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AN EFFICIENT MODELING SYSTEM FOR NATION-WIDE COMPLIANCE TESTING

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Abstract: The European commission has granted The Netherlands a postponement until 31 December 2014 of the deadline for attaining the annual limit value for NO_2. Furthermore, The Netherlandswere granted exemption from the obligation to apply the limit values for PM_{10} until 10 June 2011. For each calendar year until the calendar year following the date of expiry of the respective postponement and exemption periods, the Netherlands has to provide the European Commission with the data indicating if the concentration levels are below the respective limit values plus the maximum margins of tolerance.

The derogation was obtained on the basis of a national cooperation plan on air quality instituted by the Dutch Government. For the yearly reporting of the concentrations the Dutch standard calculation models for air quality are used in combination with the measurement results. In the modelling system, separate models are used for the large-scale background concentrations, traffic in street canyons or on highways and industrial sources. Models are used in the Netherlandsfor both compliance checking as well asmakingestimations/prognoses.The national air quality cooperation plan contains general measures on a national scale as well as many local measures in cities and in individual streets. The effects of the measures on the ambient concentration levels are taken into account by the different models.

The Dutch standard calculation models for air quality include a long-term Lagrangian transport and deposition model, an hourly Gaussian dispersion model for point sources and a yearly average Gaussian dispersion model for calculations around highways and a street canyon model. All models have been validated to some extent using data from the National Air Quality Measuring Network in The Netherlands. Every year new estimates for background levels and emission factors are prepared. Compliance with the annual limit value for NO_2 concentrations in streets and near roads is checked at some 350.000 locations.

We present an overview of the yearly modelling cycle, including a short description of the models and some details regarding the validation. The latest results of the compliance testing will also be presented.

Key words: *air quality, compliance testing.***.**

AIR QUALITY MODELLING IN THE NETHERLANDS

Although The Netherlands is a relatively small country, it is not possible to describe the air quality in the whole country using only one model; therefore, a model hierarchy is defined. At a national level large-scale (background) concentration maps are calculated at a resolution of 1x1 km2. In a band of 4 km around highways and other large roads the concentration contributions of these roads are calculated using a Gaussian dispersion model. Within urban streets the contributions of local traffic in the streets is calculated using an empirical model, derived from wind tunnel measurements. These results are combined with those of the highway model and with the background concentrations. In relevant cases a double counting of concentration contributions is corrected for.

National background concentration maps

The large-scale calculations are performed using the Dutch OPS model.OPS is a long-term Lagrangian transport and deposition model that describes relations between individual sources or source areas, and individual receptors (Jaarsveld, 2004). The model is statistical in the sense that values for the concentrations and depositions are calculated for a number of typical situations and the long-term value is obtained by summation of these values, weighted with their relative frequencies. All relations governing the transport and deposition process are solved analytically, allowing the use of non- gridded receptors and sources, and variable grid sizes. Transport from a source to a receptor is assumed to take place in straight, well-mixed sectors of 30 degrees. Corrections are applied close to the source to account for height of emission and vertical dispersion; a correction for the curved nature of real transport paths is used for larger distances. An important difference with (true) probabilistic long-term models is that this model is driven by actually observed meteorological parameters (hourly or 6-hourly synoptical).

The model schematically consists of two main parts, a pre-processor and the core model. The pre-processor calculates hourly transport trajectories arriving at a receptor on the basis of wind observations and derives secondary parameters, which define the atmospheric state along the trajectories from the observed data. This describes the necessary statistics for the relevant period. The core model itself carries out the actual calculations on the basis of various inputs. The pre-processor has to be run once for each period (month, season, year or a number of years) and for each receptor area. The results are placed in a database as a set of tables. The model selects its necessary climatological data from the database, depending on the area and period of interest.

The basic meteorological input consists of wind direction and wind speed at two heights, precipitation data, global radiation (or cloud cover), temperature and snow cover, all measured at one or more locations in the Netherlands. Other inputs to the model are information on receptors (coordinates, roughness length, land use) and information on sources (coordinates, emission strength, height, horizontal dimensions etcetera.). The output of the model includes concentration data, dry deposition and wet deposition data, presented either by receptor or in gridded form. Where possible, results of OPS are calibrated using measured data.

