Supporting Information

Le et al. 10.1073/pnas.1107177108

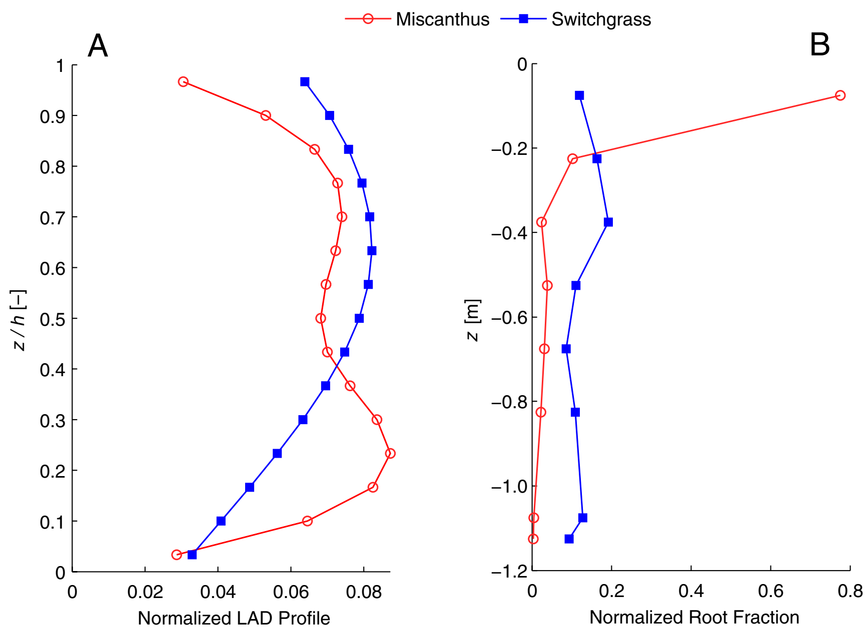

Fig. S1. Normalized canopy leaf area density profiles (*A*) and normalized root fraction in each soil layer (*B*) for miscanthus (red circles) and switchgrass (blue squares). The vertical axis in (*A*) is normalized by the height of the canopy (3.5 m for miscanthus, 2.0 m for switchgrass) to facilitate comparison between the two crops (based on data obtained from refs. 1, 2, 3).

1 Monti A, Zatta A (2009) Root distribution and soil moisture retrieval in perennial and annual energy crops in northern Italy. *Agr Ecosyst Environ* 132:252–259.
2 Kromdijk J, et al. (2008) Bundle sheath leakiness and light limitation during c4 leaf and canopy co2 uptake. *Plant Physiol* 148:2144–2155.
3 Madakadze IC, et al. (1998) Leaf area development, light interception, and yield among switchgrass populations in a short-season area. *Crop Sci*. 38:827–834.

