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Supplement of

Sources of uncertainty in the SPITFIRE global fire model: development of LPJmL-SPITFIRE1.9 and directions for future improvements

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Figure S1

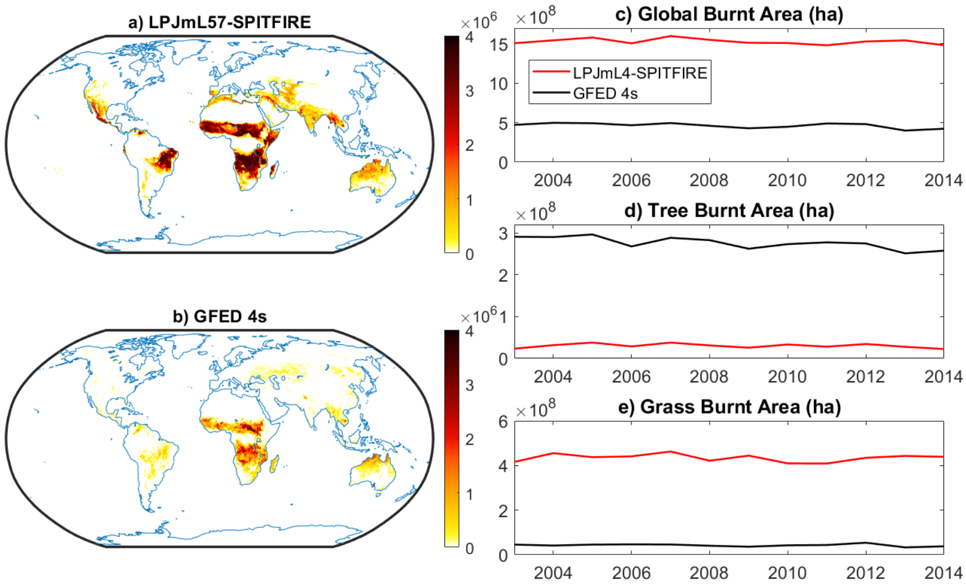
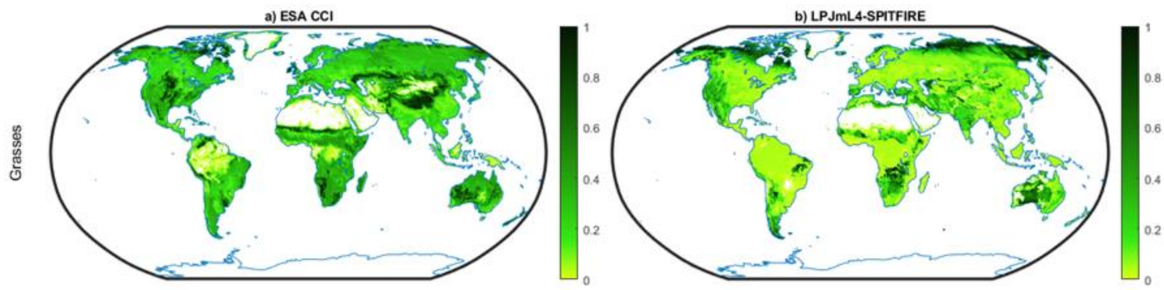


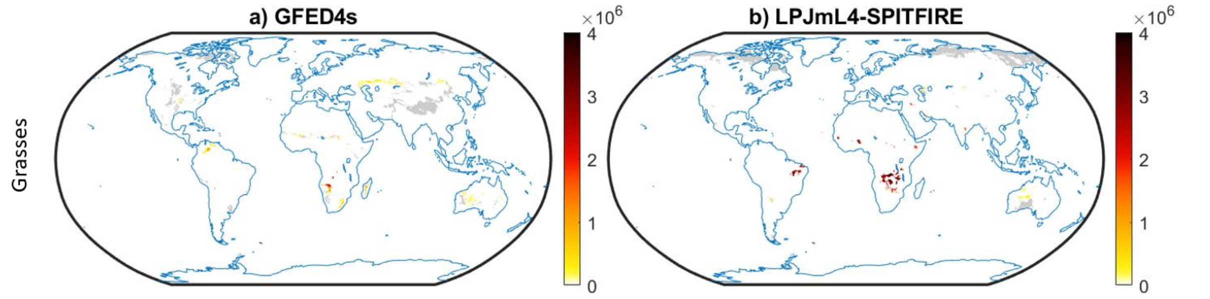
Figure 3 with the SPITFIFIRE version from LPJmL4 implemented in LPJmL57. Because this version has not been calibrated, and producing a calibrated version is out of the scope of the current work, there is a severe amount of overburning globally. However, panels d) and e) show the same tendencies as Figure 3 in the main text, i.e. that the old version of SPITIFRE shows substantially too much burnt area in grass-dominated grid cells and substantially too little in tree-dominated grid cells.

