**Text S1.**

The following equations describe the calculation of the cover and management factor, the soil erodibility factor and the topographic factor of each water erosion equation:

The **cover and management factor** is calculated the same way for each equation:

(1)

where FRSD is the crop residue factor, FBIO is the growing biomass factor and FRUF is the soil random roughness factor, which are calculated with the following equations (Wang et al., 2011; Williams et al., 2012):

(2)

(3)

(4)

where P23 is an exponential coefficient ranging from 0.01-0.5, CVRS is the amount of above ground crop residue [t ha-1], STL is the amount of standing live biomass of the crop [t ha-1], SCRP1(23) and SCRP2(23) are coefficients defining an S-shaped growth curve used to estimate the fraction of the ground covered by the plant as a function of the Leaf Area Index, P26 is an exponential coefficient ranging from 0.01-0.2, CPHT is the crop height [m] and RR is the soil surface random roughness [mm].

The **soil erodibility factor** is calculated the same way for the USLE, AOF, MUSLE, MUST and MUSS equation using a function of sand, silt, clay and organic carbon contents in the soil:

(5)

6)

(7)

(8)

(9)

(10)

(11)

Where SAND, SILT, CLAY, and OC are the sand, silt, clay, and organic carbon contents of the soil in %. For the RUSLE and RUSLE2 method soil erodibility is calculated without the organic carbon contents of the soil using the following equation:

(12)

(13)

(14)

The **topographic factor** is calculated the same way for the USLE, AOF, MUSLE, MUST and MUSS equation using a function of slope length and slope steepness:

(15)

(16)

Where SLPL is the slope length in m, SLP is the land surface slope in m/m and XM is an exponent dependent upon slope. The topographic factor for the RUSLE method is calculated using a function of slope length and slope steepness as well:

(17)

(18)

(19)

(20)

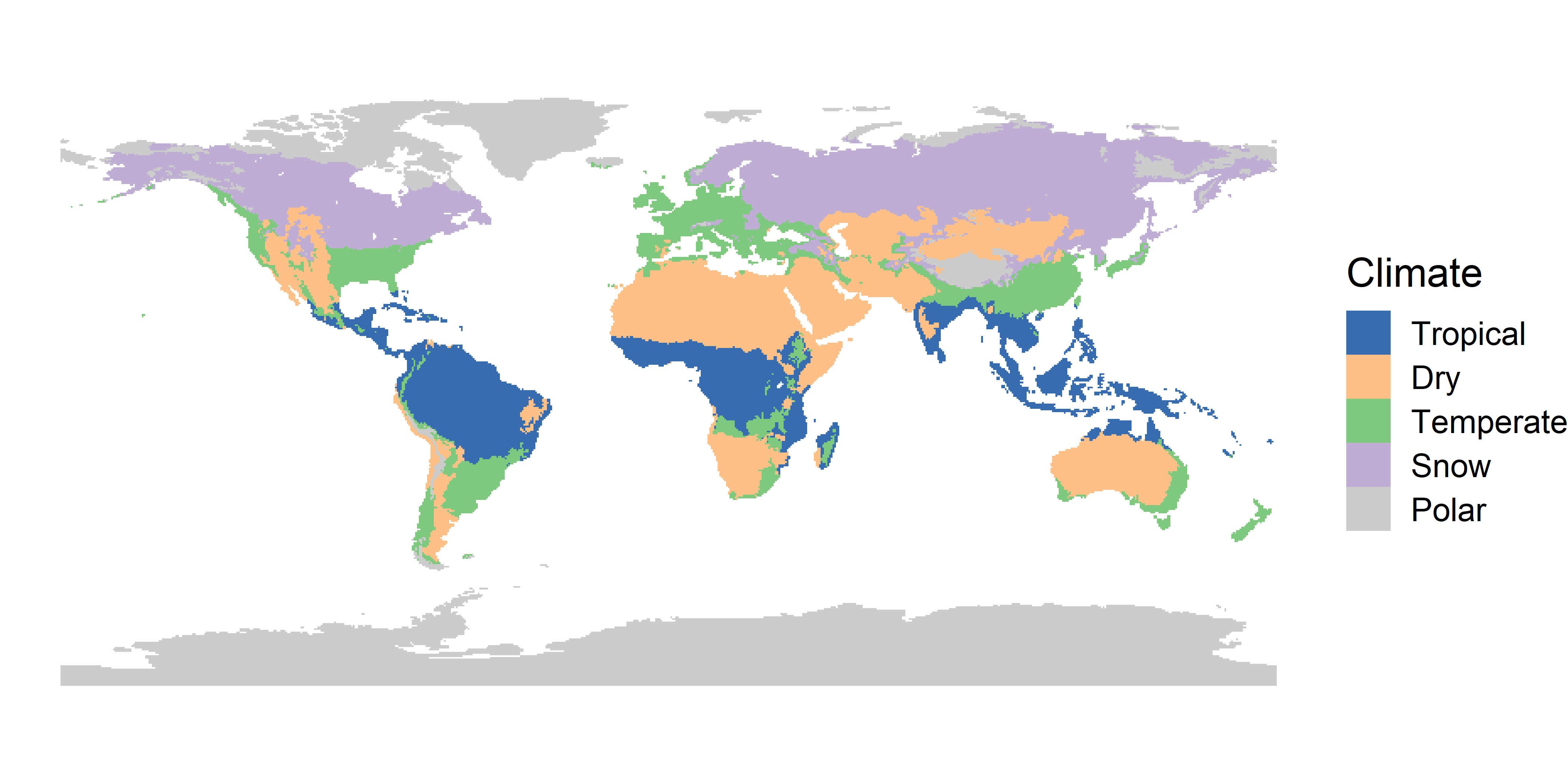
(21)

