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D5.1.3 Pilot Definition Plan V3 for Stockholm

SULVF

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1. Management summary

The Stockholm pilot is one of the two pilots that use the SUDPLAN tools in support of air quality management, the second being the Czech regional pilot. This final pilot definition plan V3 details the background, objectives and task for the last project year 2012 within WP5. The WP5 work has been specified in the form of activities and tasks. Use cases have been formulated based on those, but limited to the use of the SUDPLAN software and therefore they constitute the input to the requirement specification of the SUDPLAN software.

The list of activities has been divided into three groups, aiming to:

- Demonstrate the use of Common Services
- Demonstrate advanced visualisation of local model results
- Evaluate and visualise air quality for different urban planning scenarios

These activities have been carefully revised every year and the present V3 activities will tell the extent of what WP5 will achieve up to project end. All major changes are clearly marked and explained in the updated activity list (Section 3.6). The most important changes as compared to V1 and V2 are:

- The high resolution (~100 m spatial resolution or finer) 3D model simulations to be used for advanced 3D visualisation will be performed with SULVF's own local model, not with the Common Services downscaling model (MATCH).
- The downscaling of future scenarios will be made for one year at each execution, using one sole emission database. This means for the end user a simpler and more rapid procedure, compared to execute the downscaling for the entire period covered by climate scenarios, using multiple emission databases to capture emission changes from year to year.

There has also been a smaller revision of the Stockholm use cases, where the visualisation of air quality model results has been separated in two parts. The first part is a use case for visualisation of air pollution data on the Pan-European scale, in which a WMS is used to present air pollution concentrations. The second part is for urban downscaled results, where the visualisation requires the transfer of true gridded data to the end user web application. As the use case extensions are slightly different, it was found appropriate to split this use case in two parts.

This Stockholm Pilot Definition Plan V3 will be followed up in the D5.2.3 Stockholm pilot report V3 (m30).

2. Introduction

The Stockholm pilot is the principal demonstrator using the SUDPLAN tools in support of air quality management. The end user partner SULVF uses the tools for two types of assessments, both with a look into future decades:

- Compliance Assessment (CA): Will the Stockholm region fulfil the EU air quality directive in the coming 10-20 years?
- Urban Scenario Evaluation (USE): Decision support in planning where multiple alternatives exist.

This final definition plan V3 details the background, objectives and task for the last project year 2012 within work package WP5. The document follows the same structure as earlier definition plans V1 and V2, but contains enhanced text.

The WP5 work has been specified in the form of activities, tasks and use cases. The tasks were mainly formulated during the WP2 seminars that initiated the project. The use cases are formulated based on the tasks, but limited to the use of the SUDPLAN software. Therefore the use cases have constituted the input to the requirement specification of the SUDPLAN software, as designed in WP3. While creating the first Stockholm Pilot definition plan, it was found of interest to reformulate the tasks in a way that they could better be separated to address one of three goals of the Stockholm pilot, being to:

- Demonstrate the use of Common Services
- Demonstrate advanced visualisation of local model results
- Evaluate and visualise air quality for different urban planning scenarios

In order to connect to earlier versions V1 and V2, any change in the activity list of this final Stockholm Pilot Definition Plan V3 will be clearly marked and explained.

3. Pilot definition

This section describes why end-users at SULVF are involved in the SUDPLAN project and how the Stockholm pilot is of relevance to the original ICT-2009.6.4 target a) ICT for a better adaptation to climate change.

Further down in this section there is a list of contributions (data, software etc) from SULVF and also an overview of the needs for Common Services functionality.

Parts of the background texts of this section have originally been taken from the Description of Work (DoW) document. Note also that this V3 definition plan is an extended and updated version of the two earlier plans D5.1.1 and D5.1.2. Specifically Section 3.6 describes the activities that was initiated or fulfilled in V1-V2 and what activities will be focus in V3.

3.1. Scope

The following subsection introduces the city partner organisation SULVF and its duties in air quality management, giving relevance to the possible effects of climate change on future air quality.

3.1.1 Main pilot objectives

The pilot partner Stockholm-Uppsala Air Quality Association (SULVF) is legally a non-governmental organization consisting of 35 municipalities, two county administrations, the public enterprise handling Swedish air navigation services (LFV), Stockholm regional office of the Swedish road administration, major power production companies and some major industries. Department of Applied Environmental Science (ITM) at Stockholm University is also a member of the association. SULVF controls air pollution with respect to compliance with limit values, emissions and exposure. It is a regional cooperation with a specific mission to assure that today's and tomorrow's air pollution will not contribute to negative health effects on the population. In terms of detailed emission inventories the organization covers a larger area; 6 counties in Sweden (300 km x 400 km) with around 3.5 million people (35 municipalities; about 40% of the total population of Sweden).

Air pollution is already today a critical issue in Stockholm and the European Commission has had to start infringement proceedings against Sweden for failing to comply with the EU's air quality standard for dangerous airborne particles known as PM10. Stockholm is one of the Swedish cities that do not meet EU standards for PM10. Stockholm city is further developing the action plan to reduce PM levels, and there are concerns that climate change may bring about effects on air quality that will require special attention and other actions than those prioritised today. The Stockholm pilot will use the tools developed in the SUDPLAN project to provide local authorities and institutions in the Stockholm-Uppsala region with levels and trends in air pollution during the coming decades, including the effect on air quality of both local emission scenarios (result of urban planning) and climate change.

3.1.2 Relevance with respect to Climate Change issues

In 2006 the regional actors (the 26 municipalities of the Stockholm county, the rail track and road authorities, and the chamber of commerce among others) jointly engaged in a process aiming at producing a regional development plan. The process is led and facilitated by the Office of Regional Planning and Urban Transportation (RTK). The plan covers both spatial/physical and social and economic issues and thus has a truly integrative scope. Climate change impact assessment and adaptation studies will constitute some key elements of the planning process. The meaning of "climate adaptation" is the need for society to adapt to the impacts of a changing climate on the economic, cultural and life-supporting functions of the environment in which human beings live and act.

The Stockholm pilot is focusing on the demonstration of a sophisticated urban planning tool for avoiding hazardous air pollution events today and in the future. The simulation of the environmental factor air pollution will depart from SUDPLAN Common Services and be seamlessly downscaled to the micro scale of individual city blocks or streets, allowing the user to assess the origin of air quality on all scales and to combine climate scenarios with local changes in urban infrastructure and systems.

The most severe health effects come from exposure to ozone and PM10. Both of these pollutants are, to a major part, originating outside Sweden and transported with the wind from the European continent. The rate at which EU will be able to control emissions within member countries will thus have important consequences for future air pollution levels in Europe. Moreover, changing temperature, precipitation and vegetation in Europe will alter the processes behind the formation of ozone and inhalable particulate matter. It is important for the Stockholm administration to regulate local emissions so that a clean and safe air quality can be maintained for present conditions as well as during and after a gradual climate change. Although the process of political decisions for a better adaptation to climate change in Stockholm has started already in 2010, well before the delivery of the products developed in the present project, there will be a continuing need for further scenario[1] evaluations and visualisations as a basis for planning and training. In other words, the need for climate change impact assessments in Stockholm will not end during the SUDPLAN project lifetime (2012); it will rather be intensified with higher demands on detail and technical support.

Stockholm Vatten AB (see homepage at http://www.stockholmvatten.se/en/), a municipality-owned company responsible for water supply and waste water, has showed a great interest in SUDPLAN services of downscaled precipitation. Although Stockholm Vatten, due to staffing limitations, could not join SUDPLAN as an official partner, it constitutes a strong stakeholder and future user of the intense rainfall output. Stockholm Vatten uses a sewer waste water model to simulate the capacity of the present tube system and to dimension the future system. The Stockholm pilot will therefore invite Stockholm Vatten to test and evaluate the Common Services output of present and future intense rainfalls. The output from SUDPLAN Common Services should be very useful to generate future rainfall characteristics as input to their sewer waste water model.

