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Multidisciplinary analysis at Lake Moo : New data from a natural archive to gouge past and future trends in heavy rainfall events over Northern Apennines (Italy)

arpae emilia-romagna

EMILIA-ROMAGNA REGION ADMINISTRATION GEOLOGICAL SURVEY

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Keywords: extreme precipitation, paleoflood deposit, peat bog record, Holocene, northern Apennines, climate change, water cycle

(1) Study area identification and objectives

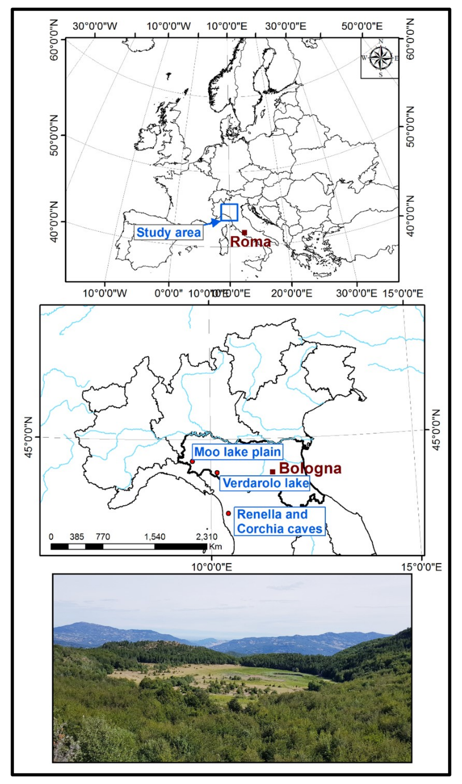

Figure 1.1 – Location and photo of the Lake Moo site.

Geological, geomorphological field surveying, core drilling and open pit soil observations were carried out in an undisturbed Sites of Community Importance (see **Fig. 1.1** for location). The Lake Moo plain (44°37'29"N, 9°32'25"E) has surface area about 0.15Km². It is located near the boundary between Emilia-Romagna and Liguria regions, in the high valley of the Nure stream at an altitude of 1130m a.s.l.. This site is strategic with respect to the dominant atmospheric flow associated with heavy precipitation events for many aspects, not least, for his undisturbed and sensitive response to debris flow. In recent time, Lake Moo area has been partially covered by a flood deposit released by the rainfall event of 09/13-14/2015 night (Grazzini et al., 2016; Figure 1.2).

