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SMHI

Meteorologi

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**Project with financial support from Swedish Environmental Protection Agency**

## Content

# 1. Introduction

The EU directives together with the Swedish environmental legislation will require the Swedish municipalities to assess how they comply with given air quality standards. Model tools will be an important and necessary complement to measurements. Air pollution originates only partly from local sources within a particular municipality and there is often an important part that is transported over long distances, even from outside Sweden. Therefore model tools that aspire to simulate total concentrations of a pollutant, have to involve sources and dispersion on different scales, starting with the entire Europe and going down to the microscale of an individual street.

In Sweden, we share the dependence of pollution contributions on different scales with our other Nordic countries. Technical demands and solutions of model systems of different scales were discussed during a Nordic workshop held at Arkösund, March 2002 (SMHI, 2002). As all Nordic countries have developed their own model system, it was not found practical to try to establish one particular Nordic model. The principle conclusion from the Nordic model workshop was to work jointly for the establishment of high quality databases that can be used for model evaluation purposes. Such an activity is ongoing since 2003, within the NORPAC project, funded by the Nordic council of Ministers (http://NORPAC.dmu.dk).

Swedish authorities (Swedish Environmental Protection Agency and Swedish National Road and Traffic Administration) have taken the decision to finance the development of a coupled model system, SIMAIR, available for the use of municipalities. Since the accomplishment of the PM10 limit values seems to be the most critical issue in many Swedish municipalities, considerable efforts have been made to gather data (Areskoug et al., 2001) and improve emission estimates, especially for mechanically generated particulate matter. A research project aimed at developing parameterisations for road wear particle emissions, including the meteorological influence, is ongoing and will be reported during 2004 (Gunnar Omstedt, pers. comm.). A parallel project has determined emission factors for benzene (Omstedt and Johansson, 2004).

A Swedish initiative to build and finance a database for model evaluation was taken by the Swedish Environmental Agency (Naturvårdverket) in 2003. The Swedish Meteorological and Hydrological Institute (SMHI) and Slb (the unit of Air and Noise pollution of the Environmental and Health Administratin of Stockholm municipality) were selected to perform the compilation and the Internet implementation of the database. The data included are taken from available databases (EMEP, IVL, Slb, DMU, etc), which means that data have already passed a quality check. However, even if the values themselves have good quality, it is not always the case that the measurement is appropriate for model evaluation. One can, as an example, find data that are correct, but not representative for the scales (spatial or temporal) of the model. The aim of the present database is that the data included should have been proven to be useful for model evaluation. Most, although not all, of the measured data stored in the database have passed a model comparison. The present report describes the results achieved so far. There is thus still a risk that the user may find some sporadic data that is not appropriate for model evaluation purposes. However, we hope that those data will be reported so that we can exclude them from the database in future updates.

## 2. Content of the database

The database consists of hourly and daily measurements. It can be accessed through the Internet based software Iairviro. The software permits data analysis and graph displays to be made rapidly, directly on the Internet. It is also possible to export stored or elaborated time series in text format. There are five types of data, stored under different "station groups":

- **STO_street**: A Stockholm street canyon data set that includes also urban and regional background data. Originally with hourly resolution. All data stored in Swedish local time (UCT+1 for winter and UCT+2 for summer). (For sitedescription etc see http://slb.nu).
- **Regional**: A set of urban background and rural background data (particle mass and a few gases) to be used for evaluation of urban and regional models. Originally with hourly resolution. All data stored in Swedish local wintertime (UCT+1, no shift for summertime).
- **Ozone**: Ozone data from 11 stations in Sweden, Denmark, Norway and Finland. Forms part of the EMEP database. Originally with hourly resolution. All data stored in Swedish local wintertime (UCT+1, no shift for summertime). See map below.
- **Urban**: Daily NO2 and weekly benzene data from 17 urban background and 2 street canyon stations, to be used for evaluation of urban and regional models. Data from the IVL Urban database (http://ivl.se).

- **EMEP**: Daily data of inorganic gases and particles from 17 rural stations in Sweden, Denmark, Norway and Finland. Forms part of the EMEP database.

The use of Swedish local time for the STO_street data is motivated by the temporal variation of the traffic emissions which follow local time. On the regional scale, simulated data are normally given in UTC time, so that a different lag in summer and in winter would require extra work for the comparison with measurements stored in the NORDIC database. We have therefore stored Regional data in Swedish wintertime, i.e. UCT+1 hour. If hourly simulations will be compared to measured data both from the STO_street station group as well as the Regional station group, this difference must be considered (time lags can be handled in the NORDIC database by plotting e.g. x1[-1] or x1[1] instead of x1).

All hourly data have been averaged to daily means and introduced also in the daily database, while the data originally measured as daily averages have been introduced as 24 constant values in the hourly database (and the weekly data first set as constant during 7 days). Note that the end of the averaging hour is used to indicate average values of the preceeding hour.

Figure 2.1.1 shows a schematic picture of the time series that are available. More details of the data and how they were processed before entering the database are found in Appendix 1.

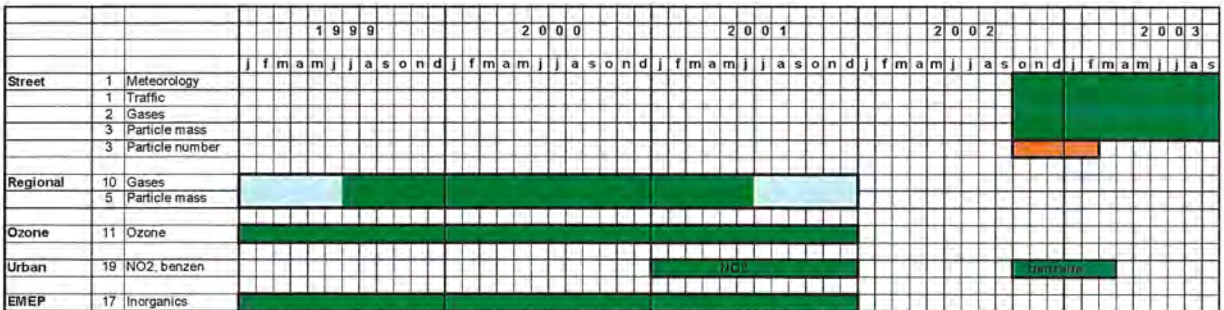



**Fig. 2.1.1** Overview over data availability. The second column gives the number of stations in the group.

The geographical location of the EMEP database stations are given in Fig. 2.1.2. The location of the Swedish stations of the other groups may be found at the web sites indicated above.


**Fig. 2.1.2** Location of "Ozone" and "EMEP" stations.

## 3. Characteristics of the data

In this section we will analyze the data of each of the five station groups, discussing one or both of two aspects:

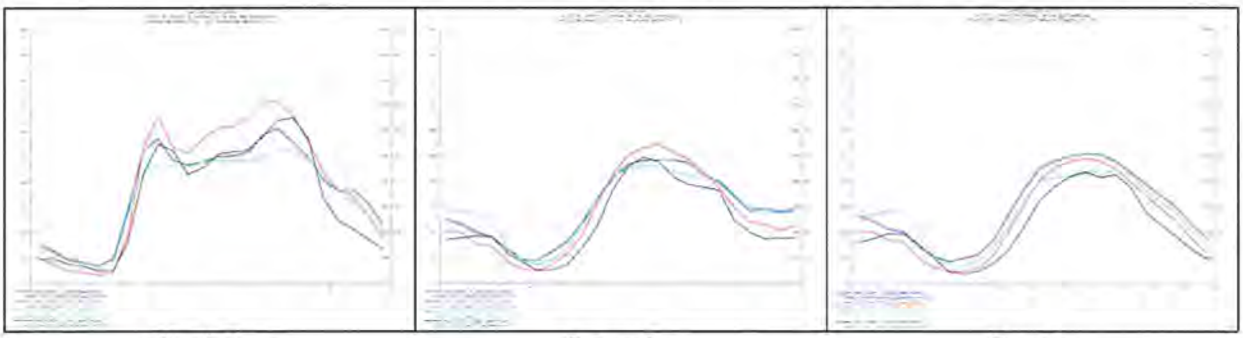
- Spatial and temporal variations in measured data.
- Published comparisons of measured data and model simulations.

This data analysis will serve the purpose of presenting the measurement database and improving the confidence of the data used for model evaluation. The term "model validated data" may be used, but it is important to state that the procedure followed is by no means rigorous or 100% accurate. The existence of erroneous and non-representative data also in the Nordic database may not be excluded. The plots presented will however make it easier for the model community to find the data they need for their particular model work.

### 3.1 Street data

Traffic data: Hourly data exist from Hornsgatan (named Hok in the database), from each of the four lanes. The street runs east-west so the northernmost lane is named N_n, the other west going lane N_s etc. Traffic volume of the west going lanes is about 10-15% larger than the east going lanes. Daily variations are found in Fig. 3.1.1. A detailed description of the measurement site at Hornsgatan may be found in Gidhagen et al. (2004a).

Note that the period Oct 21 – Nov 5 of 2003 show a changed distribution between the different lanes, probably due to construction work that increased the traffic volume on N_n and reduced it on N_s. The sum of the west going traffic seems however to be as usual.



*Weekdays* *Saturday* *Sunday*

**Fig. 3.1.1** Daily variation of traffic volume at Hornsgatan

Meteorological data: Those are taken from the roof of Maria Pol hospital, situated about 500 m east of the Hornsgatan monitor station. A 10 m mast is mounted on the roof (26 m), so that the wind anemometer is located at 36 m height. One meteorological variable, the temperature difference close to the ground, is however taken from the Högdalen tower, situated in an open area in the south of Stockholm (see also http://www.slb.nu/cgi-bin/station_descr/station?Högdalen)

CO data: For carbon monoxide there are measurements at both sides of the street (scN at the north side, scS at the south side) and also at the roof of the northern side (u_b). The roof value can be used as the urban background, e.g. to be added to simulated street levels. However, care should be taken for southerly winds, as the roof station will then be somewhat affected by the local (Hornsgatan) street canyon pollution. Actually the NOx data are better to use as an inert tracer emitted by the traffic, since the urban background station (at a different location) for NOx is less affected by local street emissions.

As can be seen from Fig. 3.1.2, the correlation between simulated and measured CO is rather high (0.77 at the northern side, 0.84 at the southern). However, simulated levels are too high. The reason is likely that the emission factor was taken from 2000, while the measured data is from October 2002 reflect an increased use of catalytic converters. The model overestimation is also higher at the northern side, but this may be due to reasons discussed below together with the NOx data. As a conclusion the street data seems to be useful for model evaluation, while some care has to be taken for the CO roof measurement.

