Table S1 Noah-MP-Crop parameters evaluated in this study.

Parameter	Description	Unit	Maize	Rice	Soybean	Winter wheat
GDDTBASE	Base temperature for GDD accumulation	°C	5~8	4~8	4~6	2~8
GDDTCUT	Upper temperature for GDD accumulation	°C	30~34	30~35	30~35	21~26
GDDS1	GDD from seeding to emergence	GDD	50~200	50~80	50~150	50~200
GDDS2	GDD from seeding to initial vegetative	GDD	250~580	440~770	475~975	480~850
GDDS3	GDD from seeding to normal vegetative	GDD	450~910	810~1400	1150~1800	940~1590
GDDS4	GDD from seeding to initial reproductive	GDD	670~1410	1000~1690	1450~2300	1100~1750
GDDS5	GDD from seeding to physical maturity	GDD	1510~1950	1270~1920	2150~3300	1730~2330
AKC	Q10 for KC25	--	1~10	1~10	1~10	1~10
AKO	Q10 for KO25	--	1~10	1~10	1~10	1~10
AVCMX	Q10 for VCMX25	--	1~10	1~10	1~10	1~10
VCMX25	Maximum rate of carboxylation at 25°C	μmol m^{-2} s^{-1}	0~80	0~80	0~80	0~80
BP	Minimum leaf conductance	μmol m^{-2} s^{-1}	$2000\sim10^{14}$	$2000\sim10^{14}$	$2000\sim10^{14}$	$2000\sim10^{14}$
MP	Slope of conductance-to-photosynthesis relationship	--	4~9	4~9	4~9	4~9
QE25	Quantum efficiency at 25°C	--	0~0.6	0~0.6	0~0.6	0~0.6
Aref	Reference maximum CO_2 assimilation	$g/CO_2/s$	3.5~10.5	3.5~10.5	3.5~10.5	3.5~10.5

	rate					
PSNRF	CO_2 assimilation reduction factor(0-1) (caused by non-modeling part, e.g., pest, weeds)	--	0.1~1	0.1~1	0.1~1	0.1~1
I2PAR	Fraction of incoming solar radiation to photosynthetically active radiation	--	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
TASSIM0	Minimum temperature for CO_2 assimilation	℃	5~10	5~10	5~10	5~10
K	Light extinction coefficient	--	0.5~0.7	0.5~0.7	0.5~0.7	0.5~0.7
EPSI	Initial light use efficiency	g MJ^{-1}	10~18.6	10~18.6	10~18.6	10~18.6
Q10MR	Q10 for maintenance respiration	--	1~10	1~10	1~10	1~10
FOLN_MX	Foliage nitrogen concentration	%	0~1.5	0~1.5	0~1.5	0~1.5
LEFREEZ	Characteristic T for leaf freezing	K	268~278	268~278	268~278	261~271
DILE_FC	Coefficient for leaf temperature stress death	--	PGS=5:0~1.8 PGS=6:0~1.8	PGS=5:0~1.8 PGS=6:0~1.8	PGS=5:0~1.8 PGS=6:0~1.8	PGS=5:0~1.8 PGS=6:0~1.8
DILE_FW	Coefficient for leaf water stress death	--	PGS=5: 0~4 PGS=6: 0~4	PGS=5: 0~4 PGS=6: 0~4	PGS=5: 0~4 PGS=6: 0~4	PGS=5: 0~4 PGS=6: 0~4
FRA_GR	Fraction of growth respiration	--	0~0.2	0~0.2	0~0.2	0~0.2
LF_OVRC	Leaf turnover coefficient	--	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2
ST_OVRC	Stem turnover coefficient	--	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2
RT_OVRC	Root turnover coefficient	--	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2	PGS=5:0~1.2 PGS=6:0~1.2

LFMR25	Leaf maintenance respiration at 25℃	μmol m^{-2} s^{-1}	0~4	0~4	0~4	0~4
STMR25	Stem maintenance respiration at 25℃	μmol m^{-2} s^{-1}	0~1	0~1	0~1	0~1
RTMR25	Root maintenance respiration at 25℃	μmol m^{-2} s^{-1}	0~0.4	0~0.4	0~0.4	0~0.4
GRAINMR25	Grain maintenance respiration at 25℃	μmol m^{-2} s^{-1}	0~0.2	0~0.2	0~0.2	0~0.2
LFPT	Fraction of carbohydrate flux to leaf	--	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1
STPT	Fraction of carbohydrate flux to stem	--	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1
RTPT	Fraction of carbohydrate flux to root	--	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1	PGS=3:0~1 PGS=4:0~1
GRAINPT	Fraction of carbohydrate flux to grain	--	PGS=5:0~1 PGS=6:0~1	PGS=5:0~1 PGS=6:0~1	PGS=5:0~1 PGS=6:0~1	PGS=5:0~1 PGS=6:0~1
BIO2LAI	Leaf area per living leaf biomass	m^2 g^{-1}	0.015~0.040	0.019~0.050	0.013~0.025	0.019~0.048
CSOIL	Volumetric soil heat capacity	J m^{-3} K^{-1}	$2*10^6$~$3*10^6$	$2*10^6$~$3*10^6$	$2*10^6$~$3*10^6$	$2*10^6$~$3*10^6$
DKSAT	Saturated soil hydraulic conductivity	m s^{-1}	$1*10^{-6}$~$1.4*10^{-5}$	$1*10^{-6}$~$1.4*10^{-5}$	$1*10^{-6}$~$1.4*10^{-5}$	$1*10^{-6}$~$1.4*10^{-5}$
DWSAT	Saturated soil hydraulic diffusivity	m^2 s^{-1}	$5*10^{-6}$~$1.4*10^{-5}$	$5*10^{-6}$~$1.4*10^{-5}$	$5*10^{-6}$~$1.4*10^{-5}$	$5*10^{-6}$~$1.4*10^{-5}$
PSISAT	Saturated soil matric potential	m m^{-1}	0.036~0.468	0.036~0.468	0.036~0.468	0.036~0.468
SMCDRY	Soil moisture where direct evaporation stops	m^3 m^{-3}	0.01~0.12	0.01~0.12	0.01~0.12	0.01~0.12
SMCMAX	Porosity	m^3 m^{-3}	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
SMCREF	Field capacity	m^3 m^{-3}	1/3*SMCMAX~SMCMAX	1/3*SMCMAX~SMCMAX	1/3*SMCMAX~SMCMAX	1/3*SMCMAX~SMCMAX

