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Highlighting the importance of subsurface representation in Earth System Models

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Complex physically-based Earth System Models (ESMs) are the primary tools for various hydrologic, atmospheric, and ecologic studies related to water and other environmental resources. In this work, we aim to highlight the importance of representing subsurface in ESMs, which can be often neglected. In particular, we illustrate the dominant impact of soil permeable (active) depth (sometimes known as depth to bedrock), soil vertical discretization, and vegetation rooting depth, as well as their interactions, on ESM simulations.

For this purpose, we conducted a comprehensive multi-criteria Global sensitivity analysis (GSA) of a complex land surface–hydrology model, Modélisation Environmentale–Surface et Hydrologie (MESH), which combines the Canadian land surface scheme (CLASS) with a hydrological routing component of WATFLOOD, WATROUTE. GSA experiments were carried out using a new variogram-based sensitivity analysis technique, called Variogram Analysis of Response Surfaces (VARS). Results from this sample study reveal that certain model parameters and configurations in MESH (as mentioned above) have a major impact on model functioning and outcomes. We also discuss that similar issues are not uncommon with application of other ESMs such as VIC. Therefore, we argue that a more careful representation of these factors is crucial for enhanced development and application of ESMs. We also re-iterate the importance of a transdisciplinary collaboration amongst Hydrologic, Atmospheric, and Ecologic scientists for this purpose.