

High-resolution photochemical modeling of air quality in Stockholm -Current and future situation

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Vision for Stockholm 2030 growth & sustainable development

- 150 000 more citizens
- Denser city
- Green belts
- Sustainable housing and workplace areas
- Recycling of waste
- New traffic systems / traffic solutions
- Fossil free 2050

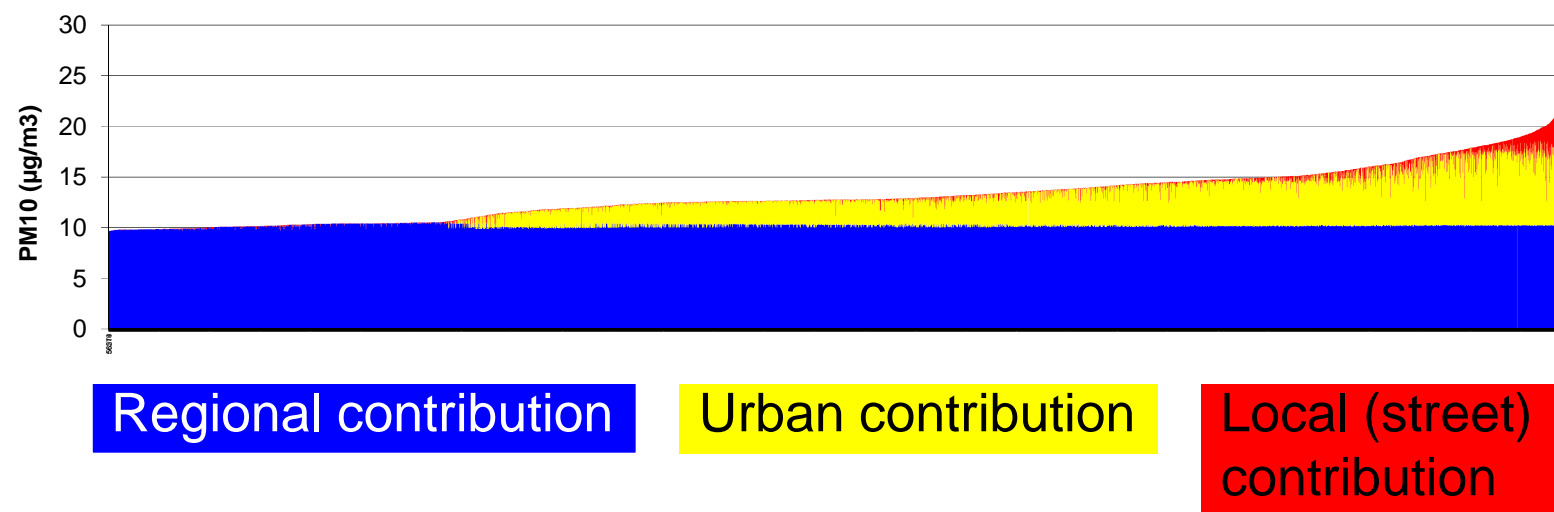


Various factors influence future urban air quality



- **Locally:** City population growth, design of transportation and energy production systems
- **Regionally:** International efforts to mitigate pollutant emissions (to curb acidification, eutrophication etc.)
- **Worldwide:** Background concentrations, climate change

Simulated annual average PM10 in ~6000 home addresses in greater Stockholm

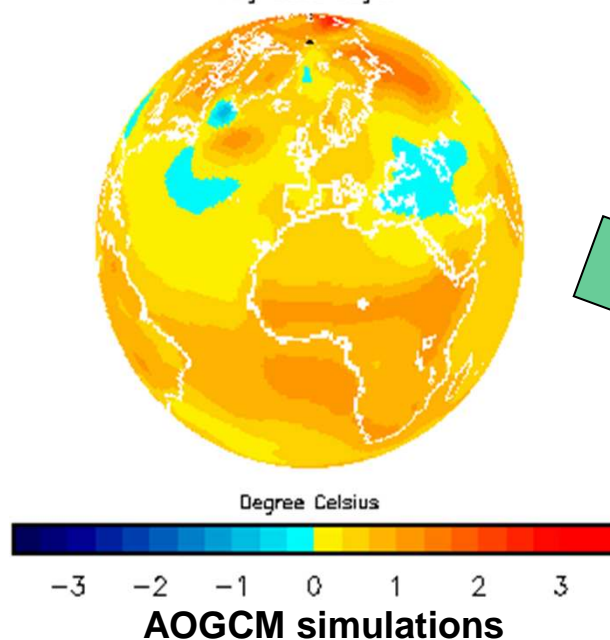


Gidhagen et al. (manuscript)

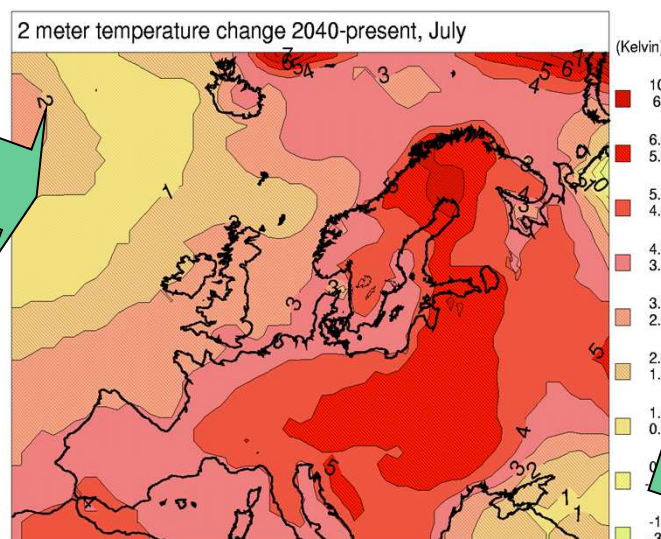
Impact of climate change on regional air pollution over Europe

