Rainfall and soil moisture conditions for the triggering of torrential flows at the Rebaixader catchment (Central Pyrenees)

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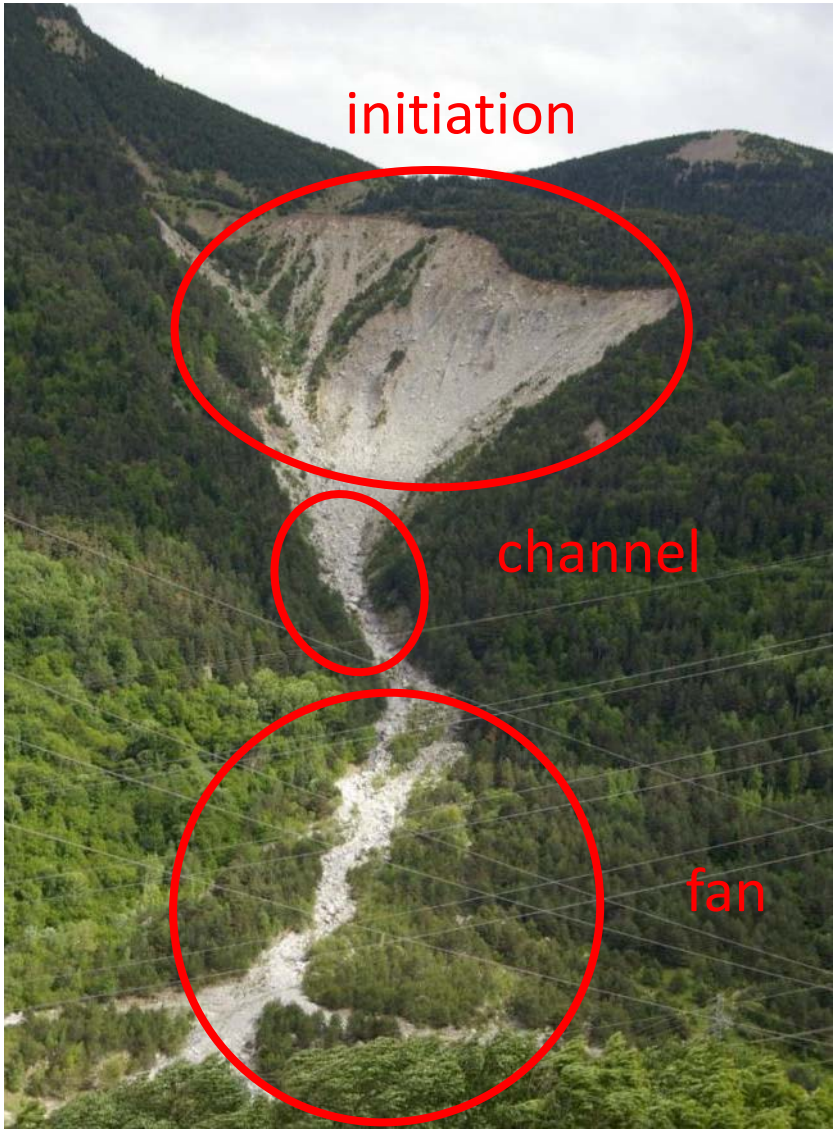
The Rebaixader test site

Characteristics:
Area: 0.5 km^2

Initiation:
- open scarp (glacial till), steep slope > 35^o
- almost unlimited sediment supply



