JULES-crop

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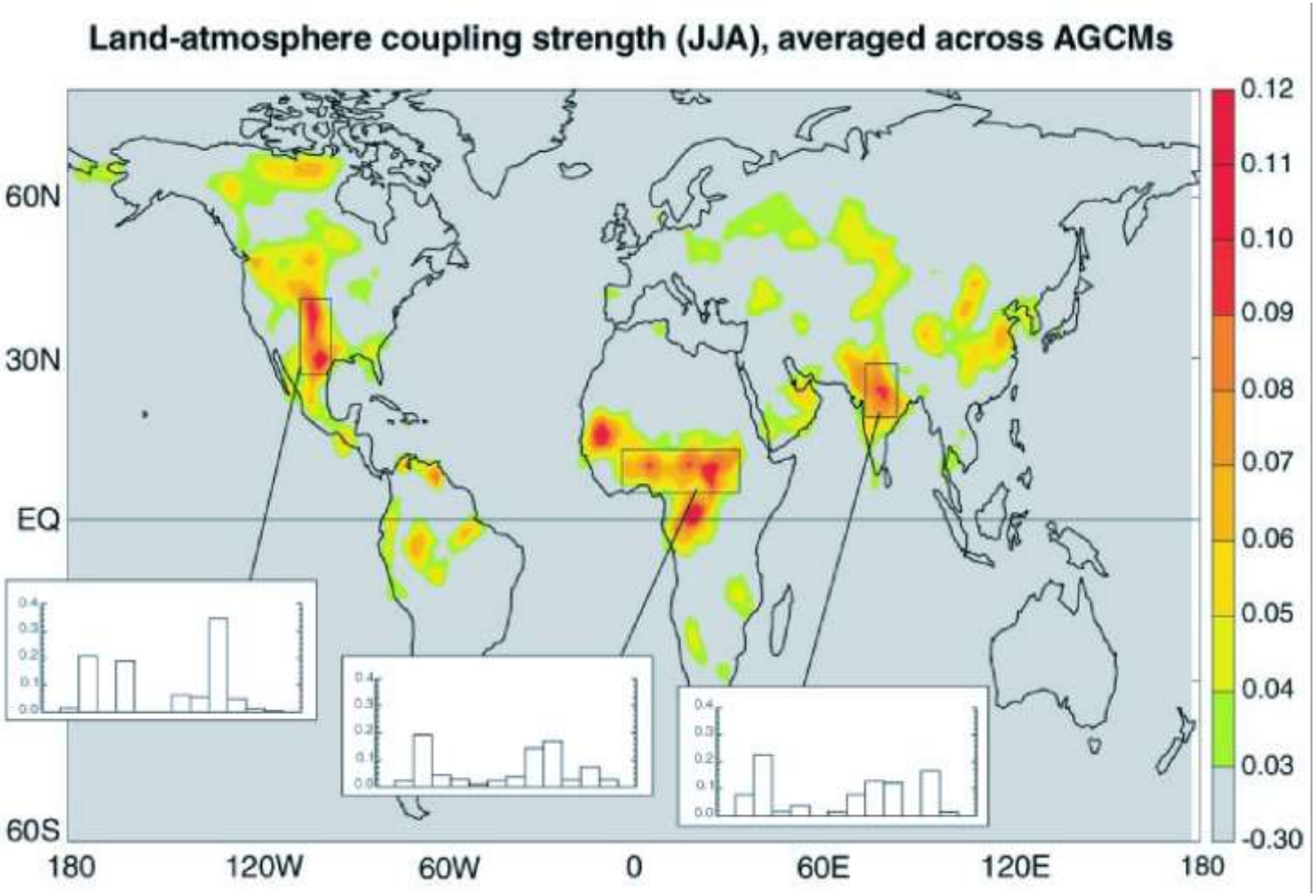
Why?

Not *another* crop model. What's new?

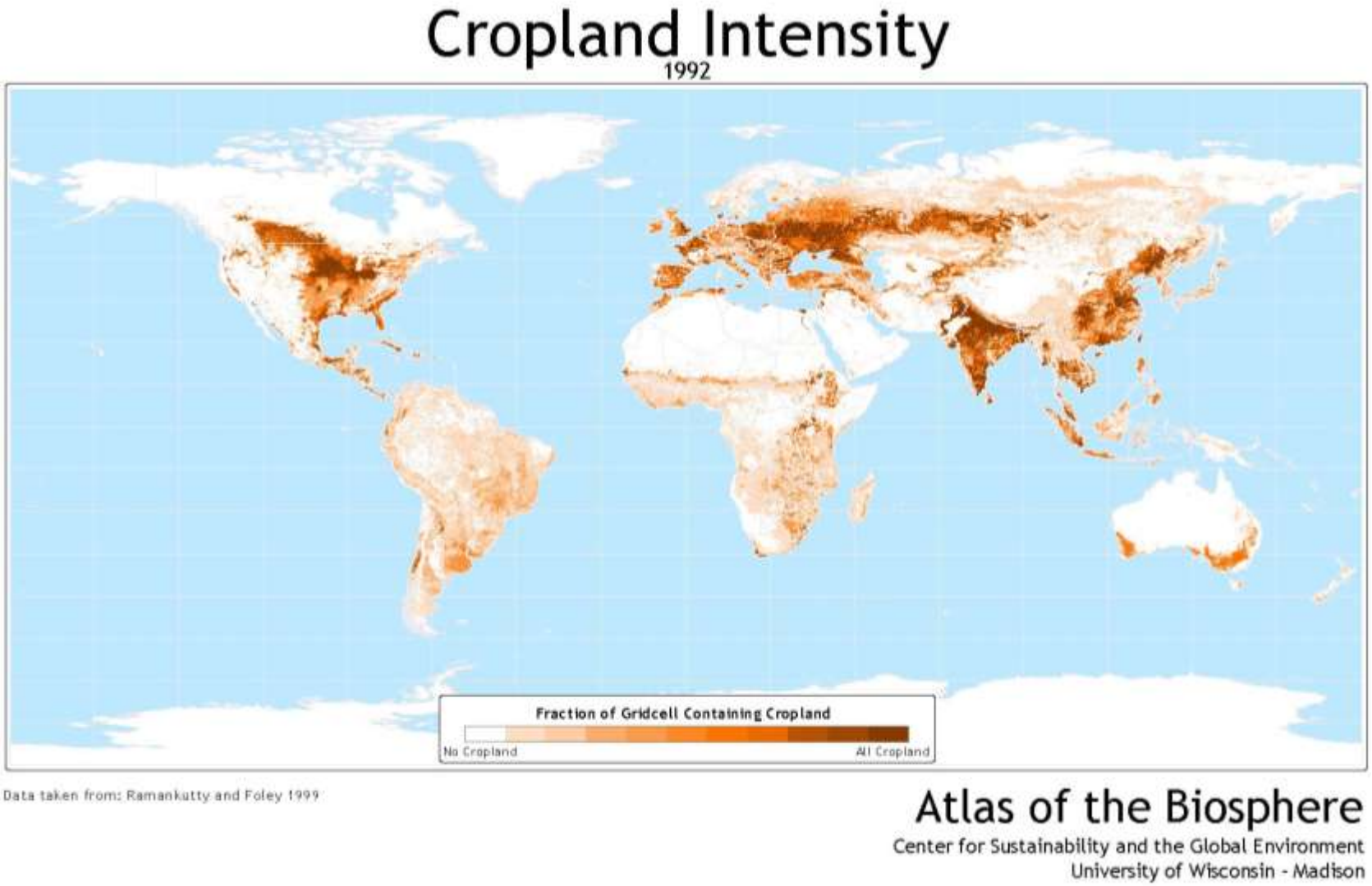
- Coupled to atmosphere
  - Improve simulation of land surface for climate model
  - Fully coupled impact assessment
- Global application
- Biophysical consistency with other land-surface processes

Land surface can affect climate.



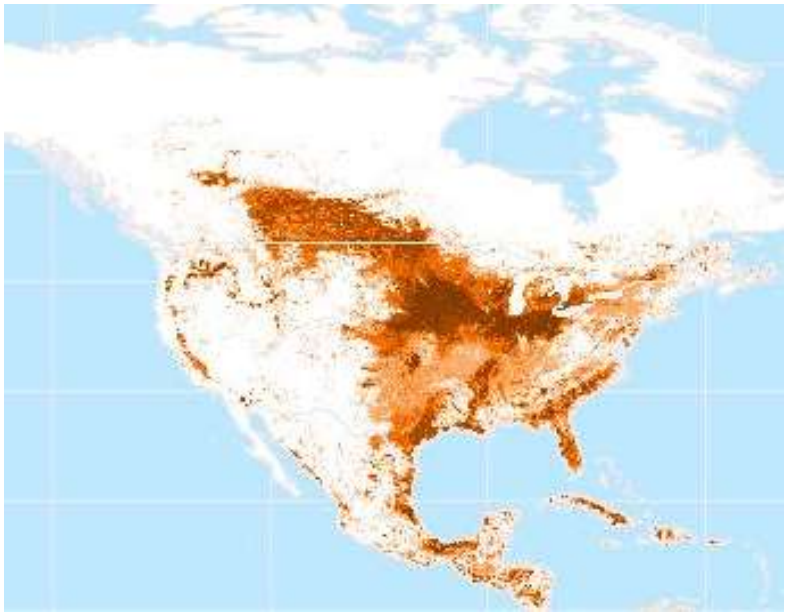
Koster *et al* (2004)

