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EMECAP
Deliverable 5.4
Part 1: Local dispersion and deposition

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Part I: Local dispersion and deposition

1 Introduction

As part of Work Package 5 of the EMECAP project, dispersion model calculations have been carried out in order to determine the concentration and deposition of Mercury in the region surrounding the selected MCCA plants. The 3 plants under study are the Bohus plant in Sweden, the Rosignano Solvay plant in Italy and the Tarnow plant in Poland. Measurement campaigns at all 3 plants during the EMECAP project have provided essential data to allow validation and verification of dispersion model results.

The dispersion and deposition of Mercury around MCCA plants is a three fold problem. The first is the dispersion itself, which is dependant on local meteorology as well as emissions from the plant. The second is the Mercury chemistry and the third is the deposition rate for varying Mercury species. Mercury can be found in several forms as a result of chemical reactions with other gases, in particular Chlorine, to transform Gaseous Elemental Mercury (GEM) into the more reactive species, Reactive Gaseous Mercury (RGM). The sum of these is known as the Total Gaseous Mercury (TGM). In addition Mercury can deposit on particles, Total Particulate Mercury (TPM). The deposition rates of these different forms can differ by up to 2 orders of magnitude, with RGM having the highest dry and wet depositions.

Results from the previous report, D5.2, have shown that chemical reactions inside the plant are a likely source for the formation of RGM, which is the Mercury species most easily deposited to the surface. Chemical reactions in the atmosphere, on short time scales, do not appear to play an important role in the formation of RGM as the dispersion of pollutants quickly reduces their concentration. The most likely site for the formation of RGM is thus in the factory itself.

Mercury can be deposited through dry deposition processes or through wash out of Mercury during precipitation events, known as wet deposition. The dry deposition velocities and wet deposition scavenging rates are not well defined for any of the Mercury species. In the previous EMECAP report, D5.3, the sensitivity of the model deposition to variations in deposition parameters was tested. The results show that uncertainty in these can significantly influence the total deposition. In that study RGM was found to be the most important source for deposition, both dry and wet.

In this study the final EMECAP dispersion model is applied to calculate yearly concentration and deposition maps around the 3 MCCA plants under study. This is done by the creation of hourly meteorological fields and then by calculating dispersion and deposition, based on emission data, for the 3 sites. The calendar year 2002 has been used for the model runs.

The results show that mercury concentrations quickly reduce to background levels within 1 to 3 km from the plants. Deposition of mercury occurs mainly within the first kilometer from the plant, in the region where concentrations are highest before dispersion, and background levels are also reached within a few kilometres. The deposition has been found to be strongly dependent on the amount of RGM emitted from the plant. Deposition is largest for the Tarnow plant in Poland where RGM emission is also the highest.

2 Description of the models and model configuration

Two models are employed in the current study. The first is 'The Atmospheric Pollution Model' (TAPM) from CSIRO in Australia, which is used for meteorological calculations. The second model is an off-line dispersion chemistry model called EPISODE. This model has been adapted to include a Mercury-Chlorine chemistry scheme and is used to calculate deposition and concentration fields of GEM, RGM and TPM.

2.1 The meteorology and dispersion model TAPM

TAPM has been developed by CSIRO in Australia as a complete pollution model that includes meteorology, dispersion and a limited photochemistry scheme (Hurley, 2002). The heart of TAPM is the meteorological model. This can be nested into a regional scale model, in this case the LAPS model (Puri et al. 1998), starting at a resolution of 10's of kilometres and reducing down with each nest to a grid spacing of around 1 km. In the current study 4 nestings have been implemented down to a resolution of 500m. Within TAPM are worldwide land-use and sea surface temperature data sets that can be used for surface exchange calculations. These have been used with appropriate alterations for the sites under study.

In addition to meteorology, TAPM can also calculate the transport and dispersion of pollutants on a pollution grid. However, this scheme is not suitable for the current studies and so a second dispersion model has been implemented, the EPISODE model.

2.2 The chemistry/transport model EPISODE

In order to calculate Mercury chemistry and deposition an off-line model, using TAPM meteorology fields, has been used. This is the EPISODE model (Slørdal et al., 2003), especially adapted to calculate Mercury chemistry and deposition. It consists of a transport and dispersion scheme, similar to TAPM, and a Mercury/Chlorine/Ozone chemistry scheme. Dry deposition is calculated by using predefined deposition velocities and wet deposition occurs during precipitation events using a wet scavenging parameterisation. In the EMECAP report D5.2 it was shown that atmospheric chemistry was not important for the transformation of Mercury species and so no chemistry has been included in the current model runs.

2.3 Model configuration

Model calculations were carried out using meteorological data for the calendar year 2002. TAPM was run for the entire year, using LAPS data as boundary input, for each of the 3 sites to determine the meteorological fields. The EPISODE model was then used to calculate dispersion and deposition of GEM, RGM and TPM. Dry deposition was calculated using constant deposition velocities and wet deposition was determined using wet scavenging ratios, Table 1. Wet deposition was calculated using the model derived precipitation fields.

Table 1. Deposition parameters used in the simulations.

Deposition	GEM	RGM	TPM
Dry deposition velocity, V_d, (cm s^{-1})	0.02	2.0	0.1
Wet deposition scavenging ratio, W ($x\ 10^6$)	0.0	1.4	0.7

TAPM was set up using 4 nests down to a local resolution of 500 m. An example, for the Rosignano plant, is shown in Figure 1 and Table 2 gives details of the grid structure.

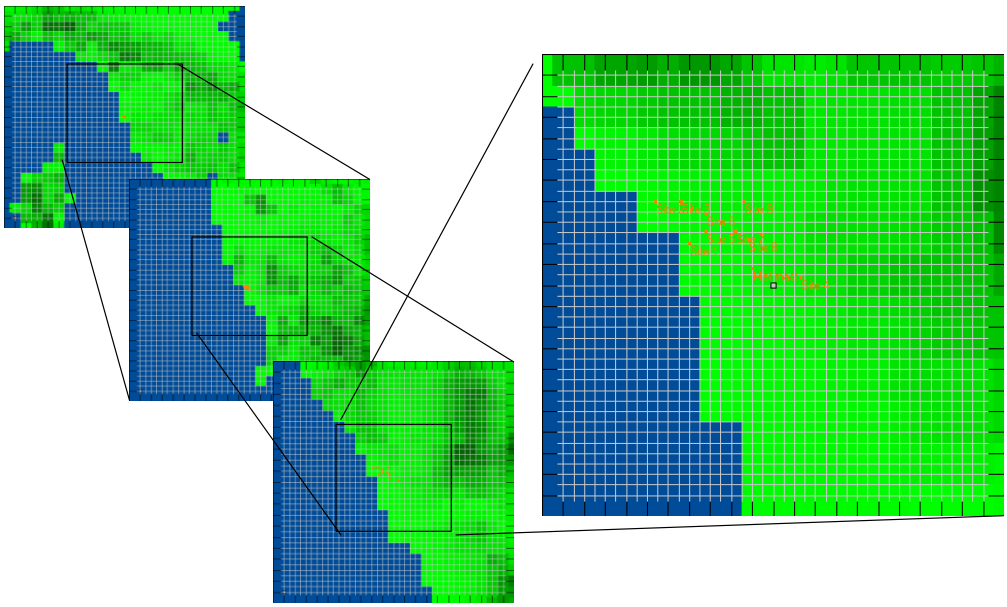


Figure 1. Showing the 4 nested meteorological grids used in the TAPM simulations for Rosignano.

Table 2. Model parameters used in the TAPM and EPISODE simulation

Model	TAPM	EPISODE
Horizontal grid dimensions	25 x 25	25 x 25
Vertical grid dimensions	30	20
Model domain	375 km – 13 km in 4 nests	13 km
Model resolution	15 km – 500 m in 4 nests	500 m
Vertical grid size	Lowest level at 10 m, extending to 8000 m	Lowest level 10 m, extending to 2000 m

2.4 Model Output

Results are presented in terms of monthly and total yearly average concentrations and deposition for the 3 Mercury species. In order to simplify the results a radius of 5 km has been defined around the plants. When total deposition is quoted this refers to the deposition within this 5 km radius. No such radius is defined for concentration data, which are presented as fields and as a function of distance from the plants.

Only emissions related to the MCCA plants have been modelled and background values have not been added to the results. Typical background values for GEM range from 1.5 to 4 ng/m^3. The RGM/TGM and TPM/TGM background ratios, based on observations made at the 3 sites during the EMECAP campaigns, are roughly 3% and 1% respectively.

3 Emission inventory

Emissions of GEM, RGM and TPM have been estimated for the three MCCA plants under study as yearly averages. These are based on observations from the LIDAR measurements, from concentrations and ventilation rates within each plant and from measurements made directly outside the plants during the various EMECAP campaigns.

3.1 Bohus

The plant in Bohus has the most consistent set of emission and concentration data. Estimates of GEM emissions made from LIDAR and internal concentration/ventilation estimates agree well with one another. The relative concentrations of RGM/GEM measured within the plant also agrees with observations made outside the plant. Though seasonal differences in emissions were measured a yearly average emission value has been determined. Table 3 summarizes these results and gives the final emissions used in the seasonal model runs.

Table 3. Summary of concentration and emission data from the Bohus plant.

BOHUS	**Mean**	**Range**	**Units**
GEM concentration inside plant	11.2	6 - 22	μg/m^3
RGM concentration inside plant	0.7	0.09 – 1.47	% of GEM
RGM concentration outside plant	0.38	0.17 – 0.85	% of GEM
TPM concentration outside plant	0.3	0.01 – 0.8	% of GEM
Ventilation	550 000		m^3/hr
GEM emission conc/vent	62		kg/yr
GEM emission LIDAR	74	44 - 122	kg/yr
Model GEM emission	74		kg/yr
Model RGM emission	0.52 (0.7)		kg/yr (%GEM)
Model TPM emission	0.22 (0.3)		kg/yr (%GEM)

3.2 Rosignano

The plant at Rosignano in Italy is different to the two other plants in that it has an open architecture such that wind can blow directly through the plant. As a result the ventilation rate, and hence emission, is wind dependent. In addition no concentration measurements have been made in or near the plant for any of the mercury compounds. The estimates of GEM emission are therefore based entirely on the LIDAR measurements.

