Winter Wheat in JULES-Crop

Dr Huiyi Yang

September 2018

Air pollution risk to agriculture and forest health in China

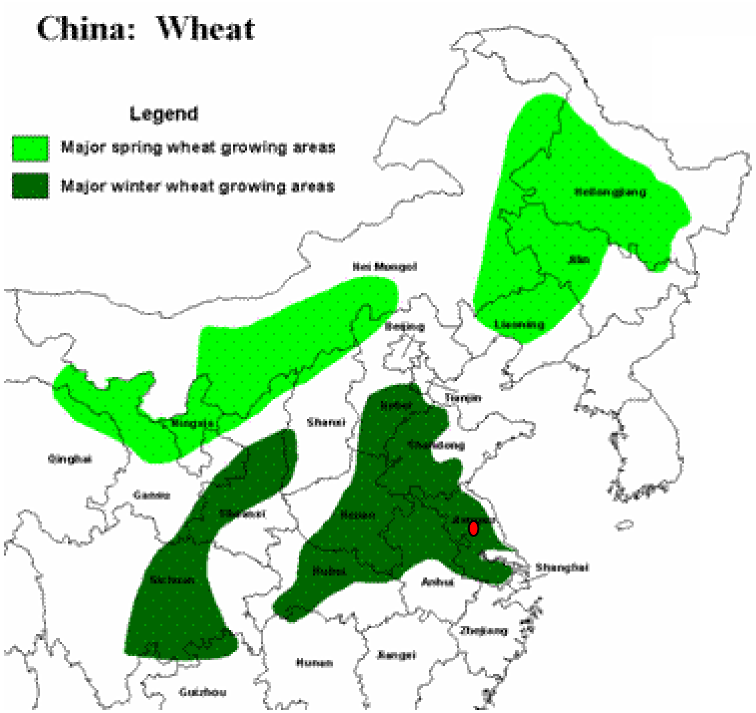
Calibration:

- Literature
- FACE-O_3 PFTs (Prof. Feng, RCEES CAS)
- FACE-O_3 Winter wheat (Prof. Feng, RCEES CAS)
- FACE-O_3 Soybean (Prof. Feng, RCEES CAS)
- FACE-O_3 Rice (Prof. Yang, Yangzhou Uni)
- FACE-O_3 Meteorology (Prof. Tang, Institute of Soil Science, CAS)

Validation:

- The global GPP/LE/SH (monthly, 0.5*0.5), upscaled from FLUXNET observations using the machine learning technique, model tree ensembles (MTE) from 1982 to 2011 (GPP_MTE)
- The global MODIS NPP/GPP product (MODIS17A2, monthly 0.5*0.5, NPP_MODIS) from 2000 to 2013
- The global MODIS LAI product (MODIS15A2, monthly 0.5*0.5, LAI_MODIS)
- FluxNet / ChinaFlux (10 sites)
- Regional yield data (maize, rice, soybean, wheat)

Winter wheat over China



Year	Planting Area (1000 ha)			Production (m t)		
	Total	Winter	Spring	Total	Winter	Spring
1990	30753	25931	4822	98.2	84.9	13.3
1991	30948	26125	4823	96.0	83.2	12.7
1992	30496	25751	4745	101.6	87.9	13.7
1993	30235	25749	4486	106.4	93.7	12.6
1994	28981	25077	3904	99.3	89.2	10.1
1995	28860	24978	3882	102.2	91.7	10.5
1996	29611	25463	4148	110.6	98.0	12.5
1997	30057	25967	4090	123.3	110.8	12.5
1998	29775	26070	3705	109.7	97.9	11.8

Source: Ministry of Agriculture, *China's Agricultural Statistics*, various issues.

- In 2009, China produced 115 million tonnes of wheat, which was 24% of the total production of food crops including rice, wheat, corn, soybean and potatoes.
- Planting area: 84% Winter wheat; 16% spring wheat (north of great wall)
- Production 89% winter wheat; 11% spring wheat

Benchmarking JULES simulation of Nature Ecosystem

- **The global MODIS NPP product (MODIS17A2, monthly 0.1*0.1, NPP_MODIS) from 2000 to 2016**
- **The global MODIS GPP product (MODIS17A2, monthly 0.05*0.05, NPP_MODIS) from 2000 to 2016**
- **The global MODIS LAI product (MODIS15A2, monthly 0.05*0.05, LAI_MODIS) from 2000 to 2016**

(Source: NASA Earth Observations; NEO)

- The global GPP/LE/SH (monthly, 0.5*0.5), upscaled from FLUXNET observations using the machine learning technique, model tree ensembles (MTE) from 1982 to 2011 (GPP_MTE)

(Source: FLUXNET 2015 dataset)

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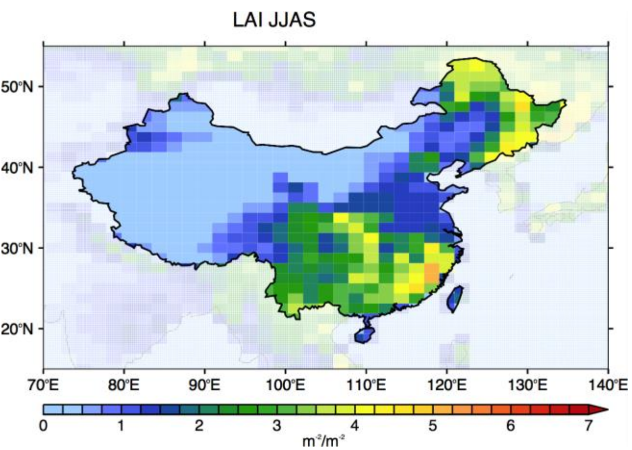
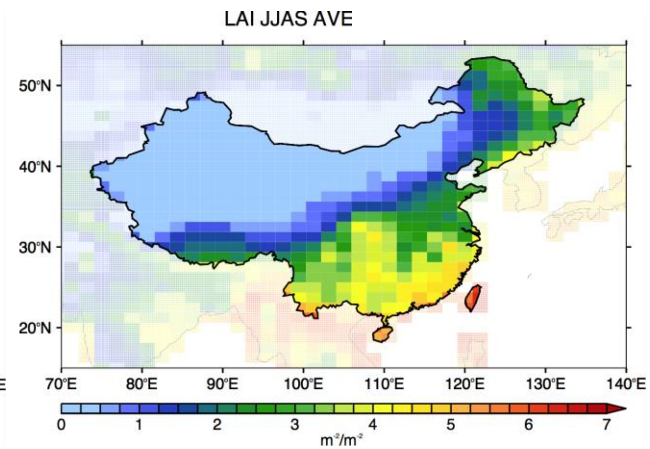
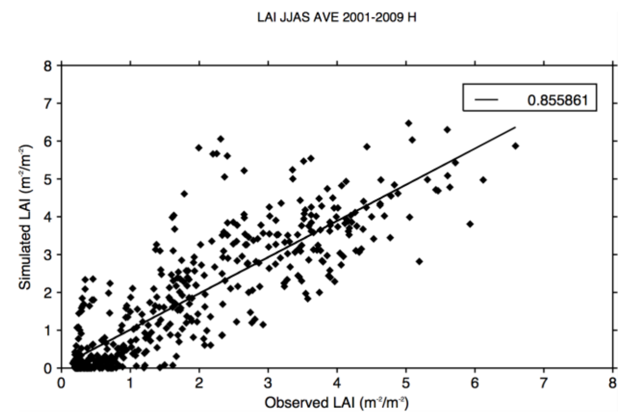
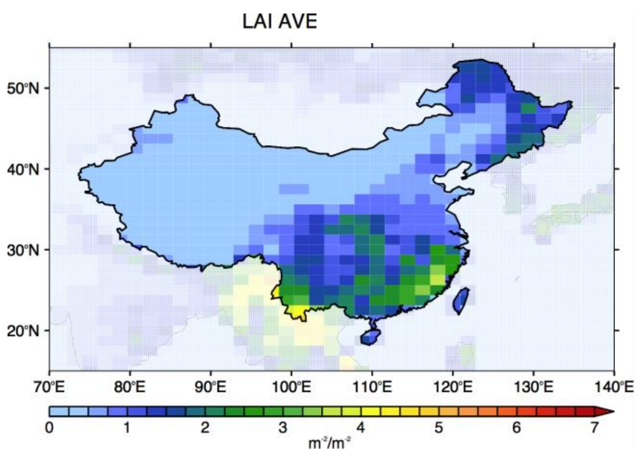
LAI

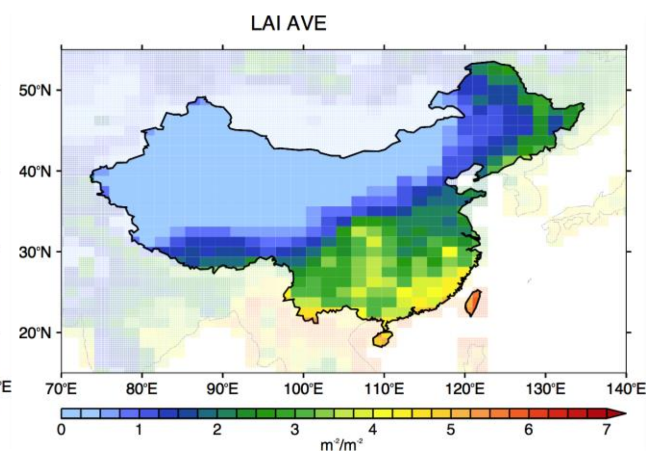
MODIS Interp | JULES output | Correlation

