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1. Management summary

The objective of this Czech pilot report V2 is to document the Czech pilot use of Common Services downscaling tools for air quality and hydrology, showing how the SUDPLAN system can complement CENIA's other information systems with extended possibilities to perform long-term projections and assessments. The report details work on activities and tasks during the year 2011 as outlined in the pilot definition plan V2. The report also documents the Czech pilot use of the SUDPLAN tools as defined in six use cases for the operation of the Common Services from the Scenario Management System user interface.

As part of the tasks dealing with air quality, emission data have been collected and uploaded to the Common Services databases, by means of which air quality projections in Prague agglomeration were calculated. The performance of the model was evaluated through the comparison between simulated data and observed air quality data. Simulated data were compared to the data from stations with higher spatial resolution (background urban or rural stations) which minimized the influence of local factors on concentrations of air pollutants (e.g. industry, transportation) that could not be covered by the model.

We found that the Common Services downscaling model realistically and in most cases accurately reproduced concentrations of nitrogen oxides and ozone whereas concentrations of particulate matter were underestimated. The problem with simulation of PM concentrations is accentuated in the winter season, where the model fails to reproduce episodes of high PM10 levels. To sum up our findings, the SUDPLAN Common Services air quality model provides sufficiently realistic results apart from concentrations of particulates PM10, for which more experimentation and validation will be performed during 2012 (V3).

In the next step, we have drawn the outlook of air quality in the Prague area. The global circulation models ECHAM and Hadley have been used in common with activity model GAINS. Results of both GCM models, using emission scenario A1B, were in conformity in terms of increasing trend of temperature towards the year 2030 and decreasing trend of background concentration of NO_x, ozone and particulates. The simulation carried out by means of the GAINS model has also shown decreasing trend of national emissions of all calculated pollutants by 2030. Data from GCMs and GAINS have been used to calculate air quality outlook by the Common Services downscaling model. The downscaling simulations performed so far indicate that air quality will generally improve during the coming decades.

Besides the implementation of the task dealing with air quality outlook, the task focused on migration assessment has also proceeded. Data describing migration have been collected as well as the questionnaire survey is ready to be implemented within the last year of the SUDPLAN project. As soon as we have data from the survey ready we will focus on outlining future migration trends under the circumstances of changing air quality in Prague agglomeration.

The second goal of the Czech pilot is to evaluate the influence of future hydrological conditions on agricultural farming in terms of crop yields and economical profitability. The calibration of the Common Services hydrological downscaling model was performed using historical discharge data. Then the validation procedure assessing the ability of the model to reproduce measured data realistically was executed with independent discharge data from the period 2000-2009. Hydrological projections based on climate scenarios as well as farm profitability function will be implemented within the coming months and reported in the V3 report.

The use case of visualisation of climate and air quality on the Pan-European scale has been evaluated. The experimentation with air quality downscaling has been performed with the web based Airviro user interface, allowing end user CENIA to execute, visualise and analyse the results. The experimentation with the hydrological downscaling model, to be integrated in the SMS environment during V3, has so far been executed offline by SMHI staff.

During V3 the WP8 setup of the complete SUDPLAN information system and its integration with existing CENIA systems, will allow the full evaluation of both air quality and hydrological downscaling, demonstrating use cases and showing the way the information can be generated and used by CENIA.

2. Introduction

The Czech pilot evaluates two of the downscaling tools of Common Services. The air quality downscaling is used to show how air quality will evolve and to investigate the relations to migration patterns around Prague. The hydrological downscaling is used to project future soil moisture and how this will affect crop productivity and the future agriculture potential in Central Bohemia.

The results achieved after the second year are discussed in separate chapters, for air quality in Section 3 and for hydrology in Section 4. The presentation follows the tasks as defined in D8.1.2 Czech Pilot Definition Plan V2. Except for the tasks that define the work to be done in WP8, the D8.1.2 document also formulates a number of use-cases. These are linked to the demonstration of the SUDPLAN software and aimed to show that the software tool developed fulfils the requirements originally formulated by the end-users of the pilot.

This report on V2 activities ends with conclusions. The management summary that is found as a first section, gives a short overview of the work performed during V2 together with conclusions, i.e. it will give the reader the major content of the entire report.

3. Work on air quality tasks during 2011

The Czech pilot evaluates the Common Services (CS) air quality downscaling and how air pollution affects quality of life and migration patterns. CENIA has provided emission data and air quality data from monitoring stations which have been used for model validation.

The Czech pilot activities are defined in the task description of Section 4 in the D8.1.2 Czech Pilot Definition Plan V2. The tasks are listed under the main area “Migration Assessment”, reflecting the overall focus of the Czech pilot. The following table 1 summarizes the tasks of the air quality part of Czech pilot.

Table 1: Tasks in the area of air quality implemented within the second reporting period

Task	*Title*	*Comment*
1.1	Gather data for air quality model input and validation	Completed in V2.
1.2	Assessing air quality in the Prague area	Partly completed in V2
1.2.1	Model validation for a historical period	Partly completed in V2, more validation of PM10 needed in V3.
1.2.2	Assessment of air quality evolution for a selected future climate scenario	Partly completed in V2, will continue in V3.
1.3	Development of the DPSIR indicator set	Initiated in V2
1.4	Gathering migration data	Initiated in V1 and the work progressed during V2. The real survey will take place during early V3
1.5	Assessment of Pilot hypothesis	Initiated in V2. The econometric model will be finished in V3
1.6	Assessment of future migration scenarios	Will be initiated and completed in V3
1.7	Analysis of the air quality and migration scenarios	Will be initiated and completed in V3

The following persons have been actively engaged in the air quality work of the Czech pilot during 2011:

CENIA: Vladislav Bizek (emissions, monitor data, analysis, team leader of air quality work)
Alzbeta Kodetova (emissions, modelling, air quality data analysis)
Leona Matouskova (emissions, modelling, air quality data analysis
Jan Mertl (emissions, air quality data analysis)
Jiri Hradec (team leader of the Czech pilot)
Radka Bezdekovska (demography, socio-economic analysis)
Tereza Suchankova (demography, socio-economic analysis)

SMHI: Lars Gidhagen (support on emission inventory using Airviro)
Magnuz Engardt (support on downscaling model simulations)
Stefan Andersson (support on model validation)

A two day workshop was held in Prague December 1-2, 2011. SMHI participated with two air quality experts. Technical meetings CENIA-SMHI were also arranged within the PMC 3 (Vienna) and PMC 4 (Kaiserslautern) meetings.

3.1. Gather data for air quality model input and validation

3.1.1 Emission data

For the purposes of the AIRVIRO emission database, relevant activity data (road network, traffic intensities, and fuel consumption) and emission data have been collected and uploaded to the AIRVIRO database.

The data for individual pollutants (sulphur dioxide, nitrogen oxides, dust (TSP), carbon monoxide, volatile organic compounds (VOC) and ammonium) has been taken from the REZZO database, which stands for Register of Emissions of Air Pollution Sources. Data in this register are divided, pursuant to the legislation which came into force in 2002, into four categories – REZZO 1-4 (hereafter mentioned as R1-4).

Extra-large, large (R1) are monitored and described individually as point sources, while medium-sized air pollution sources (R2), small sources (R3) at regional/local level and mobile sources (R4) are described as area sources. The air pollution sources monitored within the R3 include emissions from household heating, fugitive emissions from construction and agricultural activity, ammonia emissions from breeding of farm animals and application of mineral fertilizers and VOC emissions from the use of organic solvents.

Emission data has been processed, by means of the GIS software, into the emission densities, representing the amount of emissions of individual pollutants in the 5x5 kilometres grid squares. These data have been used as the input to the AIRVIRO system. Unfortunately, the smaller grid, allowing sharper model results, is not yet available.

An example of the data from the REZZO emission inventory in the year 2007 is presented in Figure 1.

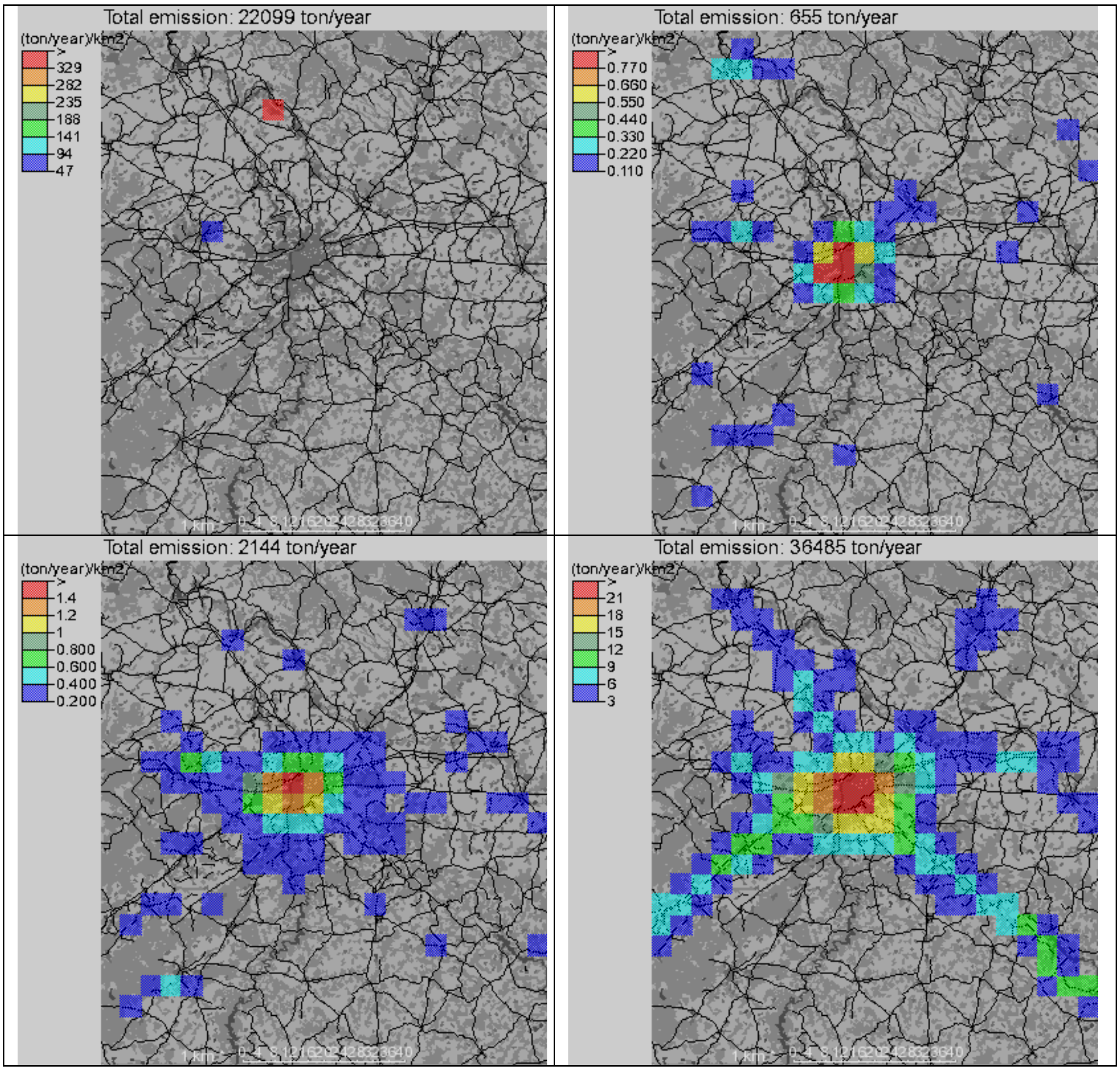


Figure 1: Emission densities of NO_x in the Czech Republic in 2007 (grids 5 x 5 km) from the source categories R1 (top left), R2 (top right), R3 (bottom left), R4 (bottom right)

Besides emissions from the REZZO database collected by the Czech Hydro meteorological Institute the traffic volume have been calculated for roads by using transportation intensities data in the Prague area taken from the transportation census carried out by Technical Administration of Roads – Institute of Transport Engineering (TSK-ÚDI). The road network with traffic volume has been used to spatially distribute the REZZO 4 emissions. Example of outputs of REZZO NO_x emissions and road NO_x emissions is shown below in figures 2 and 3, as well as the comparison of MATCH model outputs using above mentioned input data. As emissions from roads represent almost all REZZO 4 emissions in the Prague area, it is clearly seen that the simulation using data from roads provides better and sharper simulation of air quality.

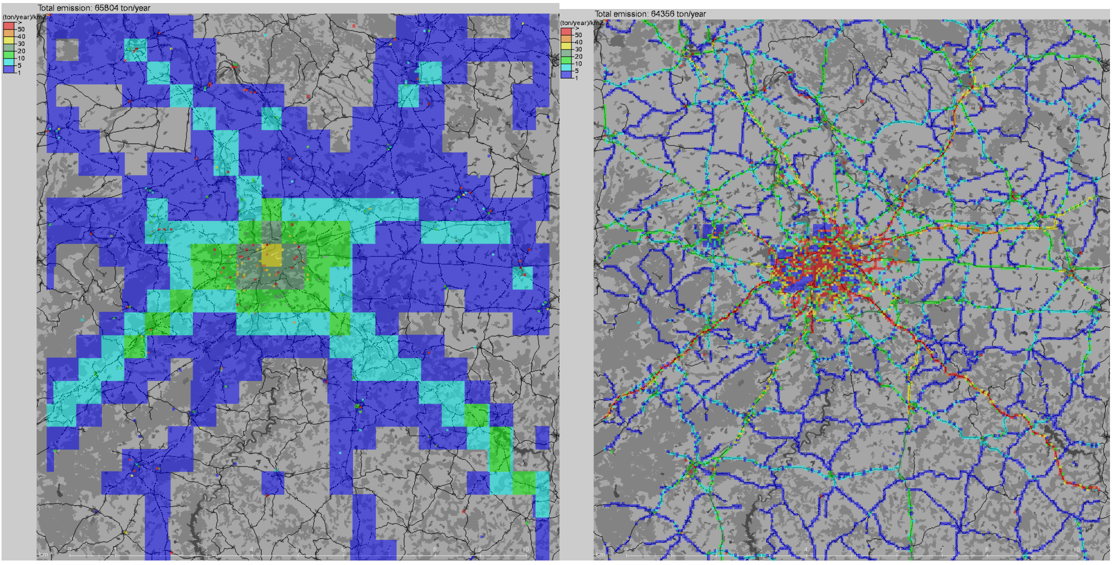


Figure 2: Emission densities of NO_x in the squares 5x5 kms (REZZO database) and from roads with 500x500 m resolution, 2007

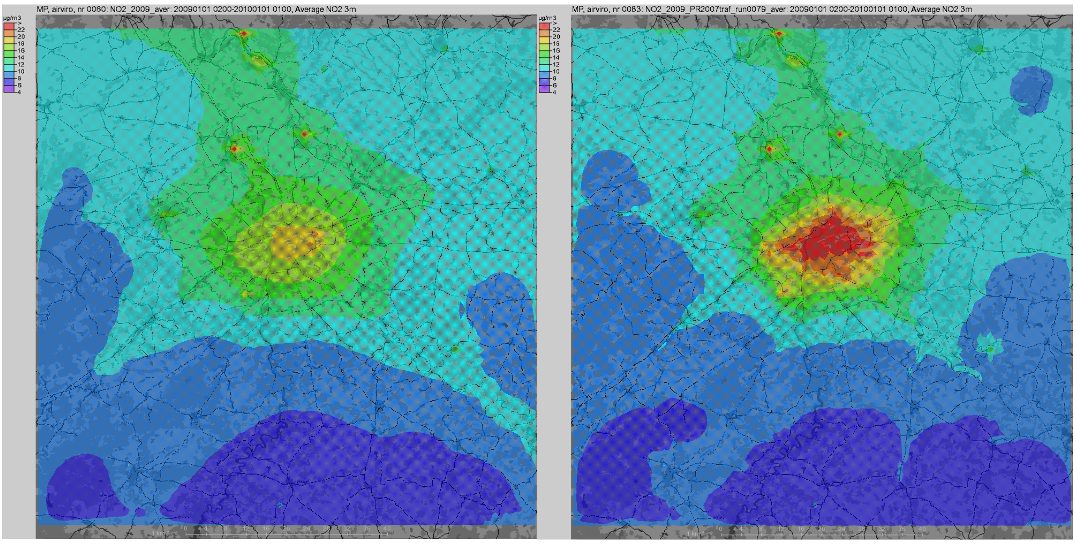


Figure 3 NO_2 concentrations in the Prague area in 2009, annual mean, simulated with 1x1 km spatial resolution and based on emission data from the REZZO database (grid 5x5 kms, left) and data from roads (grid 500x500m right), respectively.

3.1.2 Air quality data

The air quality data were used for the validation of the Common Services downscaling chemical transport model. Data have been taken from the national air pollution database called ISKO (Information System for Air Quality). This information system maintains and assesses data from air pollution monitoring network which includes AMS (Automated Monitoring Stations) and the supplementary network with manual sampling.

