

Combining meteorological and geomorphological expertise to provide evidences of rainfall precipitation extremes changes

Federico Grazzini (1), Stefano Segadelli (2), Alessandro Chelli (3)

1) **Arpae-SIMC Servizio Idro-Meteo-Clima dell'Emilia-Romagna**, Bologna, Italy

2) **Regione Emilia-Romagna, Servizio Geologico e Sismico dei Suoli**, Bologna, Italy

3) **Università di Parma**, Dipartimento di Scienza Chimiche, della Vita e della Sostenibilità Ambientale (S.C.V.S.A.), Parma, Italy

Facts

Three once in a century extreme precipitation events, in the last 4 years, have been stricken the hilly and mountainous territory of Emilia-Romagna Region (Italy). Major effects on the ground were observed: i.e. debris flows, shallow landslides, flash floods and overbank flooding.

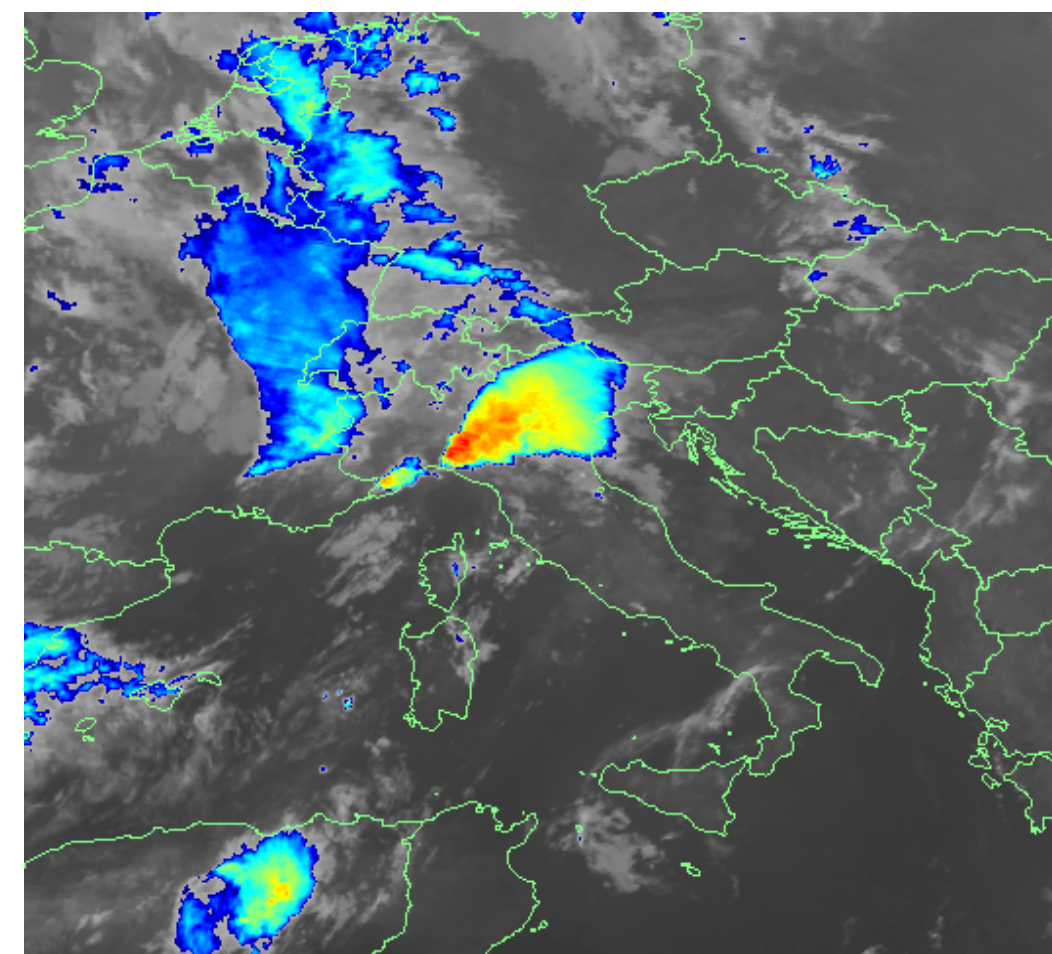


Figure 1.1 : MSG-3 satellite enhanced infrared picture at 00UTC 14 September 2015 showing the V-shaped convective system that generated the extreme precipitation of Val Trebbia - Nure event.