[1] Please see Abbreviation list for the different meanings of the term ”scenario” within the SUDPLAN project.

Climate Change Issues	Pilot Consideration
Levels and trends in urban air quality Health impact of air quality in combination with climate change	Show compliance with EU and Swedish regulation, as well as with national environmental objective values for air quality, thereby minimizing health effects and annoyance caused by air pollution, during present and future climatic conditions and for different future urban planning scenarios.
Downscaled intense rainfalls	Will generate future precipitation input data to local sewer waste water models used by Stockholm Vatten, which will help them to dimension their sewer system (the local model will not be demonstrated in the pilot, the project will only show the use of Common Services to produce future rainfall characteristics for the city).

3.2. Relevance with respect to ICT objectives of the proposal

Objective ICT-2009.6.4 ICT for Environmental Services and Climate Change Adaptation
Target Outcomes
a) **ICT for a better adaptation to climate change**
Easy-to-use, web-based systems for better preparedness, decision support and mitigation of climate change impact on population, utilities and infrastructures. Special emphasis is on scenario-based prediction, damage assessment, planning and training, 3D/4D modelling, simulation and visualisation, as well as sensor networks. Integrated solutions shall be validated in the urban context including for natural disasters, taking full advantage of recent advances in miniaturisation of sensors, wireless communications and increased computation power and data storage capacity.

ICT Objective	Pilot Consideration
ICT for a better adaptation to climate change	Long term trends in air quality, affected by climate change, presented and pedagogically visualised in 3D/4D and with high spatial resolution, to facilitate decisions between different planning options where sustainability can be evaluated.

3.3. Local models and data sources used

The SULVF air quality management system for the Stockholm-Uppsala Metropolitan area, consisting of the monitoring network, Airviro (see Abbreviation list) tools and all relevant information stored in Airviro databases was implemented already some 20 years ago, in support of urban planning. The system is a specialised Geographic Information System (GIS) application for air quality management and includes most of the common GIS functionality - possibilities to store different kinds air pollution data together with their spatial and temporal characteristics, powerful possibilities of data analysis such as e.g. time-series statistics of point wise and gridded field data, a great variety of presentation alternatives, interfaces to other GIS systems etc. The three areas of air quality management, measurements, emissions and modelling are fully integrated in the Airviro system. There are also local models that calculate the additional pollution experimented close to traffic, either in street canyons or along open roads.

The main objective of the Stockholm air quality management system is to satisfy the user requirements in Stockholm-Uppsala in terms of cost effectiveness, flexibility and air quality information. It is always cheaper to prevent than cure; that is why it is so important to assess in advance the environmental impact of an infrastructure project. Poor environmental decision information can imply the need for later reconstruction or introduction of other measures in order to avoid negative effects on population's health and to achieve necessary air quality standards. Such costs by far exceed the costs for an appropriate environmental planning tool in the early stages of an urban planning process.

The Stockholm-Uppsala air quality management system is operated by SLB Analys, part of the Environmental unit at the City Council. The SUDPLAN Stockholm application is designed for the main objective of simulating air quality in future city plans.

The following components will be of use for the Stockholm air quality pilot:

- A time-series database where measured air quality and meteorology from the SULVF area is stored as daily and hourly values. The database covers data from around 100 air quality stations and some 10-20 meteorological stations, some with historical data for up to 20 years.

- A dynamic emission database with annually updated emissions from point, line and area sources. The emissions are described with geographical coordinates, physical characteristics (release height, temperature etc) and temporal variations.

- An urban dispersion grid model that can be used with spatial resolution down to 100-200 meters.

- A street canyon model that can be used to calculate air pollution levels at street level, at the pavements on both sides of individual streets with nearby buildings on at least one side.

- An open road model that calculates air pollution at both sides of individual roads without surrounding buildings.

3.3.1 SULVF Time-series database

Monitor data from the Stockholm area are stored in SULVF's Airviro time-series database, i.e. the same type of database that is used by Common Services. Access to the monitoring data can be achieved through the use of the web based SULVF Airviro user interface, or as an alternative, it is possible to upload monitor data to the SMS repository (e.g. for comparison between monitor data and downscaling model results).

For more details on the Airviro time-series database, see Concerted Approach V2, Section 3.3.2.

3.3.2 SULVF Emission database

Emission data from the Stockholm area are stored in SULVF's Airviro database, i.e. the same type of database that is used by Common Services. This means that the format of the database is identical of that requested by Common Services downscaling models. Technically the SULVF databases can either be accessed by Common Services directly at the SULVF Airviro server, or they can be uploaded to the CS server into the Airviro databases used by CS.

For more details on the Airviro emission database, see D4.1.1 Concerted Approach V2, Section 3.3.2.

3.3.3 SULVF urban dispersion model

Change in V3: After tests it has been decided to not use the MATCH model for high resolution 3D simulations. 3D visualisation is mainly of interest on a spatial scale where individual buildings can be recognised and where concentration gradients are strong. The MATCH model can't fully reach that high spatial resolution, neither in the horizontal nor in the vertical. Instead it has been decided to use the Airviro grid model (one of the existing local models) output.

The Airviro grid model, one of SULVF's existing local models, will be used to generate 3D model results with high spatial resolution in the horizontal (e.g. 25 or 50 m) and in the vertical (every 5 m etc). The visualisation will be performed both for statistical averages and as transient hourly data during shorter periods, e.g. one week.

3.3.4 SULVF street canyon and open road models

There are two local street models available for micro-scale simulations of traffic impact on air quality. If the road of interest is not surrounded by buildings or obstacles which reduce the dispersion of traffic emissions (open road conditions), then a Gaussian line source model is used (Gidhagen et al., 2004). However, if there are houses at one or both sides, a street canyon model OSPM (Berkowicz, 2000) is used.

Both models, and in particular the OSPM street canyon model, have been evaluated in many different environments. The striking characteristic is that these kinds of models are very fast, a 1-year simulation of hourly values takes a few seconds to complete.

For the open road model geometrical properties of interest are the width of the street and the number of lanes, possibly separated by a median strip. Before the calculation the user specifies the distance of the receptor points (the location where to evaluate air quality levels) from the roadside. The vertical dispersion coefficient in the Gaussian dispersion calculation takes into account initial values influenced by traffic generated turbulence and then both convective and mechanical contributions. One-hour average concentrations are calculated by averaging concentrations in a wind direction interval, parameterized from measured standard deviations of the wind direction.

The OSPM model needs some geometrical data, since buildings close to the street will affect the dilution of emitted pollutants. Except for road width and number of lanes, the width between the surrounding houses and house heights on the two sides also form part of the road link information needed as input to the model. OSPM has one part, which is a direct plume model following the estimated wind direction at the bottom of the street canyon. The other part, taking care of the contribution from the re-circulation, is calculated by a simple box model. OSPM assumes stability conditions inside the street canyon to be neutral. The two receptor points are located at 2m height and 2m from the building facades.

3.4. Main deficiencies

The simulation of air quality scenarios stretching some 50 years or more into the future will, to a large degree, use input data with large uncertainties. During such long time spans, economic and social development can be rather different from what we, with rather high plausibility, can extrapolate for the coming 5-10 years (a time span for which already decided regulations will start to take effect). However, the main purpose of the long term future scenarios of simulated air pollution levels is to guide our decision of today, based on technology and other conditions that we can foresee. Thus the SUDPLAN results will add to our “best available” knowledge, not necessarily to a “true” knowledge about a remote future.

