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Global to Local Analysis of Systems Sustainability



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Assessing the Inter-regional Incidence of Climate Impacts on Agriculture

presented by:

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based on joint work with Uris Baldos (Purdue)
and Frances Moore (UC Davis)

Background and Overview

- Considerable scientific progress on understanding climate change impacts on crop yields
- **Less well-studied is the implications for policy-relevant variables such as economic welfare at country level**
- **Geographic distribution of welfare impacts depend on:**
 - **biophysical factors** e.g., differential rates of warming and
 - **economic factors** including bilateral trade relationships
 - **how do these interact?**

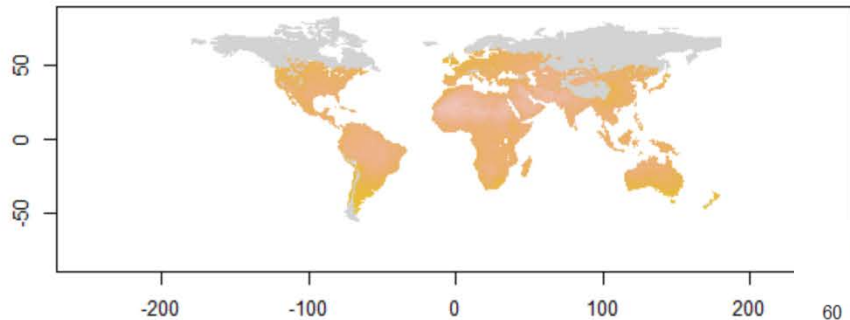
Leverage the work of Moore et al. (ERL, 2017)

Meta-analysis of 1,010 estimates (53 different studies) of wheat, rice, maize, soybean yield changes in response to temperature change compiled for IPCC (2014)

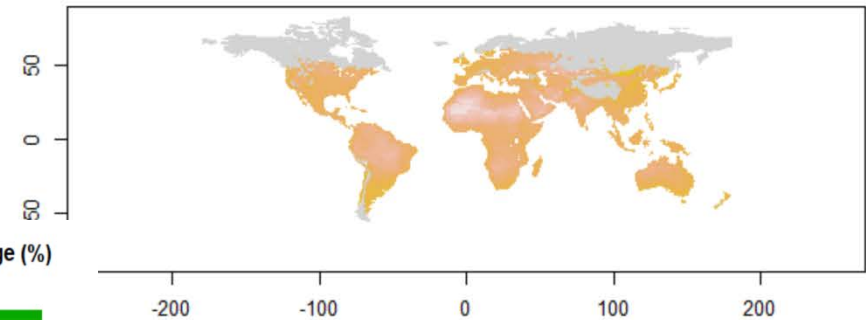
- Variables include average growing season T, change in T, Precip, CO₂ change, adaptation
- Process-based and statistical yield response estimates consistent, once control for other factors
- Climate experiments: 1, 2 and 3 degrees C global T rise, with pattern-scaling of T based on CMIP5 ensemble - RCP 8.5

