3.2 AEROSOL - The Impact of Aerosols Effects on Meteorology

Model used: **Enviro-HIRLAM**

Read, the general description of the HIRLAM (HIgh Resolution Limited Area Model) model at the HIRLAM official website at:
http://hirlam.org/index.php?option=com_content&view=article&id=64&Itemid=101
See for more details the scientific documentation on the HIRLAM model at:
http://hirlam.org/index.php?option=com_docman&task=doc_download&gid=270&Itemid=70

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Introduction Background:
The atmosphere is heavily polluted by anthropogenic sources (from urban agglomerations/ megacities) with accumulation mode aerosols which affect cloud formation and precipitation development. Consequently, continental clouds generally include more cloud droplets (by two orders of magnitude) than marine clouds. An increased number of small droplets in warm clouds will lead to an increase in cloud reflectance and also affects cloud lifetime.
A megacity is characterized by large emissions of primary and secondary pollutants such as NO_x, O_3, organic compounds as well as particles of different sizes. However, the direct influence of the emissions is not the only way the city affects air quality. In particular, the interaction between soluble particles and clouds may be of importance. Particles may be transported downwind with the urban plume into clouds where they can activate and contribute to an increase in cloud droplet number concentration (CDNC). Such an increase leads to enhanced cloud-top reflectance through the first aerosol indirect effect and modification of precipitation development through the second aerosol indirect effect. The interaction between anthropogenic aerosols and regional weather has been investigated using the on-line integrated Enviro-HIRLAM model (Environment - High Resolution Limited Area Model; *Korsholm, 2008*). The aerosol feedbacks were implemented in the modified Soft TRAnsition COndensation (STRACO) scheme (*Sundqvist et al., 1989*) and radiation scheme (*Savijärvi, 1990*). The feedbacks induced changes in meteorological parameters and in chemical reactions have been preliminary analyzed and evaluated for specific case studies (*Korsholm, 2009*).

Main Goal:
Study influence of the anthropogenic emissions from selected metropolitan area on a formation of meteorological/ chemical fields in the urban area and surroundings due to inclusion of aerosols feedback mechanisms in the Enviro-HIRLAM model by analysis of temporal and spatial variability of diurnal cycle for meteorological/chemical variables of key importance.

Specific Objectives:
1) Modify the Savijärvi and STRACO schemes of Enviro-HIRLAM model by including (a) the calculation of the activated anthropogenic aerosol number concentration, (b) wet deposition in the condensation scheme, (c) parameterization of the effect of the Cloud Condensation Precipitation Evaporation processes (CCEP) and (d) dry deposition;

2) Perform simulations for selected specific cases/dates (meteorological conditions with convective regimes and typical wind conditions) in two modes - the control run and the modified run (with feedbacks included);
3) Evaluate diurnal cycle variability for – (a) air temperature, (b) sensible heat flux, (c) latent heat flux, (d) surface temperature, (e) cloud reflectivity, and etc. – for two types of runs; estimate the impact of anthropogenic aerosols from metropolitan area, magnitude and signs of changes due to feedbacks, etc.;
4) Summaries findings and results of the exercise in a form of an oral presentation (max 15 minutes).

Literature List:

Before the Summer School, the students should read, at least, the first 2 required publications; the three other papers are highly recommended to read to be useful for the discussions/talks; the additional readings might be useful too.

REQUIRED READINGS

Korsholm U.S., A. Baklanov, A. Gross, A. Mahura, B.H. Sass and E. Kaas, **2008**: Online coupled chemical weather forecasting based on HIRLAM – overview and prospective of Enviro-HIRLAM. *HIRLAM Newsletter, **54**: 1-17.*

Korsholm U.S., **2009**: Scientific Report 09-01, PhD thesis: Integrated modeling of aerosol indirect effects, http://www.dmi.dk/dmi/sr09-01.pdf

RECOMMENDED READINGS

Boucher O., Lohmanmn U., **1995**: The sulfate-CCN-cloud albedo effect, a sensitivity study with two general circulation models. *Tellus*, 47B, 281-300.

Savijärvi H., **1990**. Fast radiation parameterization schemes for mesoscale and short-range forecast models. *J. Appl. Meteor.*, 29, 437-447.

Sundqvist H., Berge E., Kristjánsson J., **1989**: Condensation and Cloud Parameterization Studies with a Mesoscale Numerical Weather Prediction Model, *Mon. Wea. Rev.*, 117, 1641-1657.

ADDITIONAL READINGS:

Albrecht B., **1989**: Aerosols, Cloud Microphysics, and Fractional Cloudiness. *Science*, 245, 1227-1230.

Satheesh S.K., Moorthy K.K., **2005**: Radiative effects of natural aerosols: A review. *Atm. Env.*, 39, 2089-2110.

Stevens B., Feingold G., **2009**: Untangling aerosol effects on clouds and precipitation in a buffered system, *Nature*, 461, 607-613.