(22)

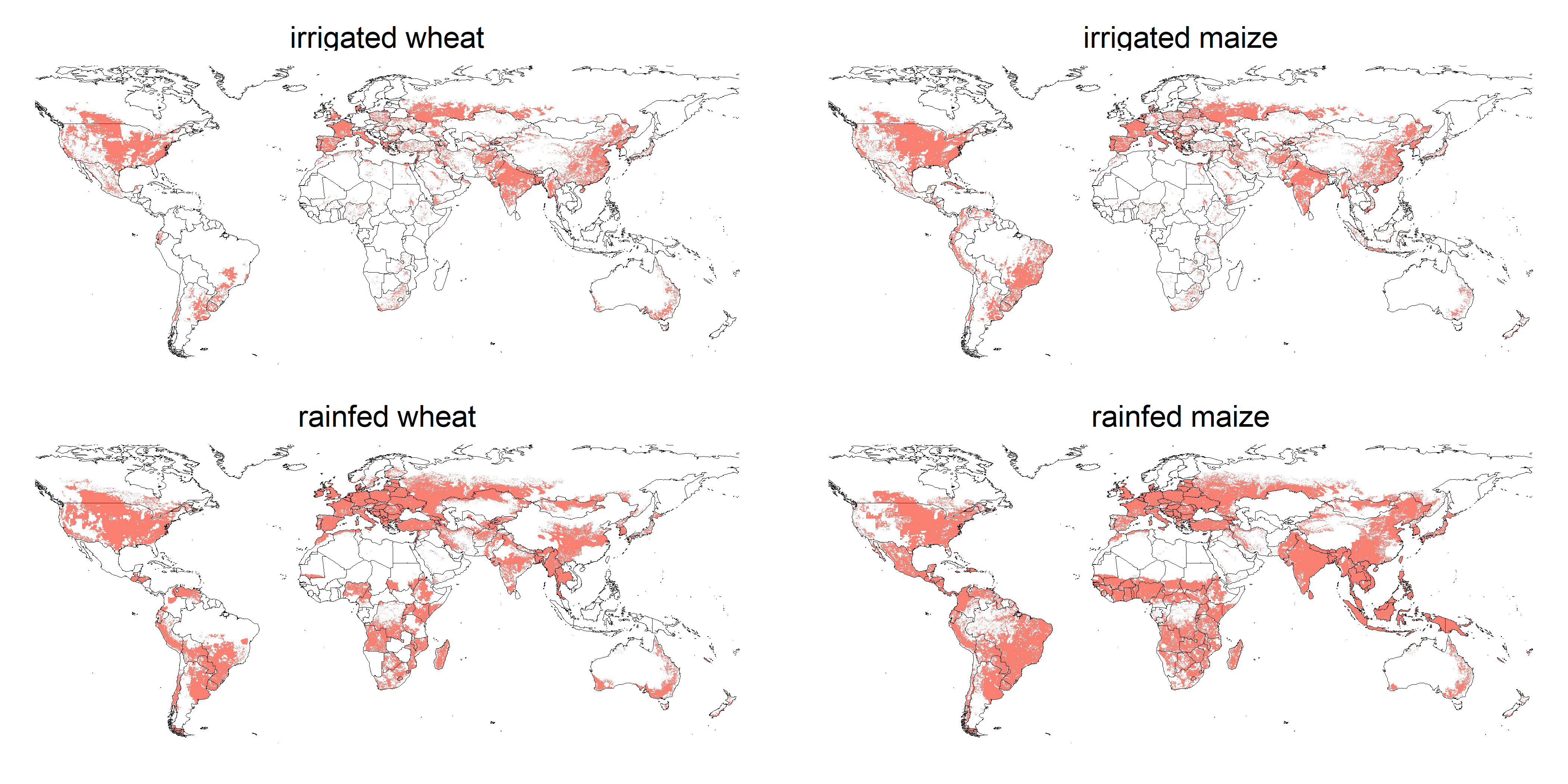
(23)

(24)