SMCWLT	Wilting point soil moisture	$m^3\ m^{-3}$	SMCDRY~ SMCREF	SMCDRY~ SMCREF	SMCDRY~ SMCREF	SMCDRY~ SMCREF
ZBOT	Depth of lower boundary soil temperature	m	2~4	2~4	2~4	2~4

Table S2 Noah-MP parameterization options.

Physical process	Option used
Vegetation	2) Dynamic simulation
Stomatal resistance	1) Ball–Berry (Ball et al. 1987)
Soil moisture factor for stomatal resistance	1) Noah type (based on soil moisture) (Chen et al. 1996)
Runoff and groundwater	1) TOPMODEL with groundwater (Niu et al. 2007)
Surface layer drag coefficient	1) Monin–Obukhov
Supercooled liquid water	1) Standard freezing point depression (Niu and Yang 2006)
Frozen soil permeability	1) Uses total soil moisture to compute hydraulic properties (Niu and Yang 2006)
Radiation transfer	3) Two-stream with canopy gap equal to 1 (shade fraction)
Snow surface albedo	1) BATS
Frozen/liquid partitioning	1) Based on Jordan (1991)
Lower boundary condition of soil temperature	2) Original Noah
Snow/soil temperature time scheme	1) Semi-implicit
Glacier treatment	1) Include phase change of ice
Crop model	2) Liu, et al. 2016
Irrigation scheme	2) Irrigation trigger based on crop season Planting and harvesting dates
Irrigation method	3) Surface flooding

Table S3 The model parameters of rice at different sites were optimized based on the results of Morris and Sobol 'sensitivity analysis.

Parameter	CS	TY	YanT	YingT	Unit
AVCMX	4.19	3.93	5.97	2.33	--
BIO2LAI	0.044	0.036	0.043	0.037	$m^2\ g^{-1}$

FOLN_MX	0.45	0.82	0.34	0.27	%
FRA_GR	0.06	0.12	0.08	0.10	--
GDDS3	988.45	1009.21	1007.06	979.32	GDD
GDDS4	1336.54	1362.58	1424.75	1479.04	GDD
GDDTBASE	5.04	6.35	6.52	5.98	GDD
GRAINPT_PGS5	0.40	0.46	0.61	0.46	--
GRAINPT_PGS6	0.78	0.73	0.79	0.85	--
LFMR25	1.06	1.55	0.91	1.12	μmol m^{-2} s^{-1}
LFPT_PGS3	0.67	0.74	0.63	0.61	--
LFPT_PGS4	0.51	0.52	0.53	0.50	--
Q10MR	4.18	5.37	3.75	5.98	--
QE25	0.074	0.074	0.059	0.082	μmol m^{-2} s^{-1}
VCMX25	58.72	43.96	56.88	39.42	μmol m^{-2} s^{-1}

Table S4 The model parameters of soybean at different sites were optimized based on the results of Morris and Sobol 'sensitivity analysis.

Parameter	SY	HL	Unit
AVCMX	6.21	6.03	--
BIO2LAI	0.018	0.017	m^2 g^{-1}
FOLN_MX	0.51	0.20	%
FRA_GR	0.11	0.18	--
GDDS3	1444.90	1447.31	GDD
GDDS4	1818.68	1876.29	GDD
GDDTBASE	7.65	6.24	GDD
GRAINPT_PGS5	0.47	0.40	--
GRAINPT_PGS6	0.87	0.89	--
LFMR25	0.38	0.30	μmol $m^{-2}s^{-1}$
LFPT_PGS3	0.66	0.51	--
LFPT_PGS4	0.30	0.30	--
Q10MR	9.43	7.98	--
QE25	0.080	0.066	μmol m^{-2} s^{-1}
VCMX25	42.34	51.86	μmol $m^{-2}s^{-1}$

Table S5 The model parameters of winter wheat at different sites were optimized based on the results of Morris and Sobol 'sensitivity analysis.

Parameter	YC	LC	FQ	Unit

AVCMX	2.34	2.13	2.27	--
BIO2LAI	0.025	0.027	0.026	$m^2 g^{-1}$
FOLN_MX	1.52	1.41	1.62	%
FRA_GR	0.20	0.20	0.21	--
GDDS3	1129.12	1113.82	1117.03	GDD
GDDS4	1587.06	1606.27	1609.34	GDD
GDDTBASE	4.06	3.81	4.38	GDD
GRAINPT_PGS5	0.99	1.00	0.90	--
GRAINPT_PGS6	1.00	0.91	0.99	--
LFMR25	0.78	0.79	0.77	$\mu mol\ m^{-2}\ s^{-1}$
LFPT_PGS3	0.40	0.41	0.42	--
LFPT_PGS4	0.20	0.17	0.20	--
Q10MR	2.03	2.10	1.99	--
QE25	0.061	0.063	0.061	$\mu mol\ m^{-2}\ s^{-1}$
VCMX25	56.67	47.60	48.99	$\mu mol\ m^{-2}\ s^{-1}$