

Identify problems in CLM4.5 crop model at the spring wheat Maricopa FACE site



Yaqiong Lu¹, Bruce Kimball²

¹NCAR, ²USDA ARS

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	Treatment #	Year	Irrigation	Nitrogen	CO ₂ (ppm)
CO ₂ and two irrigation levels & ample nitrogen	C 901	1993	Dry	High	370
	C 902	1993	Wet	High	370
	F 903	1993	Dry	High	550
	F 904	1993	Wet	High	550
	C 905	1994	Dry	High	370
	C 906	1994	Wet	High	370
	F 907	1994	Dry	High	550
	F 908	1994	Wet	High	550
CO ₂ and two N fertilization levels & ample irrigation	C 909	1996	Wet	High	370
	C 910	1996	Wet	Low	370
	F 911	1996	Wet	High	550
	F 912	1996	Wet	Low	550
	C 913	1997	Wet	High	370
	C 914	1997	Wet	Low	370
	F 915	1997	Wet	High	550
	F 916	1997	Wet	Low	550

- higher increase of shoot biomass when water was limited
- smaller increase of shoot biomass when soil nitrogen was limited (Kimball 2016)

OFFLINE SINGLE POINT CLM SIMULATIONS

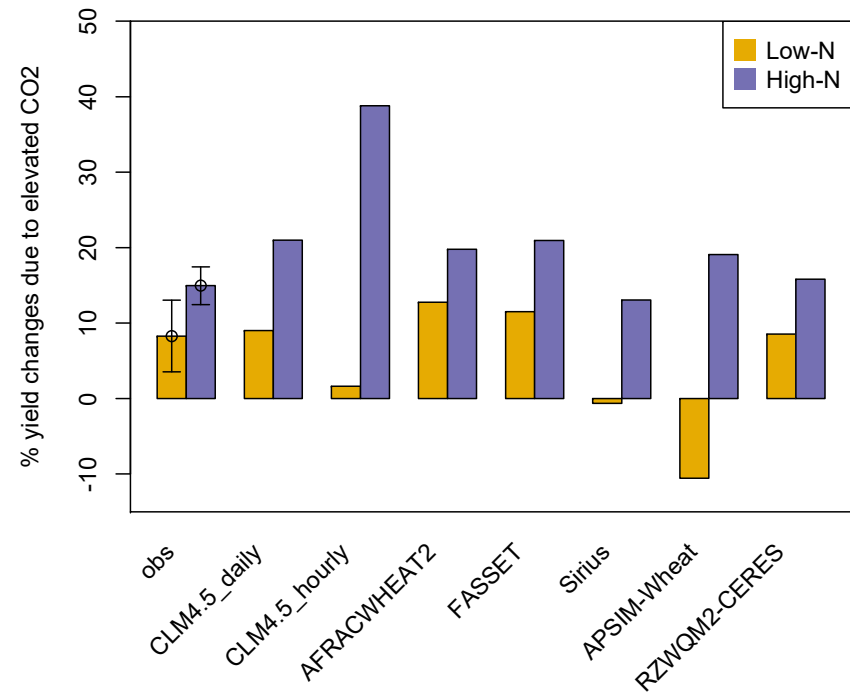
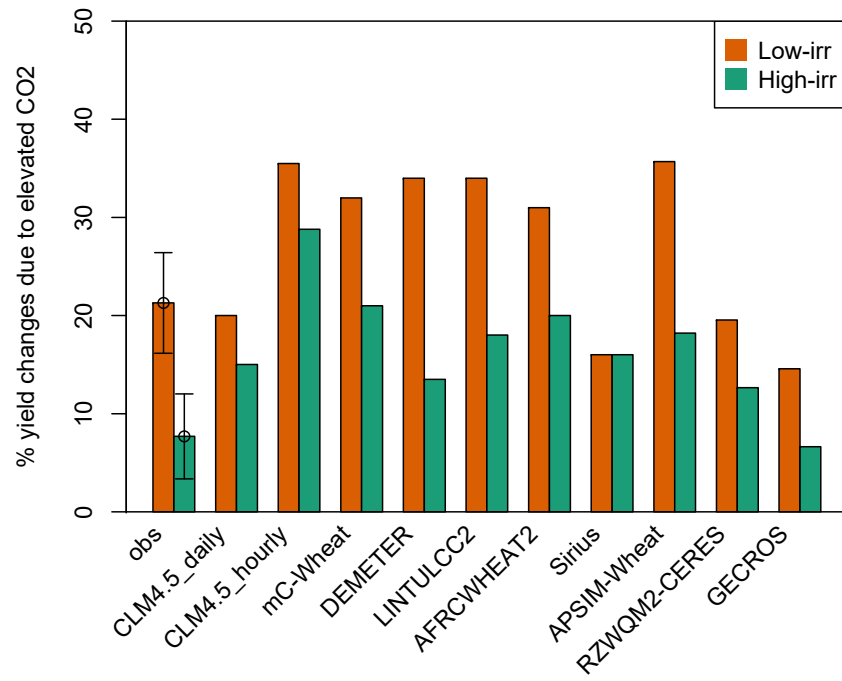
Simulations:

- CLM45: post_clm4.5
- 16 single point simulations forcing with site weather data
- 300 years spin up
- Applied the same amount of irrigation and nitrogen fertilization at the same days as in observation at each treatment.
- Observed soil texture, soil initial organic matter, soil initial mineral nitrogen

