

Air Pollution Impacts on Agriculture

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India-California Air Pollution Mitigation Program (ICAMP)
Initiative for Mitigating Air Pollution from the Transportation Sector

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Oakland CA

1. Mechanisms of Impact

- ▶ Long-lived greenhouse gases (LLGHGs)
- ▶ Short-lived climate pollutants (SLCPs)

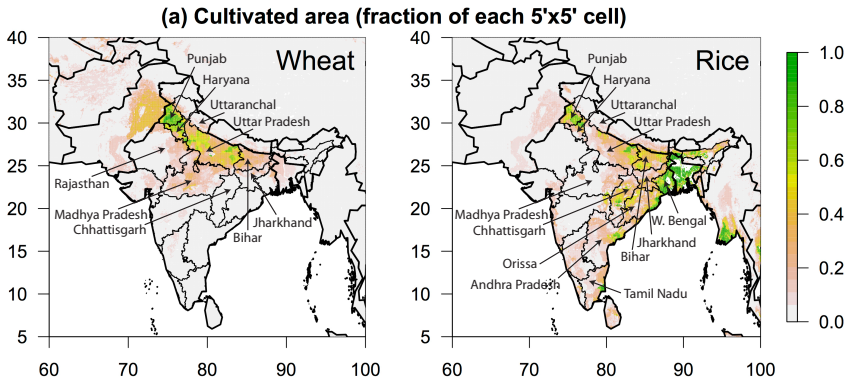
2. Co-benefits of ICAMP

- ▶ Relative climate and pollution impacts on Indian yields
- ▶ Food security impacts of transportation sector mitigation

Crop importance

- ▶ 75% of all of calories consumed worldwide come from **rice, wheat,** maize, and soybeans
- ▶ This isn't counting what gets fed to animals (i.e., even more)
- ▶ This is why we'll often focus on cereals, though they are clearly not the whole story (especially in California).

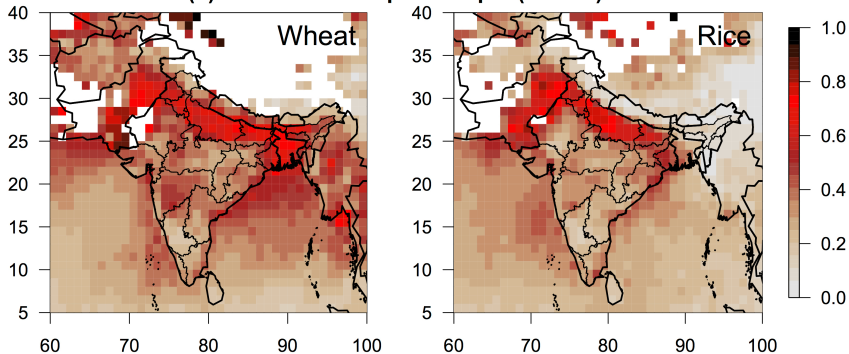
Air pollution and crops: a pictorial motivation



(Monfreda et. al. GBC 2008)

Air pollution and crops: a pictorial motivation

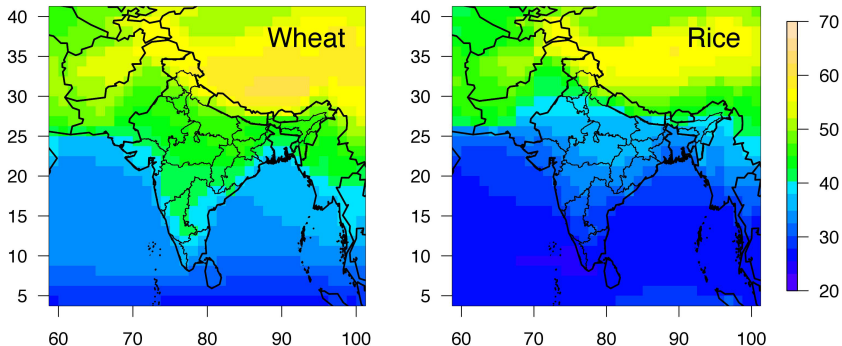
(b) Mean Aerosol Optical Depth (MODIS)



