Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)
©2013. Japan Geoscience Union. All Rights Reserved.

MIS22-P02 Room:Convention Hall Time:May 20 18:15-19:30

Lightning simulation by Poisson equations and its implication for entropic theories

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

[1]Graduate School of Environment and Information Sciences, Yokohama National University

Various studies have been reported as for simulations of lightning by Poisson equations, and its mechanisms are also well known [1]. However, a difficulty that programs require a lot of memories and long elapsed time complicates the usage of laptop PCs. This presentation introduces a practical simulation model by means of the Finite Difference Method (FDM), then, the origin of tree-shaped fractal structures of lightning is studied from the entropic viewpoint. According to the principle of Maximum Entropy Production (MEP) by Kleidon, open systems existing far from equilibrium are stabilized in the state of maximized entropy production, creating dissipative structures characterized by low entropy [2]. On the other hand, the constructal theory advocated by Bejan insists that area-to-point or area-to-volume flow optimizes itself in such a way that the global flow resistance is minimal. In other words, the flow systems that persist for a long time should provide easier access to the current flow [3],[4]. Both are optimization theories of the same kind. Since about 2010, there have been some controversies between these two about which is essential, however, fruitful results have not been produced [5],[6],[7]. We intend to help reconciliation between two theories, regarding tree networks such as lightning as dissipative structures with low entropy and inquiring its origin. We also refer to the differences between the MEP principle by Kleidon and the more classical principle of Minimum Entropy Production by Prigogine [8].

[1] Amarasinghe, D., Sonnadara, U. (2008). Fractal characteristics of simulated electrical discharges. Journal of the National Science Foundation of Sri Lanka 36(2):137-143.

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

[3] Errera M.R., Bejan, A. (1998). Deterministic tree networks for river drainage basins. Fractals 6(3):245-261.

[4] Bejan, A. (2007). Constructal theory of pattern formation. Hydrology and Earth System Sciences 11:753-768.

[5] Kleidon, A. (2010). Life, hierarchy, and the thermodynamic machinery of planet Earth. Physics of Life Reviews 7:424-460.

[6] 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.

[7] Kleidon, A. (2010). Life as the major driver of planetary geochemical disequilibrium. Reply to comments on ”Life, hierarchy, and the thermodynamic machinery of planet Earth”. Physics of Life Reviews 7:473-476.

[8] Prigogine, I. (1962). Introduction to non-equilibrium thermodynamics. Wiley Interscience, New York.

Keywords: Principle of Maximum Entropy Production (MEP), Constructal theory, Tree network, Poisson equation, Finite Difference Method (FDM), Lightning