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Global estimation of post-fire soil erosion

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Supplementary Information for “Global estimation of post fire soil erosion”

Contents

1. Result by Country

To provide post-fire soil erosion results in a higher resolution, but still identifying relevant thresholds for land management decisions, the mean post-fire soil erosion rate estimated for the first year following the fire for each country was plotted in a global figure (Fig. 1), whereas these values can be also consulted by individual countries (Table 1).

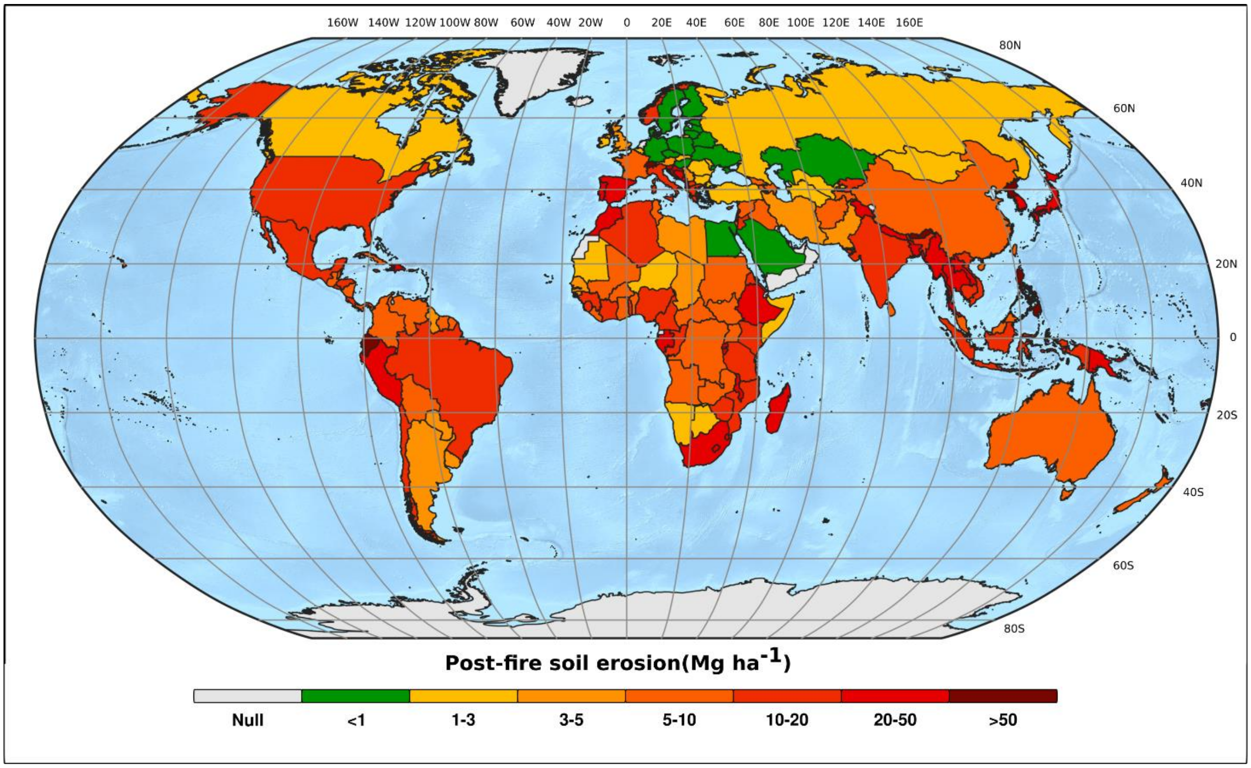

*Fig. 1 - **Mean annual post-fire soil erosion estimates for the first post-fire year for countries affected for at least 6 fire years.** Soil erosion rates are categorized into seven classes based on the European Soil Bureau classification and the Global Soil Erosion Modelling Framework (GloSEM)[1]. The basemap used in this study was provided by European Commission, Eurostat (ESTAT), GISCO, Countries 2020 and Natural Earth: Free vector and raster map data from naturalearthdata.com. (Projected Coordinate System: Sphere Robinson).*

*Table 1- **Mean annual post-fire soil erosion estimates for the first post-fire year for countries affected for at least 6 fire years.***