Global gridded yield impacts of climate change at 2 degrees C global mean T rise

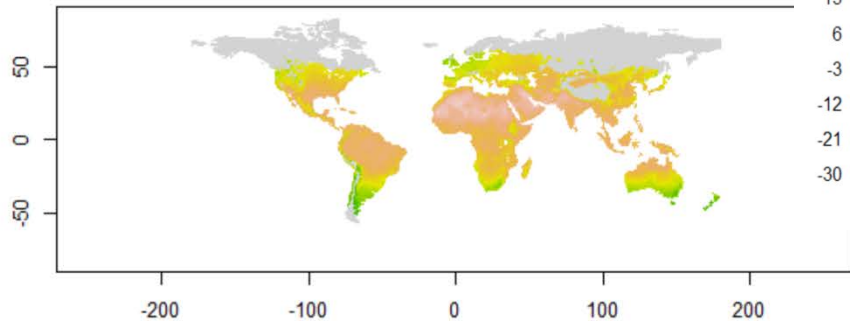
Maize



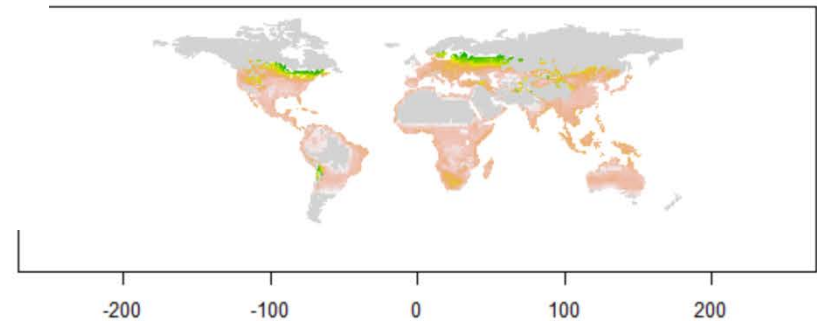
Wheat



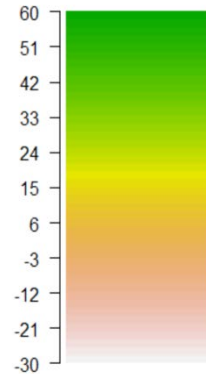
Rice



Soy



Yield Change (%)



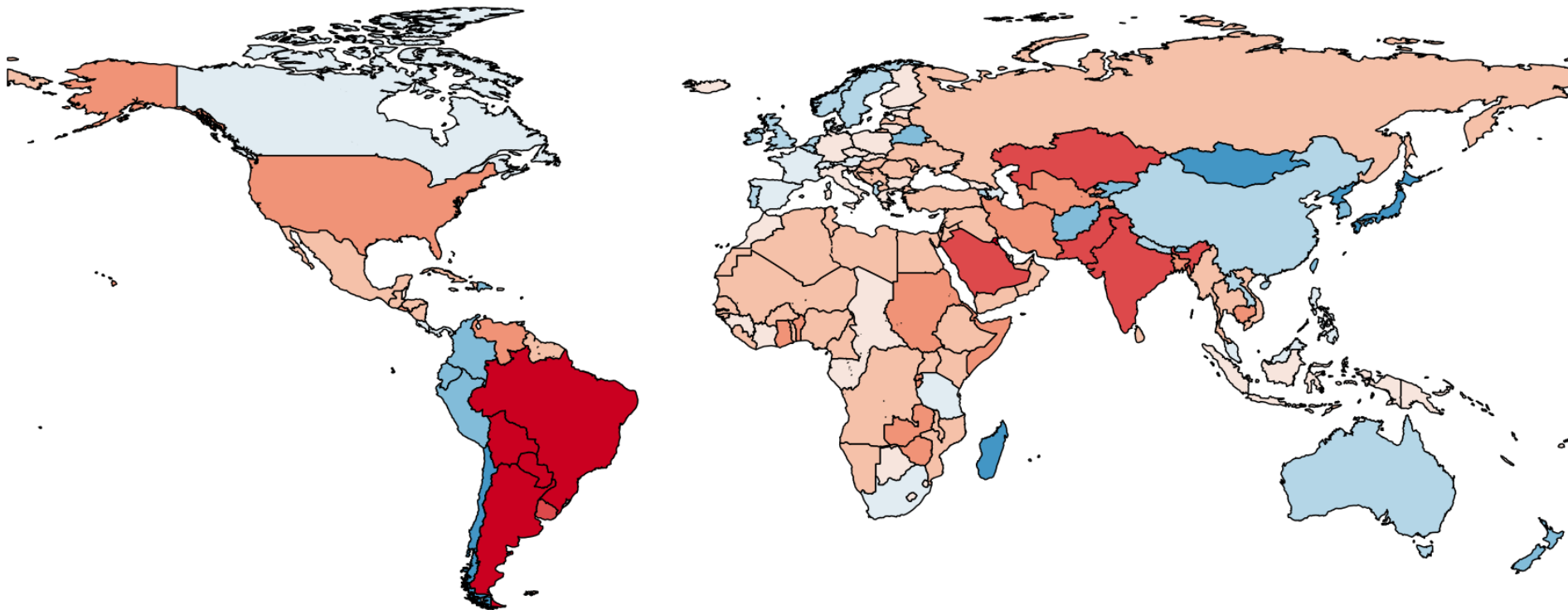
Sources of Geographic Disparities in Climate Impacts

