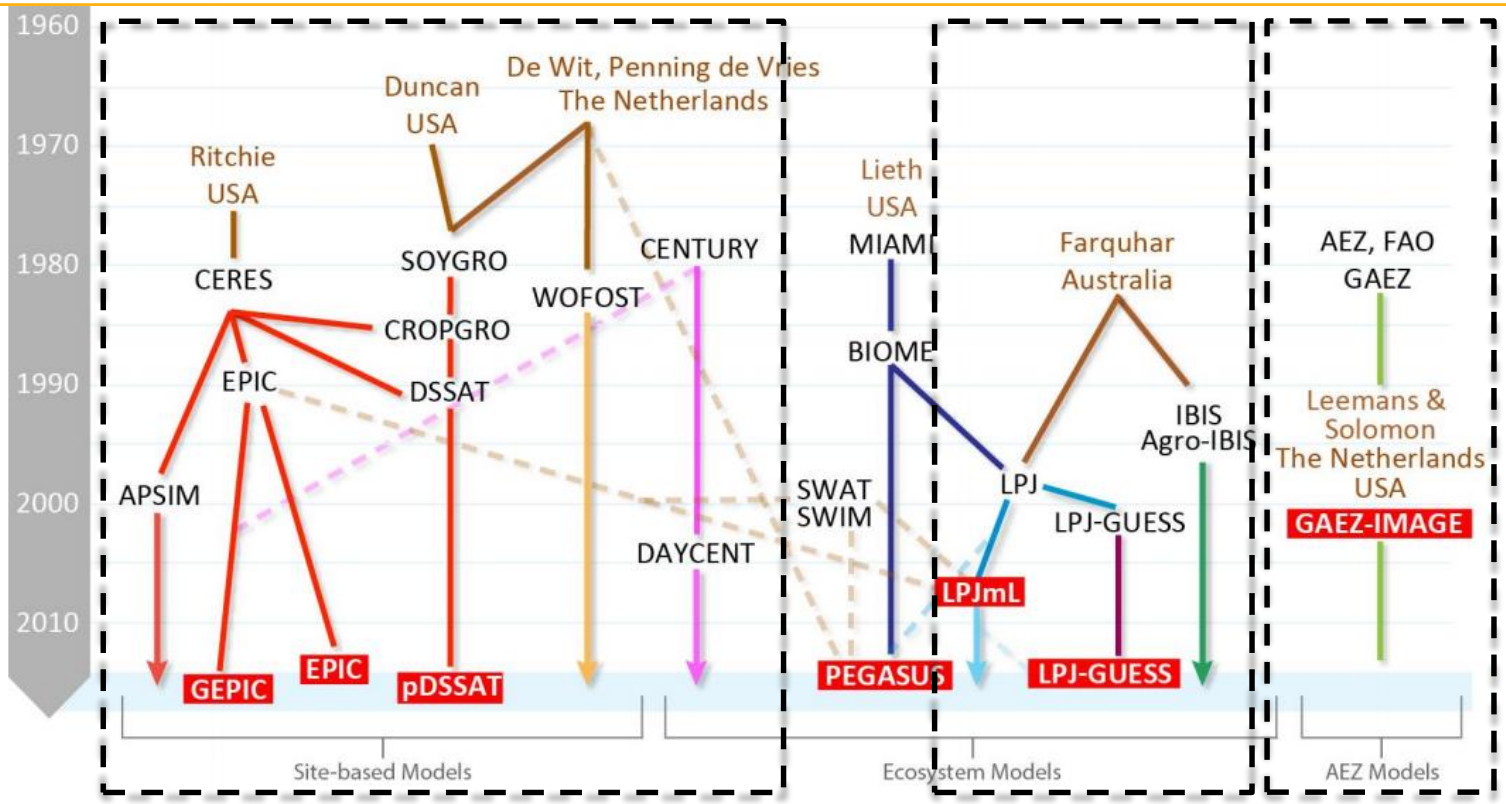
Modelling croplands with ORCHIDEE-crop, pioneering practices modelling China's rice croplands

The ORCHIDEE-crop team

Content

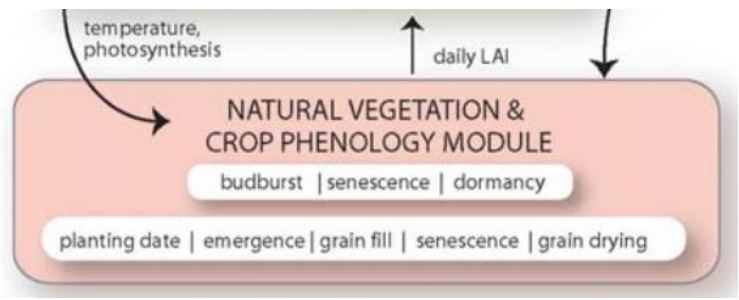
- Capability of ORCHIDEE-crop
  - Crop growth cycle
  - Crop management
- Parameterization for regional practices
- Modelling China's rice croplands
- Outlook

Introduction - crop model genealogy

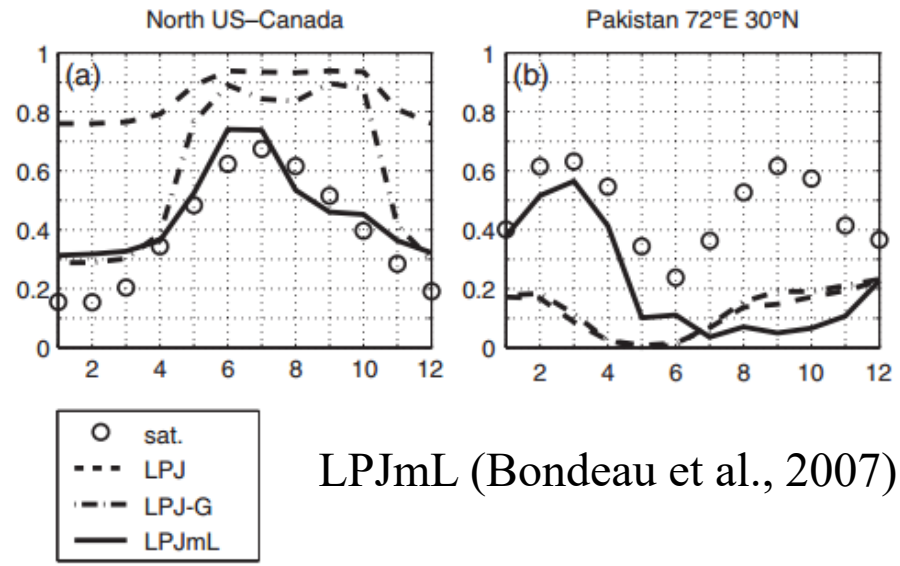


	Site-based model	Ecosystem model	AEZ model
Process/mechanism	medium	high	low
Spatial scale	site -> global	regional/global	regional/global
Input requirement	high	medium	low

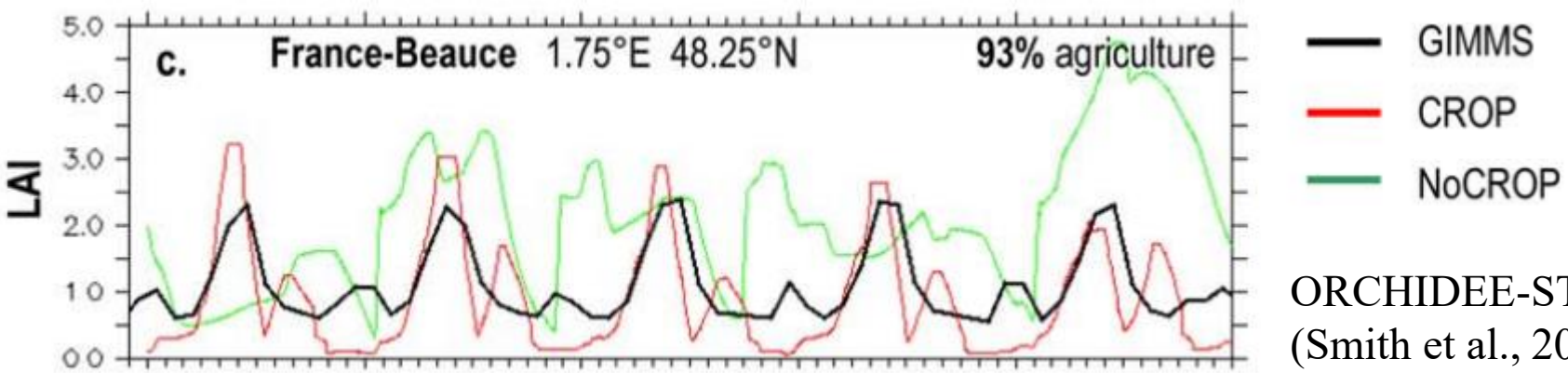
Development of agro-ecosystem model



Agro-IBIS (Kucharic et al., 2003)

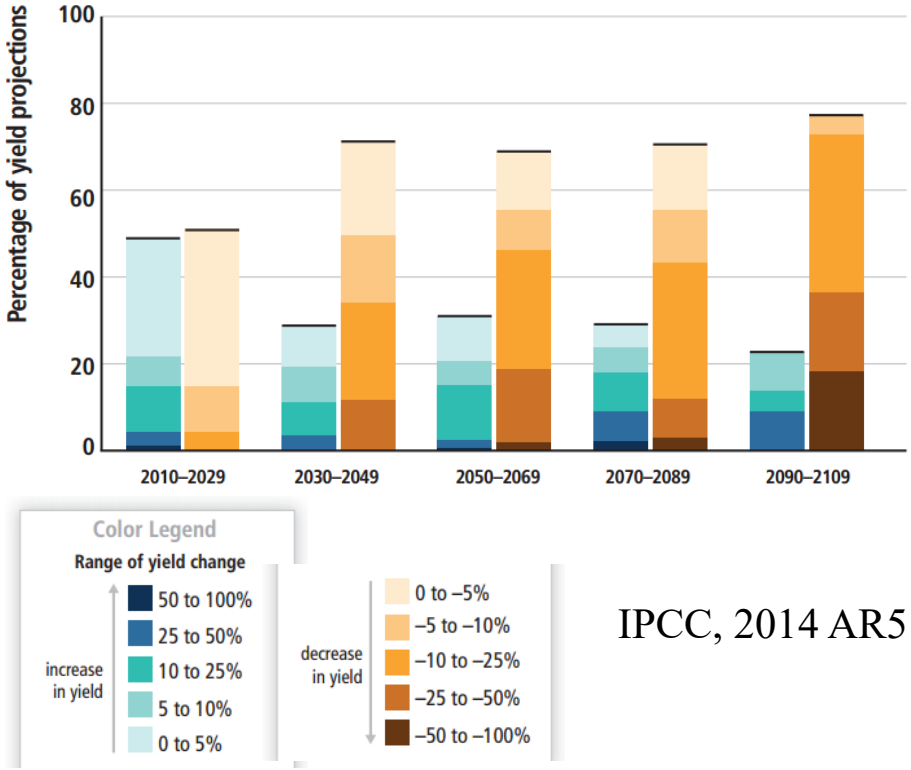


LPJmL (Bondeau et al., 2007)