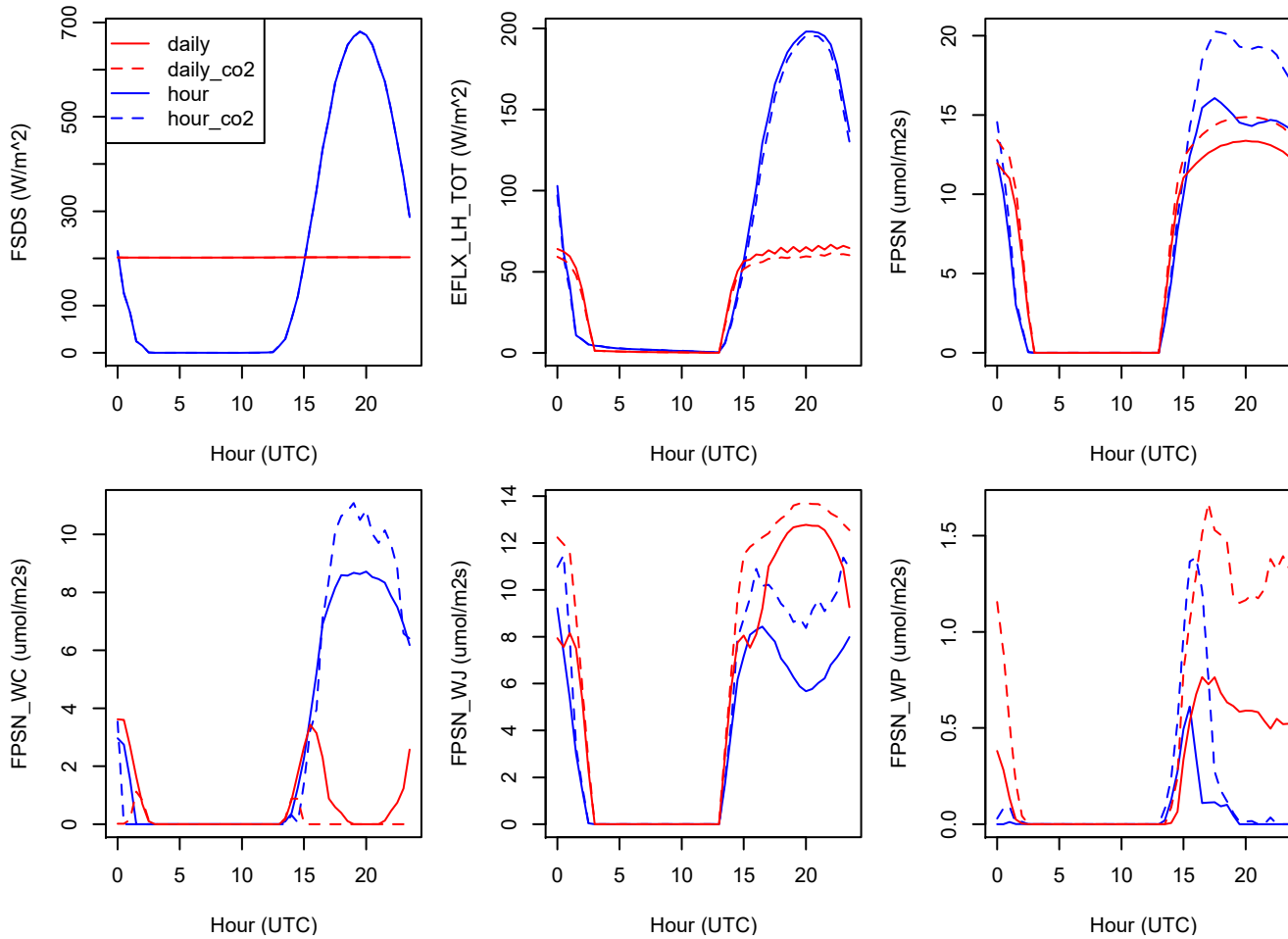
Forcing data:

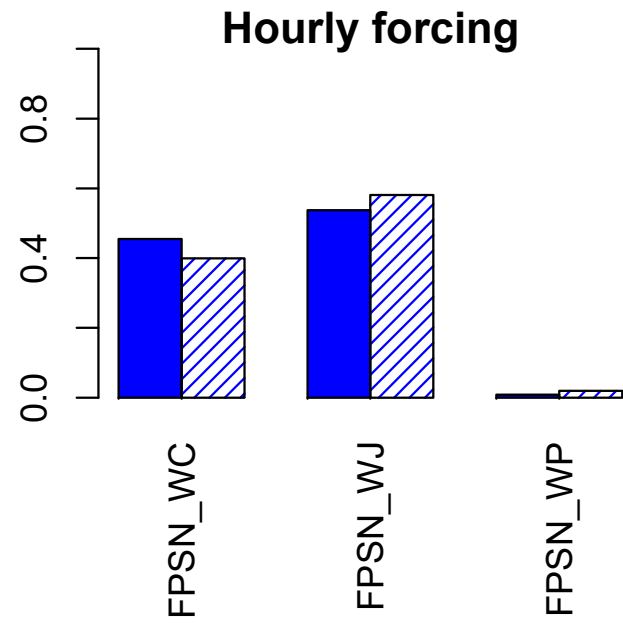
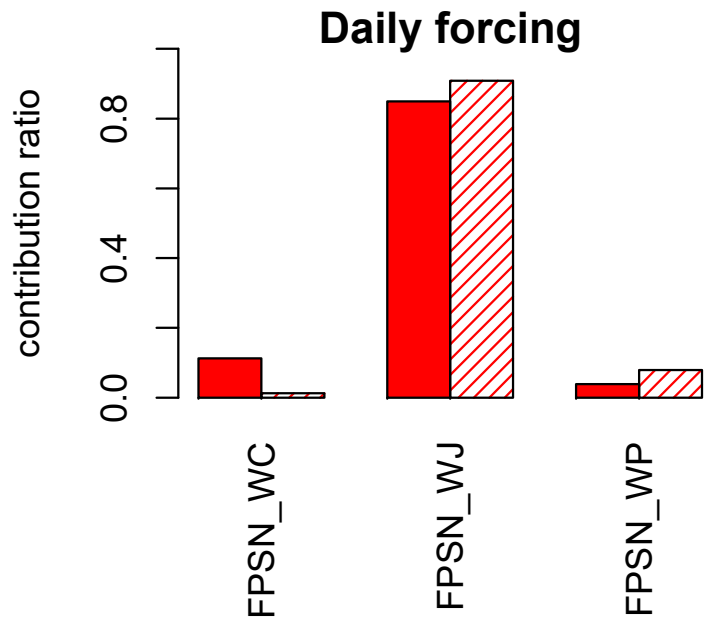
- Daily and hourly weather data (temperature, precipitation, wind, solar radiation, dew point temperature)

