Subsurface Flow Response to an Extreme Precipitation Event (H035-0012)
presented at 2020 AGU Fall Meeting, 1-17 December

Claudia Corona and Shemin Ge, University of Colorado Boulder

Abstract

Extreme precipitation events (EPEs) are a globally occurring climate phenomena that can be disastrous on the surface but important for replenishing groundwater resources. The effects of EPEs on groundwater resources warrant urgent investigation, especially as they are predicted to continue increasing in intensity and occurrence in the coming decades. One such event occurred in September 2013 along the Front Range of Colorado, where the equivalent of 80% of the region's annual precipitation fell in eight days. The event caused flooding across the Front Range, while regional aquifers showed sudden changes in water table levels. However, subsurface response to the EPE-induced water table rise and subsequent recovery remains poorly understood. Thus, our goal is to examine the subsurface hydrologic response to EPEs using the 2013 Colorado event as an example. We use a one-dimensional unsaturated-and-saturated flow model, HYDRUS-1D, to model subsurface response to the EPE. The upper boundary condition is set by precipitation and the bottom boundary is denoted by a deep drainage boundary condition. Data from a field site in the Boulder Creek Watershed in the Front Range was used to assemble model input parameters.

Initial model results show that the subsurface responds to the 2013 EPE in a temporally similar manner to well field measurements. Specifically, a rapid increase in the water table is observed and subsurface soil water storage remains above steady state for months after the EPE event. A sensitivity analysis is also conducted to identify the hydrologic parameters and soil properties that most significantly affect subsurface response to the EPE. The sensitivity analysis finds that adjusting the water content values, both residual and saturated, as well as varying air-entry pressure values have strong influences on water table fluctuations. Adjusting water content values and air-entry pressure values also affect the recovery time for soil water storage to return to a pre-EPE state. The broader implication of this work is that analyzing subsurface response to EPEs (which occur across all scales), can help illuminate how local and regional watersheds with varying soil types worldwide respond to EPE-induced water table fluctuations and subsurface water storage change.

Plain Language Summary

Extreme rainfall is predicted to increase worldwide. For our towns and cities, more rain falling in less time can lead to flooding and be destructive. For groundwater resources, more rainfall in less time can replenish groundwater resources. In September 2013, the Front Range of Colorado was battered by extreme rainfall. The area got 80% of its yearly rainfall in a few days! The event caused flooding and was thought to have replenished local aquifers. However, we do not understand how the soil beneath the surface responded to the intruding water, before reaching the aquifers. The goal of this study is to use a computer water flow model to better understand what happened to the water as it flowed downward through soil, to the aquifer. Model results show that the water moved quickly, causing an increase in soil water storage that stayed high for longer than normal. We also wanted to identify which model variables most influenced the results. We find that changes to the water content values and air-entry pressure values greatly influenced groundwater levels and soil water storage. Groundwater resources are important to us, and this research helps better understand how these resources might respond to extreme rainfall events.