Global climate change

SUL expt - temperature at 1.5m
From 1/ 9/1980 to 1/ 9/1990
Avg=0.539 Deg C

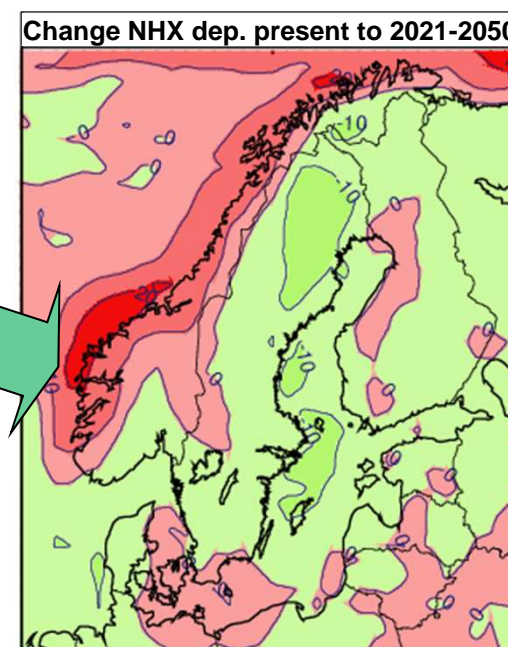


Regional climate change



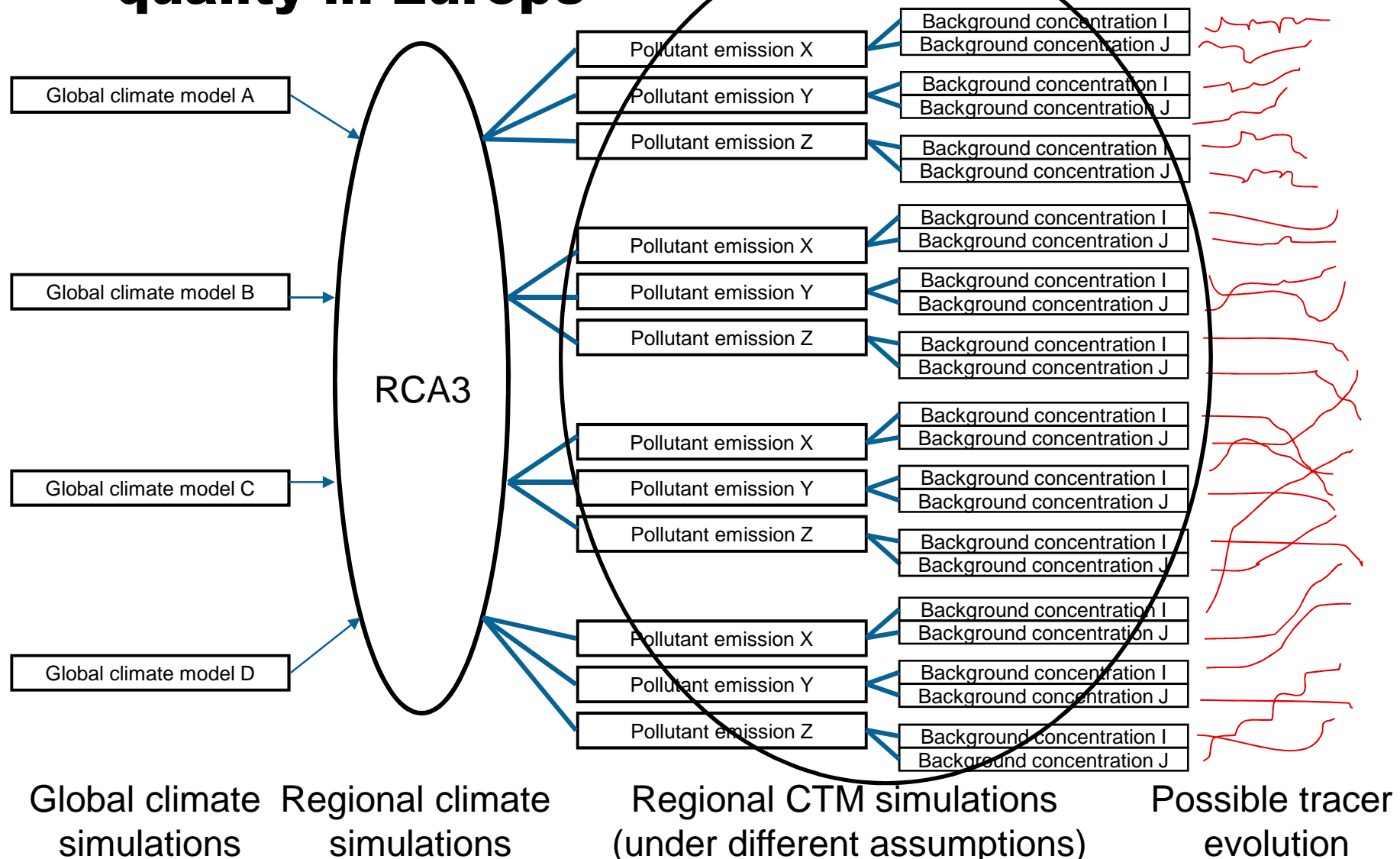
Dynamical downscaling using RCA,
Rossby Centre, SMHI

