Supplement of

A synthesis of water, energy, and carbon fluxes sensitivity to climate variables in Southeast Asia

Jianning Ren et al.

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Section S1. Supplementary text.

There are three different methods of perturbing air temperature.

- Method (i): change the air temperature, but do not change the relative humidity.

$$T_a = T_a \pm DT; U = U \quad (1)$$

$$e_{sat} = 611 \times e^{\frac{17.27 \times T_a}{237.3 + T_a}} \quad (2)$$

$$e_a = e_{sat} \times U \quad (3)$$

$$xr = 17.27 * \frac{T_a}{237.3 + T_a} + \log(U) \quad (4)$$

$$T_{dew} = 237.7 \times \frac{xr}{17.27 - xr} \quad (5)$$

$$VPD = e_{sat} - e_a \quad (6)$$

In the above equations, *DT* represents the one or two standard deviations of air temperature, e_{sat} is the saturated vapor pressure and e_a is the vapor pressure, *U* is the relative humidity, T_{dew} is the dew point temperature and *VPD* is the vapor pressure deficit, *xr* is the interim calculation term.

- Method (ii): change the air temperature, but do not change the vapor pressure.

$$T_a = T_a \pm DT;\ e_a = e_a \tag{7}$$

$$e_{sat} = 611 \times e^{\frac{17.27 \times T_a}{237.3 + T_a}} \tag{8}$$

$$U = \frac{e_a}{e_{sat}} \tag{9}$$

$$xr = 17.27 * \frac{T_a}{237.7 + T_a} + \log(U) \tag{10}$$

$$T_{dew} = 237.7 \times \frac{xr}{17.27 - xr} \tag{11}$$

$$VPD = e_{sat} - e_a \tag{12}$$

- Method (iii): change the air temperature, but do not change the vapor pressure deficit.

$$T_a = T_a \pm DT;\ VPD = VPD \tag{13}$$

$$e_{sat} = 611 \times e^{\frac{17.27 \times T_a}{237.3 + T_a}} \tag{14}$$

$$e_a = e_{sat} - VPD \tag{15}$$

$$U = \frac{e_a}{e_{sat}} \tag{16}$$

$$xr = 17.27 * \frac{T_a}{237.7 + T_a} + \log(U) \tag{17}$$

$$T_{dew} = 237.7 \times \frac{xr}{17.27 - xr} \tag{18}$$

For the three different methods, method three can represent the pure air temperature effect because it keeps the VPD the same. However, the other two methods can represent a combined effect of perturbed air temperature and part of VPD, because VPD changes with air temperature.

Section S2. Supplementary tables

Table S1. ET responses to perturbation of climate drivers. For each climate drivers, the left column is absolute changes, and right is relative changes in terms of percentage.

Site	**R_h (per 1%)**		**P_r (per 100 mm yr^{-1})**		**R_{sw} (per 1 W m^{-2})**		**W_s (per 1 m s^{-1})**		**T_a (per 1 °C) Method (i)**		**T_a (per 1 °C) Method (ii)**		**T_a (per 1 °C) Method (iii)**	
	mm yr^{-1}	**%**	**mm yr^{-1}**	**%**	**mm yr^{-1}**	**%**	**mm yr^{-1}**	**%**	**mm yr^{-1}**	**%**	**mm yr^{-1}**	**%**	**mm yr^{-1}**	**%**
ID-PDF	-17.50	-1.21	5.80	0.40	4.82	0.33	64.16	4.40	14.95	1.03	76.17	5.25	-2.15	-0.15
ID-BKS	-18.22	-1.50	4.83	0.40	4.63	0.38	61.35	5.04	10.32	0.85	83.66	6.90	-4.63	-0.38
MY-MLM	-21.22	**-1.58**	1.40	0.10	5.97	0.45	44.76	3.24	-16.61	-1.24	102.24	7.61	-29.61	-2.20
MY-PSO	-26.04	-1.82	2.86	0.20	5.17	0.36	64.84	4.53	23.88	1.67	143.87	10.07	2.18	0.15
TH-NHS	-15.94	-1.38	3.34	0.30	4.95	0.43	44.05	3.80	9.41	0.81	97.33	8.46	-2.45	-0.21
TH-FRC	-11.37	-1.10	19.73	1.84	1.97	0.20	30.85	2.82	-2.02	-0.29	50.64	4.77	-9.39	-0.98
TH-DFR	-13.73	-1.14	20.67	1.71	4.31	0.36	65.19	5.37	-0.86	-0.07	42.46	3.52	-11.50	-0.94
PH-RiF	-12.12	-1.13	4.07	0.38	5.24	0.49	118.61	**11.02**	-23.80	-2.22	20.87	1.94	-37.50	-3.50
TH-SKR	-13.98	-1.11	27.84	2.35	2.43	0.19	21.38	1.68	15.33	1.19	57.89	4.57	1.61	0.12
TH-Mae	-9.20	-0.82	25.78	2.34	2.19	0.20	15.26	1.36	5.54	0.49	31.52	2.82	-2.40	-0.22
CN-Xsh	-12.80	-1.34	5.81	0.62	4.96	0.52	49.94	5.23	20.35	2.13	72.92	7.63	9.56	1.00
HK-MPM	-19.39	-1.88	0.88	0.09	5.62	0.54	75.87	**7.36**	-14.11	-1.37	62.55	6.06	-33.97	-3.29
CN-Din	-12.91	-1.88	4.57	0.67	3.40	0.49	39.54	5.72	-5.91	-0.87	43.27	6.27	-16.93	-2.47
CN-YJS	-1.30	**-0.21**	63.49	**11.16**	0.53	**0.09**	3.16	0.49	1.76	0.29	5.02	0.81	1.27	0.21
CN-ALS	-16.02	**-2.11**	1.78	0.24	3.65	0.48	10.36	1.35	49.21	**6.46**	130.54	17.20	31.07	4.08