We can increase the robustness of our air quality climate scenario simulations by selecting different climate model output as input to our air quality simulations. This will yield a range of possible future air quality levels, which can strengthen our conclusions on trends or noise (random variations) in future air quality levels.

Emissions of air pollutants over Europe are transported as long range contributions to Sweden and Stockholm. These emissions are partly linked to the climate scenarios, e.g. through assumptions of economic growth, but also strongly given by long term EU decisions to reduce the emissions of specific air pollutants. Sources to climate forcing gases and particles are often the same as those that emit health hazardous air pollutants, making air pollution and climate forcing is a coupled process. SUDPLAN will strive for consistency between the global climate scenarios and the emissions over Europe.

There is also a major variability in the emissions resulting from alternative urban solutions/plan, assuming different distributions between public/private transport, fossil/ hybrid/electric vehicles, population sprawl/concentration etc. Local emissions are the only part that directly can be influenced in urban planning, which make it important to assess their effect as compared to external factors. Each of those local emission scenarios should thus be assessed through the use of different climate scenarios, in order to ensure “robustness” in future Stockholm air quality, i.e. to allow a realistic simulation of the future air quality levels built up by the combined effect of i) the climate change, ii) the long range transport of continental emissions and iii) the urban planning of local emissions.

3.5. Common services used

Common Services will help the city end-users to generate city specific information on future characteristics of rainfall, hydrological conditions and air quality. Climate scenario simulations on the global (GCM) or regional/European (RCM) scale have neither the spatial nor the temporal level of detail needed for urban assessments. SUDPLAN Common Services will fill this gap by downscaling RCM information to a higher spatial and temporal resolution. Output from this downscaling can be used as input to local model assessments or used directly for urban planning purposes.

The Stockholm pilot will use the SUDPLAN Common Services for two purposes (see D4.1.2 Concerted Approach V2):

- downscaled precipitation and the risk for intense rainfalls (also D4.2.2 Rainfall downscaling service V2)
- downscaled air pollution and high ambient temperatures (also D4.4.2 Air Quality downscaling service V2)

The following subsections summarise the CS functionality used.

3.5.1 Climate scenario information on the Pan-European scale (PE)

The start screen of the Common Services GUI is a map over Europe, on which some basic European scale environmental information (after regional downscaling, but without urban downscaling) can be displayed, either as gridded maps or as time-series for a given location in Europe. The Climate scenario information on the European scale is available for all pilots, contributing to the understanding of the climate change effects on a regional scale for precipitation, temperature and air pollution. It also facilitates a reference to the more detailed urban scale information given by other Common Services.

A description of the information to be visualised on the European scale is found in D4.1.2 Concerted Approach V2, Section 3.2.1.

The demonstration of this CS functionality is formulated as a use case for the Stockholm pilot. The PE functionality is highly interesting for training purposes and for specific end users to be able to compare climate change impact in their city with other European cities.

3.5.2 Intense rainfall: urban downscaling

Short-lived intense rainfall for future climatic conditions can be downscaled by Common Services to a specific city, if the user can provide historical high resolution precipitation data or statistical *Intensity Duration Frequency* (IDF) curves/tables.

A description of this Common Services functionality is found in D4.1.2 Concerted Approach V2, Section 3.2.2 and in the prototype side report D4.2.2 Rainfall Downscaling Service V2.

This CS functionality is evaluated by other project pilots (WP6 and WP7). WP5 will however present the rainfall downscaling for an external stakeholder in Stockholm that has expressed interest already at project start.

3.5.3 Intense rainfall on the urban scale: Design Storm Generator

In V3 Common Services will allow the user to produce a spatially varying intense rainfall associated to a passing storm event, where the rain maximum will move over the city. The generated time-series grid can e.g. be used as input to local sewage water system models.

A description of this Common Services functionality is found in D4.1.2 Concerted Approach V2, Section 3.2.2.

This CS functionality is evaluated by other project pilots (WP6 and WP7). WP5 will however present the output of the Design Storm Generator for an external stakeholder in Stockholm.

3.5.4 Air quality: urban downscaling

In V3 Common Services will allow the user to produce downscaled air quality by facilitating local emission data. Common Services opening page is a map over Europe which can be zoomed up over a city and on which an urban grid can be defined.

A description of this Common Services functionality is found in D4.1.2 Concerted Approach V2, Section 3.2.4 and in the prototype side report D4.4.2 Air Quality Downscaling Service V2.

This is the principal CS functionality for the WP5 end user partner (SULVF) and will be frequently used to assess future compliance with air quality standards and to evaluate different scenarios for urban development in terms of air quality and exposure.

3.6. Main pilot activities

The activities associated to the use of Common Services, local models and scenario evaluation/visualisation are listed in the following subsections. These activities define the WP5 work to be performed during the final year of the project.

3.6.1 Using Common Services

This section lists the planned activities that will use Common Services results directly, without further use of local models. Time plans reflect the availability of Common Services during the different phases of SUDPLAN.

Activity 3.6.1.1: Presenting climate scenario information on the European scale
The visualization tool will be used by users of the SULVF pilot to present climate scenario information on the European scale. This information consist of

- Distribution and trends in precipitation and temperature
- Distribution and trends in air quality (e.g. O3, NO2, PM10)

Time plan for activity: This activity was accomplished during the second year. Through the use of the SMS user interface it was possible to plot 10-year averages for the period 1965-2095 (Fig. 2 in D5.2.2 Stockholm pilot report V2). However the SMS did not allow to graphically show the evolution with other time resolutions, e.g. annual or monthly averages. Thus this activity should remain active also during V3 and the results documented in D5.2.3 Stockholm Pilot report V3.

Activity 3.6.1.2.1: Intense rainfalls (urban downscaling)

A high resolution time-series (>10 years e.g. of the "tipping bucket" rain gauge type) of precipitation registered in the Stockholm area will be identified and converted to the input format required by the Common Services. Common Services will be used to generate an equally long, future time-series, adjusted according to precipitation changes given by different climate scenarios.

The differences between present and future rainfall will be analyzed and documented in the Stockholm pilot. Generated data will be delivered to Stockholm Vatten and used externally as input to local models for waste water systems (not part of SUDPLAN documentation).

Change in V3: The V2 definition plan scheduled this activity for 2011. In order to have more functionality in the SMS-CS rainfall downscaling application and also to dispose more than two scenarios, it was decided to postpone this activity to 2012. The rainfall demonstration is primarily a responsibility for the Wuppertal and Linz pilots.

Time plan for activity: Scheduled for 2012 (V3).

Activity 3.6.1.2.2: Intense rainfall: Design Storm Generator

The design storm generator will be tested and documented for the Stockholm area. Generated data will be delivered to Stockholm Vatten. Further use of gridded storm water data, e.g. as input to models of waste water systems, will not form part of SUDPLAN documentation.

Time plan for activity: Scheduled for 2012 (V3).

Activity 3.6.1.3: Air quality: urban downscaling

This activity started in V1 with evaluation of model results against measurement data, for shorter historical periods (so called hindcast simulations). They have been documented in D4.4.1 Air Quality Downscaling Service V1 and D5.2.1 Stockholm Pilot V1. During the second year we have investigated the long term effect on air quality of different European scale scenarios. Table 1 shows the scenarios fully available in SUDPLAN Common Services (green), but offline sensitivity tests of some other scenarios have also been performed (orange). Results are presented in D5.2.2 Stockholm Pilot report V2.

Table 1 Climate scenarios evaluated in the Stockholm pilot. The scenarios marked "uploaded" (green) are fully available for presentation on the Pan-European scale, as well as for rainfall and air quality downscaling. The scenarios marked in orange have been evaluated offline and only for ozone. RCP4.5 is emission scenario and BC is boundary conditions for the European scale simulation (further details in text below).