Crops now a significant component of land surface



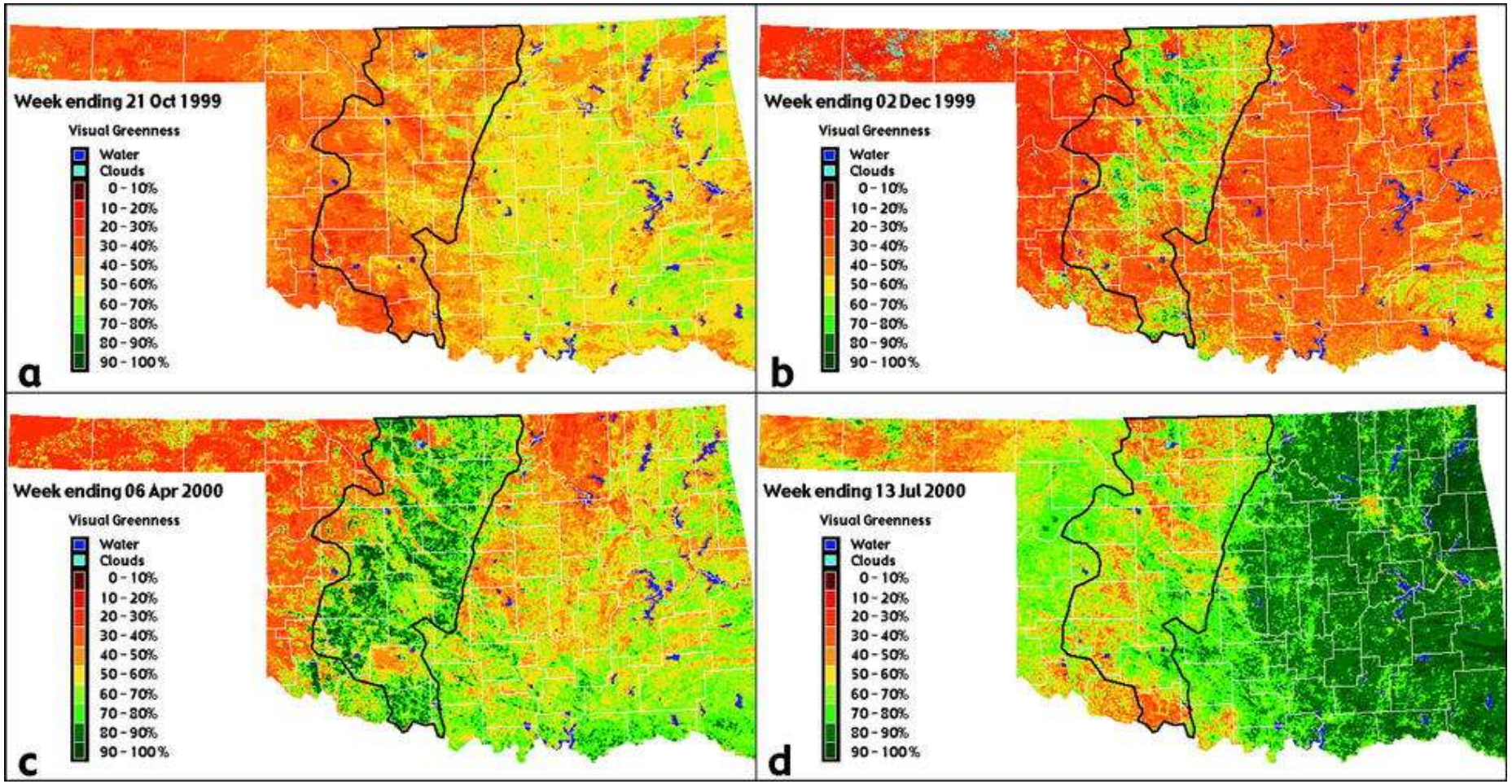
Ramankutty and Foley (1999)

Especially so in particular regions



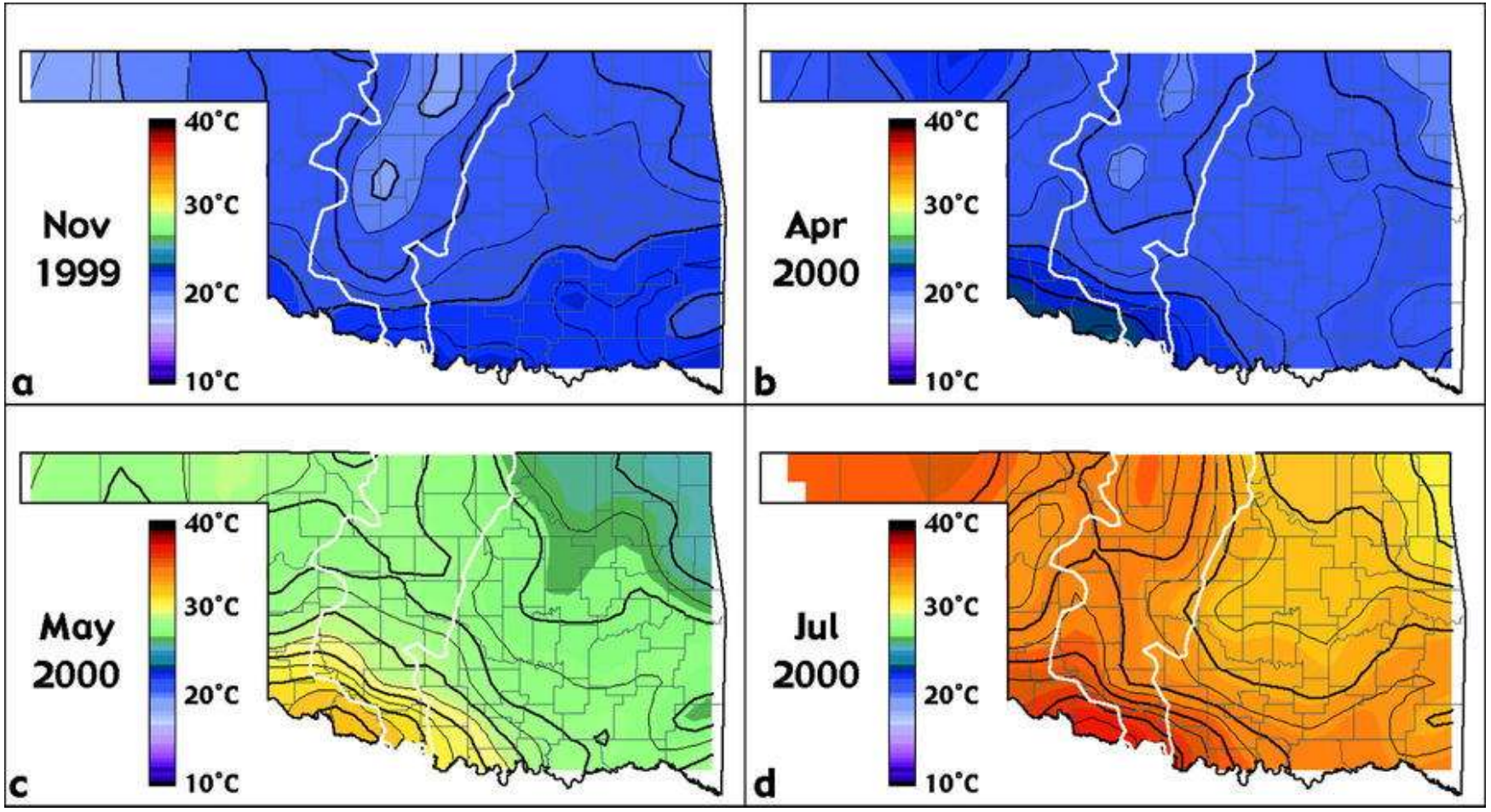
Ramankutty and Foley (1999)

Crops differ to “natural” vegetation …



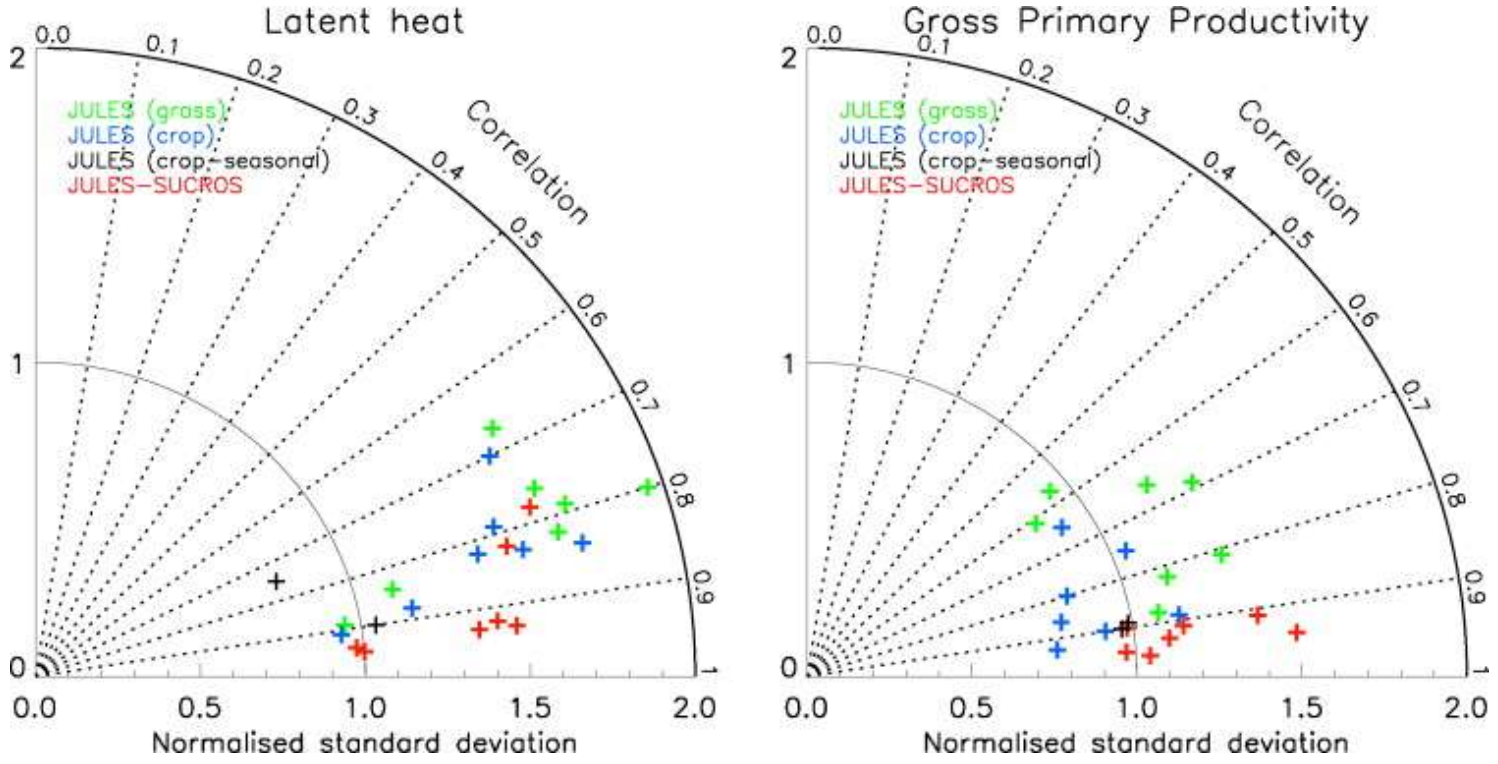
McPherson *et al.* (2004)