Impact on air pollution



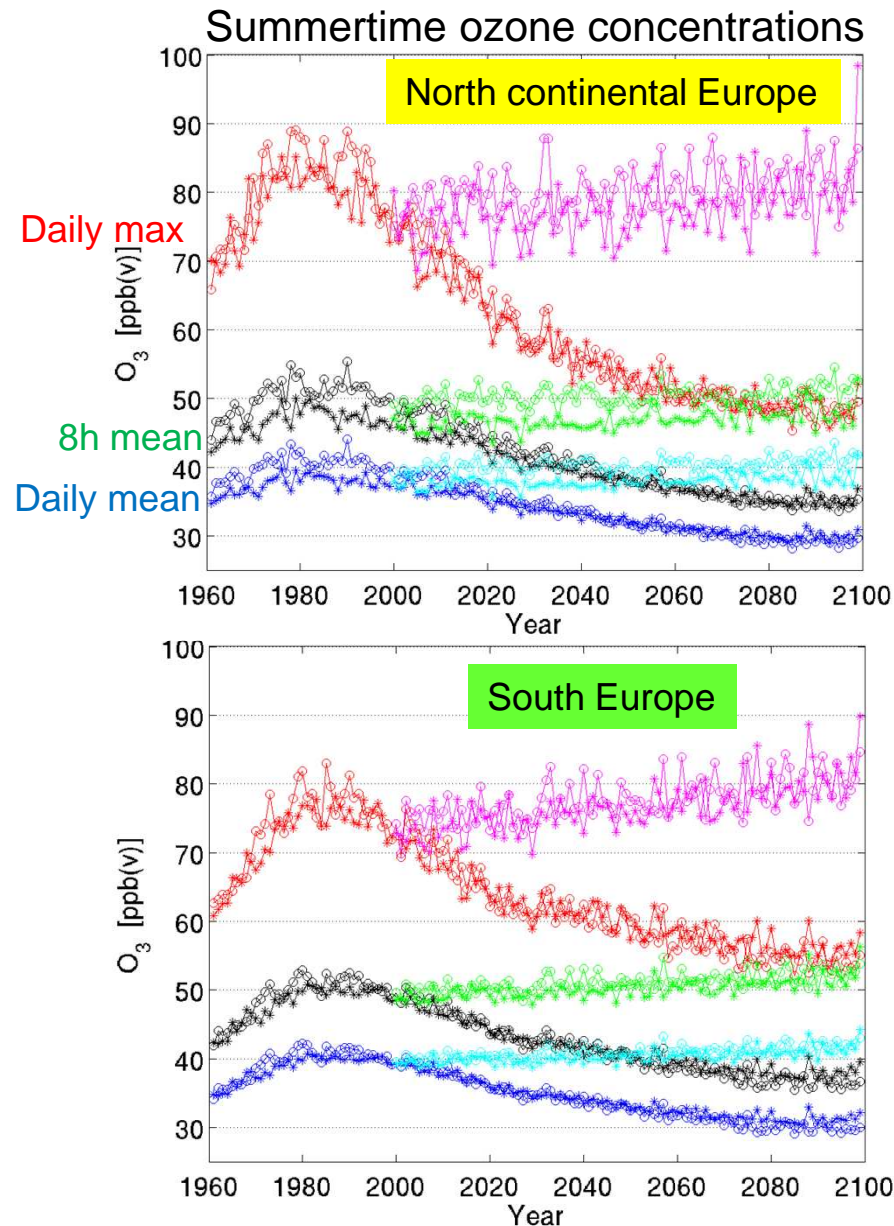
MATCH, off-line CTM

Assessing uncertainties in future air quality in Europe



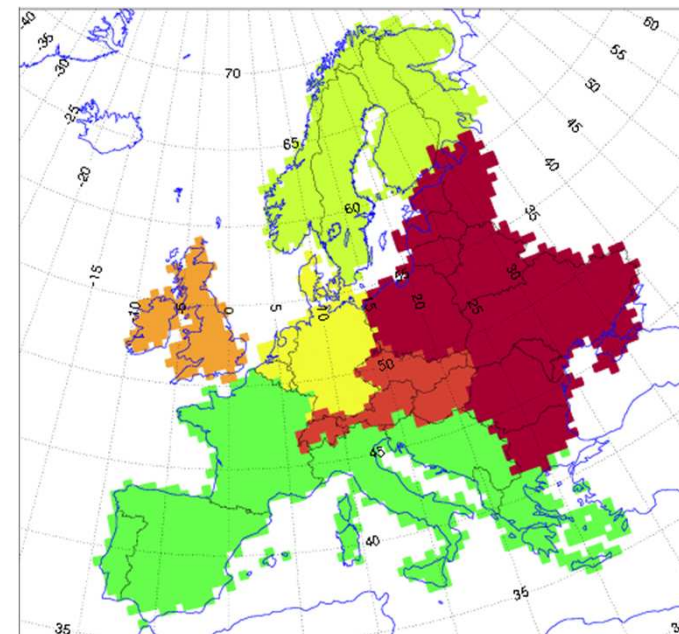
Simulated near-surface ozone

SUDPLAN

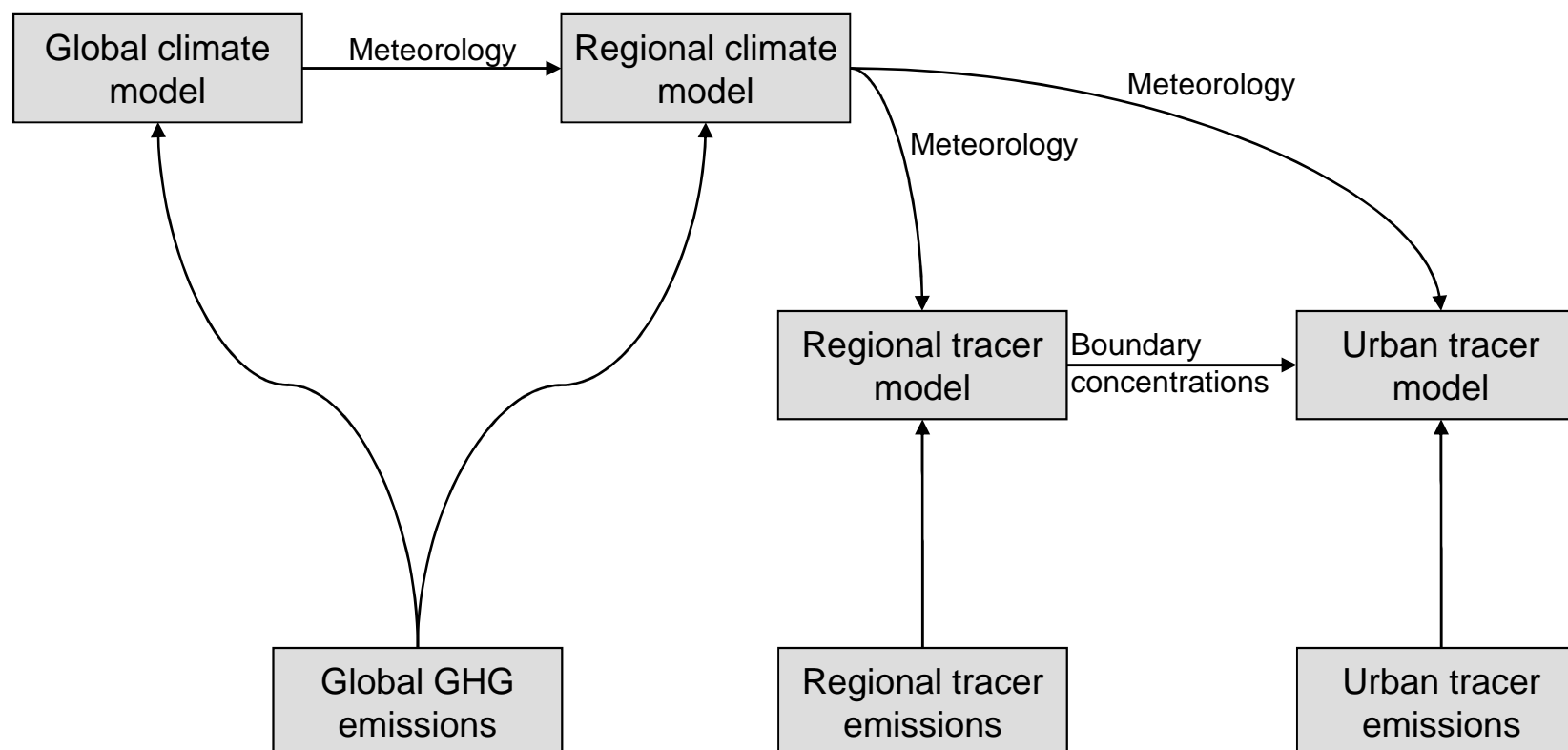


Different climate realisations and different assumptions of future European pollutant emissions (time varying RCP4.5 or held constant at ~2000 levels).