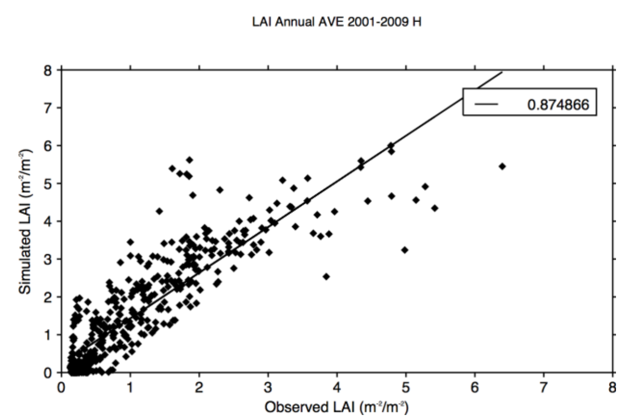










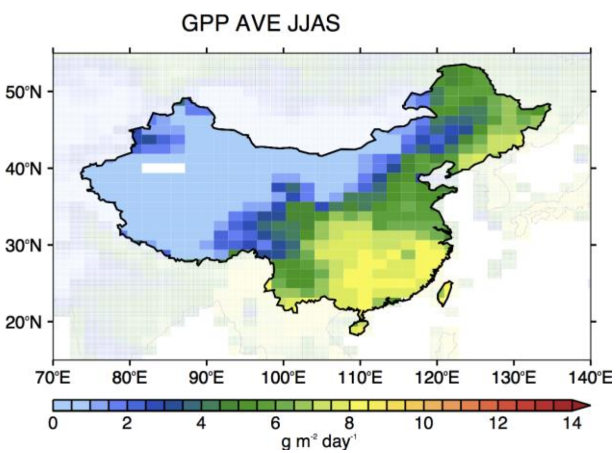


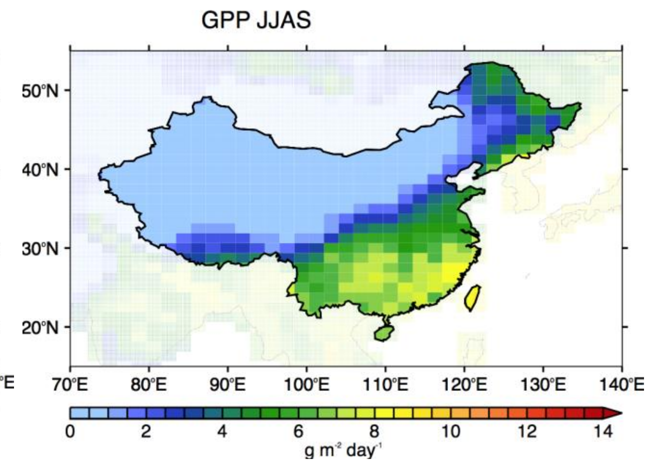
GPP

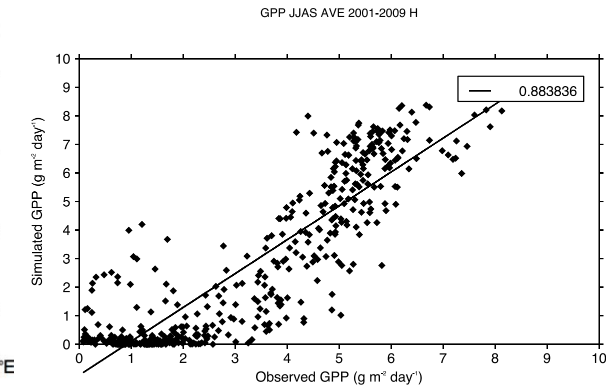
MODIS Interp

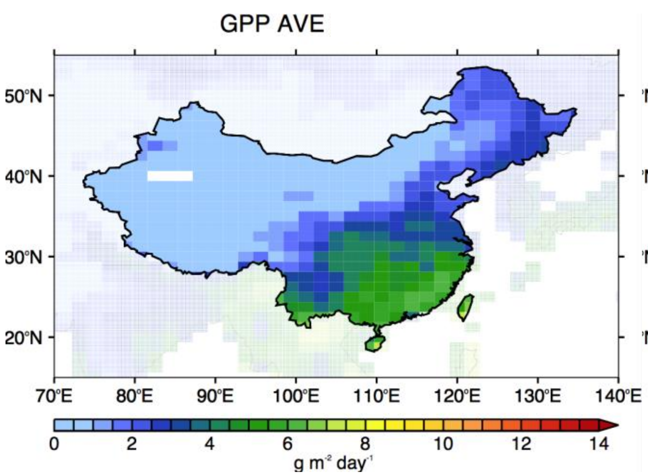
JULES output

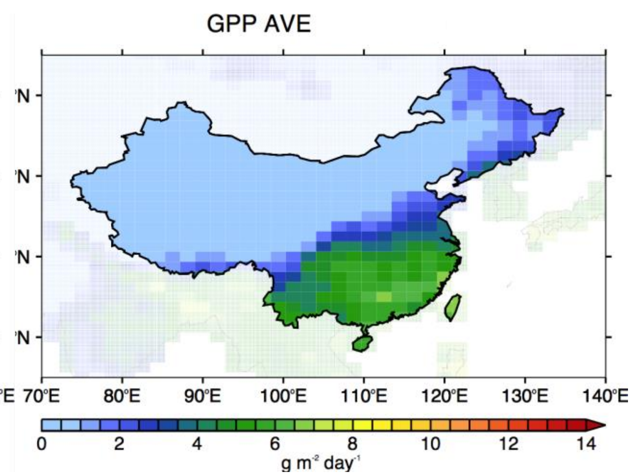
Correlation

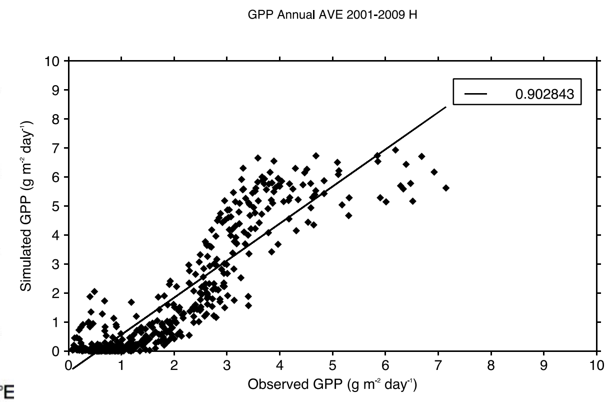






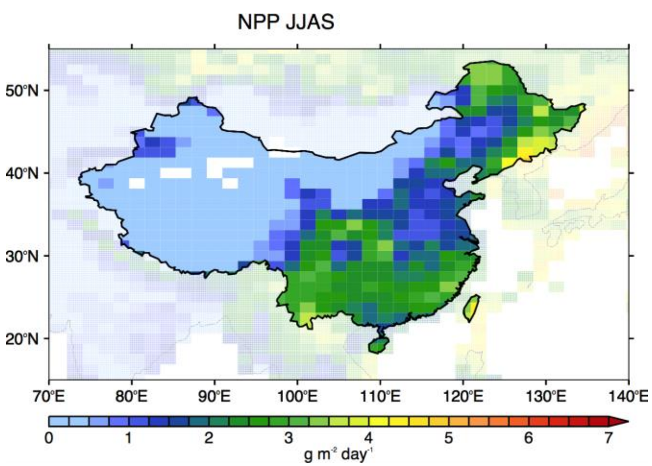


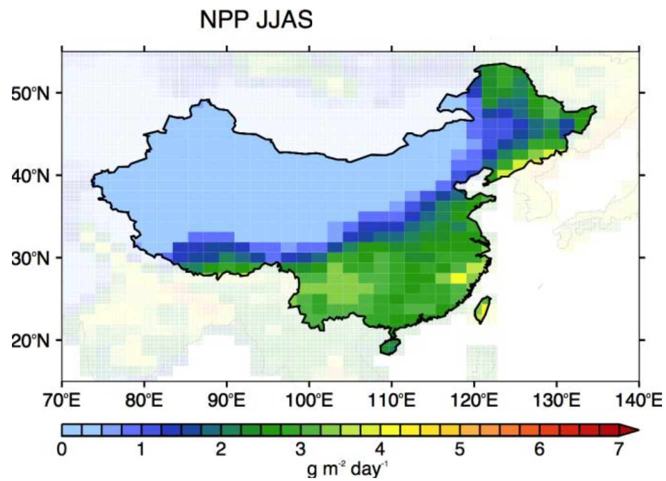


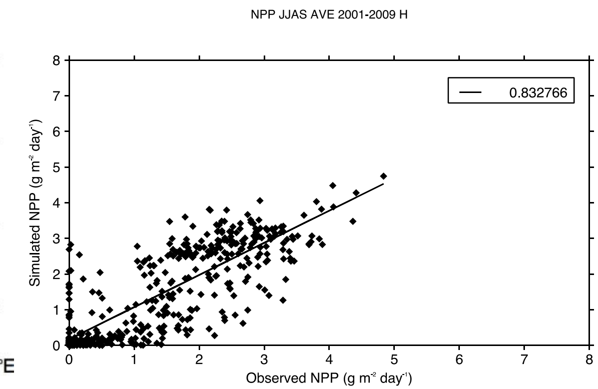


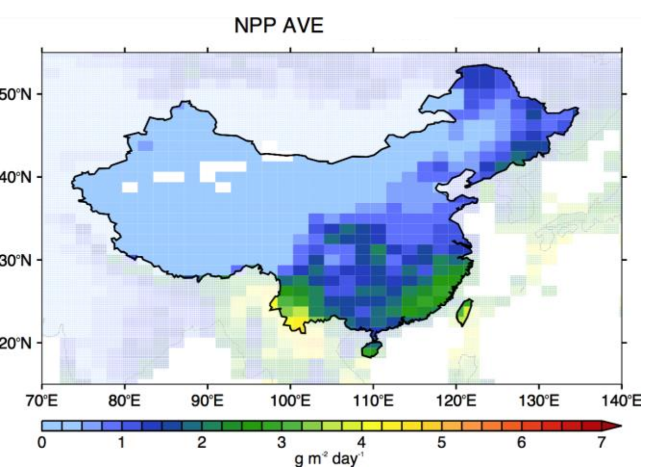
NPP

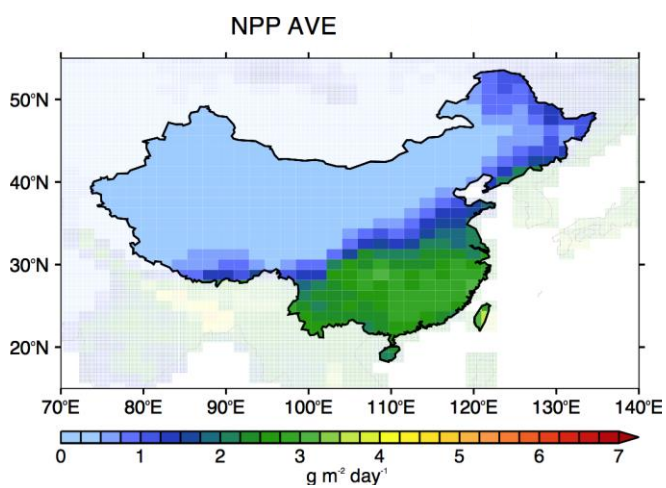
MODIS Interp | JULES output | Correlation

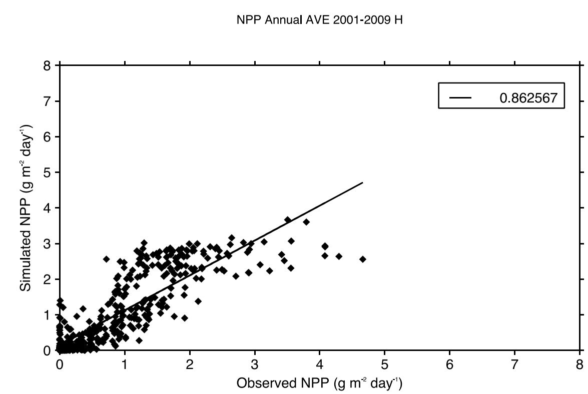












Benchmarking JULES simulation

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(Source: NASA Earth Observations; NEO)

