METER

LANDSLIDING IN PARTIALLY SATURATED MATERIALS

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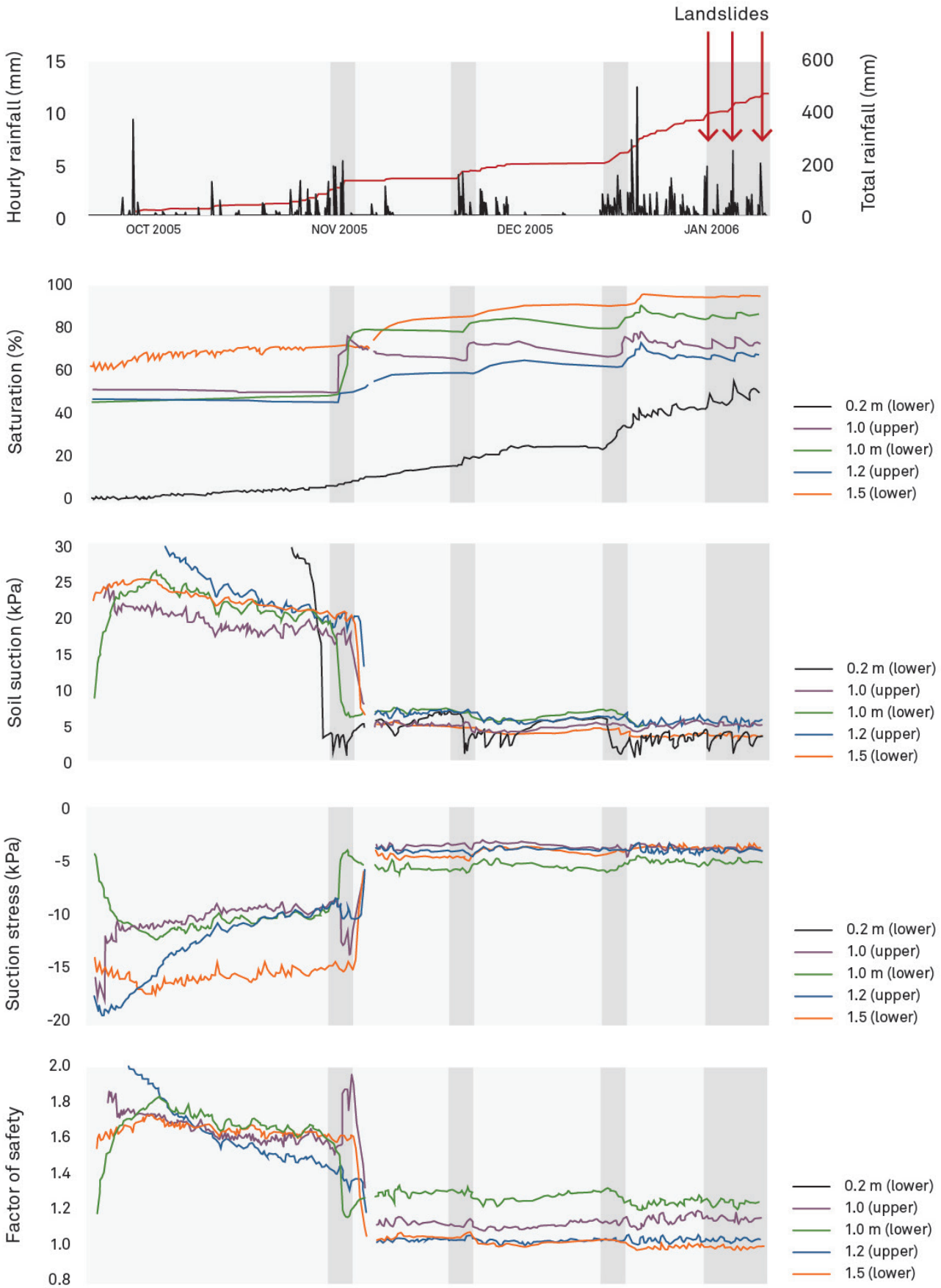
Traditional measurement of hillsides attempting to measure and quantify slope stability have previously only measured above-ground precipitation and water content at the depth of the water table. These methods did nothing to predict shallow landslides within the top few meters of soil. In addition, previous studies have focused on either unsaturated or full saturated soils, with no analysis of partially saturated soils. A partnership between Colorado School of Mines (CSM) and United States Geological Survey (USGS) strived to study exactly that, focusing on unstable slopes above and under railways and roads that threaten infrastructure in the form of collapse or washouts. This multi-year study implemented soil moisture and soil suction sensors within several at-risk slopes across the US, attempting to establish data signatures that could be used to predict the conditions for slides before they happen. This advanced warning would allow authorities to address the issue, mitigating circumstances, and close throughways to avoid danger to life and costly damage.

Understanding the soil suction properties of the slope is the key to determining if the forces holding the soil in place are stronger than the gravitational forces attempting to move the soil down the slope. Measurements of soil water content quantify the amount of water within the soil. Soil suction (or water potential) measures the energy state of the water and how tightly the soil is holding it. These two values allowed the researchers to develop an equation to calculate the slide risk for a specific slope. The graphs below illustrate the landslide monitoring over a railroad track in Edmonds, WA. In this 5-month period several instances of rain occurred that seeped into the ground, where the soil water content began to rise, continuously degrading the stability of this slope. While no one precipitation event appeared significant enough to collapse the slope, the data showed the suction stress increased over time to the point of failure. The factor of safety quantifies this change and provides data-based markers that can identify the safety of the slope at any given time.

To learn more about landslide monitoring, visit:
meter.ly/landslide-monitoring


Landslides
Hourly rainfall (mm)
15
10
5
0
600
400
200
0
Total rainfall (mm)
OCT 2005
NOV 2005
DEC 2005
JAN 2006
Saturation (%)
100
80
60
40
20
0
0.2 m (lower)
1.0 (upper)
1.0 m (lower)
1.2 (upper)
1.5 (lower)
Soil suction (kPa)
30
25
20
15
10
5
0
0.2 m (lower)
1.0 (upper)
1.0 m (lower)
1.2 (upper)
1.5 (lower)
Suction stress (kPa)
0
-5
-10
-15
-20
0.2 m (lower)
1.0 (upper)
1.0 m (lower)
1.2 (upper)
1.5 (lower)
Factor of safety
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.2 m (lower)
1.0 (upper)
1.0 m (lower)
1.2 (upper)
1.5 (lower)

REFERENCES

Godt, J.W., Baum, R., and Lu, N. Can landslides occur under unsaturated soil conditions? Geophysical Research Letters, 36, L02403, doi:10.1029/2008GL035996, 2009.