Global GCM	Climate scenario	European tracer emissions	European Air Qual.	European 30 min rain	European Temp. & Prec.
ECHAM5	A1B_3	RCP4.5	uploaded	uploaded	uploaded
HADLEY	A1B	RCP4.5	uploaded	uploaded	uploaded
ECHAM5	A1B_3	RCP4.5 constant at ~2000 BC contant at ~2000	evaluated for ozone		
ECHAM5	A1B_3	RCP4.5 constant at ~2000 BC increase 0.2 ppb/year	evaluated for ozone		
HADLEY	A1B	RCP4.5 constant at ~2000 BC increase 0.2 ppb/year	evaluated for ozone		

Global GCMs
ECHAM5 is operated by Max-Planck-Institut für Meteorologie, Hamburg, Germany. HADLEY is operated by Hadley Centre, Bracknell, UK. All global GCM results have been downscaled over Europe by the SMHI RCA3 model (Samuelsson et al., 2011).

Climate scenario
Relates to assumptions on how greenhouse gases (GHG) evolve over time and space. Present scenario A1B comes from the IPCC fourth assessment report (AR4) and it was the “middle” scenario (in terms of heating) used for model intercomparison.

European tracer emissions
In order to complement the climate scenario downscaling over Europe with tracer species (air pollutants), it is necessary to have emission scenarios also for air pollutants (not only greenhouse gases). In SUDPLAN we use RCP emissions, e.g.

- RCP4.5 (tuned to a net radiative forcing of 4.5 W/m^2 at stabilization after year 2100)
- RCP8.5 (>8.5 W/m^2 and rising also after year 2100).

So far in SUDPLAN (up to V2) the RCP4.5 emission scenario has been used, the RCP8.5 being a possible candidate for V3.

The technical, economical and legislative assumptions behind the different RCP scenarios are of interest but are currently not documented in SUDPLAN. During the project such summary will be elaborated, so that users, when they select a specific European scale result as input to an urban downscaling, can have an idea about how far reaching greenhouse gas (GHG) reductions of European emissions that are behind this specific result.

Background on atmospheric emissions is found at:
http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=welcome

The European scale air quality results from ECHAM5_A1B and HADLEY_A1B cover the period 1960-2100, i.e. 140 years. Originally it was suggested to also run the urban air quality downscaling for the same 140 years, but it has now been decided to use a simpler and more cost-effective methodology:

- Run two downscaling simulations for two time windows, sufficiently long to cover interannual variability in meteorological conditions. The window can e.g. be 5 years, centered in “present” and “desired future”, e.g. simulation 1 covering 2008-2012, simulation 2 covering 2038-2042 ➔ a total of 10 years of simulations instead of 140. In SUDPLAN the air quality downscaling simulations are made once per calendar year, so 10 model executions will be necessary.
- For each time window, use one sole emission inventory (as we are mainly interested in meteorological variability, emissions are assumed to vary much less from year to year).
- Perform downscaling with different European scale scenarios to get an idea about the uncertainty of the climate scenarios and the European emissions (both time windows must be executed).
- Perform downscaling with only the future time window but with different <u>local</u> emission inventories, to evaluate/compare different local scenarios (i.e. different urban planning solutions).

This procedure, as compared to the alternative of running all years from 1960 to 2100, is advantageous, as:

- Model calculation times will be much shorter
- Less demands on emission inventories (only the future inventory needed, no intermediate databases)

During V3 there will be more climate scenarios available, likely with different emission scenarios for Europe, but hopefully also completely new climate scenarios from the ongoing CMIP5 activity where GCMs and RCMs are producing the basis for IPCCs 5th Assessment Report. As for the different local emission scenarios, see Activity 3.6.3.

Time plan for activity: Experimentation with air quality downscaling will continue during V3 and documented in Stockholm pilot report V3 as well as on conferences and in reviewed journals.

3.6.2 Use of local models: 3D high resolution modelling and visualization

These pilot activities will show how SUDPLAN Common services can be coupled to local models of much higher spatial resolution, sufficient for assessing regulatory issues (compliance to air quality standards) as well as for use in exposure in health studies. A grid model will generate 3D gridded air quality concentrations with a spatial resolution of 50-200 m^2. In order to capture locally increased air pollution levels in street canyon, there will also be model simulations with street canyon models.

Change in V3: In earlier plans it was suggested to run 3D high resolution model runs within the SUDPLAN tool, through the SMS user interface. As stated earlier in Section 3.3.3 the CS downscaling model MATCH can't fully reach the high resolution required (~100x100m or finer, with a few m resolution in the vertical). For V3 it has been decided to use SULVFs ordinary 3D grid model, running in their existing Airviro system, instead of the MATCH model. This means that Stockholm will not run these high resolution models within the SUDPLAN system, but they will be able to import results from their local models to be visualised and analysed in the SUDPLAN SMS environment.

Expected output from SUDPLAN Stockholm pilot is a 3D visualization of grid model and street canyon concentrations over a 3D city map with building geometries. Air pollution should be possible to view from different angles, in order to identify hot spots of particularly severe air pollution concentrations.

The Stockholm pilot activities for generating input to this SUDPLAN functionality are listed here below. The time plans indicate the moment in which data will be available for communication to WP3.

Activity 3.6.2.1: 3D city map

A 3D city map over Stockholm should be generated and formatted as required for visualisation in the Scenario Management System.

During 2010 the 3D city map was used for a smaller test area of central Stockholm (Södermalm). During 2011 the full Stockholm 3D map was prepared.

Time plan for activity: Accomplished in 2011 (V2).

Activity 3.6.2.2: High resolution grid model simulation

With downscaled information from Common Services as input and boundary conditions, the SULVF Airviro system will be used to generate time-series of hourly gridded air pollution with a spatial resolution in the range from 50 to 200 m. The simulation will be for some pollutants like NOx and PM10 that are chemically inert on the city scale, and will cover periods from one week up to one maximum a year.

Change in V3: A test data set generated by the SULVF Airviro 3D grid model was delivered during 2011 (V2), with spatial resolution 50x50 m and with 13 layers in the vertical. Due to format requirements of the SMS 3D visualisation system, which is based on the World Wind Java SDK, additional programming work is needed in WP5 to allow export of shape files on the WGS84 projection from the SULVF Airviro model for upload to the SMS repository.

Time plan for activity: A test data set was delivered during 2011 (V2), but new data sets will be created in V3 using a new export and coordinate transfer functionality of the SULVF Airviro system. The V3 simulations to be visualised are likely part of the local model results produced for Activity 3.6.3.2 (model evaluation of urban planning scenarios).

Activity 3.6.2.3: Street canyon model simulations

The SULVF Airviro system will be used to generate time-series of street side concentrations for some major streets in central Stockholm, with downscaled information from Common Services as input,. The simulation will be for pollutants that are critical on the local street scale, e.g. NO2 and PM10. The simulations will cover one year and presented as annual averages or extreme values following EU legislation.

Note that the execution of the street canyon model is suggested not to be part of SUDPLAN functionality (already part of SULVF's ordinary Airviro system). However, SUDPLAN SMS will allow the selection of a particular street canyon model result and its visualization together with high resolution gridded data (Activity 2.6.2.2) and 3D city map (Activity 2.6.2.1).

Change in V3: A test data set generated by the SULVF Airviro street canyon model was delivered during 2011 (V2). Due to format requirements of the SMS 3D visualisation system, which is based on the World Wind Java SDK, additional programming work is needed in WP5 to allow export of shape files on the WGS84 projection from the SULVF Airviro model result repository.