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(Source: FLUXNET 2015 dataset)

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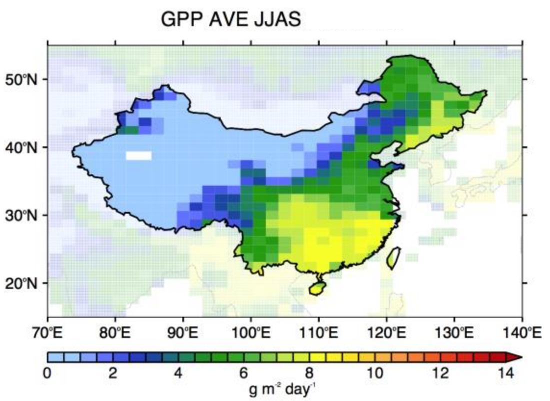
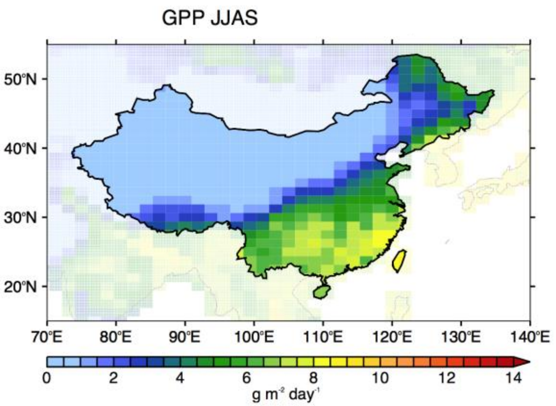
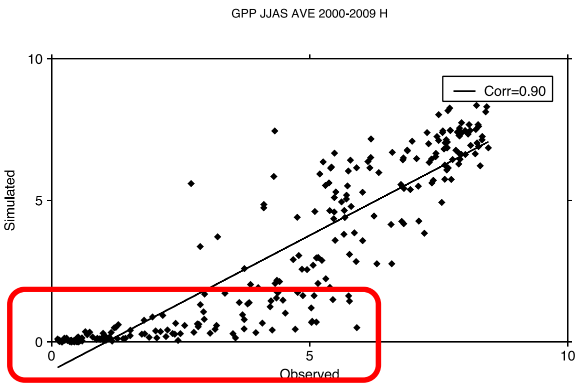
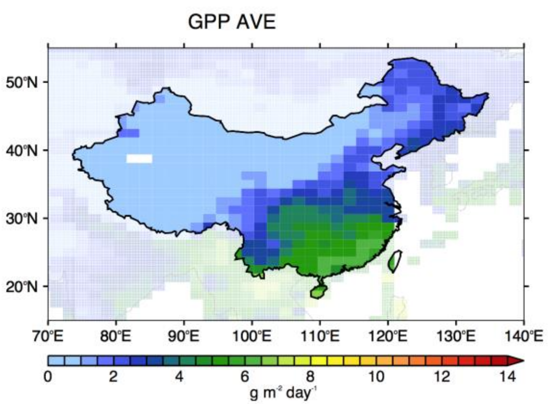
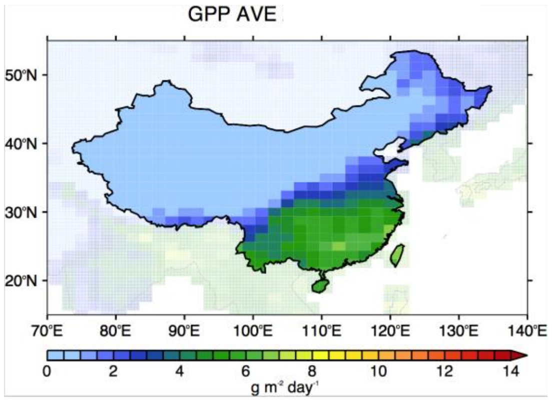
MTE data product JULES output

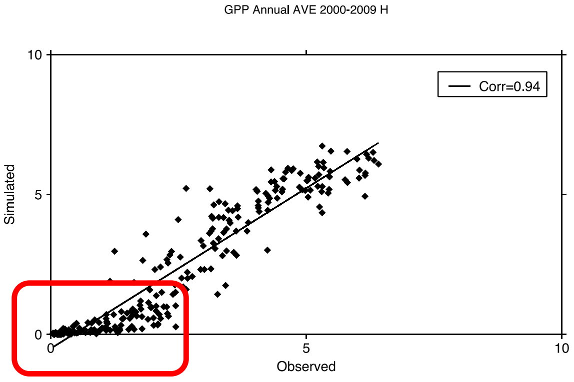










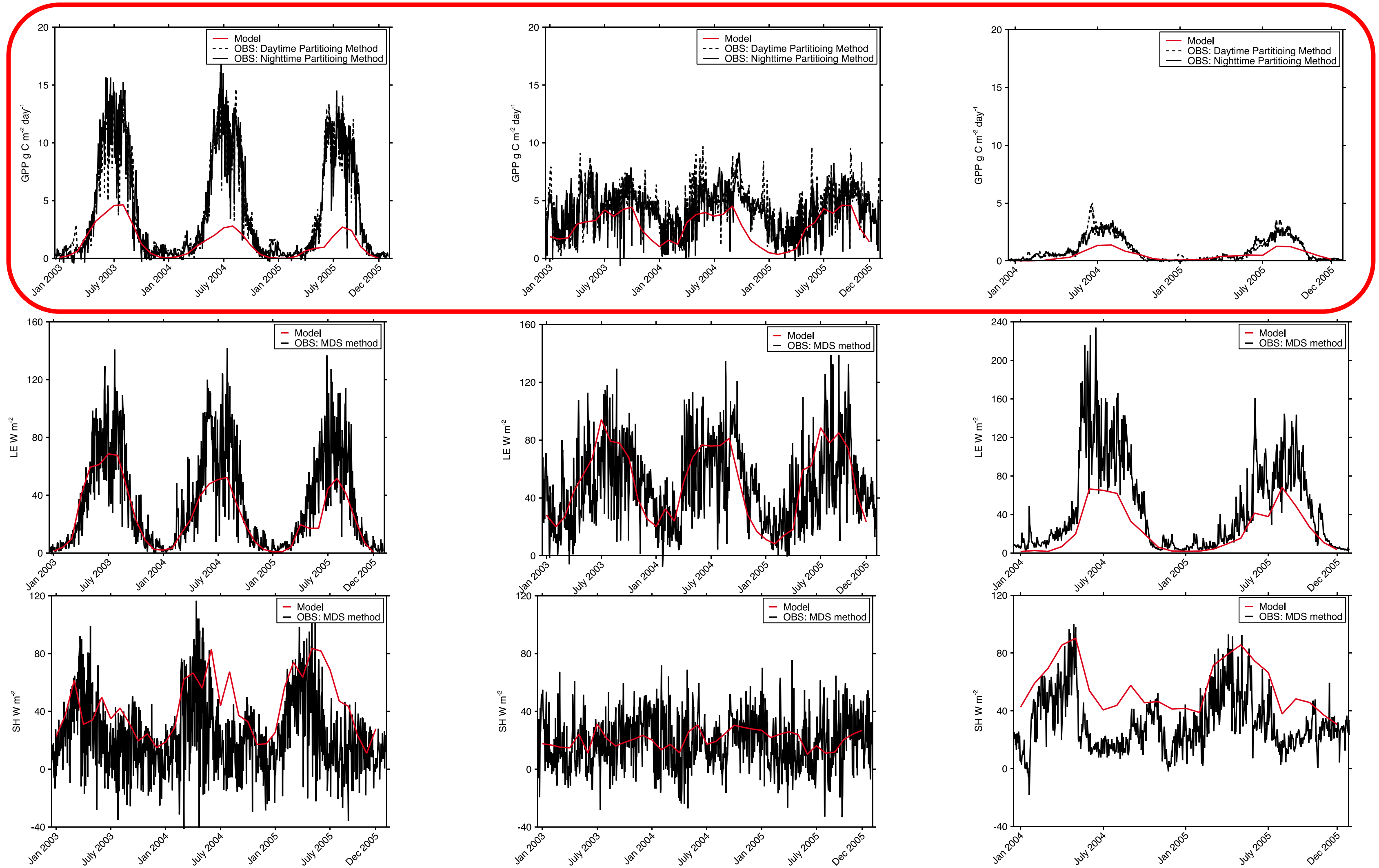


FLUXNET/CHINAFLUX

Changbaishan (Cha): MF
lat 42.4025/ lon 128.0958

Dinghushan (Din): EBF
lat 23.1733 / lon 112.5361

Dangxiong (Dan): GRA
lat 30.4978 / lon 91.0664



Vcmax

➢**Calibration:** FACE LI-COR measurements (Winter wheat)

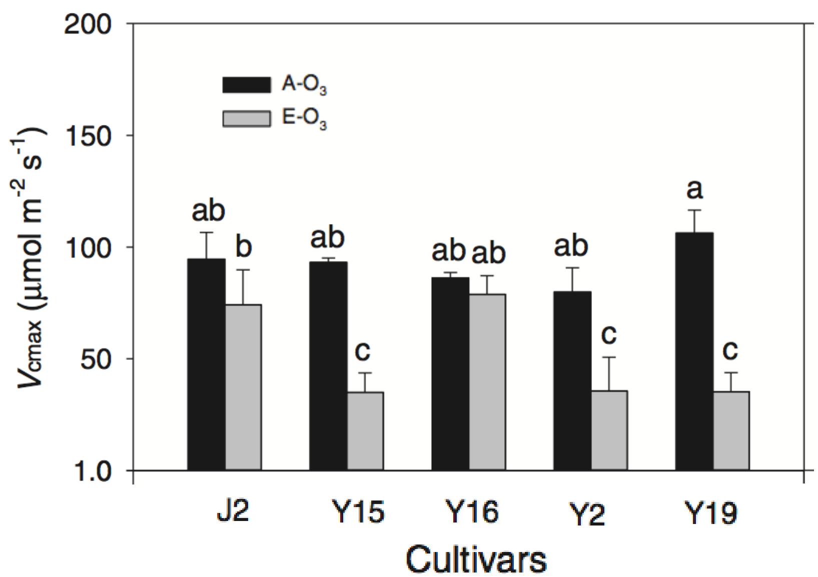
$$Max\ rate\ of\ carboxylation = quantum\ efficiency * top\ leaf\ [N]$$
$$Vc_{max} = \text{neff} * \text{nl0}$$

Vcmax (umol m^{-2} s^{-1})	BET-Tr	BET-Te	BDT	NET	NDT	C_3	C_4	Esh	DSh	Wheat	Soybean	Maize	Rice
neff	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0004	0.0008	0.0008	0.0008	0.0008	0.0004	0.0008
n10	0.046	0.046	0.046	0.033	0.033	0.073	0.06	0.06	0.06	0.073	0.073	0.06	0.073
JULES Vcmax (umol m-2s-1)	36.8	36.8	36.8	26.4	26.4	58.4	24	48	48	58.4	58.4	24	58.4
TRY database Vcmax	55	61.5	41-57	62.5-62.6	39.1	78.2	51.6	61.7	54	100.7	100.7	100.7	100.7

Table 1 PFT (plant functional type)-specific photosynthetic parameters. V_{cmax25}^{kattge} is the realized V_{cmax25} values obtained from Kattge et al. (2009); $f_1(N)$ is the prescribed nitrogen limitation factor used in CLM4.5, while $f_2(N)$ is from CLM4.0; and V_{cmax25}^{opt}, which represents the potential values for V_{cmax25}, is given by $V_{cmax25}^{opt} = V_{cmax25}^{kattge} / f_2(N)$.

