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Identification of flow type shallow landslide source based on topo-hydro indices considering extreme rainfall and Deep Neural Network

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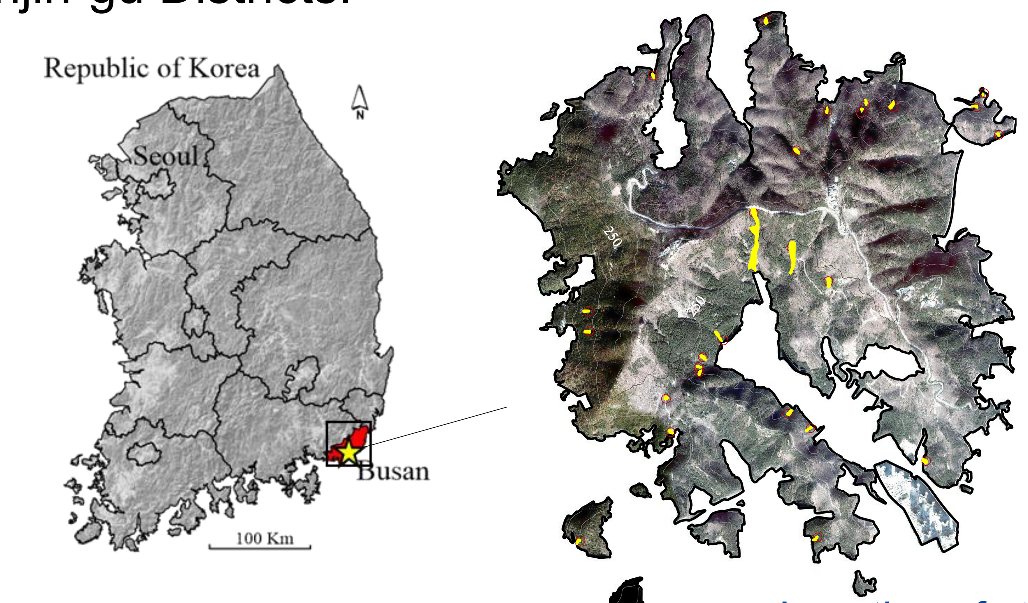
1. Introduction

Flow type shallow landslides constitute one to the most dangerous gravity-induced surface processes. Prediction of source area over a large terrain is considered a preliminary step for the planning or design of the most appropriate risk mitigation measures.

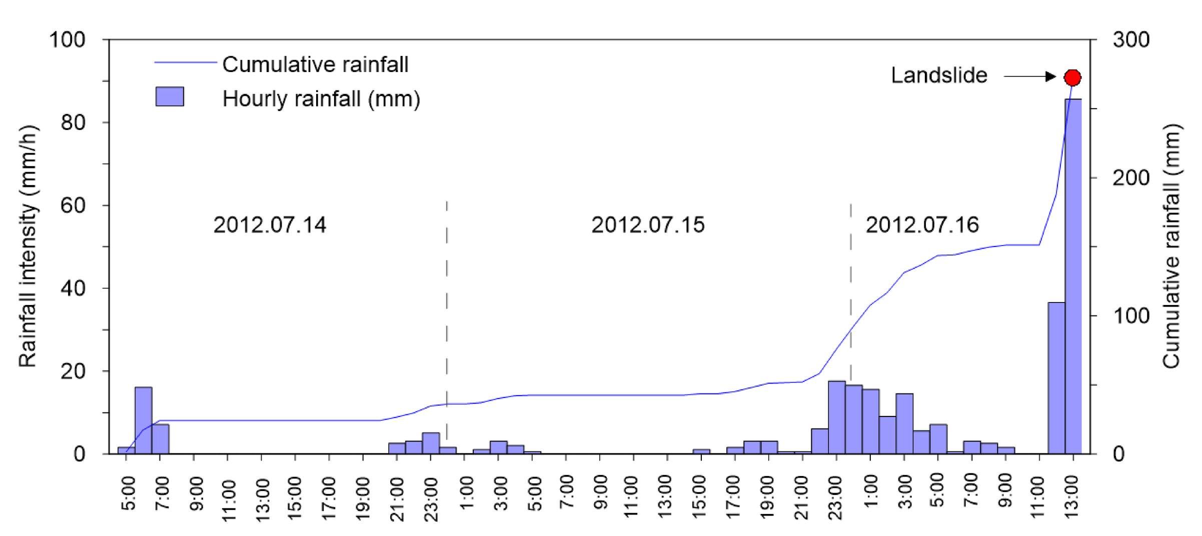
The main propose of this research is to identify most likely flow type shallow landslide initiation areas and delineate probable hazard zone.

