Supplement of Geosci. Model Dev., 10, 1403–1422, 2017
http://www.geosci-model-dev.net/10/1403/2017/
doi:10.5194/gmd-10-1403-2017-supplement

Geoscientific Model Development
Open Access

Supplement of

Global gridded crop model evaluation: benchmarking, skills, deficiencies and implications

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Contents

Simulations at non-standard resolution

Some models performed simulations at different spatial or temporal resolution than supplied in the input data sets (Table S2).

Different temporal resolution

ORCHIDEE-crop used an internal weather generator for the interpolation to sub-daily values, whereas CLM-crop created a 6-hourly weather input data set based on AgMERRA and the 6-hourly CRU NCEP data (Wei et al., 2014). For the Temperate and Precip fields the CLM-crop group took the daily AgMERRA data and then compared it to the CRU NCEP daily average values to create a daily delta which was then added to each 6hr CRU NCEP field to generate the new hybrid data set.

For Precip this worked as:

dtPrecip = (AgMERRADailyPrecip - Sum(CRU NCEP 6hr Precip (1..4))) / 4

AgMERRA6hrPrecip = max(CRUN NCEP 6hr Precip + dtPrecip,0.0)

For Temp this worked as

dtTemp = AgMERRADailyTemp - Avg(CRU NCEP 6hr Temp(1..4))

AgMERRA6hrTemp = CRU NCEP 6hr Temp + dtTemp

The CLM-crop group used the CRU NCEP solar and wind for the AgMIP simulations.

Different spatial resolution

CLM-crop used the model-internal re-gridding routine as described in the CLM 4.5 Technical Note (Oleson et al., 2013), PRYSBI2 simply averaged over all 0.5 grid cells within the 1.125 degree cells and EPIC-BOKU and EPIC-IIASA used the same climate and management input for all 5 arc minute cells (up to 36) within one single 0.5 degree grid cell.

Tables

Table S 1: Main characteristics of GGCMs.

Model	Type[1]	CO2 effects[2]	Stresses[3]	Calibration[5]	Calibrated parameters	Outputs
CGMS-WOFOST	Site-based	LF, TE	W, T	Site-specific	Tsum requirements	Actual/potential yield and biomass
CLM-crop	Ecosystem	LF, TE	W,N,H	Uncalibrated	NA	Actual yield
EPIC-BOKU	Site-based	RUE, TE	W, T, H, A, N, P, BD, AL	Site-specific (EPIC 0810)	NA	Actual yield & yield gap
EPIC-IIASA	Site-based	RUE, TE	W, T, H, A, N, P, BD, AL	Site-specific and global	F, HIpot (ric, mai) F (others)	Actual yield
EPIC-TAMU	Site-based	RUE, TE	W, T, H, A, N, P, BD, AL	Site-specific and global	HIpot (maize)	Actual yield
GEPIC	Site-based	RUE, TE	W, T, A, N, P, BD, AL	Site-specific (EPIC 0810)	F HIpot (for maize and rice)	Actual yield
LPJ-GUESS	Ecosystem	LF, SC	W, T	Uncalibrated	NA	Actual yield
LPJmL	Ecosystem	LF, SC	W, T	National	LAImax HI αa	Actual yield
ORCHIDEE-crop	Ecosystem	LF, SC	W,T,N	Uncalibrated	-	Actual yield
pAPSIM	Site-based	RUE	W, T, H, A, N	Site-specific (APSIM)	NA	Actual yield
pDSSAT	Site-based	RUE (for wheat, rice, maize) and LF (for soybeans)	W, T, H, A, N	Site-specific (DSSAT)	NA	Actual yield
PEGASUS	Ecosystem	RUE, TE	W, T, H, N, P, K	Global	β	Actual yield
PEPIC	Site-based	RUE, TE	W, T, H, A, N, P, BD, AL	Site-specific and global	F HIpot (for maize)	Actual yield
PRYSBI2	Ecosystem	LF, SC	W,T	Global yield	TH, TC, TS, LR	Actual yield

Notes: (NA where not applicable)

[1] Site-based: site-base crop model; Ecosystem: global ecosystem model

[2] Elevated CO_2 effects: LF: Leaf-level photosynthesis (via rubisco or quantum-efficiency and leaf-photosynthesis saturation; RUE: Radiation use efficiency; TE: Transpiration efficiency; SC: stomatal conductance

[3] W: water stress; T: temperature stress; H: specific-heat stress; A: oxygen stress; N: nitrogen stress; P: phosphorus stress; K: potassium stress; BD: bulk density; AL: aluminum stress (based on pH and base saturation)

[4] Fertilizer application, timing of application; NPK annual application of total NPK (nutrient-stress factor); source of fertilizer application data; timing: annual or dynamic

[5] F: fertilizer application rate; HIpot: Potential harvest index; LAImax: maximum LAI under unstressed conditions; HI: harvest index; αa: factor for scaling leaf-level photosynthesis to stand level; β: radiation-use efficiency factor; TH: Total Heat unit required for the maturity; TC: Technological coefficient; TS: Temperature sensitivity of photosynthesis; LR: ratio of leaf to above ground biomass.

Table S 2: Model inputs and agricultural management practices

Model	Spatial scale	Temporal scale[1]	Climate input variables[2]	Soil input data [3]	Spin-up [4]	Planting date decision [5]	Crop cultivars [6]	Irrigation rules[7–8]	Fertilizer application [9]	Crop residue [10]
CGMS-WOFOST	0.5° lon x 0.5° lat	D	Ta Tmn Tmx P Rad Vap WS	FAO 1:5M DSMW AWC HYD	H2O (1)	Fixed planting day	GDD fixed	NA	NA	NA
CLM-crop	1° lon x 1° lat	6-hourly	T,P,WS,Q,SW, Rad	IGBP Global Soil Data Task 2000	NA	S	GDD+V	MIRCA 2000 (Portmann et al., 2010)	N	To litter pool
EPIC-BOKU	5” lon x 5”lat (default); 0.5° lon x 0.5° lat (harmonized)	D	Tmn, Tmx, P, Rad, RH, WS	ISRIC-WISE, ROSETTA,AWC, ALBEDO (Dobos, 2006), HYD (USDA and NRCS, 2015)	Soil OM, C, NH3, NO3, H2O, P(1)	S (fraction of PHU), fixed planting window	GDD - fixed	90/100/500/50/208 maximum applied irrigation: 500 mm yr-1	automatic N input (max 200 kg Ha-1 yr-1) PK (national stat. IFA) dynamic application	No, can be simulated
EPIC-IIASA	5” lon x 5”lat (default); 0.5° lon x 0.5° lat (harmonized)	D	Tmn, Tmx, P, Rad, RH, WS	ISRIC-WISE; ROSETTA; AWC; HYD (USDA and NRCS, 2015)	Soil OM, C, NH3, NO3, H2O, P, CR (50)	F (fixed planting window)	GDD, 3 cult for mai, 2 cult for wheat fixed	90/100/2000/500/0	NP (sub-national stat by (Mueller et al., 2012) P timing: rigid; N timing: automatic (based on N stress)	No
EPIC-TAMU	0.5° lon x 0.5° lat	D	Tmn, Tmx, P, Rad, RH, WS	ISRIC-WISE	Soil OM, C, NH3, NO3, H2O, P, CR (10)	S, planting delayed until 2 deg above base temp	GDD, 2 cultivars for mai	99/100/9999/100/25	NPK at planting	No
GEPIC	0.5° lon x 0.5° lat	D	Tmn, Tmx, P, Rad, RH, WS	ISRIC-WISE	Soil OM, C, NH3, NO3, H2O, P, CR (20)	F (fixed planting window)	GDD, 2 cultivars for mai - fixed	90/100/2000/ 1000/0.018	NP (national stat. FertiSTAT), dynamic application of N, rigid application of P	Yes, Crop-specific
LPJ-GUESS	0.5° lon x 0.5° lat	D	Ta, P, cld (or Rad)	HWSD, STC HYD (Cosby et al., 1984), THM (Lawrence and Slater, 2008)	H2O (30)	S (Waha et al., 2012), fixed planting window	GDD+V (whe, sunfl, rapes); BT (mai); static (others) + clim. adap	200/90/100/100[7]	NA	Yes, does not affect yield
LPJmL	0.5° lon x 0.5° lat	D	Ta, P, cld (or Rad)	HWSD, STC HYD (Cosby et al., 1984), THM (Lawrence and Slater, 2008)	H2O, Tsoil (200)	S (Waha et al., 2012), fixed planting day after 1951	GDD+V (whe, sunfl, rapes); BT (mai); static (others) - fixed	300/90/100/varies[7]	NA	Yes, does not affect yield
ORCHIDEE-crop	0.5° lon x 0.5° lat	Half-hourly	Tmn, Tmax, P, Rad, RH, WS	NA	H2O (1)	F (Sacks et al., 2010)	Fixed	200/90/100/varies[7]	N(IFA)	Yes, does not affect yield
pAPSIM	0.5° lon x 0.5° lat	D	Tmn, Tmx,P, Rad	HSWD	NA	F (S is also possible)	GDD and/or latitude, 2-3 for each cell	NA	GGCMI	NA

pDSSAT	0.5° lon x 0.5° lat	D	Tmn, Tmx, P, Rad	HWSD	Soil OM, C, NH3, NO3, H2O (1)	S (Sacks et al., 2010) fixed planting window	GDD and/or latitude, 2-3 for each cell - fixed	40/80/100/757 ric: 30/50/100/100[7]	GGCMI	Yes, does not affect yield
PEGASUS	0.5° lon x 0.5° lat	D	Ta, Tmn, Tmx, P, cld (or sun)	AWC (ISRIC-WISE)	H2O (4)	S (Deryng et al., 2011) clim. adapt	GDD + clim. adapt	40/90/100/100[7]	NPK (national stat. IFA), annual application	NA
PEPIC	0.5° lon x 0.5° lat	D	Tmn, Tmx,P, Rad, RH, WS	ISRIC-WISE	Soil OM, C, NH3, NO3, H2O, P, CR (20)	Fixed planting day	GDD, 2 cultivars for mai	90/100/1000/500/1	NP (national stat. FertiSTAT), three times of N, rigid application of P	Yes
PRYSBI2	1.125° lon x 1.125° lat	D	Tmn, Tmx, P, Rad, RH, WS	ISLSCP-II (Hall et al., 2006)	NA	F (Sacks et al., 2010)	GDD - fixed	NA	NA	No

Notes: (NA where not applicable)

[1] D: daily time-step; M: monthly time-step; H: hourly time-step; WG: use monthly climate data interpolated to daily using a weather-generator

[2] Ta: average temperature, Tmn: minimum temperature, Tmx: maximum temperature, cld: percentage of cloud cover, sun: fraction of sunshine hours; RH: relative humidity; WS: wind speed; Vap: vapour pressure, Rad: radiation

[3] Source of soil property inputs (e.g., source of basic soil properties), plus method for manipulation to derive parameters required by the model); AWC: Available Water Capacity (Van Genuchten et al., 1992) ; HYD: hydraulic soil parameters; THM: thermal parameters; HWSD: Harmonized world soil database (Fischer et al., 2008); STC: soil texture classification based on the USDA soil texture classification (http://ufdc.ufl.edu/IR00003107/00001); ISRIC-WISE (Batjes, 2006) ; ROSETTA (Schaap and Bouten, 1996)

[4] Number of years for Spin up (x); OM: organic matter, C: carbon; NH3: ammonia; NO3: nitrate; H2O: soil water; P: phosphorus; CR: crop residues

[5] S: Simulate planting dates according to climatic conditions; F: fixed planting dates; source of planting date data if applicable; PHU: potential heat unit; fixed planting window (i.e., does not allow for adaptation to climate change); clim. adapt: dynamic planting window (adaptation to climate change)

[6] GDD: Simulate crop Growing Degree Days (GDDs) requirement according to estimated annual GDDs from daily temperature; Number of cultivars; GDD+V: GDD requirements and vernalization requirements computed based on past climate experience; BT base temperature computed based on past climate; fixed: static GDD requirement (no adaptation); clim. adapt: dynamic GDD requirement (adaptation to climate change)

[7] Irrigation rules: IMDEP: depth of soil moisture measured; ITHRL(): critical lower soil moisture threshold to trigger irrigation event; ITHRU(): upper soil moisture threshold to stop irrigation; IREFF: irrigation application efficiency

[8] Irrigation rules: EPIC and GEPIC models: BIR(): water stress in crop to trigger automatic irrigation; EFI(): irrigation efficiency - runoff from irrigation water; VIMX: maximum of annual irrigation volume; ARMX: maximum of single irrigation volume allowed; ARMN: minimum of single irrigation volume allowed

[9] Fertilizer application, timing of application; NPK annual application of total NPK (nutrient-stress factor); source of fertilizer application data; timing: annual or dynamic

[10] Remove residue or not (Yes/No)

Table S 3: Biophysical process representation in GGCMs

Model	Leaf area development[1]	Light interception[2]	Light utilisation[3]	Yield formation[4]	Stresses involved[5]	Type of heat stress[6]	Crop phenology[7]	Type of water stress[8]	Evapo-transpiration[9]	Soil water dynamic[10]	Root distribution over depth[11]	Soil CN model[12]	CO2 effects[13]
CGMS-WOFOST	DA	D	P-R	Prt	W T A	V	T DL V	S	PM	2	NON	NA	LF TE
CLM-crop	DA	D	P-R	Prt	W,N,H	V	T & DL	S	TF	10	EXP	C/N	LF, TE
EPIC-BOKU	PS	S	RUE	HIws Prt B	W T H A N P BD AL	NA	T(HU) V O	E	PM	10	EXP W	C N B(1) P(6)	RUE TE
EPIC-IIASA	PS	S	RUE	HIws Prt B	W T H A N P BD AL	NA	T(HU) V O	E	HAR	10	EXP W	C N B(1) P(6)	RUE TE
EPIC-TAMU	PS	S	RUE	HIws Prt B	W T H A N P BD AL	NA	T(HU) V O	E	PM	3	EXP W	C N B(1) P(6)	RUE TE
GEPIC	PS	S	RUE	HIws Prt B	W T A N P BD AL	NA	T(HU) V O	E	HAR	5	EXP W	C N B(1) P(6)	RUE TE
LPJ-GUESS	DA	S	P-R	HIws	W T	NA	T V	S	PT	2	LIN	NA	LF, SC
LPJmL	PS	S	P-R	HIws	W T	NA	T V	S	PT	5	EXP	NA	LF, SC
ORCHIDEE-crop	DA	S	P-R	Prt	WT N	VR	T(HU) DL O V	S	PT	11	EXP	NA	LF,SC
pAPSIM	DA	S	RUE,P-R(pasture only)	Gn, Prt, HIw (soy)	T,Dl,O, V	EXP	W,N,A, H	E, S	TE	5	EXP	C,N,P, B(3)	RUE, TE, NE
pDSSAT	PS(soy= DA)	S /D	RUE/P-R	Gn	W T H A N	V R F	T V DL O	E	PT/PM	4	EXP	C N P(3)	RUE, LF, TE
PEGASUS	DA	S	RUE	Prt	W T H N P K	V F[14]	T(HU)	E	PT	3	LIN W	NA	RUE TE
PEPIC	PS	S	RUE	HIws Prt B	W T H A N P BD AL	NA	T(HU) V O	E	PM	5	EXP W	C N B(1) P(6)	RUE TE
PRYSBI2	DA	S	P-R	HI	W T	V	HU	E	PM	2	EXP	NA	LF, SC

Notes: (NA where not applicable):

[1] DA: Dynamic simulation based on development and growth processes; PS: prescribed shape of LAI curve as function of phenology, modified by water stress & low productivity

[2] S: Simple approach: D: Detailed approach

[3] RUE: Simple (descriptive) radiation use efficiency approach; P-R: Detailed (explanatory) gross photosynthesis – respiration (for more details see Adam et al. (2011))

[4] Yield formation depending on: HI: fixed harvest – index; B: total (above – ground) biomass; Gn: number of grains and grain growth rate; Prt: partitioning during reproductive stages; HIws: HI modified by water stress

[5] W: water stress; T: temperature stress; H: specific-heat stress; A: oxygen stress; N: nitrogen stress; P: phosphorus stress; K: potassium stress; BD: bulk density; AL: aluminum stress (based on pH and base saturation)

[6] V: vegetative (source); R: reproductive organ (sink); F: number of grain (pod) set during the flowering period

[7] Crop phenology is a function of: T: temperature; DL: photoperiod (day length); O: other water/nutrient stress effects considered; V: vernalization; HU: Heat unit index
[8] E: ratio of supply to demand of water; S: soil available water in root zone
[9] PM: Penman – Monteith; PT: Priestley –Taylor; HAR: Hargreaves; TE: transpiration efficiency; TF: Turbulent Flux (Farquhar et al., 1980)
[10] (x): x number of soil layers
[11] LIN: linear; EXP: exponential; NON: no roots-just soil depth zone; W: actual roots depends on water availability in each soil layer
[12] C model; N model; P(x): x number of organic matter pools; B(x): x number of microbial biomass pools
[13] Elevated CO_2 effects: LF: Leaf-level photosynthesis (via rubisco or quantum-efficiency and leaf-photosynthesis saturation; RUE: Radiation use efficiency; TE: Transpiration efficiency; SC: Stomatal conductance
[14] see Deryng et al. (2014)

Table S 4: Model calibration, parameters, scale and methods

Model	Model origin[1]	Calibration method	Parameters for calibration[2]	Output variable and dataset for calibration[3]	Spatial scale of calibration	Temporal scale of calibration	Method for model evaluation [4]
CGMS-WOFOST	Site-based	Default parameters from site-specific analysis (WOFOST 6.0)	NA	NA	Field scale	Mostly trials from 1980-2000	NA
CLM-crop	Ecosystem	NA	NA	NA	NA	NA	NA
EPIC-BOKU	Site-based	Site-specific (EPIC 0810)	NA	Yield (FE & FAO)	Field scale & National	Various	NA
EPIC-IIASA	Site-based	Site-specific (EPIC 0810) & Global[5]	F, HIpot (ric, mai)F (others)	Yield (FE & FAO)	National	Around 2000	R2
EPIC-TAMU	Site-based	Site-specific	HIpot (mai)	Yield (SPAM 2000 by You et al. (2014))	Grid cell level	2000	various
GEPIC	Site-based	Site-specific (EPIC 0810) & Global[5]	F HIpot (mai, ric)	Yield (FE & FAO)	National	Average for 1997-2003	R2
LPJ-GUESS	Ecosystem	Uncalibrated	NA	NA	NA	NA	NA
LPJmL	Ecosystem	Global	LAImax HI alpha_a	Yield (FAO)	National	Average for 1998-2003	Wilmott
ORCHIDEE-crop	Ecosystem	Uncalibrated	NA	NA	NA	NA	NA
pAPSIM	Site-based	Default parameters from site-specific analyses	NA	NA	field scale	NA	NA
pDSSAT	Site-based	Site-specific (DSSAT)	NA	Yield (FE)	Field scale	Various	NA
PEGASUS	Ecosystem	Global	β	Yield (M3 by Monfreda et al. (2008))	Grid cell level (0.5° lon x 0.5° lat resolution)	Average for 1997-2004	Wilmott
PEPIC	Site-based	Default parameters from site-specific analyses of EPIC0810 Potential HI (maize)	NA	Yield (FAO yield statistics)	National	Average for 1998-2002	R2
PRYSBI2	Ecosystem	Global	TH, TC, TS, LR	Yield (Iizumi et al. (2014))	Grid cell level	1982-2006 (but the odd-numbered years were used as learning data for the estimation for the even years, and vice versa)	Log likelihood

Notes: (NA where not applicable)

[1] site-base crop model, ecosystem: global ecosystem model

[2] F: fertilizer application rate; HIpot: Potential harvest index; LAImax: maximum LAI under unstressed conditions; HI: harvest index; αa: factor for scaling leaf-level photosynthesis to stand level; β: radiation-use efficiency factor; TH: Total Heat unit required for the maturity; TC: Technological coefficient; TS: Temperature sensitivity of photosynthesis; LR: ratio of leaf to above ground biomass

[3] FE: field experiments; FAO: FAOSTAT national yield statistic; M3: gridded data set of crop specific yields and harvested areas for the year 2000 (Monfreda et al., 2008)

[4] Willmott: maximize Wilmott index of agreement (d) and RMSEu>RMSEs (RMSE: root-mean-square error; RMSEu: unsystematic RMSE; RMSEs: systematic RMSE) (Willmott et al., 1985), R2: coefficient of determination

[5] GEPIC & EPIC-IIASA: Default parameters coming with the field scale model EPIC v0810 are mostly used. Potential HI has been adjusted for maize cultivars based on literature and human development index (GEPIC) or major world regions (EPIC-IIASA) and for rice based on literature. Fertilizer application rates have been modified for few countries that report very high yields and low fertilizer use, whereas most of these countries are known for their intensive use of manure.