- **Biophysical determinants (Direct effect)** of geographic disparities from climate change
 - **Crops differ in temperature sensitivity** and national importance
 - **Uneven rates of warming** across the globe
 - Differential responses to rising temperatures in **cold vs. warm** regions
- **Economic geography (Terms of trade)** – determines how these biophysical disparities translate into differential welfare outcomes
- **Policy interactions (Allocative efficiency)** – Final determinant of economic welfare is the interplay with policies

Experimental Design Isolates Biophysical Factors Underpinning Geographical Impacts

- **E4: Full Geography**
- E3: Remove impact of initial temperature:
 - Initial temperature set at mean value (neutralize starting temperature)
- E2: Remove pattern-scaling of temperature
 - Initial temperature set at mean value (neutralize starting temperature)
 - No pattern-scaling of temperature (neutralize temperature variation)
- E1: Uniform climate impacts on crops -- **Geography absent**
 - Initial temperature set at mean value (neutralize starting temperature)
 - No pattern-scaling of temperature (neutralize temperature variation)
 - All crop responses to climate are the same (apply global average)

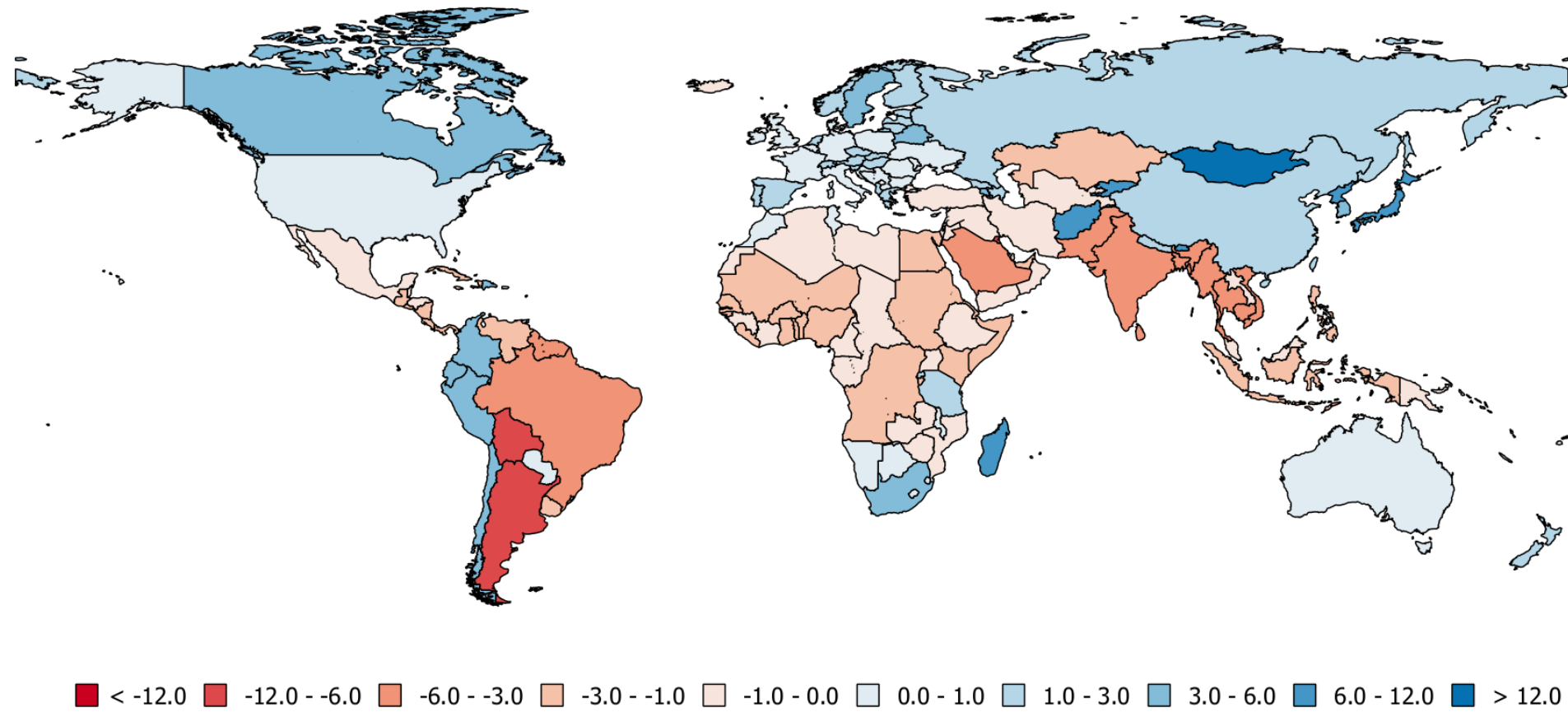
Welfare impact of biophysical (direct) climate impacts on four crops (E4)



