FAPESP
Workshop on Impacts of Global Climate Change on Agriculture and Livestock
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C4 Crop Responses to Global Climate Change

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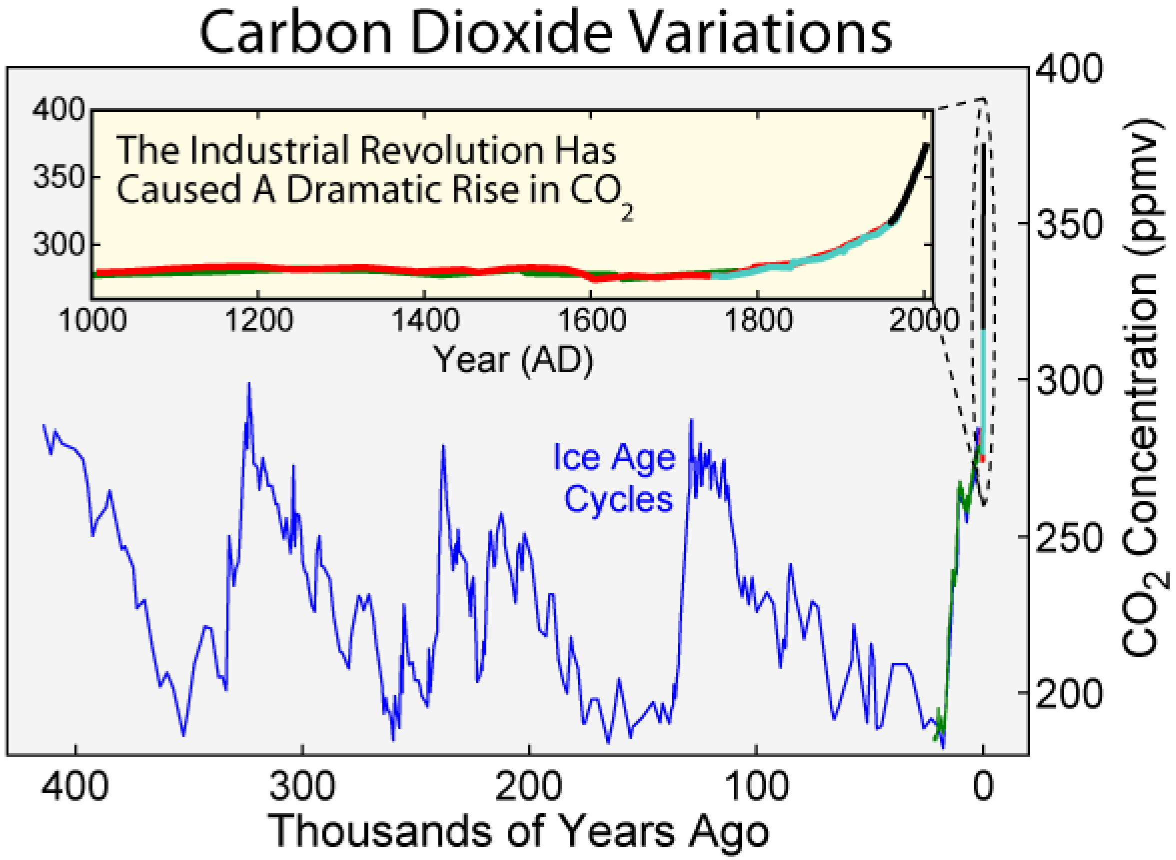
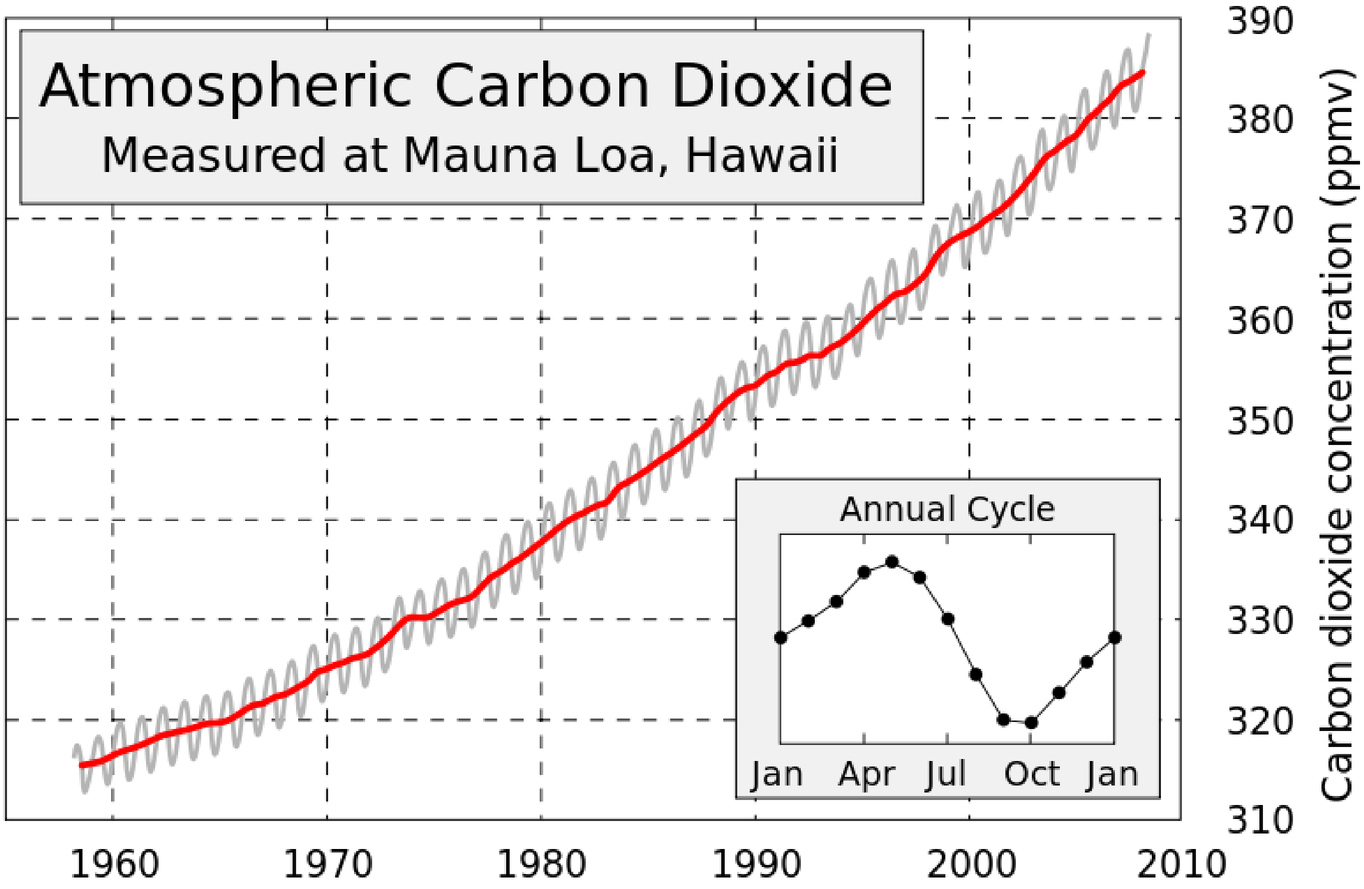
- Stephen Long

