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Supplement of

Sediment export in marly badland catchments modulated by frost-cracking intensity, Draix–Bléone Critical Zone Observatory, SE France

Coline Ariagno et al.

Correspondence to: Coline Ariagno (coline.ariagno@inrae.fr)

Supplementary Material:

Depht of probes	Full winter period used in the analysis	Aspects	Hill location	Reconstructed periods
-1	2006/2007, 2007/2008, 2008/2009, 2009/2010, 2011/2012, 2012/2013, 2013/2014, 2015/2016, 2016/2017, 2019/2020	South-facing and North-facing	Uphill and Downhill	**2011/2012 SF uphill** : 24/12 6h30 to 31/12 23h50 **2011/2012 all**: 12/03 2h20 to 26/03 12h40 **2014-2015 SF**: 7/12 11h10 to 11/12 18h30 **2015/2016 all**:4/11 18h00 to 7/11 8h40, 21/11 00h00 to 14/12 15h20, 27/12 4h00 to 29/12 18h20, 01/019h10 to 5/01 23h50
-24	2006/2007, 2007/2008, 2008/2009, 2009/2010, 2013/2014, 2014/2015, 2016/2017, 2019/2020	South-facing only	Uphill (except for 2016/2017) and Downhill	No reconstruction possible

Table S1: Information about temperature dataset available between 2006 and 2020.

