

Investigation of the exponential time integration schemes for meteorological models

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Exponential integration methods have been proposed and studied in the past as an alternative to traditional time stepping techniques. The main motivation for this research was a desire to represent correctly the entire spectrum of waves propagating in the atmosphere.

The detailed study of an exponential scheme was carried out with the icosahedral shallow water model. The essence of the method used in this work is a dynamic linearization of the equations with respect to the continuously changing state of the system and the subsequent exact analytic solution of the linear part. The exponential functions of the Jacobian of the shallow water system are evaluated using the algorithm of Niesen and Wright with the optional modifications to increase the efficiency of the calculations.

The results obtained with the shallow water equations, published in three papers, showed that the approach is promising as it allows for longer time steps as well as yields a higher accuracy of the solutions than traditional algorithms. The same conclusions were obtained with the thermal shallow water equations. The summary of the results will be outlined in the first part of the talk.

The remaining question is whether or not the exponential scheme is equally applicable for the integration of compressible Euler equations. In the second part of the talk, a detailed analysis of the results obtained with an elastic system will be presented. The paramount result of these integrations is that the exponential scheme allows the simulation of both gravity and sound waves with very large wave Courant numbers. The algorithm applied to compressible equations requires, however, slightly different approaches to optimizing calculations than those used in the shallow water model. The corresponding estimates of the execution times will conclude the talk.