… leading to differences in near-surface climate (e.g. max daily air temperature)



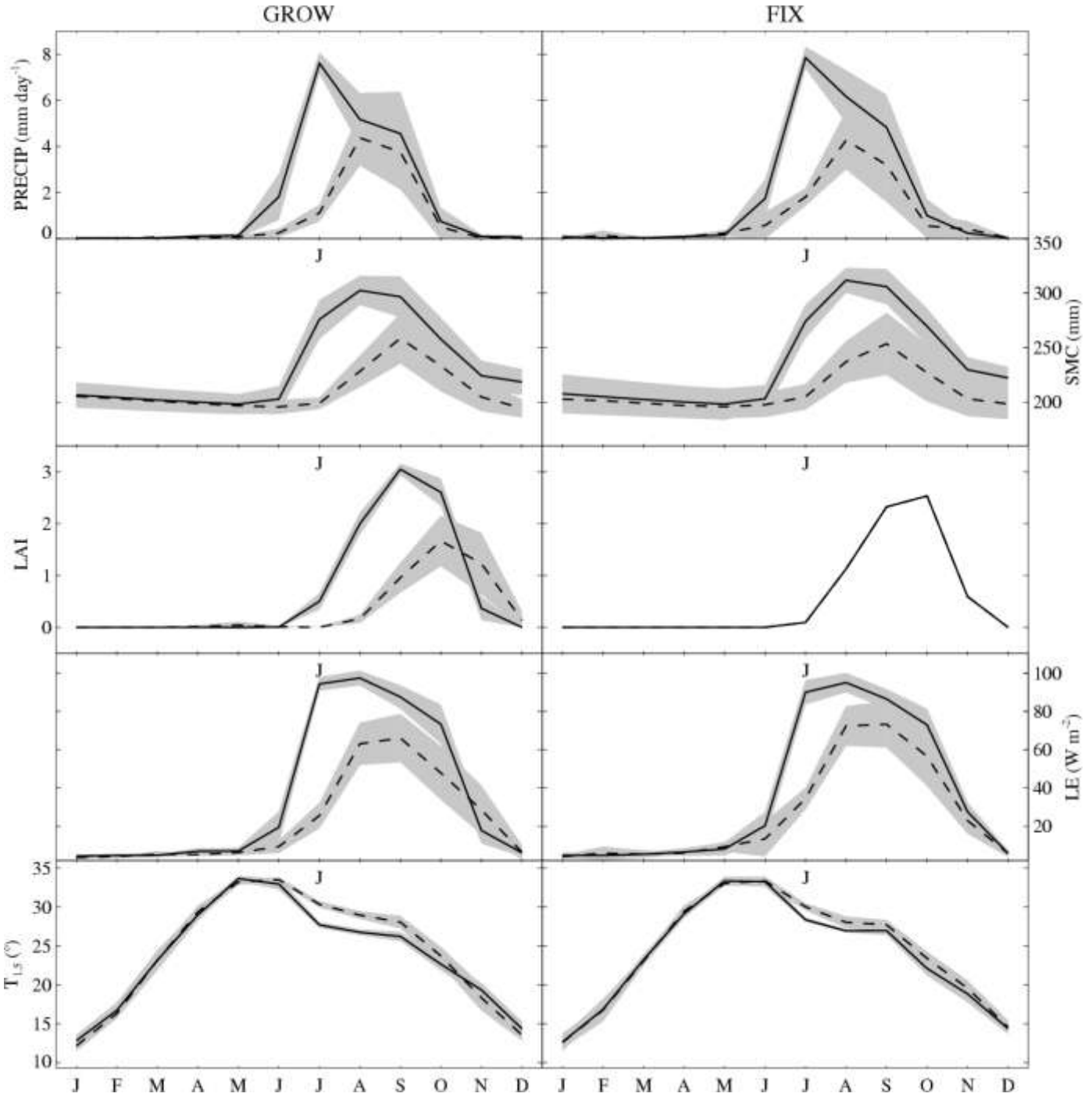
McPherson *et al.* (2004)

Including explicit crop parameterisation improves simulation of land-surface fluxes



JULES-sucros: van den Hoof et al (2011) *Agr. For. Meteor.*

Growing crops in a climate model can feedback on to simulated climate variability.



NW India

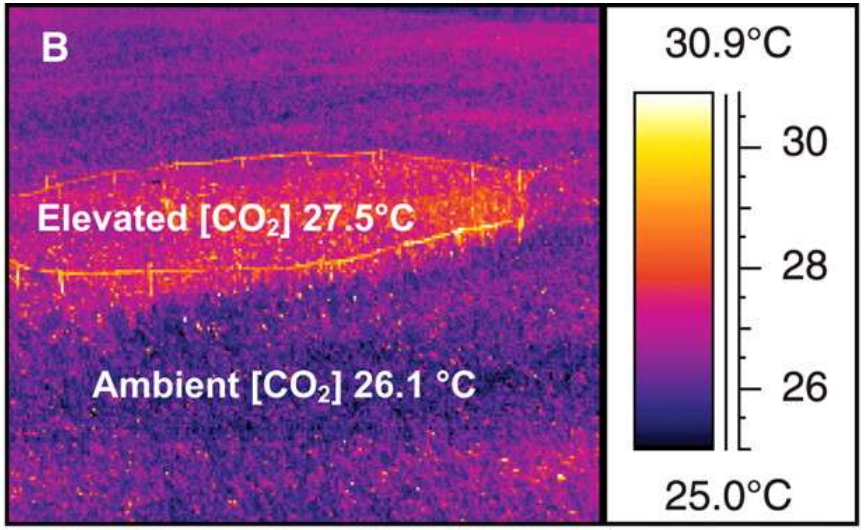
Wet

Dry

CI (5,95)

Osborne *et al* (2009)

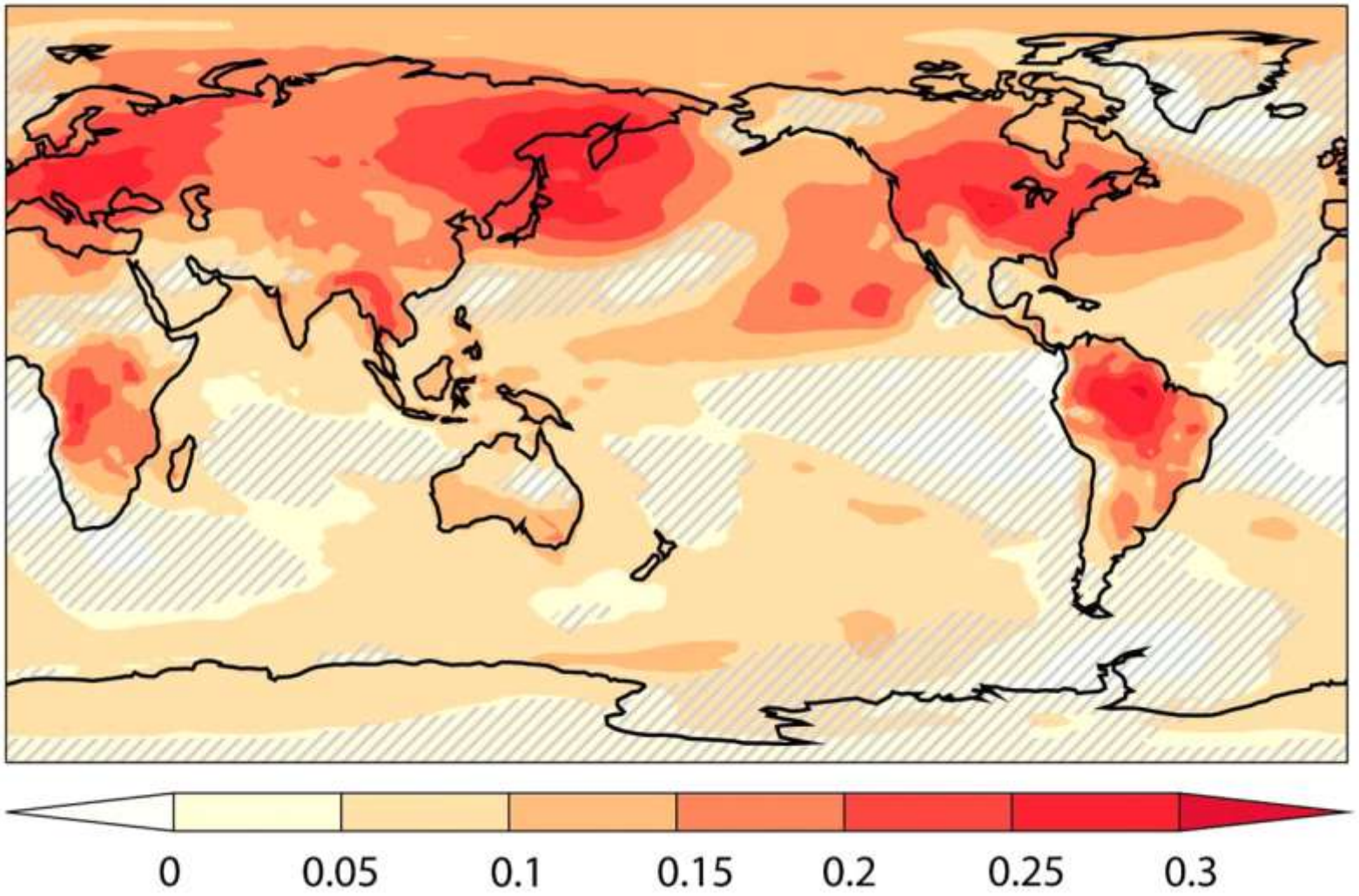
Response of vegetation to environment can affect climate.