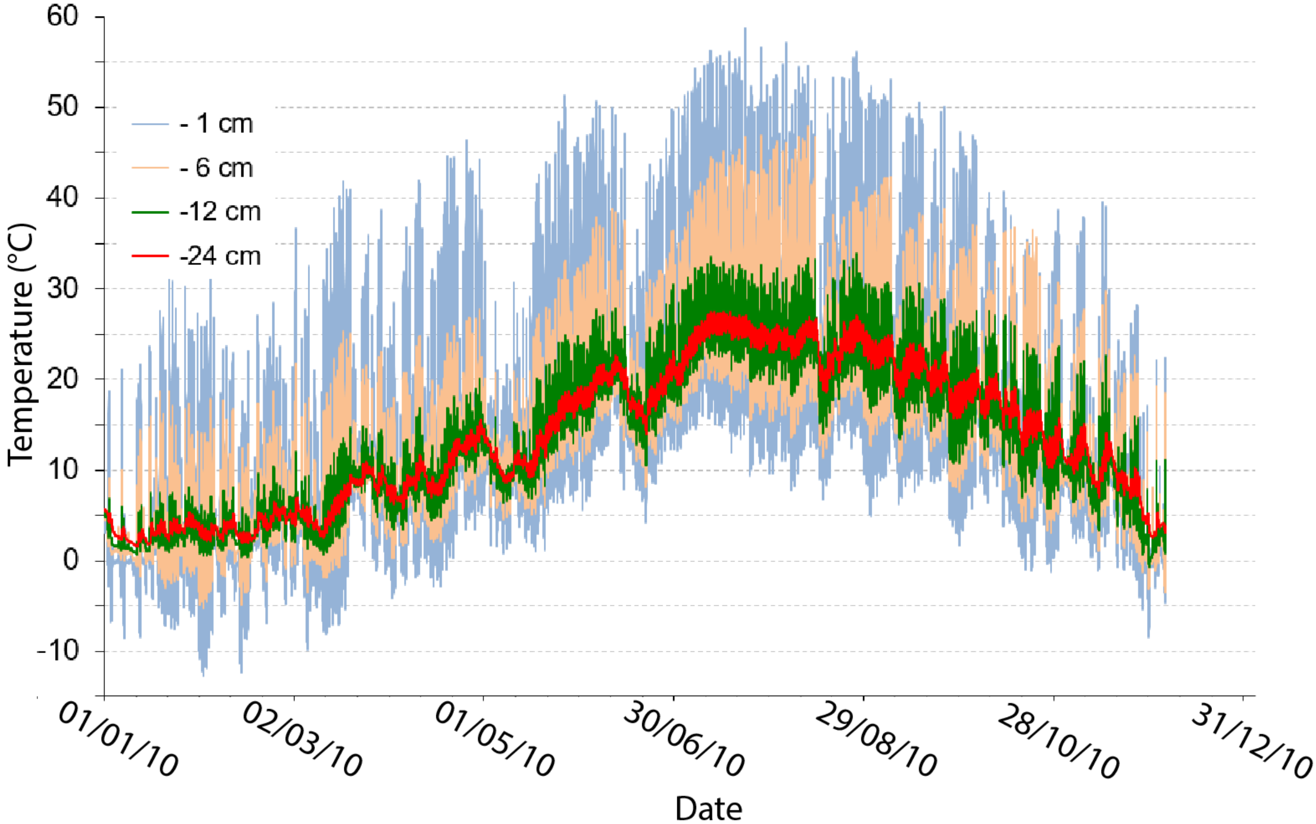

Figure S1: Annual time series of raw temperature data from four different depth probes.

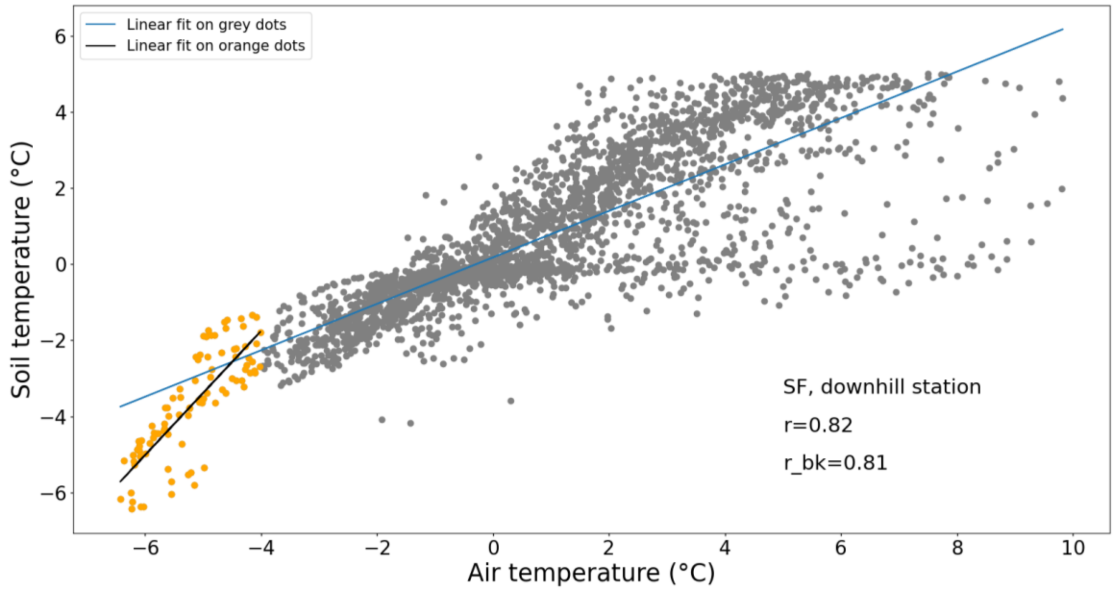

Figure S2: Correlation between soil and air temperature measurements on south-facing slope (SF) downhill station between 01/01/2014 and 31/03/2014. Since we are interested in frost weathering, temperatures were cut off at 5 °C for soil temperature and 10 °C for air temperature. We note a two-tier linear relationship between soil and air temperatures, with a steeper correlation for very low air temperatures. We therefore set a threshold for air temperature (-4°C) and regress the data above and below that threshold separately (grey / orange dots and blue / black lines, respectively; correlation coefficients r and r_bk for the higher- and lower-temperature regressions are indicated). The threshold was determined independently for every year where temperatures needed to be reconstructed. Dots aligned along 0 °C soil temperature record snow cover; Such snow-cover periods were avoided as much as possible when determining the linear regression parameters.