Figure 1.2 : Detailed distribution of 3h accumulated precipitation, during peak intensity, and censed debris/mud flow during the Val Trebbia Nure event. Accumulated precipitation is an optimal combination from radar and high resolution density regional networks*

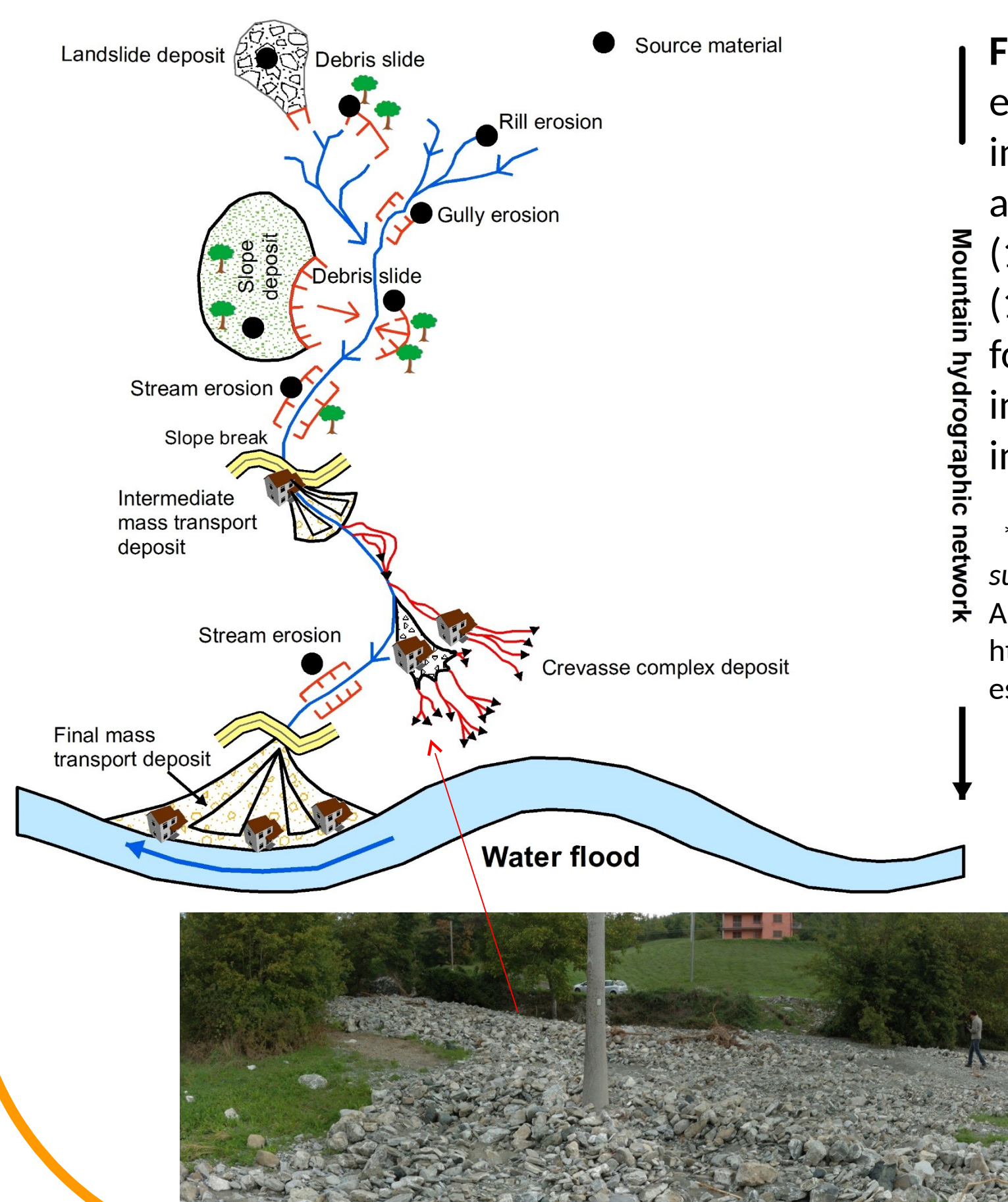
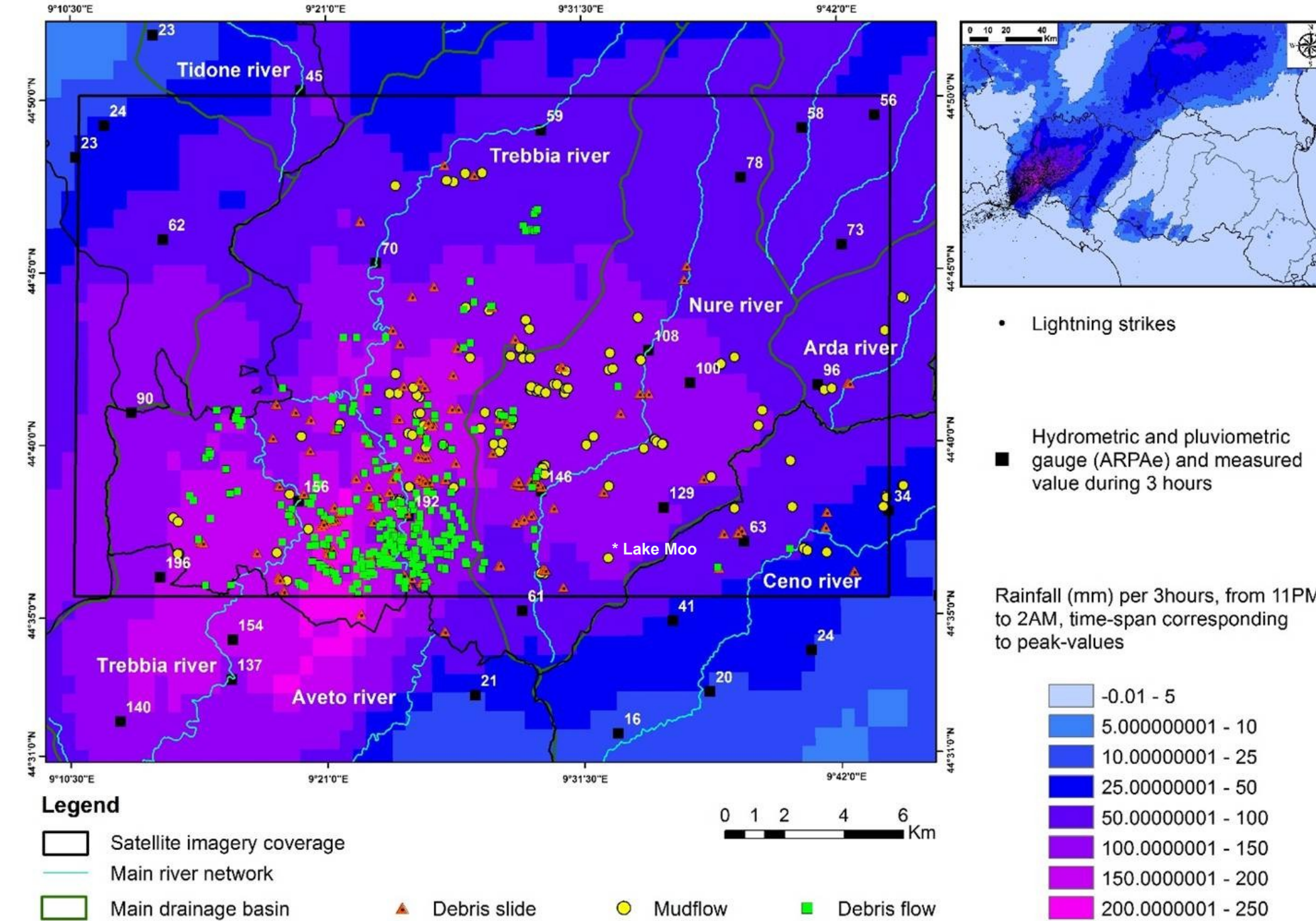


Figure 1.3 : Original schema* describing the evolution of the effects on the ground induced by extreme precipitation intensity as observed in the Val Trebbia case (14/09/2015) and Val Parma case (13/10/2014). In the next section we will focus on debris deposit, like the ones shown in figures, as surface marker for high intensity precipitation events.