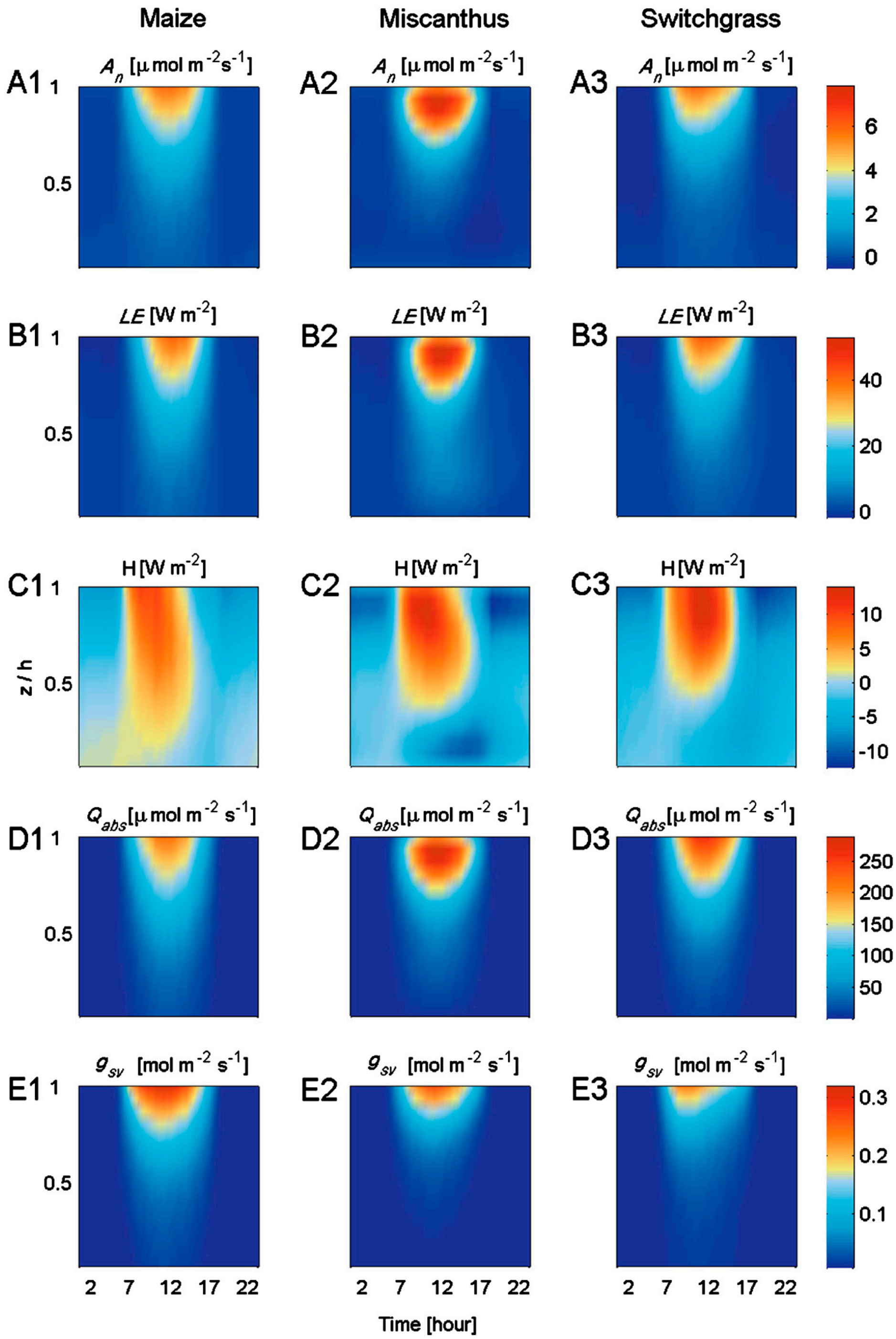

Fig. S2. Diurnally averaged profiles obtained from MLCan model simulation under present climate condition in August 2005 for photosynthetic rate A_n; latent heat LE; sensible heat H; total absorbed shortwave radiation included photosynthetically active and near-infrared bands Q_{abs}; and stomatal conductance for vapor g_{sv} for maize (left column—A1, B1, C1, D1, and E1), miscanthus (center column—A2, B2, C2, D2, and E2), and switchgrass (right column—A3, B3, C3, D3, and E3).

