1 Supplement

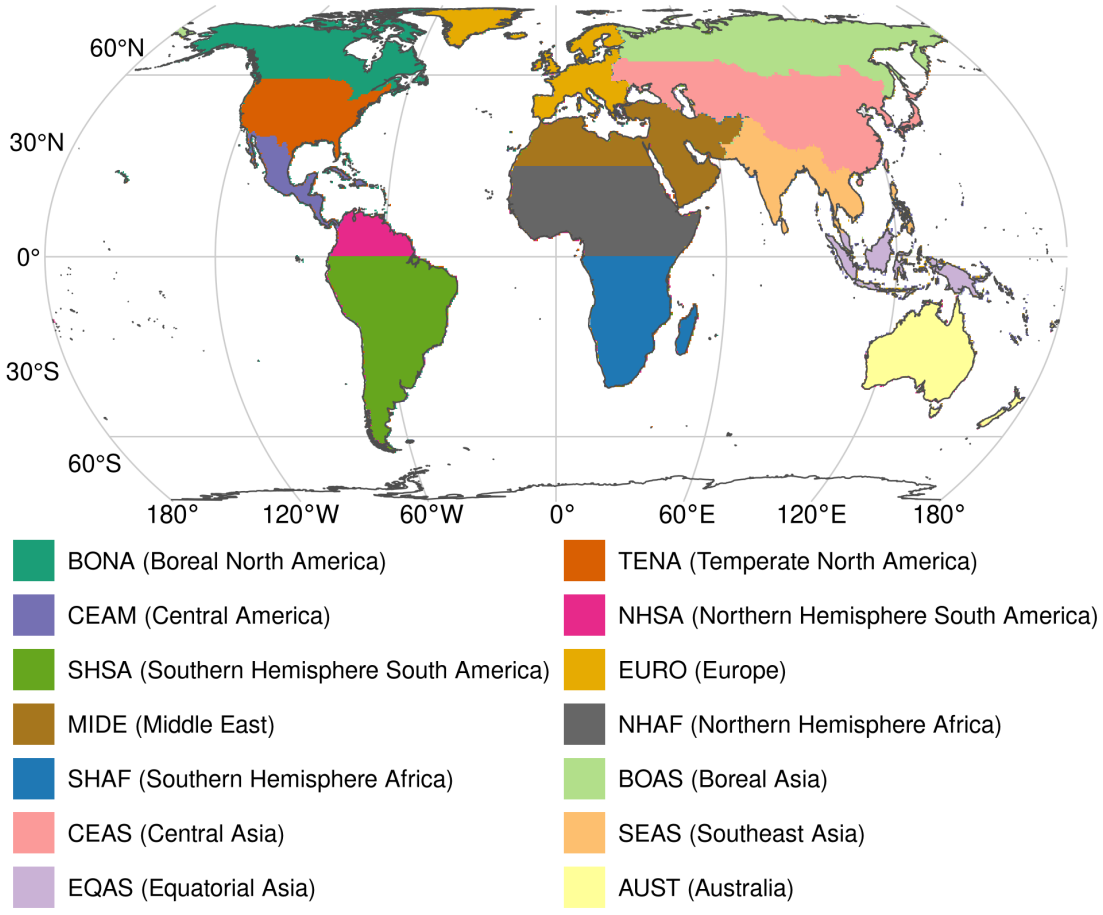

Figure S1. GFED regions used in our analysis following **?**, re-gridded to 0.5° resolution.

Region	GFED4.1s$_{nat}$	GFED5$_{nat}$	Prognostic BA	Diagnostic BA	Prog. – Diag.
GLOBAL	1.58	2.81	2.34 ± 1.75	1.84 ± 0.71	0.50
NHAF	0.38	0.66	0.41 ± 0.37	0.35 ± 0.17	0.06
SHAF	0.62	0.92	0.48 ± 0.43	0.65 ± 0.24	-0.17
SHSA	0.14	0.22	0.37 ± 0.35	0.31 ± 0.22	0.06
SEAS	0.07	0.28	0.28 ± 0.28	0.10 ± 0.06	0.18
AUST	0.10	0.17	0.14 ± 0.11	0.11 ± 0.05	0.03
BOAS	0.10	0.28	0.07 ± 0.09	0.09 ± 0.04	-0.02
CEAS	0.03	0.05	0.14 ± 0.09	0.04 ± 0.02	0.10
CEAM	0.01	0.07	0.08 ± 0.08	0.04 ± 0.03	0.04
NHSA	0.02	0.03	0.04 ± 0.04	0.06 ± 0.04	-0.02
TENA	0.02	0.02	0.09 ± 0.07	0.03 ± 0.02	0.06
MIDE	0.00	0.00	0.05 ± 0.05	0.01 ± 0.01	0.04
EQAS	0.01	0.02	0.02 ± 0.02	0.02 ± 0.02	0.00
BONA	0.06	0.08	0.06 ± 0.07	0.03 ± 0.02	0.03
EURO	0.00	0.01	0.07 ± 0.06	0.01 ± 0.01	0.06