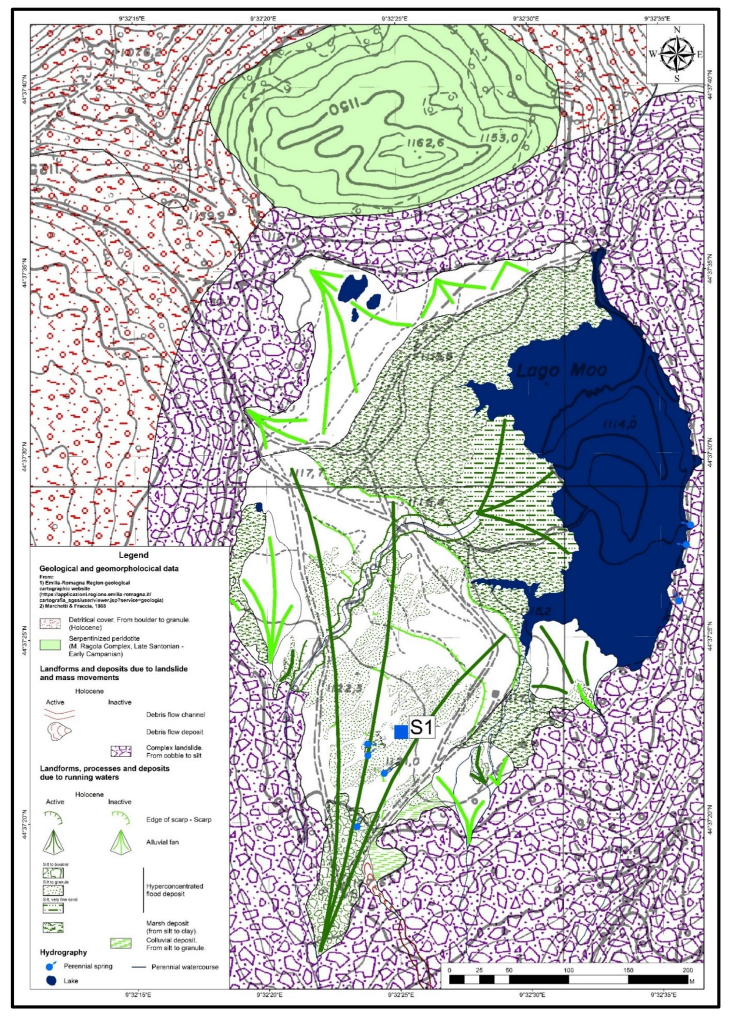

Figure 1.2 - Detailed geomorphological mapping of the flood deposit and S1 coring location.

