21st century hydrological modelling for optimizing ancient water harvesting techniques

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ABSTRACT

In order to increase dryland productivity, water harvesting techniques (WHT) have received renewed attention, leading to their massive implementation in marginal drylands. However, the tools to evaluate their efficiency under a wide range of conditions still need to be developed. For a case study in the arid central-northern zone of Chile, a fully coupled 3D surface-subsurface hydrological model based on the Richards' and the Saint Venant equations was parameterized with detailed runoff and soil-water content data collected during simulated rainfall from a 6 x 2 m experimental plot including a catchment area and infiltration trench. Using six responsive parameters identified by a global sensitivity analysis surface and subsurface flow processes were calibrated simultaneously. The calibrated model accurately reproduced observed soil moisture contents (R^2 0.92) and runoff amounts (R^2 0.97), and represented the overflowing infiltration trench, which is a clear improvement over existing frameworks. A comparative analysis with a natural slope demonstrated that the trench was efficient in capturing runoff under high rainfall intensities, such as the one simulated, resulting in a significant decrease (46%) of runoff. However, when extended to natural rainfall seasons, runoff water harvesting was insufficient in dry, normal and wet years, while only under very wet conditions 55% of the potential runoff was effectively harvested and stored in the soil profile. As such, this test case shows the importance of correct water harvesting design to become an effective tool in dryland management, taking both soil physical and climatic constraints into account. The model was further tested on a much larger scale of two ca. 3 ha large catchments in semi-arid Chile, one with infiltration trenches for rainwater harvesting and one without. Good agreement was observed between measured and simulated runoff out the catchment outlet.

Keywords: hydrological model, water harvesting, surface flow, subsurface flow, parameterization, Chile