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Rainfall patterns of fast- and slow-mass movement in the Barcelonnette basin

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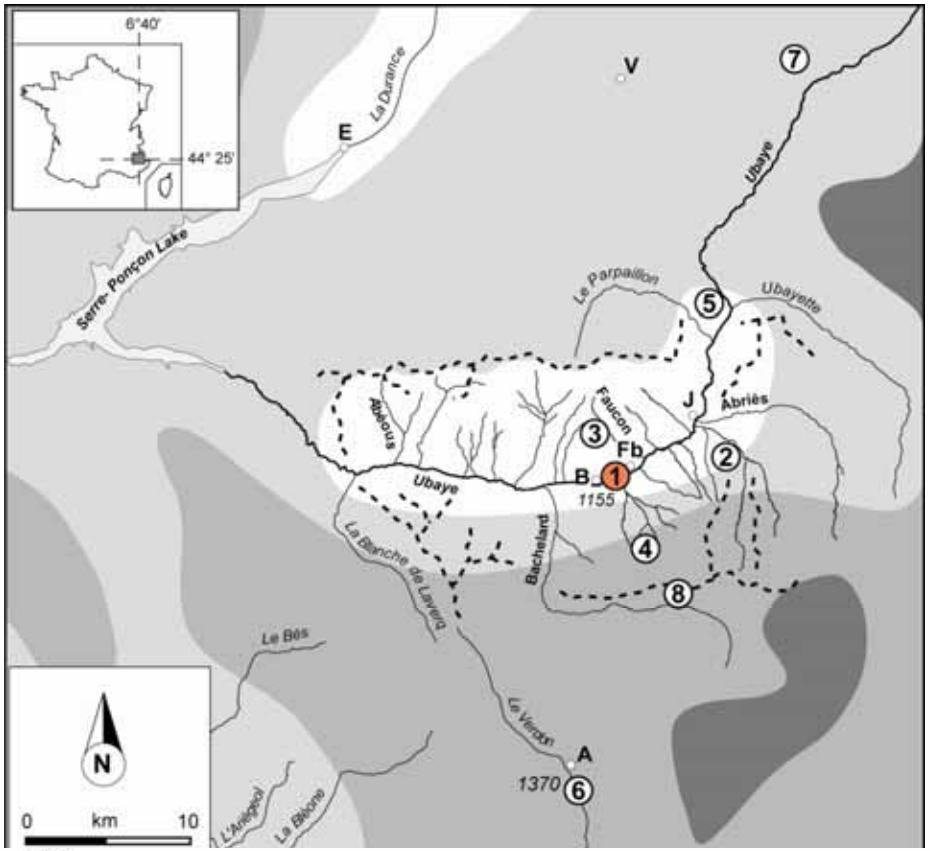
The Barcelonnette basin: different types of mass movement…

- **Slow-moving landslides (S.-Sauze, La Valette, etc.) ;**

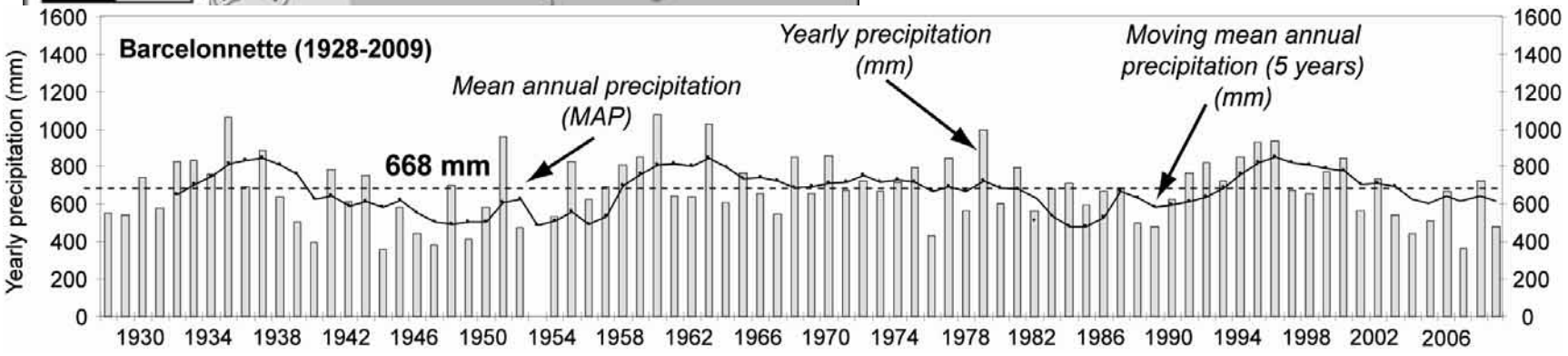
- **Debris flows and mudflows ;**



- **The Barcelonnette basin is located in the intra-Alps dry area: moutainous climate with a strong mediterranean influence**