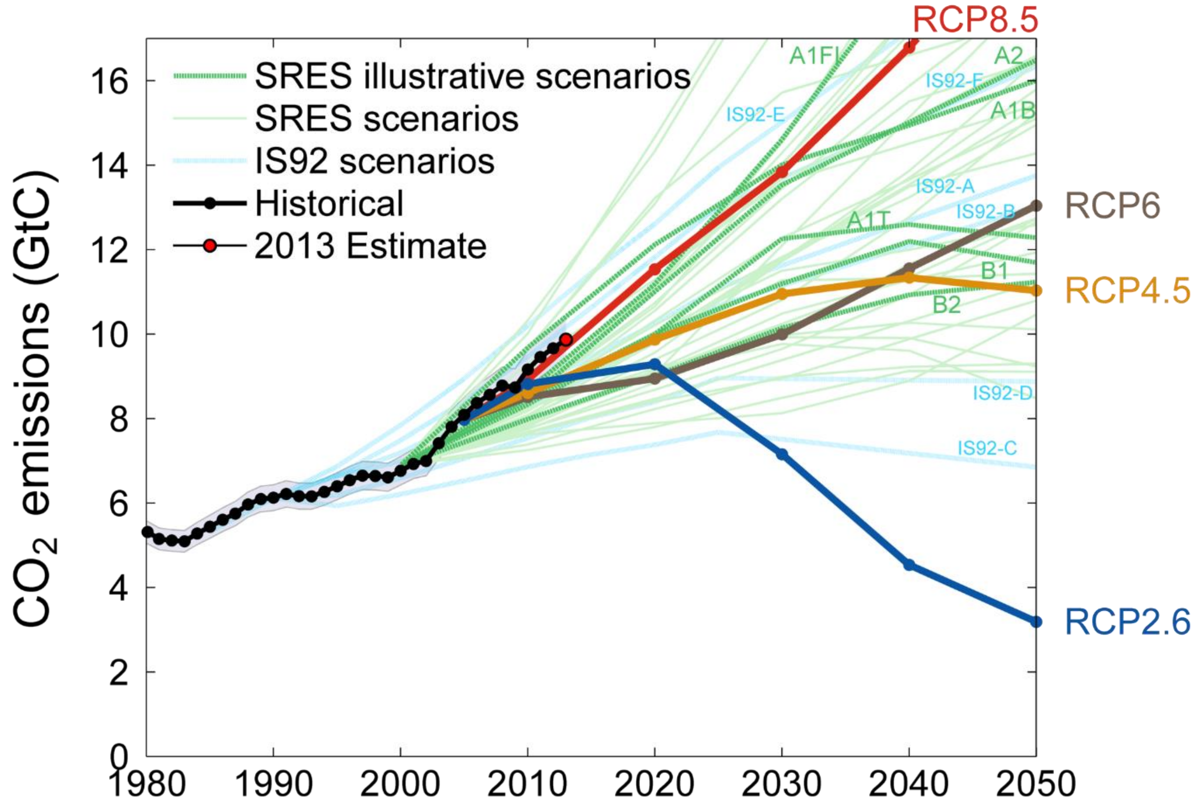
Historic CO_2



Historic CO_2



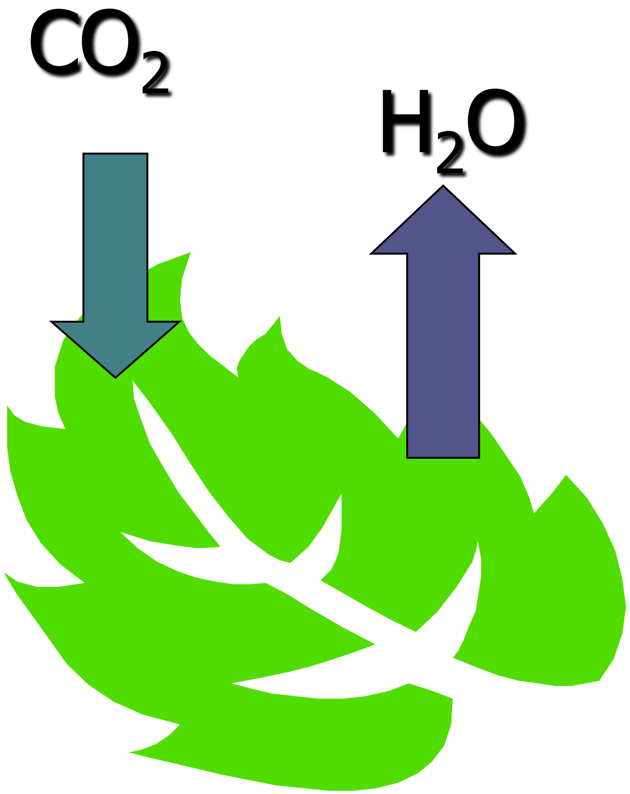
Modeled vs. Measured

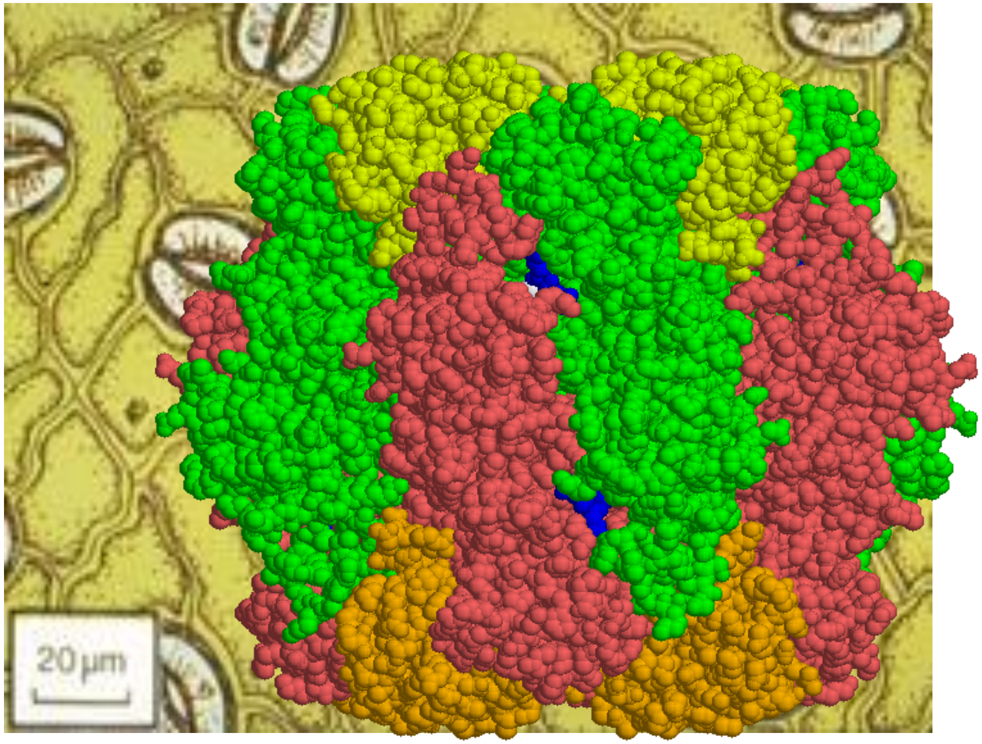


Main periods of use: SA90 (1990–1992, not shown), IS92 (1992–2000), SRES (2000–2012), RCPs (2012+)

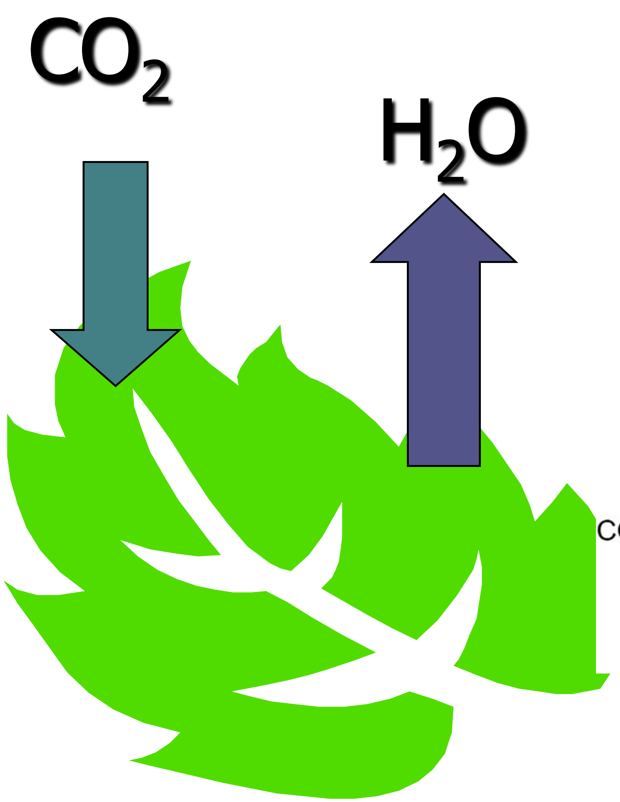
Source: Peters et al. 2012a; CDIAC Data; Global Carbon Project 2013

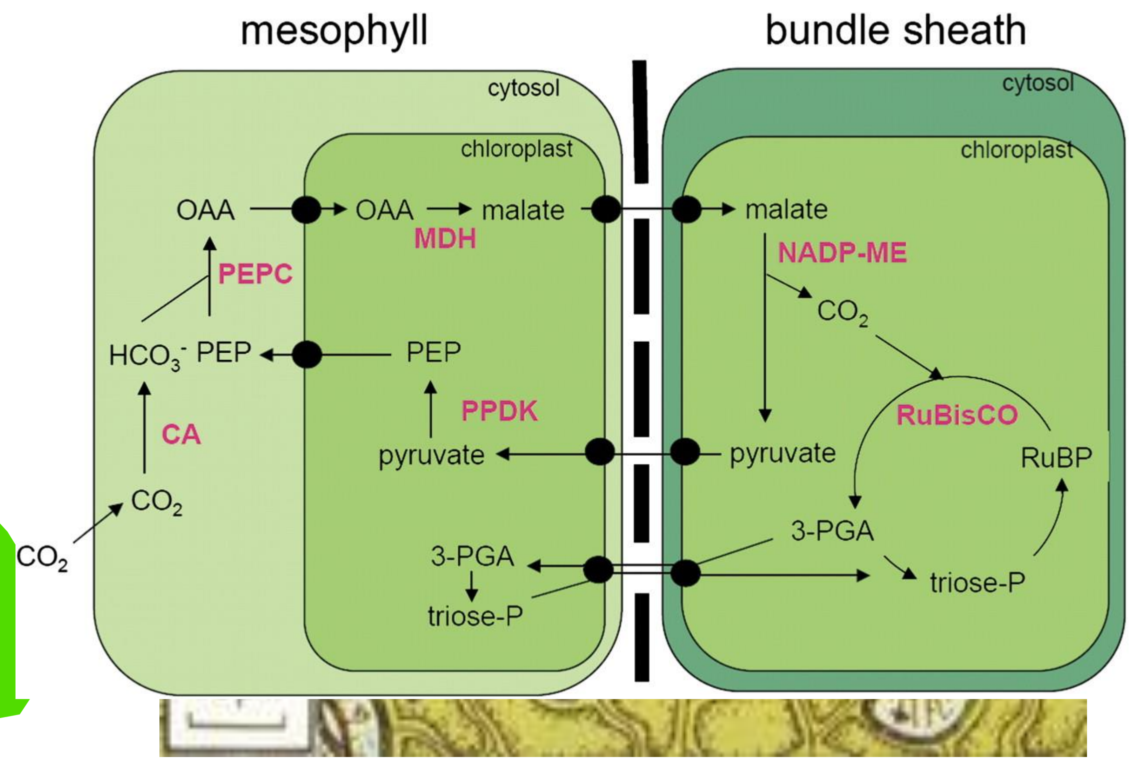
Elevated CO_2: Primary effect on C3 plants