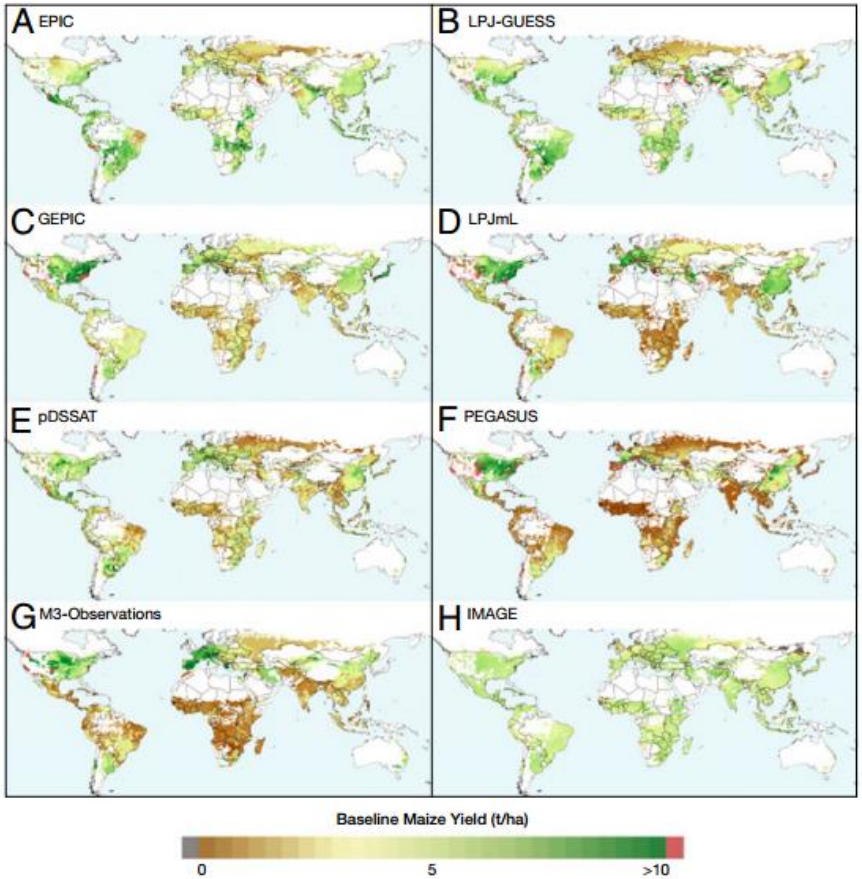


ORCHIDEE-STICS (Smith et al., 2010)

Global crop models



IPCC, 2014 AR5



Rosenzweig et al., 2014 PNAS

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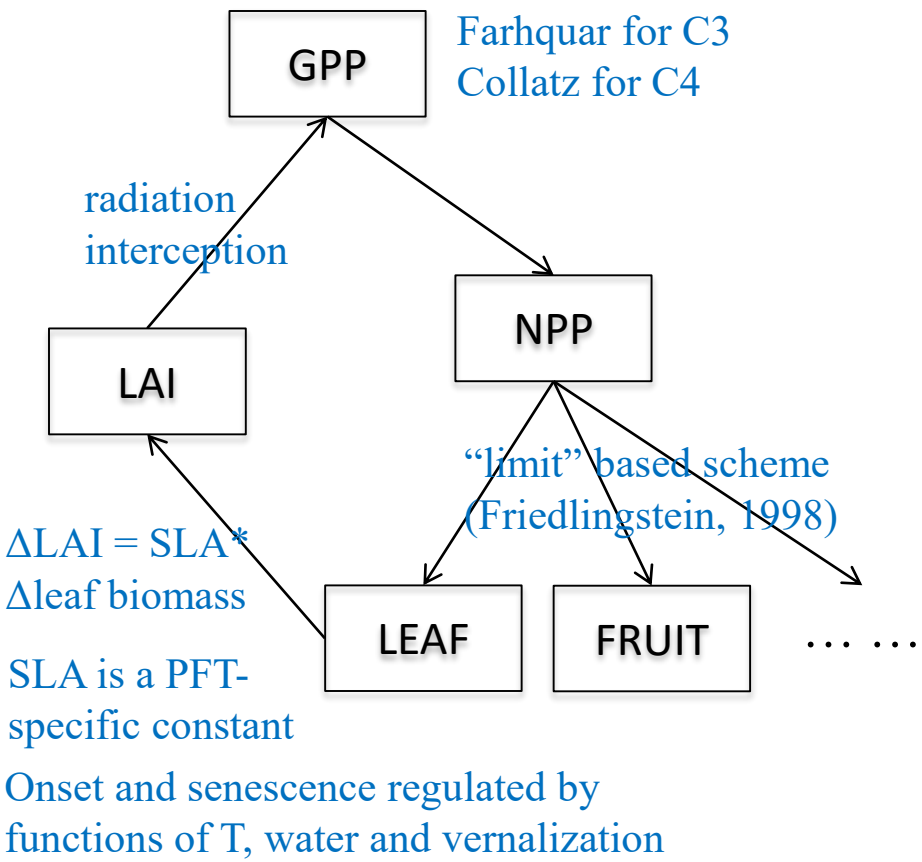
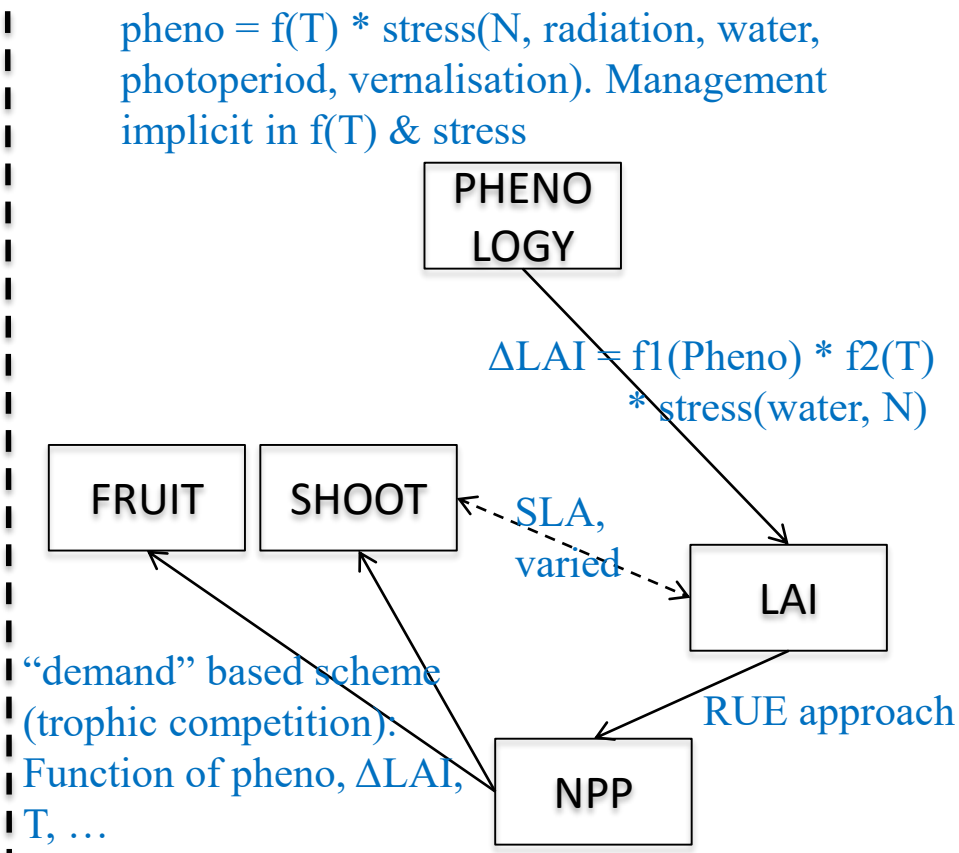
growth cycle simulation

Ecosystem model (ORCHIDEE)



Site-based crop model (STICS)

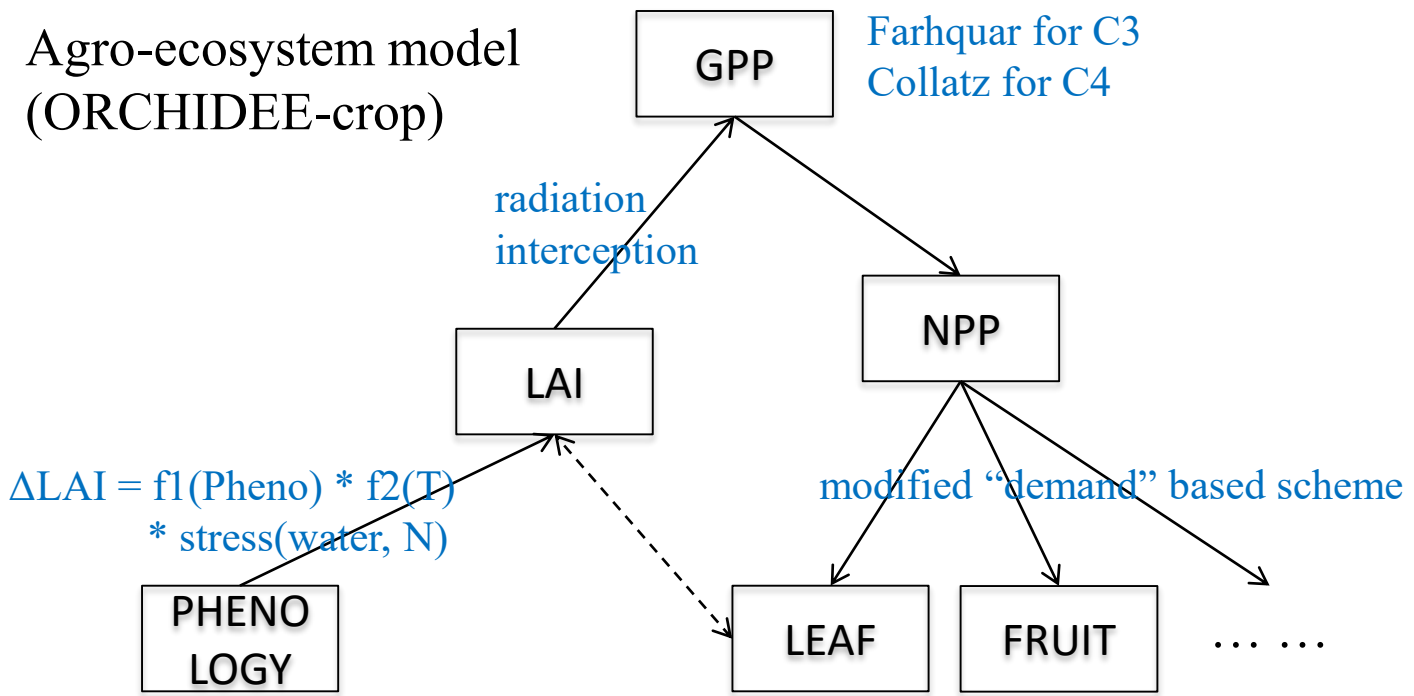


growth cycle simulation

Ecosystem model (ORCHIDEE) + Site-based crop model (STICS)