FACE: Free Air CO_2 enrichment

Long *et al* (2006)

Fraction of total surface warming (warming caused by the combined CO2-radiative and physiological effects) associated with the physiological forcing of CO2.



Cao L et al. PNAS 2010;107:9513-9518

Development of JULES-crop

Aims:

1) Improved representation of land surface in cropped regions.
2) Physically consistent prediction of crop yields under variable environmental conditions.

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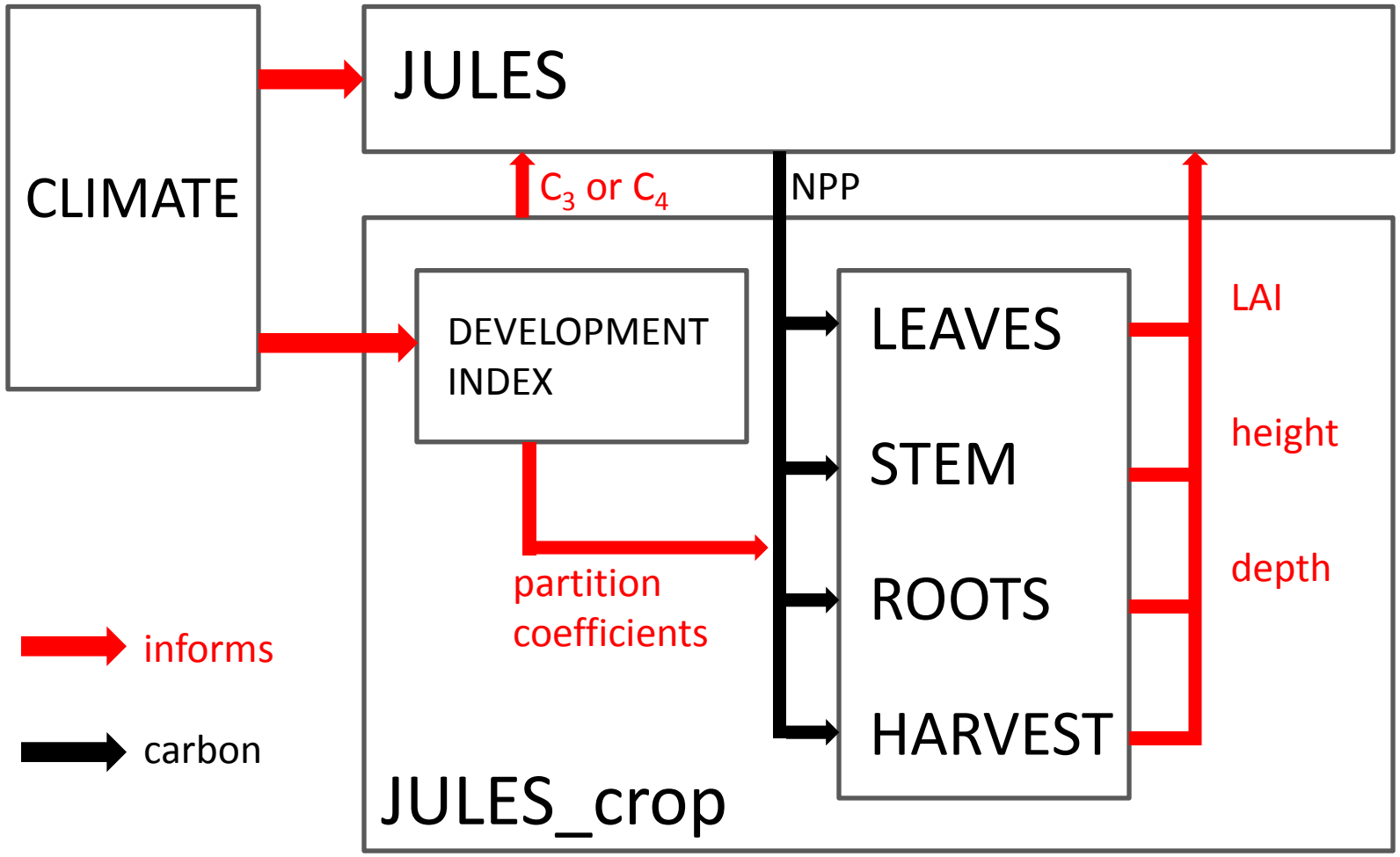
Challenges:

1) Representing the wide variety (175, Monfreda *et al*) of crops
   – Crop Functional Types.
2) Generic parameterisation suitable for all crop types.
3) Parameterisation of management (non-climatic influences)

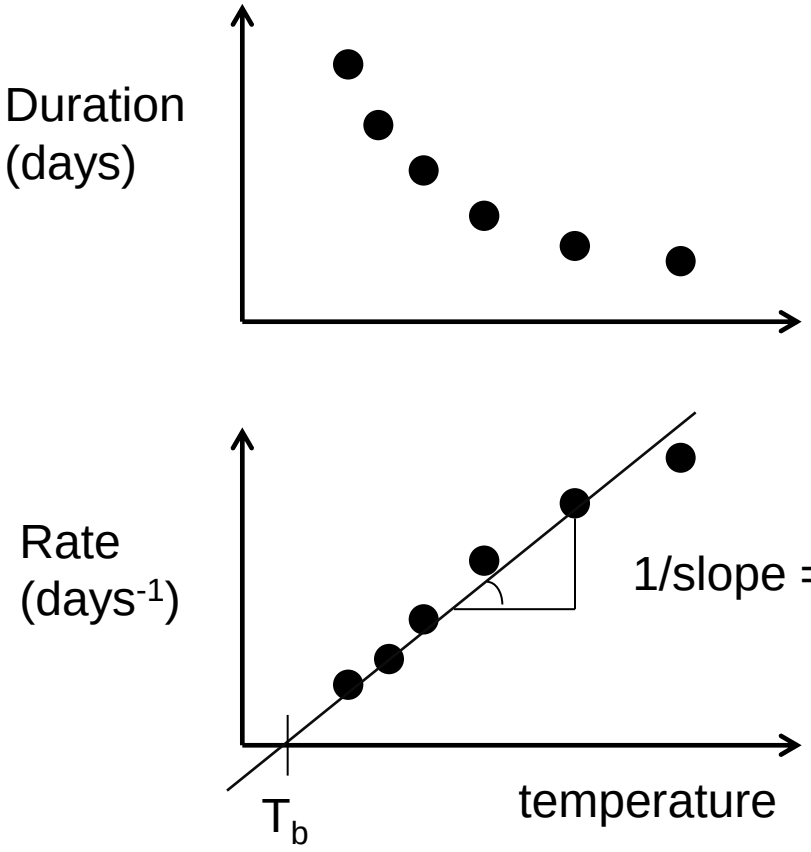
Crop Functional Types

PHOTO SYNTHESIS	PHOTO SENSITIVITY	C / L / O	OTHER	CFT	EXAMPLE
C_3	LONG DAY SENSITIVE	CEREAL	----------	1	WHEAT, BARLEY, RYE, OAT
		LEGUME	OILSEED	2	GROUNDNUT
			NOT	3	LENTIL, CHICKPEA, DRYBEAN
		OTHER	ROOT / TUBER	4	POTATO, SUGARBEET
			NOT	5	RAPE
	SHORT DAY SENSITIVE	CEREAL	----------	6	RICE
		LEGUME	----------	7	SOYBEAN
		OTHER	ROOT / TUBER	8	CASSAVA, SWEET POTATO
			NOT	9	COTTON
C_4	----------	CEREAL	SMALL GRAIN	10	SORGHUM, MILLET
			LARGE GRAIN	11	MAIZE
		OTHER	----------	12	SUGARCANE

