A shallow water model on a sphere as a part of SPMODEL

Masatsugu Odaka[1]; Masaki Ishiwatari[2]; Shin-ichi Takehiro[3]; Keiichi Ishioka[4]; Yoshi-Yuki Hayashi[1]

[1] Earth and Planetary Sci., Hokkaido Univ.; [2] Graduate School of Environmental Earth Science, Hokkaido University; [3] Earth and Planetary Sci., Kyushu Univ.; [4] Graduate School of Mathematical Sciences, University of Tokyo

http://www.gfd-dennou.org/arch/spmodel/

We have been developing hierarchical spectral models for geophysical and planetary fluid dynamics (SPMODEL, Takehiro et al., 2002) as an experiment to develop numerical models with high readability and extendibility. The goal of SPMODEL is to provide a series of spectral models of typical equation systems which appear in the fields of geophysical and planetary fluid dynamics. In SPMODEL, Fortran90 functions for spectral translations are developed and prepared for the series of models, and gt4f90io, a Fortran90 netCDF I/O library (gtool4 project, 2000), is used for the data input/output methods of the models. By the use of these modules and libraries, the source codes of the entire models have the same coding style, and it is expected that readability and extendibility of source codes are greatly improved.

We have already shown that, in the case of a model for a relatively simple equation system such as a barotropic vorticity equation, construction of a model in the framework of SPMODEL yields a model source code with high readability and extendibility. In this study, for the purpose of investigating the possibility of developing a numerical model of a more complex equation system in the framework of SPMODEL, we try to construct a model of shallow water equation on a sphere as a part of SPMODEL, and examine readability and extendibility of the source code.

The basic equation is spherical shallow water equation represented by vorticity and divergence form. Numerical diffusion is not considered. Calculation of non-linear terms is performed by using spectral translation method and the triangular spectral truncation is adapted. Time discretization is performed by using a semi-implicit scheme which is a combination of the leapfrog and trapezoidal implicit scheme. In order to remove the computational mode, the Asselin time filter is introduced.

Performance of the numerical shallow water model is examined by the case 5 of the standard test for shallow water models proposed by Williamson et al. (1992). The spectral truncation wavenumbers adopted are 21, 42, 63 and 106. For each resolution, the simulated flow over an isolated mountain and resultant wave propagation are consistent with those obtained by the spectral shallow water model of Williamson et al. (1995). The order of magnitudes of the normalized errors of total energy and potential enstrophy from those of initial values converges to 10E-7. The increase of computational cost due to massive usage of Fortran90 functions whose arguments are array is practically negligible. The source code has a good correspondence with the model basic equation, and it is easy to extend it to multi-layer models or to models with other physical processes.

We are going to examine, in the line of the framework of SPMODEL, the possibility of the development of a numerical model, such as an atmospheric general circulation model, where the combination of finite difference method with grid points and spectrum method is used.

References

Takehiro et al. 2002: http://www.gfd-dennou.org/arch/spmodel/, GFD Dennou Club.
gtool4 project 2000: http://www.gfd-dennou.org/arch/gtool4/, GFD Dennou Club.
Williamson et al. 1992: J. Comput. Phys., 102, 211-224.
Williamson et al. 1995: J. Comput. Phys., 119, 164-187.