What problems that were caused by the daily forcing data?

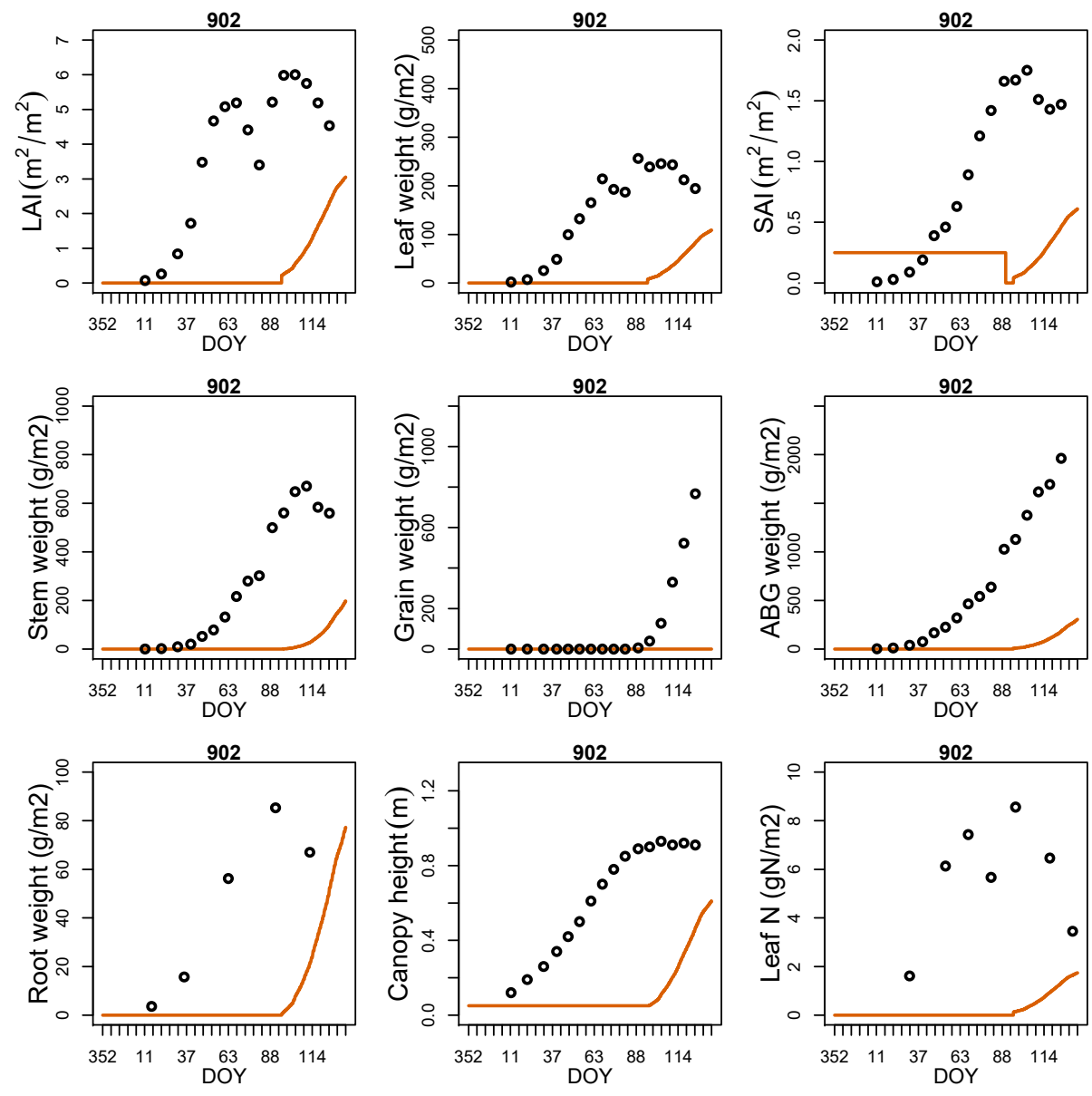


Daily forcing data resulted low energy fluxes, the photosynthesis was largely light limited



