Warming and the Global Harvest

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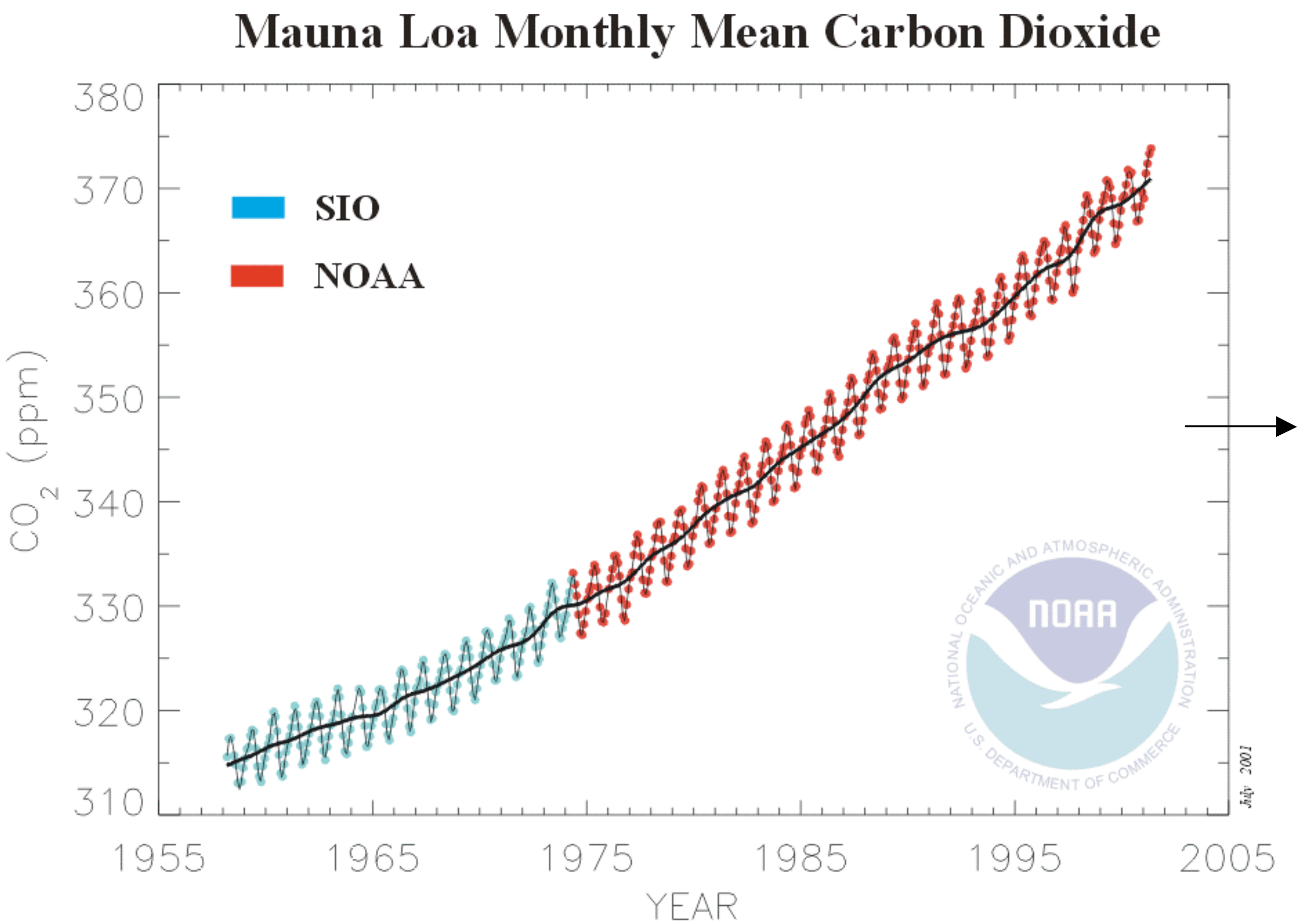
Outline