Continent	Country	Post-fire soil erosion	Continent	Country	Post-fire soil erosion
		$Mg\ ha^{-1}$			$Mg\ ha^{-1}$
Africa	Algeria	14.87	Africa	Mali	7.44
Africa	Angola	6.68	Africa	Mauritania	1.56
Africa	Benin	9.56	Africa	Mauritius	22.78
Africa	Botswana	1.48	Africa	Morocco	25.85
Africa	Burkina Faso	5.82	Africa	Mozambique	11.39
Africa	Burundi	31.19	Africa	Namibia	1.97
Africa	Côte d'Ivoire	11.62	Africa	Niger	2.48
Africa	Cameroon	19.87	Africa	Nigeria	10.36
Africa	Central African Republic	6.33	Africa	Rwanda	25.26
Africa	Chad	3.96	Africa	Senegal	4.43
Africa	Comoros	96.76	Africa	Sierra Leone	14.26
Africa	Congo	14.79	Africa	Somalia	1.40
Africa	Democratic Republic of The Congo	9.86	Africa	South Africa	27.09
Africa	Egypt	0.03	Africa	South Sudan	6.18
Africa	Eritrea	14.17	Africa	Sudan	5.11
Africa	Eswatini	36.68	Africa	Togo	17.92
Africa	Ethiopia	31.71	Africa	Tunisia	9.99
Africa	Gabon	22.41	Africa	Uganda	9.81
Africa	Gambia	3.47	Africa	United Republic of Tanzania	13.14
Africa	Ghana	9.57	Africa	Zambia	7.41
Africa	Guinea	15.82	Africa	Zimbabwe	16.91
Africa	Guinea-Bissau	4.45	Asia	Afghanistan	6.77
Africa	Kenya	12.71	Asia	Armenia	9.94
Africa	Lesotho	39.71	Asia	Azerbaijan	5.81
Africa	Liberia	7.944	Asia	Bangladesh	39.03
Africa	Libya	4.50	Asia	Bhutan	185.40
Africa	Madagascar	43.89	Asia	Brunei	6.17
Africa	Malawi	25.39	Asia	Cambodia	12.20

*Table 1 (Continuation) - **Mean annual post-fire soil erosion estimates for the first post-fire year for countries affected for at least 6 fire years.***

Continent	Country	Post-fire soil erosion	Continent	Country	Post-fire soil erosion
		Mg ha^{-1}			Mg ha^{-1}
Asia	China	9.55	Asia	Turkey	2.44
Asia	Cyprus	6.78	Asia	Turkmenistan	2.51
Asia	Georgia	8.95	Asia	Uzbekistan	1.17
Asia	India	13.49	Asia	Vietnam	19.54
Asia	Indonesia	13.91	Europe	Albania	62.56
Asia	Iran	3.02	Europe	Austria	3.14
Asia	Iraq	7.37	Europe	Belarus	0.33
Asia	Israel	6.08	Europe	Belgium	1.20
Asia	Japan	41.80	Europe	Bosnia and Herzegovina	24.01
Asia	Jordan	11.88	Europe	Bulgaria	2.02
Asia	Kazakhstan	0.57	Europe	Croatia	21.28
Asia	Kyrgyzstan	13.16	Europe	Czechia	0.87
Asia	Laos	20.68	Europe	Denmark	0.37
Asia	Lebanon	32.92	Europe	Estonia	0.27
Asia	Malaysia	7.95	Europe	Finland	0.24
Asia	Mongolia	2.58	Europe	France	9.957
Asia	Myanmar/Burma	44.82	Europe	Germany	0.84
Asia	Nepal	47.17	Europe	Greece	12.30
Asia	North Korea	52.001	Europe	Hungary	0.71
Asia	Pakistan	4.86	Europe	Ireland	2.71
Asia	Palestine	3.31	Europe	Italy	13.63
Asia	Philippines	57.71	Europe	Latvia	0.31
Asia	Saudi Arabia	0.43	Europe	Lithuania	0.31
Asia	South Korea	33.22	Europe	Moldova	1.63
Asia	Sri Lanka	5.69	Europe	Montenegro	48.37
Asia	Syria	7.55	Europe	North Macedonia	10.35
Asia	Tajikistan	8.46	Europe	Norway	15.10
Asia	Thailand	25.24	Europe	Poland	0.45

*Table 1 (Continuation - **Mean annual post-fire soil erosion estimates for the first post-fire year for countries affected for at least 6 fire years.***