Estimates of RGM and TPM emissions from the plant are based on measurements made during the campaigns several kilometres away in the town of Rosignano. These indicate an average RGM/GEM and TPM/GEM ratio of 3% and 1% respectively, after the subtraction of background values, but there is no significant measured correlation between the different Mercury species due to the low time resolution of RGM and TPM measurements If these ratios are accepted as representative of the emission ratios then inverse modelling is required to determine the actual emissions from the plant. Running the model with a dry deposition velocity of 2.0 cm/s for RGM and 0.1 cm/s for TPM requires an emission ratio of approximately 4.2% and 1.0% respectively in order to obtain the same ratio at the observational distance, see D5.3 for more details. These values are not unrealistic but without measurements in the plant itself it is not possible to determine the emission ratios accurately. Table 4 summarizes these results and gives the final emissions used in the seasonal model runs.

Table 4. Summary of concentration and emission data from the Rosignano plant.

ROSIGNANO	Mean	Range	Units
GEM concentration inside plant	-	-	$\mu g/m^3$
RGM concentration inside plant	-	-	% of GEM
RGM concentration outside plant	3.0	0.2– 18.0	% of GEM
TPM concentration outside plant	1.1	0.5 – 1.7	% of GEM
Ventilation	-		m^3/hr
GEM emission conc/vent	-		kg/yr
GEM emission LIDAR	72.1 x U (1)	87 - 788	kg/yr
RGM emission estimated from inverse modelling	4.2	-	% of GEM
TPM emission estimated from inverse modelling	1.1	-	% of GEM
Model GEM emission	72.1 x U (1)		kg/yr
Model RGM emission	3.0 x U (1) (4.2)		kg/yr (%GEM)
Model TPM emission	0.72 x U (1) (1.0)		kg/yr (%GEM)

(1) Emissions as function of wind speed in m/s

3.3 Tarnow

Observational data is limited for the plant at Tarnow and the data that is available is sometimes contradictory. GEM measurements made inside the plant during the EMECAP measurement campaigns due not always agree with monthly means supplied by the plant. In summer EMECAP measurements are a factor of 4 higher, though in winter they give similar values. It must be noted that EMECAP measurements are single point measurements made over several days, whereas

measurements supplied by the plant are multiple measurements made on a single day each month.

When combined with ventilation data for the summer campaign, EMECAP measurements give emissions that are a factor of 3.5 lower than the emissions measured with LIDAR. Plant supplied concentrations give emissions that are a factor of 10 lower than the LIDAR measurements. From measurements of soil and building materials surrounding the plant it is clear that the factory area is highly contaminated with Mercury. The discrepancy in the LIDAR and concentration/ventilation emissions could be due to emissions from the contaminated building and ground but the LIDAR measurements do not indicate an extended emission region. It is most likely that the concentrations in the roof ventilation of the plant, which leads to emissions, are not represented by the floor level measurements made during the EMECAP campaigns.

In addition, measurements of RGM made both inside and outside the plant do not agree. RGM/TGM ratios of around 40% were measured inside the plant, whereas this ratio was measured to be < 1% outside the plant. During the campaigns the wind direction took the cell house plume away from the observational site and so the measured RGM must have come from other sources, such as contaminated surfaces. It is thus not possible to confirm the internal measurements, as was done at the Bohus plant. Similarly TPM measured at this site, which are high in this area, are likely due to re-emission from surfaces, rather than from the cell plant itself.

LIDAR measurements of elemental Mercury emissions have proven to be robust (Wängberg, 2003) and so it is assumed that LIDAR measurements correctly determine the Mercury emission from the plant. If this is the case then an enhancement factor is required to account for the difference between LIDAR measured emissions and concentration/ventilation determined emissions. From the summer campaign, when internal concentrations and LIDAR emissions were simultaneously measured, this factor has been calculated to be 3.5. The yearly emissions for the model have been determined by multiplying the plant supplied yearly emissions of TGM by this factor, with an assumed RGM/GEM ratio of 40%. When this is done the GEM emissions from the Tarnow plant are similar to those from the Bohus plant, though the RGM emissions are significantly higher.

Table 5 summarizes these results as yearly mean values and gives the final emissions used in the seasonal model runs.

Table 5. Summary of concentration and emission data from the Tarnow plant.

TARNOW	**Mean**	**Range**	**Units**
GEM concentration inside plant (EMECAP)	35 (summer) 13 (winter) 24 (mean)	25 – 54 8 - 22	$\mu g/m^3$
TGM concentration inside plant (from plant)	26.3 (yearly mean)	11.4 - 56	$\mu g/m^3$
RGM concentration inside plant	28 (summer) 78 (winter)	12 – 65 48 - 150	% of GEM
RGM concentration outside plant	0.4 (summer)	0.03– 0.76	% of GEM
TPM concentration outside plant	1.6 (summer) 8.2 (winter)	0.5 – 4.0 4.0 – 16.0	% of GEM
Ventilation	220000 (summer) 88000 (winter)		m^3/hr
GEM emission (EMECAP) (conc/vent)	68 (summer) 10 (winter) 39 (mean)	-	kg/yr
GEM emission (LIDAR)	243	148 - 306	kg/yr
TGM emission (from plant)	24.7	16 - 38	kg/yr
Model GEM emission:	61		kg/yr
Model RGM emission	24.5 (40)		kg/yr (%GEM)
Model TPM emission	3.0 (5)		kg/yr (%GEM)

Emissions from other sources, such as home heating and power plants, near the Tarnow plant were ignored for the seasonal calculations. Sensitivity runs made for the first EMECAP campaign in Tarnow show that their contribution is small compared to the MCCA plant.

4 Results

4.1 Meteorological comparison

TAPM has been used to produce meteorological fields for the year 2002 at the 3 sites. It is important that the meteorological results be representative of the either the local climatology or the meteorology for that period. Meteorological data of mean monthly temperature, wind speed and precipitation are available at sites nearby the Rosignano and Tarnow plants and precipitation only is available from the Bohus plant. A comparison of TAPM and observed meteorology is shown for these 3 sites in Figures 2 – 4.

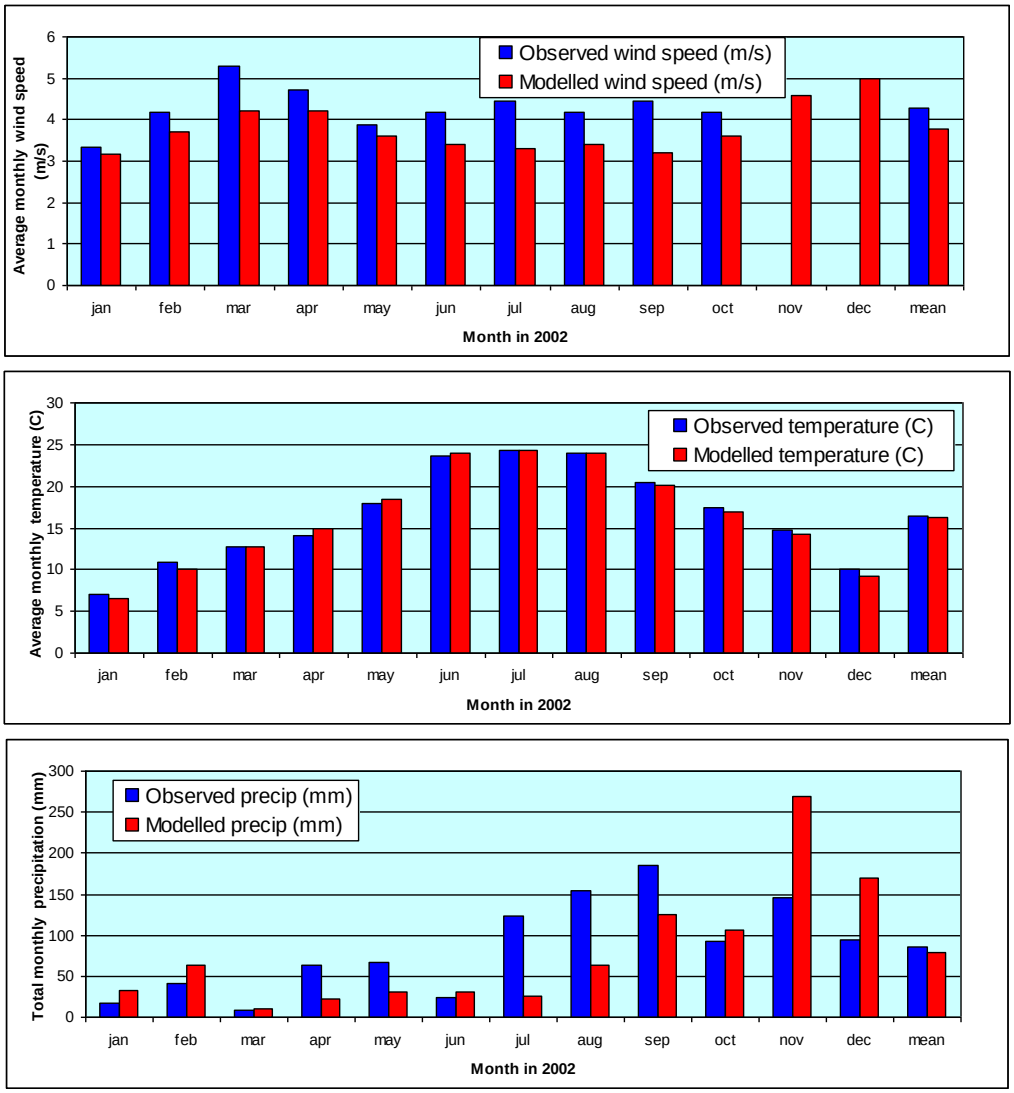


Figure 2. Comparison of modelled and observed wind speed, temperature and precipitation for the site at Rosignano in Italy. Observational data available on the public web site" http://web.tiscali.it/rosignanometeo/2002.htm".

