

1 Supporting Information

2 Title

3 Development of an ensemble-adjoint optimization approach to derive uncertainties in
4 net carbon fluxes

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17 **Figures and Tables**

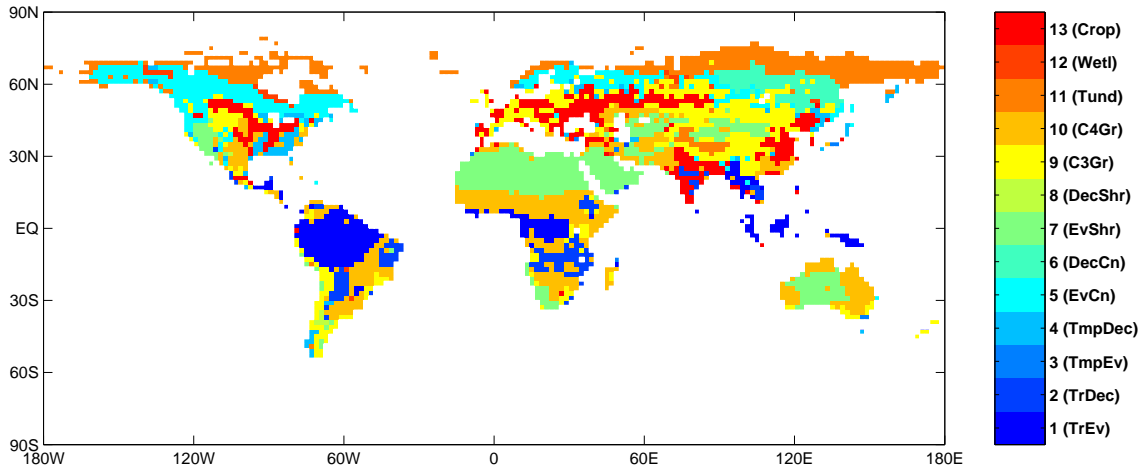


Figure S1: Distribution of the dominant PDF per grid cell. PFT labels are given in Table S3.

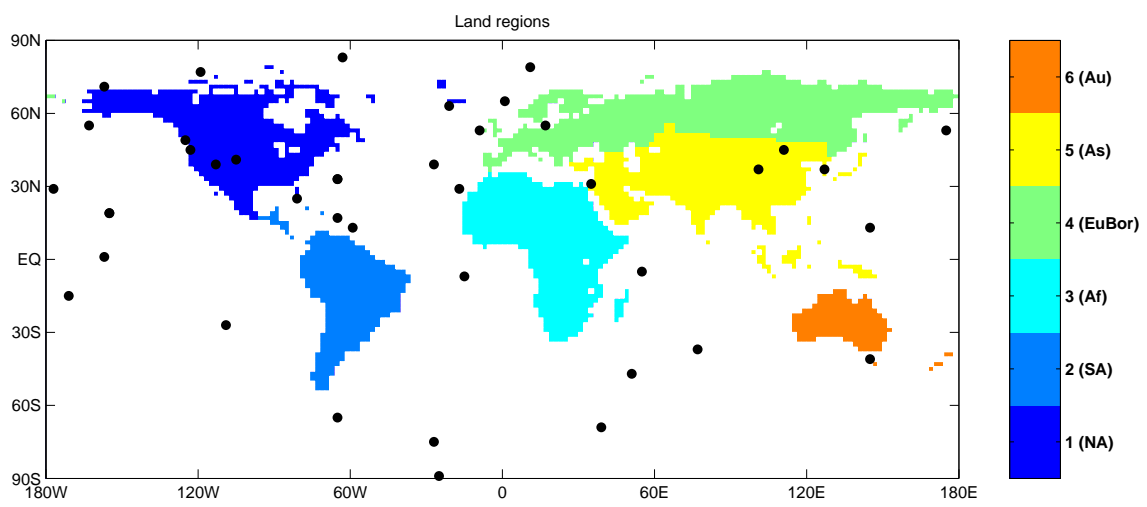


Figure S2: Land regions and the location of the 41 stations used in CCDAS. Labels are given in Table S4.