With the OPS model the large-scale concentration maps for The Netherlands are calculated for all relevant species (NOx,

NO_2, PM_{10}, PM2.5) . Each year an update is made using the then best available information on emissions. Both national and European emission data are updated, national on a more detailed scale. For prognostic calculations, the best estimates for future emissions are combined with an estimate of how measures taken by the government will influence these emissions. For changes in the input, procedures or models a protocol has been defined. When possible, new model features or better emission distributions are taken into account during the yearly cycle.

In March of every year the ministry of Infrastructure and the Environment issues new concentration maps, emission factors and other relevant data that must be used in formal air quality calculations during the coming 12 months. It is not allowed to use other data in a calculation without permission of the ministry.

Local dispersion calculations

Since 2006 Dutch law allows for 3 dispersion models to be used for local air quality calculations:
- Standard model 1 for urban streets: an empirical model derived from wind tunnel measurements than estimates yearly average concentrations within street canyons and similar streets;
- Standard model 2 around highways: a yearly average Gaussian dispersion model for distances up to several kilometres;
- Standard model 3 around industries: a steady-state hourly Gaussian dispersion model for distances up to 25 kilometres.

The ministry of Infrastructure and the Environment has extensively documented these models (Ministry of Infrastructure and Environment, 2011). The ministry furthermore provides free executable versions of the models. Other models may be used after being evaluated and approved by the ministry. During the evaluation, performed by National Institute of Public Health and the Environment (RIVM), they must be shown to be at least equivalent to one of the standard models, be well documented and sufficiently validated. For National calculations, only the standard models are used.

All three standard models have been validated to some extent. Every year, results of the urban model are compared to measurements of the Air Quality Measuring Network (AQMN) of the RIVM. NO_2 and PM_{10} concentrations are measured in 14 streets in The Netherlands. For these streets traffic data are available. The NO_2 concentrations calculated from these data are compared to measured concentrations. In 2007 a more extensive calibration of the model was performed, during which measured NO_2, NOx, CO and PM_{10} concentrations were compared to calculated values. A satisfactory agreement was obtained. In 2008 the results of the model were compared to results of the Danish Operational Street Pollution Model (OSPM) (Nguyen and Wesseling, 2009). For yearly averaged concentrations a satisfactory agreement was obtained. A comparison of measured and calculated NO_2 concentrations is shown in figure 1. The highway model has been tested in several measuring campaigns and in several wind tunnel studies. Furthermore, the model has been compared to a number of similar models, both Dutch and other. Overall, the model seems quite suited for the calculations it is used for.

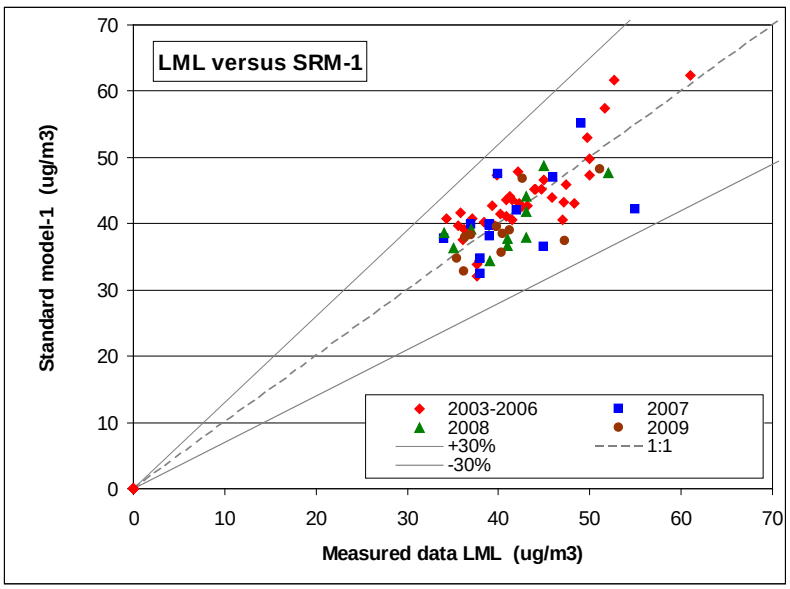

Figure 1 A comparison of measured and calculated concentrations at urban locations.

