

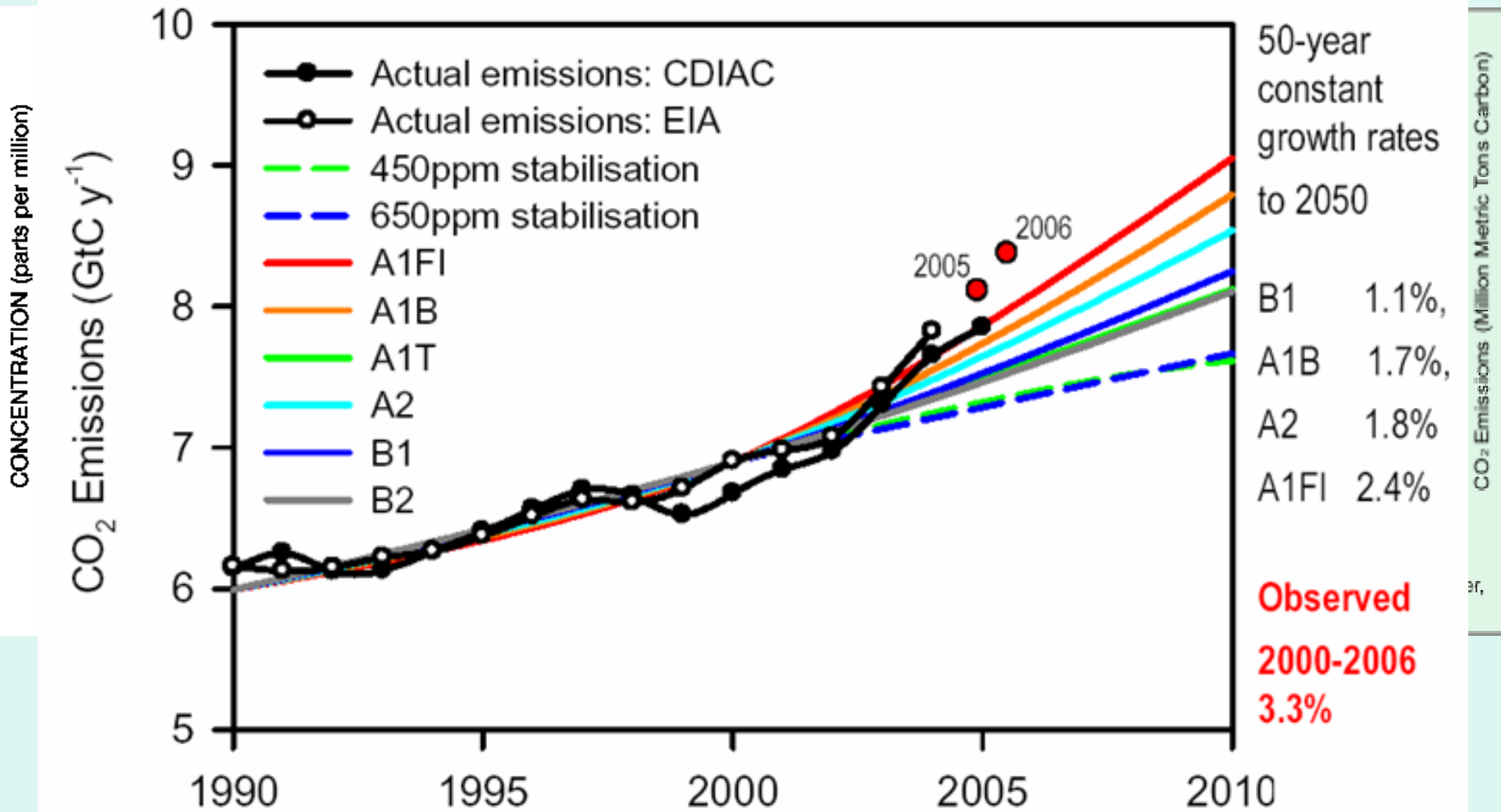
Impacts of climate change / CO₂ on agriculture.



The slowly varying aspects of the atmosphere–hydrosphere–landsurface system. It is typically characterized in terms of suitable averages of the climate system over periods of a month or more, taking into consideration the variability in time of these averaged quantities