* See technical report (*Precipitazioni estreme e effetti al suolo sul reticolo minore: il caso del 14-09-2015*, ARPAE/SGSS Emilia-Romagna, https://www.arpae.it/cms3/documenti/Report_effetti_preci_estremi_final_last.pdf)

Changing atmospheric conditions

Rainfall rates are dependent on the vertical moisture flux that is being fed into the cloud. High rainfall rates require high moisture content (*precipitable water* or TCWV) along with strong ascent. Global warming is inducing a moistening of Mediterranean air masses, with an increase potential for high intensity precipitation.

$$P_{\text{intensity}} = - \frac{\epsilon \omega S(T,p)}{\dots}$$

Precipitation efficiency (microphysics, entrainment, rh, shear, evaporation)

Vertical velocity (pressurecoordinates) Thermodynamic component .dq_{dp} at Thetae constant

Total column water vapour (TCWV) is important and is effecting all the tree components

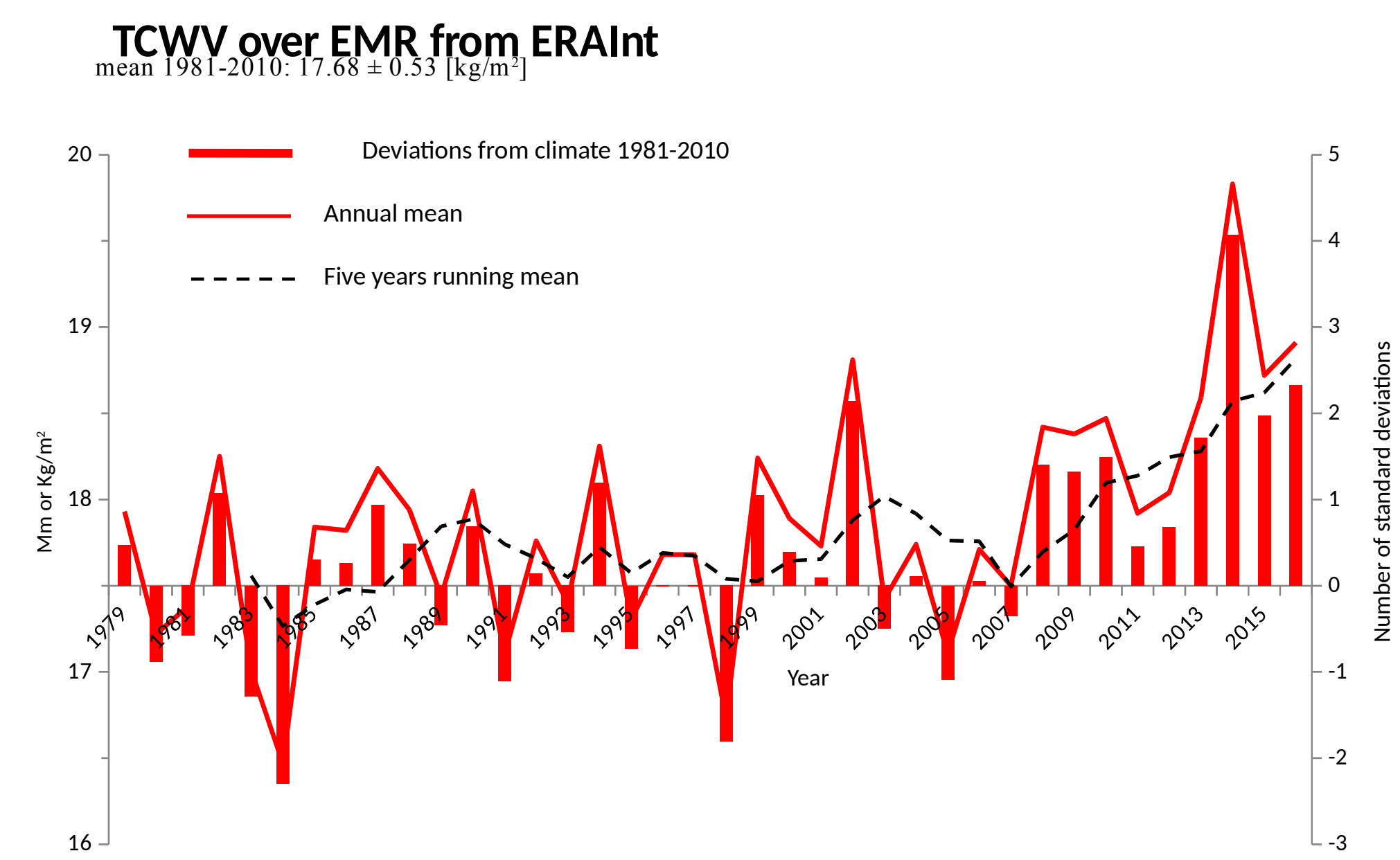


Figure 2.1 : TCWV is in marked increase over Mediterranean area and Emilia-Romagna region after 2007, with an annual anomaly between 2-3 standard deviations respect to 1981-2010 average. During high intensity precip. events (>30mm/h) , TCWV over EMR is on average 27mm, 10-20% above its climatological value. Is also evident a trend showing an increasing anomaly, now on average above 20% its climatological value

