Atmos. Chem. Phys. Discuss., 13, C9540–C9547, 2013
www.atmos-chem-phys-discuss.net/13/C9540/2013/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Modelling NO_2 concentrations at the street level in the GAINS integrated assessment model: projections under current legislation" *by* G. Kiesewetter et al.

G. Kiesewetter et al.

kiesewet@iiasa.ac.at

Received and published: 2 December 2013

We thank the Referee for his/her constructive comments and suggestions on how to improve the manuscript. Below we provide detailed point by point replies to the questions. Referee comments are quoted in ***bold italicised*** font.

2.3.2 It is not clear to me how the primary NO2 fraction is calculated (p in Eq. 9). It is stated it cannot be be known at specific stations, but it is not clear how

this variable is estimated. Given the importance of primary NO2 close to roads more explicit information is needed in this section. Note also when historical trends are estimated (section 3), several countries are shown to have less of a decrease in observed NO2 concentrations than is suggested by the model. The authors state that this could be due to the value of p. This is actually a critical issue for any model estimates made at roadside locations. There are also important implications of failing to capture the variation in time and space of p and the lack of reduction in observed (but not modelled) NO2 at locations such as London. These locations will drive the exceedances of NO2 in future in Europe and failing to capture the trends has important implications. I would like to see more discussion of this issue.

We apologize that the original manuscript was a bit unclear on how the NO2/NOx emission shares are used in the model. We have tried to clarify this in the manuscript (added a paragraph in Sect. 2.4.1, and a bullet point in the uncertainties discussion in Sect. 4).

We are combining a bottom-up calculation with the calibration to observations as follows: We use standard emissions factors derived from COPERT IV for each vehicle technology (= Euro norm). Most uncertain are assumptions for diesel cars and light trucks. The share of primary NO2 in the exhaust is taken from the Handbook Emission Factors for road transport (HBEFA) 3.1 (http://www.hbefa.net), which is based on representative chassis dynamometer tests. Different values have been reported in different studies (see Table 1). The HBEFA shares fall in the middle of other literature values mentioned by the reviewer, and we therefore consider them a good choice.

Carslaw and Rhys-Tyler (2013) were to our knowledge the first to publish only very recently observations of variable NO2/NOx ratios e.g. by (car) engine size and (bus) manufacturer. This may point to yet another factor of uncertainty in the whole modelling chain. However, to our understanding it does not fundamentally change the uncertainties: As the reviewer indicates it is known and also documented in the mentioned references for London, that different locations are characterized by different fleet mix, e.g. different shares of urban buses. Also traffic volumes have developed differently at different stations, hence the temporal development of the resulting primary NO2 emission shares might differ between them. However, detailed time series are at best only available for traffic volumes at (or close to) selected stations, typically counting "long" and "short" vehicles, hence without information on fuel type, let alone vehicle technology. Hence, the best we can do is to use national average for the fleet mix, and its temporal development. If detailed data on the temporal development of fleets at air quality measurement stations were available we would be to integrate it in our analysis, but due to unavailability on the one hand, and constraints in capacity to generate input data for 500+ stations this is for the moment infeasible.

Parts of the uncertainty in p are compensated by the parameter estimation process that constrains the model to observed concentrations in the base year. E.g., higher p values will lead to compensating negative background representativeness corrections and shorter mixing times. We have varied the p-shares between the extremes found in the literature; the impacts on the compliance situation are limited.

The differences between observed and modelled NO2 trends in some countries (e.g. UK) may be connected to p in the sense that when strong changes in p occur (such as seen in the UK) the model will have difficulties to reproduce urban background NO2 trends as p is not considered for modelling urban background NO2 – the NO2/NO concentration ratio in urban background air is assumed to remain constant at 2009 values. However, it is not clear that this mismatch of past trends should be continued in the future, as it depends on the actual evolution of (fleet average) p. Since projected future changes in p are smaller than the large increases in the past, the effects on trends will be less pronounced.

End of section 3/Figure 10b. There is quite a large variation in the NO2/NOx

ratio across the EU, which will be governed by vehicle fleet differences. To what extent do those locations with high NO2/NOx emissions also correspond to locations with future NO2 exceedances?

This is an interesting question, and we checked the data explicitly: It is not straightforward that the locations (countries) with higher p should see more exceedances, as roadside NO2 is made up from background and increment, the latter depending primarily on the amount of total NOx emitted in the street canyon (i.e. on traffic volume) and, aside from p, also strongly on the mixing time and background O3 levels. We find a clear relation between the primary share of the roadside NO2 increment and p, but for total roadside NO2 the relation is less clear.