To assess the national air quality some 350000 locations have been defined for which the air quality has to be calculated for the previous year, as well as for 2011, 2015 and 2020. Combining pre-calculated large-scale concentrations and the local models, has made it possible to perform the necessary detailed calculations within a few hours. A highly specialised model of the RIVM can perform the necessary calculations around roads for one year within 10 minutes. With these models it is possible to quickly determine the effects of a variety of national and local measures to improve air quality.

THE AIR QUALITY MONITORING PROCESS

For reporting the status of the air quality in The Netherlands while the national air quality plan is being executed, a monitoring process has been established. It is a time table for all parties involved, detailing what has to be done during the yearly cycle, when it has to be done and which parties are involved.A schematic overview is presented in figure 2. Basically,

all parts of the Dutch government, national, provincial and municipal are responsible for the information concerning everything they are responsible for that influences air quality in a non-trivial manner. The national government provides information on most industrial emissions and has these incorporated in the large-scale concentration maps. It is, furthermore, responsible for providing information regarding the emissions on the national highways and on the waterways. Provincial and municipal authorities provide information on all relevant traffic emissions within their regions. They also provide information on agricultural activities and livestock farms in their regions, as these are relevant for PM_{10} concentrations. In August and September all data are processed by the RIVM and the results are reported to the government.

A Dutch company has created an online database containing the relevant data for all streets where air quality has to be assessed. All parties in the Netherlands responsible for road traffic (municipalities, regional and national authorities) can upload their most recent traffic data to this database. Each year they have to provide data for the preceding year, as well as for 2011, for 2015 and for 2020. After the results of the monitoring process haven been reported to the government, in the month of November,the resultsare also available to the public and can be downloaded using the monitoring website.

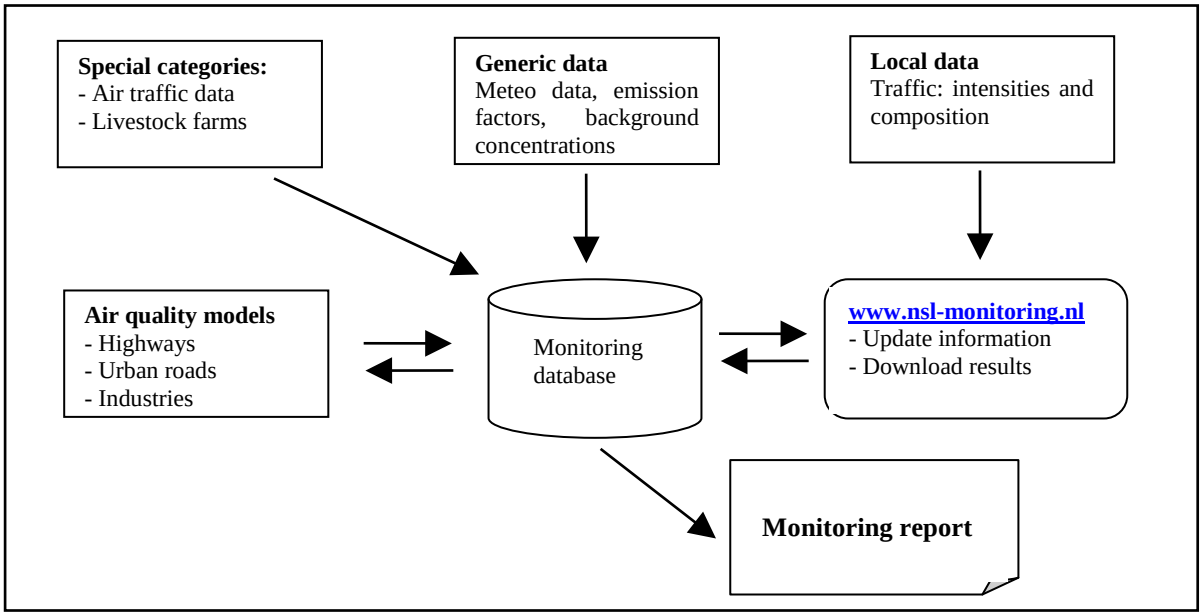

Figure 2 Schematic overview of the monitoring process in The Netherlands.