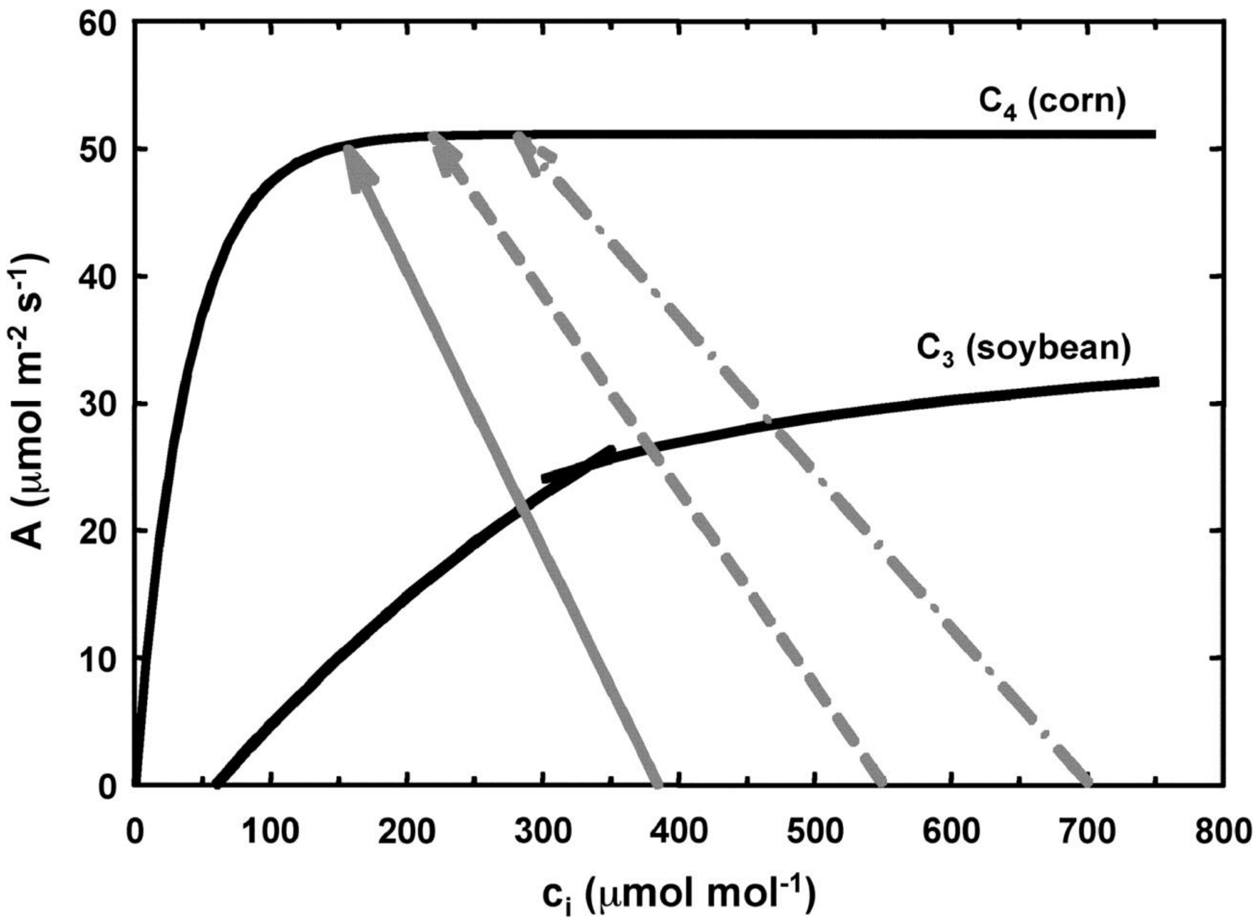


Elevated CO_2:
Primary effect on C4 plants



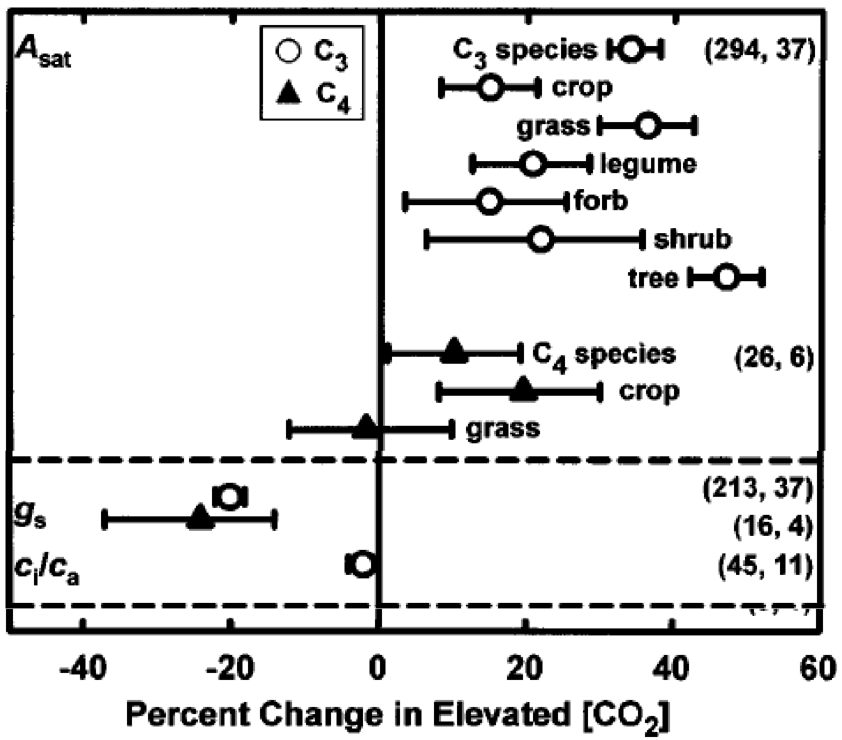


C3 vs. C4 crops and elevated CO_2



Leakey et al., 2009

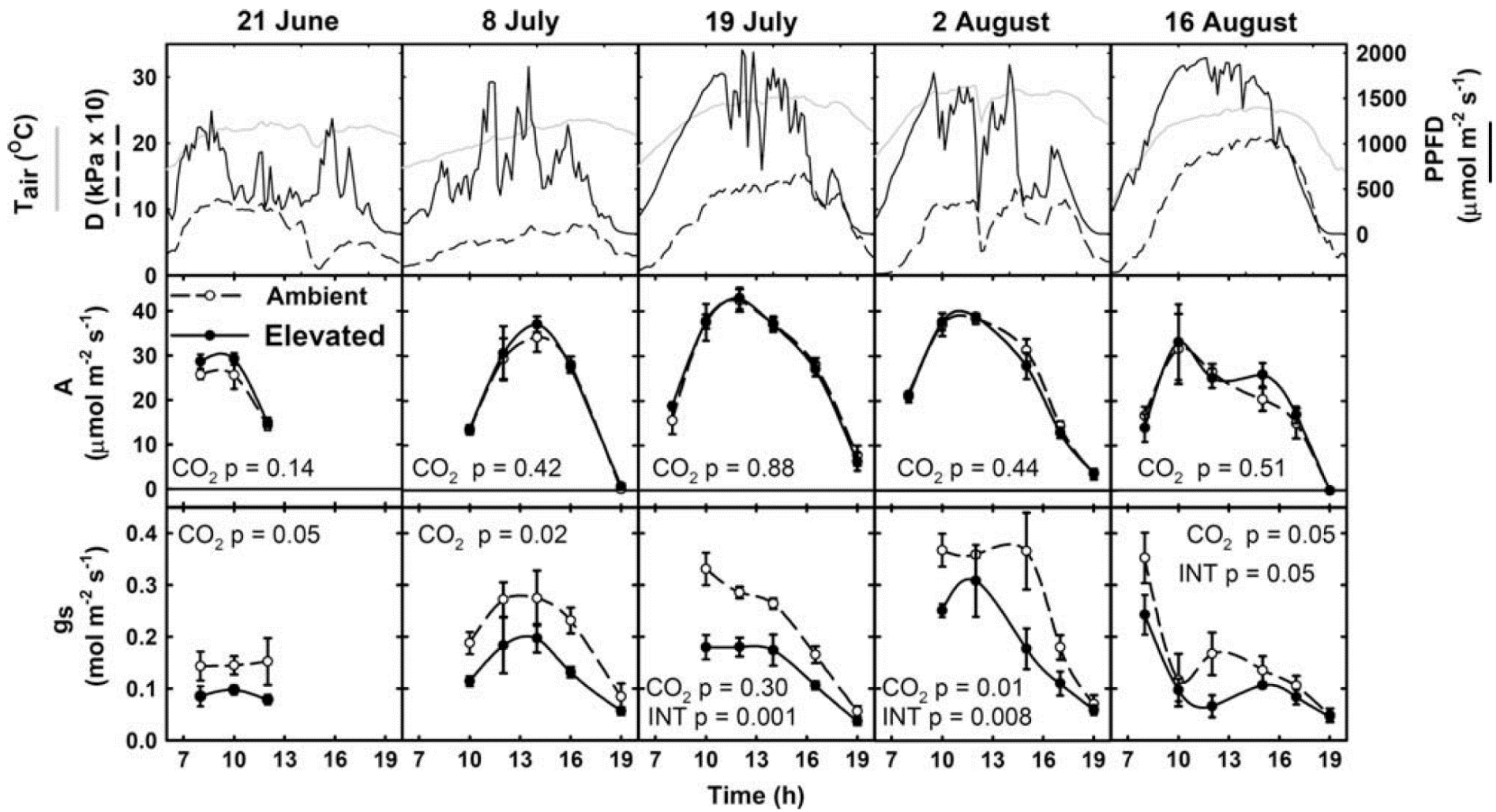
Meta-analysis results



Long et al., 2004, Annu Rev Plant Biol 55: 591-628

SoyFACE Global Change Research Facility Investigating crop responses to elevated CO_2

