A nestable, multigrid - friendly grid on a sphere for global spectral models based on Clenshaw-Curtis quadrature

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Nonhydrostatic atmospheric models with semi-implicit time-stepping require iterative solution of an elliptic boundary-value problem, which is difficult for modern massively-parallel supercomputers to solve efficiently. The multigrid method is a promising approach with good scalability for this type of problems, but such an approach is hard to implement on the irregularly placed Gaussian grid which is adopted by the current global spectral models. In this study, we propose a new grid system on a sphere which allows for straightforward implementation of both spherical - harmonics - based spectral methods and gridpoint - based multigrid methods. The latitudinal gridpoints in the new grid are equidistant and spectral transforms in the latitudinal direction are performed using Clenshaw–Curtis quadrature. The spectral transforms with this new grid and quadrature are shown to be exact within machine precision provided that the grid truncation is such that there are at least 2N + 1 latitudinal gridpoints for the total truncation wavenumber of N. The new grid and quadrature is implemented and tested on a shallow - water equations model and the hydrostatic dry dynamical core of the global NWP model JMA - GSM. The integration results obtained with the new quadrature are shown to be almost identical to those obtained with the conventional Gaussian quadrature on a Gaussian grid. A strategy to smoothly and gradually transition from the current spectral model to a grid-based (or grid/spector hybrid) model will also be discussed.