Figure S2



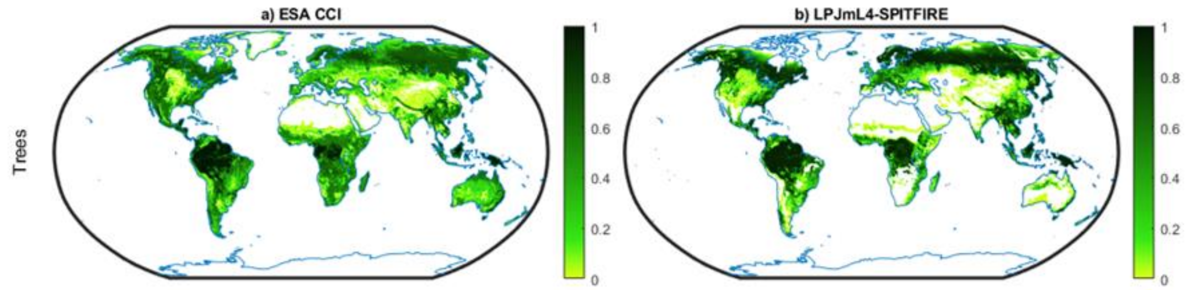
Overall grass FPC in a) the ESA CCI validation data, split into PFTs by Forkel et al. (2019), and b) in LPJmL4 with SPITFIRE. There are some substantial disagreements between the two, in particular a broadly lower amount of grass FPC in LPJmL4. This may be in part attributed to many grasslands being classified as managed in LPJmL4, thereby reducing the grass fraction relative to the ESA CCI-based data. There is stronger agreement in cells where the total grass FPC is over 0.5 and there is burnt area, shown in the next figure.

Figure S3



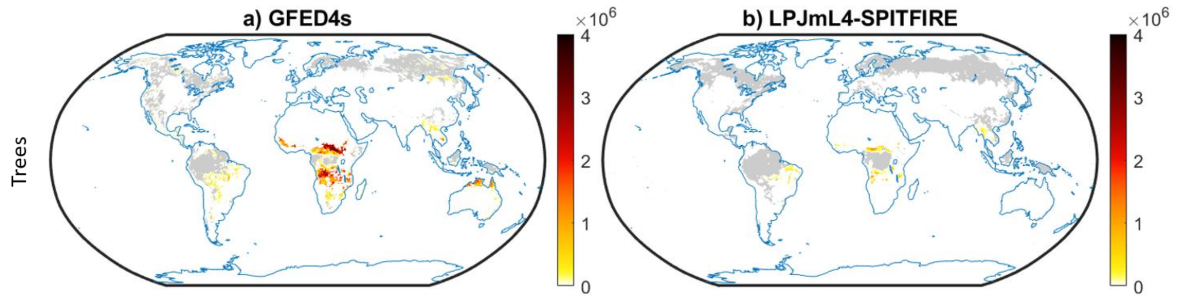
Mapped comparison of burnt area in grid cells with a grass FPC over 0.5. Panel a) shows satellite observed burnt area from GFED4s in grid cells where the ESA CCI data show a total grass FPC over 0.5. Panel b) shows simulated burnt area from LPJmL4-SPITFIRE on grid cells with a simulated grass FPC over 0.5. Grid cells with no burnt area are shown in grey for visibility. There is a rough geographic agreement in the locations of cells where most of the burnt area is present, and LPJmL4-SPITFIRE shows a much larger burnt area in these cells.

Figure S4



Overall tree FPC in a) the ESA CCI validation data, split into PFTs by Forkel et al. (2019), and b) in LPJmL4 with SPITFIRE. A major source of disagreement between the two is the frequent absence of modelled trees in areas where SPITFIRE simulates substantial fire (e.g. southern Africa, Mexico and India).

