Spatial tendency filters permitting long time steps for fast modes

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Here we introduce specially designed pressure-gradient filters to control the phase-speed and stability of fast modes in atmospheric models, which are based on forward-backward (staggered in time) time stepping schemes. It is shown that using a global - and therefore inefficient - filter one can replicate the traditional semi-implicit (SI) time stepping scheme. This has some similarity to the regularization of the pressure gradient introduced by Frank et al. 2005, and Wood et al. 2006. However, it is also possible to construct an explicit, local and directionally sequential filter, which suffers less from dispersion errors than the SI scheme. To perform numerically stable simulations, the filter must include all grid cells within the domain of dependence for fast modes. The filter is proposed as an alternative to e.g. semi-implicit methods, exponential time stepping or Laplace transforms.

Simple successful tests are presented for the rotating shallow water equations and fast vertically propagating sound waves.