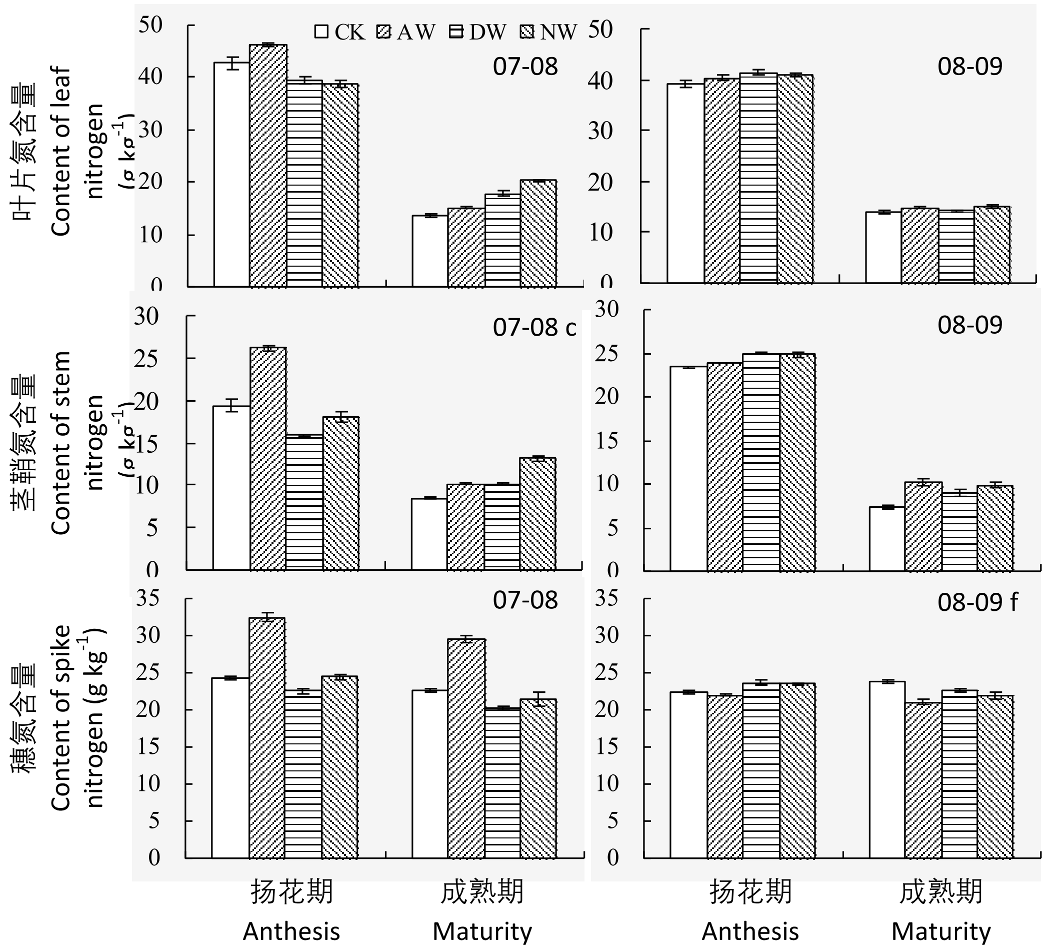
Plant functional type	V_{cmax25}^{kattge}	$f_1(N)$	$f_2(N)$	V_{cmax25}^{opt}
Needleleaf evergreen tree, temperate	62.5	1	0.72	86.8
Needleleaf evergreen tree, boreal	62.6	1	0.78	80.2
Needleleaf deciduous tree, boreal	39.1	1	0.79	49.5
Broadleaf evergreen tree, tropical	55.0	1	0.83	66.3
Broadleaf evergreen tree, temperate	61.5	1	0.71	86.8
Broadleaf deciduous tree, tropical	41.0	1	0.66	62.1
Broadleaf deciduous tree, temperate	57.7	1	0.64	90.1
Broadleaf deciduous tree, boreal	57.7	1	0.70	82.4
Broadleaf evergreen shrub, temperate	61.7	1	0.62	99.5
Broadleaf deciduous shrub, temperate	54.0	1	0.60	90.0
Broadleaf deciduous shrub, boreal	54.0	1	0.76	71.0
C3 grass, arctic	78.2	1	0.68	115.0
C3 grass	78.2	1	0.61	128.1
C4 grass	51.6	1	0.64	80.6
Crop	100.7	1	0.61	165.1

TRY – a global database of plant traits



The maximum carboxylation (Vcmax) measurement at the mid-grain filling stage under ambient [O3] and elevated [O3] (Feng et al., 2016)

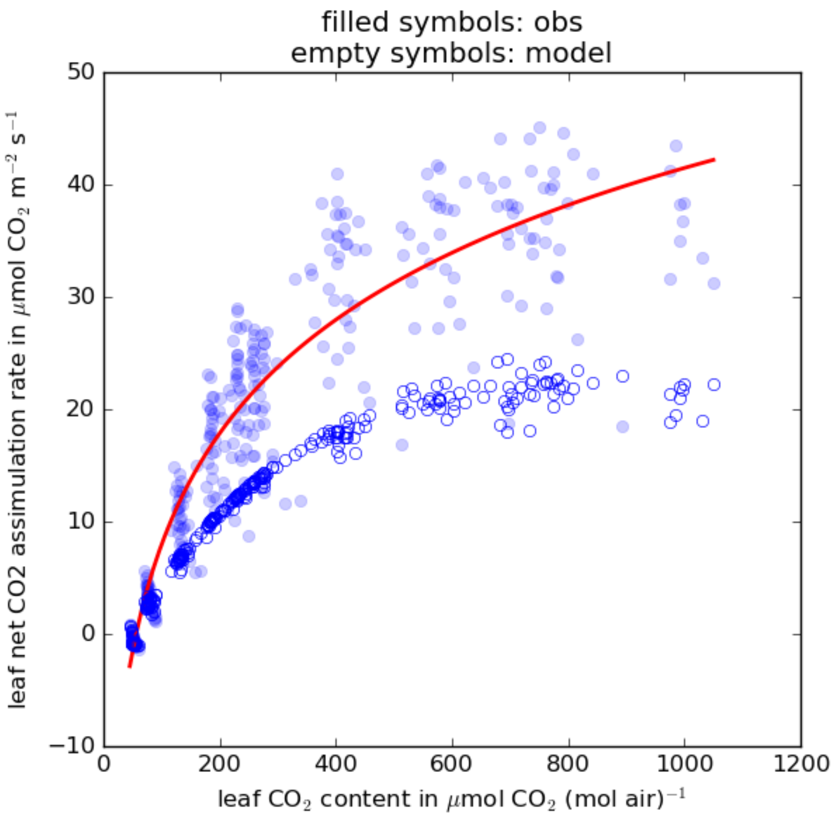
Ratio of stem nitrogen concentration to leaf nitrogen concentration.