Continent	Country	Post-fire soil erosion	Continent	Country	Post-fire soil erosion
		Mg ha^{-1} y^{-1}			Mg ha^{-1} y^{-1}
Europe	Portugal	21.77	North America	United States	11.21
Europe	Romania	1.10	Oceania	Australia	8.07
Europe	Russian Federation	2.01	Oceania	Fiji	83.70
Europe	Serbia	3.04	Oceania	New Caledonia	52.94
Europe	Slovakia	1.22	Oceania	New Zealand	6.14
Europe	Slovenia	27.01	Oceania	Papua New Guinea	29.40
Europe	Spain	21.52	South America	Argentina	4.87
Europe	Sweden	0.34	South America	Bolivia	6.73
Europe	Switzerland	53.60	South America	Brazil	14.21
Europe	Ukraine	0.86	South America	Chile	18.122
Europe	United Kingdom	4.89	South America	Colombia	8.72
North America	Bahamas	7.09	South America	Ecuador	50.14
North America	Barbados	3.945	South America	Guyana	3.52
North America	Belize	9.20	South America	Paraguay	4.90
North America	Canada	2.74	South America	Peru	28.68
North America	Costa Rica	13.10	South America	Suriname	7.36
North America	Cuba	7.13	South America	Uruguay	4.45
North America	Dominican Republic	30.24	South America	Venezuela	9.08
North America	El Salvador	17.29	Other	Abyei	2.36
North America	Guatemala	5.43	Other	Arunachal Pradesh	72.85
North America	Haiti	89.11	Other	Ilemi Triangle	7.91
North America	Honduras	11.69	Other	Jammu Kashmir	32.27
North America	Jamaica	14.58	Other	Timor-Leste	122.51
North America	Mexico	19.06			
North America	Nicaragua	9.30			
North America	Panama	8.53			
North America	Puerto Rico	25.05			
North America	Trinidad and Tobago	8.65			

2. Comparison with Field Measurements

Data previously compiled and harmonized under the study "Effectiveness of post-fire soil erosion mitigation treatments: A systematic review and meta-analysis"[2], was used with some minor updates (Table 2). To compare RUSLE estimates with field data, only control plots were used (i.e. plot data without mitigation measures), summing up to a total of 516 observations under burned, and 9 observations under unburned conditions. Observations correspond to a single plot erosion result, or the average erosion from a series of replicates under the same field conditions. Error bars describing standard deviation of measurements were included whenever available.

Should be highlighted that this database has a strong bias towards field studies that included the assessment of mitigation measures after fire and therefore might not represent the entire universe of post-fire soil erosion values measured in situ. Moreover, despite harmonization, data comparison should be taken with care since measurements were retrieved trough different methodologies and scales, while local climate conditions and the history of disturbances of the field sites might impact results[3].

*Table 2 – **General characteristics of the experiments for post- the database used for comparison.** Includes authors names, year of publication, fire date, burn severities represented in the data, monitoring period, slope or range of slope (%), scale (micro, plot, slope, swale, catchment), plot size (m^2), and method for the determination of soil erosion rates in the field (Microplots, Erosion plots, Gerlach, Sediment fences).*

Authors	Year	Country	Fire Date (year)	Burn Severity	Monitoring Period (years)	Slope (%)	Scale	Plot Size (m^2)	Method
Badía and Martí[4]	2000	Spain	1991	Moderate	2	32-40	Slope	8	Gerlach
Badía et al.[5]	2015	Spain	2009	Moderate/ High	2	49-50	Slope	2	Gerlach
Bautista et al.[6]	1996	Spain	1992	Not assessed	2	25-36	Slope	16	Erosion Plots
Cole et al.[7]	2020	USA	2015	High	5	n/a	Plot	75	Sediment Fences
Costa et al.[8]	2018	Brazil	2014	Unburned/ Low/ Moderate	1	n/a	Plot	1	Erosion Plots
Díaz-Raviña et al.[9]	2012	Spain	2010	Moderate/ High	0.31	30	Slope	80	Gerlach
Díaz-Raviña et al.[10]	2018	Spain	2010	Moderate/ High	1	30	Slope	80	Gerlach
Fernández & Vega a[11]	2014	Spain	2010	High	2	60	Slope	500	Sediment Fences
Fernández & Vega b[12]	2016	Spain	2010	High	3	35	Slope	80	Sediment Fences
Fernández & Vega c[13]	2016	Spain	2013	Moderate/ High	2	22-55	Slope	80	Sediment Fences
Fernandez & Vega d[14]	2021	Spain	2016	High	2	31 – 52	Slope	180	Sediment Fences
Fernández et al. a[15]	2007	Spain	2003	Moderate/ High	2	25-40	Slope	510	Sediment Fences
Fernández et al. b[16]	2011	Spain	2006	High	2	40	Slope	500	Sediment Fences
Fernández et al. c[17]	2016	Spain	2013	High	2	27-53	Slope	80	Sediment Fences
Fernández et al. d[18]	2019	Spain	2015	Moderate	2	25-51	Slope	80	Sediment Fences
Fernández et al. e[19]	2019	Spain	2016	Moderate	2	37-43	Slope	80	Sediment Fences
Fernández et al. f[20]	2020	Spain	2015	Moderate	2	42-70	Slope	80	Sediment Fences
Fernández et al. g[21]	2021	Spain	2015	Moderate/High	3	30-37	Slope	80	Sediment Fences
Fernández-Fernández[22]	2016	Spain	2012	Moderate	1	33-38	Slope	400	Sediment Fences
Hosseini et al. a[23]	2016	Portugal	2012	Moderate	1	36-55	Micro	0.25	Microplots