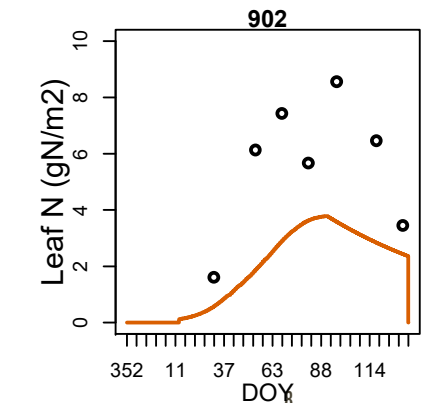
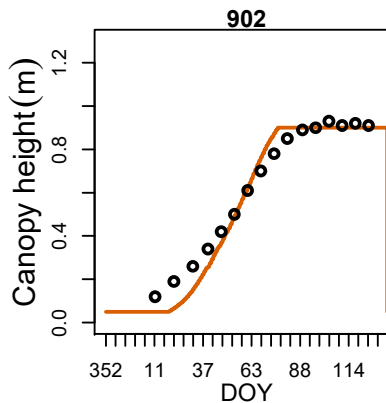
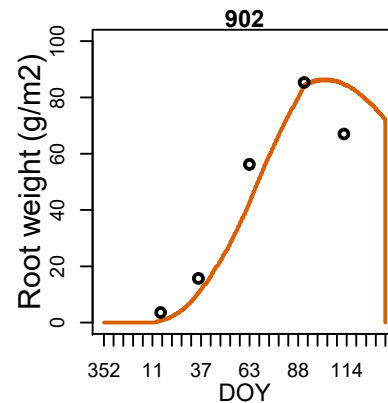
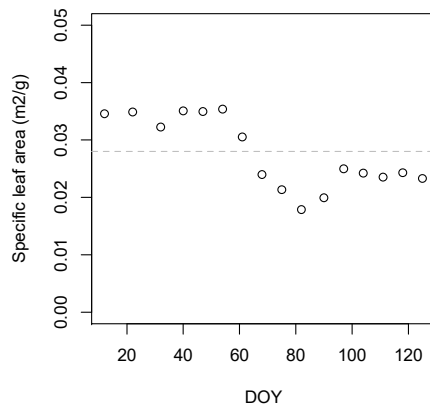
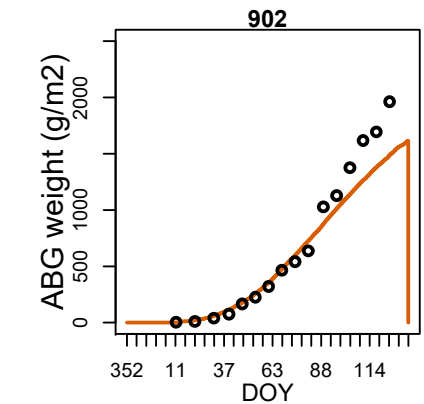
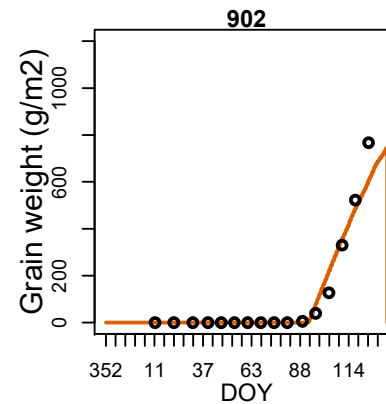
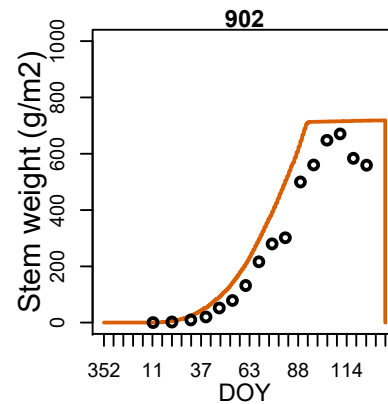
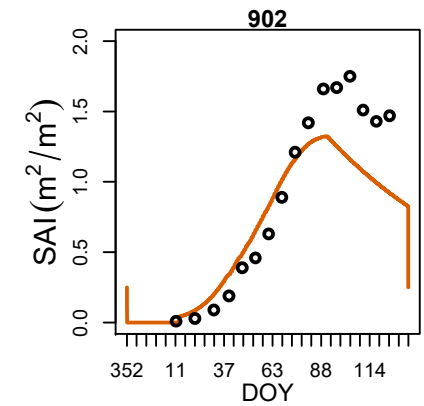
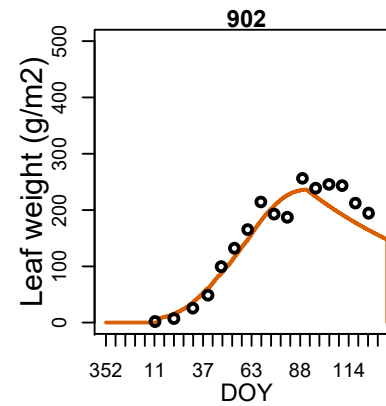
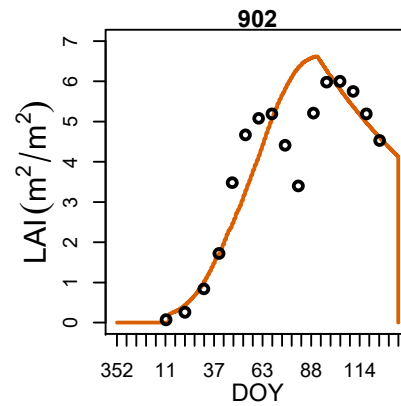


What problems that could not be resolved by calibration?