Figures

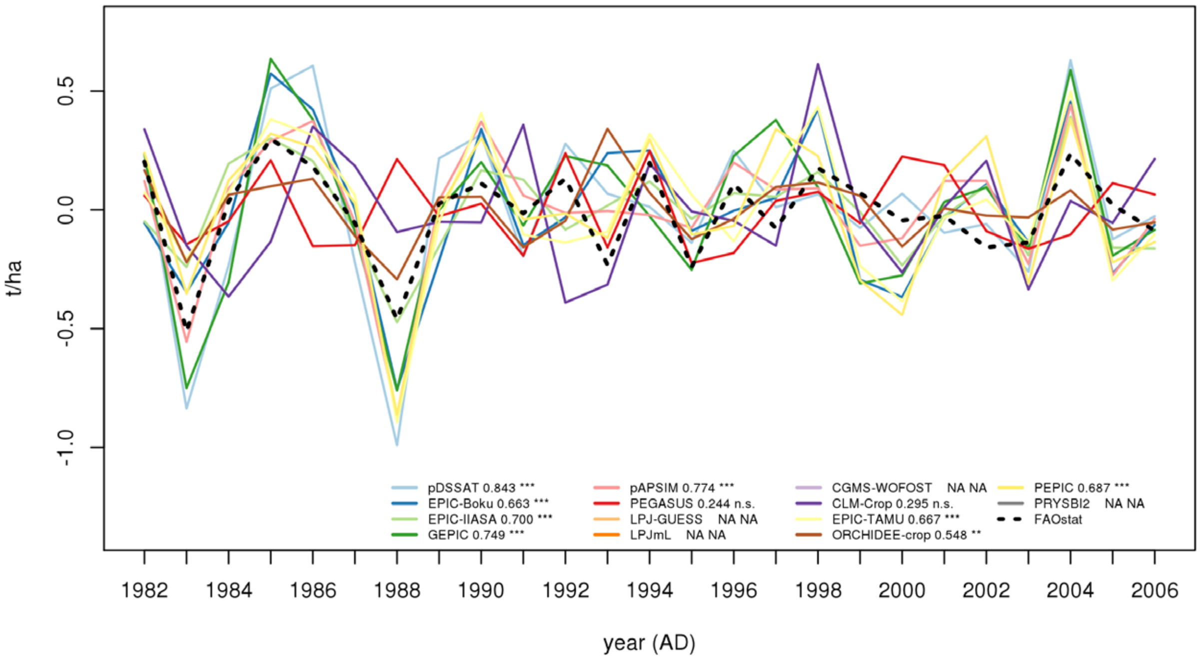


Figure S 1: As figure 1 in the main text, but for the maize *fullharm* setting.
NA indicates that this model/harmonization combination is not available (Table 2).

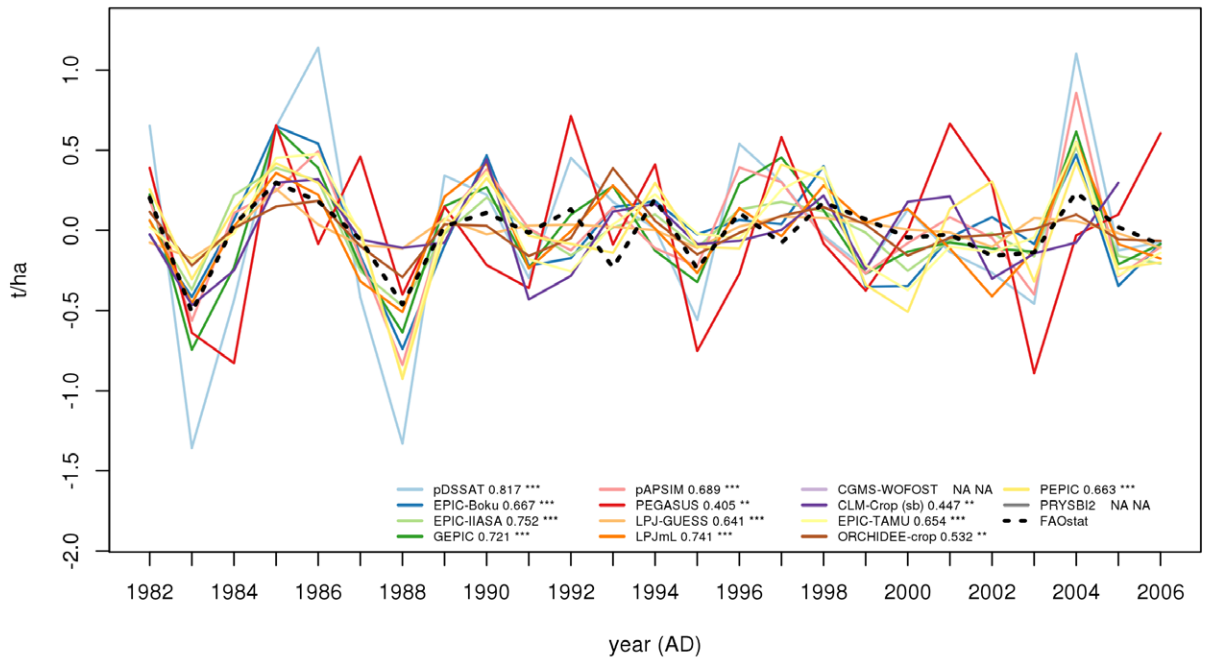


Figure S 2: As figure 1 in the main text, but for the maize *harm-suffN* setting. NA indicates that this model/harmonization combination is not available (Table 2).

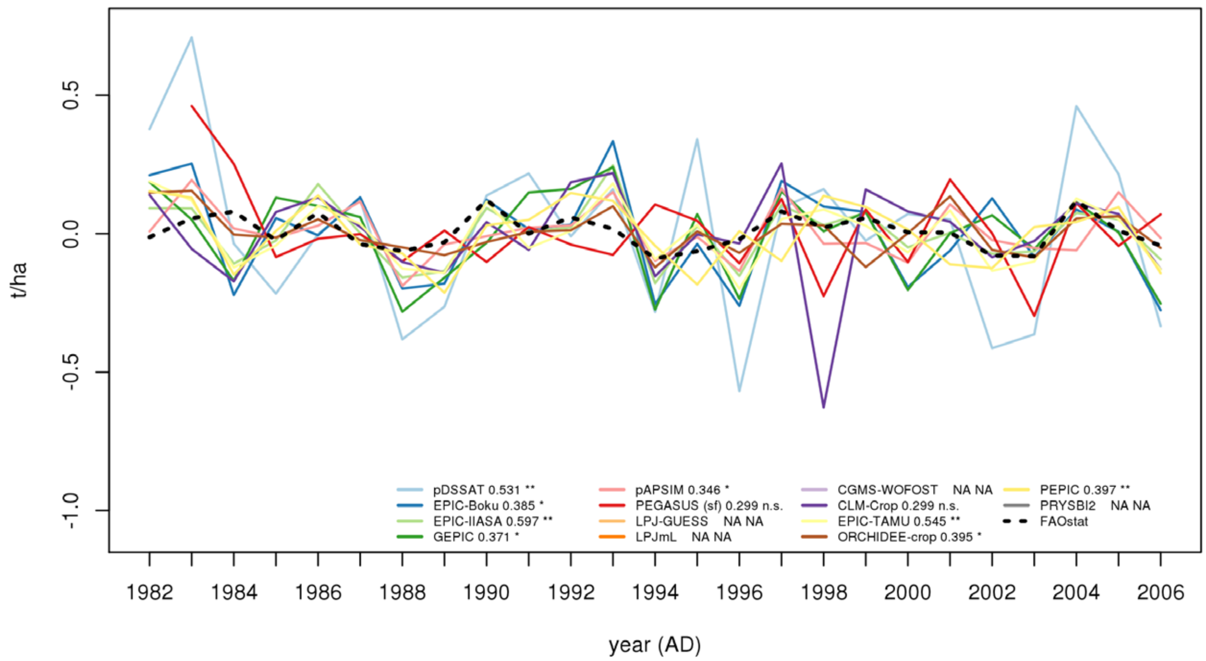


Figure S 3: As figure 2 in the main text, but for the wheat *fullharm* setting. NA indicates that this model/harmonization combination is not available (Table 2).

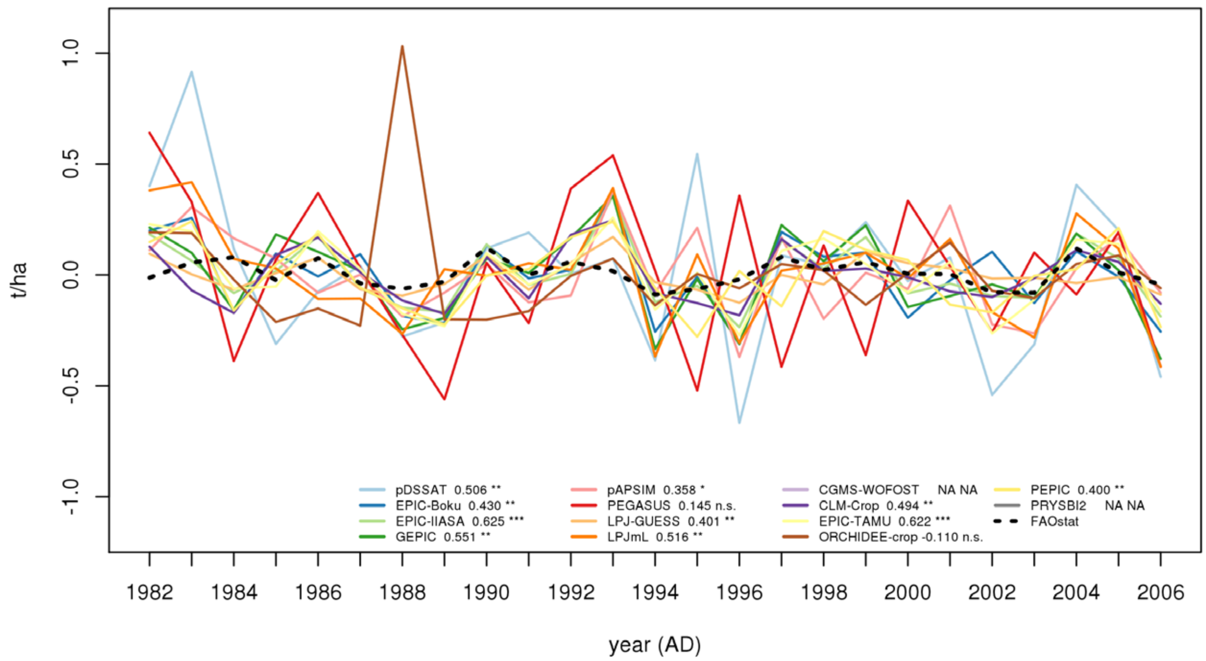


Figure S 4: As figure 2 in the main text, but for the wheat *harm-suffN* setting.
NA indicates that this model/harmonization combination is not available (Table 2).

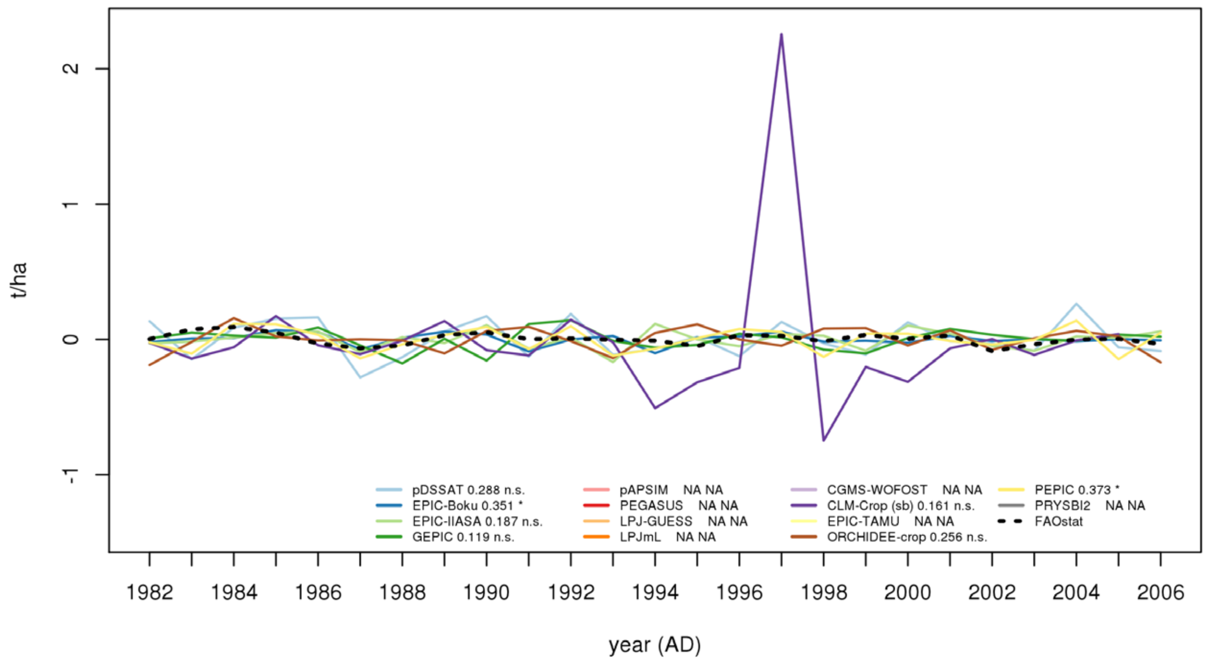


Figure S 5: As figure 3 in the main text, but for the rice *fullharm* setting.
NA indicates that this model/harmonization combination is not available (Table 2).

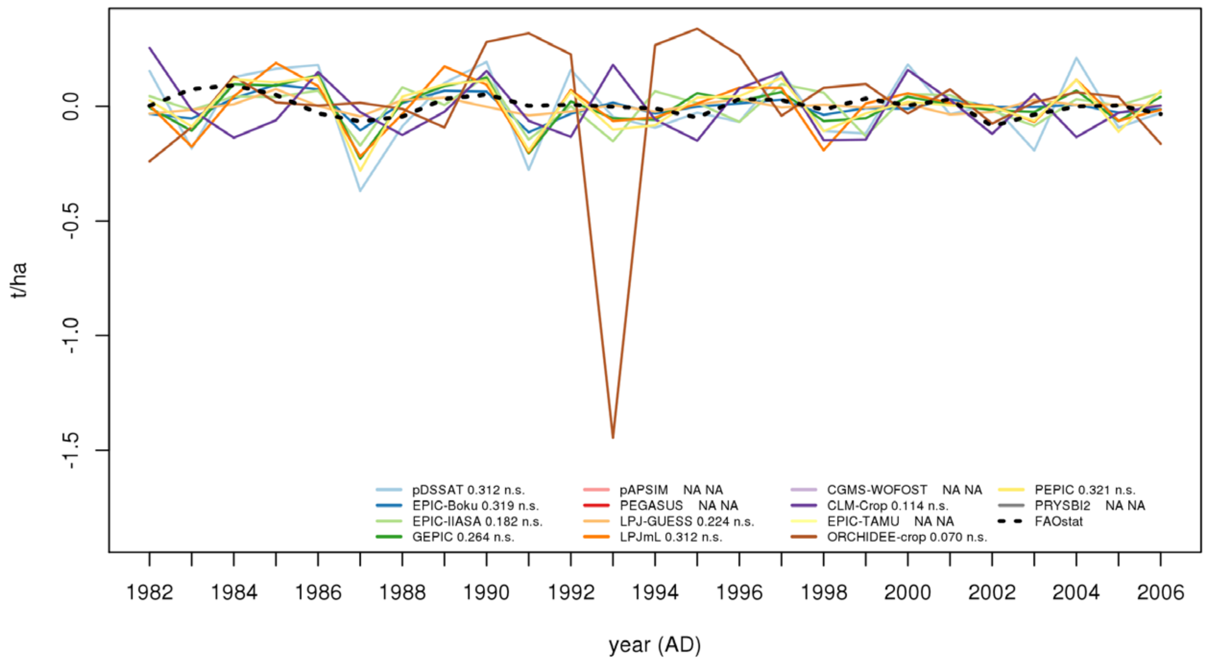


Figure S 6: As figure 3 in the main text, but for the rice *harm-suffN* setting.
NA indicates that this model/harmonization combination is not available (Table 2).

