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A Generalized Multi-method Approach to Assess Sensitivity of Dynamical Distributed Watershed Models

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Distributed dynamical physically-based watershed models are being increasingly used as the primary tool for water resources planning and management due to advances in computational power and data availability. For an enhanced and efficient development and application of these complex models, it is therefore critical to understand the dynamical behavior of these models and identify the most influential factors (e.g., parameters) controlling it. Global Sensitivity Analysis (GSA) techniques can be used for this purpose.

The challenge here is that GSA results depend on the GSA approach (e.g., derivative-based, variance-based, or variogram-based), and the type of model response considered. They can also vary with time. To address these challenges a new approach called Generalized Global Sensitivity Matrix (GGSM) is proposed by Razavi and Gupta (2018). When coupled with STAR-VARS algorithm, GGSM, can use any GSA approach, and model response, and time-aggregated or time-varying sensitivity indices, to conduct a comprehensive GSA, and produce a wealth of model sensitivity information, with only a single GSA experiment.

In this study, we aim to illustrate how the STAR-VARS algorithm coupled with the GGSM approach facilitates a computationally-efficient comprehensive GSA using different methods, and how it enables learning about the temporal variability of dominant factors in response of distributed watershed models. For this purpose, we use the VARS-TOOL software toolbox, a comprehensive GSA toolbox, developed based on the VARS (variogram analysis of response surfaces) approach.

For our case study, we use Modélisation Environmentale–Surface et Hydrologie (MESH) as applied to Nottawasaga river basin in Canada. MESH is a semi-distributed physically-based coupled land surface-hydrology modelling system developed by Environment and Climate Change Canada (ECCC) for various water resources management purposes in Canada. MESH couples the Canadian land surface scheme (CLASS) with a routing module, WATROUTE. We will consider multiple model responses such as streamflow, baseflow, and evapotranspiration to assess how the influence of various parameters differs across various model responses.