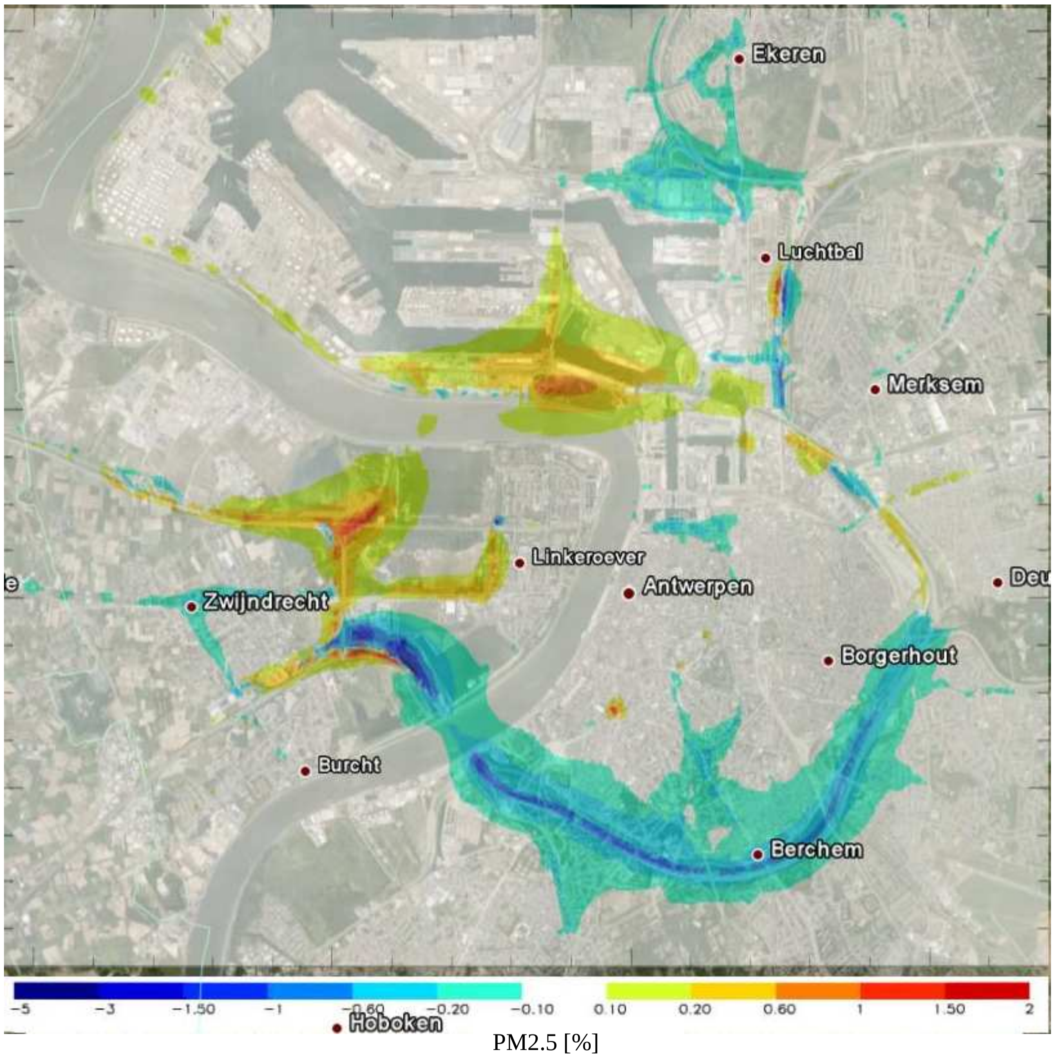

Figure 1: Relative differences (in %) in PM2.5 concentrations after closure of the north-western part of the ring way of Antwerp, Belgium.