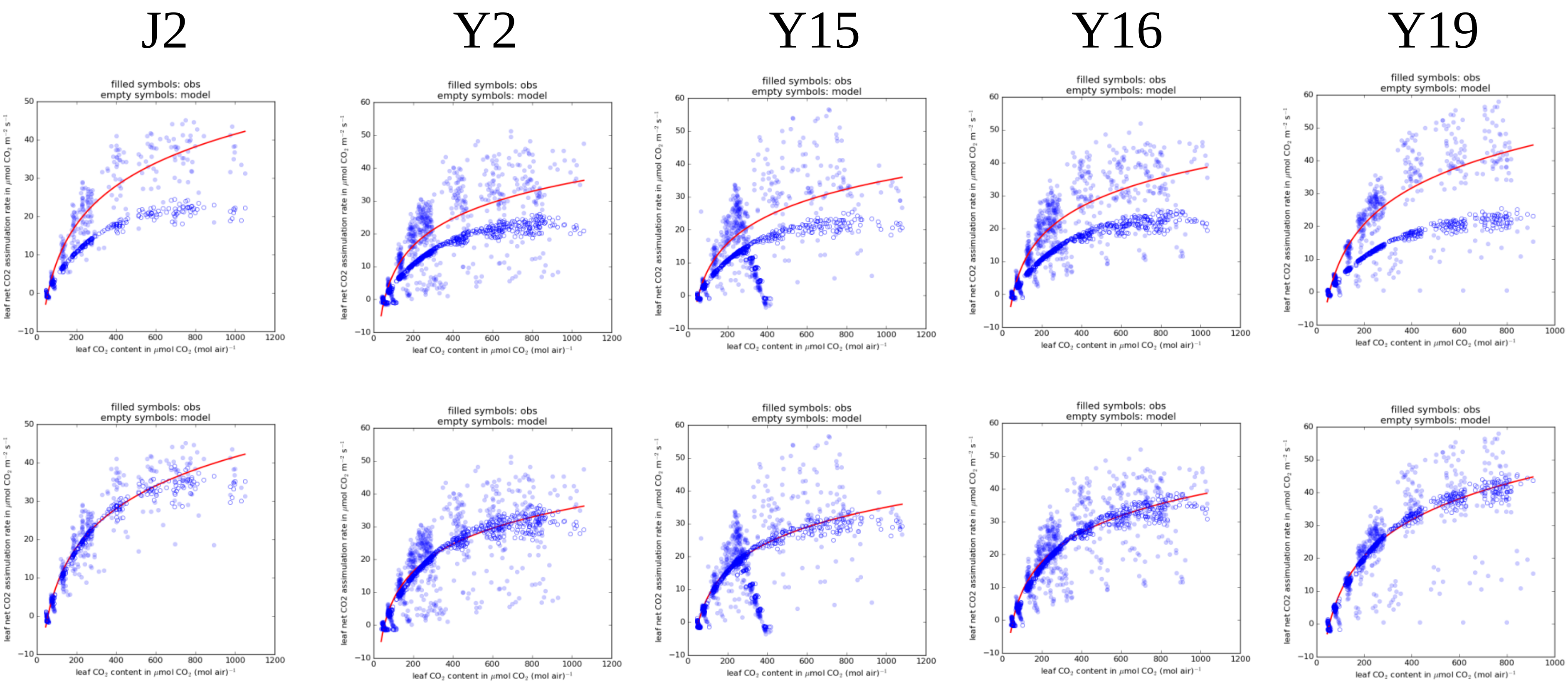
ns_nl_io from
1 to 0.5

Yunlu Tian, PhD thesis; Supervisor: Prof. Weijian Zhang

Leaf_simulator and fitted curve



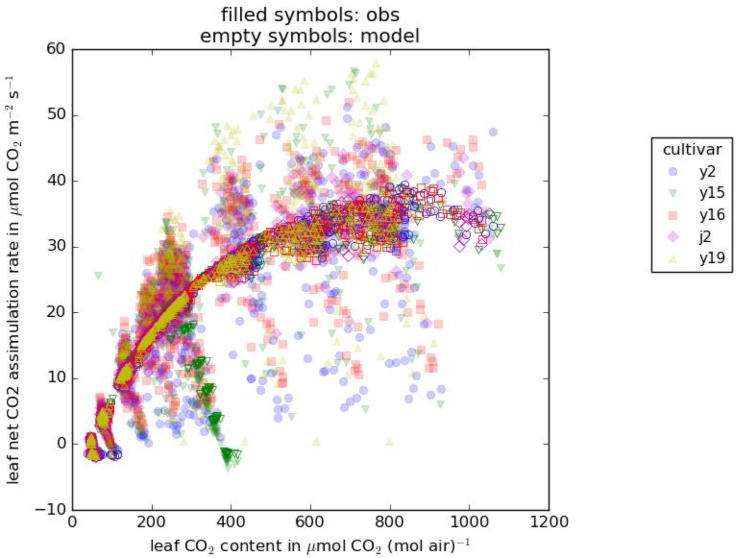
$$y = a \log_b^{(cx+d)} + e$$



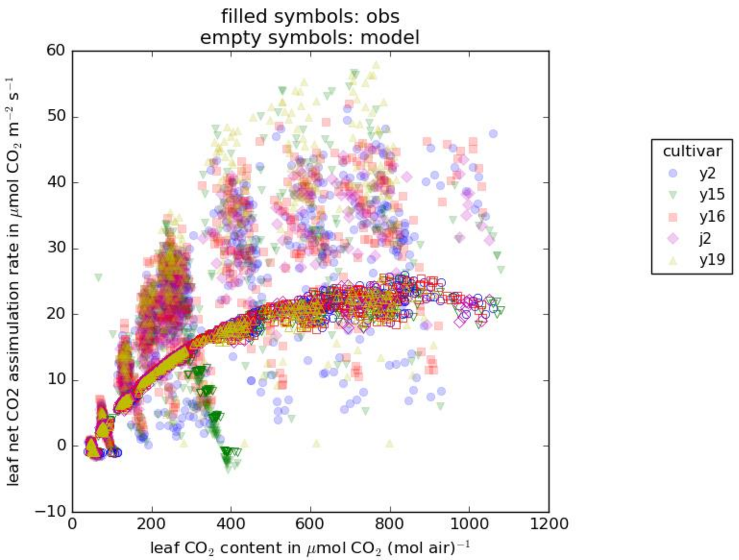
	J2	Y2	Y15	Y16	Y19	AVE	Brattleby	Default
neff	1.10E-3	1.10E-3	1.16E-3	1.16E-3	1.46E-3	1.2E-3	1.0E-3	8.00E-4
nl0	0.083	0.083	0.083	0.083	0.083	0.083	0.09	0.073
Vcmax	91.3	91.3	78.85	96.28	121.18	95.78	90	58.4
ns_nl	0.5	0.5	0.5	0.5	0.5	0.5	-	1
beta_1	0.97	0.6	0.6	0.6	0.6	0.674	-	0.83
beta_2	0.93	0.90	0.83	0.93	0.93	0.904	-	0.93

Calibrated A-Ci plot

Calibrated

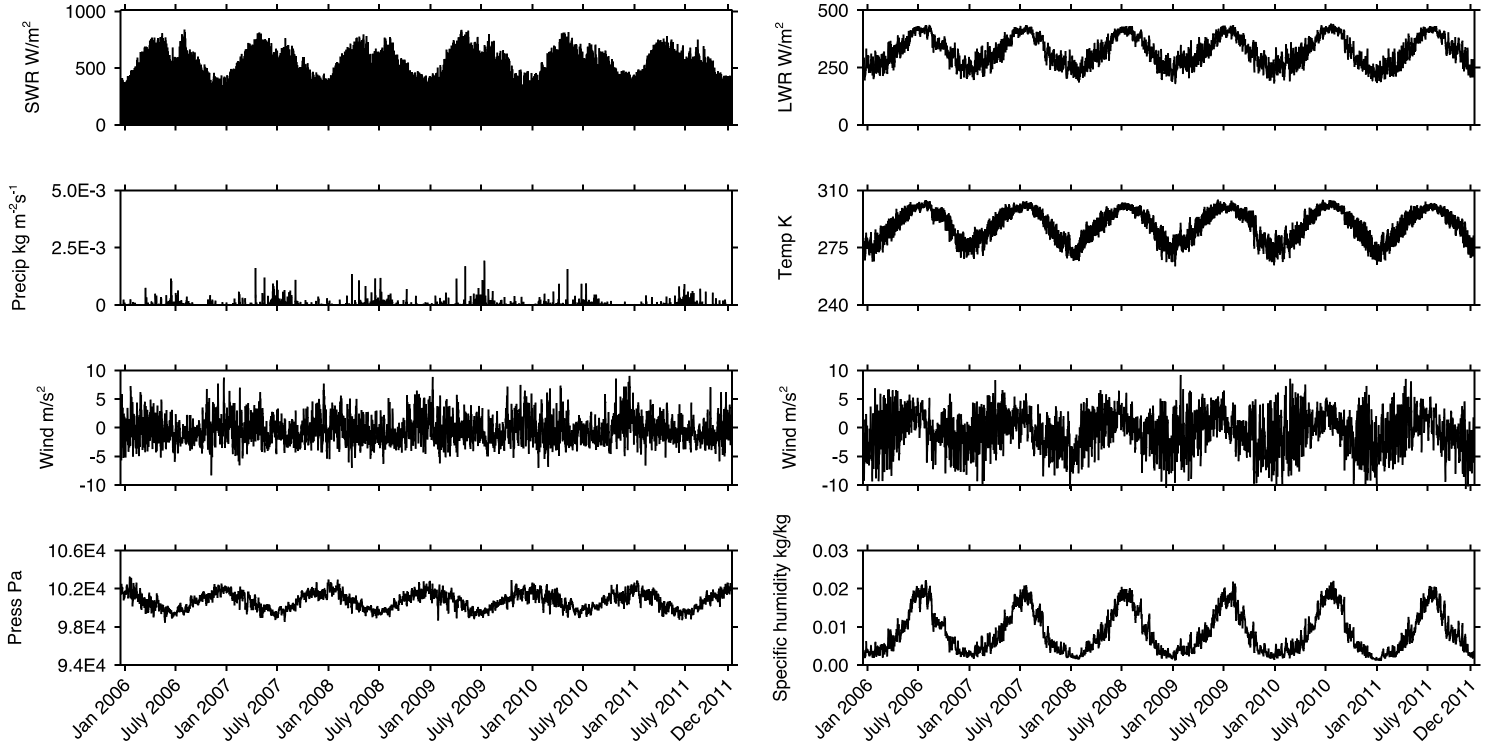


Default



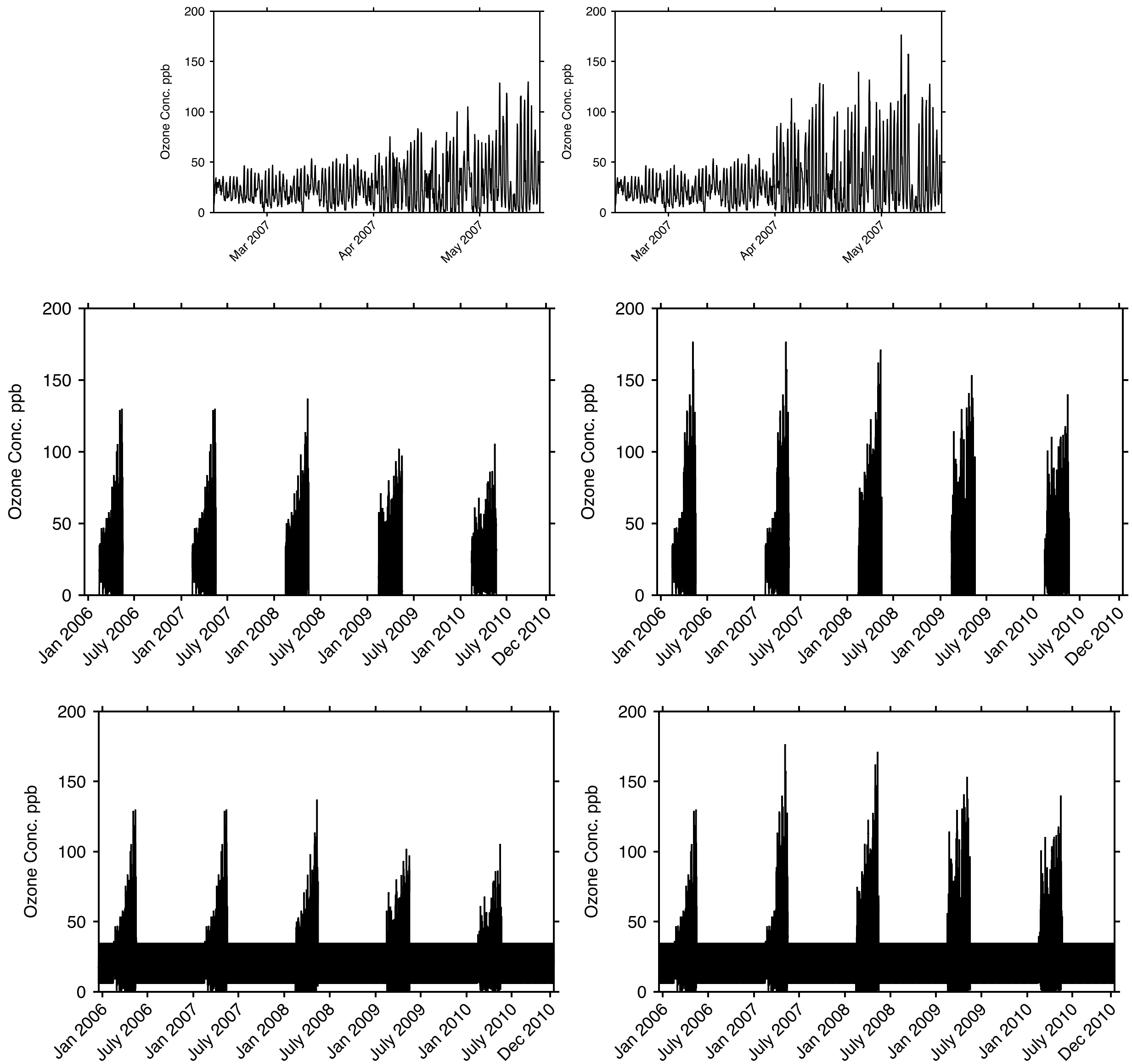
	Calibraed	**Default**
neff	1.2E-3	8.00E-4
nl0	0.083	0.073
Vcmax	95.78	58.4
ns_nl	0.5	1
beta_1	0.674	0.83
beta_2	0.904	0.93