From: Glossary of Meteorology

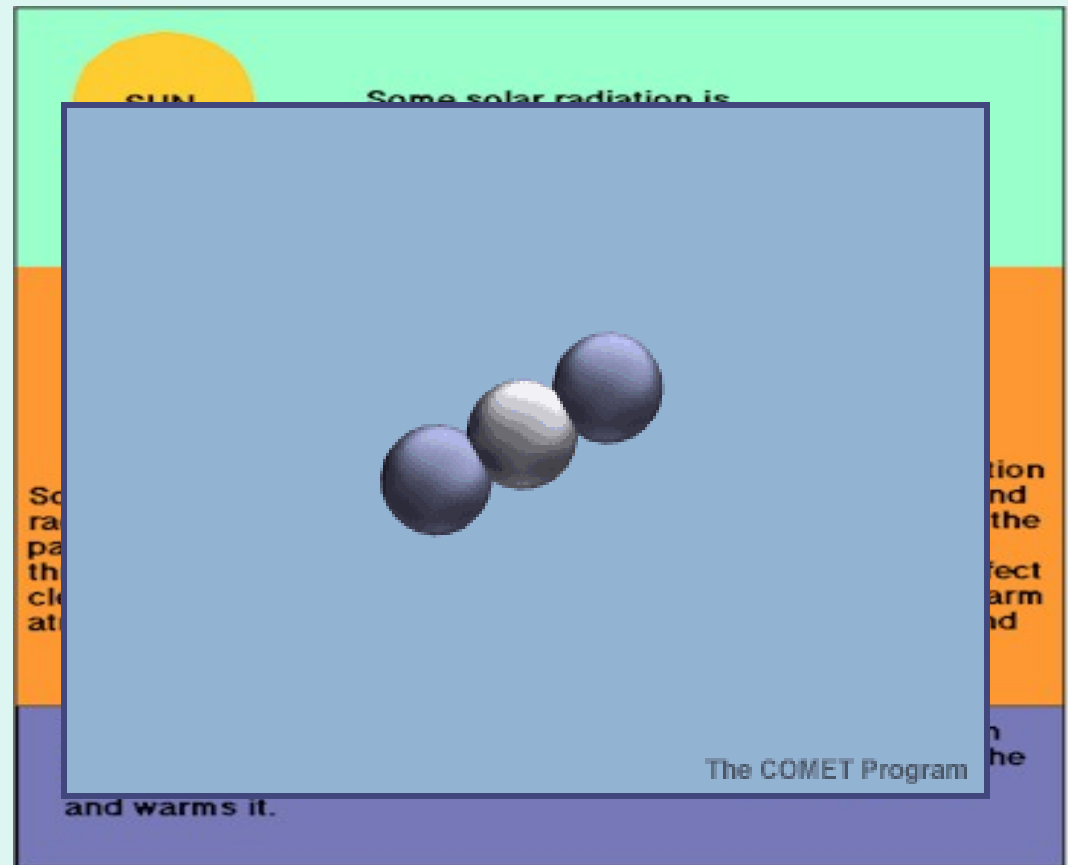
Atmospheric CO₂



So what if CO₂ goes up?

An indirect effect of rising carbon dioxide: warmer temperatures.

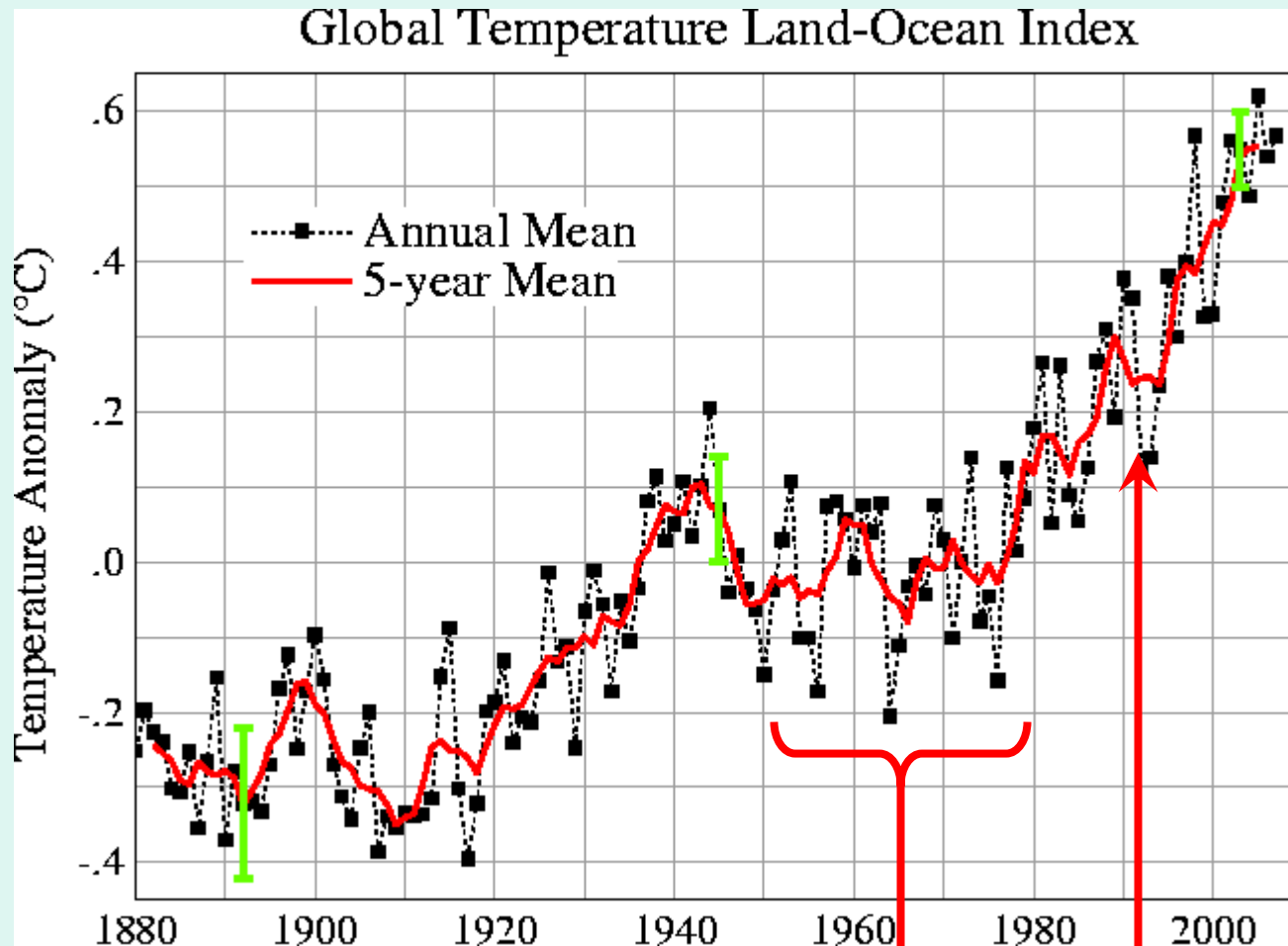
Gas	%
Nitrogen (N ₂)	78.1
Oxygen (O ₂)	20.1
Argon (Ar)	0.93
Carbon Dioxide (CO ₂)	0.038 up to 0.100
Water (H ₂ O)	0.05 to 1.00



