Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

MIS024-16 Room:301B Time:May 25 18:15-18:30

Emergence of dissipative structures and Maximum Entropy Production (MEP)...Application to climatic system

Hiroshi Serizawa[1*], Takashi Amemiya[1], Kiminori Itoh[2]

[1]Yokohama National University, [2]Yokohama National University

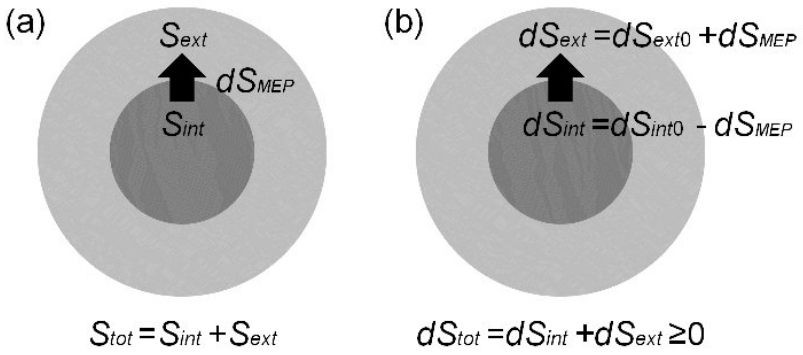
Since before, it has been well known that dissipative structures characterized by low entropy can emerge spontaneously in open systems maintained in the state of far from equilibrium. However, optimization theories that show how dissipative structures are stabilized have not been sufficiently investigated. In recent years, two major trends, the principle of Maximum Entropy Production (MEP) by Kleidon [1] and the Constructal theory by Bejan [2], have occurred in this field. A controversy as for which is more fundamental has started last year, and two theories are expected to progress further through mutual arguments [3],[4]. It seems that low entropy in dissipative structures and MEP are inconsistent with each other. In this presentation, we first give outlines of these two theories, using basic heat transfer models from the tropical to the polar region. Next, we intend to resolve the dilemma, mainly referring to the MEP theory, where a two-hierarchy model with the dissipative structure (the internal of the system) and environment (the external of the system) is proposed. The important point is that MEP means maximization of entropy emission from the internal structure to the external environment. Assuming that the energy source such as the sun is included in external environment, the second law of thermodynamics is also guaranteed, because the total system can be regarded as almost isolated. It seems to be various kinds of dissipative structures on the Earth such as lives and human societies. We finally discuss the applicability of optimization theories introduced in this presentation to other fields such as biology, sociology and economics beyond climatology and meteorology. In the appended figure, the filled circle (dark gray), the ring (light gray) and the arrow mean the dissipative structure, external environment and maximized entropy production, respectively.

[1] Kleidon, A., Lorenz, R.D. (2004). Non-equilibrium thermodynamics and the production of entropy: life, Earth, and beyond. Springer Verlag, Heidelberg.

[2] Bejan, A., Reis, A.H. (2005). Thermodynamic optimization of global circulation and climate. International Journal of Energy Research 29:303-316.

[3] Kleidon, A. (2010). Non-equilibrium thermodynamics, maximum entropy production and Earth-system evolution. Philosophical Transactions of the Royal Society A 368:181-196.

[4] Bejan, A. (2010). Design in nature, thermodynamics, and the constructal law. Comment on ”Life, hierarchy, and the thermodynamic machinery of planet Earth” by Kleidon. Physics of Life Reviews 7:467-470.



Keywords: Principle of Maximum Entropy Production (MEP), Open system, Constructal theory, Dissipative structure, Far from equilibrium, Non-equilibrium thermodynamics