Time plan for activity: A test data set of street canyon results was delivered during 2011 (V2), but new data sets will be created in V3 using a new export functionality of the SULVF Airviro system. The V3 simulations to be visualised are part of the local model results produced for Activity 3.6.3.2 (model evaluation of urban planning scenarios).

3.6.3 Scenario evaluation and visualizations for urban planning

The following activities will show how the SUDPLAN Stockholm pilot can be used for decision support in urban planning. Different urban planning scenarios (i.e. different local emission scenarios) will be compared and evaluated from an air quality perspective, where air quality limit values and health effects (population exposure) are parameters that determine the sustainability of a certain scenario.

This functionality will require that SUDPLAN can access different model results and display them simultaneously or display the difference, at different times on the climate scenario time axis (part of the UC-522 use case in Section 6).

Activity 3.6.3.1: Creation of different urban planning scenarios
The scenarios are based on different emission databases and variations in geographical data (land use). Both the SUDPLAN air quality downscaling model (MATCH) and the SULVF Airviro grid and street models will be able to generate air pollution concentrations based on these different emissions and geographical data. The creation of different emission databases can e.g. reflect different strategic decisions on the type of public transport, i.e. decisions that will have consequences over long time periods (decades) and be of interest to evaluate within a changing climate perspective.

The creation of different land use databases will reflect strategic decisions on urban expansion and planning of green and forested areas. Forests of different types have different uptake of pollutants due to dry deposition.

Note that the creation of local urban planning scenarios (emission databases, land use maps) will be performed outside the SUDPLAN platform, using the Airviro web interface.

A first set of two future emission scenarios for the year 2030 was achieved during 2011 (V2). The effect of a new planned transit road was compared to the scenario of “no project”. More details are given in D5.2.2 Stockholm pilot report V2 and were also presented in a paper on the MODSIM 2011 conference in Perth, Australia.

During 2012 these two scenarios will be checked and improved, as a basis for a more detailed analysis. The persons involved in the impact assessment of the project are in contact with the SUDPLAN project and may ask for additional scenarios to be created.

Time plan for activity: Two future scenarios accomplished during 2011 (V2). During V3 these will be quality checked and improved. External stakeholders linked to the road transit project have announced another scenario to be created and evaluated.

Activity 3.6.3.2: Model simulations of urban planning scenarios
Both the SUDPLAN air quality downscaling model (MATCH) and the SULVF Airviro models will be able to generate air pollution concentrations based on the different emissions and geographical data generated in Activity 3.6.3.1. The SUDPLAN downscaling capabilities will give typical urban background concentrations (spatial resolution about 1x1 km) while the SULVF Airviro models can generate air pollution concentrations with much higher spatial resolution (even down to individual street scale). Note that the SUDPLAN downscaling model will give the air pollution in the incoming air, as determined by climate change and changes in

European emissions, while the SULVF Airviro models will only consider to local emission changes (air pollution contributions in incoming air to be added).

This activity compares and evaluates model simulation results, based on different urban planning scenarios as outlined in Activity 3.6.3.1. The simulations will be done with the use of the MATCH model and the Airviro models for one or various climate scenarios.

The SMS allows the selection and visualization of different model results, as well as the visualisation of the differences between scenarios, in order to facilitate an effective evaluation of air quality advantages or disadvantages of different urban planning solutions.

A first evaluation of the effect on year 2030 air quality of a planned new transit road project was compared to the scenario of "no road project" (future traffic using present road network). The evaluation has been documented in D5.2.2 Stockholm pilot report V2 and it was also presented in a paper on the MODSIM 2011 conference in Perth, Australia. The assessment used the Common Services downscaling model, with 2x2 km spatial resolution. These urban planning scenarios will be further analysed during V3, e.g. it is of interest to calculate population exposure for the different scenarios. Thus a higher spatial resolution will be needed, involving local Airviro models in parallel to the Common Services downscaling.

<u>Time plan for activity</u>: Initiated in 2011 (V2), assessment of road transit project to be completed during 2012 (V3).

3.7. Expected Added value

SUDPLAN Common Services will facilitate the assessment of future precipitation and air quality on a regional grid covering Stockholm and Uppsala. The precipitation data, especially the risk for intense rainfalls (storm water flooding), will be of great value for the dimensioning of municipalities waste water systems. This data will be made available to all public institutions in the area, but its further use in e.g. sewage water pipe network models, will be not be demonstrated in this pilot. The Stockholm pilot will, as specified in the DoW document, focus on the demonstration of the long term planner to assure a good air quality. The present air quality management system is regional, with no model coupling of the larger European scales down to the local models. Nevertheless, the major part of particulate originates outside of Sweden, from European sources (Johansson et al., 2006).

The enhanced decision support capabilities provided by SUDPLAN will in particular allow the nesting of a photochemistry model covering all of Europe down to an urban grid model covering the Stockholm-Uppsala area. SUDPLAN will considerably deepen local authorities' understanding of the origins of harmful air pollution and therefore help them to formulate adequate action plans for mitigation. This is valid for the present air quality situation, but the possibility to also assess future air quality and its relation to a changed climate will bring completely new information to city planners in the area. The broad cooperation of the Stockholm-Uppsala Air Quality Association, with political decision makers mixed with city planners, air quality experts, health people and industrial representatives makes it possible to rapidly and correctly interpret and take into account SUDPLAN results in the urban planning process.

The advanced 3D visualisation of model results, both generated by the Common Services downscaling model (MATCH) and by SULVF own local models, will facilitate a new and effective way of communicating the expected impact of different urban planning scenarios to external end users.

4. Users

The definition of users for the SUDPLAN pilots and specifically for the Stockholm pilot was formulated during the WP2 “Product Concept and Validation” seminars in Kaiserslautern and Saarbrücken, after interviews with pilot end-users.

4.1. Primary Users

There are two types of users who will make regular and direct use of the Stockholm Pilot system: Stockholm SLB technical/scientific experts and System Administrators.

4.1.1 Technical/Scientific Experts

Stockholm’s air quality analysis is carried out by technical experts from Stockholm SLB. These individuals are very comfortable with computers. As modellers they want to interact with the models used in the pilot. They have sophisticated GIS experience. Their analyses are carried out collaboratively, and the English language may be used. Current staff supporting air quality modelling at SLB:

- Malin Ekman (head of SLB)
- Christer Johansson (Associate Professor, atmospheric chemistry, aerosols, modeller)
- Kristina Eneroth (PhD, atmospheric chemistry, modeller)
- Michael Norman (PhD, atmospheric chemistry, aerosols, measurements)
- Boel Lövenheim (GIS specialist, emission inventories, modeller)

4.1.2 System Administrator

The System Administrator for the SULVF pilot will be an SLB staff member who is comfortable with computers and software installation. They may not be sophisticated GIS users. In general they have no domain knowledge regarding climate or air pollution modelling. Current IT staff supporting air quality management systems at SLB:

- Lars Törnquist (IT specialist, administrates all model systems at SLB including SULVF Airviro)

4.2. Secondary Users

The sole type of secondary user envisioned for the Stockholm pilot consists of managers and planners from Stockholm and the participating neighbouring municipalities, members of the SULVF association. As representatives of this user group, two external end users have been connected to the SUDPLAN project:

- Mrs Marie Westin, Swedish Transport Administration and responsible for environmental aspects of the “Förbifart Stockholm” (Stockholm Transit) project.
- Mrs Marianne Klint, consultant of the WSP Sweden company, responsible for the Environmental Impact Assessment of “Förbifart Stockholm”.

They have been invited and agreed to participate in the evaluation of the SUDPLAN tool in what concerns impact assessment of a road transit project.

