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Title:
Numerical analyses of explicit time-stepping methods for use in atmospheric forecasting models

Sarah-Jane Lock, University of Leeds, Leeds LS2 9JT, UK
s.j.lock@leeds.ac.uk

Abstract:
Next generation weather and climate forecasting models must be capable of exploiting future massively parallel computers. The Gung-Ho (or UM Dynamical Core) project aims to develop a new dynamical core fit for the UK Met Office's operational forecasting from ~2020 onwards. One particular aspect for consideration is the time-integration method. The current Met Office Unified Model (UM) uses a 3D semi-implicit solver to enable efficient integration of the fast-moving waves that occur in the compressible atmospheric equations. By avoiding any stability constraints, the semi-implicit approach enables a long time-step but at the expense of the global communication required to solve the resulting Helmholtz problem. An alternative approach is to use an explicit time-stepping scheme, thus restricting the time-step on stability grounds but requiring only local communications.

This study considers the stability and accuracy characteristics of a range of explicit time-integration schemes. The schemes are analysed in isolation and in combination with 1D implicit solvers for use as horizontally-explicit vertically-implicit (HEVI) schemes. Amplitude, phase and group velocity errors are considered. The results are compared with those from a pure (off-centred) implicit solver and, where possible, against an exact solution. Results from this study will help inform decisions on the time-integration scheme for use in the Gung-Ho project.