- o- HADCM3 A1B
- *- ECHAM5 A1B



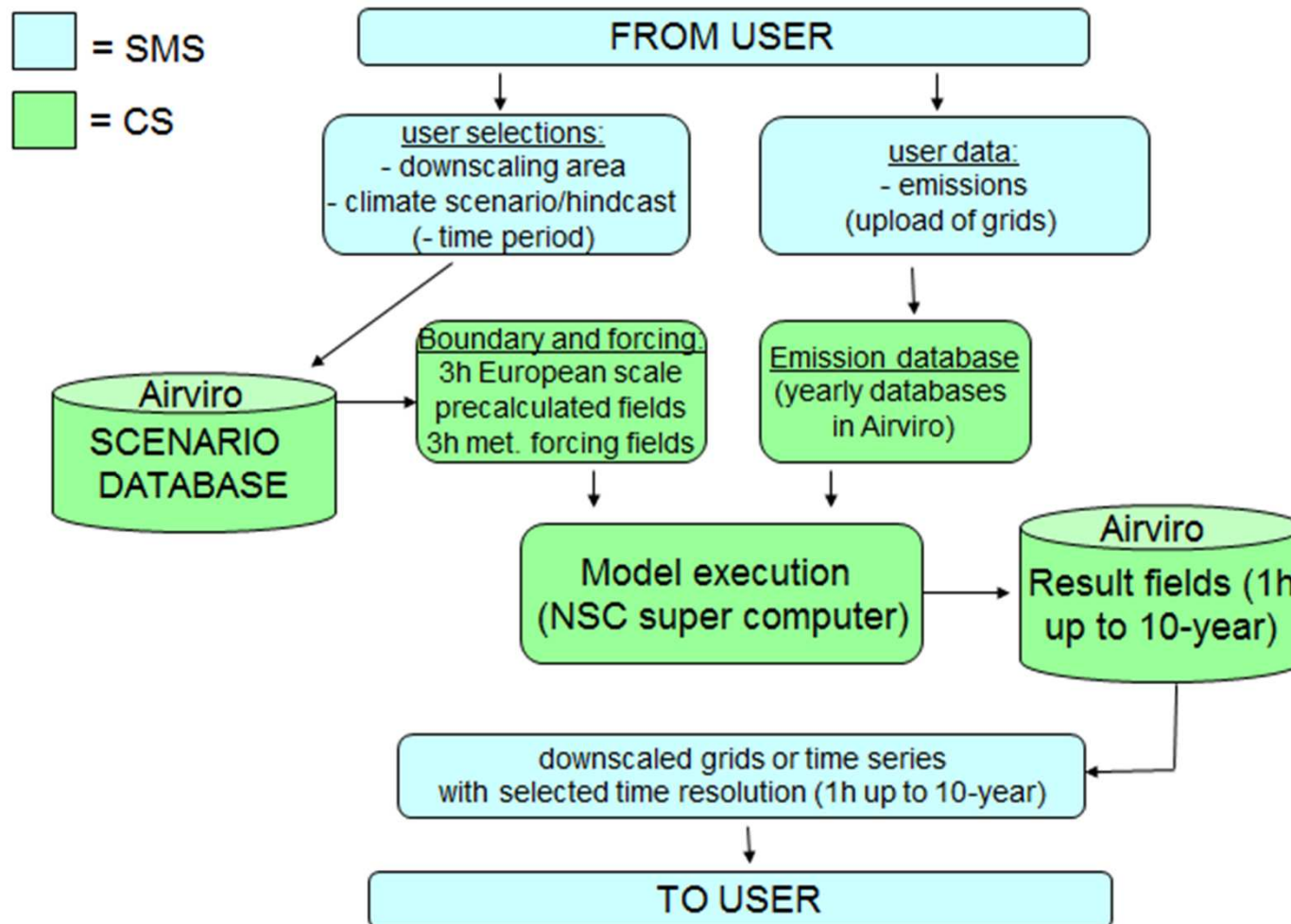
Nesting of air quality models to urban scale



Data flows for an air quality downscaling in **SUDPLAN**

User input: Emissions NO_x, NH₃, VOC, SO₂, CO and PM₁₀

Output: Concentration levels of NO_x/NO₂, O₃, SO₂ and PM₁₀

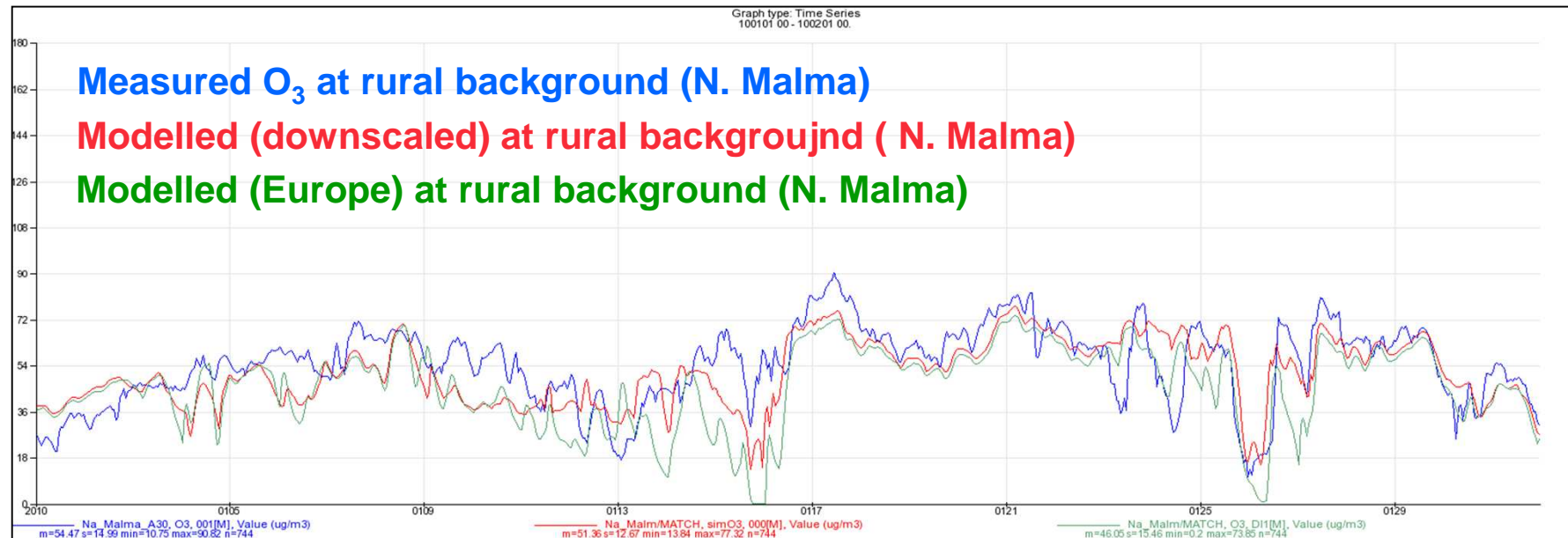
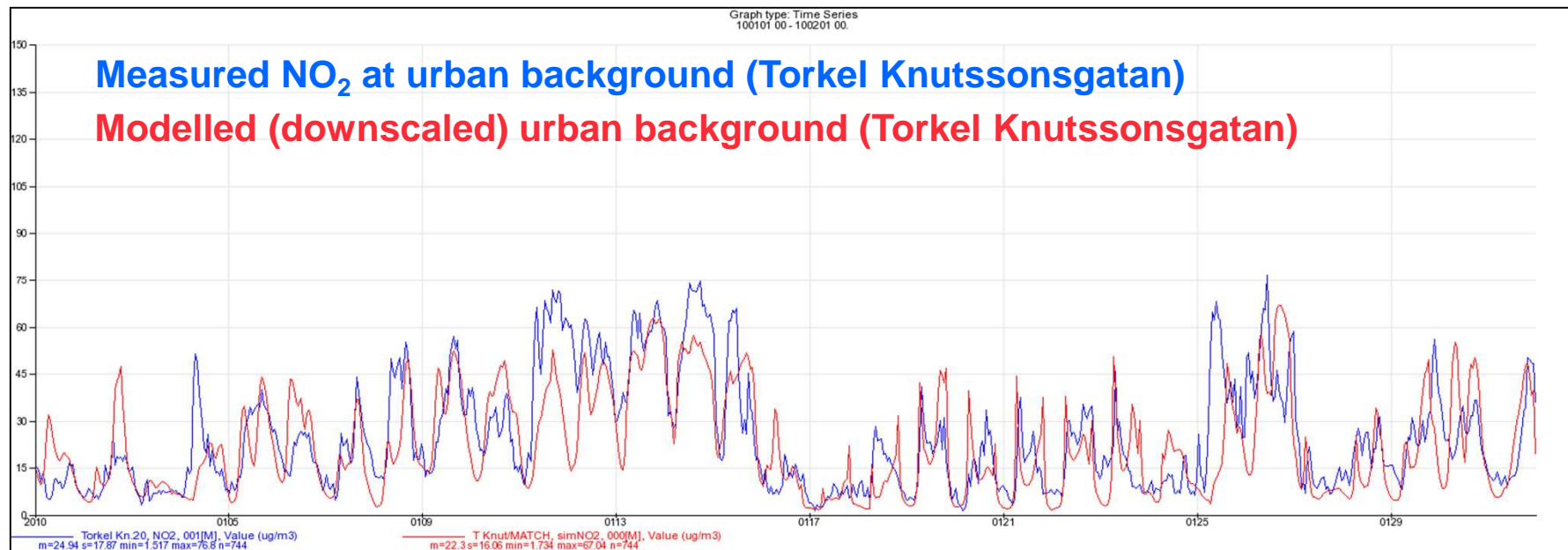