Maize: Photosynthesis



Leakey et al., 2006

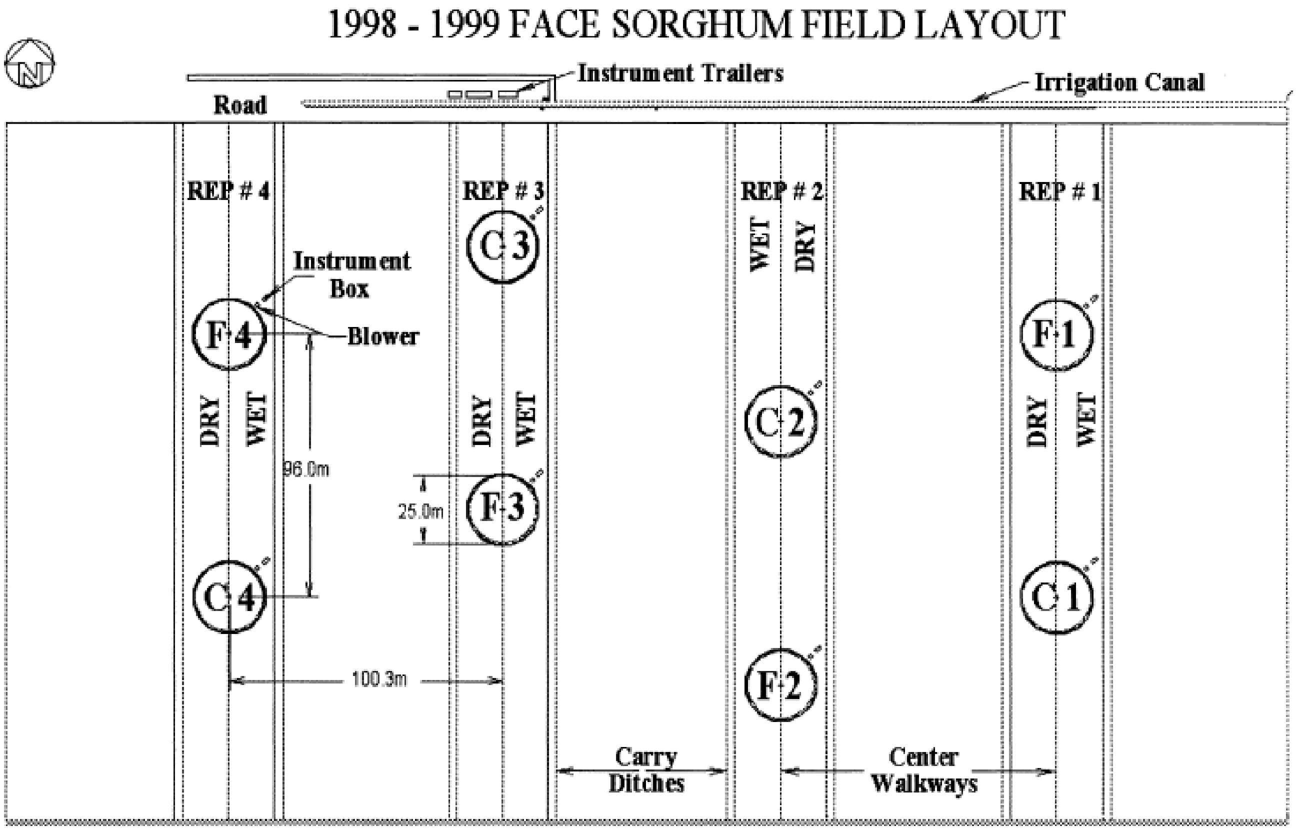
Maize yields

Table III. *Biomass of stover and grain, kernel number, individual kernel weight, total leaf area, and DOY of anthesis and silking for maize grown at ambient (370 µmol mol^{-1}) or elevated [CO_2] (550 µmol mol^{-1}) upon harvest at the end of the growing season in 2004 at SoyFACE in Urbana, IL*

Parameter	[CO_2] 370	[CO_2] 550	*P*
Stover biomass R6 (g plant^{-1})	134 ± 11	131 ± 9	0.68
Grain biomass R6 (g plant^{-1})	140 ± 6	142 ± 6	0.8
Kernel number (plant^{-1})	598 ± 38	609 ± 29	0.37
Kernel weight (mg)	248 ± 7	247 ± 5	0.83
Total leaf area (cm^2 plant^{-1})	6,280 ± 471	6,304 ± 365	0.48
Anthesis date	188.9 ± 0.3	188.7 ± 0.2	0.53
Silking date	188.3 ± 0.3	188.1 ± 0.3	0.63

Leakey et al., 2006

Sorghum FACE Experiment



Ottman et al., 1999

Drought increased yield in elevated CO_2

New Phytologist

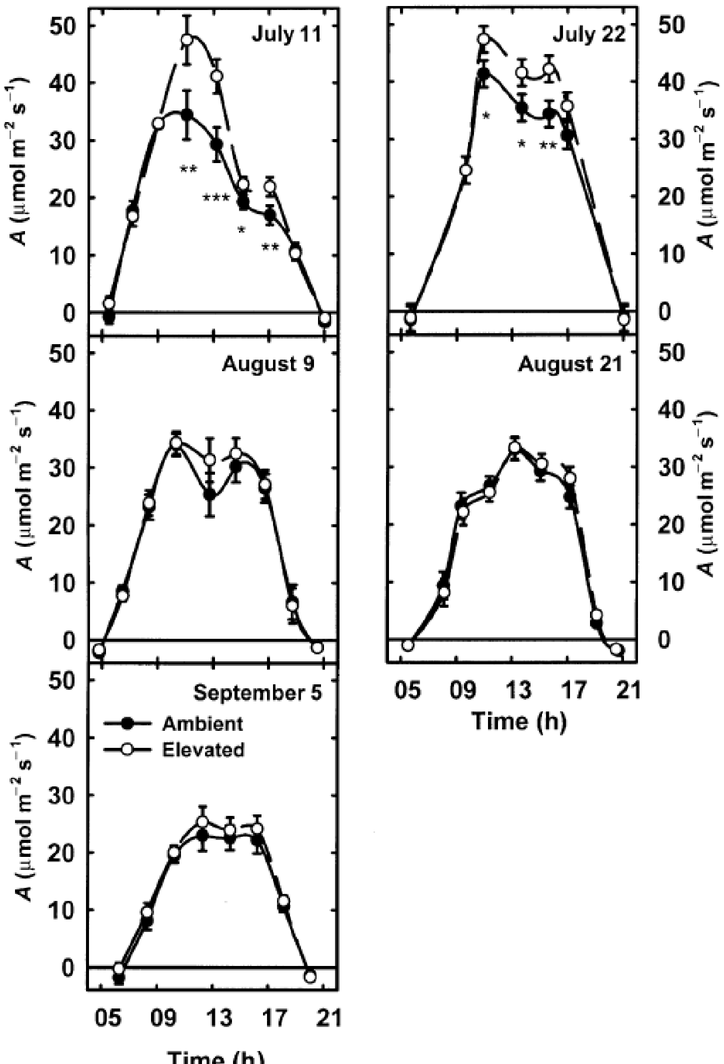
Research

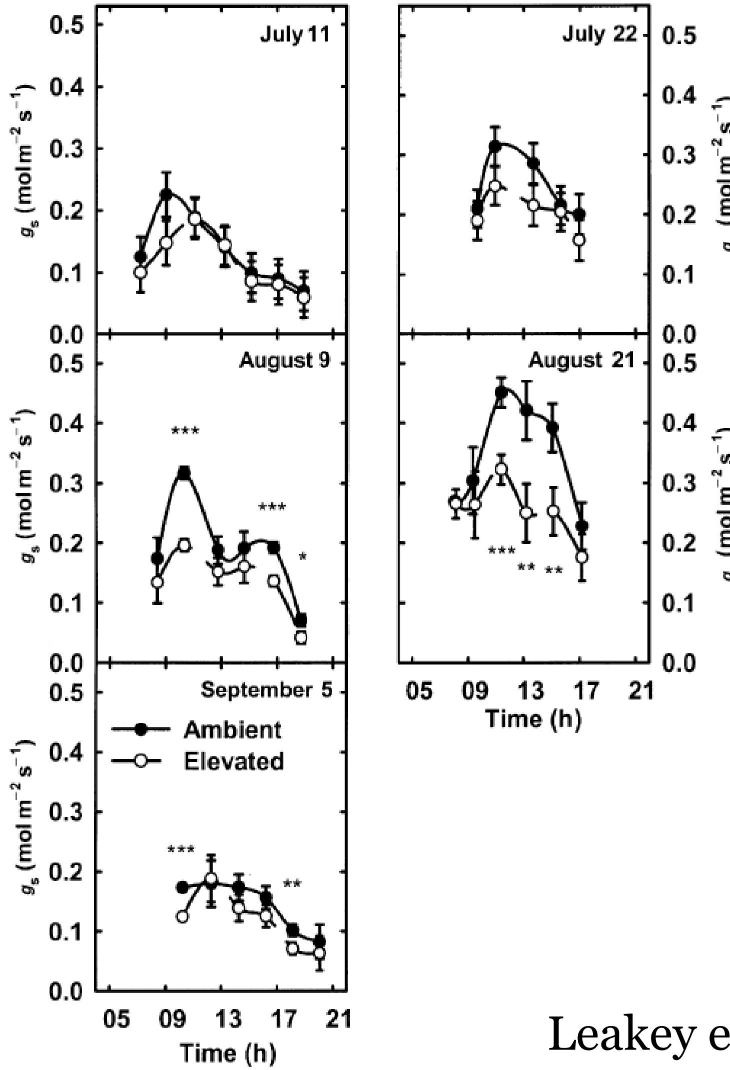
Elevated CO_2 increases sorghum biomass under drought conditions

M. J. Ottman[1], B. A. Kimball[2], P. J. Pinter[2], G. W. Wall[2], R. L. Vanderlip[3], S. W. Leavitt[4], R. L. LaMorte[2], A. D. Matthias[5] and T. J. Brooks[2]