Would reducing the fraction of NO2 in exhaust but not reducing total NOx remove most of the exceedances?

This is indeed an interesting question. Firstly, such a measure would affect only the roadside increment while leaving the urban background unchanged (at least in the idealised model world, see discussion on p above), which makes up roughly 50% of total roadside NO2. Within the roadside increment, only the direct NO2 contribution would be affected (roughly 50% of roadside increment). In an extreme case, one would reduce direct NO2 emissions to zero; however, the decrease in primary NO2 would to a certain degree be compensated by secondary NO2 as more NO is available.

We have tested this extreme scenario, leaving NOx emissions constant after 2009 but reducing p to zero. While this would bring some alleviation, moving several stations into compliance, it would not be sufficient to eliminate the notorious hot spots: there, only partly reducing the roadside increment is simply not enough. Already before 2020 the effects of total NOx emission reductions under the CLE scenario described in the manuscript would outweigh the effects of reducing only p.

I would like to see some discussion on how the predicted NO2 is made up e.g. background, primary, secondary (NO + O3).

We have added a paragraph at the beginning of Sect. 2.4. The individual contributions vary from station to station and country to country. On a European average, about half of roadside NO2 is background and half roadside increment (40% – 70% in different countries). The increment itself can again be split into roughly 50% primary NO2 and 50% secondary; the primary fraction varies from 40% – 70% with a strong dependency on p.

One of the main conclusions of this work is the strong improvement in NO2 air quality towards 2030. This conclusion is very dependent on the performance of Euro 6/VI. While the authors are aware of this I would like to have seen a sensitivity analysis looking at the implications of the new emission standards not delivering the expected reduction in NOx emissions. One of the key reasons the paper is relevant is that historically emission standards for NOx in Europe have not delivered the expected reductions in NOx - particularly for light duty diesel vehicles. What if this were to happen again for Euro 6/VI - what are the implications for European NO2 concentrations. I would not suggest lots of additional work but it would be a good opportunity to get a feel for the implications Europe-wide of a less than expected reduction in NOx emissions.

We are aware that this is an important question, and we have undertaken some analysis addressing exactly this issue. However, in view of the considerable length of the present manuscript, we have decided to defer sensitivity studies to a separate publication and present only the baseline case here. The manuscript is under preparation and will be submitted shortly. In brief, we do see a considerable impact of possible shortcomings of the Euro 6 standard for diesel cars (e.g., assuming a reduction of the real world Euro 5 emission factor only proportional to the reduction in limit values leads to a tripling of the number of stations remaining in the "uncertain compliance" and "unlikely compliance" categories in 2030).

There is a better reference for Carslaw and Rhys Tyler (2013): Carslaw, D. C. and Rhys-Tyler, G. (2013). New insights from comprehensive on-road measurements of NOx, NO2 and NH3 from vehicle emission remote sensing in London, UK. Atmospheric Environment, Vol. 81 339-347.

We have exchanged the reference.

References:

Carslaw, D. C. and Rhys-Tyler, G.: New insights from comprehensive on-road measurements of NOx, NO2 and NH3 from vehicle emission remote sensing in London, UK. Atmospheric Environment, 81, 339-347, 2013.

Grice, S., Stedman, J., Kent, A., Hobson, M., Norris, J., Abbott, J., Cooke, S.: Recent trends and projections of primary NO2 emissions in Europe. Atmospheric

Environment, 43, 2154-2167, 2009.

Sjödin, Å. and Jerksjö, M.: Evaluation of European road transport emission models against on-road emission data as measured by optical remote sensing, Proceedings of the 17th International Transport and Air Pollution Conference, Graz, Austria, 2008.

Weiss, M., Bonnel, P., Hummel, R., Provenza, A., Manfredi, U.: On-Road Emissions of Light-Duty Vehicles in Europe. Environ. Sci. Technol. 45, 8575-8581, 2011.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 22687, 2013.

Table 1. Primary NO2 emission shares in the literature. a: Sjödin and Jerksjö (2008); b: Grice et al. (2009); c: HBEFA 3.1 (2010); d: Carslaw and Rhys-Tyler (2013); e: Weiss et al (2011). (c) is used in GAINS.

control	(a)	(b)	(c)	(d)	(e)
no	14%	11%	8%	15%	
Euro 1	14%	11%	8%	14%	
Euro 2	14%	11%	11%	9%	
Euro 3	47%	30%	28%	16%	
Euro 4	55%	55%	47%	28%	40%
Euro 5	55%	55%	36%	25%	46%