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Evolving Complex Networks Analysis of Space-Time Multi-Scale Wavelike Fields: Application to African Rainfall Dynamics

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Evolving complex networks analysis is a very recent and very promising attempt to describe, in the most realistic ways, complex systems or multi-system dynamics.

The Earth system is comprised of many attractors that are multi-scaled, multi-complexity non-linear systems of systems. Space time propagations responsible for precipitation is one example in which the interactions between the aforementioned properties of complex systems can be applied; especially the spatio-temporal wave likeness of spatial patterning and temporal recurrences representative of the underlying dynamics.

Tobler's first law of geography states: "Everything is related to everything else, but near things are more related than distant things" (Waldo Tobler, 1970 Economic Geography 46: 234-40). Most time-series analysis are pairwise correlations and even when faced with gridded data, the neighborhood characteristics is never used as an input variable. In our point of view, such analysis ignore vital information on the multi-scale non-linear spatial patterns of the continuities and singularities possibly resulting from underlying random processes.

This work in progress is an application, mainly inspired by wave theory and non-linear dynamics. It is a systematic method of methods, which exploits the nonlinear multi-scale wave nature of virtually everything in nature including financial data, disease dynamics et cetera and applies it to climate through complex network analysis of rainfall data. The method uses a continuous spatial wavelet transform for non-linear multi-scale decomposition. Such an output carries all vital information pertaining the singularity structures in the data. Similarity measures are obtained by considering the multi-fractal nature of the distribution of discontinuities. The more similar the point-wise generalized dimensions are in-terms of their continuity, fractal, entropy, information and correlation dimensions, the higher the chance that they characterize similar underlying dynamics. The similarities are then weighted by their recurrence rate to ensure that the similarities are not a one time noise but regular temporal occurrence. Finally, the evolving complex networks are constructed. These networks are envisioned to shade more light into the patterns of African rainfall dynamics and their possible underlying sources. Last but not least, the global measures from the network will give new time series to compare with external possible forcing in the global network and the the rainfall dynamics.