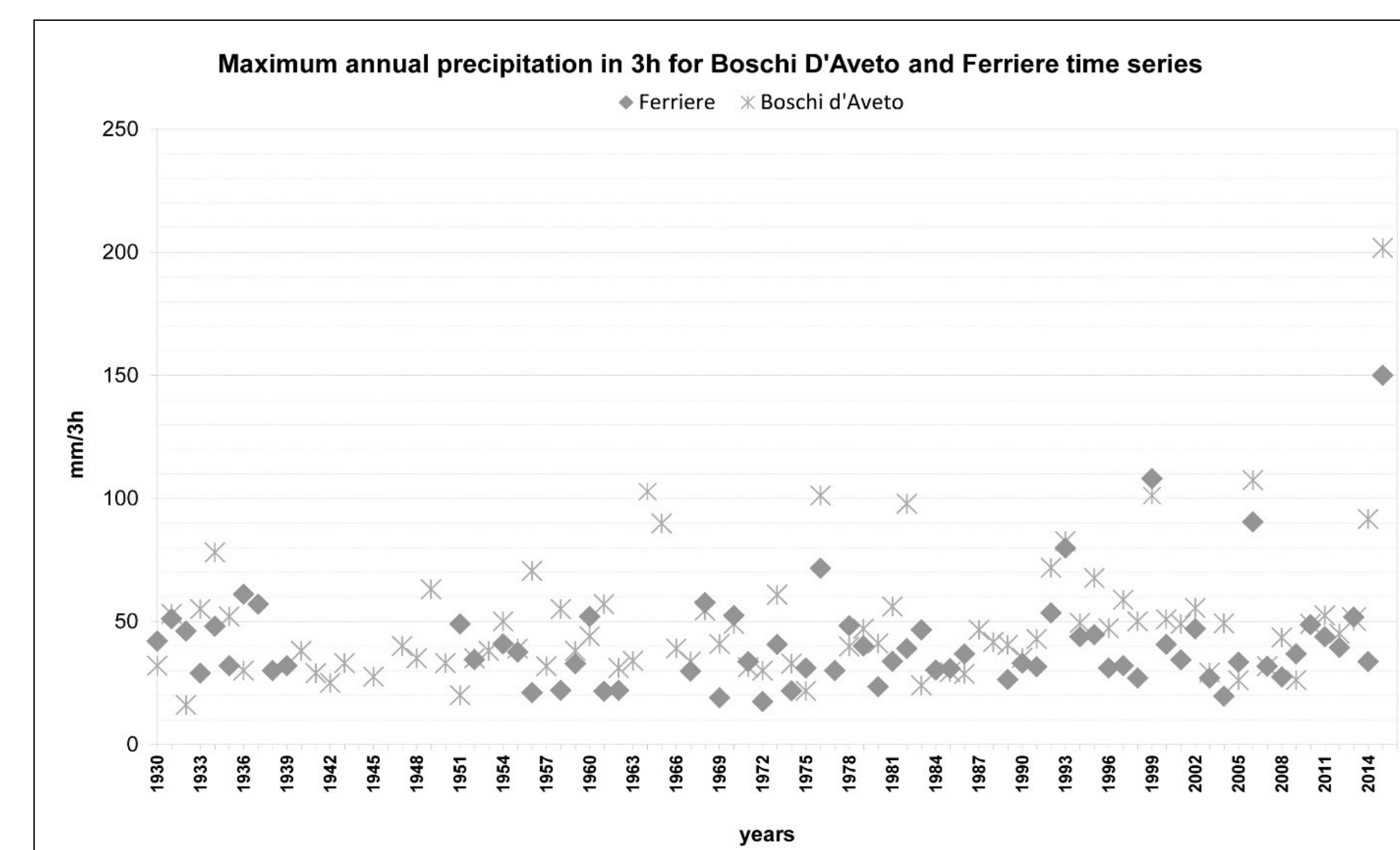


Figure 3.1 : Evidences are showing that recent heavy precipitation are becoming more extreme, very often breaking long instrumental records. It is the case of two selected stations, with an almost continuous annual precipitation maximum time series (at different accumulation time range) dating back to 1930. In these stations, the event of September 2015 is by far the most intense recorded in the last 87 years.

What is the frequency of these events ?

