Integrated 3D Surface-Subsurface Hydrosystem Modeling Across Scales: Past, Present and Future

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ABSTRACT: Providing a scientific basis for water management policy, and assessing the physical characteristics underlying hydrologic risk, typically requires watershed-scale assessments that encompass a few hundred km$^2$ at a minimum. However, as an example, water resources for agriculture or resource development often require an understanding of river basin scale processes, which can cover areas up to or greater than 100,000 km$^2$. Given the recent increase in losses attributed to large-scale extreme climate related events (i.e. overland pluvial flooding, excess moisture, and drought), and the concern that the frequency of these events will progressively increase in response to climate change, there is growing demand for large-scale hydrologic risk assessments. Because of complex nonlinear interactions between climate, surface water, groundwater and soil moisture across large watersheds, robust physically-based 3D integrated hydrologic models provide a holistic means of performing water-related risk assessment for these types of applications.

In this presentation I will discuss the results from a series of studies covering a range of scales whereby fully-integrated surface/subsurface water models have been developed using the HydroGeoSphere platform, including its capability to perform real-time 3D forecasting of the entire hydrosphere as driven by an ensemble of weather forecasts and guided by data assimilation using wireless field instruments. Within the platform, hydrologic responses within sub-basins are nested seamlessly within full-basin scale models in order to capture additional details at an increased resolution. These simulations facilitate large-scale spatially-distributed projections of flood, drought, and other water-related risks relevant to, for example, crop production at unprecedented detail, over temporal intervals ranging from days to decades. The basin response can also be used to gain insight into the potential impact of a changing climate on water resource availability from both water quantity and quality prespectives. Results from this work demonstrate that comprehensive physically-based hydrologic simulation platforms are becoming increasingly relevant and feasible tools for addressing global water related challenges.

BIO: Edward A. Sudicky, Professor, Ph.D., P.Eng., FCAE, FRSC: Dr. Sudicky, principal founder and Board Chair of Aquanty, Inc. located in Waterloo, retired in 2017 as a full professor in the Department of Earth and Environmental Sciences at the University of Waterloo, and was on the faculty since 1985. Aquanty is a specialized R&D tech company focusing on integrated hydrosystem simulation and data analytics. He received his B.A.Sc. degree in Civil Engineering
(1977), and M.Sc. (1979) and Ph.D. (1983) degrees in Earth Sciences, all at the University of Waterloo. Dr. Sudicky was the Association of Ground Water Scientists and Engineers’ Henry Darcy Distinguished Lecturer in 1994, received the O.E. Meinzer Award from the Geological Society of America in 1999, the Hydrology Award from the American Geophysical Union in 2002 and the M. King Hubbert Award from the National Ground Water Association in 2007. He is a Fellow of the Royal Society of Canada, the Canadian Academy of Engineering, the American Geophysical Union and the Geological Society of America.