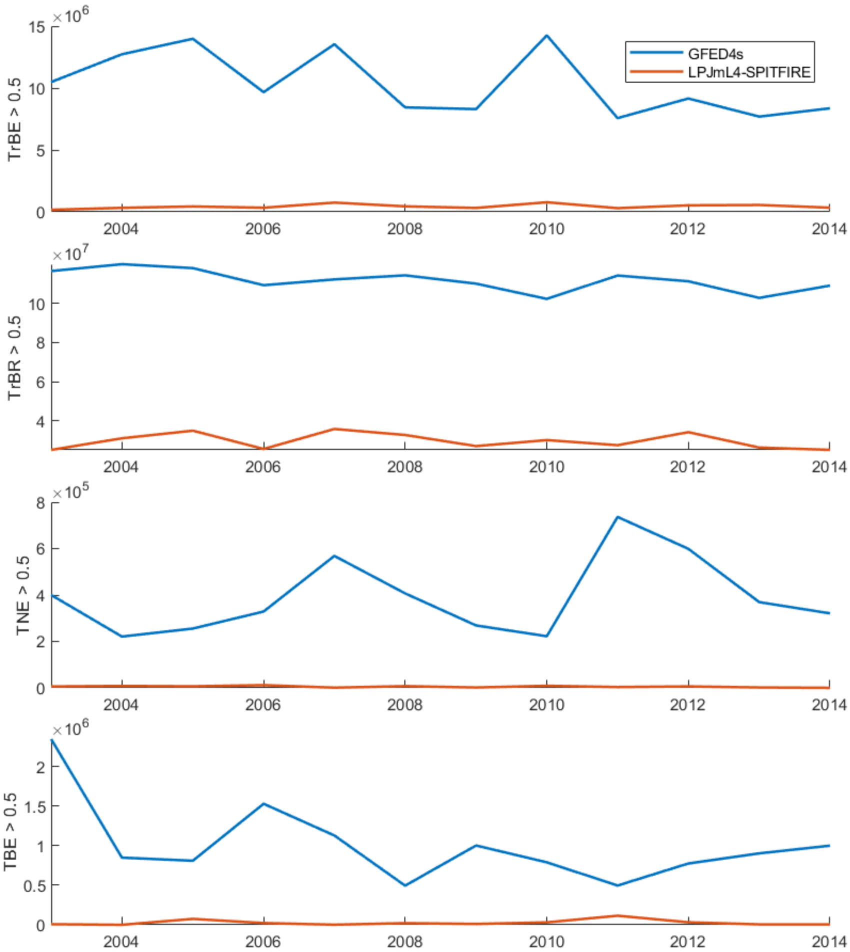
Figure S5



Mapped comparison of burnt area in grid cells with a tree FPC over 0.5. Panel a) shows satellite observed burnt area from GFED4s in grid cells where the ESA CCI data show a total grass FPC over 0.5. Panel b) shows simulated burnt area from LPJmL4-SPITFIRE on grid cells with a simulated grass