No H₂O and CO₂? Surface temperature would be -18°C . With H₂O and CO₂? Surface temperature is 15°C .

Adding CO₂ reduces the amount of heat leaving the atmosphere temporally or spatially where H₂O is low (e.g. poles, deserts, winter, not tropics).

2007 was tied for 2nd warmest year since 1880

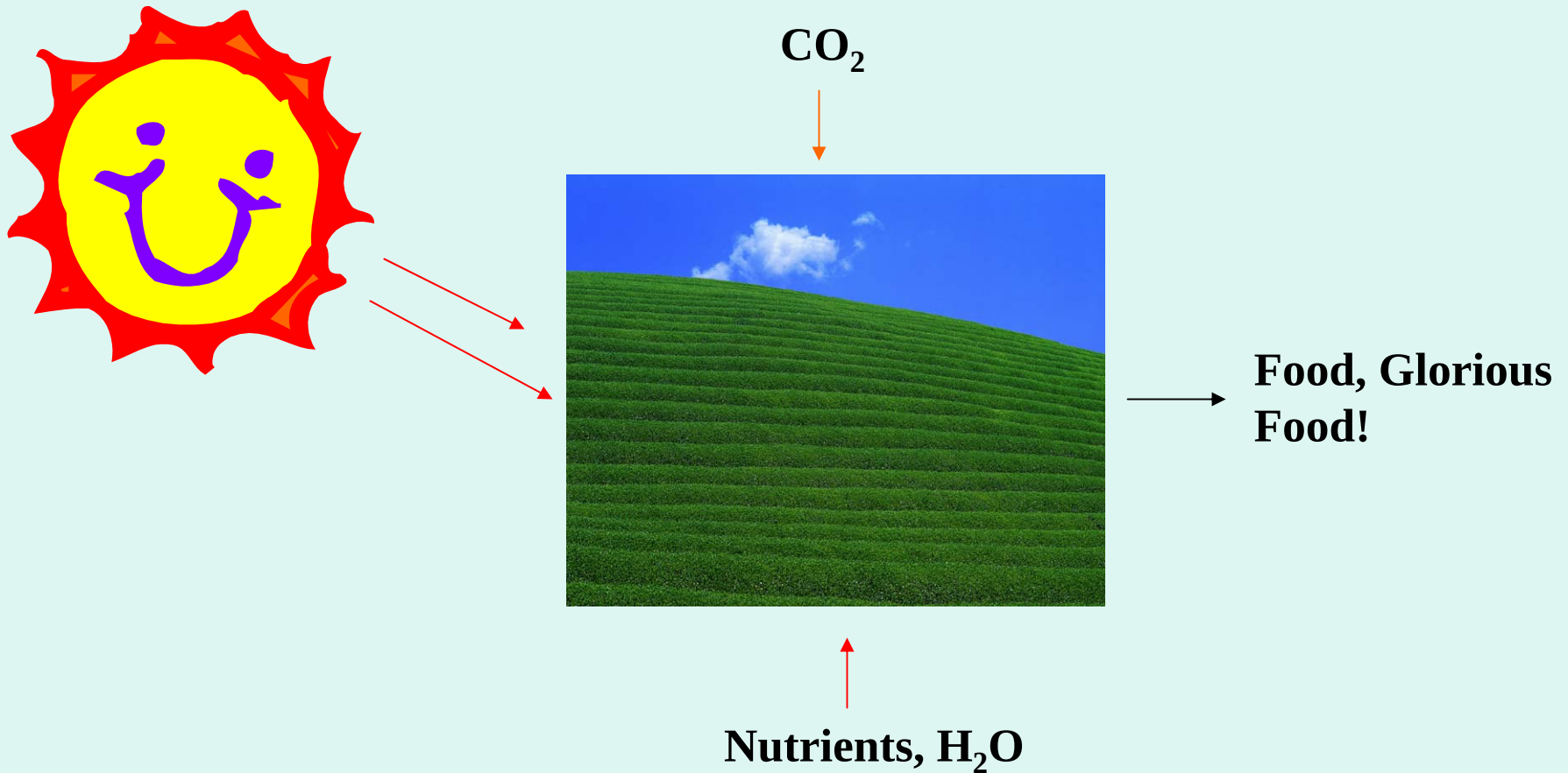


Anomaly is measured
relative to the average in
this period (1951-1980)

Pinatubo
Volcano

2005	.62
1998	.57
2007	.57
2002	.56
2003	.55
2006	.54
2004	.49
2001	.48
1997	.40
1990	.38
1995	.38
1991	.35
1999	.33
2000	.33
1988	.31
1996	.30
1981	.27
1987	.27
1983	.26
1994	.24

A direct effect of rising CO₂: Stimulation of plant growth.



