

## Supplementary material

### S1. The role of rainfall seasonality on EW dynamics

As it is possible to see from Figure 5, regarding the Italian case studies, the soil is wetter and more acidic in Sicily during summer when corn is considered, since it requires to be irrigated, given the scarcity of precipitation. This provides a faster olivine dissolution in Sicily during this season. During the rest of the year, soil in the Padan plain is as wet as in Sicily, meaning that the ratio maintains values equal to about 1, leading to similar olivine dissolution dynamics. For wheat, soil moisture is higher in the Padan plain than in Sicily during summer, given the near absence of rainfall in Sicily in this period. Therefore, soil tends to be more acidic and weathering rate tends to be higher (e.g., average daily weathering rate ratio higher than 1). For the rest of the year, values of the ratio of the weathering rate between the two places, tend to be slightly less than 1, translating to similar olivine dissolution dynamics, even though more favorable in Sicily.

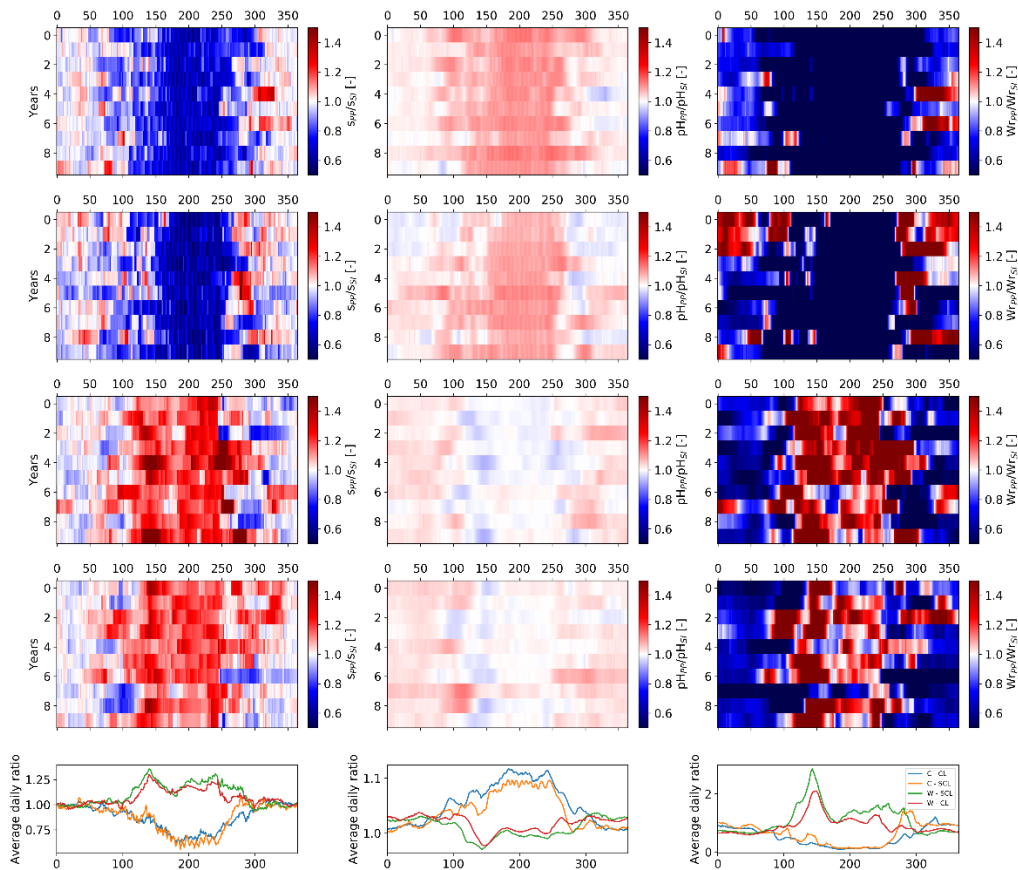


Figure S1 - Time-series heatmaps of the ratio between soil moisture, pH and weathering rate achieved in the case of the Padan plain and those related to Sicily computed within 10 years after olivine addition. These are related to corn planted in a clay loam soil (panels in the first row of the figure), corn planted in a silty clay loam soil (panels in the second row of the figure), wheat planted in a silty clay loam soil (panels in the third row of the figure) and wheat planted in a clay loam soil (panels in the fourth row of the figure). The average daily ratios of the three considered variables are shown in the last panel of the figure.