Data were available for PM_{10}, sulphur dioxide, nitrogen dioxide, carbon monoxide, ground-level ozone and at certain stations also for $PM_{2.5}$ and benzo(a)pyrene.

The table below shows the list of monitoring stations selected for validation purposes. All stations are AMS and have been selected according to their classification. Since the model results should be compared with stations with larger spatial representativeness, background urban and rural stations were used. The location of monitoring stations is displayed in figure 4.

Table 2 List of air monitoring stations used for validation purposes, including geographical coordinates and classification

Station name	X	Y	PM10	O3	NO2	SO2	Clasification
Beroun	4612131	2990976	X	X	X	X	T/U/RCI
Kladno_Svermov	4613806	3014480	X	X	X	X	B/U/RI
Kladno-střed města	4613968	3011598	X	X	X	X	B/U/R
Kosetice	4688058	2952644	X	X	X	X	B/R/AN-REG
Mlada Boleslav	4669879	3046888	X	X	X	X	B/U/R
Ondrejov	4664104	2989282		X	X	X	B/R/N-REG
Pha1-Nam-Republiky	4637784	3006875	X	X	X	X	B/U/C
Pha10-Prumyslova	4645597	3004439	X	X	X	X	T/U/IC
Pha10-Vrsovice	4639108	3004583	X	X	X	X	T/U/R
Pha2-Riegrovy sady	4638768	3006265	X	X	X	X	B/U/NR
Pha4-Branik	4636867	3001723	X	X	X	X	B/S/R
Pha4-Libus	4639604	2997957	X	X	X	X	B/S/R
Pha5-Mlynarka	4634725	3004892	X	X	X	X	T/U/RC
Pha5-Smichov	4635616	3005056	X	X	X	X	T/U/RC
Pha5-Stodulky	4631077	3001804	X	X	X	X	B/U/R
Pha6-Suchdol	4634356	3010961	X	X	X	X	B/S/R
Pha6-Veleslavin	4632201	3007543	X	X			B/S/R
Pha8-Karlin	4638545	3007524	X				T/U/C
Pha8-Kobylisy	4640282	3010878	X	X			B/S/R
Pha8-Vysocany	4642890	3009760	X	X			T/U/CR
Pribram	4609873	2960278	X	X			T/U/R

The classification of localities is based on the Council Decision 97/101/EC on exchange of information and criteria for EUROAIRNET. The requirements of above mentioned Council Decision are obligatory for the EU member states. Stations are classified as follows:

1. **Type of the station** – the first letter
   a. Traffic (T) – the representativeness is dependent on the length of communication, it is from approx. 100 in inner cities up to more than 1000 metres in suburbs

   b. Industrial (I) – locality directly influenced by industry. The area of representativeness of the station is 10-100 meters. There are no industrial stations selected in the list
   c. Background (B) – area of representativeness is between 1-1,5 kms in urban and suburban areas up to 60 kms in rural areas
2. **Type of the area** – the second letter after the slash
   a. Urban (U) – stations B/U – representativeness around 1 km
   b. Suburban (S) – stations B/S – up to 5 kms
   c. Rural (R) – stations B/R from around 5 kms up to more than 60 kms
3. **Characteristics of the area** - third letter(s)
   a. Residential (R)
   b. Comercial (C)
   c. Industrial (I)
   d. Agricultural (A)
   e. Natural (N)
4. **Type of B/R stations**
   a. Near-city (NCI) – representativeness around 5 kms
   b. Regional (REG) – between 20-60 kms
   c. Remote (REM) – more than 60 kms

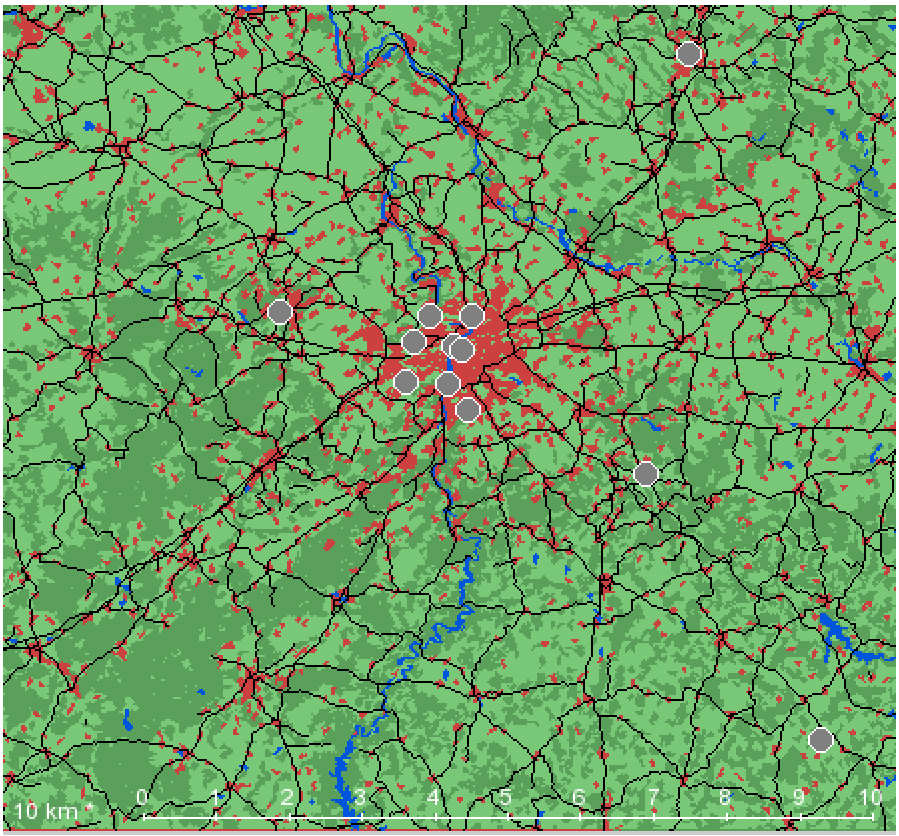


Figure 4 Monitoring stations used in the validation task (image exported through the Airviro user interface)

3.2. Assessing air quality in the Prague area

This task deals with air quality simulations in Central Bohemian area, first for validation purposes and then the projections using climate scenarios have been carried out.

3.2.1 Model validation for a historical period

The model validation procedure was performed by means of a comparison between data simulated by the model and data observed. The results of validation were visualized in scatter plots and line graphs. Moreover, the statistical indicators of the correlation between two sets of data have been derived.

The monitoring stations used in the validation procedure were selected according to their classification. We used those stations with higher spatial representativeness which are classified as background, further divided between urban, suburban and rural. This selection ensured that the data monitored were not affected by local factors which are mainly transportation and industry.

The results of validation carried out have shown that the O_3 and NO_2 concentrations are reproduced more-less realistically whereas PM_{10} concentrations are underestimated by the model.

If we look at validation of annual mean values in the year 2009 for seven background urban and two background rural stations expressed in the scatter graph following conclusions can be stated:

- Annual concentrations of tropospheric ozone at urban stations are reproduced almost perfectly by the model while at rural stations are slightly underestimated (figure 5)

- Annual concentrations of NO_2 at urban stations are a bit more scattered around monitored results, but the inconsistencies are not significant (up to 10 $\mu m/m^3$). This is probably connected with local factors influencing air quality in cities, which cannot be detected by the model. On the other hand, NO_2 concentrations at rural stations are reproduced very well (figure 6).

- Annual concentrations of particulate matter (PM) are underestimated by the model; either at urban or rural stations (figure 7). Values at some sites are simulated at the level of about 50 % of the real (monitored) value, which represents really significant underestimation.

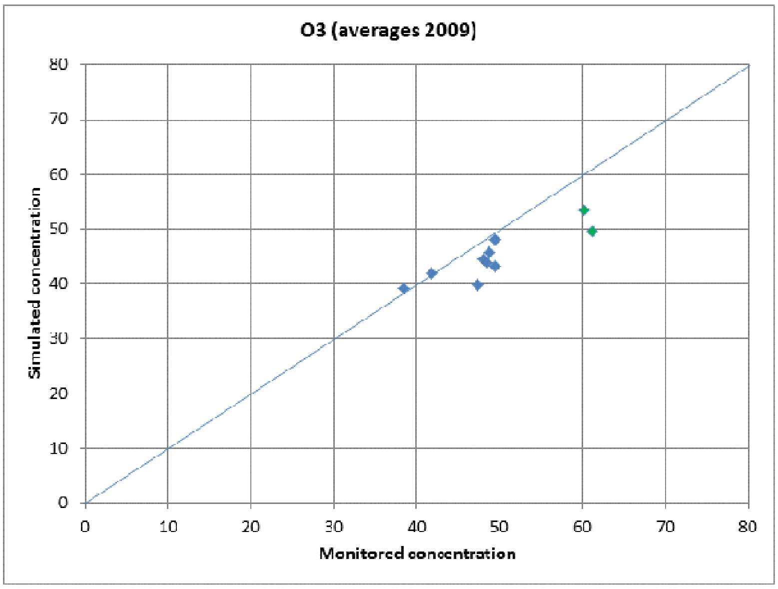


Figure 5: Scatter plot of annual mean concentrations of ozone at urban stations Kladno – stred mesta, Mlada Boleslav, Pha1 – Nam-Republiky, Pha4 – Libus, Pha5 – Stodulky, Pha 6 – Suchdol, Pha6 – Veleslavin, Pha 8 – Kobylisy and rural stations Kosetice and Ondrejov in the year 2009. (Urban locations in blue, rural in green).

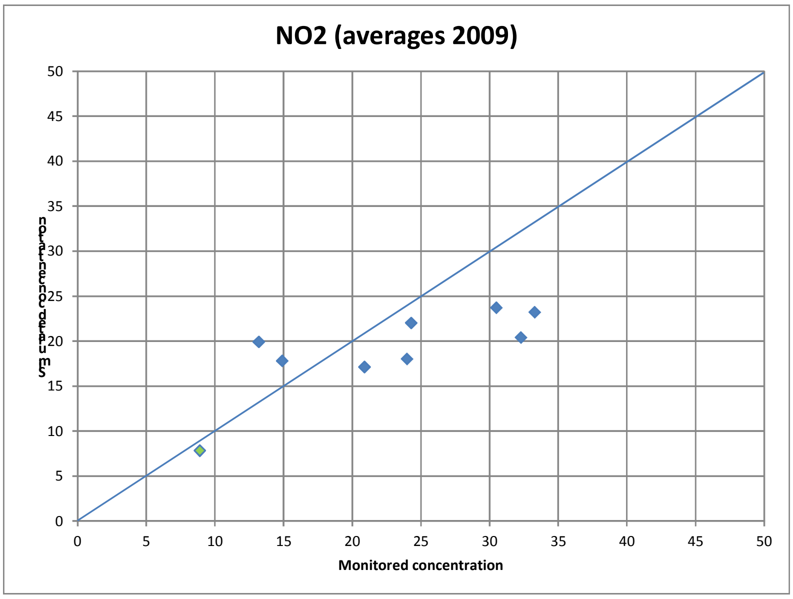


Figure 6: Scatter plot of annual mean concentrations of NO_2 at the stations displayed in figure 5 in the year 2009. (Urban locations in blue, rural in green).

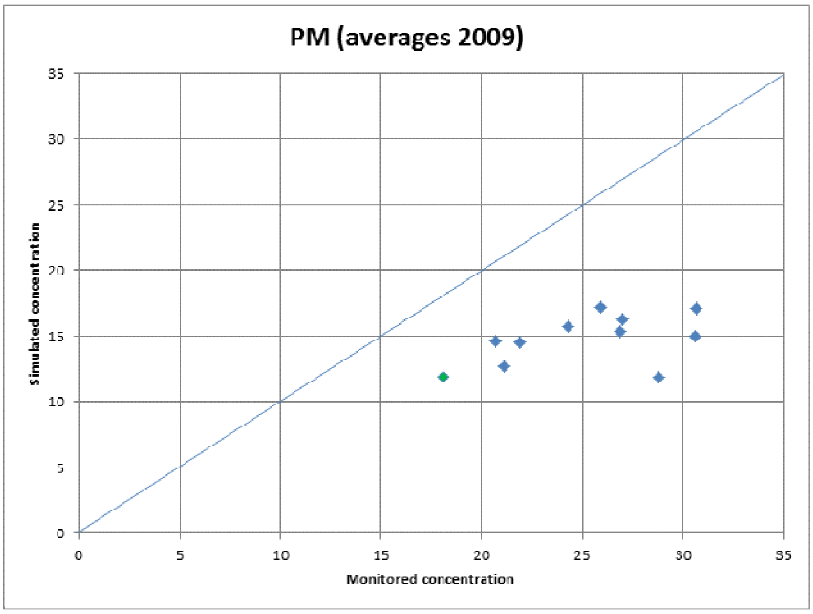


Figure 7: Scatter plot of annual mean concentrations of PM_{10} at the stations displayed in figure 5 in the year 2009. (Urban locations in blue, rural in green).

While looking at daily time-series the similar results of model performance are observed. Daily concentrations of ozone at the station Kosetice (rural station approx. 70 kms south-easterly from Prague) are reproduced well including daily and seasonal fluctuations (figure 8). NO_x concentrations at Libus station, which is urban station located in the southern part of Prague, are reproduced also correctly, however, daily peaks especially in winter season are clearly underestimated (figure 9). Nevertheless, the similar standard deviation of simulated series (S = 8,83) and monitored series (S = 10,45) has shown that the levels of daily variability of monitored and simulated data are similar, therefore, it can be concluded that the result of the model is more-less representative.

With regard to daily series of PM_{10} concentration, the ability of the model to reproduce them realistically is significantly lower than for the other pollutants assessed. The poor model performance for PM_{10} is illustrated in the Figure 10, which depicts daily monitored and simulated concentrations at the station Kladno – inner city (stred mesta in Czech), the urban station located around 20 kms westerly from Prague. The most significant inconsistencies are detected in the winter season, when the model is unable to reproduce some episodes with very high peaks. On possible explanation to this can be episodic increases in Czech PM emissions that are not described in the Prague emission data input to the model. However, it should also be noted that the current version of Common Services air quality downscaling uses boundary conditions from model output on the Pan-European scale which only involves Secondary Inorganic Aerosols (SIA), i.e. a proxy to PM10. Although the levels seems relevant during summer conditions, there may be episodic emissions on the Pan-European scale (forest/vegetation fires, domestic wood burning during cold winter days etc.) that can explain the high PM10 peaks registered at monitor stations.

The variability of daily monitored values at this station, measured by standard deviation, is 15,42 whereas S = 5,22 for the simulated time series. We can therefore conclude that the variability of

PM10 concentrations is represented by the model even worse than mean values. More experimentation and validation work is needed for PM10.