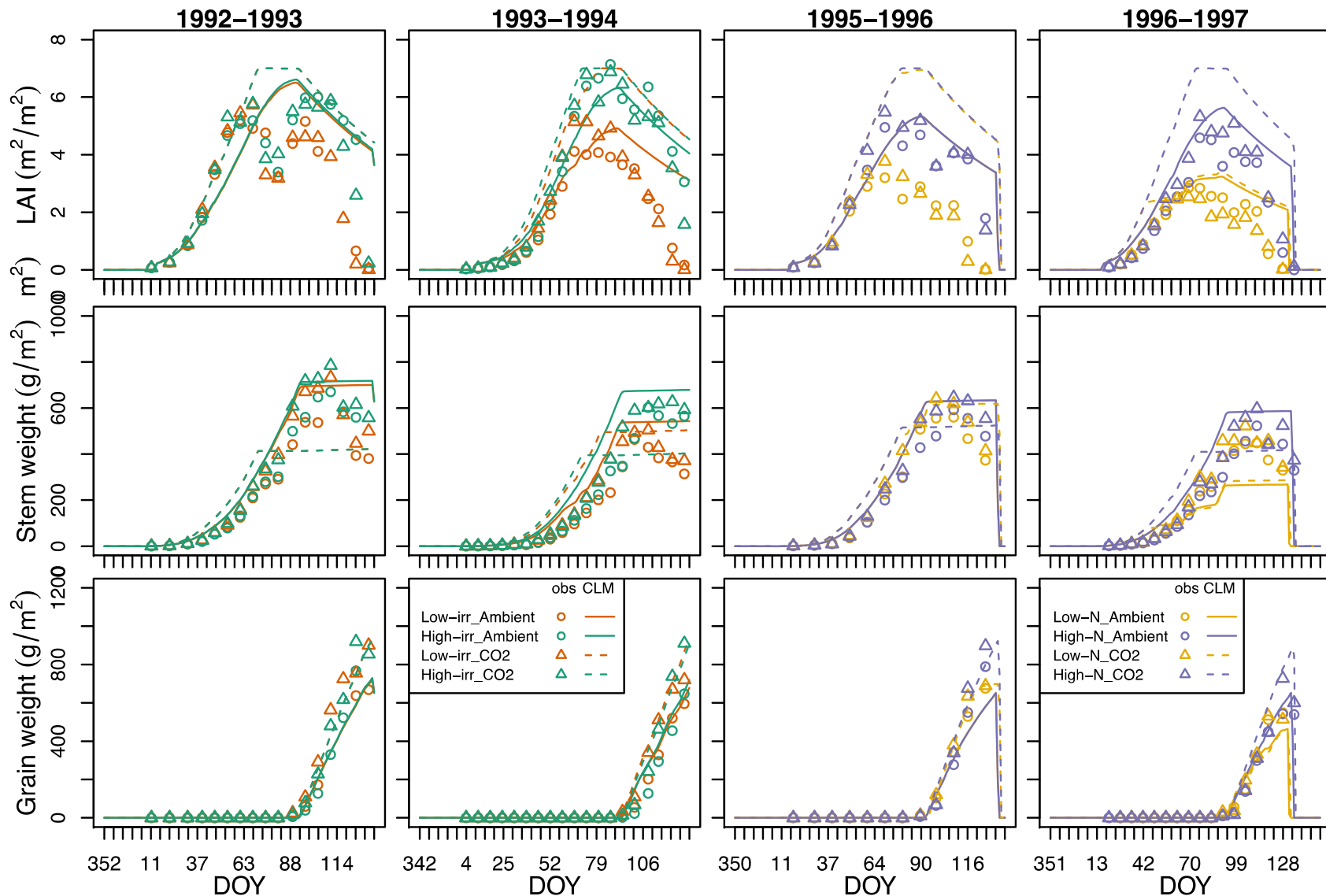


What problems that could not be resolved by calibration?

- No leaf senescence during leaf emerge phase
- Inconsistent SAI with stem weight
- Stem weight not decline during the grain fill phase
- Underestimated above ground biomass during the grain fill phase due to not considering chaff weight
- Fixed specific leaf area



What new problems that were revealed by validations?



- Too positive leaf growth and incorrect stem growth response to elevated CO₂
- Insufficient response to higher irrigation and nitrogen fertilization