2. Study area

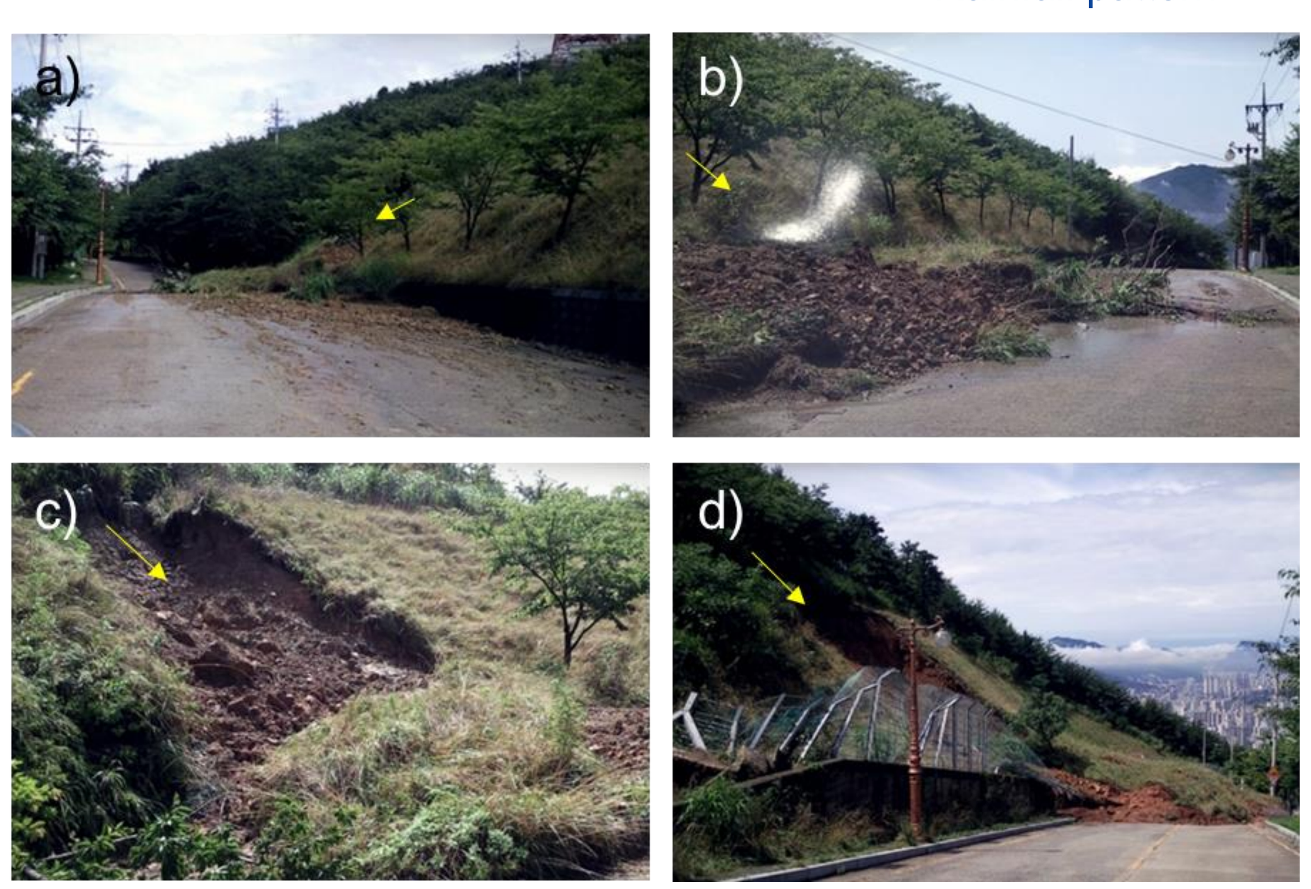
Mt. Hwangyeon, central Busan was selected as the test site. The mountain encompasses a wide area of the city, including the Nam-gu, Suyeong-gu, Yeonje-gu, and Buanjin-gu Districts.