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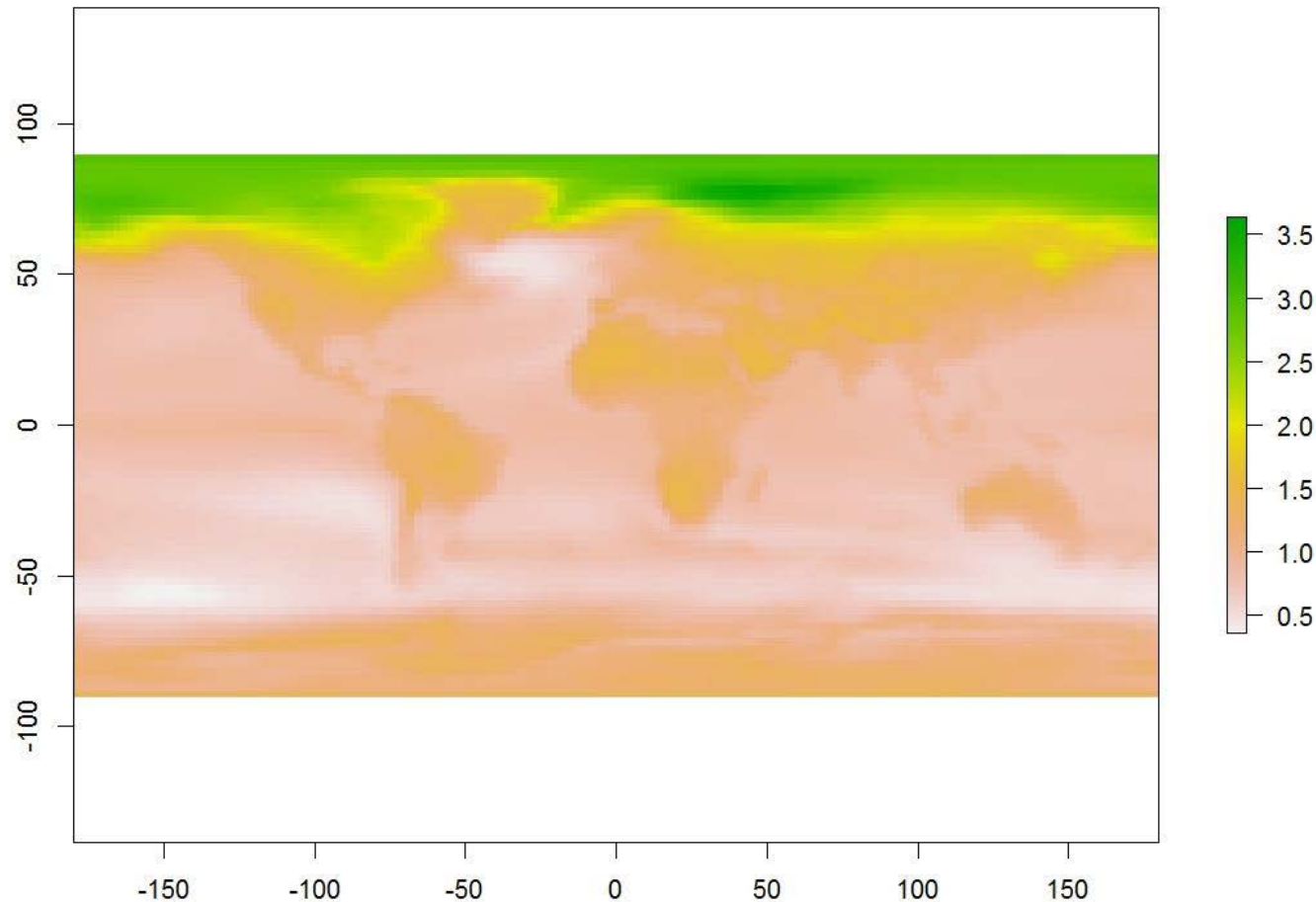
National welfare, normalized by output value for four crops
2 degrees C global mean T rise