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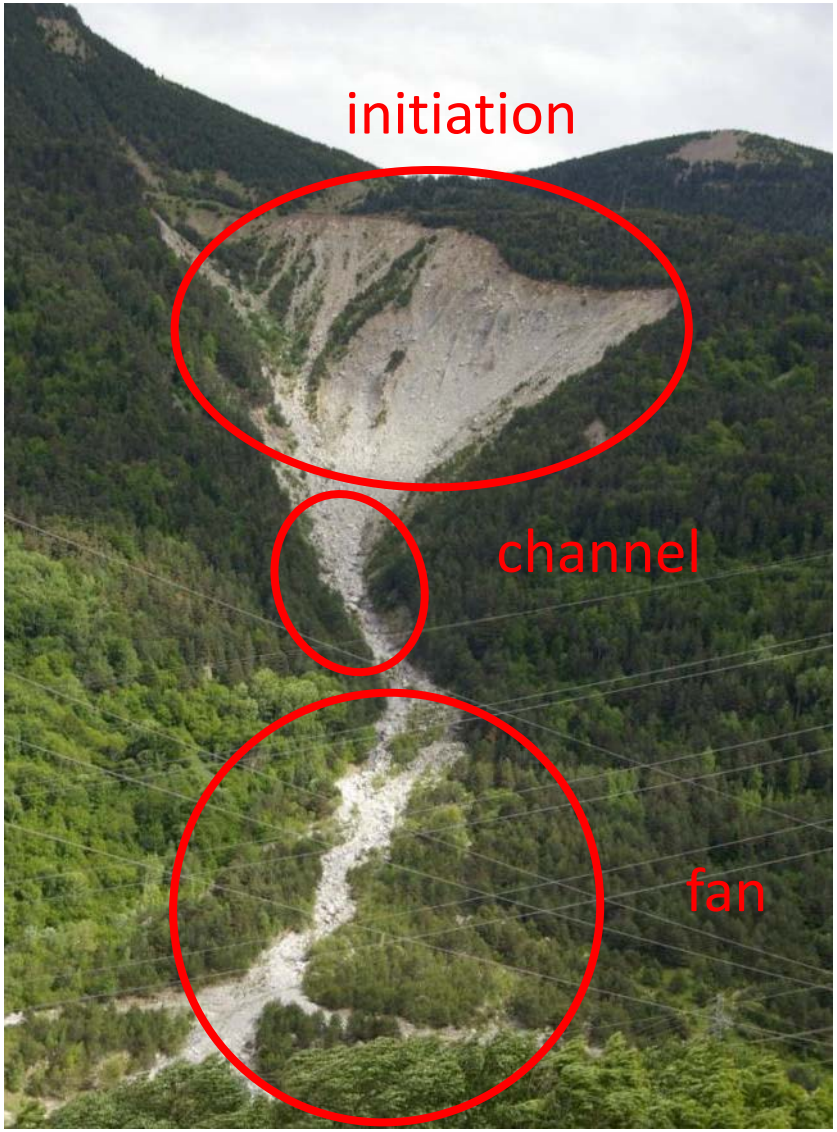
Channel:
- transition zone, slope ~21^o

Fan:
- deposition zone, slope ~10^o

High torrential activity:
11 debris flows and 24 debris floods detected (2009-2019)

