The online coupled atmospheric-chemistry-aerosol model LM-MUSCAT

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The modelling department of the IfT has developed the state-of-the-art multiscale model system LM-MUSCAT . It is qualified for process studies as well as the operational forecast of pollutants in local and regional areas. The model system consists of two online coupled codes. The operational forecast model LM (Local Model) of the German Weather Service is a non-hydrostatic and compressible meteorological model. Driven by the meteorological model, the chemistry transport model MUSCAT (Multi-Scale Atmospheric Transport Model) treats the atmospheric transport as well as chemical transformations for several gas phase species and particle populations. The transport processes include advection, turbulent diffusion, sedimentation, dry and wet deposition. Due to the online coupling between LM and MUSCAT, the calculations exploit the actual properties of the atmosphere. The implicit-explicit time integration scheme of MUSCAT operates independently from the meteorological model, thus allowing for autonomous time steps and different horizontal grid resolutions in selected regions of the model domain.

The coupler provides MUSCAT with meteorological fields like temperature, humidity, and density from LM. To provide consistent mass fields a projection step is included to fulfil a discrete mass continuity equation. In contrast to other approaches all three components of the wind field are corrected, which leads only to a small correction of the vertical component of the wind field. Moreover, a feedback is implemented whereby the aerosol particle distribution calculated by MUSCAT influences the aerosol optical thickness and, hence, the radiation budget in LM.

In the parallel version of the code each processor is assigned to carry out one partition of the coupled codes alternately. Since the workload of each model code is distributed equally over all processors, imbalances between the model codes are compensated. All processors first calculate the meteorology over one coupling interval. Then the meteorological coupling data are exchanged and all processors continue with the calculation of chemistry-transport over the same interval. Required arrays for feedback are sent from MUSCAT to LM, before the next coupling step is performed..

Two applications with different characteristics are presented. The ''Europe'' scenario has been utilized to supply boundary values for a scenario in a nested region. The model region comprises central Europe. The ''Samum'' scenario is used for investigations of the influence of Saharan dust particles on the radiation budget. The emission, transport, and deposition of dust particles without aerosol dynamical processes are considered. A uniform grid of 150 x 150 horizontal cells is used in LM and MUSCAT.