Geophysical Research Abstracts,
Vol. 11, EGU2009-8648, 2009
EGU General Assembly 2009

Combined effects of urban features and air pollution from megacities on meteorology and environment at different scales

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For the urban meteorology/climate or atmospheric pollution modelling studies, as a rule, urban effects (heat island, land-use, roughness, storage heat capacity, soil moisture, precipitation change, etc) and effects of urban emissions / air pollution (e.g. direct, semi-direct, first and second indirect effects of aerosols) are considered separately. However, the processes are continuously interacting with each other and hence, result in influence of megacities and large hot-spots on the atmospheric environment chemical composition and meteorology/climate on different scales. Therefore, to understand the mechanisms of interactions and their non-linearity, and correctly model the effects of megacities, online coupled/integrated models with two-way interaction of meteorological and chemical/aerosol processes on different scales should be considered.

In our study, such integration methodology is discussed, and the interacting processes and mechanisms responsible for the combined effects are analysed. Depending on temporal and spatial scales, the key-processes and types of their interaction are different. For micro-scale (up to 1 km) the obstacle-resolved approach is used, and the only pollutant gas density feedbacks are of importance. For the city scale (1-100 km) it includes statistical description of urban characteristics, and semi-direct and second indirect aerosol feedbacks are dominated. For regional scale (more than 100 km) it is based on parameterised urban effects, and all the above mentioned gas and aerosol feedbacks represent the highest interest.

Some examples are considered from case studies for the Copenhagen and Paris metropolitan areas. The results are based on the Enviro-HIRLAM (online integrated 'meteorology-chemistry-aerosol-clouds') modelling system with different urban parameterisations and two-way feedbacks and nested micro-scale obstacle-resolved M2UE model. Comparative sensitivity analysis with combined urban features and urban aerosol effects and with separated effects is discussed.