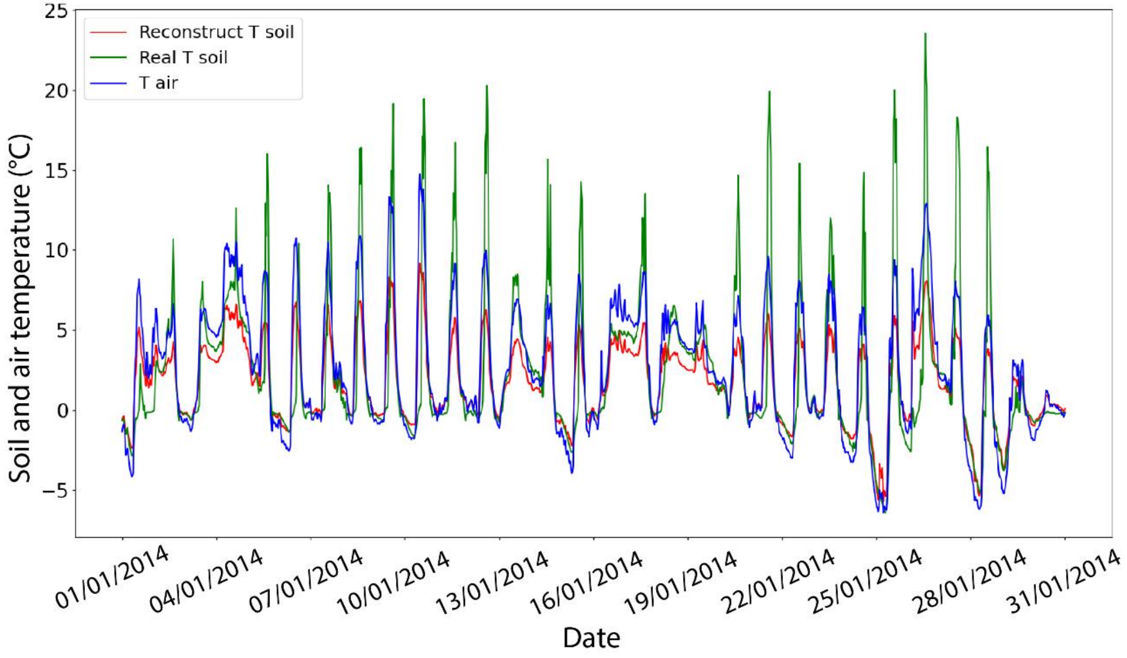

Figure S3: Comparison of measured soil temperatures (green line) and reconstructed temperatures (red line) for a complete temperature series (January 2014). Note that the model is only calibrated for soil temperatures <5 °C (Supplementary Figure 2). Air temperature is also shown (in blue).