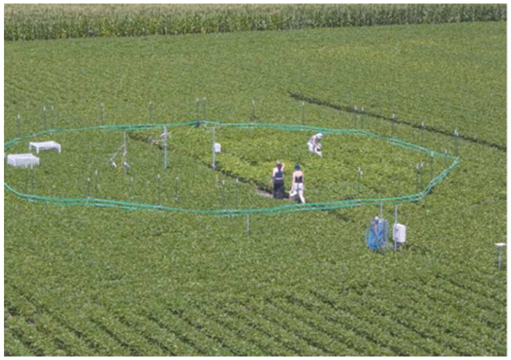
- Impacts
- Feedbacks
- Adaptations

Impacts

Impacts are largely driven by 2 opposing factors: CO_2 and Climate



100s of CO_2 response studies



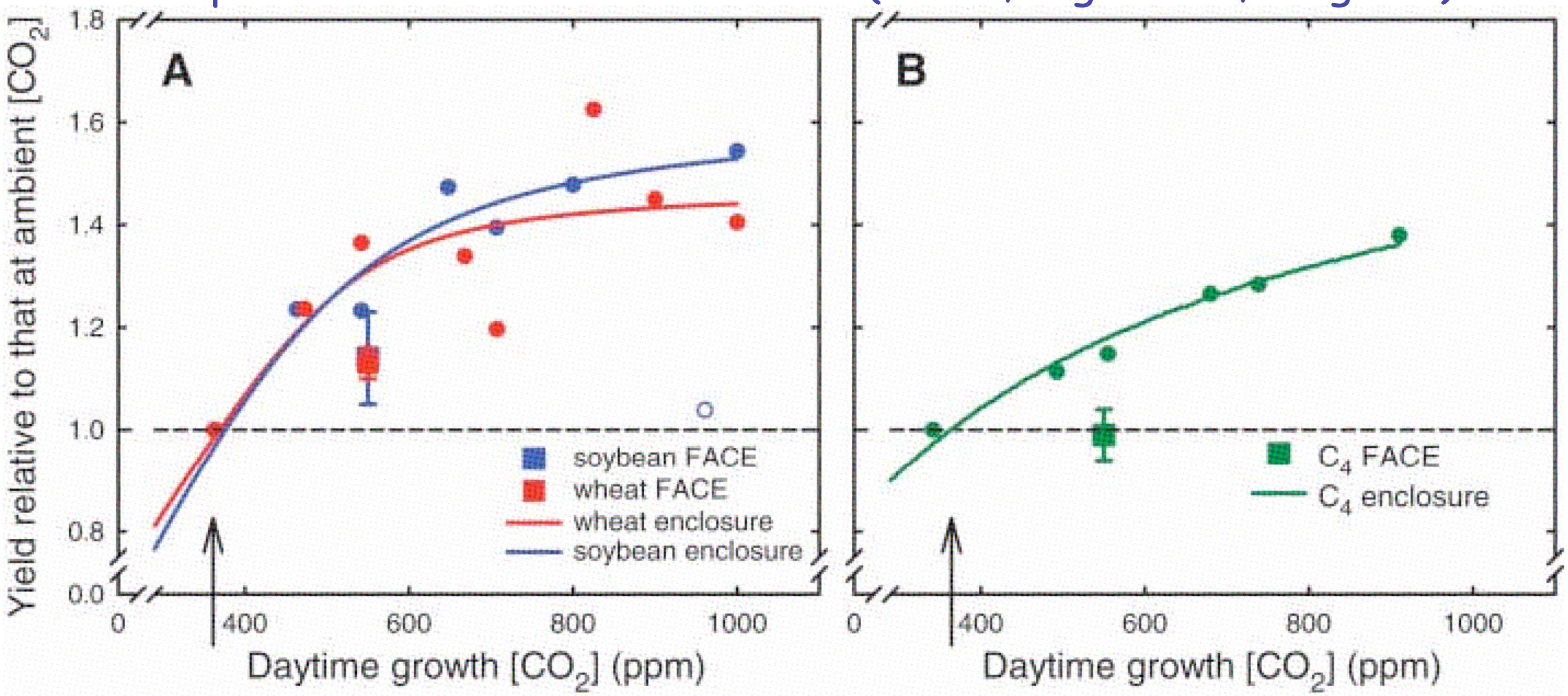
Impacts

Impacts are largely driven by 2 opposing factors: CO_2 and Climate

-CO_2 enhances crop growth and yield

~17% increase for C3 crops at 550pm

~6% increase for C4 crops (maize, sugarcane, sorghum)



Long et al. 2006, *Science*

Impacts

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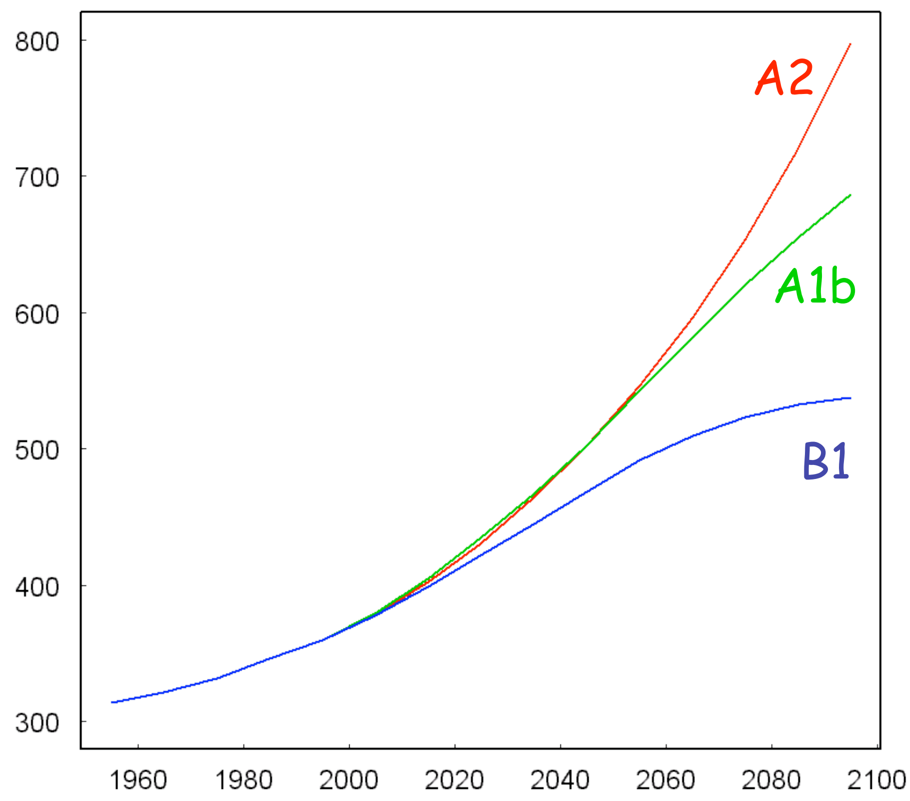
Future CO_2 for several emission scenarios



