



D15 Complexity vs. Uncertainty in Models

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Learning Overview: After attending this presentation, attendees will be able to discuss the trade-offs between complex models requiring many parameters to be estimated versus the uncertainty associated with the parameters required in complex models.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by making practitioners aware of the pitfalls of overly complex mathematical models.

With the advent of high-performance computing, there has been a tendency to build models that are more and more complex. This is exacerbated by the ability to generate very large data sets using remote sensing, high-speed telemetry-using cell phone networks and similar data networks, and the prevalence of Geographic Information Systems (GIS) to process these data.

In environmental settings such as groundwater modeling where the parameters in these models are uncertain, complex models can result in very large predictive uncertainty. Parameter estimation programs such as BeoPEST can be used to estimate a large number of parameters quite effectively, thus reducing the predictive uncertainty. However, depending on the observation data set, there may be a substantial parameter null space that cannot be estimated.

This presentation provides a review of groundwater models used in litigation over the past 30 years. Many of these models have been used in Interstate Compact litigation and have been the topic of disputes before the Supreme Court of the United States. This presentation explores the complexity of the models and the methods applied to reduce the uncertainty of the model. In particular, this presentation reviews the increase in complexity over time and attempts to answer the question of whether the increased complexity leads to increased or decreased uncertainty in the predictions of the models. In a litigation environment, there is the additional element that the trier of fact may not be well versed in modeling, calibration, and uncertainty, and yet the outcome of litigation where there are competing models may depend on a decision selecting one model over another.

Occam's Razor in a modeling context may require that instead of using very complex models, we ask more fundamental questions. For example, can the question be resolved by targeted measurements, or by a water budget analysis, or using a simpler analytical solution, or perhaps using a change model, as opposed to building a complex model. To what extent does a simpler approach result in predictions that are as reliable as a more complex model?

This presentation demonstrates that complexity does not necessarily translate to greater certainty and, particularly in a litigation context, how complexity often calls into question the results of a more complex model.

Complexity, Uncertainty, Models