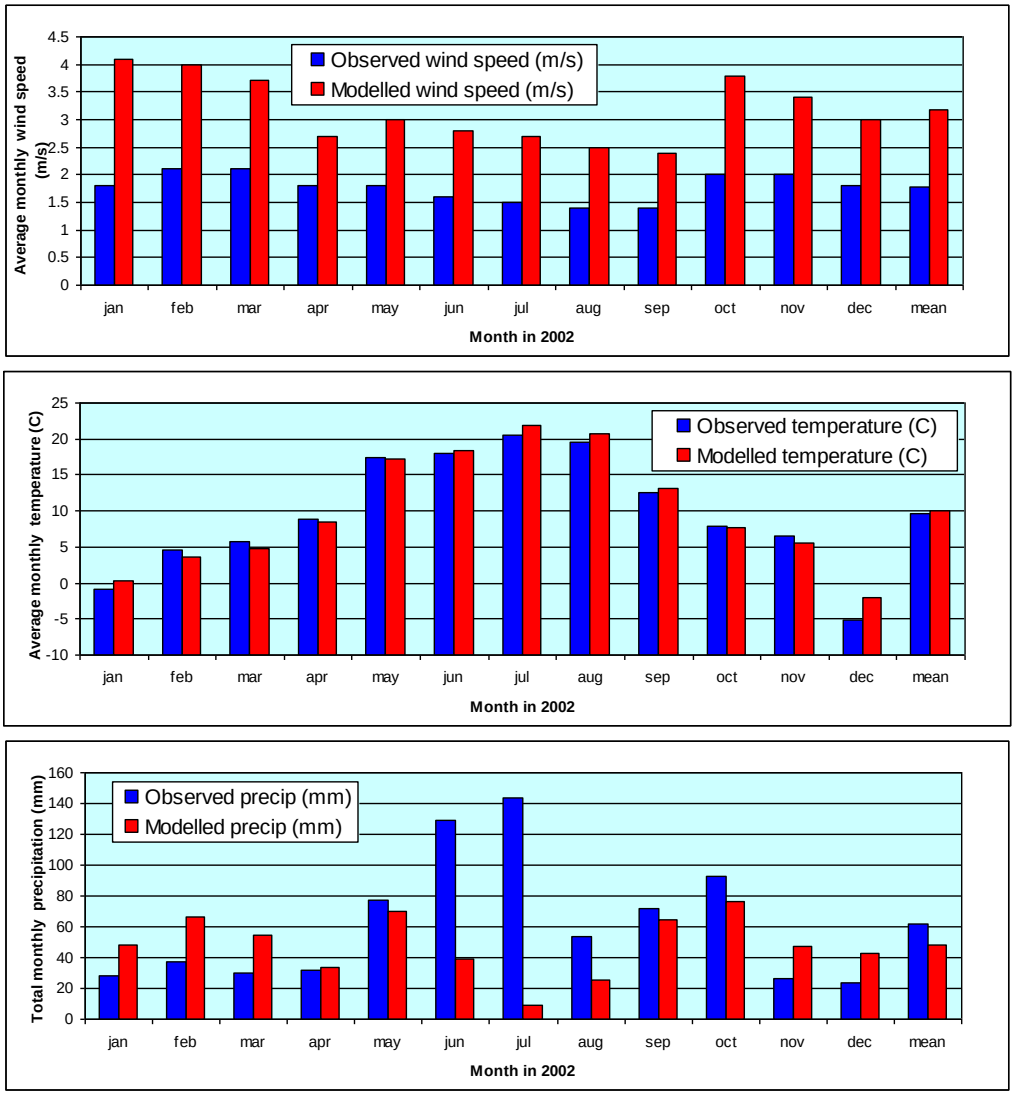


Figure 3. Comparison of modelled and observed wind speed, temperature and precipitation for the site at Tarnow in Poland. Observational data from the Polish meteorological bureau.

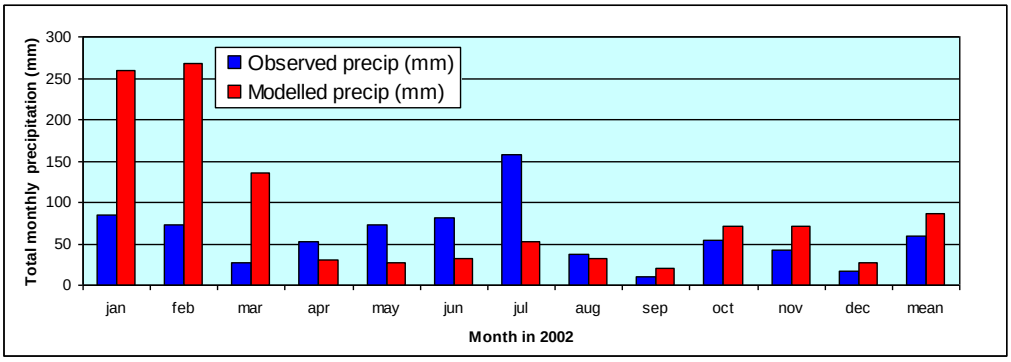


Figure 4. Comparison of modelled and observed precipitation for the site at Bohus in Sweden.

Average monthly wind speeds are well represented by the model at Rosignano but the model seems to over predict wind speeds when compared to observations at Tarnow. Monthly mean temperatures are well simulated for both sites.

Yearly precipitation is reasonable simulated by the model for all the sites but there is a large difference in the summer months at the Tarnow site, the model severely underestimating precipitation during this period, and during the winter months at the Bohus site. This has important concesquences for the wet deposition during these months.

The important model parameters of wind speed and precipitation, at the 3 sites, are summarized in Table 6 below.

Table 6. Summary of modelled and observed meteorological parameterws for the 3 sites.

Site	**Annual mean wind speed (m/s)**		**Total annual precipitation (mm)**	
	Observed	Modelled	Observed	Modelled
Rosignano	4.2	3.8	1105	950
Tarnow	1.8	3.1	746	577
Bohus			709	1029

4.2 Concentration fields

The yearly mean concentration fields for TGM are shown in Figures 5-7 for the 3 plants. These fields are based on the sum of GEM and RGM fields. Only for the Polish plant is TGM significantly different from GEM.

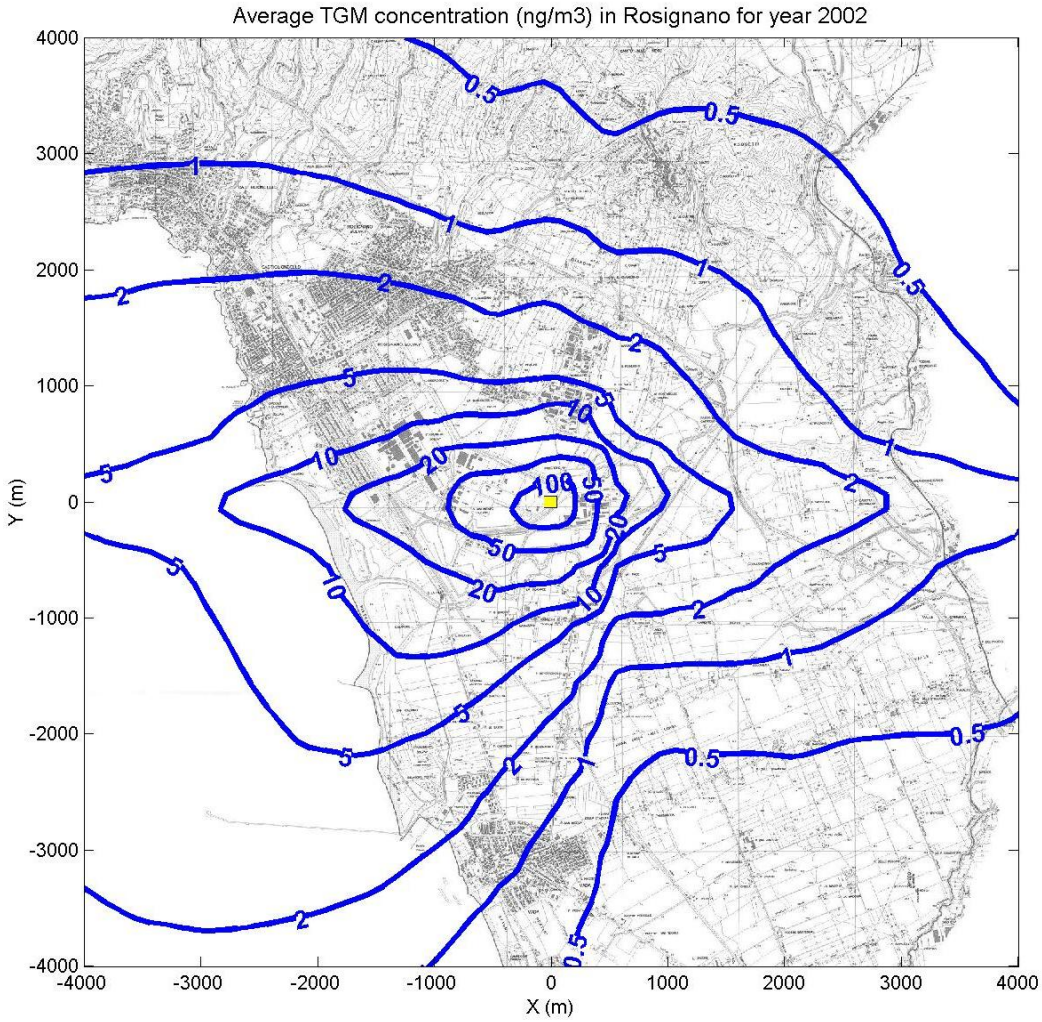


Figure 5. Average annual TGM concentration (ng/m^3) for the Rosignano plant in Italy, calculated for the year 2002. Contours are in uneven intervals of 0.5, 1, 2, 5, 10, 20, 50, 100 and 200. The yellow square shows the position of the plant. Background concentrations are not included.