Generic parameterisation



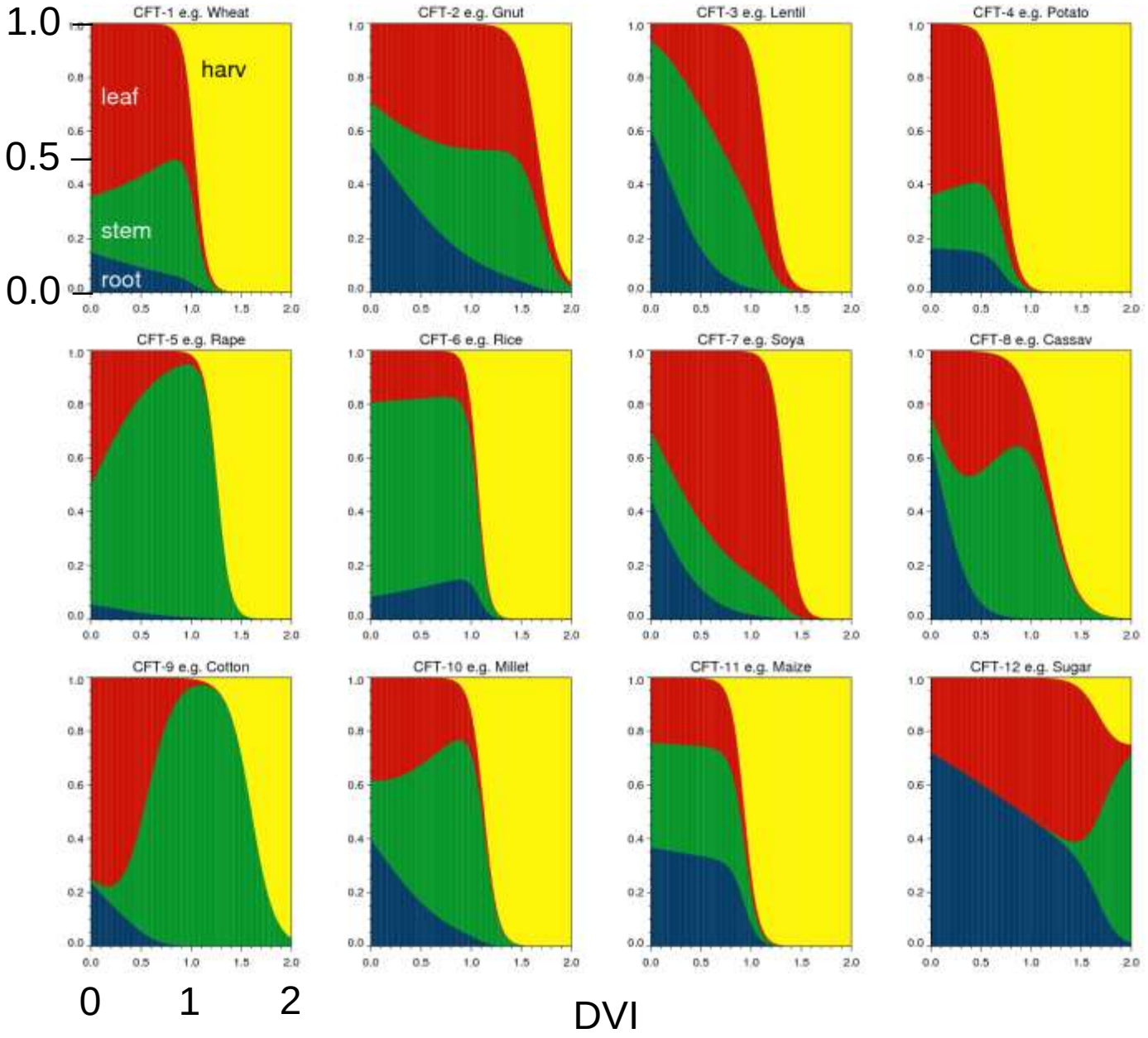
Development Index (DVI)



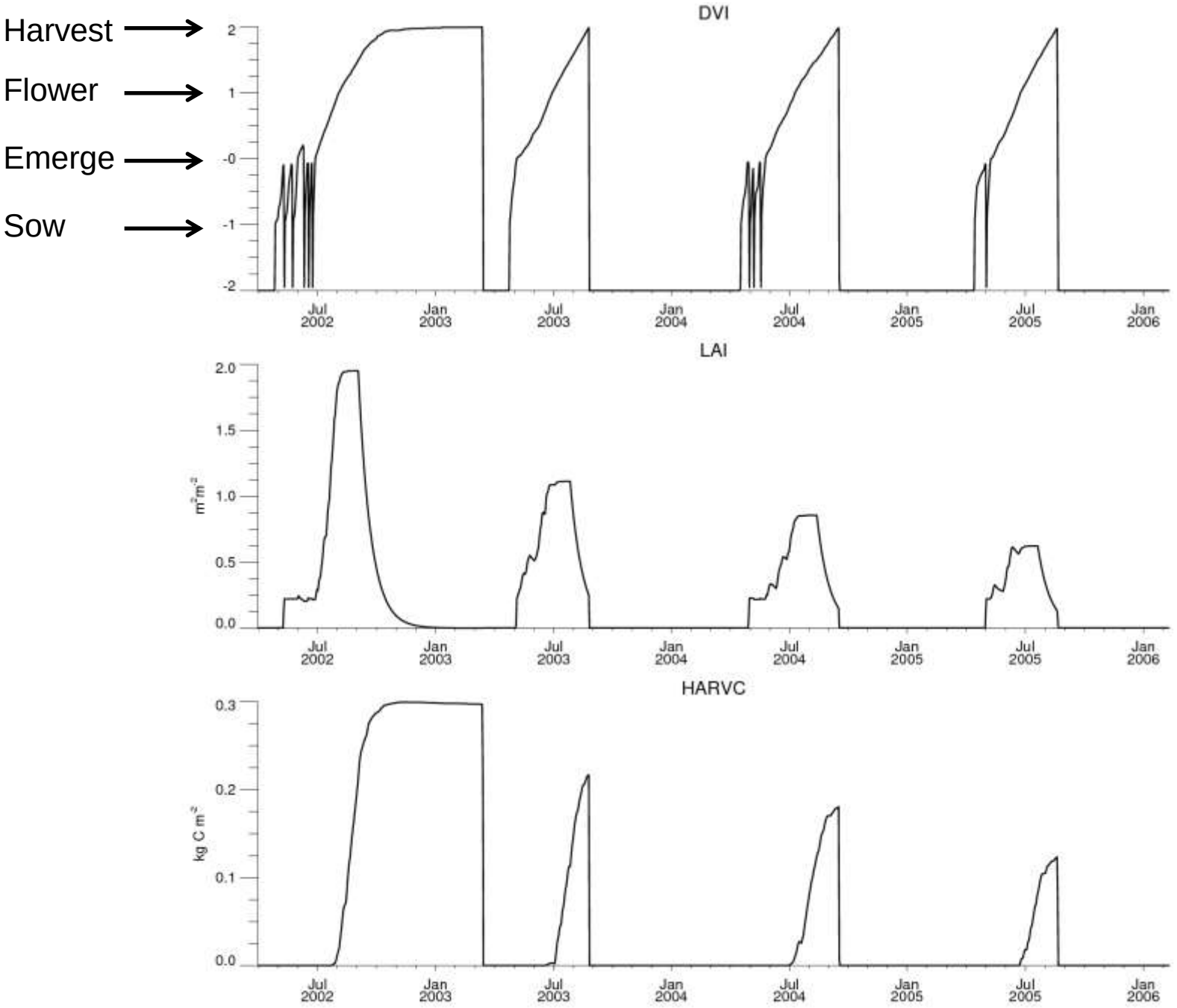
Stage	DVI
Sowing to emergence	-1 - 0
Emergence to flowering	0 - 1
Flowering to maturity	1 - 2

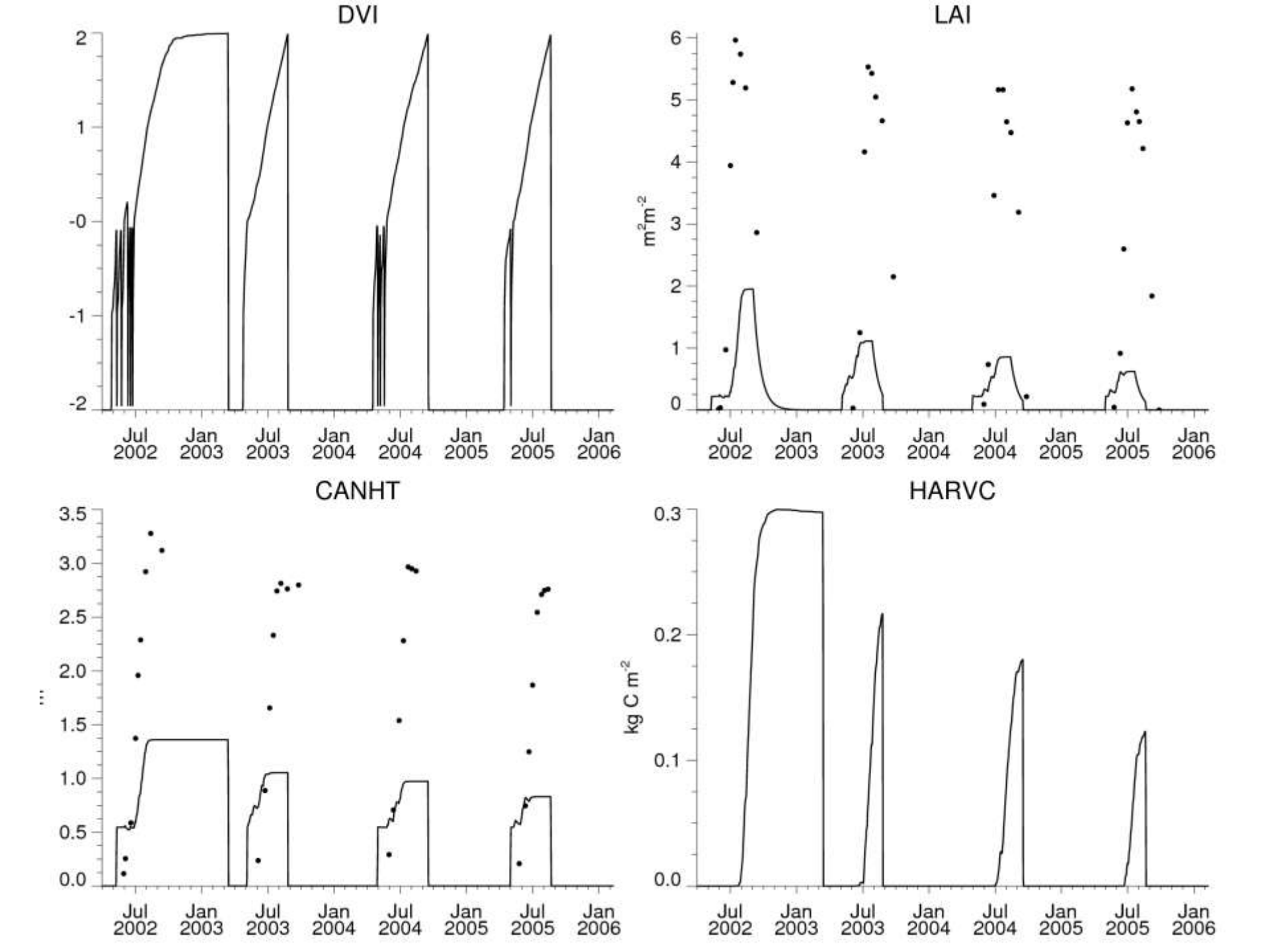
But, complicated by daylength, vernalisation, high temperatures

