Supporting Information for "Uncertainty in land carbon budget simulated by land surface models: the role of atmospheric forcing"

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Text S1. Analysis of variance

We use the same methodology for each of the analysed fluxes at both global and regional scales. We compute the global (respectively regional) means of the yearly fluxes and average the resulting times series over the period of interest (1960-2012). We express each estimation of a variable y, made by the model i with the atmospheric forcing j as:

$$y_{ij} = \bar{y}_{..} + m_i + f_j + s_{ij} \tag{1}$$

where $\bar{y}_{..}$ is the overall mean for the variable y, m_i is the effect of the model i, f_j is the effect of the forcing j, and s_{ij} the non-additive effect of the interaction term between model i and forcing j. By construction there is no residual and our statistical model explains all the variability ($R^2 = 1$). An example of y_{ij} is the global GPP averaged over 1960-2015 simulated by CLM5 forced with GSWP3.

We use the sum of the squared deviation from the mean (SS) to explain the fractional contribution of models, forcing and interactions. The total variation is quantified by the total sum of squares:

$$SS(T) = \sum_{i=1}^{I}\sum_{j=1}^{J}(y_{ij} - \bar{y}_{..})^2, \tag{2}$$

where $I = 3$ is the number of CMIP6 models and $J = 3$ the number of atmospheric forcings used to run the simulations. Since we have an equal number of levels per factor ($I = J$), the total variation $SS(T)$ can be partitioned between the variation attributed to models $SS(M)$, the variation attributed to atmospheric forcings $SS(F)$, and the variation attributed to interactions $SS(I)$,

$$SS(T) = SS(M) + SS(F) + SS(I). \tag{3}$$

The sum of the squared deviation from the models mean is calculated as

$$SS(M) = \sum_{i=1}^{I}(\bar{y}_{i\cdot} - \bar{y}_{..})^2, \tag{4}$$

where $\bar{y}_{i\cdot}$ is the mean value of the three simulations with model i with the three different forcings. Similarly, we can express the variation attributed to forcings as

$$SS(F) = \sum_{j=1}^{J} (\bar{y}_{\cdot j} - \bar{y}_{\cdot\cdot})^2, \tag{5}$$

where $\bar{y}_{\cdot j}$ is the mean value obtained for forcing j by the three CMIP6 models. The variation attributed to interaction is the remaining term in the $SS(T)$ decomposition,

$$SS(I) = \sum_{i=1}^{I} \sum_{j=1}^{J} (y_{ij} - \bar{y}_{i\cdot} - \bar{y}_{\cdot j} + \bar{y}_{\cdot\cdot})^2. \tag{6}$$

The fractional contribution to uncertainty is then $\frac{SS(M)}{SS(T)}$ for the model structure, $\frac{SS(F)}{SS(T)}$ for the atmospheric forcing, and $\frac{SS(I)}{SS(T)}$ for the interaction term.