[1]Plant Sciences Department, 303 Forbes Bldg., University of Arizona, Tucson, AZ 85721 USA; [2]U.S. Water Conservation Lab, USDA-ARS, 4331 E. Broadway Rd., Phoenix, AZ 85040 USA; [3]Department of Agronomy, 3724 Throckmorton Hall, Kansas State University, Manhattan, KS 66506 USA; [4]Laboratory of Tree Ring Research, 218 West Stadium, University of Arizona, Tucson, AZ 85721 USA; [5]Department of Soil, Water, and Environmental Science, 529 Shantz Bldg., University of Arizona, Tucson, AZ 85721 USA

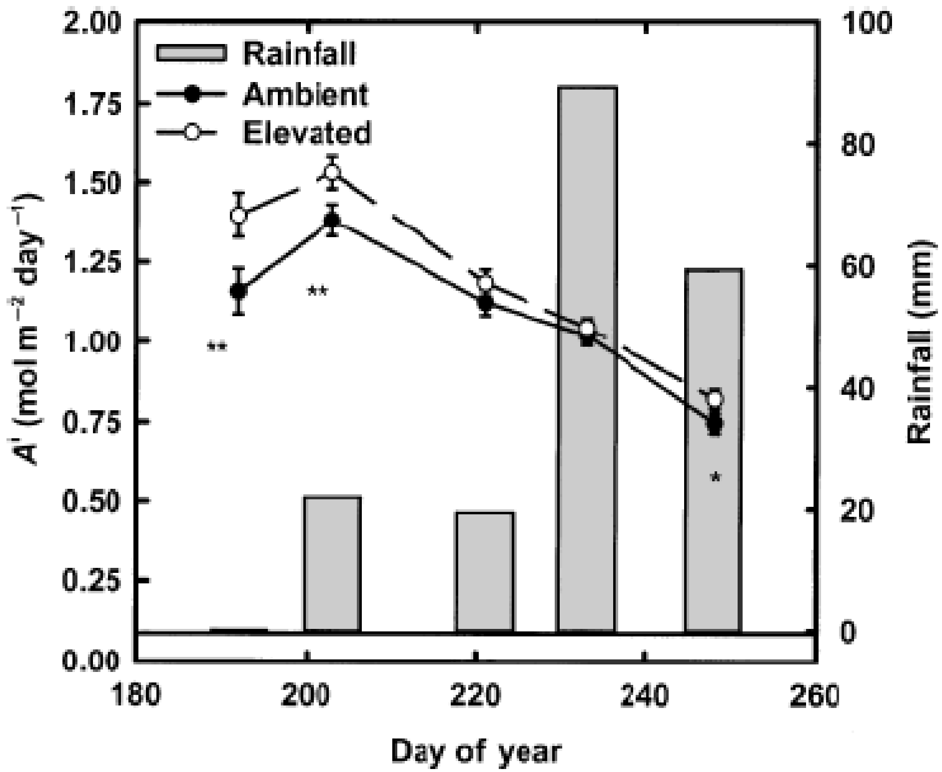
Maize Photosynthetic Responses to elevated CO_2





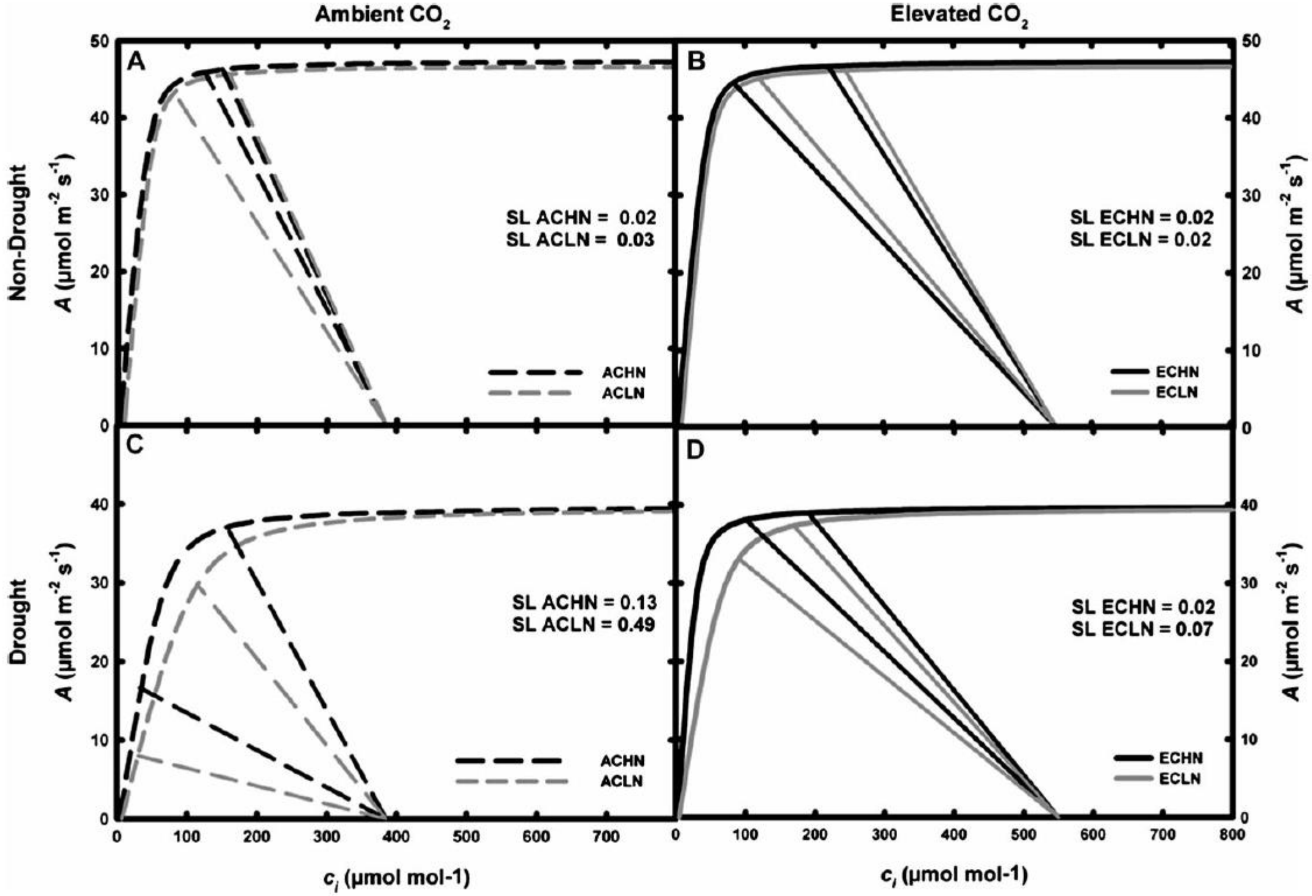
Leakey et al., 2004

Integrated daily carbon uptake



Leakey et al., 2004

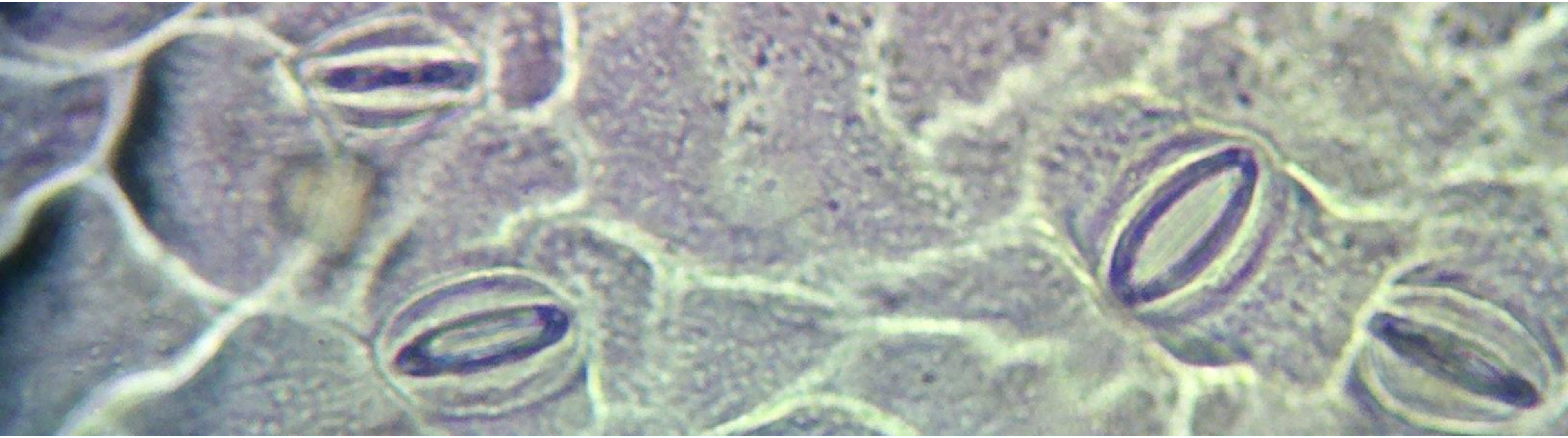
Maize Photosynthesis



Markelz et al., (2011) J Exp Bot 62: 3235–3246

Stomatal conductance and elevated CO_2

- Universally, stomatal conductance is lower in elevated CO_2
- Do these decreases in leaf stomatal conductance translate to decreases in canopy water use?

