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*Supplement of*

## **Representation of fire, land-use change and vegetation dynamics in the Joint UK Land Environment Simulator vn4.9 (JULES)**

**Chantelle Burton et al.**

*Correspondence to:* Chantelle Burton ([chantelle.burton@metoffice.gov.uk](mailto:chantelle.burton@metoffice.gov.uk))

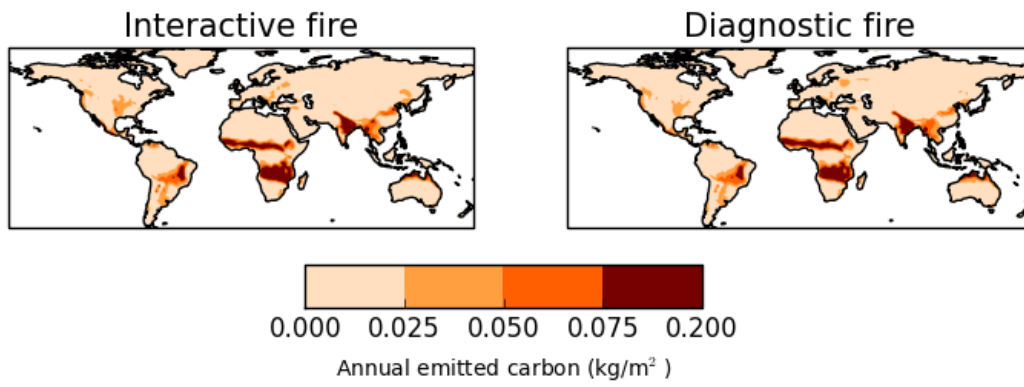
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<b>Global</b>	<b>Trees</b>	<b>Shrubs</b>	<b>Grasses</b>	<b>Soil</b>
S2 no fire (S2)	26.28	23.23	16.52	33.97
S3 no fire (S3)	21.46	14.83	28.91	34.80
S2 + fire (S2F)	16.59	10.57	32.07	40.77
S3 + fire (S3F)	15.08	6.81	37.50	40.61
Observations (Obs)	23.01 (range = 22.06)	10.95 (range = 2.87)	32.94 (range = 3.40)	33.10 (range = 25.56)
<b>% change S2 / S3F</b>	<b>-42.60</b>	<b>-70.69</b>	<b>126.95</b>	<b>19.54</b>
<b>% difference S2 / Obs</b>	<b>13.26</b>	<b>71.83</b>	<b>-66.38</b>	<b>2.60</b>
<b>% difference S3F / Obs</b>	<b>-41.61</b>	<b>-46.66</b>	<b>12.94</b>	<b>20.38</b>