Contribution of *initial temperature* to welfare

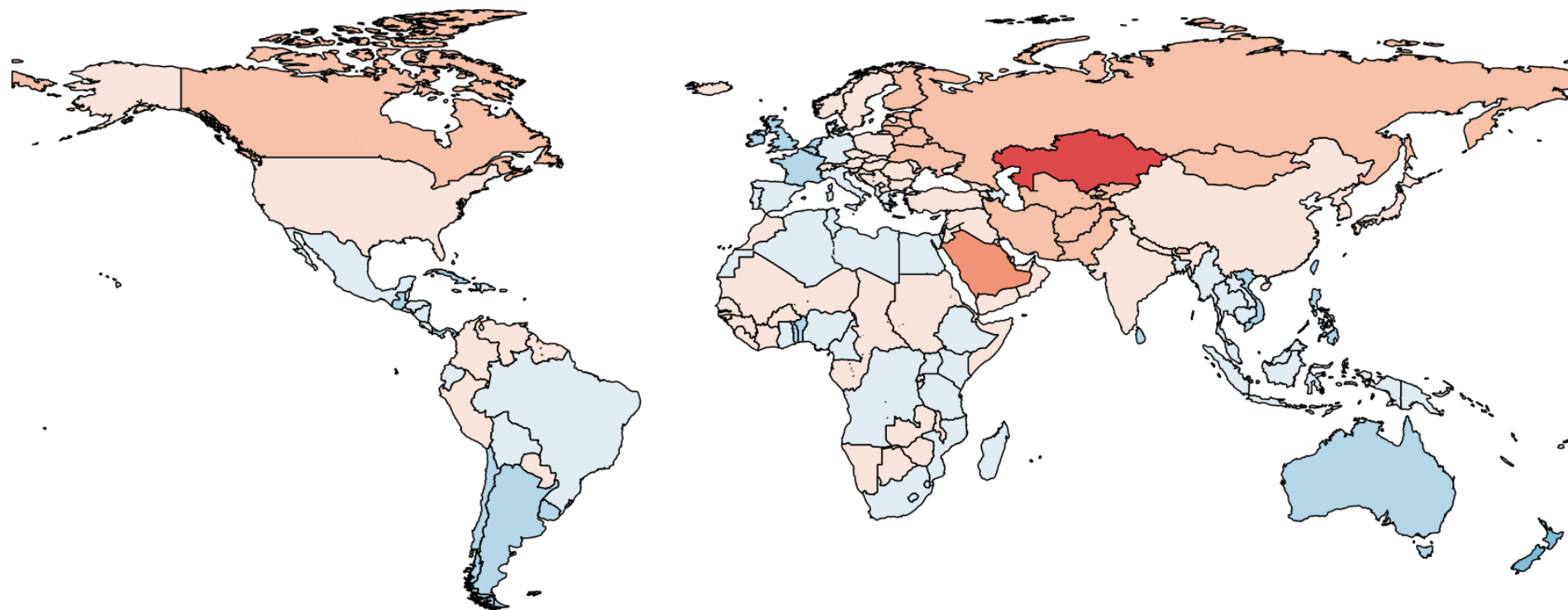


National welfare, normalized by output value for four crops: **E4 – E3**
2 degrees C global mean T rise

For E2 Remove pattern-scaling: This is the local *change in T per one degree C increase* in global mean T : CMIP5 ensemble mean under RCP 8.5

