Integrated surface-subsurface hydrologic modeling to evaluate risks to agricultural production at regional scales

M.V. Callaghan, S.K. Frey, Y.-J. Park, H.-T. Hwang
Aquanty Inc., Waterloo, ON, Canada
R.D. McConnell
DYMAC Risk Management Solutions, Lacombe, AB, Canada
E.A. Sudicky
University of Waterloo, Waterloo, ON, Canada

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, agriculture-focused water resources challenges often encompass much larger areas, and can easily extend to major river basins (>100,000 km^2). Because of complex interactions between climate, surface water, groundwater, and soil moisture across much of the agricultural landscape, physics-based 3-D integrated surface-subsurface hydrologic models provide a holistic means of performing water-related risk assessment for these types of applications. Recent improvements in numerical techniques, access to high-performance computing resources and the increasing availability of large spatially distributed data sets has allowed fully integrated models to be applied at larger scales with a higher degree of spatial resolution than in the past. The integrated nature of these models implicitly includes hierarchical (regional to local) groundwater flow systems and their effects on water table levels and soil moisture.
In this presentation, we discuss a large-scale modelling-based agricultural risk assessment project whereby fully integrated surface/subsurface water models are being developed using the HydroGeoSphere (HGS) platform for the South Saskatchewan River Basin (SSRB, ~150,000 km^2) located in Western Canada. Recent advances in HGS model development include the implementation of water resources management such as reservoir operation and irrigation. Hydrologic responses within its major sub-basins are nested within the full-basin model in order to capture additional detail at an increased resolution. Visualization of transient model results includes spatially distributed soil moisture, groundwater levels, recharge and discharge patterns at high resolution in relation to surface topographic controls and water bodies. Once complete, the SSRB modelling platform will facilitate large-scale projections of excess soil moisture, drought, and other water-related risks to crop production.