Table 2 (Continuation) - ***General characteristics of the experiments for post- the database used for comparison.*** *Includes authors names, year of publication, fire date, burn severities represented in the data, monitoring period, slope or range of slope (%), scale (micro, plot, slope, swale, catchment), plot size (m^2), and method for the determination of soil erosion rates in the field (Microplots, Erosion plots, Gerlach, Sediment fences).*

Authors	Year	Country	Fire Date (years)	Burn Severity	Monitoring Period (years)	Slope (%)	Scale	Plot Size (m^2)	Method
Hosseini et al. b[24]	2017	Portugal	2012	Moderate	0.83	25	Slope	0.25	Microplots
Hubbert et al.[25]	2012	USA	2003	Moderate	3	18-27	Slope	n/a	Sediment Fences
Inbar et al.[26]	2015	Israel	2009	Low/Moderate	1	40	Slope	4.5	Sediment Fences
James and Krumland[27]	2018	USA	2012	High	3	26-30	Swale	3500-5600	Sediment Fences
Keizer et al.[28]	2018	Portugal	2015	Moderate/ High	1	51	Slope	16	Sediment Fences
Kim et al. a[29]	2008	South Korea	2000	Not assessed	1.16	52	Slope	30	Erosion Plots
Kim et al. b[30]	2021	South Korea	2000	Not assessed	10	52	Slope	30	Erosion Plots
Lopes et al.[31]	2020	Portugal	2015	Moderate	1	36-51	Slope	15.02	Sediment Fences
Lucas-Borja et al.[32]	2019	Spain	2016	High	0.7	15-20	Slope	200	Sediment Fences
Malvar et al. a[33]	2016	Portugal	2005	Moderate	2	27-47	Plot	0.25	Erosion Plots
Malvar et al. b[34]	2017	Portugal	2015	Moderate	1	52 – 54	Plot	18	Sediment Fences
Olsen et al. [35]	2021	USA	2013	High	4	15-27	Swale	910-5800	Sediment Fences
Prats et al. a[36]	2012	Portugal	2007	Low/ Moderate	1.2	44	Slope	16	Sediment Fences
Prats et al. b[37]	2014	Portugal	2010	Moderate/ High	1	47	Slope	0.28	Microplots
Prats et al. c[38]	2016	Portugal	2008	Moderate	3	47	Slope	0.5	Microplots
Prats et al. d[39]	2016	Portugal	2010	Moderate	5	47	Slope	110	Sediment Fences
Prats et al. e[40]	2019	Portugal	2015	Moderate/ High	2.83	23	Swale	807	Sediment Fences
Prats et al. f[41]	2021	Spain/ Portugal	2018	Moderate	1	23-53	Micro	1	Sediment Fences
Robichaud et al.[42]	2006	USA	1998	High	4	28-54	Slope	36	Sediment Fences
Robichaud et al. a[43]	2008	USA	1998	High	4	19-50	Catchmen t	113000	Sediment Fences
Robichaud et al. b[44]	2008	USA	2000	High	3	52-61	Slope	100	Sediment Fences
Robichaud et al. a[45]	2013	USA	2002	High	7	17-44	Catchmen t	46000	Sediment Fences
Robichaud et al. b[46]	2013	USA	2002	High	5	17-68	Slope	23	Sediment Fences
Robichaud et al. c[47]	2013	Canada	2009	High	2	38-51	Slope	84	Sediment Fences
Robichaud et al.[48]	2019	USA	2010	High	2	26-62	Slope	224	Sediment Fences
Robichaud et al.[49]	2020	USA	2015	High	4	n/a	Plot	92	Sediment Fences
Schmeer et al. [50]	2018	USA	2012	High	3	n/a	Swale	2300	Sediment Fences
Serpa et al.[51]	2020	Portugal	2010	Moderate	2	n/a	Slope	0.25	Microplots
Shakesby et al.[52]	2015	Portugal	2009	Low/ Moderate	1	n/a	Slope	498	Sediment Fences
Silva et al.[53]	2019	Portugal	2015	Moderate	1	53 -62	Slope	0.25	Microplots
Vega et al.[54]	2015	Spain	2009	High	2	36	Slope	110	Sediment Fences
Vega et al.[55]	2020	USA	2015	Moderate	2	n/a	Slope	2780	Sediment Fences

Table 2 (Continuation) - ***General characteristics of the experiments for post- the database used for comparison.*** *Includes authors names, year of publication, fire date, burn severities represented in the data, monitoring period, slope or range of slope (%), scale (micro, plot, slope, swale, catchment), plot size (m^2), and method for the determination of soil erosion rates in the field (Microplots, Erosion plots, Gerlach, Sediment fences).*