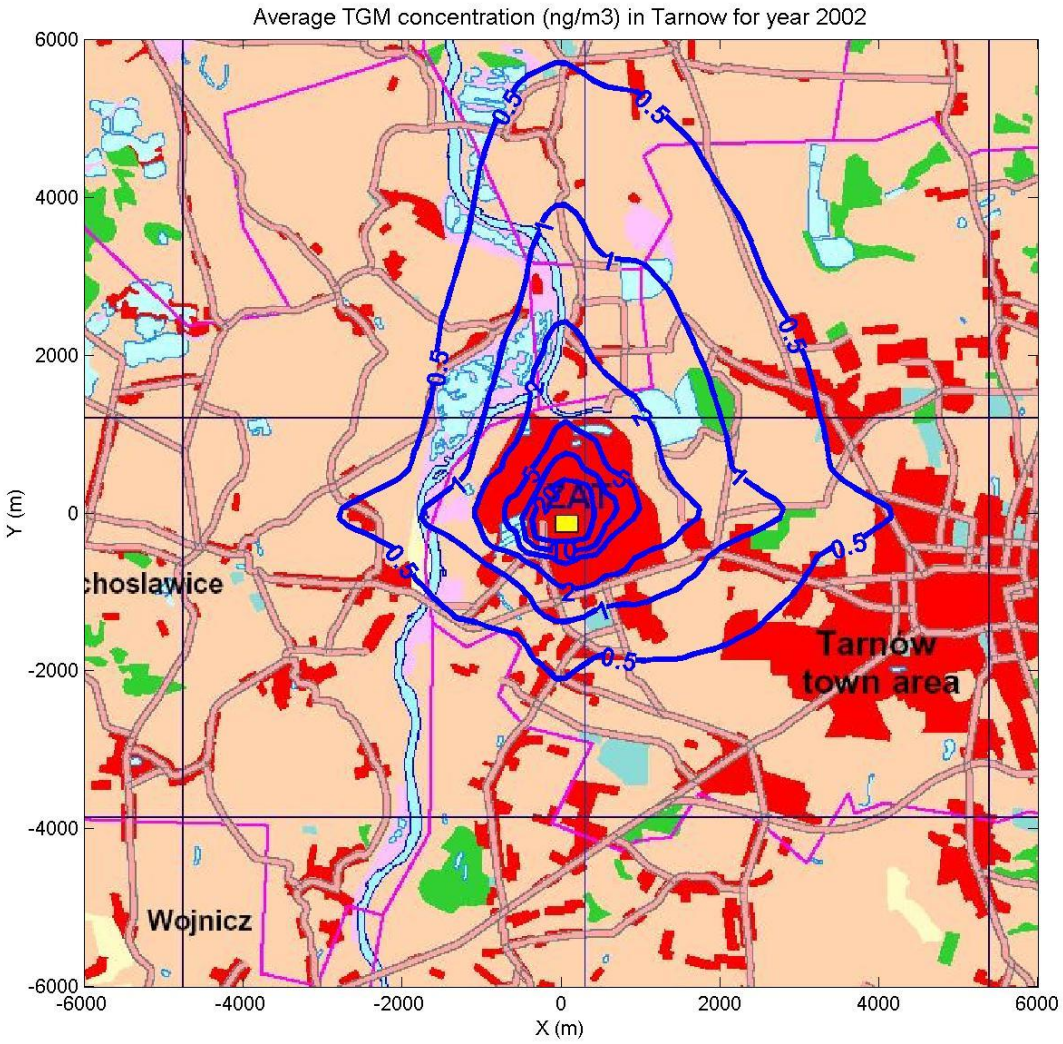


Figure 6. Average annual TGM concentration (ng/m^3) for the Tarnow plant in Poland, calculated for the year 2002. Contours are in uneven intervals of 0.5, 1, 2, 5, 10, 20 and 50. The yellow square shows the position of the plant. Background concentrations are not included.

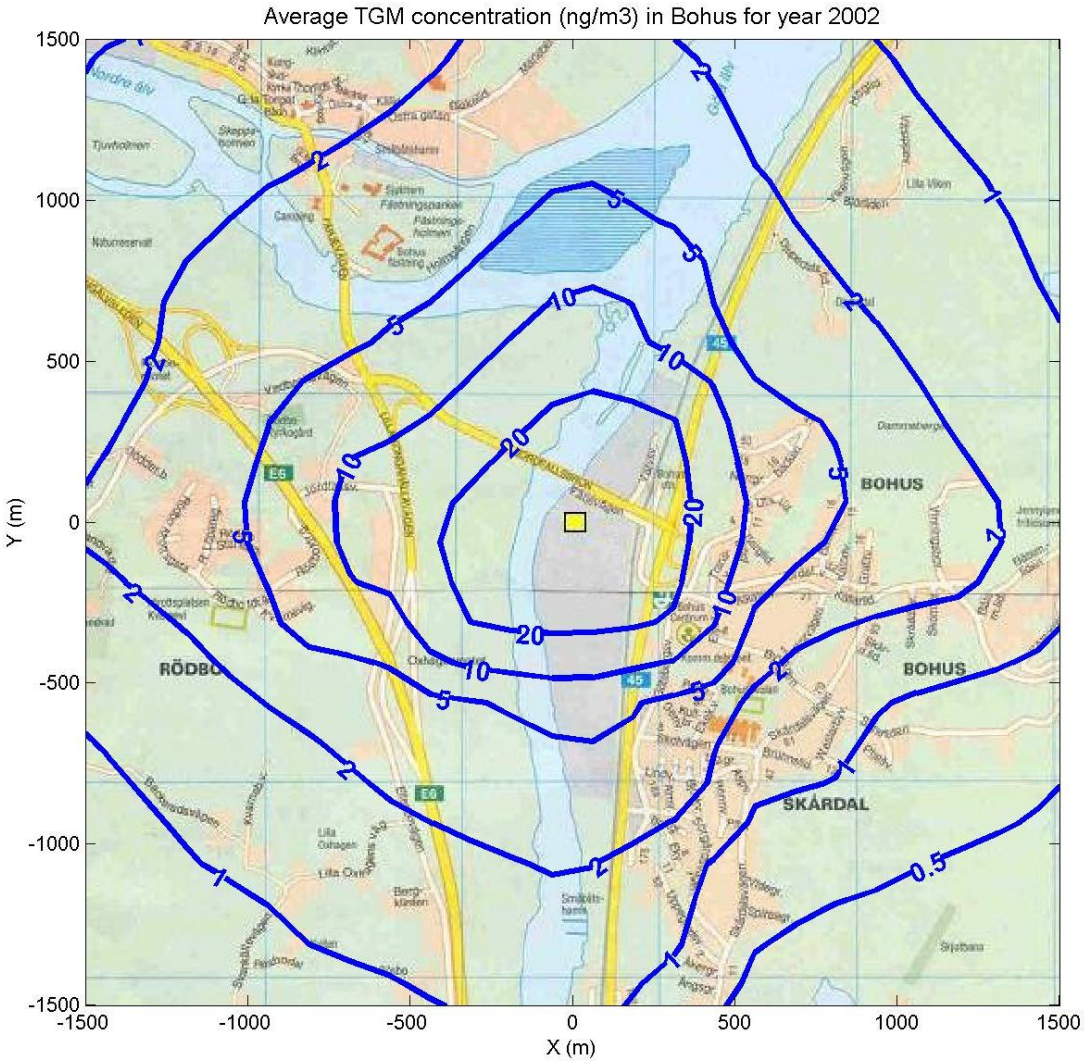


Figure 7. Average annual TGM concentration (ng/m^3) for the Bohus plant in Sweden, calculated for the year 2002. Contours are in uneven intervals of 0.5, 1, 2, 5, 10, 20 and 50. The yellow square shows the position of the plant. Background concentrations are not included.

As can be seen from the maps, concentrations decrease rapidly with distance from the plant. For the plant in Rosignano the village is well located with respect to the plant as the dominant land/sea breeze effects lead to East-west wind directions. The site at Tarnow shows highest concentrations towards the north, well away from the town centre. The other site at Bohus shows a more symmetrical distribution of concentration as no particular wind direction is favoured.

In figure 8 the TGM concentration has been averaged in all directions and presented as a function of distance from the plant. The total emissions for the two plants in Bohus and Tarnow are quite similar and this is reflected in the lower concentrations around the plant. Higher emissions, roughly a factor of 4, come from the Rosignano plant and this is reflected in Figure 8.

For all 3 plants the concentration reaches background levels, shown in the figure as 2 ng/m^3, within 1 to 3 km of the plant.