## S2. Case-study application of EW

Sicily and the Padan plain present small differences in terms of the seasonality of soil moisture, pH and, in turn, weathering rate. The highest soil moisture values for Sicily happen in the first (i.e., before Julian day 100) and the last (i.e., from Julian day 300 onwards) part of the year since, during those days, the greatest part of the total annual rainfall occurs. Soil moisture assumes low values from the Julian day 100 to about 250 mainly due to the scarcity of rainfall during the summer period. On those days where soil moisture is high, pH and weathering rate reach their minimum and maximum values, respectively, as compared to the rest of the year, confirming the fact that weathering reactions are favored by wet and acid conditions. The two Italian case studies are characterized by a higher annual average pH (7.46 in Sicily and 7.55 in the Padan plain) and lower weathering rate ( $4.79 \times 10^{-13} \text{ mol m}^{-2} \text{ s}^{-1}$  in Sicily and  $3.17 \times 10^{-13} \text{ mol m}^{-2} \text{ s}^{-1}$  in the Padan plain) respect to the two sites in the USA.

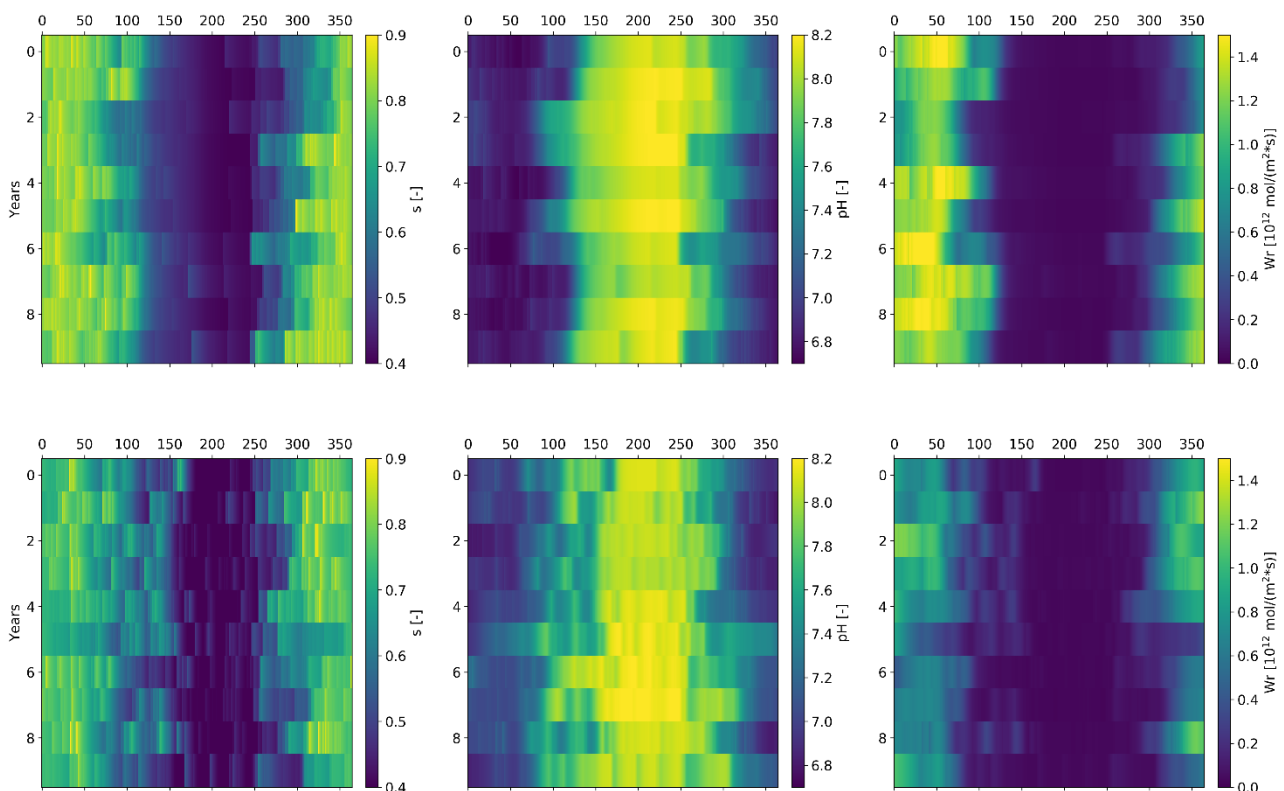


Figure S2 - Time-series heatmaps of soil moisture, pH and weathering rate computed within 10 years after olive addition. These are related to wheat planted in clay loam soil for Sicily (panels in the first row of the figure) and corn in a silty clay loam soil for the Padan plain (panels in the second row of the figure).