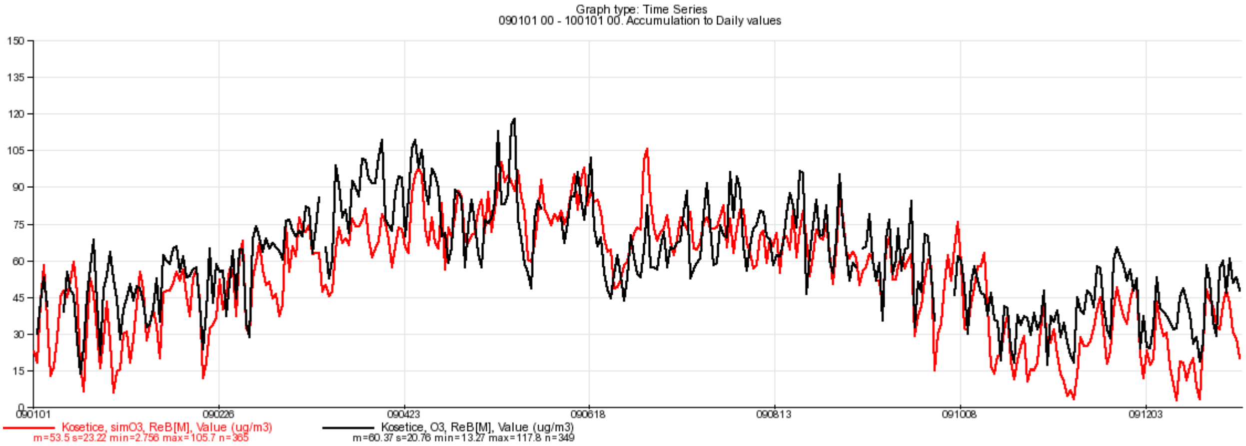


Figure 8: Daily simulated values (red line) and observed values (black line) of ozone at the station Kosetice in 2009

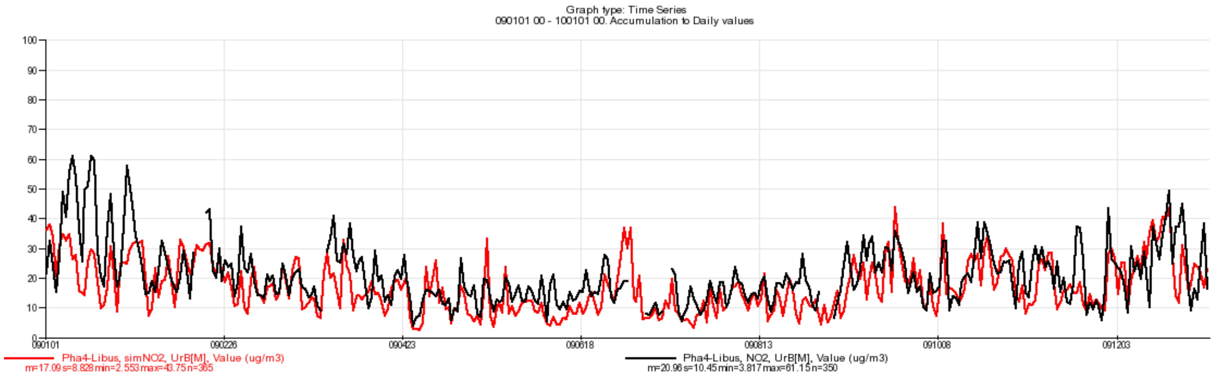


Figure 9: Daily simulated values (red line) and observed values (black line) of NOx concentrations at the station Praha – Libus in 2009

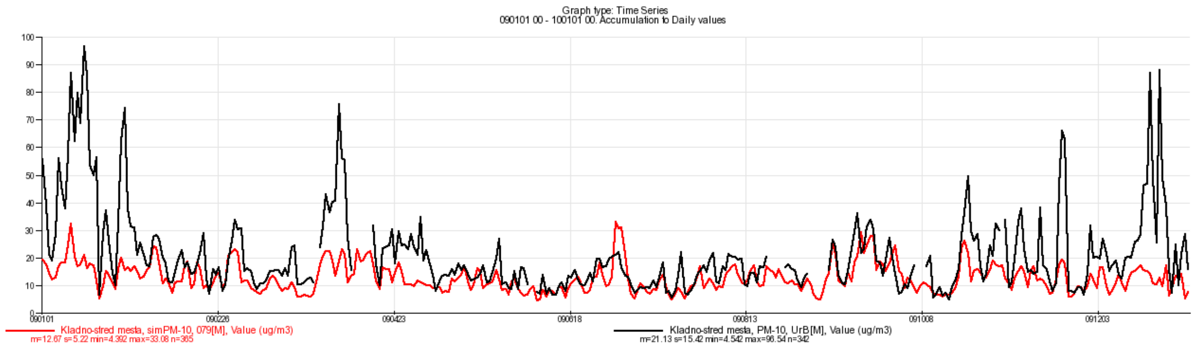


Figure 10: Daily simulated values (red line) and observed values (black line) of PM_{10} concentrations at the station Kladno – stred mesta in 2009

3.2.2 Assessment of air quality evolution for a selected future climate scenario

The outlook of air quality in the Prague area presented below has been processed by means of global circulation models ECHAM and Hadley. Future European emissions have been taken from the RCP4.5 scenario used in the current CMIP5 coordinated modelling work preparing for the ICCPs 5th Assessment Report. Czech emission scenarios have been simulated by the GAINS model. We assumed that the future development of air quality relates to the development of climate characteristics and emission volumes, especially those connected with combustion of fossil fuel.

The results of above mentioned GCM models for the emission scenario A1B have shown that temperature will rise between 0,5-1 °C by 2030 (figure 11) while precipitations are likely to increase by some 20 mm/year within this period (figure 12).

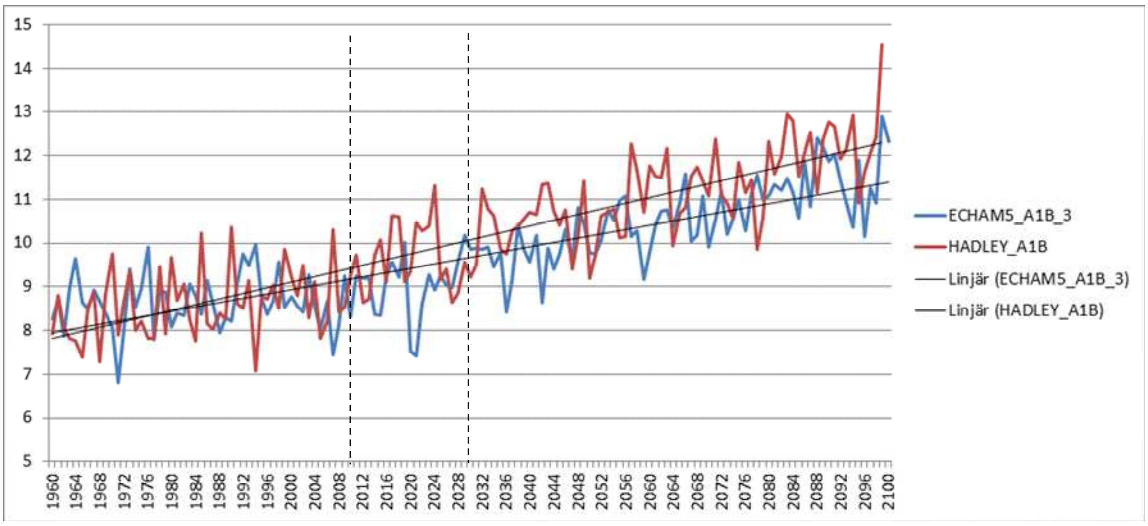


Figure 11: Annual mean temperature in the period 1960-2100 simulated by ECHAM (blue line) and Hadley GCM model (red line) and linear trends of temperature. Location: Prague

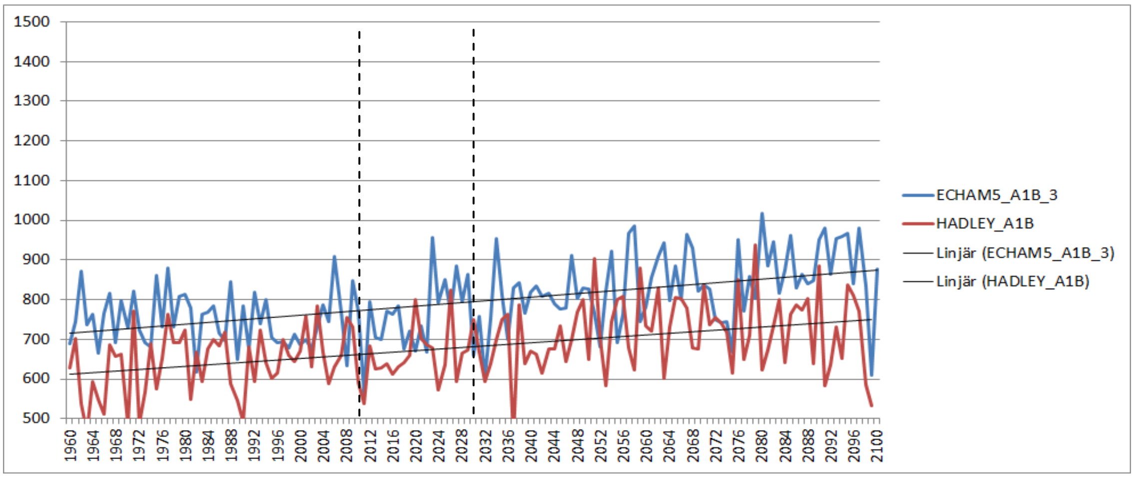


Figure 12: Annual mean precipitation in the period 1960-2100 simulated by ECHAM (blue line) and Hadley GCM model (red line) and linear trends of precipitation. Location: Prague.

The changes in climatic conditions will affect air quality, mostly positively. These results are described in the charts 13-15 where future development of regional background for ozone and NO_2 emissions is depicted. The background concentrations are independent on local sources of pollution, and can be considered as the lowest concentrations of individual pollutants originated from natural and anthropogenic sources and influenced by the global patterns of changing climate.

According to the simulation, ozone background concentration will decrease by approximately 10 % to the level of around 50 um/m^3 until 2100. NO_2 and secondary inorganic aerosols (SIA) background concentrations will decrease as well, see Figure 14 and 15.

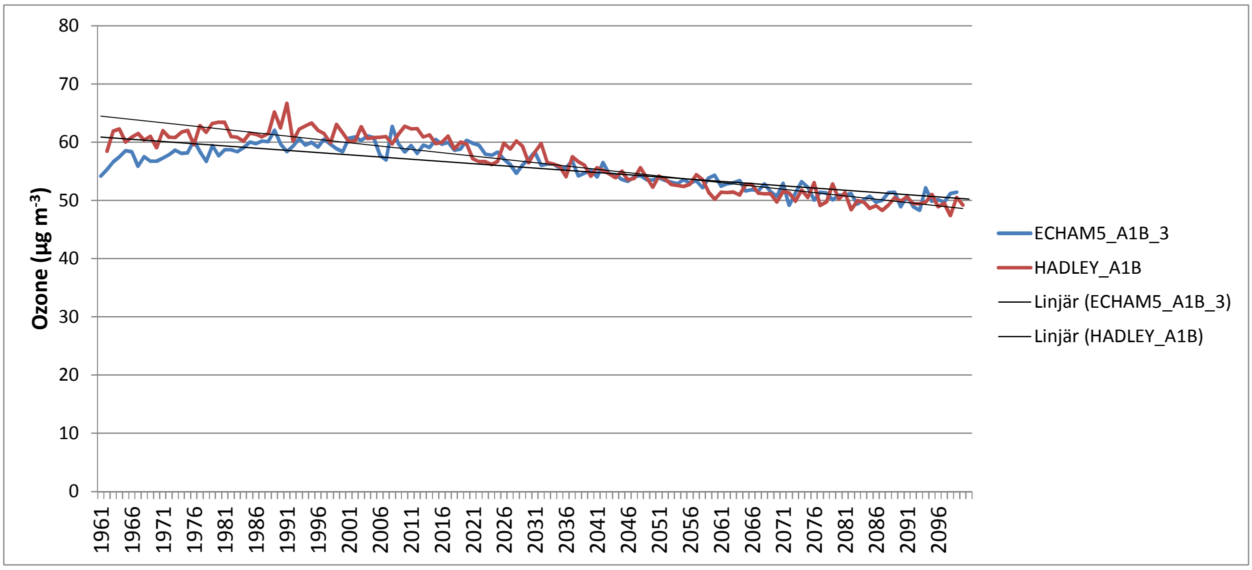


Figure 13: Background concentrations of tropospheric ozone for the Prague area in the period 1960-2100 according to ECHAM GCM model.

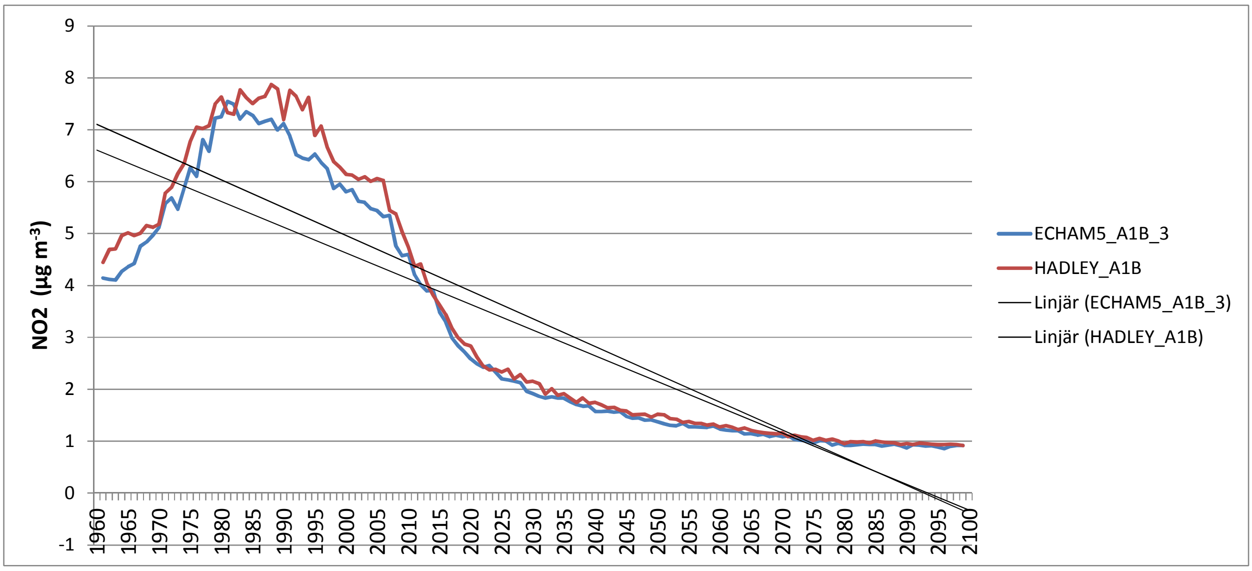


Figure 14: Background concentrations of NO_2 for the Prague area in the period 1960-2100 according to ECHAM GCM model

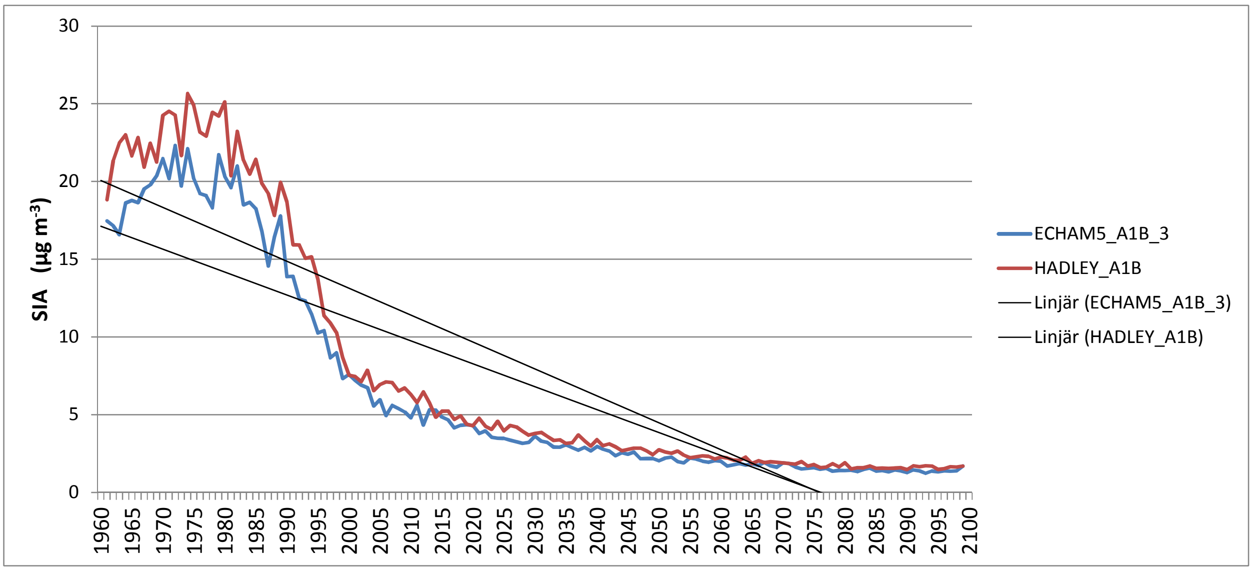


Figure 15 Background concentrations of secondary inorganic aerosols (SIA, large part of PM_{10}) for the Prague area in the period 1960-2100 according to ECHAM GCM model

The emission data for 2007 (see Section 2.1.1) has been extrapolated to 2030 using the GAINS model scenario EC4MACS Baseline, as reported in the EC4MACS Interim Assessment 2010 report (available at http://gains.iiasa.ac.at/reports/EC4MACS_IR_11.pdf). The assumptions behind and input data for this projection are summarized as follows:

Activity projections:

- PRIMES energy projections (as of December 2009);
- Energy policies in the EU-27 are as of spring 2009. Scenario does not include targets on renewable energy sources and on greenhouse gases from the non-ETS sector;
- Projections are based on trends from the IEA World Energy Outlook 2009;
- Agricultural activities include, for the year 2005, national livestock data (as reported to EUROSTAT) and national mineral nitrogen fertilizer use and production (as reported to EFMA/IFA and FAO). Projections are based on trends estimated by the CAPRI model (December 2009).

Legislation related to emissions of greenhouse gases:

- National legislation in all countries.
- For EU-27 Member States - implementation of the Landfill Directive, Waste Directive, CAP reform, F-gas Directive, Motor Vehicles Directive and the ETS system for controlling CO_2 emissions. The latter assume adoption of mitigation options in ETS sectors at marginal costs less than the carbon price levels of 13.6 Euro/t CO_2 in 2010, 18.7 Euro/t CO_2 in 2015, 23.4 Euro/t CO_2 in 2020, 30 Euro/ton CO_2 in 2025, and 36.6 Euro/ton CO_2 in 2030 (in Euro 2005 prices).

Legislation on air pollution:

- Current policies: EU and national legislation (if stricter) plus revised Industrial Emissions Directive for combustion sources plus Euro VI on heavy-duty vehicles.

Remarks:

1. Slight differences between emissions in the report and those displayed on-line are due to updates implemented (after 22 February 2010) in result of the on-line review of input data to GAINS within the revision of the Gothenburg Protocol to the CLRTAP.