(2) Lago Moo core description

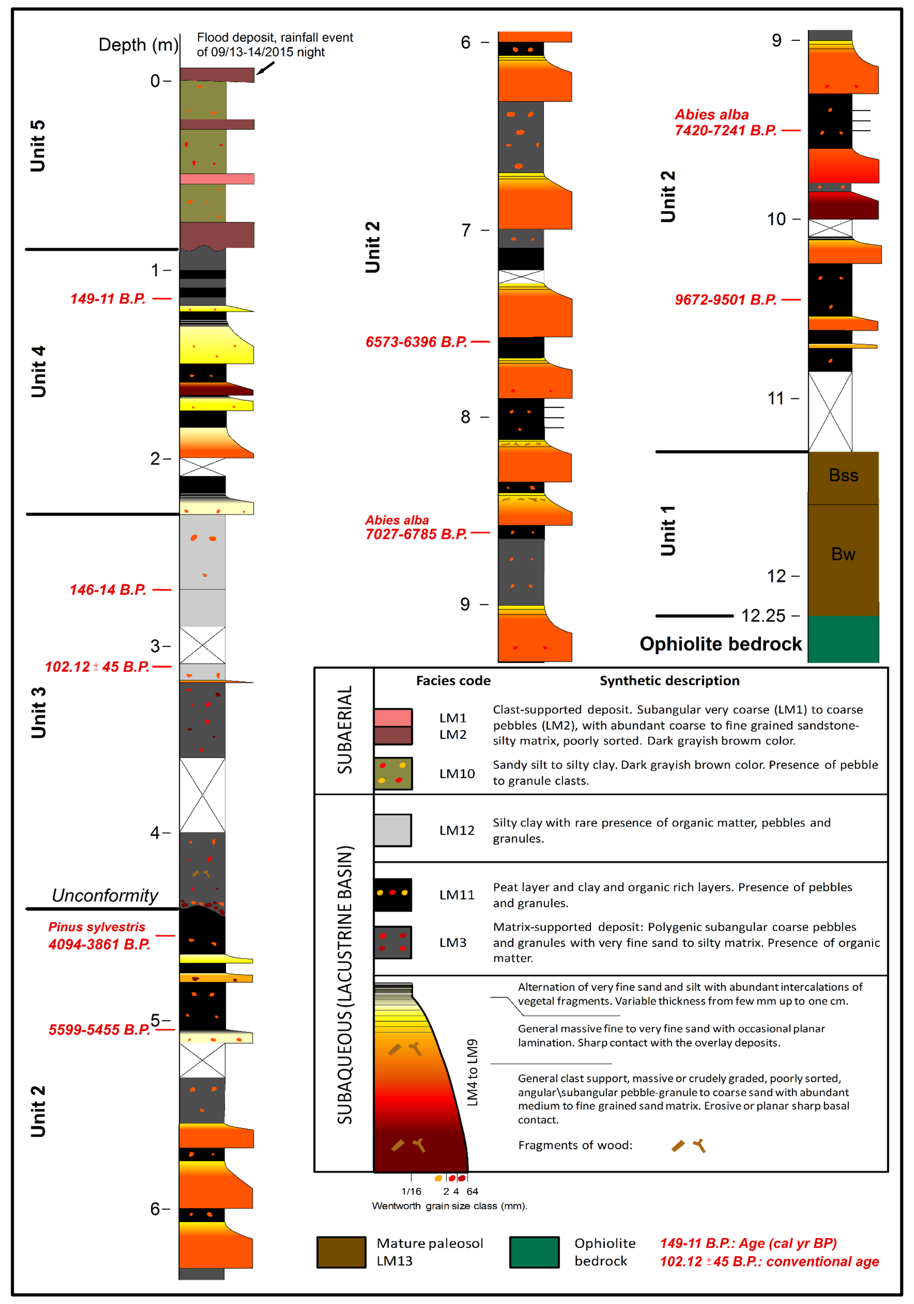

Figure 2.1 – Sediment core description, radiocarbon dates

Thirteen different facies types have been identified and named from LM1 to LM13. Relatively to the Lake Moo site, the different coarse-grained facies from LM1 to LM9 have been interpreted as the extreme flood events triggered only by high-intensity convective rainfall events in the catchment area that flow into the Lake Moo as hyperpycnal flow. Our main assumption is that, with favorable sediment transfer into lake and small catchment area (<2km²), high density flood can be triggered only by high precipitation intensity events due to erosion of material from the drainage system network (Milliman and Syvitski, 1992; Mulder and Syvitski, 1995; Mutti et al., 1996). The facies from LM1 to LM9 were grouped according to the genetic approach and therefore on the basis the concept of facies tract as described in figure 2.1 (Lowe, 1982; Mutti et al., 1996).

The core succession is subdivided into five informal units. We interpret the local lacustrine and subaerial succession is like to the infill of a structural depression produced by gravitational block sliding that was induced by post-glacial fluvial incision.

The flood deposits produced by the rainfall event of September 13th and 14th 2015 closes the sequence.

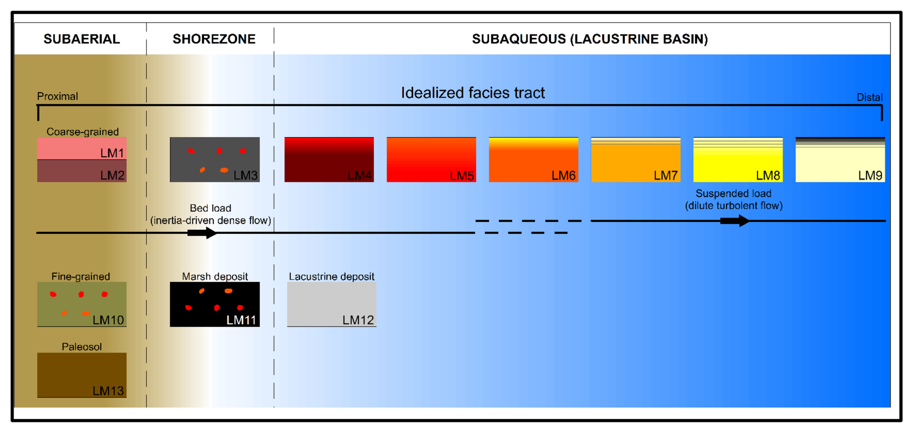

Figure 2.2 – Idealized genetic facies tract interpretation of clastic deposits associated with S1 core.