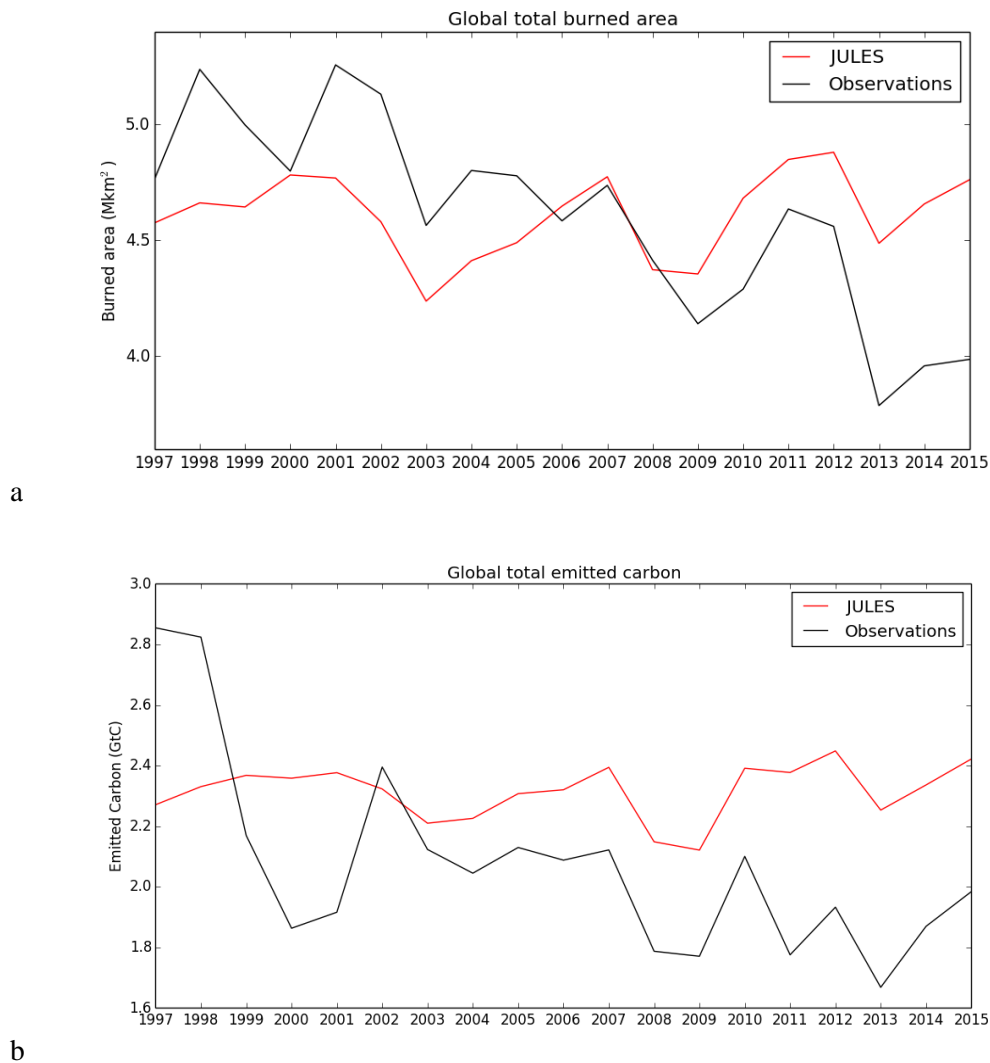
**Table S1: Total present day vegetation (percentage) globally. The totals are shown for total tree cover, shrubs, grasses and bare soil, with and without disturbance as labelled. The percentage change between experiments and percentage difference compared to ESA CCI Observations is calculated and shown in the lower rows**

<b>Tropical forest</b>	<b>Trees</b>	<b>Shrubs</b>	<b>Grasses</b>	<b>Soil</b>
S2 no fire (S2)	66.57	15.85	15.18	2.41
S3 no fire (S3)	55.34	9.76	32.40	2.50
S2 + fire (S2F)	49.12	14.39	31.26	5.23
S3 + fire (S3F)	44.05	8.15	42.72	5.08
Observations (Obs)	53.25	12.46	29.88	4.42
<b>% change S2 / S3F</b>	<b>-33.83</b>	<b>-48.57</b>	<b>181.43</b>	<b>111.07</b>
<b>% difference S2 / Obs</b>	<b>22.23</b>	<b>23.92</b>	<b>-65.24</b>	<b>-58.80</b>
<b>% difference S3F / Obs</b>	<b>-18.91</b>	<b>-41.83</b>	<b>35.38</b>	<b>14.08</b>

**Table S2: Total present day vegetation (percentage) for tropical forests. The totals are shown for total tree cover, shrubs, grasses and bare soil, with and without disturbance as labelled. The percentage change between experiments and percentage difference compared to ESA CCI Observations is calculated and shown in the lower rows**



**Figure S1: Present day emitted carbon (kg m<sup>-2</sup>), as modelled by the coupled JULES-INFERNO (left panel) and diagnostic INFERNO as presented in Mangeon et al (2016) (right panel)**



**Figure S2: Global total burnt area (Mkm<sup>2</sup>) (a) and global total emitted carbon (GtC) as modelled by JULES-INFERNO (red line) and GFED 4.1s (black line), from 1997-2015**

