Definition of Rainfall Thresholds for Shallow Landslides in Colombian Tropical Mountainous Terrains

Edier Aristizábal[1], Edwin F. García-Aristizábal[2], Ricardo Jaramillo-González[1], Emanuel Castillo[1], Luis Martinez[1]

1Departamento de Geociencias y Medio Ambiente, Universidad Nacional de Colombia, Medellín, Colombia, 2Facultad de Ingeniería, Escuela Ambiental, Universidad de Antioquia UdeA, Medellín, Colombia

Abstract: Colombian Andean region exhibits a complex tropical hydrometeorological dynamic affected by different temporal and spatial scale climate processes. It is composed of a diverse geological and geomorphological setting characterized by high steep slopes and morphogenic conditions that are predisposed to gravitational hillslope processes. Rainfall thresholds can be defined by empirical-statistical and physically-based methods. Empirical-statistics is based on historical data on rainfall and mass movements; and physically-based models consider the effects of rainfall coupling distributed hydrological and geotechnical models providing landslide spatial distribution by calculating the distributed safety factor.

Study Zone

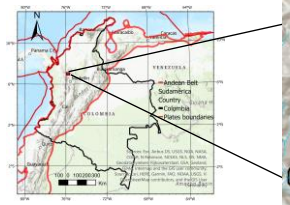

Fig. 1 Watershed within the Andean Colombian Region

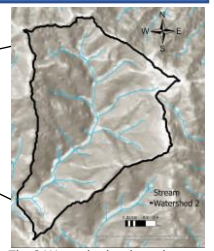

Fig. 2 Watershed selected to analyze

Data

Morphometric Parameters	Values	Geotechnial-Hydraulic Parameters	Values
Melton Index	0.32	$c'(Pa)$	1500
Form Factor (Ff)	0.43	ϕ (°)	30
Elongation Ratio (Re)	0.74	$\gamma_s\ (N/m^3)$	19000
Circularity Ratio (Rc)	0.51	$D_0(m/s)$	1.00E-02
Compactness Coefficient (Cc)	1.41	$k_s(m/s)$	1.00E-04
Spatial Resolution (DEM) (Alos Palsar)	12,5mx12,5m	θ_{sat}	0.54
Area(Km^2)	8.129375	θ_{res}	0.16
Mean Slope (°)	31.54	α	0.19

Table 1. Watershed Morphometric, Geotechnial and Hydraulic Parameters

IDF Curves

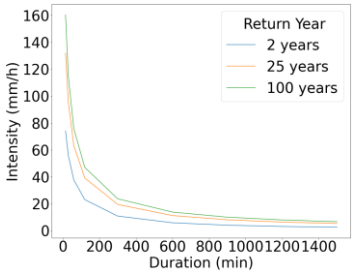

Fig. 3 IDF curves provide historical rainfall I-D data from different returns of years

Physically-Based Thresholds

We are proposing an approach where the definition of the rainfall thresholds integrates IDF gauge-based rainfall data and the physically-based model (TRIGRS) to calculate the cumulative density function from the histogram of the distributed safety factor within a basin, providing a better comprehension of the response to heavy rainfall events in a basin scale in tropical mountainous terrains.

Results

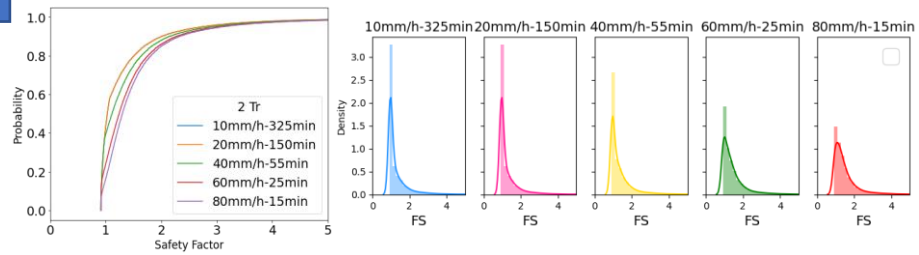

Fig. 4 Cumulative Density Function CDF Curves and Histograms of the distributed Safety Factor in Basin A for 2 years of return (Tr2)

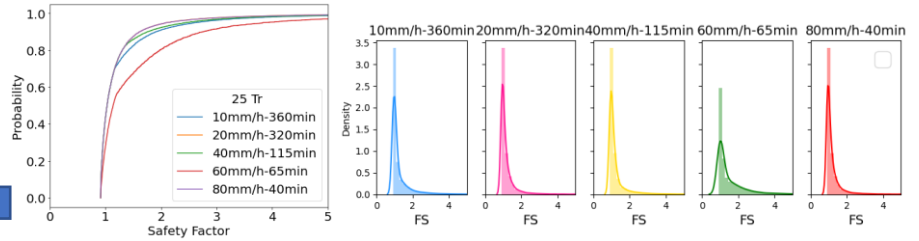

Fig. 5 Cumulative Density Function CDF Curves and Histograms of the distributed Safety Factor in Basin A for 25 years of return (Tr25)

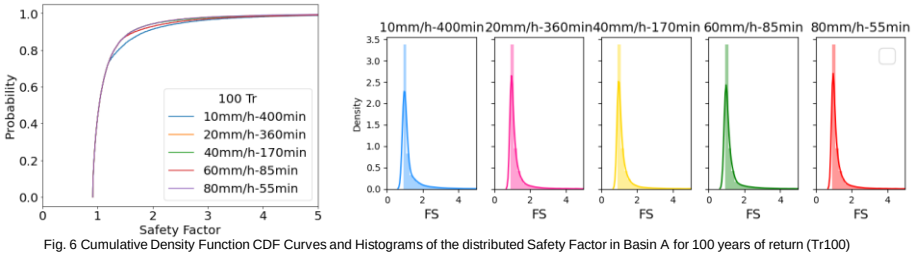

Fig. 6 Cumulative Density Function CDF Curves and Histograms of the distributed Safety Factor in Basin A for 100 years of return (Tr100)

Study Zone

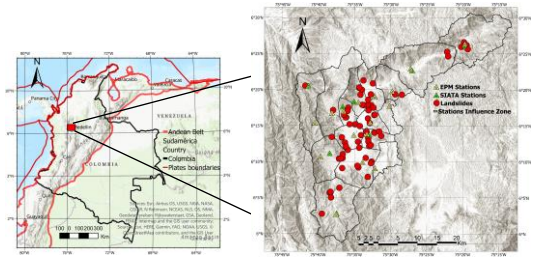

Fig. 7 Aburrá Valley and Rain Gauges Location

Empirical Thresholds

Empirical rainfall thresholds based on the analysis of I-D curves are based on landslides inventories and rain data that allow the definition of rainfall events that trigger landslides, rainfall measurements are obtained for specific rainfall events and antecedent rainfall conditions in which rainfall is measured by rain gauge networks, radar and satellite distributed data

Data

Source	Type	Range available	Landslides	Period	Temporal Resolution	Spatial Resolution
EPM (1)	Rain Gauge (14)	1948-2016	45	2008-2016	5 min - 15 min	-
SIATA (2)	Rain Gauge (19)	2012-present	36	2013-2018	1 min -5 min	-
GPM (3)	Satellite	2000-present	63	2008-2018	30 min	0.1°x0.1° (10x10 km)
SIATA (4)	Radar	2013-2019	36	2013-2018	5 min	600x600 m

Table 2. Rainfall data base

Results