Impacts

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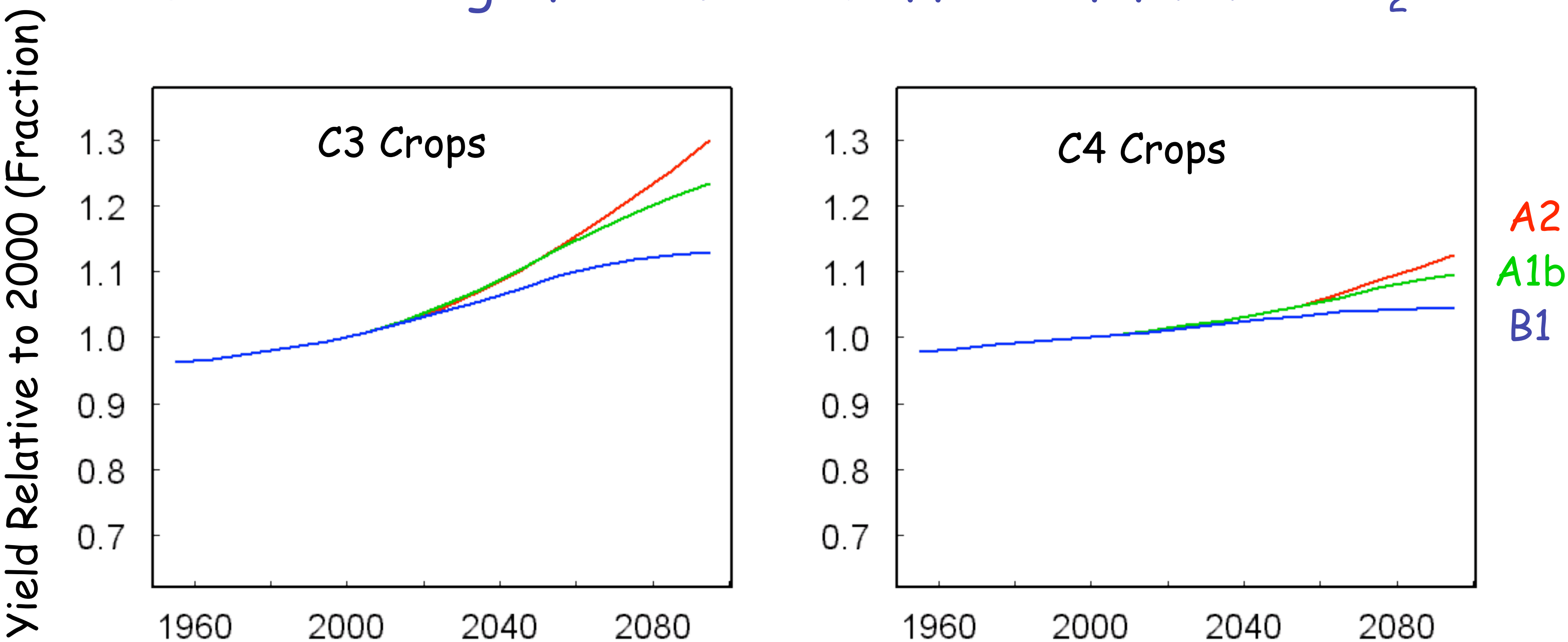
Global average fertilization effect of future CO_2



Impacts

Impacts are largely driven by 2 opposing factors: CO_2 and Climate

-Warming reduces crop yields in most regions

C3 crops: ~6% yield loss per °C

C4 crops: ~8% yield loss per °C (Lobell and Field, 2007, *ERL*)

