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An online-coupled NWP/ACT model with conserved Lagrangian levels

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Numerical weather and climate modelling is under constant development. Semi-implicit semi-Lagrangian (SISL) models have proven to be numerically efficient in both short-range weather forecasts and climate models, due to the ability to use long time steps.

Chemical/aerosol feedback mechanism are becoming more and more relevant in NWP as well as climate models, since the biogenic and anthropogenic emissions can have a direct effect on the dynamics and radiative properties of the atmosphere. To include chemical feedback mechanisms in the NWP models, on-line coupling is crucial. In 3D semi-Lagrangian schemes with quasi-Lagrangian vertical coordinates the Lagrangian levels are remapped to Eulerian model levels each time step. This remapping introduces an undesirable tendency to smooth sharp gradients and creates unphysical numerical diffusion in the vertical distribution.

A semi-Lagrangian advection method is introduced, it combines an inherently mass conserving 2D semi-Lagrangian scheme, with a SISL scheme employing both hybrid vertical coordinates and a fully Lagrangian vertical coordinate. This minimizes the vertical diffusion and thus potentially improves the simulation of the vertical profiles of moisture, clouds, and chemical constituents. Since the Lagrangian levels suffer from traditional Lagrangian limitations caused by the convergence and divergence of the flow, remappings to the Eulerian model levels are generally still required - but this need only be applied after a number of time steps - unless dynamic remapping methods are used. For this several different remapping methods has been implemented. The combined scheme is mass conserving, consistent, and multi-tracer efficient.