4.2.1 Managers/Planners

SULVF Managers and Planners participating in the Stockholm pilot will be shown results by the modellers, and may sit with them at the system itself to engage in "what if" scenario sessions. They may or may not have technical backgrounds, most likely they do not. In general, the English language will be acceptable.

4.3. Tertiary Users

There are three types of tertiary users of the SULVF pilot: city politicians/managers, regulators, and the public. All of these will interact with the system only in the sense that they will be shown results/reports whose content was produced by the system.

4.3.1 City Politician/Managers

The politician/manager will be the recipient of reports generated by primary users of the pilot system. While the content of these reports will in part come from the system, other content and formatting will generally be the product of other tools. The politician/manager is generally assumed to have little to no technical training or knowledge, but will be familiar with the general issues of urban air pollution. In general, the English language will be acceptable.

4.3.2 Regulators

Regulators will receive reports including content from the pilot system. These regulators are likely familiar with the technical aspects of urban air pollution, and may have technical training. The English language will be acceptable.

4.3.3 General Citizen

The general citizen of Stockholm and its neighbouring communities may be provided with information resulting from sessions conducted with the SULF pilot, perhaps through publication on a web site. While the content of these publications will in part come from the system, other content and formatting will generally be the product of other tools. The general citizen is assumed to have no technical training or knowledge, and they may be only slightly familiar with the general issues of urban flooding and property protection. In general all information should be given in Swedish.

4.4. Stakeholders

Since SULVF is an association built up by a wide range of public and private organisations, there are numerous ways to reach external stakeholders which are asking for air quality information. As WP5 is including rainfall downscaling as a second, although not prioritised activity, we will just mention the stakeholder that has expressed – already at project start - an interest in that part of Common services output. This stakeholder is the most important actor in water management in Stockholm.

4.4.1 Stockholm Water company

One stakeholder of the SULF pilot is the Stockholm Water company, responsible for the sewer and runoff systems of the Stockholm area. They will be invited to work together with SUDPLAN partners, using the Common Services downscaling of intense rainfalls. Stockholm Water company disposes and uses hydrodynamic models for the sewer system, for which SUDPLAN time-series of precipitation can serve as input.

5. Pilot Tasks

The task description for the Stockholm pilot was a result of the WP2 "Product Concept and Validation" seminars in Kaiserslautern and Saarbrücken, after interviews with pilot end-users. The tasks describe all activities needed for reaching pilot objectives as outlined in Section 2 (Pilot definition). The tasks are also the basis for the Use-cases that describe the work to be done directly with the SMS of the SUDPLAN platform.

5.1. Decisions/Analyses to be supported

SULVF today has a clear picture of present air quality levels and how they compare to Swedish air quality standards. Air quality maps show that levels of PM10 and NO2 are non-compliant to these standards in many traffic dominated locations in the SULVF area. Hot spots and sources are identified and there exists, as this is compulsory for non-compliant cities, an action plan to mitigate emissions and lower the air pollution levels during coming years. Note that compliance will not only refer to EU air quality standards, as SULVF also must determine compliance with more strict environmental standards and objectives defined on both national and local level.

Expected long term changes in meteorology, background concentrations and emissions, related to a climate change scenario, will have consequences for the possibilities to achieve or maintain compliance of PM10, NO2 and O3. SULVF will use SUDPLAN to investigate the predicted long term trends in air quality, taking climate change into account. Of interest is to determine separately the climate change effects on air quality, as well as the impact on air quality resulting from possible future scenarios of activity patterns, emissions and land use. The changes in land use include the planning of urbanized/industrial/commercial areas, green and forested areas, road/train/boat infrastructure etc.

The climate aspect is of relevance for only a few, rather extreme, emission and land use scenarios. Individual projects like new roads, new house constructions etc. may be evaluated for current conditions. However, SULVF counts on an improved visualisation of different scenarios of the type "with" or "without" planned infrastructure project, contributing to more effective decisions also for studies not oriented to the effect of climate change.

5.1.1 Compliance Assessment

The Compliance Assessment (CA) task is intended to determine the overall air quality in Stockholm in comparison to EU and Swedish regulatory standards and environmental objectives, for present conditions and for a few climate scenarios.

The task assumes that for the Stockholm area:

- A historical year of gridded hourly climate and air quality data should be available
- Measurement data exist that can be used to validate simulated levels for the historical year
- At least two different climate and air quality scenarios (5 or 10 year windows centred in the future) should be available, in order to show the robustness of the climate change prediction

The normal procedure in assessments of future air quality is:

1. Show that your model can produce results for a historical period that compare well with independent measurements. For the downscaling over Stockholm you need boundary values on the European scale and emission data over Stockholm area for the historical period. You also need historical air quality measurements for the validation of the model output.

2. Use your model to simulate future air quality levels. For this you need the climate scenario on the European scale as boundary values and also emission data over Stockholm for future years.

In the following we try to decompose the different tasks and describe them in more detail. The Stockholm pilot aims at the support of the following tasks, to be accomplished during the three years of SUDPLAN activities.

Task	1 Develop emission and land use scenarios
Description	Develop consistent (in the meaning comparable, with the same degree of detail etc) emission and land use scenarios for present and at least two future occasions. The present scenario should already be available (this is part of SULVF normal activity), but the future scenarios will define the different urban planning options that SULVF can foresee. This means mapping future residential areas, industries, transport systems etc, together with activity data and emission factors.
Actor	Primary users at SULVF (SLB) Secondary users involved in planning e.g. new transit road project
Goal	Consistent emission databases and maps over the Stockholm area stored in SULVF Airviro system, for present conditions and for at least two future scenarios.
Input	Existing SULVF emission inventories, regional plans, emission factors from Swedish National Road Administration and other sector institutions.
Output	A number of Emission Databases (EDBs) in Common Services Airviro database, selectable through the SUDPLAN GUI.
Components	Editing of emission scenarios and creation of land use maps will be made outside SUDPLAN platform
Constraints	

Task	2 Make physiographic data and 3D map available to SUDPLAN platform
Description	Make physiographic data (land use, roughness etc) and 3D map (buildings, topography) available to SUDPLAN platform, for present and for relevant future scenarios, to be used as input to the MATCH model used for the pilot

	specific 3D high resolution air quality modelling and also for visualisation in the SMS.
Actor	Primary users at SULVF(SLB)
Goal	Land use and maps stored in Airviro, accessible for SUDPLAN high resolution model execution and visualisation
Input	3D city map is available (but with costs) for part of the city centre, consisting of laser scanned 3D building cubes and a grid of ground elevations with 5 m resolution. Physiographic data can be generated from land use maps (task 1).
Output	All necessary 3D grids and maps stored accessible to CS and/or SMS, where so required for model execution and visualisation.
Components	
Constraints	3D visualisation to be made in WGS84 projection (SULVF models work on UTM projections).

Task	**3 CS downscaling for historical period**
Description	CS Air Quality downscaling for a historical period
Actor	Primary users at SULVF (SLB), SMHI
Goal	Generate simulated data that can be compared to monitored historical data.
Input	Pre-calculated MATCH model results on the European scale for a particular year. Emission database for the same year.
Output	Gridded air quality concentrations (hourly data during specific year, different averages obtained after post processing)
Components	SMS, CS, Super computer centre for model runs.
Constraints	Model runs on super computer has to be approved in advance by the Consortium, so that sufficient computing resources can be allocated.

Task	**4 Evaluation of model performance for historical period**
Description	Evaluation of the CS Air Quality downscaling model for a historical period. Simulated data from a monitor location will be compared directly to measurements from that site, this for a given historical period.
Actor	Primary users at SULVF (SLB), SMHI
Goal	Confidence in quality of input data and model tool.
Input	Model results for a historical period (Task 3). Measured air quality data from the same year.
Output	Statistical measures expressing model performance (as compared to monitored

	values).
Components	SMS, CS
Constraints	Differences between model calculation and experimental data might be considerable for some pollutants and for some stations. Use standard statistics recommended by EU to quantify model quality.

