Implementation of the reduced grid in the shallow-water prototype of the global finite-difference SL-AV model

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Today, many global spectral models apply the reduced grid (i.e. the grid where the number of points in longitude is gradually reduced while approaching the poles). The construction of the global finite-difference semi-Lagrangian SL-AV model [1] enables the implementation of the reduced grid: some part of calculations is carried out in space of Fourier coefficients in longitude. Also, the semi-Lagrangian advection is used (so there are no nonlinear advective terms). Necessary latitudinal derivatives (i.e. geopotential gradient) can be calculated in Fourier space. The algorithm for construction of reduced grids for a finite-difference semi-Lagrangian model was developed by R. Fadeev in [2]. It is based on the estimation of accuracy for semi-Lagrangian interpolation on the sphere and takes into account that the number of grid points at each latitudinal circle should be suitable for FFT.

Explicit terms of dynamics equations and semi-Lagrangian advection are calculated on the reduced grid. Calculation of nonlinear terms in the grid-point space requires some averaging, which is difficult to calculate on the reduced grid. Nonlinear terms are calculated on the full grid and then interpolated to the reduced one. Calculations in Fourier space are carried out as in the case of the full grid. At the end of these calculations, some variables are restored on the full grid, others – on the reduced one.

The reduced grid was implemented and tested in the framework of the shallow-water prototype for the SL-AV model [3] with the standard test set by Williamson et al [4]. First, the grid was constructed in a somewhat arbitrary way; the reduction of total number of grid points was 20 %. The resolution was 1.5 degrees in longitude and latitude everywhere except high latitudes. Tests 2, 3, 6 and 7 were carried out. It turned out that the results of the tests are sensitive to the choice of the grid, especially for test 7a with `real' data, where there is a significant cross-polar flow - see Fig.1, curves 'full' and 'red'. Then the reduced grid calculated following [2] was used, with the relative reduction of total number of grid points 9.3 %. The proper construction of the reduced grid provides the results hardly distinguishable from the ones obtained with the full grid (curve 'new red' in Fig.1). Some grids constructed using [2] are shown in Fig.2. Further tests will be carried out using grids having more reduction.

It is planned to implement the reduced grid in the full 3D version of the SL-AV model.

References

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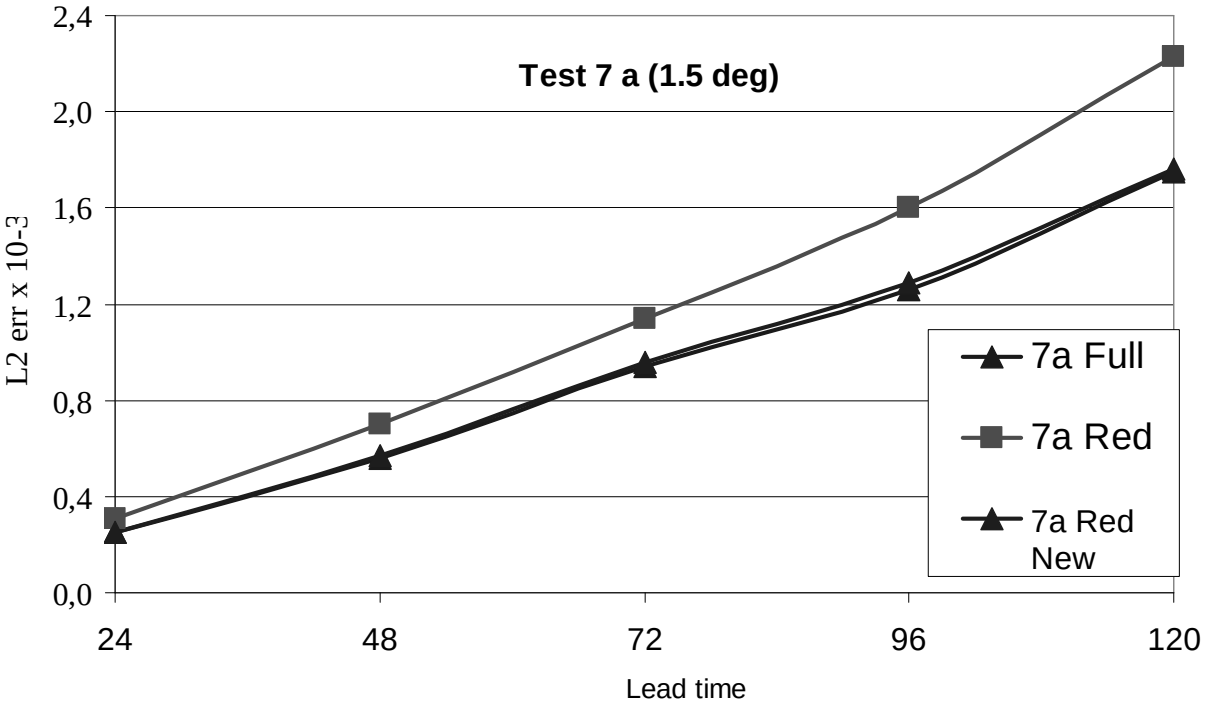