Any change in light, water, nutrients or carbon dioxide will alter plant growth.

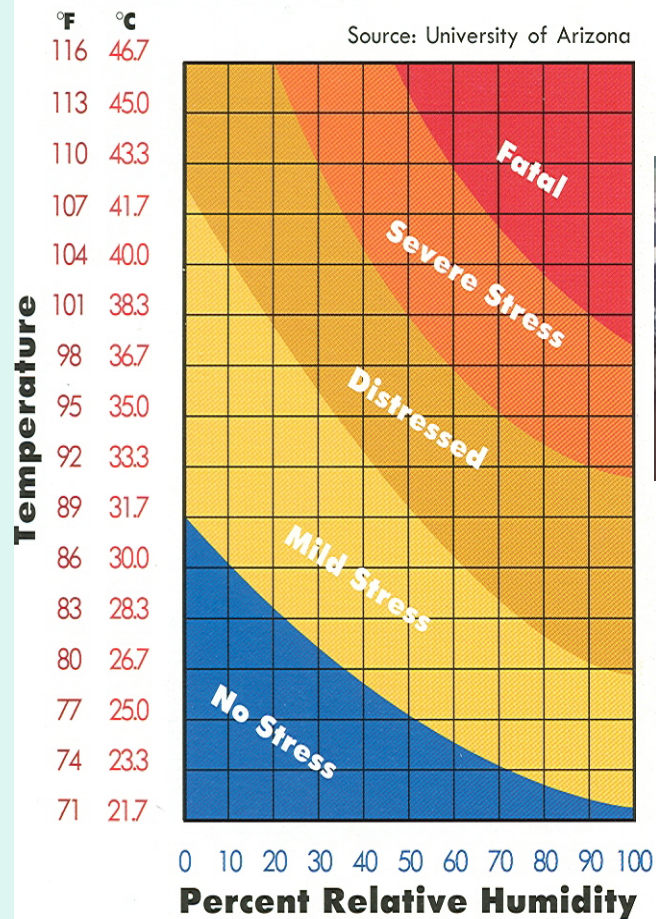
- **As temperature and carbon dioxide change, what are the implications for agriculture?**
- **Temperature**
- **Temperature+CO₂**
- **Water**
- **Agro-ecosystems.**

Temperature:

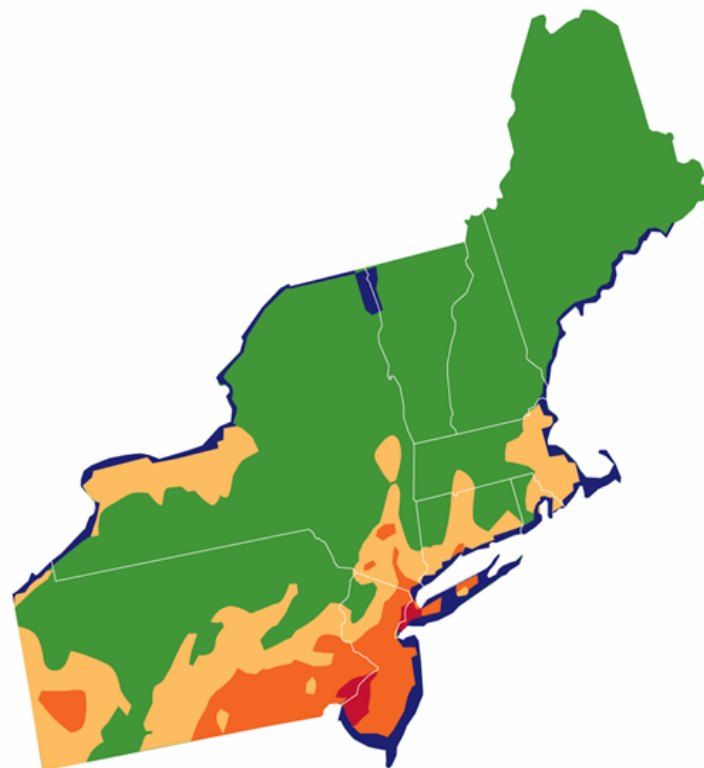
What about dairy production?

Dairy Heat Stress Chart

Source: University of Arizona



To use this chart: Simply match up the temperature on the vertical scale with the day's relative humidity on the horizontal scale.



0-10% decline
10-15% decline
15-20% decline
>20% decline
no data

www.climatechoices.org/ne/

Estimated decline in dairy production with IPCC BAU projections.