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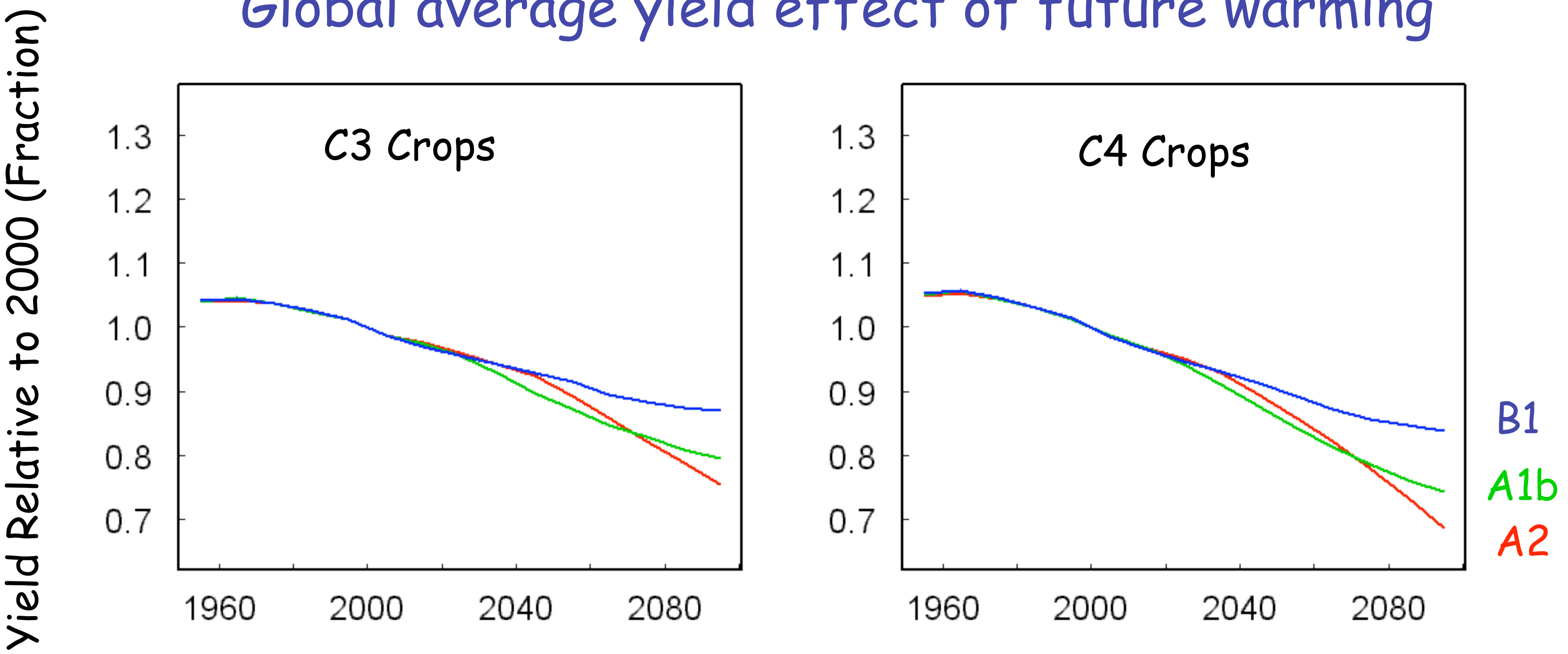
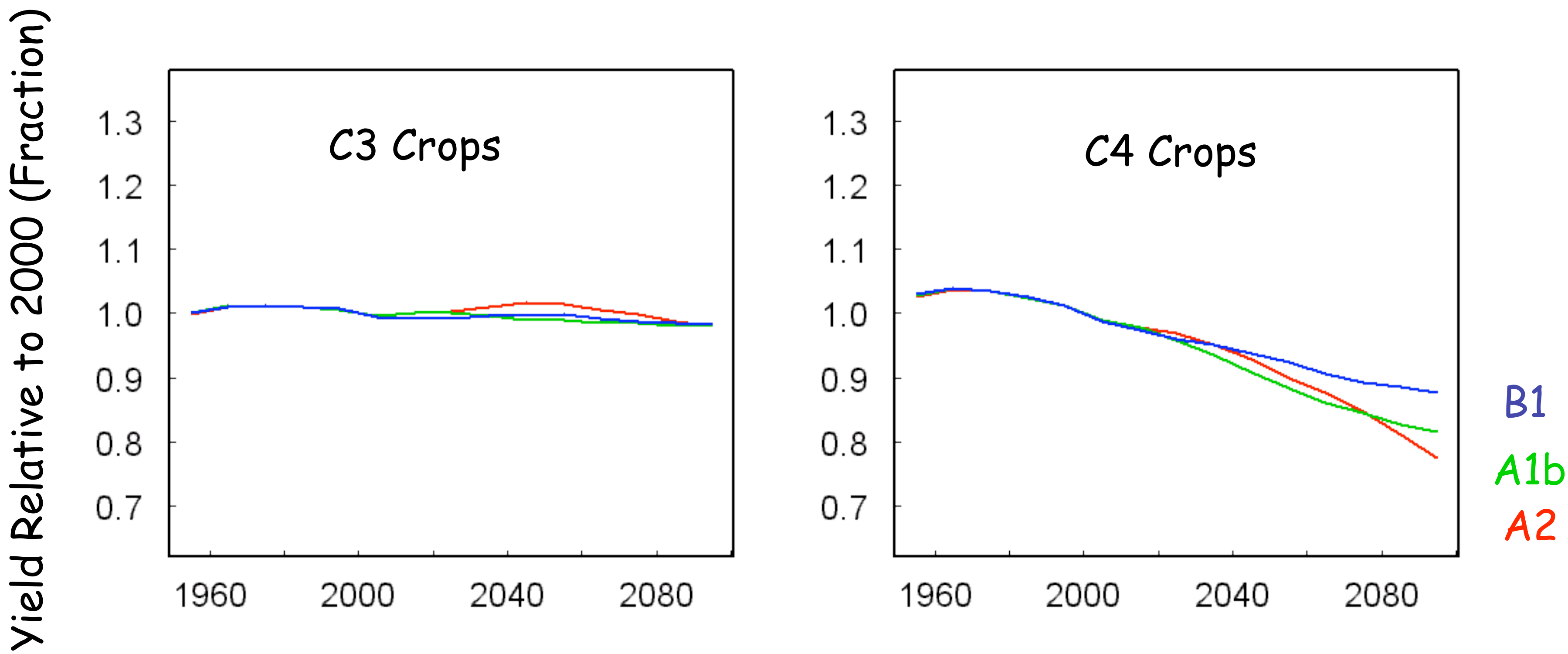
Global average yield effect of future warming



Impacts

Global average combined effect of future warming + CO_2



Impacts

This balancing of CO_2 and warming effects until ~2050 (or ~2° C) underlies most global assessment models, although assumptions about climate, crops, and adaptations can affect the details.