Table S1. Mean fire emissions across the shared GFED period (2002–2016) in the GFED4.1s and GFED5 products (with land-use associated fires removed) and multi-model averages in the prognostic and diagnostic BA simulations, with inter-model spread (S.D) shown. The final column shows the difference in the multi-model mean (Prognostic BA minus Diagnostic BA).

Region	GFED4.1s$_{nat}$	GFED5$_{nat}$	Prognostic BA	Diagnostic BA
GLOBAL	0.39	0.42	0.37 ± 0.16	0.44 ± 0.17
NHAF	0.28	0.30	0.27 ± 0.17	0.27 ± 0.14
SHAF	0.37	0.39	0.44 ± 0.17	0.40 ± 0.15
SHSA	0.64	0.50	0.60 ± 0.16	1.06 ± 0.75
SEAS	0.62	0.66	0.47 ± 0.15	1.00 ± 0.62
AUST	0.23	0.34	0.33 ± 0.14	0.26 ± 0.13
BOAS	1.30	1.12	0.65 ± 0.37	0.73 ± 0.36
CEAS	0.30	0.23	0.62 ± 0.30	0.38 ± 0.19
CEAM	0.67	0.69	0.42 ± 0.13	1.76 ± 1.30
NHSA	0.44	0.30	0.64 ± 0.28	1.10 ± 0.81
TENA	1.00	0.62	0.42 ± 0.21	1.08 ± 0.79
MIDE	1.33	0.35	0.21 ± 0.14	0.34 ± 0.38
EQAS	1.46	0.78	1.68 ± 1.75	3.66 ± 3.31
BONA	2.86	2.86	0.59 ± 0.33	1.33 ± 0.89
EURO	0.79	0.61	0.66 ± 0.22	1.54 ± 1.25

Table S2. Mean fire combustion rates across shared GFED period (2002–2016) in the GFED4.1s and GFED5 products (with land-use associated fires removed) and multi-model averages in the prognostic and diagnostic BA simulations, with inter-model spread (S.D) also shown.

Region	Benchmark		DGVM Name				
	GFED4.1s$_{nat}$	GFED5$_{nat}$	JULES	EDv3	VISIT-UT	ORCHIDEE	OCN
GLOBAL	0.66*	–	0.16	-0.34	0.52	0.20	0.16
	–	1.20*	0.21	-0.07	0.62*	0.36	0.31
NHAF	0.73*	–	0.29	-0.14	0.16	0.55*	0.62*
	–	1.01*	0.69	0.62	0.67	1.08*	1.55*
SHAF	0.30	–	-0.01	0.11	0.14	-0.10	-0.05
	–	0.26	-0.03	0.41	0.20	-0.01	0.10
SHSA	-0.79*	–	-0.63*	-2.01*	-0.38	-0.32	-1.12
	–	0.93*	-0.67*	-1.32	-0.56	-0.27	-0.93
SEAS	-2.03*	–	0.37	1.25	0.79	0.48	0.87
	–	0.79*	0.13	0.53	0.56	0.24	0.70
AUST	-0.21	–	0.11	-2.43	-0.11	0.23	-0.46
	–	4.46*	0.96	13.50	1.34	1.24	4.15
BOAS	3.14*	–	0.46	0.60	1.69*	0.92	1.16*
	–	8.52*	-0.26	-1.22	1.84*	1.18*	0.38
CEAS	0.11	–	1.85*	6.68*	3.72	1.45	3.24*
	–	0.74	0.30	0.24	-0.11	-0.09	0.64
CEAM	-0.08	–	-0.63	0.45	0.55	0.15	0.36
	–	0.90*	-0.20	0.15	0.18	0.12	-0.21
NHSA	0.45	–	0.85	1.90	1.75	0.68	1.97
	–	1.53*	0.70	1.09	0.89	0.45	0.93
TENA	1.16	–	0.96	1.29	0.58	0.99	1.23
	–	3.42*	0.63	-0.03	0.84	0.48	0.07
MIDE	-0.85	–	-0.20	-1.34	1.94	0.22	-0.30
	–	1.72	0.41	-0.59	1.98	0.61	-0.57
EQAS	-1.11	–	1.05*	3.34*	0.94	-0.01	2.57*
	–	-0.40	0.41	0.86	-0.67	0.97	-0.19
BONA	2.94*	–	0.69	1.14	0.23	0.21	0.88
	–	-0.55	1.01	1.41	-0.42	-0.39	2.46*
EURO	0.96	–	-0.61	0.28	2.26	-0.31	2.49
	–	2.22	-0.32	0.21	2.64	0.19	1.20