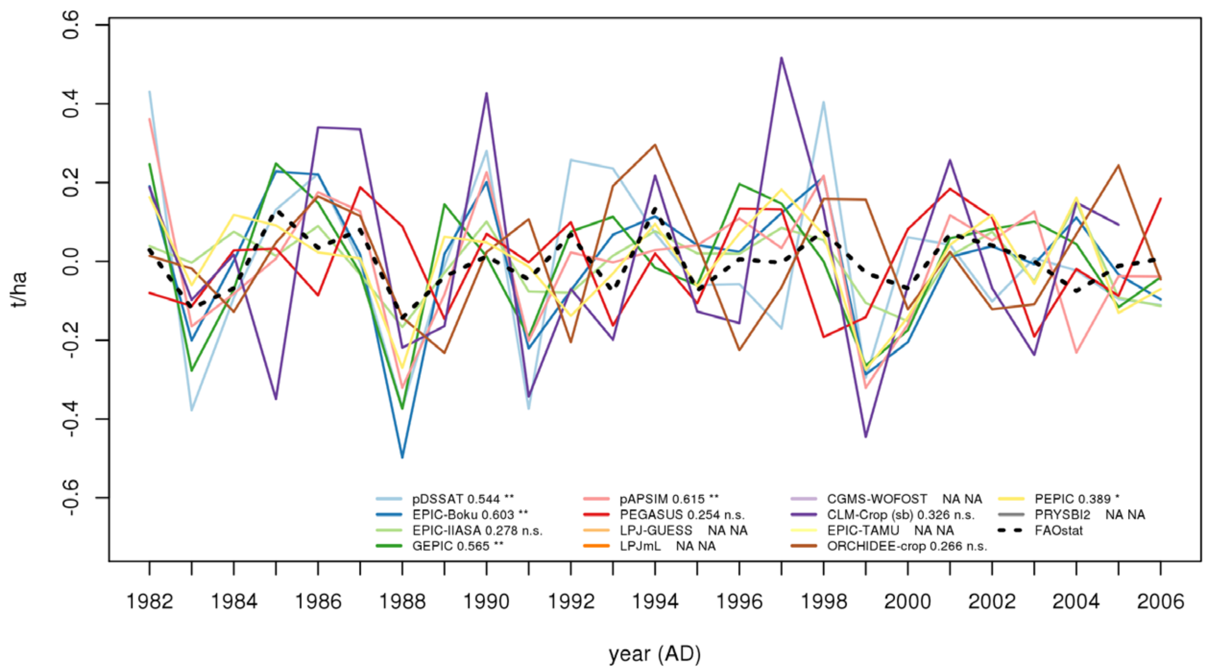


Figure S 7: As figure 4 in the main text, but for the soybean *fullharm* setting.
NA indicates that this model/harmonization combination is not available (Table 2).

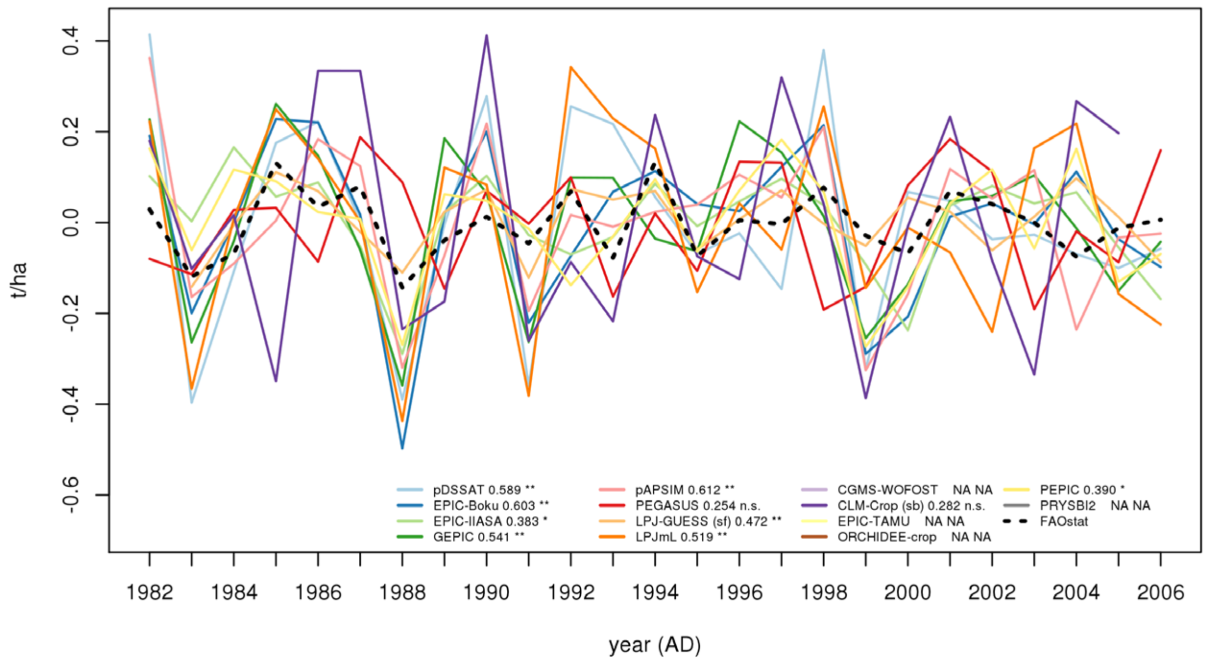


Figure S 8: As figure 4 in the main text, but for the soybean *harm-suffN* setting.
NA indicates that this model/harmonization combination is not available (Table 2).

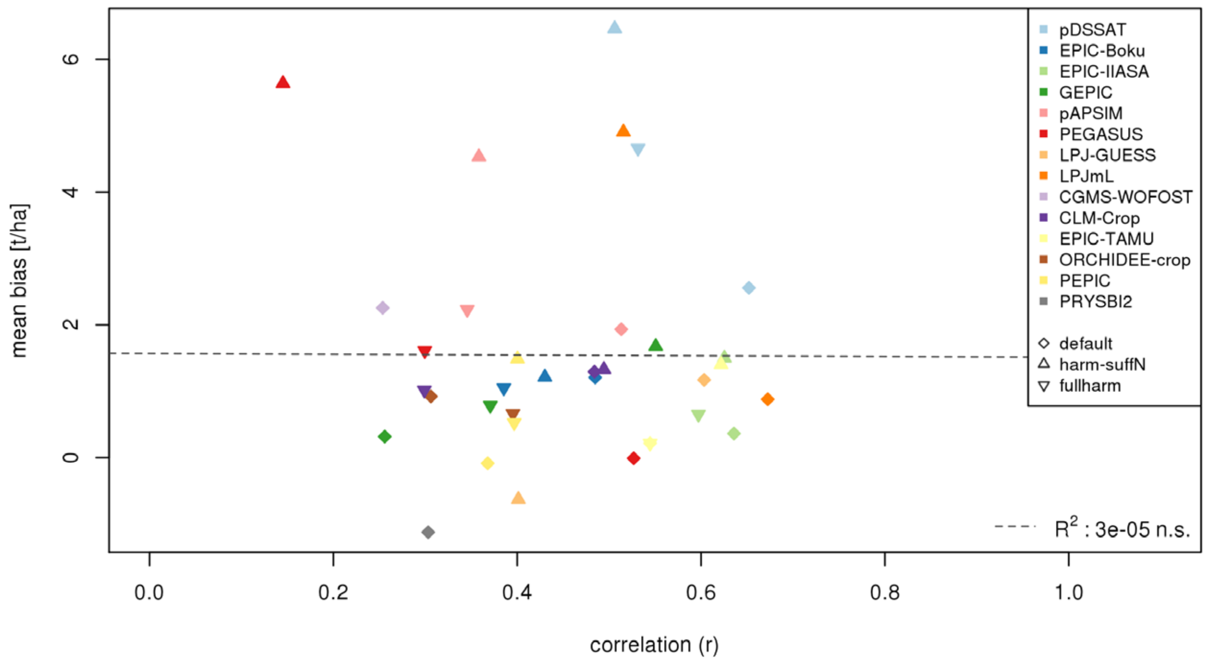


Figure S 9: As figure 5 in the main text, but for wheat.

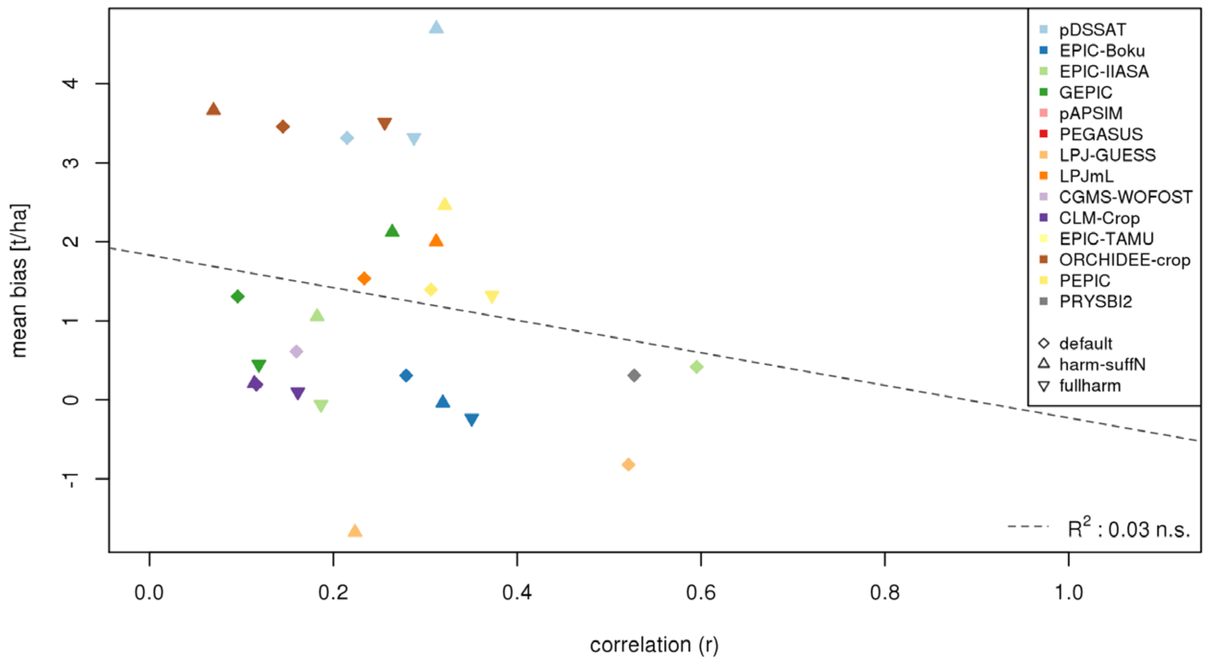


Figure S 10: As figure 5 in main text, but for rice.

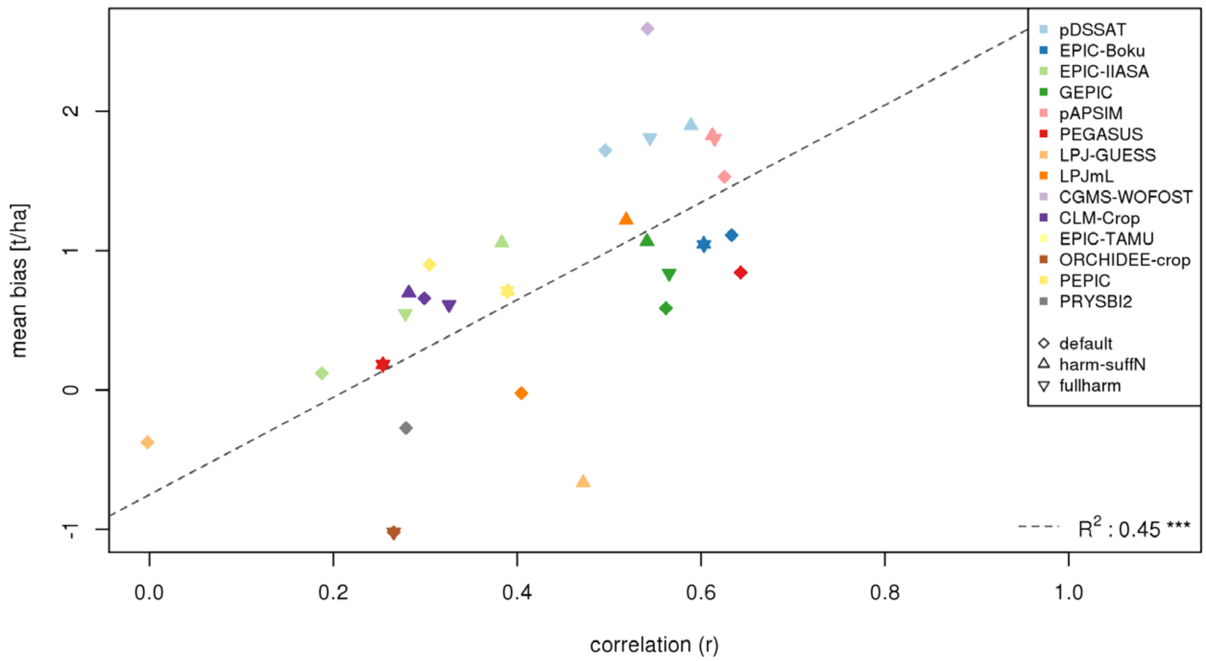


Figure S 11: As figure 5 in main text, but for soybean.

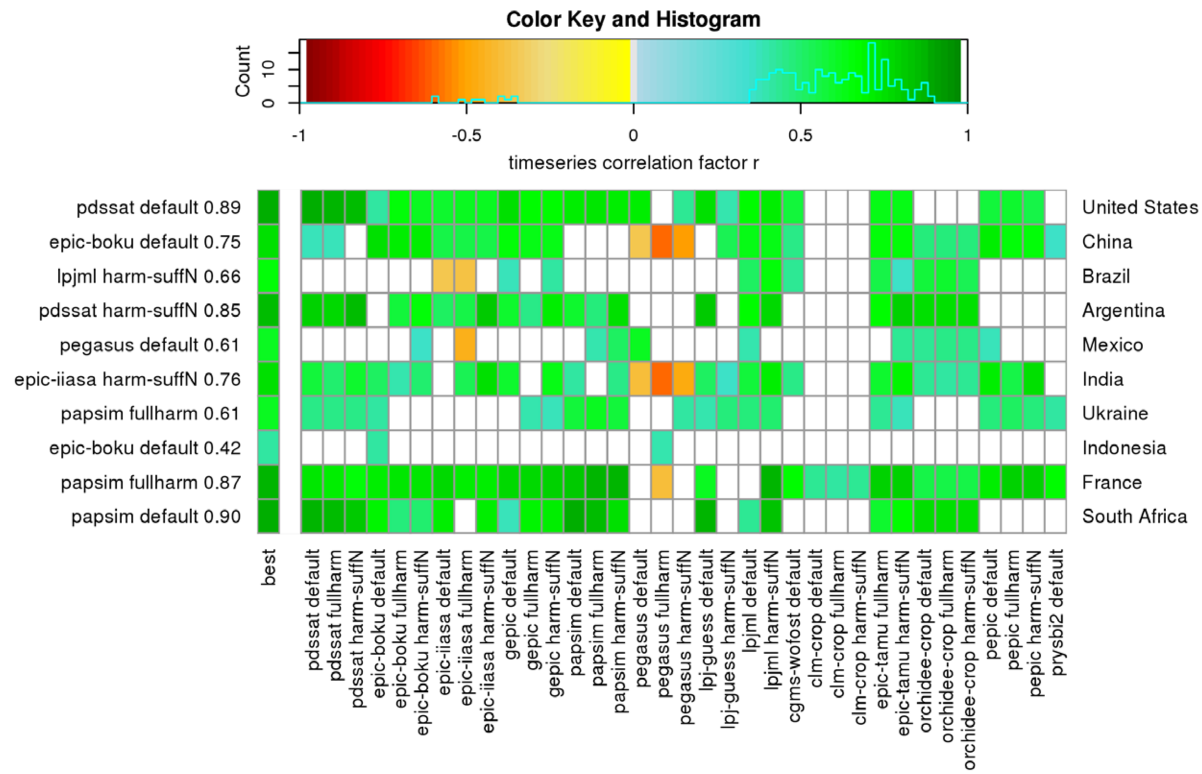


Figure S 12: As figure 6 in main text, but without allowing for time shifts of one year in the correlation analysis.

