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Application of the online coupled meteorology-chemistry model WRF/chem and the Lagrangian model GRAL to the Santiago de Chile region

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Introduction

Continuing high levels of pollution due to traffic emissions, industrial and domestic activities in the metropolitan area of Santiago de Chile pose a major risk to the population in terms of health and quality of life. According to observational data PM_{10} is still above the Chilean limit value (50 µg/m³) and way above the WHO guideline of 20 µg/m³. O_3 values are above the WHO guideline 8-hour mean value of 100 µg/m³ and the Chilean limit value of 120µg/m³. Only the NO_2 value has come close to the WHO guideline annual mean of 40 µg/m³ and lies well below the Chilean threshold of 100 µg/m³, Furthermore, industrial activities contribute regionally to high SO_2 concentrations.

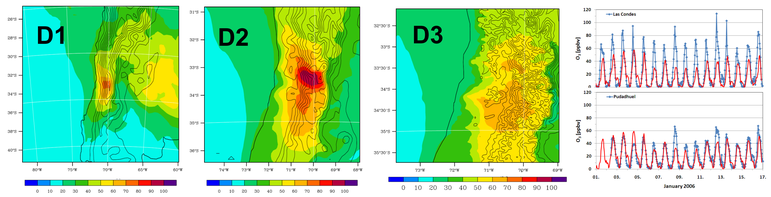
As a contribution to the Risk-Habitat-Megacities project regional simulations with WRF/chem and micro scale simulations of traffic induced NO_x and PM at street level with the Lagrangian model GRAL have been made for the year 2006.

Model setup

WRF/chem was set up for tree nested domains with 36km, 12 km, and 4 km horizontal resolution, respectively. Chemistry boundary conditions for the first domain were derived from 6-hourly output of a global simulation with MATCH-MPIC from MPI Mainz. Anthropogenic emissions for the first two domains are based on RETRO global emissions data which were complemented with additional emissions of SO_2, NH_3, and PM compounds. For the third domain an emission inventory for 2006 with 1 km horizontal resolution was supplied by the Chilean environmental agency CONAMA.

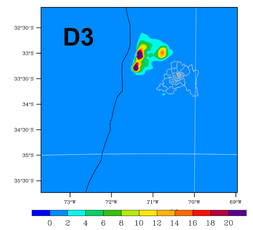
GRAL was resolved on a sampling grid with 25 m resolution for the simulations of the Santiago area. Traffic emissions were calculated for all streets sections, based on the ESTRAUS traffic model and the MODEM traffic emission model. So far, only meteorological parameters from observations or mesoscale simulations can be used as input for GRAL.

WRF simulations

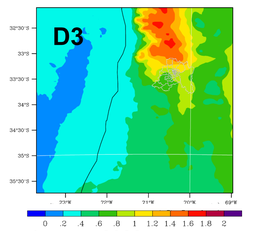


Ozone mixing ratios in ppb for January 19 2006, 15 h local time

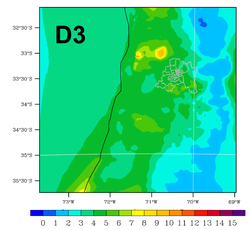
Since VOC emissions are strongly underestimated in the supplied emission inventory for 2006, WRF/chem subsequently underpredicts the frequently observed high ozone concentrations of the Santiago plume (e.g. Las Condes) for D3. In regions (luv-wards of the city) with a higher amount of NOx emissions (Pudadhuel) the simulations and observations are in good agreement. Simulated ozone maxima for D1 and D2, where RETRO emission data were used, were generally 50-80 % higher than those for D3. For NO_x concentrations generally good agreement is found also in the case of D3.



January 2006 mean SO2 mixing ratio in ppb



January 2006 mean aerosol sulfate in µg/m³

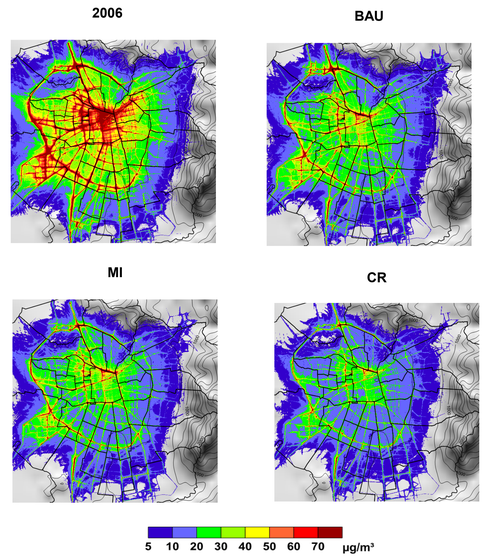


January 2006 mean PM2.5 in µg/m³

Although SO_2 emissions were strongly reduced in Chile during the last years there exist still locations with significant SO_2 emissions, e.g. in the Valparaiso region near the coast. The SO_2 pattern is also reflected in the distributions of sulfate. Since PM emissions are also strongly underestimated in the emission inventory PM concentrations are generally too low. PM2.5 concentrations in Santiago are not higher than in the surrounding area which can also be seen in observations.

Scenario simulations with GRAL

Traffic induced NO_x fields at street level were simulated with GRAL for the baseline year 2006 and different scenarios for the year 2030 . Since no emissions from industrial and domestic activities were available with an appropriate resolution, background concentration levels must be added, which can be approximated from the results of the regional simulations.



Distribution of yearly mean of NO_x concentrations due to traffic emissions for 2006 and projected traffic emissions for 2030 based on simulations with GRAL. For the scenarios the meteorological conditions are based on the year 2006.

Considered scenarios: BAU (Business as Usual), MI (Market Individualism), and CR (Collective Responsibility)

Summary and Outlook

With the focus on ozone concentrations, WRF/chem simulations show significant differences to the observations lee-wards of the city. The inhomogeneous emission inventory need further and significant adjustments in order to perform reliable air quality assessment studies. The update of the emission inventory with its focus on the adjustment of VOC emissions is an important step also for the calculation of background concentrations as input to the micro scale simulations based on GRAL.