Rossby-wave nonlinear interactions and large-scale structure formation in two-dimensional turbulence on a rotating sphere

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Abstract

Two-dimensional barotropic model on a rotating sphere is one of the simplest mathematical models describing the dynamics of planetary atmospheres. The two -dimensional turbulence shows the spontaneous formation of large-scale zonal flows similar to those seen on giant gas planets such as Jupiter. However, this mechanism has not been fully clarified yet. The aim of this study is to understand the formation mechanism of zonal flows by investigating in detail the non-linear interactions of Rossby wave solutions, which is characteristic of this system.

Reasons and benefits of using JAXA Supercomputer System

Since the research group with which we might collaborate had an account on the JAXA supercomputing system, we considered it desirable to use this system for sharing data in case of collaboration. Also, as the research was a continuation of the previous year's research and most of the data required was located on the JAXA supercomputing system, we wished to continue using the system.

Achievements of the Year

The time variation of flow field on a rotating sphere can be described in terms of Rossby wave dynamics. It is known that the Rossby waves corresponding to zonal flow correspond to the spherical harmonic Y_n^0, where n is an integer. Among those, only Rossby waves corresponding to spherical harmonics with odd n develop, and no energy accumulation occurs in the Rossby waves with even n.

We considered this as a clue to elucidate the mechanism of zonal flow formation, and first investigated the source of the difference due to even and odd n by calculating the interaction coefficients of the non-linear interactions of Rossby waves. As a result, the following two points were confirmed.

* The form of the nonlinear term in the governing equation itself does not cause the difference in the development of zonal Rossby waves due to even-odd values of n.

* The even-odd difference of n in the development of zonal Rossby waves is highly dependent on the overall state of the flow field. In the time evolution from (probably) an arbitrary initial state, a background flow field satisfying the conditions for the development of zonal Rossby waves with an odd number of n is first formed and maintained.

Then the energy transport due to nonlinear interactions is further investigated in detail using the flow field data, and the following was confirmed.

* The energy accumulation to Rossby waves with an even integer of n does not occur, but these waves are also involved in nonzero energy transport, and the result of the time integration of the energy transport is only zero.

We have also formulated hypotheses based on some other results obtained and are currently testing them. These will be reported as soon as the results are finalised.

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	N/A
Number of Processes	1
Elapsed Time per Case	24 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	42,895.30	0.00
TOKI-ST	0.00	0.00
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	160.00	0.14
/data and /data2	10,440.00	0.08
/ssd	200.00	0.03

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2 (%)
ISV Software Licenses (Total)	0.00	0.00

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.