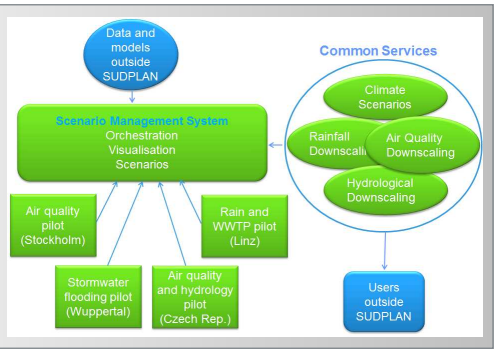
Assessment of Future Urban Air Quality considering Climate Change Effects

SUDPLAN

Introduction

SUDPLAN is an EU FP7 project under the Information Communication Technology Programme (ICT-2009-6.4 ICT for Environmental Services and Climate Change Adaptation). The goal is the development of a decision support and training tool to support urban planning. The project addresses the environmental impacts of stormwater flooding, hydrological conditions and air quality in the urban or metropolitan environment, under present and future conditions and taking into account climate change scenarios. Cornerstones are the *Scenario Management System* with the user interface and the *Common Services* with climate scenarios and downscaling models [1].

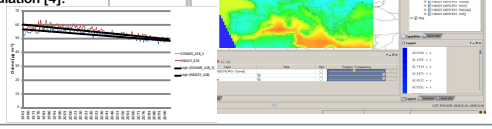
The scope of the SUDPLAN system is to facilitate assessments where the global-scale climate change signal and other large scale factors can come into local urban planning scenarios. The environmental aspect of urban planning deals with local mapping of critical areas in the city (hot spots) which mainly depend on local conditions, but which are affected by processes and conditions that occur on scales larger than the city. The use of multiple climate scenarios (ensemble approach) will indicate the robustness of model output.



Scenario Management System

The *Scenario Management System* provides a common GUI organising and providing background information and downscaling models to users in European cities. It gives access to climate scenarios and hydrological/air quality model output on the European scale. Local models e.g. for sewage systems, surface runoff or local scale dispersion can be wrapped into the system to receive input data from *Common Services* downscaling models.

Common Services visualisation of air quality projections based on regionally downscaled climate scenarios [2]. Ozone ten-year averages centered 2030 span 49-94 µgm^{-3}, based on ECHAM5 A1B-r3 [2] output and RCP4.5 [3] emissions used as input to the (offline) CTM simulation [4].

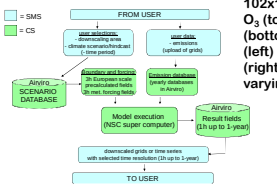


Annual average ozone levels in Stockholm for the period 1960-2100, output from CTM European scale model with RCP4.5 time varying emissions and constant hemispheric boundaries [4].

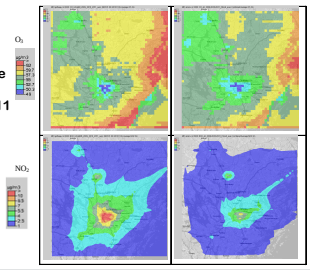
Common Services air quality downscaling

Current air quality scenarios on the European scale have a spatial resolution of 50x50 km^2. SUDPLAN allows a downscaling simulation over a city using a grid resolution down to 1x1 km^2. The downscaling is only meaningful if the user provides local emissions with a corresponding spatial resolution.

Overview of downscaling procedure in Common Services

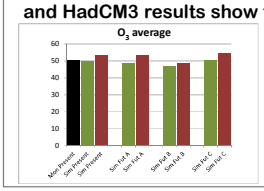


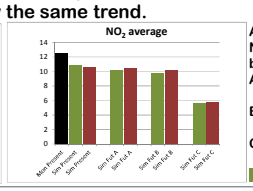
Downscaled results over Stockholm-Uppsala domain 102x102 km^2. Average O_3 (top) and NO_2 (bottom) for 2009-2011 (left) and 2029-2031 (right), using time varying emissions .



Future urban background levels in Stockholm

Downscaling simulations have been performed with forcing from two climate scenarios, for a present (2009-2011) and future (2029-2031) three-year period. European emissions have evolved according to the RCP4.5 emission scenario. Stockholm emissions are as present (database 2010) and for a future scenario based on existing road network but considering planned changes in residential areas and work places. Resulting concentrations in the city centre (roof top monitor) show that the model simulates present conditions in line with monitor levels. Future NO_2 levels will be significantly lower, while O_3 levels will be similar as today. ECHAM5 and HadCM3 results show the same trend.





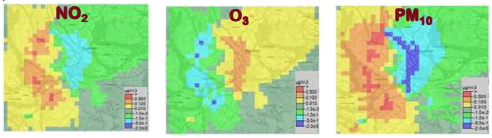
Annual averages of O_3 (left) and NO_2 (right) at a city center urban background monitor station.
A: only climate change, all emissions at 2010 level
B: climate change plus changed European emissions
C: climate change plus changed European and local emissions
ECHAM5 HadCM3

Case study: Planned transit road for Stockholm

SUDPLAN downscaling has been used to assess two future 2030 scenarios, one with expected traffic increase on current road network (Reference) and one where the transit traffic is taken west of the city (planned transit road project).

Western part of Stockholm with major roads as of today (black) and two planning alternatives for north-south transit through the city (red and yellow lines). Broken lines indicate passage through tunnels. The alternative assessed here below is the westernmost marked in red.

Differences in annual average concentrations between future scenarios "transit road project" and "Reference". Simulation made with 1x1 km^2 spatial resolution.



Conclusions

European scale simulations based on ECHAM5 A1B and HadCM3 A1B both indicate lowered O_3 and NO_2 concentrations in long-range transported air arriving to Stockholm around year 2030. Downscaled urban background concentrations of NO_2 will be significantly lower due to a cleaner Stockholm vehicle fleet, while city centre O_3 will be similar to today or slightly increase due to the lowered NO emissions. Climate change effects are included in this assessment, but its effect on O_3 and NO_2 levels are small compared to the effect of expected changes in precursor emissions in Europe and in Stockholm (see also regional summer ozone study [4]).

An impact assessment of two 2030 scenarios shows that a planned road transit will reduce NO_2 and PM_{10} levels in the city centre, but will instead increase the levels to the west of the city. O_3 changes are anti-correlated to NO_2 changes, as O_3 is consumed by traffic NO emissions. A future study will compare differences in population weighted exposure for these two road alternatives. Absolute PM_{10} levels for 2030 have not been possible to assess, as there are large uncertainties in the future evolution of important parts of PM, e.g. organics and sea salt.

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PROJECT COORDINATES

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Duration: 36 months

http://sudplan.eu

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