(MODIS, 2008)

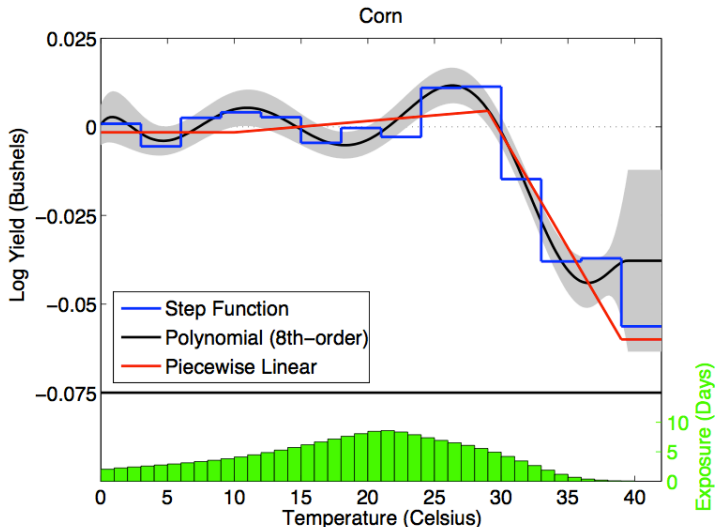
Air pollution and crops: a pictorial motivation

(c) Mean Modeled Surface Ozone Concentration, ppbv (MERRA)



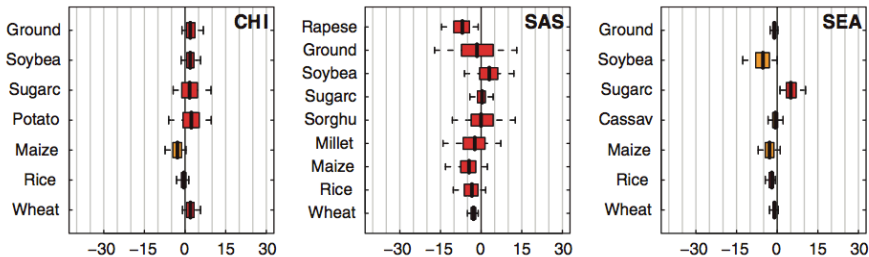
(MERRA, 2008)

Crops grow at an optimal temperature



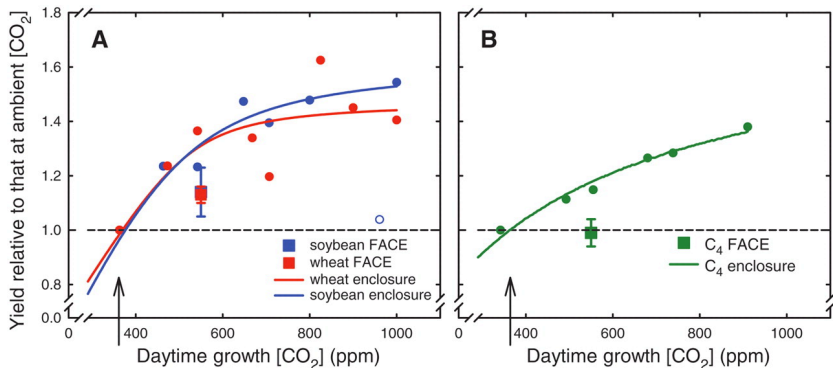
(Schlenker & Roberts PNAS 2009)

