EGU2018-7047

Multidisciplinary analysis at Lake Moo site. A natural archive to gouge past and future trends in heavy rainfall events over Northern Apennines.

arpae emilia-romagna

EMILIA-ROMAGNA REGION ADMINISTRATION GEOLOGICAL SURVEY

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and with support of Ferriere municipality

Keywords: extreme precipitation, past flood events, peat bog, Holocene deposits, northern Apennines, climate change, water cycle

(1) Facts, objectives and study area identification

In the last 5 years, heavy rainfalls with secular recurrence stroke the hilly and mountainous territory of Emilia-Romagna Region (Italy). Major effects and field geomorphological evidences were observed and mapped, with a main incidence in the westernmost mountainous sector: i.e. debris flow phenomena, shallow landslides, deposits due to flash floods and overbank flooding (**Fig. 1.1**).

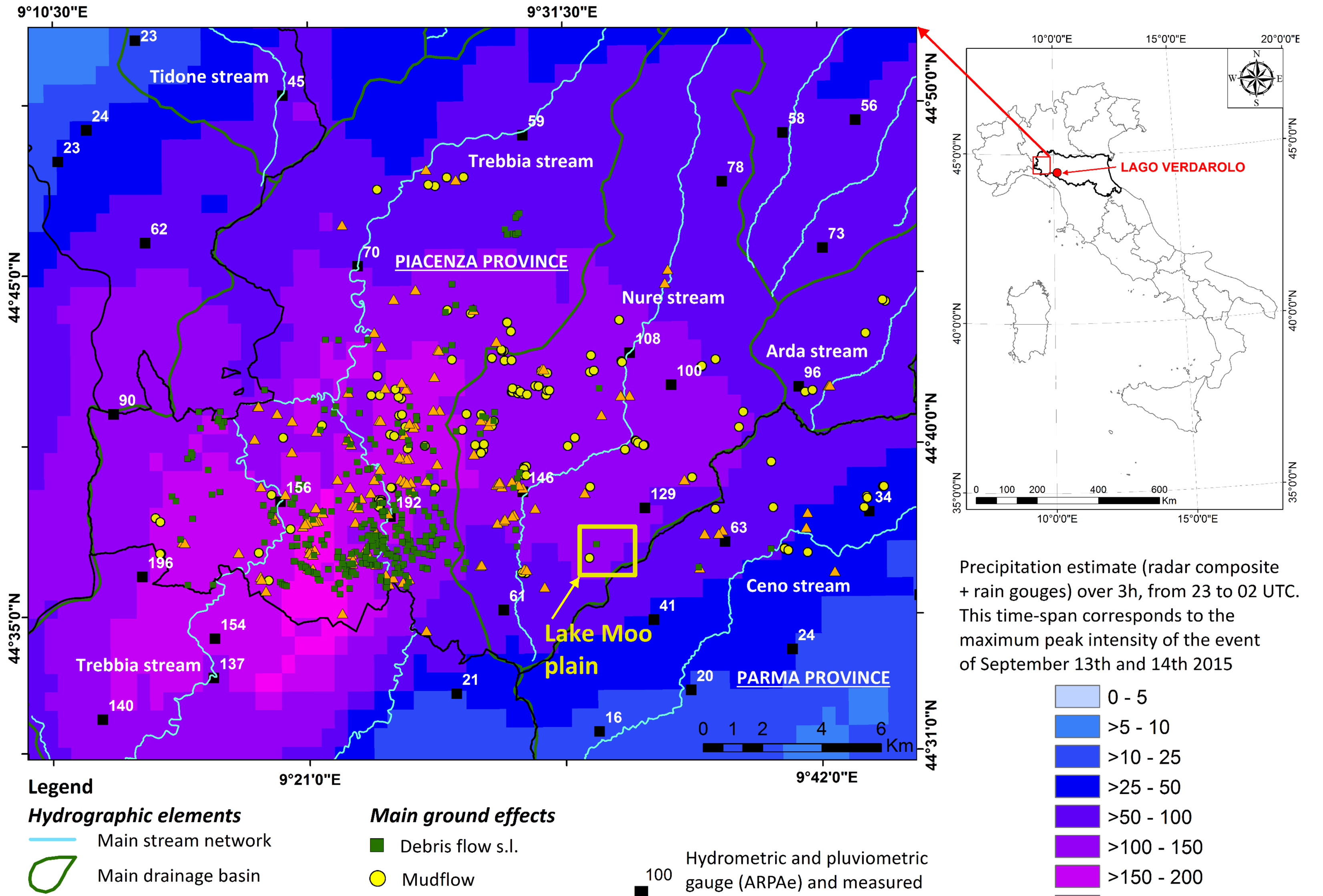

Figure 1.1

Geological, geomorphological field surveying, core drilling and open pit soil observations were carried out in an abundant Sites of Community Importance (see **Fig. 1.1** for location, white square). The study of outcropping and subsurface deposits aimed at identifying those genetically related to similar past mass-flow events. 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. (Piacenza province) and has been partially covered by a flood deposit released by the rainfall event of 09/13-14/2015 night, as documented by the figures below (**Figs. 1.2.a and 1.2.b**).

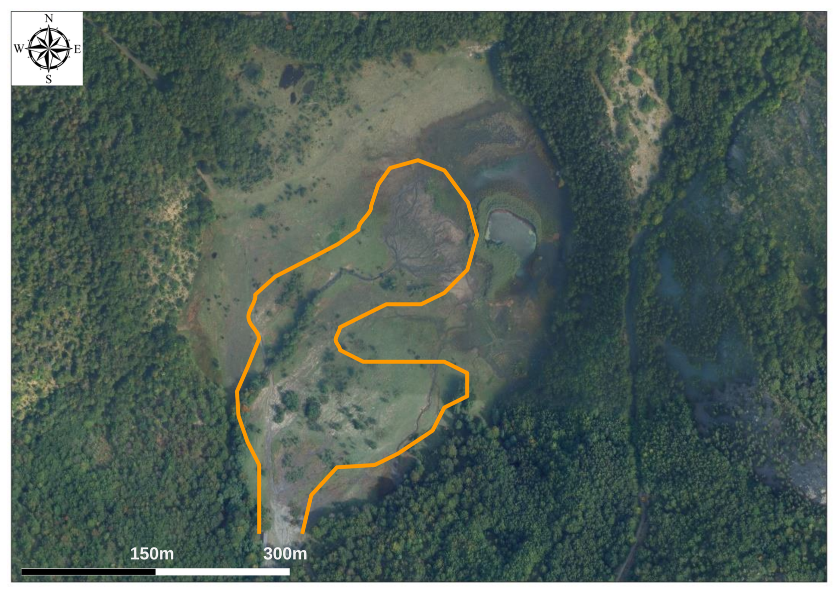

Figure 1.2a. – The Lago Moo landscape after rainfall event. The flood deposit is indicated by orange line.