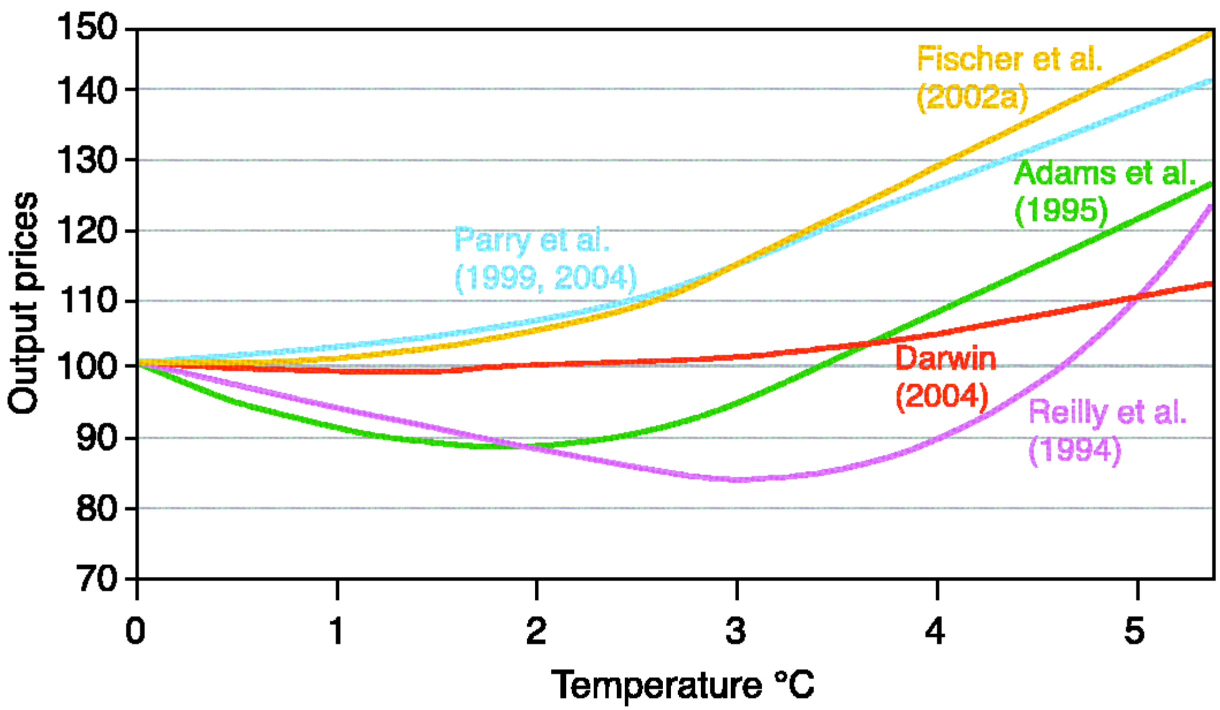


Figure 5.3. *Cereal prices (percent of baseline) versus global mean temperature change for major modelling studies. Prices interpolated from point estimates of temperature effects.*

IPCC, AR4, 2007

Impacts

Impacts of other climate aspects are less certain and often not modeled, but probably negative:

-Rainfall
-Flooding
-Extreme heat events
-Pests and weeds
-Loss of irrigation water sources

"Glaciers in the Himalaya are receding faster than in any other part of the world and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate." IPCC AR4, WGII

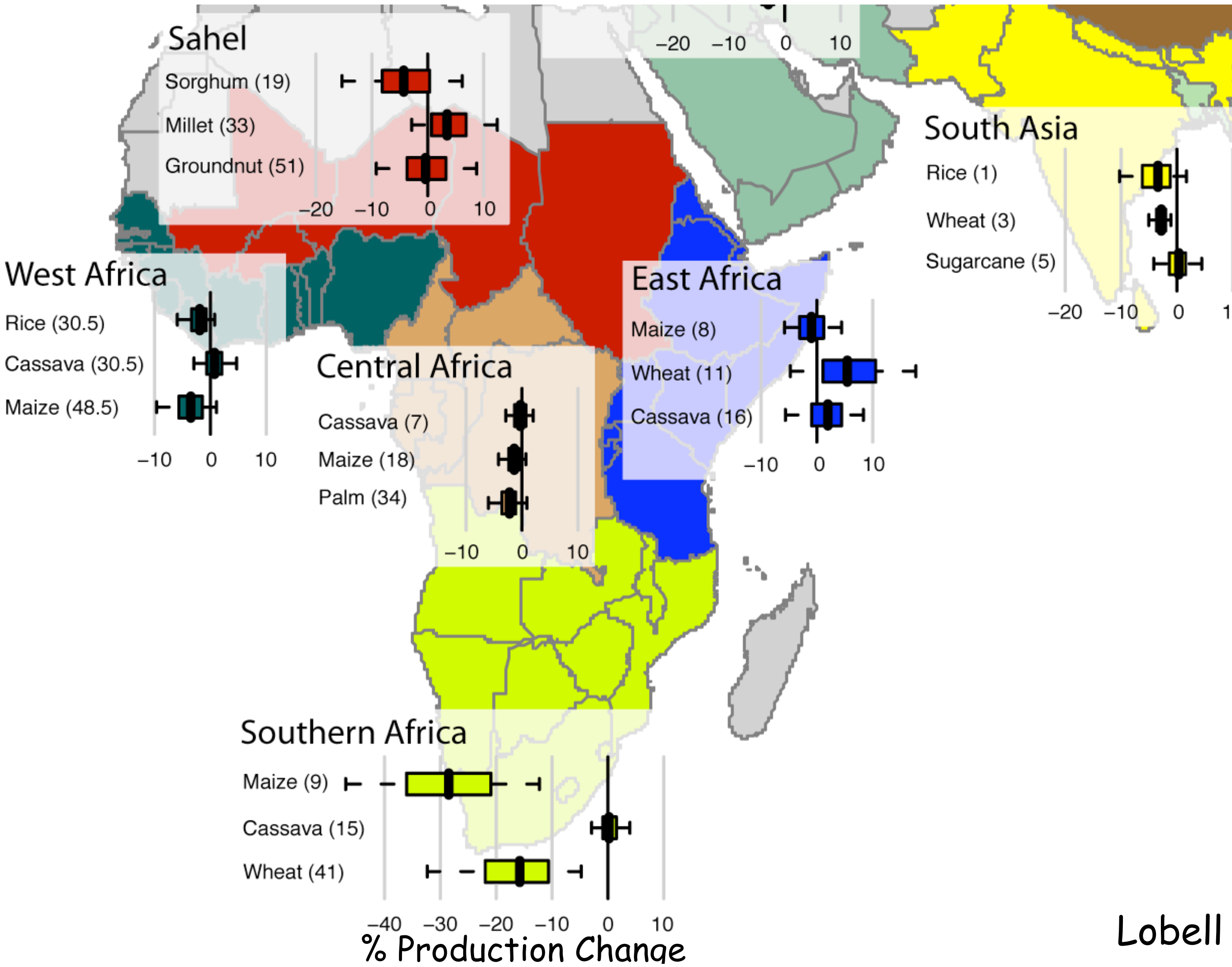
Table 10.9. *Record of retreat of some glaciers in the Himalaya.*

