Supplementary material for:

Enhancement and validation of a state-of-the-art global hydrological model H08 (v.bio1) to simulate second-generation herbaceous bioenergy crop yield

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Table s1. Location of the sites used to model calibration for *Miscanthus*.

ID	Country	Longitude	Latitude
1	Indonesia	107.70	-7.00
2	US	-97.10	36.10
3	US	-88.67	37.45
4	Turkey	33.23	38.17
5	US	-88.39	38.38
6	US	-90.82	39.81
7	US	-88.23	40.08
8	US	-88.19	40.17
9	US	-88.85	41.85
10	Italy	10.32	43.67
11	Switzerland	9.13	47.57
12	Germany	10.00	48.00
13	Austria	14.22	48.11
14	Germany	9.97	48.13
15	Austria	14.15	48.14
16	Austria	16.39	48.18
17	Austria	15.55	48.19
18	Austria	15.00	48.30
19	Germany	11.54	48.31
20	Germany	10.26	48.49
21	Germany	11.63	48.60
22	Germany	9.00	48.70
23	Germany	8.93	48.73
24	Germany	8.92	48.75
25	Germany	9.19	48.78
26	Germany	8.10	49.00
27	Germany	6.72	49.82
28	France	3.00	49.87
29	France	3.01	49.87
30	Germany	9.90	49.90
31	Germany	10.77	50.97
32	Blegium	3.80	51.00
33	UK	-1.26	51.10
34	Poland	22.63	51.23
35	Germany	6.70	51.50
36	Germany	6.70	51.52
37	Germany	7.62	51.78
38	UK	-0.40	51.80
39	UK	-2.64	51.80
40	UK	-0.35	51.80
41	UK	-0.36	51.82
42	UK	-0.62	52.01

43	UK	-0.03	52.25
44	Poland	16.92	52.42
45	UK	0.09	52.42
46	UK	-4.02	52.43
47	Germany	10.80	52.60
48	Germany	8.26	52.61
49	Germany	10.81	52.62
50	Ireland	-7.83	52.65
51	Ireland	-7.27	52.67
52	Germany	8.81	52.68
53	Netherlands	7.06	52.88
54	UK	-3.78	53.22
55	Netherlands	6.95	53.30
56	Poland	19.38	53.78
57	Germany	12.60	53.90
58	UK	-1.11	54.12
59	UK	-0.64	54.12
60	Denmark	9.12	54.90
61	Sweden	14.00	56.00
62	UK	-3.06	56.46
63	Denmark	9.60	56.50
64	Denmark	9.40	56.80

Table s2. Location of the sites used to model calibration for switchgrass

ID	Country	Longitude	Latitude
1	US	-97.70	28.45
2	US	-89.94	30.30
3	US	-87.32	32.00
4	US	-98.20	32.23
5	US	-85.90	32.44
6	US	-85.65	32.82
7	US	-87.87	33.88
8	US	-85.97	34.28
9	US	-88.90	35.60
10	US	-78.70	35.70
11	US	-83.95	35.88
12	US	-84.00	35.90
13	US	-97.07	36.12
14	China	109.32	36.85
15	US	-78.23	36.92
16	US	-87.80	37.10
17	US	-80.40	37.20
18	US	-88.67	37.45
19	China	118.49	37.46
20	US	-77.97	38.02
21	US	-78.10	38.20
22	US	-88.39	38.38
23	US	-88.96	38.95
24	China	113.18	39.55
25	US	-79.90	39.60
26	US	-90.82	39.81
27	US	-75.38	39.92
28	US	-96.77	39.99
29	US	-88.23	40.08
30	China	116.12	40.19
31	US	-78.00	40.70
32	US	-93.42	40.97
33	US	-93.40	41.00
34	US	-83.07	41.37
35	US	-83.05	41.50
36	US	-88.85	41.85
37	US	-88.90	41.90
38	US	-100.00	42.00
39	US	-93.77	42.02
40	US	-76.45	42.45
41	US	-77.00	42.87
42	US	-99.80	43.70

43	US	-100.00	44.00
44	US	-96.70	44.20
45	US	-100.00	44.28
46	US	-96.77	44.32
47	Italy	11.50	44.40
48	US	-73.75	45.47
49	US	-95.88	45.60
50	US	-97.23	46.65
51	US	-97.02	46.95
52	US	-100.00	47.00
53	Germany	8.93	48.73
54	Blegium	3.80	51.00
55	UK	-0.35	51.80