~4 events per year
- ~1 debris flows
- ~ 3 debris floods

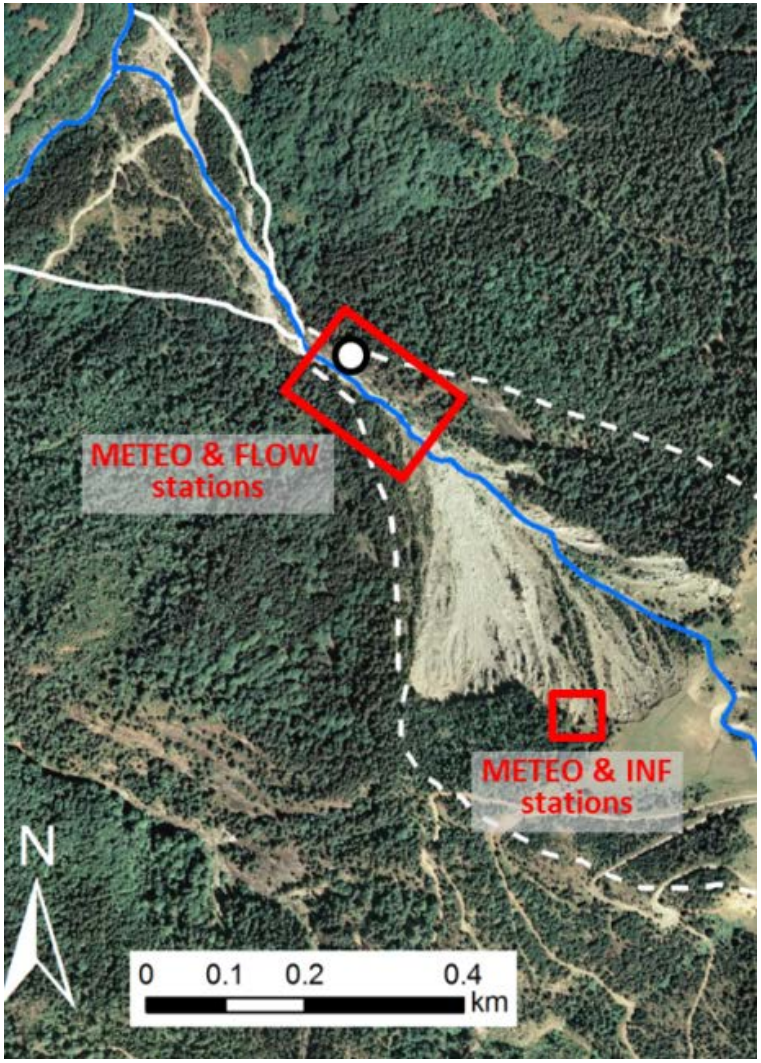
Monitoring:
-rainfall infiltration (raingauge, soil moisture…)
-process detection (geophones, radar…)



Monitoring system

2 x meteorological stations
(sampling rate 5min)

2 x tipping bucket rain gauge (not heated)
1 x air temperature
1 x relative humidity
1 x snow height



Abancó et al. (2014) doi.org/10.5194/nhess-14-929-2014

Monitoring system

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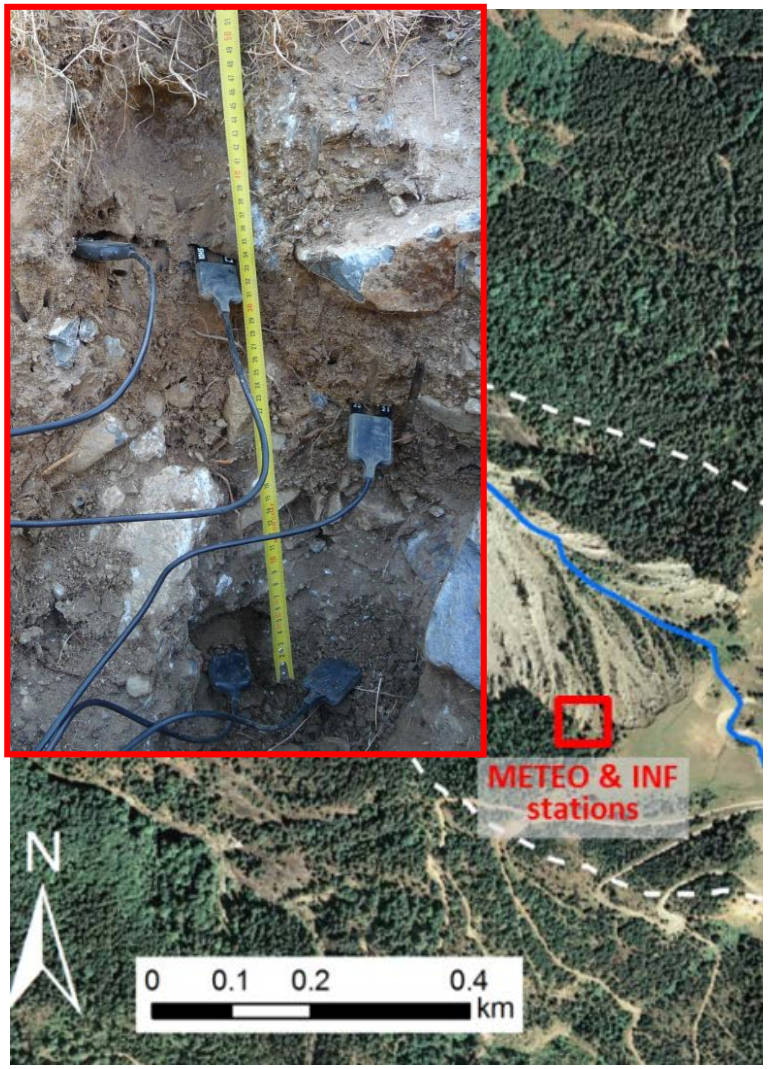
2 x infiltration stations
(sampling rate 5min)