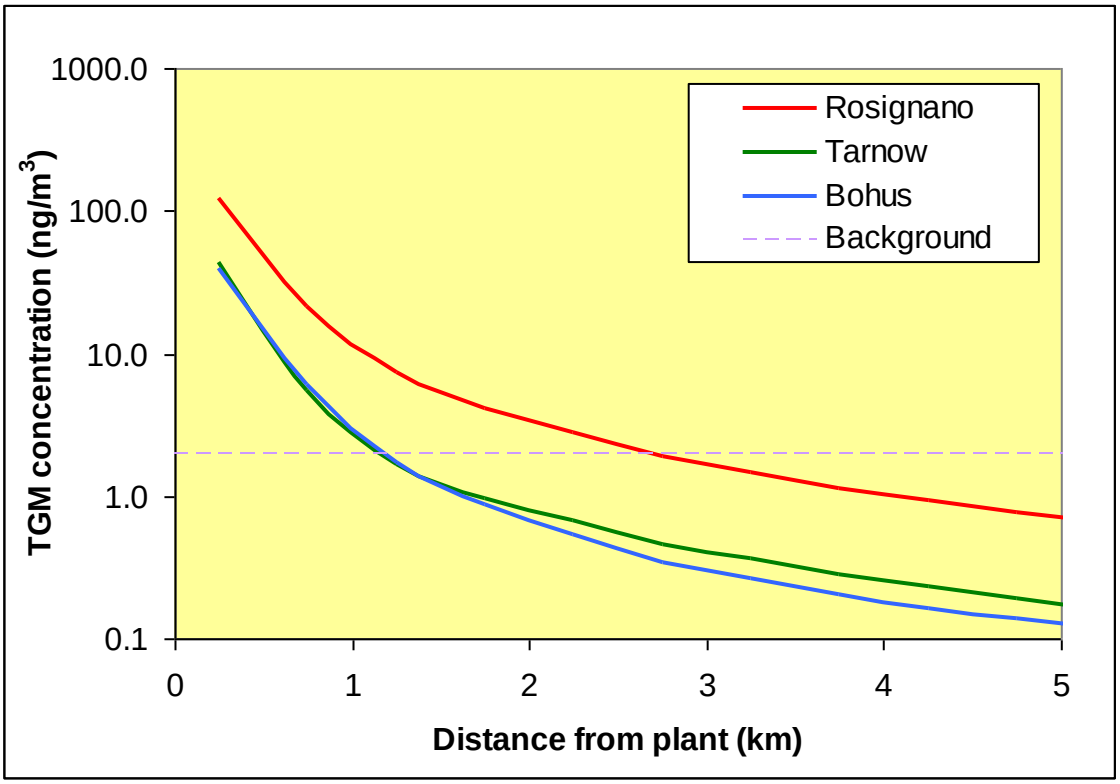


Figure 8. Average annual TGM concentration (ng/m^3) for all 3 plants, calculated for the year 2002, and shown as a function of distance from the plant. The vertical scale is shown as logarithmic.

4.3 Monthly and annual deposition values

The monthly deposition of Mercury within a 5 km radius of the plants, separated into both dry and wet deposition and into the 3 different mercury species, is shown in Figure 9. The most significant contribution at all plants is through the dry and wet deposition of RGM. This is particularly true at the Tarnow plant due to the high emissions of RGM.

Most of the monthly variability of the deposition is the result of wet deposition, as it is dependent on precipitation rates and duration.

As was discussed in the previous EMECAP report D5.3, the total deposition of each species is quite varied. At all plants approximately 0.5% of the emitted GEM is deposited within the 5 km region. This is in contrast to RGM where around 25% of the emitted RGM is dry deposited and approximately 20% is wet deposited, depending on precipitation. Most of the deposition occurs within the first kilometer of the plant, as described in report D5.3.

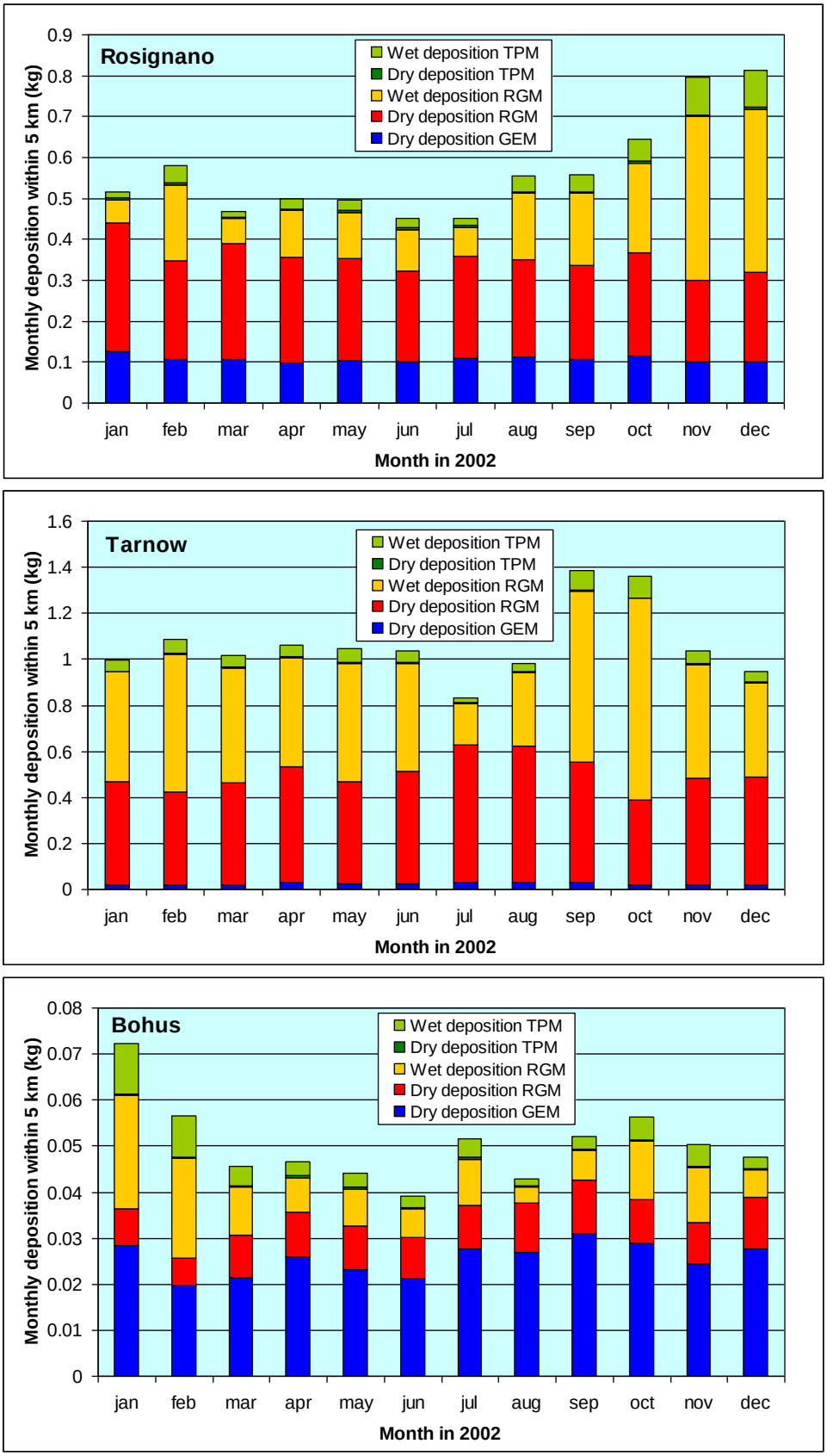


Figure 9. Monthly mercury deposition at the 3 sites, split into the 3 mercury species (GEM, RGM and TPM) and the two processes of dry and wet deposition. Shown is the total monthly deposition within a 5 km radius of the plant.

The results are summarized as yearly means for all 3 plants, Figure 10, as the total mass deposited by the various processes within a 5 km radius of the plant. The largest total deposition occurs at the Tarnow plant in spite of the fact that TGM emissions are similar to the Bohus plant. This discrepancy is the result of the much higher emission of mercury in the form of RGM, which is much more easily deposited through dry and wet processes.

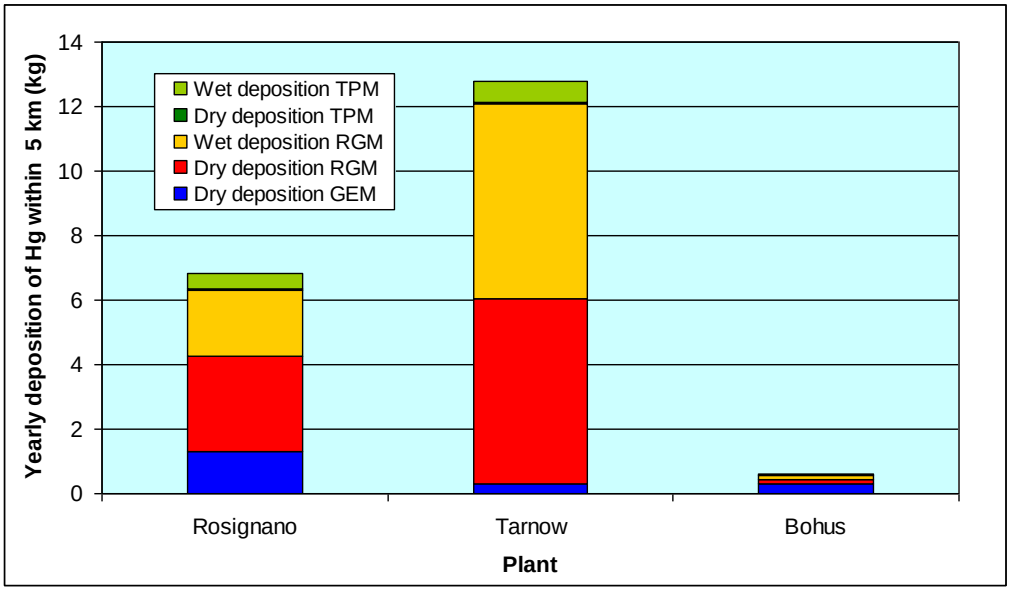


Figure 10. Yearly mercury deposition at the 3 sites, split into the 3 mercury species (GEM, RGM and TPM) and the two processes of dry and wet deposition. Shown is the total yearly deposition, in kilograms, within a 5 km radius of the plant.

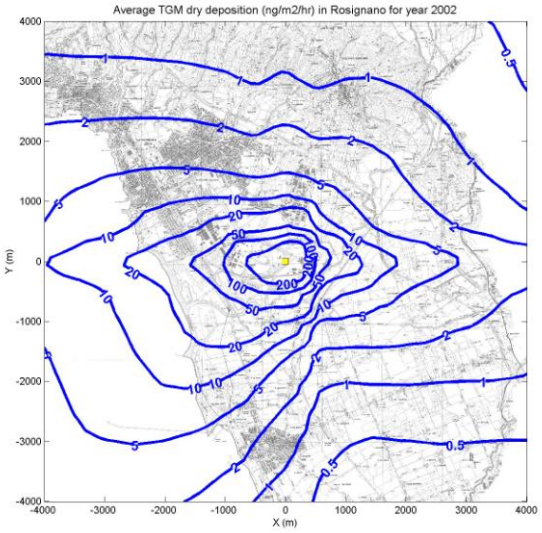
In Table 7 the deposition results are simply summarized. Importantly the plant with the highest deposition rate is the plant with the highest emission rate for RGM.