TW-Chn	-16.08	**-2.74**	0.36	**0.06**	4.48	**0.76**	12.65	2.17	24.88	4.22	181.23	30.85	19.51	3.31
CN-PDS	-8.17	-1.47	2.14	0.38	3.83	0.69	2.67	0.47	19.75	3.52	59.12	10.61	11.73	2.08
CN-Qia	-9.78	-1.34	10.99	1.50	3.00	0.41	27.45	3.76	-6.61	-0.90	35.34	4.85	-16.53	-2.26
CN-Dan	-1.84	-0.51	27.05	**7.38**	1.13	0.31	-2.85	-0.78	17.57	4.83	21.34	5.86	15.79	4.34
CN-Hgu	-1.78	-0.27	17.13	**3.05**	1.68	0.27	21.88	3.65	31.97	**5.41**	39.61	6.59	27.00	4.61

Table S2. GPP responses to perturbation of climate drivers. For each climate drivers, the left column is absolute changes, and right is relative changes in terms of percentage.

Site	**R_h (per 1%)**		**P_r (per 100 mm yr^{-1})**		**R_{sw} (per 1 W m^{-2})**		**W_s (per 1 m s^{-1})**		**T_a (per 1 °C) Method (i)**		**T_a (per 1 °C) Method (ii)**		**T_a (per 1 °C) Method (iii)**	
	gC m^{-2} yr^{-1}	**%**	**gC m^{-2} yr^{-1}**	**%**	**gC m^{-2} yr^{-1}**	**%**	**gC m^{-2} yr^{-1}**	**%**	**gC m^{-2} yr^{-1}**	**%**	**gC m^{-2} yr^{-1}**	**%**	**gC m^{-2} yr^{-1}**	**%**
ID-PDF	7.44	0.24	11.32	0.36	3.93	0.12	-7.04	-0.25	-94.42	-2.98	-142.90	-4.53	-74.12	-2.34
ID-BKS	9.36	0.33	12.24	0.42	4.43	0.15	11.86	0.41	-97.23	-3.36	-148.97	-5.16	-76.61	-2.65
MY-MLM	-0.19	**-0.01**	-0.03	0.00	5.60	0.17	60.46	1.86	-82.84	-2.53	-111.27	-3.40	-75.88	-2.32
MY-PSO	-0.30	-0.01	0.03	0.00	6.05	0.19	23.46	0.73	-51.16	-1.59	-71.85	-2.23	-42.35	-1.32
TH-NHS	7.47	0.28	9.64	0.36	8.00	0.27	21.19	0.68	-110.82	-3.88	-162.38	-5.75	-95.24	-3.32
TH-RFC	16.82	0.74	58.38	2.52	-0.51	0.01	9.47	0.80	-136.88	-6.40	-234.38	-10.87	-110.99	-5.24
TH-DFR	6.39	0.22	53.62	1.87	6.77	0.24	43.14	1.49	-144.83	-5.04	-206.41	-7.16	-122.46	-4.26
PH-RiF	-0.19	-0.01	-0.21	-0.01	7.47	0.46	70.39	**4.34**	-54.38	-3.34	-72.60	-4.46	-46.46	-2.86
TH-SKR	23.46	0.88	64.37	**2.40**	2.31	0.08	-24.24	-0.95	-58.81	-2.18	-142.19	-5.28	-22.33	-0.82
TH-Mae	13.83	0.61	54.62	**2.40**	0.75	0.03	-1.70	-0.08	-77.50	-3.39	-133.02	-5.83	-46.38	-2.01

CN-Xsh	3.57	0.15	13.85	0.57	5.59	0.22	61.42	**2.41**	-3.65	-0.16	-31.46	-1.28	6.98	0.27
HK-MPM	-1.34	-0.05	-0.01	0.00	8.91	0.32	33.52	1.21	-60.59	-2.19	-77.35	-2.79	-53.63	-1.94
CN-Din	4.10	0.26	7.08	0.46	1.94	0.12	-18.11	-1.18	14.13	0.88	-9.90	-0.66	25.91	1.62
CN-YJS	10.20	1.13	**107.17**	**11.90**	-0.86	-0.10	33.46	3.73	-23.20	-2.58	-47.97	-5.33	-5.39	-0.60
CN-ALS	0.58	0.03	1.07	0.05	7.36	0.31	4.66	0.20	115.04	4.86	107.52	4.54	118.16	4.99
TW-Chn	**-0.10**	**-0.01**	**0.00**	**0.00**	**5.45**	**0.29**	**4.90**	**0.26**	74.19	3.92	71.25	3.76	74.71	3.94
CN-PDS	-0.04	0.00	0.09	0.01	5.45	0.45	9.06	0.76	21.55	1.79	17.88	1.48	23.50	1.95
CN-Qia	7.26	0.40	24.67	1.33	1.55	0.08	-12.28	-0.71	5.31	0.30	-29.86	-1.63	23.87	1.31
CN-Dan	2.60	0.76	37.94	10.96	-0.93	-0.27	9.81	**2.82**	28.32	8.30	20.79	6.11	32.13	9.41
CN-Hgu	9.88	1.03	40.63	4.42	-1.58	-0.20	-6.78	-1.11	119.90	11.25	79.52	7.05	135.46	12.89

Table S3. WUE responses to perturbation of climate drivers. for each climate drivers, the left column is absolute changes, and right is relative changes in terms of percentage.