- **Data: raingauges in the Barcelonnette basin ;**

- **For this work, two stations are used: Barcelonnette and Jausiers ;**



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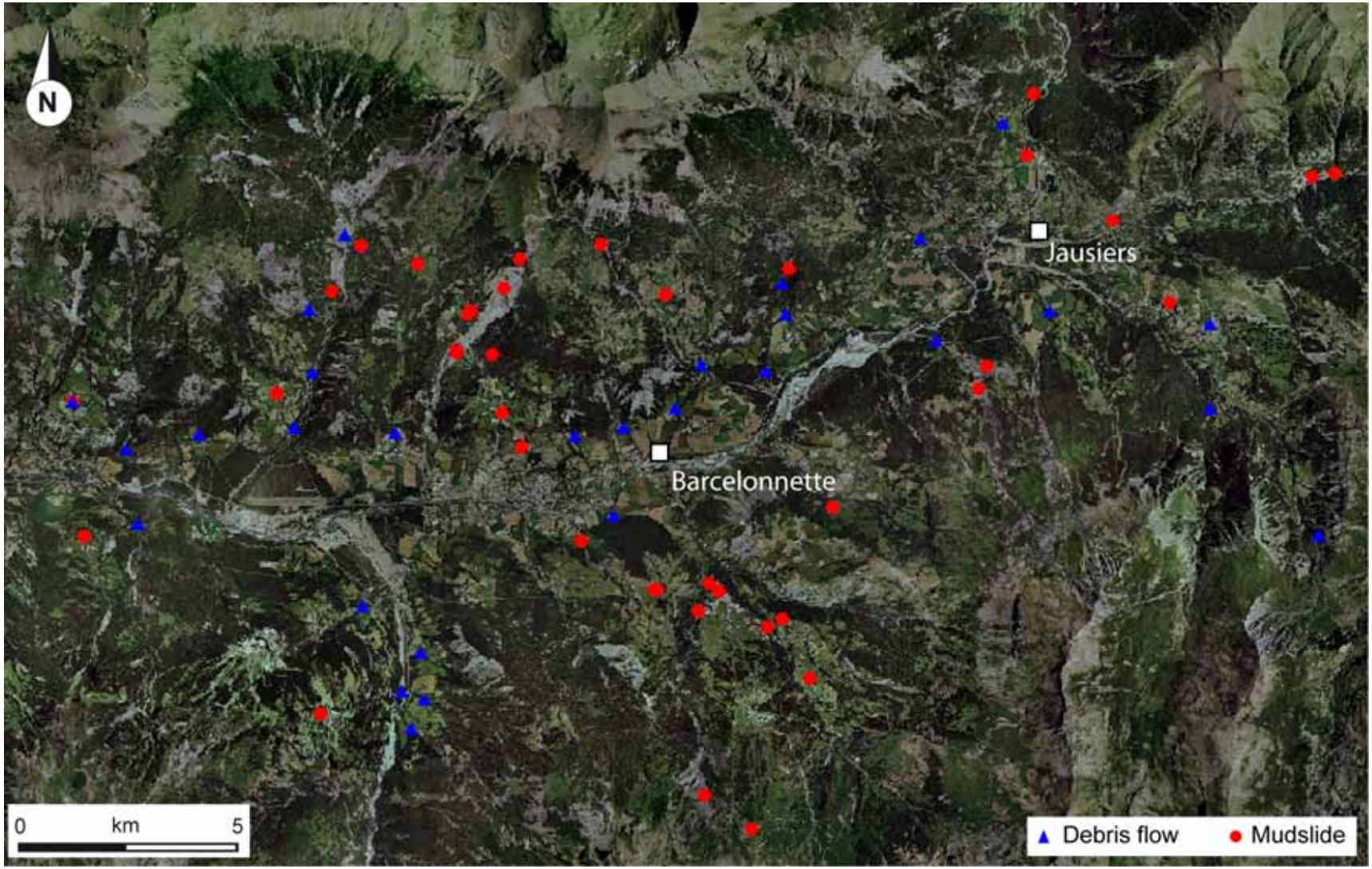

Location of fast- and slow-movement in the Barcelonnette basin…

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You are in charge to study the rainfall patterns associated to debris flows and slow-moving landslides in the Barcelonnette basin.

In order to study these rainfall patterns, you have access to a set of data:

(-) The debris-flow and landslides data base (xls or sxls);
(-) The daily rainfall (1980-2009) for the Jausiers station (xls, sxls or txt);
(-) The daily rainfall (1980-2009) for the Barcelonnette station (xls, sxls or txt);
(-) The hourly rainfall (1999-2009) for the Barcelonnette station (xls, sxls or txt).