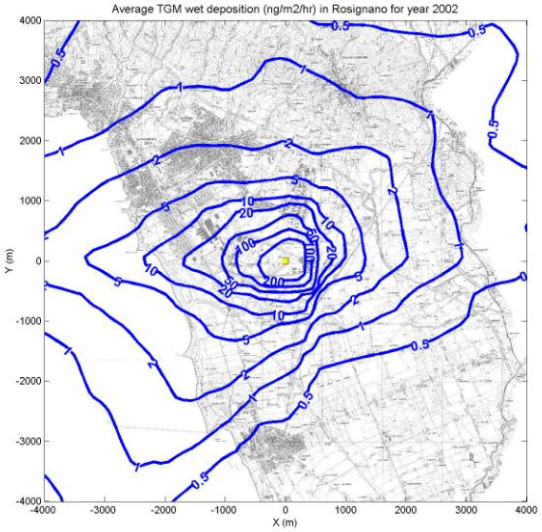
Plant	Total emission of Hg (kg/yr)	Total deposition of Hg within 5 km (kg/yr)	Percentage of emission deposited within 5 km (%)
Rosignano	285	6.8	2.3
Tarnow	88.4	12.8	14
Bohus	74	0.61	0.8

Table 7. Summary of model calculations for the total deposition of Mercury within a 5 km radius of the plant.

4.4 Deposition fields

The yearly mean mercury deposition fields, split into dry and wet deposition as well as total deposition, are shown in Figures 11-13 for the 3 plants.


Average TGM dry deposition (ng/m2/hr) in Rosignano for year 2002
Y (m)
X (m)


Average TGM wet deposition (ng/m2/hr) in Rosignano for year 2002
Y (m)
X (m)

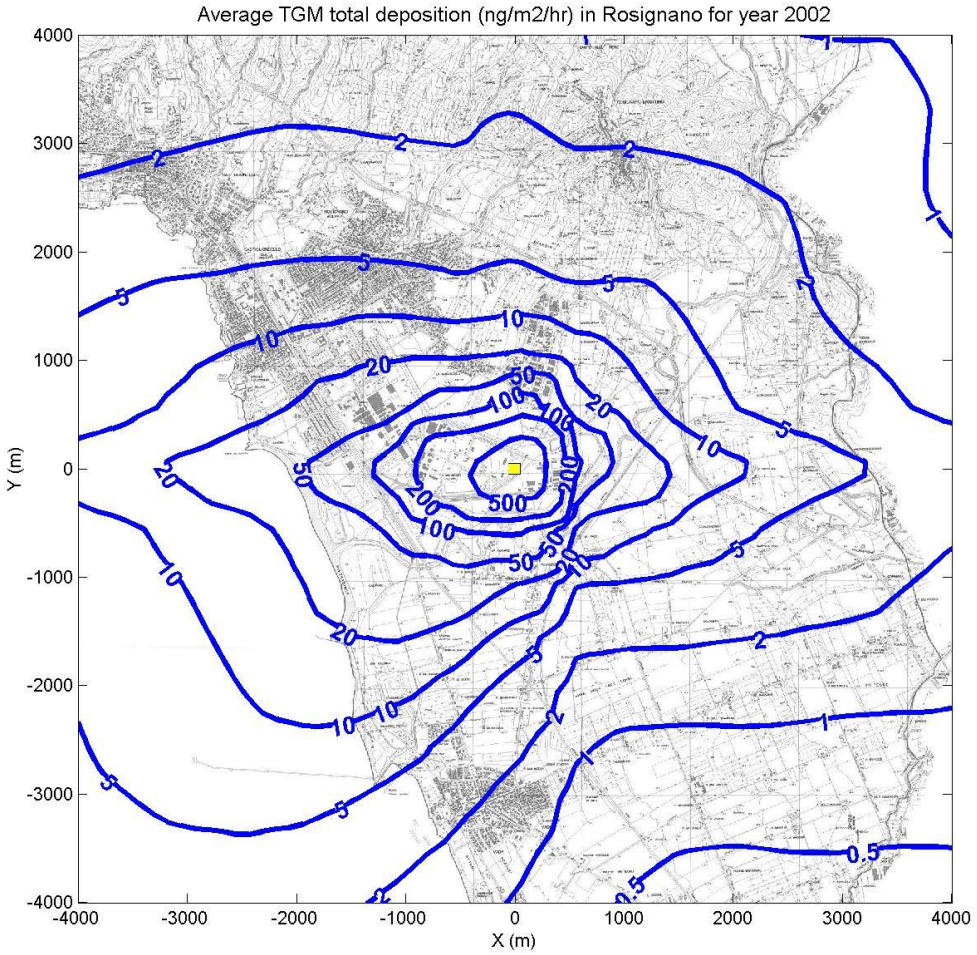
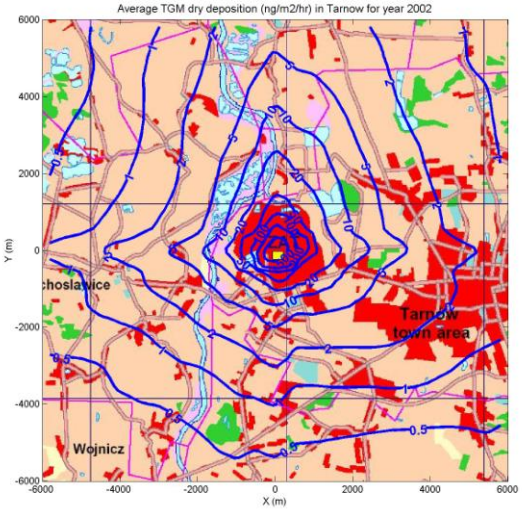
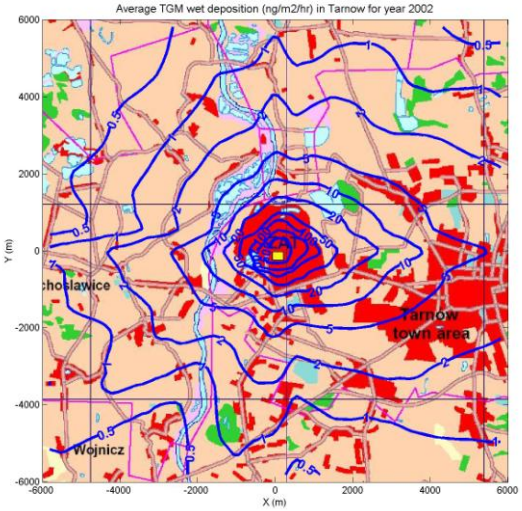


Figure 11. Annual average mercury dry deposition (top left), wet deposition (top right) and total deposition rate (ng/m2/hr) for the Rosignano plant in Italy, calculated for the year 2002. Contours are in uneven intervals of 0.5, 1, 2, 5, 10, 20, 50, 100, 200 and 500. The yellow square shows the position of the plant.


Average TGM dry deposition (ng/m2/hr) in Tarnow for year 2002
Tarnow
town area
Wojnicz
Y (m)
X (m)


Average TGM wet deposition (ng/m2/hr) in Tarnow for year 2002
Tarnow
town area
Wojnicz
Y (m)
X (m)

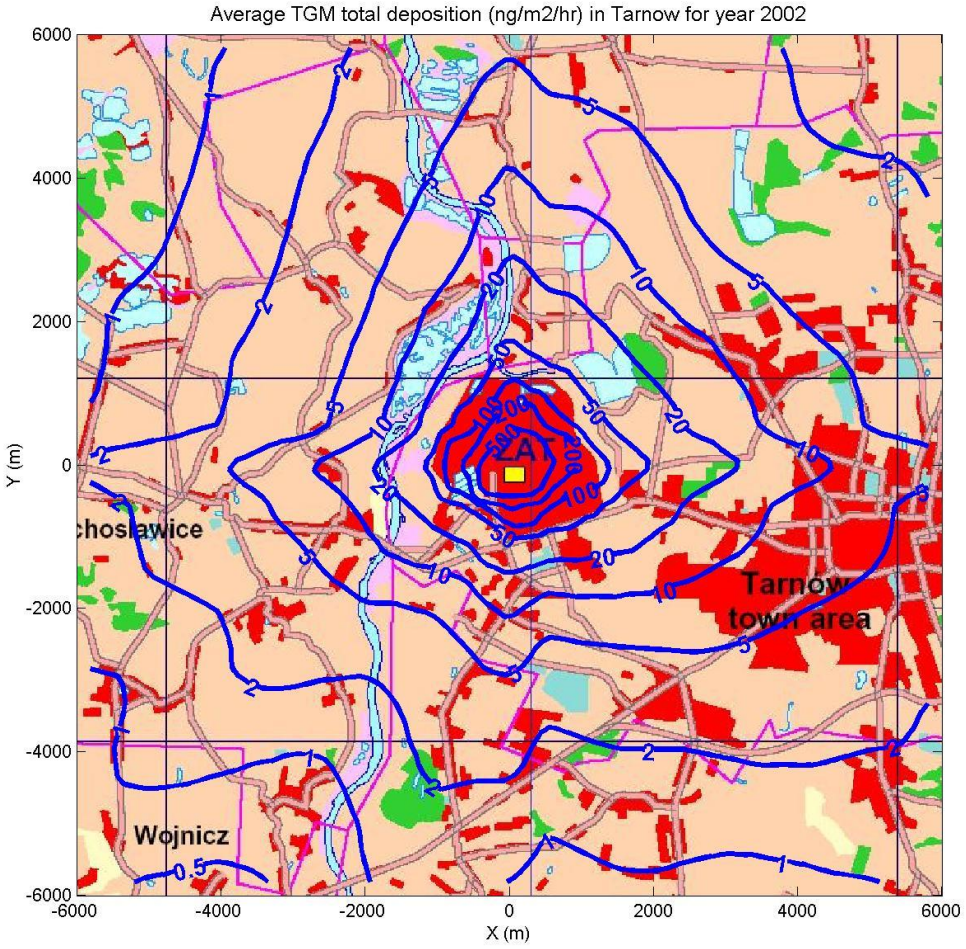
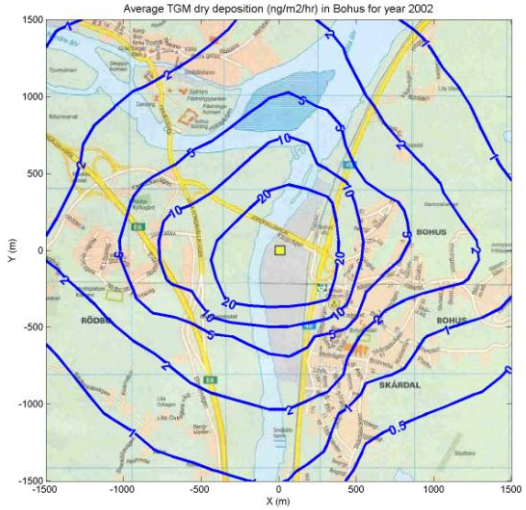
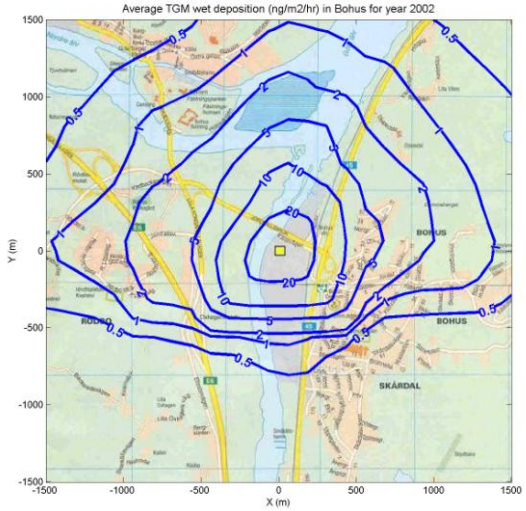


