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# An efficient multi-resolution grid for global models and coupled systems

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The latitude-longitude (lat-lon) grid is the most widely used global coordinate system for various purposes and it is used in many operational and research models for its simplicity and convenience. With increased data assimilation in operational models and coupled systems, its convenience becomes even more obvious or indispensable. However, its singularity at the Pole and the vector polar problems associated with its converging meridians have hindered its applications and reduced its efficiency. Well from the very start of numerical modelling history, quite a few grids have been attempted to tackle these problems and reduced grid is the simplest one among other tested grids. But the reduced grid is almost abandoned by modern numerical modellers due to its unsatisfactory results for dynamical models in the polar region.

Spherical multiple-cell (SMC) grid is similar to the reduced grid apparently but uses the unstructured technique for efficiency. It merges longitudinal cells at high latitudes like the reduced grid to overcome the CFL restriction and introduces a polar cell to remove the singularity at the Pole. As it uses the lat-lon grid quadrilateral cells, numerical modes are minimized and the simple finite-difference schemes on lat-lon grids are retained. It also supports quad-tree-like mesh refinement to form a multi-resolution grid. To tackle the vector polar problem associated with the increased curvature at high latitudes, the SMC grid uses a new fixed reference direction to define vector components near the poles for improved polar performance.

Global tracer transportation is quite efficient on the SMC grid with optional first, second or third order transportation scheme, thanks to the removal of the CFL restriction at high latitudes and parallelization of unstructured 1-D arrays. Possible dynamical applications on the SMC grid is demonstrated with a model of shallow-water equations (SWEs). The SMC grid has been successfully implemented in the WAVEWATCH III ocean surface wave model and its multi-resolution feature has been exploited to develop a unified global and regional wave forecasting model in the Met Office. Its potential applications for global climate models and coupled systems are to be explored.