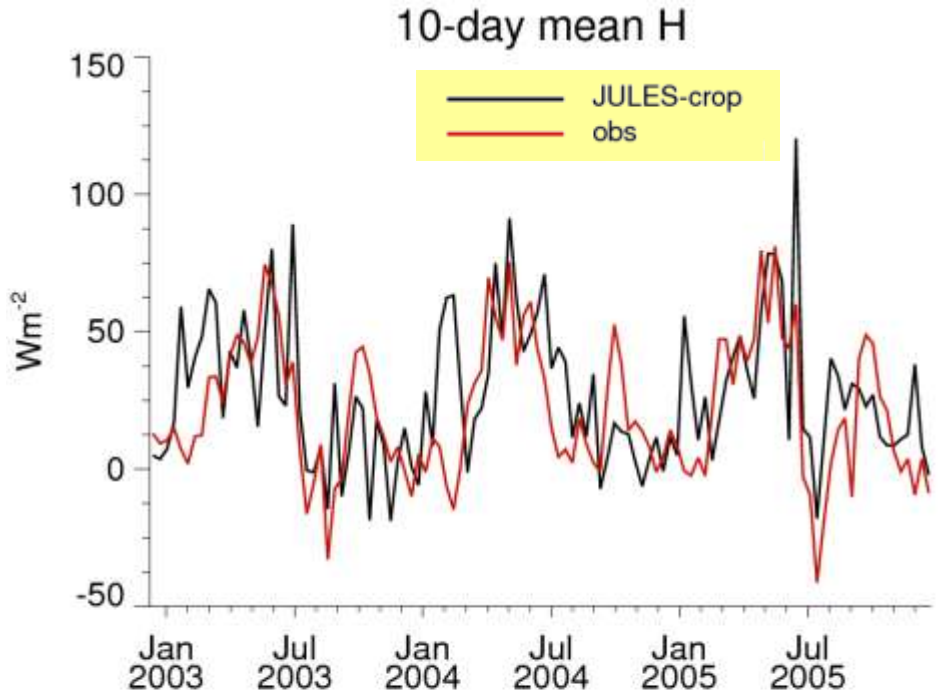
Partitioning of NPP

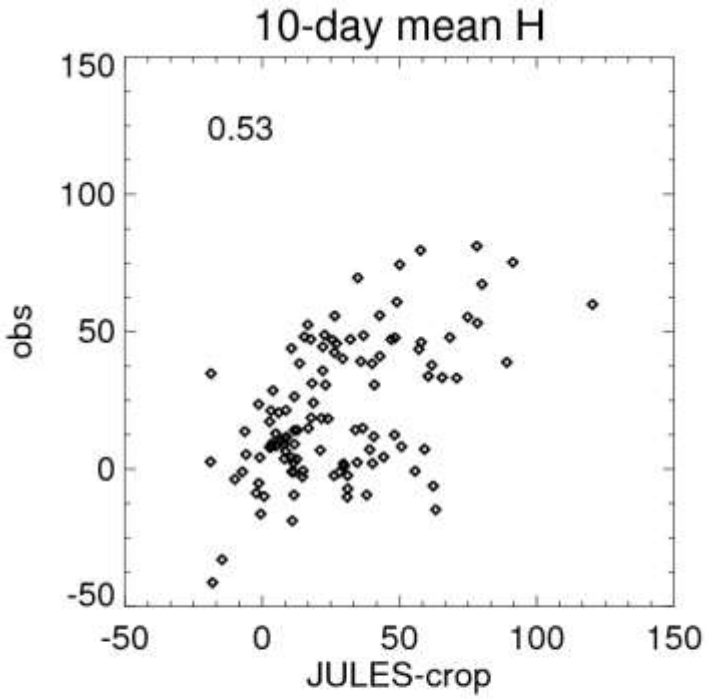


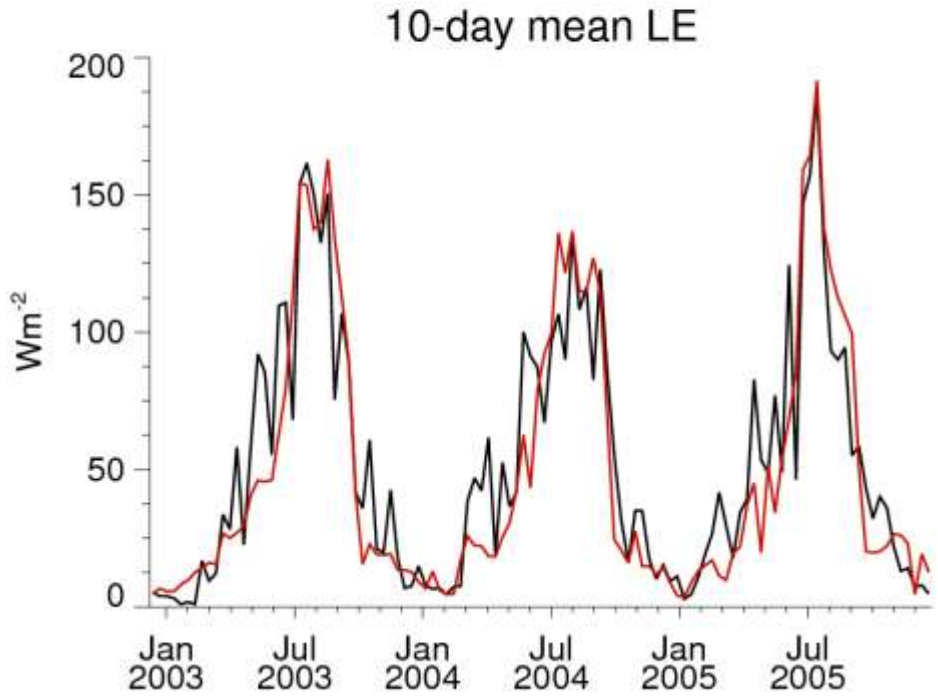
Site evaluation: Mead, NE

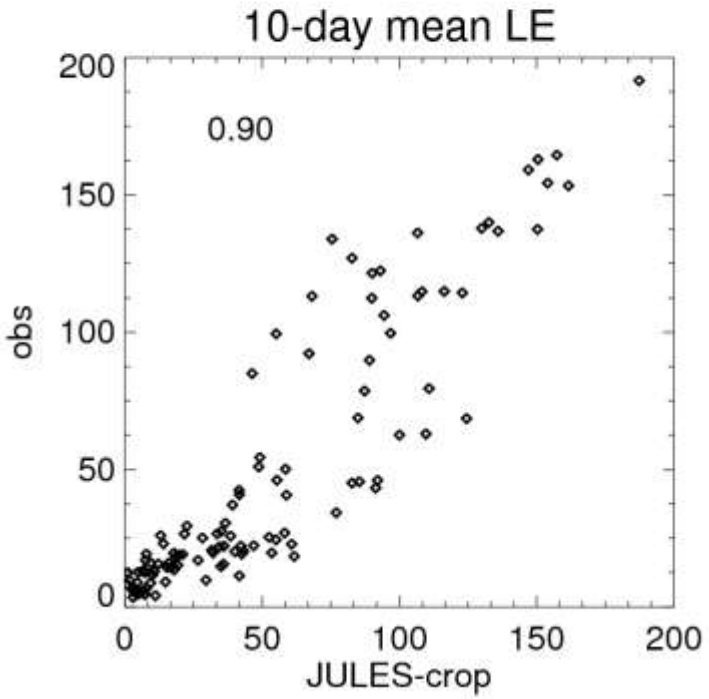

Harvest
Flower
Emerge
Sow
DVI
2
1
-0
-1
-2
Jul 2002
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Jan 2005
Jul 2005
Jan 2006
LAI
2.0
1.5
1.0
0.5
0.0
m²m⁻²
HARVC
0.3
0.2
0.1
0.0
kg C m⁻²