Table S1: Prior parameter values and uncertainties for the NPP related parameters. Units: V_{max}^{25} , $\mu\text{mol}(\text{CO}_2)\text{m}^{-2}\text{s}^{-1}$; $a_{\Gamma,T}$, $\mu\text{mol}(\text{CO}_2)\text{mol}(\text{air})^{-1}(\text{°C})^{-1}$; activation energies E , J/mol; all others unitless. Uncertainties are in percentage and represent one standard deviation.

No.	Parameter	Initial value	Prior uncertainty
1	$V_{max}^{25}(TrEv)$	60.00	20
2	$V_{max}^{25}(TrDec)$	90.00	20
3	$V_{max}^{25}(TmpEv)$	41.00	20
4	$V_{max}^{25}(TmpDec)$	35.00	20
5	$V_{max}^{25}(EvCn)$	29.00	20
6	$V_{max}^{25}(DecCn)$	53.00	20
7	$V_{max}^{25}(EvShr)$	52.00	20
8	$V_{max}^{25}(DecShr)$	160.00	20
9	$V_{max}^{25}(C3Gr)$	42.00	20
10	$V_{max}^{25}(C4Gr)$	8.00	20
11	$V_{max}^{25}(Tund)$	20.00	20
12	$V_{max}^{25}(Wetl)$	20.00	20
13	$V_{max}^{25}(Crop)$	117.00	20
14	$a_{J,V}(TrEv)$	1.96	5
15	$a_{J,V}(TrDec)$	1.99	5
16	$a_{J,V}(TmpEv)$	2.00	5
17	$a_{J,V}(TmpDec)$	2.00	5
18	$a_{J,V}(EvCn)$	1.79	5
19	$a_{J,V}(DecCn)$	1.79	5
20	$a_{J,V}(EvShr)$	1.96	5
21	$a_{J,V}(DecShr)$	1.66	5
22	$a_{J,V}(C3Gr)$	1.90	5
23	$a_{J,V}(C4Gr)$	14.00	5
24	$a_{J,V}(Tund)$	1.85	5
25	$a_{J,V}(Wetl)$	1.85	5
26	$a_{J,V}(Crop)$	1.88	5
27	α_q	0.28	5
28	α_i	0.04	5
29	K_C^{25}	460×10^{-6}	5
30	K_O^{25}	0.33	5
31	$a_{\Gamma,T}$	1.70	5
32	E_{K_O}	35948	5
33	E_{K_C}	59356	5
34	$E_{V_{max}}$	58520	5
35	E_k	50967	5
36	E_{R_d}	45000	5
37	$f_{R.leaf}$	0.40	25
38	$f_{R.growth}$	1.25	5

Table S2: Prior and posterior parameter values including their uncertainties for the carbon balance parameter β and the offset. Upper and lower percentiles equivalent to one standard deviation are given. The first index for the β parameters refers to the PFT (labels see Table S3) and the second one to the region (labels see Table S4). Units: offset, ppmv; β , unitless.

