Representation of disturbance in the Joint UK Land Environment Simulator Vn4.8 (JULES)

Supplementary Information
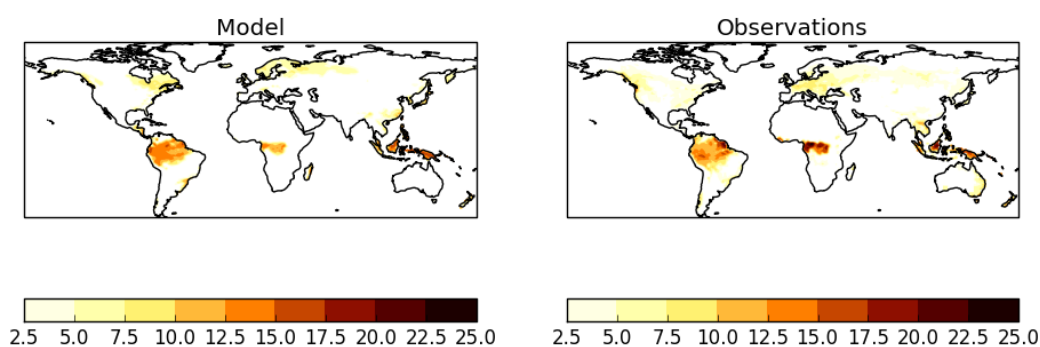

Figure SI-1: Vegetation carbon (kg m^{-2}), as modelled by JULES-INFERNO (left panel) and observations from Avitabile et al (2016)

Global	Trees	Shrubs	Grasses	Soil
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)
% change S2 / S3F	-42.60	-70.69	126.95	19.54
% difference S2 / Obs	13.26	71.83	-66.38	2.60
% difference S3F / Obs	-41.61	-46.66	12.94	20.38

Table SI-1: Total 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

Tropical forest	Trees	Shrubs	Grasses	Soil
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
% change S2 / S3F	-33.83	-48.57	181.43	111.07
% difference S2 / Obs	22.23	23.92	-65.24	-58.80
% difference S3F / Obs	-18.91	-41.83	35.38	14.08

Table SI-2: Total 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
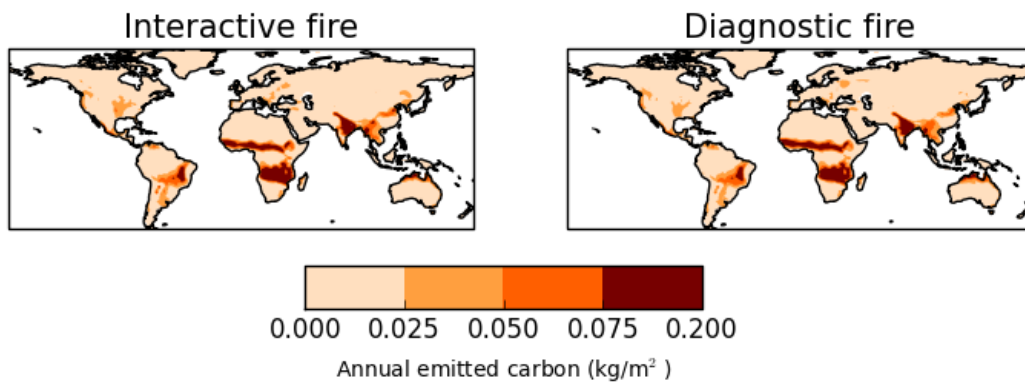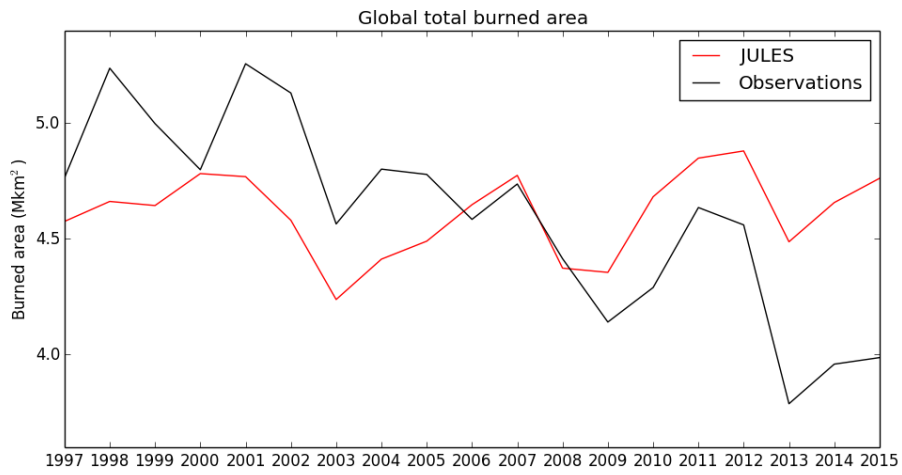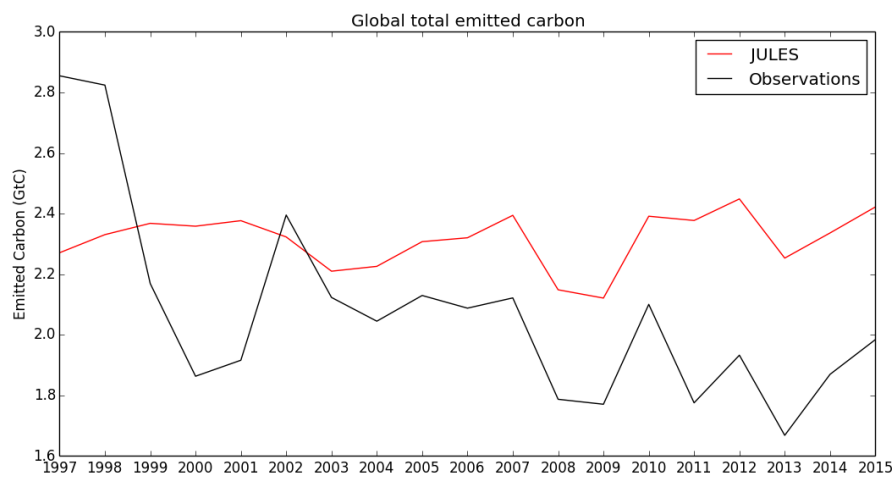