2. The scenario does not fully include changes in the structure of energy activities resulting from comparison of national pathways with the PRIMES ones. Also corrections of fuel consumption in the non-road mobile sources sector are not fully implemented. However, this causes only minor differences in emission estimates.

The results of the GAINS model simulation for the Czech Republic have confirmed the decreasing trend of emissions of PM_{10}, SO_2, NO_x and VOC within the period 2010 - 2030. According to this model simulation, the main decrease of particulate matter emissions will be observed in the categories of household heating and road transport. NO_x emission will significantly decrease from road transport while SO_2 emissions from energy sector (see fig. 16-18).

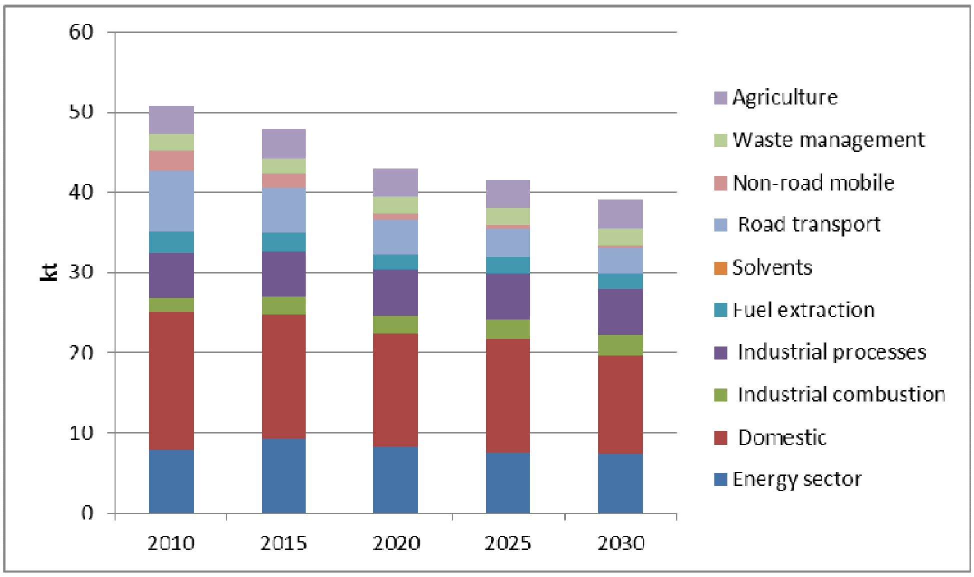


Figure 16: PM_{10} emissions from SNAP categories of sources based on GAINS model simulation, 2000-2030

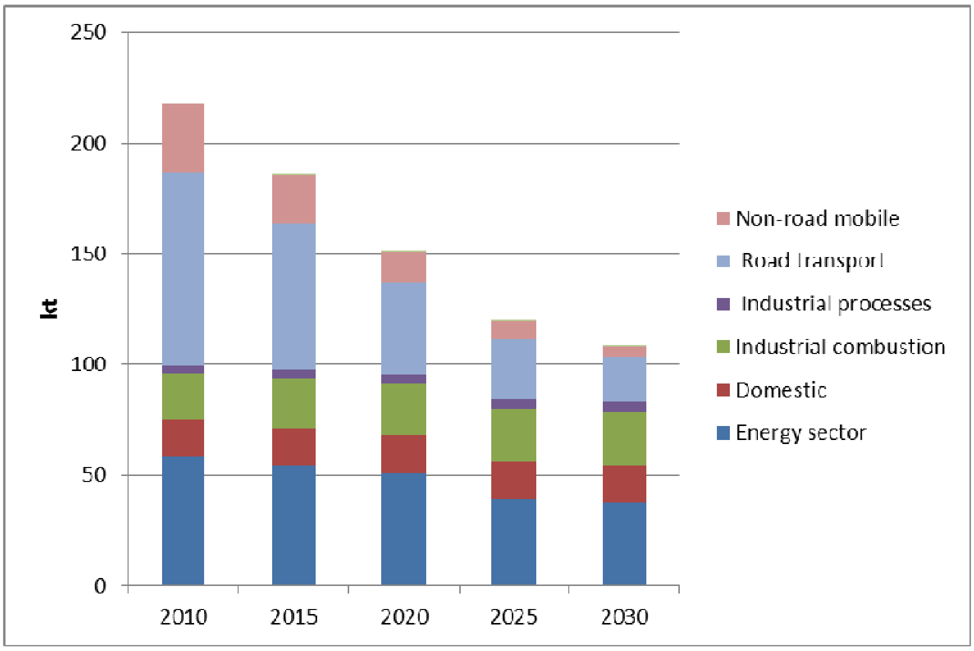


Figure 17: NO_x emissions from SNAP categories of sources based on GAINS model simulation, 2000-2030

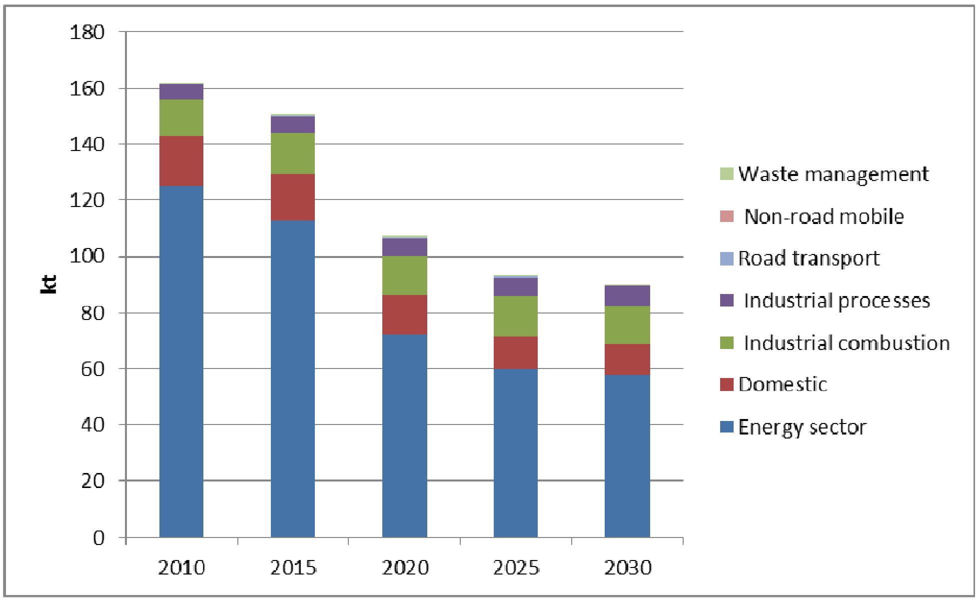


Figure 18: SO_2 emissions from SNAP categories of sources based on GAINS model simulation, 2000-2030

The emission scenario coming out from the GAINS model has been also recalculated to the categories of sources R1-4 by attributing different SNAP codes of sectors to those four categories. Tables 3-7 summarize the calculation for five pollutants. The results of simulation are shown in figures 19-23.

Table 3: PM_{10} emissions trends according to GAINS scenario, including the breakdown of SNAP sectors into categories of sources R1-4 (kt/year)

SNAP1 Code	2010	2015	2020	2025	2030	Break-down
01: Energy sector	7.85	9.30	8.36	7.60	7.39	70 % R1, 30 % R2
02: Domestic	17.21	15.47	13.96	14.19	12.29	100 % R3
03: Industrial combustion	1.80	2.23	2.31	2.44	2.51	70 % R1, 30 % R2
04: Industrial processes	5.66	5.67	5.71	5.78	5.80	70 % R1, 30 % R2
05: Fuel extraction	2.57	2.40	2.01	1.91	1.89	100 % R2
06: Solvents	-	-	-	-	-	-
07: Road transport	7.66	5.59	4.17	3.49	3.20	100 % R4
08: Non-road mobile	2.48	1.62	0.94	0.52	0.33	100 % R4
09: Waste management	2.03	2.05	2.05	2.05	2.04	90 % R1, 10 % R2
10: Agriculture	3.53	3.56	3.56	3.58	3.60	20 % R1, 15 % R2, 65 % R3
Sum	**52.80**	**47.88**	**43.09**	**41.56**	**39.05**	

Table 4: SO_2 emissions trends according to GAINS scenario, including the breakdown of SNAP sectors into categories of sources R1-4 (kt/year)

SNAP1 Code	2010	2015	2020	2025	2030	Break-down
01: Energy sector	125.02	112.76	71.96	59.65	57.94	95 % R1, 5 % R2
02: Domestic	17.85	16.45	13.96	11.81	10.56	100 % R3
03: Industrial combustion	12.85	14.60	14.15	14.34	14.18	95 % R1, 5 % R2
04: Industrial processes	5.55	6.15	6.45	6.76	6.91	95 % R1, 5 % R2
05: Fuel extraction	-	-	-	-	-	-
06: Solvents	-	-	-	-	-	-
07: Road transport	0.12	0.13	0.13	0.13	0.13	100 % R4
08: Non-road mobile	0.06	0.08	0.09	0.10	0.10	100 % R4
09: Waste management	0.06	0.06	0.06	0.06	0.06	100 % R1
10: Agriculture	-	-	-	-	-	-
Sum	**161.51**	**150.22**	**106.79**	**92.85**	**89.98**	

Table 5: NO_x emissions trends according to GAINS scenario, including the breakdown of SNAP sectors into categories of sources R1-4 (kt/year)

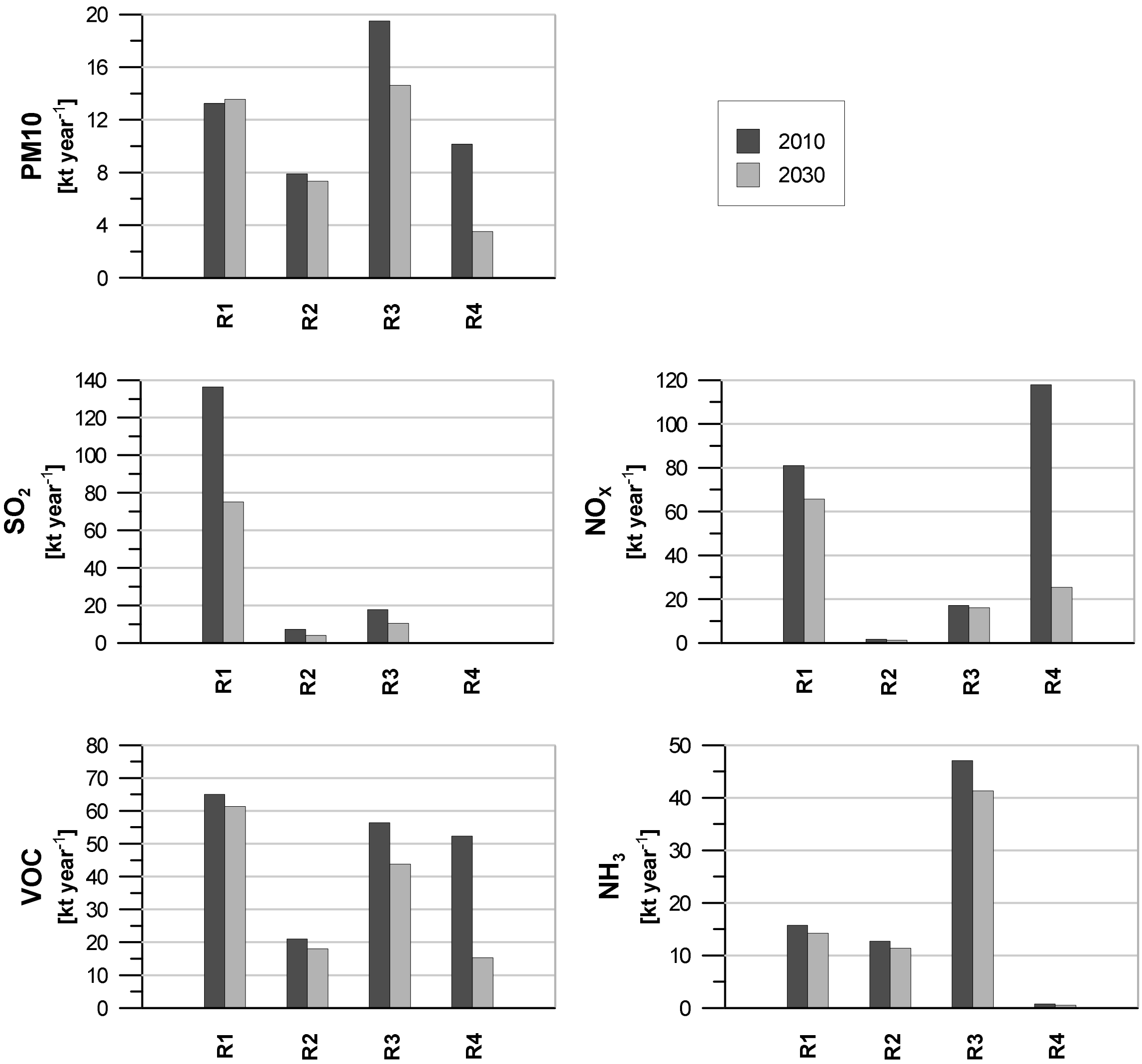
SNAP1 Code	2010	2015	2020	2025	2030	Break-down
01: Energy sector	58.27	54.15	50.74	39.16	38.02	98 % R1, 2 % R2
02: Domestic	17.13	17.23	17.31	16.94	16.05	100 % R3
03: Industrial combustion	20.61	22.61	22.97	23.71	24.27	98 % R1, 2 % R2
04: Industrial processes	3.56	4.07	4.44	4.56	4.59	98 % R1, 2 % R2
05: Fuel extraction	-	-	-	-	-	-
06: Solvents	-	-	-	-	-	-
07: Road transport	87.11	65.79	41.54	27.43	20.51	100 % R4
08: Non-road mobile	30.77	21.98	13.67	7.87	4.85	100 % R4
09: Waste management	0.13	0.13	0.13	0.13	0.13	100 % R1
10: Agriculture	-	-	-	-	-	-
Sum	**217.57**	**185.97**	**150.79**	**119.79**	**108.42**	

Table 6: VOC emissions trends according to GAINS scenario, including the breakdown of SNAP sectors into categories of sources R1-4 (kt/year)

SNAP1 Code	2010	2015	2020	2025	2030	Break-down
01: Energy sector	5.61	5.20	4.92	4.51	4.42	75 % R1, 25 % R2
02: Domestic	30.80	27.96	24.90	24.04	20.23	100 % R3
03: Industrial combustion	1.24	1.40	1.41	1.59	1.64	75 % R1, 25 % R2
04: Industrial processes	16.26	16.73	16.96	17.08	17.06	85 % R1, 15 % R2
05: Fuel extraction	4.25	2.55	2.54	2.49	2.39	100 % R2
06: Solvents	82.68	76.31	71.86	73.96	75.79	55 % R1, 15 % R2, 30 % R3
07: Road transport	41.86	24.91	16.03	11.34	8.85	100 % R4
08: Non-road mobile	10.49	8.94	7.86	6.87	6.43	100 % R4
09: Waste management	0.32	0.32	0.32	0.32	0.32	100 % R1
10: Agriculture	1.25	1.25	1.25	1.25	1.25	20 % R1, 15 % R2, 65 % R3
Sum	**194.76**	**165.58**	**148.05**	**143.45**	**138.38**	

Table 7: NH_3 emissions trends according to GAINS scenario, including the breakdown of SNAP sectors into categories of sources R1-4 (kt/year)

SNAP1 Code	2010	2015	2020	2025	2030	Break-down
01: Energy sector	0.47	0.44	0.49	0.66	0.65	95 % R1, 5 % R2
02: Domestic	0.59	0.59	0.59	0.59	0.53	100 % R3
03: Industrial combustion	0.09	0.11	0.11	0.12	0.12	95 % R1, 5 % R2
04: Industrial processes	0.92	0.92	0.92	0.92	0.92	100 % R1
05: Fuel extraction	-	-	-	-	-	-
06: Solvents	-	-	-	-	-	-
07: Road transport	0.75	0.61	0.53	0.49	0.46	100 % R4
08: Non-road mobile	0.02	0.03	0.03	0.04	0.04	100 % R4
09: Waste management	1.95	1.95	1.95	1.95	1.95	100 % R2
10: Agriculture	71.49	67.87	63.71	63.08	62.78	20 % R1, 15 % R2, 65 % R3
Sum	**76.28**	**72.51**	**68.32**	**67.84**	**67.44**	



Figures 19-23: National emissions of PM10, SO2, NOx, VOC and NH3 in 2010 and 2030 for source categories R1-4 using GAINS model simulation, kt/year.

Air quality downscaling has been executed for present and future scenarios, using a calculation grid with 2x2 km horizontal resolution and the ECHAM5 A1B_3 climate scenario as forcing and with RCP4.5 emissions (see “Emission scenario” in Section 8 Glossary and “RCP4.5” in Section 9 Acronyms and Abbreviations) used for long range European impact over the Prague modelling domain.