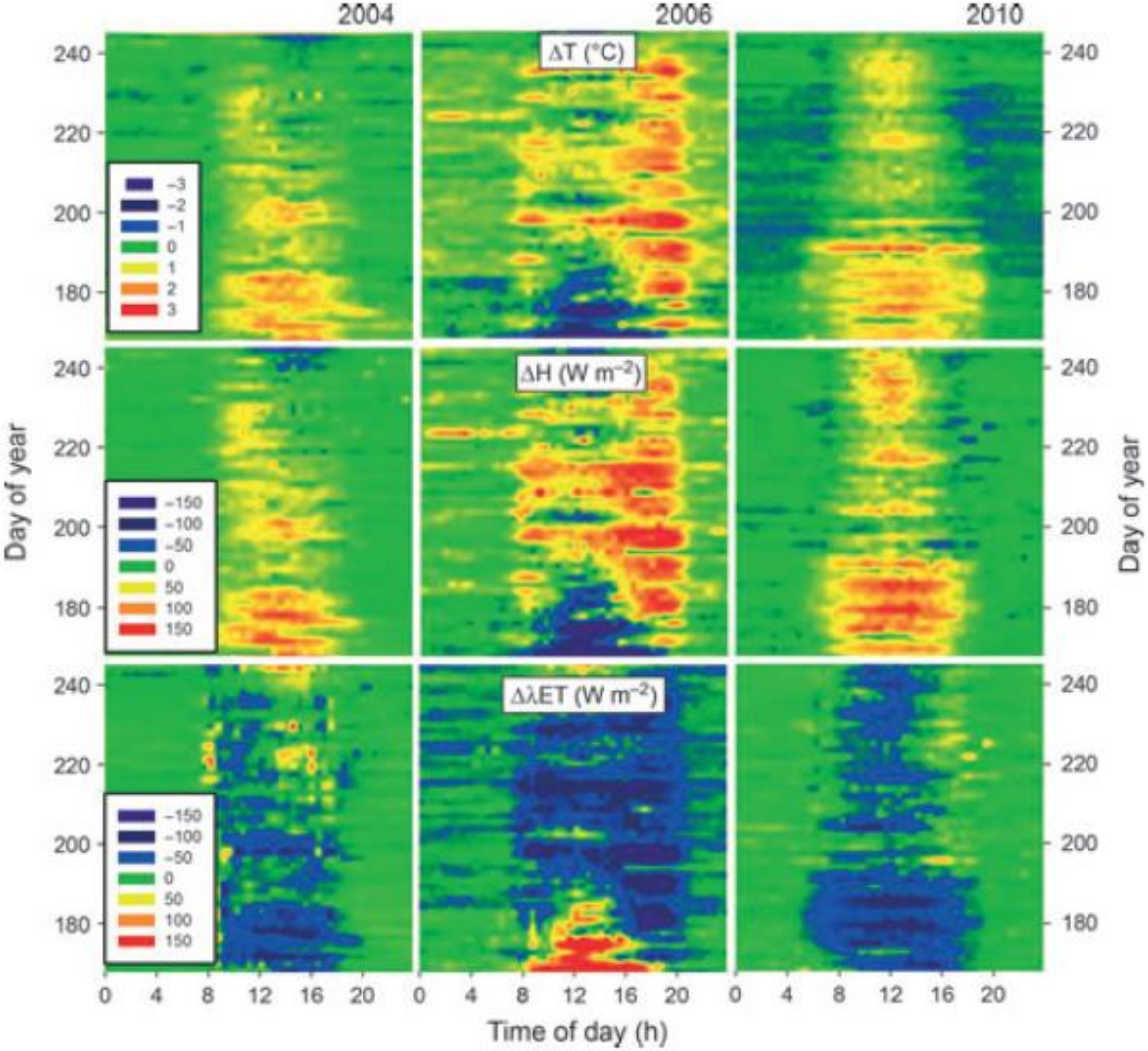


Evapotranspiration

Water moves from the soil into the roots, through the plant, is transpired from the leaves, and enters the atmosphere (Transpiration), or it evaporates from surfaces (Evaporation)

In intercontinental regions, a majority of atmospheric humidity can come directly from the evopotranspired water, which can falls as precipitation