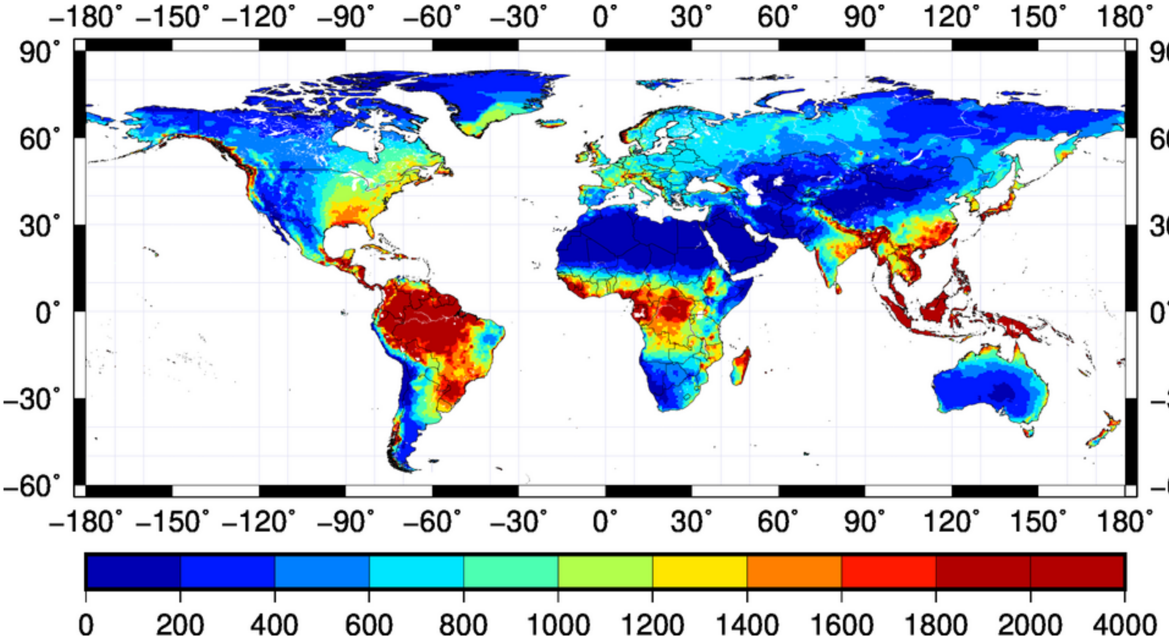

Fig. s1 Spatial distribution of averaged annual precipitation (mm yr^{-1}) from 1979 to 2016.

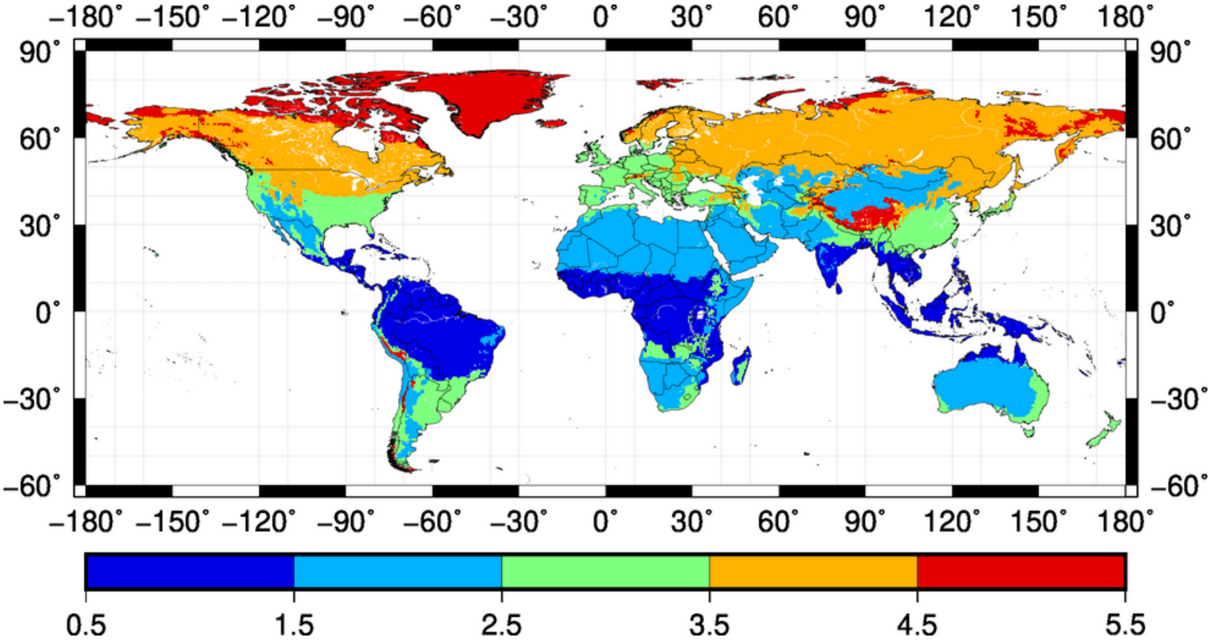

Fig. s2 Five different kinds of Köppen climate zones based on the average meteorological data from 1979 to 2016. The specific categories are as follows: 1 (dark blue) for tropical climate zone; 2 (light blue) for dry climate zone; 3 (green) for temperature climate zone; 4 (yellow) for continental climate zone; 5 (red) for polar climate zone.