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Some results …

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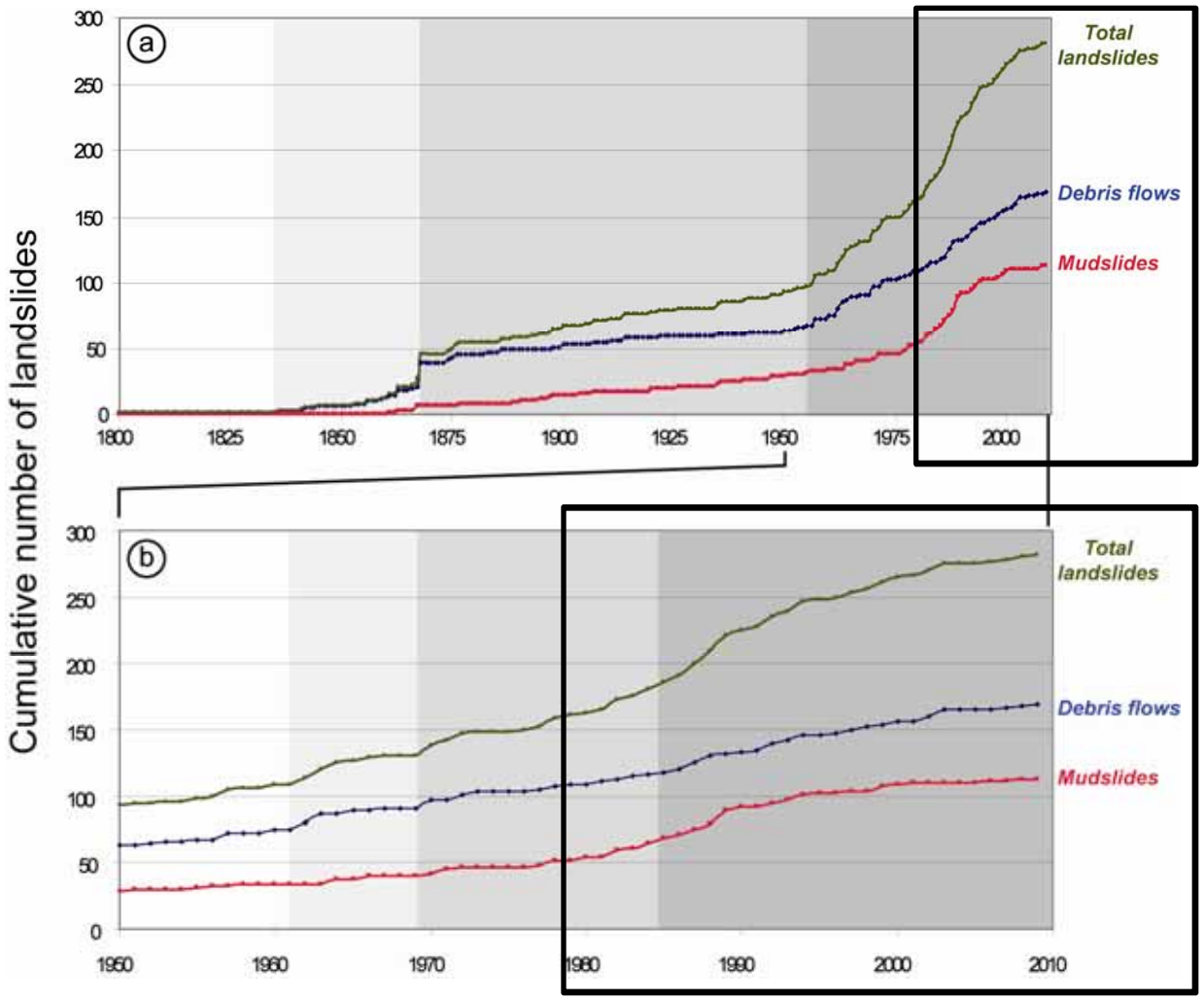
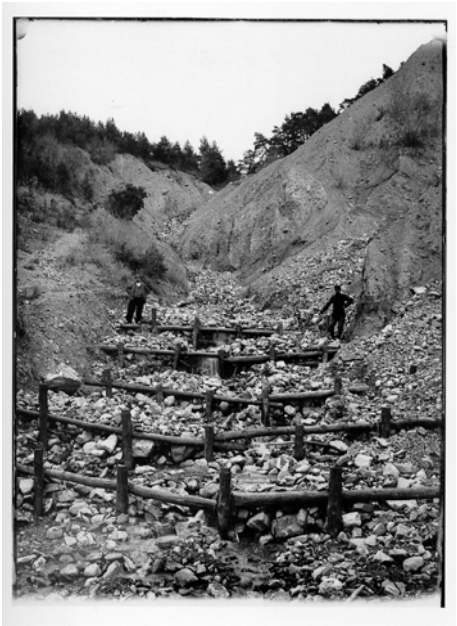
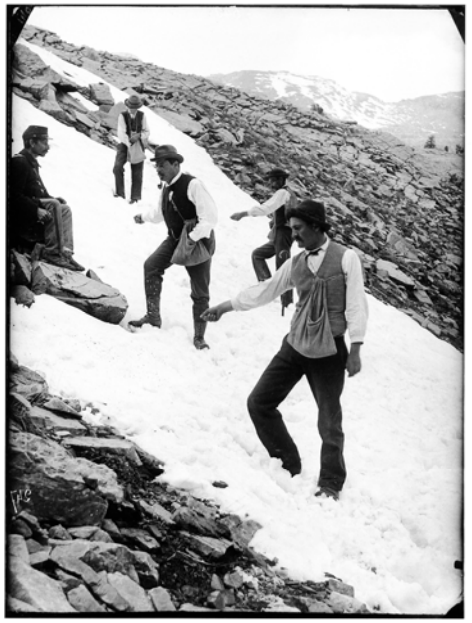
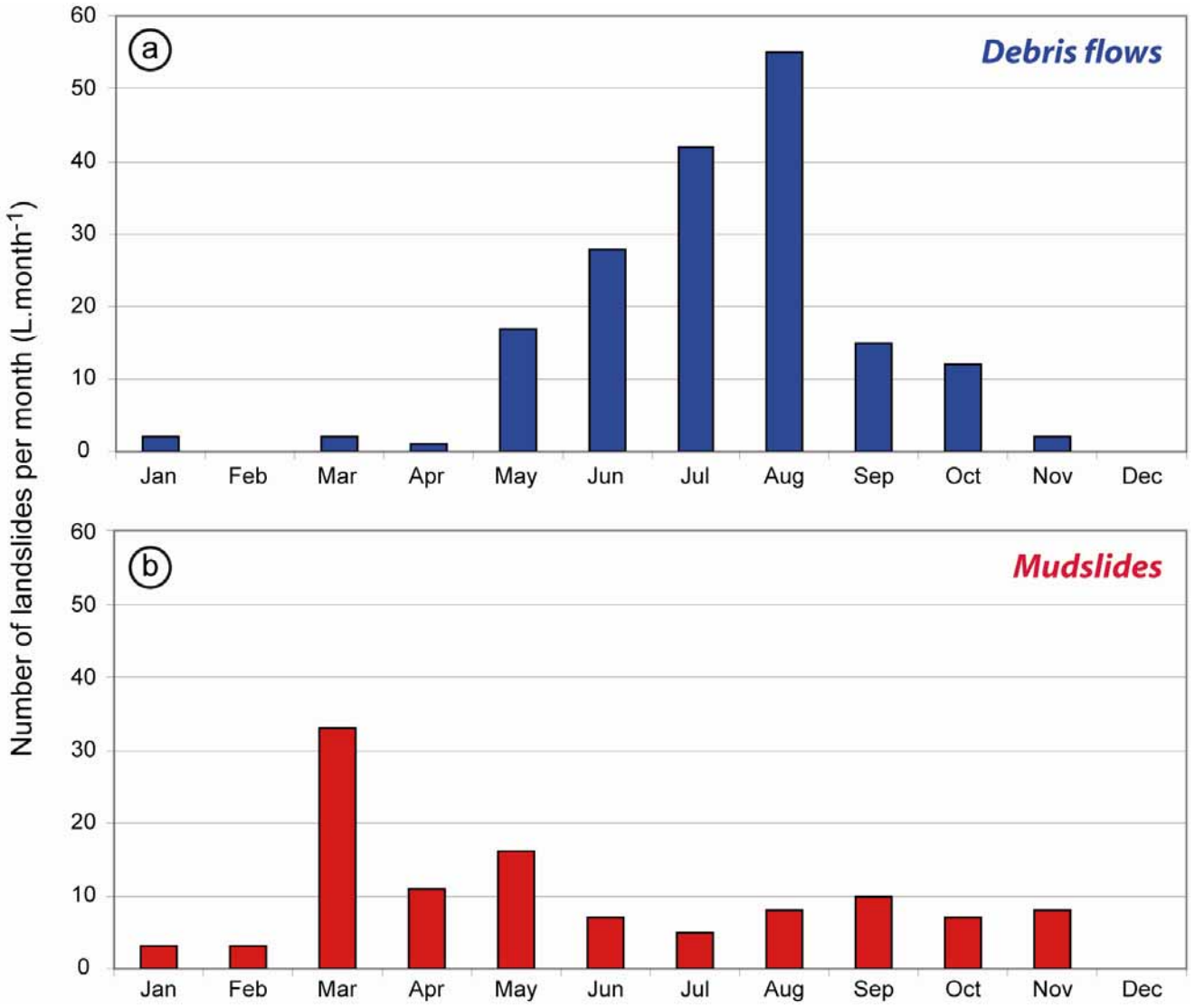