Comparison	Observations	Items/VCF field	CCI / JULES PFT
Vegetation cover	VCF	Woody	BL, NL, Shrub
		Grass	C3, C4
		Bare soil	Bare soil
	CCI	Tree	BL, NL
		Shrub	Shrub
		Grass	C3, C4
		Bare soil	Bare Soil
Tree cover	CCI	Tree	BL, NL
		Non-tree	Shrub, C3, C4, Bare soil
Wood cover	VCF/CCI	Woody	BL, NL, shrub
		Non-woody	C3, C4, bare soil
Grass cover	VCF/CCI	Grass	C3, C4
		Non-grass	BL, NL, shrub, bare soil
Leaf type	VCF/CCI	BL	BL
		NL	NL
BL	CCI	BL	BL
		Non-BL	NL, Shrub, C3, C4, bare soil
NL	CCI	NL	NL
		Non-NL	BL, Shrub, C3, C4, Bare soil
C3	CCI	C3	C3
		Non-C3	BL, NL, Shrub, C4, Bare soil
C4	CCI	C4	C4
		Non-C4	BL, NL, Shrub, C3, C4, Bare soil
Shrub	CCI	Shrub	Shrub
		Non-Shrub	BL, NL, C3, C4, Bare soil

**Table S3: MM comparison combinations. Items column shows vegetation cover items used in equation MM (equation 10), which is the sum of cci/JULES PFT cover. BL = Broadleaf tree PFT; NL = needleleaf; C3 = C3 grass; C4 = C4 grass.**

Comparison	Observations	Time period	Metric Step	Null Models			JULES				Improvement from control		
				Median	Mean	Randomly Resampled	S2 - Control	S3 - Land use	SF2 - fire	SF3 - Land use and fire	S3	SF2	SF3
Vegetation Cover	VCF	2002-2012	MM	0.60	0.62	0.81 +/- 0.0034	0.78	0.60	0.54	0.51	23.08%	30.77%	34.62%
	CCI	2010		0.76	0.77	0.99 +/- 0.0068	0.72	0.60	0.64	0.63	16.67%	11.11%	12.50%
Tree Cover	CCI			0.39	0.4	0.51 +/- 0.0048	0.35	0.28	0.30	0.30	20.00%	14.29%	14.29%
Wood Cover	VCF	2002-2012		0.39	0.4	0.51 +/- 0.0036	0.64	0.43	0.33	0.29	32.81%	48.44%	54.69%
	CCI	2010		0.47	0.47	0.62 +/- 0.0061	0.45	0.31	0.35	0.36	31.11%	22.22%	20.00%
Grass cover	VCF	2002-2012		0.46	0.47	0.63 +/- 0.0057	0.64	0.48	0.43	0.42	25.00%	32.81%	34.38%
	CCI	2010		0.41	0.4	0.53 +/- 0.0039	0.43	0.33	0.40	0.42	23.26%	6.98%	2.33%
Bare Soil	VCF	2002-2012		0.44	0.51	0.64 +/- 0.0045	0.29	0.30	0.32	0.32	-3.45%	-10.34%	-10.34%
	CCI	2010		0.53	0.59	0.73 +/- 0.0064	0.29	0.30	0.33	0.33	-3.45%	-13.79%	-13.79%
Leaf type	VCF	1992-1993		0.75	0.77	0.93 +/- 0.014	0.56	0.55	0.50	0.53	1.79%	10.71%	5.36%
	BL NL C3 C4 Shrub	CCI		2010	0.57	0.66	0.81 +/- 0.0078	0.56	0.56	0.51	0.54	0.00%	8.93%
0.27					0.3	0.38 +/- 0.0032	0.18	0.15	0.17	0.17	16.67%	5.56%	5.56%
0.16					0.23	0.27 +/- 0.0021	0.25	0.22	0.18	0.17	12.00%	28.00%	32.00%
0.31					0.32	0.44 +/- 0.0035	0.34	0.36	0.38	0.43	-5.88%	-11.76%	-26.47%
0.23					0.26	0.31 +/- 0.0021	0.2	0.21	0.21	0.21	-5.00%	-5.00%	-5.00%
0.14					0.14	0.2 +/- 0.0013	0.36	0.28	0.26	0.23	22.22%	27.78%	36.11%