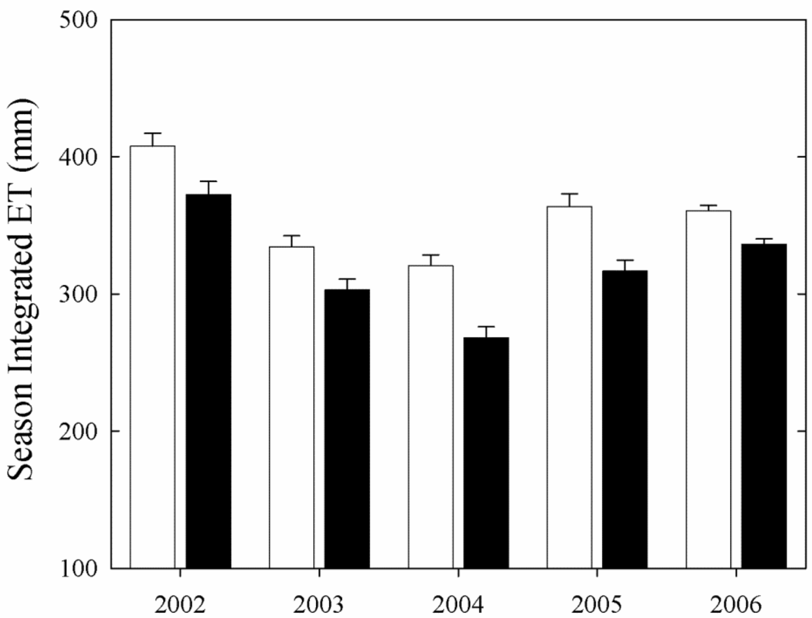
Canopy Temperatures: Maize

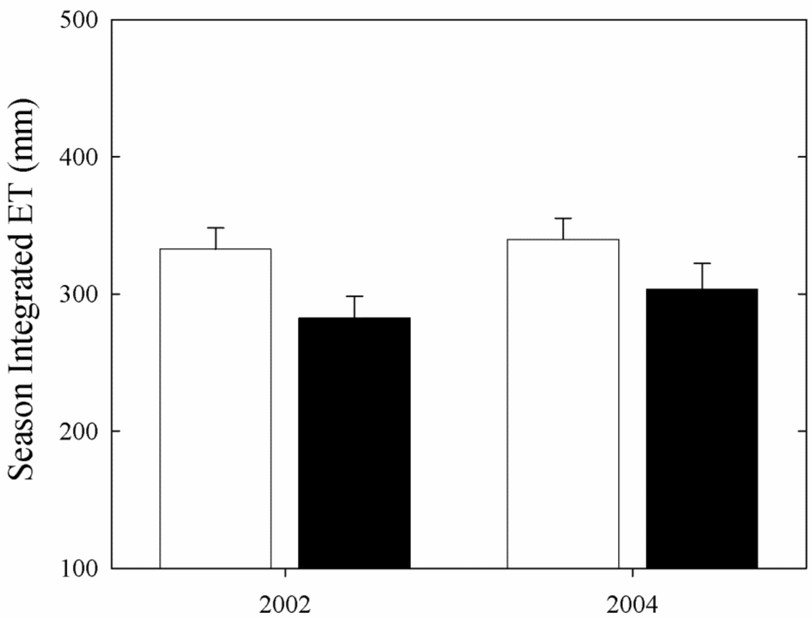


Elevated CO_2 and water use

Soybean

Maize

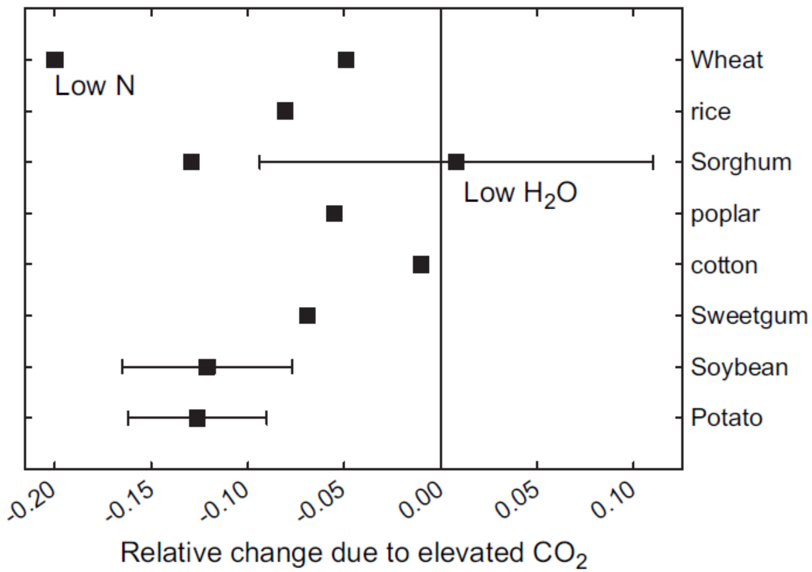


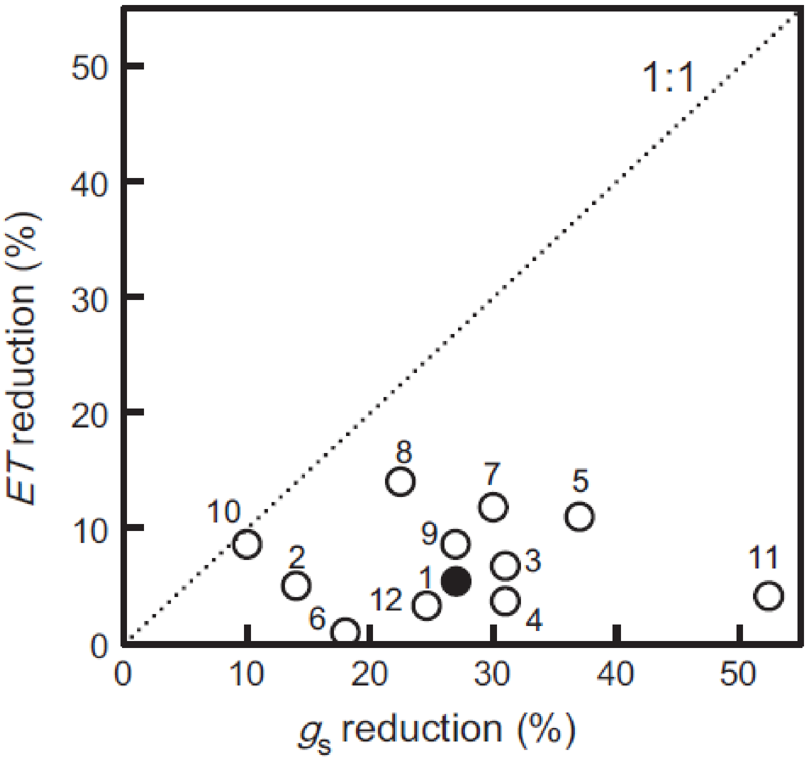


Bernacchi et al., 2007

Hussein et al., 2013

Linkages between g_s and ET

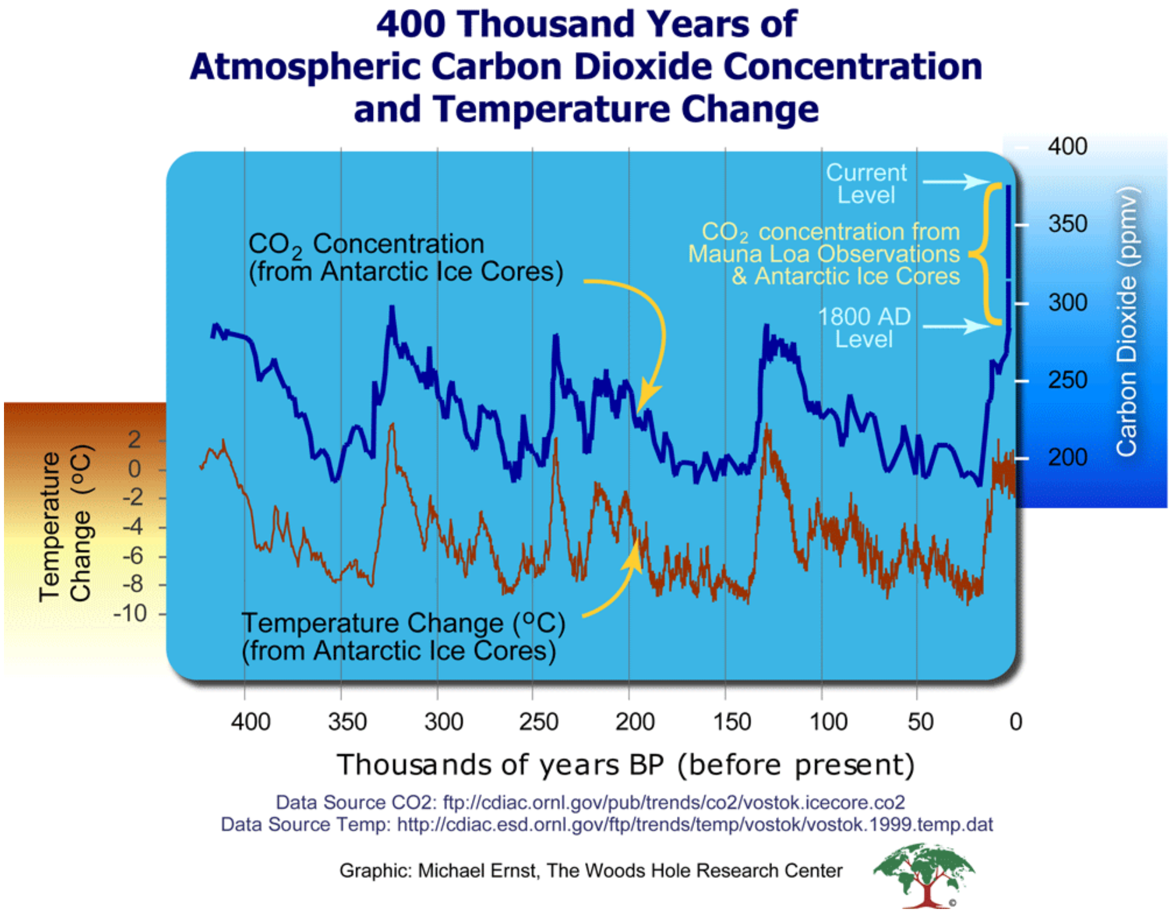




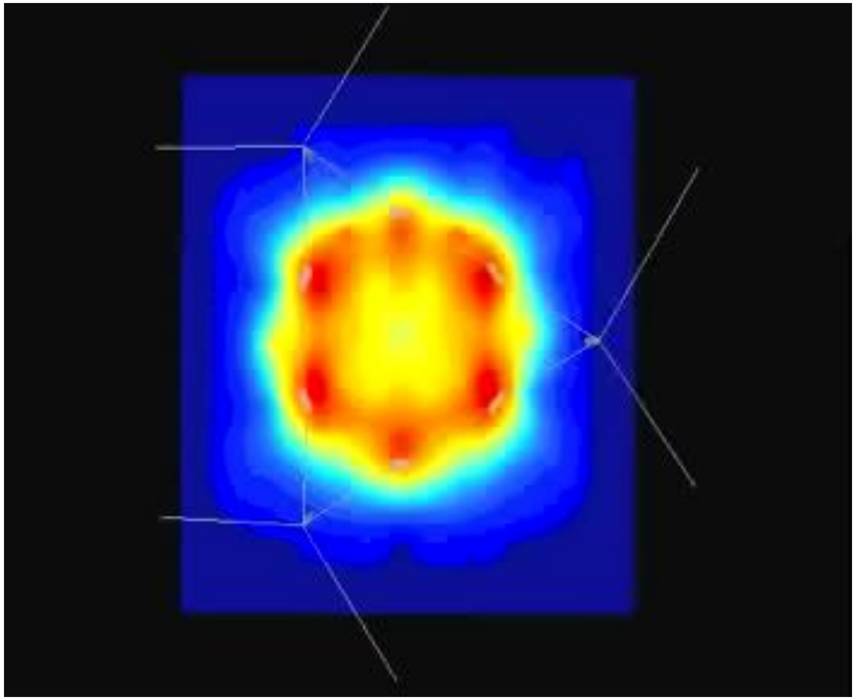
Leakey et al., 2009

Shimono et al., (2013) GCB 19, 2444-2453

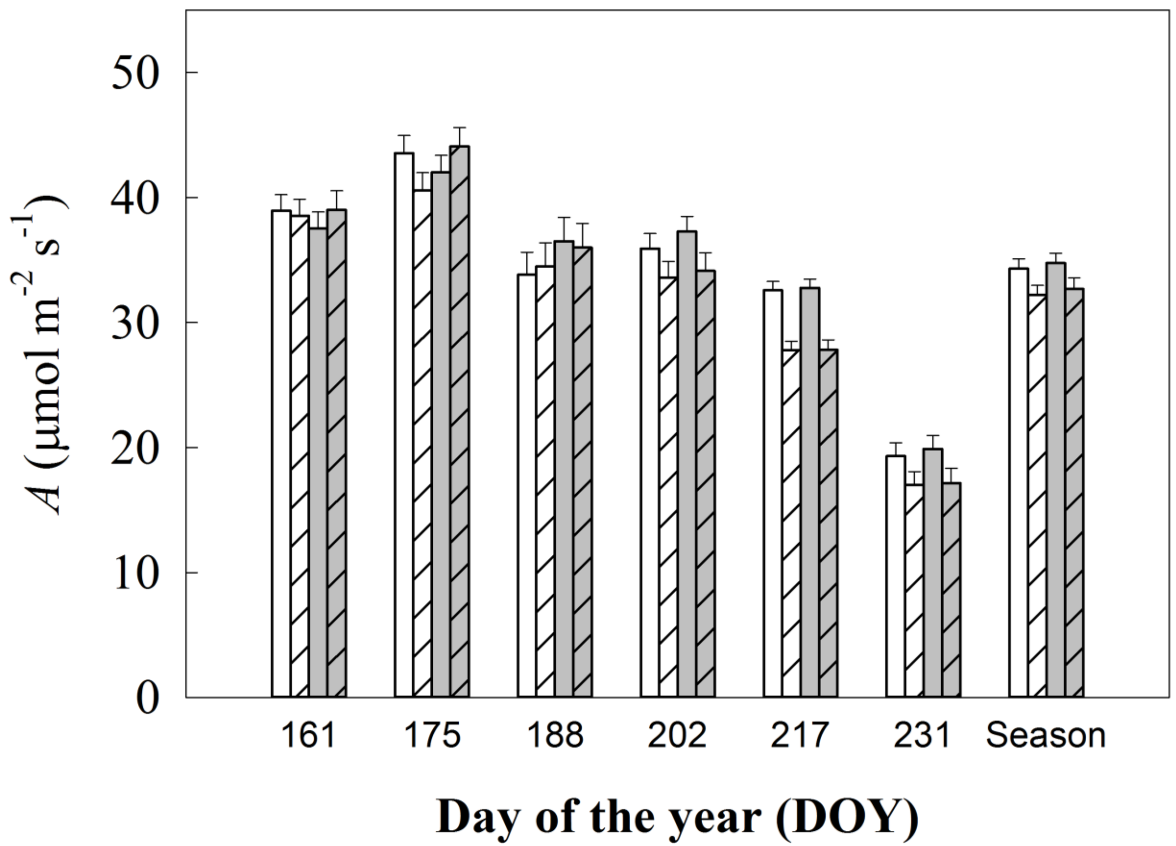
Global Temperatures are linked to CO_2



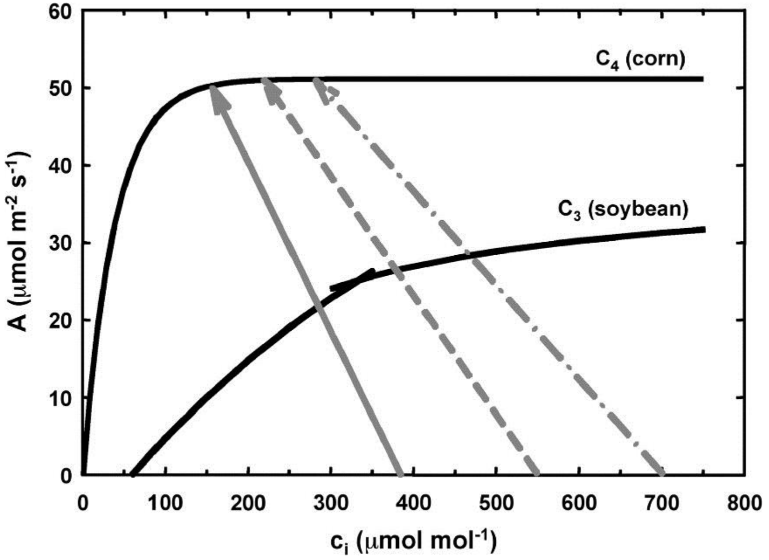
T-FACE: Understanding crop responses to temperature