Location of study area

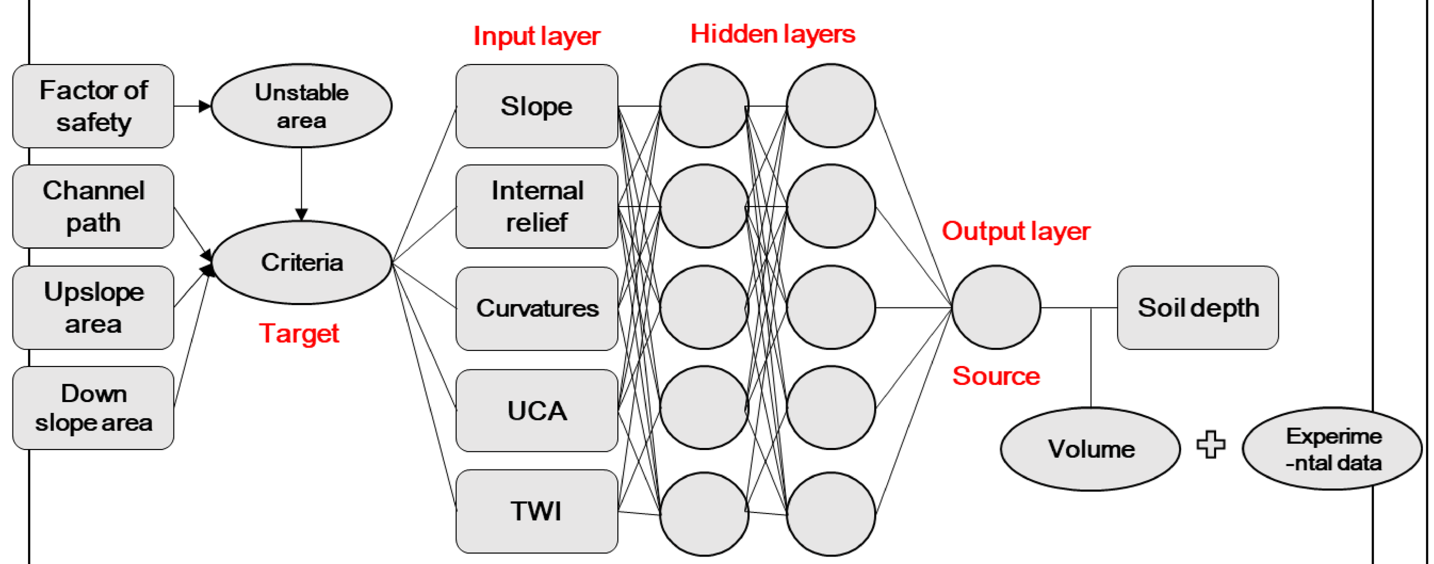


Rainfall pattern



Landslides at Mt. Hwanggeon

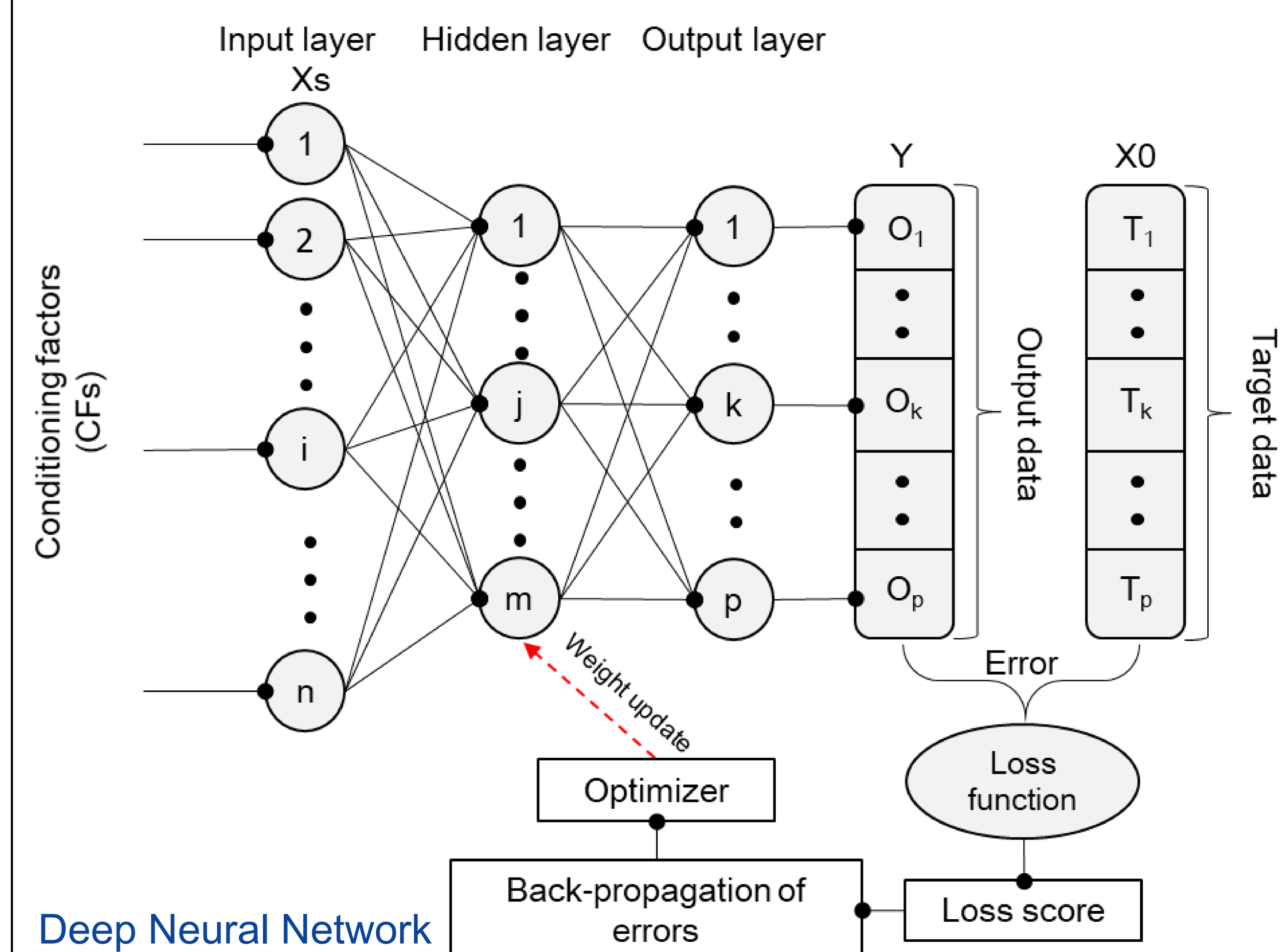
4. Methodology



Procedure

- The equation to calculate the safety factor of the slope according to the infiltration of rainfall for an infinite slope model is given by

$$FS(Z,t) = \frac{\tan\phi'}{\tan\delta} + \frac{c' - \psi(Z,t)\gamma_W \tan\phi'}{\gamma_S Z \sin\delta \cos\delta}$$



Deep Neural Network

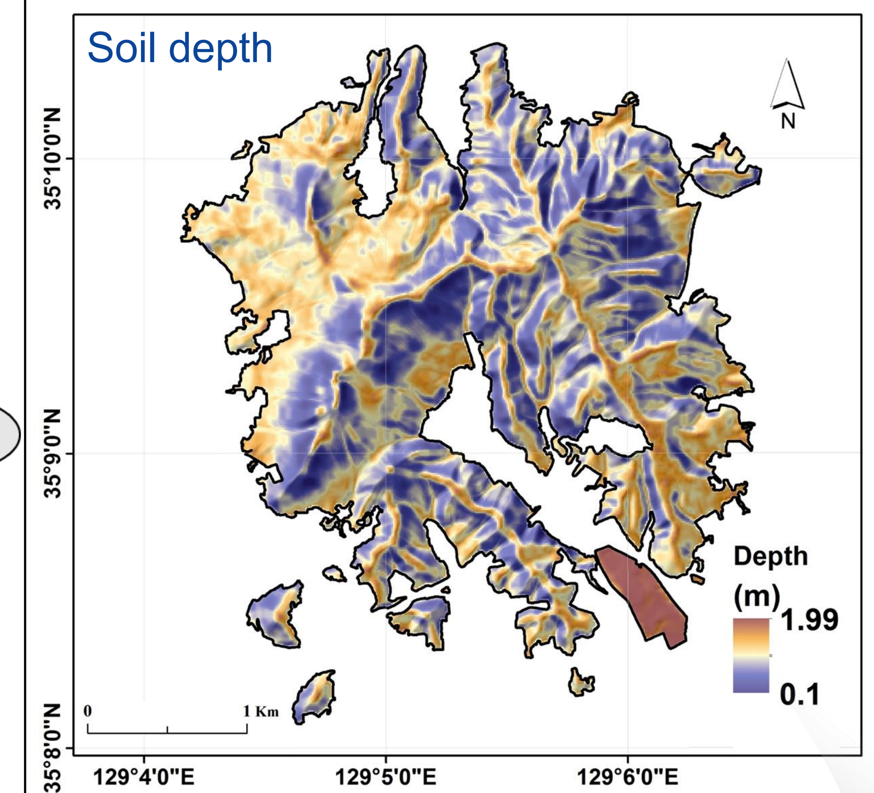
Governing equation

- A two-dimensional debris flow model based on a rectangular grid was used to estimate the sediment transport area in a hillslope catchment.
- We implemented the Voellmy resistance model for its simplicity, as it only requires two parameters, which makes the model easy to use and calibrate.
- The model employs two-dimensional depth-integrated shallow water equations to simulate debris flow. The hyperbolic conservation form of the mass and momentum balance equation is written as follows

$$\frac{\partial \mathbf{q}}{\partial t} + \frac{\partial \mathbf{f}}{\partial x} + \frac{\partial \mathbf{g}}{\partial y} = \mathbf{s}$$