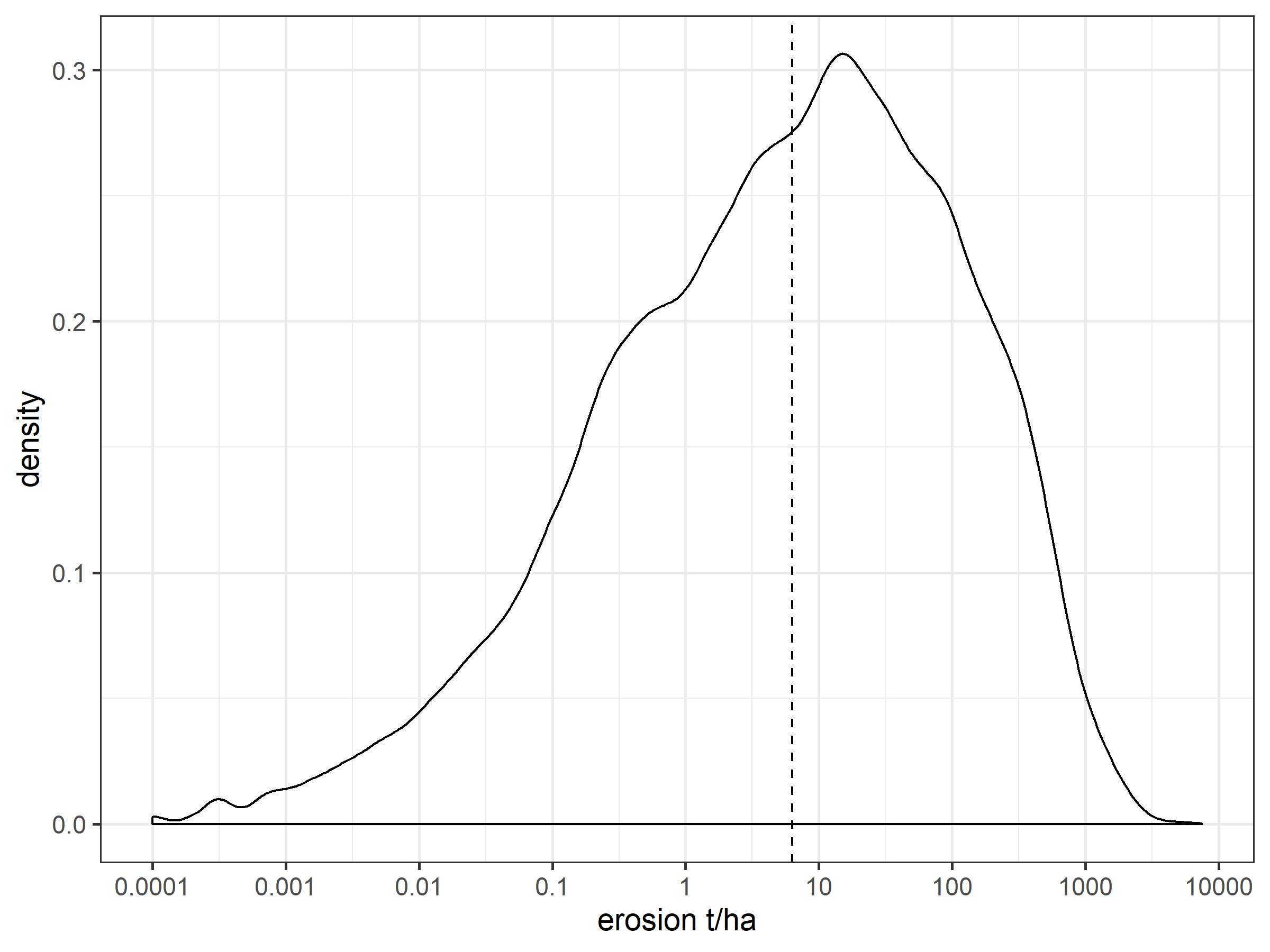
Where SLPL is slope length in m and SLP is land surface slope in m/m. The slope steepness factor RSF is adjusted for different slope steepness and slope length thresholds based on experimental data (Renard et al., 1997). The slope length factor RLF includes an exponent RXM, which is a function of the ratio B of rill erosion caused by flow and interill erosion caused by raindrop impact (USDA-ARC, 2013). B reflects how steepness affects rill erosion differently than it does interrill erosion. Rill erosion is assumed to vary linearly with steepness. The topographic factor for the RUSLE2 method is calculated the same way than for the RUSLE equation if the transport capacity determined by a function of flow rate and slope steepness exceeds sediment load. When sediment load exceeds transport capacity RUSLE2 computes deposition. Interrill erosion is assumed to occur even when RUSLE2 computes deposition, which can be calculated without a distance term as detachment is solely caused by impacting raindrops (USDA-ARC, 2013). Therefore, the slope length factor is not considered in the RUSLE2 equation when deposition occurs.