Air quality model evaluation

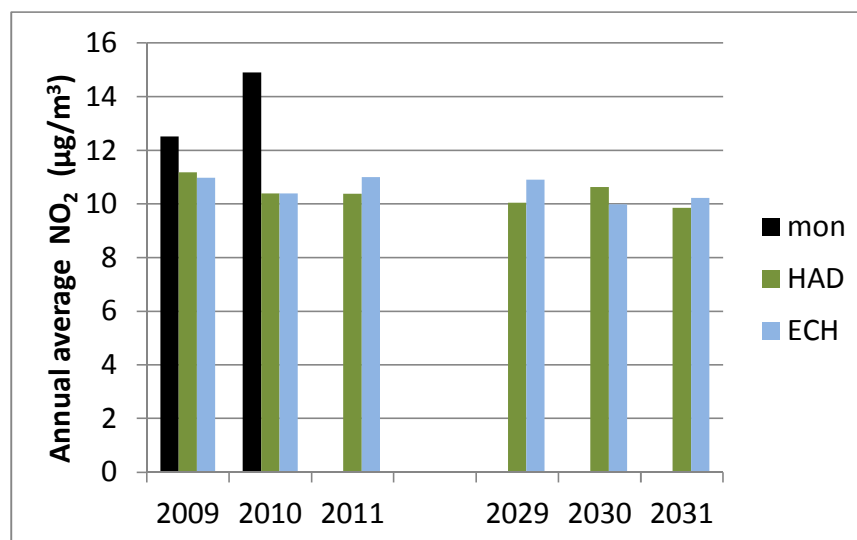
- 1) Run model with observed meteorology for a recent period. Use emissions valid for that period. Compare hour-to-hour with observations.
- 2) Run model with meteorology from a climate model simulating a recent period. Use emissions valid for that period. Compare averages with observations

Hour-to-hour January 2010

SUDPLAN

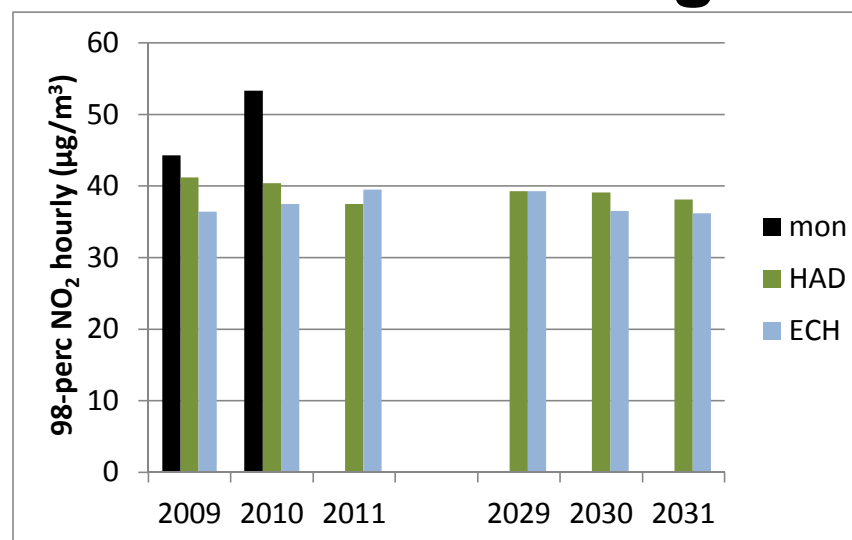


Urban background concentrations of NO₂ in the center of Stockholm. Climate data.



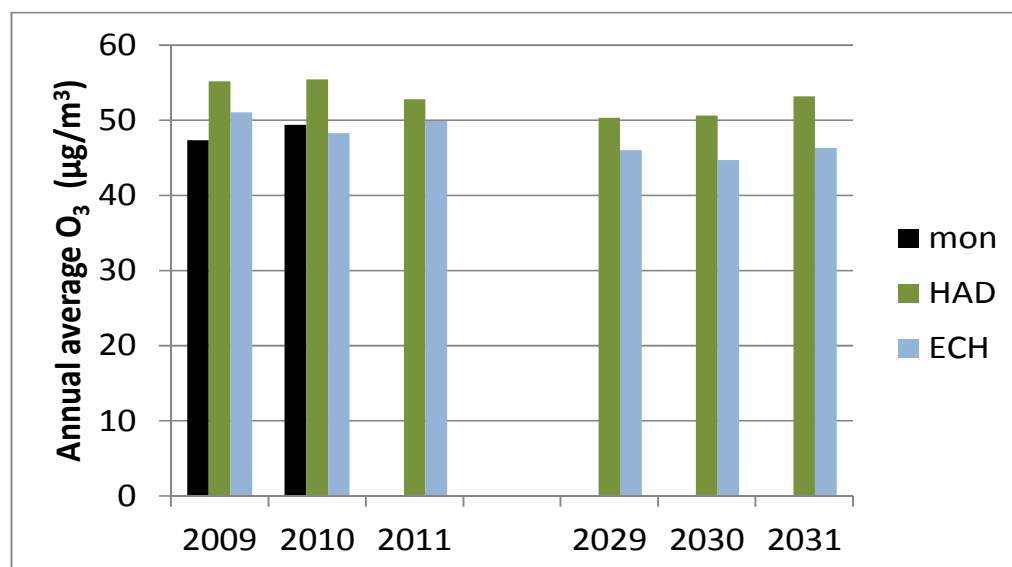
Annual averages

Torkel Knutssongatan



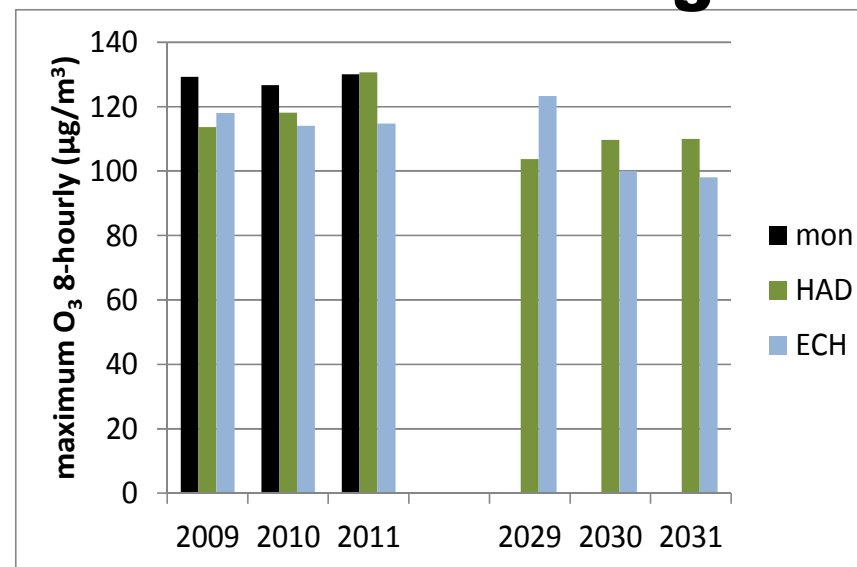
98-percentile of hourly values

Urban background concentrations of O₃ in the center of Stockholm. Climate data.