Site	**R_h (per 1%)**		**P_r (per 100 mm yr^{-1})**		**R_{sw} (per 1 W m^{-2})**		**W_s (per 1 m s^{-1})**		**T_a (per 1 °C) Method (i)**		**T_a (per 1 °C) Method (ii)**		**T_a (per 1 °C) Method (iii)**	
	gC m^{-2} mm^{-1}	**%**	**gC m^{-2} mm^{-1}**	**%**	**gC m^{-2} mm^{-1}**	**%**	**gC m^{-2} mm^{-1}**	**%**	**gC m^{-2} mm^{-1}**	**%**	**gC m^{-2} mm^{-1}**	**%**	**gC m^{-2} mm^{-1}**	**%**
ID-PDF	0.05	1.80	0.008	0.27	-0.007	-0.24	-0.15	-5.06	-0.13	-4.35	-0.31	-10.83	-0.06	-2.10
ID-BKS	0.07	2.31	0.008	0.24	-0.008	-0.25	-0.19	-5.93	-0.15	-4.60	-0.44	-13.66	-0.07	-2.08
MY-MLM	0.14	**2.51**	0.031	0.55	-0.022	-0.39	-0.05	-0.91	-0.12	-2.20	-0.75	-13.28	-0.02	-0.33
MY-PSO	0.07	2.20	0.005	0.17	-0.006	-0.21	-0.13	-4.42	-0.11	-3.80	-0.40	-13.41	-0.04	-1.51
TH-NHS	0.07	1.93	0.005	0.14	-0.007	-0.20	-0.11	-3.26	-0.16	-4.65	-0.46	-13.38	-0.09	-2.71

TH-RFC	0.06	2.04	0.027	1.00	-0.006	-0.23	-0.05	-1.58	-0.15	-5.64	-0.37	-13.69	-0.10	-3.54
TH-DFR	0.04	1.54	0.012	0.44	-0.004	-0.16	-0.05	-1.65	-0.14	-4.89	-0.29	-10.17	-0.09	-3.05
PH-RiF	0.10	1.73	0.041	0.70	-0.013	-0.23	-0.02	-0.28	-0.10	-1.74	-0.43	-7.61	0.04	**0.59**
TH-SKR	0.06	2.11	0.000	0.02	-0.004	-0.13	-0.04	-1.68	-0.09	-3.56	-0.26	-10.02	-0.03	-1.00
TH-Mae	0.04	1.67	0.017	0.67	-0.005	-0.18	-0.02	-0.78	-0.10	-3.94	-0.23	-9.03	-0.04	-1.62
CN-Xsh	0.06	1.67	0.016	0.48	-0.012	-0.35	-0.13	-3.92	-0.10	-2.83	-0.32	-9.49	-0.03	-0.93
HK-MPM	0.06	1.84	0.004	0.12	-0.009	-0.26	-0.07	-1.98	-0.05	-1.54	-0.29	-8.17	0.02	**0.57**
CN-Din	0.07	2.24	0.015	0.47	-0.014	-0.44	-0.16	-5.07	0.02	0.48	-0.22	-7.00	0.10	**3.13**
CN-YJS	0.03	1.38	0.064	**3.26**	-0.006	-0.31	0.08	3.98	-0.06	-3.07	-0.12	-5.97	-0.02	-1.13
CN-ALS	0.07	2.01	0.001	0.04	-0.007	-0.21	-0.01	-0.24	-0.10	-3.00	-0.42	-12.28	-0.01	-0.29
TW-Chn	0.14	**2.54**	0.005	0.10	-0.032	-0.60	-0.13	-2.42	-0.09	-1.71	-1.14	-20.87	-0.02	-0.30
CN-PDS	0.04	1.51	0.006	0.22	-0.009	-0.35	0.02	0.87	-0.06	-2.48	-0.22	-8.58	-0.02	-0.66
CN-Qia	0.06	1.73	0.026	0.79	-0.013	-0.39	-0.11	-3.44	0.01	0.39	-0.18	-5.59	0.10	**3.12**
CN-Dan	0.01	1.06	0.072	5.91	-0.009	-0.72	0.08	6.58	0.02	1.24	-0.01	-0.97	0.03	**2.71**
CN-Hgu	0.03	1.18	0.085	3.11	-0.016	-0.59	-0.03	-1.05	0.11	4.03	-0.01	-0.35	0.18	**6.37**

Table S4. CUE responses to perturbation of climate drivers. for each climate drivers, the left column is absolute changes, and right is relative changes in terms of percentage.