↓

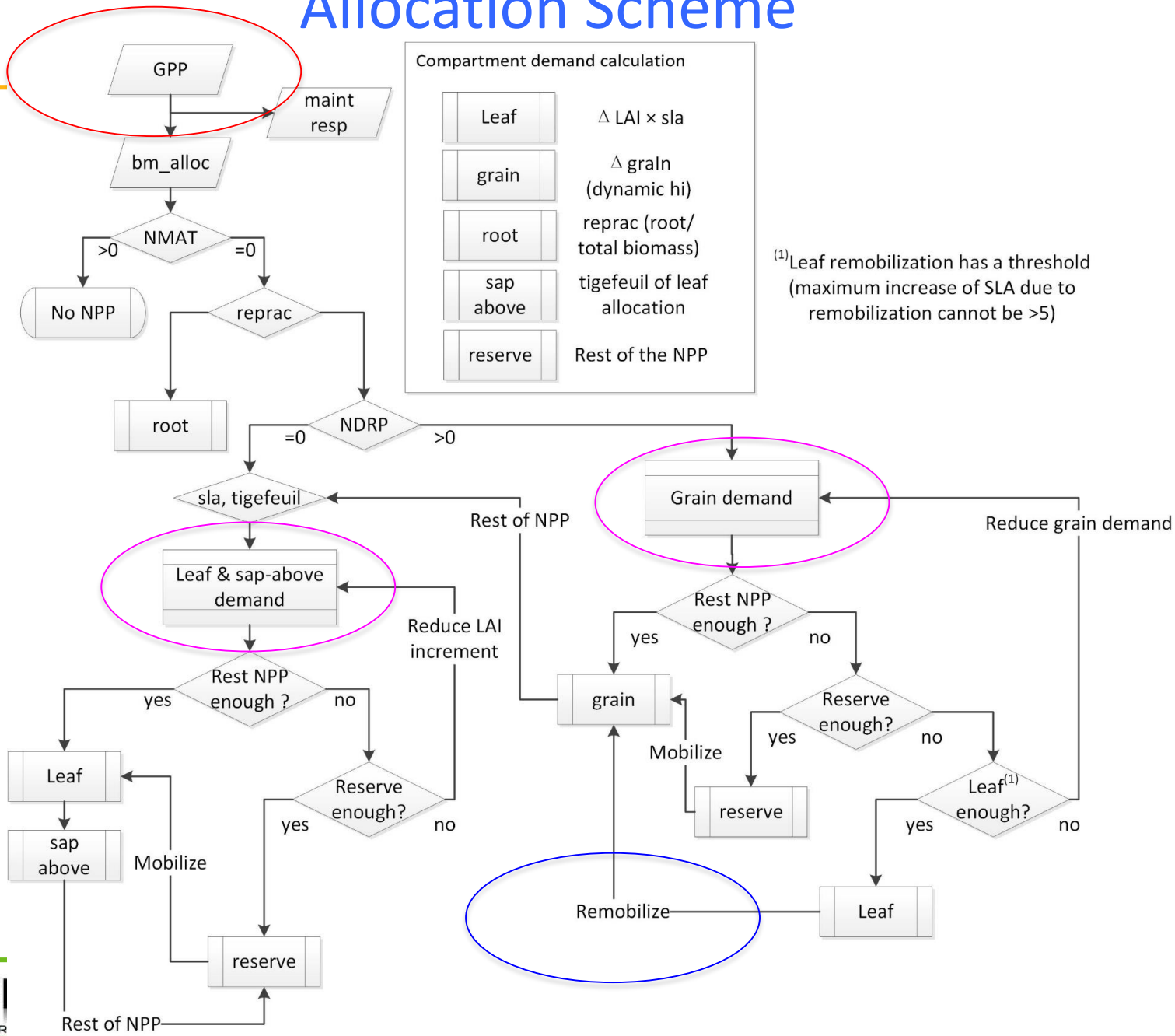
Agro-ecosystem model (ORCHIDEE-crop)