Authors	Year	Country	Fire Date (years)	Burn Severity	Monitoring Period (years)	Slope (%)	Scale	Plot Size (m^2)	Method
Vieira et al. [56]	2016	Portugal	2008	Moderate	4	44-58	Plot	0.25-0.5	Microplots
Wagenbrenner et al.[57]	2006	USA	2000	High	4	35	Slope/ Swale	1900	Sediment Fences
Wagenbrenner et al.[58]	2015	USA	2006	Moderate/ High	4	n/a	Slope/ Swale	74-15000	Sediment Fences
Zema et al. [59]	2020	Spain	2016	Unburned/burned	1	11	Plot	9	Erosion plots
Zhu et al. [60]	2018	Australia	2013	Unburned/ Low/ High	3	25-37	Slope	9	Erosion plots

3. Quality assessment with previous EU-scale assessment

Given the current adaptation of this methodology[61] to allow the temporal and spatial upscaling framed in this study, we have conducted a series of assessments to determine how much the change model inputs (resolution, burned area and severity, FCOVER) would lead to error propagation until the final post-fire erosion prediction. Therefore, we have compared the results obtained under the current methodology at global scale with the previous one at EU scale for the first post-fire year of 2017 regarding:

- **Burned area delineation and severity.** Previous methodology included a highly detailed fire perimeter and the determination of Normalized Burn Ration (NBR) index at a resolution of 25m. The processing of this information was done for each individual wildfire, in total 2,679 wildfires in the EU. Under the new methodology, this information was now retrieved through the MOSEV database[62] at much coarser resolution (500m). Despite the decrease in resolution, significant benefits were brought by the increase in temporal scale offered by such database (1 vs. 18 years) and by reducing the manual technical assessment burden of individual fires at global scale (2,679 vs ~80,506,100 fires). Another benefit concerns the identification of reburns, which was not considered previously despite positive observations.
- **Ground cover by FCOVER**. Previous methodology used a coarse resolution (300m) FCOVER product provided by Copernicus[63], and now it includes the determination of FCOVER at 30m resolution. Moreover, reference unburned conditions are updated in case of reburns, whereas the full history of fire occurrence and FCOVER could be assessed since the first wildfire in that given pixel. Another required adaptation was the timing of the year in which FCOVER data was retrieved. Previously a fixed date (30 October) was used to represent ground cover after fire, being revisited annually at the same time of the year to assess recovery, which was considered a good approximation given the fact that AOI was in the northern hemisphere and most of the fires generally occur before this date. Now, and because it was required to assess distinct wildfire seasons all over the globe, we follow up every single fire event in each pixel, recording the pre-fire FCOVER with the best imagery available previously to the date provided by MOSEV, recording the post-fire FCOVER based on the best imagery available for post-fire period, and then following up annually until the limit of MOSEV temporal window.

3.1. Burned area delineation and severity

Our analysis under 100m resolution shows a similar burn severity classification over the same simulated area (Table 1) as the previous study[61], with natural reduction of the high severity classes due to the reduction of the resolution. A fraction of the low (1%) and high (9%) burn severity classes were merged with the moderate severity (10%).

Table 3- ***Comparison and error determination between the manual burn severity assessment [61] and the usage of MOSEV database for the 2017 burned areas in EU.***

	Manual NBR	MOSEV	error (total% change)
Low	17%	16%	-1%
Moderate	51%	60%	10%
High	32%	23%	-9%

However, the limited availability of data for global burned areas and their severity presented itself the major limitation of this study, whereas the usage of MOSEV led to a loss of 28% in area, which correspond to fires smaller than 25ha (Fig. 2) in the EU, as also confirmed in another study[64]. This underestimation is also in line with the coefficient of variation of the estimated burned area found for temperate (23.3%) and Mediterranean forest (42.4%)[64].