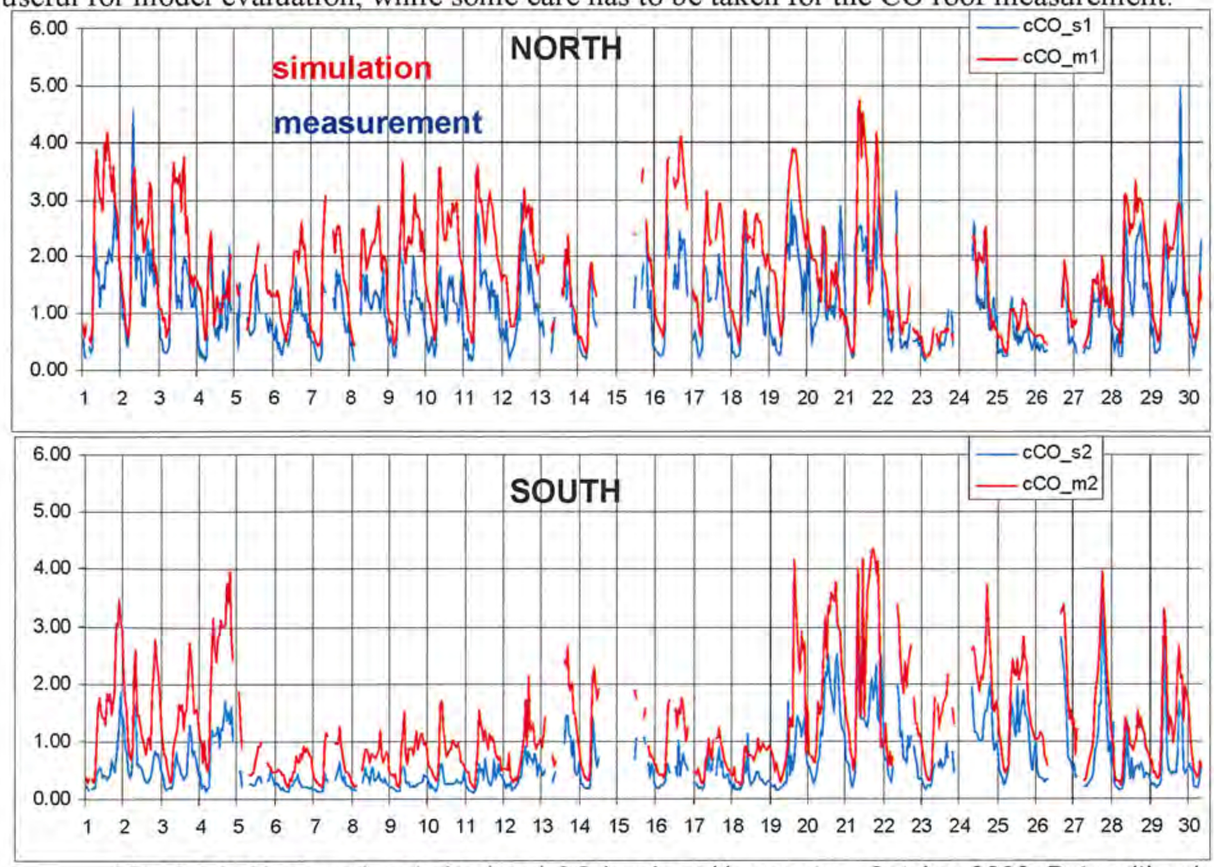



**Fig. 3.1.2** Measured and simulated CO levels at Hornsgatan, October 2002. Data with rain have been excluded. Model: OSPM. Integral emission factor: 13.24 g/veh,km.

NOx data: A model analysis made in Gidhagen et al. (2004a) shows that the higher NOx levels registered at the north side of the street, as compared to the southern side, can only be satisfactorily simulated with different emission factors for west going (northern lane) and east going (southern lane) traffic. This is due to road inclination and traffic signals, contributing to uphill driving under heavy acceleration for the west going (northern lane) traffic.

Fig. 3.1.3 shows the NOx model evaluation, with different emission factors for the two sides and also with a smaller contribution from neighboring streets.

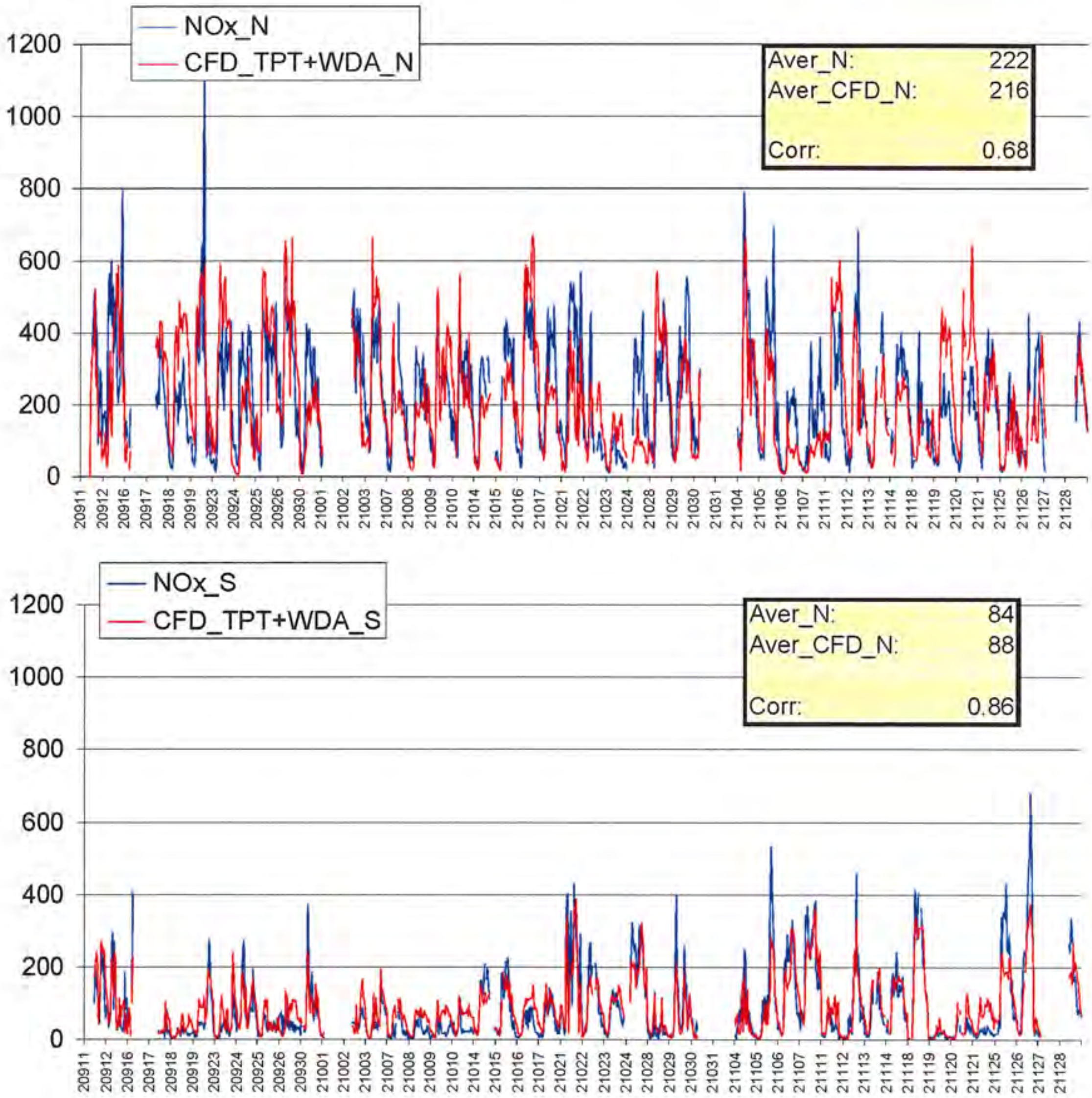



**Fig. 3.1.3** Comparison between simulated and measured NOx levels at Hornsgatan, Sep 11 to Nov 28 of 2002. Urban background is excluded. Model: StarCD. Emission factors: 2.0 g/veh,km for uphill driving, 0.66 g/veh,km for down hill driving. TPT (Traffic Produced Turbulence) and WDA (Wind Direction Averaging) corrections have been performed on CFD model output. Rainy events are excluded.

Particle number concentration (ToN) data: Also these data were analyzed in the Gidhagen et al. (2004a) paper. ToN is only measured at the northern side of the street, but also for ToN there were indications of higher-than-normal emissions due to uphill driving. But measured data is clearly useful for model evaluation (Fig. 3.1.4).

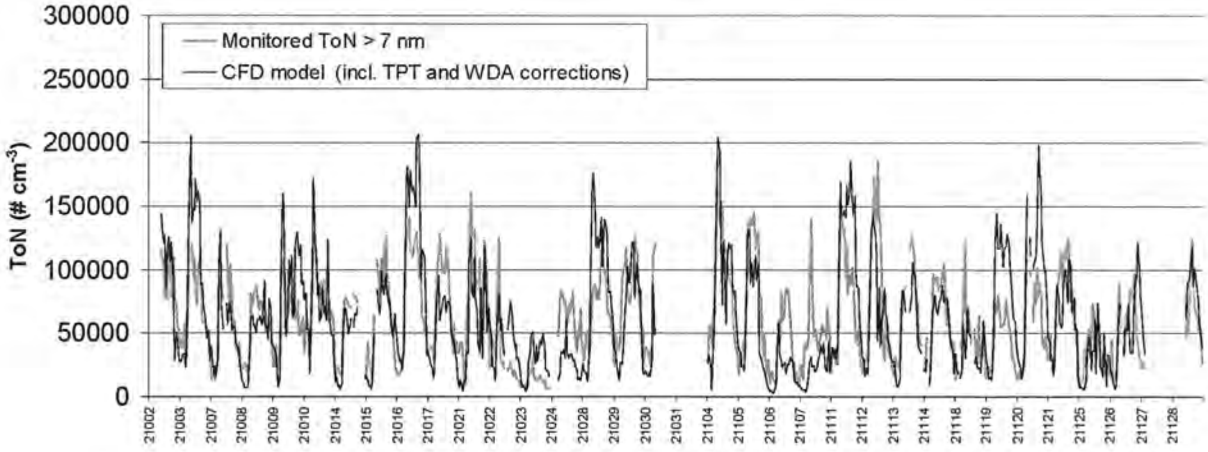



**Fig. 3.1.4** Measured and simulated ToN levels excluding urban background at Hornsgatan North, Oct 1 – Nov 28 of 2002. Model: StarCD without particle dynamics. Emission factors: 7.0 $10^{14}$ (uphill) and 0.78 $10^{14}$ (downhill) particles/veh,km. Rainy events excluded.

Particle mass (PM10): The Hornsgatan data have been used to assess the non exhaust particles that originate from the traffic, i.e. road and tyre wear particles. The latter is highly variable during the year, with peak values during spring March-April. At Hornsgatan the non-exhaust particle emissions contribution to PM10 values is about 10 times higher than the exhaust pipe PM emission. This means that a model simulation of PM10 must include a specific emission model for non-exhaust emissions. Note also that the regional background (long range transport) contributes to 60-70% of measured annual PM10 levels in Stockholm.

