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Effects of slope smoothing in river channel modeling

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In extending dynamic river modeling with the 1D Saint-Venant equations from a single reach to a large watershed there are critical questions as to how much bathymetric knowledge is necessary and how it should be represented parsimoniously. The ideal model will include the detail necessary to provide realism, but not include extraneous detail that should not exert a control on a 1D (cross-section averaged) solution. In a Saint-Venant model, the overall complexity of the river channel morphometry is typically abstracted into metrics for the channel slope, cross-sectional area, hydraulic radius, and roughness. In stream segments where cross-section surveys are closely spaced, it is not uncommon to have sharp changes in slope or even negative values (where a positive slope is the downstream direction). However, solving river flow with the Saint-Venant equations requires a degree of smoothness in the equation parameters or the equation set with the directly measured channel slopes may not be Lipschitz continuous. The results of non-smoothness are typically extended computational time to converge solutions (or complete failure to converge) and/or numerical instabilities under transient conditions. We have investigated using cubic splines to smooth the bottom slope and ensure always positive reference slopes within a 1D model. This method has been implemented in the Simulation Program for River Networks (SPRNT) and is compared to the standard HEC-RAS river solver. It is shown that the reformulation of the reference slope is both in keeping with the underlying derivation of the Saint-Venant equations and provides practical numerical stability without altering the realism of the simulation. This research was supported in part by the National Science Foundation under grant number CCF-1331610.