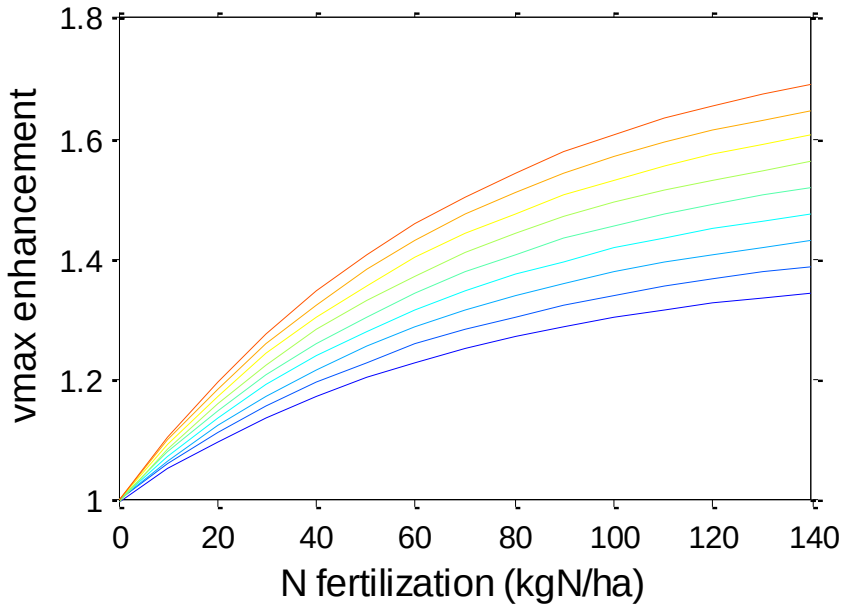
pheno = f(T) * stress

Management implicit in f(T) & stress

Allocation Scheme

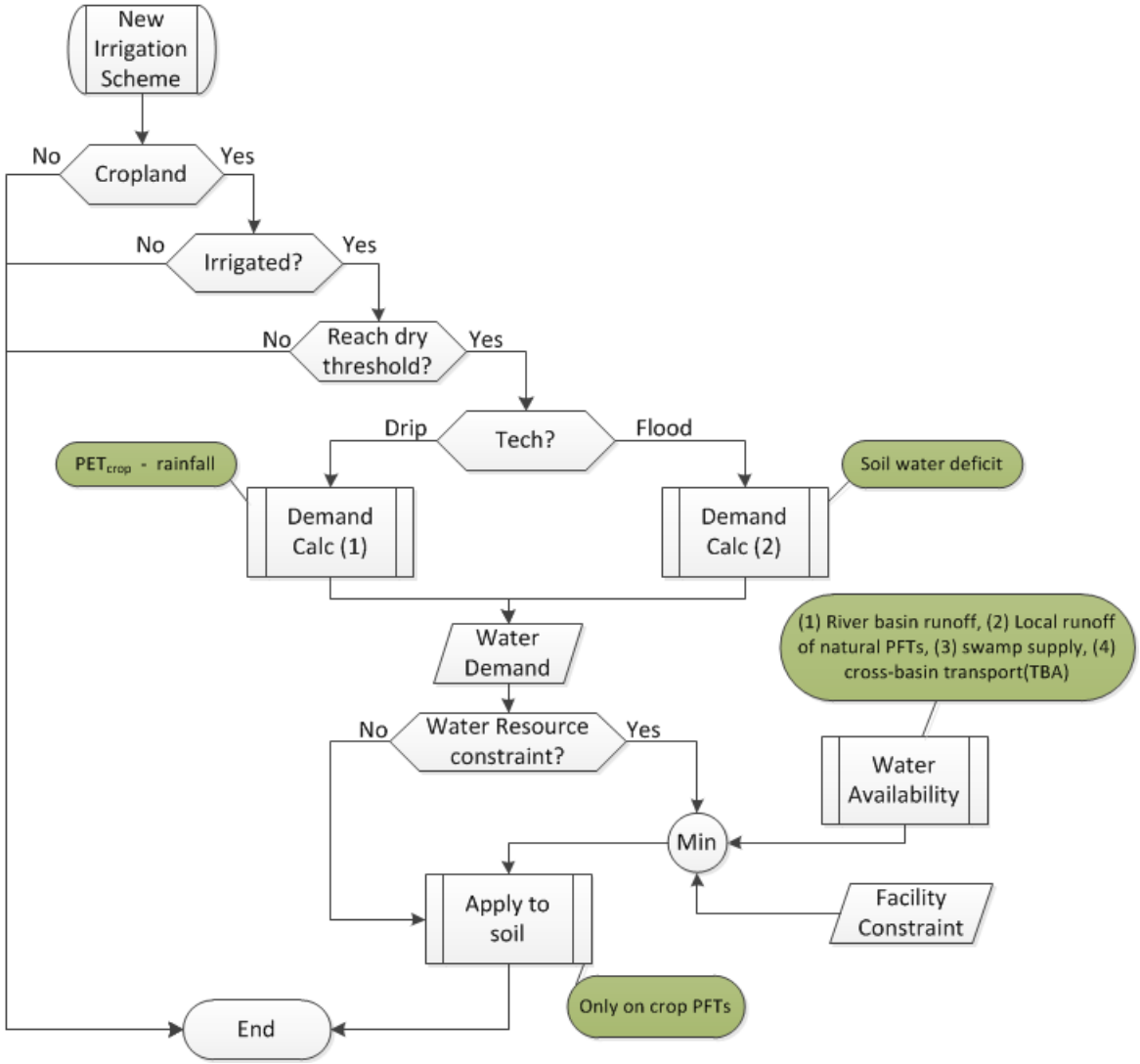


Nitrogen fertilizer response



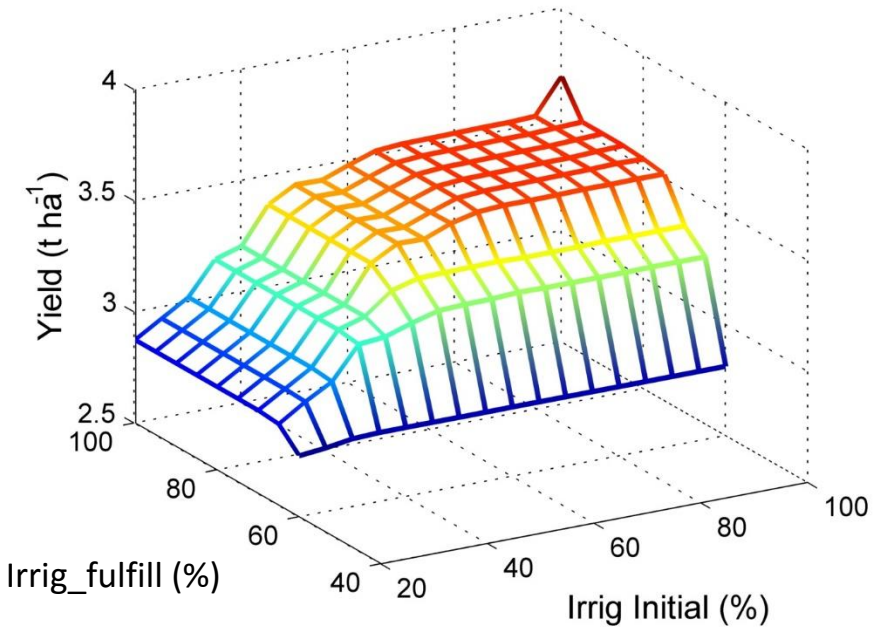
ORCHIDEEcrop irrigation scheme

- Addressing:
  - When
  - Where
  - How much
  - How

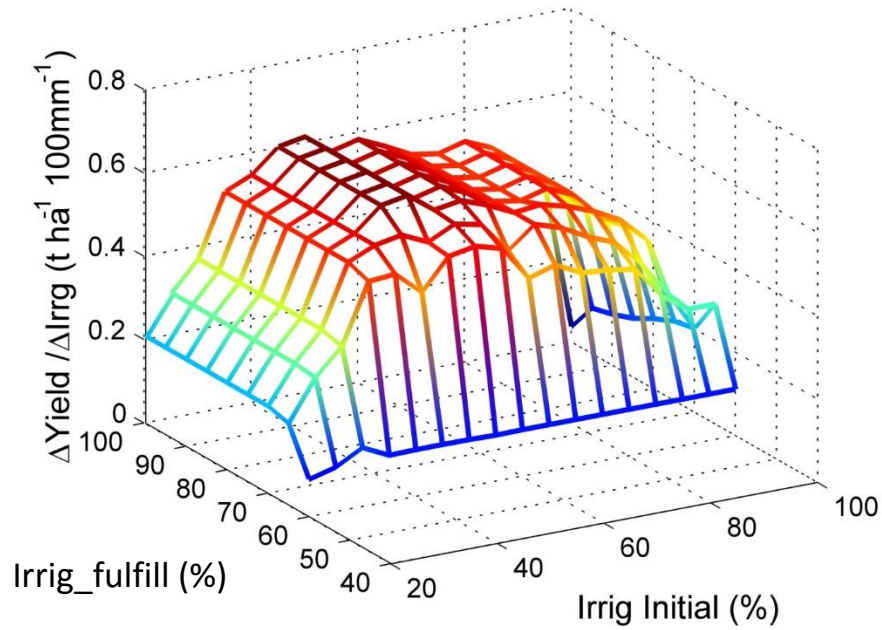


A decision support system

Yield ~ irrigation



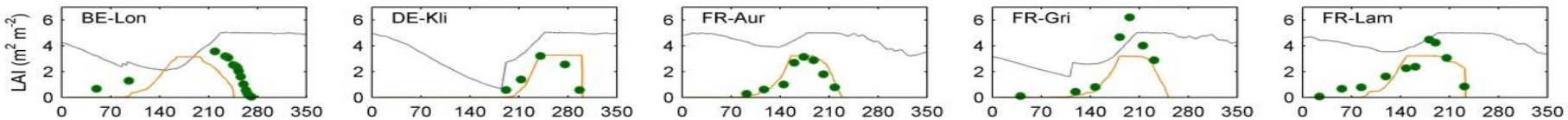
Irrigation Efficiency ~ irrigation



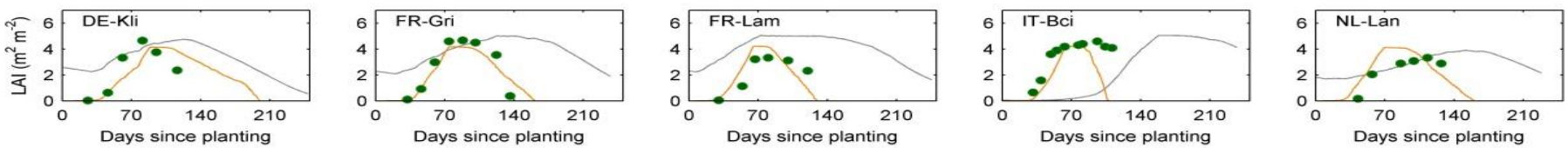
Irrigation Efficiency (t/ha/100mm) = dYield/dIrrigationWater

ORCHIDEE-standard vs. ORCHIDEE-crop

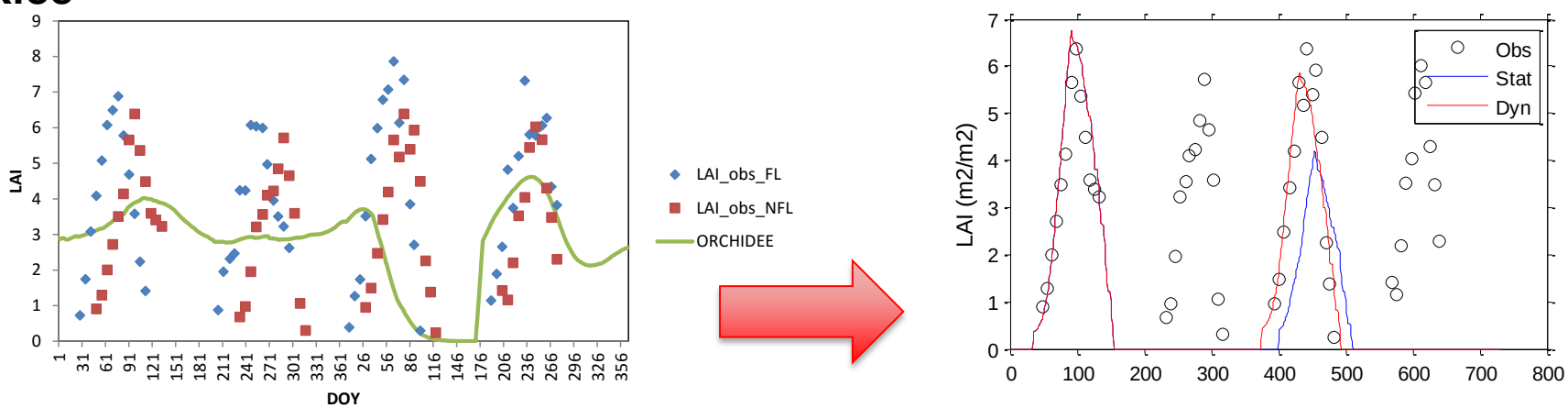
Wheat



Maize



Rice



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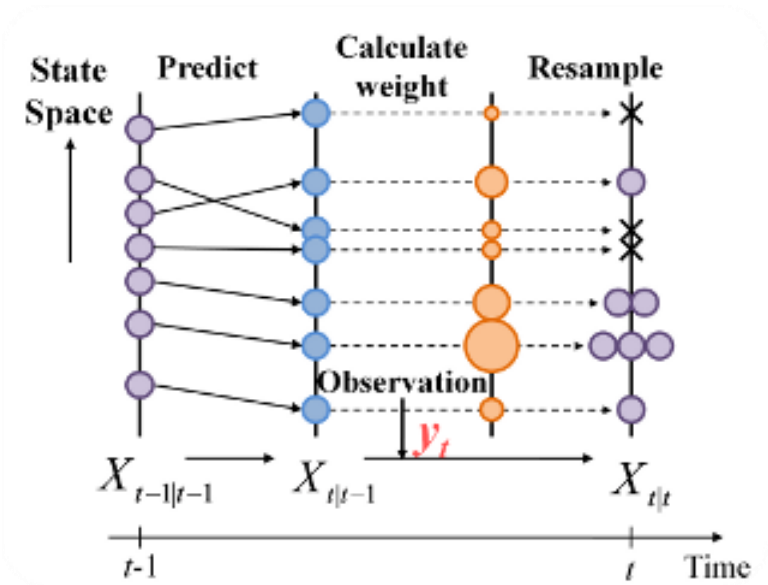
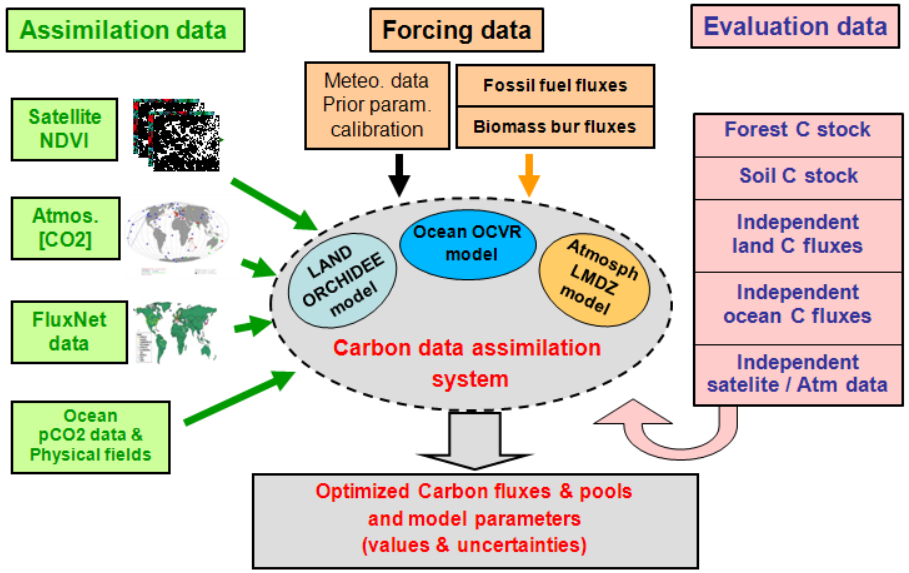
The optimization system