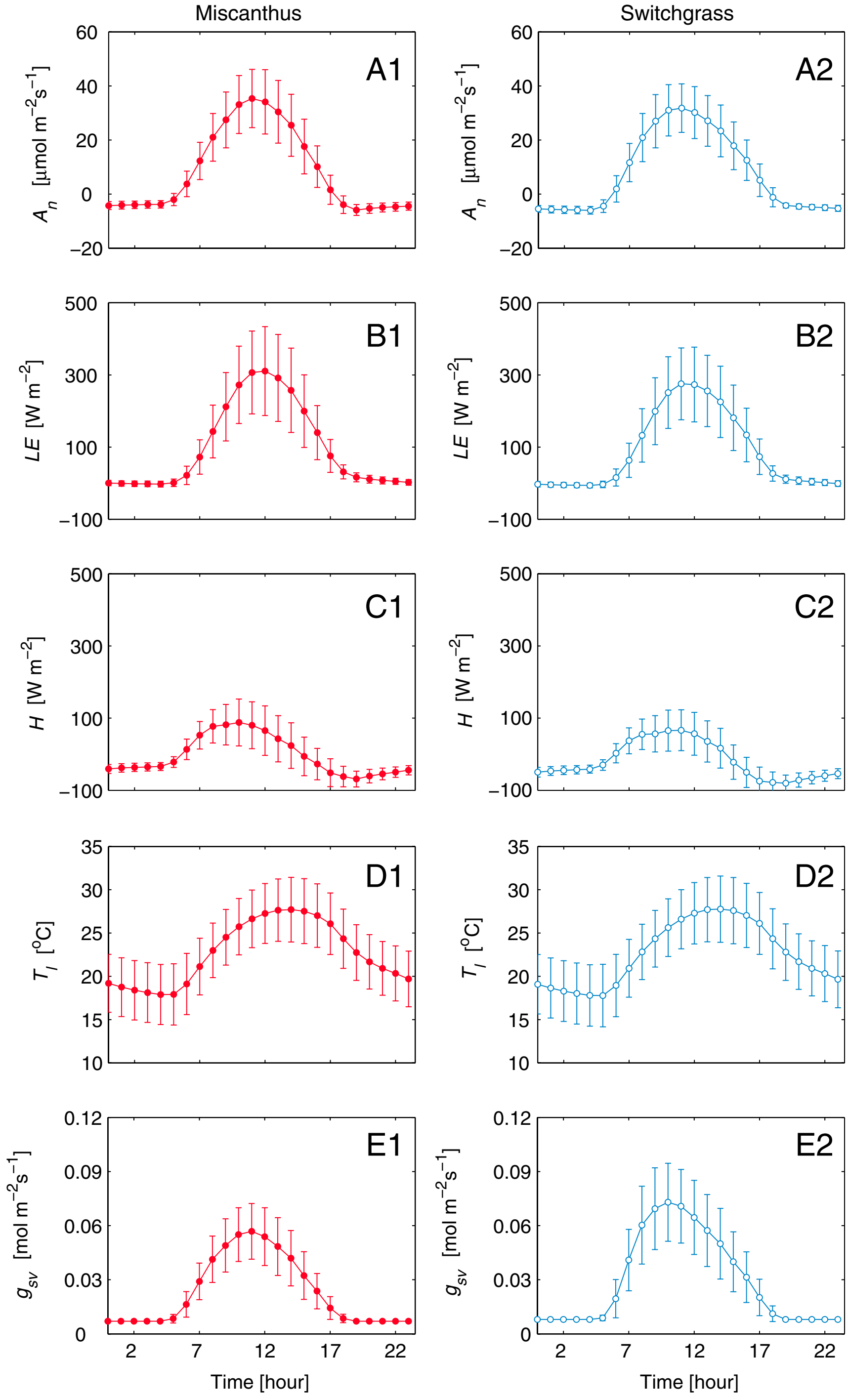

Fig. S3. Diurnally averaged net-canopy fluxes and variables obtained from the MLCan model under present climate condition in 2005 with vertical bars representing ± one standard deviation over one growing season of (*A*) Photosynthetic rate A_n; (*B*) Latent heat LE; (*C*) Sensible heat H; (*D*) Leaf temperature T_l; and (*E*) Stomatal conductance for vapor g_{sv} for miscanthus (in red—A1, B1, C1, D1, and E1) and switchgrass (in blue—A2, B2, C2, D2, and E2).

