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Category Theory as the Language of Modelling Environmental Interfaces – Complex Biophysical Systems

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An environmental interface can be defined as a surface between two abiotic or biotic systems that are in relative motion and exchange mass, energy and momentum through biophysical and/or chemical processes. These processes are fluctuating temporally and spatially. The study of interfaces is a crucial prerequisite toward a better understanding of the environment, but it is enormously complex and is expected to occupy scientists for some significant time in the future. In environmental fluid mechanics, there are four main environmental interfaces that need to be considered, namely air-water, air-land, water-sediment, and water-vegetation interfaces. They are ideal places for considering the complex systems. As an open system, an environmental interface interacts in a coherent way, producing new structures, building up cohesion and new structural boundaries. It goes through emergence and self-organisation where (1) emergence means the appearance of a new property of a system which cannot be deduced or previously observed as a functional characteristic of the systemic parts and (2) self-organisation means appearance of new system structures without explicit pressure from outside the system, or involvement from the environment.

Category theory (or topos) is recommended as a powerful modern tool for modelling biophysical systems and consequently environmental interfaces. It provides the mathematical framework for modelling physically observable structures and at the same time the logical conceptualisation of this modelling as well. However, in the modelling world, general notations, previously expressed in the vernacular world, acquire the unambiguous and exact expression possible only in mathematical language. It seems that

the formal category theory has the power to fully realise replacement of the vernacular with the mathematical. It can also patent many latent assumptions in the theory of differential equations. The aim of this paper is to point out the possible application of the category theory in modelling environmental interfaces in nature.