- A step-by-step Bayesian optimization system with particle filter
  - Global optimization, but large computing cost



Particle filter (e.g. Van Leeuwen et al., 2009)

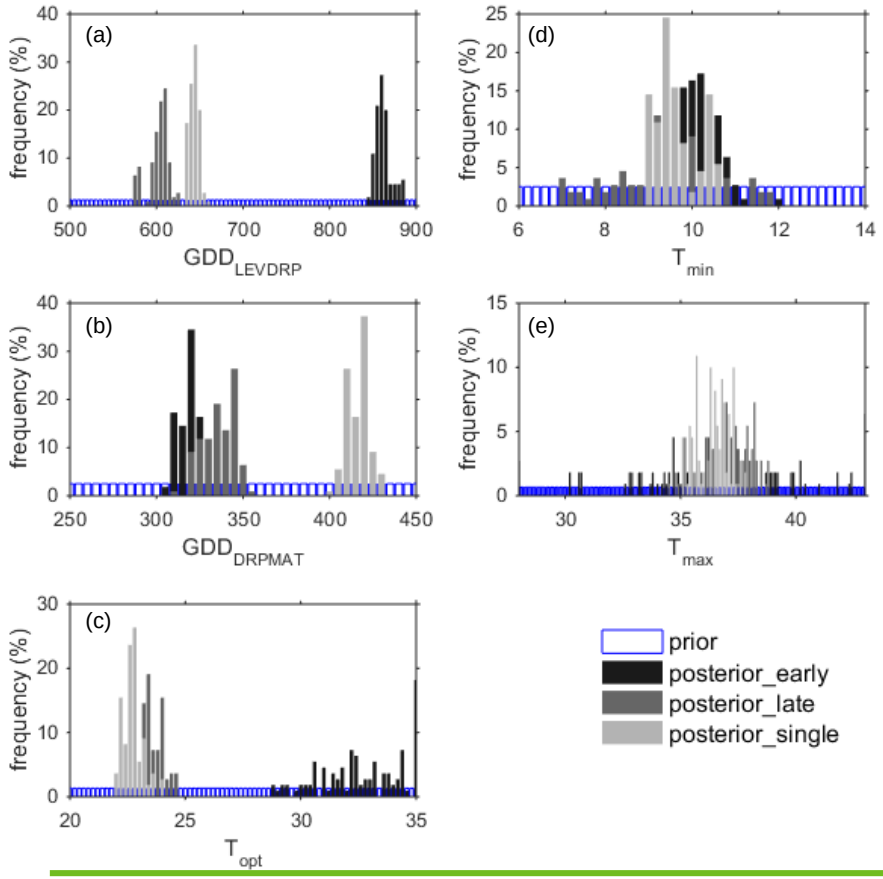


Step-by-step procedure
(see P Peylin's presentation on CCDAS)

Optimized parameters

Parameter selection with Morris sensitivity tests when needed

Posterior probability (often multi-module)



Classification	Parameter	Explanation	Default	Min	Max	Rank
Phenology thermal unit	GDD_{LEVAMF}	Cumulated development units between LEV and AMF	265	100	500	15
	GDD_{AMFLAX}	Cumulated development units between AMF and LAX	510	300	700	16
	GDD_{LEVDRP}	Cumulated development units between LEV and DRP	959	300	1050	4
	GDD_{DRPMAT}	Cumulated development units between DRP and MAT	442	100	600	2
Temperature thresholds for crop development	T_{min}	Min threshold temperature for development	13.0	6.0	17.0	1
	T_{opt}	Optimum temperature for development	30.0	20.0	35.0	6
	T_{max}	Optimum temperature for growth	40.0	35.0	45.0	23
	Tc_{min}	Min temperature for leaf growth	13.0	6.0	17.0	8
	Tc_{opt}	Optimum temperature for leaf growth	30.0	20.0	35.0	21
Grain formation	V_{ircarb}	Grain filling rate per thermal unit	0.0012	0.0011	0.0024	7
	IR_{max}	Maximum harvest index	0.65	0.45	0.65	29
	Tr_{min}	Min temperature for grain filling	14.0	11.0	16.0	5
	Tr_{max}	Max temperature for grain filling	38.0	27.0	41.0	17
	N_{grain}	Days before grain filling to form the sink	30	27	46	27
LAI related	$dLAI_{max}$	Max rate of LAI increment	0.005	0.004	0.007	14
	durvief	Development units for leaf duration	480	300	600	13
allocation	$reprac_{max}$	Max partition ratio for root	0.24	0.20	0.30	28
	$reprac_{min}$	Min partition ratio for root	0.047	0.03	0.20	12
	$Frac_{gr}$	Partition fraction for growth respiration	0.28	0.23	0.30	11

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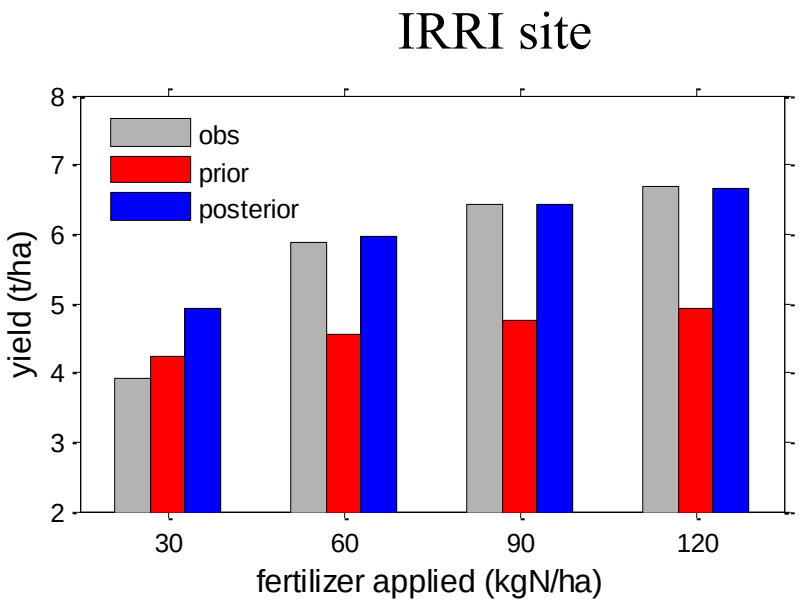
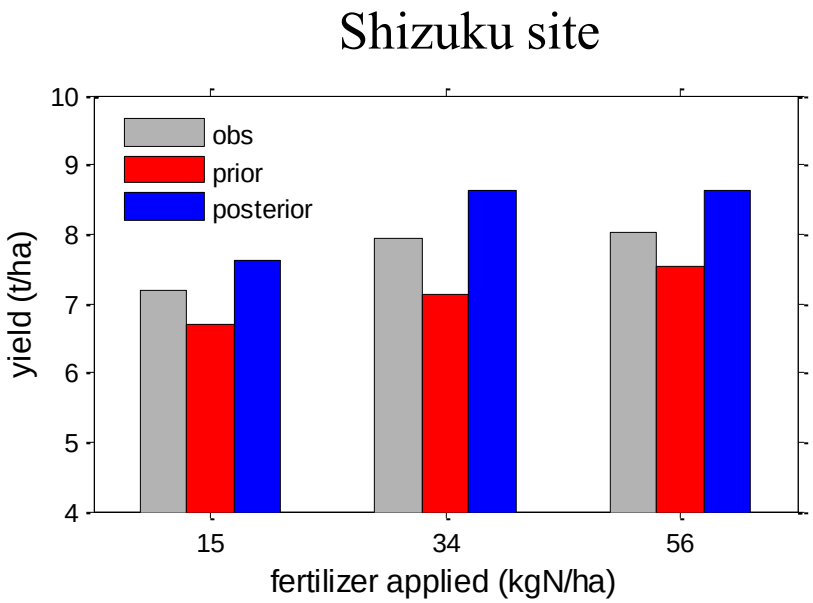
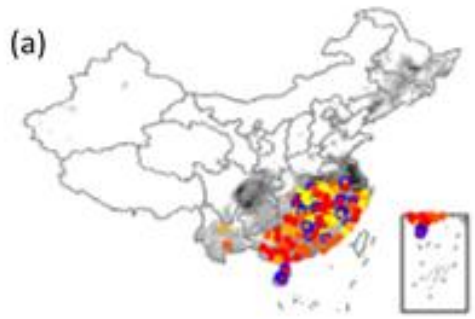
Step 1: response to nitrogen fertilizers



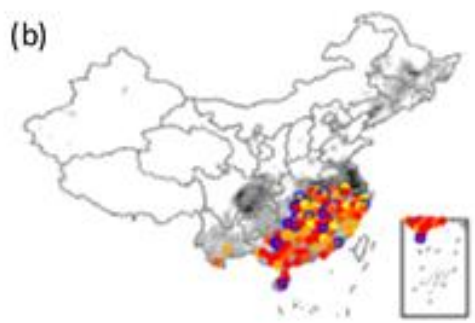


Step 2: on rice phenology (1)

