# Monte Carlo Enhancement Using Simulation Decomposition: Visual Analytics in Environmental Decision-Making

**Julian Scott Yeomans**
OMIS Area, Schulich School of Business, York University, Toronto
syeomans@schulich.yorku.ca

**Abstract**
Environmental and energy engineering problems frequently require the need for decision-making in situations containing considerable degrees of uncertainty. Monte Carlo simulation methods have been used in a wide array of environmental planning settings to incorporate these uncertain features. Simulation-generated outputs are commonly displayed as probability distributions. Recently simulation decomposition (SIMDEC) has enhanced the visualization of the cause-effect relationships of multi-variable combinations of inputs on the corresponding simulated outputs. SIMDEC is a visual analytics approach that partitions sub-distributions of the Monte Carlo outputs by pre-classifying selected input variables into states, grouping combinations of these states into scenarios, and then collecting simulated outputs attributable to each multi-variable input scenario. Since it is a straightforward task to visually project the contribution of the subdivided scenarios onto the overall output, SIMDEC can illuminate previously unidentified connections between the multi-variable combinations of inputs on the outputs. SIMDEC is readily generalizable to any Monte Carlo method with negligible additional computational overhead and can, therefore, be readily extended into most environmental analyses that use simulation models. This presentation provides a background to the overall SIMDEC methodology, highlights various areas for advancement, and demonstrates the relative efficacy of SIMDEC for supporting decision-making in environmental/energy engineering by highlighting a number of case applications.

**Biography**
Julian Scott Yeomans is a Professor of Operations Management and Information Systems at York University's Schulich School of Business in Toronto, Canada. He holds degrees in management science/information systems, environmental engineering, and statistics. He generally teaches courses on VBA programming, business analytics, and spreadsheet-based decision support systems. He has published 5 books (including 3 on incorporating climate change uncertainties into environmental assessments) and over 125 peer-reviewed, academic journal articles on a wide spectrum of topics. His most recent research has focused on the applications of different combinations of simulation-optimization, machine learning, visual analytics, population-based metaheuristics, and modelling-to-generate-alternatives. Current application areas of these methods include environmental informatics, waste management, empirical finance, and the optimal osmotic dehydration of fruits, vegetables, and fungi.