Figure SI-2: Emitted carbon (kg m⁻²), as modelled by the coupled JULES-INFERNO (left panel) and diagnostic INFERNO as presented in Mangeon et al (2016) (right panel)

a

b

Figure SI-3: Global total burnt area (Mkm^2) (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 SI-3: 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
Life form	VCF	2002-2012			0.60	0.62	0.81 +/- 0.0034	0.78	0.60	0.54	0.51	30.00%	44.44%	52.94%
	CCI	2010			0.76	0.77	0.99 +/- 0.0068	0.72	0.6	0.64	0.63	20.00%	12.50%	14.29%
Tree Cover	CCI				0.39	0.4	0.51 +/- 0.0048	0.35	0.28	0.3	0.3	25.00%	16.67%	16.67%
Wood Cover	VCF	2002-2012			0.39	0.4	0.51 +/- 0.0036	0.64	0.43	0.33	0.29	48.84%	93.94%	120.69%
	CCI	2010			0.47	0.47	0.62 +/- 0.0061	0.45	0.31	0.35	0.36	45.16%	28.57%	25.00%
Grass cover	VCF	2002-2012			0.46	0.47	0.63 +/- 0.0057	0.64	0.48	0.43	0.42	33.33%	48.84%	52.38%
	CCI	2010			0.41	0.4	0.53 +/- 0.0039	0.43	0.33	0.4	0.42	30.30%	7.50%	2.38%
Bare Soil	VCF	2002-2012	MM		0.44	0.51	0.64 +/- 0.0045	0.29	0.3	0.32	0.32	-3.33%	-10.00%	-10.00%
	CCI	2010			0.53	0.59	0.73 +/- 0.0064	0.29	0.3	0.33	0.33	-3.33%	-12.12%	-12.12%
Leaf type	VCF	1992-1993			0.75	0.77	0.93 +/- 0.014	0.56	0.55	0.5	0.53	1.82%	12.00%	5.66%
					0.57	0.66	0.81 +/- 0.0078	0.56	0.56	0.51	0.54	0.00%	9.80%	3.70%
BL					0.27	0.3	0.38 +/- 0.0032	0.18	0.15	0.17	0.17	20.00%	5.88%	5.88%
NL	CCI	2010			0.16	0.23	0.27 +/- 0.0021	0.25	0.22	0.18	0.17	13.64%	38.89%	47.06%
C3					0.31	0.32	0.44 +/- 0.0035	0.34	0.36	0.38	0.43	-5.56%	-10.53%	-20.93%
C4					0.23	0.26	0.31 +/- 0.0021	0.2	0.21	0.21	0.21	-4.76%	-4.76%	-4.76%
Shrub					0.14	0.14	0.2 +/- 0.0013	0.36	0.28	0.26	0.23	28.57%	38.46%	56.52%

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	0.96	1	1.32 +/- 0.014	0.85	0.84	0.96	0.98	1.19%	-11.46%	-13.27%
				2				0.79	0.75	0.75	0.76	5.33%	5.33%	3.95%
				3				0.8	0.74	0.74	0.74	8.11%	8.11%	8.11%
Spatial Burnt Area	Meris	2006-2009	NME	1	0.71	1	1.13 +/- 0.072			0.95	0.95			0.00%
				2						0.92	0.92			0.00%
				3						0.93	0.93			0.00%
	MCD45	2001-2008		1	0.72	1	1.15 +/- 0.0028			0.91	0.91			0.00%
				2						0.87	0.87			0.00%
				3						0.88	0.88			0.00%
	GFED4	1997-2014		1	0.72	1	1.14 +/- 0.0066			0.84	0.84			0.00%
				2						0.8	0.8			0.00%
				3						0.84	0.84			0.00%
	GFED4s	1997-2014		1	0.75	1	1.19 +/- 0.023			0.8	0.8			0.00%
				2						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	0.78	1	1.21 +/- 0.0032			0.77	0.76			1.32%
				2						0.89	0.9			-1.11%
				3						1.02	1.02			0.00%

Table SI-4: 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.