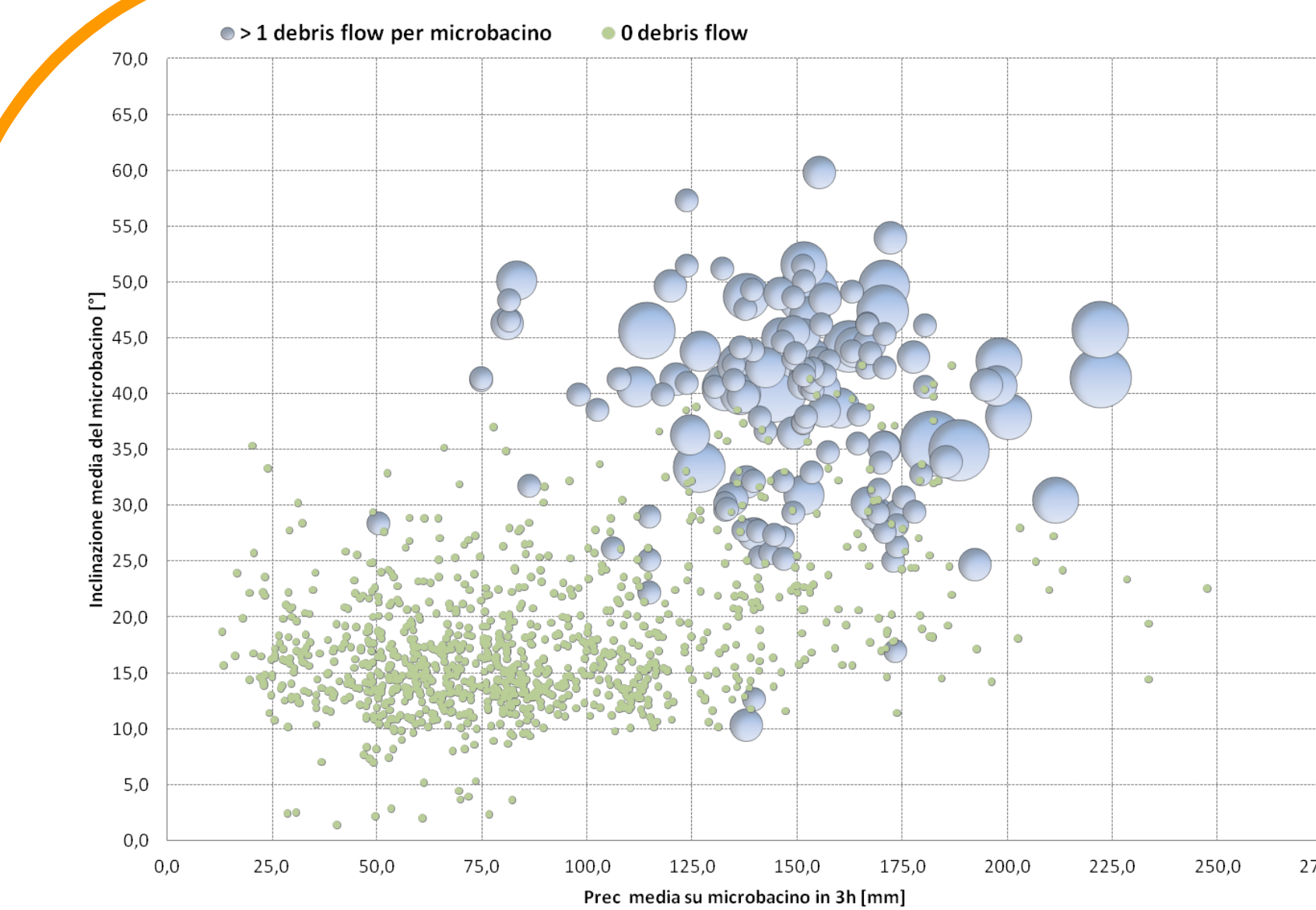


Figure 3.1 : The analysis of large amount of data from the event of 14/09/2015 shows a robust relation< between average precip. intensity over unit hydrological area (microbasins) and number of debris, on microbasins with acclivity greater than 25°. This relation provides a