Figure 1. Global normalized height error vs time for Test 7a from [4] for full grid, the grid with the relative reduction of number of points by 20 %, and the reduced grid with the reduction by 9.3 % constructed with the algorithm [2].

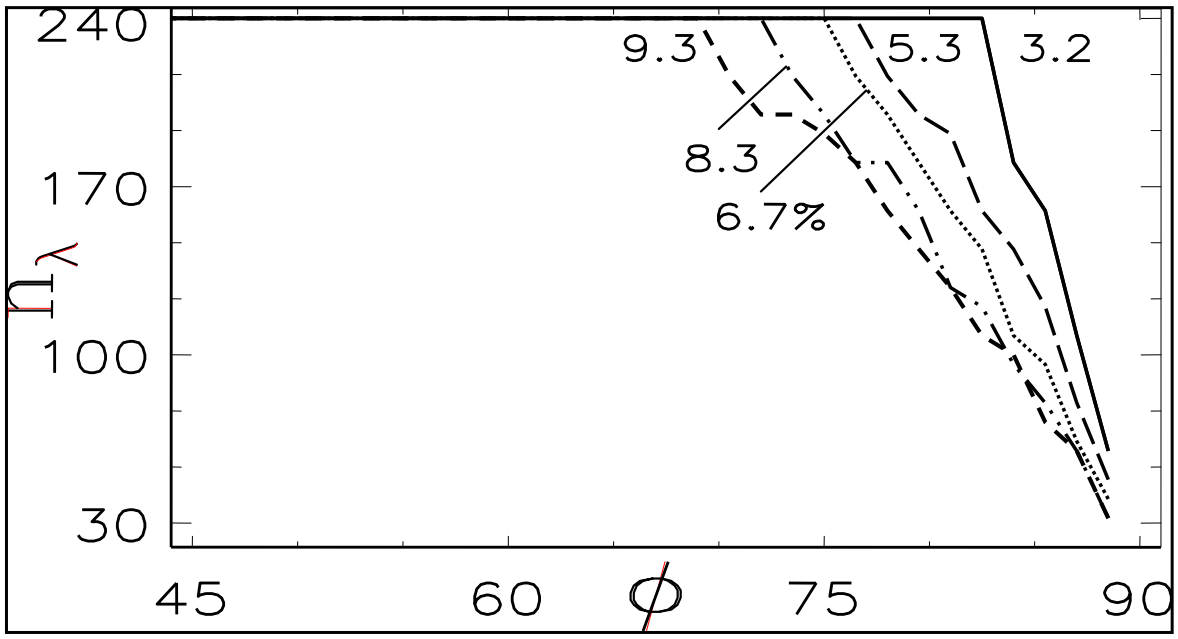

Figure 2. Number of grid points at given latitude circle as a function of latitude (in degrees) for different reductions (%) of total number of points. Grids are constructed with the algorithm [2].