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Thermodynamics of the Oceanic General Circulation: A Global Perspective of the Ocean System and Living Systems

SHINYA SHIMOKAWA[1] and HISASHI OZWA[2]

[1] *National Research Institute for Earth Science and Disaster Prevention, Tsukuba 305-0006, Japan <simokawa@bosai.go.jp>*

[2]*Institute for Global Change Research, Frontier Research System for Global Change, Yokohama 236-0001, Japan*

We investigate thermodynamics of a global-scale open ocean circulation and discuss the physical properties of "living systems", that is, individual organisms, by analogy to the behavior of the ocean system. It is shown with numerical simulations that multiple steady states can exist under the same set of boundary conditions in the ocean system, and the state can be shifted by applying perturbations at the surface boundary. The perturbations tend to shift the system to a state of higher entropy production, except when a perturbation destroys the initial circulation completely (Fig. 1). This result supports the hypothesis that a nonlinear dynamic system tends to move to a state with higher entropy production by producing an active circulation in the system when triggered by perturbations. Finally, an analogy is suggested between the ocean system and a living system, in which a highly organized circulatory structure of fluids has evolved from a less organized primeval one, thereby producing entropy in the surrounding system at an increased rate (Fig. 2).

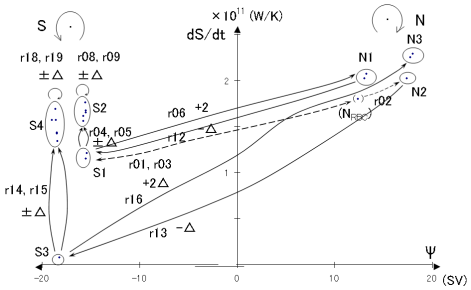

Fig. 1 (upper): The relationship between rates of the entropy production (dS/dt) and strength of the circulation (Ψ) during transitions among multiple steady states.

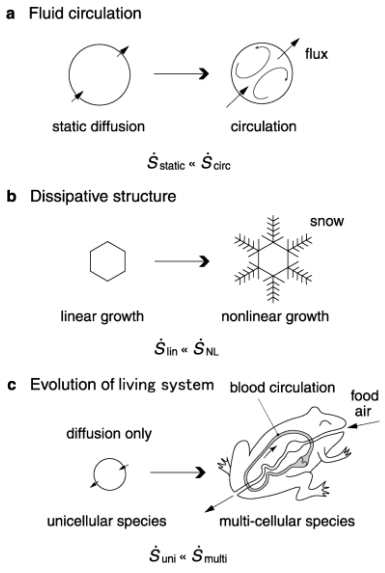

Fig. 2 (right): An analogy among fluid circulation, dissipative structure, and the evolution of a living system.