Rhythmic Phenomena in Nonlinear Systems and Oceanic General Circulation

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Various oscillation phenomena such as transition between meander and non- meander paths of western boundary current such as the Kuroshio exist in the oceanic general circulation. These phenomena can be related to nonlinear rhythmic phenomena such as synchronization, stochastic resonance and stochastic synchronization. Synchronization 1) is a phenomenon for an adjustment of rhythms of two or more self-sustained oscillating systems, which have different periods. Stochastic resonance 2) is a phenomenon in which a kind of noise amplifies and elicits weak signals under detection thresholds. Both phenomena are observed in various nonlinear systems such as climate system, living system, and electric circuits. Also, the coupling of both phenomena was found and is called stochastic synchronization 3).

Thus, we investigate the responses of oceanic double-gyre to external wind forcing with and without noise using a 1.5 layer quasi-geostrophic model, and considered the possible role of nonlinear rhythmic phenomena in oceanic general circulation 4)-7). The variable parameter is the amplitude of external seasonal forcing, α, the amplitude of red noise, ε, and the Reynolds number, Re.

Synchronization at two times the period of the forcing occurs at a parameter range of α and Re without noise (ε =0). For cases with adequate (not too weak and not too strong) noise, potential signals in the system appear at the front as actual signals (i.e., stochastic resonance) such as intermittent large variations in energy. Also, by adding red noise to external forcing, synchronization (i.e., stochastic synchronization) occurs when the amplitude of external forcing is smaller than that in the case without noise. These results suggest that potential signals in the system are amplified and appear as stochastic resonance or synchronization in relation to the added noise.

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