History of D.F. & Mudslides in the Barcelonnette basin



Seasonnal repartition of fast- and slow-movement in the Barcelonnette basin…

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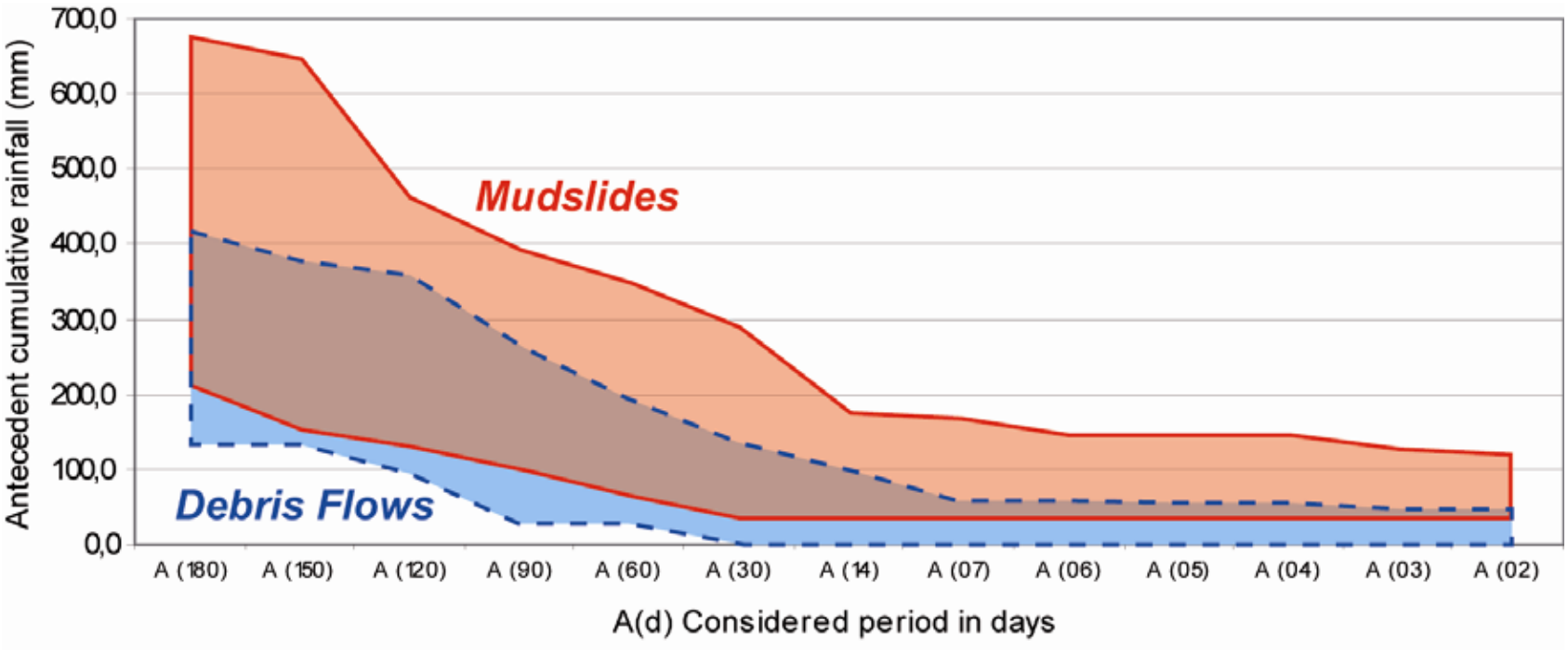
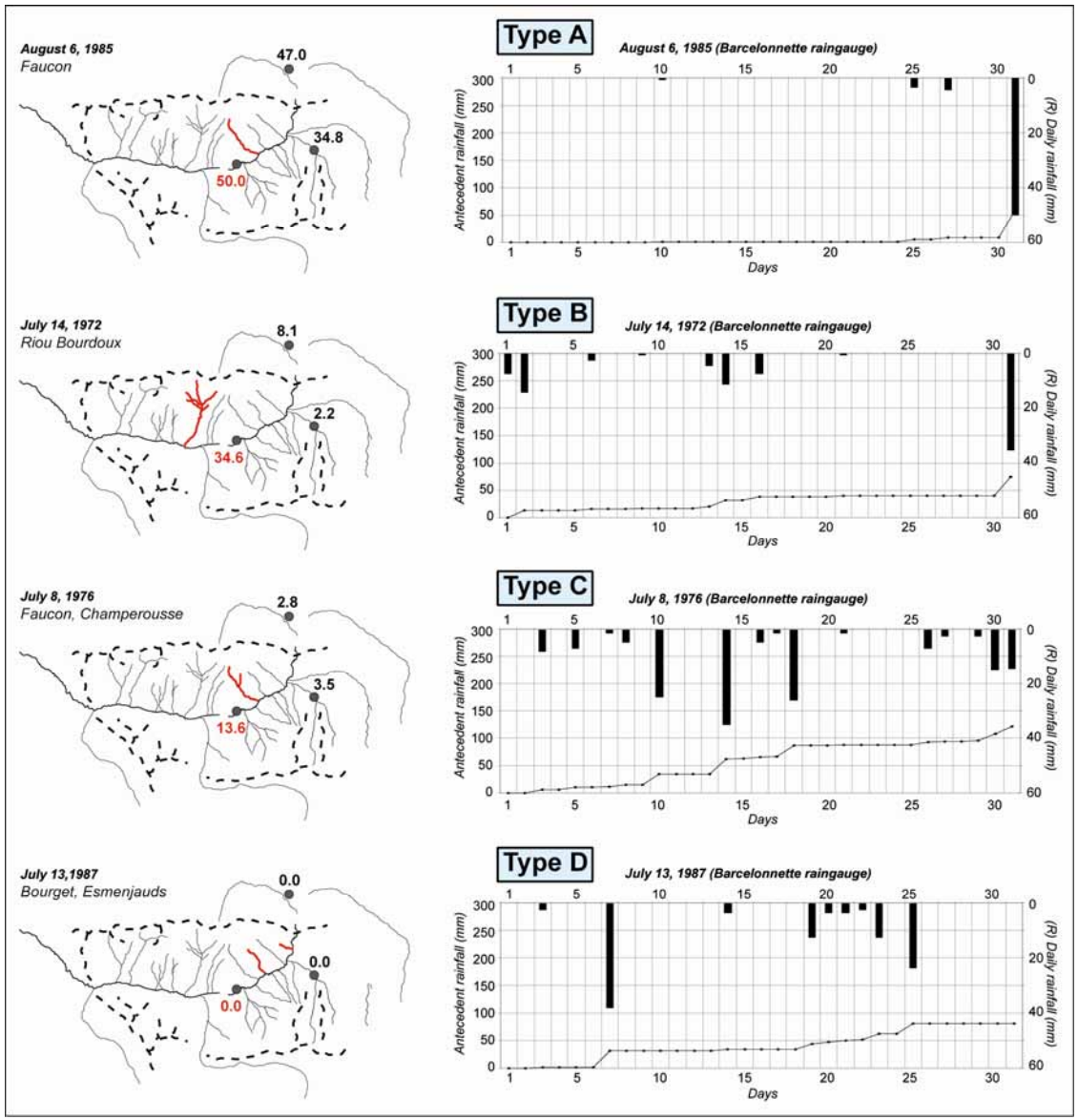