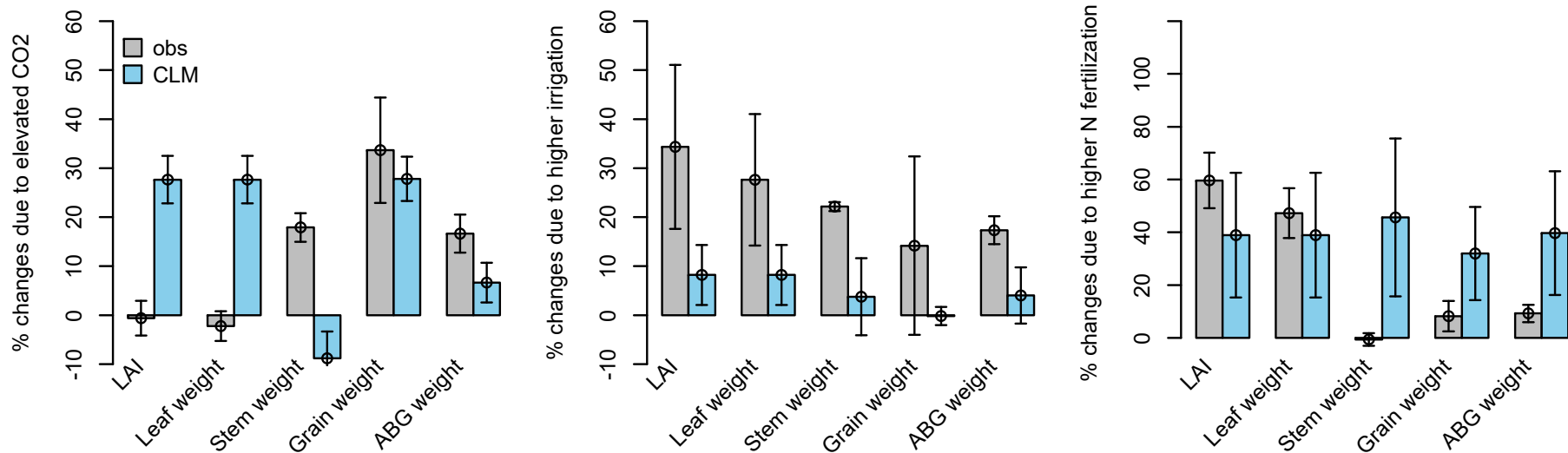
- Too positive leaf growth and incorrect stem growth response to elevated CO₂
- Insufficient response to higher irrigation and nitrogen fertilization
- Crops in reality may wisely invest carbon to different tissues when response to different stresses

In CLM4.5:

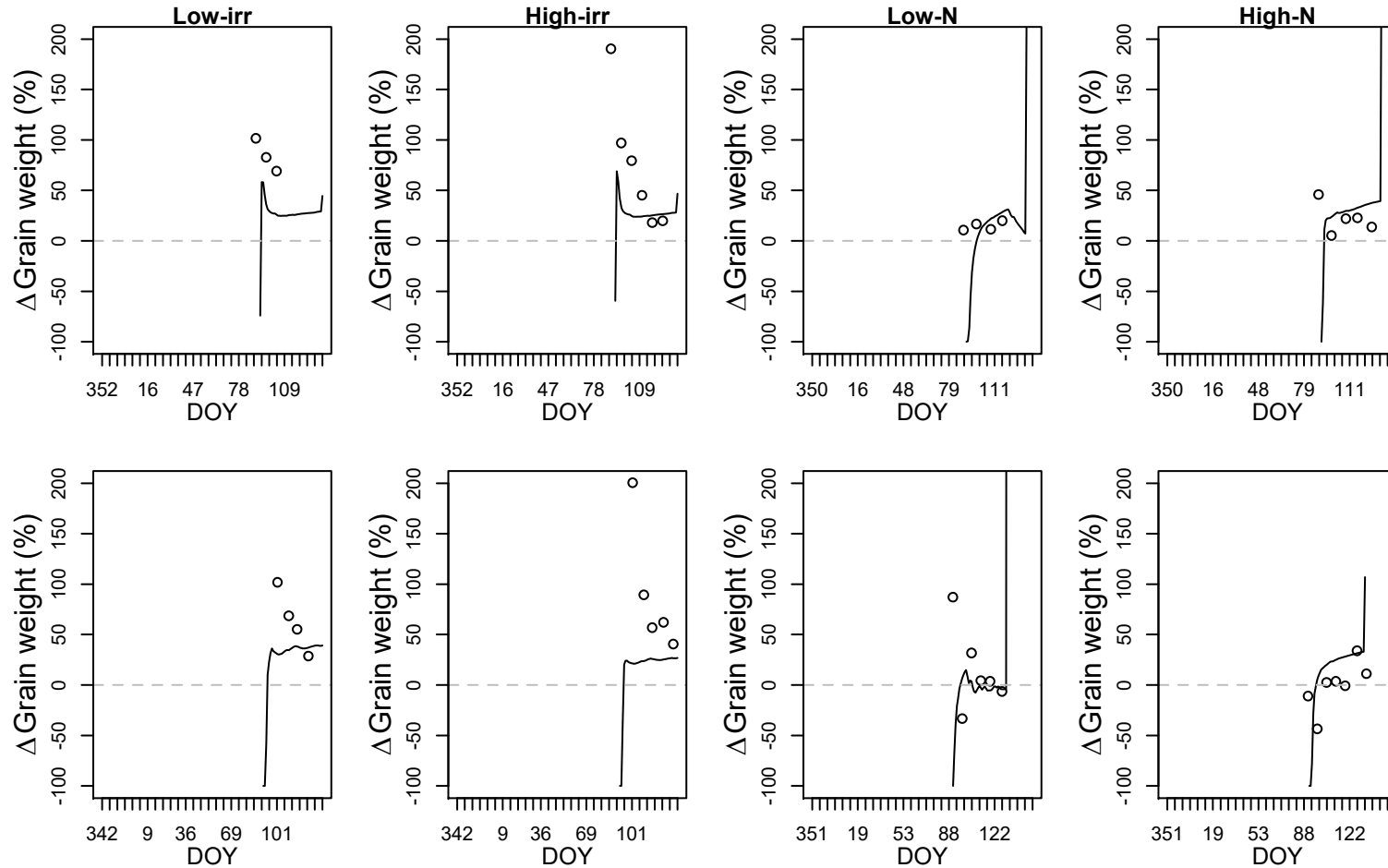
CO₂ => internal leaf CO₂ partial pressure => photosynthesis and stomatal conductance