Glacier	Period	Retreat of snout (metre)	Average retreat of glacier (metre/year)
Triloknath Glacier (Himachal Pradesh)	1969 to 1995	400	15.4
Pindari Glacier (Uttaranchal)	1845 to 1966	2,840	135.2
Milam Glacier (Uttaranchal)	1909 to 1984	990	13.2
Ponting Glacier (Uttaranchal)	1906 to 1957	262	5.1
Chota Shigri Glacier (Himachal Pradesh)	1986 to 1995	60	6.7
Bara Shigri Glacier (Himachal Pradesh)	1977 to 1995	650	36.1
Gangotri Glacier (Uttaranchal)	1977 to 1990	364	28.0
Gangotri Glacier (Uttaranchal)	1985 to 2001	368	23.0
Zemu Glacier (Sikkim)	1977 to 1984	194	27.7

Impacts

Impacts will be vary large in some regions, even in the next 20-30 years

2030 Impacts of Temperature and Rainfall Changes on top 3 crops, by region (with no adaptation)



Lobell et al., 2007

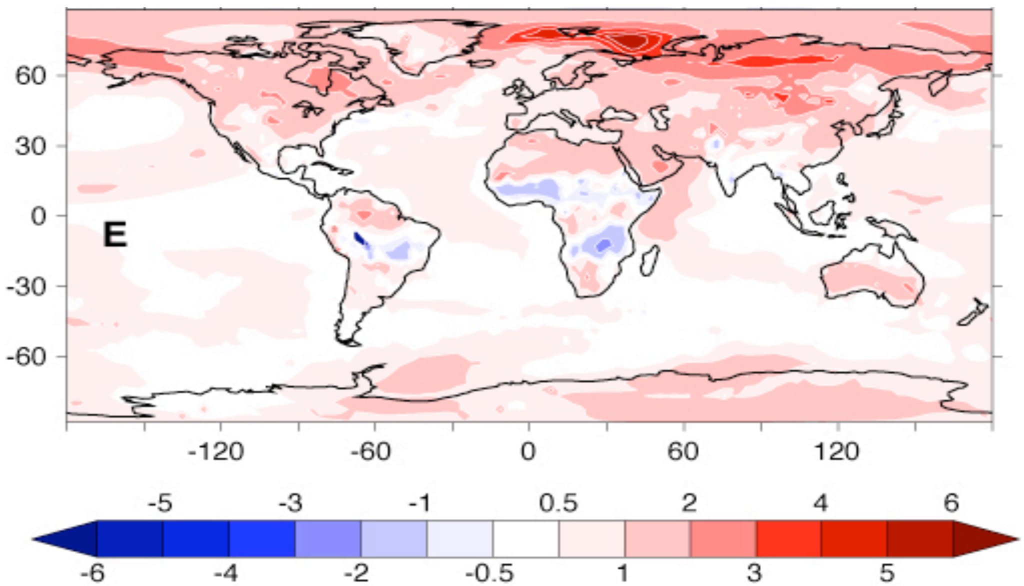
Feedbacks

1) Crop area expansion to cope with lower yields could amplify climate change

-Most likely areas for expansion are Latin America and Africa (FAO)

-Deforestation in these regions tends to promote warming

Simulated effect of tropical (20°S-20°N) deforestation



ΔTemperature (°C)

Bala et al., 2007, *PNAS*

Feedbacks

2) Crop area expansion to cope with biofuel demand could amplify climate change

In 2006, 14% of U.S. corn went to ethanol production. USDA expects this number to reach 30% by 2009.

Higher demand for biofuels will likely drive up food prices and, as a result, expansion of crop area into forests
(1 tank of corn ethanol ≈ Grain to feed 1 person for 1 year)

Cellulosic ethanol may soon be viable, but potential supply from non-agricultural, non-forest lands is only ~5% of global fossil fuel consumption.