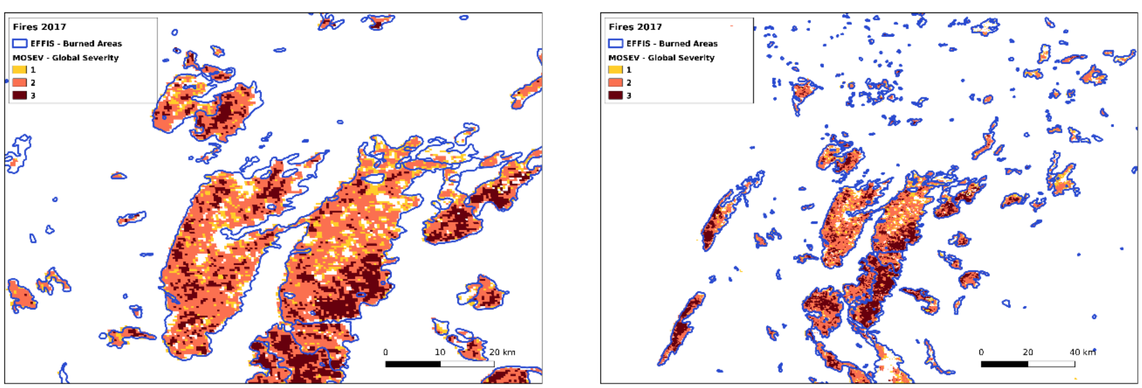

Fig. 2 – ***Examples of MOSEV coverage (pixel) and fire perimeter (line) for the 2017 burned areas in EU at different resolution.*** *Overlay of MOSEV database[62] at 500m resolution with fire perimeter data[65] from the European forest Fire Information System (EFFIS), for burned areas of 2017.*

3.2. Ground cover by FCOVER

Following the comparison of the FCOVER data from the available Copernicus product (300m) with the new methodology used under the Landsat Collection (30m), a double step correction was required to keep the previous model calibration[61] based on the previous estimations performed at EU scale. We have focused on the different signals obtained by both systems (PROBA-V vs. Landsat) but also taking into consideration that FCOVER under the previous methodology concerned one moment in time (October) while the novel one is determined immediately after each fire. Therefore, the following transformation was applied which allowed us to keep the same range and interquartile as the original data collected:

$$FCOVER\ corr_{(t\ variable,\ scale\ 30m)} = FCOVER_{(t\ variable,\ scale\ 30m)} - \left(xFCOVER_{(t\ october2017,\ scale\ 30m)} - x\ FCOVER_{\ (october2017,\ scale\ 300m)}\right) \quad (1)$$

Where FCOVER $corr_{(t\ variable,\ scale\ 30m)}$ corresponds to the corrected FCOVER input used in the current approach, the $FCOVER_{(t\ variable,\ scale\ 30m)}$ corresponds to the data as retrieved from Google earth Engine and Landsat Collection 2, x $FCOVER_{(t\ october,\ scale\ 30m)}$ corresponds to the mean FCOVER product from Landsat for single date in 30 October, and $FCOVER_{(t\ october,\ scale\ 300m)}$ the mean FCOVER product from PROBA-V for single date in 30 October.

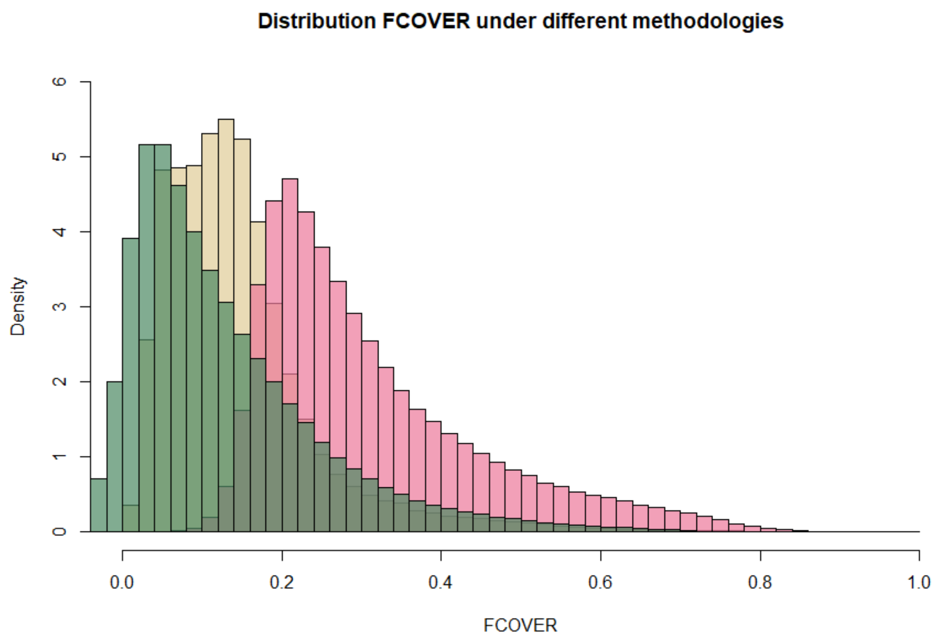

*Fig. 3 - **Distribution of FCOVER data under different methodologies for the 2017 burned areas in EU.** Note FCOVER from Copernicus (PROBA-V) at 300m resolution (yellow), FCOVER obtained by Google Earth Engine following Song et al. (2022) using NDVI from Landsat Collection 2 at 30m resolution (pink), and FCOVERcorr as determined by equation 1.*

3.3. Resulting post-fire soil erosion estimations

As a result of these methodological changes, soil erosion estimations resulted in a somehow more conservative methodology with reductions on the mean from 33.22 to 30.08 Mg ha^{-1} and a shift of the median from 21.2 Mg ha^{-1} to 16.92 Mg ha^{-1} for the first post fire year, with a 0.504 correlation coefficient when compared to the former approach.