Antecedent cumulative rainfall for fast- and slow-movement…



Different types of rainfall event (at the daily scale)

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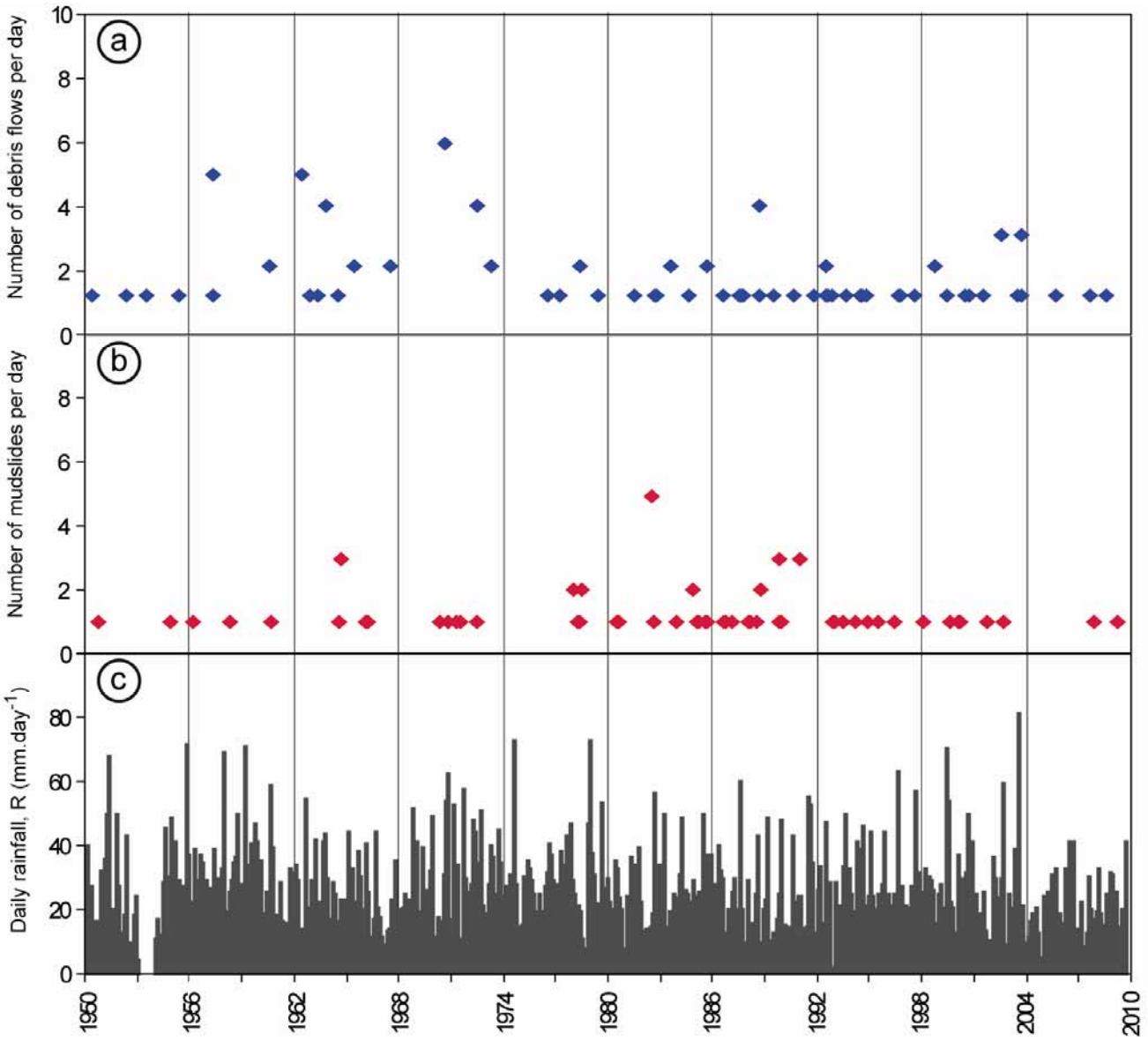

Daily rainfall vs mass movement occurrence

	Event rainfall classes (mm)									
	[0]	[0-10]	[10-20]	[20-30]	[30-40]	[40-50]	[50-60]	[60-70]	[70-80]	[> 80]
Debris Flows (1971-2000)	3	5	12	9	7	4	3	0	0	0
Landslides (1971-2000)	19	5	11	8	0	5	1	0	0	0
Total (1971-2000)	22	10	23	17	7	9	4	0	0	0

	Event rainfall classes (mm)									
	[0]	[0-10]	[10-20]	[20-30]	[30-40]	[40-50]	[50-60]	[60-70]	[70-80]	[> 80]
Number of days (1971-2000)	8046	2129	489	191	58	26	12	2	3	3
Prob. (Debris Flows)	0,0004	0,0023	0,0245	0,0471	0,1207	0,1538	0,2500	x	x	x
Prob. (Landslides)	0,0024	0,0023	0,0225	0,0471	0,0000	0,1923	0,0833	x	x	x
Prob. (Total Mass Mov.)	0,0027	0,0047	0,0470	0,0890	0,1207	0,3462	0,3333	x	x	x

