Forschungszentrum Karlsruhe
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Regional Scale Modelling in the Alps

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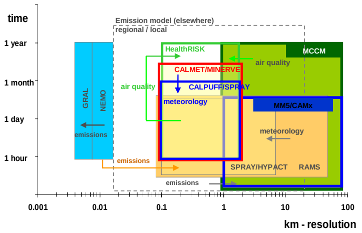
Introduction

The high and still increasing transport volume in Central Europe results in major air pollution problems in particular in the sensitive Alpine region. It was one objective of the ALPNAP project to assess and predict air pollution with numerical models. The modelling activities within ALPNAP include air quality simulations on all scales for the different target areas.

Regional air quality modelling is an essential tool for the estimation of the effect of emissions and meteorological conditions on the regional distribution of pollutants over extended areas. It is a useful requisite for the assessment of the spatial and temporal distribution of primary (e.g. NO_x) and secondary pollutants (e.g. ozone), for the introduction of emission and abatement strategies, and for health impact assessment studies.

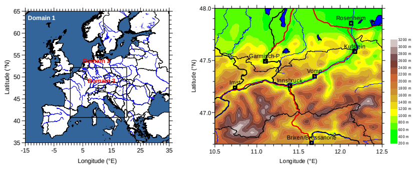


Placement of the regional simulations with MCCM within the ALPNAP model hierarchy

For the example shown here, regional simulations with the coupled meteorology-chemistry model MCCM (Mesoscale Climate Chemistry Model, Grell et al, 2000) were performed for the lower Inn valley and the Brenner North region for the entire year 2004. In order to assess the effect of emission reduction strategies a scenario simulation was carried out for the same conditions as in 2004 but for changed traffic emissions.

Setup of the regional simulations

The coupled meteorology-chemistry model MCCM, which was applied for the regional simulations is based on the meteorological community model MM5. MCCM simulates simultaneously the meteorological and pollutant fields over the model domain. It includes chemical transformation of gas phase compounds, an aerosol module, transport and deposition of pollutants as well as online computation of photolysis frequencies and biogenic VOC emissions.

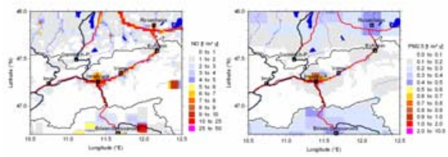


Domain 1: 66x59 grid points 60 km
Domain 2: 101x111 grid points 12 km
Domain 3: 66x76 grid points 2.4 km

Setup of the nested model domains (left) and representation of the topography for the innermost model domain with 2.4 km resolution (right)

In order to account for meteorological effects as well as the long range transport on the distribution of pollutants a nesting strategy with three nested domains was applied. The innermost model domain 3 for the region of Tyrol and the Brenner area has a horizontal resolution of 2.4 km.

Emission data are most crucial for regional air quality simulations. Emission data from five different data bases with different resolutions and source specifications had to be combined. For Tyrol a local traffic emission inventory and data on domestic heating supplied by the 'Amt der Tiroler Landesregierung' were incorporated into the coarser emission inventories in order to obtain the necessary spatial coverage for the regional simulations.

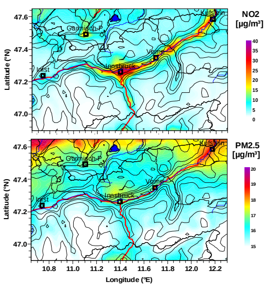


Yearly NO (left) and PM2.5 (right) emissions of all sectors for model domain 3 with 2.4 km resolution

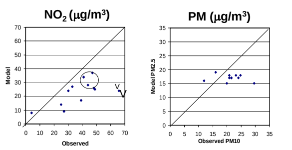
Base case simulation for 2004

In accordance with the patterns of the NO emissions the highest modelled NO_2 concentrations in Tyrol are found along the Inn valley and in the area of Innsbruck.

The spatial patterns of the simulated NO_2 concentrations reflect well the observations during 2004. However, the simulated values are lower than observed for sites near strong sources with small horizontal extension. In contrast, the pollution situation in the city of Innsbruck, where the emissions cover a larger area, is well reproduced. Such a systematic bias can be taken into account during further analysis of model results.



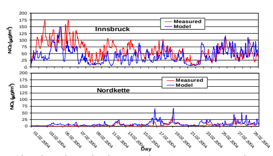
Simulated annual mean of near surface NO_2 (top) and PM2.5 (bottom).



Scatter plot of annual mean NO_2 (left) and particulate matter (right). The circle indicates the sites located in Innsbruck, 'V' the site 'Vomp Raststätte'.

Simulated PM2.5 (which is about 70 to 90% of PM10) is strongly dominated by secondary aerosol material (mostly. HNO_3) does mot match very with the observed patterns. The probably too weak primary emissions contribute only less than 25% to the total mass of PM2.5.

Meteorological conditions have a strong impact on near surface pollutant concentrations. Inversion situations or frontal passages, which are generally well reproduced by the model, are reflected in the temporal course of the NO_2 concentration.

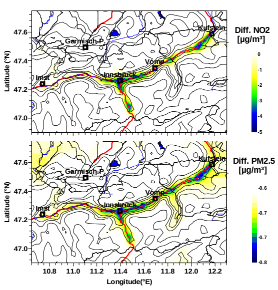


Simulated and observed NO_2 concentrations during February 2004.

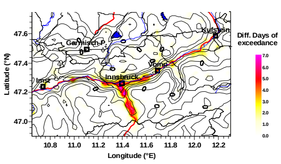
Scenario simulations

For the scenario simulations a traffic emission scenario for 2010 from TU Graz was used which relies on a detailed traffic development model by MONITRAF. The traffic development scenario is composed of a 'Business as usual'-scenario in combination with additional measures for heavy duty vehicles.

Since most emissions are considerably lower for the scenario than for the year 2004 due to the expected fleet renewal a decrease of the mean NO_2 concentrations by up to 25% was calculated for the city of Innsbruck and along the motorway A12.



Difference between base case simulation and scenario for annual mean of NO_2 (top) and PM2.5 (bottom).



Simulated change in the number of days with exceedances of the 120 µg/m³ threshold for the 8-hourly mean ozone for scenario.

Emission reduction measures for NO and VOC can also affect the concentrations of ozone. However, this effect is only comparatively small for the considered scenario.

Conclusions

Regional air quality modelling permits an estimate of the effect of emission reduction measures on the background fields of primary and secondary pollutants. For the investigation of the effect of strong local sources regional air quality modelling should be combined with microscale modelling. In order to obtain more realistic patterns for simulated particulate matter concentrations more effort has to be put into the development of a consistent and complete emission inventory.

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