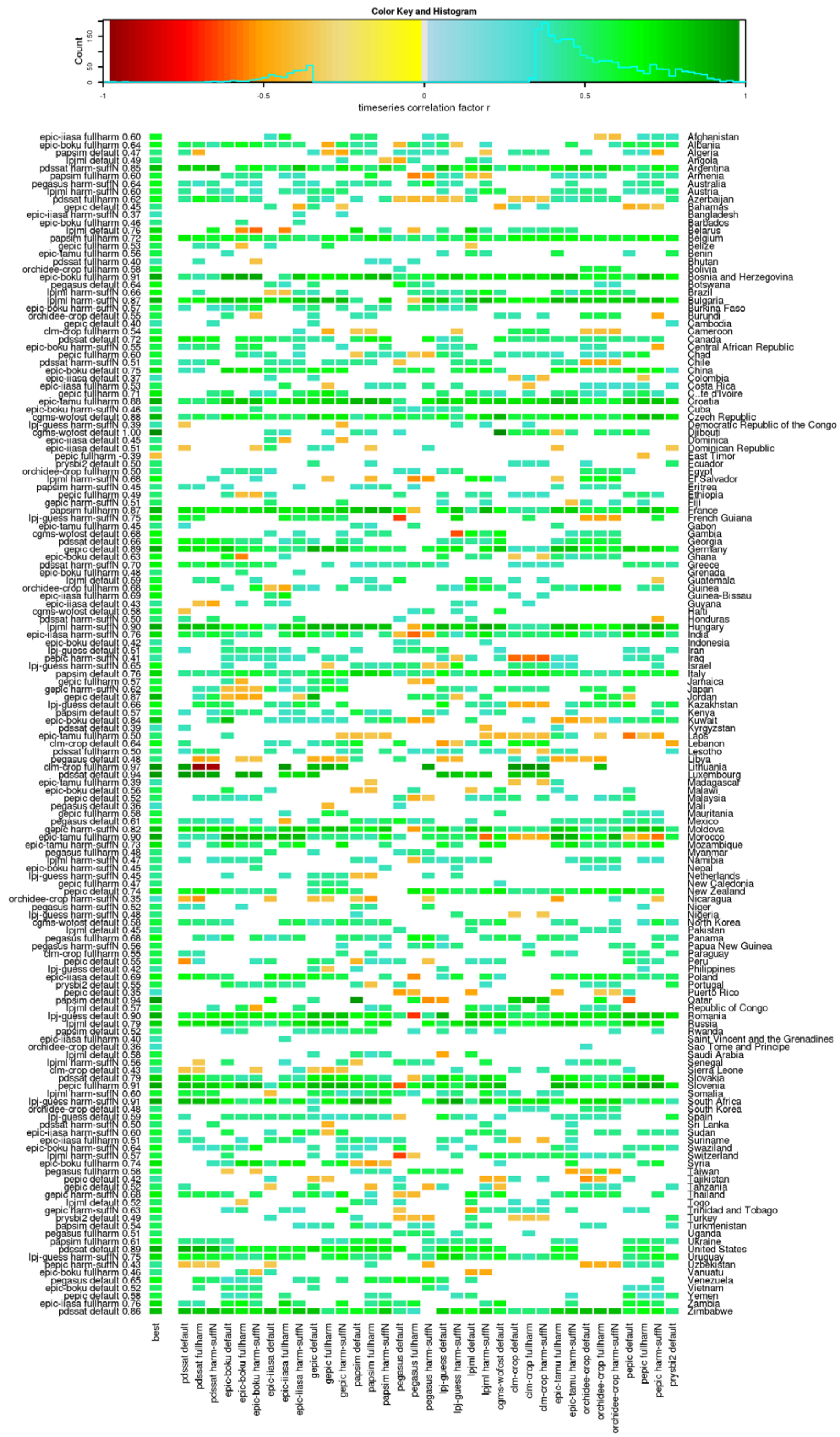


Figure S 13: As figure 6 in main text, but for all maize producer countries simulated here.

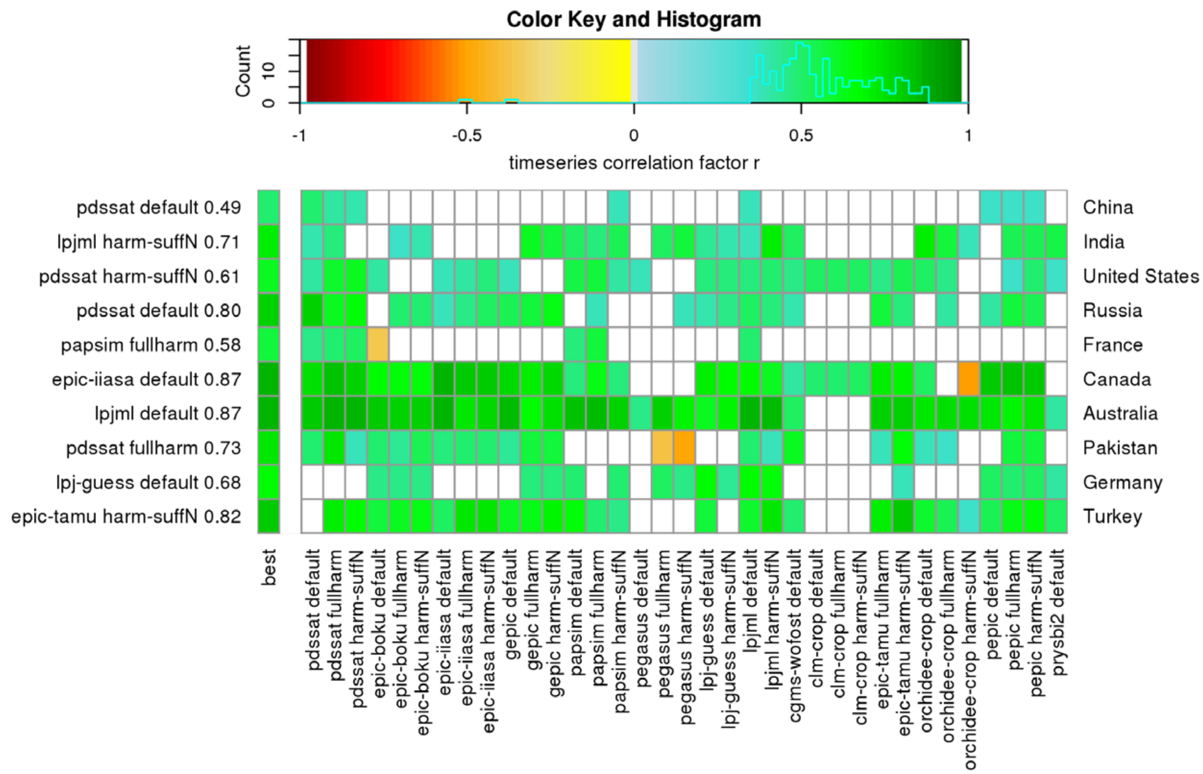


Figure S 14: As figure 6 in main text, but for wheat.

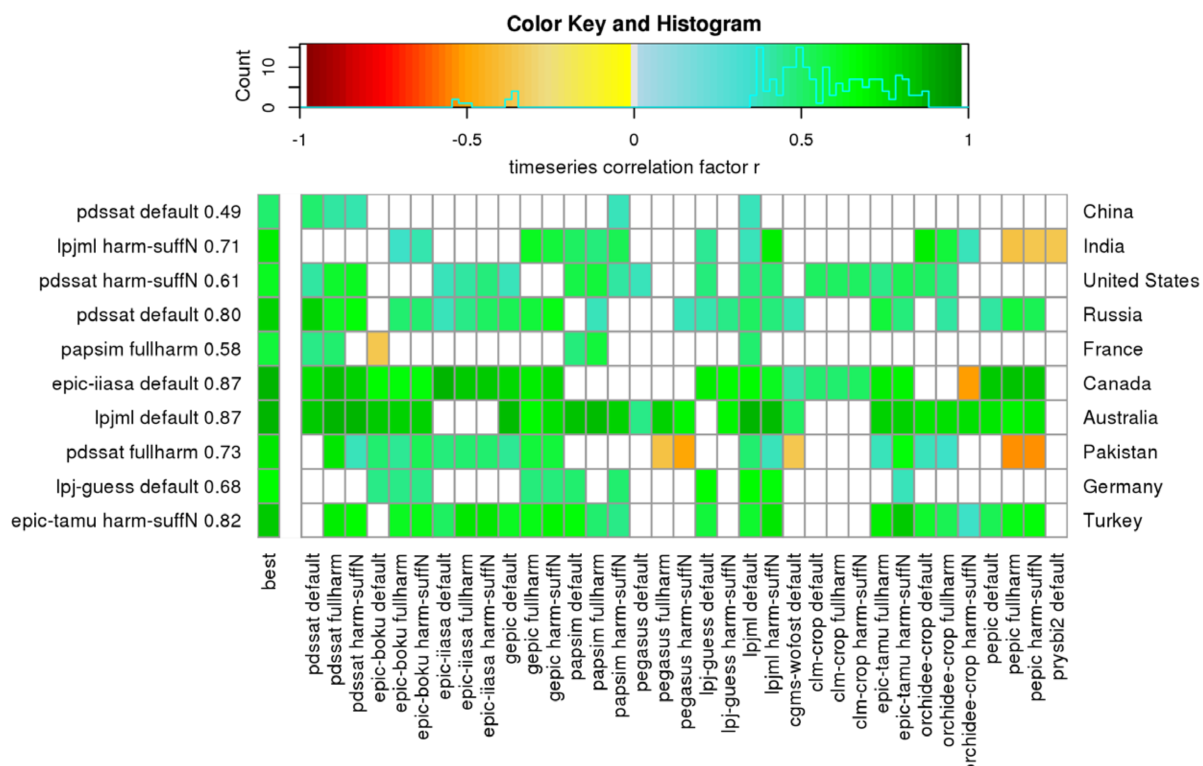


Figure S 15: As Figure S12, but for wheat.

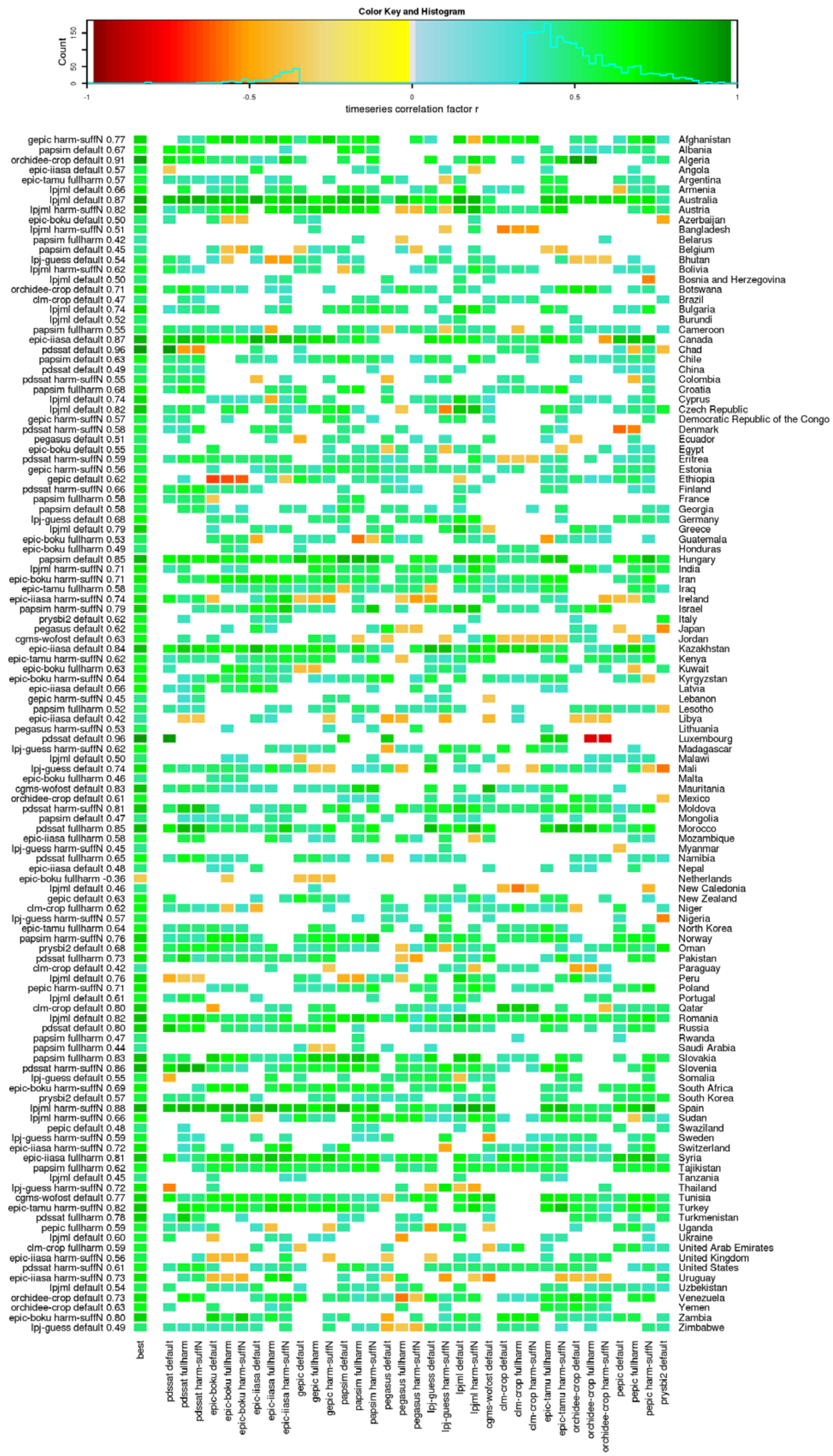


Figure S 16: As figure 13, but for wheat.

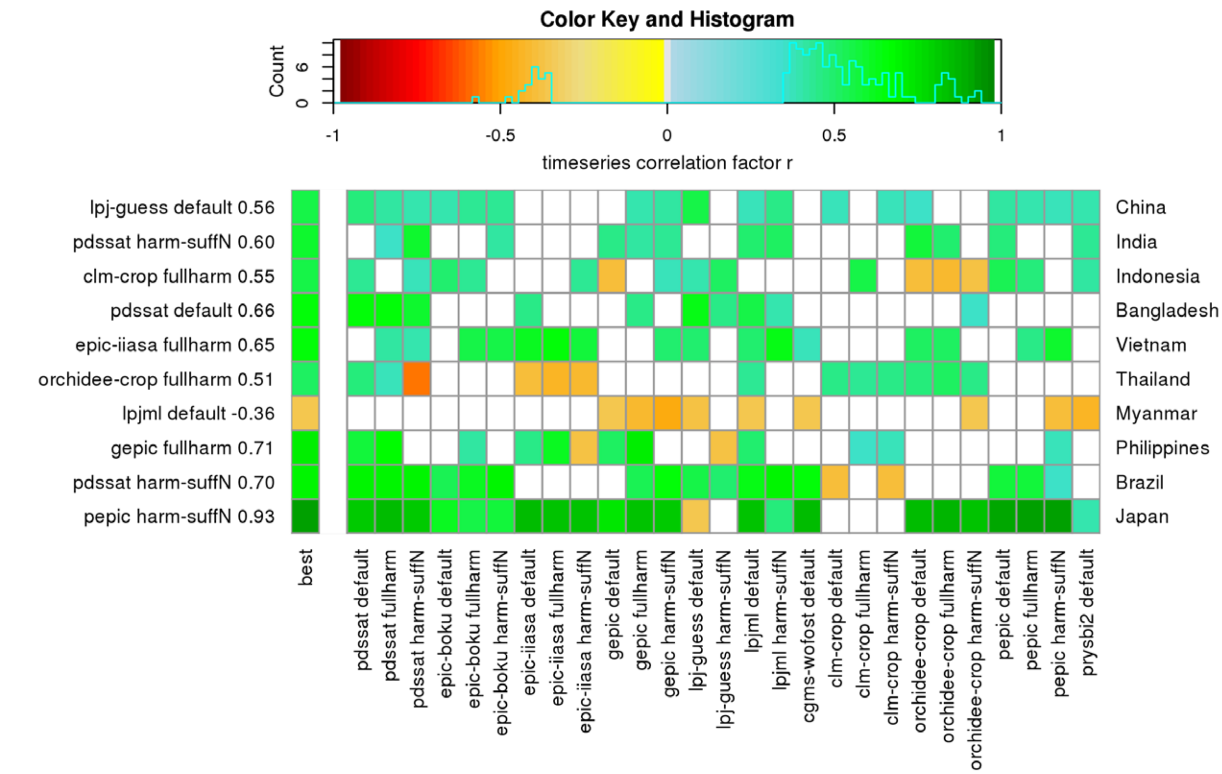


Figure S 17: As figure 6 in main text, but for rice.

