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A new interpolation method for gridded extensive variables with application in Lagrangian transport and dispersion models

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In discretised form, an extensive variable usually represents an integral over a 3-dimensional (x,y,z) grid cell. In the case of vertical fluxes, gridded values represent integrals over a horizontal (x,y) grid face. In meteorological models, fluxes (precipitation, turbulent fluxes, etc.) are usually written out as temporally integrated values, thus effectively forming 3D (x,y,t) integrals. Lagrangian transport models require interpolation of all relevant variables towards the location in 4D space of each of the computational particles. Trivial interpolation algorithms usually implicitly assume the integral value to be a point value valid at the grid centre. If the integral value would be reconstructed from the interpolated point values, it would in general not be correct. If nonlinear interpolation methods are used, non-negativity cannot easily be ensured.

This problem became obvious with respect to the interpolation of precipitation for the calculation of wet deposition FLEXPART (http://flexpart.eu) which uses ECMWF model output or other gridded input data. The presently implemented method consists of a special preprocessing in the input preparation software and subsequent linear interpolation in the model. The interpolated values are positive but the criterion of cell-wise conservation of the integral property is violated; it is also not very accurate as it smoothes the field.

A new interpolation algorithm was developed which introduces additional supporting grid points in each time interval with linear interpolation to be applied in FLEXPART later between them. It preserves the integral precipitation in each time interval, guarantees the continuity of the time series, and maintains non-negativity. The function values of the remapping algorithm at these subgrid points constitute the degrees of freedom which can be prescribed in various ways. Combining the advantages of different approaches leads to a final algorithm respecting all the required conditions. To improve the monotonicity behaviour we additionally derived a filter to restrict over- or undershooting.

At the current stage, the algorithm is meant primarily for the temporal dimension. It can also be applied with operator-splitting to include the two horizontal dimensions. An extension to 2D appears feasible, while a fully 3D version would most likely not justify the effort compared to the operator-splitting approach.