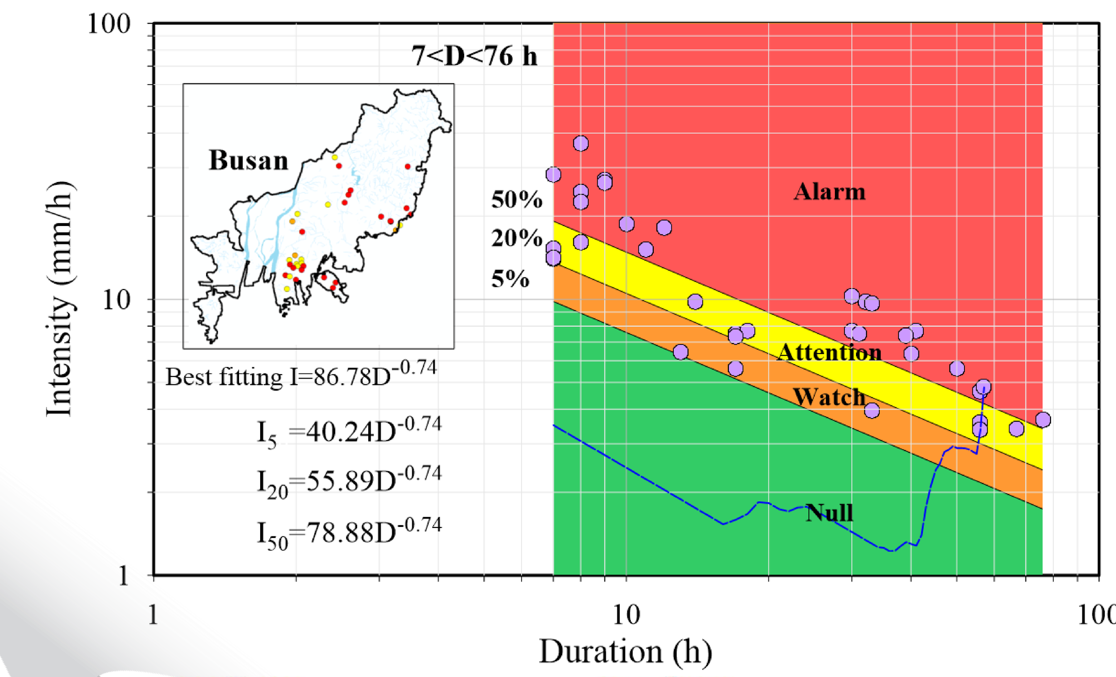
where t denotes time, x and y are Cartesian coordinates, and q, f, g, and s are vectors representing conserved variables, fluxes in the x and y directions, and source terms, respectively.

5. Results



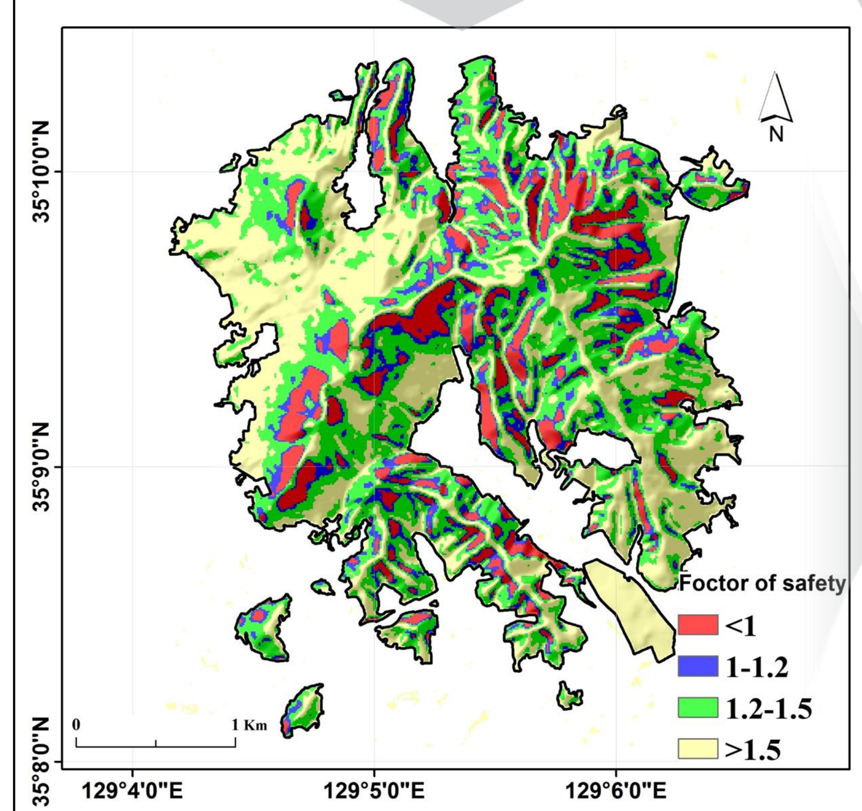
The soil depth of the study area was estimated using an internal-relief (IR) model (Pradhan et al., 2018a). The IR corresponds to local height differences within a unit area. The soil depth is expressed as a function of IR as follows:

$$Depth_i = Depth_{max} - \frac{IR_i - IR_{min}}{IR_{max} - IR_{min}}(Depth_{max} - Depth_{min}),$$