Annual averages

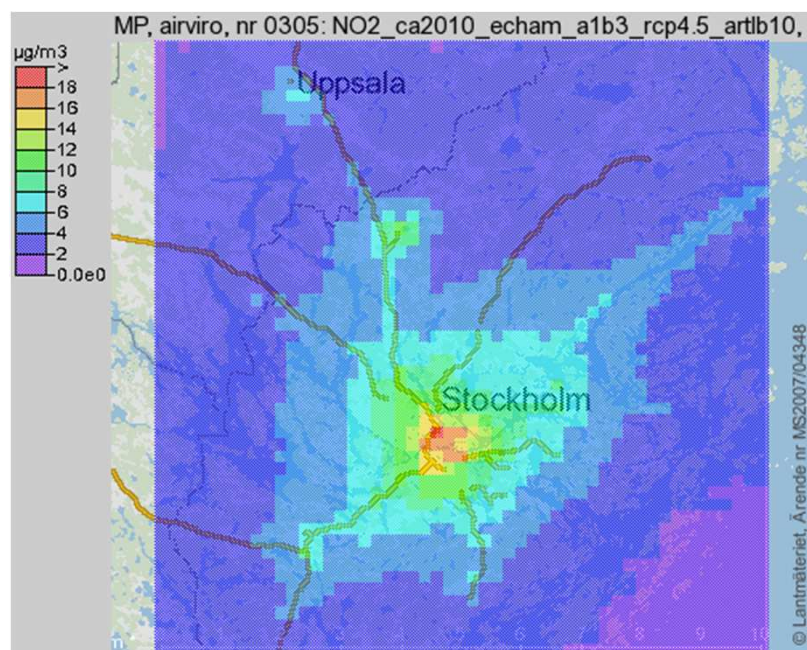
Torkel Knutssongatan



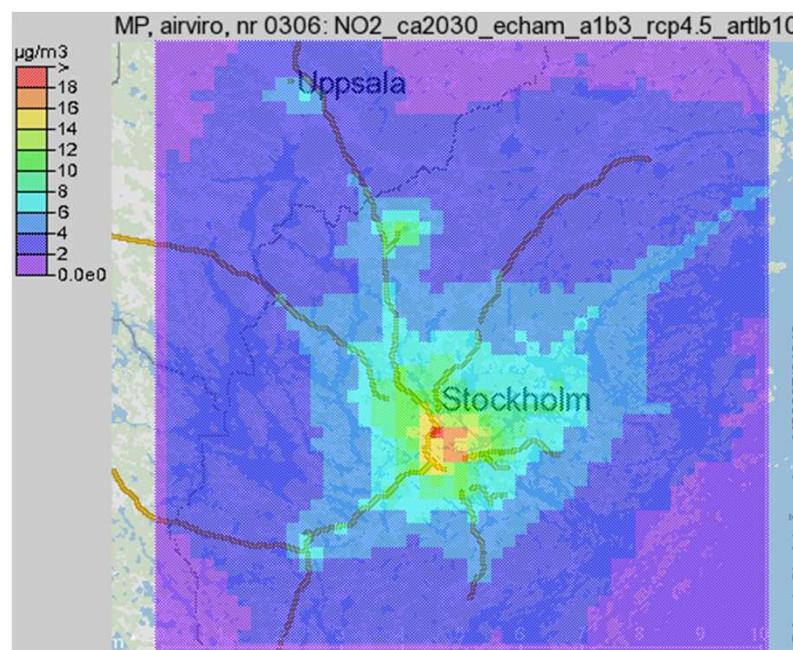
Maximum of running 8h mean

Modelled NO₂ concentration over Stockholm -Current and future situation

~2010

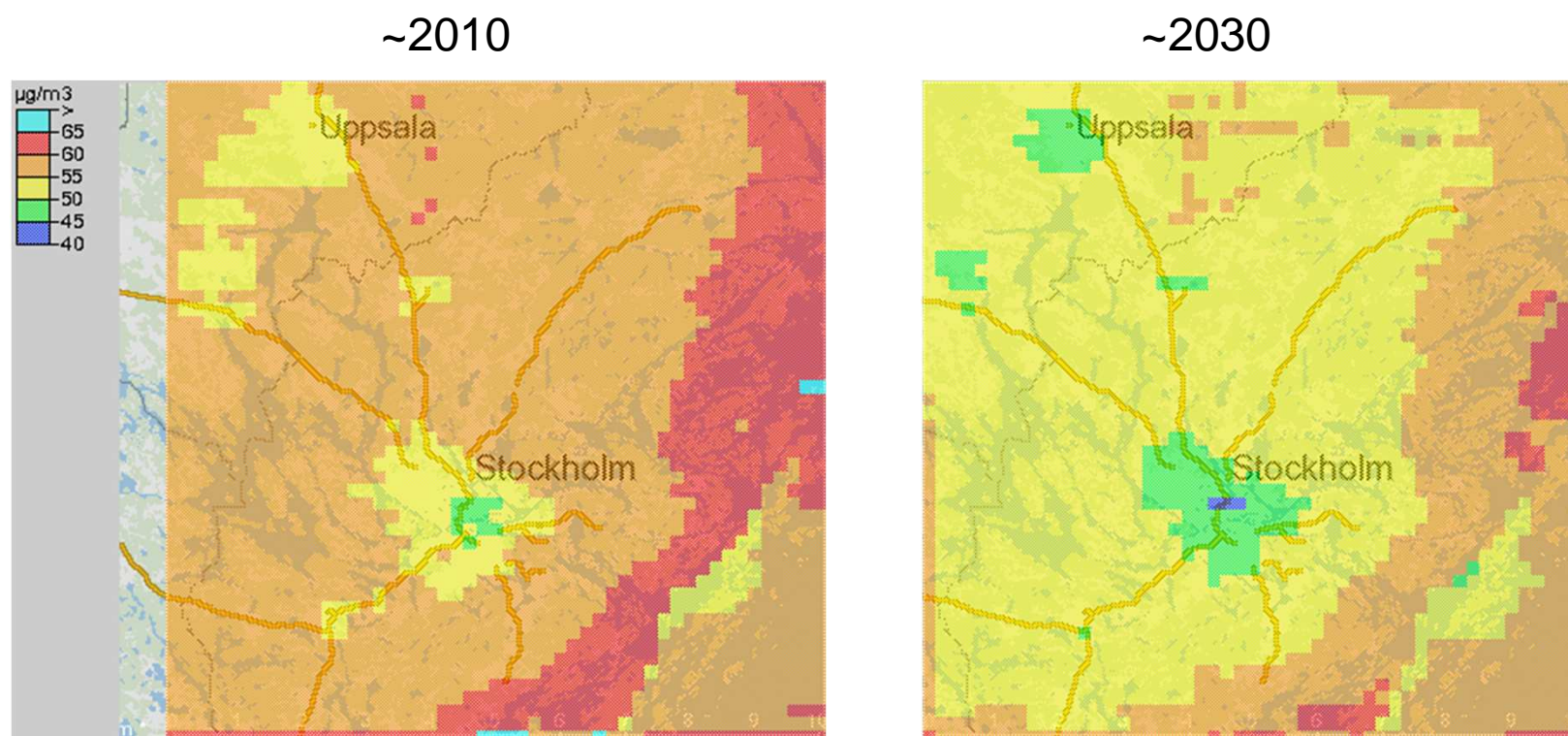


~2030



3-year average NO₂ concentration (*ca. 2010 left, ca. 2030 right*). The panels depict a situation where the local emissions were kept at the levels of 2010, but climate were changing according to the ECHAM5 A1B scenario and European tracer emissions following RCP4.5.