8 x VWC sensors
2 x water potential sensors



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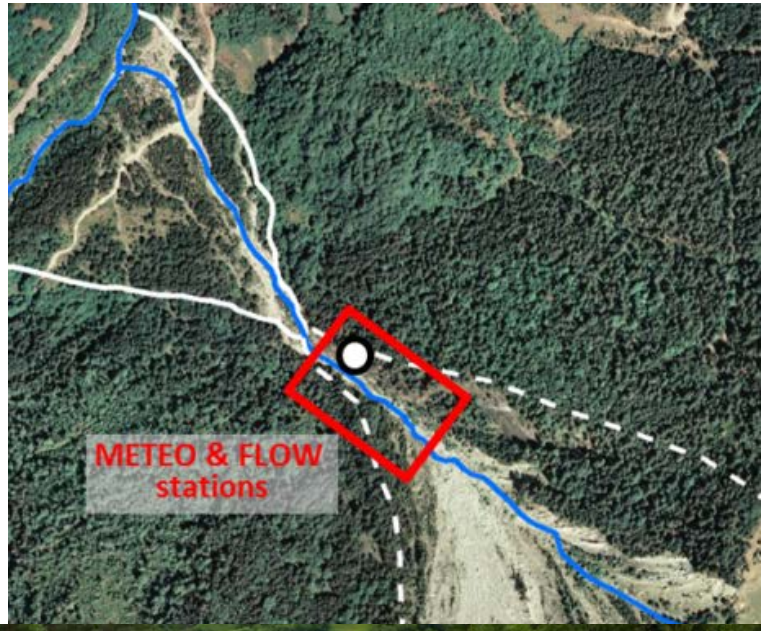
8 x VWC sensors
2 x water potential sensors

1 x station regarding flow dynamics
(sampling rate 1 sec when event detected)

5 x geophones
2 x stage sensors (radar, US)
1 x video camera



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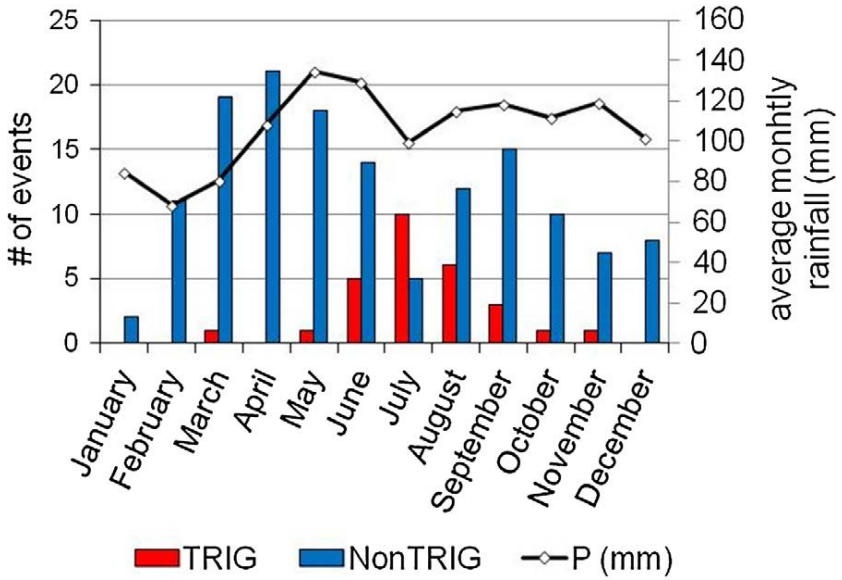
Rainfall analysis: dataset