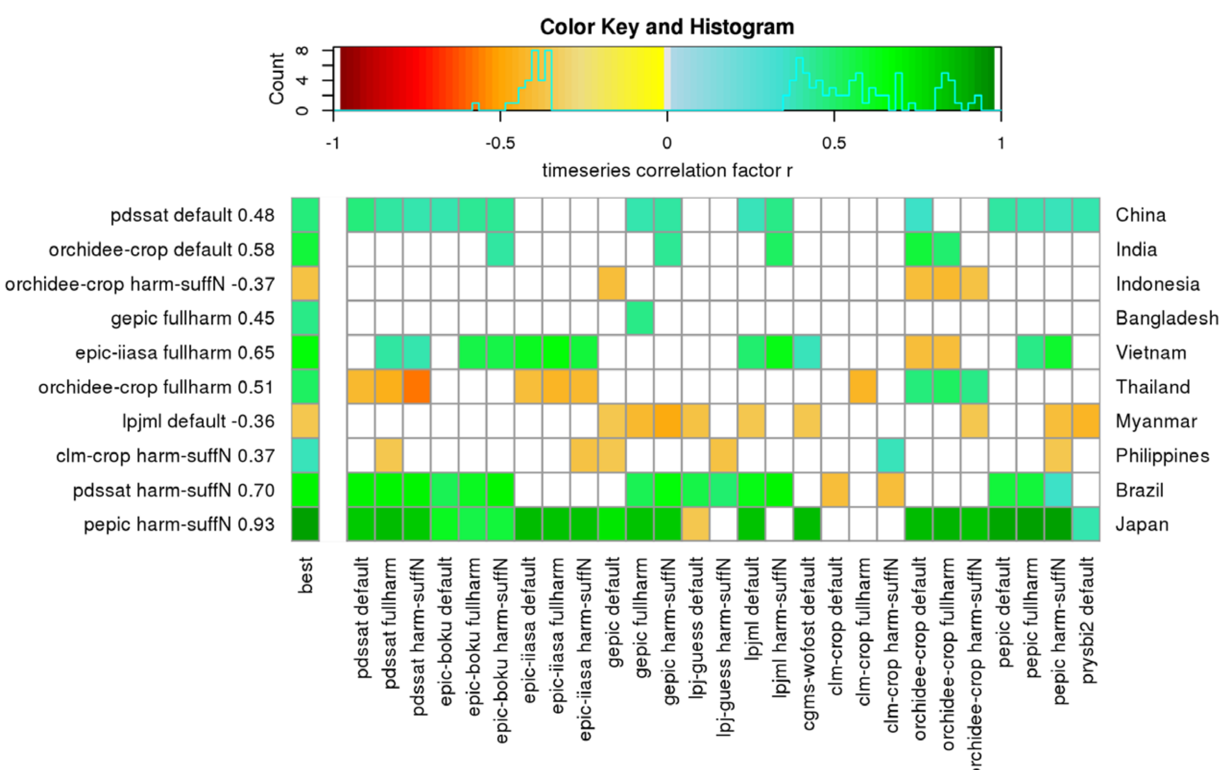
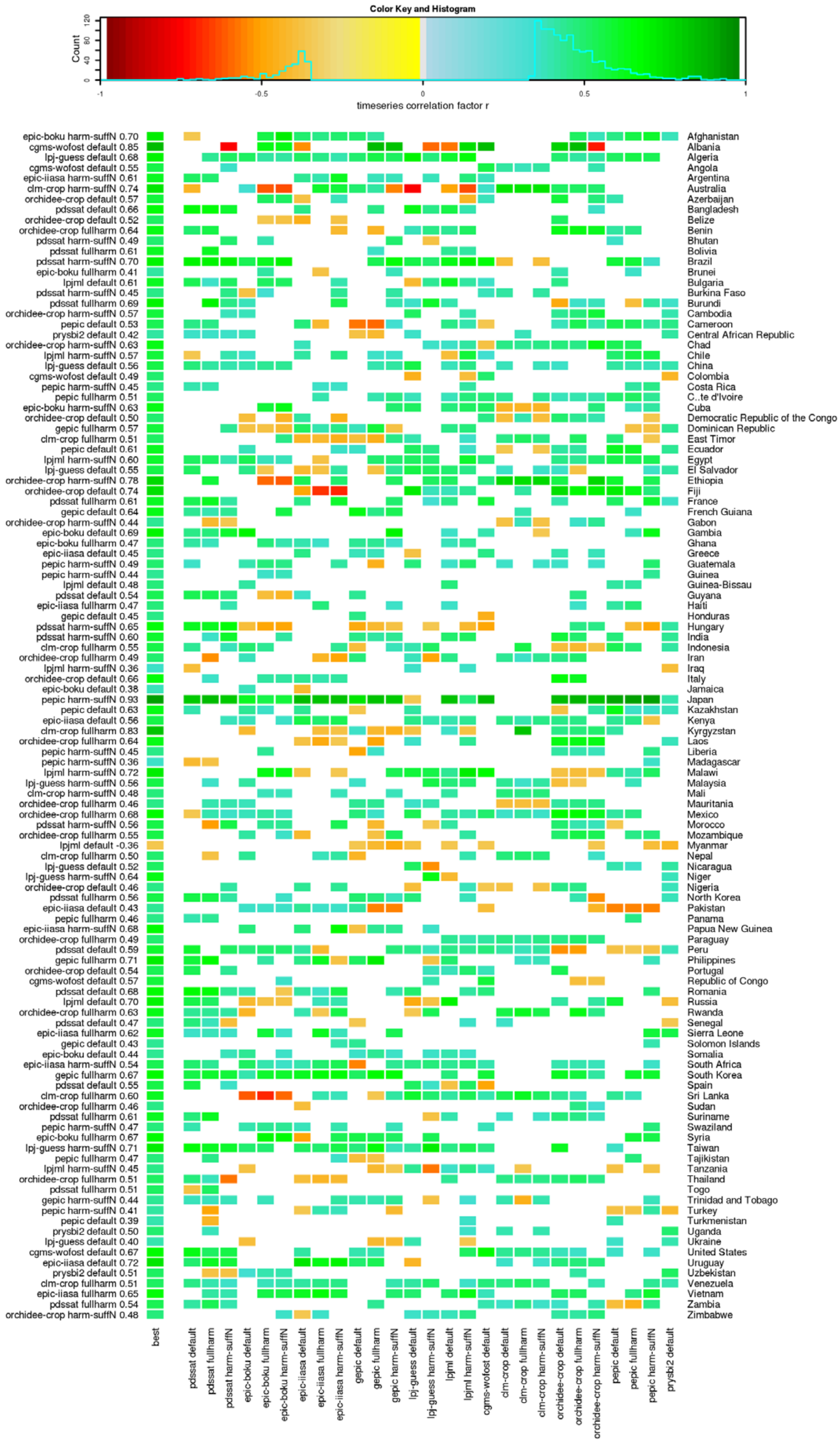


Figure S 18: As Figure S12, but for rice.


Color Key and Histogram
Count
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-1 -0.5 0 0.5 1
timeseries correlation factor r
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lpj-guess default 0.68
cgms-wofost default 0.55
epic-iiasa harm-suffN 0.61
clm-crop harm-suffN 0.74
orchidee-crop default 0.57
pdssat default 0.66
orchidee-crop default 0.52
orchidee-crop fullharm 0.64
pdssat harm-suffN 0.49
pdssat fullharm 0.61
pdssat harm-suffN 0.70
epic-boku fullharm 0.41
lpjml default 0.61
pdssat harm-suffN 0.45
pdssat fullharm 0.69
orchidee-crop harm-suffN 0.57
pepic default 0.53
prysbi2 default 0.42
orchidee-crop harm-suffN 0.63
lpjml harm-suffN 0.57
lpj-guess default 0.56
cgms-wofost default 0.49
pepic harm-suffN 0.45
pepic fullharm 0.51
epic-boku harm-suffN 0.63
orchidee-crop default 0.50
gepic fullharm 0.57
clm-crop fullharm 0.51
pepic default 0.61
lpjml harm-suffN 0.60
lpj-guess default 0.55
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gepic default 0.64
orchidee-crop harm-suffN 0.44
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pepic harm-suffN 0.44
lpjml default 0.48
pdssat default 0.54
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pdssat harm-suffN 0.65
pdssat harm-suffN 0.60
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lpj-guess harm-suffN 0.56
clm-crop harm-suffN 0.48
orchidee-crop fullharm 0.46
orchidee-crop fullharm 0.68
pdssat harm-suffN 0.56
orchidee-crop fullharm 0.55
lpjml default -0.36
clm-crop fullharm 0.50
lpj-guess default 0.52
lpj-guess harm-suffN 0.64
orchidee-crop default 0.46
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epic-iiasa harm-suffN 0.68
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pdssat default 0.59
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cgms-wofost default 0.57
pdssat default 0.68
lpjml default 0.70
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gepic default 0.43
epic-boku default 0.44
epic-iiasa harm-suffN 0.54
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pdssat fullharm 0.61
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epic-boku fullharm 0.67
lpj-guess harm-suffN 0.71
pepic fullharm 0.47
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cgms-wofost default 0.67
epic-iiasa harm-suffN 0.72
prysbi2 default 0.51
clm-crop fullharm 0.51
epic-iiasa fullharm 0.65
pdssat fullharm 0.54
orchidee-crop harm-suffN 0.48
Afghanistan
Albania
Algeria
Angola
Argentina
Australia
Azerbaijan
Bangladesh
Belize
Benin
Bhutan
Bolivia
Brazil
Brunei
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Central African Republic
Chad
Chile
China
Colombia
Costa Rica
C..te d'Ivoire
Cuba
Democratic Republic of the Congo
Dominican Republic
East Timor
Ecuador
Egypt
El Salvador
Ethiopia
Fiji
France
French Guiana
Gabon
Gambia
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
India
Indonesia
Iran
Iraq
Italy
Jamaica
Japan
Kazakhstan
Kenya
Kyrgyzstan
Laos
Liberia
Madagascar
Malawi
Malaysia
Mali
Mauritania
Mexico
Morocco
Mozambique
Myanmar
Nepal
Nicaragua
Niger
Nigeria
North Korea
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Portugal
Republic of Congo
Romania
Russia
Rwanda
Senegal
Sierra Leone
Solomon Islands
Somalia
South Africa
South Korea
Spain
Sri Lanka
Sudan
Suriname
Swaziland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
Togo
Trinidad and Tobago
Turkey
Turkmenistan
Uganda
Ukraine
United States
Uruguay
Uzbekistan
Venezuela
Vietnam
Zambia
Zimbabwe
best
pdssat default
pdssat fullharm
pdssat harm-suffN
epic-boku default
epic-boku fullharm
epic-boku harm-suffN
epic-iiasa default
epic-iiasa fullharm
epic-iiasa harm-suffN
gepic default
gepic fullharm
gepic harm-suffN
lpj-guess default
lpj-guess harm-suffN
lpjml default
lpjml harm-suffN
cgms-wofost default
clm-crop default
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orchidee-crop fullharm
orchidee-crop harm-suffN
pepic default
pepic fullharm
pepic harm-suffN
prysbi2 default

Figure S 19: As Figure S13, but for rice.

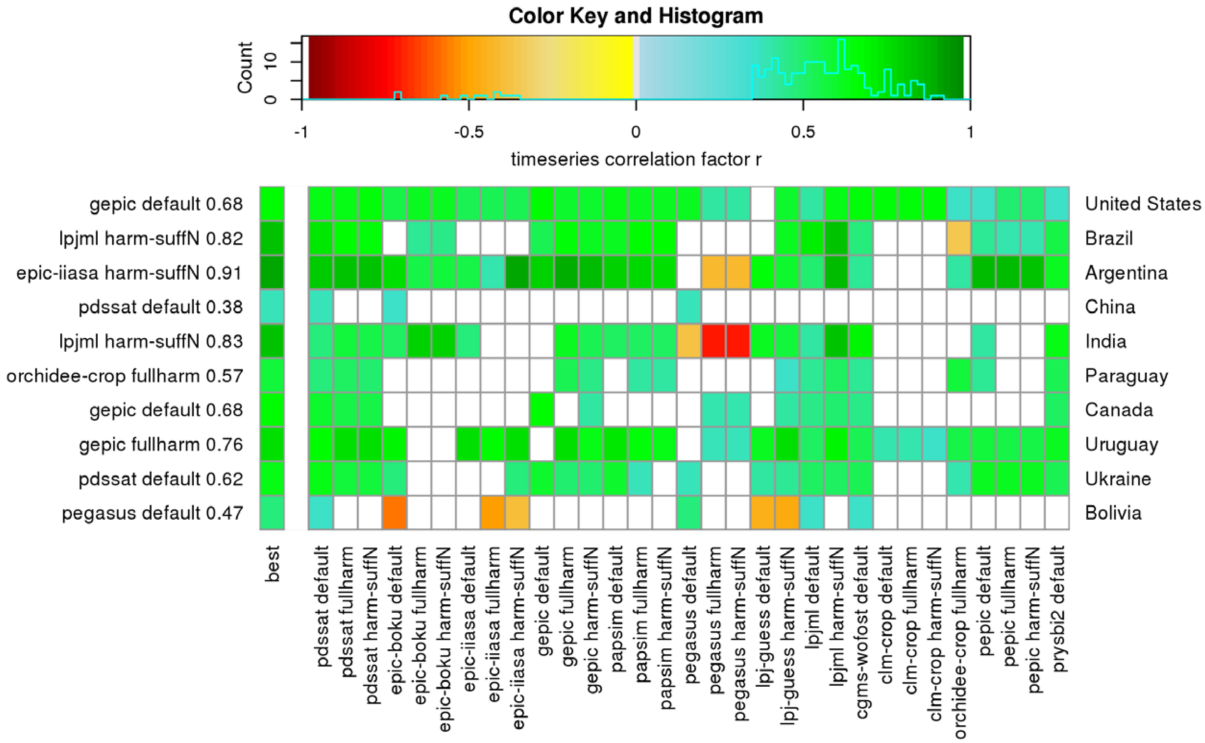

Figure S 20: As figure 6 in main text, but for soybean.

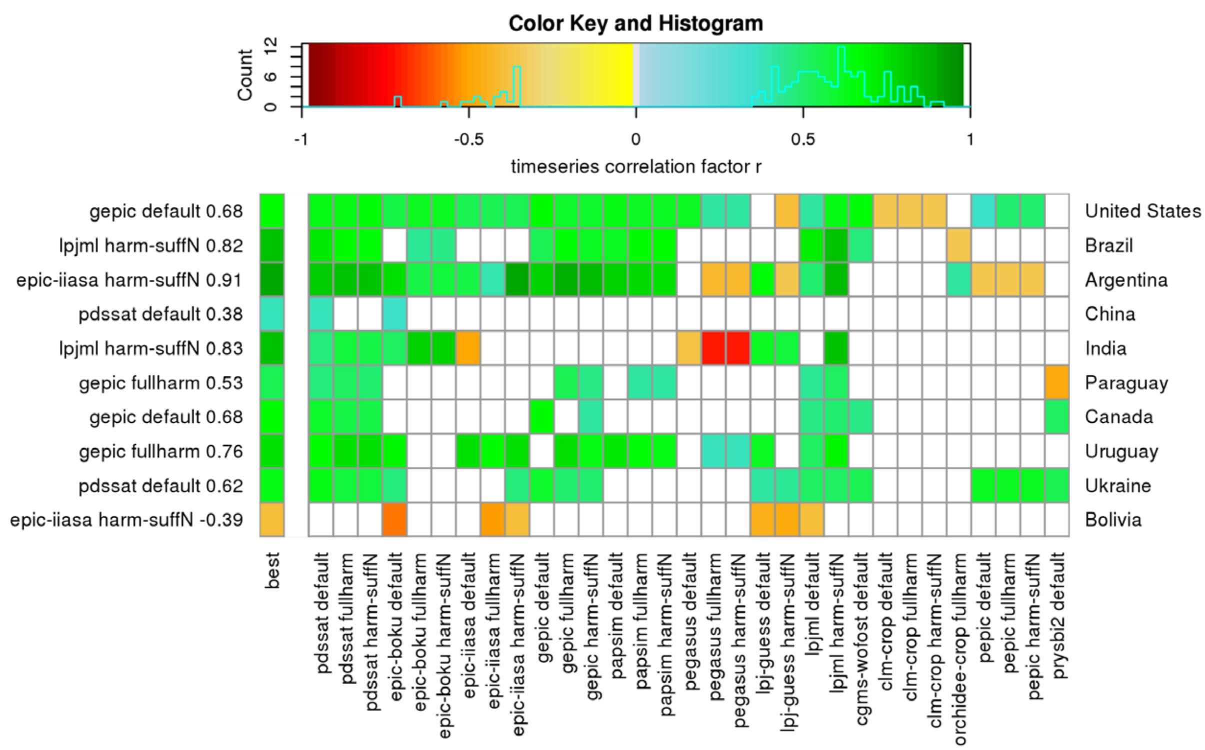

Figure S 21: As Figure S12, but for soybean.

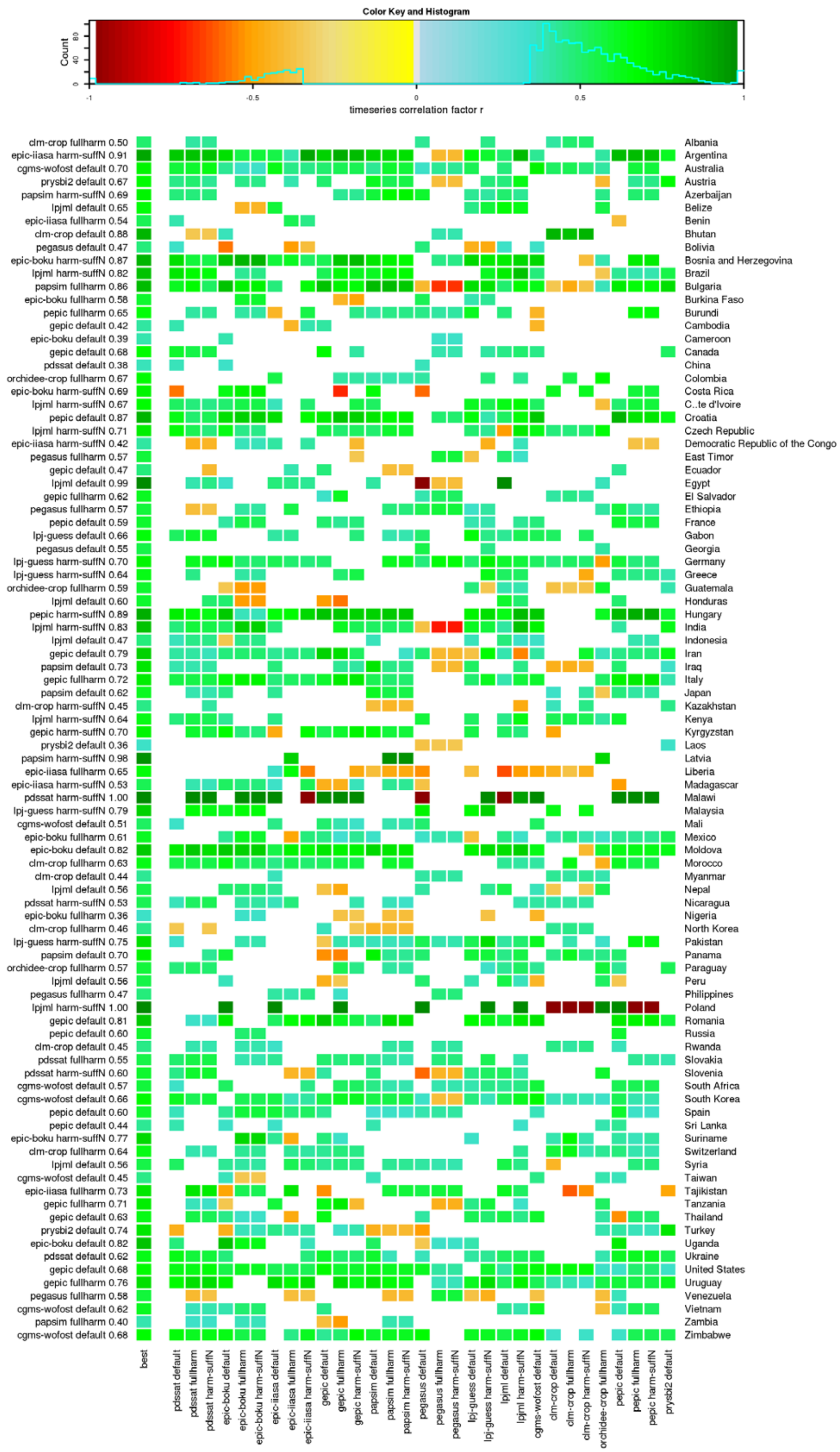

Figure S 22: As Figure S13, but for soybean.