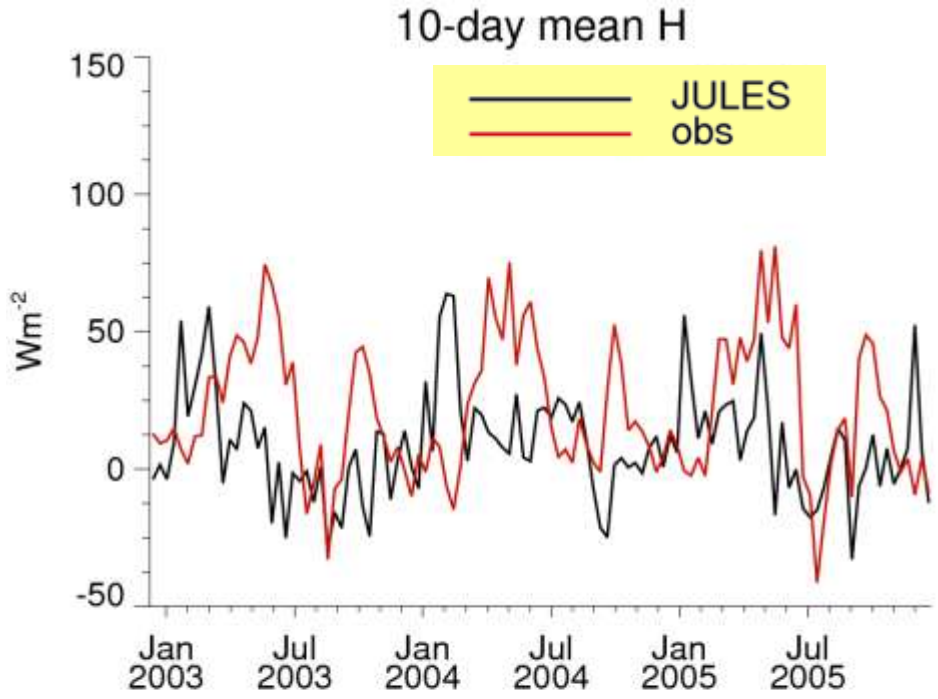

DVI
LAI
CANHT
HARVC
m²m⁻²
kg C m⁻²
Jul 2002
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Jan 2005
Jul 2005
Jan 2006

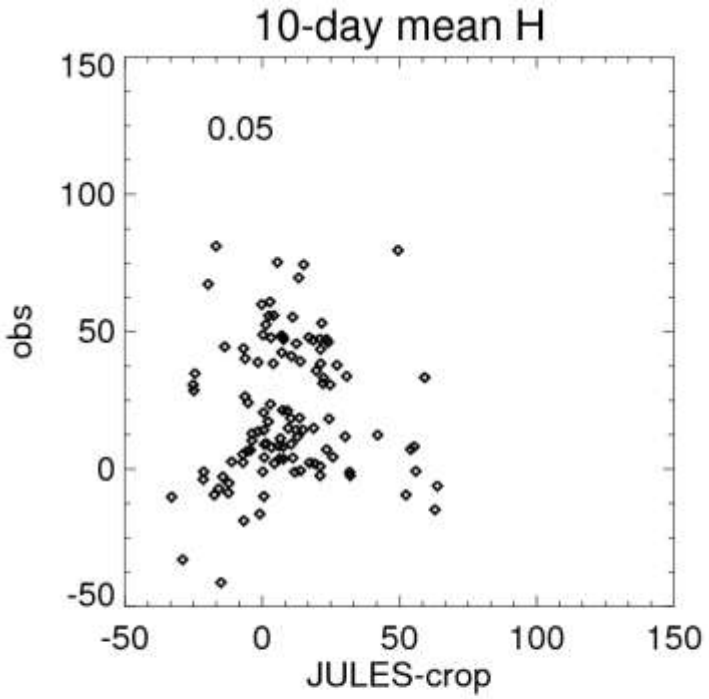

10-day mean H
JULES-crop
obs
Wm-2
150
100
50
0
-50
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Jan 2005
Jul 2005

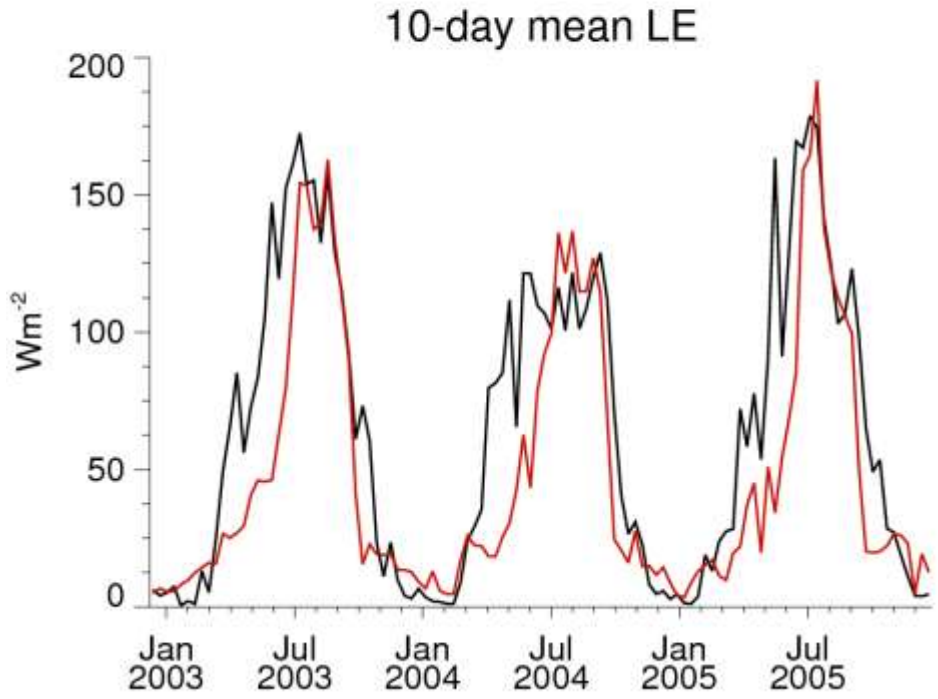

10-day mean H
0.53
obs
JULES-crop
150
100
50
0
-50
-50
0
50
100
150

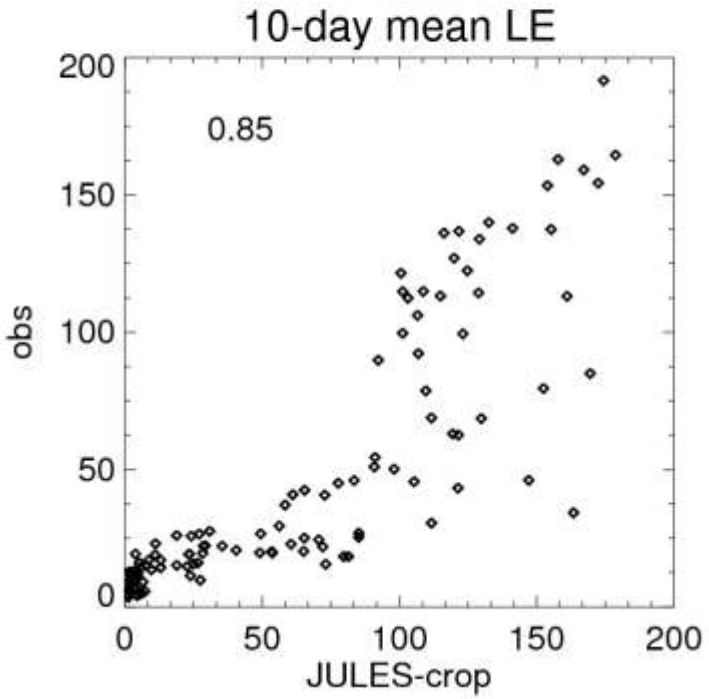

10-day mean LE
Wm-2
200
150
100
50
0
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Jan 2005
Jul 2005


10-day mean LE
0.90
obs
JULES-crop
200
150
100
50
0
0
50
100
150
200

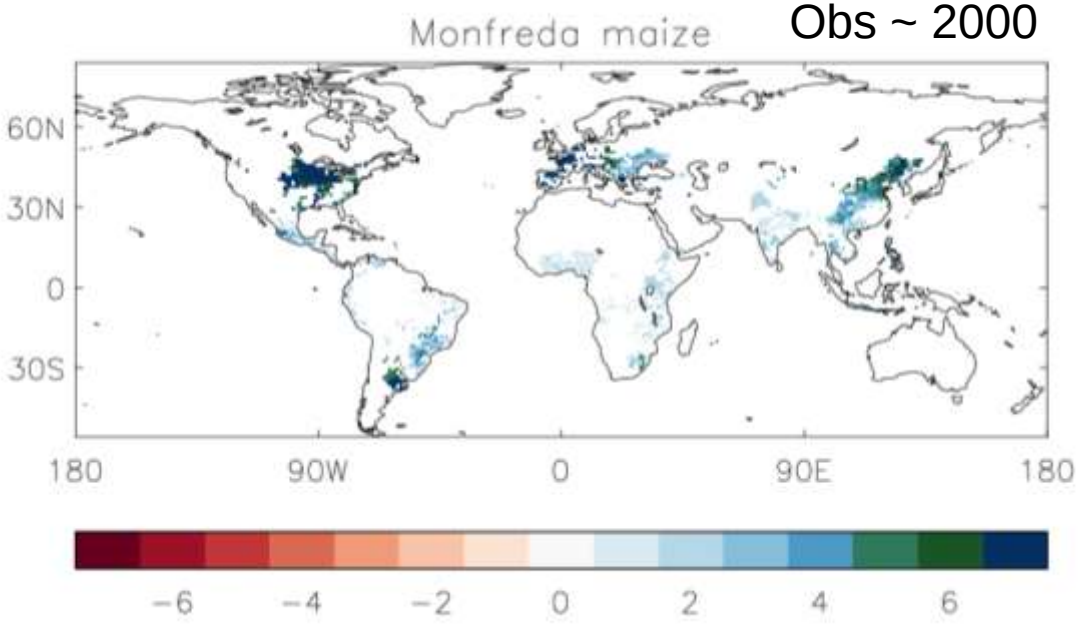

10-day mean H
JULES
obs
Wm-2
150
100
50
0
-50
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Jan 2005
Jul 2005