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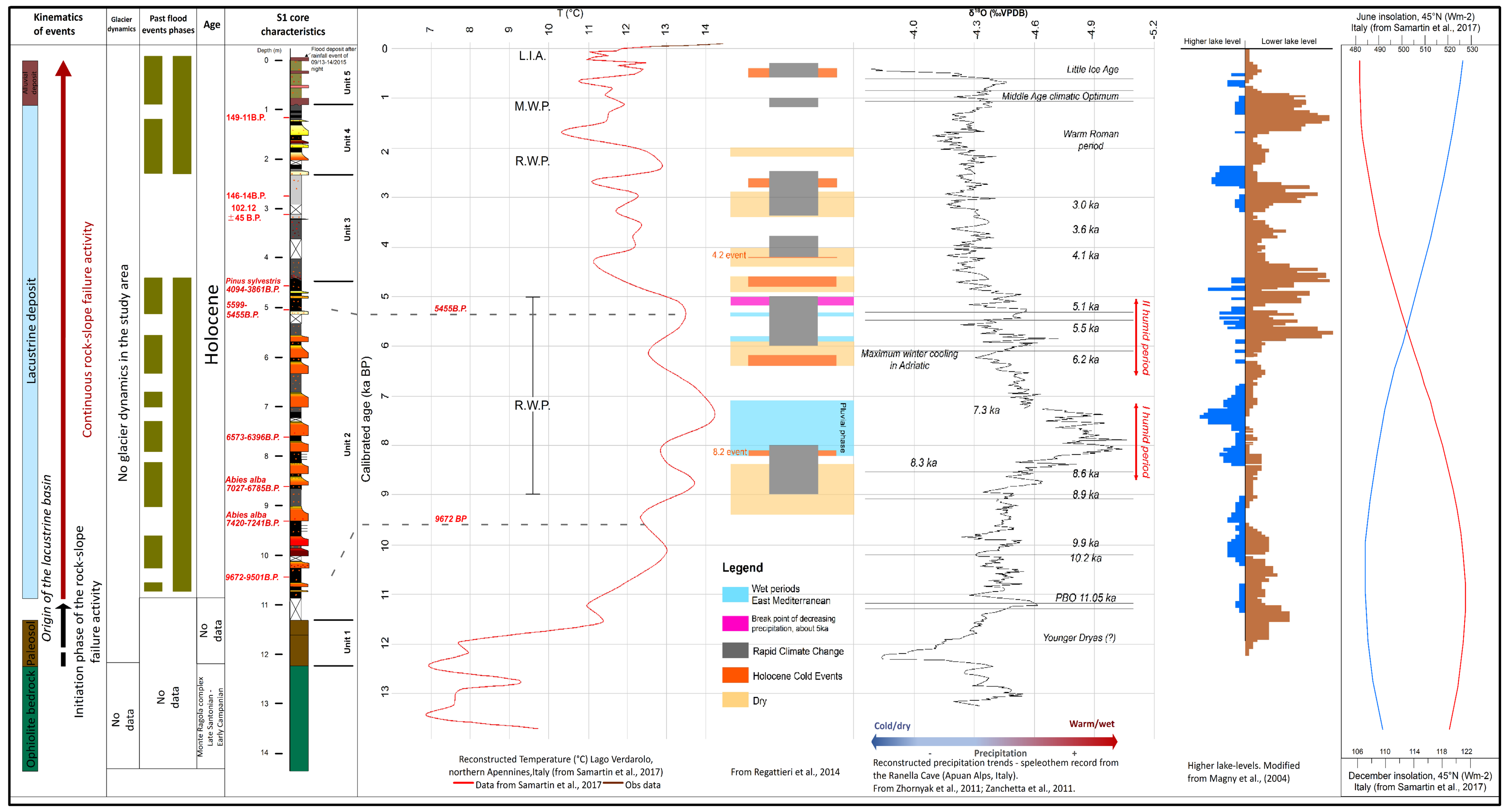