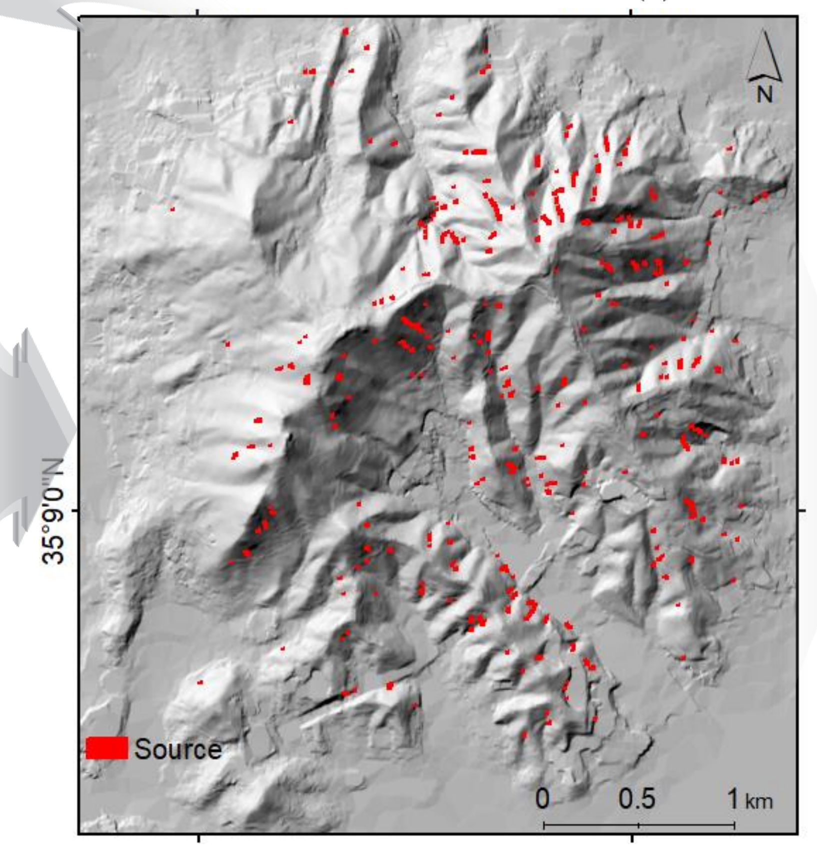


A frequentist approach was employed assuming the existence of a threshold curve of the form $I = \alpha D^{-\beta}$, where α and β are constants; this is commonly used to define rainfall thresholds

