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Semi-Lagrangian Methods in Air Pollution Models.

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Various semi-Lagrangian methods are tested for use in air pollution modeling. The aim is to find a method fulfilling as many of the desirable properties by Rasch and Williamson (1990) and Machenhauer et al. (2008) as possible. The focus is on accuracy, local mass conservation and computational efficiency.
The methods tested are, first, classical semi-Lagrangian cubic interpolation, see e.g. Durran (1999), second, semi-Lagrangian cubic cascade interpolation, by Nair et al. (2002), third, semi-Lagrangian cubic interpolation with the modified interpolation weights, by Kaas (2008), and last, semi-Lagrangian cubic interpolation with a locally mass conserving monotonic filter by Kaas and Nielsen (2008).
Semi-Lagrangian (sL) interpolation is a classical method for atmospheric modeling, cascade interpolation is more efficient computationally, modified interpolation weights assure mass conservation and the locally mass conserving monotonic filter imposes monotonicity.
All schemes are tested with advection alone or with advection and chemistry together under both typical rural and urban conditions using different temporal and spatial resolution. The methods are compared with a current state-of-the-art scheme presently used at the National Environmental Research Institute (NERI) in Denmark.
The test cases are based either on the traditional slotted cylinder, see e.g. Zerroukat et al. (2002), or the rotating cone, see e.g. Molenkamp (1968) and Crowley (1968), where the schemes' ability to model both steep gradients and slopes are challenged.
The tests showed that the locally mass conserving monotonic filter improved the results significantly for some of the test cases, however, not for all. It was found that the semi-Lagrangian schemes, in almost every case, were not able to outperform the currently used ASD scheme used in DEHM, see e.g. Frohn et al. (2002).

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