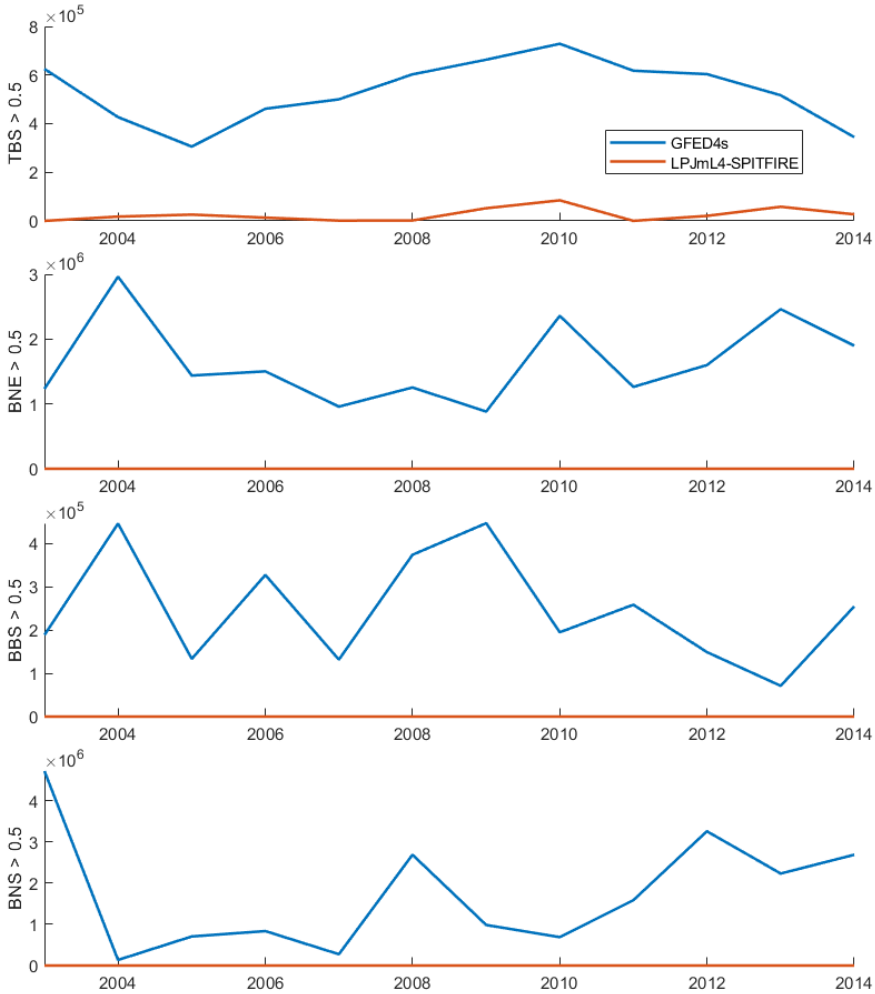
FPC over 0.5. Grid cells with no burnt area are shown in grey for visibility. The substantially lower burnt area in tree-dominated grid cells in LPJmL4-SPITFIRE can largely be attributed to there being many fewer of these cells in the presence of modelled fire. This can be explained by our findings showing that biases in SPITFIRE may cause excessive tree mortality.

Figure S6



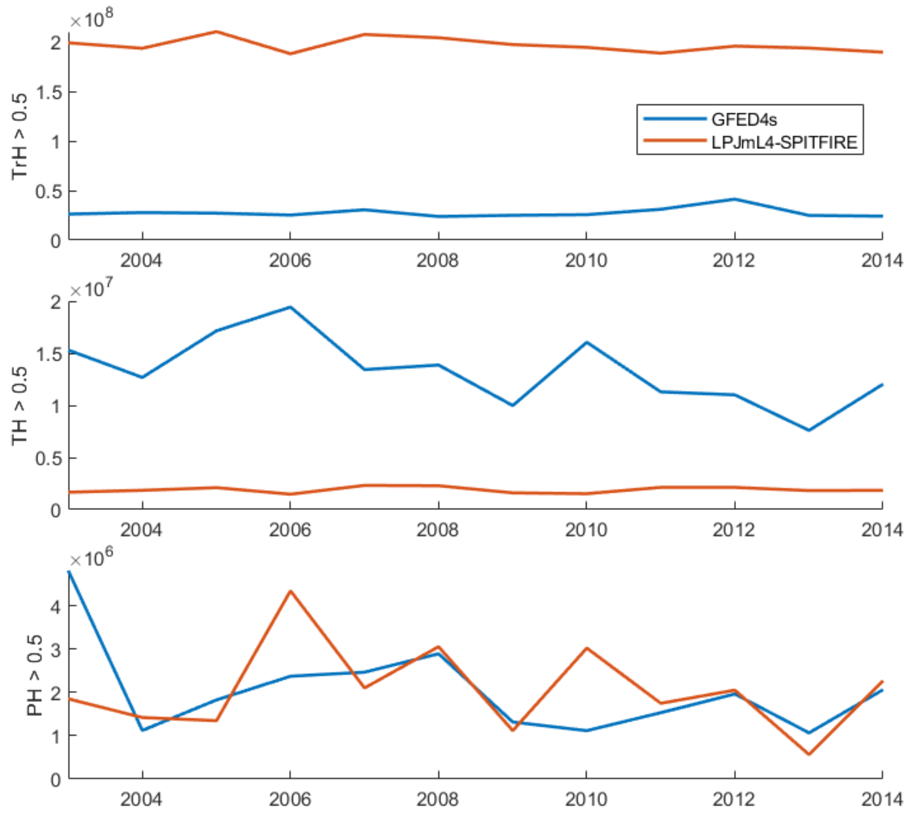
Comparison of GFED4s burnt area and LPJmL4-SPITFIRE burnt area for grid cells in which a specific PFT has an FPC that covers over half of the grid cell. Shown here for the first four tree PFTs. LPJmL4 burnt areas are generally much lower.