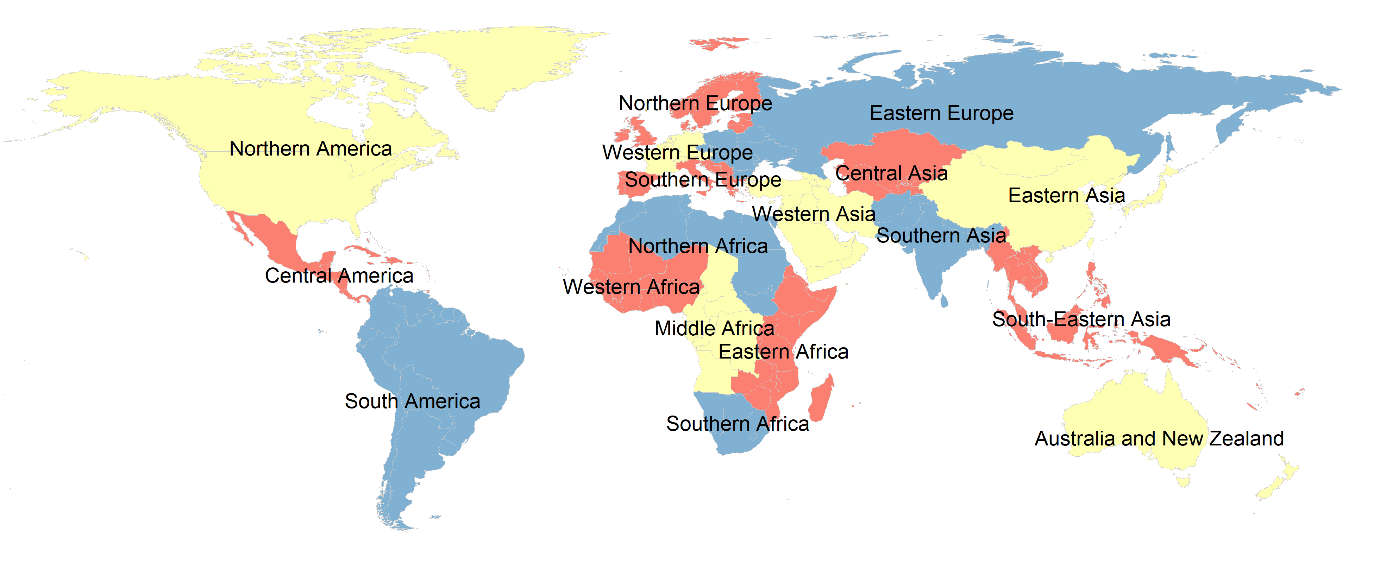
**Figure S1**. Main climate zones using the updated Koeppen-Geiger climate classification (Peel et al., 2007).



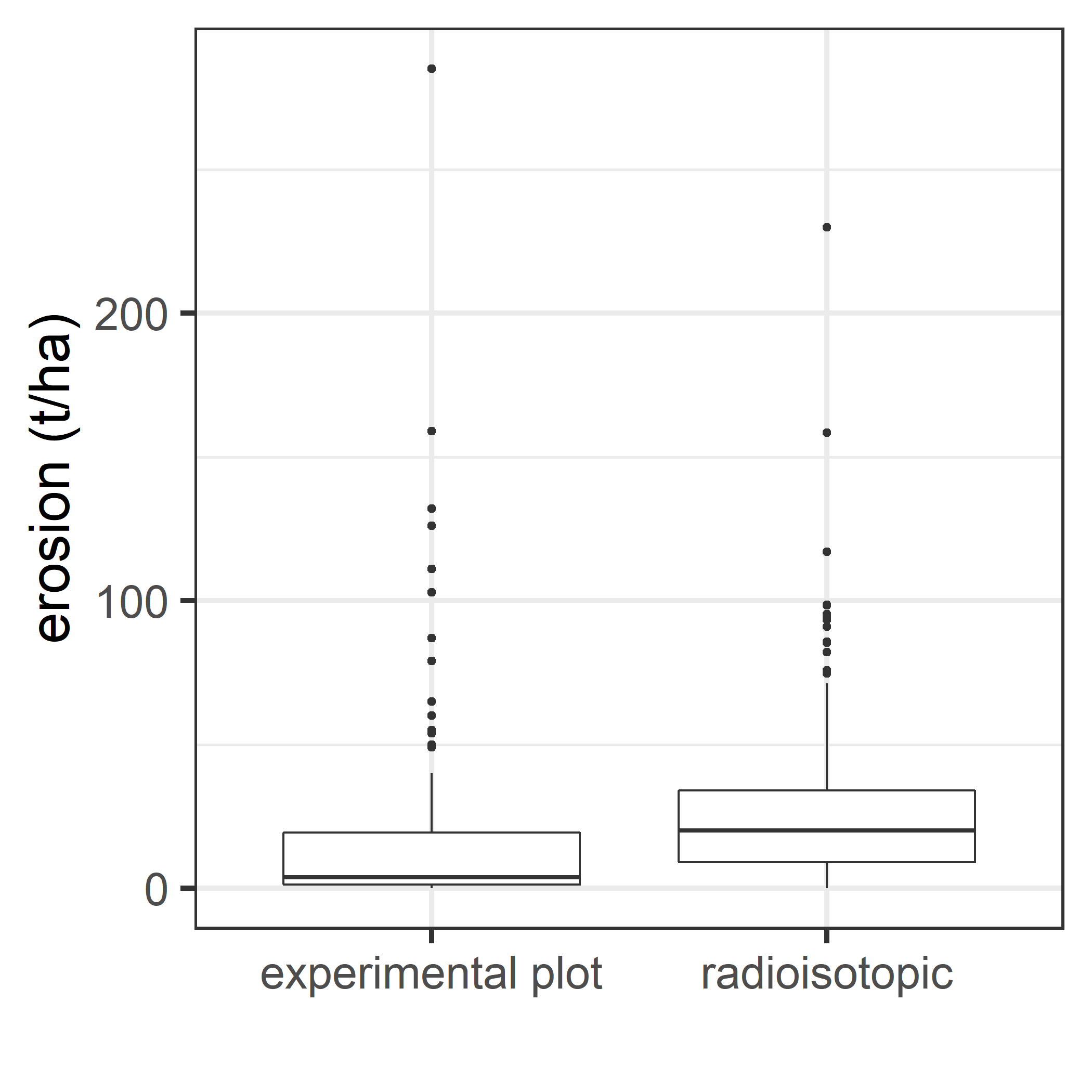
**Figure S2**. Grids with irrigated and rainfed wheat and maize cultivation around the year 2000 (Portmann et al., 2010).