An emission model for PM10 has been suggested by Omstedt (2004a). The model has been evaluated for a data set from Hornsgatan, but for a time period – year 2000 - outside the Nordic database. The stations used are however the same as included in the Nordic database, so the model comparison made in Fig. 3.1.5 has relevance and shows that the PM10 data from Hornsgatan may be used for model evaluation purposes. A comparison with the 2003 data will be made later this year.

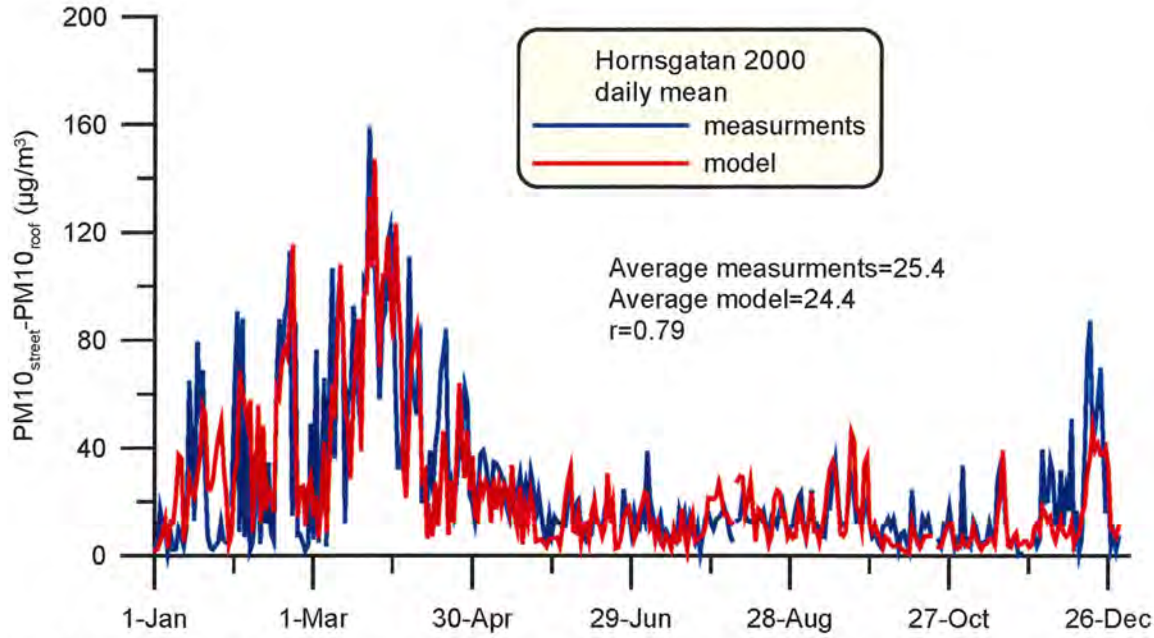



**Fig. 3.1.5** Measured and simulated daily average values of PM10 (µg/m$^3$) showing the local contribution (urban background excluded). Emissions according to Omsted (2004a). Note that the comparison is for a time period outside the Nordic database (a simulation and model evaluation for 2003 will be made later this year).

<u>Benzene data:</u> There are only continuous benzene measurements at Hornsgatan North. Concentrations representative for urban background (roof) exist only sporadically and are not included in the database. According to a study of benzene emission factors (Omstedt and Johansson, 2004), the urban background concentration in central Stockholm is fairly constant at around 0.7 µg/m$^3$ (between 0.5 and 1 µg/m$^3$). Using simultaneously measured NOx and benzene concentrations and fairly well known emission factors for NOx (as described above) an average emission factor for benzene of 35 mg/veh,km was obtained for 2003. Using this emission factor modeled and measured concentrations are compared in figure 3.1.6. The annual average model calculated and measured values are 3.3 and 3.9 µg/m$^3$ respectively.

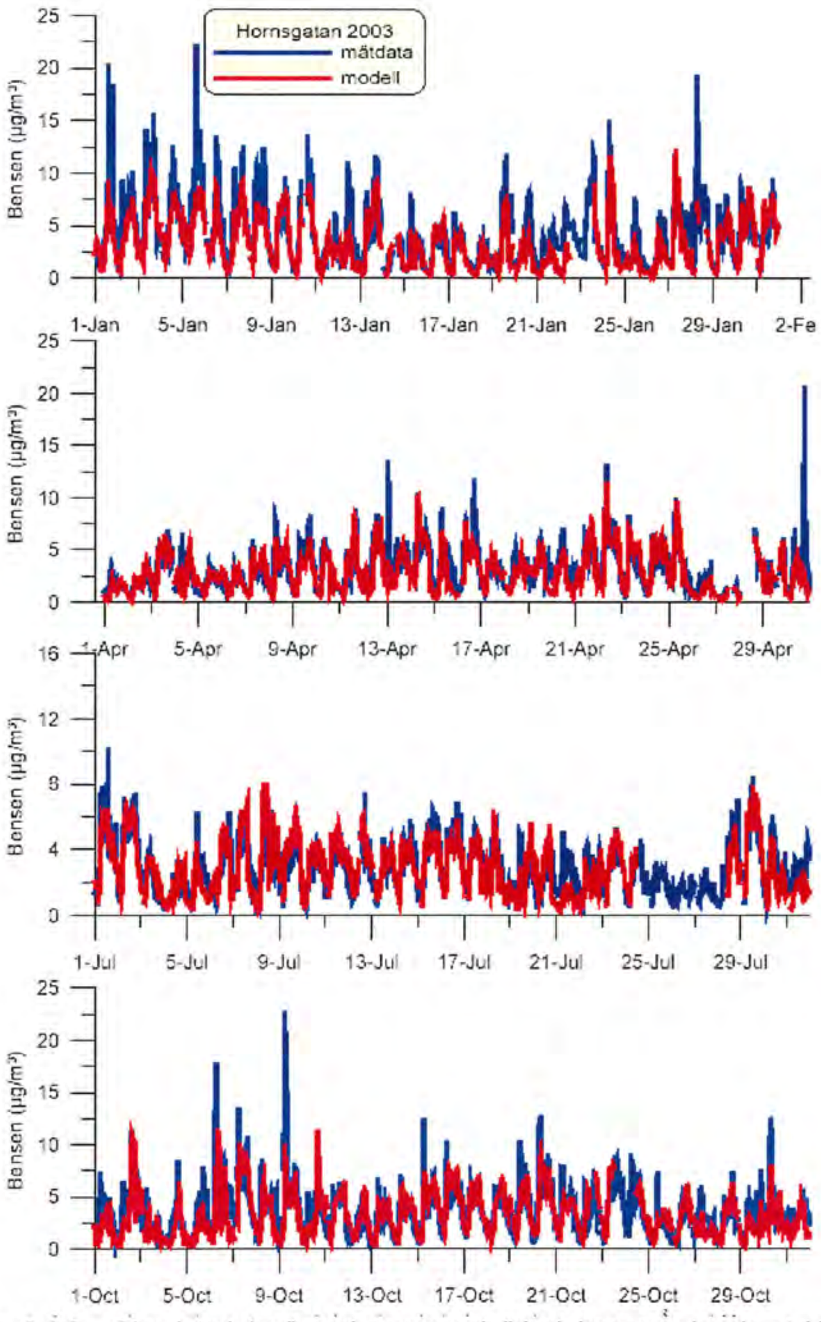



**Fig. 3.1.6** Simulated (red) and measured (blue) benzene levels at Hornsgatan North for 2003. For these calculations a total emission factor for the vehicle fleet at Hornsgatan was 35.3 mg/veh,km.

### 3.2 Regional data

The main purpose of this station group is to provide hourly data for evaluation of PM10 and NO2, as simulated by regional models. The database also include NOx, SO2, O3 and CO measurements. The stations included are either rural stations (r_b) or urban background (u_b) stations. The latter are typically roof stations representative for rather large areas in the central part of larger cities.

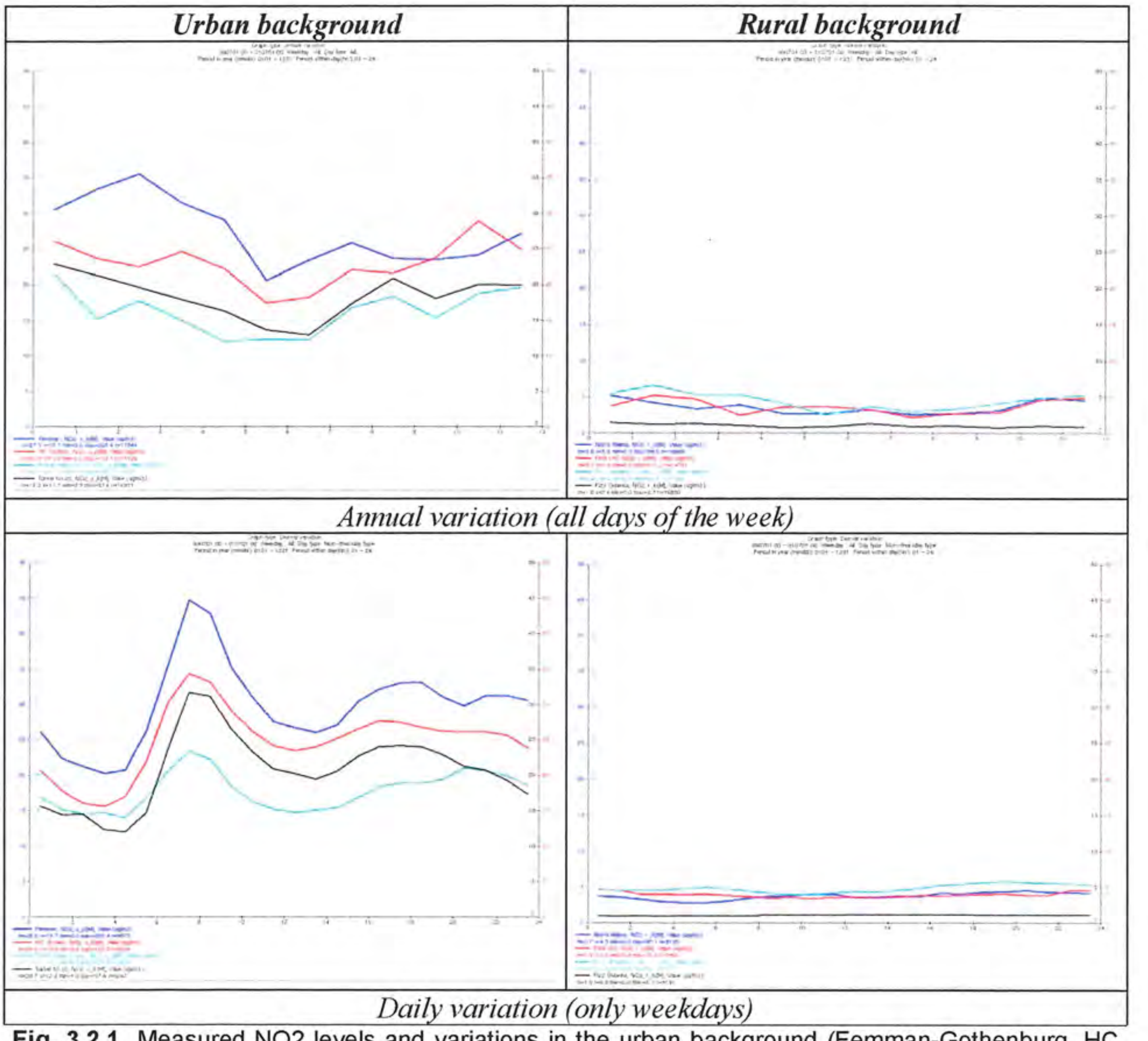



**Fig. 3.2.1** Measured NO2 levels and variations in the urban background (Femman-Gothenburg, HC Örsted-Copenhagen, Rosen-Norrköping and Torkel-Stockholm) and in the rural background (Norra Malma-Stockholm, Utö, Virolahti and Oulanka). Period: July 1999 – June 2001.