Figure S7



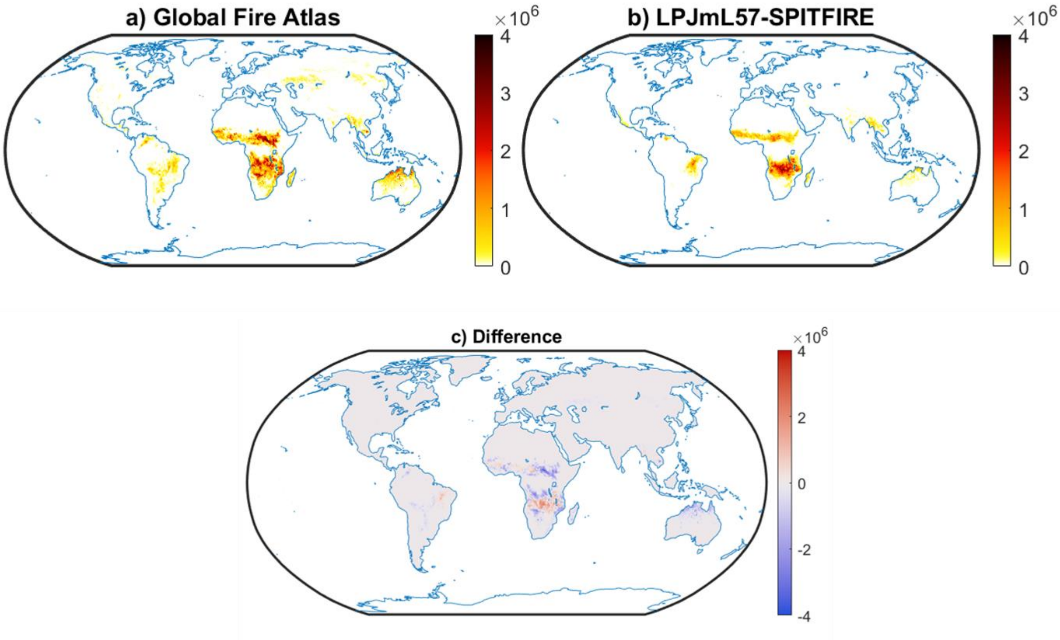
Comparison of GFED4s burnt area and LPJmL4-SPITFIRE burnt area for grid cells in which a specific PFT has an FPC that covers over half of the grid cell. Shown here for the remaining four tree PFTs. LPJmL4 burnt areas are generally much lower.

Figure S8



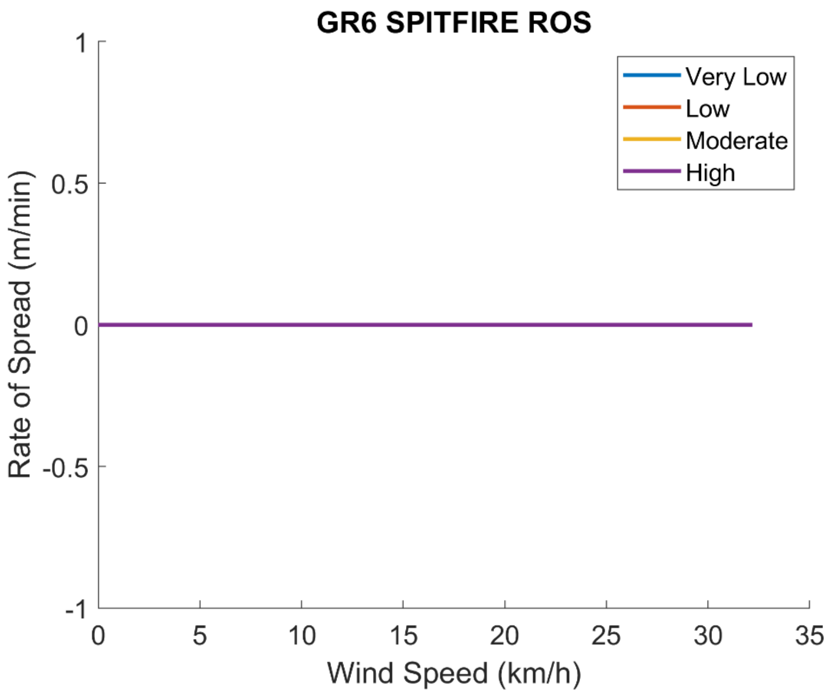
Comparison of GFED4s burnt area and LPJmL4-SPITFIRE burnt area for grid cells in which a specific PFT has an FPC that covers over half of the grid cell. Shown here for the three grass PFTs. The TrH PFT accounts for the substantial overburning in Africa. The lower burnt area in TH in SPITFIRE can be accounted for by a lack of temperate herbaceous dominated grid cells in areas with substantial fire (particularly a region north of the Caspian Sea also visible in Figure S3, but there are very few of these cells in the model in general). The burnt areas for polar herbaceous-dominated grid cells roughly agree with one another, but this comes from a smaller area of modelled cells that burn.