Local emission data in 2010 for the downscaling domain are represented by the PR2007 emission database (see Section 2.1.1) with the assumption that emission changes from 2007 to 2010 are small as compared to the changes estimated up to 2030.

Table 8 summarizes the attributes of three scenarios analysed.

Table 8 Overview of the air quality downscaling scenarios. Model simulation domain: (4590000, 2950000, 4690000, 3050000), i.e. 100x100 km^2 or 50x50 cells of size 2x2 km^2-

Scenario	Prague Emissions	Meteorology & boundary conditions
Present	PR2007	ECHAM5 A1B_3 with RCP4.5 emissions, simulated for 2009
Future with Prague emissions held fixed at present conditions	PR2007	ECHAM5 A1B_3 with RCP4.5 emissions, simulated for 2030
Future	PR2030 (Fig. 19-23 changes applied to PR2007)	ECHAM5 A1B_3 with RCP4.5 emissions, simulated for 2030

Figure 24 shows the annual concentration averages for PM_{10} during present (2010) and future (2030) conditions. As can be seen a significant reduction in PM_{10} concentration levels is expected, both due to lower background pollution levels as well as to emission reductions in sector R3 and R4.

The simulated concentrations of NO_2, O_3 and PM_{10} have been evaluated in 22 rural and urban background monitoring stations which we used also for validation purposes (see table 2).

The average values (plus max and min) at the 22 monitoring stations are shown in Fig. 25. Future NO_2 levels will be lower, partly by lower background levels, but mostly because of local emission reductions. Long range ozone levels will be slightly lower, but in over the city the reduced NO_2 emissions in the future will actually tend to raise the ozone levels (the city is a sink for long range ozone due to the titration effect, i.e. ozone is consumed for oxidation of NO). The PM_{10} levels will also be reduced, both due to lower levels in incoming air and to reduced PM emissions in the city.

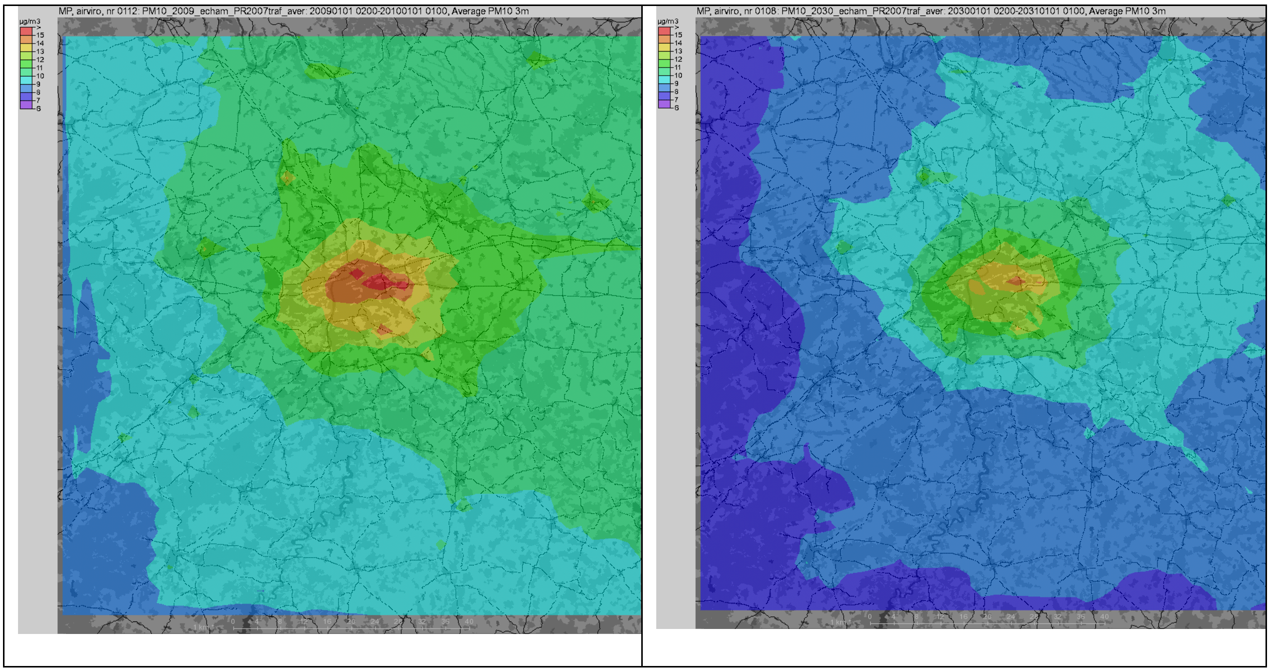


Figure 24: Annual mean of PM10 as simulated by SUDPLAN Common Services downscaling, representing present conditions around 2010 (left) and future conditions around 2030 (right)

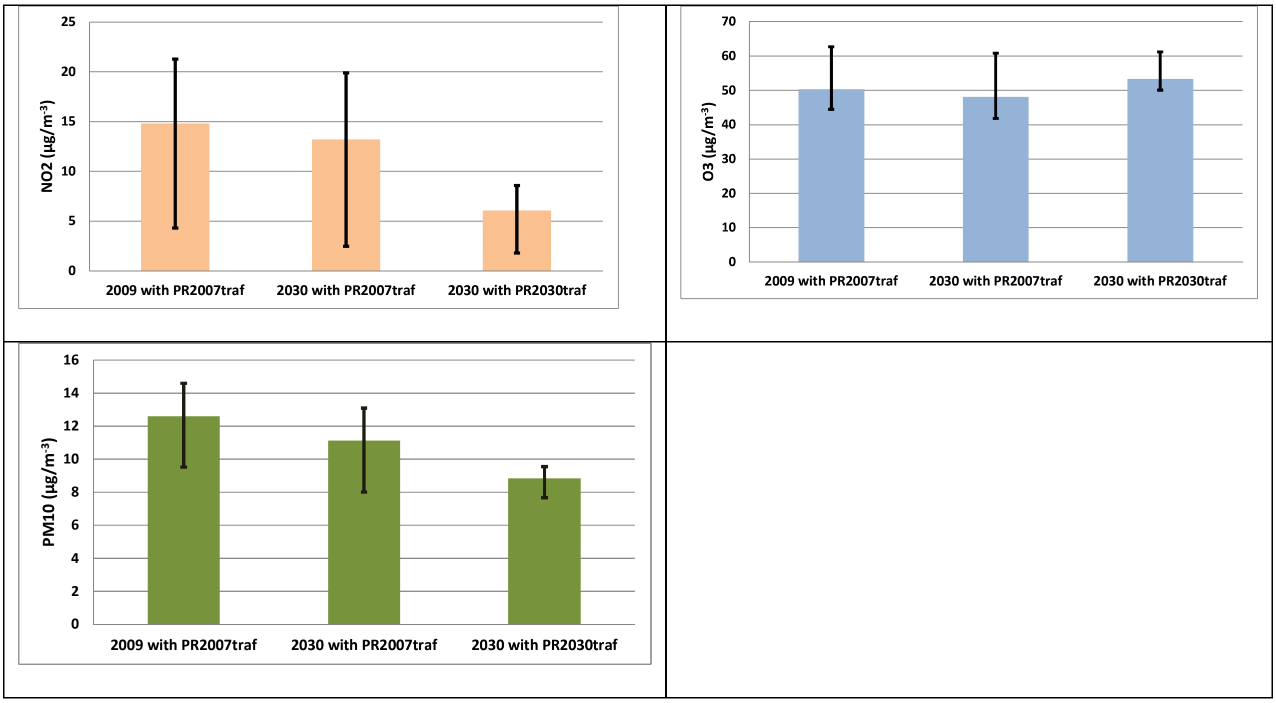


Figure 25: Simulated annual averages (average/max/min over the 22 monitoring locations) for NO_2 (top left), ozone (top right) and PM_{10} (bottom left) for three cases (see table 8) in 2009 and 2030

3.3. Development of the DPSIR indicator set

The DPSIR indicator system will be employed in the pilot to describe relationships between pressures, state and impacts of deteriorated air quality in the Prague area. Following indicators will be used on the level of Prague zone and the Middle Bohemian region:

Driving forces

- GDP per capita (PPP, constant prices 2005; if available, then 2010)
- Share of industry in GDP
- Share of agriculture in GDP
- Number of cars (per 1000 inhabitants)

Pressures

- Emissions of particulate matter (total per year, per capita, per unit of GDP)
- Emissions of sulphur dioxide (total per year, per capita, per unit of GDP)
- Emissions of nitrogen oxides (total per year, per capita, per unit of GDP)
- Emissions of volatile organic compounds (total per year, per capita, per unit of GDP)
- Emissions of ammonia (total per year, per capita, per unit of GDP)

State

- The area of zones with deteriorated air quality with regard to the applicable limit values (in % of total country area; five-year moving average)
- The area of zones with exceeded target values (in % of total country area; five-year moving average)

Impact

- Percentage of population living in areas with poor air quality (five-year moving average)
- Area of ecosystems with exceeded critical loads for eutrophication (five-year moving average)
- The area of forests with exceeded critical loads for acidification (five-year moving average)

Note: Persistent organic pollutants and heavy metals are described in a separate indicator, because they get into the air as part of particulate pollutants.

These indicators will be quantified and assessed within the third year of Sudplan project implementation (Pilot report V3).

3.4. Gathering migration data

The migration data task 1.4 was initiated in V1 and the work progressed a lot during V2. Data for total migration to and from the area of interest (Central Bohemia region) was completely collected, as well as data of migration inside the area (between component districts in Central Bohemia regions and Prague).

Migration inside the region by type is more complicated. The Czech Statistical Office (CSO) collects data for migration by type. These data are recorded as “reasons of immigration” or “reasons of emigration” to/from component districts. The problem is that the survey finished in 2004 and we don’t have any accessible data for the further period. In addition, the migration types needed for SUDPLAN analysis are not entirely monitored by the CSO. CSO monitoring covers only following reasons: change in workplace, moving closer to workplace, study, health, marriage, divorce, housing, following a family member, and other. The “health” includes more reasons than only poor air quality; the “bed migration” is not recorded at all. So, as this situation was supposed and then confirmed, CENIA planned to create and perform the questionnaire survey and then analyze the data collected. In V2, the questionnaire was created and statistical representative sample was defined. The real survey will take place in early V3.

Assessing trend in migration and the impact of “bed migration” on daily transport intensities will be realized in V3.

3.5. Assessment of pilot hypothesis on population migration

The goals of this task 1.5 are:

- To build a suitable model based on the results of factor analysis.
- To estimate related parameters and test the predicate ability of the model.
- To interpret results and to develop conclusion on the main Pilot hypothesis.

The task 1.5 was initiated in V2. Due to dependency on tasks 1.3 and 1.4 the task could not proceed so fluently. The three mentioned partial goals are dependent also mutually. The second can be accomplished only after the first one was finished and the third depend on the results from the second. Due to the fact that tasks 1.3 and 1.4 have not been finished yet, only model building phase was started. The analysis of existing models was done and the relevant factor analysis as well. The representative econometric model (mathematical formulation) will be finished in the beginning of V3.

As stated above, the partial goals are strongly related. The first one will be accomplished in the very beginning of V3 and the realization of the other two will follow.

3.6. Assessment of future migration scenarios

The goals of this task 1.6 are:

- To analyze existing activity, emission and socioeconomic projections.

- To create emission scenarios of expected development.
- To create air quality scenarios based on CS downscaling projections for a climate scenario.
- To use the established relation between air quality and migration to map future population settlement and commuting scenarios, in response to the air quality evolution.

In the case that relation between air quality and migration is not found, the following steps are suggested:

- Extrapolation of existing trend in migration,
- Assessment of extrapolated migration on the projection of transport intensity (additional transport intensity),
- Inclusion of additional transport intensity into scenarios as additional input.

As this task is fully dependent on task 1.5, it couldn't be initiated in V2. The task 1.6 will be initiated and completed in V3.

3.7. Analysis of the air quality and migration scenarios

The goals of this task 1.7 are:

- To assess the air quality projections for future migration scenarios (defined in Task 1.6)
- To prepare, execute and analyze SUDPLAN migration scenario analysis with respect to air quality.

Note: In the case that relation between air quality and migration was not found, pre-final result will be the final result of the Pilot Project.

As this task is dependent on task 1.5, it couldn't be initiated in V2. The task 1.7 will be initiated and completed in V3.

4. Work on hydrological tasks during 2011

The list of tasks implemented within the hydrological part of WP8 during the second reporting period is outlined in the table 9.

Table 9: tasks of WP8 in the field of farming abandonment

Task	*Title*	*Comment*
2.1	Assessment of the influence of future hydrological conditions	Initiated in V2, to be completed in V3
2.1.1	Validation of auto calibration with historical discharge data	Completed in V2
2.1.2	Model validation for a historical period	Completed in V2
2.1.3	Hydrological simulations based on climate	Will be initiated and completed in V3

	scenarios	
2.1.4	Create cost-revenue model for farming profitability	Will be initiated and completed in V3
2.2	Assessment of Pilot hypothesis of farm abandonment	Will be initiated and completed in V3

The following persons have been actively engaged in the hydrology work of the Czech pilot during 2011:

CENIA: Jitka Brázková (hydrology)
Ondřej Ledvinka (hydrology)
Radka Bezděkovská (demography, socio-economic analysis)
Tereza Suchánková (demography, socio-economic analysis)

SMHI: Jafet Andersson (supporting model simulations)
Frédéric Cortat (supporting auto-calibrations)

A two day workshop was held in Prague December 1-2, 2011. SMHI participated with two hydrological model experts.

4.1. Assessment of the influence of future hydrological conditions

4.1.1 Validation of auto calibration with historical discharge data

The implemented auto calibration provides a set of methods for automatic calibration of the Common Services hydrological model Hype with historical discharge data for a local area. All implemented methods are adaptations of well-established algorithms within numerical optimization. A full description of the implemented method is given in D4.3.2 Hydrological Downscaling Service V2. In this section we describe the results of our evaluation of the methods featured in the implementation.

The following optimization methods for automatic calibration methods have been evaluated:

1. **Progressive Monte Carlo method**. A simple way to gather knowledge of an objective function is to sample realizations of this function under variation of its argument values. The Monte Carlo method relies on random sampling; parameter sets are generated without any form of organization, and all parameter values are varied simultaneously. This method offers the advantage of being applicable to parameter spaces of any dimension. The Monte Carlo method used in the auto calibration incorporates a refinement, consisting of a progressive, stage-wise reduction of the parameter space around promising parameter sets. The concept is based on the radius of the original parameter space that is defined as half the distance between the original parameter space boundaries.

2. **Quasi-Newton**: Quasi-Newton methods are a class of optimization methods based on the first order Newton expansion of the gradient of the objective function. After determining the gradient the method then performs a line search in the calculated direction. A wide range of methods satisfying these conditions have been developed in the framework of optimization.

Three of those have been implemented in our auto calibration routine: BFGS, DFP and Steepest descent. Here we present the result of the currently most promising of these:

a. **BFGS** (Broyden-Fletcher-Goldfarb-Shanno formula)
b. **DFP** (Davidson-Fletcher-Powell formula)

3. **Brent method**: In the Brent method, determination of the step direction is trivial since the method permutes through all dimensions of the parameter space, reducing the problem to that of successive line searches. Given a starting parameter set, $\vec{p}_0$, the algorithm first proceeds to a line search along the dimension of the first component, from boundary to boundary, but keeping the value of all other parameter set components constant in the process. The line search is performed so as to find a first component value that improves the objective function in the sense of optimization. Once a better value has been found, the parameter sets first component is updated. The algorithm then proceeds similarly to improve the other parameters in the set component. Thus, the method performs a series of successive updates of all parameter set components, one after the other, in a fixed order.

In the performed evaluations the goal was to investigate the optimal performance of each of the methods. Therefore we have run the algorithms using high number of steps trying to find the optimal parameter setup for the local model. Table 10 shows the stopping conditions used for each algorithm. For the Monte Carlo method, we only used a stopping criteria based on number of iterations, while for the other methods we also looked at other criteria, such as change in parameter values and improvement in result criteria.

Table 10: Stop conditions used in evaluating the different algorithms

Interruptor	Monte Carlo	Brent	Quasi-Newton
Max amount of iterations	Featured	Featured	Featured
Max amount of time	-	Featured	Featured
Criteria changed less than specified tolerance over specified amount of iterations	-	Featured	Featured
ALL parameter values changed less than specified tolerance over specified amount of iterations	-	Featured	Featured
Gradient norm smaller than specified tolerance	-	-	Featured
Perpendicularity of gradient and step	-	-	Featured

The evaluations were performed based on the E-HYPE parameterization. The driving data based on pan-European information were replaced with local data for the Prague area. The results were evaluated against real data from 2 gauging stations. This evaluation shows that the Monte Carlo methods gives the best performance for the auto calibration (mean R^2 0.45), however, the drawback of this method is that it requires most time for the computation. Another interesting method is BFGS which also shows an almost as good result (mean R^2 0.29) using less than half the computation time and number of model runs compared to Monte Carlo.