A brief description of the algorithms in crop growth sub-module of H08

To make it clear for the function of the parameters we calibrated, here we briefly describe the algorithms in the crop growth sub-module of H08. The crop module of H08 accumulates daily heat units (Huna(t)), which are expressed as the daily mean air temperature (T_a) greater than the plant's specific base temperature (Tb; given as a crop-specific parameter):

$$Huna(t) = T_a - Tb \tag{1}$$

Then the heat unit index ($Ihun$) is calculated as the ratio of accumulated daily heat units $\sum Huna(t)$ and the potential heat unit (Hun):

$$Ihun = \frac{\sum Huna(t)}{Hun} \tag{2}$$

When the accumulated daily heat units $\sum Huna(t)$ reach the potential heat unit (Hun) required for the maturity of the crop, the crop is mature and is harvested. During the growth period, the daily increase in biomass (ΔB) is calculated using a simple photosynthesis model:

$$\Delta B = be * PAR * REGF \tag{3}$$

Where be is radiation use efficiency, PAR is photosynthetically active radiation, and $REGF$ is the crop regulating factor. PAR is calculated using shortwave radiation (Rs) and leaf area index (LAI) as follow:

$$PAR = 0.02092 * Rs * [1 - \exp(-0.65 * LAI)] \tag{4}$$

LAI is calculated according to the growth stage indicated by $Ihun$, if $Ihun < \lfloor \mathrm{dpl1} \rfloor * 0.01$,

$$LAI = \frac{(dpl1 - \lfloor \mathrm{dpl1} \rfloor) * Ihun}{\lfloor \mathrm{dpl1} \rfloor * 0.01} * blai \tag{5}$$

if $\lfloor dpl1 \rfloor * 0.01 \leq Ihun < \lfloor dpl2 \rfloor * 0.01$,

$$LAI = \left\{ (dpl1 - \lfloor dpl1 \rfloor) + \frac{[(dpl2 - \lfloor dpl2 \rfloor) - (dpl1 - \lfloor dpl1 \rfloor)] * (Ihun - \lfloor \mathrm{dpl1} \rfloor * 0.01)}{\lfloor dpl2 \rfloor * 0.01 - \lfloor dpl1 \rfloor * 0.01} \right\} * blai \tag{6}$$

if $\lfloor dpl2 \rfloor * 0.01 \leq Ihun < dlai$,

$$LAI = \left\{ (dpl2 - \lfloor dpl2 \rfloor) + \frac{[1 - (dpl2 - \lfloor dpl2 \rfloor)] * (Ihun - \lfloor dpl2 \rfloor * 0.01)}{dlai - \lfloor dpl2 \rfloor * 0.01} \right\} * blai \tag{7}$$

if $dlai < Ihun$,

$$LAI = 16 * blai\ (1 - Ihun)^2 \tag{8}$$

$REGF$ is calculated as:

$$REGF = \min\ (Ts, Ws, Ns, Ps) \tag{9}$$

Where Ts, Ws, Ns, Ps is respectively the stress factors for temperature, water, nitrogen, and phosphorous. Temperature stress (Ts) is calculated as an asymmetrical function according to the relationship between air temperature (*Ta*) and optimal temperature (*To*). When air temperature is below (or equal) optimal temperature (*To*), Ts is calculated as:

$$Ts = exp\{ln(0.9) * [\frac{Ctsl(To-Ta)}{Ta}]^2\} \tag{10}$$

Where *Ctsl* is the temperature stress parameter for temperature below to, and is calculated as:

$$Ctsl = \frac{To+Tb}{To-Tb} \tag{11}$$

When air temperature is above optimal temperature, Ts is calculated as:

$$Ts = exp\{ln(0.9) * [\frac{(To-Ta)}{Ctsh}]^2\} \tag{12}$$

Where *Ctsh* is the temperature stress parameter for temperature below to, and is calculated as:

$$Ctsh = 2 * To - Ta - Tb \tag{13}$$

Water stress (Ws) is calculated as the ratio of actual evapotranspiration (*Ea*) to potential evapotranspiration (*Ep*) as:

$$Ws = \frac{Ea}{Ep} \tag{14}$$

As for nitrogen and phosphorous stress, currently we take it as neglectable since the bioenergy crop yield simulated by H08 is with no constrains of nutrient.

The crop yield (Yld) is finally estimated by the aboveground biomass (Bag) with crop-specific harvest index ($Harvest$) at the harvesting date as:

$$Bag = [1 - (0.4 - 0.2 * Ihun)] \sum \Delta B \tag{15}$$

$$Yld = Harvest * \frac{WSF}{WSF + \exp(6.117 - 0.086 * WSF)} * Bag \quad (16)$$

Where WSF is a ratio of SWU (the accumulated actual plant transpiration in the second half of the growing season), and SWP (the accumulated potential evapotranspiration accumulated actual plant transpiration):

$$WSF = \frac{SWU}{SWP} * 100 \quad (17)$$