Adaptation

In theory, many changes will happen to adapt agriculture to climate change

Autonomous adaptation:
✓Adjust planting dates
✓Switch to later maturing varieties
✓Switch to more heat-tolerant crops
✓Shift into new regions
✓Increase irrigation, promote soil water retention
✓Diversify farm incomes

Planned adaptation:
✓Develop new varieties
✓Add irrigation infrastructure

Most assessments (including IPCC) assume a significant amount of adaptation will occur

Adaptation

In practice, adaptation may be slow and difficult because of:

- ✓ Difficulty of recognizing trends in the midst of large year-to-year variability
- ✓ Large up-front expenses
- ✓ Time and difficulty of developing new varieties
- ✓ Risk that adaptations won't be effective or necessary

Investments in agricultural research typically take 15+ years until large benefits are apparent

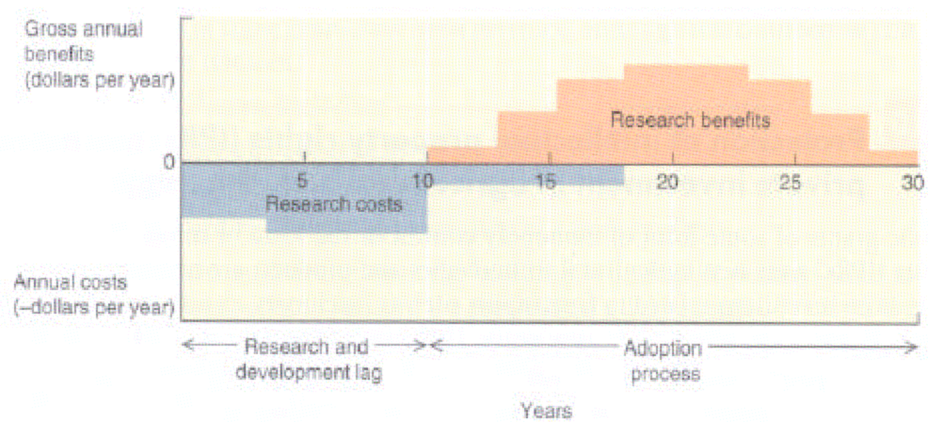


Figure 2.13 Flows of research costs and benefits. Notice that at the start (left) the costs exceed the benefits, and that after a lag of several years the benefits come on line. *Source:* J. M. Alston, M. C. Marra, P. G. Pardey, and T. J. Wyatt (2000), *A Meta Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem?* IFPRI Research Report No. 113 (Washington, DC: International Food Policy Research Institute).

Summary

✓Rising CO_2 provides some benefits for agriculture, but the global negative effects of climate changes are likely to outweigh these after ~550 ppm (mid-century).

✓Large regional changes will occur well before this point, with negative impacts in Southern Africa and South Asia the most pressing.

✓Land use changes to cope with impacts are likely to amplify further warming.

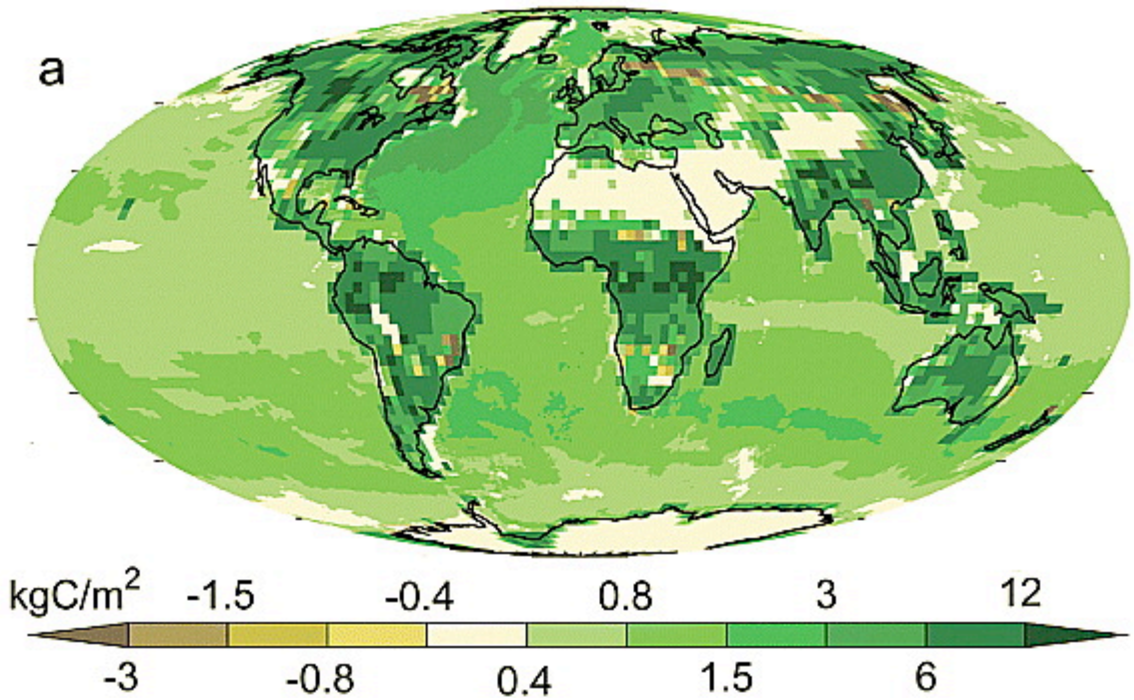
✓The biggest uncertainty for 2050 is how much we will adapt. Adaptations are possible to avoid some (most?) of the projected impacts, but they will not be easy.