Comparison	Observations	Time period	Metric	Step	Null Models			JULES				Improvement from control		
					Median	Mean	Randomly Resampled	S2 - Control	S3 - Land use	SF2 - fire	SF3 - Land use and fire	S3	SF2	SF3
Vegetative Carbon	Avitabile et al	2000-2010	NME	1			1.32 +/- 0.014	0.85	0.84	0.96	0.98	1.18%	-12.94%	-15.29%
				2	0.96	1		0.79	0.75	0.75	0.76	5.06%	5.06%	3.80%
				3				0.8	0.74	0.74	0.74	7.50%	7.50%	7.50%
Spatial Burnt Area	Meris	2006-2009	NME	1			1.13 +/- 0.072			0.95	0.95			0.00%
				2	0.71	1			0.92	0.92			0.00%	
				3				0.93	0.93			0.00%		
	MCD45	2001-2008		1			1.15 +/- 0.0028			0.91	0.91			0.00%
				2	0.72	1			0.87	0.87			0.00%	
				3				0.88	0.88			0.00%		
	GFED4	1997-2014		1			1.14 +/- 0.0066			0.84	0.84			0.00%
				2	0.72	1			0.8	0.8			0.00%	
				3				0.84	0.84			0.00%		
GFED4s	1997-2014	1			1.19 +/- 0.023			0.8	0.8			0.00%		
		2	0.75	1			0.79	0.79			0.00%			
		3				0.87	0.86			1.16%				
Seasonal phase	GFED4	1997-2014	MPD		0.53	0.48	0.49 +/- 0.00042			0.37	0.37			0.00%
	GFED4s	1997-2014			0.51	0.49	0.49 +/- 0.00098			0.35	0.35			0.00%
Spatial fire carbon emissions	GFAS	2000-2009	NME	1			1.21 +/- 0.0032			0.77	0.76			1.32%
				2	0.78	1			0.89	0.9			-1.11%	
				3				1.02	1.02			0.00%		

**Table S4: Benchmarking results for experiments with disturbance added. Lower results for all metrics indicates results that are closer to observations, with a perfect score being 0. Colours indicate how many null models the configuration exceeds: Blue = all; green = all but one; yellow = only exceeds one; red = none exceeded. Grey shading indicates the most improvement, with the darkest being the best.**

Comparison	Dataset	Experiment	S2 - Control	S3 - Land use	SF2 - fire	SF3 - Land use and fire
Vegetation Cover	VCF	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
	CCI	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
Tree Cover	CCI	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
Wood Cover	VCF	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
	CCI	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
Grass Cover	VCF	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
	CCI	S2	100	0	0	0.03
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0.03	0	0	100
Bare Ground	VCF	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0.38
		SF3	0	0	0.38	100
	CCI	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	21.92
		SF3	0	0	21.92	100
Leaf Type	VCF	S2	100	0	0	0
		S3	0	100	0	0.22
		SF2	0	0	100	0
		SF3	0	0.22	0	100
	CCI	S2	100	20.91	0	0
		S3	20.91	100	0	0.01
		SF2	0	0	100	0
		SF3	0	0.01	0	100

Comparison	Dataset	Experiment	S2 - Control	S3 - Land use	SF2 - fire	SF3 - Land use and fire
BL	CCI	S2	100	0	0.17	0
		S3	0	100	0	0
		SF2	0.17	0	100	0
		SF3	0	0	0	100
NL	CCI	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
C3	CCI	S2	100	0	0	0
		S3	0	100	0	0
		SF2	0	0	100	0
		SF3	0	0	0	100
C4	CCI	S2	100	0	0.08	0.02
		S3	0	100	1.58	8.14
		SF2	0.08	1.58	100	8.77
		SF3	0.02	8.14	8.77	100
Shrub	CCI	S2	100	0	0	0
		S3	0	100	0.01	0
		SF2	0	0.01	100	0
		SF3	0	0	0	100
Spatial Burnt Area – NME Step 1	GFED4s	SF2	-	-	100	96.4
		SF3	-	-	96.4	100
Spatial Burnt Area – NME Step 2	GFED4s	SF2			100	35.6
		SF3			35.6	100
Spatial Burnt Area – NME	GFED4s	SF2			100	3.7
		SF3			3.7	100

**Table S5: Statistical significance of improvement compared to observations for each experiment using a standard T-Test, where the P values are shown in percentage. Grey shading shows tests that are statistically significant at the 95% confidence interval (P<5%)**