background to infer heavy precipitation from past geological records.

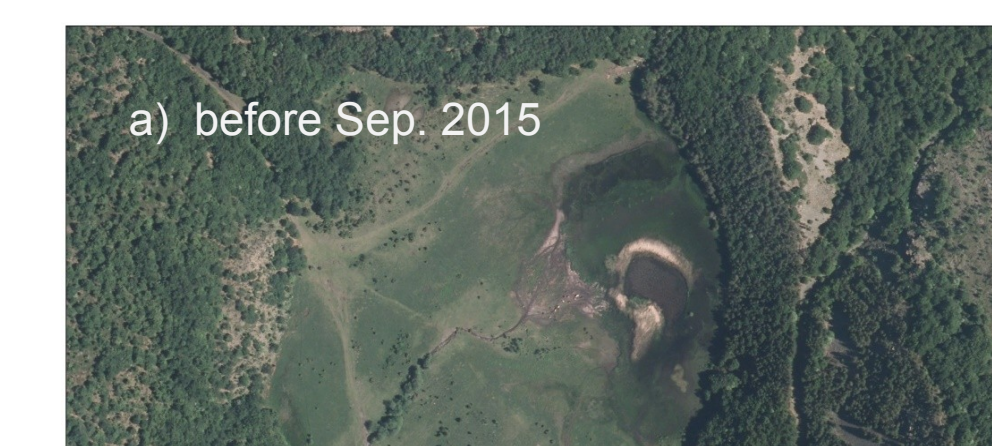


Figure 3.2 : We will conduct geological analysis, like borehole drilling and trench inspections in an undisturbed SIC natural habitat (see Fig. 1.1 for location) to search for similar deposits below surface.