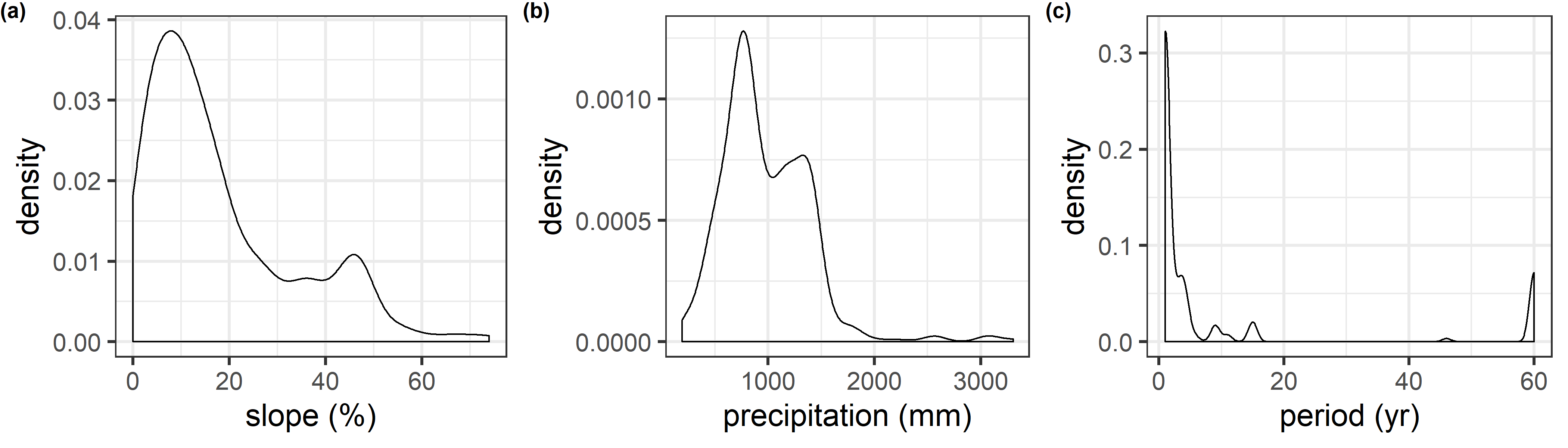
**Figure S3**. Distribution of average water erosion values from 1980 – 2010 simulated with the baseline scenario and weighted for each simulation grid. The dashed vertical line illustrates the median of the distribution, which represents global median water erosion of 6 t ha-1 a-1. Average water erosion at each grid and the global average water erosion of 19 t ha-1 a-1 has been calculated as a weighted average based on the distribution of irrigated and rainfed maize and wheat acreage (Portmann et al., 2010).