Figure 1.2b - Particular of the flood deposit

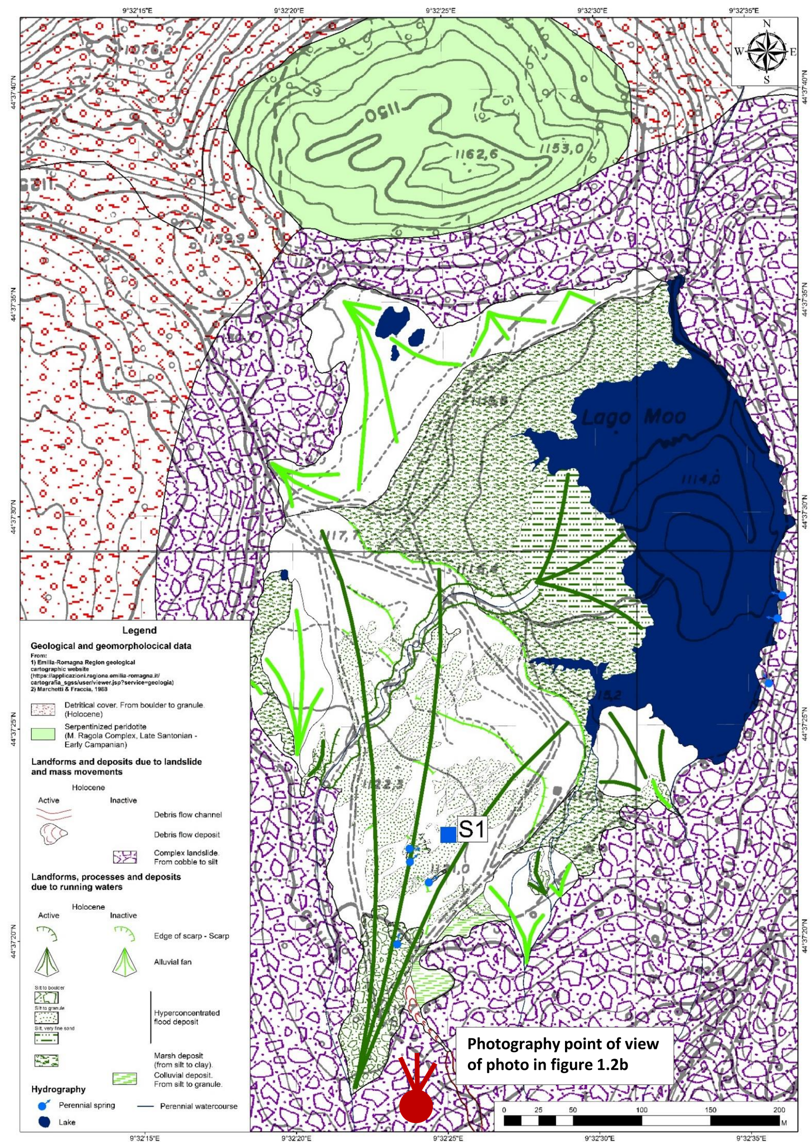

Figure 1.3 - Detailed geomorphological mapping of the flood deposit and S1 coring location.

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Acknowledgments

This research was funded by Regional Agency of Civil Protection of the Emilia-Romagna Region in the framework of cooperation agreement with ARPAE-SIMC.

(2) Linking rain intensity, temperature and water vapour

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 air masses , as observed over the Emilia-Romagna area (**Fig. 2.1**).

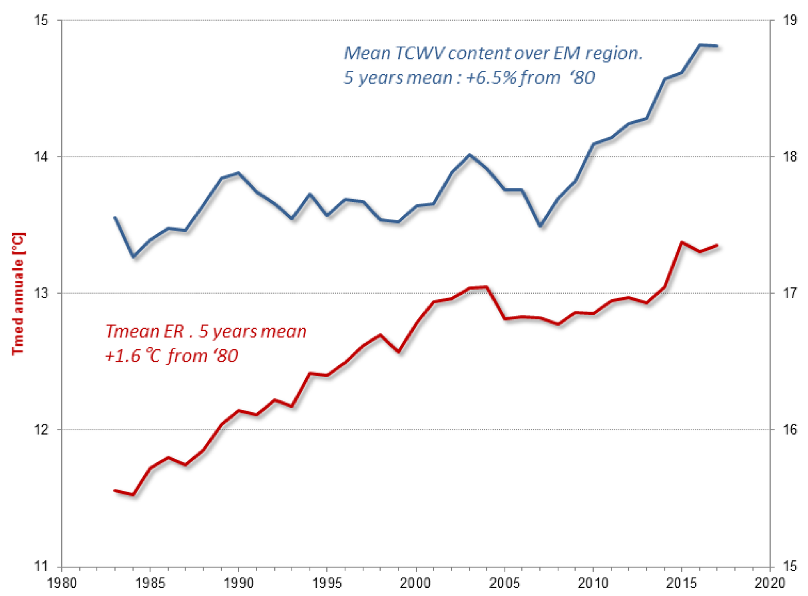


Figure 2.1 – Tmean Emilia-Romagna Region (ER) is derived from ERACLITO climate dataset (Antolini et al., 2017), Total column water vapour (TCWV) over ER is derived from ECMWF Era-Interim reanalyses .

