

MICHIGAN STATE UNIVERSITY
Department of Statistics and Probability

A Workshop on Future Directions in Fractional Calculus Research and Applications

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Applications, Challenges, and Suggestions of Fractional-Derivative Models in Simulating Hydrologic Processes

Abstract

Natural geologic media including aquifers, soil, and streams, typically contain intrinsic multi-scale physical and chemical heterogeneities, which provide an ideal and diverse base for testing the application of fractional-order partial differential equations. This presentation is an introduction of our efforts to develop, solve, and apply fractional-derivative models (FDM) to the quantification of various processes in the hydrologic cycle within and across scales. Results clearly show that FDMs can provide an efficient black-box model for the computational hydrology community. However, our laboratory experiments and Monte Carlo simulations also show serious challenges such as poor predictability and unstable values of model parameters, which hinder the further application and expansion of fractional calculus to a much larger area of hydrology and geology. We suggest to combine stochastic theory such as FDMs and geological information when characterizing bounded hydrological dynamics in natural geological media with complex boundary conditions, nonstationary heterogeneity, and transient flow field.