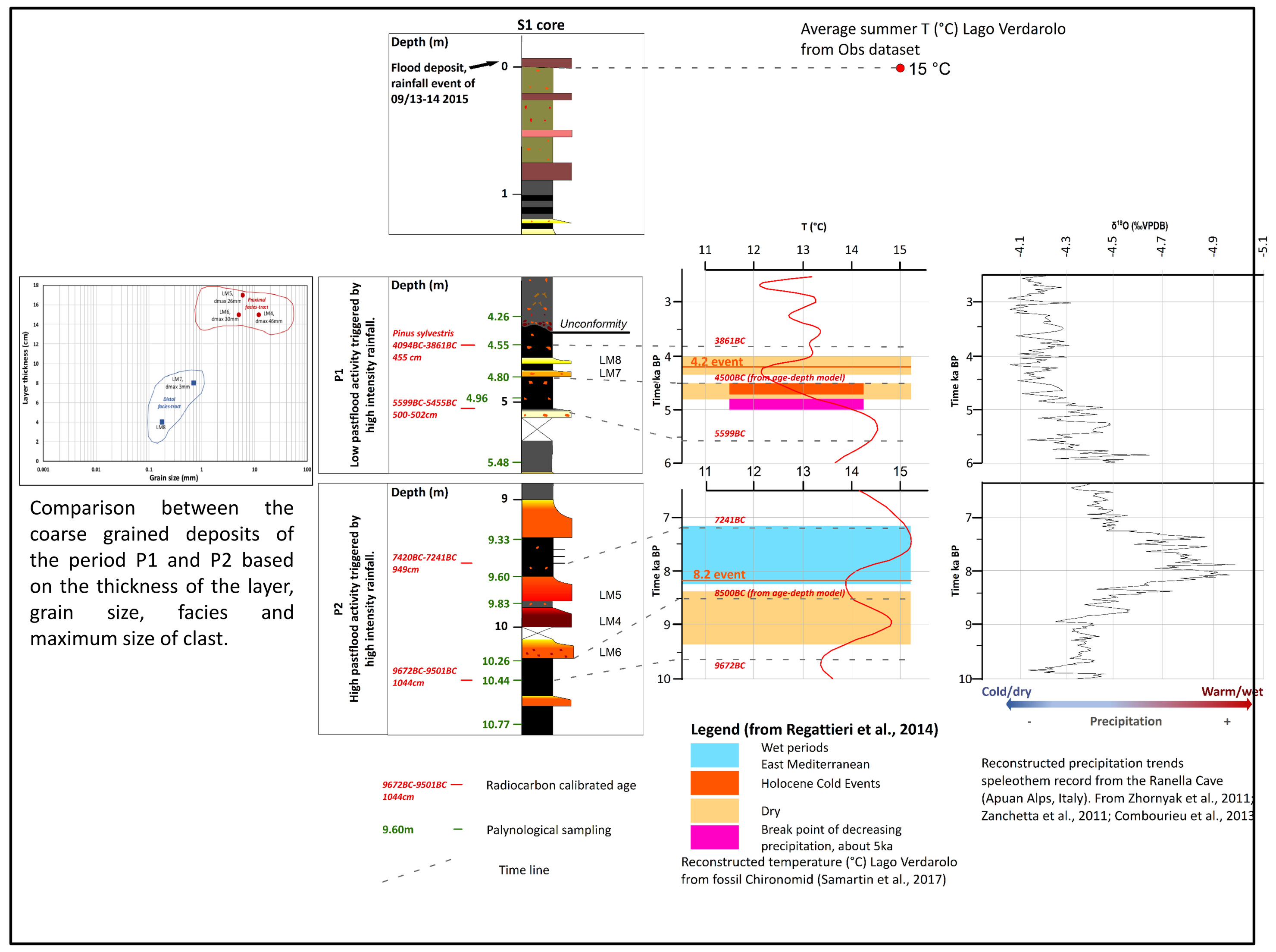
(3) Holocene hydrological changes