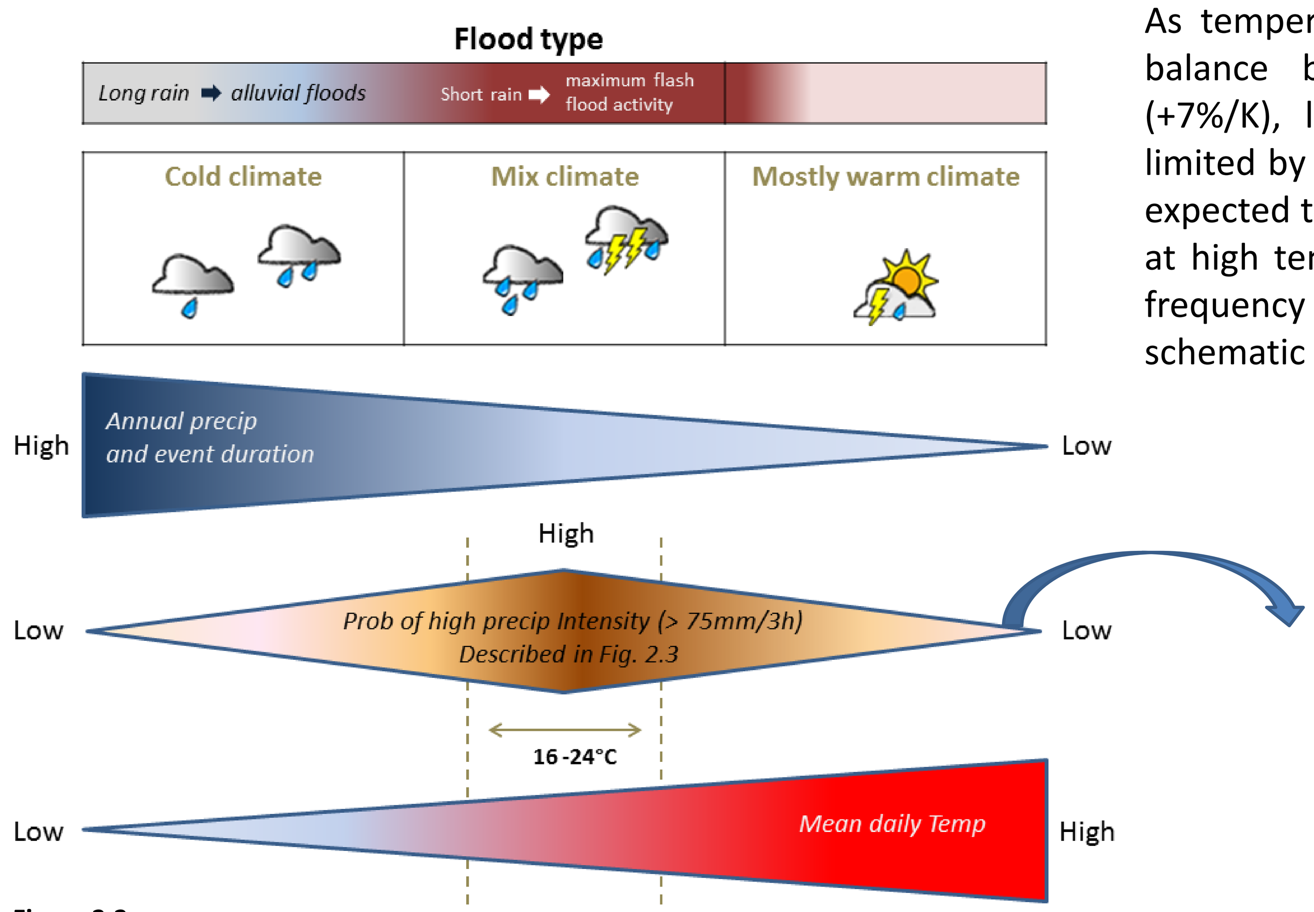


Figure 2.2

As temperature rises, climate precipitation response is governed by the balance between increasing atmospheric moisture holding capacity (+7%/K), leading to higher intensities, and actual moisture availability limited by slower evaporation increase (+2%/K). At midlatitudes, precip are expected to increase (mainly in intensity) at low temperatures and decrease at high temperatures (in summer) due to combined effect of decrease of frequency and intensity (Westra et al., 2014). See a conceptual model schematic in **Fig. 2.2** and **Fig. 2.3**.