No.	Parameter	Prior			Posterior					
		μ	$\mu - \sigma$	$\mu + \sigma$	Base Case			Superimposed		
					μ	$\mu - \sigma$	$\mu + \sigma$	μ	$\mu - \sigma$	$\mu + \sigma$
1	$\beta_{1,1}$	1.00	0.75	1.25	0.65	0.47	0.87	0.66	0.47	0.88
2	$\beta_{2,1}$	1.00	0.75	1.25	0.42	0.31	0.56	0.43	0.30	0.65
3	$\beta_{3,1}$	1.00	0.75	1.25	0.82	0.60	1.07	0.82	0.60	1.07
4	$\beta_{4,1}$	1.00	0.75	1.25	0.25	0.20	0.32	0.25	0.19	0.33
5	$\beta_{5,1}$	1.00	0.75	1.25	1.56	1.52	1.60	1.57	1.49	1.66
6	$\beta_{7,1}$	1.00	0.75	1.25	1.04	0.86	1.22	1.01	0.71	1.26
7	$\beta_{8,1}$	1.00	0.75	1.25	0.75	0.55	0.99	0.77	0.54	1.07
8	$\beta_{9,1}$	1.00	0.75	1.25	0.61	0.49	0.74	0.62	0.46	0.79
9	$\beta_{10,1}$	1.00	0.75	1.25	1.29	1.21	1.36	1.24	1.08	1.37
10	$\beta_{11,1}$	1.00	0.75	1.25	1.28	1.16	1.40	1.26	1.07	1.42
11	$\beta_{12,1}$	1.00	0.75	1.25	1.38	1.18	1.55	1.37	1.14	1.56
12	$\beta_{13,1}$	1.00	0.75	1.25	0.22	0.17	0.28	0.21	0.16	0.29
13	$\beta_{1,2}$	1.00	0.75	1.25	0.74	0.72	0.76	0.74	0.68	0.78
14	$\beta_{2,2}$	1.00	0.75	1.25	1.86	1.82	1.89	1.85	1.80	1.89
15	$\beta_{4,2}$	1.00	0.75	1.25	1.73	1.65	1.80	1.73	1.63	1.80
16	$\beta_{5,2}$	1.00	0.75	1.25	1.62	1.49	1.72	1.61	1.47	1.72
17	$\beta_{7,2}$	1.00	0.75	1.25	1.73	1.64	1.80	1.73	1.63	1.80
18	$\beta_{8,2}$	1.00	0.75	1.25	1.86	1.81	1.89	1.85	1.79	1.89
19	$\beta_{9,2}$	1.00	0.75	1.25	1.93	1.92	1.95	1.93	1.91	1.95
20	$\beta_{10,2}$	1.00	0.75	1.25	0.80	0.76	0.85	0.84	0.66	1.04
21	$\beta_{11,2}$	1.00	0.75	1.25	1.06	0.81	1.30	1.05	0.80	1.30
22	$\beta_{12,2}$	1.00	0.75	1.25	1.33	1.11	1.52	1.33	1.11	1.52
23	$\beta_{13,2}$	1.00	0.75	1.25	1.59	1.46	1.70	1.58	1.43	1.70
24	$\beta_{1,3}$	1.00	0.75	1.25	1.23	1.14	1.31	1.19	0.93	1.40
25	$\beta_{2,3}$	1.00	0.75	1.25	0.13	0.10	0.16	0.13	0.10	0.17
26	$\beta_{3,3}$	1.00	0.75	1.25	0.84	0.62	1.08	0.86	0.62	1.12
27	$\beta_{4,3}$	1.00	0.75	1.25	0.94	0.70	1.19	0.94	0.70	1.20
28	$\beta_{7,3}$	1.00	0.75	1.25	0.44	0.33	0.58	0.45	0.32	0.69
29	$\beta_{8,3}$	1.00	0.75	1.25	1.51	1.35	1.65	1.49	1.08	1.66
30	$\beta_{9,3}$	1.00	0.75	1.25	1.35	1.24	1.46	1.34	1.15	1.49
31	$\beta_{10,3}$	1.00	0.75	1.25	1.07	1.03	1.11	1.06	0.98	1.14
32	$\beta_{12,3}$	1.00	0.75	1.25	1.18	0.94	1.41	1.18	0.93	1.41
33	$\beta_{13,3}$	1.00	0.75	1.25	1.34	1.13	1.52	1.31	1.04	1.52
34	$\beta_{3,4}$	1.00	0.75	1.25	1.04	0.79	1.29	1.04	0.79	1.29
35	$\beta_{4,4}$	1.00	0.75	1.25	0.96	0.73	1.18	0.98	0.68	1.28
36	$\beta_{5,4}$	1.00	0.75	1.25	0.79	0.68	0.91	0.80	0.65	0.96
37	$\beta_{6,4}$	1.00	0.75	1.25	1.52	1.40	1.62	1.54	1.30	1.72
38	$\beta_{7,4}$	1.00	0.75	1.25	0.55	0.40	0.73	0.56	0.39	0.78