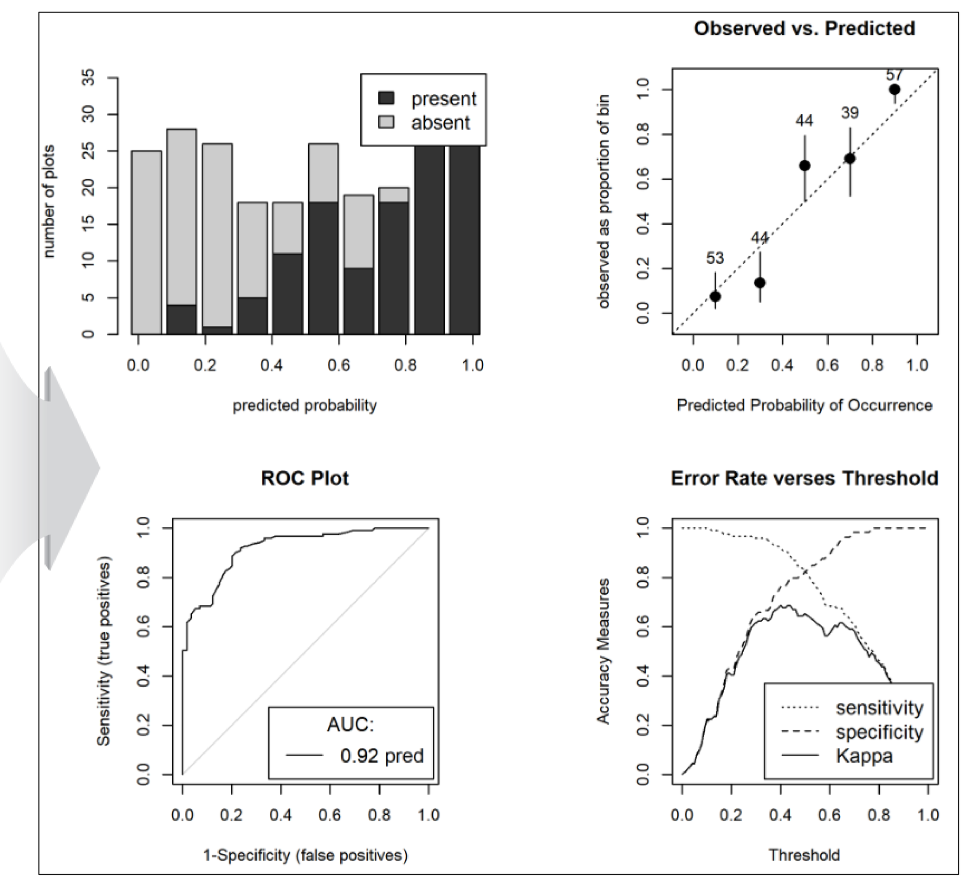
Rainfall threshold



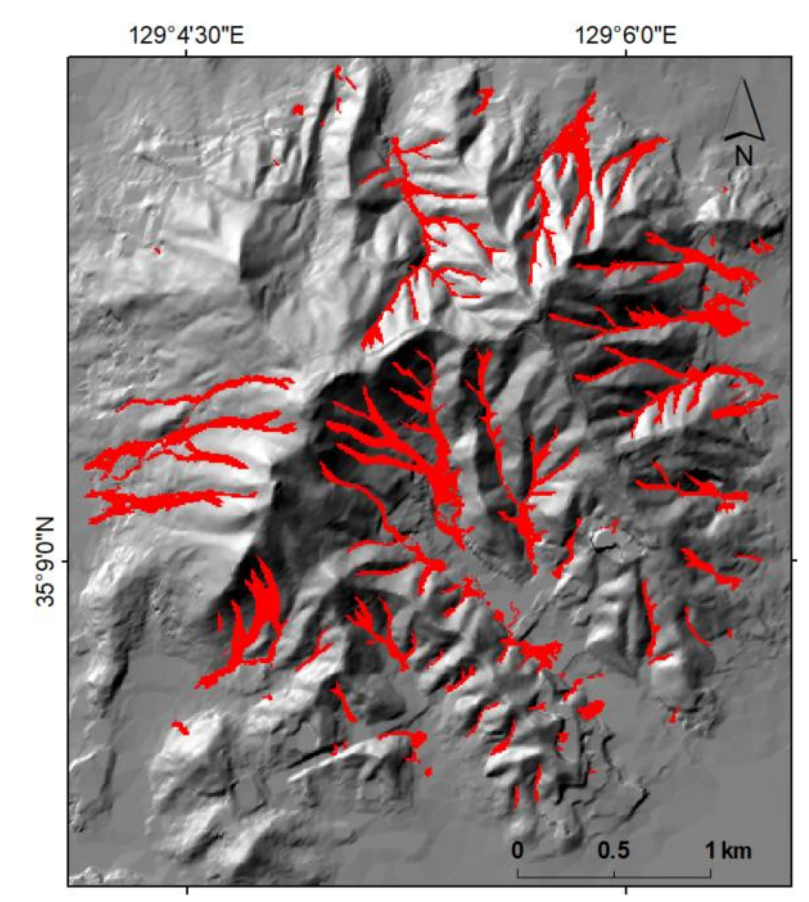
Factor of safety



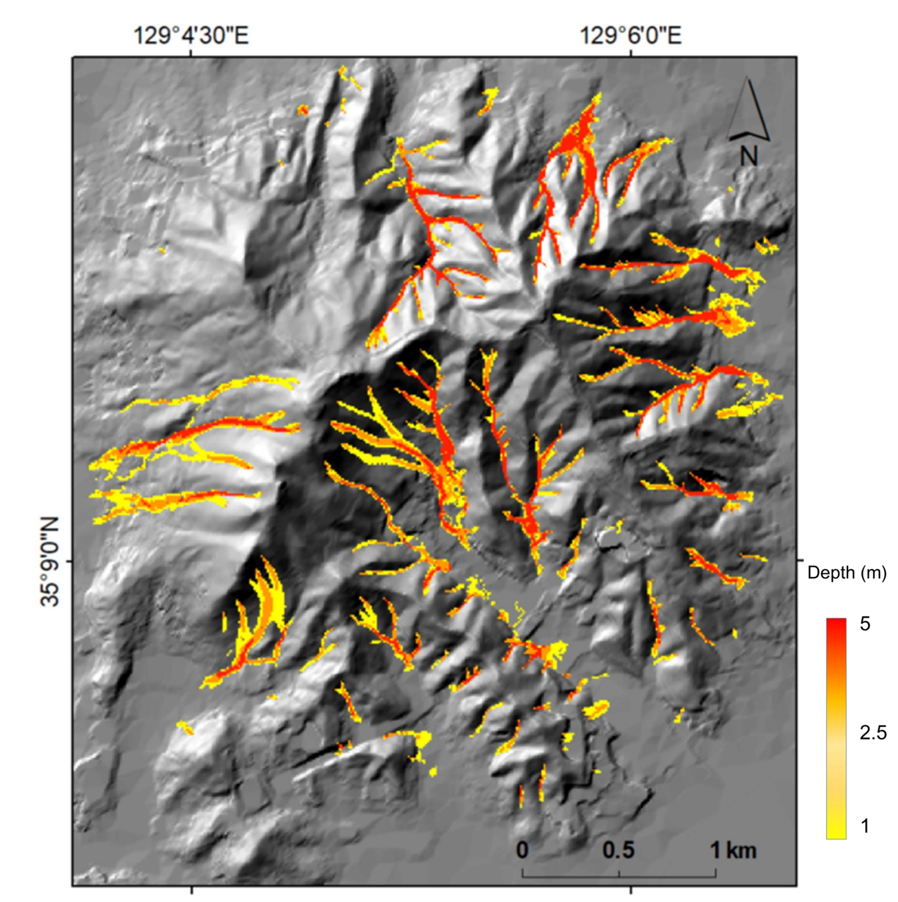
Predicted source area