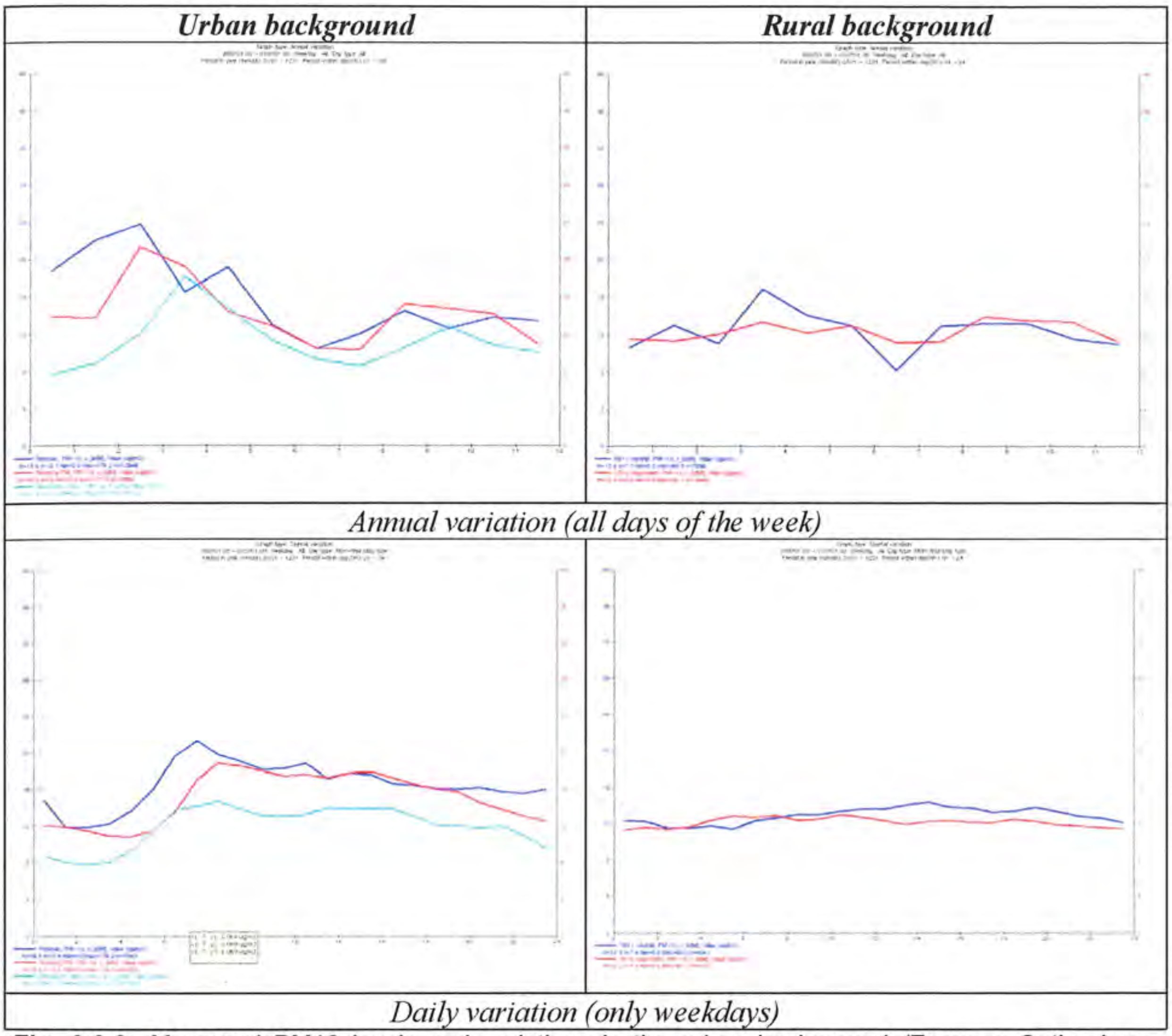



**Fig. 3.2.2** Measured PM10 levels and variations in the urban background (Femman-Gothenburg, Rosenlundsgatan-Stockholm and Biblioteket-Umeå) and in the rural background (Vavihill and Aspvreten). Period: July 1999 – June 2001.

Fig. 3.2.1 and 3.2.2 show the much stronger influence of local emissions on NO2 levels, which also imply a traffic related daily variation. For PM10 the urban background is not very different from the regional background. The effect of the springtime drying up of the road surfaces contributes to a marked annual variation in PM10 levels, peaking in February-March.

The NORDIC "Regional" data set has been compared to simulated MATCH data. The simulated data have been generated during autumn of 2003 as part of the EURODELTA and TNO model evaluation projects. For practical reasons daily average values is used for the comparison (as shown by Fig. 3.2.1 the daily variation of NO2 is important for the urban background, not for rural stations).

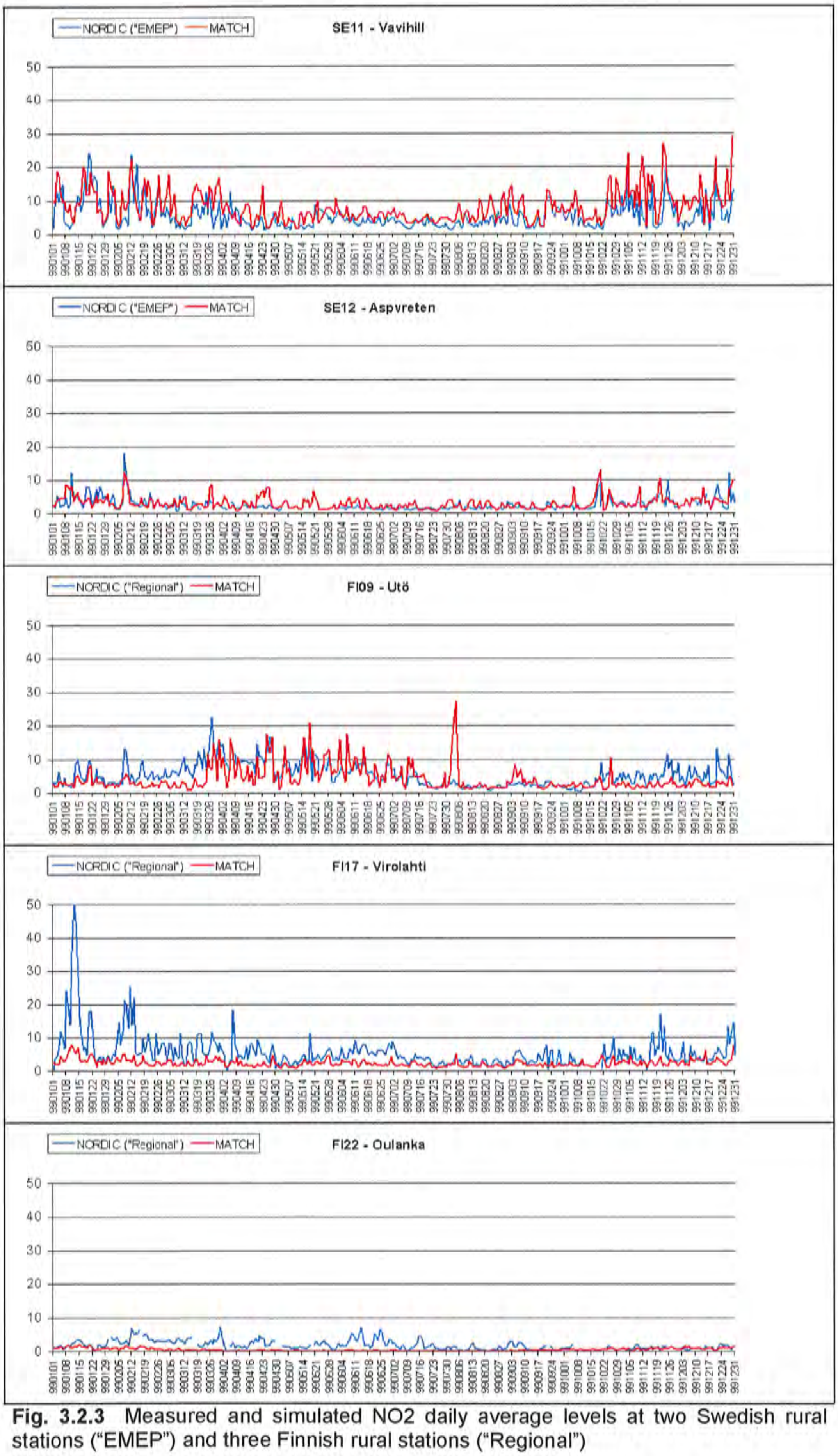



**Fig. 3.2.3** Measured and simulated NO2 daily average levels at two Swedish rural stations ("EMEP") and three Finnish rural stations ("Regional")

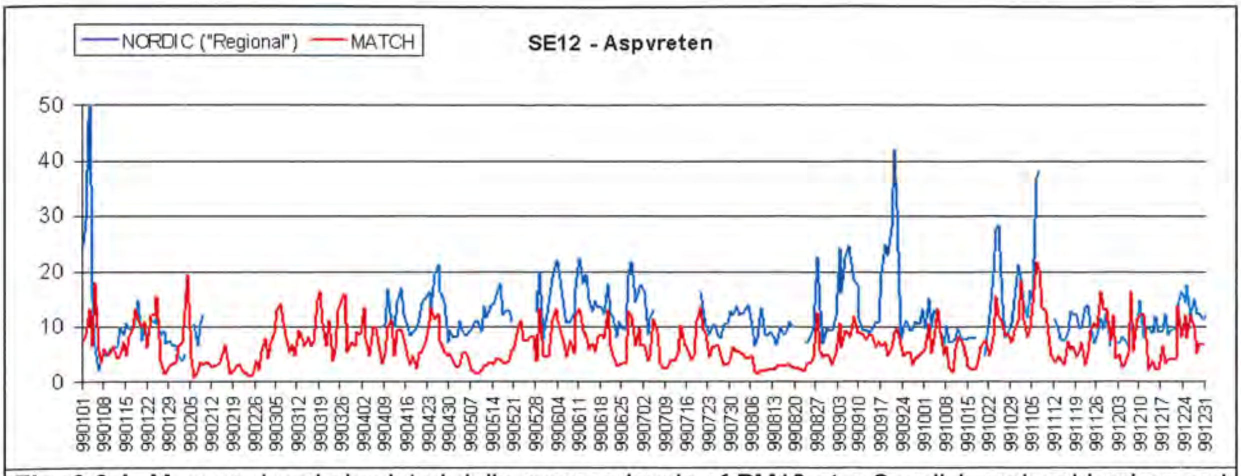



**Fig. 3.2.4** Measured and simulated daily average levels of PM10 at a Swedish regional background stations. Note that simulated data does not include the organic fraction.