Table S3. Simulated fire combustion rate regional trends under diagnostic BA (% year^{-1}), with * denoting significance at the 95% level. Values are shown as 2001–2016 (top) and 2002–2020 (bottom), since the augmented "natural" GFED4.1s and GFED5 data spans 2001–2016 and 2002–2020, receptively.

Region	GCB Inversions$_{adj}$	Prognostic BA	Diagnostic BA	Prog. – Diag.	Bias Reduction
GLOBAL	2.62 ± 0.62	3.23 ± 1.28	2.88 ± 1.13	0.35	0.35
NHAF	0.04 ± 0.30	0.27 ± 0.14	0.25 ± 0.13	0.02	0.02
SHAF	0.08 ± 0.20	0.33 ± 0.15	0.22 ± 0.13	0.11	0.11
SHSA	0.28 ± 0.48	0.46 ± 0.46	0.37 ± 0.42	0.09	0.09
SEAS	0.31 ± 0.38	0.22 ± 0.12	0.20 ± 0.09	0.02	-0.02
AUST	0.07 ± 0.17	0.04 ± 0.13	0.01 ± 0.12	0.03	-0.03
BOAS	0.56 ± 0.27	0.42 ± 0.14	0.38 ± 0.17	0.04	-0.04
CEAS	0.45 ± 0.47	0.31 ± 0.17	0.31 ± 0.15	0.00	0.00
CEAM	0.02 ± 0.12	0.11 ± 0.08	0.10 ± 0.06	0.01	0.01
NHSA	-0.02 ± 0.10	0.18 ± 0.15	0.16 ± 0.14	0.02	0.02
TENA	0.29 ± 0.31	0.20 ± 0.19	0.19 ± 0.19	0.01	-0.01
MIDE	-0.03 ± 0.10	0.04 ± 0.04	0.05 ± 0.05	-0.01	-0.01
EQAS	0.25 ± 0.15	0.20 ± 0.10	0.19 ± 0.10	0.01	-0.01
BONA	0.37 ± 0.15	0.26 ± 0.08	0.27 ± 0.08	-0.01	0.01
EURO	0.04 ± 0.16	0.16 ± 0.11	0.17 ± 0.11	-0.01	-0.01

Table S4. Mean natural land sink (NBP) in the land-use emission and river flux adjusted GCB inversions and multi-model averages in the prognostic and diagnostic BA simulations, with inter-model spread (S.D) shown. The final columns show the difference in the multi-model mean (Prognostic BA minus Diagnostic BA), and the reduction in absolute bias relative to the adjusted GCB inversion means when diagnostic BA is used over prognostic.

