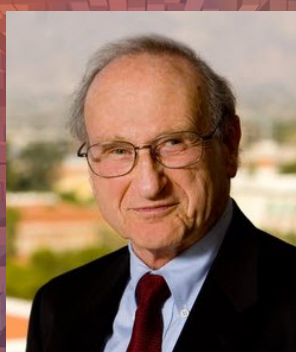
Distinguished Scientist Seminar Series

Friday
March 14, 2014
10:30 a.m. - 12:00 noon
Building 66 Auditorium
Lawrence Berkeley National Laboratory
Host: Daisuke Asahina

A Multiscale Approach to Geospatial Analysis of Hydrogeologic (and Many Other) Data



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Professor Neuman has summarized his scientific contributions in over 310 professional papers, books and reports. His name appears on two ISI lists of Highly Cited Researchers, one in Engineering and one in Environmental Science. Professor Neuman is a member of the U.S. National Academy of Engineering; Corresponding member of the Bologna (Italy) Academy of Sciences; Fellow of the American Geophysical Union, the Geological Society of America, and Galileo Circle of the UA College of Science; Concurrent Professor of Nanjing University in China; and Honorary Professor of the Nanjing Hydraulic Research Institute in China. Professor Neuman has received numerous awards and honors including the Robert E. Horton Medal and the Hydrology Award from the American Geophysical Union, the O.E. Meinzer Award from the Geological Society of America, the M.K. Hubbert Award from the Association of Groundwater Scientists and Engineers, the C.V. Theis Award from the American Institute of Hydrology, and a certificate of appreciation by the U.S. Department of Agriculture. He has been named Birdsall Distinguished Lecturer by the Geological Society of America, and fourth Langbein Lecturer in Hydrology by the American Geophysical Union.

Abstract

The spatial statistics of many hydrogeologic variables scale in a way that is difficult to detect with standard geostatistical methods. Common manifestations of such scaling include (a) highly irregular (at times intermittent) spatial variability; (b) symmetric, non-Gaussian frequency distributions characterized by heavy tails that often decay with separation distance or lag; (c) nonlinear power-law scaling of sample structure functions (statistical moments of absolute increments) in a midrange of lags, with breakdown in such scaling at small and large lags; (d) extended power-law scaling (linear relations between log structure functions of successive orders) at all lags; (e) nonlinear scaling of power-law exponent with order of sample structure function; and (f) pronounced anisotropy in these behaviors. Similar statistical scaling behaviors are known to be exhibited by a wide variety of earth, environmental and other variables (including ecological, biological, physical, astrophysical and financial). The literature has traditionally interpreted this to imply that the variables are multifractal, which however explains neither the observed breakdown in power-law scaling at small and large lags nor extended power-law scaling. We offer an alternative interpretation that is simpler and consistent with all the above phenomena. Our interpretation views the data as samples from stationary, anisotropic sub-Gaussian random fields subordinated to truncated fractional Brownian motion (tfBm) or truncated fractional Gaussian noise (tfGn). Such sub-Gaussian fields are mixtures of Gaussian fields with random variances. Truncation of monofractal fBm (which is non-stationary) and the fGn entails filtering out components below the measurement or resolution scale of the data and above the scale of their sampling domain. Our novel interpretation of the data allows us to obtain maximum likelihood estimates of all parameters characterizing the underlying truncated sub-Gaussian fields. These parameters in turn make it possible to downscale or upscale all statistical moments to situations entailing smaller or larger measurement or resolution and sampling scales, respectively. They also allow one to perform conditional or unconditional Monte Carlo simulations of random field realizations corresponding to these scales. Aspects of our approach are illustrated on field and laboratory measured porous and fractured rock permeabilities, as well as soil texture characteristics and neural network estimates of unsaturated hydraulic parameters in a deep vadose zone near Phoenix, Arizona.

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