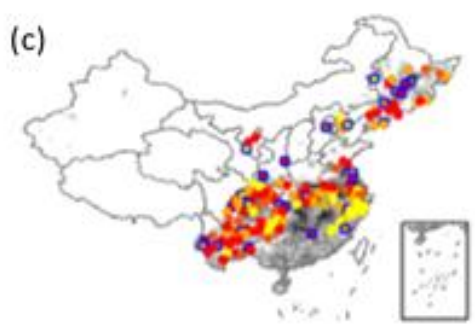
Early Rice



Late Rice

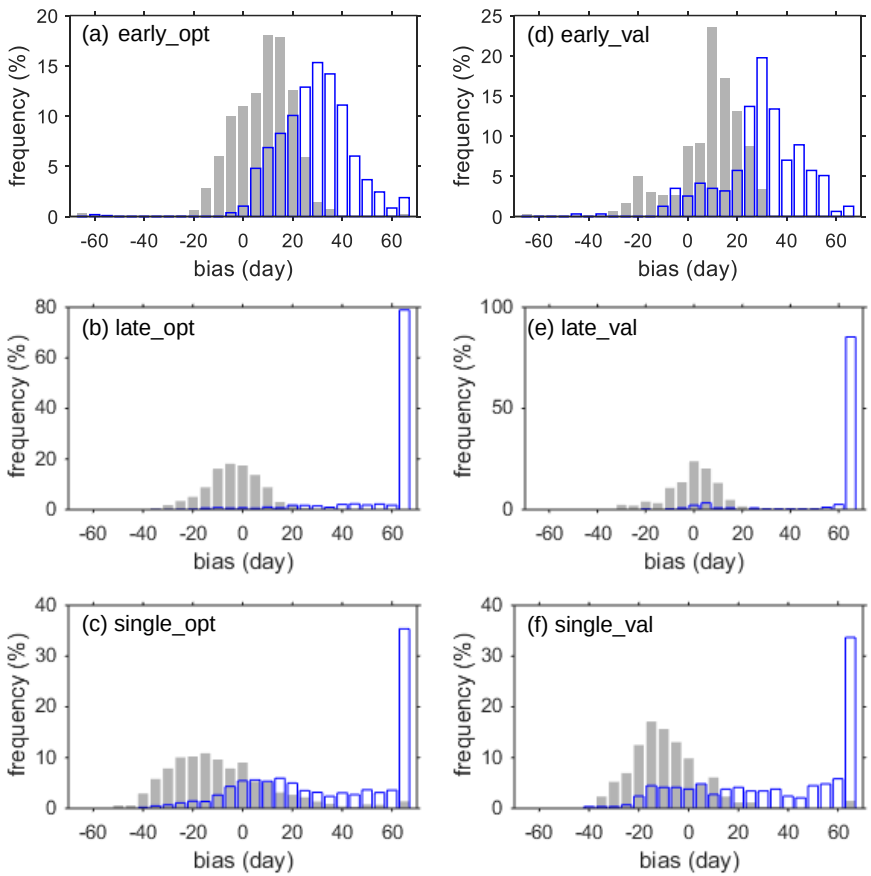


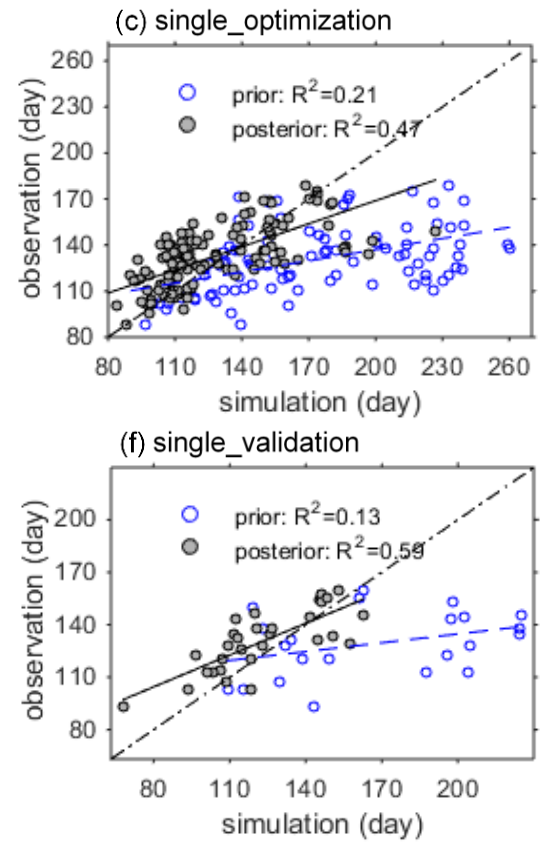
Single Rice



The blue-circled sites are not used in the optimization of parameters, but only used as validation to the optimized parameters

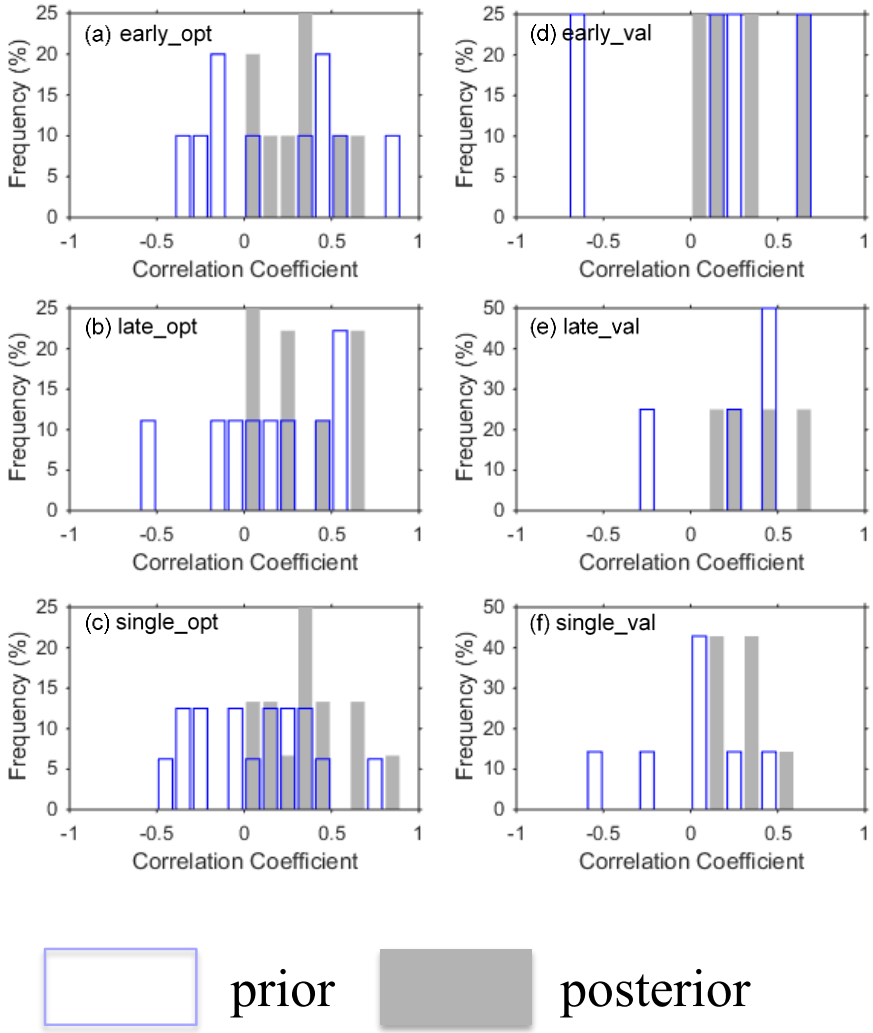
Step 2: on rice phenology (2)

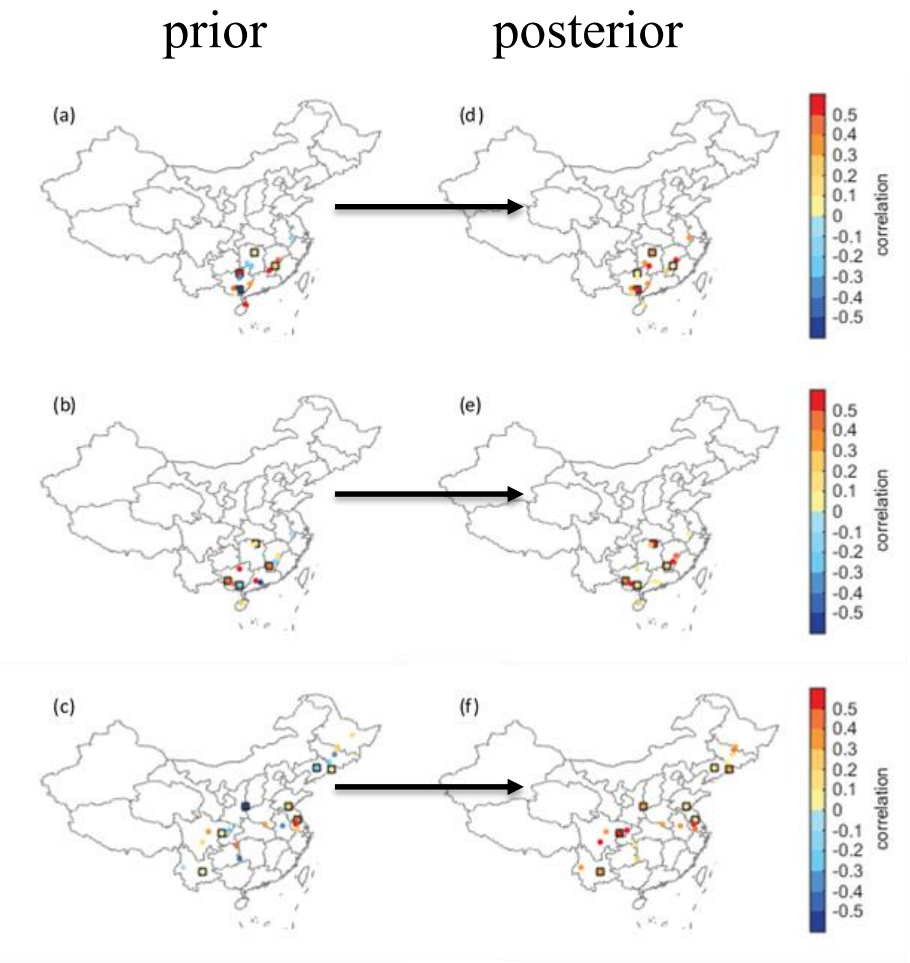




prior posterior

Step 3: on rice yield variability





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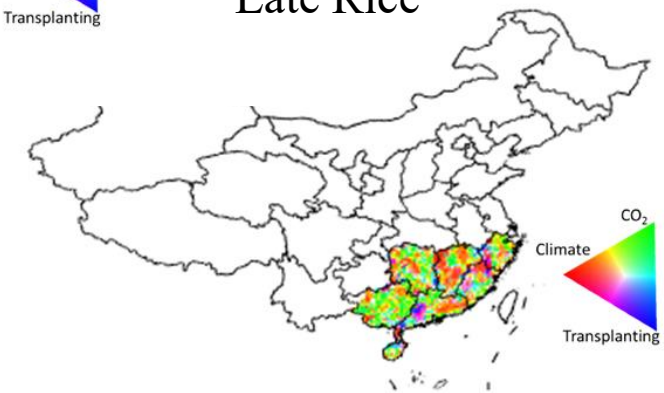
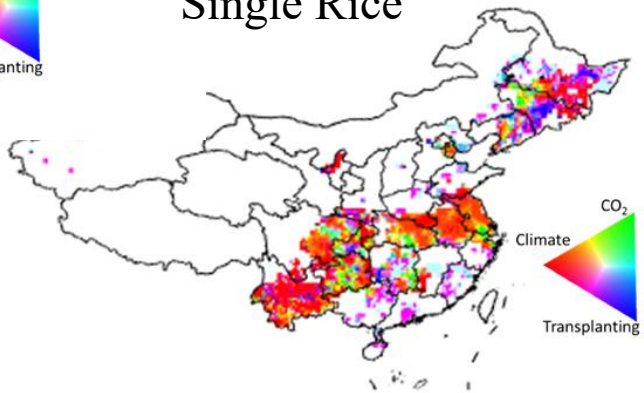
Historical attribution (1)