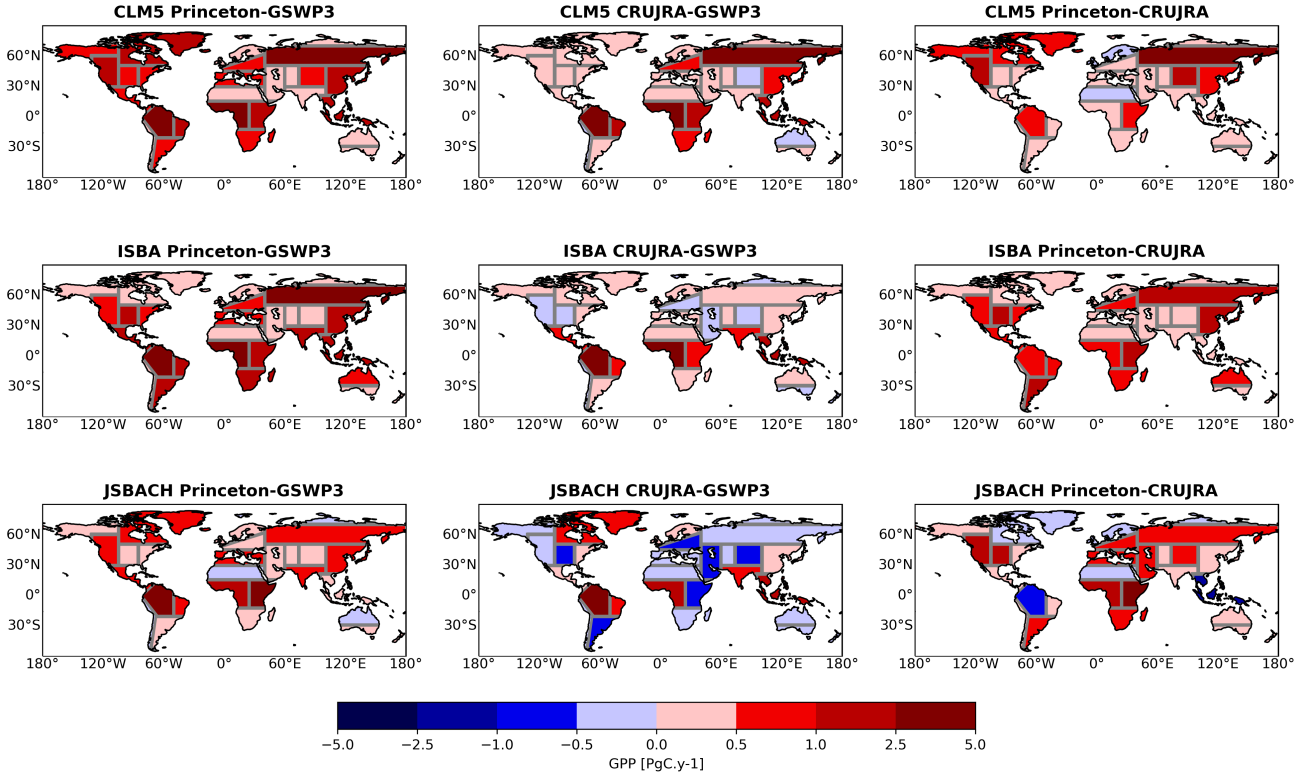

Figure S1. Differences in annual mean GPP computed with the 3 forcings (columns), by the 3 TBMs (lines)