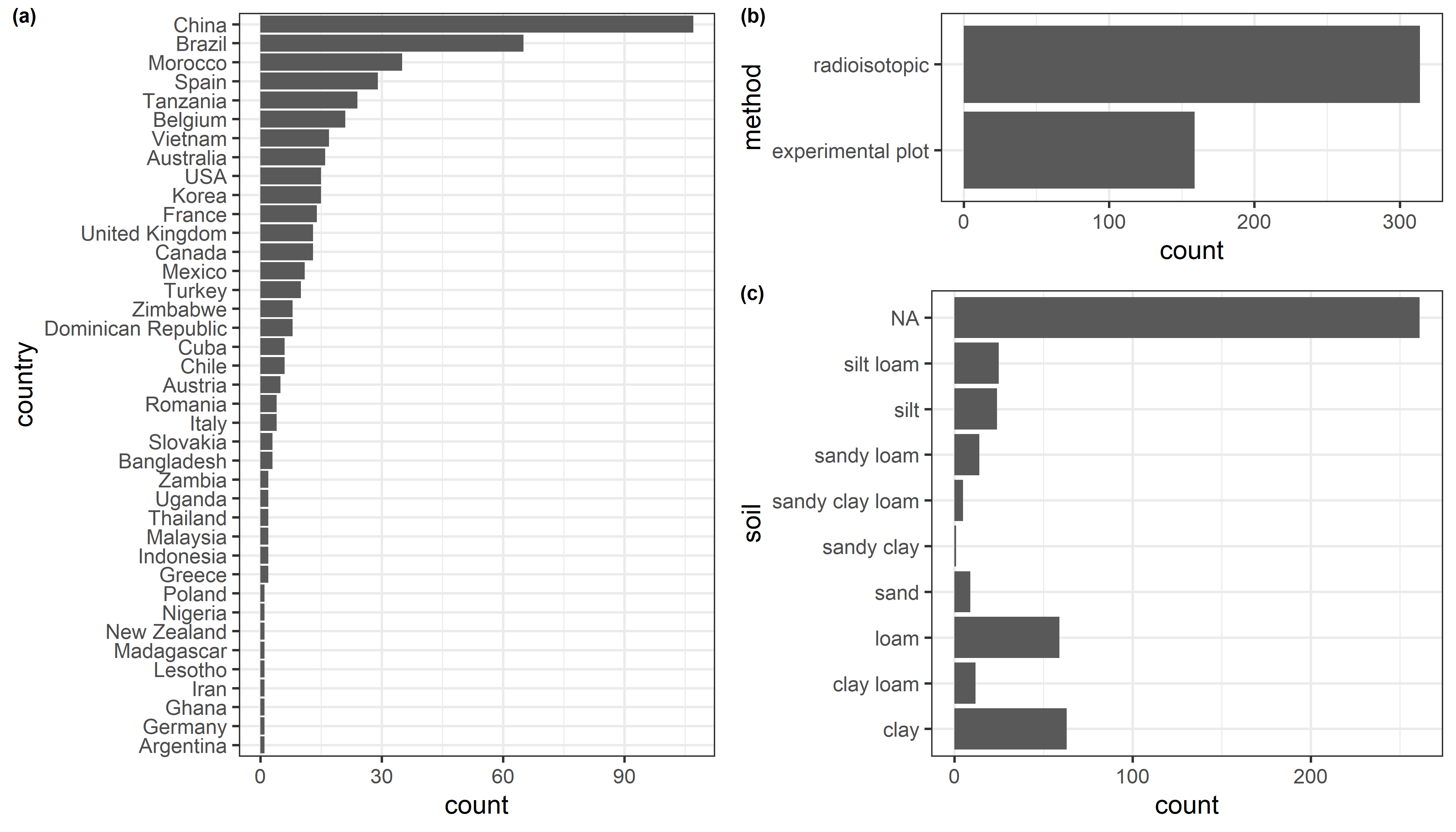
**Figure S4**. World regions classified using the United Nations geoscheme with minor modifications (UN, 1999): Melanesia has been added to South-Eastern Asia and Caribbean has been added to Central America.



