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Laplace Transform Time Integration Schemes in OpenIFS

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The Laplace Transform Integration Scheme (LTIS), was originally developed in Lynch 1991. The original scheme used a numerical form of the modified inverse Laplace Transform and was implemented in two Shallow Water models, Eulerian and semi-Lagrangian (Clancy & Lynch, 2011a/b). An analytic form of the modified LT inverse was later implemented in an Eulerian SW model (Lynch & Clancy 2016). The LTIS filters out high frequency components, allowing longer time steps to be used while maintaining accuracy compared to the widely-used Semi-Implicit (SI) method.

A number of schemes based upon the LTIS have been implemented in the SW version of the OpenIFS model, using Eulerian and semi-Lagrangian advection. These schemes use the analytic form of the LT inversion. Testing has been done using the Williamson SW test-case suite (Williamson et al. 1992) and a number of other test cases that we have added to the code of the OpenIFS SW model, including the analytic test case of Läuter (Läuter et al. 2005) and the barotropically unstable jet case of Galewsky (Galewsky et al. 2004).

The construction of some Hough mode initial conditions (Kasahara 1976) has also been included in the code of the OpenIFS SW model. The Hough modes, which are solutions of the linearised SW equations, form an interesting set of potential test cases. Several of these, such as the Kelvin Wave and Five-day Wave, are of meteorological significance.

References:

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