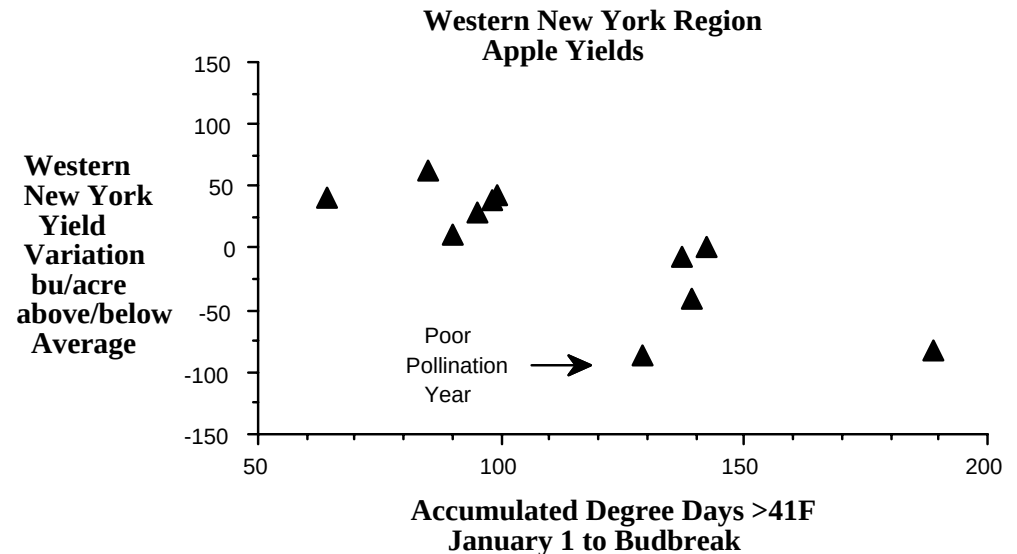
Temperature:

What about crop production?



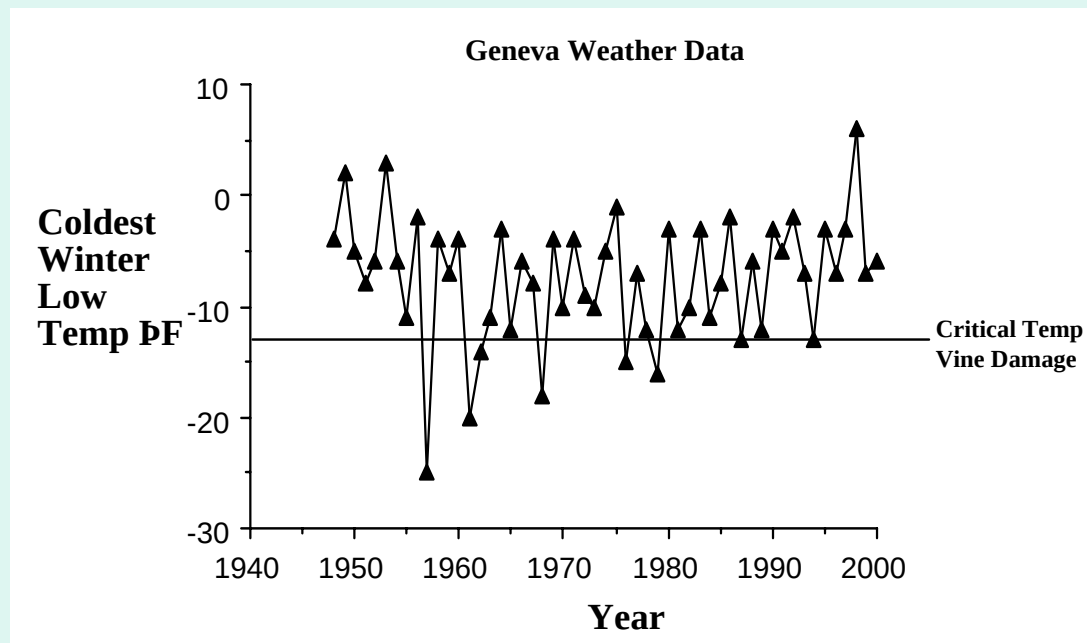
Apple flowering is negatively impacted by warmer temperatures.

Warmer winters mean less fruit set.



Temperature:

Warmer winters may benefit European wine grapes (*V. vinifera*) by reducing winter damage to roots and vines

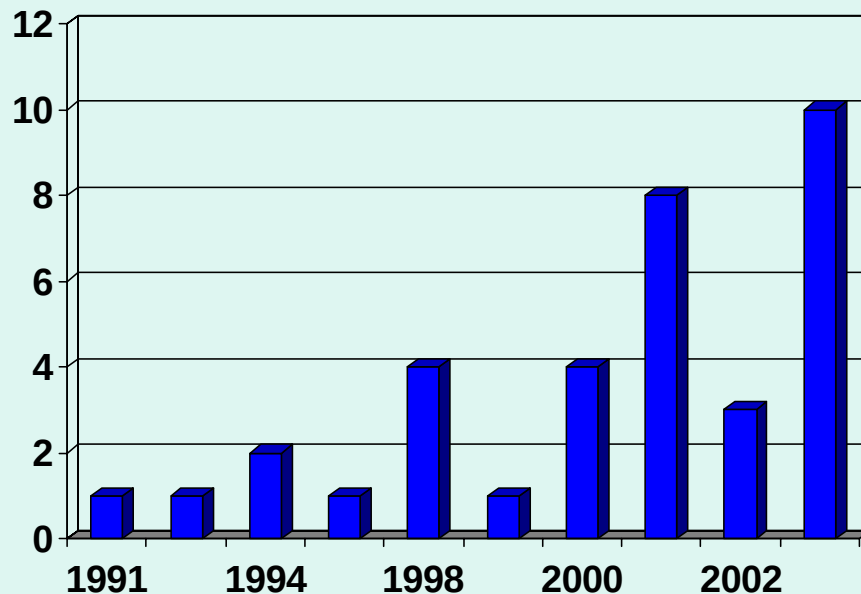


Source: A. Lakso, Cornell

Opportunities for warm season crops could occur

Temperature:

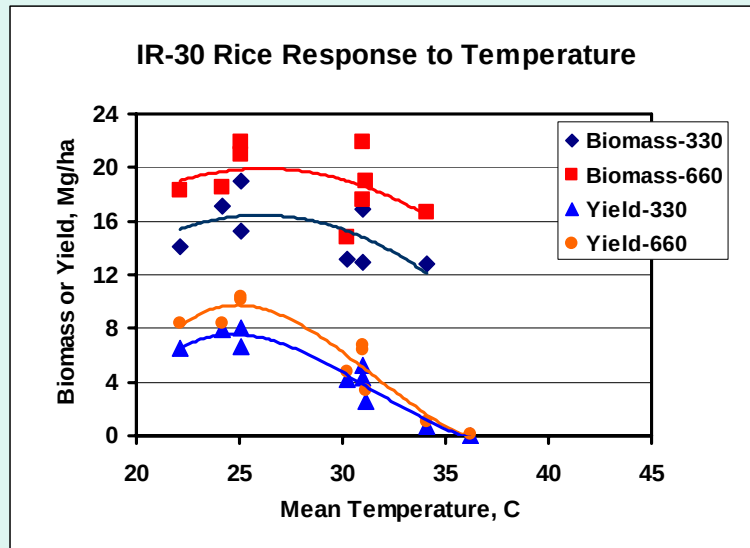
What about crop production?



Number of days per year in Wuhan, China where minimum temperature exceeded 30°C.

Data from IRRI (Peng et al. 2004, PNAS) indicate that grain yield may decline by ~10% for each 1°C increase in minimum temperature *in situ*.

Rice yield if CO₂ and temperature increase simultaneously.



Hartwell Allan Data

Difference relative to ambient CO₂

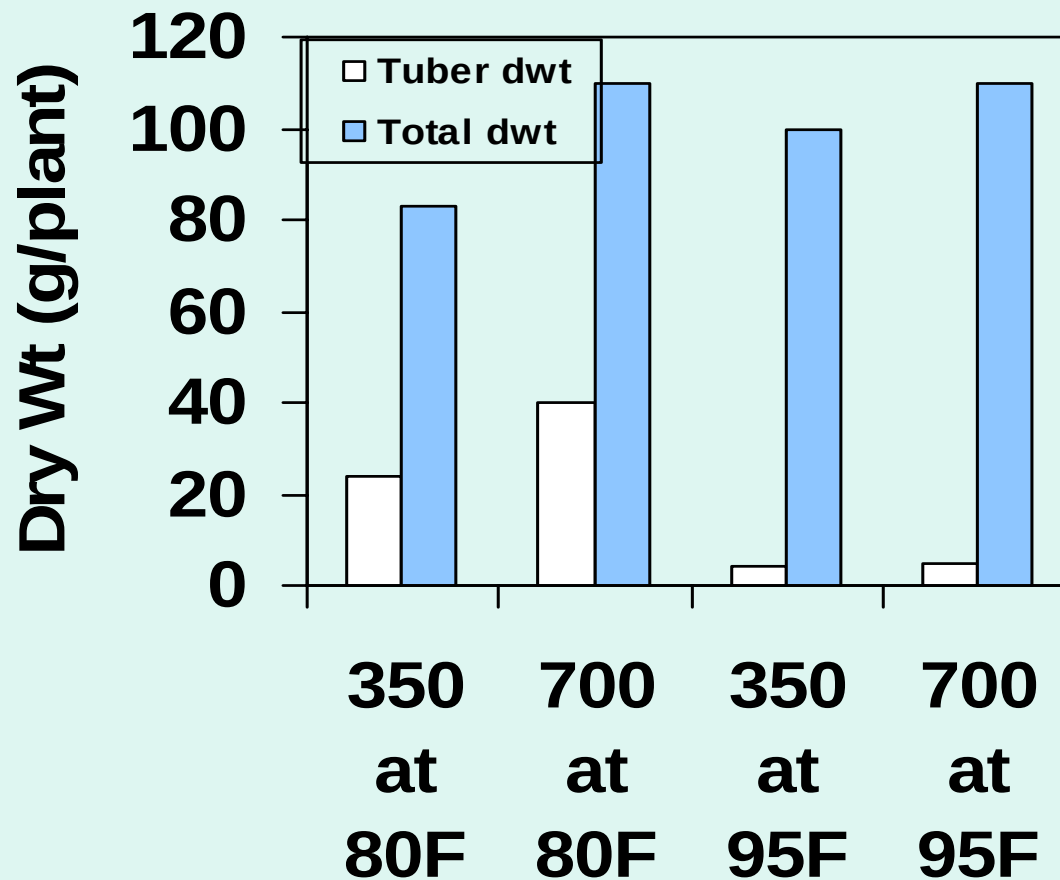
CO₂ Alone:	+200 ppm	+300 ppm
Wet Season	0.3 Mg Ha ⁻¹	0.9 Mg Ha ⁻¹
Dry Season	1.2 Mg Ha ⁻¹	1.4 Mg Ha ⁻¹
CO₂ + 4°C:	+200 ppm	+300 ppm
Wet Season	-0.5 Mg Ha ⁻¹	-0.7 Mg Ha ⁻¹
Dry Season	0.1 Mg Ha ⁻¹	0.5 Mg Ha ⁻¹

Ziska et al. 1997, Agron J. 89:45.

