Geophysical Research Abstracts
Vol. 13, EGU2011-9840, 2011
EGU General Assembly 2011

Realistic case studies of a new time splitting approach for one dimensional advection schemes in numerical weather prediction models.

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Today, in most three dimensional numerical weather prediction models, advection is treated with one dimensional flux form advection schemes. This requires the application of a time splitting approach by integrating the transport equation separately for every space direction. It is well-known that time splitting destroys the consistency of one dimensional advection schemes if deformational wind fields occur. Especially in steep topographical terrain, deformational errors may lead to serious problems, in extreme cases even model aborts may occur.

In order to reduce these time splitting errors, a new time splitting algorithm has been developed. In this method, during each one dimensional advection step deformational correction terms are added to the transport equation. After the time splitting approach, the sum of all these deformation terms is again subtracted from the advected quantity, thus preserving mass conservation of the scheme. With this treatment, a consistent form of the one dimensional advection scheme is obtained when time splitting is performed. Large Courant numbers are treated by applying local timestep reduction. The resulting scheme is strictly mass conservative, positive definite and nearly shape preserving.

In idealised flow experiments, the new time splitting advection was tested yielding satisfactory results. Recently, the new advection scheme has been implemented into the non hydrostatic weather forecast model COSMO of the German Meteorological Service. In this talk, the results of different numerical experiments are presented. Firstly, idealised experiments are shown with a passive tracer transported over a mountain ridge. The simulations with the conventional COSMO version using the original advection scheme are compared to those using the modified scheme for the advection of positive definite atmospheric quantities. While in both simulations of the tracer experiment the main structure of the advected quantity remains quite similar, in strong deformational wind fields the new model yields significantly improved results. Furthermore, case studies of real atmospheric situations with strongly deformative wind fields are presented. In these situations the deformational correction turns out to be very important. Especially at meteorological fronts and mountain ridges significant changes in atmospheric moisture content and precipitation rates are observed.