Task	**5 CS downscaling for climate scenarios**
Description	Running CS Air Quality downscaling model for various climate scenarios. Understanding variability in Stockholm air quality between different climate scenarios as well as variability due to different local emission scenarios
Actor	Primary users at SULVF (SLB), SMHI Secondary users involved in planning e.g. new road transit project
Goal	Generate long term simulations (5 year windows) of air quality levels during the period 1980-2050
Input	Pre-calculated MATCH climate scenario results on the European scale. Emission databases selectable in SULVF Airviro representative for the time window to be simulated (possibly various emission scenarios to be evaluated for each time window).
Output	Gridded air quality concentrations (hourly data, different averages obtained after post processing)
Components	SMS, CS, Super computer centre for model runs.
Constraints	

Task	**6 Compliance assessment including climate change effects**
Description	Evaluation of climate scenario simulations of downscaled air quality over Stockholm, analysing trends and compliance with present legislation and environmental objectives.
Actor	Primary (SLB) and secondary users at SULVF (Swedish Road Administration, municipalities, etc)
Goal	Quantitative information on future air quality for different climate scenarios and different future emission scenarios for Stockholm.
Input	Downscaled model results. Air quality standards and environmental objectives expressed as annual averages or percentiles.
Output	Statistical measures expressing compliance or non-compliance.
Components	SMS, CS

Constraints	

Task	**7 Local model application: 3D high resolution modelling**
Description	High resolution air quality modelling over Stockholm for a historical period and/or for a climate scenario time window, performed with SULVF's Airviro models and the result transferred on specified format to SUDPLAN SMS.
Actor	Primary (SLB) and secondary users at SULVF (Swedish Road Administration, municipalities, etc)
Goal	Hourly high resolution (50-200 m) gridded data and street canyon results for periods up to a historical year and/or a time period window from some climate scenarios, presented in 3D visualization where also buildings can be seen.
Input	3D city map is available for the city, consisting of 2D building polygons with heights given as attribute. Simulated air pollution in 3D grid (typically 100x100 m spatial resolution) plus street side concentrations on major roads (two pavement concentrations per road link/block), generated outside SUDPLAN. Results from CS air quality downscaling (Task 5) needed to extract air pollution contribution in incoming air, to be added to local model results.
Output	3D air pollution levels and street canyon results imported to SUDPLAN SMS and presented over 3D city map using format specified by SMS.
Components	SUDPLAN UI, SMS, CS, SULVF Airviro system
Constraints	Local high resolution models will be executed outside SUDPLAN, but results will be managed, analyzed and visualised in SUDPLAN SMS.

Task	**8 Downscaling of intense rainfall**
Description	Downscaling of intense rainfall for at least two climate scenarios
Actor	Primary user at SULVF (SLB) Primary and secondary users at stakeholder Stockholm Water company
Goal	Downscaled high time resolution precipitation data (time-series of 15 min for different climate scenarios 1980-2050) for locations where historical high temporal resolution data are available.
Input	Historical high temporal resolution precipitation data from Stockholm-Uppsala area.
Output	High resolution precipitation data extending into future according to different climate scenarios
Components	SMS, CS

Constraints	The results will be generated, analyzed and presented together with Stockholm Water company, stakeholder but not a formal SUDPLAN partner

5.1.2 Urban Scenario Evaluation

The Urban Scenario Evaluation (USE) task is intended to build on the performance evaluation capability of the CA task and further allow the analyst to consider the differences on air quality impact of different scenarios. The scenarios will be of three types:

- Comparison between two time windows from the same climate and air quality scenario (e.g. between a 5-year averages centred at 2030 and 2010)
- Comparison between two climate and air quality scenarios, within the same time window (e.g. 5-year averages centered at 2030)
- Comparison between two urban scenarios, for the same climate and air quality scenario

The presentation of the differences will allow a better decision support for non-modelling urban planners, allowing a rating of the degree of sustainability – in the air quality meaning - of different future scenarios.

Task	**1 Urban Scenario Evaluation**
Description	Assess the effects on air quality of different local scenarios for urban planning and emissions, today and in the future with different climate change signals.
Actor	Primary (SLB) and Secondary users at SULVF
Goal	Facilitate a basis for recommendations on sustainable urban planning solutions (transport, industry, residential areas etc) that can assure a good air quality.
Input	One or various results (from Common Services or from high resolution with local model)
Output	Visualised differences (2D/3D/4D)
Components	SMS, CS, visualization tools
Constraints	

6. Use-cases

Use-cases will be used to describe, in a format understandable both for end-users as well as IT developers, the actions and functionality expected to be accessible through the SUDPLAN SMS. They reflect the earlier task description in section 4, but omit work and actions taken outside the SUDPLAN platform.

Use-cases are identified as UC-XYZ, where the last three numbers have the following meaning:

X – Pilot work package number (e.g. 5 for Stockholm)

Y – Application process number (e.g. 1 for the current)

Z – Use-case number (given in order starting from 1)

6.1. Narrative explanation of use-cases

Table 1 shows an overview of the use-cases formulated for the Stockholm pilot application of the SUDPLAN tool, to be completed during the final project year (2012). The first four use-cases are based on Common Services functionality, while the fifth involves the generation and 3D visualisation of high resolution local model results generated outside SUDPLAN.

Change in V2: The UC-512 "Post-process model results" has been eliminated, as all downscaled air quality results will be automatically post-processed as part of model execution.

Change in V3: The UC-511 "Visualise air quality model results" has been separated in two use cases UC-511a "Visualise CS air quality results on the Pan-European scale" and UC-511b "Visualise CS air quality urban downscaling result". The reason is that the technical solution is different (the PE visualisation is based on WMS images, while the downscaling results are available as gridded data). This means that use case extensions will differ.

Change in V3: The UC-531 "Local 3D model execution" has been changed to "Visualisation of local model results", this since local model execution will not be part of the Stockholm pilot application of the SUDPLAN tool.

Table 1 Overview of use-cases for Stockholm pilot definition plan V2

Use-case	Part of Common Services	Objective
UC-511a "Visualise CS air quality results on the Pan-European scale"	Climate scenario information on the European scale	Visualise distribution and trends of air quality model results (European scale)
UC-511b "Visualise CS air quality urban downscaling results"	Air Quality Downscaling service	Visualise distribution and trends of air quality model results (downscaled over Stockholm)
UC-513 "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
UC-521 "Execute air quality downscaling"	Air Quality Downscaling service	Start an air quality downscaling simulation over pilot city area
UC-531 "Visualisation of local model results"	Air Quality Downscaling service	Via SMS user interface, import 2D/3D grid model and street model result files for 3D visualisation.

6.2. Detailed description of use cases

6.2.1 UC-511a "Visualise CS air quality results on the Pan-European scale"

Acronym	
	UC-511a
Description	
	The user wants to access air quality model results for different climate scenarios for visualisation and analysis in the scenario management system. Therefore the system shall present the user with a list pre-calculated model results for the whole of Europe. The results will be presented to the user in form of maps with the spatial distribution of pollutants. Time series diagrams will be possible for user-defined locations.
Primary actor	
	Primary users at SULVF (SLB)
Stakeholder	
	SULVF and urban planners connected to SULVF members
Goal	
	Visualisation of available air quality results, export of visualised results
Input	
	List of available model results (gridded data) List of air pollutant (variables) available in the model results
Output	
	Raw data model results (air quality grids) Map showing distribution of selected air pollutant at a certain time Time-series graph showing temporal evolution at certain location
Components	
	SMS, CS
Preconditions	
	User properly logged in with access to CS controls for air quality
Main success scenario	
1	The user selects the desired air quality model results from a list of available results
2	The user selects the pollutant of the model result to be displayed
3	The system displays the requested model results in the map
Extensions	
3a	The user can change the time point of the simulation currently shown in the map.
3b	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.
3c	Export visualised model time series to other formats (Excel etc.)