The same EURODELTA model exercise is behind Fig. 3.2.4, showing a comparison between MATCH simulated PM10 and measured PM10 at a Swedish rural station (from the second rural station Vavihill there is for 1999 only a short period available). At Aspvreten the simulated levels are typically lower than measured. As the MATCH model only include inorganic nitrate and sulphate compounds (no organics as part of the aerosol), one would expect the simulated levels to be lower, as they are at Aspvreten. The regional modeling of PM10 will definitely need more work to be done in the future (except for organics, also resuspended dust and vehicle generated wear particles need to be properly taken into account in future regional models).

### 3.3 Ozone data

Ozone data exists as hourly data within the EMEP database. Fig. 3.3.1 shows the temporal variations of a station from each of the Nordic countries. The general variations as well as the average levels (55-60 $\mu g\ m^{-3}$) are fairly similar all over Scandinavia.

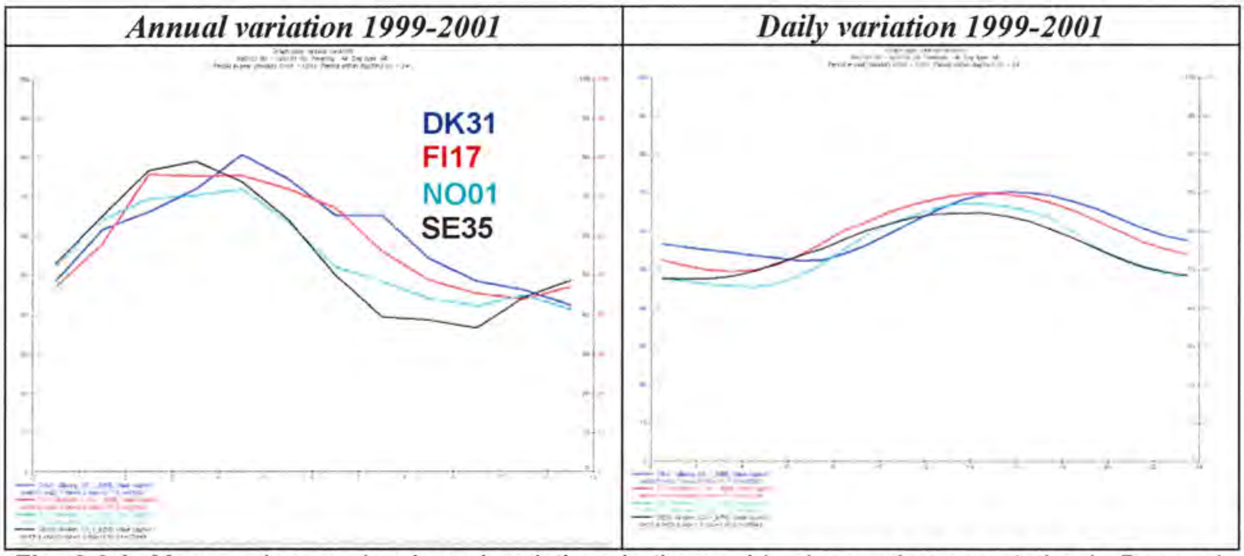



**Fig. 3.3.1** Measured ozone levels and variations in the rural background at one station in Danmark (DK31 Ulborg), Finland (Fi17 Virolahti), Norway (NO01 Birkenes) and Sweden (SE35 Vindeln). Period: 1999 – 2001. *Note:* All ozone data in Swedish local wintertime.

Hourly results from the MATCH Europe model (40 x 40 km grid) are compared to measured data from four Swedish rural stations in Fig. 3.3.2-5. Seasonal and synoptic variations are mostly well captured by the MATCH model (Fig. 3.3.4). Smaller, short term errors in measured hourly data are difficult to assess without a more detailed study.

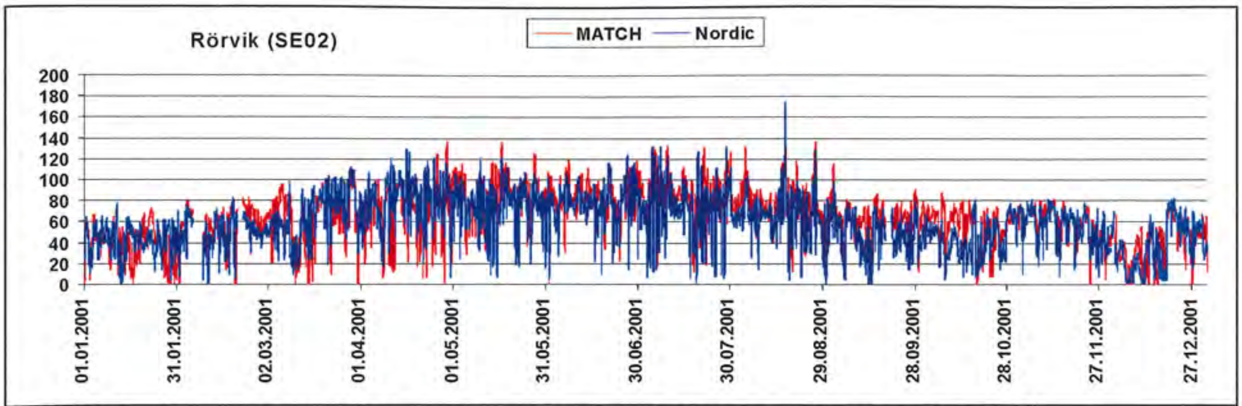



**Fig. 3.3.2** Simulated MATCH (red) and measured (blue) ozone at Rörvik. Unit: µg $m^{-3}$. Average levels for MATCH was 65 (measured 59) µg $m^{-3}$, with a correlation coefficient of 0.72.

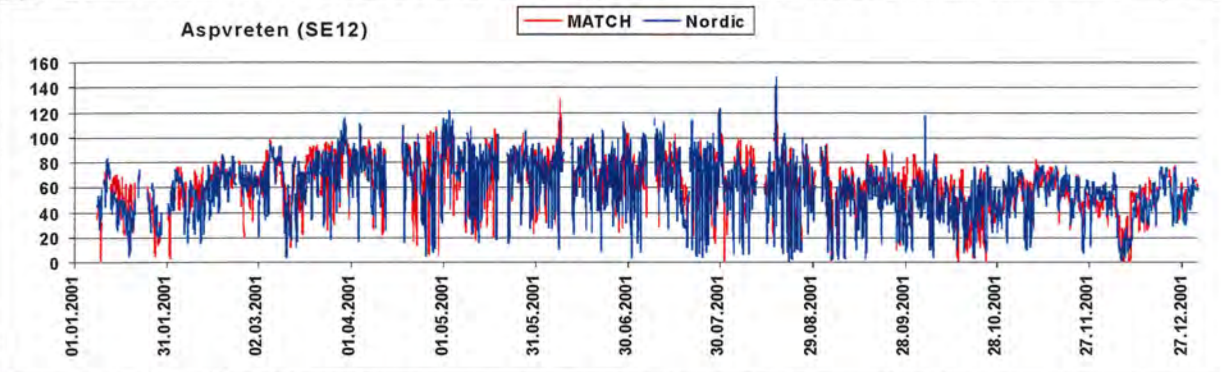



**Fig. 3.3.3** Simulated MATCH (red) and measured (blue) ozone at Aspvreten. Unit: µg $m^{-3}$. Average levels for MATCH was 63 (measured 59) µg $m^{-3}$, with a correlation coefficient of 0.75.

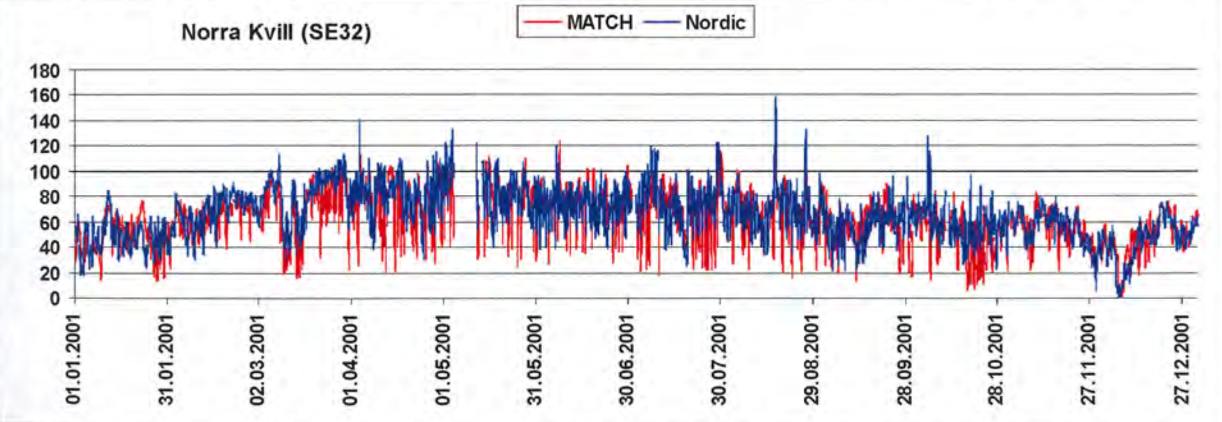



**Fig. 3.3.4** Simulated MATCH (red) and measured (blue) ozone at Norra Kvill. Unit: µg $m^{-3}$. Average levels for MATCH was 63 (measured 66) µg $m^{-3}$, with a correlation coefficient of 0.70.