Site	**R_h (per 1%)**		**P_r (per 100 mm yr^{-1})**		**R_{sw} (per 1 W m^{-2})**		**W_s (per 1 m s^{-1})**		**T_a (per 1 °C) Method (i)**		**T_a (per 1 °C) Method (ii)**		**T_a (per 1 °C) Method (iii)**	
	-	%	-	%	-	%	-	%	-	%	-	%	-	%
ID-PDF	0.0001	0.02	0.0004	0.10	0.0001	0.03	0.000	-0.07	-0.014	-3.21	-0.015	-3.43	-0.013	-3.07
ID-BKS	0.0002	0.04	0.0006	0.14	0.0001	0.03	0.001	0.24	-0.014	-3.47	-0.015	-3.76	-0.014	-3.29
MY-MLM	-0.0002	-0.05	0.0000	-0.01	0.0002	0.05	0.001	0.11	-0.011	-2.57	-0.011	-2.50	-0.011	-2.54
MY-PSO	-0.0002	-0.05	0.0000	0.00	0.0002	0.05	0.001	0.25	-0.012	-2.72	-0.012	-2.65	-0.012	-2.69
TH-NHS	0.0002	0.08	0.0004	0.17	0.0003	0.10	0.001	0.42	-0.014	**-5.01**	-0.015	**-5.49**	-0.014	**-4.74**
TH-RFC	0.0003	0.09	0.0015	0.54	-0.0003	-0.01	0.005	2.39	-0.019	**-7.89**	-0.022	**-9.23**	-0.018	**-7.44**
TH-DFR	-0.0001	-0.01	0.0007	0.21	0.0003	0.08	0.003	0.72	-0.013	-3.42	-0.014	-3.66	-0.013	-3.30
PH-RiF	-0.0001	-0.02	0.0000	0.00	0.0003	0.05	0.001	0.19	-0.007	-1.16	-0.007	-1.18	-0.006	-1.14
TH-SKR	0.0009	0.20	0.003	0.68	0.0001	0.02	-0.002	-0.41	-0.013	-2.82	-0.016	-3.51	-0.011	-2.50
TH-Mae	0.0004	0.08	0.003	0.71	0.0000	0.01	0.001	0.15	-0.013	-3.05	-0.015	-3.42	-0.012	-2.77
CN-Xsh	0.0000	-0.00	0.0006	0.12	0.0003	0.06	0.005	1.13	-0.012	-2.49	-0.012	-2.60	-0.011	-2.42
HK-MPM	-0.0004	-0.11	0.0000	0.00	0.0003	0.09	-0.001	-0.22	-0.013	-3.46	-0.012	-3.12	-0.013	-3.52
CN-Din	0.0000	0.00	0.0005	0.10	0.0001	0.02	-0.001	-0.28	-0.009	-1.83	-0.010	-1.98	-0.008	-1.72
CN-YJS	0.0003	0.08	0.0053	1.44	-0.0002	-0.06	0.003	0.68	-0.012	-3.16	-0.013	-3.39	-0.012	-3.12
CN-ALS	-0.0001	-0.02	0.0001	0.02	0.0003	0.07	0.001	0.12	-0.008	-1.63	-0.008	-1.61	-0.008	-1.63
TW-Chn	-0.0002	-0.03	0.0000	0.00	0.0003	0.05	0.000	0.08	-0.008	-1.59	-0.007	-1.32	-0.008	-1.61
CN-PDS	-0.0001	-0.03	0.0000	0.01	0.0003	0.07	0.002	0.43	-0.011	-2.37	-0.010	-2.28	-0.011	-2.35
CN-Qia	0.0006	0.17	0.0023	0.58	-0.0001	-0.02	-0.001	-0.32	-0.011	-2.52	-0.014	-3.30	-0.010	-2.13

CN-Dan	0.0001	0.02	0.0108	2.07	-0.0005	-0.10	0.005	1.01	-0.006	-1.13	-0.007	-1.30	-0.005	-1.00
CN-Hgu	0.0007	0.16	0.0067	1.47	-0.0007	-0.15	0.002	0.23	-0.008	-1.69	-0.011	-2.30	-0.007	-1.41

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Section S3. Supplementary figures

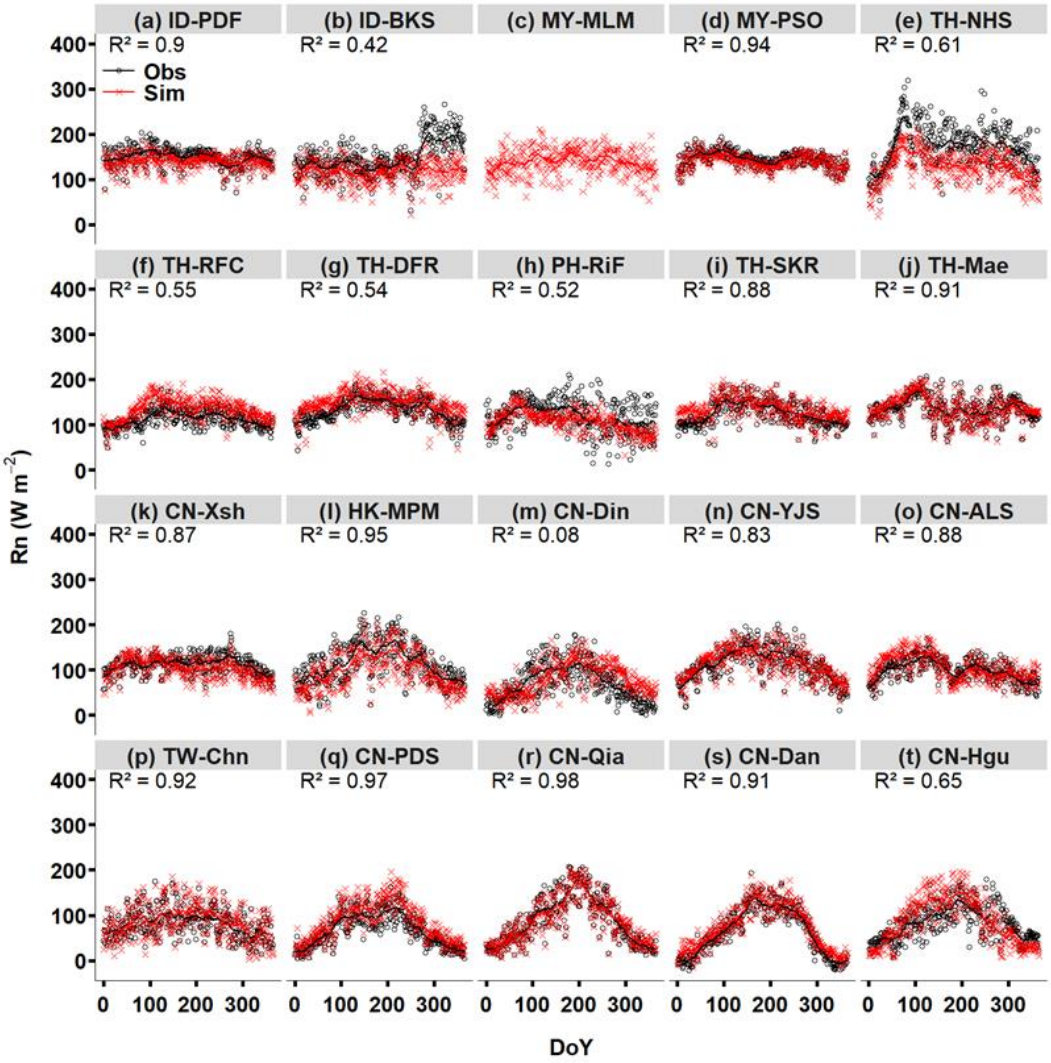

Figure S1. Comparison of T&C model simulation with the net radiation (R_n) data from flux towers. The mean daily R_n is calculated for every day of year (DoY) considering all the years with observations. We also applied a moving average method with a window of 30 days to calculate the smoothed seasonality (the continuous line) of observed and simulated R_n. Coefficient of determination (R^2) of simulated vs. observed R_n at the daily scale are shown at the top left for each site.

