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Simple numerical GFD experiments by use of spectral models constructed with ISPACK and gtool4

Shin-ichi Takehiro[1], Keiichi Ishioka[2], Eizi TOYODA[3], Masaki Ishiwatari[4], Yoshi-Yuki Hayashi[5]

[1] Earth and Planetary Sci., Kyushu Univ., [2] Graduate School of Mathematical Sciences, University of Tokyo, [3] JMA NPD, [4] Graduate School of Environmental Earth Science, Hokkaido University, [5] Earth and Planetary Sci., Hokkaido Univ.

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

1. Introduction

Nowadays, numerical methods become popular for obtaining solutions of governing equations which describe physical processes of natural phenomena. However, for understanding of the results of numerical calculations performed by another persons, only consideration with the presented resultant figures are insufficient. It is better to follow the numerical calculations by ourselves and perform further additional experiments by changing the parameters. But the cost for development of the programs and analyses of the numerical results is usually significant.

For the purpose of reduction of such difficulties of numerical calculations, we are now developing a set of spectral models suitable for performing standard numerical experiments of geophysical and planetary fluid dynamics problems (GFD Dennou Club specrtal model project, http://www.gfd-dennou.org/arch/spmodel). Our policy for the development of the program codes is,

1) anyone can read, use and modify the source programs
2) the sources programs should be so understandable that anyone can re-build and modify the programs
3) visualization and post-processing should be performed easily.

In order to satisfy the first and second requirements, we have tried programming with Fortran90 and ISPACK Fortran77 library. For the third requirement, we have implemented data output with 'gtool4' to the models and examined its efficiency.

2. ISPACK and Fortran90

ISPACK(http://www.gfd-dennou.org/arch/ispack/), developed by Ishioka, is a Fortran77 library for numerical calculations of fluid dynamics with spectral methods. We have wrapped each subroutine of ISPACK with a function written in Fortran90. With the help of array handling features of Fortran90, such as automatic elemental operations and user-defined array functions, we have prepared basic array functions describing data conversion between grid and spectral spaces and space-differentiations. All functions are named systematically according to the form '(output data type)_(action)_(input data type)'. We expect that the explicit indication of the types of the arrays and the action is useful for safer programming, although the name of each function becomes lengthy. By using these fundamental functions, we can simply program governing equations for time development of fluid motions. Since the source codes can be written in a similar form to the original mathematical expressions, the programs can be understood easily. Moreover, programs are easy to be modified due to the systematic naming of the functions.

3. Output with gtool4 data format

The self descriptive data format 'gtool4' is proposed by GFD Dennou Club davis project (http://www.gfd-dennou.org/arch/davis) for the purpose of efficient post-processing of massive data. The data can keep not only values of variables but also supplemental information for post-processing and visualization, such as grid point data, title, values of parameters. Although this data format is developed for massive data such as output of GCM or observation of satellite systems, we found it is also useful for the output of small models presented here.

By using 'gtool_history' module developed by Toyoda and others, it is easy to implement data output with gtool4 to the model program sources (Takehiro et al, the Joint Meeting of Earth and Planetary Science 2001, S4-P007). It is possible to realize output with gtool4 data format by adding several statements which issue the commands of data definition, variable definition, output of the values, and data closing. 'gtview' command can visualize output with gtool4 data format by contours on a 2-dimensional plane or 1-dimensional graphs. Commands for some simple post-processing, such as averaging and arithmetic operations, are also prepared.