Figure S9



Comparison of burnt area per grid cell from fires in the Global Fire Atlas to the burnt area per grid cell when starting the same fires in the SPITFIRE version from LPJmL4, but implemented in LPJmL5.7. This supplements Figure 4 in the main text showing LPJmL4 with its own SPITFIRE version. The generally high burnt area in this uncalibrated version also causes the burnt area in panel b) to increase. However, the overall finding, that the burnt area is strongly reduced when incorporating prescribed firestarts, remains the same.

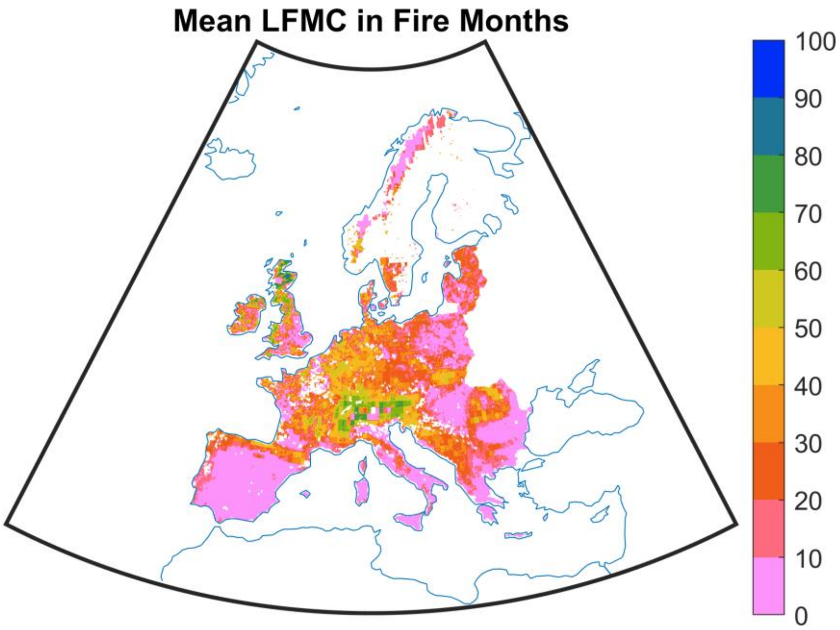
Figure S10



Rate of spread as a function of wind speed when using the GR6 Scott and Burgan fuel model with a live herbaceous moisture content of 60% as an input to the SPITFIRE rate of spread calculation as reproduced in a Matlab code. The manner in which live and dead fuel moistures are combined in the

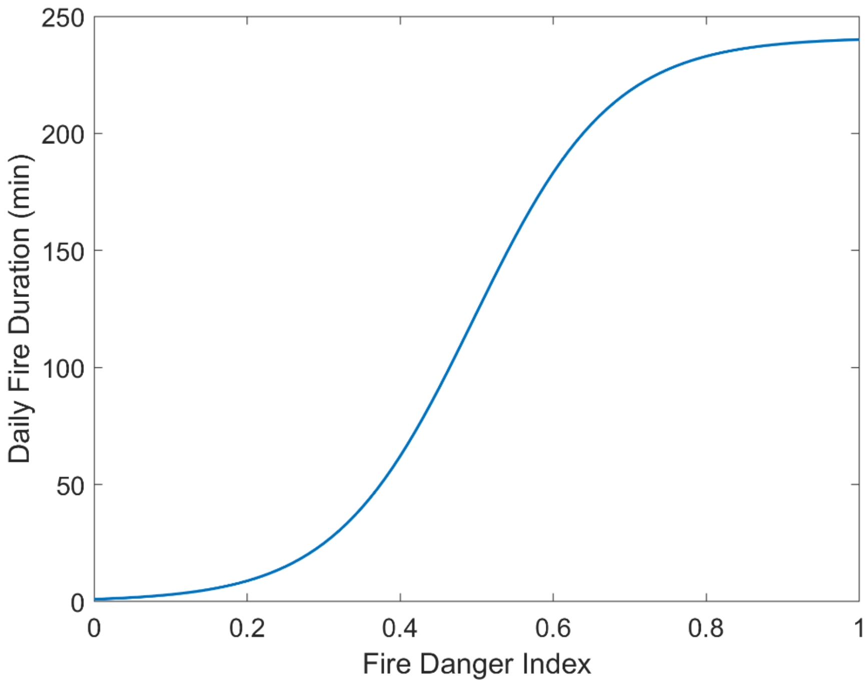
SPITFIRE approach allows realistic live fuel moistures to cause fire extinction under conditions where this is not the case when applying the correct version of the Rothermel model.