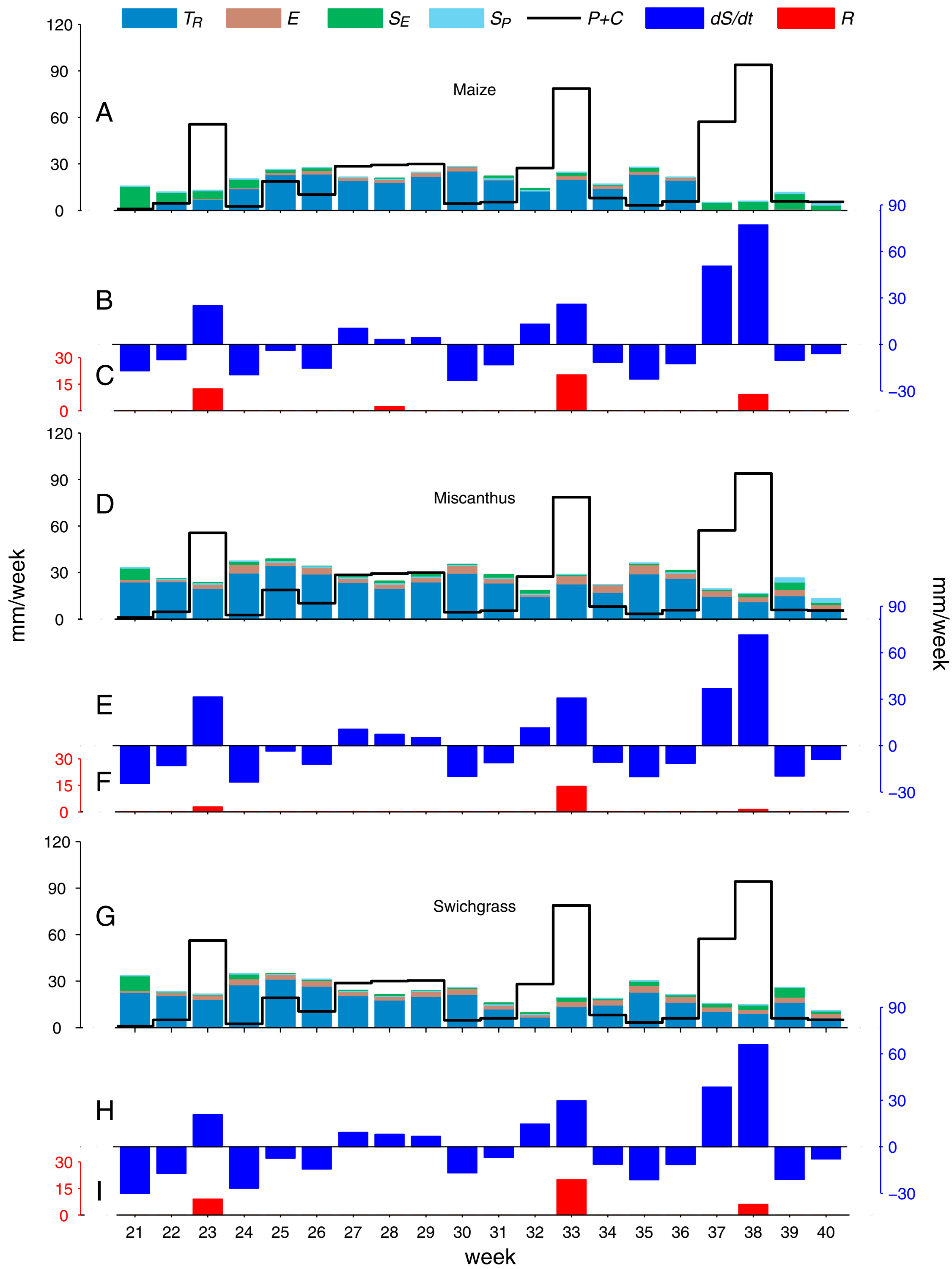

Fig. S4. Weekly mean water balance, soil-water storage change, and total specific surface runoff obtained using MLCan for three crops during several weeks in the 2005 growing season under present CO_2 conditions (370 ppm). (*A*, *D*, *G*) Weekly mean water balance; (*B*, *E*, *H*) weekly change of soil water storage dS/dt; and (*C*, *F*, *I*) total specific surface runoff for maize, miscanthus, and switchgrass, respectively. Black solid lines in (*A*, *D*, *G*) represents the total weekly precipitation P and condensation C on foliage (incoming water). Color boxes in (*A*, *D*, *G*) represent outgoing water components include: Transpiration T_R (dark blue); Evaporation E (brown); Soil Evaporation S_E (green); Seepage S_P (cyan). Note that: the first two and last four weeks are outside of the maize growing season.

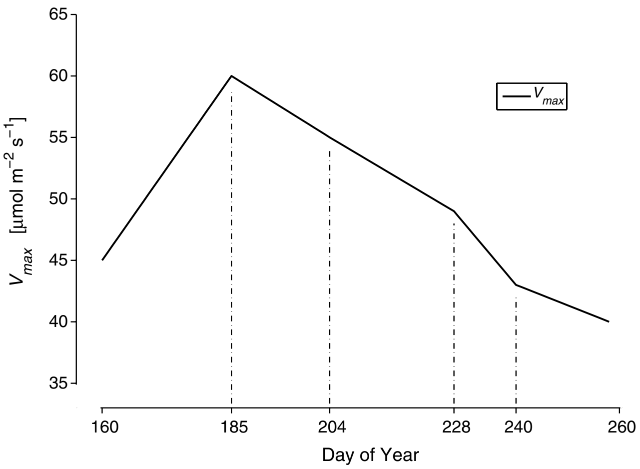

Fig. S5. To understand the impact of seasonality of leaf photosynthetic capacity on the results presented earlier, $V_{\max}$ for maize was varied as shown here. The values of $V_{\max}$ from day 185 to the end of the growing season was obtained and interpolated linearly from the study by Markelz, et al. (1). We also assumed a linear increase of $V_{\max}$ at the beginning of the season until it reached the maximum value at day 185 (2, 3).

1 Markelz RJC, Strellner RS, Leakey ADB (2008) Impairment of C4 photosynthesis by drought is exacerbated by limiting nitrogen and ameliorated by elevated $[CO_2]$ in maize. *J Exp Bot* 62:3235–3246.
2 Wilson KB, Baldocchi DD, Hanson PJ (2000) Spatial and seasonal variability of photosynthetic parameters and their relationship to leaf nitrogen in a deciduous forest. *Tree Physiol* 20:565–578.
3 Xu L, Baldocchi DD (2003) Seasonal trends in photosynthetic parameters and stomatal conductance of blue oak (Quercus douglasii) under prolonged summer drought and high temperature. *Tree Physiol* 23:865–877.