Modelled O_3 concentration over Stockholm -Current and future situation



3-year average O_3 concentration (ca. 2010 left, ca. 2030 right). The panels depict a situation where the local emissions were kept at the levels of 2010, but climate were changing according to the ECHAM5 A1B scenario and European tracer emissions following RCP4.5.

- The SUDPLAN system allow downscaling of air quality for whatever European city. Required input from end-user are gridded emissions (annual averages).
- In SUDPLAN we "nest" urban models with European scale models simulating future air quality, taking into account climate and emissions changes.
- An "ensemble" of simulations provides a measure of uncertainty for the climate change and the development of European tracer emissions.
- The performance of the Common Services air quality downscaling has been evaluated for the European domain and the Stockholm area:
 - NO_x and O₃ works well
 - PM₁₀ is underestimated due to omission of some sources (work is underway to remedy this)
- Ozone concentrations in greater Stockholm will decrease due to emission reductions in Europe, climate change will partly mitigate this.

Thank you for your attention!

SUDPLAN

FP7 ICT-2009-6.4

<http://www.suplan.eu/>

Partners

1. Swedish Meteorological and Hydrological Institute
2. Austrian Institute of Technology
3. cismet GmbH
4. Czech Environmental Information Agency
5. Apertum IT AB
6. Deutsches Forschungszentrum für Künstliche Intelligenz
7. Stockholm Uppsala Air Quality Management Association
8. City of Wuppertal
9. Technische Universität Graz

SMHI

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cenia

APERTUM

DFK Deutsches
Forschungszentrum
für Künstliche
Intelligenz GmbH

LF STOCKHOLMS OCH UPPSALA
LÄNS LUFTVÅRDSFÖRBUND

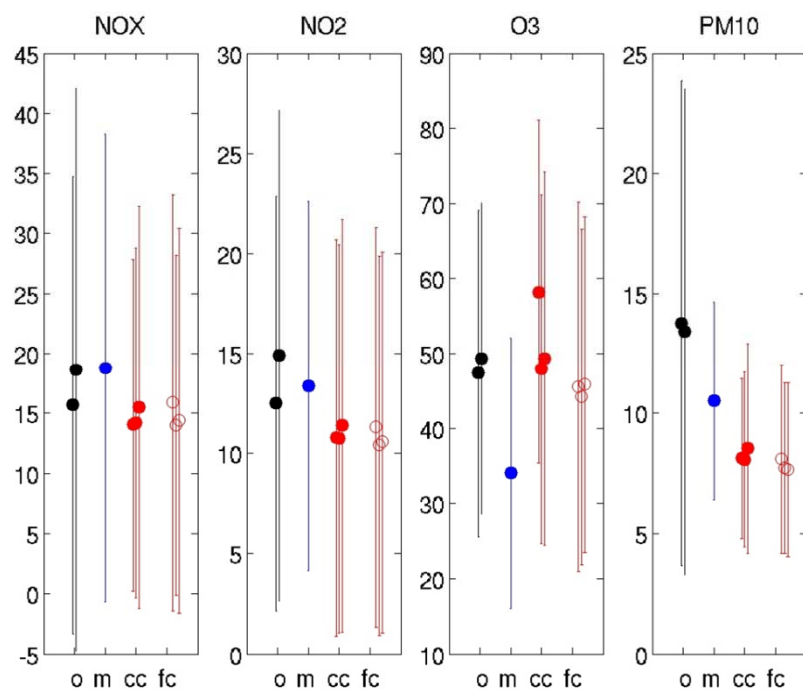
Wuppertal

TU
Graz

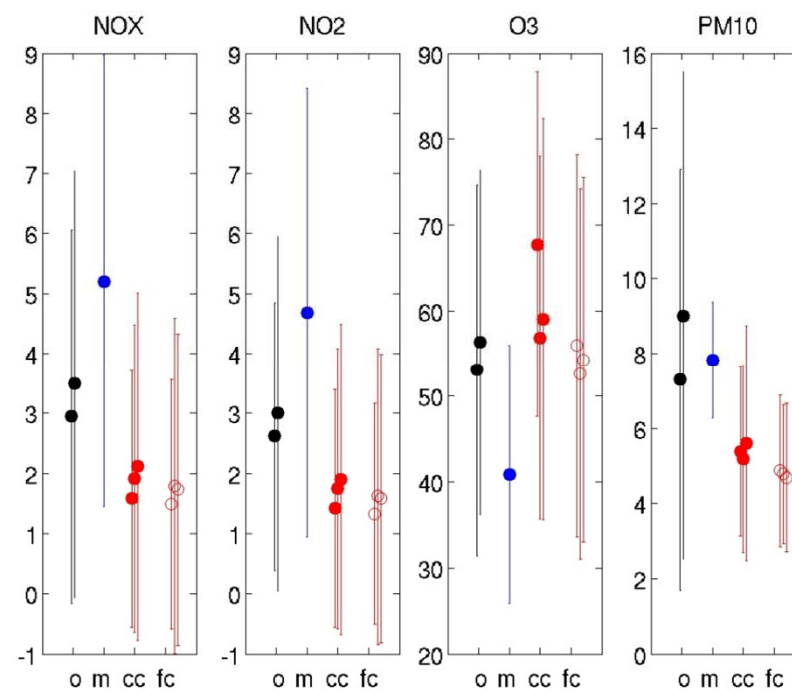
Comparison of annual averages

- Measured (2009 and 2010)
- Modelled-Stockholm (current climate, ~2010)
- Modelled-Europe (2010)
- Modelled-Stockholm (future climate, ~2030)

Urban background



Rural background



Urban downscaling in Stockholm

- Use local emission inventories from city
- Use meteorology from regional climate models
- Use boundary conditions from European CTM simulations