39	$\beta_{8,4}$	1.00	0.75	1.25	0.38	0.28	0.51	0.40	0.28	0.56
40	$\beta_{9,4}$	1.00	0.75	1.25	1.62	1.55	1.69	1.60	1.45	1.73
41	$\beta_{10,4}$	1.00	0.75	1.25	0.25	0.19	0.33	0.25	0.18	0.34
42	$\beta_{11,4}$	1.00	0.75	1.25	0.58	0.49	0.68	0.61	0.38	0.88
43	$\beta_{12,4}$	1.00	0.75	1.25	0.81	0.59	1.05	0.81	0.57	1.07
44	$\beta_{13,4}$	1.00	0.75	1.25	0.31	0.24	0.40	0.31	0.21	0.46
45	$\beta_{1,5}$	1.00	0.75	1.25	0.25	0.20	0.31	0.26	0.19	0.34
46	$\beta_{2,5}$	1.00	0.75	1.25	1.85	1.80	1.88	1.84	1.76	1.88
47	$\beta_{3,5}$	1.00	0.75	1.25	0.52	0.38	0.69	0.53	0.38	0.73
48	$\beta_{4,5}$	1.00	0.75	1.25	0.27	0.21	0.36	0.28	0.21	0.38
49	$\beta_{5,5}$	1.00	0.75	1.25	0.33	0.24	0.43	0.33	0.24	0.46
50	$\beta_{7,5}$	1.00	0.75	1.25	0.31	0.24	0.40	0.32	0.20	0.51
51	$\beta_{8,5}$	1.00	0.75	1.25	1.46	1.29	1.61	1.43	1.19	1.60
52	$\beta_{9,5}$	1.00	0.75	1.25	0.63	0.57	0.70	0.63	0.48	0.77
53	$\beta_{10,5}$	1.00	0.75	1.25	0.29	0.24	0.36	0.28	0.20	0.40
54	$\beta_{11,5}$	1.00	0.75	1.25	0.93	0.69	1.18	0.92	0.68	1.17
55	$\beta_{12,5}$	1.00	0.75	1.25	1.04	0.79	1.29	1.04	0.79	1.29
56	$\beta_{13,5}$	1.00	0.75	1.25	1.86	1.81	1.89	1.85	1.71	1.89
57	$\beta_{1,6}$	1.00	0.75	1.25	0.88	0.64	1.13	0.88	0.64	1.13
58	$\beta_{2,6}$	1.00	0.75	1.25	0.99	0.75	1.24	1.00	0.75	1.25
59	$\beta_{3,6}$	1.00	0.75	1.25	0.47	0.35	0.61	0.47	0.34	0.63
60	$\beta_{4,6}$	1.00	0.75	1.25	1.40	1.20	1.56	1.39	1.18	1.56
61	$\beta_{5,6}$	1.00	0.75	1.25	1.27	1.04	1.47	1.27	1.03	1.47
62	$\beta_{7,6}$	1.00	0.75	1.25	0.23	0.18	0.30	0.23	0.16	0.34
63	$\beta_{8,6}$	1.00	0.75	1.25	0.78	0.56	1.02	0.79	0.56	1.05
64	$\beta_{9,6}$	1.00	0.75	1.25	0.38	0.31	0.47	0.39	0.28	0.53
65	$\beta_{10,6}$	1.00	0.75	1.25	1.54	1.48	1.59	1.51	1.37	1.61
66	$\beta_{11,6}$	1.00	0.75	1.25	1.03	0.78	1.28	1.03	0.78	1.28
67	$\beta_{13,6}$	1.00	0.75	1.25	0.61	0.44	0.80	0.61	0.44	0.83
68	offset	338.00	337.00	339.00	336.53	336.48	336.58	336.51	336.42	336.59

Table S3: PFTs as used in CarbonBETHY.

PFT	
1	Tropical broadleaved evergreen tree (TrEv)
2	Tropical broadleaved deciduous tree (TrDec)
3	Temperate broadleaved evergreen tree (TmpEv)
4	Temperate broadleaved deciduous tree (TmpDec)
5	Evergreen coniferous tree (EvCn)
6	Deciduous coniferous tree (DecCn)
7	Evergreen shrub (EvShr)
8	Deciduous shrub (DecShr)
9	C3 grass (C3Gr)
10	C4 grass (C4Gr)
11	Tundra vegetation (Tund)
12	Swamp vegetation (Wetl)
13	Crops (Crop)

Table S4: Regions as used in CarbonBETHY.

Region	
1	North America (NA)
2	South America (SA)
3	Africa (Af)
4	Boreal Europe/Asia (EuBor)
5	Asia (As)
6	Australia (Au)