The role of Rossby waves, which are invariant sets with respect to time evolution, in the formation of large-scale structures.

● **Responsible Representative**

Kiori Obuse, Associate Professor, Okayama University

● **Contact Information**

Kiori Obuse(obuse@okayama-u.ac.jp)

● **Members**

Kiori Obuse

● **Abstract**

One of the simplest mathematical models describing the dynamics of planetary atmospheres, the 2D barotropic flow on a rotating sphere, shows the spontaneous formation of large-scale zonal flows such as those seen in giant gas planets. However, this mechanism has not been fully clarified. This study aims to clarify what kind of Rossby wave interaction strongly contributes to the formation of large-scale structures.

● **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**

For large-scale zonal flow formation in unforced 2D turbulence on a rotating sphere, it has been suggested that the Rossby wave three-wave interaction $Y_{(n1)}^{(m)} \times Y_{(n2)}^{(-m)} \to Y_{(n3)}^0$ (where Y_n^m is the spherical harmonic function), where

(1) $m_1 = -m_2$ is small

(2) $|n_1 - n_2|$ is very small

(3) n_1, n_2 are very large

have been suggested to be important (Hagimori et al , 2024). However, it is not yet known how and to what degree these conditions operate in the structure formation. In this study, therefore, calculations were carried out to confirm whether or not the large-scale zonal flow formation depends on the initial conditions and to clarify which of the above conditions (1)-(3) works most strongly.

The results showed that, firstly, if the zonal flow formation is continuously inhibited up to a certain stage, the zonal flow does not become predominant when the normal time development condition is subsequently restored. Furthermore, even if a large perturbation was applied to the state where the zonal flows ceased to dominate, the zonal flows did not resume their developments and dominate the flow filed. This result indicates that the faomation of large-scale zonal flows depend on initional conditions. In order to consider the importanc of conditions (1)-(3) above, the time evolution for various initial flow filed with various energy distributions (with particular attention to the distribution of m) was subsequently investigated. The results suggest that (1) is of relatively low importance. The importance of (3) is also considered to be low because of the reverse cascade that occurs when zonal flows dominate. Therefore, it was found that condition (2) "$|n\_1 - n\_2|$ being very small" may be of relatively high importance among the three conditions.

● **Publications**

- Oral Presentations

1) Kiori Obuse, Hagimori Yusuke, and Michio Yamada, "Rossby wave nonlinear interactions and large-scale zonal flow formation in two-dimensional turbulence on a rotating sphere", EGU General Assembly 2024, Austria Center Vienna, 14th-19th Apr. 2024

2) Kiori Obuse and Michio Yamada, "Large-scale zonal structure formation by Rossby wave nonlinear interaction on a rotating sphere.", Annual Meeting of JSFM, Forest Sendai, 25-27 Sep. 2024

● **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	8.76	0.00
TOKI-ST	0.07	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	140.00	0.09
/data and /data2	10,240.00	0.05
/ssd	0.00	0.00

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.