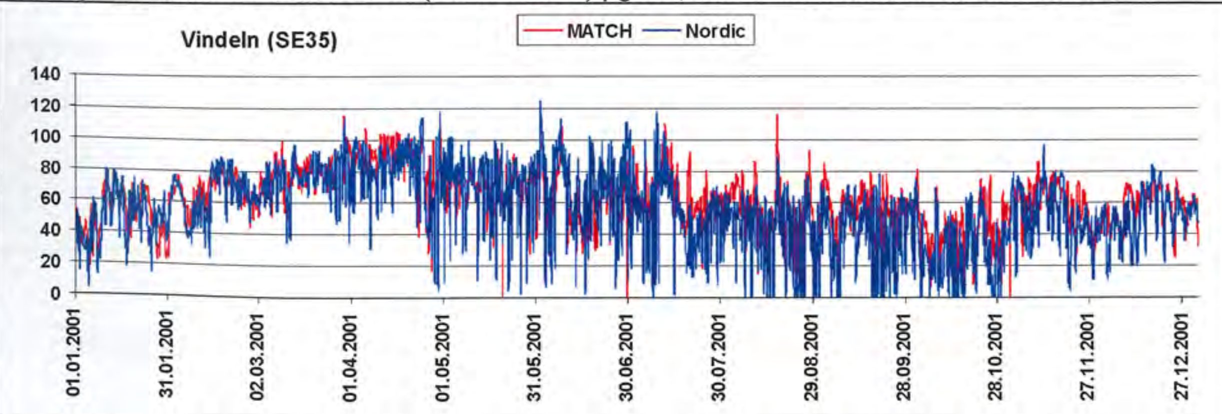
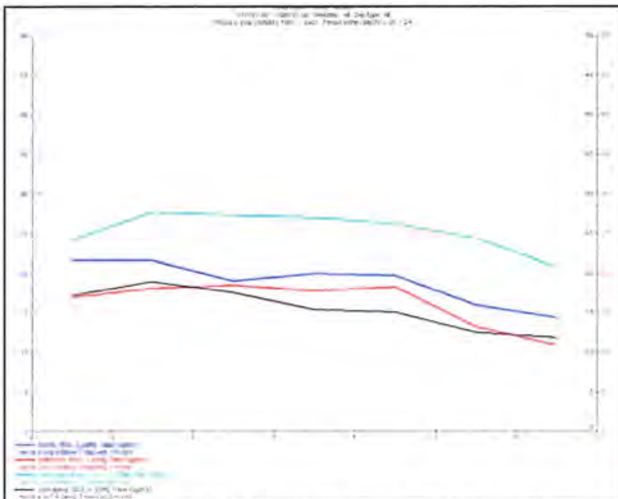



**Fig. 3.3.5** Simulated MATCH (blue) and measured (blue) ozone at Vindeln. Unit: µg $m^{-3}$. Average levels for MATCH was 62 (measured 56) µg $m^{-3}$, with a correlation coefficient of 0.75.

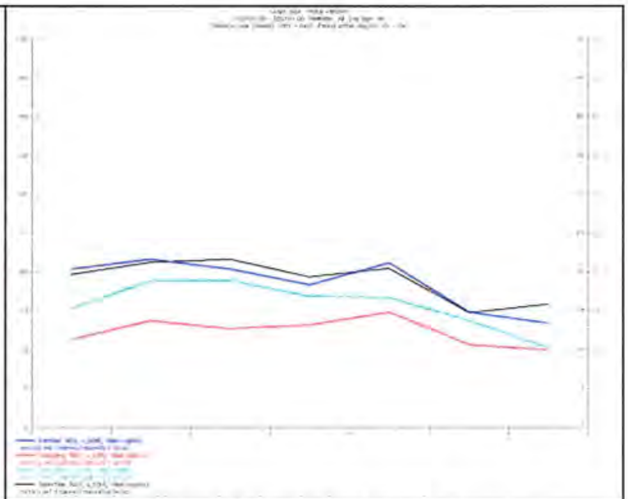
### 3.4 Urban data

The urban data set originates from the IVL database (see http://ivl.se for methods and site descriptions). For NO2 all data are urban background, most of it based on passive sampling with 24 hour exposure, a few based on continuous data that have been averaged over 24 hours. The benzene data is all originating from passive sampling with a week exposure.

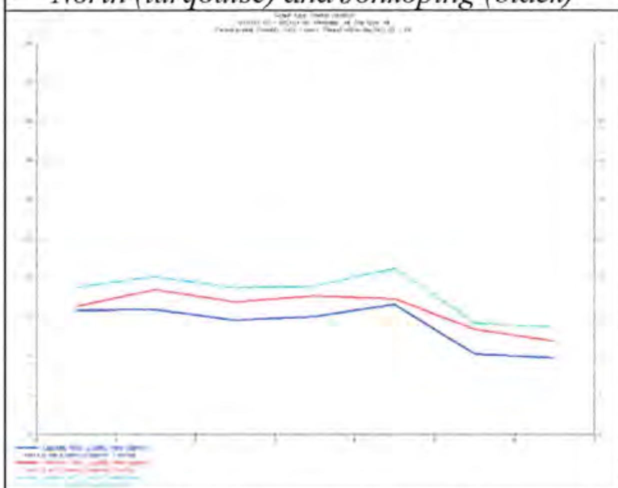
For NO2 the urban background shows a weekly variation with lower levels during weekends, i.e. the contribution of local emissions to registered NO2 levels is significant (Fig. 3.4.1). There is also a clear seasonal variation with higher levels during winter and lower during summer (Fig. 3.4.2). The rather large difference in average levels indicates that some stations are closer to large local sources.



*Borås (blue), Halmstad (red), Helsingborg North (turqouise) and Jönköping (black)*

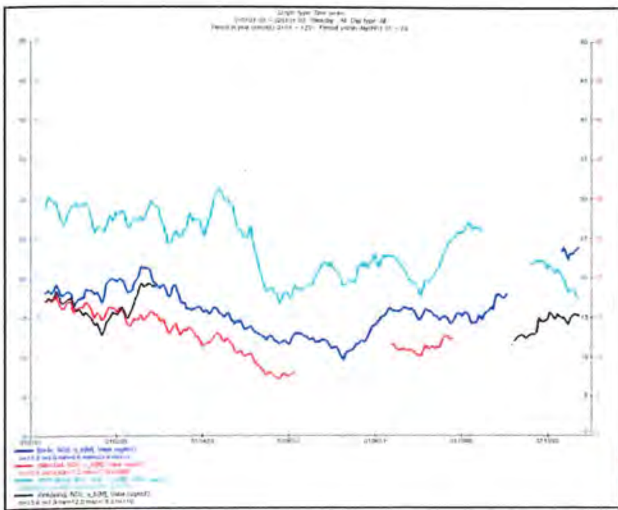


*Karlstad (blue), Linköping (red), Lund (turqoises) and Södertälje (black)*

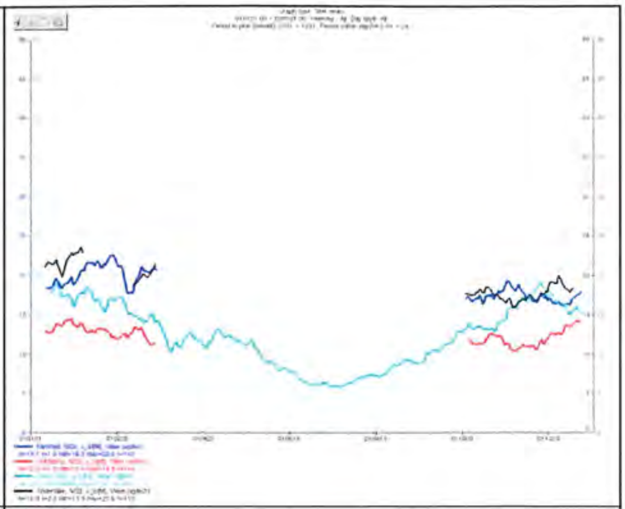


*Uppsala (blue), Västerås (red) and Örebro (turqoise)*

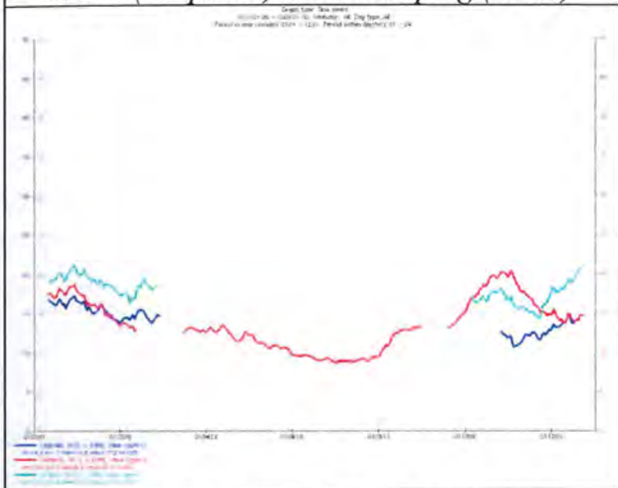
**Fig. 3.3.1** Weekly variations (day 6 is Saturday, day 7 Sunday) of measured NO2 levels at urban background stations (based on daily avareges from the IVL database).
Period: Jan - Dec 2001.



*Borås (blue), Halmstad (red), Helsingborg North (turqouise) and Jönköping (black)*



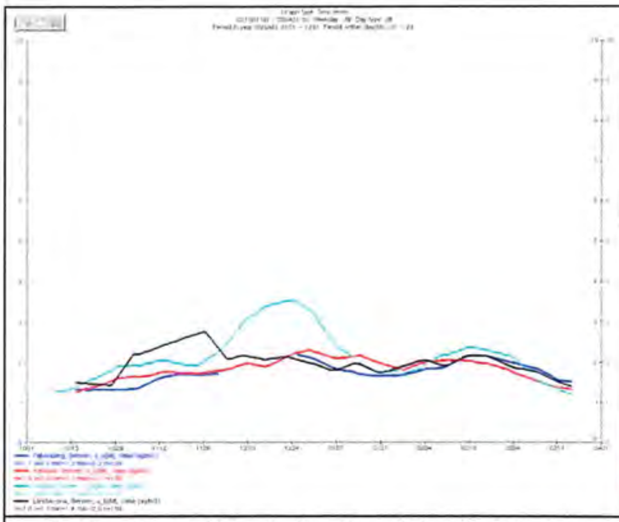
*Karlstad (blue), Linköping (red), Lund (turqoises) and Södertälje (black)*



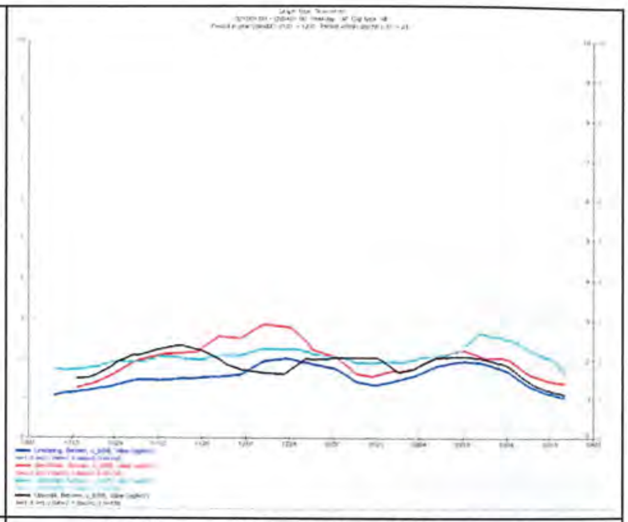
*Uppsala (blue), Västerås (red) and Örebro (turqoise)*

Fig. 3.3.2 Measured NO2 levels at urban background stations (based on daily avareges from the IVL database). Running monthly values. Period: Jan – Dec 2001.