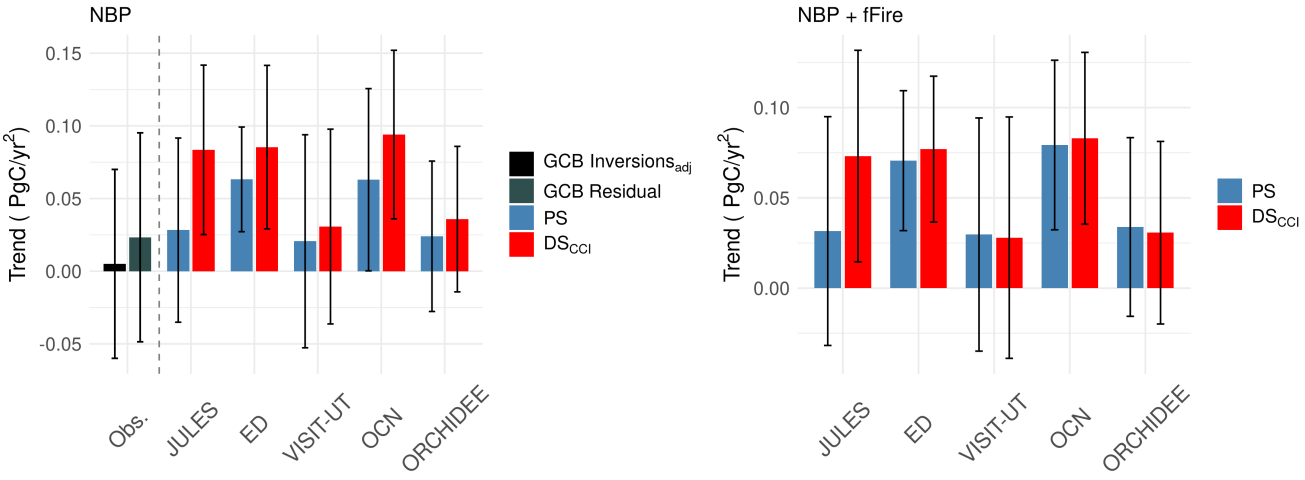

Figure S2. Bar plots of the linear trends in NBP and NBP plus fire emissions across all models over 2001–2020, with whiskers showing and 95% confidence intervals. In panel a, trends in the GCB residual and GCB inversion datasets (adjusted for land-use change emissions and the river flux) are also shown.