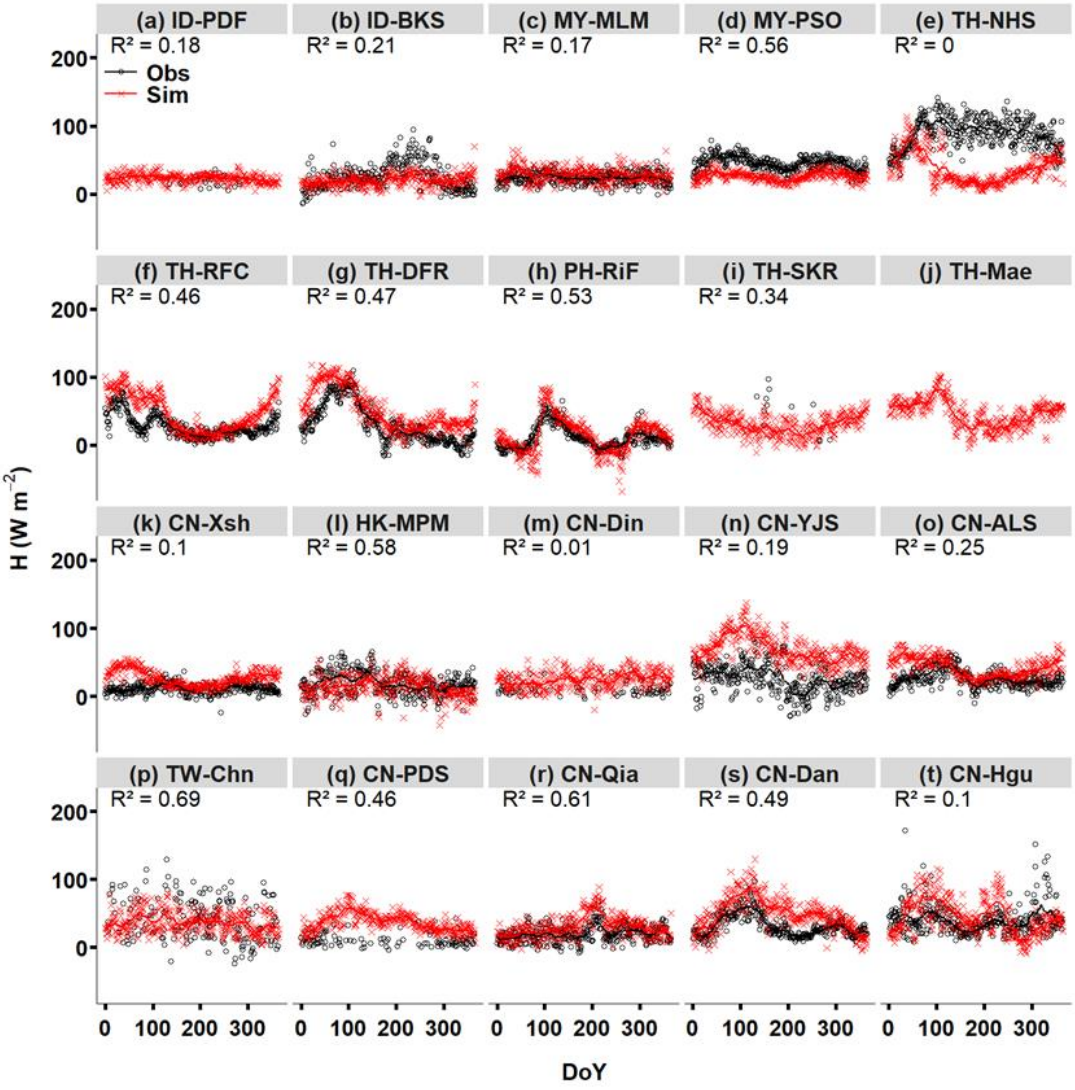

Figure S2. Same as Figure S1, but for sensible heat (H). Coefficient of determination (R^2) of simulated vs. observed H at the daily scale are shown at the top left for each site.

