The value of in-situ soil hydrological information for regional landslide early warning
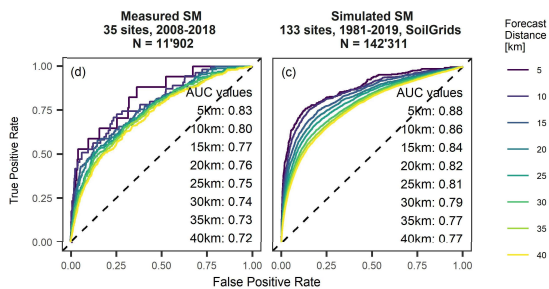
Adrian Wicki[1], Peter Lehmann[2], Christian Hauck[3], Manfred Stähli[1]

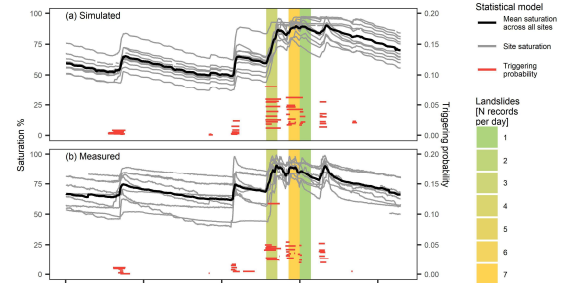[1]Swiss Federal Research Institute WSL (Birmensdorf), [2]University of Fribourg, [3]ETH Zurich

Can in-situ soil moisture measurements be used for regional landslide early warning systems?

Yes, temporal variation of normalized soil moisture showed specific correlation with regional landslide activity. The forecast goodness decreases with the distance from site to landslide.

How do models perform compared to measurements?

Simulated soil moisture performs generally better at predicting landslides. However, measured soil moisture better captures the long-term water storage variation and thus antecedent wetness conditions.
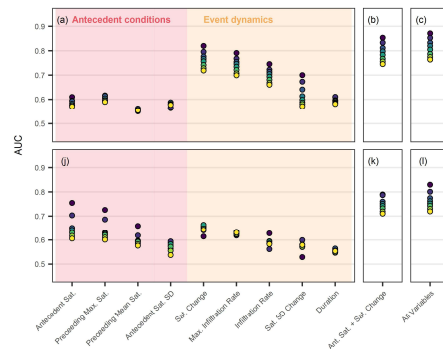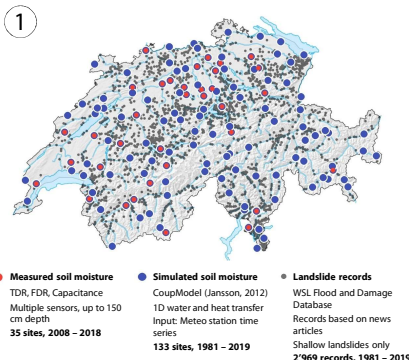
What are meaningful statistical precursors to regional landslide activity?

Antecedent saturation and saturation change were found to best predict landslides. Antecedent saturation is important for landslides triggered by long-lasting rainfall events whereas saturation change is more important for landslides due to thunderstorms.

Data base

Measured soil moisture
TDR, FDR, Capacitance
Multiple sensors, up to 150 cm depth
35 sites, 2008 – 2018

Simulated soil moisture
CoupModel (Jansson, 2012)
1D water and heat transfer
Input: Meteo station time series
133 sites, 1981 – 2019

Landslide records
WSL Flood and Damage Database
Records based on news articles
Shallow landslides only
2'969 records, 1981 – 2019

All available continuous soil moisture measurements in Switzerland were gathered and soil moisture was simulated at meteorological sites. Soil moisture was normalized ('saturation') and profile mean and SD was calculated. Landslide information was taken from the Swiss Flood and Landslide database (WSL).
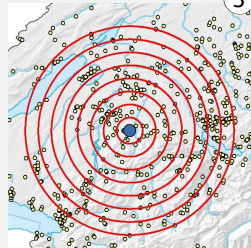
Infiltration events ②
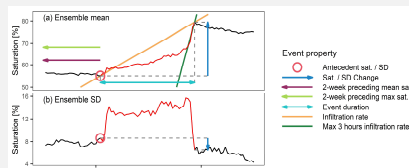
Periods of continuous saturation increase were identified ('infiltration events') and specific event properties were characterized.

Landslide triggering classification ③

Infiltration events are flagged landslide triggering if a landslide was observed within a specific forecast distance.

The binary landslide triggering class is modelled using a multiple logistic regression model with the infiltration event properties as independent variables. Model evaluation was performed using ROC analysis.

Empirical landslide modelling ④