A STATISTICAL ANALYSIS OF TOKUNAGA'S BRANCHING RATIOS IN TOPOLOGICALLY RANDOM NETWORKS

Carmelo Agnese (1) and Antonio Criminisi (2)
(1) D.I.T.A.F., Viale delle Scienze, 90128, Palermo (ITALY)
(2) D.I.I.A.A., Viale delle Scienze, 90128, Palermo (ITALY)

Firstly *Tokunaga* introduced an infinite subset of deterministic topological binary trees, exhibiting self-similar property. These trees, based on the Horton-Strahler's ordering scheme, satisfy some constraints about side tributaries to Strahler's streams of all orders. Let $T_{\omega,\omega-k}$ be the average number of side tributaries of order ω-k joining a stream of order ω. Tokunaga's trees satisfied the topological conditions: $T_{\omega-k,\omega} = T_k$, where T_k (branching ratio) depends on k but not ω, and T_{k+1}/T_k =c for all k. Similarly, random self-similar trees (rSSTs) could be defined that trees satisfying only in average the topological properties associated to dSSTs. Among the examples of probability distributions by which random trees of a given size may occur, the simplest and most well-studied is the so-called Random Model (RM). According to this, large-diameter random networks are generated in order to analyze the statistical properties of Tokunaga's branching ratios. As expected, the average state of infinite topologically random networks, which satisfies Tokunaga's constraints about branching ratios, is asymptotically approached with increasing diameter. Interestingly, almost all single realizations of random networks display self-similar property, evidencing that fractal arrangement could spontaneously emerge from simple randomness.

NP1 Scaling, multifractals and nonlinear variability in geophysics

03 Scaling vs. non-scaling methods in rainfall modelling *(co-sponsored by HS)*

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THE SCALING MODEL OF STORM HYETOGRAPH VERSUS TYPICAL STOCHASTIC RAINFALL EVENT MODELS

D. Koutsoyiannis; N. Mamassis
Dept. of Water Resources, National Technical University, Heroon Polytechneiou 5, GR-157 80 Zografou, Greece, dk@hydro.ntua.gr

The Scaling Model of Storm Hyetograph (Koutsoyiannis and Foufoula, 1993) is fitted to short time scale point rainfall data of several regions. In addition, other typical descriptions of rainfall events with different stochastic structures are examined using the same data sets. The comparison provides evidence that the scaling model fits satisfactory to several rainfall data sets of regions with different climates and different population of storms (e.g. intense rainfall events only) and is superior to typical stochastic rainfall event models in capturing rainfall statistical properties even if they are not explicitly used for the model fitting.

A SPACE AND TIME MODEL FOR DESIGN STORM GENERATION

A.W. Seed(1), R. Srikanthan(2), M. Menabde(3)
(1) CRCCH, Bureau of Meteorology, GPO Box 1289K, Melbourne, VIC 3001, a.seed@bom.gov.au
(2) Hydrology, Bureau of Meteorology, GPO Box 1289K, Melbourne, VIC 3001
(3) Physics Department, University of Auckland, P. Bag 92019 Auckland, New Zealand

Realistic rainfields that represent storms with a known return period are required as input into design calculations for hydrological projects that cover a wide range of hydrological scales. The current standard practice is to assume either that the storm is uniform in time and space, or that it varies in some simple manner. Multi-affine models of rainfall based on the concept of a multiplicative cascade provide the possibility of generating a stochastic space/time series of rainfall that reproduces the scaling behaviour of rainfall that is observed. This paper reports the development of a space/time model of rainfall based on a multiplicative cascade that is able to model the spatial and temporal variability of rainfall over a wide range of scales. The model requires the duration and mean areal intensity derived from a standard Intensity-Frequency-Duration analysis based on raingauge data, and the variance of the rainfield which can be estimated as a function of the mean rain rate. Characteristic values for the model parameters that control the scaling characteristics of the rain fields have been estimated from an analysis of a number of significant storms in the Australian radar data archive and are used to generate plausible rain fields with a known return period.

A STOCHASTIC HIERARCHICAL SPATIAL RAINFALL MODEL MEETING SCALING PROPERTIES OF RAINFALL

P. Willems
Katholieke Universiteit Leuven, Hydraulics Laboratory, de Croylaan 2, B-3001 Leuven, Belgium, Patrick.Willems@bwk.kuleuven.ac.be

A stochastic spatial rainfall model has been developed at the scale of small hydrographic and urban catchments on the basis of data of a dense network of rain gauges. The model is of the conceptual and hierarchical type as it describes spatial rainfall in a macroscopic physically-based way by distinguishing rainfall entities with different scales: rain cells, small and large mesoscale areas (or rain storms). The model structure building is based on a detailed analysis of 809 observed rain cells and 104 rain storms. The physical characteristics of individual rain cells have been studied first on the basis of geostatistical methods and Taylor's hypothesis on turbulence. It has been found that rain cells can be described well by a Gaussian distribution of rainfall intensities in space and by advection and diffusion, together with a decrease or increase of rain cell volumes in time. Afterwards, the rain cells have been placed in a larger model of spatial rainfall analogous to many existing models. In this model, a spatial Poisson process is used on the basis of the description of the occurrence of rain cells in mesoscale areas. After calibration of all observed rain storms by two methods (e.g. Kalman filter), the model parameters have been represented in a stochastic way by probability distributions and correlations. The derived stochastic structure applies to the stochastic generation of long-term time series of spatial rainfall. The model has been tested by comparing the spatial and temporal scaling properties of the generated and historical rainfall series. The scaling properties are represented very well for a large range of scales.
Because this model seems to be able to explain the scaling properties of rainfall by the physical features of spatial rainfall, it will contribute to the convergence between two approaches of rainfall modelling: those using scaling properties and those using the traditional hierarchical approach.