Daily rainfall vs mass movement: probabilities of mass m. occurrence for daily rainfall categories…

	Event rainfall classes (mm)									
	[0]	[0-10]	[10-20]	[20-30]	[30-40]	[40-50]	[50-60]	[60-70]	[70-80]	[> 80]
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	Event rainfall classes (mm)									
	[0]	[0-10]	[10-20]	[20-30]	[30-40]	[40-50]	[50-60]	[60-70]	[70-80]	[> 80]
Number of days (2071-2100)	6331	3921	490	144	46	17	6	0	1	0
Debris Flows (2071-2100)	2	9	12	7	8	3	2	x	x	x
	-33%	*133%*	*0%*	*-67%*	*33%*	*-33%*	*-33%*			
Landslides (2071-2100)	15	9	11	6	0	3	1	x	x	x
	-133%	*133%*	*0%*	*-67%*	*0%*	*-67%*	*0%*			
Total (2071-2100)	17	18	23	13	6	6	2	x	x	x
	-167%	*267%*	*0%*	*-133%*	*-33%*	*-100%*	*-67%*			

Daily rainfall vs mass movement: probabilities of mass m. occurrence for daily rainfall categories… Influence of climate change?

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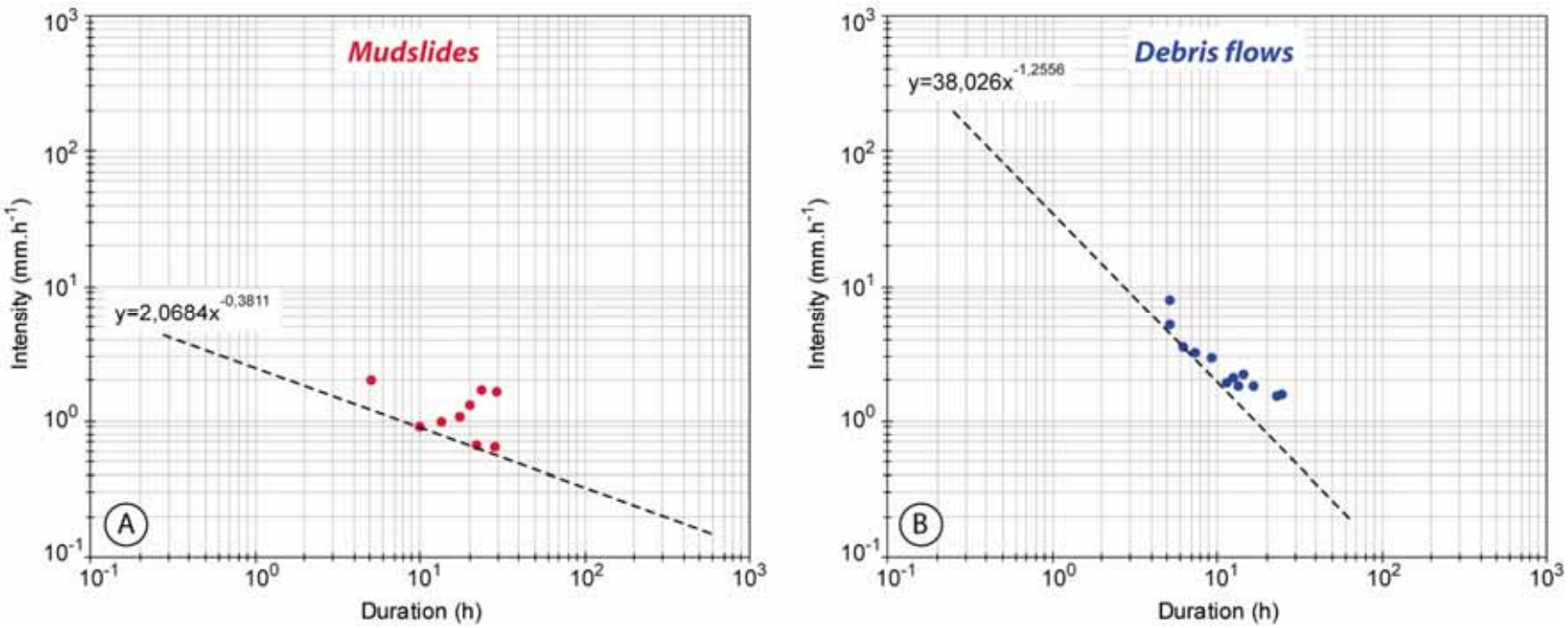
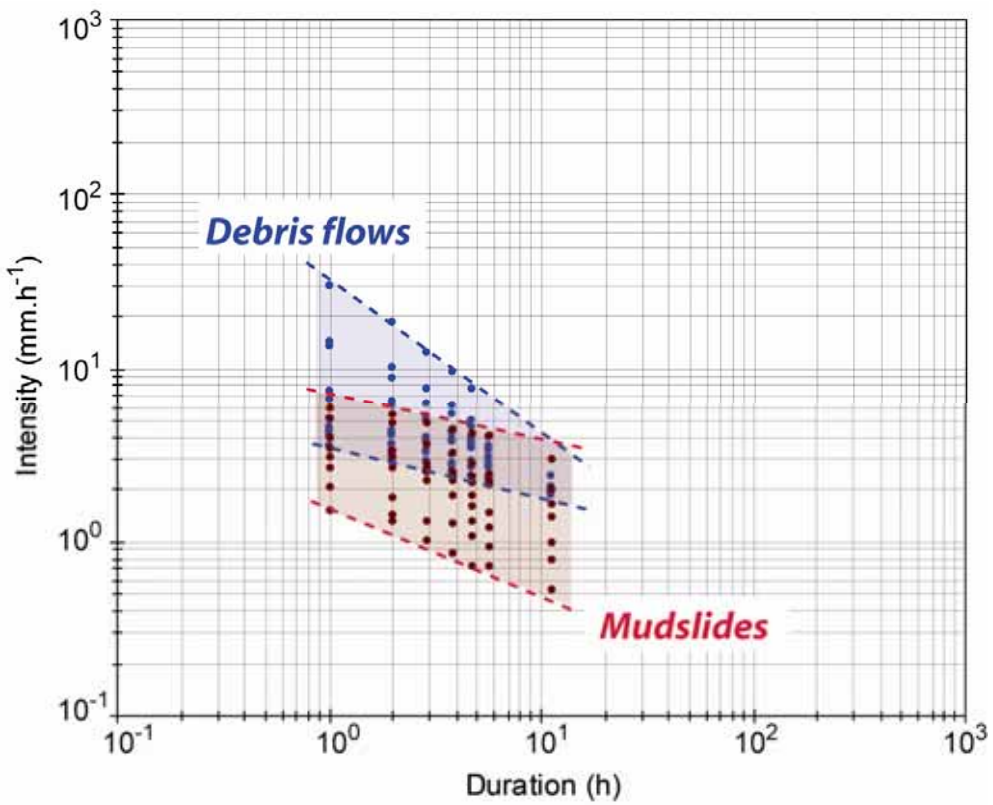