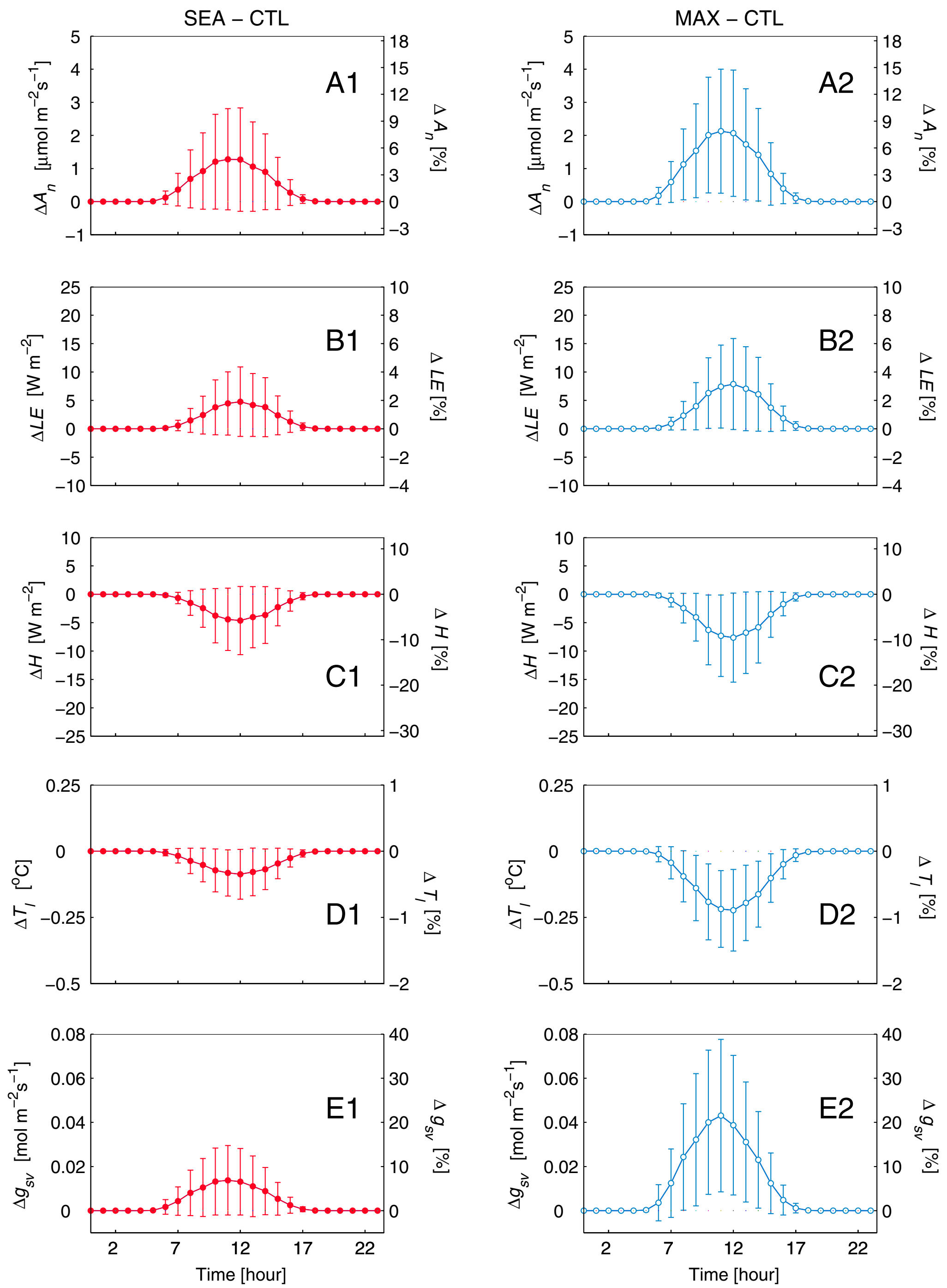

Fig. S6. Diurnally averaged change of net-canopy fluxes and variables obtained for maize during 2005 using the MLCan model with vertical bars representing ± one standard deviation over one growing season of (*A*) Photosynthetic rate A_n; (*B*) Latent heat *LE*; (*C*) Sensible heat *H*; (*D*) Leaf temperature T_l; and (*E*) Stomatal conductance for vapor g_{sv}. SEA represents the case with seasonal variation of V_{max} as shown in Fig. S5, CTL represents the control case presented earlier and MAX represents the situation when V_{max} is set to a constant but at seasonally high value of 60 μmol m^{-2} s^{-1}. The differences between SEA and CTL cases are presented in red (A1, B1, C1, D1, and E1) while differences between MAX and CTL are presented in blue (A2, B2, C2, D2, and E2). The right axes represent percentage change with respect to the maximum diurnally averaged value in the corresponding CTL simulation for maize.