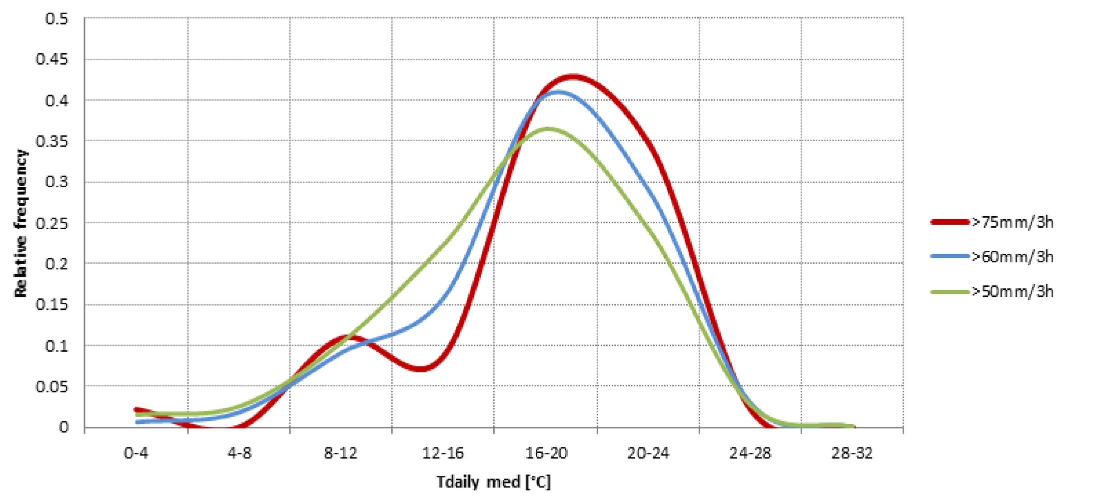
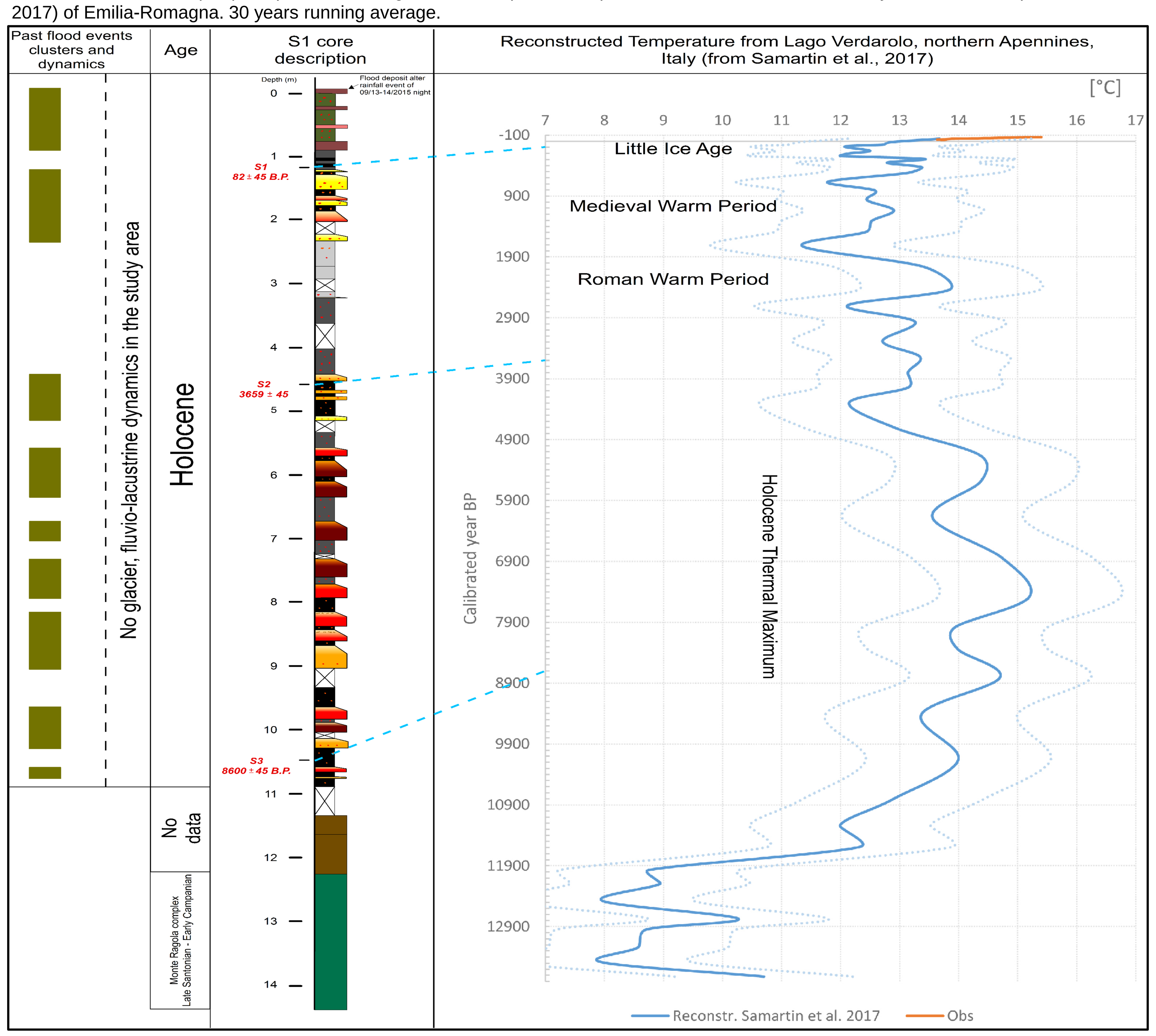


