Nonlinear phenomena appeared in a Q-G oceanic double gyre under seasonal external forcing

SHINYA SHIMOKAWA[1] and TOMONORI MATSUURA[2]

[1] *National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan*
[2] *Toyama University, Toyama, Japan*

In an oceanic double-gyre system, nonlinear oscillations of the ocean under seasonally changing external forcing are investigated using a 1.5 layer quasigeostrophic model and a simple model related to energy balance of the oceanic double gyre (Shimokawa and Matsuura, 2010). In the experiments, the variable parameter is the amplitude of external seasonal forcing, and the Reynolds number is fixed as 39, at which periodic shedding of inertial subgyres occurs. We found that entrainment (at two times the period of the forcing) and intermittency (on–off type), phenomena often seen in nonlinear systems, emerge with increasing amplitude of the forcing. It is known in nonlinear dynamics that entrainment (or synchronization) is crucial to the understanding of self-organization phenomena occurring in the fields of coupled oscillators of the dissipative type (Kuramoto 1984). It is also known that when entrainment is broken in a nonlinear system, intermittency often emerges (Berge et al. 1984). These two phenomena seem to be related to the generation mechanism and characteristics of long-term (from interannual to decadal) variations in the strong current region of subtropical gyres such as the Kuroshio and its extension region.

Keywords: nonlinear, entrainment, intermittency, oceanic general circulation, Kuroshio, quasigeostrophic, Brusselator

References

[1] Berge, P., Y. Pomeau, and C. Vidal, Order within chaos: Towards a deterministic approach to turbulence, Harmann, Paris, 380 pp (1984)..

[2] Kuramoto, Y., Chemical Oscillations, Waves, and Turbulence, Springer-Verlag, Berlin., 153 pp (1984). (re-published by Dover in 2003).

[3] Shimokawa, S. and T. Matsuura, Chaotic behaviors in the response of Q-G oceanic double-gyre to seasonal external forcing, J. Phys. Oceanogr., 40, (in press), (2010)..