Table S1. Value of model parameters for maize, miscanthus, and switchgrass used in the multilayer canopy-root-soil model (MLCan)

Description	Symbols	Unit	Maize*	Miscanthus	Switchgrass
Canopy height	h_{can}	m	2.5	3.5 (1)	2.0 (2)
Leaf width	d_o	m	0.08	0.03	0.01
Decay coefficient for leaf nitrogen content	k_n	-	0.5	0.15	0.4
Leaf emissivity	ϵ_v	-	0.94	0.95 (3)	0.95 (3)
Leaf absorptivity to photosynthetic active radiation (PAR)	$\alpha_{L\text{-PAR}}$	-	0.80	0.84 (1, 4)	0.8 (5)
Leaf absorptivity to near-infrared (NIR)	$\alpha_{L\text{-NIR}}$	-	0.23	0.2 (5)	0.2 (5)
Diffuse extinction coefficient	K_d	-	0.55	0.68 (6)	0.67 (2)
Leaf angle distribution parameter	x	-	1.64	1.64	1.64
Intrisic quantum yield C_4 photosynthesis	α	mol mol^{-1}	0.035	0.035	0.034
Initial slope of C4 photosynthetic CO_2 response	k_4	mol m^{-2} s^{-1}	0.7	0.7	0.7
Reference value fo leaf respiration	R_d	μ mol m^{-2} s^{-1}	0.8	0.8	0.6
Reference value for substrate saturated Rubisco capacity	V_{max}	μ mol m^{-2} s^{-1}	40	66	48
Temperature sensitivity of temperature-dependent C_4 parameters	$Q_{10,4}$	-	2.0	2.5	0.5
Stomatal slope parameter in Ball Berry model	m	-	7.0	5.7	8.0
Stomatal intercept parameter in Ball Berry model	b	mol m^{-2} s^{-1}	0.008	0.007	0.008
Stomatal sensitivity parameter	s_f	MPa^{-1}	6.5	6.5	6.5
Ψ_l at which half potential g_s is lost	Ψ_f	MPa	−1.3	−1.3	−1.3

Parenthetic numbers refer to references.

*Values for maize are obtained from the study of Drewry, et al. (2010a) (7).

1 Kromdijk J, et al. (2008) Bundle sheath leakiness and light limitation during c4 leaf and canopy co2 uptake. *Plant Physiol* 148:2144–2155.
2 Madakadze IC, et al. (1998) Leaf area development, light interception, and yield among switchgrass populations in a short-season area. *Crop Sci* 38:827–834.
3 Brutsaert W (1982) *Evaporation into the Atmosphere: Theory, History, and Applications*. (D. Reidel, London).
4 Farage PK, Blowers D, Long SP, Baker NR (2006) Low growth temperatures modify the efficiency of light use by photosystem II for CO_2 assimilation in leaves of two chilling-tolerant C4 species, Cyperus Longus l. and Miscanthus × Giganteus. *Plant Cell Environ* 29:720–728.
5 Campbell GS, Norman JM (1998) *An Introduction to Environmental Biophysics*. (Springer-Verlag, New York).
6 Clifton-Brown JC, Neilson B, Lewandowski I, Jones MB (2000) The modeled productivity of Miscanthus × Giganteus (Greef et deu) in Ireland. *Ind Crop Prod* 12:97–109.
7 Drewry D, et al. (2010a) Ecohydrological responses of dense canopies to environmental variability: 1. Interplay between vertical structure and photosynthetic pathway. *J Geophys Res* 115:G4, G04022.

Table S2. Change of total evapotranspiration (*ET*) and specific surface runoff (*R*) for the two cases shown in Fig. S6

Simulations	ΔET [mm]	ΔET [%]	ΔR [mm]	ΔR [%]
SEA—CTL	6.8	1.8	−0.7	1.7
MAX—CTL	12.2	3.2	−1.55	3.7

For CTL simulation, Total $ET = 380$ mm, and $R = 42$ mm (See Table 2 and Fig. 4 in the text)