RESULTS AND DISCUSSION

For each of the three case studies, the relative impact of the mitigation measure on PM10 or PM2.5 concentrations is simulated. In all cases a base case and a scenario analysis including the specific measure is modelled. A relative comparison of those results is presented in Figure 1 - Figure 3.

The model predicts a limited impact of the Oosterweelverbinding on PM2.5 (Figure 1): increased concentrations of a few percent along the new northern segment of the Ring and decreased concentrations along the southern part of the Ring due to the reduction of traffic (in particular heavy duty vehicles) on this part.

For the implementation of the LEZ and the implementation of local traffic plans, model simulations estimate a reduction of about 1% of PM10 concentrations in the city centre (Figure 2). Maximum reductions are obtained on the most busy traffic lanes which are used most frequently by trucks and busses to cross the city centre. It is interesting to note that the implementation of the LEZ combined with the local traffic plans also causes an increase in PM10 concentrations in the outside regions of the city and on the Ring road.

For the speed limit reduction case, model simulations are not performed for a whole year as in the first two cases but for two smog episodes in 2007 and 2008 only. Model calculations point out that a decrease in the traffic emissions is up to about 30% (somewhat higher for PM2.5) on the highways where the speed limit enters into force. However, the decrease in PM10 concentrations is only visible close to the highways where the speed reductions have been applied. In the direct vicinity of most of these highways, the changes are not higher than 1.5% with a maximum close to 5%. The difference is larger for PM2.5, although the effects remain also limited (Figure 3). Maximum changes for PM2.5 increase up to 8%.

As an overall conclusion of those three case studies, it can be stated that the impact of traffic related mitigation strategies on PM10 and PM2.5 levels is limited. In the three examples for which an impact assessment was calculated, the maximum reduction is only a few percent. As such, it is questionable if these particulate matter parameters are most suited to evaluate such kind of measures.

To further pin down this assumption, the third case study (speed limits on highways), is used to model the impact on the elemental carbon (EC) component of PM. After all, it is assumed that this EC content directly emitted by traffic, is one of the most harmful for the exposed population. Model simulations point out that in this case the measure can have a significant impact on the EC concentrations. EC concentration decreases up to 30% were modelled in a wider vicinity of the highway. This is in sharp contrast with the reduction levels that are seen for the more classical PM pollutants such as PM_{10} and $PM_{2.5}$. The reason for this can be attributed to the high secondary particulate matter fraction and the large background contribution which are observed for both PM_{10} and $PM_{2.5}$. For EC, a primary pollutant, the overall background is estimated to be very low and local contribution of traffic emissions have a clear signal on the concentrations in ambient atmosphere.