Figure 3.1



The figure 3.1 show the stratigraphic succession of the S1 core compared with the most relevant climate proxy available from literature for the area of interest. Instrumental data, available since the second half of the last century from the Eraclito ER dataset (Antolini et al., 2016), were added to the Verdarolo curve to allow a comparison between geological time and recent instrumental data. The overlap with the latest part of Verdarolo reconstructed curve suggest a good accuracy of the reconstruction technique in this region. Interestingly, during the HTM, we observed a maximum of coarse grained deposits inside the lake succession and that the current summer temperature values are comparable with the maximum temperature values reached during the HTM.

Figure 3.2



We observed a good correspondence of maximum summer temperature with the main precipitation peak deducted from nearby speleothem records from Renella cave (P2 time interval). Thanks to the genetic facies tract approach, for the (P2) time interval we observed that coarse grained deposits are occurring in proximal facies (LM4 to LM6) as a result of precipitation of extreme intensity. While in the (P1) time interval, the hyperpycnal deposits are expression of distal facies (LM7 to LM8) indicating low flood activity and a reduced number of extreme precipitation. This is in agreement with the physical linkage between high temperatures and high precipitation intensity discussed in chapter below.

(4) Physical processes and precipitation intensity

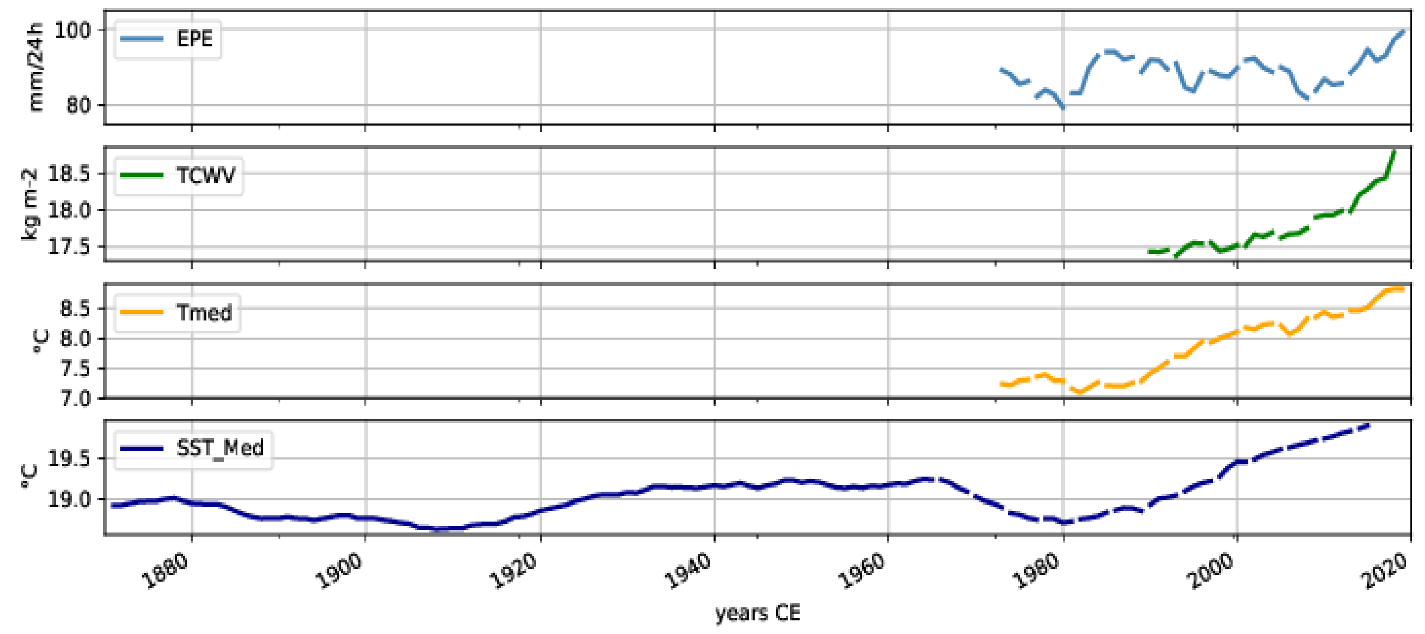


Figure 4.1 – Recent trend of key variables (11 years running mean) related to precipitation intensities. From top, 99° of daily precipitation on wet days at Verdarolo site (EPE)[1]. Total column water vapour (TCWV)[2]. Verdarolo yearly T2m average (Tmed)[1]. SST yearly average over Med. Basin. (SST_Med)[3].