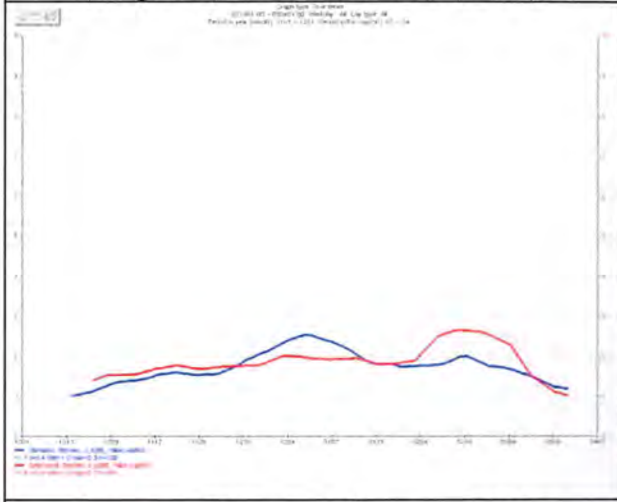
For benzene the annual average urban background levels are found in the range 1.5-2 μg $m^{-3}$, while street canyon data are typically twice as high. There is a certain tendency for higher values during wintertime. As discussed in Wideqvist et al. (2003) the absolute values registered with the passive samplers may be too high, due to uncertainties regarding the uptake rate for the samplers.



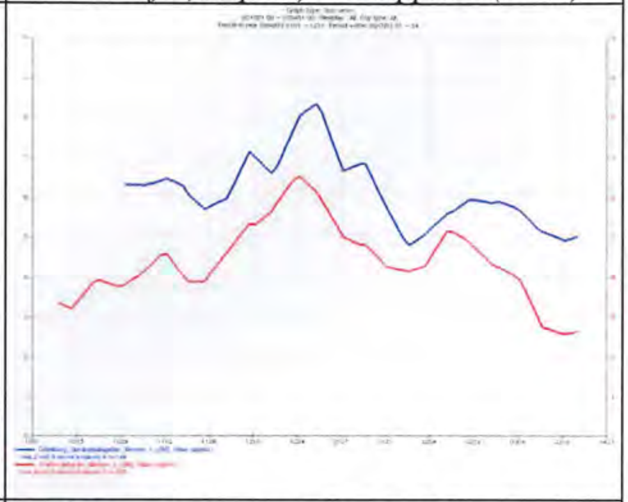
*Falkenberg (blue), Karlstad (red), Köping (turqouise) and Landskrona (black)*



*Linköping (blue), Sandviken (red), Södertälje (turqoise) and Uppsala (black)*



*Värnamo (blue) and Östersund (blue)*



*Göteborg Sprängkullsgatan (blue) and Örebro street canyon (red)*

**Fig. 3.3.3** Measured benzene levels at urban background (top two and lower left) and street canyon (lower right) stations, based on weekly averages from the IVL database. A running monthly average has been applied in order to smooth out the weekly time resolution. Period: October 2002 to March 2003.

### 3.5 EMEP data

The EMEP data set will be important for the PM10 modeling, as it allows to identify errors in the inorganic sulphur and nitrogen emissions and chemistry. For Sweden the inorganic aerosol in the southern part is considerably higher than in the northern part, a fact that must be reflected in the PM10 modeling of the regional background e.g. in the SIMAIR system.

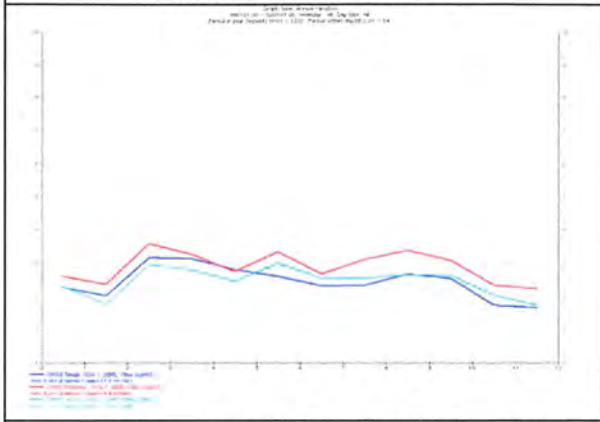
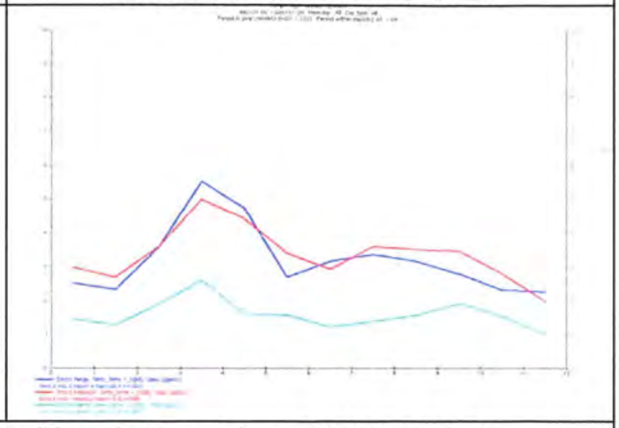
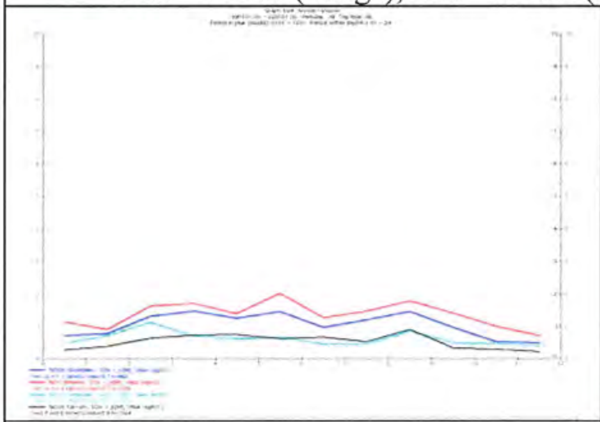
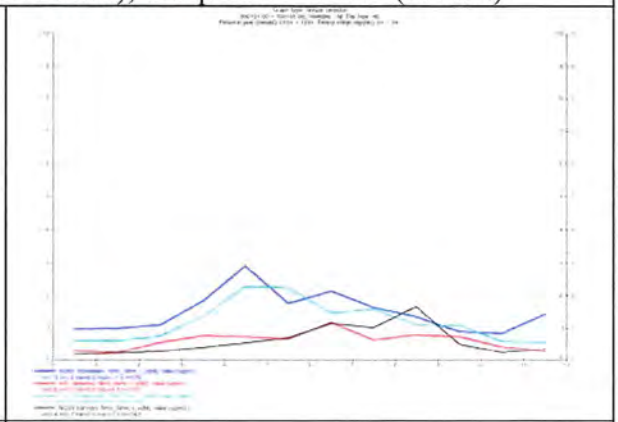
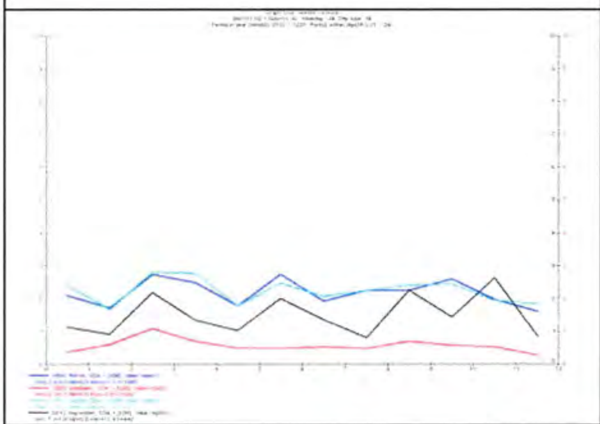
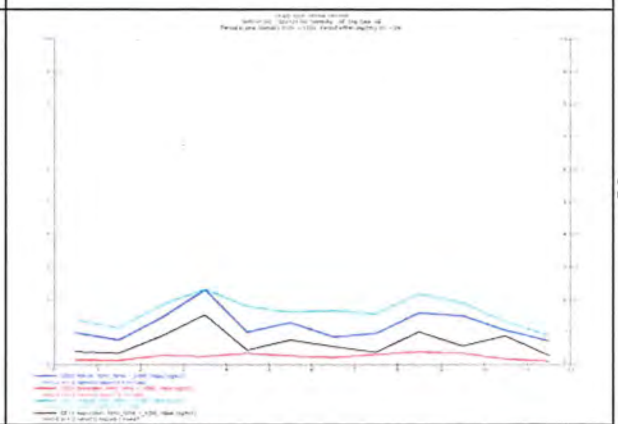
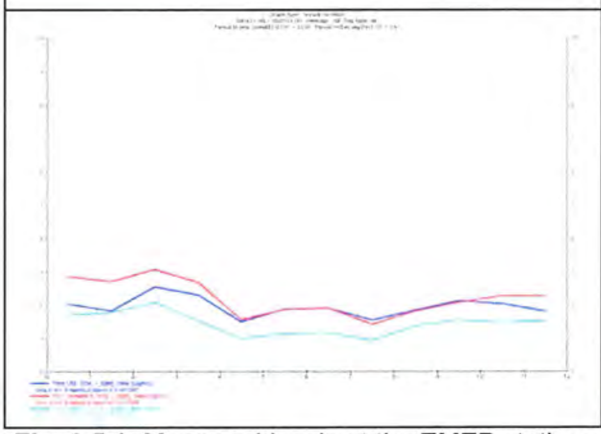
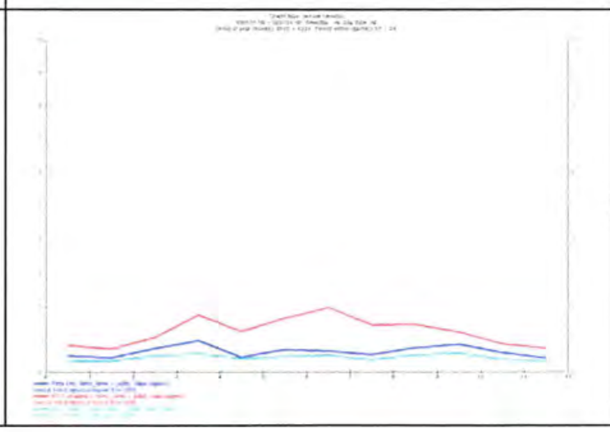
| ***Annual variation SO4*** | ***Annual variation NH3+NH4*** | |
|---|---|---|
|  |  | Denmark |
| Blue = DK03 (Tange), Red = DK05 (Keldsnor), Turquoise = DK08 (Anholt) | | |
|  |  | Norway |
|  |  | Sweden |
|  |  | Finland |

