Appendix A Equations of the biochemical photosynthetic model, stomatal regulation sub-model, and leaf energy balance model

Equations	Description	No.
Biochemical photosynthetic model		
$P_n = \min\left\{P_c, P_j\right\} - R_d$	Calculation of net photosynthetic rate	A1
$P_c = V_{c\max} \dfrac{C_i - \Gamma_*}{C_i + K_c(1 + O / K_o)}$	Rubisco-limited photosynthetic rate	A2
$P_j = \dfrac{J(C_i - \Gamma_*)}{4(C_i + 2\Gamma_*)}$	RuBP regeneration limited photosynthetic rate	A3
$\theta J^2 - (I_2 + J_{\max})J + I_2 J_{\max} = 0$	Light dependence of rate of electron transport	A4
$K_T = k_{25} \exp[E_a(T_L - 25) / \{298R(T_L + 273)\}]$	Arrhenius function; temperature dependence of K_c, K_o, R_d and V_{cmax}	A5
$J_{\max} = J_{m25} \exp[\dfrac{(T_L - 25)E_a}{R(T_L + 273)298}] \dfrac{[1 + \exp(\dfrac{S298 - H}{R298})]}{[1 + \exp(\dfrac{S(T_L + 273) - H}{R(T_L + 273)})]}$	Temperature dependence of J_{max}	A6
$\Gamma_* = 36.9 + 1.88(T_L - 25) + 0.036(T_L - 25)^2$	Temperature dependence of Γ_*	A7
Stomatal regulation sub-model		
$C_i = C_a - \dfrac{P_n}{g_{sc}}$	Estimation of intercellular CO_2 concentration	A8
$g_{sc} = \dfrac{g_s}{1.6}$	Stomatal conductance for CO_2	A9
$g_s = mP_n RH_s / C_s + g_0$	Stomatal conductance for H_2O	A10
$C_s = C_a - \dfrac{1.37P_n}{g_b}$	Estimation of CO_2 concentration at the leaf surface	A11
Leaf energy balance model		
$T_L = T_a + \dfrac{R_{abs} - \varepsilon\sigma T_a{}^4 - \lambda g_v D / P_a}{c_p(g_h + g_r) + \lambda((de_s(T_a) / dT) / P_a) g_v}$	Linear solution of the energy budget equation for T_L	A12
$T_r = 2g_v(\dfrac{e_s(T_L) - e_a}{P_a})$	Calculation of Transpiration rate	A13

Appendix B Variables, parameters and their values used in the model

Symbol	Description	Units	Value
Biochemical photosynthetic model			
Γ_*	CO_2 compensation point in the absence of R_d	μmol mol^{-1}	-
θ	Curvature of response of electron transport to PAR	-	0.7
C_i	Intercellular CO_2 partial pressure	μmol mol^{-1}	-
E_a	Activation energy	kJ mol^{-1}	-
H	Curvature parameter of the temperature dependence J_{max}	kJ mol^{-1}	220
I_2	Incident PAR	μmol m^{-2} s^{-1}	-
J	Electron transport rate	μmol m^{-2} s^{-1}	-
J_{max}	Maximum rate of electron transport	μmol m^{-2} s^{-1}	-
J_{m25}	Potential rate of electron transport at 25 ℃	μmol m^{-2} s^{-1}	200
K_c	Michaelis-Menten constant rubisco carbonxylation	μmol mol^{-1}	404.9
K_o	Michaelis-Menten constant rubisco oxygenation	mmol mol^{-1}	278.4
O	Oxygen partial pressure	mmol mol^{-1}	210
P_c	Rubisco-limited photosynthetic rate	μmol m^{-2} s^{-1}	-
P_j	RuBP regeneration limited photosynthetic rate	μmol m^{-2} s^{-1}	-
P_n	Net photosynthetic rate	μmol m^{-2} s^{-1}	-
R	Universal gas constant	J mol^{-1} K^{-1}	8.314
R_d	Dark respiration	μmol m^{-2} s^{-1}	-
S	Electron transport temperature response parameter	J mol^{-1} K^{-1}	0.71
T_L	Leaf temperature	℃	-
V_{cmax}	Maximum rate of rubisco carboxylation	μmol m^{-2} s^{-1}	-
Stomatal regulation sub-model			
C_a	Ambient CO_2 partial pressure	μmol mol^{-1}	-
C_s	CO_2 partial pressure at the leaf surface	μmol mol^{-1}	-
g_0	Residual g_s when PAR approaches zero	mol m^{-2} s^{-1}	-
g_b	Boundary layer conductance to water vapor	mol m^{-2} s^{-1}	-
g_s	Stomatal conductance to water vapor	mol m^{-2} s^{-1}	-
g_{sc}	Stomatal conductance to CO_2	mol m^{-2} s^{-1}	-
m	Slope of Ball-Berry model	-	-
RH_s	Relative humidity at leaf surface	-	-
Leaf energy balance model			
ε	Emissivity of leaf	-	0.97
σ	Stenfan-Boltzmann constant	W m^{-2} K^{-4}	5.67×10^{-8}
λ	Specific heat of air	kJ mol^{-1}	44.0
C_p	Specific heat capacity of air	J mol^{-1} C^{-1}	29.3
e_a	Vapor pressure in the ambient air	kPa	-
e_s	Vapor pressure at the leaf surface	kPa	-
g_h	Heat conductance for boundary layer	mol m^{-2} s^{-1}	-
g_r	Radiative conductance	mol m^{-2} s^{-1}	-
g_v	Total water vapor conductance	mol m^{-2} s^{-1}	-
P_a	Atmospheric pressure	kPa	100
R_{abs}	Absorbed long-wave and short-wave radiation	W m^{-2}	-
T_r	Transpiration rate	mol m^{-2} s^{-1}	-