Figure S11



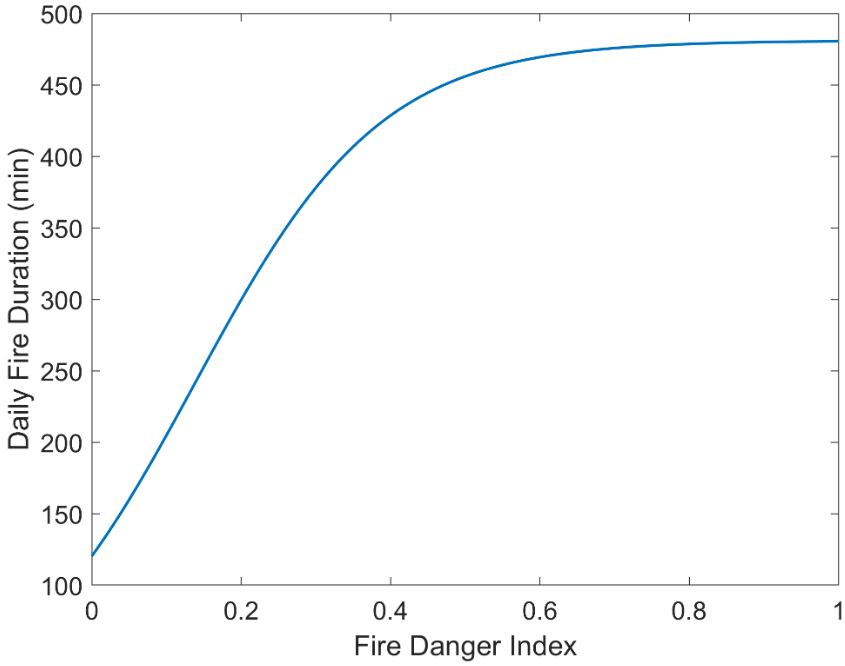
Live grass moisture in the months during which there is fire in the old SPITFIRE parametrization, for the European domain