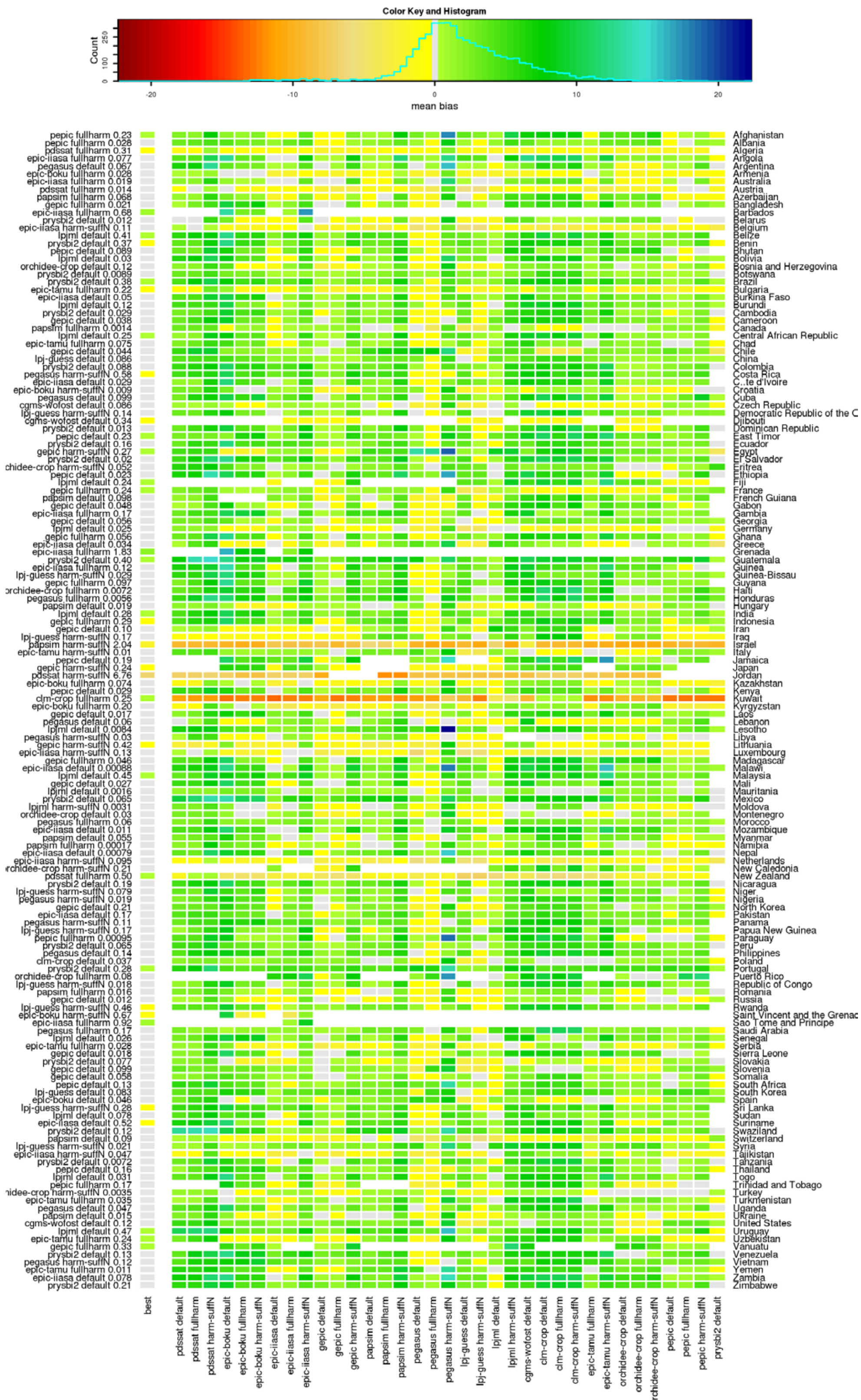

Figure S 23: As figure 7 in main text, but for all maize producing countries included here.

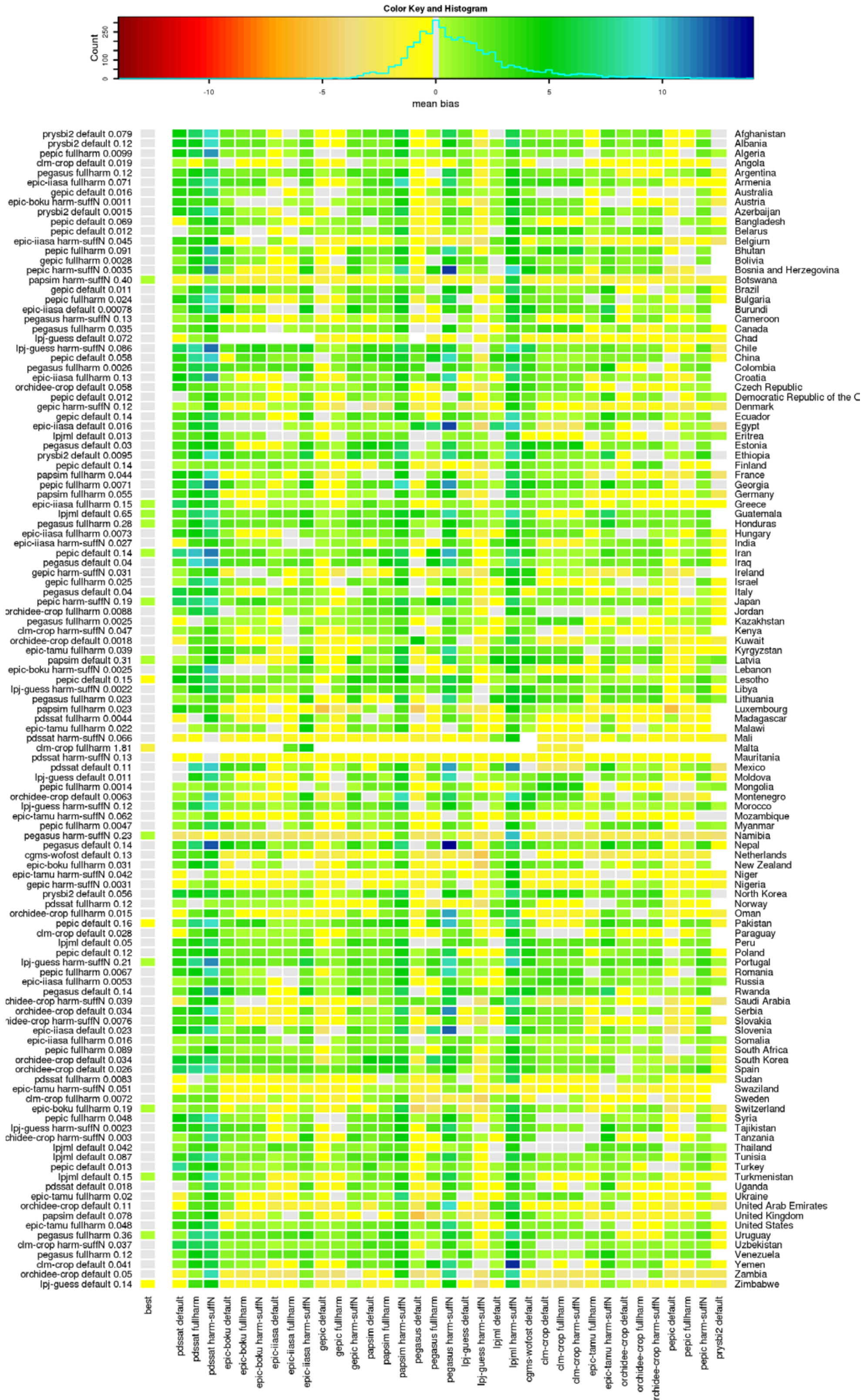

Figure S 24: As Figure S23, but for wheat.

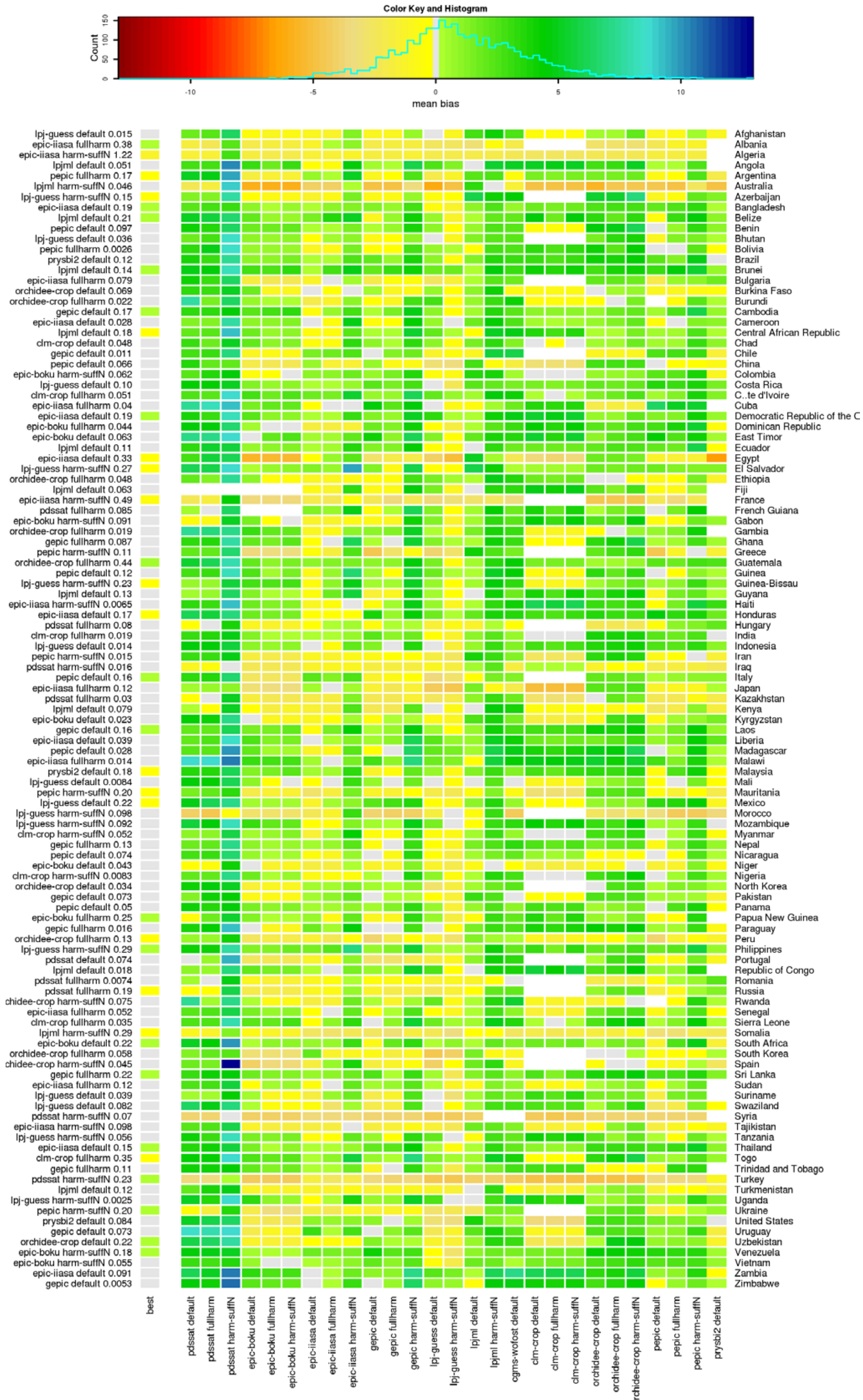

Figure S 25: As Figure S23 but for rice.

Figure S 26: As Figure S23 but for soybean.

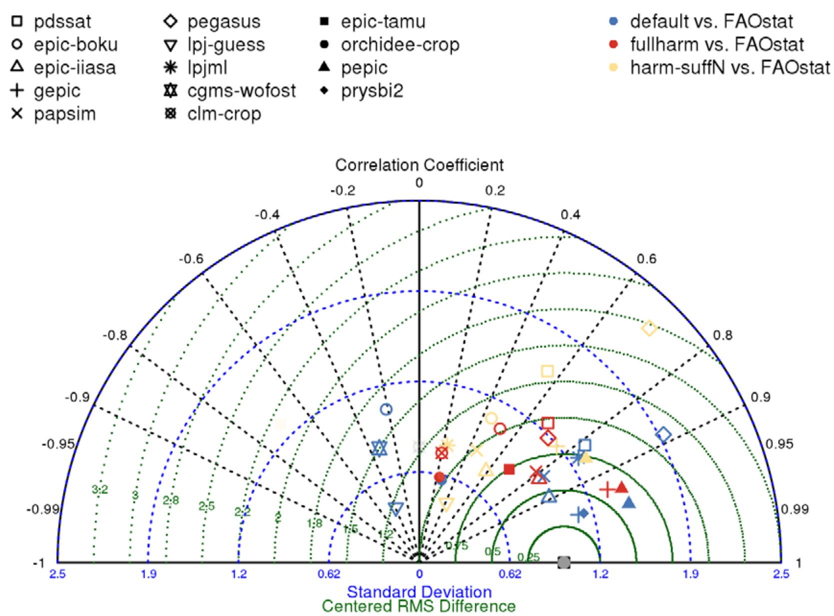

Figure S 27: As figure 8 in main text, but with flattened time dimension.
Instead of individual values for each year, we here use the multi-annual mean per country only, focusing on the correlations, variance and RMSD of the spatial pattern only.

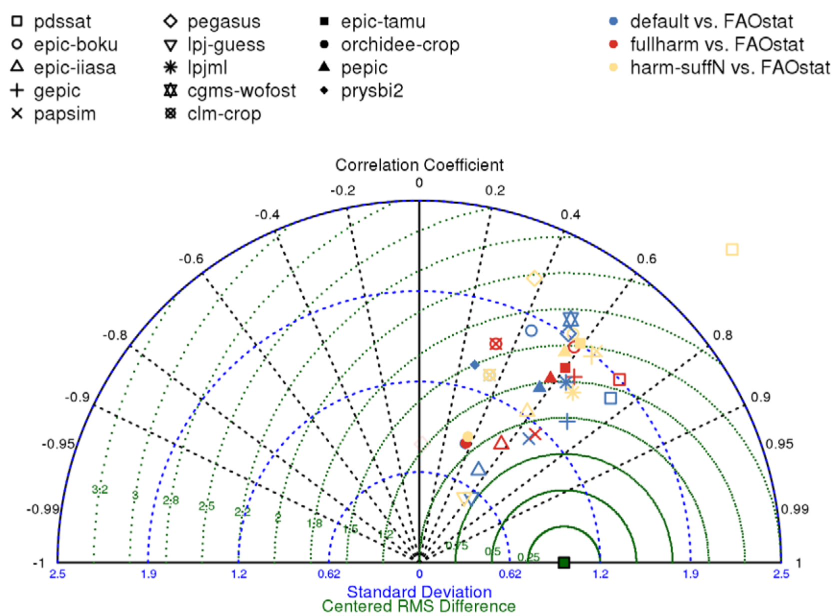

Figure S 28: As figure 8 in main text, but after removing national means.
By removing national mean yields, spatial differences between countries are eliminated (all with mean of zero) so that the analysis explicitly focuses on the year-to-year variability.

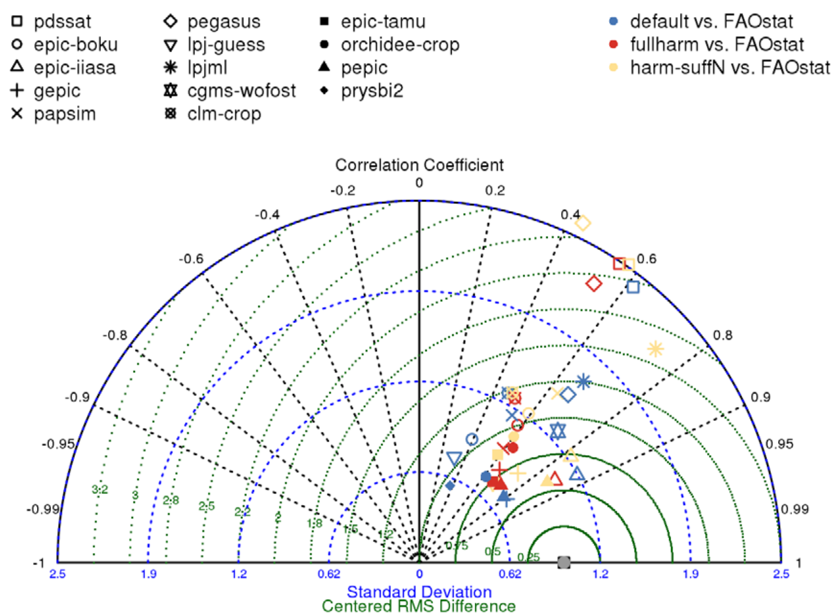

Figure S 29: As figure 8 in main text, but for wheat.

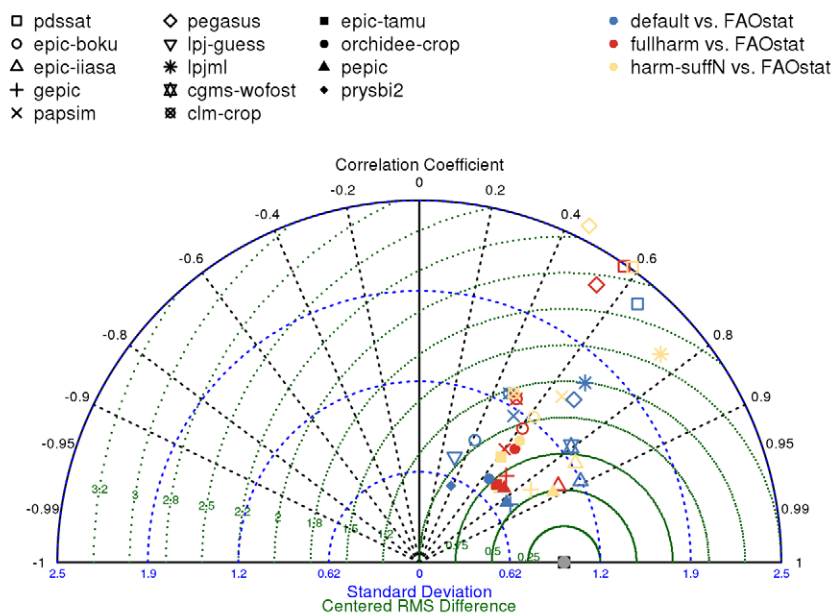

Figure S 30: As Figure S27, but for wheat.

