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Impacts of Extreme Precipitation on Water in the Subsurface

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Introduction and Motivation

A current focus of science today is the issues of anthropogenic warming and the alterations it is having on precipitation intensity and distribution. However, there is less research done on the effects that precipitation have on the land surface as a result of these changes. **To better understand impacts of extreme precipitation on water in the subsurface, we model three different locations at Gordon Gulch using Hydrus 1-D.** This allows us to quantify the results by calculating the change in soil water storage volume at each of the different locations.

Background

Study Area

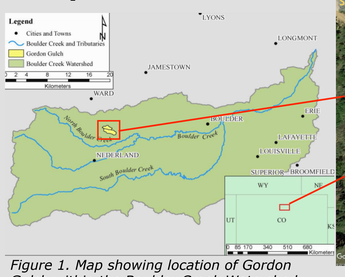


Figure 1. Map showing location of Gordon Gulch within the Boulder Creek Watershed. The red square indicates where Gordon Gulch is located in Colorado (Murphy, 2006).

Figure 2. Map of study showing the locations where soil (orange square) was collected and infiltrometer test (blue square) were conducted.

Precipitation and Soil Moisture at Gordon Gulch

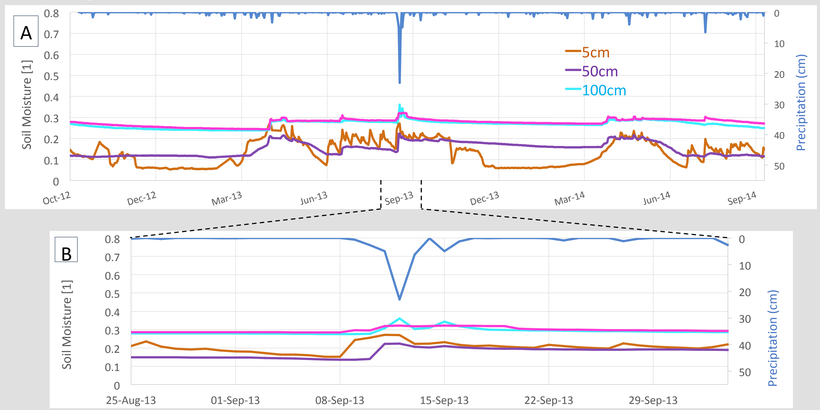


Figure 3. **A** shows a two year period of precipitation and soil moisture levels at Gordon Gulch. **B** highlights the Colorado 2013 flood event and the response of water in the subsurface.

Methodology

Double-ring Infiltrometer Test

Purpose: Measure downward component of flow through soil

- Create a level surface at sample site
- Maintained constant water level in outer-ring used to minimize lateral flow
- Measured infiltration rate of water into the soil over 1hr period

*Figure 5. Image **A** shows site during set-up of double-ring infiltrometer test. Image **B** is a close-up view of double-ring infiltrometer.*

Permeameter Testing: Calculating Hydraulic Conductivity (K) Value

- Purpose: Determine hydraulic conductivity values of soil samples at each of the test location
- Methods per sample:
  - Calculate pore space
  - Record Pressure head (psi)
  - Record length of sample
  - Solve for K with Darcy's Law

$$K = \frac{QL}{Ath}$$

K	Hydraulic conductivity
Q	Discharge (cm^3/s)
L	Length of sample
A	Area of cross section of sample
t	Duration of test time
h	Pressure head

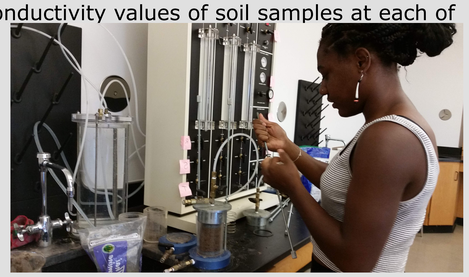


Figure 6. Image of a scientist conducting permeameter test using a Standard Panel M 100000 Permeameter to measure soil permeability

Hydrus 1-D: Modeling Infiltration to Subsurface

Purpose: Identify changes in soil water storage for three cases over a 150 day period of precipitation.