Table 11: Result of the evaluations

	Calibration Method	Mean R^2	Model runs	Time
	E-HYPE default (none)	-0.29	1	10s
1	Monte Carlo	**0.45**	30 000	3 days 19h
2a	BFGS	**0.29**	13 534	1 day 11h
2b	DFP	-0.06	3 183	8h
3	Brent	0.26	23 958	2 days 16h

Finally, we wanted to investigate whether it was possible to reduce the computation time by changing the stop conditions forcing the calibration methods to perform a lower number of iterations. Figure 26 shows a plot over the improvement expressed as mean R^2 for each iteration of three of the methods. This graph shows that all the methods give a high improvement for the first iterations, while subsequent runs give less of an improvement. This is promising as it suggests that it should be possible to get a much faster auto calibration by performing a lower number of iterations and using the mean R^2 as the stopping criteria. However, as shown by the DFP method, the increase in performance can at some points be stabilized at one level, and then suddenly increase after several iterations which means that that R^2 alone as a stopping criteria may not be sufficient. We will further investigate these issues to improve the computing time of the auto calibration method.

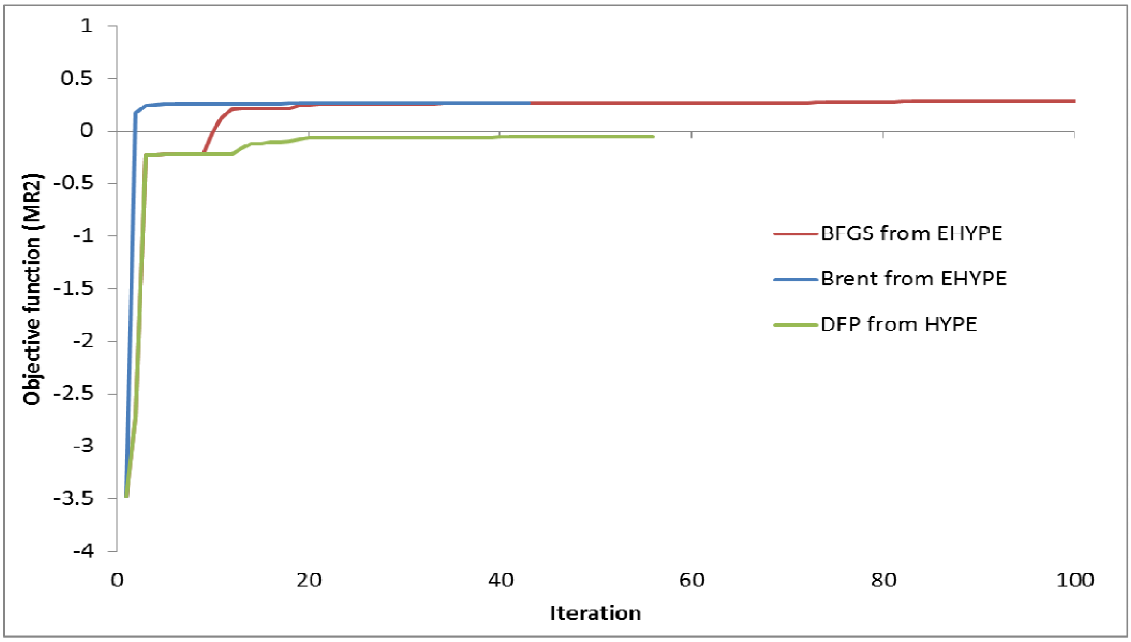


Figure 26: Improvement of result per iteration

4.1.2 Model validation for a historical period

In this section we discuss the results from validating the auto calibration module for selected areas. For this validation we used the following setup:

Calibration: Calibration was carried out for the period 1990-1999 against four discharge stations provided by the Czech Hydrometeorological Institute (CHMI) as well as three stations from GRDC and EWA (red in Figure 27).

Validation: Two independent CHMI stations were used for validation (green in Figure 27). In addition the period 2000-2009 was used for validation at all stations.

Objective function: The objective function (O) was MR2 – 0.1*abs(MRE), where MR2 is the mean Nash-Sutcliffe Efficiency criteria for all stations, and MRE is the mean relative error for all stations.

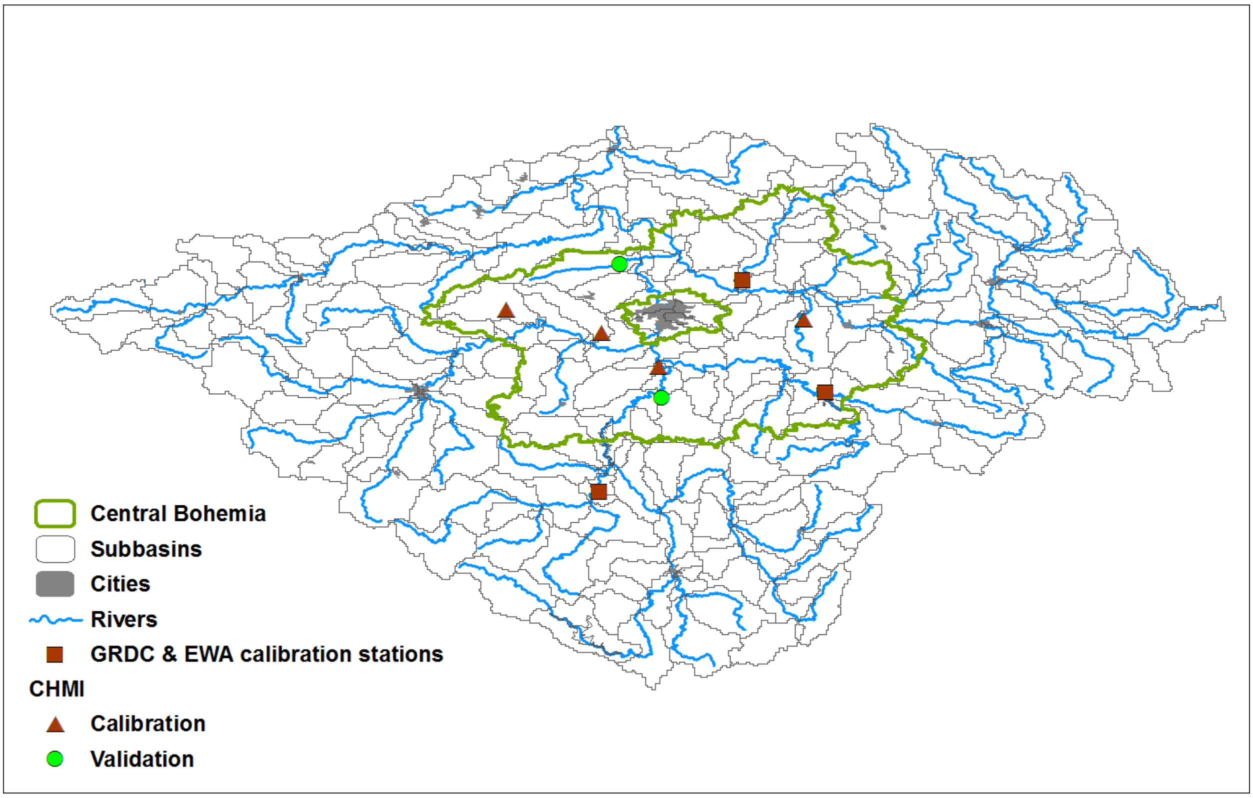
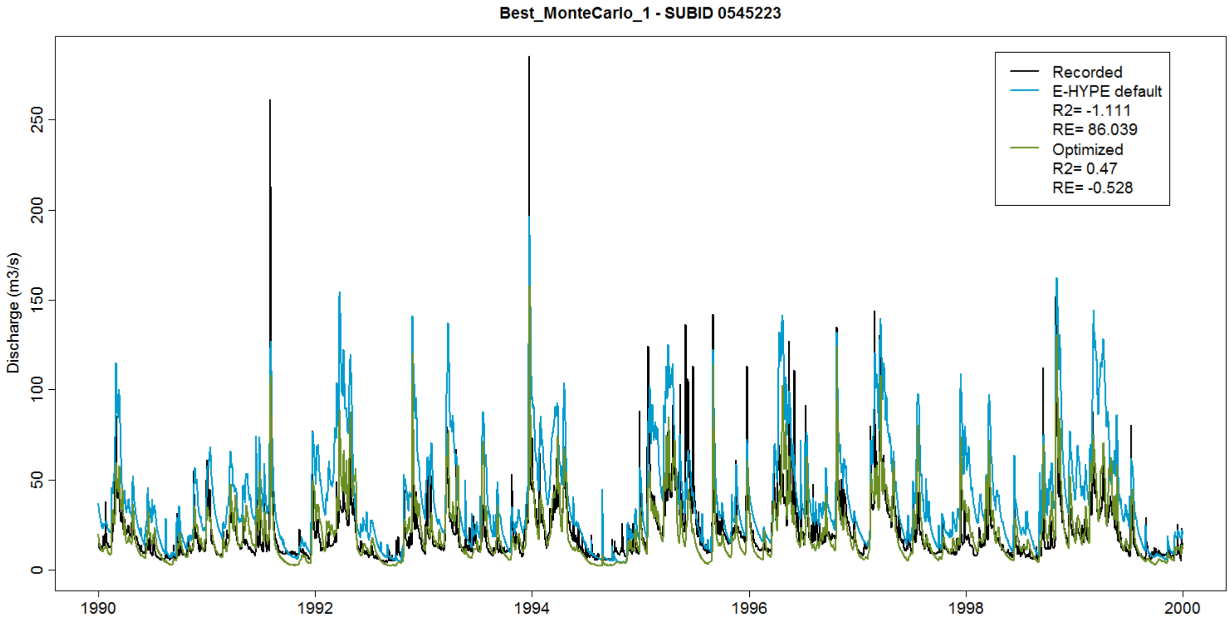


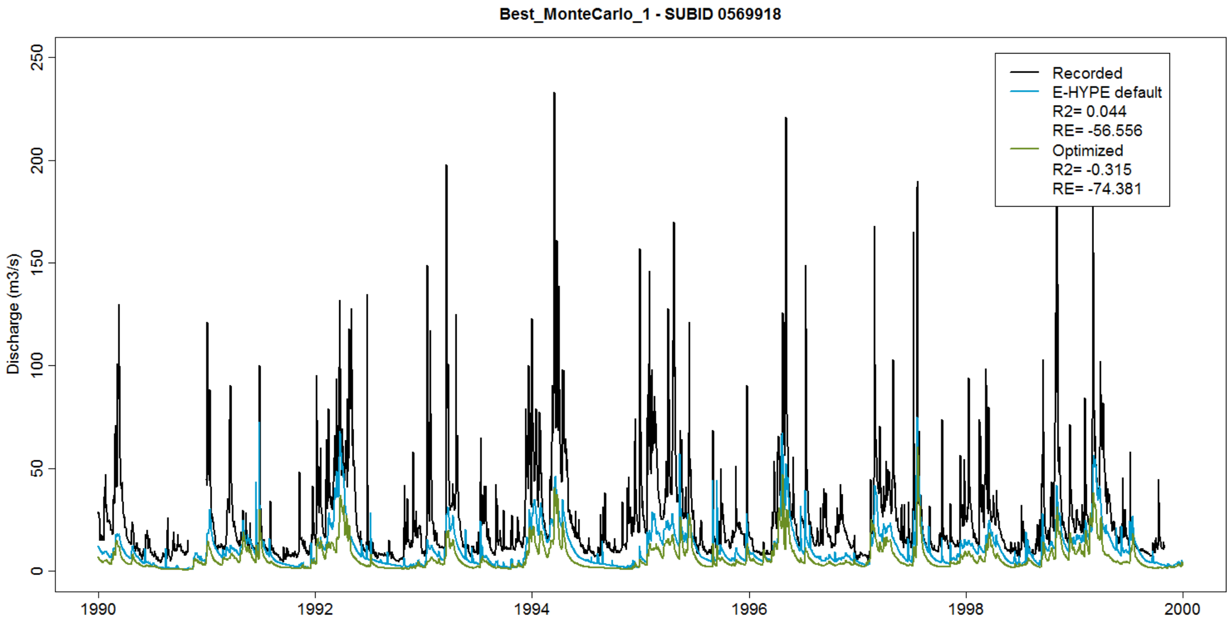
Figure 27: The Central Bohemia pilot area and the E-HYPE model setup for the auto calibration

Table 12: Calibration results (Monte Carlo)

	Calibration Method	Starting conditions	O	Mean R^2	Mean RE	Model runs
	E-HYPE default (none)		-0.183	-0.28	-0.13	1
1	Monte Carlo	E-HYPE	**0.068**	0.1	-0.30	180 000

For this validation, the Monte Carlo method showed the most promising results why we studied the results for subareas of Central Bohemia. In some areas the auto calibration improved model performance (e.g. for sub basin 545223, Figure 28 (a) & 29 (a)). In other areas the performance got worse relative to the E-HYPE default parameterization (e.g. for sub basin 569918, Figure 28 (b) & 29 (b)). Overall, however, the auto calibration improved the model performance (Table 12).





Figures 28: Hydrograph at subbasin 545223 (upper chart), and 569918

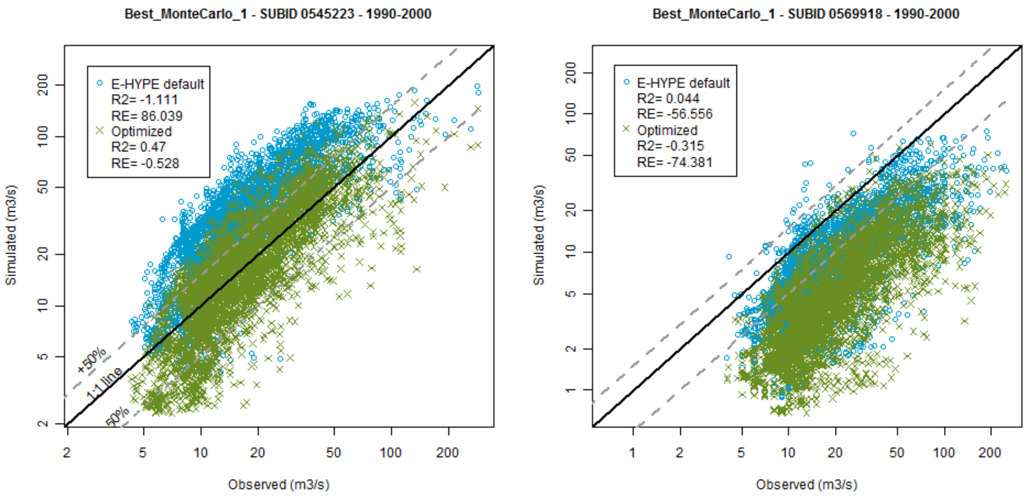
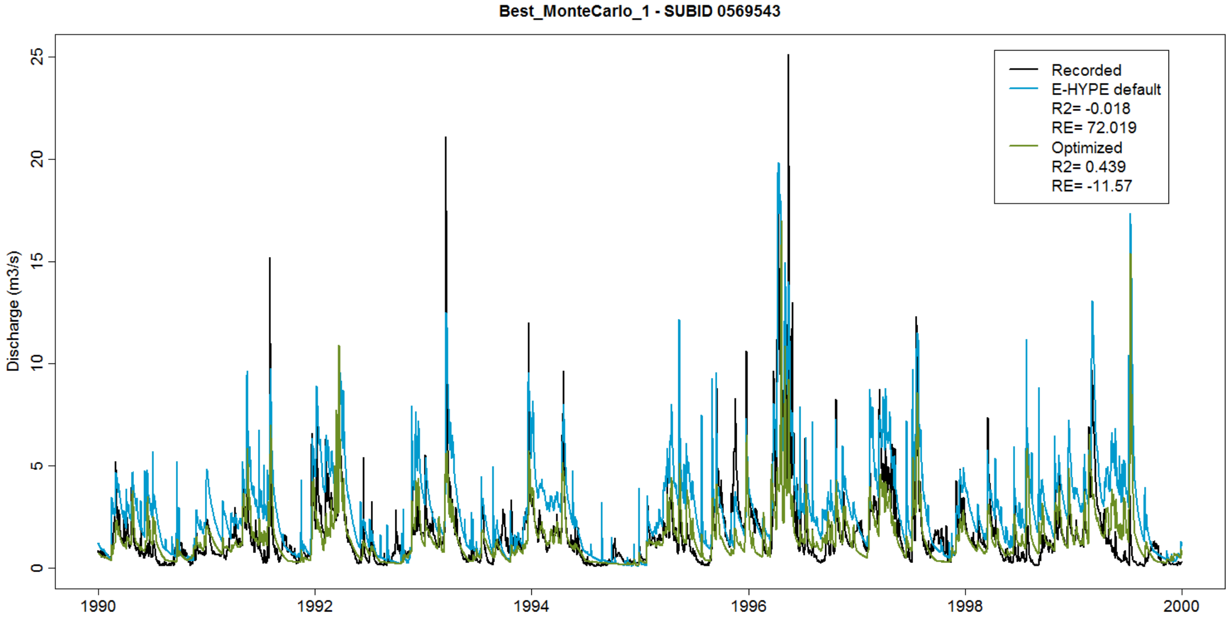


Figure 29: Simulated versus observed discharge at subbasin (a) 545223 (chart on the left), and (b) 569918

The performance also varied considerably at independent validation stations. At sub basin 569543, the Monte Carlo parameterization clearly improved performance relative to the E-HYPE default (Figure 30). The station is located in the upper reaches of the modelled area and its upstream area is dominated by agricultural land. This suggests that the auto calibration routine does improve the representation of water fluxes in agricultural lands, although not unanimously.