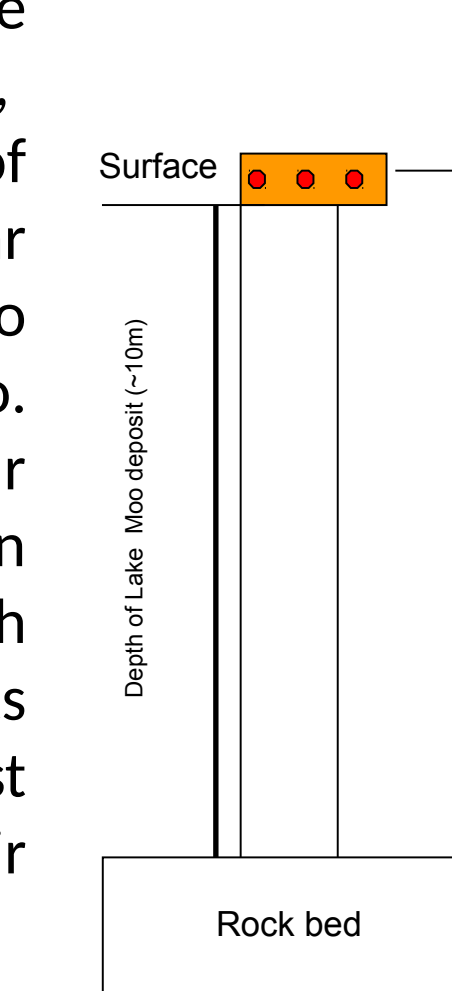


The Lake Moo site, a peat bog located at 1130m asl in the Ferriere municipality (PC), has been partially covered by a debris flow released in the event of 14/09/2015, as documented in the pictures

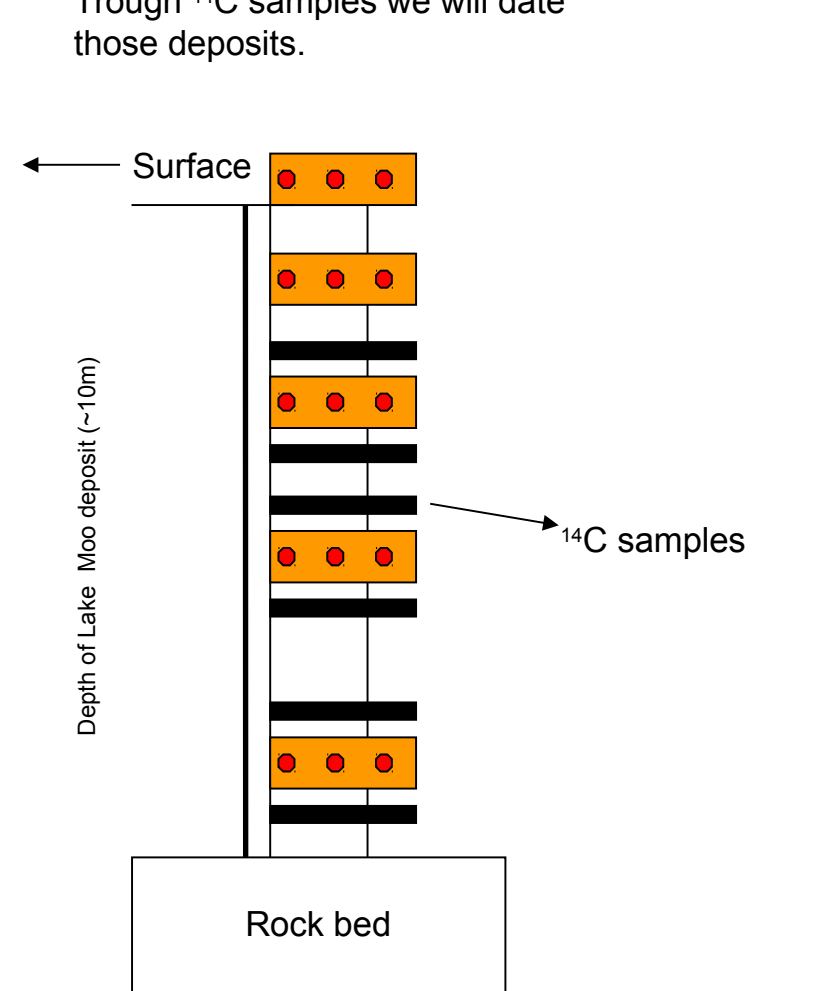


Figure 3.3 : The main idea of this field survey, that will be conducted during summer 2017, is to verify the existence of similar deposits in the near surface geological records and to date them trough ¹⁴C mass ratio. In case of presence of similar deposits (scenario 2) we can conclude that other high intensity precipitation events have been observed in the past and we could estimate their frequency.

Scenario 1: no other debris flow deposit found



Scenario 2: more debris flows found below surface. Trough ¹⁴C samples we will date those deposits.



On the contrary, in case no other similar deposit will be found (scenario 1), we could assume the event of Sep. 2015 is really exceptional, non only in during the short chronological time of instrumental records, but also on a longer geological perspective. with important consequences on climate changes assessments