Figure 2.3. Max annual 3h precip intensity by class of daily temperature, North Apennine 1961-2015

(3) Lago Moo core, first results

The S1 core facies are synthetically described in Fig. 3.2. Different coarse-grained levels are recognized in the lower-middle/ upper part of the core. The C^{14} radicarbon dating of three levels allows a correlation with the reconstructed summer temperature at nearby Lago Verdarolo (Samartin et al., 2017). In addition, instrumental data, available since the second half of the last century, were added to the Verdarolo curve to characterize the latest years (see Obs in figure 3.1). The instrumental data present a good overlap with the latest part of Verdarolo reconstructed curve, suggesting a good accuracy of the reconstruction technique in this region. The current summer temperature values are comparable with the maximum temperature values reached during the Holocene Thermal Maximum (H.T.M.). Interestingly, during the H.T.M., we observed a maximum of hyperpicnal flows inside the lake basin of Lake Moo. In accordance with the conceptual scheme in fig2.2 and 2.3., this high fluvial activity might be consequence of an increase of convective events -with high rainfall intensities- in response of warmer temperatures recorded during the H.T.M. It follows a period of apparent inactivity of the fluvial system, until its reactivation documented in the uppermost part of the core, with the consequent disappearance of lake deposits replaced by fluvial ones. At the depth of nearly 2.5m there is an increase of coarse-grained deposits (coarsening upward). The flood deposits produced by the rainfall event of September 13th and 14th 2015 closes the sequence.

Figure 3.1 - Comparison between the Lago Moo core S1 (legend in fig. 3.2) and reconstructed Holocene summer temperature at Lago Verdarolo (1349m asl, in the Parma province, Italy) only 50Km away Lago Moo. On Verdarolo site a temperature reconstruction was produced by Samartin et al., 2017 by a fossil Chironomid midges inference.
Obs: Recent summer (JJA) temperature at Lago Verdarolo (1979-2017) from instrumental climate reanalysis ERACLITO (Antolini et al., 2017) of Emilia-Romagna. 30 years running average.



