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New developments in Enviro-HIRLAM online integrated modeling system

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Enviro-HIRLAM is developing as a fully online-coupled numerical weather prediction (NWP) and chemistry transport model (CTM) for research and forecasting. The integrated modeling system is developed mainly by DMI as well as other collaborators and included by the HIRLAM consortium as the baseline system in the HIRLAM Chemical Branch. During the last years different modules were developed for applications in meteorology and climatology, chemical and biological weather forecasting.
The current version of Enviro-HIRLAM is based on reference HIRLAM version 7.2. The model's dynamic core was improved by adding locally mass conserving semi-Lagrangian numerical advection scheme, which improves forecast accuracy and makes it possible to perform longer duration runs. A new tropospheric condensed gas-phase chemistry scheme Carbon Bond Mechanism version-Z with a fast solver based on radical balances has been implemented in the model. A sophisticated "pseudomodal" aerosol dynamics module M7 and EQuilibrium Simplified Aerosol Model have been also implemented in the Enviro-HIRLAM. Moreover, several new parameterizations of dust and sea-salt fluxes have been added. To make the model suitable for chemical weather forecasting over urbanized areas the meteorological part was also improved by implementation of urban sub-layer parameterizations. This version is still under development and needs further validation. The modeling system is also used for operational pollen forecasting in Denmark since 2009.
Analysis of different most important meteorology and chemistry interactions and feedbacks on radiation (direct and semi-direct effects) and on cloud microphysics (first and second indirect effects) in online-coupled regional models is realized. For instance, in operational version of DMI-HIRLAM, the precipitation release in condensation-convection cloud scheme STRACO is more dependent on cloud droplet effective radius; and cloud droplet number is prognostic. Nucleation is dependent on aerosol properties and the ice-phase processes are reformulated in terms of classical nucleation theory. The Savijarvi radiation scheme has been improved to account explicitly for aerosol radiation interactions. So that the short-wave radiative transfer calculations are performed as standard 2-stream calculations for averages of aerosol optical properties weighted over the entire spectrum. The accuracy of these calculations have been tested by comparing to a detailed radiative transfer model and found to be accurate to within a few percent; for optically thick layers of absorbing aerosols, e.g. black carbon with AOD > 1.5 or load > 0.2 g/m^2, the 2-stream approximation is found to be less accurate.