Winter Wheat (cv. Mercia): Temperature and CO2 Response

<u>Yield Component</u>	<u>Ambient T 350 CO2</u>	<u>Ambient T 700 CO2</u>	<u>+ 7 F 350 CO2</u>	<u>+ 7 F 700 CO2</u>
Grain Yield (g/m2)	1173	1361	957	1087
mg/grain	41.4	39.0	49.9	54.5
Ears/m2	896	1088	816	949
Grains/ear	32.0	32.3	23.6	21.2

Potato Biomass and Yield Response



Mountains / Snow / Water / Irrigation

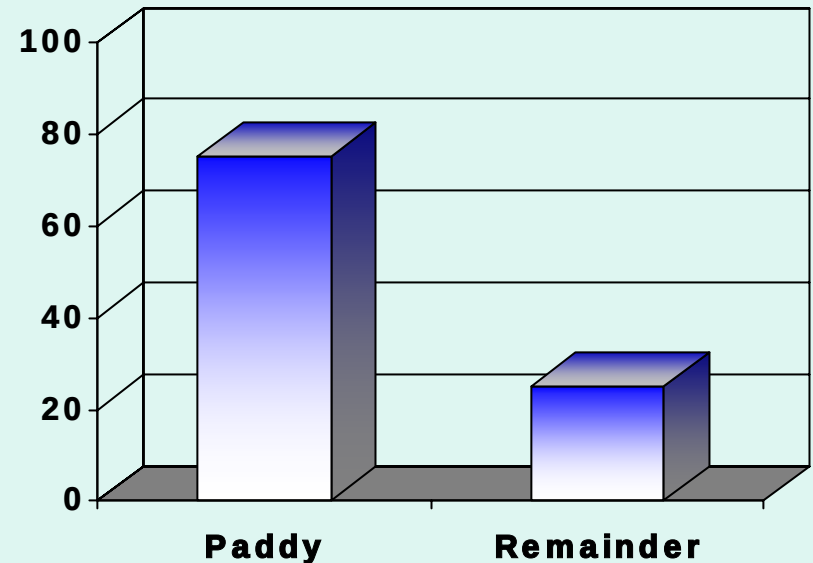


California supplies ~50% of fresh fruits and vegetables for the United States. It can only supply these commodities through irrigation.

Global Agriculture

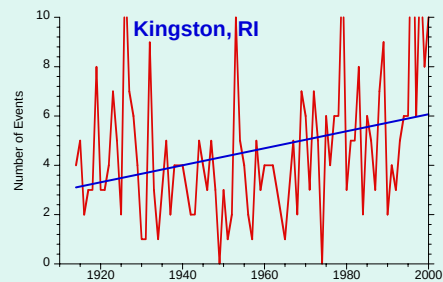
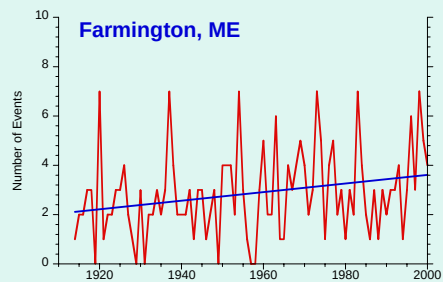
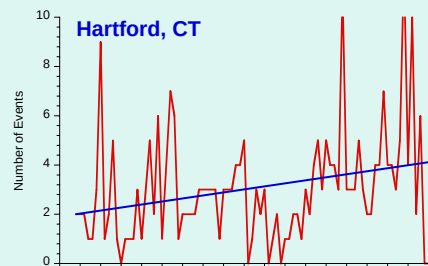
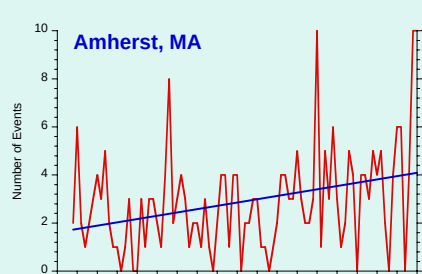


- *Irrigated rice makes up 75% of global rice production.*
- *No water. No rice.*



Water:

Extreme Precipitation Events (>2 in in 48 hrs)



Too much, too fast?



Increased frequency of wet winters may exacerbate invasion

Blumenthal, Chimner, Welker and Morgan. 2008. New Phytologist



- Added snow led to invasion by several forbs in otherwise invasion resistant upland prairie.
- By comparison, addition of summer water or N had relatively minor effects on invasion.