10-day mean H
0.05
obs
JULES-crop
150
100
50
0
-50
-50
0
50
100
150

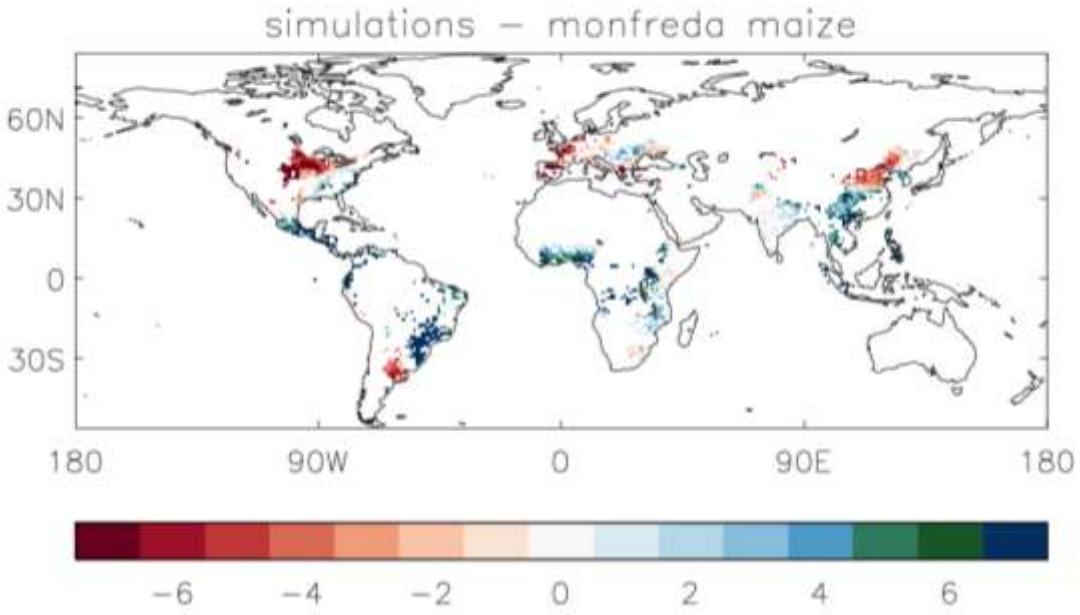

10-day mean LE
Wm-2
200
150
100
50
0
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Jan 2005
Jul 2005


10-day mean LE
0.85
obs
JULES-crop
200
150
100
50
0
0
50
100
150
200

Obs ~ 2000



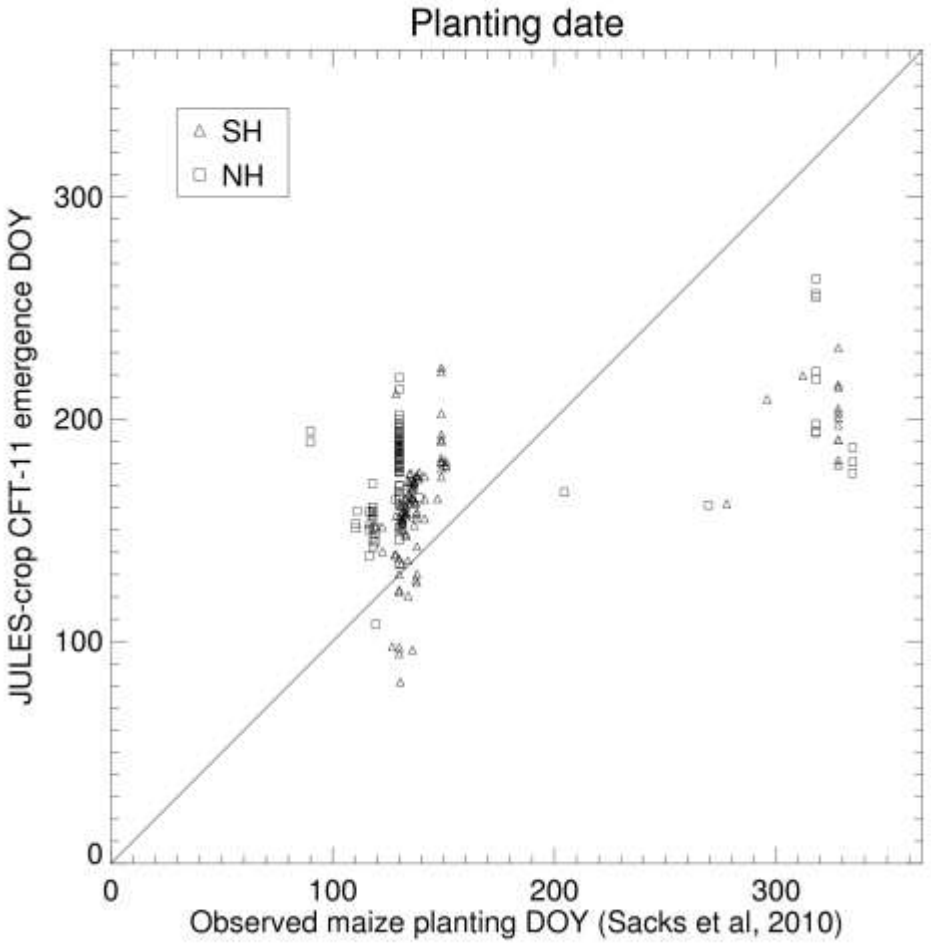
JULES-crop (GSWP) - Obs



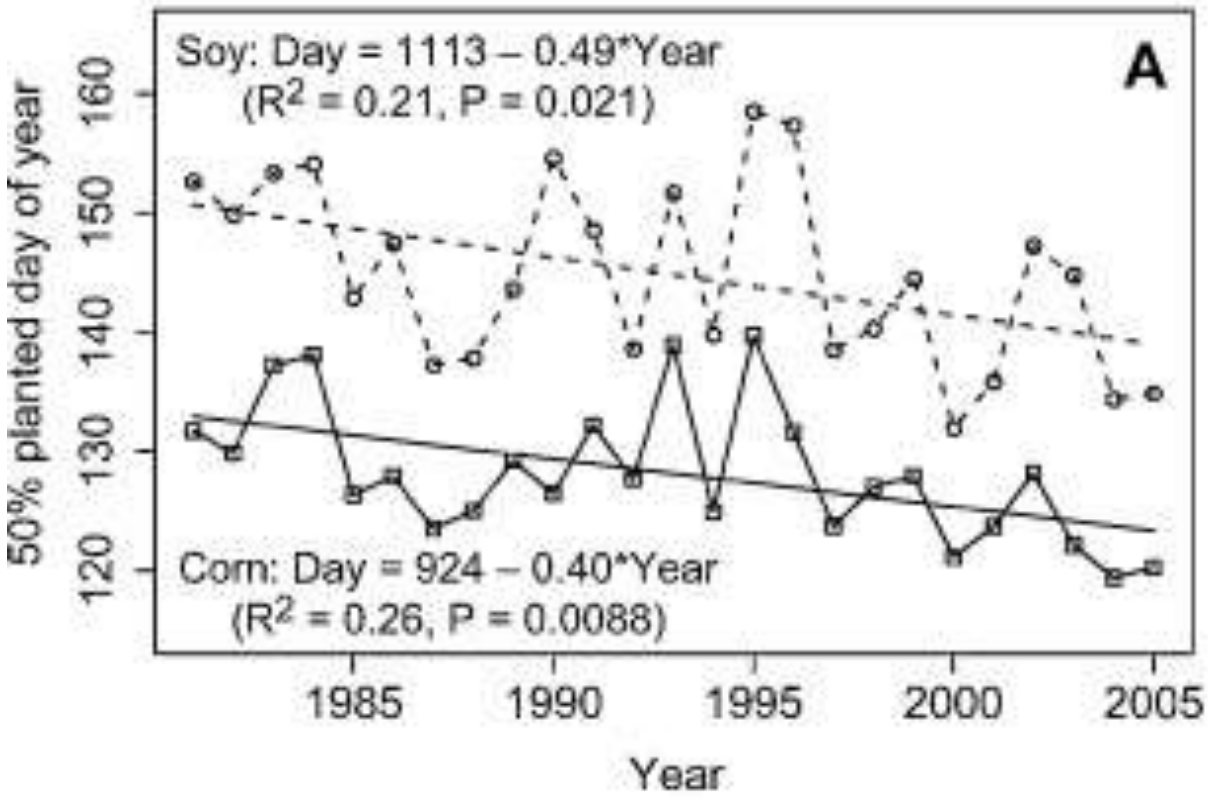
- Different time periods
- Maize varieties
- Yield Gap
- It’s a model

Evaluation of planting date

200 grid cells with largest fractional coverage in Monfreda et al dataset.



Earlier planting of crops in US: part climate, part technology



Sacks and Kucharik (2011)

- JULES-crop technically works. But:

- Does it meet its duel aims?
  - Too many CFTs for weather and climate models
  - Not crop-specific for impacts

- Still a need to properly calibrate and validate.
  - Sufficient data to do both properly and independently
  - Depends on intended use (local v global, NWP v impacts)