Selected rainfalls: July 2009 - October 2018

- 35 triggering rainfalls → TRIG
  - 11 debris flows
  - 24 debris floods

- 446 non-triggering rainfalls → Non-TRIG

Rainfall temporal distribution



Abancó et al. (2016) - doi.org/10.1016/j.jhydrol.2016.01.019

Shift between higher average monthly rainfall (May –June) and month with highest torrential flow frequency (July)

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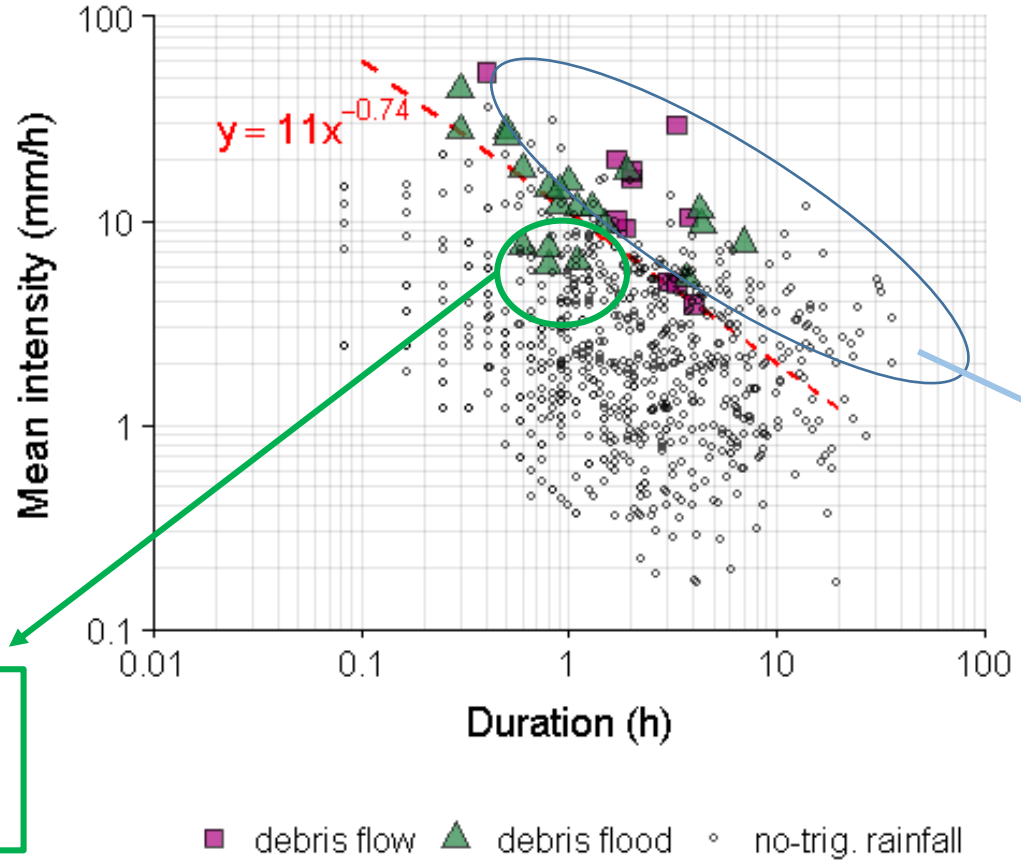
suggests that soil moisture conditions affect the triggering of torrential flows (depending on antecedent rainfall and/or snowmelt)

Rainfall analysis: definition of thresholds

Rainfall threshold:

Mean intensity vs total duration



False alarms: non-triggering rainfalls above threshold

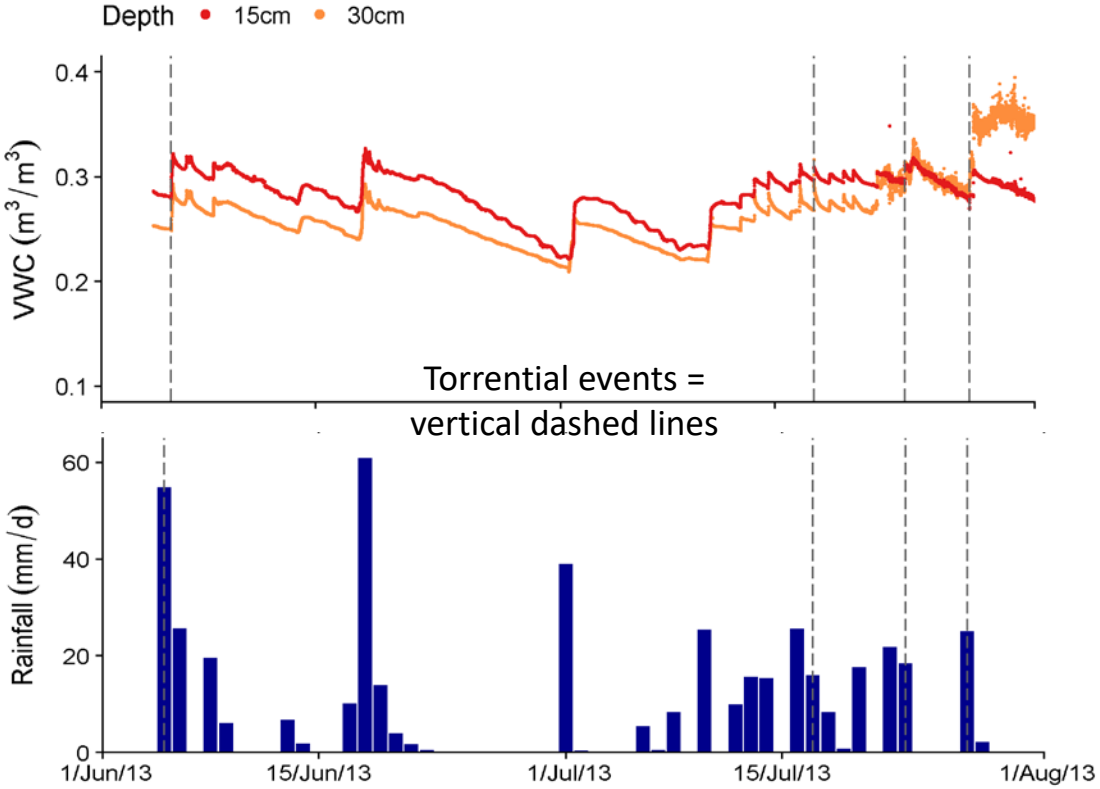
High number false alarms considering only rainfall thresholds

Failed alarms

4 little debris floods below threshold (volume=<1000m^3)

Rainfall and soil moisture analysis

VWC and soil moisture data:



Effect of antecedent soil moisture

Generally:

- Higher rainfall amounts needed for the triggering of torrential processes if soil is initially dryer
- Lower rainfall amounts needed for the triggering of torrential flows if soil is initially wetter

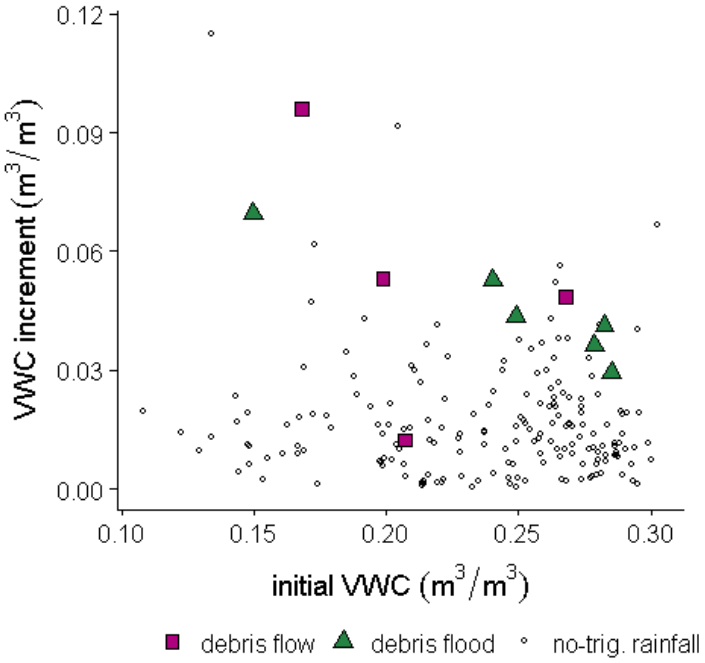
Data suggests:

Wetter soil →	Lower infiltration capacity →	Higher runoff →	Higher erosion and probability of triggering torrential flow →	Lower amounts rainfall needed
Dryer soil →	Higher infiltration capacity →	Lower runoff →	Lower erosion and probability of triggering torrential flow →	Higher amounts rainfall needed

Rainfall and soil moisture analysis

VWC data:

VWC increment vs initial VWC



Effect of antecedent soil moisture

Generally:

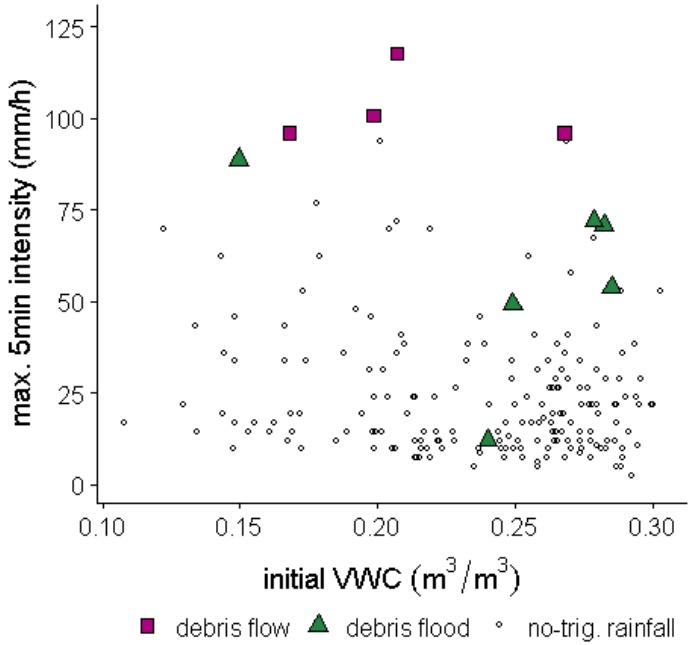
- Lower $\triangle$VWC if soil is initially wetter at beginning of triggering rainfall event.

- Higher $\triangle$VWC if soil is initially dryer at beginning of triggering rainfall event.

Rainfall and soil moisture analysis

VWC and soil moisture data:

Max 5 minute rainfall intensity vs initial VWC



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Final remarks:

- Soil moisture conditions affect the triggering of torrential flows (depending on antecedent rainfall and/or snowmelt)
- Analysis of VWC data complicated in contrast to only rainfall data, since time series are shorter (2013-2019) and the physical interpretation is not straightforward.
- Additional data are necessary to confirm and define soil moisture thresholds triggering torrential flows.

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References

- Abancó, C., Hürlimann, M., and Moya, J. (2014): Analysis of the ground vibration generated by debris flows and other torrential processes at the Rebaixader monitoring site (Central Pyrenees, Spain), Nat. Hazards Earth Syst. Sci., 14, 929–943, https://doi.org/10.5194/nhess-14-929-2014

- Abancó C., Hürlimann M., Moya J., Berenguer M. (2016): Critical rainfall conditions for the initiation of torrential flows. Results from the Rebaixader catchment (Central Pyrenees). Journal of Hydrology, volume 541 part A:218–229, https://doi.org/10.1016/j.jhydrol.2016.01.019.