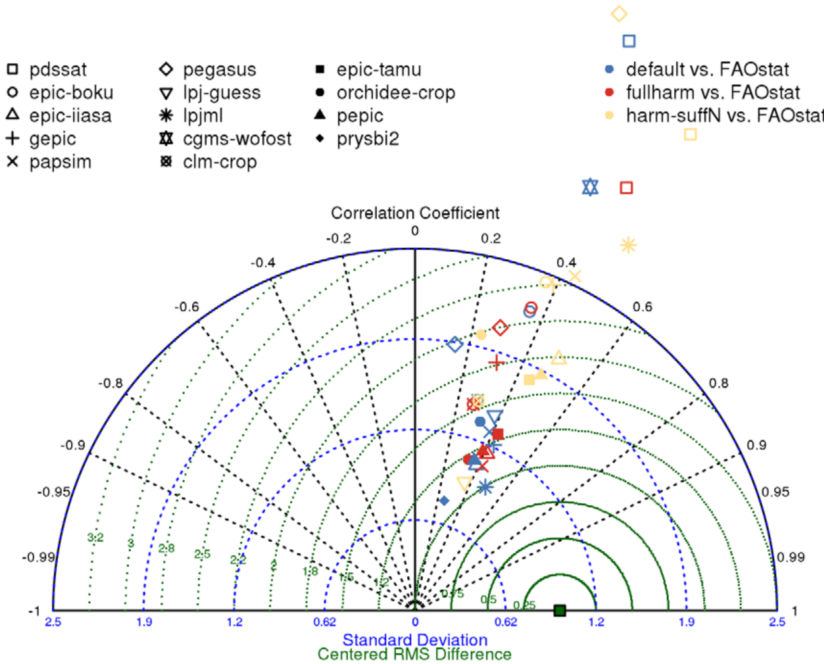

Figure S 31: As Figure S28, but for wheat.

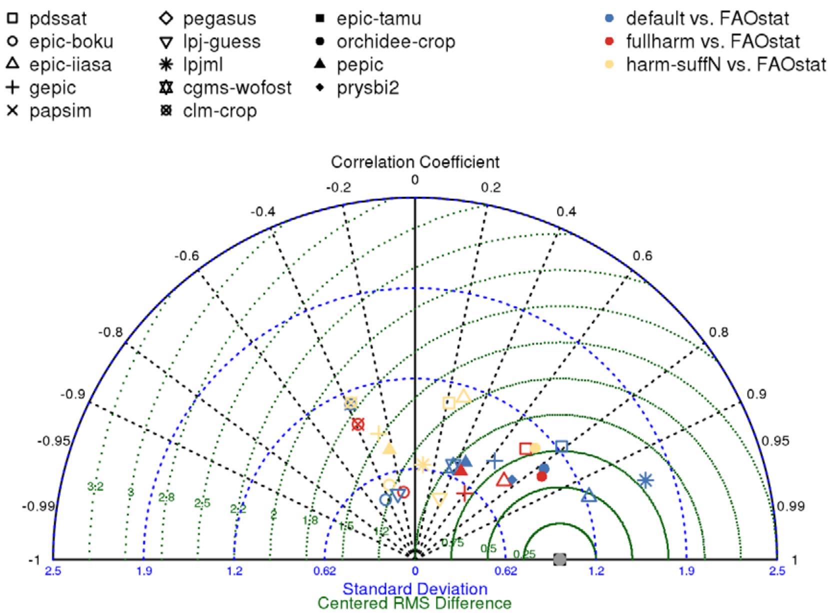

Figure S 32: As figure 8 in main text, but for rice

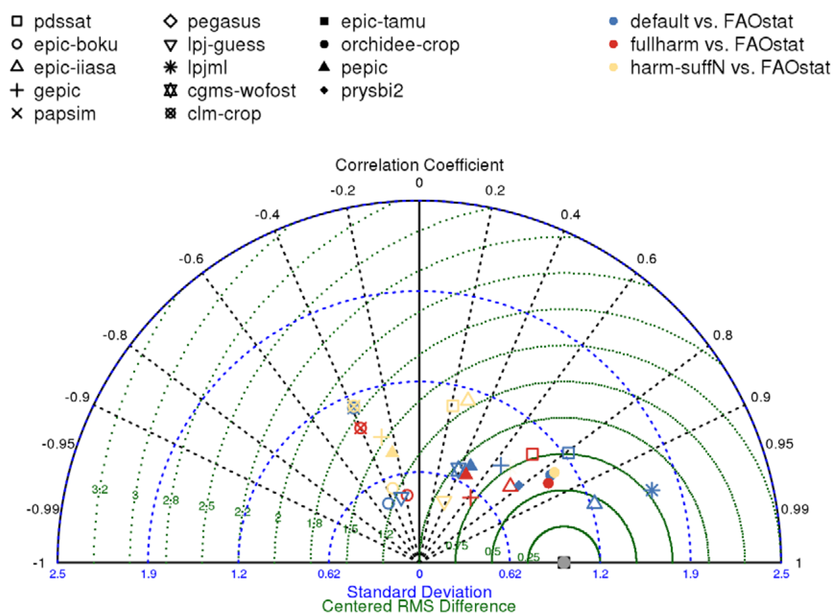

Figure S 33: As Figure S27, but for rice.

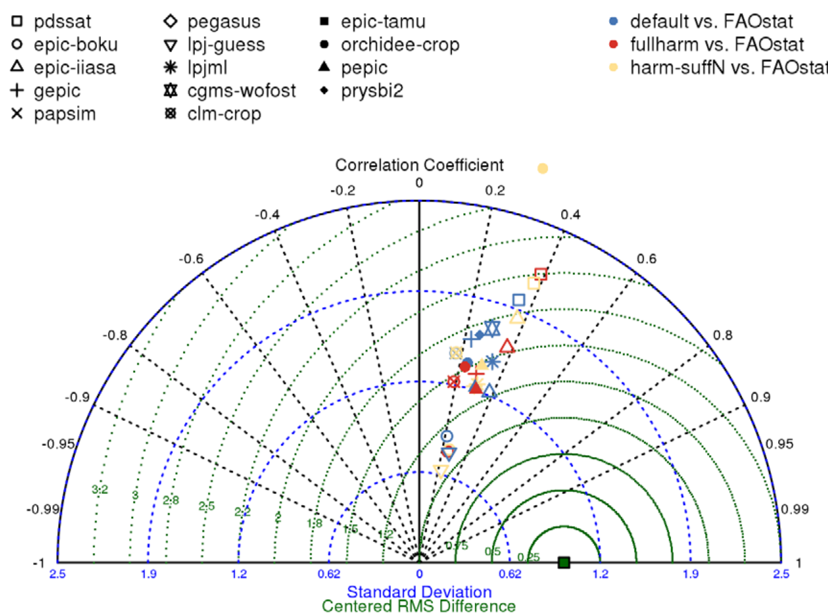

Figure S 34: As Figure S28, but for rice.

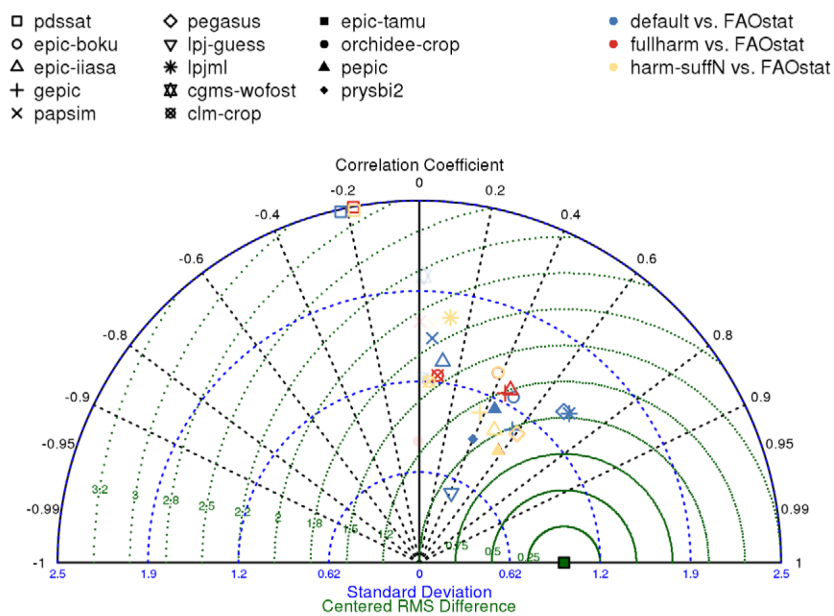

Figure S 35: As figure 8 in main text, but for soybean.

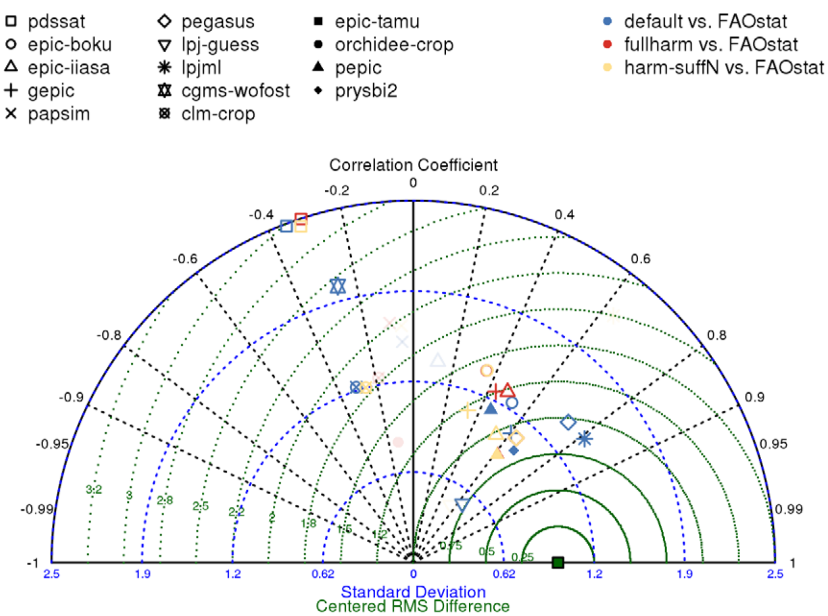

Figure S 36: As Figure S27, but for soybean.

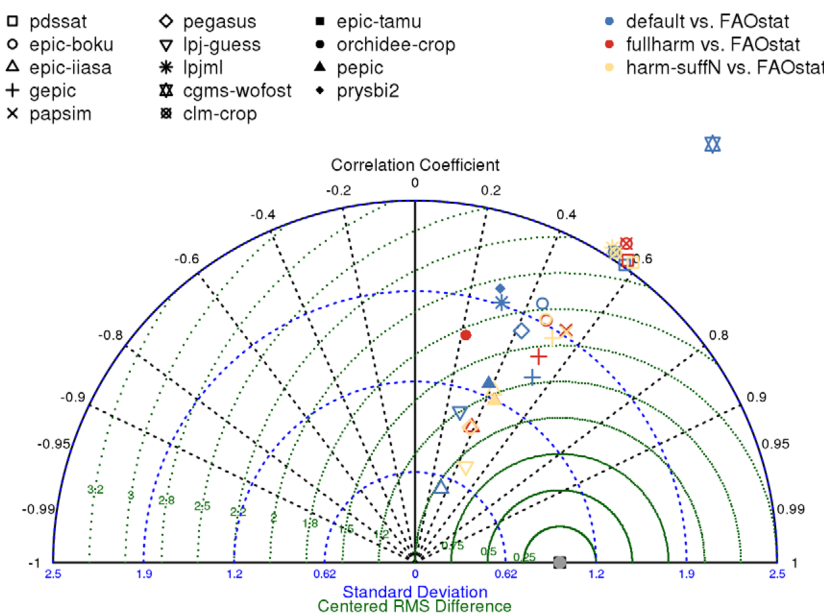

Figure S 37: As Figure S28, but for soybean.

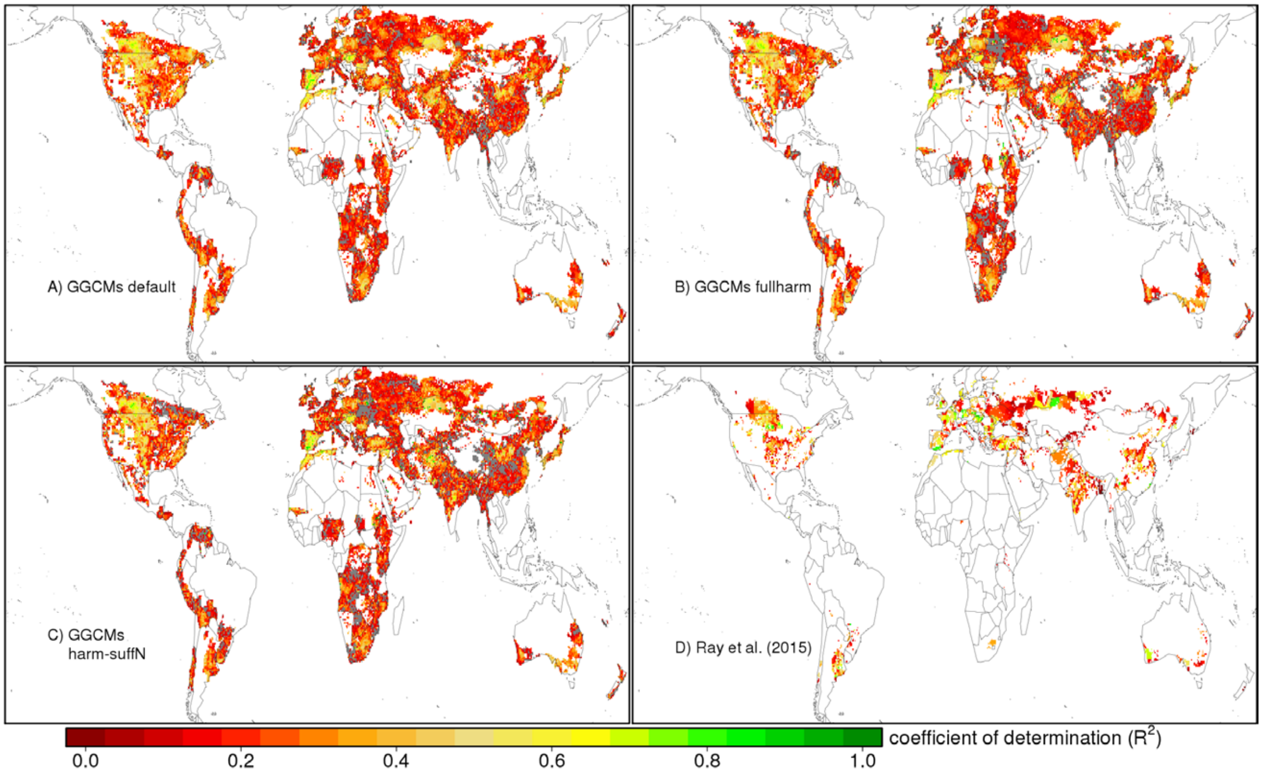

Figure S 38: As figure 10 in main text, but for wheat.

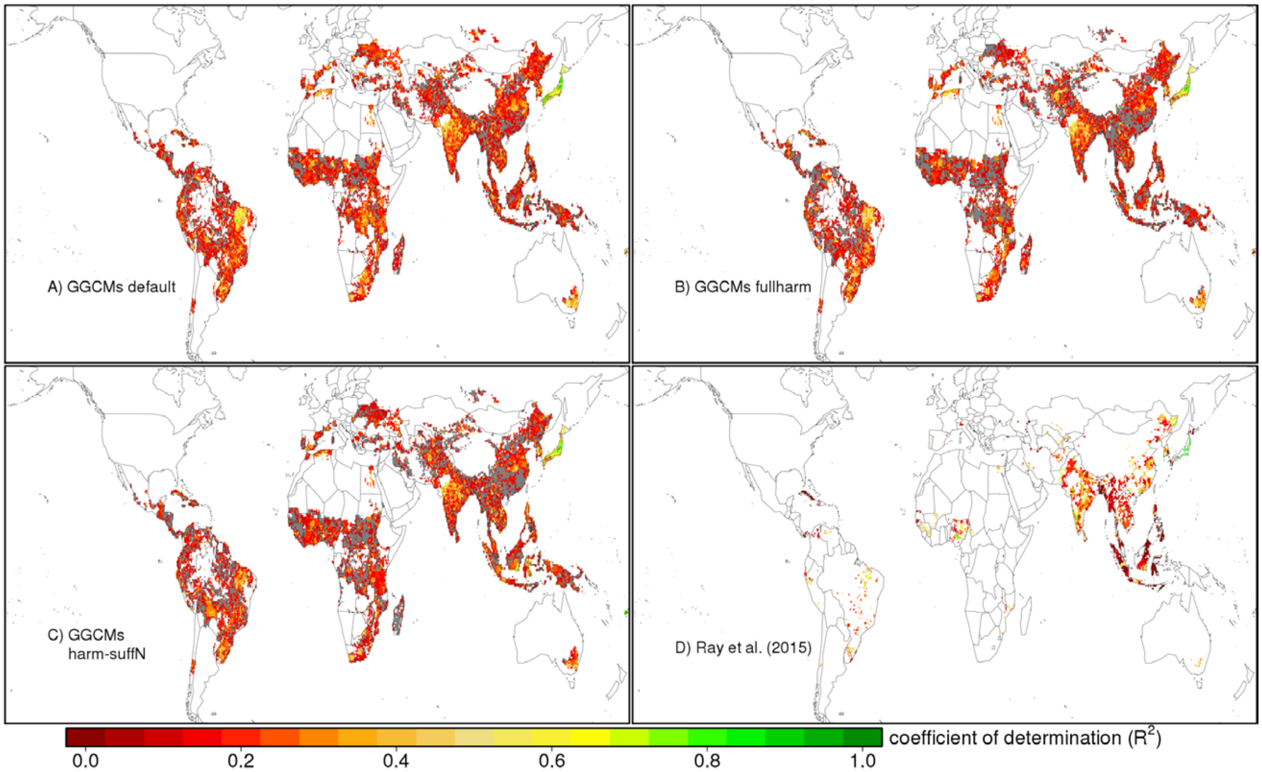

Figure S 39: As figure 10 in main text, but for rice.