Rising temperatures have reduced crop yields globally



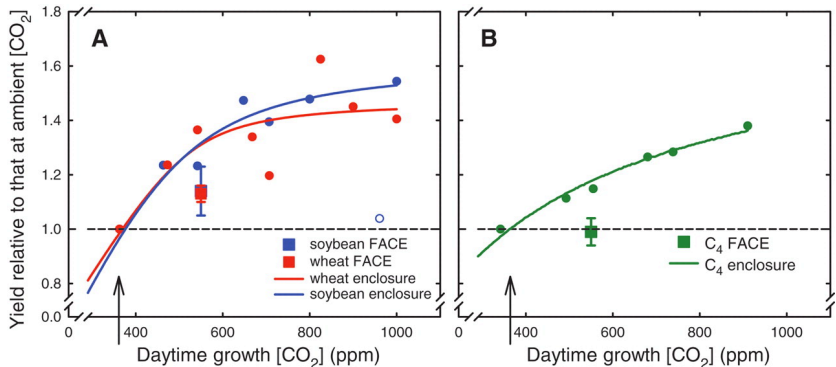
(Lobell et. al. Science 2008)

Crops need carbon dioxide



(Long et. al. Science 2006)

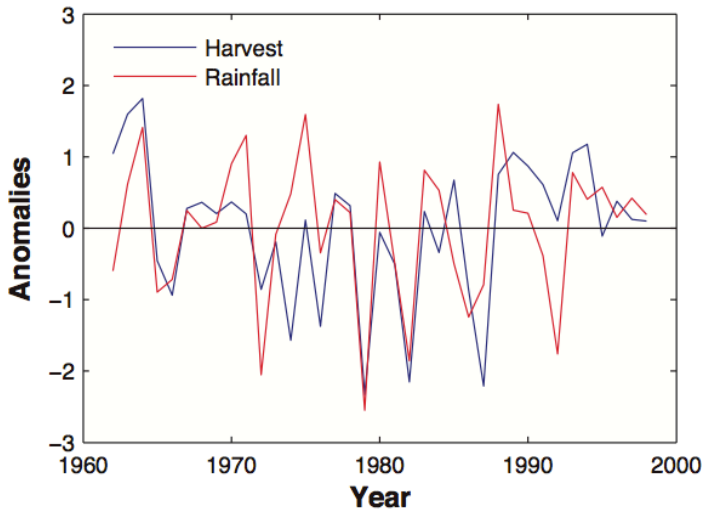
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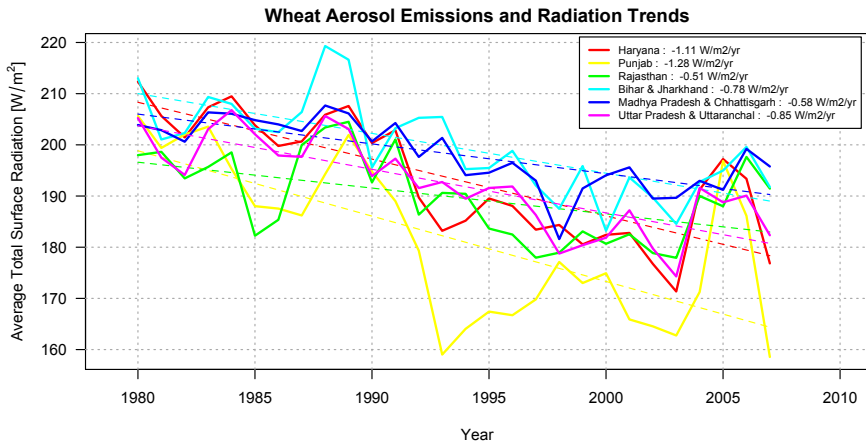
...but CO₂ fertilization has not offset losses due to warming.