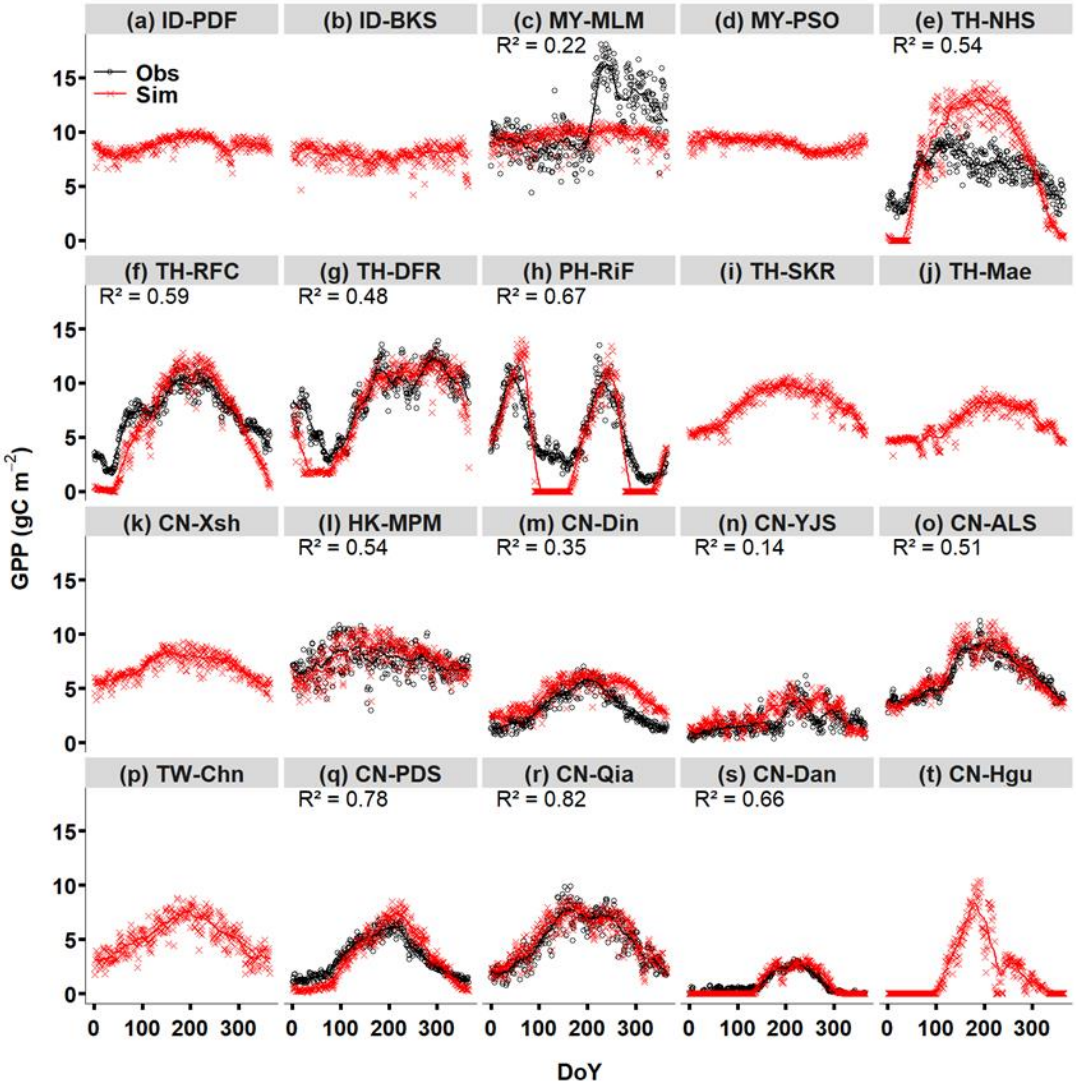

Figure S3. Same as Figure S1, but for GPP. Coefficient of determination (R^2) of simulated vs. observed GPP at the daily scale are shown at the top left for each site.

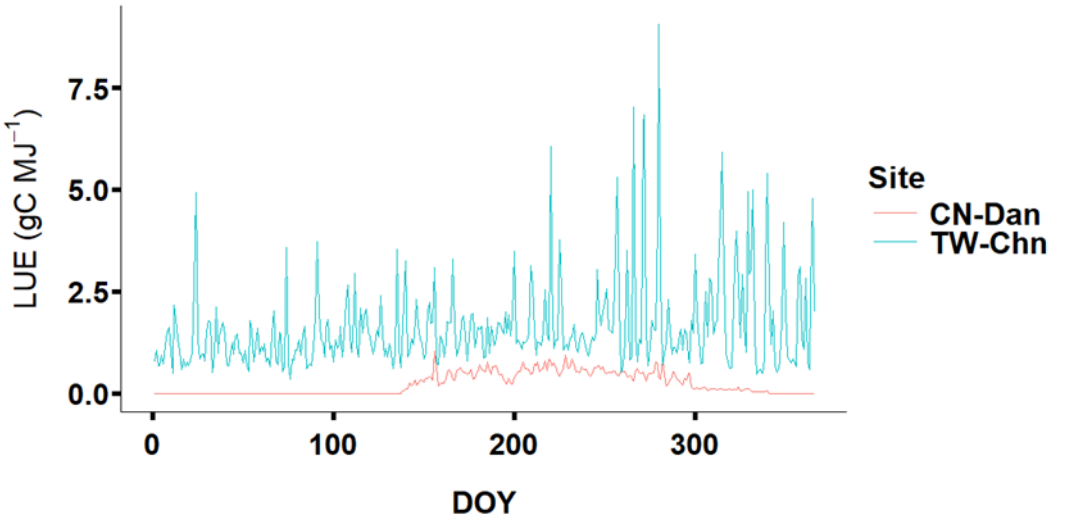

Figure S4. Daily values of light use efficiency (LUE) for two sites CN-Dan and TW-Chn.