Figure 12. Annual average mercury dry deposition (top left), wet deposition (top right) and total deposition rate (ng/m2/hr) for the Tarnow plant in Poland, calculated for the year 2002. Contours are in uneven intervals of 0.5, 1, 2, 5, 10, 20, 50, 100, 200 and 500. The yellow square shows the position of the plant.


Average TGM dry deposition (ng/m2/hr) in Bohus for year 2002
Y (m)
X (m)
BOHUS
RÖDBO
SKÅRDAL


Average TGM wet deposition (ng/m2/hr) in Bohus for year 2002
Y (m)
X (m)
BOHUS
RÖDBO
SKÅRDAL

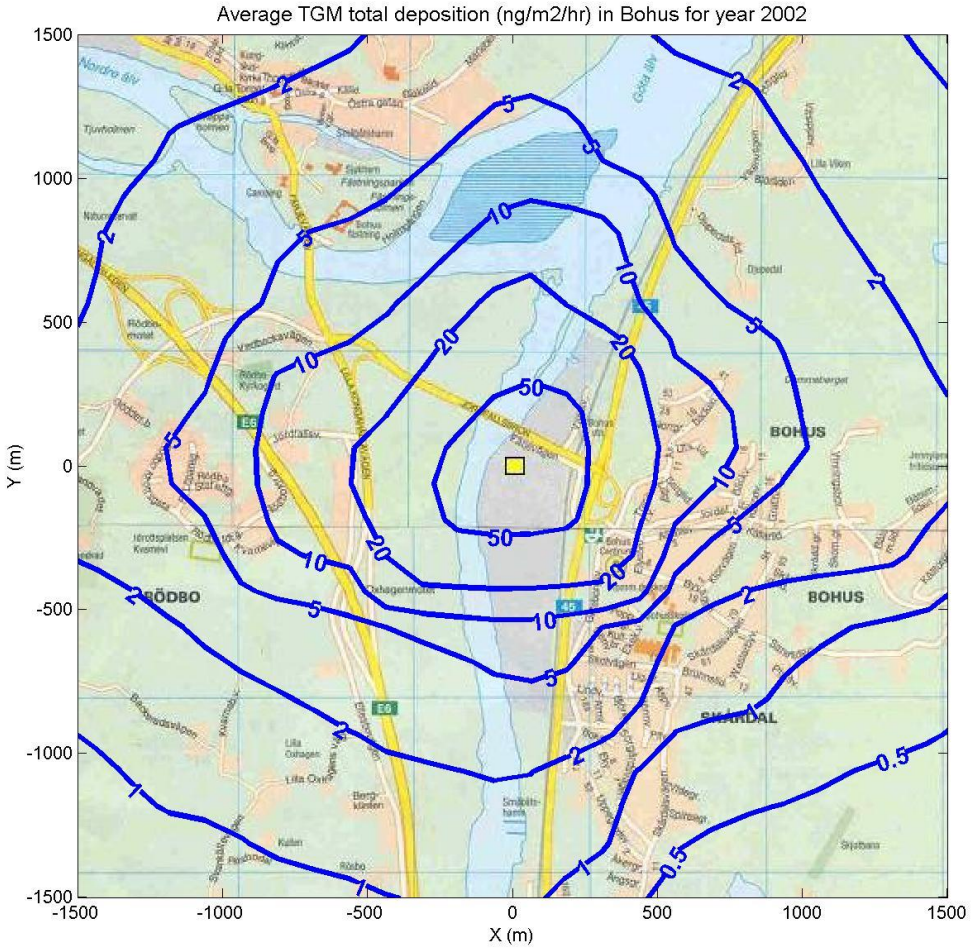


Figure 13. Annual average mercury dry deposition (top left), wet deposition (top right) and total deposition rate (ng/m2/hr) for the Bohus plant in Sweden, calculated for the year 2002. Contours are in uneven intervals of 0.5, 1, 2, 5, 10, 20, 50 and 100. The yellow square shows the position of the plant.

In Figure 13 the total mercury deposition rate is averaged in all directions and presented as a function of distance from the plant. The lowest deposition occurs at the Bohus plant as a result of the low emission of RGM. The highest deposition rates are at Tarnow, due to its high RGM emissions. This is in spite of the fact that it has a similar total emission to that of Bohus.

For all 3 plants the deposition reaches background dry and wet deposition levels within a few kilometres of the plant. The background dry deposition rate is calculated based on the deposition parameters used in the model for GEM and assuming a background level of 2 ng/m^3. This calculation ignores the contribution of RGM to the dry deposition. The wet deposition rate is taken from measurements made at the EMEP station (RÅÖ) approximately 50 km from the Bohus plant in Sweden.

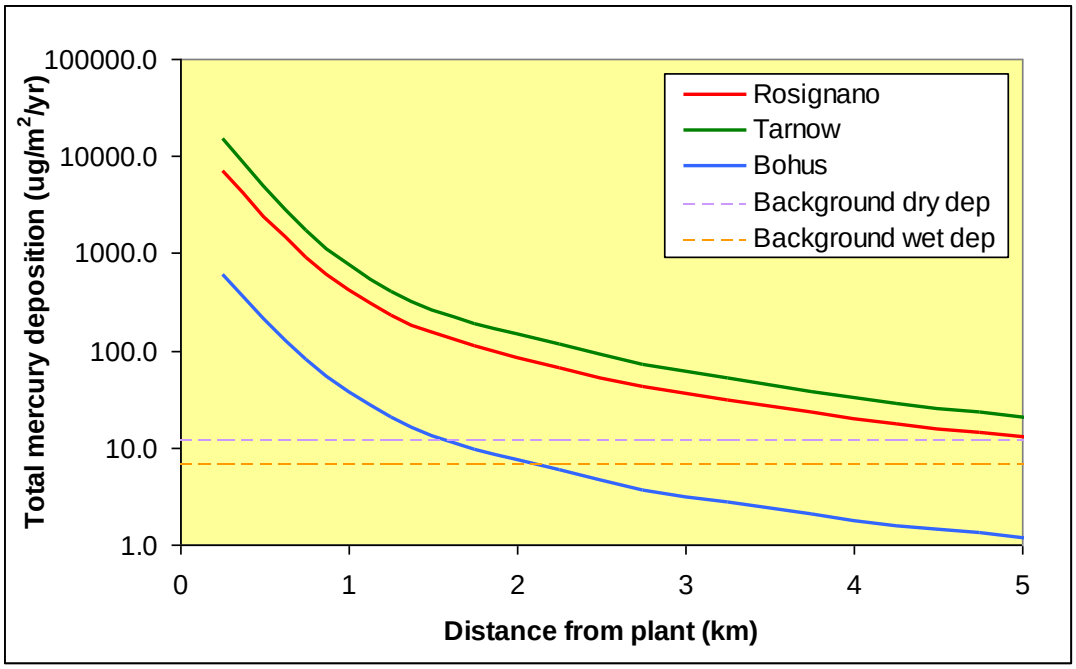
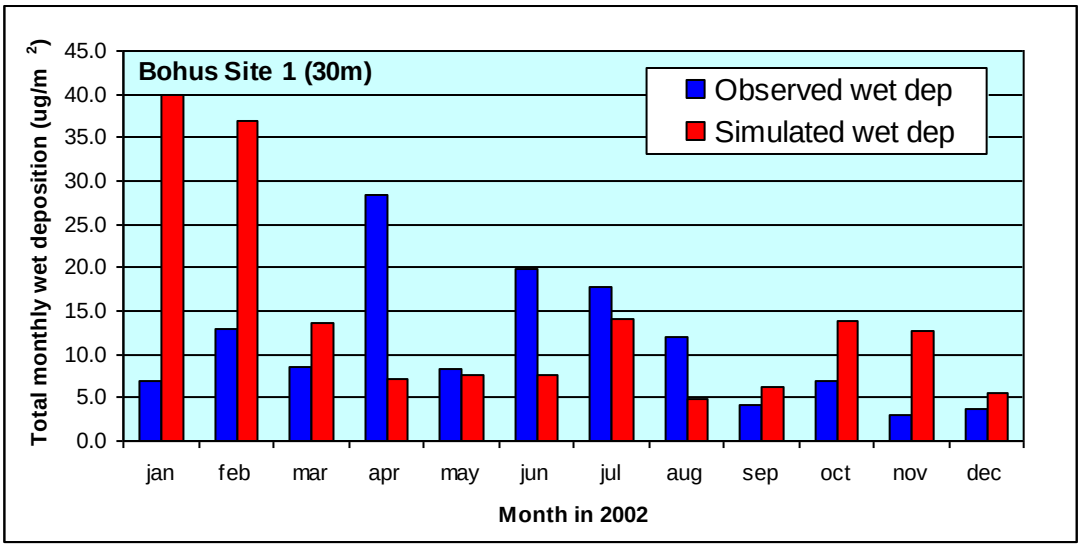


Figure 13. Average annual mercury deposition rate (ug/m^2/yr) for all 3 plants, calculated for the year 2002, and shown as a function of distance from the plant. The vertical scale is shown as logarithmic.