Water => stomatal conductance, scale parameters used in photosynthesis (v_{cmax} and j_{max})

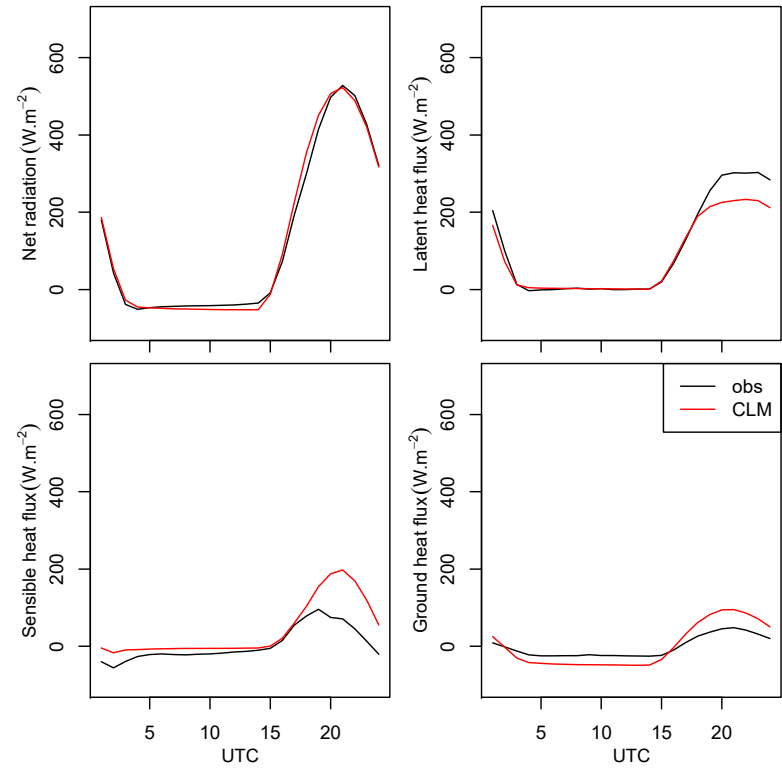
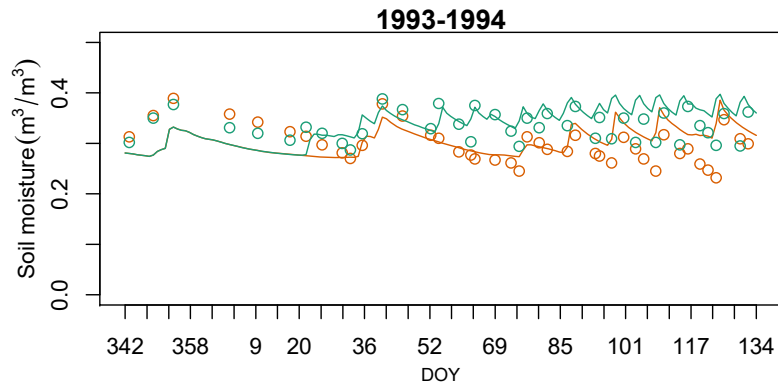
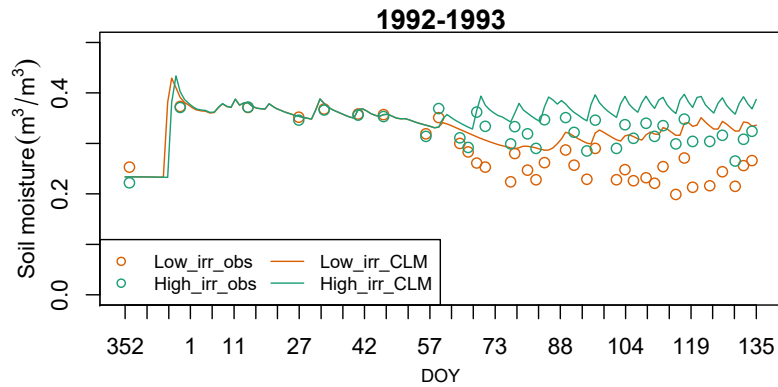
Nitrogen => down regulation on potential photosynthesis



Underestimated averaged grain weight response to CO₂ Overestimated grain yield response to CO₂