1. *Eraclito4 reanalysis*
2. *ERA5 reanalysis*
3. *EEA reconstructed SST*

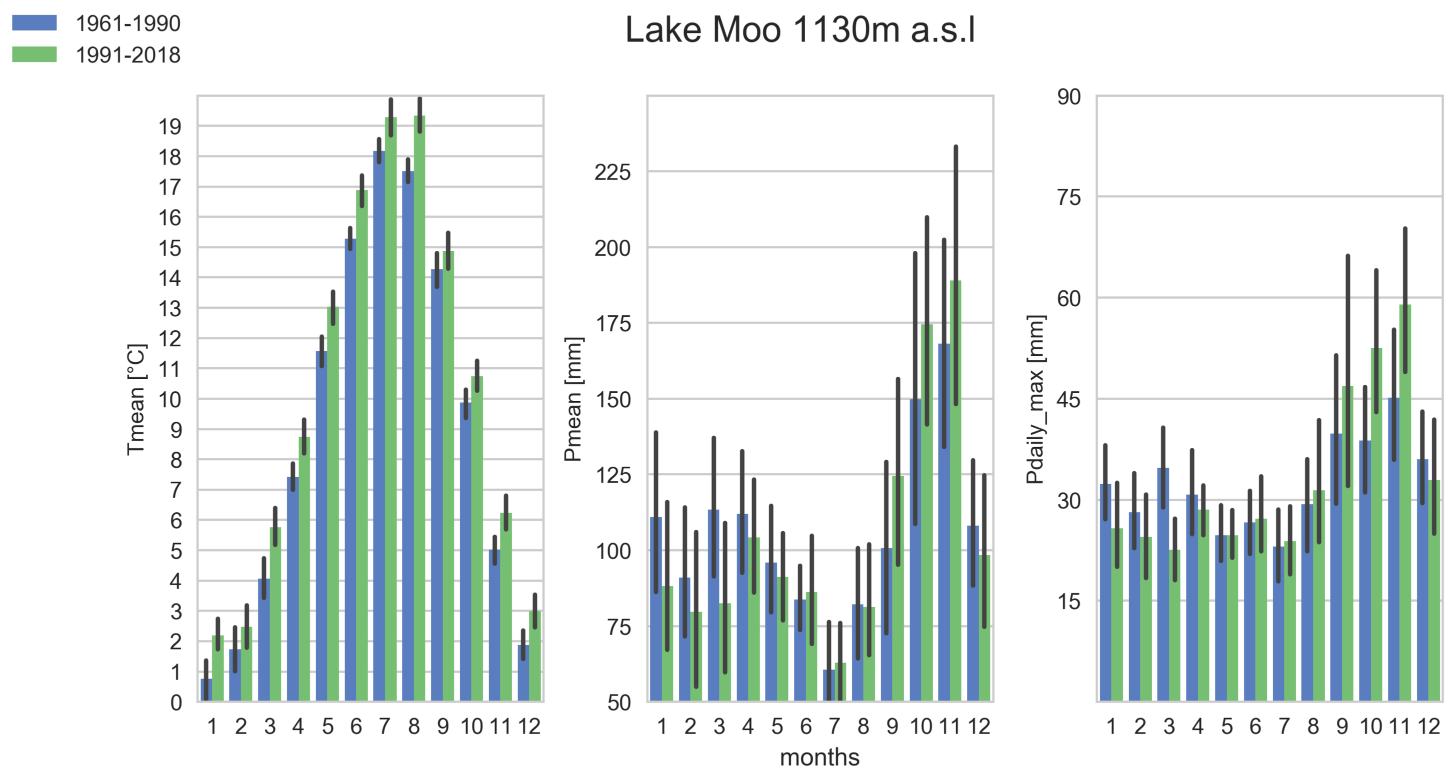


Figure 4.2 – Observed changes in the monthly distribution of two meter temperature and precipitation at Lake Moo site, from reference climate period 1961-1990 until recent climate 1991-2018. Black bars are showing uncertainty estimate with a bootstrapping method. Largest temperature increase is observed in summer months while precipitation, mean and maximum, is decreasing in every months with exception of autumn. Same behavior is observed at Verdarolo site