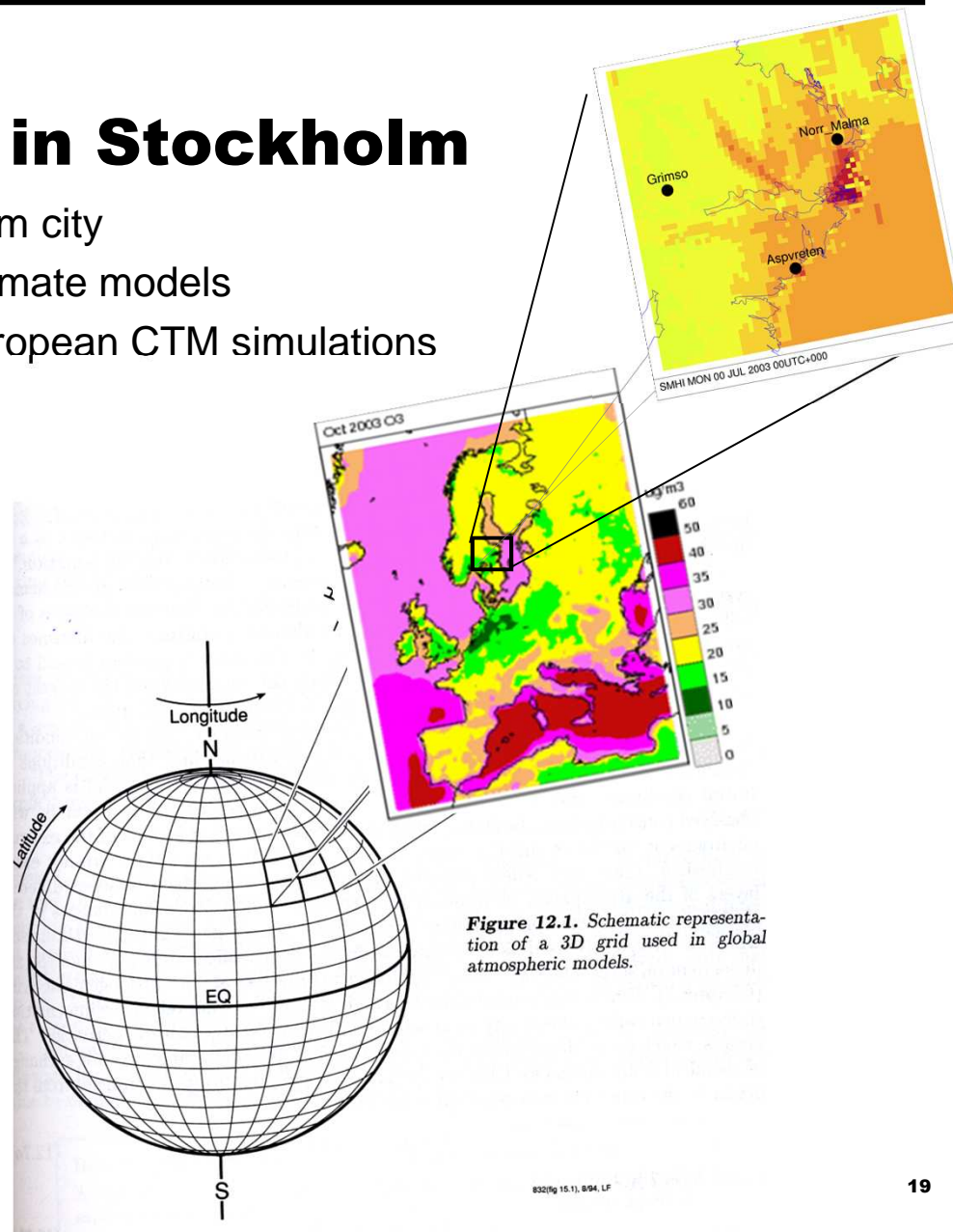
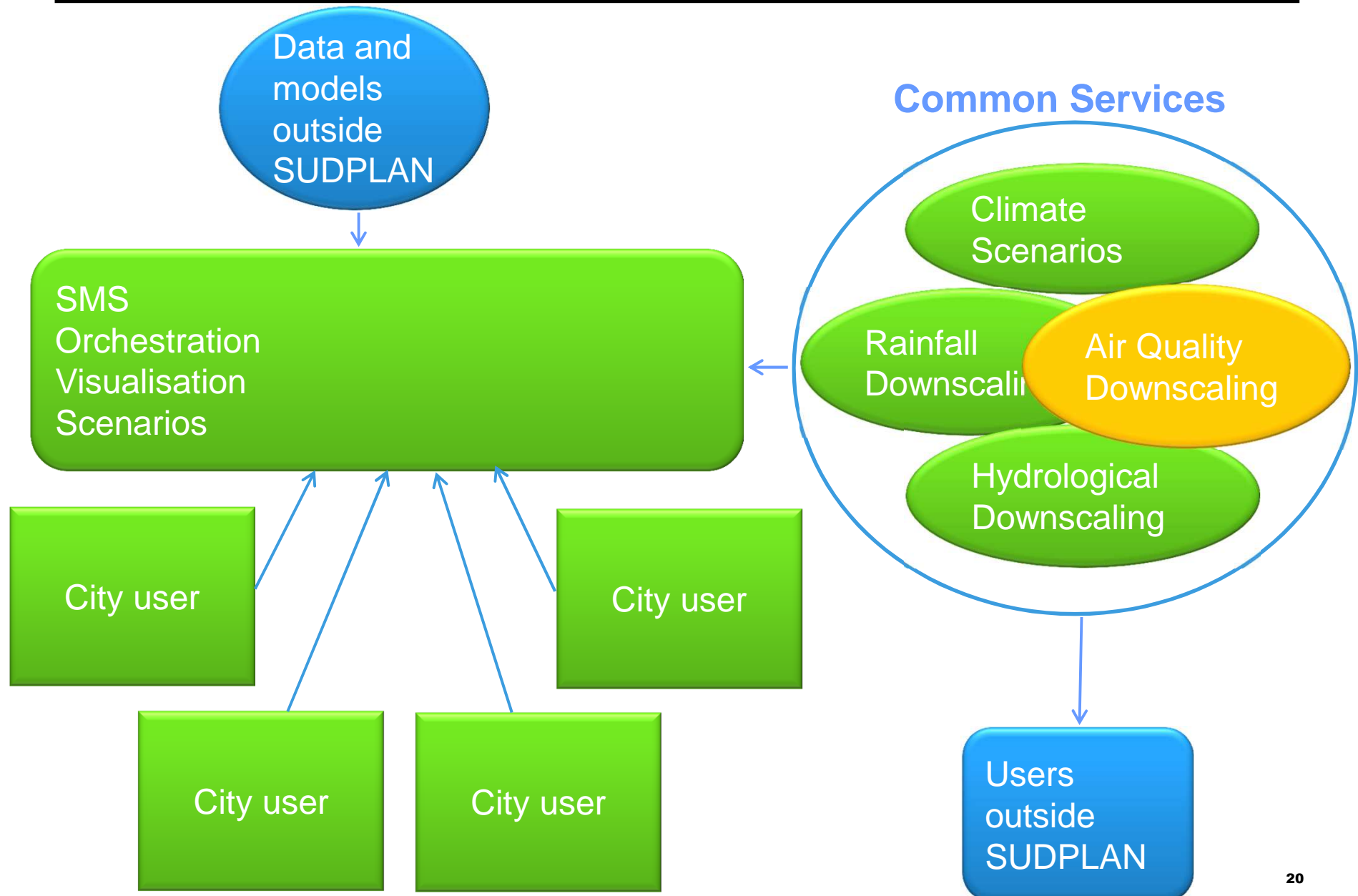


Figure 12.1. Schematic representation of a 3D grid used in global atmospheric models.



Urban Scenario Evaluation:

Comparison of two proposed traffic solutions bypassing Stockholm

- Connect north and south
- Provide efficient ways to pass the city
- Increase possibility for creating new residential areas and commercial centers



User input: Emissions NO_x, NH₃, VOC, SO₂, CO and PM₁₀

Output: Concentration levels of NO_x/NO₂, O₃, SO₂ and PM₁₀