- Three soil cases: homogeneous soil, four-layered profiles (hilltop, slope) with varying soil hydraulic properties.
- Input data: 150-days of precipitation.
- Day 1: September 1, 2013 to
- Day 150: January 28, 2014.

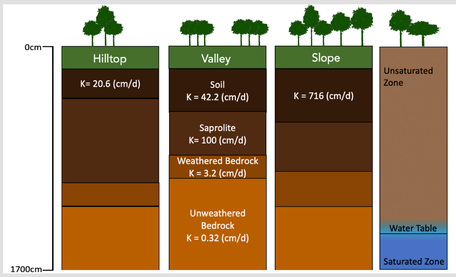


Figure 7. Location specific soil profile columns

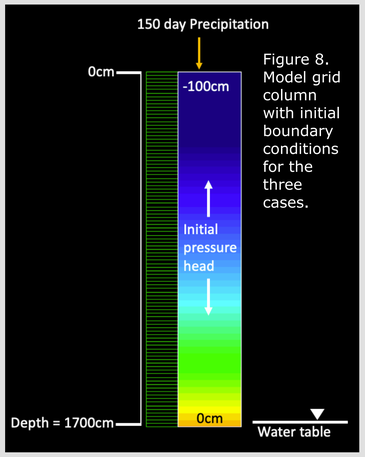


Figure 8. Model grid column with initial boundary conditions for the three cases.

Results

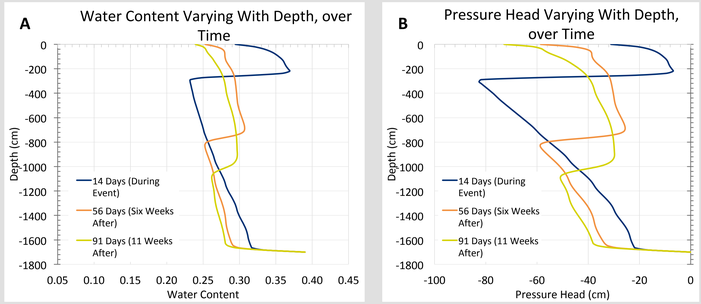
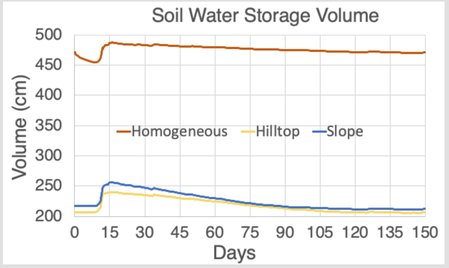


Figure 9. **A** shows the varying soil water content for the homogenous soil profile, emphasizing the change in soil water content during and after an extreme precipitation event. **B** records the change in pressure head over the same time intervals.

Soil Water Storage Volume

Figure 10. Soil water storage of homogeneous (one soil), hilltop, and slope cases (09/01/13 – 01/28/14). Soil water storage increases for all cases analogous to the increase in measured soil moisture data for the same period.



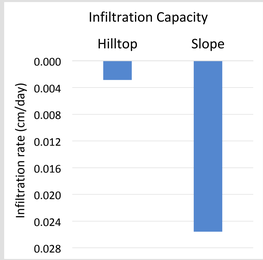


Figure 11. Calculated infiltration capacity of hilltop and slope field sites

Conclusions

- Modeled soil water storage agrees with the observed general patterns of soil moisture.
- Homogeneous soil stores more than double the amount of water of the hilltop and slope cases. The heterogeneity of the hilltop and slope cases affects their ability to store more water.
- In each case, the soil profile becomes wetter with infiltration until the soil reaches full saturation, after which water storage continues to decrease over time but soil remains partially saturated.
- After six weeks, the soil moisture of each profile remains higher than the initial condition.

References

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