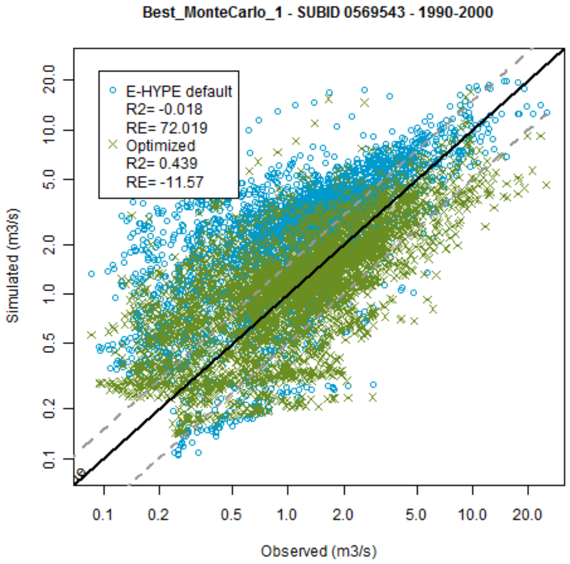


Figure 30: Simulated and observed flows at subbasin 569543 hydrograph (upper chart), (b) Simulation vs. Observation plot (bottom chart)

The different parameterizations yield considerable differences in the simulation of soil moisture content (Figure 31). The E-HYPE parameterization is more homogeneous in space, and generally has higher soil moisture levels than the Monte Carlo parameterization. The best parameterization is to be used in subsequent steps of this project.

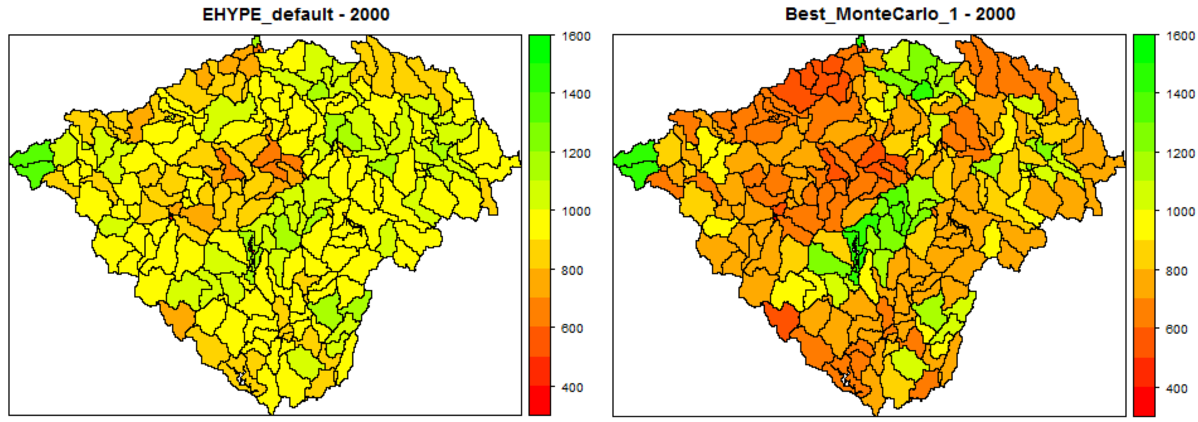


Figure 31: Soil moisture content in each subbasin. The value represents the annual average for the year 2000, averaged over all classes in each subbasin.

4.1.3 Hydrological simulations based on climate scenarios

This task 2.1.3 has not yet been performed as Pan-European hydrological model results have not been available.

4.1.4 Create cost-revenue model for farming profitability

Creating cost-revenue model for farming abandonment is dependent on the output of task 2.1.3 and hydrological data per district from Czech Hydro-meteorological Institute (CHMI) and fertilizer/pesticide data from Czech Statistical Office (CSO). The last type of data is not available in needed structure (fertilizer/pesticide per crop in the region e.g. in tones). Neither the hydrological predictions (scenarios) weren't available in V2.

Fortunately, the agricultural, hydrological and economic data per region (not district which is needed) are published by CSO so the work could be initiated. This data availability enables the process of formulating, estimating and testing crop yield production functions in the regional scope (once all district data will be accessible the regional model could be applied to the district scale). The wheat production function (in CES form) was formulated, estimated and tested on the regional level. The production functions for the other crops are similar in methodic way.

The other possibilities of formulating crop yield production functions will be tested in V3 as the data for soil moisture are not available at the end of V2 and this factor is not present in actual production function. This one is formulated by the relation between crop yield and temperature and precipitation factors (but it can be assumed that the temperature and precipitation factor is strongly correlated with soil moisture).

Formulating Farm profit function and then Farm Internal Rate of Return is dependent on the crop yield production functions results. This phase will be initiated and completed in V3.

4.2. Assessment of Pilot hypothesis of farm abandonment

As this task 2.2 is dependent on the tasks 2.1.3-4, it couldn't be initiated in V2. The task 2.2 will be initiated and completed in V3.

5. Implemented Use Cases

The Czech pilot will demonstrate the use of Common Services with one application dealing with air quality and another with hydrological conditions. In total six use cases will be demonstrated (see Table 13).

Table 13: Overview of use cases for the Czech Pilot Definition Plan V2

Use-case (planned for version)	Part of Common Services	Objective	Status
UC-811 (V1) "Visualise air quality model results"	Climate scenario information on the European scale & Air Quality Downscaling service	Visualise distribution and trends of air quality model results (European scale or downscaled over Prague)	Completed for European scale
UC-813 (V2) "Add monitor data to compare with model results"	Air Quality Downscaling service	Allowing model results and monitor data to be presented in the same graph, used to validate model output for historical periods	Partly completed using Airviro user interface
UC-821 (V1 and V2) "Execute air quality downscaling"	Air Quality Downscaling service	Start an air quality downscaling simulation over pilot city area. (Extension to allow upload of gridded urban emissions in V2)	Partly completed using Airviro interface
UC-831 (V2) "Visualise hydrological information on the panEuropean scale"	Climate scenario information on the European scale & Hydrological downscaling service	For each polygon and for each statistical variable show: • Each climate scenario • Mean value over all scenarios • Standard deviation over all scenarios • Max and min values	Will be evaluated in V3.
UC-832 (V3) "Autocalibration of the CS hydrological model"	Hydrological downscaling model with auto calibration routine	Select polygon of interest Select Q-station for calibration Run model in calibration mode	Partly completed offline
UC-833 (V3) "Execute CS hydrological model"	Hydrological downscaling model	Select Q-station (same as calibrated for) Run model with climate scenario input	Partly completed offline

Experimentation can, through the use of SMHI-Apertum software, be performed for most aspects of the use cases and has also been documented in Section 2 (work on air quality tasks) and Section 3 (work on hydrological tasks). However, the full demonstration of use cases requires the integration of the complete SUDPLAN product chain. In this section the status of the use cases will be commented one by one.

5.1. Use Case UC-811 Visualise air quality model results

The Common Services functionality to visualise pan Pan-European (PE) air quality results is demonstrated below. Visualisation of downscaled air quality results from the Prague area is yet not implemented.

The user interface to access the PE model results is shown in Fig. 32. Underlay WMS maps can be easily drawn from the Capabilities area (upper right corner) in over the central map area. Different layers can be displayed and the order of the layers can be altered. Here we have used country borders and coastlines to get a good orientation of air quality distribution maps. The example shows ozone concentrations when forced by climate scenario ECHAM5_A1B_3 and simulated with RCP4.5 ozone precursor emissions. The spatial distribution of 10-year averaged ozone concentrations can be visualised from 1970 up to 2100, going back and forth in time by moving the slider at the top of the map window.

The transparency of the WMS maps can be set by the user; however colours are automatically scaled to cover the data interval for the variable in the active layer.

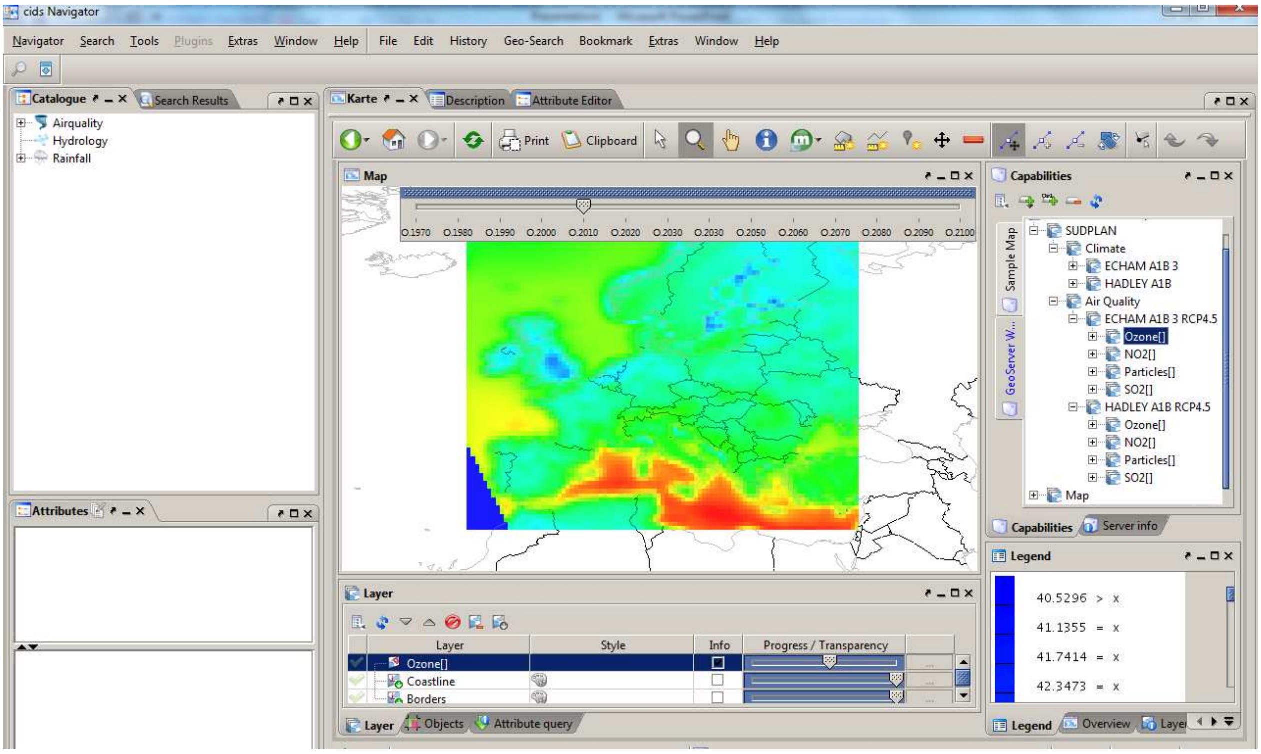


Figure 32: SMS user interface for the visualisation of climate and air quality projections on the PanEuropean (PE) scale.

Fig. 33 illustrates the differences in ozone concentrations for year 2010 and year 2070, as given by this specific scenario. From 2010 and onwards, ozone shows diminishing concentration levels all over Europe.

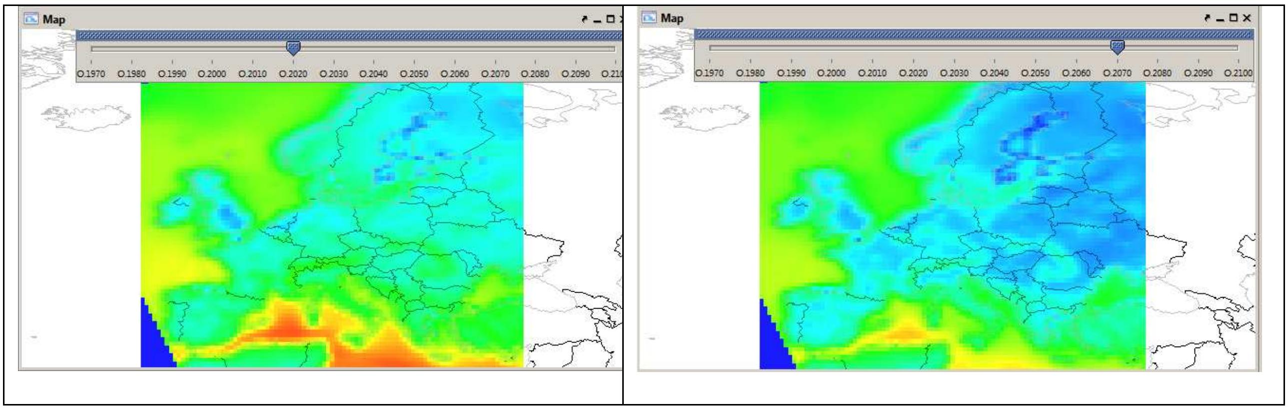


Figure 33: Ozone concentrations as given by the ECHAM5_A1B_3 climate scenario for year 2010 (left) and 2070 (right). The concentration intervals are for 2010 from about 50 µgm^{-3} (blue) to 100 µgm^{-3} (orange-red) while the interval for 2070 is from 65 µgm^{-3} to 90 µgm^{-3}

Time series output is possible from the selected active layer. Fig. 34 shows the time series of ozone concentrations (Hadley A1B scenario with RCP4.5 emissions) for Prague (red), Brno region (blue) and Pilsen (green), for comparison purposes. The current version only allows 10-year averaged data to be presented in the diagram.

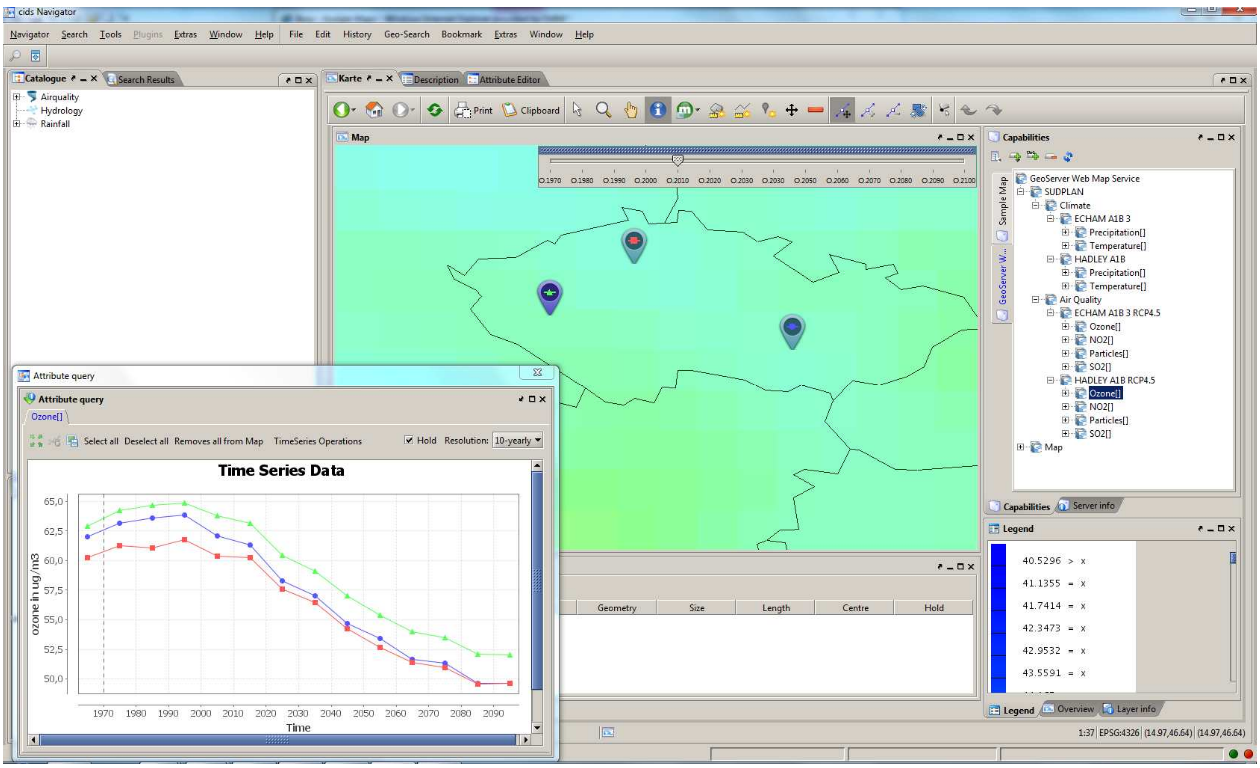


Fig. 34 Showing time series of ozone concentrations 1960-2100 in three locations, according to Hadley A1B climate scenario and RCP4.5 ozone precursor emissions.