FACE Met - CRU



SWR W/m2
1000
500
0
LWR W/m2
500
250
0
Precip kg m-2s-1
5.0E-3
2.5E-3
0
Temp K
310
275
240
Wind m/s2
10
5
0
-5
-10
Press Pa
10.6E4
10.2E4
9.8E4
9.4E4
Specific humidity kg/kg
0.03
0.02
0.01
0.00
Jan 2006
July 2006
Jan 2007
July 2007
Jan 2008
July 2008
Jan 2009
July 2009
Jan 2010
July 2010
Jan 2011
July 2011
Dec 2011

FACE Ozone



Ozone Conc. ppb
0
50
100
150
200
Mar 2007
Apr 2007
May 2007
Ozone Conc. ppb
0
50
100
150
200
Mar 2007
Apr 2007
May 2007
Ozone Conc. ppb
0
50
100
150
200
Jan 2006
July 2006
Jan 2007
July 2007
Jan 2008
July 2008
Jan 2009
July 2009
Jan 2010
July 2010
Dec 2010
Ozone Conc. ppb
0
50
100
150
200
Jan 2006
July 2006
Jan 2007
July 2007
Jan 2008
July 2008
Jan 2009
July 2009
Jan 2010
July 2010
Dec 2010
Ozone Conc. ppb
0
50
100
150
200
Jan 2006
July 2006
Jan 2007
July 2007
Jan 2008
July 2008
Jan 2009
July 2009
Jan 2010
July 2010
Dec 2010
Ozone Conc. ppb
0
50
100
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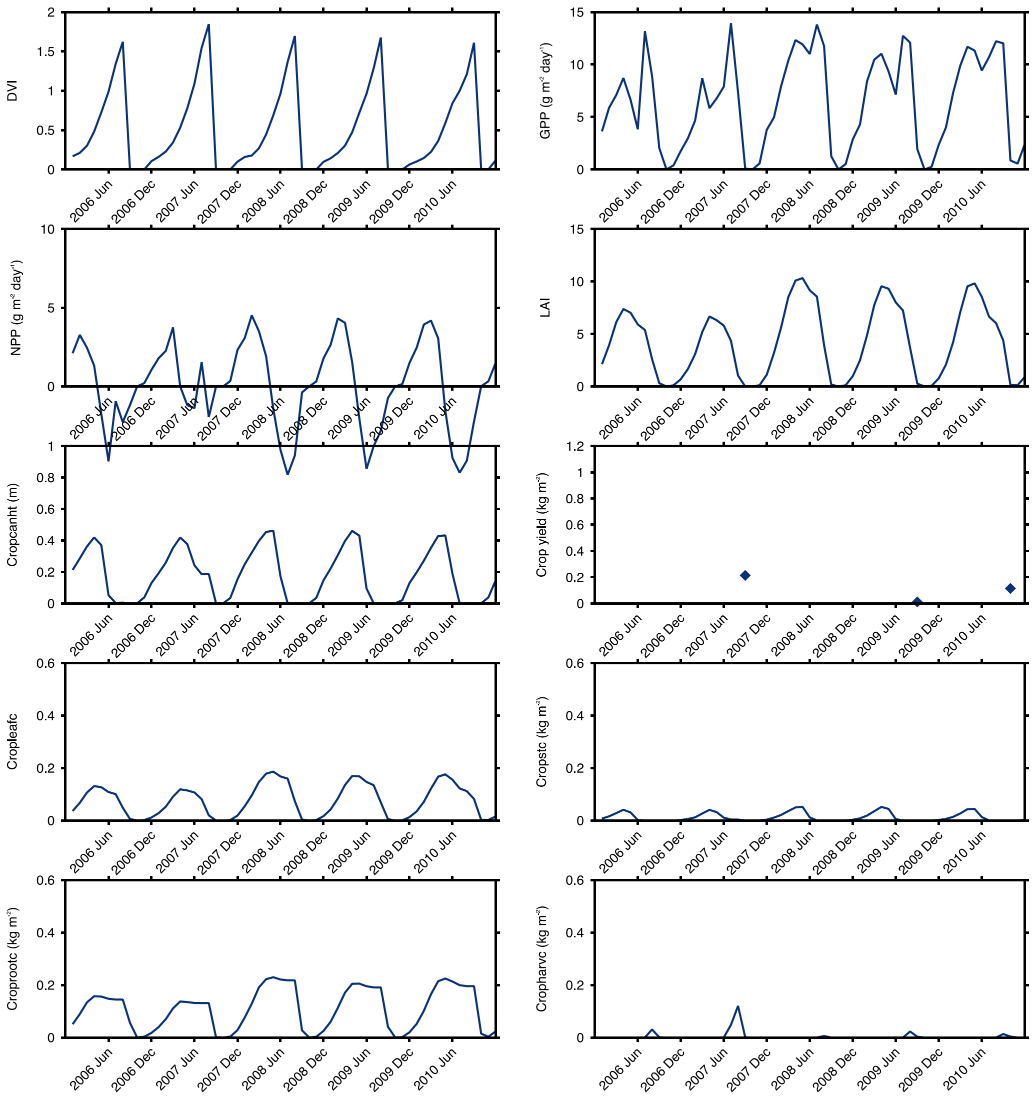
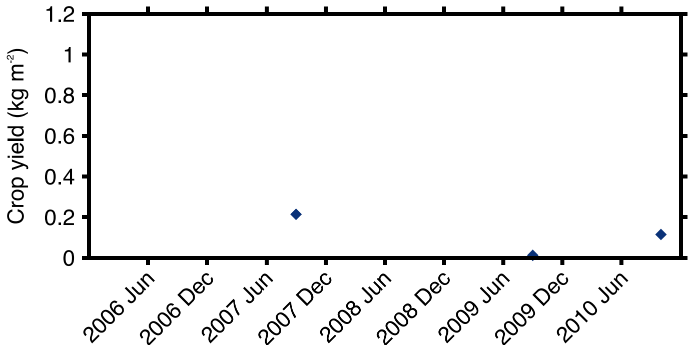
Jan 2006
July 2006
Jan 2007
July 2007
Jan 2008
July 2008
Jan 2009
July 2009
Jan 2010
July 2010
Dec 2010