Early Rice

Late Rice



Single Rice



Projected yield change (1)

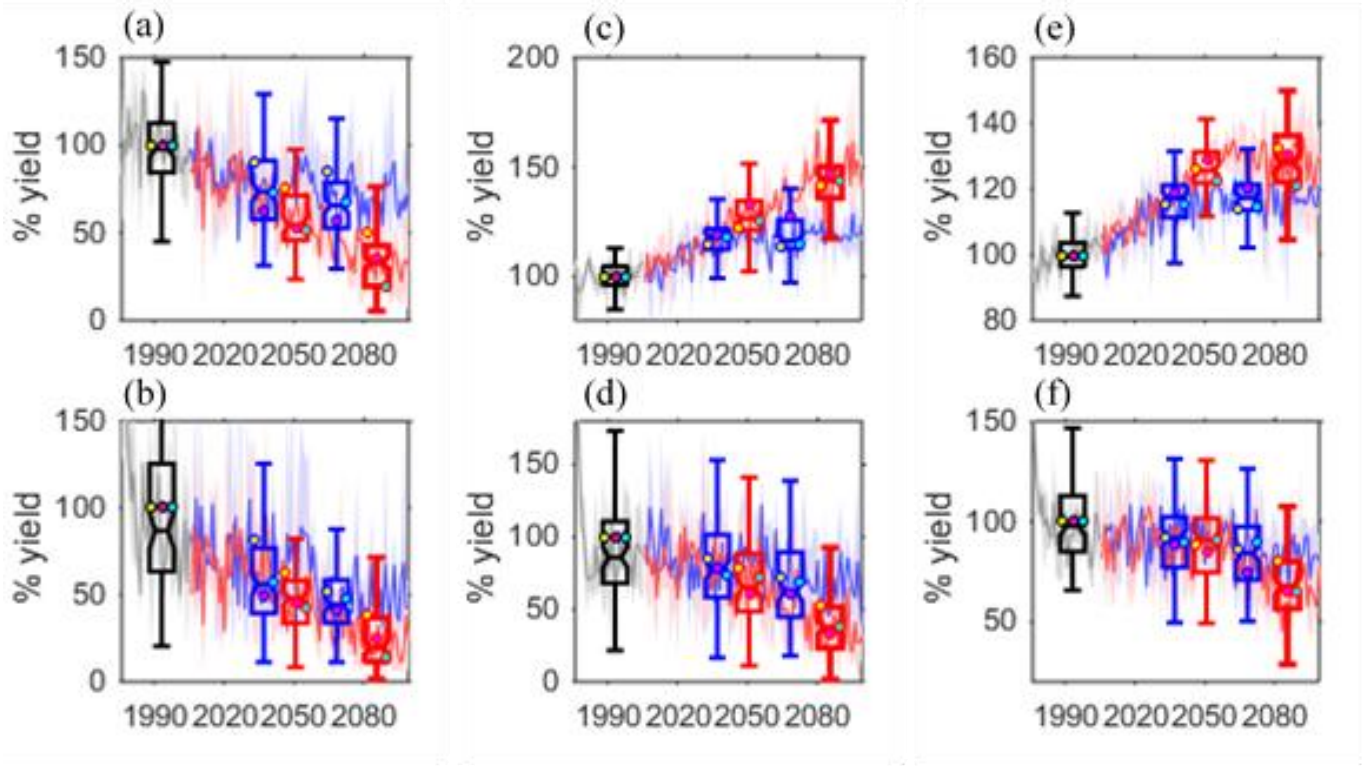
RCP8.5

RCP2.6

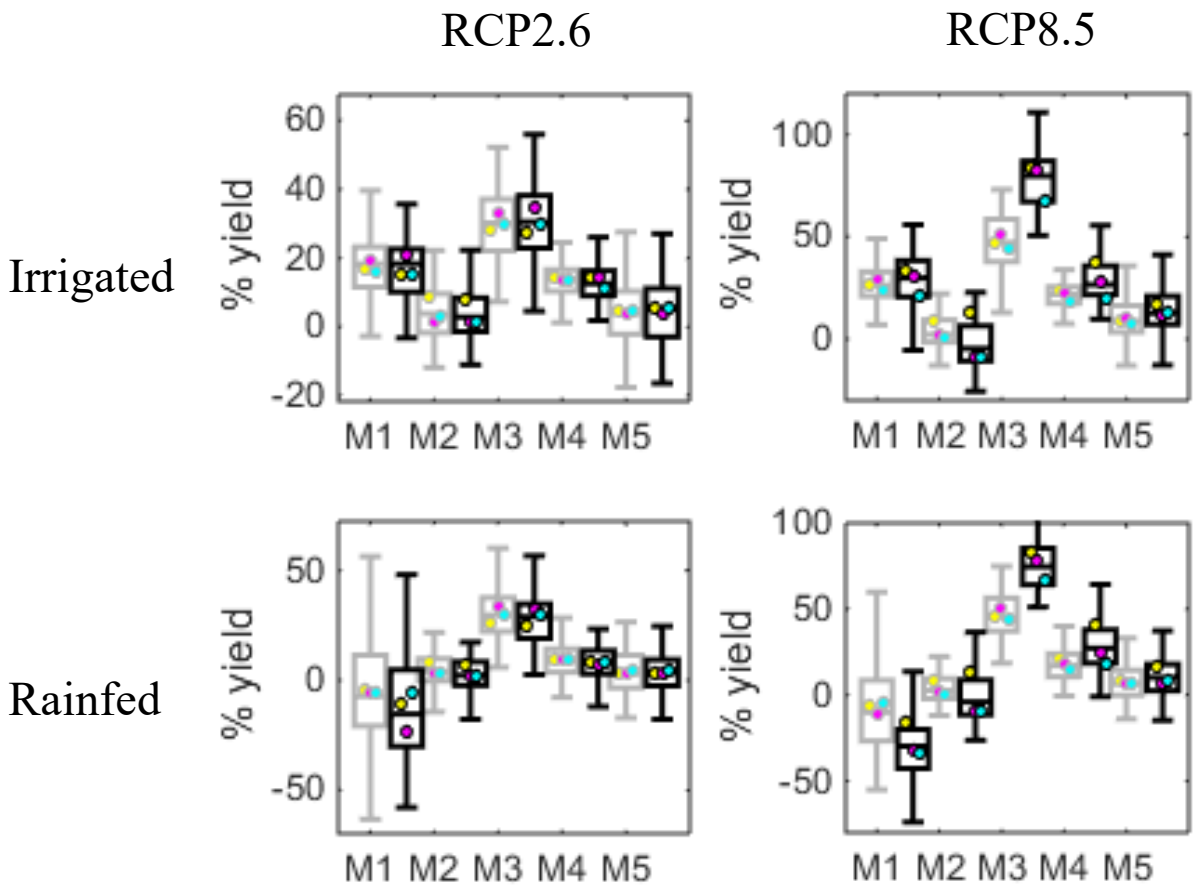
Early Rice | Late Rice | Single Rice

Irrigated

Rainfed



Projected yield change (2)

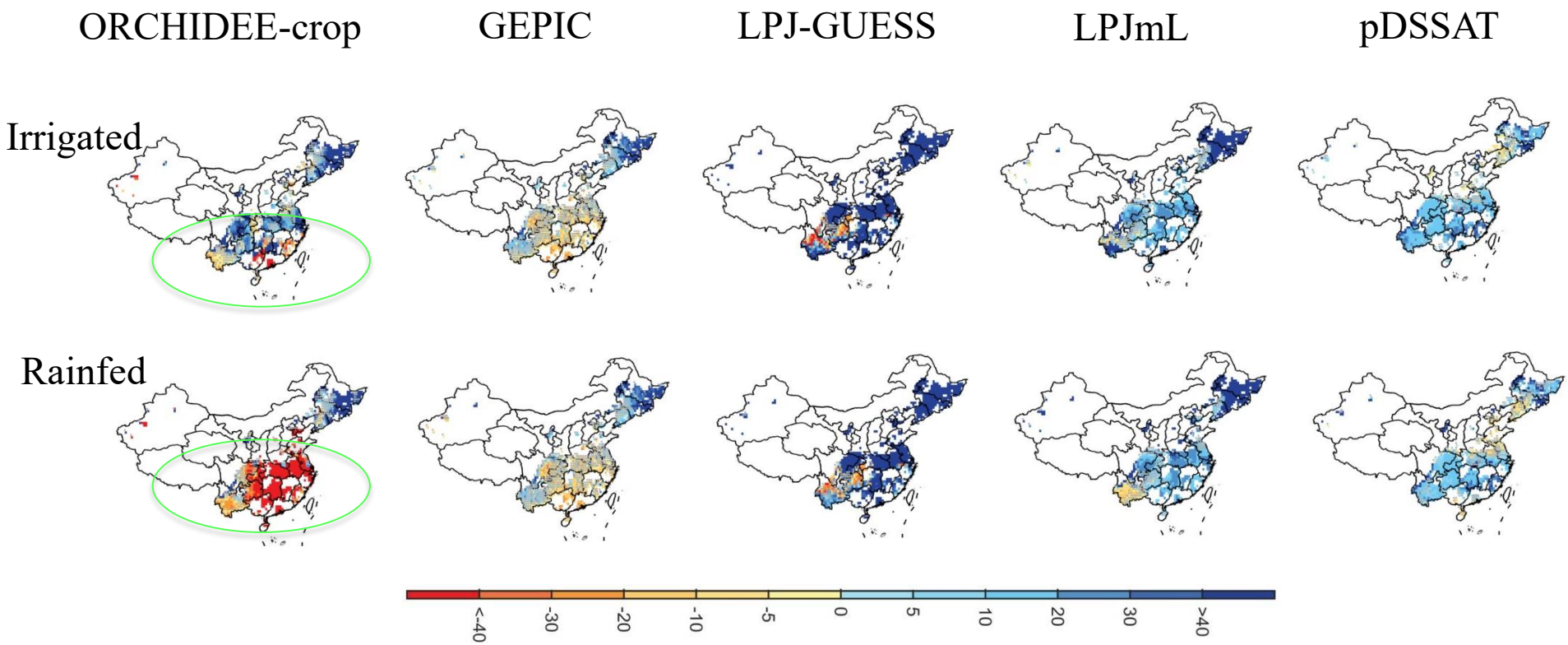


2050s (2036-2065)