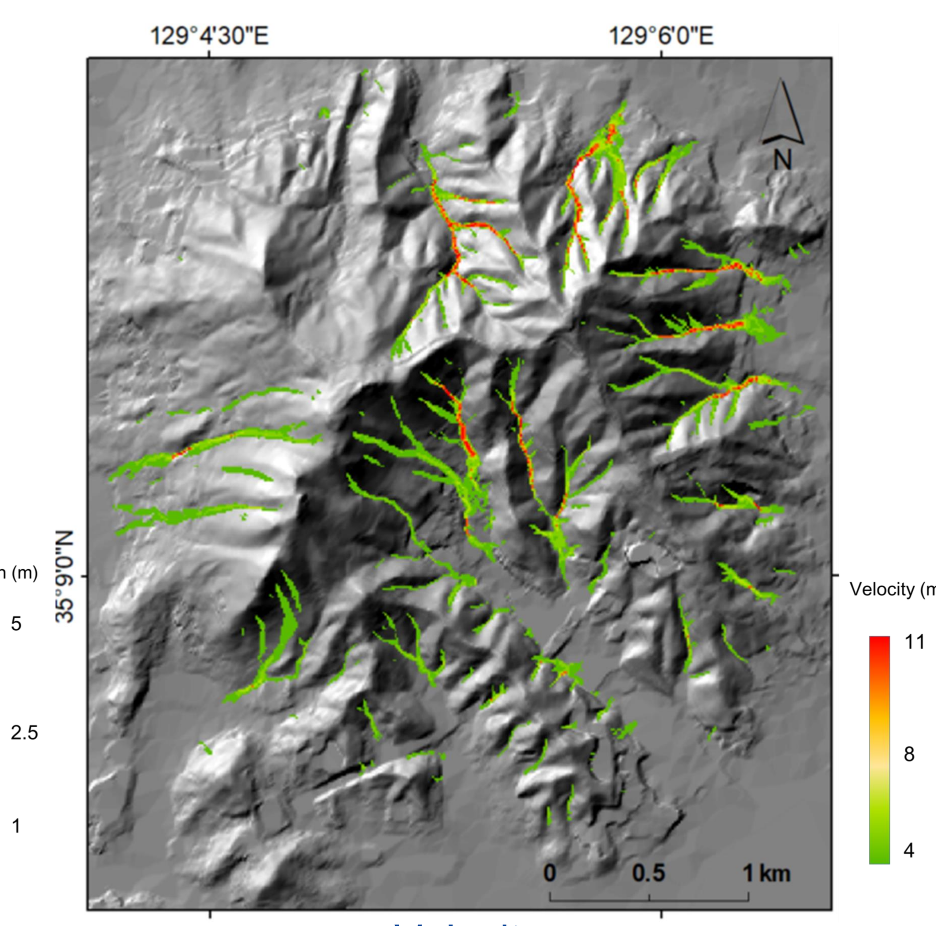
Accuracy assessment



Runout zone



Depth of debris deposit



Velocity

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