Geophysical Research Abstracts
Vol. 19, EGU2017-8858, 2017
EGU General Assembly 2017

Nonlinear Synergistic Emergence and Predictability in Complex Systems: Theory and Hydro-Climatic Applications

Rui A. P. Perdigão (1), Julia Hall (1), Carlos A. L. Pires (2), and Günter Blöschl (1)

(1) Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology (TU Wien), Vienna, Austria (perdigao@hydro.tuwien.ac.at), (2) Instituto Dom Luiz, Universidade de Lisboa, Lisboa, Portugal

Classical and stochastic dynamical system theories assume structural coherence and dynamic recurrence with invariants of motion that are not necessarily so. These are grounded on the unproven assumption of universality in the dynamic laws derived from statistical kinematic evaluation of non-representative empirical records.
As a consequence, the associated formulations revolve around a restrictive set of configurations and intermittencies e.g. in an ergodic setting, beyond which any predictability is essentially elusive.

Moreover, dynamical systems are fundamentally framed around dynamic codependence among intervening processes, i.e. entail essentially redundant interactions such as couplings and feedbacks.
That precludes synergistic cooperation among processes that, whilst independent from each other, jointly produce emerging dynamic behaviour not present in any of the intervening parties.

In order to overcome these fundamental limitations, we introduce a broad class of non-recursive dynamical systems that formulate dynamic emergence of unprecedented states in a fundamental synergistic manner, with fundamental principles in mind. The overall theory enables innovations to be predicted from the internal system dynamics before any a priori information is provided about the associated dynamical properties.

The theory is then illustrated to anticipate, from non-emergent records, the spatiotemporal emergence of multiscale hyper chaotic regimes, critical transitions and structural coevolutionary changes in synthetic and real-world complex systems.

Example applications are provided within the hydro-climatic context, formulating and dynamically forecasting evolving hydro-climatic distributions, including the emergence of extreme precipitation and flooding in a structurally changing hydro-climate system.

Validation is then conducted with a posteriori verification of the simulated dynamics against observational records. Agreement between simulations and observations is confirmed with robust nonlinear information diagnostics.