CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

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Project Number

S1427

Project Title

A Geostatistical Solution to the Inverse Problem in Groundwater Modeling Using Stochastic Partial Differential Equations

Abstract

Objectives/Goals

The objective of this project is to develop a new stochastic groundwater flow model by characterizing the hydrogeological variables (including hydraulic head and transmissivity) as stochastic processes. This will enable hydrogeologists to better characterize heterogeneous aquifer properties while illustrating groundwater flow patterns.

Methods/Materials

A new variable, the logarithm of the inverse transmissivity, was introduced into the deterministic groundwater flow equation, and the resulting equation was transformed into a stochastic partial differential equation through the implementation of small-perturbation methods. The fluctuations of the hydrogeological variables about their expected values were described by cylindrical Wiener processes on infinite-dimensional Banach space. Through the elimination of pure deterministic terms (which could be estimated using numerical finite difference and finite element methods), a second-order linear stochastic partial differential equation relating the fluctuations was obtained. Stochastic convolution methods were then used to establish a definite formula for calculating the fluctuation of the hydraulic head given deterministic information of the transmissivity.

Results

The new formula allows for the easy quantification of the random nature of the hydraulic head through the simple substitution of known deterministic information. The new methodology was extensively tested and yielded results that very closely characterized the random moments of the simulated datasets.

Conclusions/Discussion

My new stochastic groundwater flow model allows hydrogeologists to accurately incorporate the diverse physical properties of aquifers while characterizing flow patterns. Hydrogeologists no longer need to make unjustified assumptions regarding the homogeneity of aquifers. They can now truly understand the groundwater flow patterns apparent in heterogeneous porous media. By accurately implementing my stochastic groundwater formula, practitioners can better illustrate the complex process of contaminant transport and groundwater flow occurring in the subsurface.

Summary Statement

I developed a novel stochastic groundwater flow model that allows hydrogeologists to better characterize the heterogeneous physical properties of aquifers while describing groundwater flow patterns.

Help Received