Feedbacks

3) Crop area expansion, even in the absence of climate change, will modify other ecosystem feedbacks

-Most current climate models explicitly or implicitly assume significant uptake of carbon in tropical ecosystems, but ignore potential land use changes

Simulated uptake of anthropogenic carbon, 1870-2100



Thompson et al., 2005, *GRL*

Impacts (instead of previous one?)

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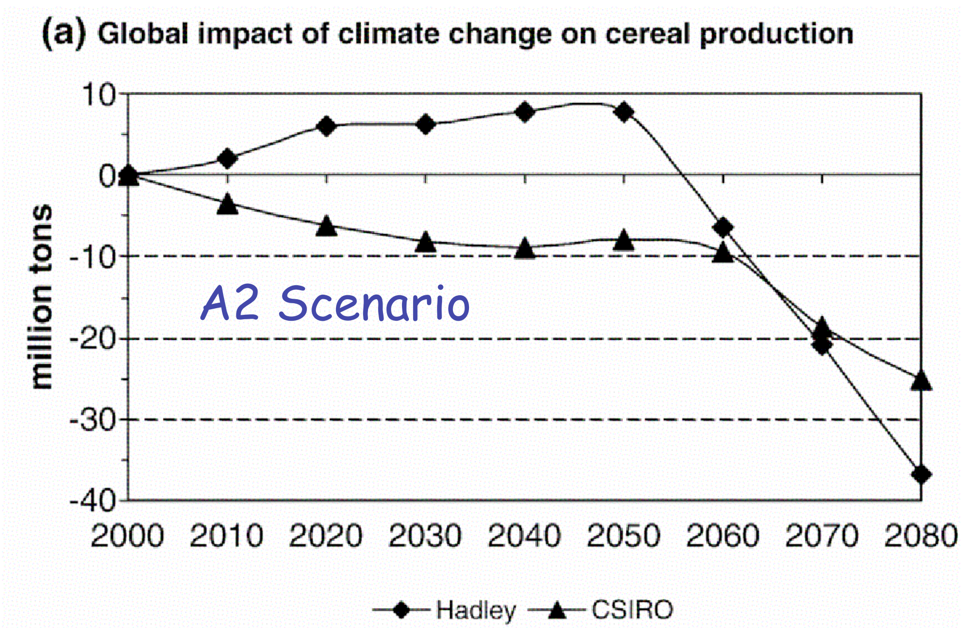
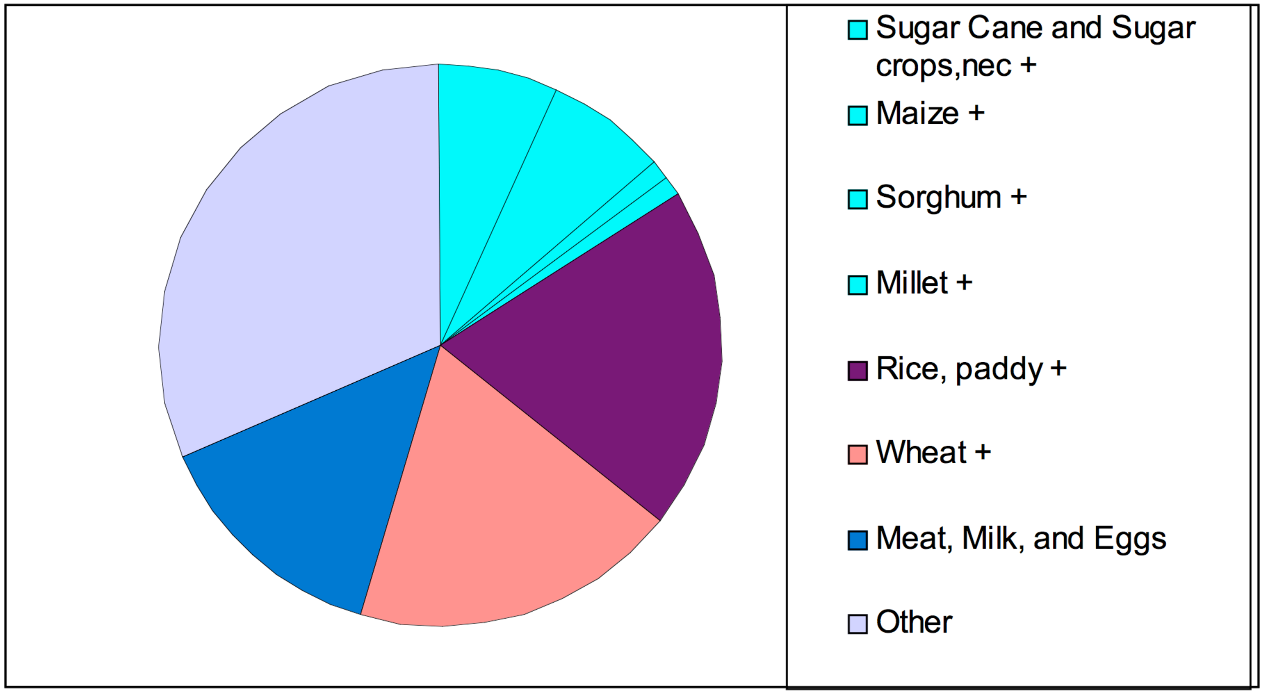


Tubiello and Fischer, 2007

2005 annual calorie consumption, global average (FAO)



C4 crops ~14% of direct calories
Meat, milk, and eggs another 12%