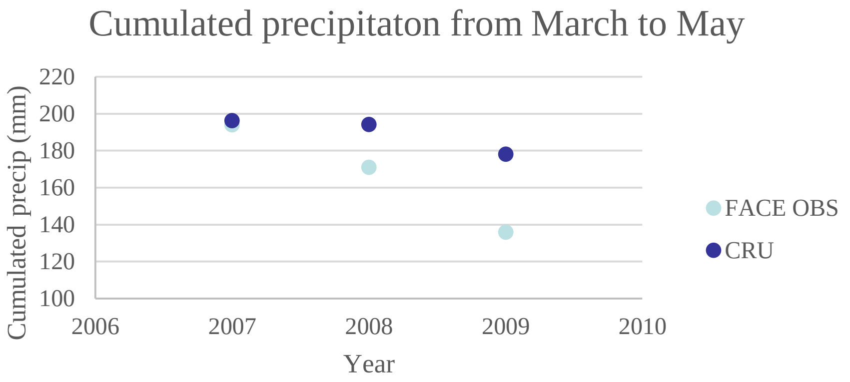
Default parameters



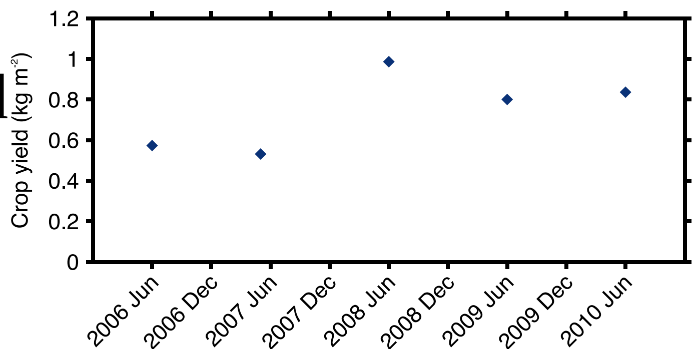
Calibration - yield

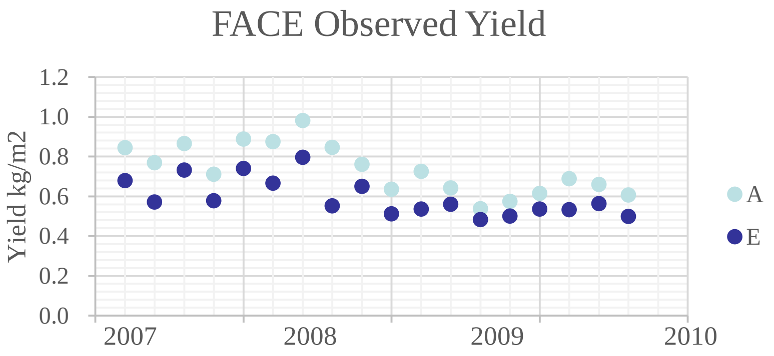
Default





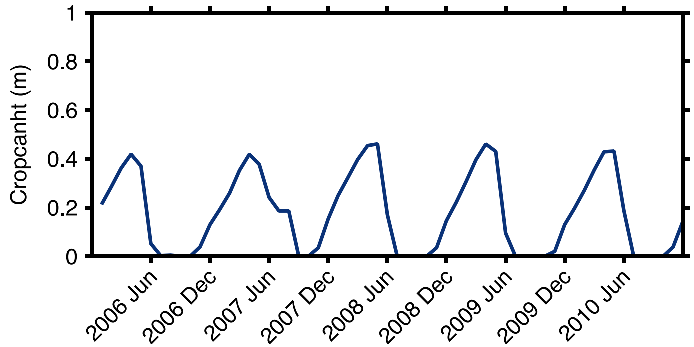
Calibrated



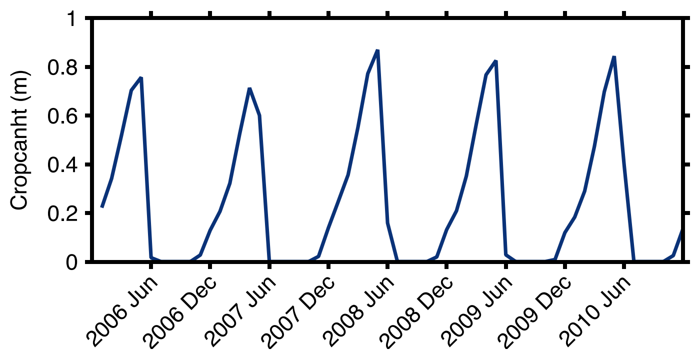


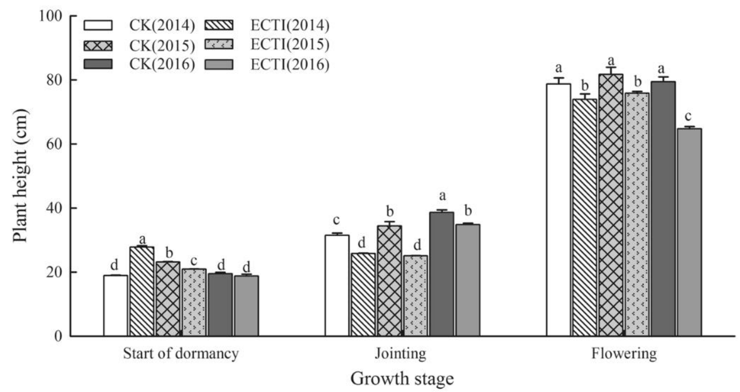
Calibration – canopy height

Default



Calibrated

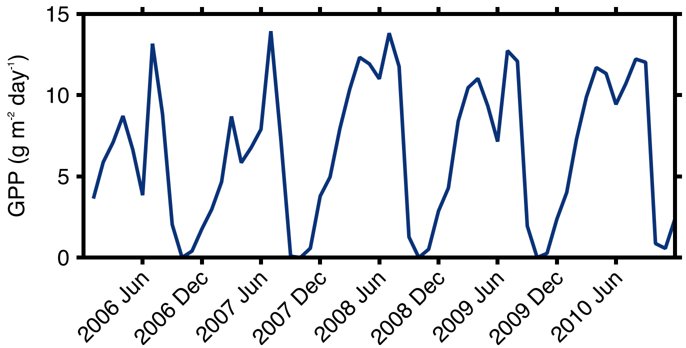




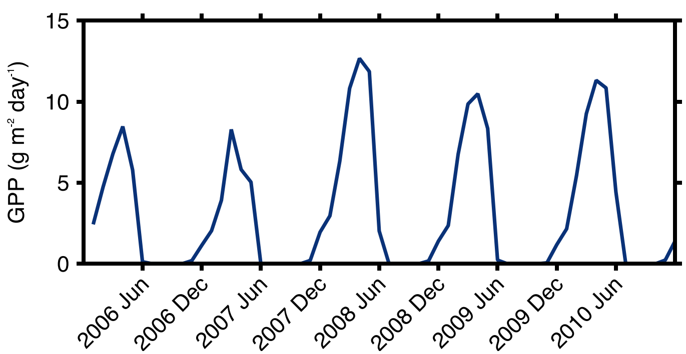
(Tang et al., 2018 Scientific reports)

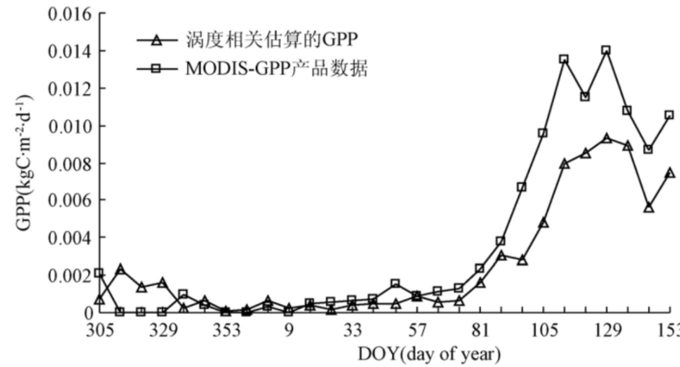
Calibration – GPP

Default



Calibrated

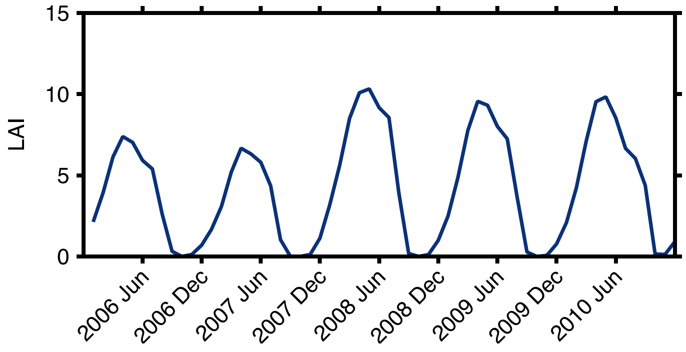




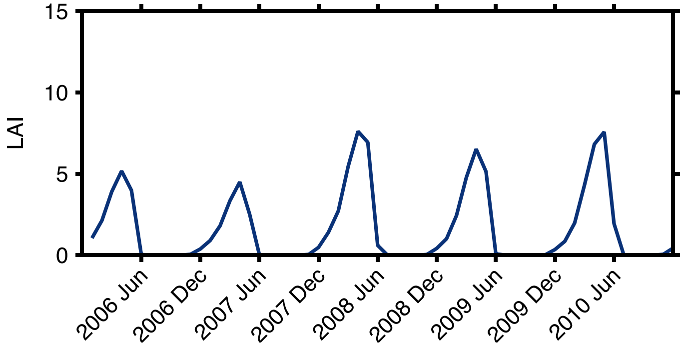
(Zhao, 2011, Fluxtower and Modis)

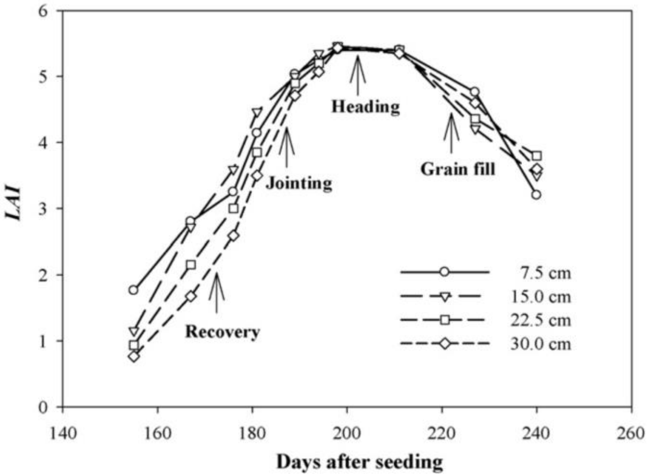
Calibration – LAI

Default



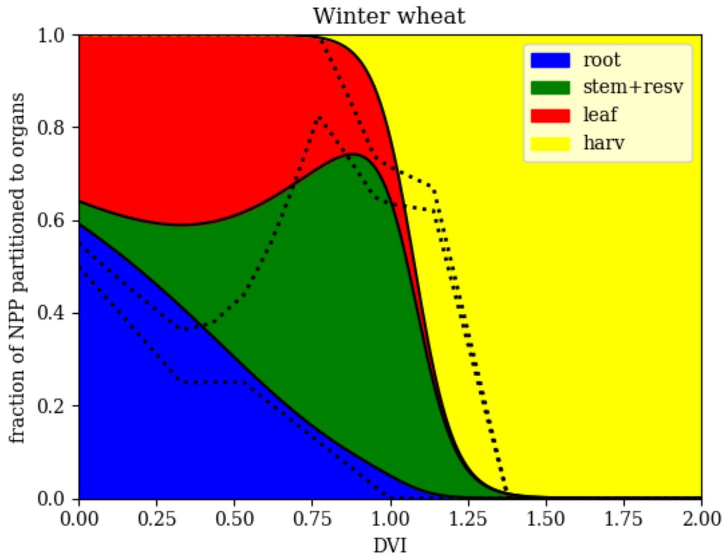
Calibrated

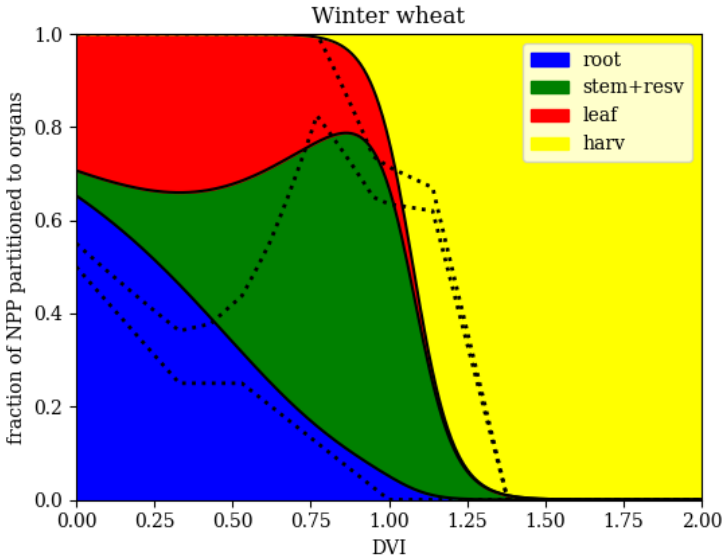


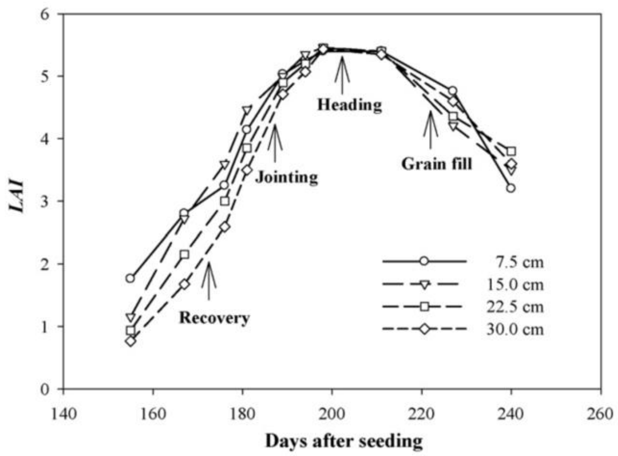


(Chen et al., 2010)