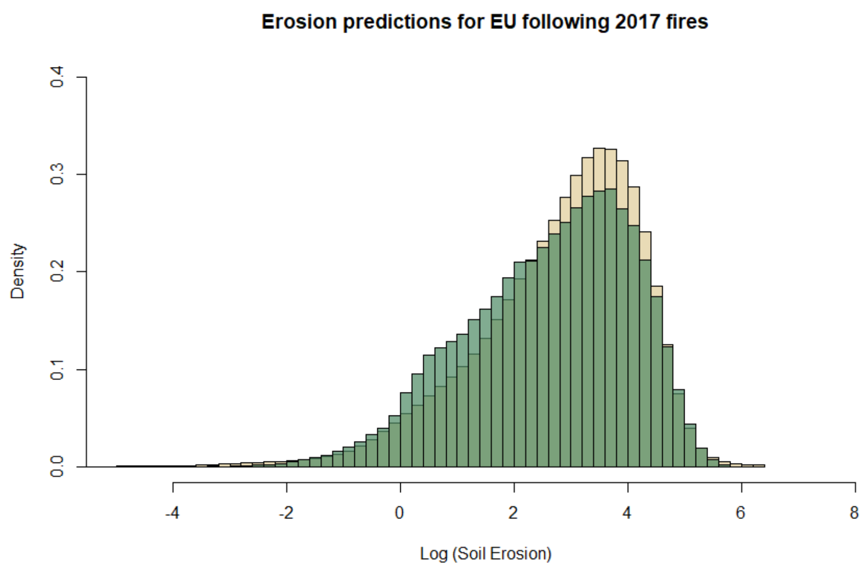

*Fig. 4 - **Distribution of soil erosion estimations (Log scale) under different methodologies.** Note manual severity assessment and FCOVER from Copernicus products (yellow), and from MOSEV database and FCOVER as determined by equation 1 (green), for the 2017 burned areas in EU at 100m resolution.*

4. Identification of uncertainties

During the development of this assessment was possible to identify several sources of uncertainties, mostly resulting from the adaptation to coarser resolution products such as the use of MOSEV[62]. Notwithstanding, we also profited from the opportunity to improve the methodology[61] used, which in overall allowed us to create the first global estimation of its kind. The quality assessment performed to EU+UK 2017 burned area identifies several limitations when adapting this study to a global scale as follows:

- There is a substantial underestimation of burned areas when using the MOSEV database by not considering small sized burned areas (<25ha), leading to data losses of approximately 28% for EU+UK 2017 burned area. Such errors have already been quantified[64] across biomes types, whereas the lowest errors concerned Boreal Forest, Tropical Savanna and Temperate Savanna, while the highest were observed in the Tropical Forest, Temperate Forest and Mediterranean biomes.
- A slight reduction in the areas classified with high burn severity (9% total) to moderate severity was observed because of resolution changes for EU+UK 2017 burned area. Such proportion might change in other continents, depending on the contribution of high severity areas to the total burned area, but also the size of the wildfires, since high severity burns are more likely to occur in burned areas with greater dimension[67].
- Despite FCOVER determination used in this work[66] was based on the same vegetation indices (NDVI) as the ones from Copernicus FCOVER product, the use of data originated from two different remote sensing methodologies might lead to further differences beyond the ones tackled in this study.
- Post-fire soil erosion estimates in this study are produced at 200 m resolution. While land cover at 100 m and NDVI at 30 m improve representation, some of the detail is lost once resampled. While the total erosion budget remains robust because values are additive across pixels, the identification of localised hotspots with high erosion rates is less certain, as the averaging inherent to a 200 m grid reduces heterogeneity.
- This study relies exclusively on globally harmonized datasets, which ensures internal consistency of the modelling framework. However, when comparing model outputs with soil erosion data measurements from field studies, the latter are less harmonized and may reflect different

methodological standards, scale, or erosion processes. Therefore, caution is required when interpreting discrepancies between model estimates and validation observations.