Crops need adequate soil moisture



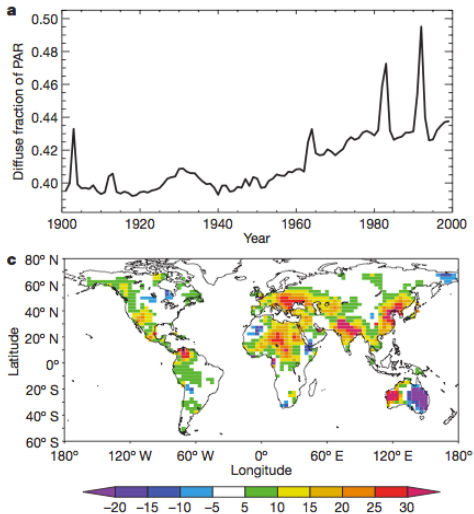
(Auffhammer et. al. PNAS 2006)

Crops need adequate radiation



(World Radiation Data Centre)

Changes in diffuse fraction of light



(Mercado et. al. Nature 2009)

Other pollutants are toxic to plants, especially ozone



(NASA Earth Observatory)

Ozone dose-response + CTM

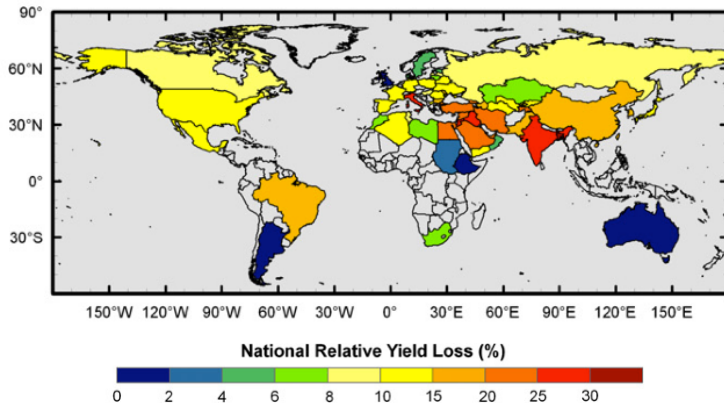
Table 4

Regionally aggregated relative yield loss RYL for wheat, rice, maize and soybean.

	WORLD	EU25	N.Am	China	India
<i>Wheat</i>					
AOT40	12.3%	4.1%	4.1%	19.0%	27.6%
M7	7.3%	4.6%	4.4%	9.8%	13.2%
<i>Rice</i>					
AOT40	3.7%	4.7%	3.2%	3.9%	8.3%
M7	2.8%	3.5%	2.6%	3.1%	5.7%
<i>Maize</i>					
AOT40	2.4%	3.1%	2.2%	4.7%	2.0%
M12	4.1%	5.1%	3.6%	7.1%	4.0%
<i>Soybean</i>					
AOT40	5.4%	20.5%	7.1%	11.4%	4.7%
M12	15.6%	27.3%	17.7%	20.8%	19.1%

(Van Dingenen et. al. Atmospheric Environment 2009)

Ozone dose-response + CTM (cont.)



(Avnery et. al. Atmospheric Environment 2011)

Overall picture gets complicated quickly

If we think about this from an **air pollution** perspective and what might be gained from mitigation:

- ▶ GHGs have indirect impact through warming; direct impact for CO₂
- ▶ Aerosols and ozone precursors have indirect impacts through warming and precipitation changes; direct impacts through radiation changes and toxicity

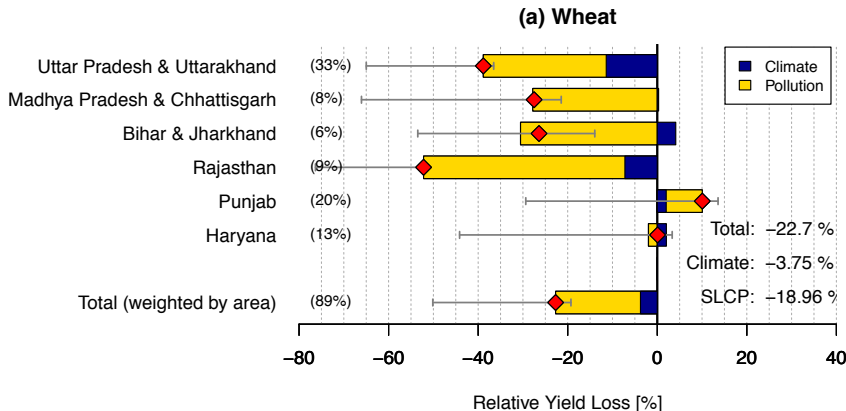
Most important, we'd expect **heterogeneous**, localized impacts.