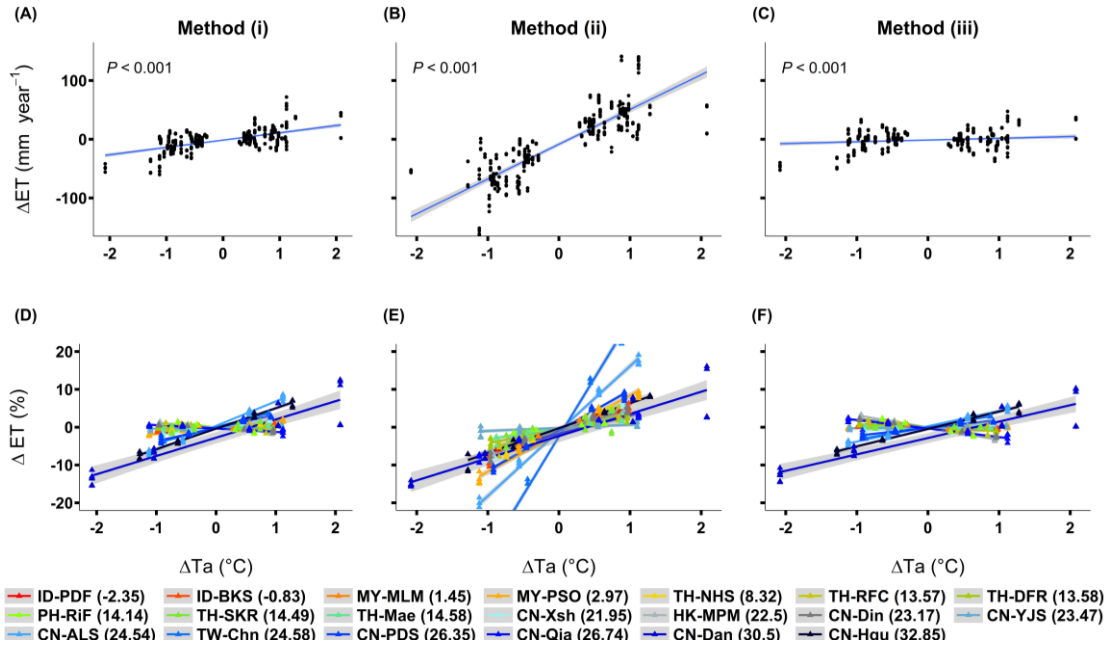

Figure S5. ET responses to perturbation of air temperature with three different methods. Note that some of the extreme points beyond the plotting range are not shown for visual clarity; however, all data points were included in the regression fit.

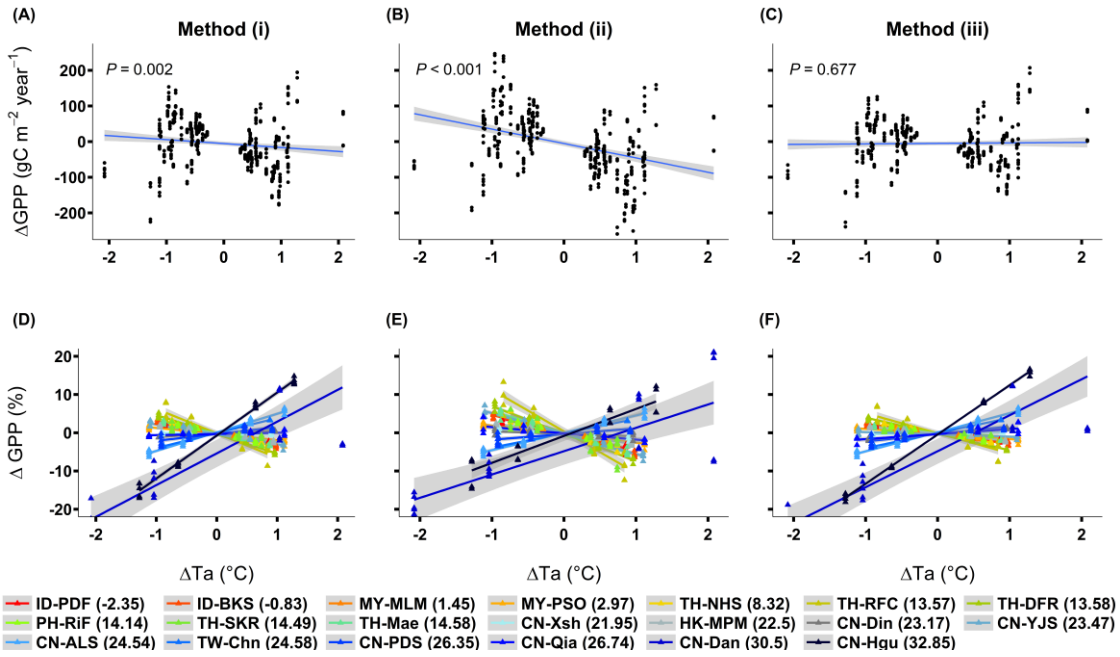

Figure S6. GPP responses to perturbation of air temperature with three different methods. Note that some of the extreme points beyond the plotting range are not shown for visual clarity; however, all data points were included in the regression fit.

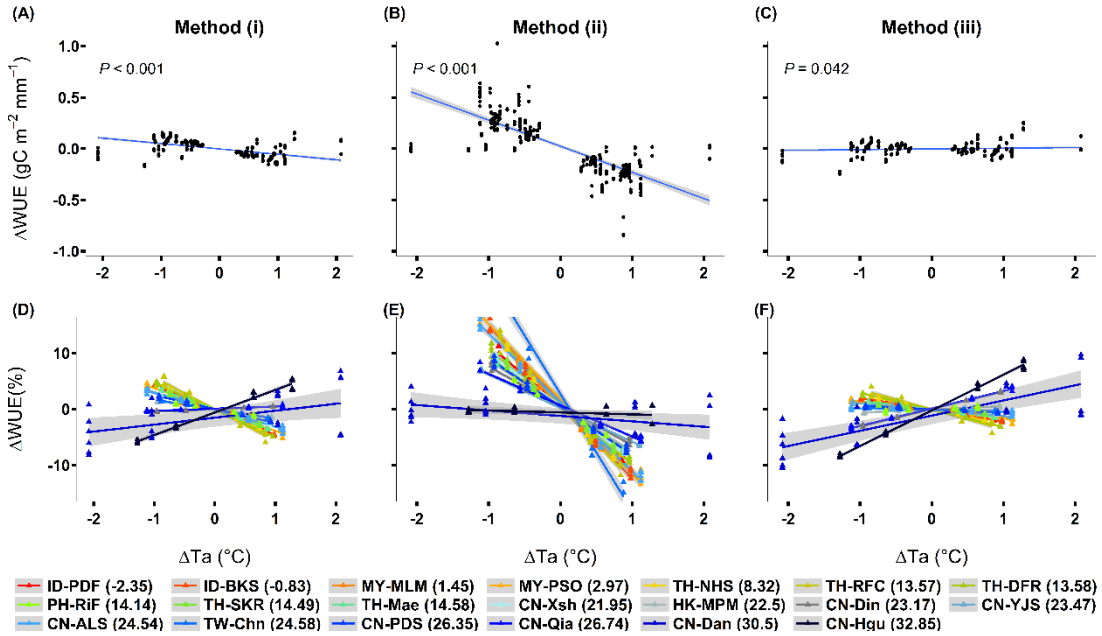

Figure S7. WUE (GPP/Trans) responses to perturbation of air temperature with three different methods. Note that some of the extreme points beyond the plotting range are not shown for visual clarity; however, all data points were included in the regression fit.