Calibration – Partition fraction



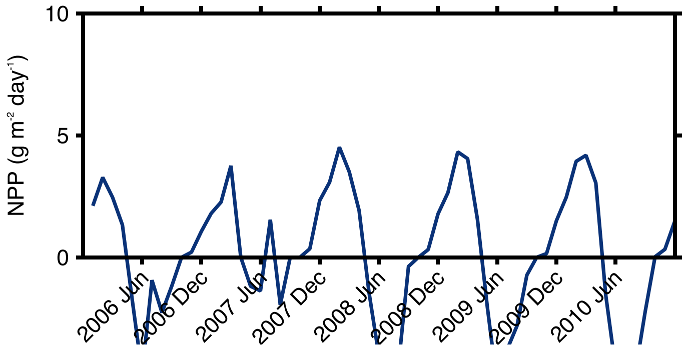




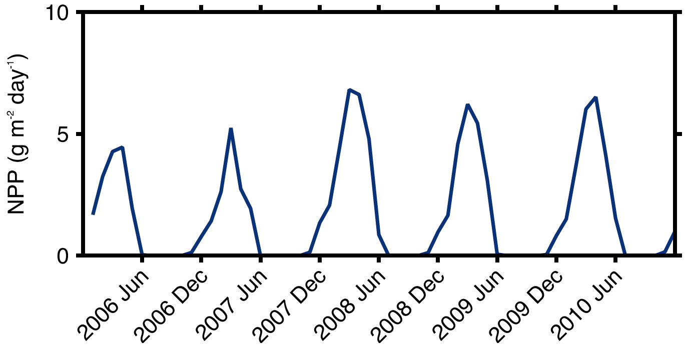
(Chen et al., 2010)

Calibration – NPP

Default

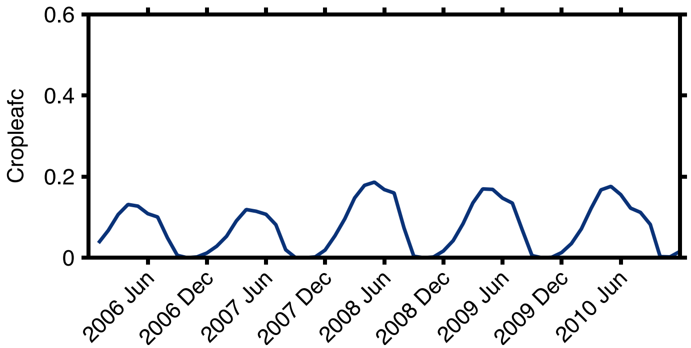


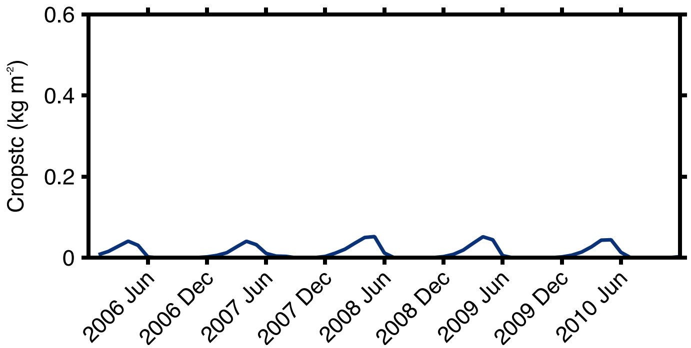
Calibrated



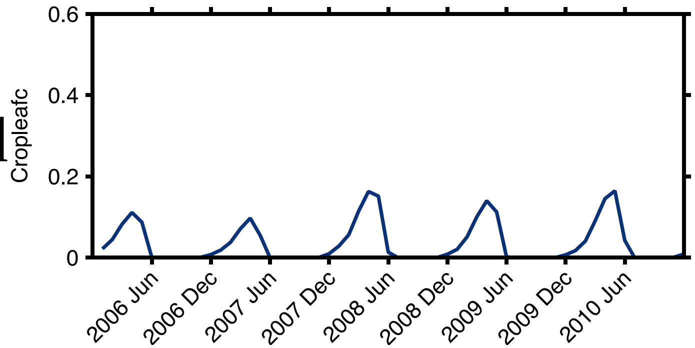
Calibration – Cropleafc / cropstc

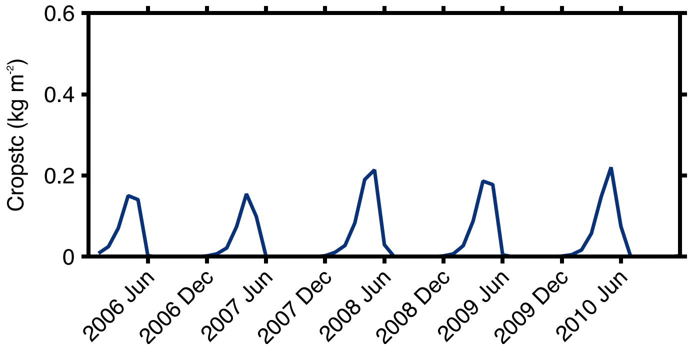
Default





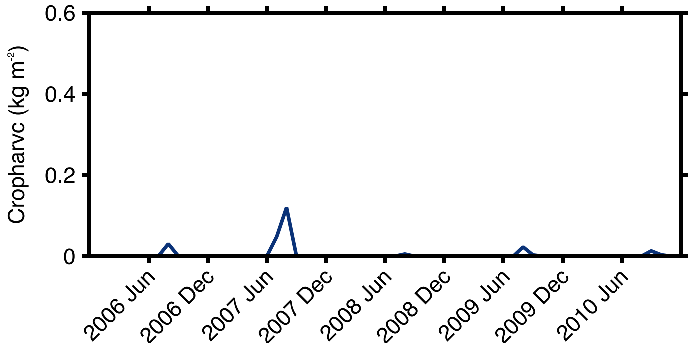
Calibrated

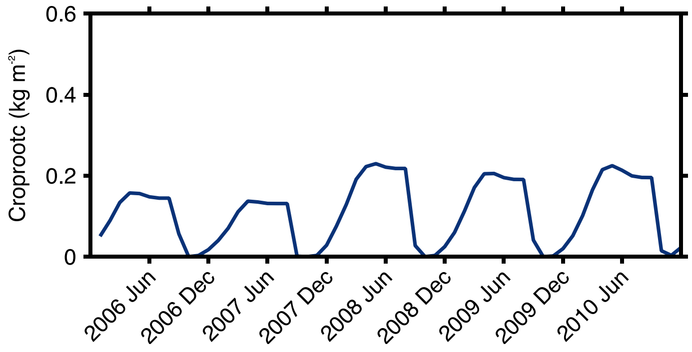




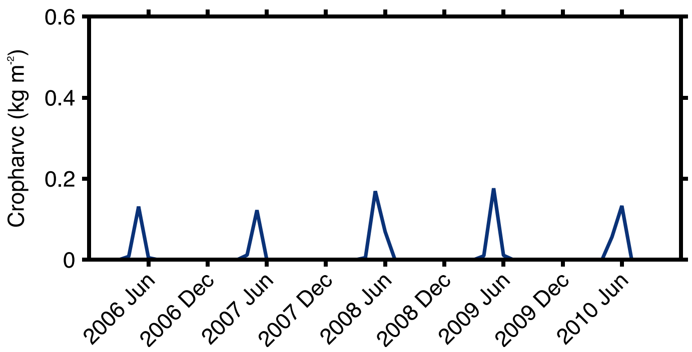
Calibration – Cropharc / croprootc

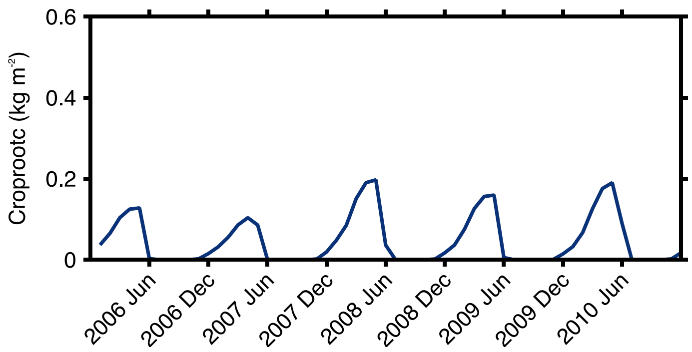
Default





Calibrated





List of calibrated parameters

Parameter Name	Osbone et al., (2015)	Calibrated (leaf and canopy)	Parameter Name	Osbone et al., (2015)	Calibrated (leaf and canopy)
nl0	0.073	0.083	**ns_nl_io**	1	0.5
neff	0.8E-03	1.1E-03	**nr_nl_io**	1	0.1
Vcmax	58.4	91.3	**sen_dvi_io**	1.5	1.5
Beta	0.93	0.63	**mu_io**	0.05	0.05
alpha_root	18.5	18.5	**t_opt_io**	-	22
alpha_stem	16	16	**t_bse_io**	-	0
alpha_leaf	18	17.7	**t_max_io**	-	32
beta_root	-20	-20	**t_mort_io**	-	-20
beta_stem	-15	-15	**t_emr_io**	-	100
beta_leaf	-18.5	-18.5	**tt_veg**	-	1301
delta_io	-0.0507	-0.0407	**tt_rep**	-	867
gamma_io	27.3	23.3	**Sowing date**	-	319

Open question - Vernalization

Supplementary Table S2. Consideration of temperature in wheat simulation models (For details see Alderman et al.[72]).

Model	Phenology	Vernalization	Light Utilization	Respiration	Leaf growth	Canopy temperature	Senescence	Grain set	Grain growth	Grain N Uptake	Root growth	Cold Hardening
APSIM-E	Am	Am	Am	-	Am	-	An, Sm	-	Am	Am	Am	-
APSIM-Nwheat	Am	Am	Am	-	Am	-	Am, Ae, Af	Am	Am	Am	Sm	-
APSIM-wheat	Am	Am, Ax, An	Am	-	Am	-	Am, Af	Am	Am	Am	Sm	-
AQUACROP	Am	-	-	-	Am[1]	-	Am	Ax, An	Am	-	Am	-
CropSyst	Am	Am	Am	-	-	Cm	Am, Ae, Af	Ah	-	-	-	Ah

(Asseng, 2014, NCC)

Vernalisation, a cold temperature requirement for development in some crops, is not included in this model version

(Osborne et a., 2015 GMD)

Thank you !