Insufficient response irrigation \leq higher soil moisture \leq lower ET

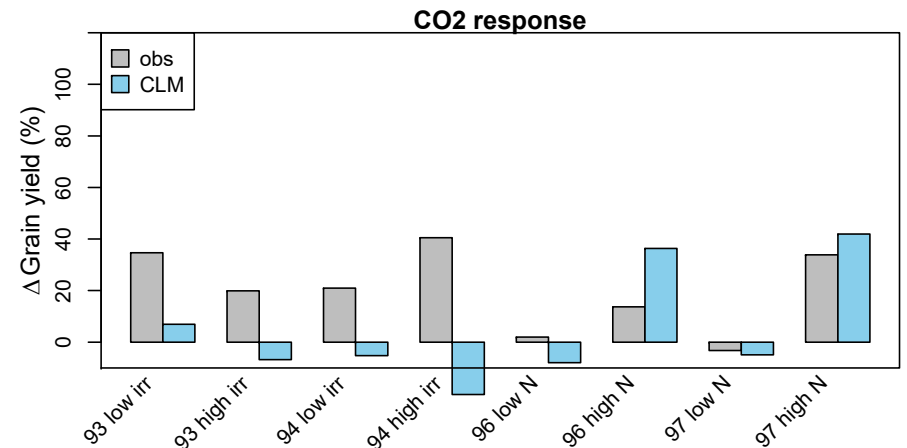
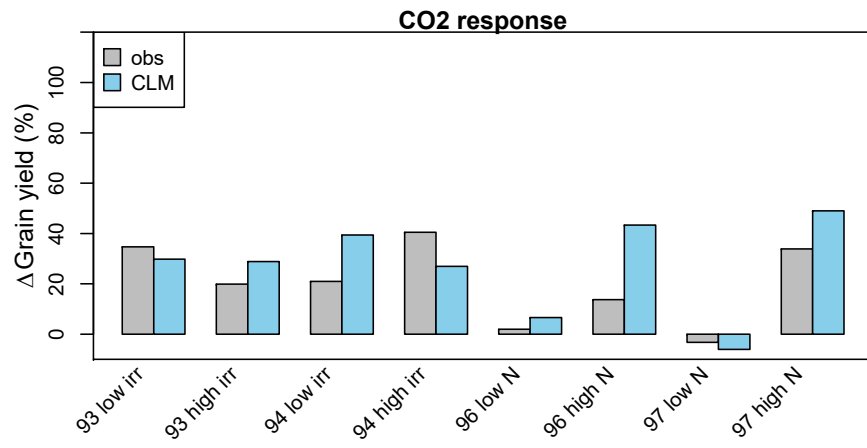
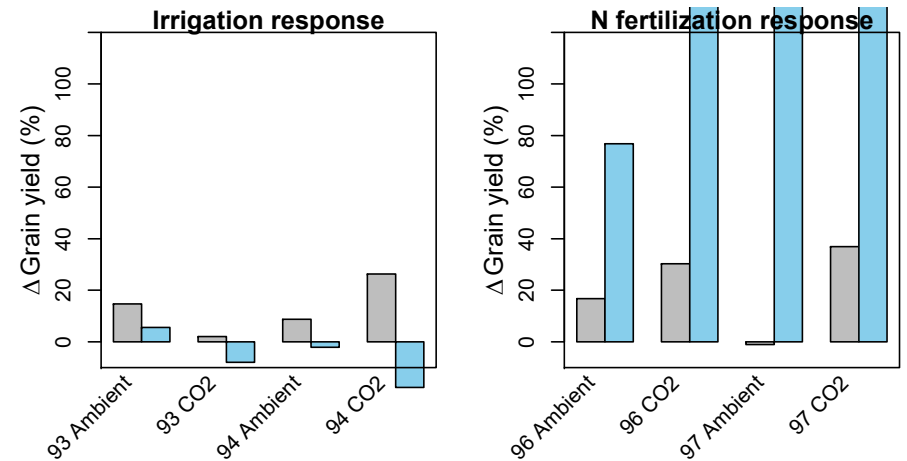
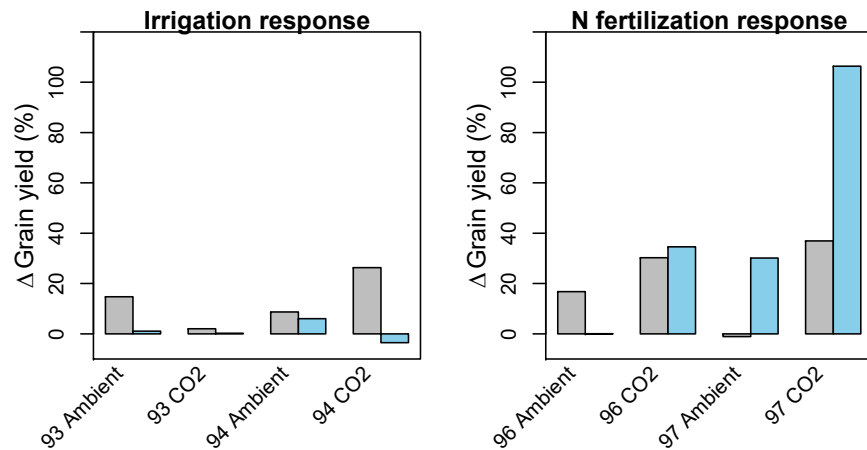


In sufficient response to N fertilization \leq the fixed tissue C:N ratio

Reduce the tissue C:N ratio could increase the nitrogen limitation, but also resulted reduction of the CO₂ effects due to higher nitrogen limitation

Default: Leafcn=25 frootcn=43 graincn=50

Leafcn=20 frootcn=30 graincn=25



Summary

What problems that were caused by the daily forcing data ?

- Low energy fluxes
- Photosynthesis was largely limited by light, results insufficient response to elevated CO₂

What problems that could not be resolved through calibration ?

- Leaf senescence during leaf emerge phase
- Inconsistent SAI with stem weight
- Stem weight not decline during the grain fill phase
- Underestimated above ground biomass during the grain fill phase due to not considering chaff weight
- Fixed specific leaf area

What new problems that were revealed by validations ?

- Incorrect phenology when LAI reached the maximum
- Too positive leaf growth response to elevated CO₂
- Insufficient response to higher irrigation and nitrogen fertilization
- High soil moisture and low latent heat flux