Results of the Monitoring in 2010

In 2010 the monitoring of the national air quality plan was performed for the first time (Beijk*et al*, 2010). The prognosis for 2011 and 2015, based on the results obtained using the available data, is that the concentrations of PM_{10} and NO_2will fall below the EU limit values in most parts of the Netherlands. However, exceedances of the limit values do occur at specific locations. The locations of remaining exceedances for PM_{10} in 2011 and for NO_2 in 2015 are shown in figure 3.

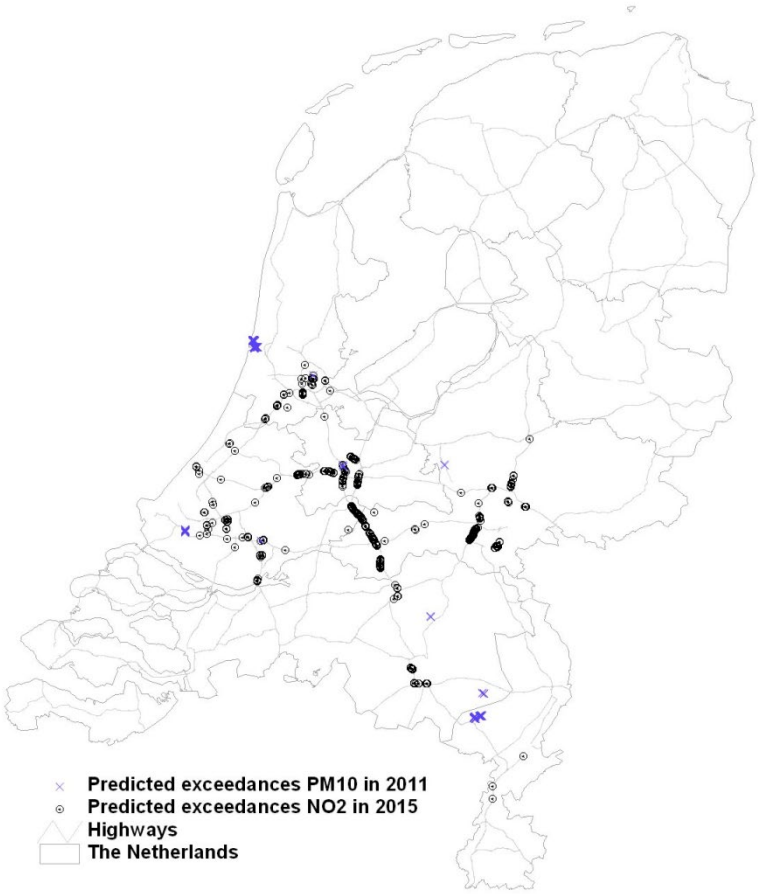

Figure 3 Locations of remaining exceedances for PM_{10} in 2011 and for NO_2 in 2015.

For PM_{10}, the remainingexceedances mostly occur close to a number of industrial sites and stock farms. Particularly high exceedances in the vicinity of these stock farms will make it difficult to meet the limit values by mid 2011 at these locations. The prognostications for NO_2 show a less favourable decline in NO_2 concentrations than was modelled at the establishment of the national cooperation plan on air quality. This is mostly due to the decline in traffic emissions falling short of expectations, resulting in new exceedances.At many locations, the calculated concentrations in the prognostications fall just under the limit value and, consequently, there will be a large increase in the number of exceedances when one or more of the premises become less favourable. This possibility, combined with the large and partially unknown uncertainty in the calculation results, leads to a risk for not meeting the limit values by the date of compliance.If necessary, additional measures have to be taken within the yearly monitoring of the national cooperation plan, to reduce that risk.

CONCLUSIONS

As part of the national air quality plan that is presently being executed in the Netherlands a fast and flexible assessment system has been devised. The system enables all parties involved to upload their data on (traffic) emissions to a central system. The available Dutch air quality models have been combined in such a way that all necessary calculations using the provided data can be performed within a short time, allowing for the possibility to estimate the effects of measures. Every year, in November, the status of the air quality in the whole of the Netherlands is reported.

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