Figure S12



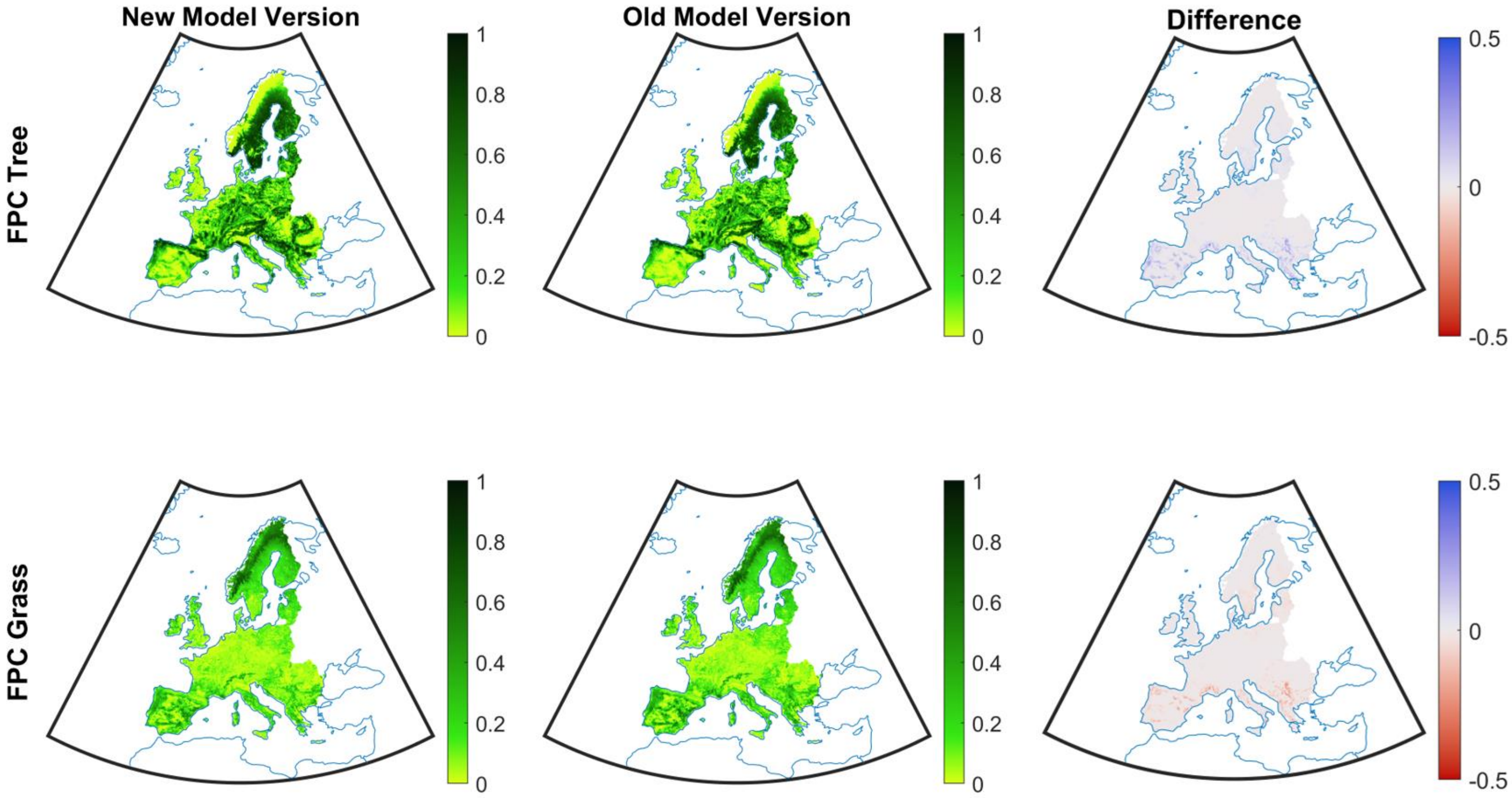
The original fire duration function from the SPITFIRE model

Figure S13



The updated fire duration function. In this case, the maximum fire duration is set to 480 minutes, the minimum fire duration is set to 120 minutes and the scaling parameter is set to -8.

Figure S14



Foliar Projective Cover (FPC) of tree PFTs and grass PFTs in LPJmL5.7-SPITFIRE with the old SPITFIRE version compared to the new SPITFIRE version. The difference plots show the fpc values of the old model version subtracted from those from the new model version. The new SPITFIRE version shows significantly more trees and less grass in fire-prone regions due to the removal of the upward bias in tree mortality through crown scorch

Table S1

Validation of the corrected implementation of the Rothermel fire spread model in SPITFIRE against a Matlab implementation of the Rothermel model. The Andrews et al. (2013) wind speed limit was used for all runs.

Fuel Model	Wind Speed (m/min)	Rate of Spread			Fireline Intensity		
		Model Code (m/min)	Matlab (m/min)	Difference (%)	Model Code (kW/m)	Matlab (kW/m)	Difference (%)
GR6	100	18.56	18.51	-0.27	4611.7	4562.8	-1.07
	200	50.84	50.71	-0.26	12633	12504	-1.03
	300	93.37	93.14	-0.25	23201	22965	-1.03
TU2	100	3.46	3.46	0.00	309	306.9	-0.68
	200	8.78	8.77	-0.11	783.7	778.5	-0.67
	300	15.42	15.42	0.00	1377.2	1368.4	-0.64
TL3	100	0.5487	0.5573	1.54	24.22	24.85	2.54
	200	1.2472	1.268	1.64	55.06	56.52	2.58
	300	1.971	2.011	1.99	87.00	89.67	2.98