**Fig. 3.5.1** Measured levels at the EMEP stations

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Appendix 1: Details of the data from the five station groups

## Nordic database for model evaluation: Station group "STO_street"

Case: Hornsgatan Period: Oct 01 2002 – Dec 31 2003

| *Variable* | *type* | *from station* | *Attribute* | *start* | *stopp* |
|---|---|---|---|---|---|
| PM10 | Street (North) | Hornsg_part V01 | scN | 021001 00 | 040101 00 |
| | u.b. | Rosenl:g_PM 000 | u_b | 021001 00 | 040101 00 |
| | rural | Aspvreten duo | r_b | 021001 00 | 040101 00 |
| PM2.5 | Street (North) | Hornsg_part V01 | scN | 021001 00 | 040101 00 |
| | u.b. | Rosenl:g_PM 000 | u_b | 021001 00 | 040101 00 |
| | rural | Aspvreten duo | r_b | 021001 00 | 040101 00 |
| PM-antal | Street (North) | Hornsg_part 001 | scN | 021001 00 | 030301 00 |
| | u.b. | Rosenl:g_PM Tot | u_b | 021001 00 | 030301 00 |
| | rural | Aspvreten | r_b | 021001 00 | 030301 00 |
| NO2 | Street (North) | Hornsg_A30 001 | scN | 021001 00 | 040101 00 |
| | Street (South) | Hornsg_A30 002 | scN | 021001 00 | 040101 00 |
| | u.b. | Torkel Kn.20 001 | u_b | 021001 00 | 040101 00 |
| NOx | Street (North) | Hornsg_A30 001 | scN | 021001 00 | 040101 00 |
| | Street (South) | Hornsg_A30 002 | scS | 021001 00 | 040101 00 |
| | u.b. | Torkel Kn.20 001 | u_b | 021001 00 | 040101 00 |
| CO | Street (North) | Hornsg_A30 001 | scN | 021001 00 | 040101 00 |
| | Street (South) | Hornsg_A30 002 | scS | 021001 00 | 040101 00 |
| | u.b. | Hornsg_A30 003 | u_b | 021001 00 | 040101 00 |
| Bensen | Street (North) | Hornsg_part 001 | scN | 021001 00 | 040101 00 |
| O3 | u.b. | Torkel Kn.20 001 | u_b | 021001 00 | 040101 00 |
| Wind speed | | Maria_p_mast 036 | 036 | 021001 00 | 040101 00 |
| Wind dir. | | Maria_p_mast 036 | 036 | 021001 00 | 040101 00 |
| Temp | | Maria_p_mast 020 | 026 | 021001 00 | 040101 00 |
| Globalstr. | | Maria_p_mast 001 | 026 | 021001 00 | 040101 00 |
| DiffT | | Högd/met 020 | 020 | 021001 00 | 040101 00 |
| RH | | Maria_p_mast 001 | 026 | 021001 00 | 040101 00 |
| Regn | | Maria_p_mast 001 | 026 | 021001 00 | 040101 00 |
| Trafikfl. | | Hok 00a | N_n | 021001 00 | 040101 00 |
| Trafikfl. | | Hok 00b | N_s | 021001 00 | 040101 00 |
| Trafikfl. | | Hok 00c | S_n | 021001 00 | 040101 00 |
| Trafikfl. | | Hok 00d | S_s | 021001 00 | 040101 00 |

Appendix 1: Details of the data from the five station groups

## Nordic database for model evaluation: Station group “Regional”

**Case:** Urban and rural background
**Period:** jan 1999 – dec 2001 (a few only jul 1999 – jun 2001)
**Variables:** PM10, PM25, NO2, NOx, SO2, O3
**Original time resolution:** Hourly data

| *Station* | *Location* | *Attribute* | *PM10* | *PM2.5* | *NOx* | *NO2* | *SO2* | *O3* | *CO* |
|---|---|---|---|---|---|---|---|---|---|
| Femman | Göteborg | u_b | X | X | X | X | X | | X |
| Biblioteket | Umeå | u_b | X | X | | | | | |
| HC Ørsted | Köpenhamn | u_b | | | X | X | | | X |
| Rosenl.g. | Stockholm | u_b | X | X | | | | | |
| Torkel Kn.20 | Stockholm | u_b | | | X | X | | X | |
| Södermalm DOAS | Stockholm | u_b | | | | X | X | X | |
| Rosen Nkpg DOAS | Norrköping | u_b | | | | X | X | X | |
| Växjö DOAS | Växjö | u_b | | | | X | X | X | |
| SE11 Vavihill | Skåne | r_b | X | X | | | | | |
| SE12 Aspvreten | Nyköping | r_b | X | X | | | | | |
| Norra Malma | Norrtälje | r_b | | | X | X | | X | |
| FI09 | Utö | r_b | | | | X | | | |
| FI17 | Virolahti | r_b | | | | X | | | |
| FI22 | Oulanka | r_b | | | | X | | | |

### Conversions and changes made to data

- **Femman:** PM2.5 shows a lot of negative values, often high numbers. The quality is poor, possibly there is a decrease in average levels which is spurious. For the Nordic database, all PM2.5 levels < 0.1 ug/m3 have been eliminated.

- **HC Örsted:** Gases are given in ppb and ppm (CO). The following conversions have been used: NO (1.29), NO2 (1.98), O3 (2.07), SO2 (2.76), CO (1.21).

- **Finnish EMEP NO2 stations:** NO2 given as ug N/m3. Conversion used to convert to ug/m3: 3.29 (46/14)

Appendix 1: Details of the data from the five station groups

## Nordic database for model evaluation: Station group "Ozone"

**Case:** Nordic (EMEP hourly)
**Period:** 1999 – 2001 (3 years)
**Variable:** O3
**Original time resolution:** Hourly data

| *Station* | *Name* | *type* |
|---|---|---|
| SE02 | Rörvik | r_b |
| SE32 | Norra-Kvill | r_b |
| SE12 | Aspvreten | r_b |
| SE35 | Vindeln | r_b |
| DK31 | Ulborg | r_b |
| DK32 | Fredriksborg | r_b |
| NO1 | Birkenes | r_b |
| NO15 | Tustervatn | r_b |
| FI09 | Utö | r_b |
| FI17 | Virolahti II | r_b |
| FI22 | Oulanka | r_b |

Suggestions for ***naming*** in the Nordic database:

A. Variable name: O3
B. Variable key: Standard Airviro
C. Station names: Use both "Station" and "Name" in the table above, e.g. "SE02 Rörvik"
D. Station key: Not important, invent!
E. For each variable: Store measurement value with attribute according to column "type" (i.e. "r_b")
F. Load both as daily and hourly values.

Appendix 1: Details of the data from the five station groups

## Nordic database for model evaluation: Station group "URBAN"

**Case:** Urban background NO2: Period: jan – dec 2001
Urban background and street canyon benzene data: Period: Oct 2002 – March 2003.

**Variables**: NO2, benzene

**Original time resolution**: Daily data (from IVL, mainly URBAN network)

| *Station* | *Attribute* | *NO2* | *Benzene* |
|---|---|---|---|
| Helsingborg N | u_b | X | |
| Halmstad | u_b | X | |
| Borås | u_b | X | |
| Jönköping | u_b | X | |
| Lund | u_b | X | |
| Örebro | u_b | X | |
| Västerås | u_b | X | |
| Karlstad | u_b | X | X |
| Linköping | u_b | X | X |
| Södertälje | u_b | X | X |
| Uppsala | u_b | X | X |
| Falkenberg | u_b | | X |
| Köping | u_b | | X |
| Landskrona | u_b | | X |
| Sandviken | u_b | | X |
| Värnamo | u_b | | X |
| Östersund | u_b | | X |
| | | | |
| Göteborg Sprängkullsgatan | s_c | | X |
| Örebro gaturum | s_c | | X |

### Conversions and changes made to data

The data from IVL has been stored in the datase without any corrections.

Appendix 1: Details of the data from the five station groups

## Nordic database for model evaluation

**Case:** Nordic (EMEP daily)
**Period:** 1999 – 2001 (3 years)
**Variable:** SO4, SO2, NO2,NH3+NH4(particulate), HNO3+NO3(particulate), HNO3(gas),NH3(gas),Na,Cl, summed inorganic
**Original time resolution:** Daily data

| *Station* | *Name* | *SO4* | *SO2* | *NO2* | *NH3+ NH4* | *HNO3 +NO3* | *HNO3* | *NH3* | *Na* | *Cl* | *inorg* | *SPM* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE02 | Rörvik | X | X | X | X | X | | | | | | X |
| SE05 | Bredkälen | X | X | X | X | X | | | | | | X |
| SE08 | Hoburg | X | X | X | | | | | | | | X |
| SE11 | Vavihill | X | X | X | X | X | | | | | | X |
| SE12 | Aspvreten | X | X | X | X | X | | | | | | |
| DK03 | Tange | X | X | | X | X | | | | | | |
| DK05 | Keldsnor | X | X | | X | X | | | | | | |
| DK08 | Anholt | X | X | X | X | X | | X | | | | |
| NO01 | Birkenes | X | X | X | X | X | X | X | X | X | | |
| NO08 | Skreådalen | X | X | X | X | X | X | X | X | X | | |
| NO15 | Tustervatn | X | X | X | X | X | X | X | X | X | | |
| NO39 | Kårvatn | X | X | X | X | X | X | X | X | X | | |
| NO41 | Osen | X | X | X | X | X | X | X | X | X | | |
| FI09 | Utö | X | X | X | X | X | | | | | | |
| FI17 | Virolahti II | X | X | X | X | X | | | | | | |
| FI22 | Oulanka | X | X | X | X | X | | | | | | |
| FI37 | Ähtäri II | X | X | X | X | X | | | | | | |

Suggestions for ***naming*** in the Nordic database:

- Variable names: According to table above (SO4, SO2 etc…)
- Variable key: For some of them use Slb standard. Invent something for the remaining.
- Station names: Use both "Station" and "Name" in the table above, e.g. "SE02 Rörvik"
- Station key: Not important, invent!
- For each variable: Store measurement value with attribute "r_b", status flag with attribute "flg"
- Load both as daily and hourly values.

**Conversions and changes made to data**

- SO4: 3.0
- SO2: 2.0
- NO2: 3.3
- NH3+NH4: 1.25
- HNO3: 4.5
- NH3: 1.2
- HNO3+NO3: 4.45

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Sveriges meteorologiska och hydrologiska institut
601 76 Norrköping · Tel 011-495 8000 · Fax 011-495 8001
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