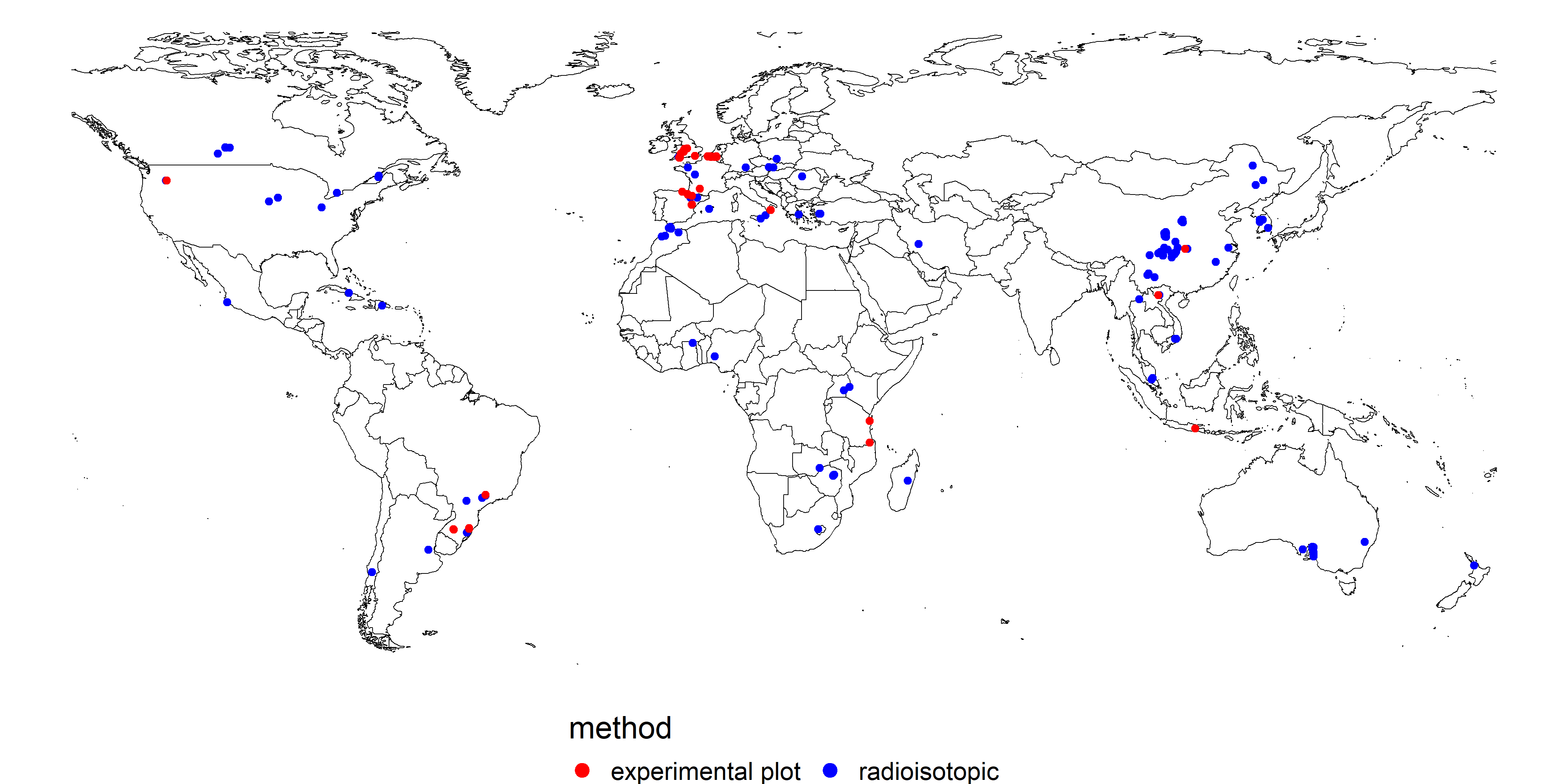
**Figure S5**. Distribution of erosion (t ha-1) values measured in agricultural fields using plot experiments (n = 159, Mean = 17 t ha-1; Median = 4 t ha-1) and the 137Cs method (n = 314, Mean = 26 t ha-1; Median = 20 t ha-1).