6.2.2 UC-511b “Visualise CS air quality urban downscaling results”

Acronym	
	UC-511b
Description	
	The user wants to access air quality model results for different climate scenarios for visualisation and analysis in the scenario management system. Therefore the system shall present the user with a list of available results already downscaled over the city (see UC-521). The results will be presented to the user in form of maps with the spatial distribution of pollutants and time series diagrams.
Primary actor	
	Primary users at SULVF (SLB)
Stakeholder	
	SULVF and urban planners connected to SULVF members
Goal	
	Visualisation of available air quality results, export of visualised results
Input	
	List of available model results (gridded data) List of air pollutant (variables) available in the model results
Output	
	Raw data model results (air quality grids) Map showing distribution of selected air pollutant at a certain time Time-series graph showing temporal evolution at certain location
Components	
	SMS, CS
Preconditions	
	User properly logged in with access to CS controls for air quality
Main success scenario	
1	The user selects the desired air quality model results from a list of available results
2	The user selects the pollutant of the model result to be displayed
3	The system displays the requested model results in the map
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 time series to other formats (Excel etc.)
3d	Export visualised model grid results in other formats (Excel etc.)
3e	Perform simple mathematical operations with one or multiple gridded results (e.g. difference between two results)

6.2.3 UC-513 “Add monitor data to compare with model results”

Acronym	
	UC-513
Description	
	The actor wants to compare air quality models results together with historical sensor data (monitored air quality) in order to validate the model output and create confidence in later climate scenario downscaling. The comparison could include some statistical output for each time series such as averages, standard deviations etc. The actor eventually also want to export both model and sensor data.
Primary actor	
	Primary users at SULVF (SLB)
Stakeholder	
	SULVF
Goal	
	Simultaneous graphic visualisation to compare simulated and monitored air quality data, allowing an evaluation of the quality of the simulated results.
Input	
	Model results for a historical period displayed as in UC-511a and UC-511b. Monitor data from the same area of interest to be used as a reference for evaluation of model results.
Output	
	Simulated and monitored values presented in the same graphs, allowing a statistical comparison.
Components	
	SMS, CS, access to database with monitor data
Preconditions	
	User properly logged in with access to CS controls for air quality and model result files as in UC-511a and UC511b. List of monitored stations and variables available for selecting the proper data to compare to model results.
Main success scenario	
1	Import of local time series from measurement station to SMS repository, add to SMS list of available monitor data
2	In SMS list of available monitor data, select monitoring station of interest
3	Drag data/station into the map
4	Show available information for the monitoring station
5	Define period of time to be plotted
6	Plot time series of monitor data together with model results for comparison purposes
Extensions	
6a	Export time-series visualised in the graph to EXCEL or other external format

6.2.4 UC-521 "Execute air quality downscaling"

Acronym	
	UC-521
Description	
	The actor wants to start a downscaling scenario execution from the SMS, using the CS air quality downscaling option.
Primary actor	
	Primary users at SULVF (SLB)
Stakeholder	
	SULVF and urban planners connected to SULVF members
Goal	
	Successful downscaling of air quality over Stockholm
Input	
	List of European scale model result files to be used as boundary conditions (can be either historical years or climate scenario long term simulations). List of emission databases covering the downscaling area, each representing a particular time window.
Output	
	Model executes as a batch job, yielding status and termination notifications. Result grids stored in CS database.
Components	
	SMS, CS, Super computer
Preconditions	
	User properly logged in with access to CS controls for air quality downscaling. User has prepared at least one emission database in the CS database (Stockholm uses Airviro interface for this purpose) Consortium has been given full privileges for the user to launch a model simulation on a super computer.
Main success scenario	
1	Define area interest / bounding box in which downscaling simulation will take place
2	Select one European scale air quality result from list of available simulations to be used as boundary conditions (can be a shorter historical period or a long term climate scenario result).
3	Define time period for simulation (maximum one calendar year)
4	List available emission databases, one database to be selected.
5	Execute downscaling (batch job, i.e. job will run independently from SMS activity, informing on job status and when completed)
Extensions	

6.2.5 UC-531 "Visualisation of local model results"

Acronym	
	UC-531
Description	
	The actor wants to import local model results to advanced 3D visualisation in SUDPLAN SMS.
Primary actor	
	Primary users at SULVF (SLB)
Stakeholder	
	SULVF and urban planners connected to SULVF members, city residents
Goal	
	High resolution model results visualised together with 3D building map.
Input	
	2D/3D shape files of gridded model results or shape files of road link data (street model), both in format and projections required by SMS
Output	
	Advanced 3D visualisation of model results together with a 3D building map.
Components	
	SMS
Preconditions	
	User properly logged in User has prepared local model results in the required format.
Main success scenario	
1	Import of new local model results to SMS repository, add to list of available model results to be displayed with 3D visualisation
2	In the list of available model results, select the one to be displayed in 3D
3	3D visualisation
Extensions	
3a	Possibility to set colours, change viewpoint etc
3b	Possibility to create a standard image (e.g. GIF, JPG) to be stored on local disc.

7. Conclusions

This document contains the final definition plan V3 for the SUDPLAN Stockholm pilot, which focuses on air quality management. It details the background, objectives and task for this work package (WP5), what was achieved during V1 (2010) and V2 (2011) and it specifies the activities that have to be completed during V3 (2012).

The V3 activities are defined under Section 3.6.1 "Using Common Services":

- 3.6.1.1 Presenting climate scenario information on the Pan-European Scale
- 3.6.1.2.1 Intense rainfalls (urban downscaling)
- 3.6.1.2.2 Intense rainfall: Design Storm Generator
- 3.6.1.3 Air quality: urban downscaling

where the results of the rainfall simulations will be handed over to a water management stakeholder outside SUDPLAN (the rainfall downscaling is evaluated by two other pilots).

V3 work is also defined under Section 3.6.2 "Use of local models":

- 3.6.2.1 3D city map
- 3.6.2.2 High resolution grid model simulation
- 3.6.2.3 Street canyon model simulations

The last V3 activities are defined under Section 3.6.3 "Scenario evaluation and visualisations for urban planning":

- 3.6.3.1 Creation of different urban planning scenarios
- 3.6.3.2 Model simulation of urban planning scenarios

The completion of those activities will be evaluated in the final D5.2.3 Stockholm pilot report V3. The end-user driven IT development in WP3 should also permit the Stockholm pilot to demonstrate five use cases:

- UC-511a "Visualise CS air quality results on the Pan-European scale"
- UC-511b "Visualise CS air quality urban downscaling results"
- UC-513 "Add monitor data to compare with model results"
- UC-521 "Execute air quality downscaling"
- UC-531 "Visualisation of local model results"

8. References

Berkowicz R. (2000). OSPM – a parameterised street pollution model. Environmental Monitoring and Assessment, 65, p 323-331.

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SUDPLAN documents referenced:

DoW, Description of Work with date December 01, 2010

D4.1.2 Concerted Approach V2 (delivery date M25)

D4.2.2 WP4 Common Services: Rainfall Downscaling Service V2 (delivery date M25)

D4.4.2 WP4 Common Services: Air Quality Downscaling Service V2 (delivery date M25)

D5.2.2 Stockholm Pilot V2 (delivery date M24)

9. 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.

10. 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.
GHG	GreenHouse Gases
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