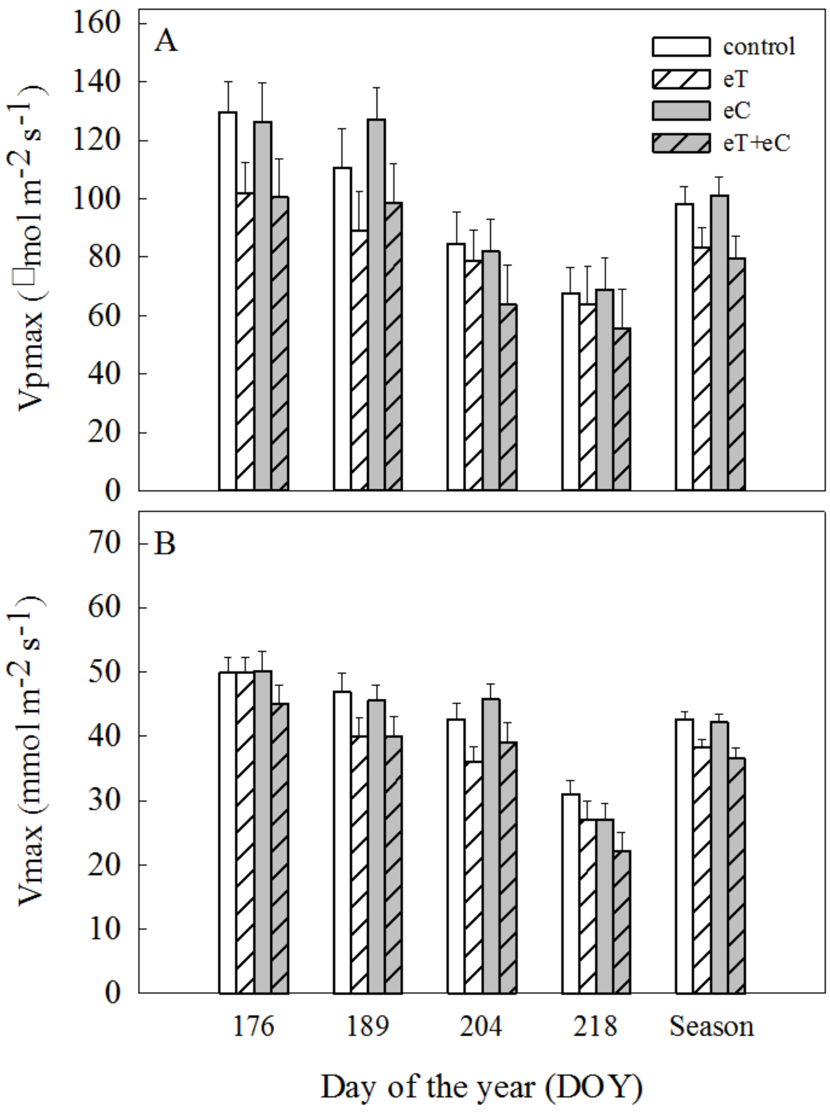


Maize Photosynthesis

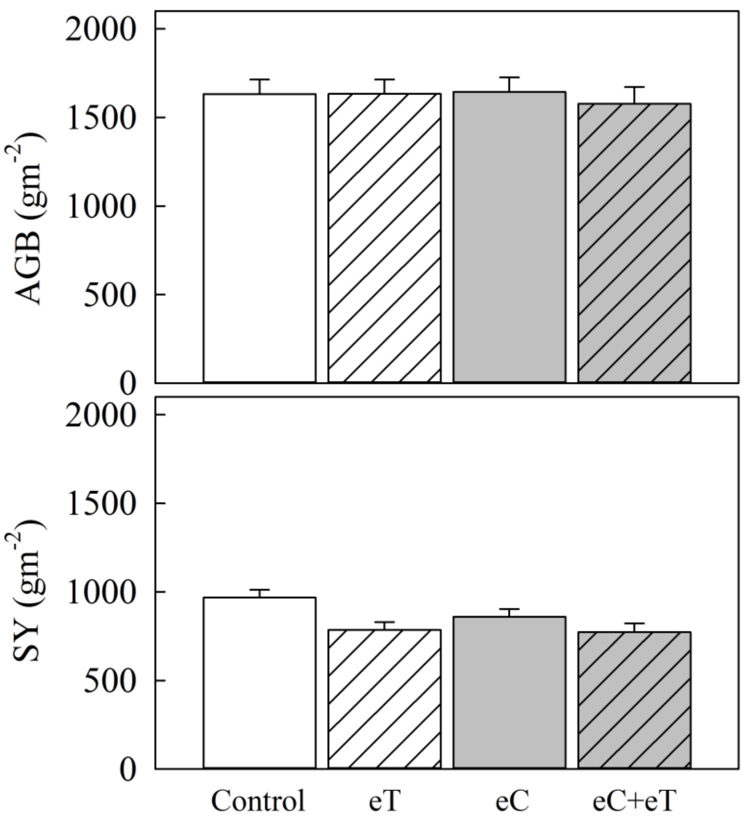


Photosynthetic Acclimation

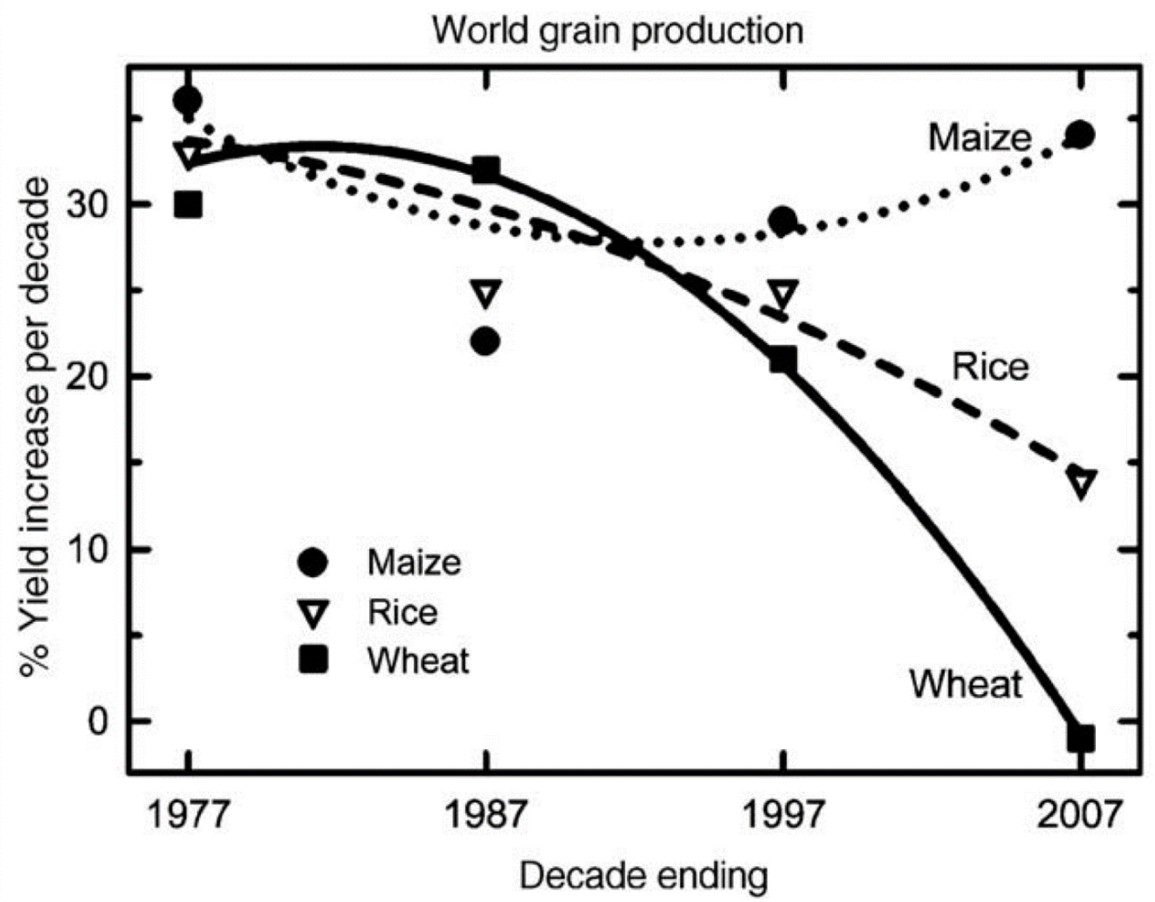




Maize: Biomass and Yield



Adapting Crops to Atmospheric Change



Summary: CO_2 and temperature

- Elevated CO_2
  - No impact on maize yield
  - Decreases water use of major crops
- Higher Temperatures
  - Reduce maize yields
  - CO2 does not "protect" against yield losses from temperature
- Improvements to Photosynthesis
  - Yields decline with temperature and do not increase as much as theoretically possible with rising CO_2
    - We are beginning to understand the physiology behind the responses and identify the opportunities to maximize yields