Supporting information

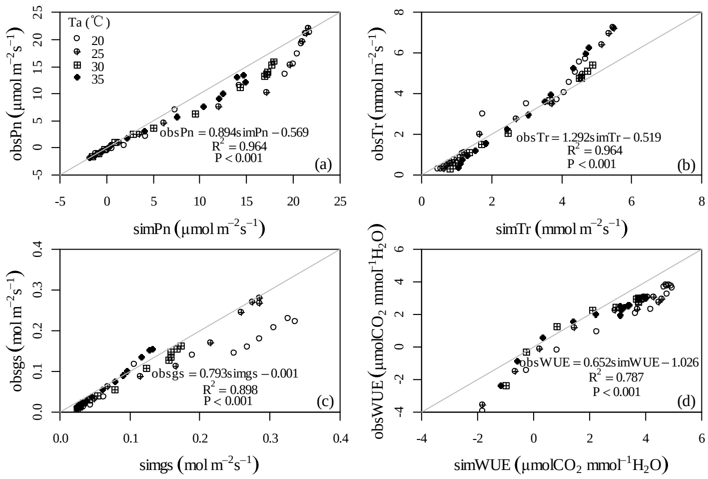

Fig. S1 Comparison between observed and simulated gas exchange change parameters for well-watered spring wheat under different air temperature. obsPn indicates observed net photosynthesis and simPn indicates simulated net photosynthesis. obsTr indicates observed transpiration and simTr indicates simulated transpiration. obsgs indicates observed stomtal conductance and simgs indicates simulated stomtal conductance. obsWUE indicates observed water use efficiency (obsPn/obsTr) and simWUE indicates simulated water use efficiency (simPn/simTr).

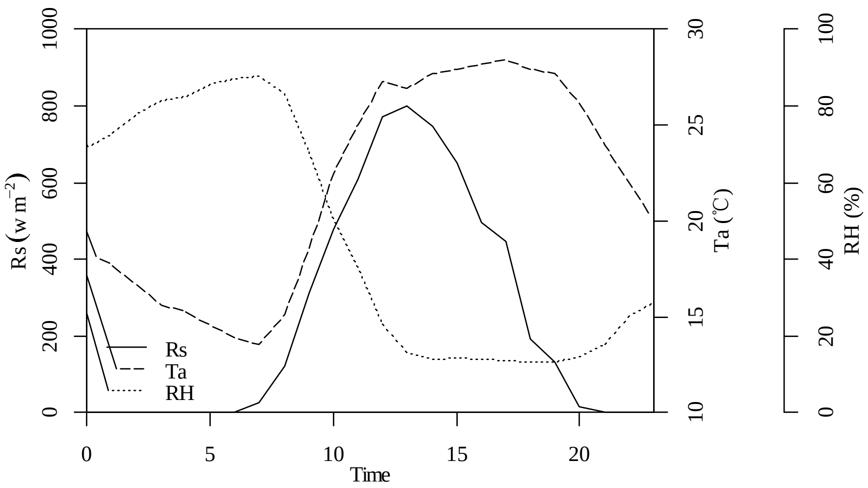

Fig. S2 Diurnal variation of meteorological variables, global radiation (Rs), air temperature (Ta), and relative humidity (RH) at 1.5 m height during a typical day in Dingxi, 2014.