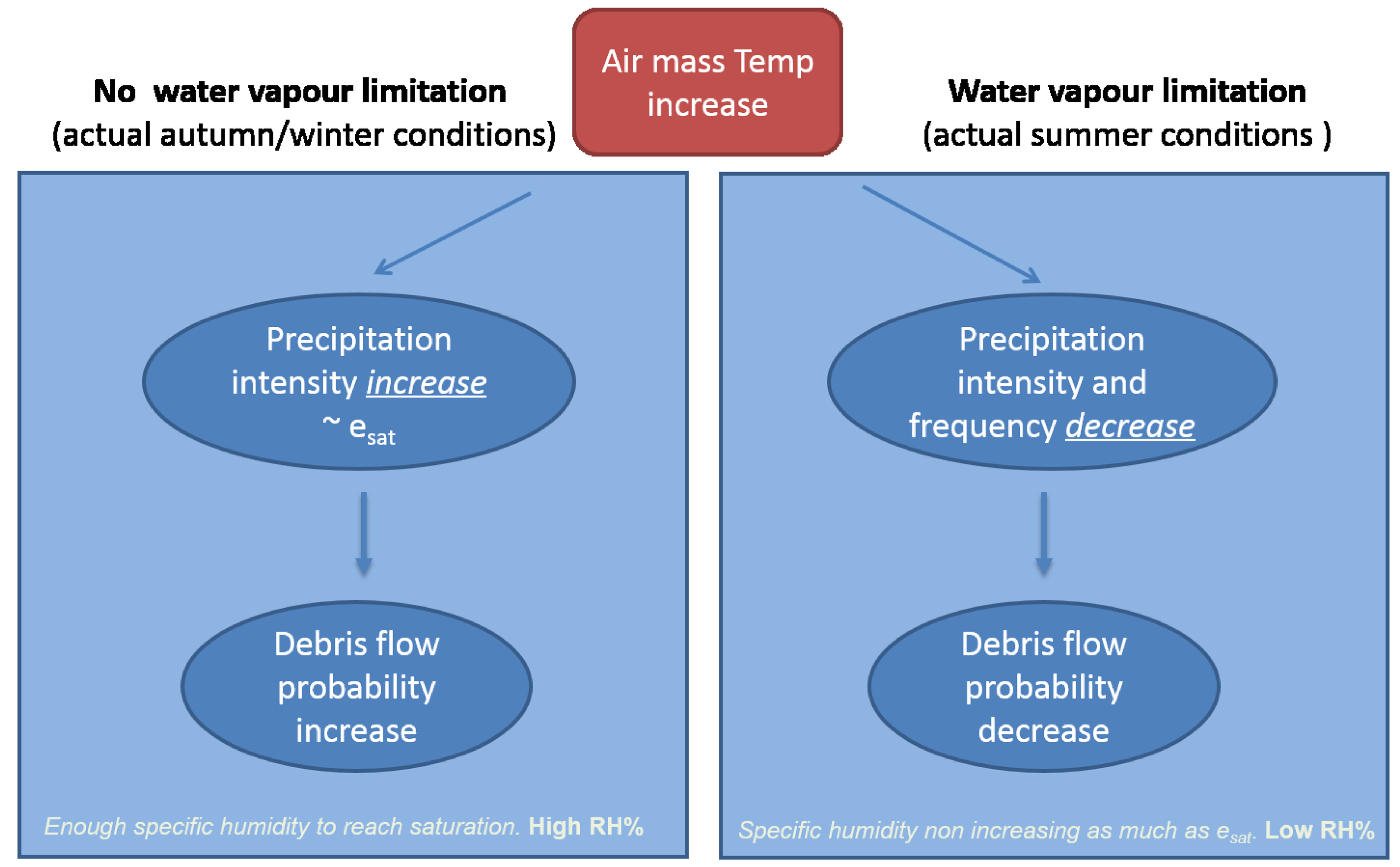


Figure 4.3 – conceptual model explaining precipitation intensity sensitivity respect to air-mass temperature increase over studied area.

Periods with powerful debris flow into Lake Moo occurred in concomitance of HTM. As air mass warms up, the (e_s) saturation vapour pressure increase, leading to higher precipitation intensities, if saturation can be reached. Precipitation type is shifting, with greater predominance towards convective events. Summer temperature now are increasing faster than other months and specific humidity increase is not compensating (limitation in evaporation) the quick rise of e_s. Condensation process, responding to threshold behaviour introduces strong asymmetries, favouring precipitation on the cooling seasons (autumn and early winter). We presume that that powerful debris flow in HTM occurred mostly due to an increase of (convective?) precipitation in Autumn and Winter, as also supported by simulation results by Tinner et al., 2013 and Skynner and Paulsen (2016). Evidences from cores show stronger debris activity during HTM compared to currents days, with vegetation coverage unchanged or even more extended during middle Holocene. This suggests that, should the temperature continue to increase, a growing high risk of debris flow in the future (mostly concentrated in autumn).