Title of Manuscript:
Arc hydro hillslope and critical duration: new tools for hillslope-scale runoff analysis

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Prominent Issues:
- Potential to Attract Media Interest/Attention
- Represents a Significant Scientific Advancement
- Significantly Affect Existing or Future Policy
- Potential Trade Implications
- Associated with Emerging and/or Invasive Organisms or First Report of a Pest(s)
Interpretive Summary:
Runoff is a fundamental hydrologic process that delivers water downslope. On hillslopes, depending on the topography runoff can diverge, or converge to form channel networks. Understanding how runoff travels across landscapes is important for developing models that predict how runoff will be routed as it travels. New tools are needed to help delineate hillslope areas and flow paths. We present a new set of tools, named Arc Hydro tools, that delineate hillslopes, identify flow width functions, and model overland flow while accounting for hillslope curvature. We tested the model in subwatersheds in Arizona and California. We found that, for these two case study subwatersheds, divergent hillslopes account for approximately 45% of the subwatershed area. In addition, we found that hillslope curvature can impact peak runoff predictions by up to a factor of 3 on some hillslopes, although the impact is small for most hillslopes. We anticipate that the new Arc Hydro tools will allow practitioners to readily incorporate hillslope shape in improved predictions of runoff.

Technical Abstract:
Hillslopes are a fundamental unit of surface hydrology, mediating the flow of water to fluvial networks through overland flow and subsurface pathways. Hillslope-scale analysis and theory have been instrumental in broadening scientific understanding of hydrology, and many hydrological models rely on flow routing from hillslopes to channel networks. However, the lack of a standard method for hillslope delineation impedes the application of hillslope-scale theory to real landscapes. In this study, we present Arc Hydro tools to delineate hillslope outlines, identify hillslope width functions (HWFs) and implement a simple overland flow model that accounts for hillslope curvature. We take advantage of the new capabilities provided by this tool to investigate in subwatersheds of the Walnut Gulch Experimental Watershed, AZ and Las Trampas Creek Watershed, CA: (i) the prevalence of convergent, divergent, and uniform-width hillslopes, (ii) how well exponential HWFs match real hillslope morphologies, and whether real hillslopes are curved enough to make a substantial impact on hydrological predictions at the (iii) hillslope and (iv) catchment scales. We found that, for these two case study subwatersheds, divergent hillslopes account for approximately 45% of the subwatershed area, and the median R2 fit of exponential HWFs ranges from 0.56 to 0.78. Curvature is substantial enough to impact peak flow predictions by up to a factor of 3 on some hillslopes, although the impact is small for most hillslopes. Simple watershed-scale analysis indicates that delays in the timing of peak flows can be exaggerated at larger scales.