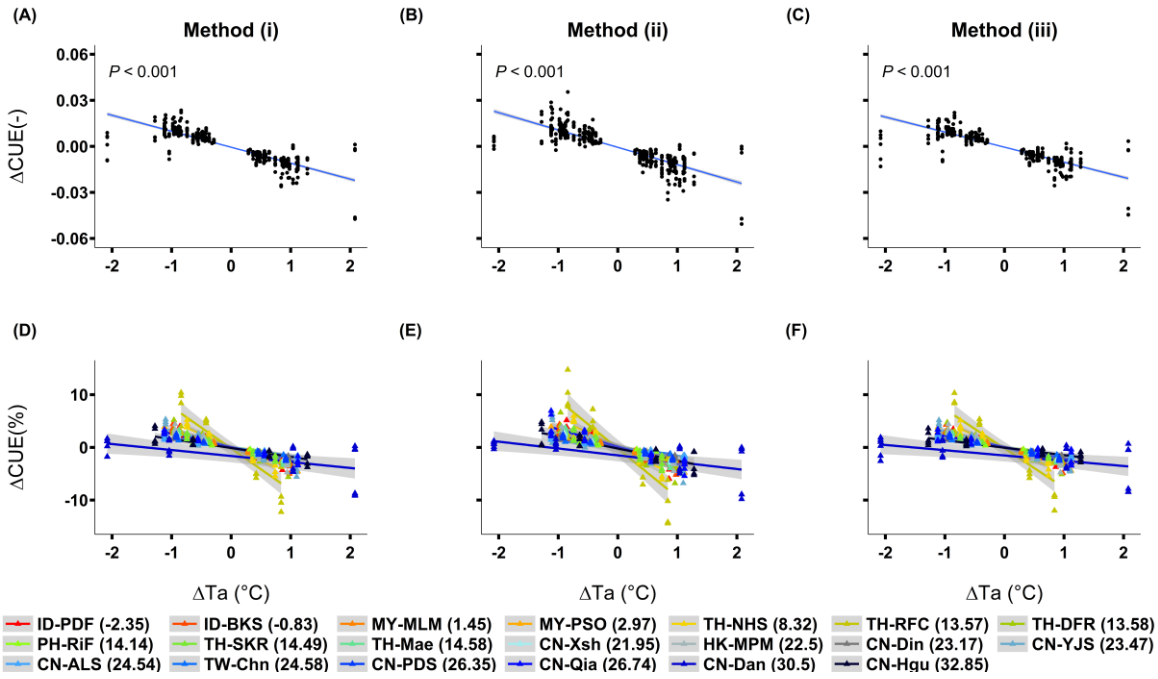

Figure S8. CUE (NPP/GPP) responses to perturbation of air temperature with three different methods. Note that some of the extreme points beyond the plotting range are not shown for visual clarity; however, all data points were included in the regression fit.

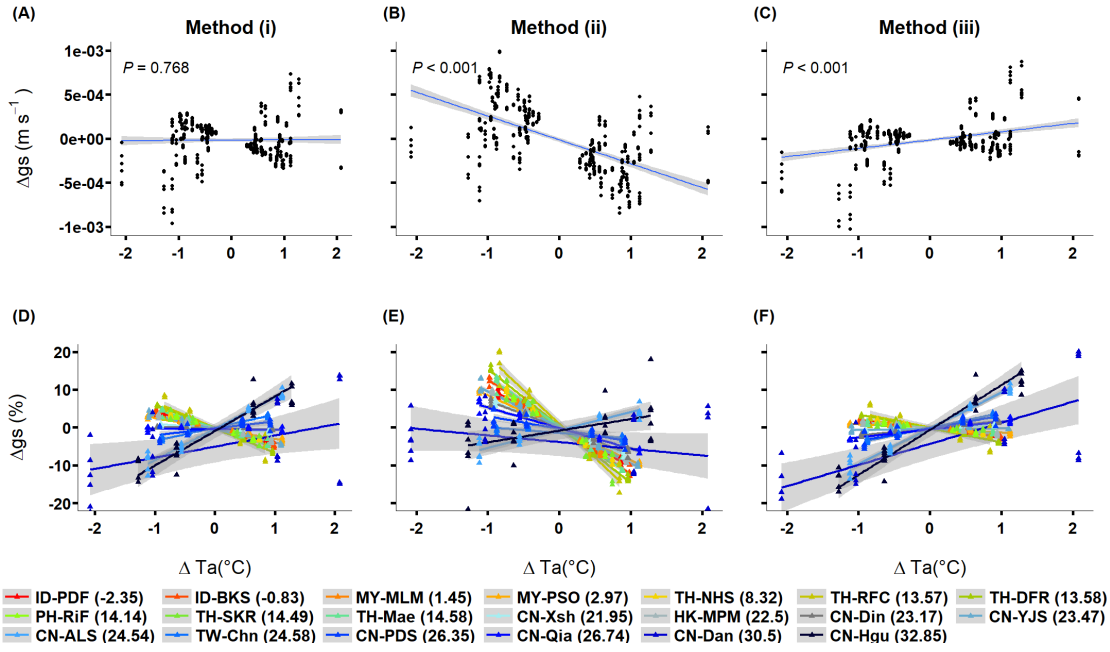

Figure S9. Canopy conductance responses to perturbation of air temperature with three different methods. Note that some of the extreme points beyond the plotting range are not shown for visual clarity; however, all data points were included in the regression fit.