- The quality assessment for soil erosion after fire allowed us to evaluate the agreement between both methodologies on the EU+UK 2017 burned area, revealing that the new methodology provides more conservative soil erosion estimations after fire. However, in other continents where post-fire soil erosion is less documented and estimated[2,68] these uncertainties may rise. This is particularly significant in the case of the African and South American continents, which hold a substantial contribution of burned area, and in this case soil erosion, annually.
- The main focus of this research is to estimate the soil erosion on burned areas, however this work does not address other forest disturbances such as drought, pests, or wind [69,70], or anthropogenic actions leading to disturbances such as logging, thinning or afforestation [71].
- The use of RUSLE in the assessment of post-fire soil erosion globally, represent only a portion of the post-fire impacts in geomorphic processes occurring after fire. While RUSLE can grasp the most frequent hillslope possesses occurring after fire (sheet, interrill and rill erosion), estimating the potential of sediment to be transported to channels, it lacks the connectivity and the temporal scale to address processes at larger spatial scales such as mass movements (e.g. debris flows, landslides) or sediment transport and deposition at catchment scale.
- Model adaptation to burn conditions (not exclusive to RUSLE) still require further development on the impact of fire-induced changes to soil erodibility[68], and how these factors change with time. Moreover, the use of vegetation proxies (FCOVER) might not entirely represent the impact of fire in soil health condition.
- The current projections of post-fire soil erosion for 2050 and 2070 are driven by projected changes in rainfall intensity and amount (i.e. Rainfall Erosivity). They do not include potential changes in land use and management, nor shifts in fire dynamics such as occurrence, severity, or burned area. Thus, the results should be interpreted as climate-driven projections under present-day land use and fire regime conditions.

5. Development of C-factors

The consideration of a RCOVER class allowed us to adopt a succession of C-factor equations according to the status of the vegetation recovery progress (**Error! Reference source not found.**). For the first 2 classes ' No Recovery' ([0.0 - 0.3 [) and 'Ongoing Recovery' ([0.3 - 0.6[) the C factor would be calculated as described for equations (2) to (5) according to the initial burn severity classification and land cover attributes. In the case of 'Near Recovery' ([0.6 - 1.0[) class, this would lead to the adoption of the equation with one burn severity level lower than the original one. In a similar way, the 'Recovered' (≥ 1.0) class would lead to adoption of the equation corresponding to unburned conditions. This formulation allows us to use FCOVER as constant input for C estimations, while reducing the impact of severity proportionally to the pre-fire conditions.

*Table 4 – **Conditions and succession of equations for the determination of C factor in function of the observed FCOVER**. Not code of colors for High (red), Moderate (orange), Low (yellow) burn severities, gradients of green to express RCOVER classes: [0-0.3[- No Recovery, [0.3-0.6[- Ongoing Recovery, [0.6-1.0[-Near recovery, and RCOVER>= 1 – Recovered following[61] , and gradient of grey to identify distinct equations*

Condition 1 (Burn severity)	Condition 2 (RCOVER)	Forest	Shrubland	Grassland
High	[0.0 - 0.3 [	3.0199*EXP(-9.217*FCOVER)	0.7378*EXP(-5.505*FCOVER)	0.9825*EXP(-4.588*FCOVER)
High	[0.3 - 0.6[	3.0199*EXP(-9.217*FCOVER)	0.7378*EXP(-5.505*FCOVER)	0.9825*EXP(-4.588*FCOVER)
High	[0.6 - 1.0[	1.4189*EXP(-8.462*FCOVER)	0.7378*EXP(-5.505*FCOVER)	0.9825*EXP(-4.588*FCOVER)
Moderate	[0.0 - 0.3 [	1.4189*EXP(-8.462*FCOVER)	0.7378*EXP(-5.505*FCOVER)	0.9825*EXP(-4.588*FCOVER)
Moderate	[0.3 - 0.6[	1.4189*EXP(-8.462*FCOVER)	0.7378*EXP(-5.505*FCOVER)	0.9825*EXP(-4.588*FCOVER)
Moderate	[0.6 - 1.0[	0.2996*EXP(-6.906*FCOVER)	0.2245*EXP(-4.315*FCOVER)	0.2989*EXP(-3.398*FCOVER)
Low	[0.0 - 0.3 [	0.2996*EXP(-6.906*FCOVER)	0.2245*EXP(-4.315*FCOVER)	0.2989*EXP(-3.398*FCOVER)
Low	[0.3 - 0.6[	0.2996*EXP(-6.906*FCOVER)	0.2245*EXP(-4.315*FCOVER)	0.2989*EXP(-3.398*FCOVER)
Low	[0.6 - 1.0[	0.2996*EXP(-6.906*FCOVER)	0.2245*EXP(-4.315*FCOVER)	0.2989*EXP(-3.398*FCOVER)
Any	≥ 1.0	0.0949*EXP(-5.756*FCOVER)	0.1010*EXP(-3.517*FCOVER)	0.1345*EXP(-2.599*FCOVER)

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