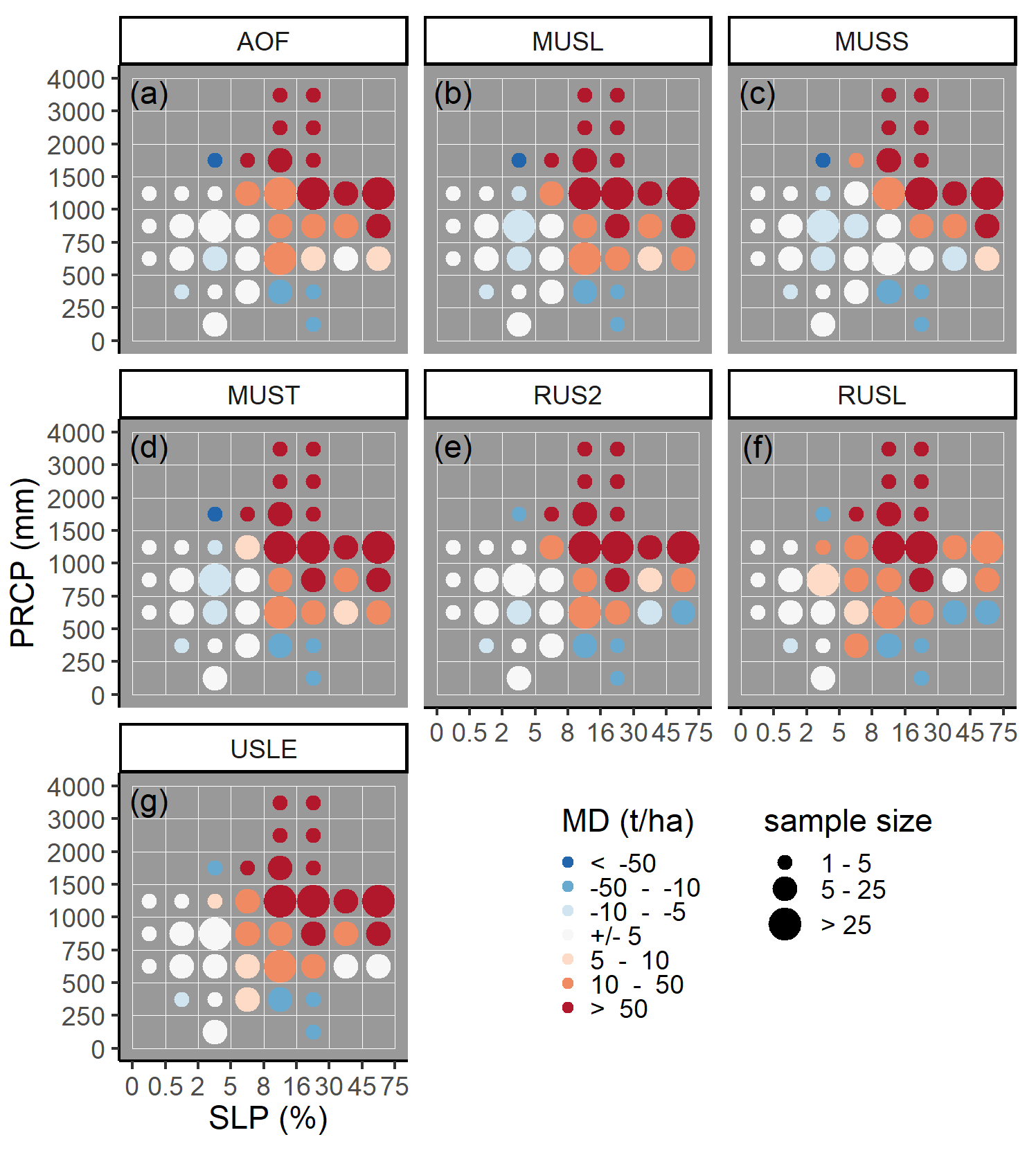
**Figure S6**. (a) Distribution of slope steepness (%) records for measured erosion values (n = 473; Mean = 18.3 %; Median = 13 %). (b) Distribution of annual precipitation (mm) records for measured erosion values (n = 473; Mean = 974 mm; Median = 872 mm). (c) Distribution of recorded measurement periods for soil loss experiments excluding radioisotopic methods (n = 159; Mean = 10 a; Median = 1 a).



**Figure S7**. (a) Number of measured water erosion records (n=473) per country (n=39). (b) Methods used to measure water erosion in agricultural fields (n=473). (c) Soil texture recorded at sites of water erosion measurement (n = 473).



**Figure S8.** Locations of water erosion field data from cropland where coordinates were recorded (n=468).



**Figure S9**. Median deviation (MD) in t ha-1 between measured and simulated water erosion using the baseline scenario with different water erosion equations. Measured and simulated medians were calculated for different slope and precipitation classes.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Dominant slope class | Lower value (%) | Upper value (%) | Mid value (%) | Slope length (m) | Field size (ha) |
| 1 | 0 | 0.5 | 0.25 | 200 | 10 |
| 2 | 0.5 | 2 | 1.25 | 200 | 10 |
| 3 | 2 | 5 | 3.5 | 200 | 10 |
| 4 | 5 | 8 | 6.5 | 200 | 10 |
| 5 | 8 | 16 | 12 | 100 | 5 |
| 6 | 16 | 30 | 18 | 75 | 5 |
| 7 | 30 | 45 | 35.5 | 50 | 1 |
| 8 | 45 | 100 | 60 | 20 | 1 |

**Table S1**. A set of rules for field size and slope length estimation for each dominant slope class. The area/dominant slope class was assigned to each grid from a global slope and terrain dataset (Fisher et al., 2007) providing 3 arc-sec spatial resolution distributions of nine slope gradient classes: 0–0.5%, 0.5–2%, 2–5%, 5–8%, 8–16%, 16–30%, 30–45%, and > 45% interpreted from SRTM elevation data (CGIAR-CSI, 2006). Mid-interval value of the dominant slope class was used as an input for EPIC.

**Table S2**. Input parameters for the sensitivity analysis of the water erosion equations. Random values assigned to each input parameter in the sensitivity analysis are defined by a range of discrete values or a triangular distribution defined by the values given in the table.

**Table S3**. First- and total-order sensitivity indices (SI) ranking for 30 input parameters for each water erosion equation.

**Table S4**. Spearman coefficients explaining the positive or negative correlation between the first- and total-order sensitivity indices of the input parameters from each equation and the amount of annual rainfall at a location.

**Table S5**. Measured water erosion values collected from 101 studies. The reference list of each study is available at TWCarr-si02.docx.