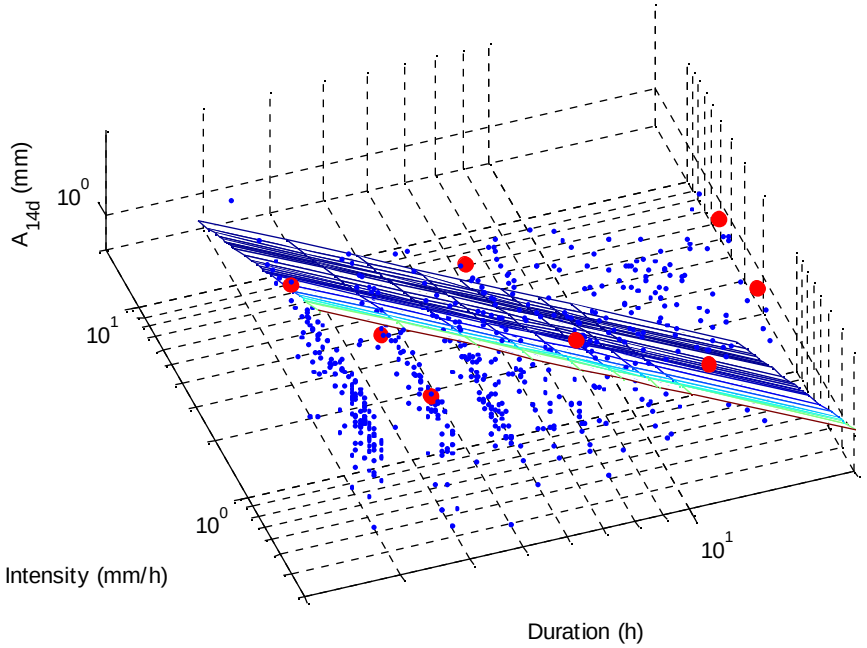
Mean hourly rainfall intensity for slow- and fast-mass movementsDaily…



Peak hourly rainfall intensity for slow- and fast-mass movementsDaily…

Generalization of I-D model

$$I = \underbrace{[\alpha_1 A_n{}^{\alpha_2}]}_{\alpha \text{ in I-D model}} D^{\beta}$$



where:

I, *D* and β as in *ID* model

A_n: antecedent *n*-day precipitation (mm)

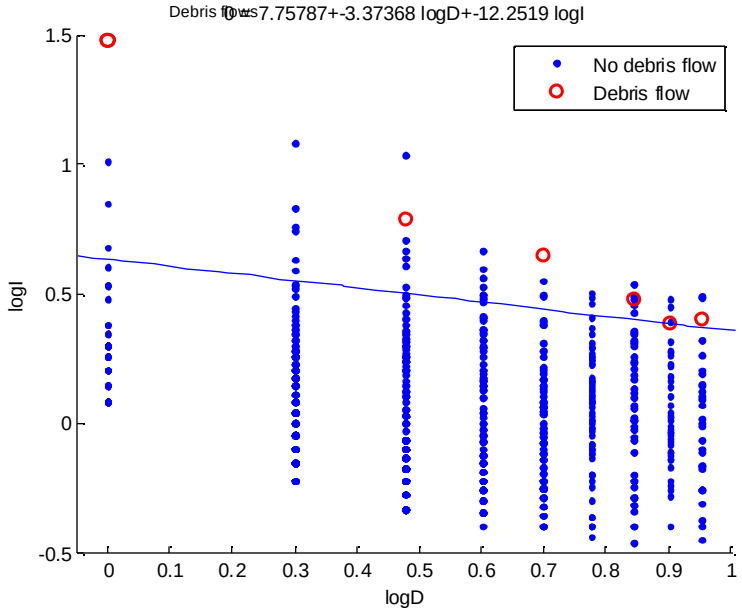
α_1 and α_2: constants of the model

➔ the term in brackets account for the effects of antecedent precipitation

➔ the model requires a calibration of the value of "n", and the constants $\alpha 1$, $\alpha 2$ and β

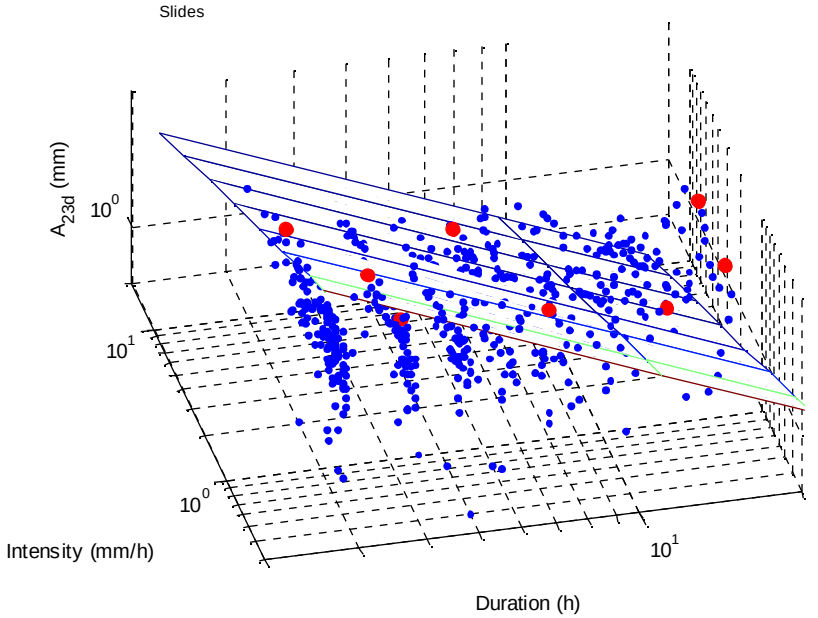
Cepeda, Nadim, Høeg & Elverhøi (2009)