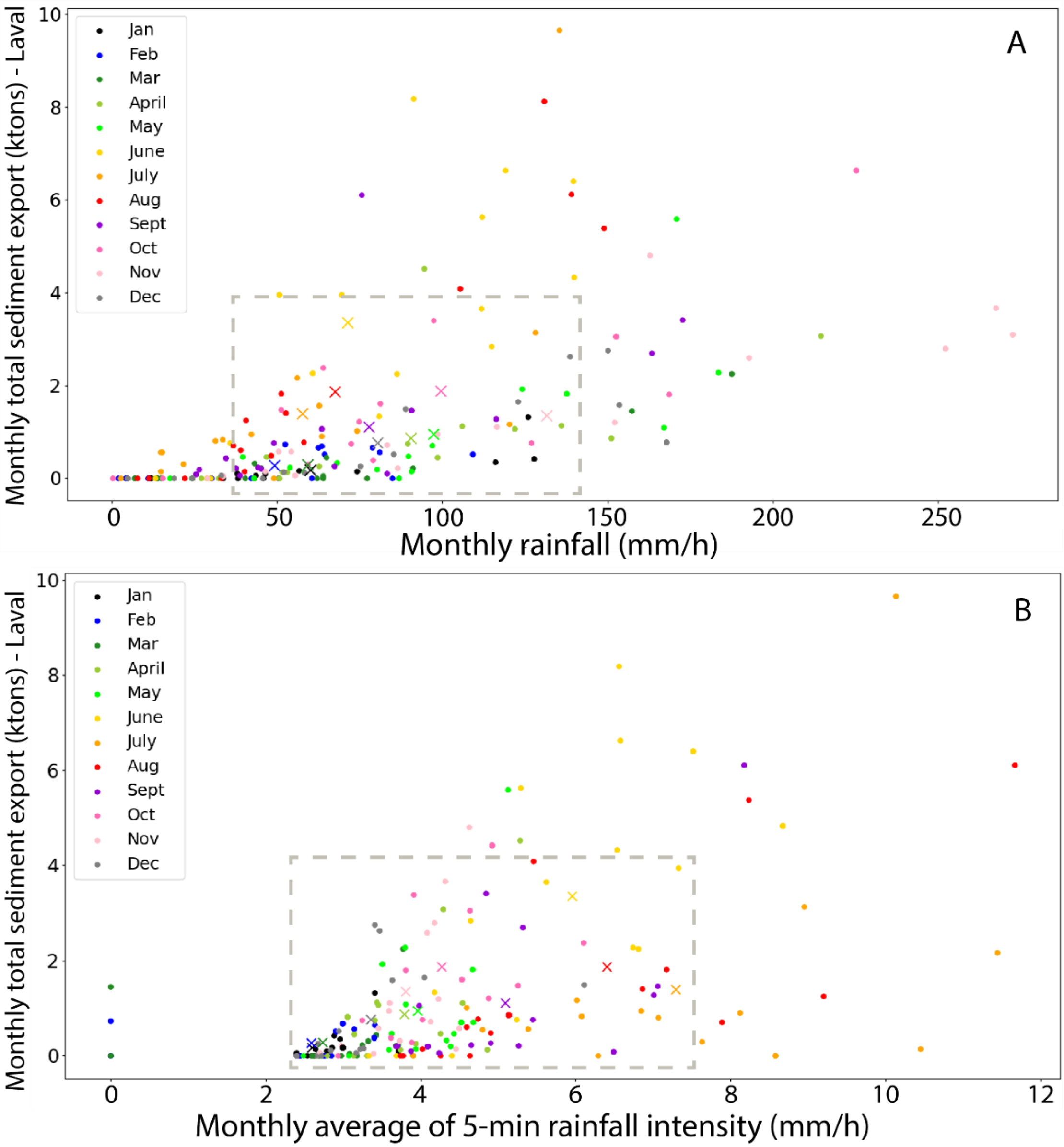

Figure S4: Monthly sediment export (ktons) from the Laval catchment versus (A) monthly rainfall between 2003 and 2020. (B) Monthly average of 5-min rainfall intensity (mm/h). Dots are individual values for each month and crosses are interannual monthly averages over the analysed period. Dashed boxes show limits of Figure 4A, B.

