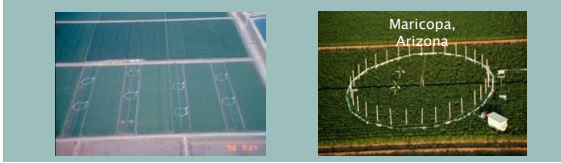


Validation of spring wheat responses to elevated CO₂, irrigation, and nitrogen fertilization in the Community Land Model 4.5

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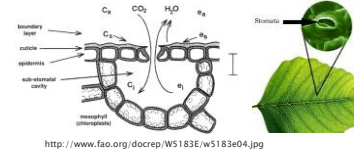
²U.S. Arid-Land Agricultural Research Center, Agricultural Research Service, USDA, Maricopa, Arizona



ELEVATED CO₂ EFFECTS ON PLANTS

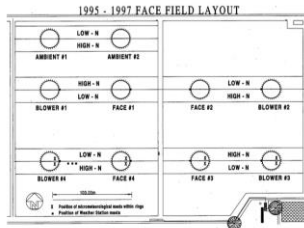
More efficient plants (Drake *et al.*, 1997)

- reduction in stomatal conductance and transpiration
- improved water-use efficiency
- higher rates of photosynthesis
- increased light-use efficiency



http://www.fao.org/docrep/w5183e/w5183e04.jpg

SPRING WHEAT FACE FREE AIR CO₂ ENRICHMENT EXPERIMENT



FACE established by Brookhaven National Laboratory (BNL) [Lewin *et al.*, 1992]

First tested for cotton, then applied for wheat, sorghum, at Maricopa site

Figure 1. Field plot plan for the 1995-1997 FACE experiments showing four replicate circular FACE plots and four corresponding blower plots that provide air flow that is ambient CO₂. Also shown are two ambient plots that had no blower air advantage and no added CO₂. All of the circular main plots were split into conventional high and low N plots. Blower nitrogen treatments were applied via a subsurface drip irrigation system in strips across the field as indicated.

Kimball *et al.*, (1999)

ISSUES WITH FACE



1. Blowers that used to mixing the CO₂ and surrounding air could result warm night temperature and accelerate the phenology (Pinter *et al.*, 2000)
2. The elevated CO₂ in the open FACE field are subject to fluctuations due to air turbulence and instability, may explain the lower yield stimulation (Kimball 2016)

	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
CO ₂ and two N fertilization levels & ample irrigation	F 907	1994	Dry	High	550
	F 908	1994	Wet	High	550
	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

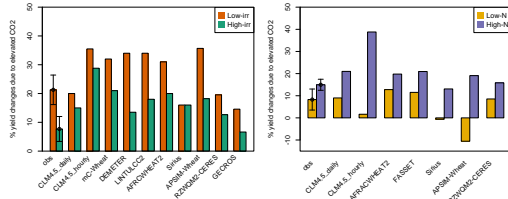
Simulations:

- 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:

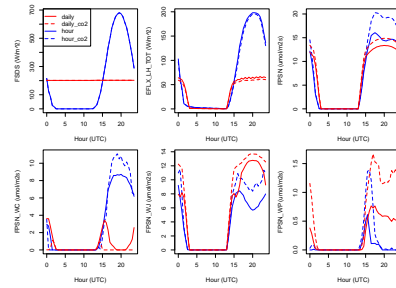
- Daily and hourly weather data (temperature, precipitation, wind, solar radiation, dew point temperature)

What problems that were caused by the daily forcin



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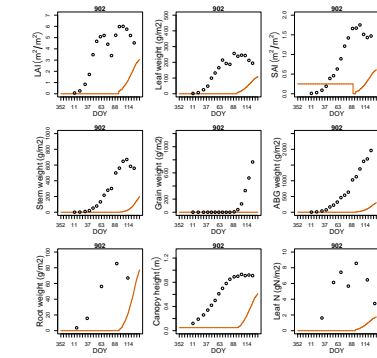
Daily forcing data resulted low energy fluxes, the photosynthesis was largely light limited



A₁: Rubisco limited A₂: Light limited A₃: Product limited rate

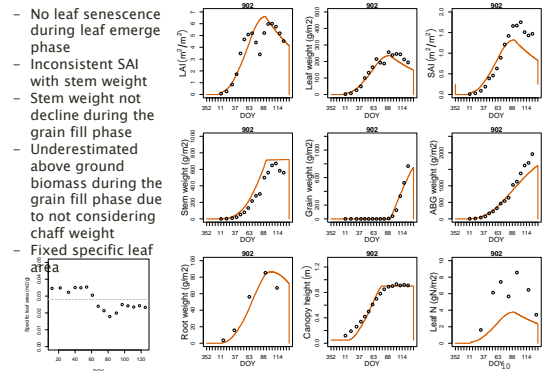
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What problems that could not be resolved by calibra

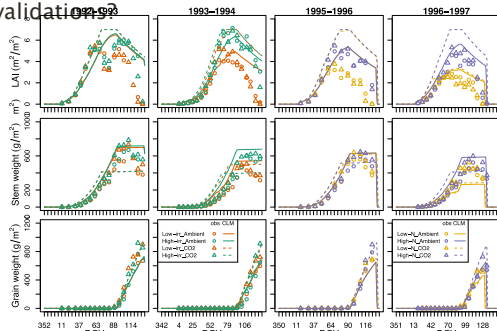


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What problems that could not be resolved by calibr.



What new problems that were revealed by validation

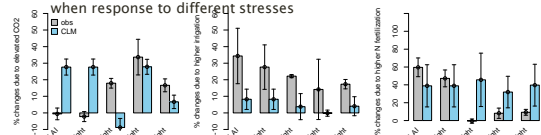


- Too positive leaf growth and incorrect stem growth response to elevated CO2

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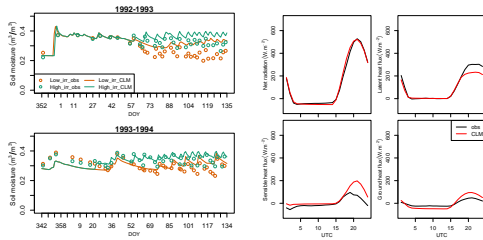
In CLM4.5: CO2=> internal leaf CO2 partial pressure => photosynthesis and stomatal co Water=> stomatal conductance, scale parameters used in photosynthesis (vcrr Nitrogen=>down regulation on potential photosynthesis

- 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



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



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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

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