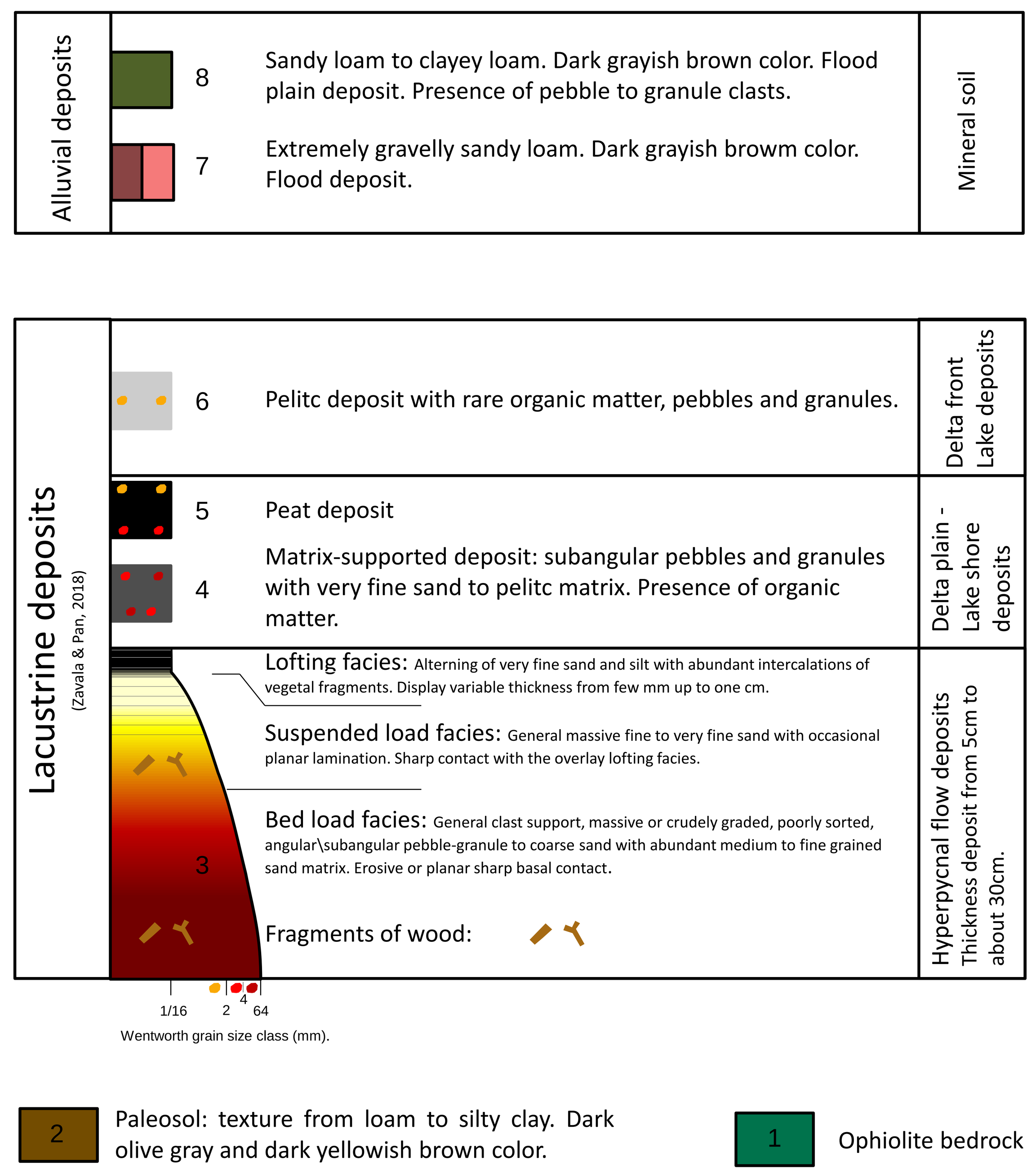


Figure 3.2 – Schematic description core facies analysis

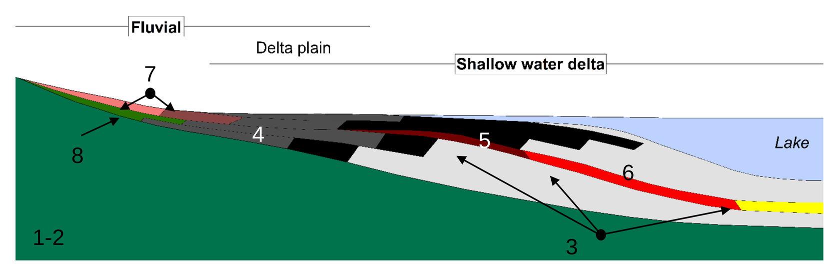


Figure 3.3 - Hypothetical reconstruction of depositional environments according to the facies recognized in the "Lake Moo" core.

Field survey photo gallery

Example of hyperpycnal flow deposit