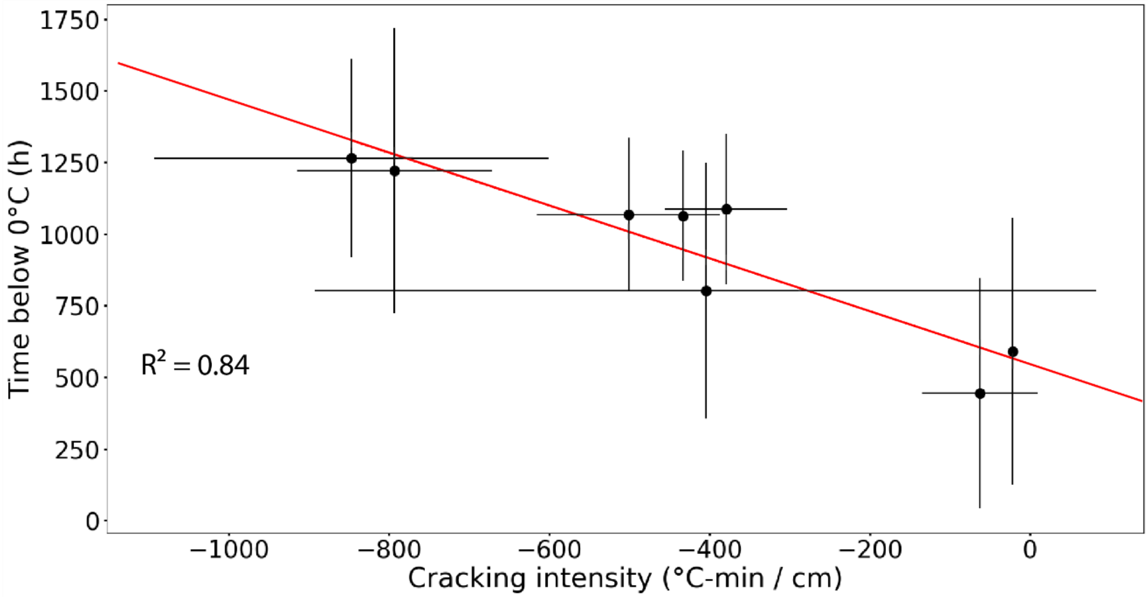

Figure S5: Regression analysis between frost-cracking intensity and the time below 0°C, the two temperature indicators that best predict the sediment export anomaly (Fig.7). Horizontal and vertical error bars refer to the difference between measurements at uphill and downhill locations (temperature measurements for 2017 and 2019 were only available for the downhill location; for these years the average difference for the other years was taken). Red line shows ordinary least-squares (OLS) linear regression giving a coefficient of determination R^2 = 0.84.

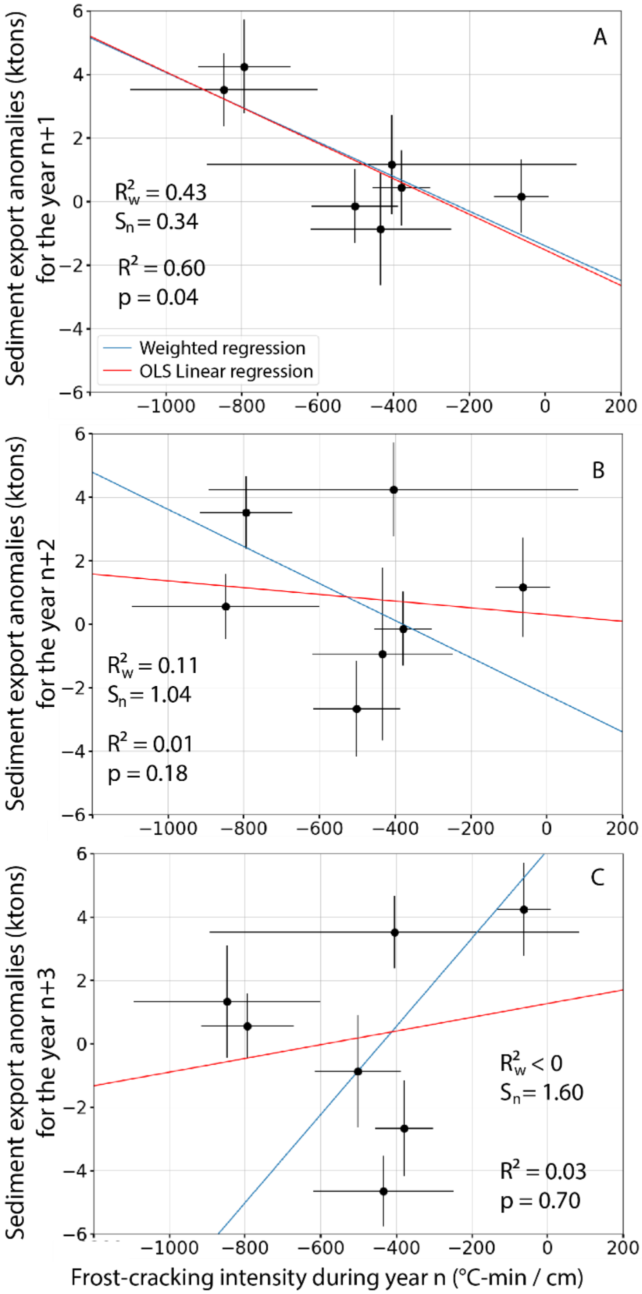

Figure S6: Regression analysis between frost-cracking intensity on the south-facing slope for the years (n =) 2007 - 2010, 2014, 2015 and 2017 and the sediment-export anomalies of A) the year n+1, B) the year n+2, C) the year n+3 (See text for explanation). Horizontal error bars refer to the difference between measurements at uphill and downhill locations (temperature measurements for 2017 were only available for the downhill location, thus uncertainty on frost-cracking intensity was computed as the average of the uncertainties from the others years); vertical error bars are ±2σ uncertainty in export anomaly. Red line shows ordinary least-squares (OLS) linear regression whereas blue line shows weighted linear regression following York et al. (2004). Weighted determination coefficients R^2_w and associated normalized goodness-of-fit indicator S_n = S / (n-2) are indicated for the weighted regression. Standard R^2 and associated p-value indicate significance of the ordinary least-squares (unweighted) regression.