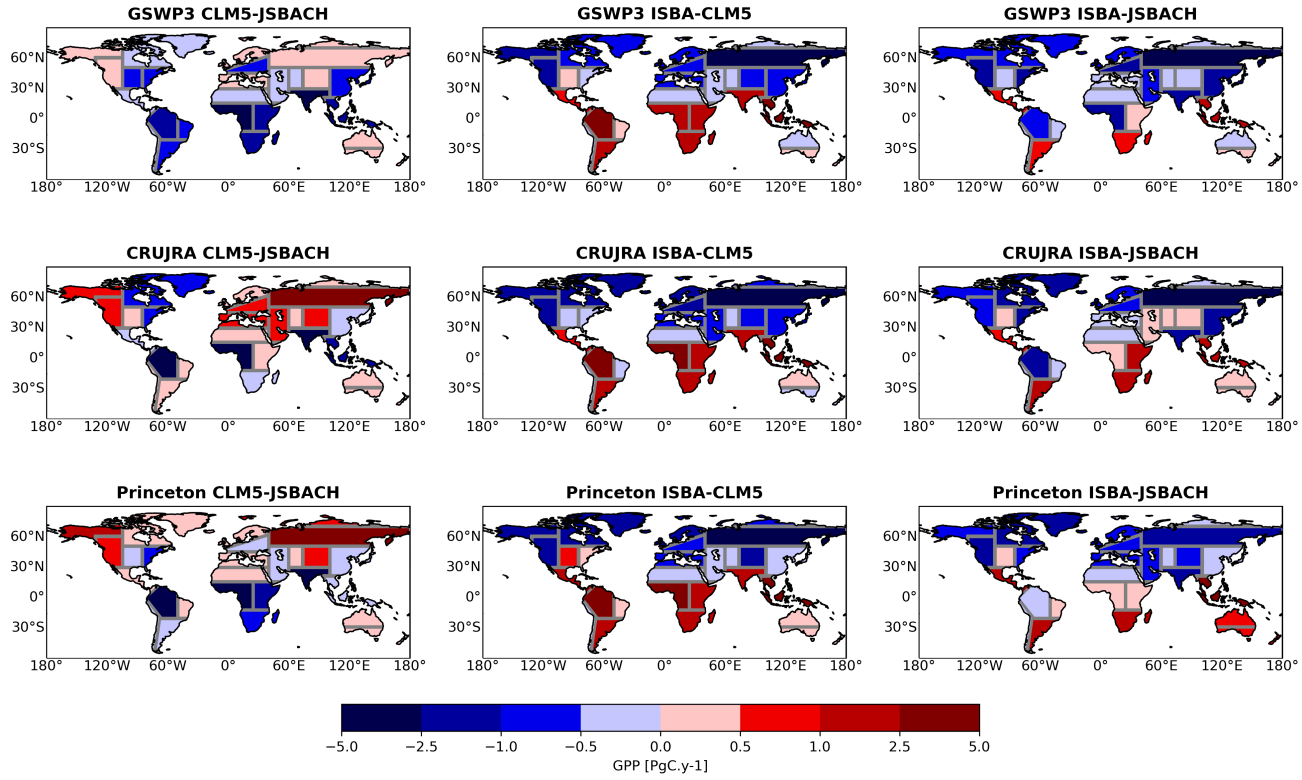

Figure S2. Differences in annual mean GPP between the 3 TBMs (columns), forced by the 3 forcings (lines)

Table S1. Global land averages of atmospheric forcing variables : pr (precipitation), huss (relative humidity), rlds (longwave downwelling radiation), rsds (shortwave downwelling radiation), surface air temperature (tas), surface wind speed (sfcWind)

Forcing	pr ($mm.y^{-1}$)	huss (g/kg)	rlds ($W.m^{-2}$)	rsds ($W.m^{-2}$)	tas (K)	sfcWind ($m.s^{-1}$)
CRUJRA	746	7.1	301.1	189.5	282.5	3.36
GSWP3	762	7.2	308.5	182.6	282.5	3.41
Princeton	729	8.1	308.3	183.8	282.1	3.45

Table S2. Percentage of total variance of GPP (rigth-most column) explained by model, forcing and interactions (middle columns) for 30 sub-continental SREX regions

		Percentage of total variance			Total variance
		Model	Forcing	Interactions	(kg m^{-2} yr^{-1})^2
Alaska/N.W. Canada	ALA	91	7	3	10.64
Amazon	AMZ	52	47	1	133.89
Central America/Mexico	CAM	60	34	5	5.49
small islands regions Caribbean	CAR	97	1	1	1.64
Central Asia	CAS	42	31	28	0.31
Central Europe	CEU	51	33	17	5.92
Canada/Greenland/Iceland	CGI	72	22	6	7.06
Central North America	CNA	3	72	25	3.64
East Africa	EAF	35	54	12	38.24
East Asia	EAS	39	54	7	10.75
East North America	ENA	67	28	5	4.44
South Europe/Mediterranean	MED	52	40	8	3.55
North Asia	NAS	69	20	11	140.31
North Australia	NAU	28	40	32	1.42
North-East Brazil	NEB	0	89	11	6.07
North Europe	NEU	90	6	3	4.30
Southern Africa	SAF	79	12	8	14.93
Sahara	SAH	91	0	9	0.14
South Asia	SAS	94	6	1	43.28
South Australia/New Zealand	SAU	56	36	9	0.92
Southeast Asia	SEA	76	18	6	41.01
Southeastern South America	SSA	67	21	11	11.87
Tibetan Plateau	TIB	58	32	10	4.31
West Africa	WAF	55	41	3	76.31
West Asia	WAS	38	32	30	1.93
West North America	WNA	70	28	2	12.28
West Coast South America	WSA	26	57	16	0.53
Arctic	ARC	91	3	6	1.04
Pacific Islands region	PIR	99	1	0	0.24

