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Climate and Air Pollution Modelling in South America with Focus on Megacities

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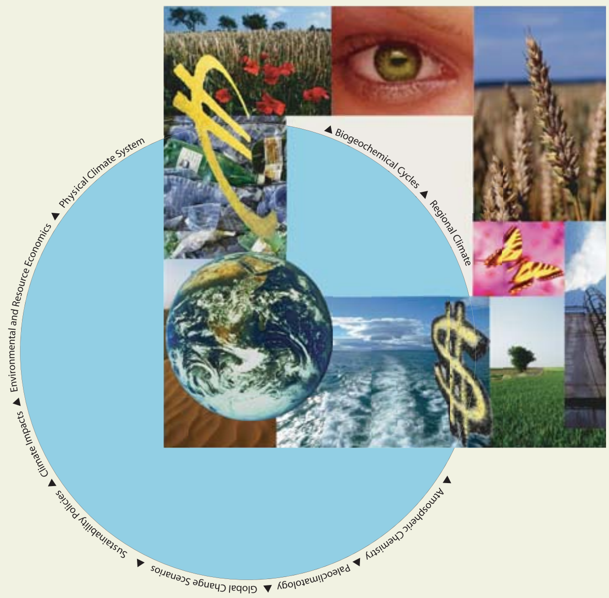

Summary

The two major sources of air pollutants in South America are anthropogenic emissions and biomass burning emissions. Anthropogenic megacity emissions play a special role with respect to air pollution: a relatively large amount of pollutants is released in a small area potentially leading to non-linear chemical processes, which may further aggravate air pollution. Megacities in South America - themselves being highly populated - are mainly located in coastal areas which have a relatively high population density. Wildland fires on the other hand are located in the inner continent, predominantly south of the Amazon basin, in a region with relatively low population density.

In order to compare the impact of these two emission sources in South America on a climatological timescale, a regional climate model is used, which calculates meteorological processes together with chemical processes. The implementation of a chemical mechanism into the latest operational version of the regional climate model REMO (REMO 5.7) is done in the frame of this study. Additionally the vertical convection scheme for trace gases is improved in order to assure realistic trace gas concentrations.

In this study, the chemical state of the atmosphere is simulated for the year 2000. The simulation is embedded in a long term climate run of REMO and includes the main seasons of biomass burning. Simulated tracer concentrations are compared to MOPITT satellite data and to measurements from the INCA field campaign. Modelled spatial patterns of total column CO concentrations agree well with MOPITT data. The model reproduces well vertical profiles of ozone measured during INCA, while it has a slight positive bias in the lower troposphere with respect to CO concentrations, possibly due to an overestimation of emissions in the region.

In the frame of this study, the influence of the two temporally and spatially different emission sources, megacities and biomass burning, on the regional air quality in South America is investigated. While biomass burning exhibits a strong seasonal cycle, megacity emissions are about constant throughout the year. Here, the combined effect of changes in emissions and meteorology are studied for the dry season (biomass burning season) and the wet season. The impact area, i.e., the area in which air pollution levels increase by more than 10 %, stays about constant throughout the year in the case of CO emissions from megacities. For less homogeneously mixed atmospheric trace species like NO_x the impact area shows a peak in southern hemisphere winter. The impact area from biomass burning emissions shows a strong seasonal cycle for ozone, CO and NO_x with peak extent in the biomass burning season. This temporal pattern is predominantly controlled by the emission cycle while changes in the meteorology play a minor role.

In this study the population impact, i.e., the number of people affected by air pollution increases of more than 10 %, due to megacity or biomass burning emissions is investigated. Outside the biomass burning season, the population impact of CO from biomass burning is relatively small (below 10 million inhabitants) compared to the population impact from megacity emissions (about 83 million inhabitants). During the biomass burning season, population impact of CO emissions from biomass burning is about twice as high as population impact of megacity emissions although the latter are 14 times smaller. This can be related to the fact that megacity emissions affect mainly populated coastal areas where biomass burning emission impact is relatively low compared to the inner continent as they are strongly diluted during atmospheric transport.

The population impact of megacity emissions with respect to ozone is relatively small compared to other trace gases. This can be related to the immediate destruction of ozone by NO in the vicinity of the emission sources (the megacities). Ozone is produced again further downwind of the emission source, away from the highly populated areas.