4.5 Comparison with observations

Wet deposition measurements were carried out at the Bohus and Tarnow plants. For the Bohus plant monthly wet deposition measurements for the year 2002 are available at 4 different sites. For the Tarnow plant deposition measurements were only made during the two EMECAP campaigns, which do not correspond to the simulated period. The results for Bohus are shown in Figure 14 and summarized in Table 7. Only 3 of the sites are shown as one site was placed on contaminated ground and the observations are strongly influenced by this.



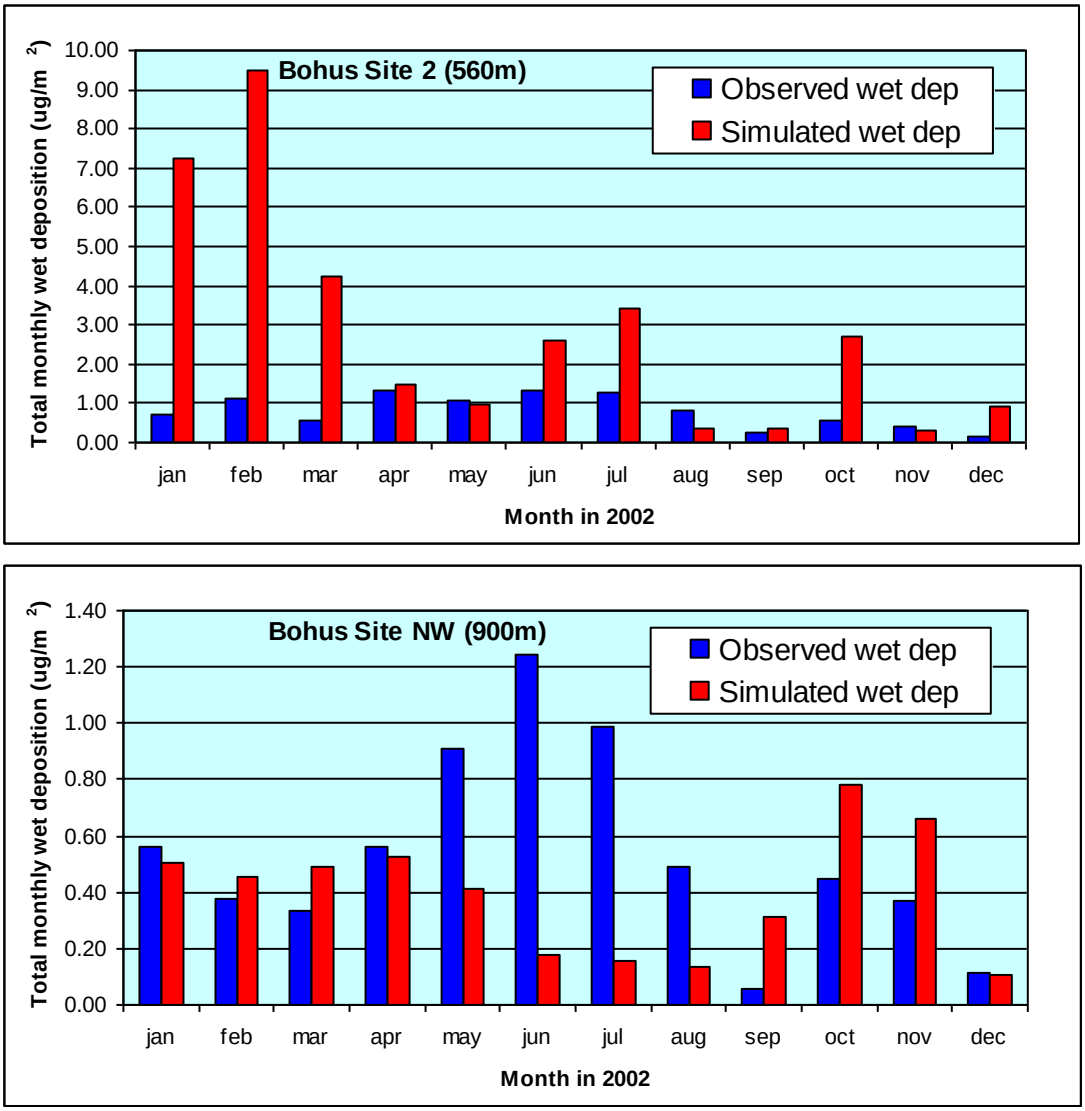


Figure 14. Total monthly wet deposition of mercury (ug/m^2) for the Bohus plant, simulated and observed for the year 2002.

Table 7. Summary comparison between observed and simulated wet deposition of mercury for the year 2002 at the Bohus plant. The site names and distances from the plant are shown.

Site	**Observed wet deposition of Hg (ug/m^2/yr)**	**Simulated wet deposition of Hg (ug/m^2/yr)**
1 (30m)	129	170
2 (560m)	9.6	34
NW (900m)	6.4	4.7

Wet deposition is a process dependent on many factors, including wind speed and direction, precipitation rate as well as scavenging rate. It is thus difficult to simulate wet deposition from a single point source. In spite of this the simulated wet deposition of mercury, which is chiefly due to the wet deposition of RGM, is relatively close to the observed values. The main discrepancies occur during

periods when the model over or underestimates precipitation, see Figure 4, as can be seen in the first 2 months of the year.

The comparison at the site closest to the plant is the best. This is not surprising as it is less dependent on wind direction than the other two sites.

5 Summary and conclusions

The dispersion and deposition of Mercury emitted from 3 MCCA plants has been simulated for the year 2002. The first model used in dispersion calculations, TAPM, is a meteorological and dispersion model in one but has only been used to produce meteorological fields. The second model, EPISODE, which is a chemistry transport model, has used these meteorological fields to model the dispersion and deposition of Mercury.

The results confirm that Mercury emissions from the MCCA plants only lead to heightened concentrations in a region less than 1 km away from the plant. For the two plants with lowest emissions, Bohus and Tarnow, concentrations reach background levels within 1 km. The Rosignano plant reaches background levels within 3 km of the plant. Mercury concentrations as a result of the plant emissions are at or below background levels at the closest population centres.

Deposition of mercury is a more complicated process, particularly wet deposition. However, given the current knowledge on this process then the total deposition is strongly dependent on the amount of RGM emitted by a plant, rather than the total mercury emitted. The Tarnow plant, with its RGM emission of 40% of total mercury, has the highest deposition rate within a 5 km radius of the plant. 12% of all Mercury emitted is deposited in this region as a result. In contrast the Bohus plant, with an RGM emission of 0.7% of total mercury, has the lowest deposition of just 0.8%. The rest of the mercury is thus released into the global atmospheric pool.

The high deposition rates of RGM make it desirable, from a local pollution context, to reduce RGM emissions from MCCA plants. One simple and possible suggestion is that if RGM is created within the plants through gas phase reactions with chlorine, as described in D5.2 and D5.3, then improving ventilation rates could help to decrease the RGM emissions.

Some points should be noted in regard to the simulations and areas for improvement.

1. The average concentration fields produced by the model are expected to well represent the concentrations around the plant. Much effort has gone into improving the emission inventory during the EMECAP project for just this purpose. However, due to the limited resolution of the model, concentrations within 500m of the plant are likely to be less representative.

2. The deposition rates are based on current knowledge of mercury processes and are in need of review and further research. This is particularly true for dry

deposition processes which requires a significant improvement in its description. This must be done through observational campaigns aimed at improving knowledge of this.

3. The wet deposition is dependent not just on wet scavenging ratios but also on the simulated precipitation. When this is incorrect then wet depostion rates will also be incorrect. There is thus a need for the best precipitation data available.

4. Estimates of RGM and TPM emissions from the Rosignano plant are crude and really require insitu measurements to establish these correctly.

5. Due to time limitations only two short observational campaigns were carried out at the Tarnow plant. The resulting data sets were not comprehensive enough for a thorough validation of the model results. These observations also appear to have been influenced by other sources of mercury, such as contaminated soil at the site or possibley from coal burning at the factory power plant. The number of measurements made within the plant to determine the RGM/TGM ratio is also limitted. The high deposition rate simulated at the Tarnow plant is the result of the assumed high emissions of RGM measured during these short periods. A longer observational campaign would be required to confirm this.

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ABSTRACT

As part of Work Package 5 of the EU FP5 EMECAP project, dispersion model calculations have been carried out in order to determine the concentration and deposition of Mercury in the region surrounding 3 selected Mercury Cell Chlor-Alkali (MCCA) plants. In this study the dispersion modelling is applied to calculate the yearly concentration and deposition maps surrounding the 3 MCCA plants under study. The calendar year 2002 has been used for the model runs. The results show that mercury concentrations quickly reduce to background levels within 1 to 3 km from the plants.

Deposition of mercury occurs mainly within the first kilometre from the plant and background levels are reached within a few kilometres. The deposition has been found to be strongly dependent on the amount of RGM emitted from the plant. Deposition is largest for the Tarnow plant in Poland where RGM emission is also the highest.

NORWEGIAN TITLE

KEYWORDS		
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ABSTRACT (in Norwegian)

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- *B Restricted distribution*
- *C Classified (not to be distributed)*