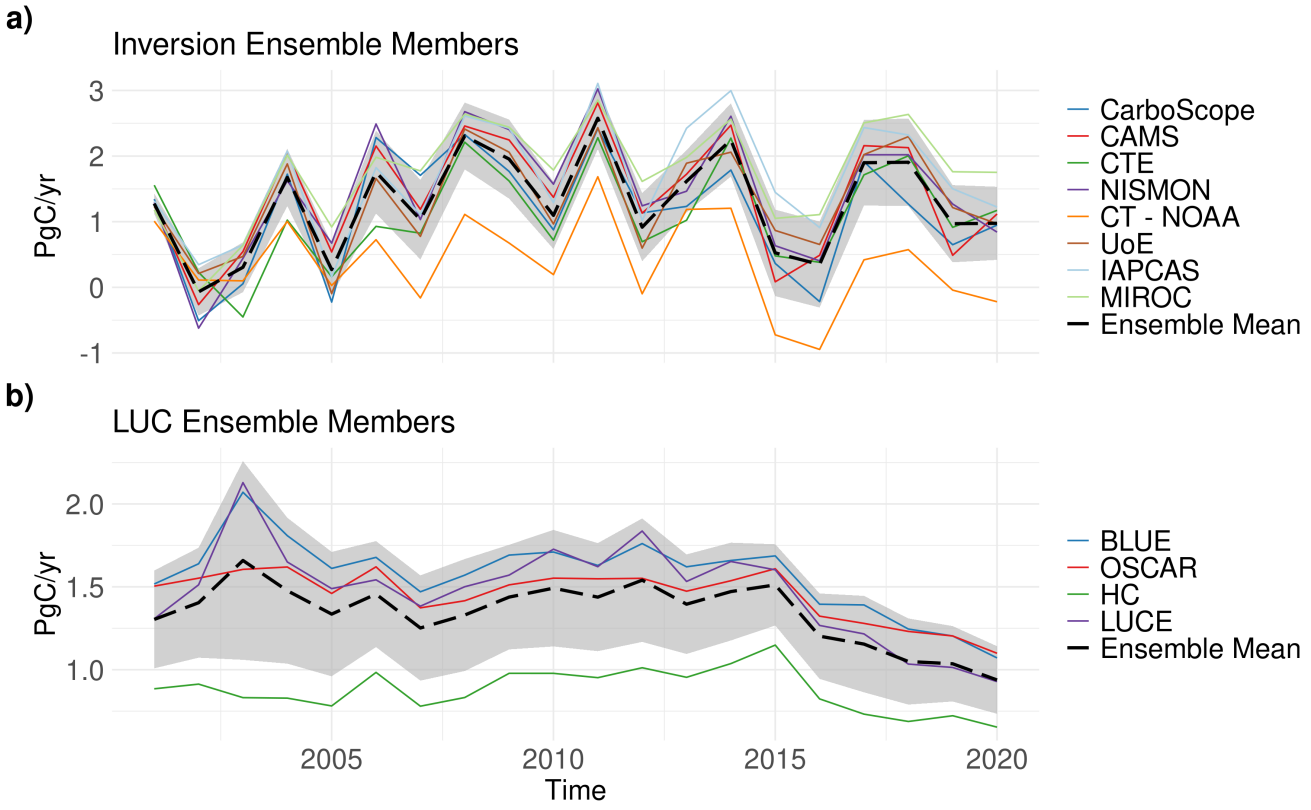

Figure S3. Atmospheric inversion estimates used in GCB over 2001–2020 adjusted for the lateral river flux (n = 8, panel a) and land-use change emission estimates (n = 4, panel b) from each model used in the GCB ensembles, further described in Section **??**. Ensemble means are added in black (dashed) and shaded area show area enclosed by 1 inter-model S.D about the mean.

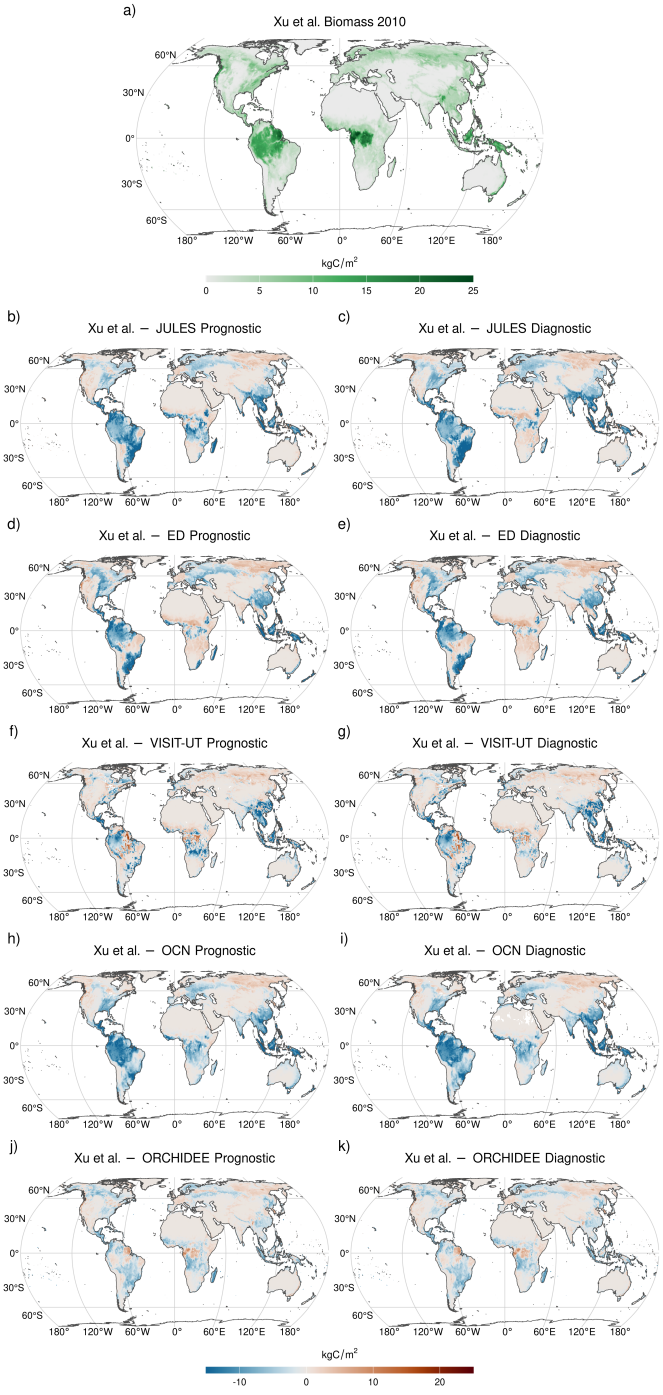

Figure S4. Spatial plots of the difference between biomass carbon estimates from each participating model and the **?** biomass product globally in 2010.