Diffuse knapweed



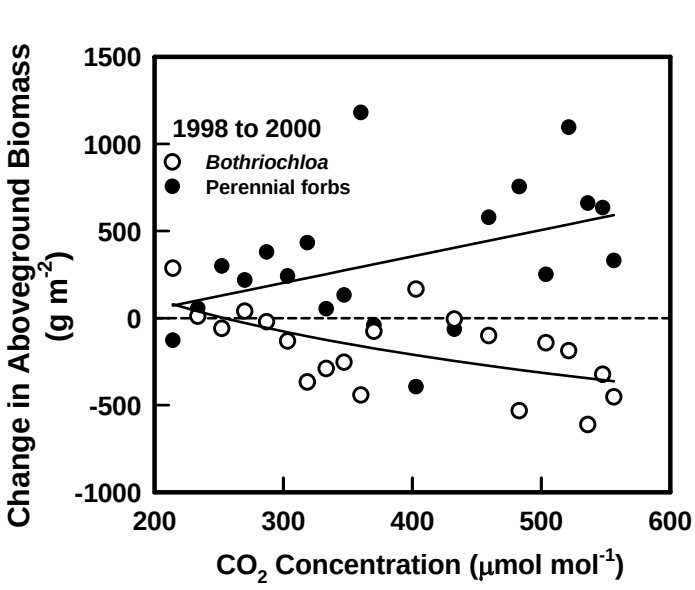
Dalmatian toadflax



Baby's breath

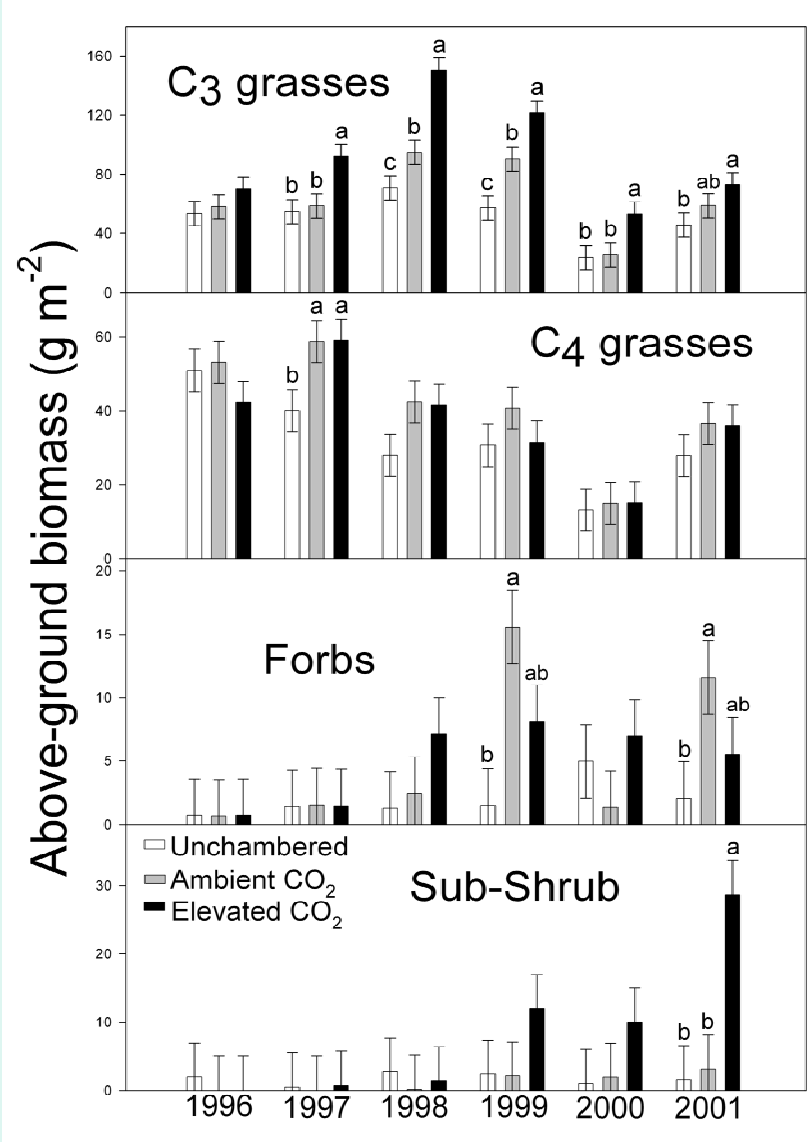


Species Diversity in Rangelands



Sub-Shrub (*Artemisia frigida*)
only group to exhibit temporal
trend of increased production

A 40-fold increase in 5 yrs



Greater selection for invasive species

Does rising carbon dioxide favor invasive weeds within the plant community?

Species	Community	Favored?	Reference
Yellow star thistle	California grassland	Yes?	Dukes, 2002
Honey mesquite	Texas prairie	Yes.	Polley et al. 1994
Japanese honeysuckle	Forest under-story	Yes.	Belote et al. 2003
Cherry laurel	Forest under-story	Yes.	Hattenschwiler & Korner 2003
Red Brome	Desert	Yes.	Smith et al. 2000

What about diseases and insects?

Weed Control

Ambient CO₂

Future CO₂



Increasing CO₂ reduces herbicide efficacy.

e.g. Ziska et al. *Weed Science* 52:584-588, 2004

How will beneficials respond to climate change?



Impacts of Climate Change

- Temperature effects on crop production may negate any positive effect of rising carbon dioxide. However, may increase opportunities for warm season crops in northern latitudes.
- A more intense hydrological cycle. Distribution of rainfall events geographically, changes in precipitation temporally.
- Uncertainty with respect to future water supply and sustainability of that supply.
- Changes with respect to species diversity, with initial experiments suggesting a greater advantage to invasive species and possible reduced biological diversity.
- Reduced efficacy in chemical control of invasive and agronomic weeds.
- Uncertainty in the impacts on insects and pests (both good and bad).

In addition:

Concerns regarding decision support systems. Will models of the past be useful in the future?

How will diverting corn to biofuels affect agricultural productivity?

What are the links between agriculture, climate change and health? (e.g. nutritional changes, food security, increased pesticide use).

Finally, this:

Investment in Agricultural Research.