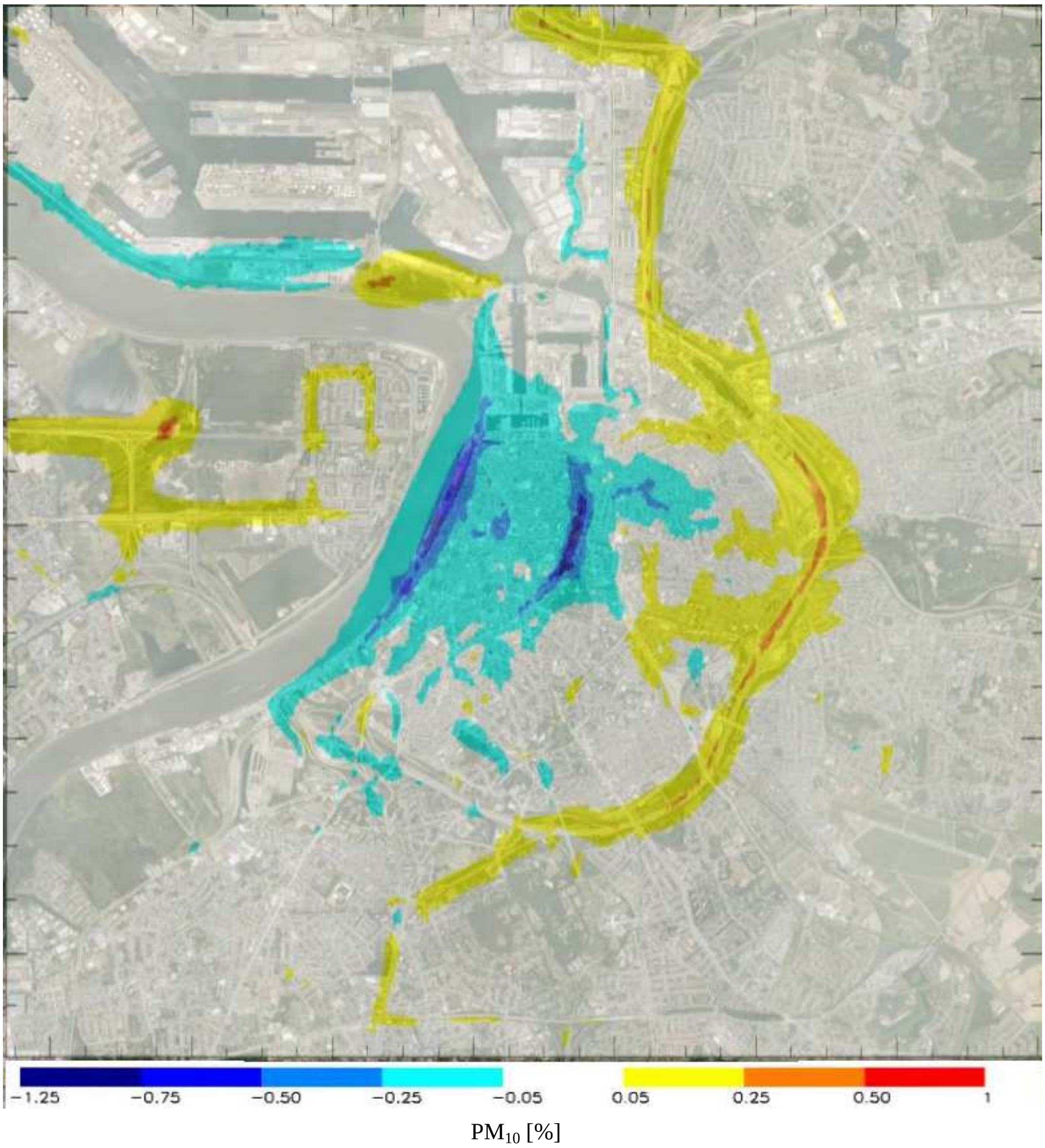

Figure 2: Relative differences (in %) in PM10 concentrations after implementation of a low emission zone in the city centre of Antwerp, Belgium.