Table S3. Percentage of total variance of Ra (rigth-most column) explained by model, forcing and interactions (middle columns) for 30 sub-continental SREX regions

		Percentage of total variance			Total variance
		Model	Forcing	Interactions	(kg m^{-2} yr^{-1})^2
Alaska/N.W. Canada	ALA	96	3	1	3.63
Amazon	AMZ	77	22	1	116.38
Central America/Mexico	CAM	68	26	6	3.22
small islands regions Caribbean	CAR	97	1	1	0.72
Central Asia	CAS	67	16	16	0.18
Central Europe	CEU	83	13	4	3.52
Canada/Greenland/Iceland	CGI	86	10	4	2.63
Central North America	CNA	15	68	17	1.07
East Africa	EAF	28	63	9	12.63
East Asia	EAS	33	50	17	3.32
East North America	ENA	64	27	8	1.35
South Europe/Mediterranean	MED	75	20	5	2.23
North Asia	NAS	89	7	4	56.73
North Australia	NAU	72	18	10	1.61
North-East Brazil	NEB	43	48	9	3.87
North Europe	NEU	93	4	3	2.33
Southern Africa	SAF	61	26	13	3.13
Sahara	SAH	95	0	5	0.08
South Asia	SAS	96	4	1	25.83
South Australia/New Zealand	SAU	62	30	8	0.30
Southeast Asia	SEA	91	6	2	51.36
Southeastern South America	SSA	63	21	15	5.37
Tibetan Plateau	TIB	76	18	6	1.36
West Africa	WAF	52	42	6	30.88
West Asia	WAS	63	17	19	1.18
West North America	WNA	84	14	2	5.67
West Coast South America	WSA	43	48	10	0.17
Arctic	ARC	95	2	3	0.31
Pacific Islands region	PIR	99	1	1	0.12

Table S4. Percentage of total variance of Rh (rigth-most column) explained by model, forcing and interactions (middle columns) for 30 sub-continental SREX regions

		Percentage of total variance			Total variance
		Model	Forcing	Interactions	(kg m^{-2} yr^{-1})^2
Alaska/N.W. Canada	ALA	80	12	8	2.27
Amazon	AMZ	93	7	0	128.17
Central America/Mexico	CAM	56	38	6	0.45
small islands regions Caribbean	CAR	97	2	1	0.18
Central Asia	CAS	27	41	32	0.03
Central Europe	CEU	29	38	33	1.12
Canada/Greenland/Iceland	CGI	64	29	7	1.76
Central North America	CNA	40	36	23	1.34
East Africa	EAF	63	26	11	9.01
East Asia	EAS	59	34	7	3.54
East North America	ENA	74	17	9	1.28
South Europe/Mediterranean	MED	49	38	12	0.49
North Asia	NAS	33	43	25	27.36
North Australia	NAU	78	9	13	0.42
North-East Brazil	NEB	70	26	4	3.45
North Europe	NEU	73	14	14	0.31
Southern Africa	SAF	91	5	4	4.27
Sahara	SAH	82	2	16	0.01
South Asia	SAS	87	12	0	2.36
South Australia/New Zealand	SAU	66	25	9	0.24
Southeast Asia	SEA	76	16	8	4.99
Southeastern South America	SSA	66	18	16	1.56
Tibetan Plateau	TIB	30	48	22	0.93
West Africa	WAF	86	12	2	31.07
West Asia	WAS	10	47	43	0.15
West North America	WNA	49	40	11	1.76
West Coast South America	WSA	48	37	15	0.18
Arctic	ARC	83	6	11	0.27
Pacific Islands region	PIR	99	1	0	0.02