Our research

Goal: Understand with certainty what yield impacts would be associated with various mitigation measures.

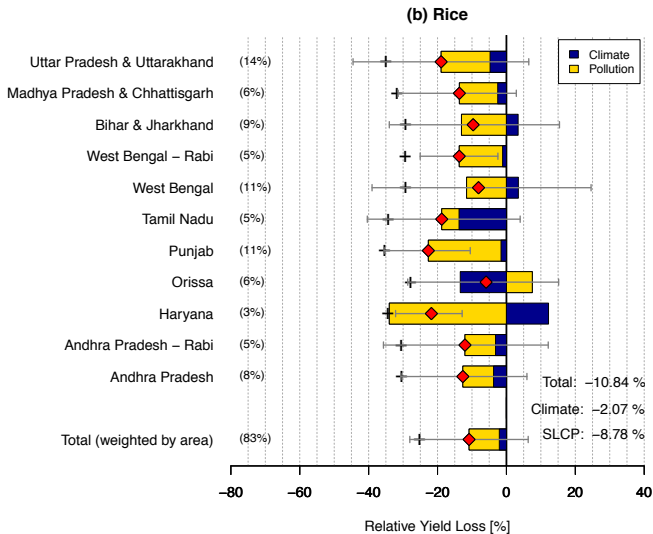
- ▶ Combine chamber / field experiments (dose-response relationships) or process-based crop models with climate / chemical transport models
- ▶ Statistical panel models with historical data

Impact on wheat



(Burney & Ramanathan 2013)

Impact on Rice



Perspective

- ▶ About 14 Mt of wheat and 15Mt of rice
- ▶ India imports about 6 Mt of wheat annually

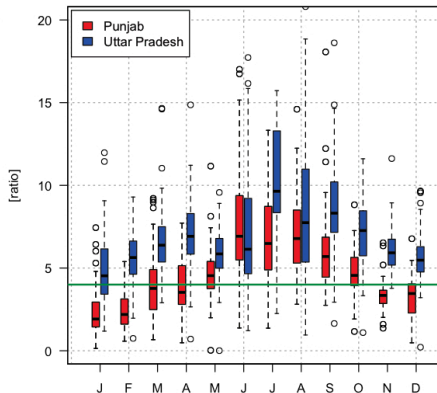
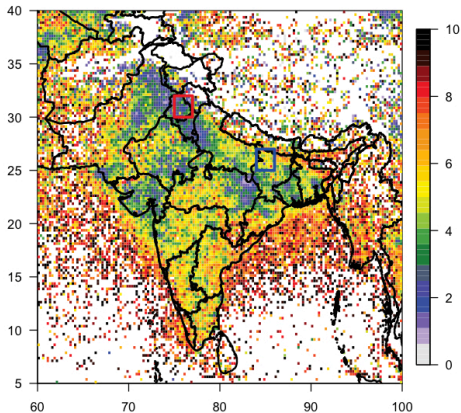
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Perspective

- ▶ About 14 Mt of wheat and 15Mt of rice
- ▶ India imports about 6 Mt of wheat annually but...
- ▶ Need to be careful about differing impacts

Ozone chemistry is non-linear



ICAMP agricultural co-benefits

- ▶ Reduce BC, sulfates, NO_x
- ▶ Need to be careful about regional differences, relative reductions
- ▶ Need to do this study more carefully in CA, continue work in India.

Thank you

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