The use case UC-811 includes five extensions:

Extensions	
3a	The user can change the time point of the simulation currently shown in the map.
3b	The user can set the colour scale of the pollutant distribution.
3c1	If the user clicks in the map a time-series diagram will be presented for the specific location. The diagram shows the pollutants concentration over the complete time of the simulation. The current position time point viewed in the map will be indicated in the diagram.
3c2	Export visualised model or monitor time series to other formats (Excel etc.)
3d	Export visualised model grid results in other formats (Excel etc.)

Extensions 3b and 3d are only possible for downscaled air quality result visualisation and will be evaluated in V3. Extensions 3a and 3c1 have been shown above, while 3c2 will be implemented and tested in V3.

5.2. Use Case UC-813 Add monitor data to compare with model results

This use case covers the requirements during model evaluation for historical periods, i.e. when downscaled model results for a historical period are compared to measured air pollutant concentrations. The use case cannot be demonstrated as Common Services integration with the Scenario Management System is not fully operational (the OGC communication to back-back end not completed). Experimentation of this model evaluation task has been performed using the Airviro web interface, fully accessible for the Czech pilot users (see Section 2.2.1).

5.3. Use Case UC-821 Execute air quality downscaling

This use case covers the principal requirement to execute an air quality downscaling over whatever European city, either using an historical model simulation as initial and boundary conditions, or selecting a climate scenario simulation that goes into the future decades. The use case cannot be demonstrated as as Common Services integration with the Scenario Management System is not fully operational (the OGC communication to back-back end not completed). However, experimentation of this model evaluation task has been performed using the Airviro web interface, fully accessible for the Czech pilot users (see Section 3.2).

5.4. Use Case UC-831 Visualise hydrological information on the pan European scale

The Czech pilot demonstrates of the hydrological downscaling capability of the SUDPLAN Common Services. The Pan-European data of river discharges, soil moisture and hydrological forcing variables for different climate scenarios are still not available and the user interface is not implemented, but the functionality will be as described for air quality in Section 4.1.

5.5. Use Case UC-832 Autocalibration of the CS hydrological model

This use case covers the basic requirement of the SUDPLAN user to upload a river discharge data set and use it for calibration of the model setup for the upstream watershed area, this with the objective of improving model performance. The model calibration can be done simply and automatically for whatever river subbasin in Europe. The use case cannot be demonstrated as the integration of CS hydrological downscaling with the Scenario Management System is scheduled for V3. Experimentation of the calibration routing has been made offline and results are discussed in Section 3.1.2.

5.6. Use Case UC-833 Execute CS hydrological model

This use case covers the principal requirement of the SUDPLAN user to allow the execution of the Common Services hydrological model, either for a historic period or for a specific climate scenario. The use case UC-833 assumes that auto-calibration and validation have been performed prior to the proper model execution of climate scenarios. The use case cannot be demonstrated as the integration of CS hydrological downscaling with the Scenario Management System is scheduled for V3.. Experimentation of model simulations for historical periods has been made offline and results are discussed in Section 3.1.3.

6. Conclusions

Within the tasks dealing with air quality, emission data have been collected and uploaded to the Common Services databases, by means of which air quality projections in Prague agglomeration were calculated. The performance of the model was evaluated through the comparison between simulated data and observed air quality data. We found that the Common Services downscaling model realistically and in most cases accurately reproduced concentrations of nitrogen oxides and ozone whereas concentrations of particulate matter were underestimated. The problem with simulation of PM concentrations is accentuated in winter season, where the model fails to reproduce episodes of high PM10 levels. The SUDPLAN Common Services air quality model provides sufficiently realistic results apart from concentrations of particulates PM10, for which more experimentation and validation will be performed during 2012 (V3).

Projections of future air quality have been carried out with climate scenario information from two global models and with future emissions taken from the GAINS model. The air quality downscaling projections show that air quality in the Prague area will generally improve.

The calibration of the Common Services hydrological downscaling model was performed using historical discharge data. Then the validation procedure assessing the ability of the model to reproduce measured data realistically was executed with independent discharge data from the period 2000-2009. Hydrological projections based on climate scenarios as well as farm profitability function will be implemented within the coming months and reported in the V3 report.

The use case of visualisation of climate and air quality on the Pan-European scale has been demonstrated. The experimentation with air quality downscaling has been performed with the web based Airviro user interface, allowing end user CENIA to execute, visualise and analyse the results. The experimentation with the hydrological downscaling model, to be integrated in the SMS environment during V3, has so far been executed offline by SMHI staff.

During V3 the WP8 setup of the complete SUDPLAN information system and its integration with existing CENIA systems, will allow the full evaluation of both air quality and hydrological downscaling, demonstrating use cases and showing the way the information can be generated and used by CENIA.

7. References

CHMI-2010: Air Pollution in the Czech Republic in 2009; Czech Hydrometeorological Institute, Prague, 2010,

CHMI-web: Website of the Czech Hydrometeorological Institute: http://www.chmi.cz

DEMA-2010: Dema Agency; http://www.dema-praha.cz

D3.1.1 Integrated Scenario Management System V1

D4.1.1 Common Services concerted approach V1

D4.3.1 Hydrological downscaling service V1

D4.4.1 Air Quality downscaling service V1

D8.1.1 Czech Pilot Definition Plan V1

D8.2.1 Czech Pilot Report V1

D8.1.2 Czech Pilot Definition Plan V2

D5.2.1 Stockholm Pilot report V1

D5.2.2 Stockholm Pilot report V2

8. Glossary

2D	Two-dimensional, typically a field that varies in east-west and north-south direction. The field may also vary in time –this is typical for e.g. air pollution and population density. The former varies from one hour to another while the latter maybe varies from one year to another.
3D	Three-dimensional, typically a field that varies in east-west and north-south direction as well as vertically. The field may also vary in time.
4D	Four-dimensional. Most often 3D field that explicitly also varies in time. It could also be when a certain 3D parameter (e.g. a particular air pollutant) also varies according to another 3D parameter (e.g. temperature). It will then be possible to study the variation of the first 3D parameter as a function of space (x,y,z) and the second parameter.
Airviro	Air quality management system consisting of databases, dispersion models and utilities to facilitate data collection, emission inventories etc, see http://www.Airviro.smhi.se/
Climate scenario	*Climate scenarios* means the resulting climate evolution over time, as simulated by global (GCMs) and regional (RCMs) climate models. Climate scenarios are products of certain emission scenarios that reflect different economic growth and emission mitigation agreements.
Common Services	*Common Services* is the climate downscaling services for rainfall, river flooding and air quality, developed in the SUDPLAN project and accessed through the SUDPLAN platform (Scenario Management System)
Common Services server	*Common Services* models will be executed at a SMHI server, accessible through OGC communication.
Emission scenario	These are of three types, of which the first one is behind the climate scenarios used in all SUDPLAN Common Services. The two remaining emission scenario types are only relevant for air quality downscaling.

- *IPCC emission scenarios*	*IPCC emission scenarios* are estimates of future global greenhouse gas concentrations based on assumptions about global development (economic growth, technical development, mitigation agreements, etc). During the first two years of the SUDPLAN projects, the climates scenarios based on SRES (Special Report on Emission Scenarios) A1B scenario from the 4th assessment have been used. The SRES emission scenarios do not include emissions of the pollutants of interest for air quality. If available the climate scenarios based on the 5th assessment RCP (Representative Concentration Pathways) emissions scenarios will also be used within the SUDPLAN project. They include emissions of air pollutants.
- *European tracer gas emissions (air pollutants)*	*European tracer gas emissions (air pollutants)* thus may or may not be included in IPCC emission scenarios. For creating Pan-European air quality fields under climate scenarios driven by the SRES A1B emission scenario, SUDPLAN uses tracer gas emissions from the more recent RCP emission scenarios. This inconsistency will be solved when climate scenarios based on RCP emission scenarios are available.
- *Local emission scenarios*	*Local emission scenarios* (to the atmosphere) are those of a particular European city. These will to a large extent influence future air quality in the city, but have little influence on global climate, nor do they influence air pollution concentrations in incoming long-range transported air. SUDPLAN will typically need gridded emissions with 1x1 km or finer spatial resolution as input to its urban air quality downscaling model.
Hind cast	A simulation of a historical period. Often done to compare model simulations with data which is available during that period.
Hot spot	Point (or small area) which is very different from its surroundings. In the present context, most often high concentrations of air pollutants, or extreme meteorological conditions.

Information product	Raw data, such as the results of mathematical modelling, and the analysis thereof, will often need to be packaged in such a way as to be accessible to the various stakeholders of an analysis. The medium can be one of a wide variety, such as print, photo, video, slides, or web pages. The term *information product* refers to such an entity.
Mockup	A model of a design used for demonstrating the functionality of a system.
Model	A *model* is a simplified representation of a system, usually intended to facilitate analysis of the system through manipulation of the model. In the SUDPLAN context the term can be used to refer to mathematical models of processes or spatial models of geographical entities.
PM_{10}	'PM10' shall mean particulate matter which passes through a size-selective inlet as defined in the reference method for the sampling and measurement of PM10, EN 12341, with a 50 % efficiency cut-off at 10 µm aerodynamic diameter;
$PM_{2.5}$	'PM2,5' shall mean particulate matter which passes through a size-selective inlet as defined in the reference method for the sampling and measurement of PM2,5, EN 14907, with a 50 % efficiency cut-off at 2,5 µm aerodynamic diameter;
Profile	Within SUDPLAN a *profile* is a set of configuration parameters which are associated with an individual or group, and which are remembered in order to facilitate repeated use of the system.
Regional downscaling	A climate scenario may be downscaled to a higher spatial resolution, typically 25-50 km, by a Regional Climate Model (RCM). The regional downscaling in SUDPLAN will be performed by SMHI's RCM (RCA, see below) and will generate climate scenarios at 44 or 22 km resolution.
Report	A *report* is a particular type of information product which is usually static and might integrate still images, static data representations, mathematical expressions, and narrative to communicate an analytical result to others.

Scenario	A *scenario* is a set of parameters, variables and other conditions which represent a hypothetical situation, and which can be analysed through the use of models in order to produce hypothetical outcomes. In SUDPLAN a scenario is an individual model simulation outcome to be used in urban planning. The model simulation may or may not include Common Services downscaling (with specific input) and may or may not include a local model simulation (with specific input and parameters).
Scenario Management System	*Scenario Management System* is synonymous with SUDPLAN platform
Scenario Management System Framework	The *Scenario Management System Framework* is the main Building Block of the Scenario Management System. It provides the Scenario Management System core functionalities and integration support for the other Building Blocks.
Scenario Management System Building Block	Scenario Management System Framework is composed of three distinct *Building Blocks*: The Scenario Management System Framework, the Model as a Service Building Block and the Advanced Visualisation Building Block.
Street canyon	Volume between high buildings in cities. Due to poor circulation (and high emissions) prone to poor air quality. Street canyons have unexpected circulation patterns, thus dedicated models are needed to study air pollution here.
SUDPLAN application	A *SUDPLAN application* is a decision support system crafted by using the SUDPLAN platform and integrating models, data, sensors, and other services to meet the requirements of the particular application.
SUDPLAN platform	The *SUDPLAN platform* is an ensemble of software components which support the development of SUDPLAN applications.
SUDPLAN system	*SUDPLAN system* is synonymous with SUDPLAN application

Urban downscaling	This refers to further downscaling of the regional climate scenarios for Europe to the urban scale within SUDPLAN. This will be possible for a) *rainfall/precipitation* where the temporal resolution will be 30 minutes or less. The spatial resolution will be that of a precipitation gauge, i.e. representative for a point rather than a certain area. b) *hydrological variables (river runoff, soil moisture etc*) where the temporal resolution is daily and the spatial resolution linked to catchment areas which presently count approximately 35000 and with average size 240 km^2. *c) air quality (PM, NO2/NOx, SO2, O3, CO).* The temporal resolution will be hourly for gridded output fields and the spatial resolution typically 1x1 kilometres.
User	The term *user* refers to people who have a more or less direct involvement with a system. Primary users are directly and frequently involved, while secondary users may interact with the system only occasionally or through an intermediary. Tertiary users may not interact with the system but have a direct interest in the performance of the system.
Web-based	Computer applications are said to be *web-based* if they rely on or take advantage of data and/or services which are accessible via the World Wide Web using the Internet.

9. Acronyms and Abbreviations

Acronym	Description
A1B	Emission scenario used for global climate modelling in IPCCs Fourth Assessment Report (AR4)
Airviro	Air quality management system to facilitate data collection, emission inventories etc, see http://www.airviro.smhi.se/
CS	Common Services
AVDB	Airviro Time Series database (used for storage in Common Services)
AR4, AR5	Fourth and Fifth Assessment Report of IPCC
AQ	Air Quality
C API	Application Programming Interface written in C
CMIP5	Coupled Model Intercomparison Project, phase 5 (coordinated model exercise in support to AR5)
CS	Common Services (SUDPLAN functionality)
CTM	Chemistry Transport Model
CTREE	FairCom CTREE database (Index database, core of AVDB)
DBS	Distribution-Based Scaling, a method to bias-correct (i.e. remove systematic errors in) the temperature and precipitation of the RCM output
DoW	SUDPLAN Description of Work
DSS	Decision Support Systems
ECHAM5	GCM developed at Max Planck Institute for Meteorology, DE
ECMWF	The European Centre for Medium-Range Weather Forecasts (also co-ordinating FP7-SPACE project MACC)
EDB	Airviro Emission database
EEA	European Economic Association
E-HYPE	HYdrological Predictions for the Environment (European set-up), hydrological rainfall-runoff model developed and used by SMHI
EM&S	Environmental Modelling and Software
ESA	European Space Agency
ESDI	European Spatial Data Infrastructure
EU	European Union
GCM	Global Climate Model or, equivalently, General Circulation Model. Physically based computer model that simulates the global climate on a 200-300 km resolution. Can be used both to reproduce historical climate and estimate future climate, e.g. in response to changes in greenhouse gas concentrations.
GTE	Georeferenced Time-series Editor
GIS	Geographic Information System
HadCM3	GCM developed at Met Office Hadley Centre, UK
HIRLAM	HIgh Resolution Limited Area Model, numerical weather prediction model developed and used operationally by SMHI

ICT	Information and Communication Technologies
ID	Identifier
IDF-curve	Intensity Duration Frequency-curve, a curve (or a table of values) showing the rainfall intensity associated with a certain duration (i.e. time period) and frequency (i.e. probability, generally expressed as a return period). Calculated from short-term rainfall observations and widely used in design of urban drainage systems.
iEMSs	International Environmental Modelling & Software Society
IFIP	International Federation for Information Processing
IPCC	The Intergovernmental Panel on Climate Change, the leading body for the assessment of climate change
IPR	Intellectual Property Rights
ISAM	Indexed Sequential Access Method, a method for indexing data for fast retrieval
ISO	International Standardization Organisation
ISESS	International Symposium on Environmental Software Systems
IST	Information Society Technology
MATCH	Multiple-scale Atmospheric Transport and Chemistry modelling system, a CTM developed and used by SMHI.
MODSIM	International Congress on Modelling and Simulation
OASIS	1) Organization for the Advancement of Structured Information Standards 2) Open Advanced System for Disaster and Emergency Management (FP6 project)
OGC	Open Geospatial Consortium
O&M	Observation and Measurements
ORCHESTRA	Open Architecture and Spatial Data Infrastructure in Europe (FP6 IST-511678)
OSGeo	Open Source Geospatial Foundation
OSIRIS	Open architecture for Smart and Interoperable networks in Risk management based on In-situ Sensors (FP6 IST-33799)
PMC	Project Management Committee
RC	Rossby Centre, climate research unit at SMHI
RCA	Rossby Centre Atmospheric model, RCM developed by SMHI and used in SUDPLAN
RCM	Regional Climate Model, commonly used to increase the spatial resolution of climate scenarios to 25-50 km in a specific region.
RCP4.5	Radiative Concentration Pathways: A set of four emission scenarios to be used for the AR5 simulations. The scenarios are named according to their radiative forcing at 2100, e.g. 4.5 W/m^2.
RNB	Airviro Field database
SANY	Sensors Anywhere (FP6 IST-033654)
SDI	Spatial Data Infrastructure
SISE	Single Information Space in Europe for the Environment

SISE	Single Information Space in Europe for the Environment
SMHI	Swedish Meteorological and Hydrological Institute
SMS	Scenario Management System
SOA	Service Oriented Architecture
SOS	Sensor Observation Service
SPS	Sensor Planning Service
SWE	Sensor Web Enablement
SUDPLAN	Sustainable Urban Development PLANner for climate change adaptation
SWE	Sensor Web Enablement
Tbd	To be determined
UWEDAT	AIT environmental data management and monitoring system
WCC	World Computer Congress
WCS	Web Coverage Service
WFS	Web Feature Service
WP	Work Package
WPS	Web Processing Service
WMS	Web Map Service