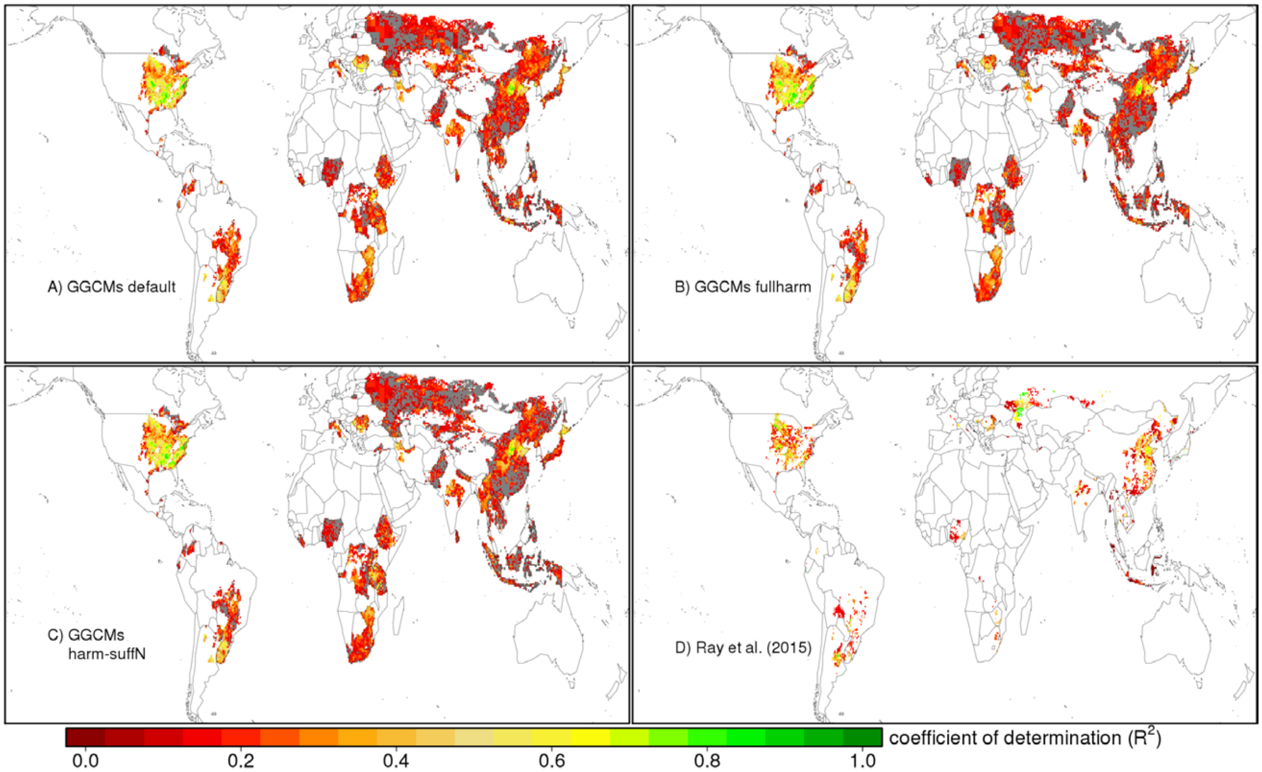

Figure S 40: as figure 10 in main text, but for soybean.

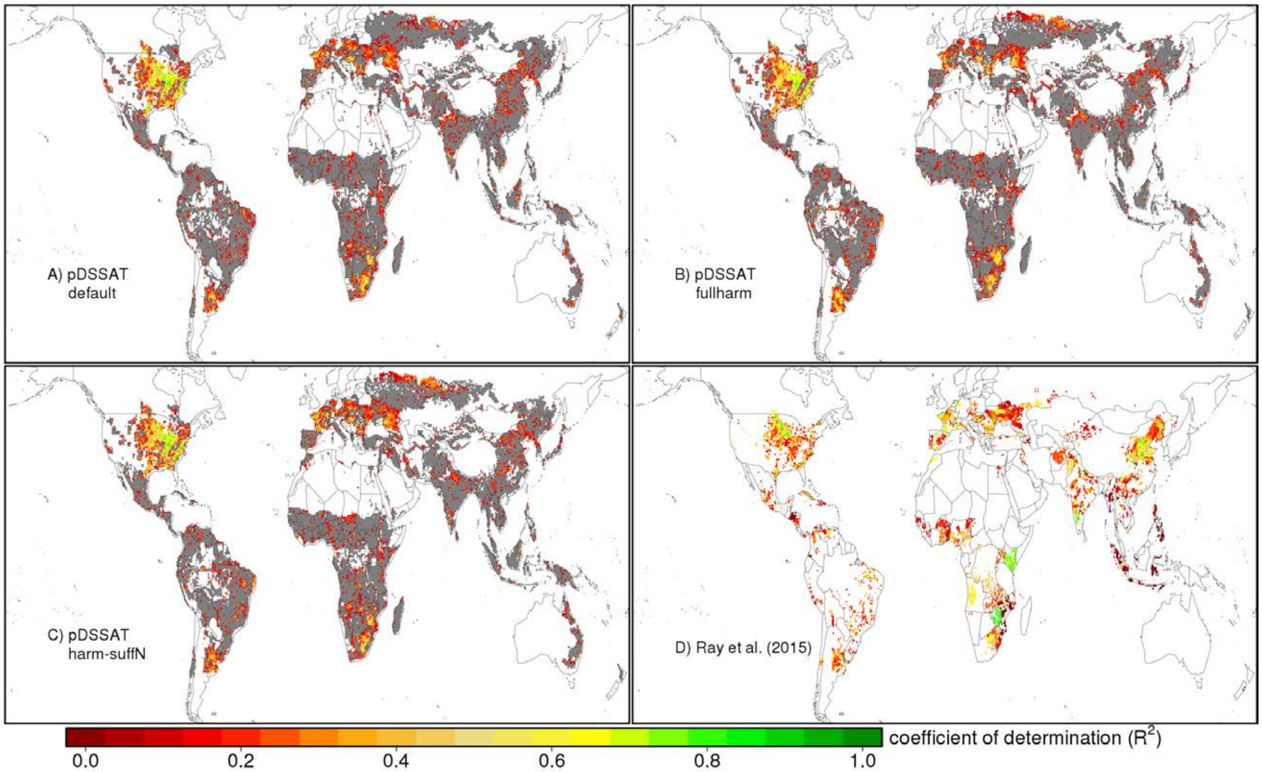

Figure S 41: as figure 10 in main text, but for pDDSAT only.

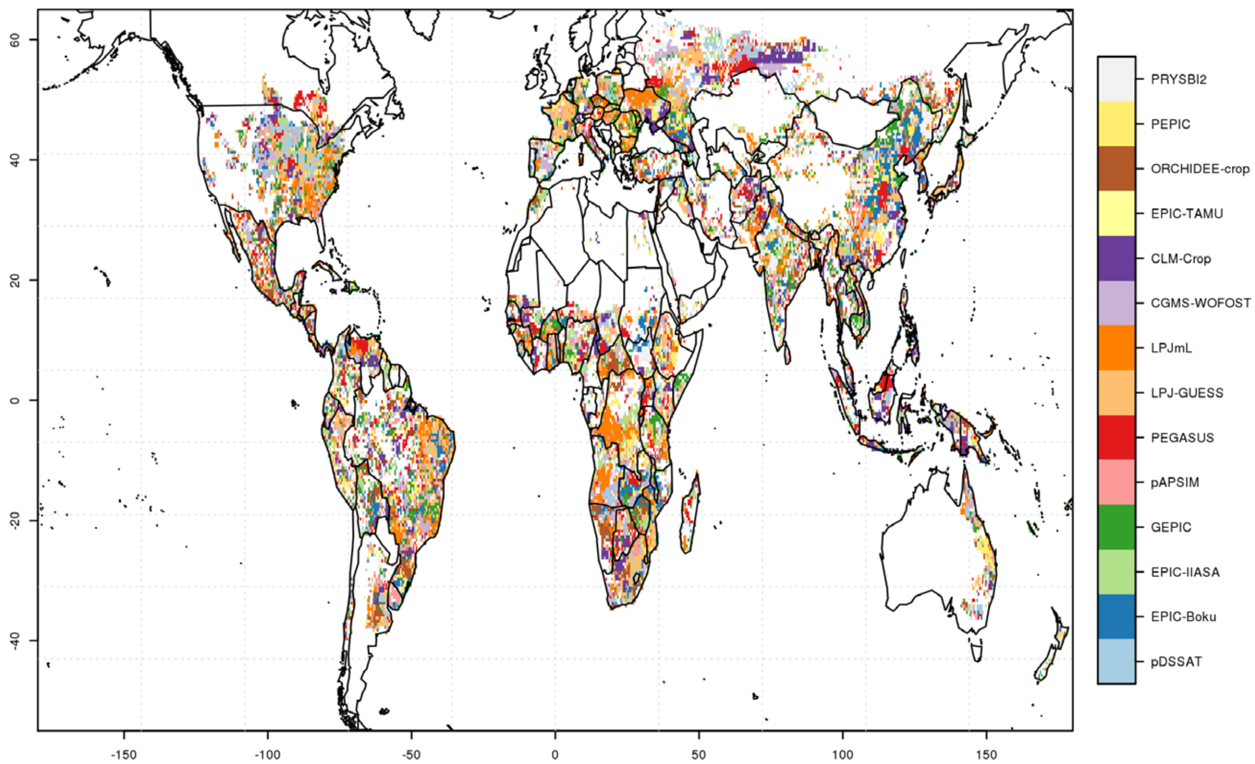

Figure S 42: Best performing (R^2) GGCM per grid cell for maize (*default*).
Individual GGCMs are depicted by color. White areas are either outside cropping areas or none of the GGCMs achieves a statistically significant correlation with the Ray et al. (2015) data set.

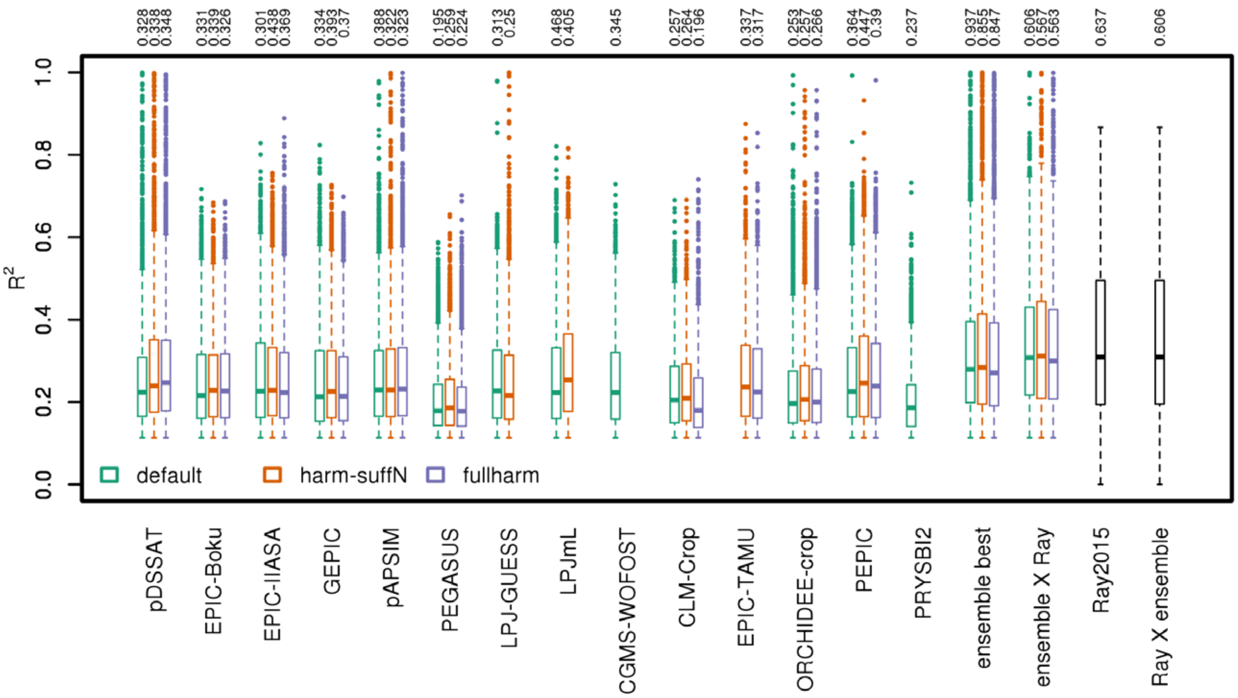

Figure S 43: as figure 11 in main text, but for wheat.

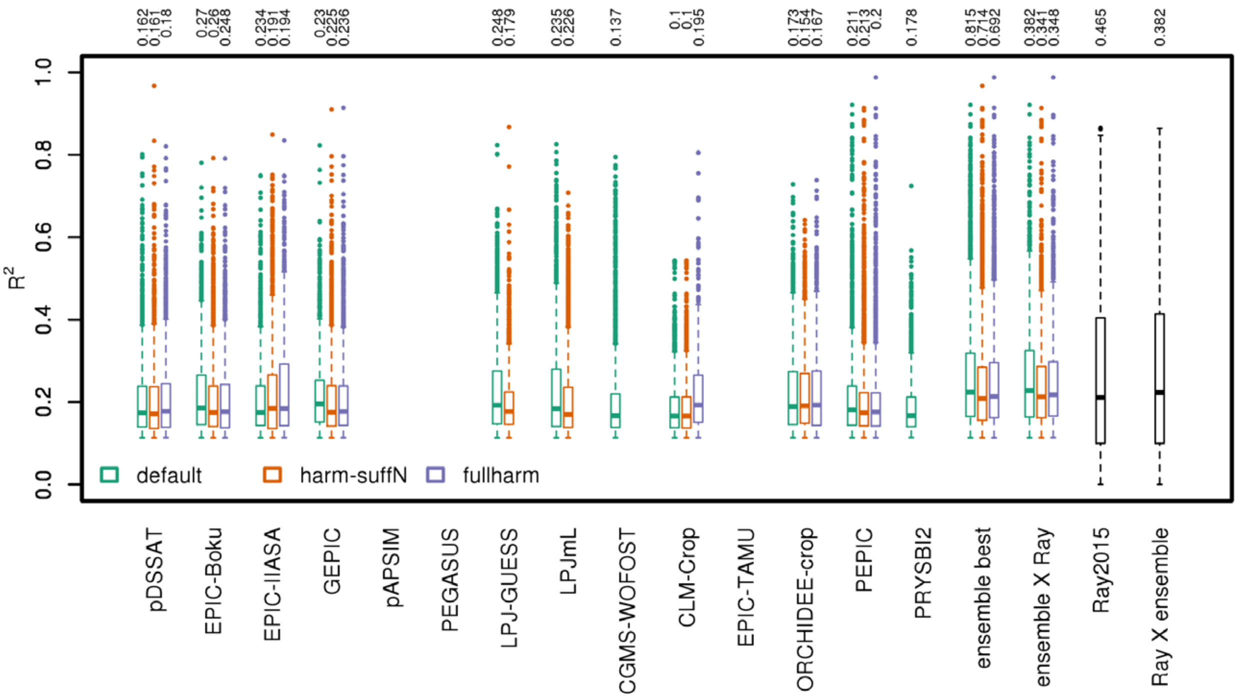

Figure S 44: as figure 11 in main text but for rice.

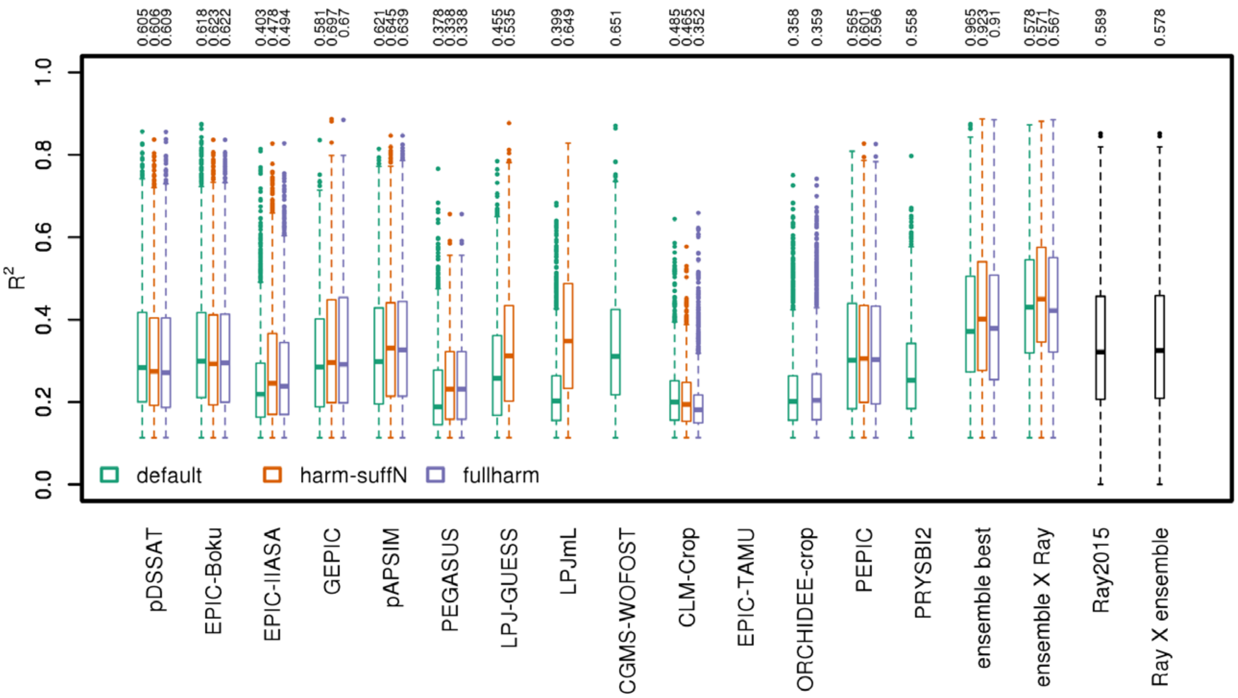

Figure S 45: as figure 11 in main text, but for soybean.

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