2080s (2066-2095)

M1: ORCHIDEE-crop
M2: GEPIC
M3: LPJ-GUESS
M4: LPJmL
M5: pDSSAT

Projected yield change (3)



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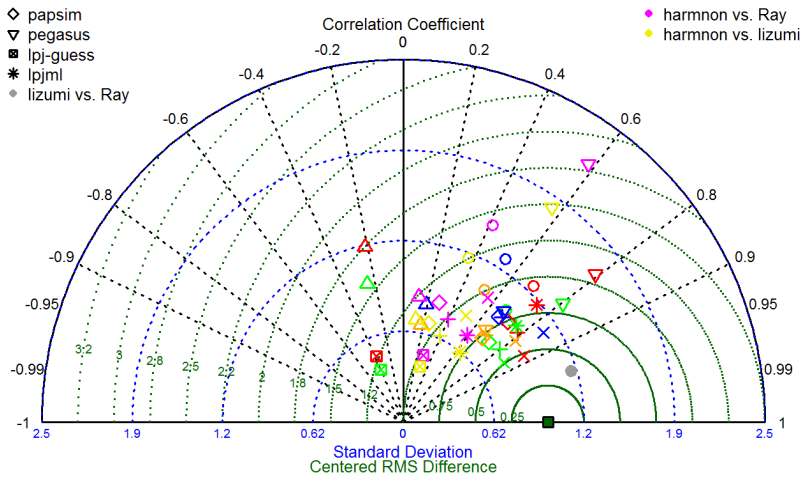
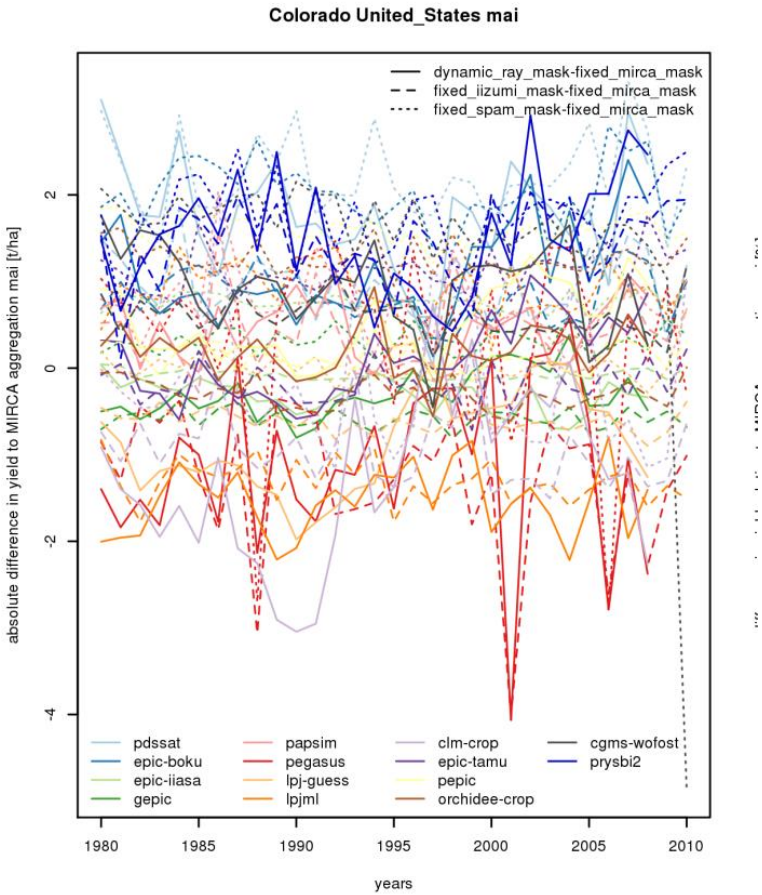
Global Gridded Crop Model Intercomparison

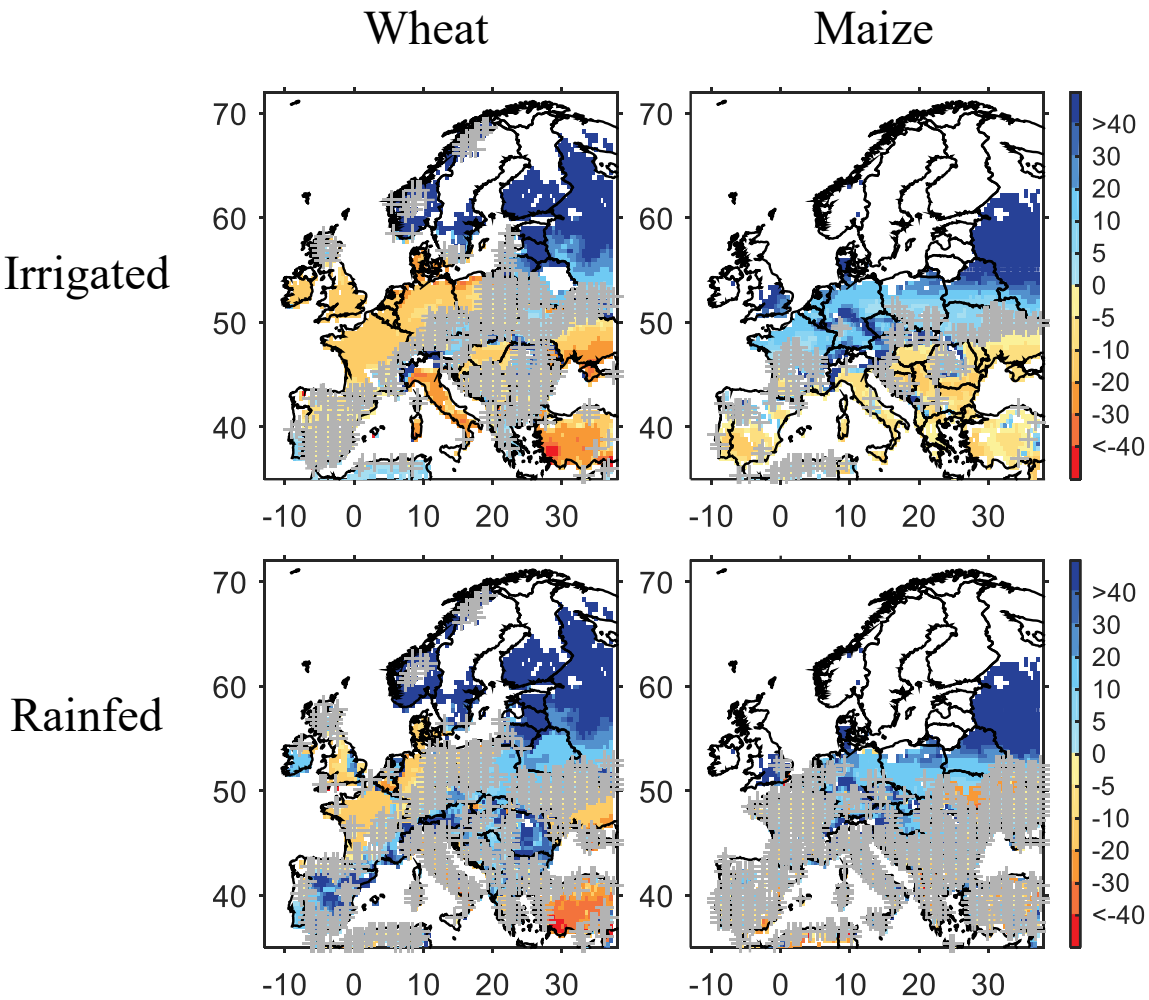


Model evaluations (Muller et al., in preparation)



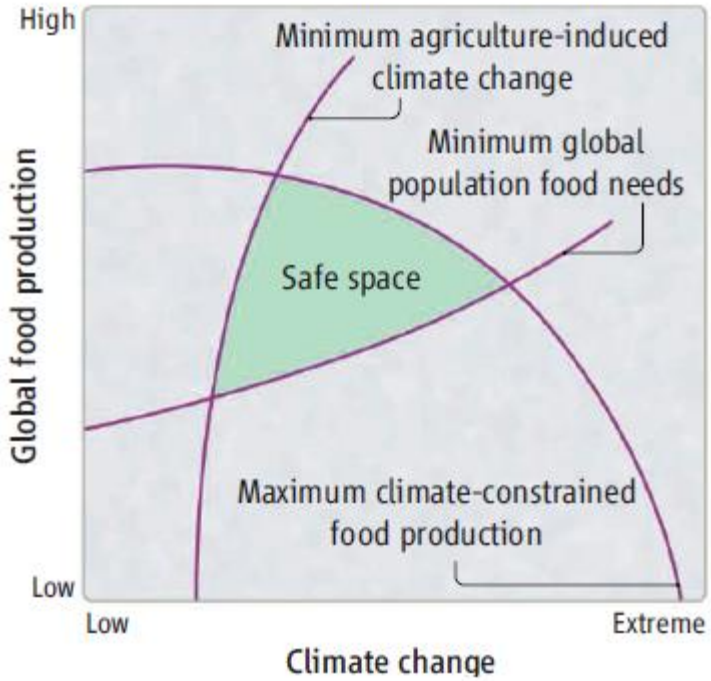
Porwollik et al EJA submitted

Impact of climate change on European cropland



- The impact of 4K warmer climate on European croplands (HELIX)
- The impact of 2K warmer climate on European croplands (IMPACT2C)

Ways ahead



A schematic of an integrated conceptual framework for the scientific community to define and test limits, thresholds, and dynamics that affect food security in the face of climate change. Modified from (*14*).

- Biophysical impact on the climate system
- Interaction with land use change
- Linkage with global agro-economic models

Beddington et al., 2012 *Science*

Thanks for your attention ☺