Results: Barcelonnette



D: 1 to 9 hours

$$I = 4.297 D^{-0.275}$$



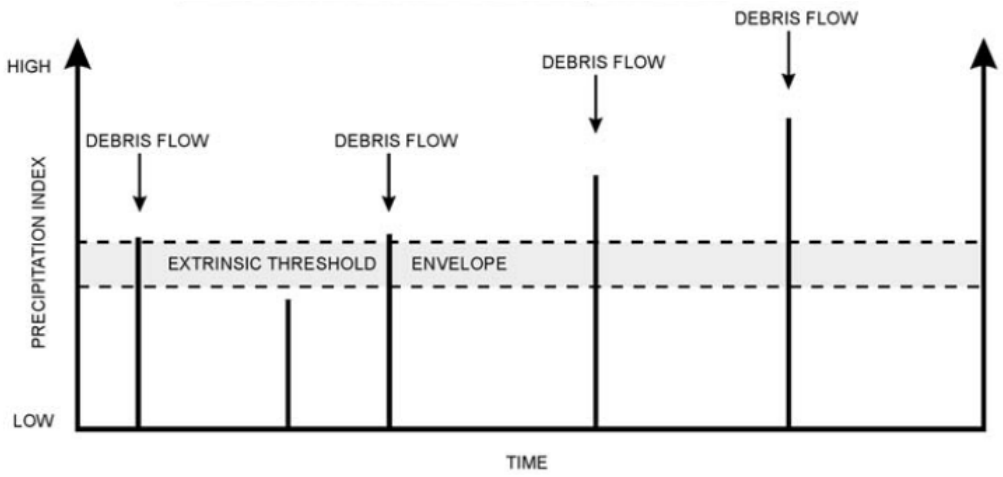
D: 3 to 17 hours

$$I = 181.2 A_{23d}^{-0.6788} D^{-1.5163}$$

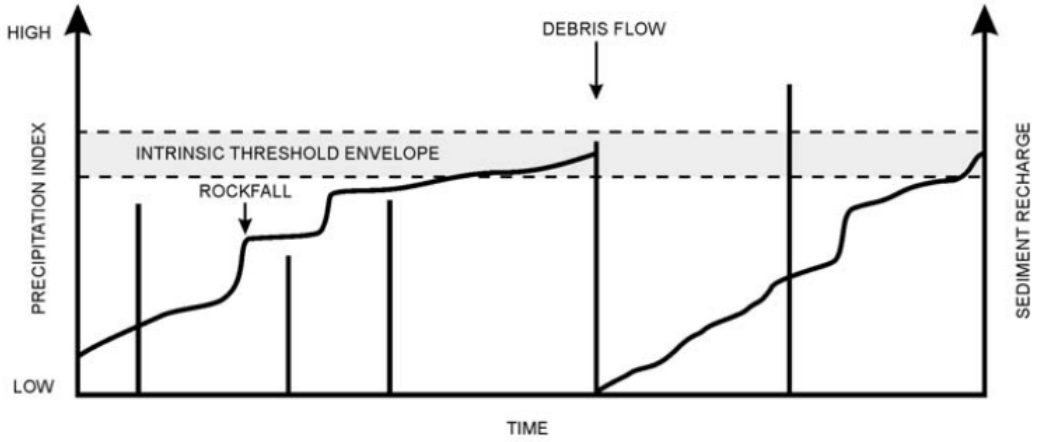
➔for debris flows, a traditional ID threshold is sufficient
+ triggering rainfall 1 to 9 hrs
+ no need of antecedent rain

➔for slides, an improved performance is achieved with the IAD model
+ triggering rainfall 3 to 17 hrs
+ need of antecedent rain of 50 days

+ Frequency of the triggers does not directly provides the frequency of the landslides



sediment supply-unlimited catchment

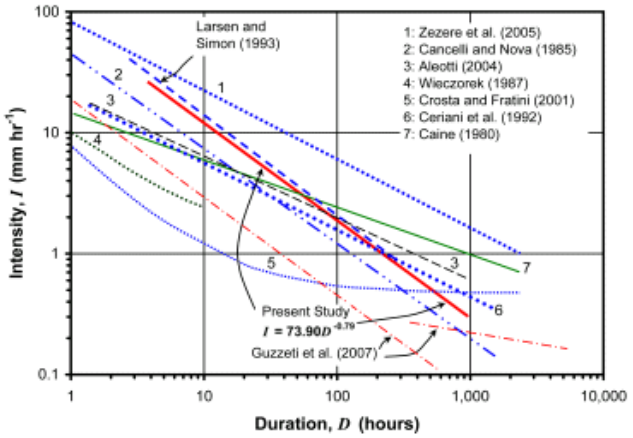


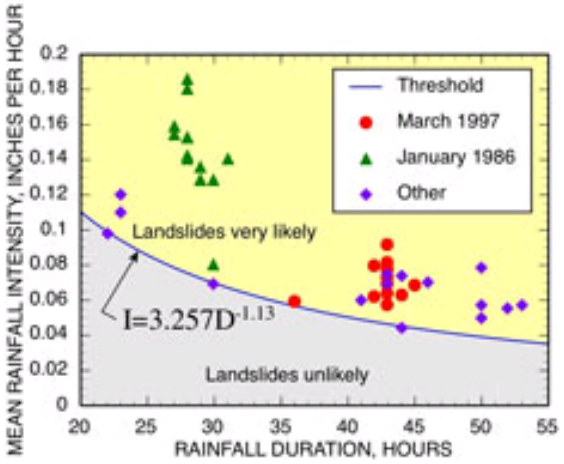
sediment supply-limited catchment

Conclusions:

- At monthly scale (antecedent cumulative rainfall), there is a clear distinction between debris flows (thunderstorm after a relatively long dry period) and the slow-moving landslide (at least 200 mm rainfall during the last 6 months) ;

- At daily and hourly scales, still difficult to construct real predictive rainfall thresholds, even if there is a clear distinction between fast- and slow-moving mass movements…





- Problems and difficulties: (1) spatialization of rainfall data in a mountainous environments, (2) recording of rainfall data associated to snow or hail events… (3) validity of the event database (events which have occurred but not observed)…