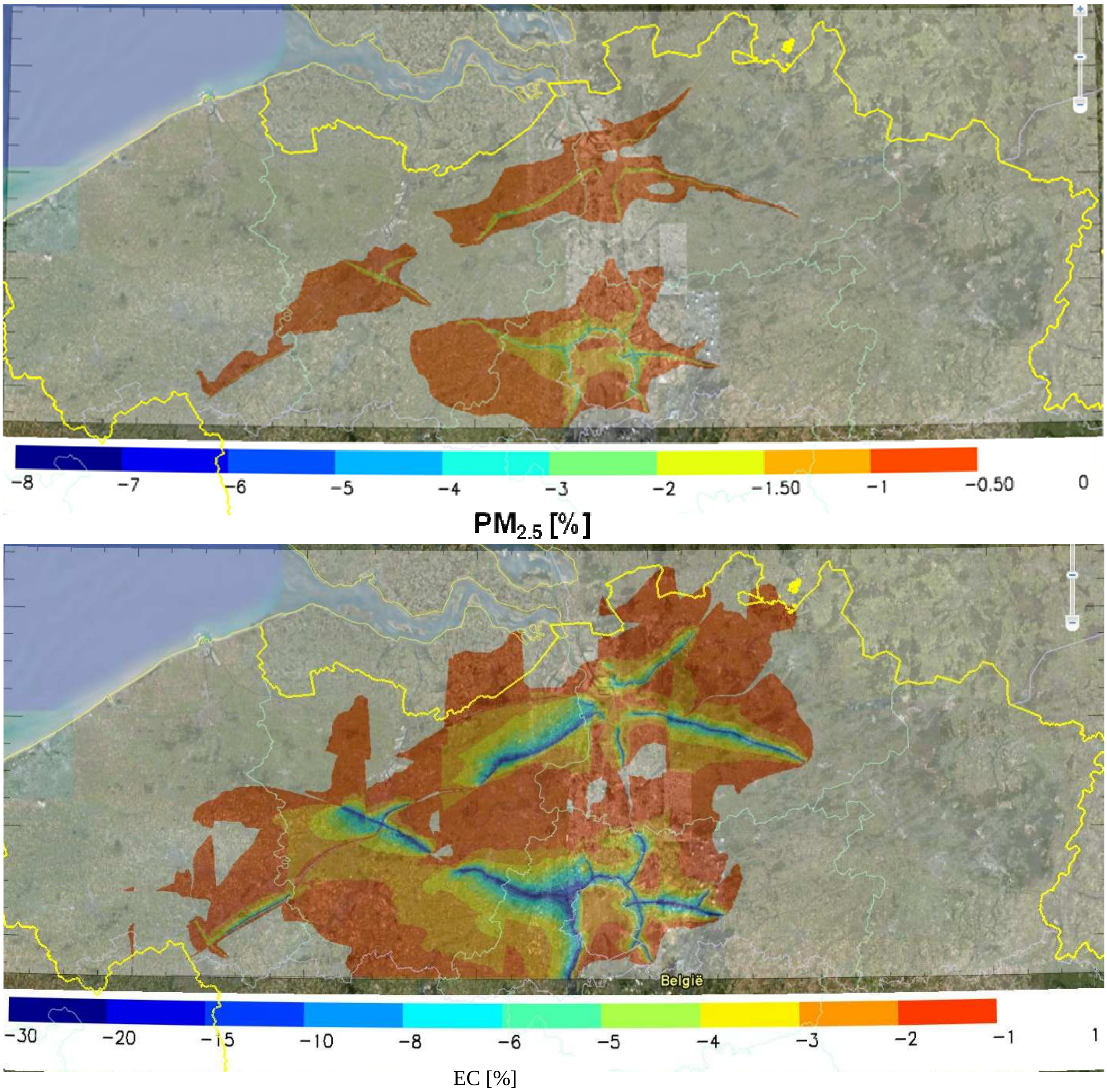

Figure 3: Relative differences (in %) in PM2.5 (upper panel) and Elemental Carbon (EC, lower panel) concentrations after imposing a speed limit reduction from 120km/h to 90km/h.

CONCLUSIONS

In this paper, three different case studies are examined implementing traffic related mitigation measures for air pollution. The mitigation measures cover the redistribution of traffic on the Ring road of Antwerp due to the closing of the Antwerp ring road, the implementation of a low emission zone in the city centre of Antwerp and the enforcement of a speed limit reduction of 90 km/h on a number of highway segments in Flanders.

For all cases, a relatively low impact (percent level) of the measures is observed for the classical total mass PM10 and PM2.5 pollutants. However, a much higher impact (up to ~30%) is observed on the elemental carbon (EC) fraction of particulate matter, which is assumed to be more harmful for population exposure. It turns out that EC is a better traffic related air quality indicator which contains a much more pronounced signal of traffic emissions. Therefore it is questionable if the classical pollutants such as total mass PM10 and PM2.5 are well suited to evaluate traffic related measures for air pollution reductions. As a result of the current legislation, policy makers are facing the situation that mitigation strategies do not help very much in meeting the EU air quality limit values but might be relevant in reducing the health impact of the exposed population.