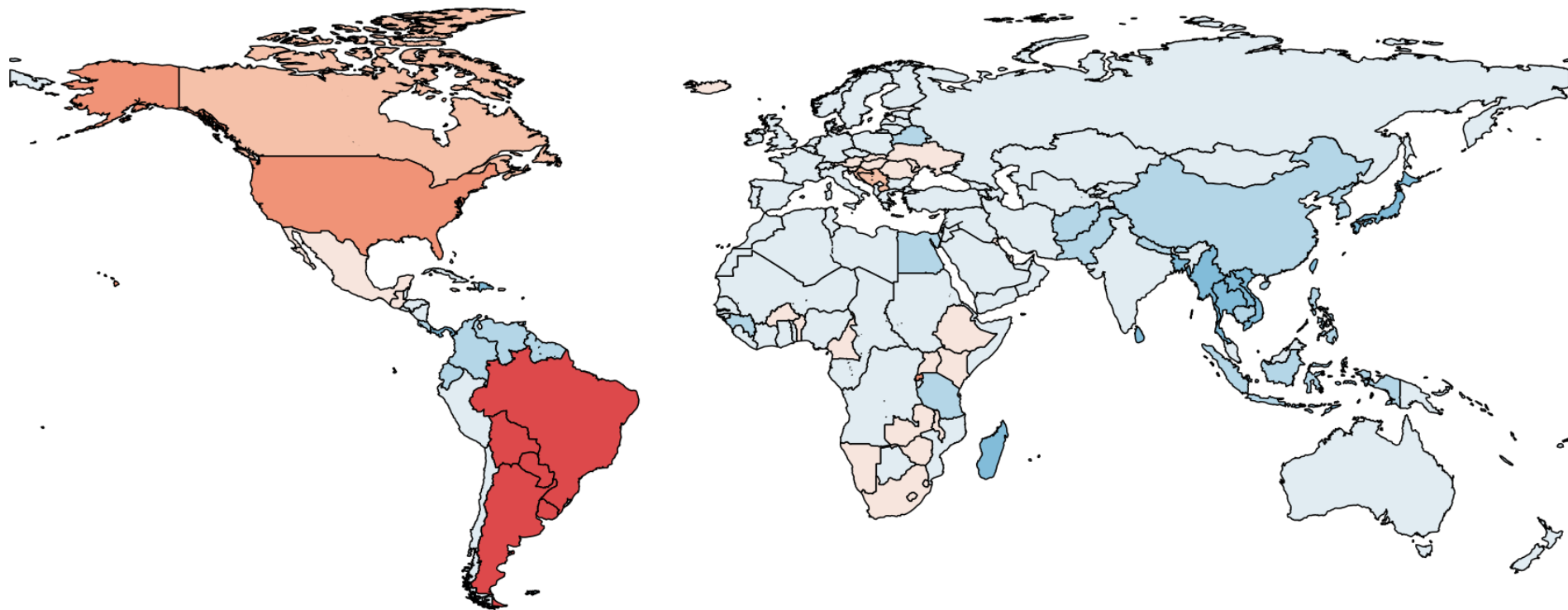


Contribution of *pattern-scaling* to welfare



National welfare, normalized by output value for four crops: **E3 – E2**

Contribution of *crop composition* to welfare



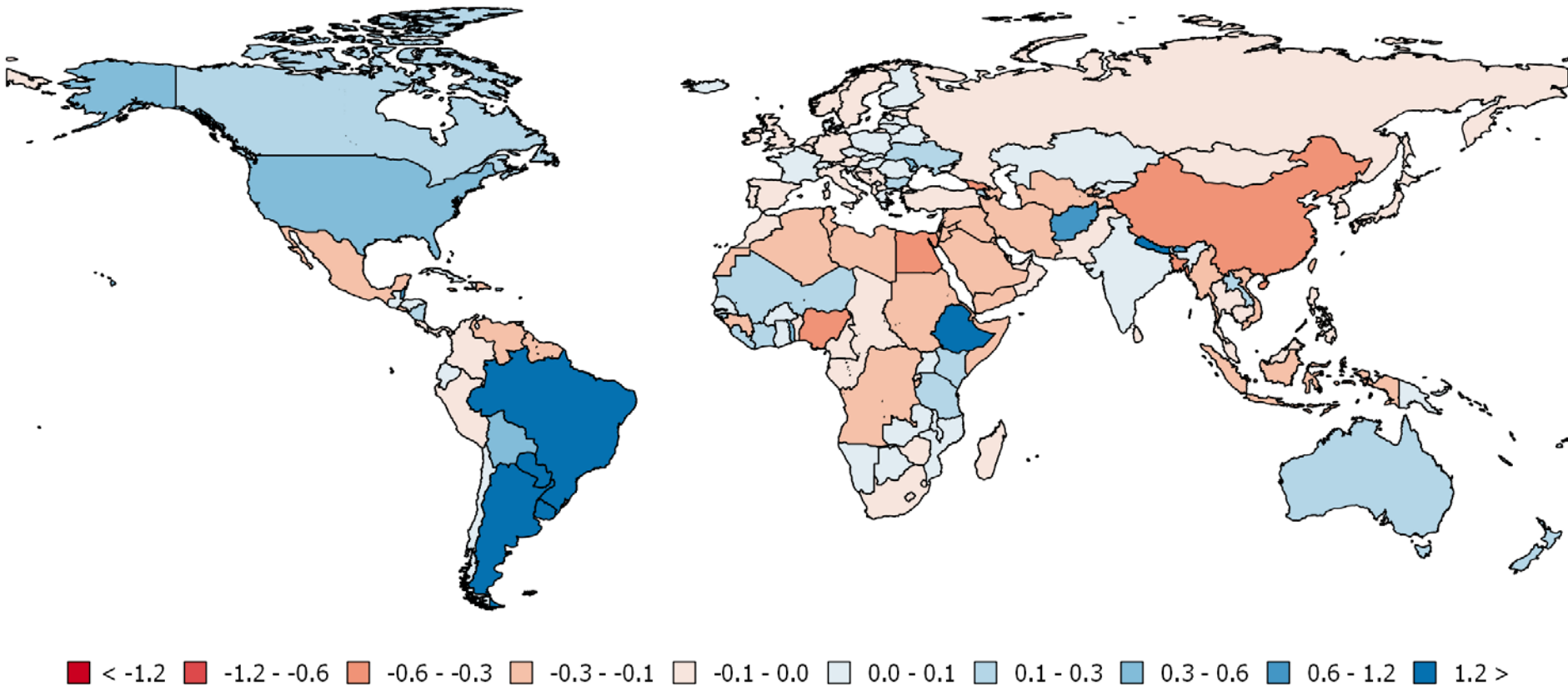
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National welfare, normalized by output value for four crops: $E2 - E1$
2 degrees C global mean T rise

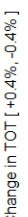
Sources of Geographic Disparities in Climate Impacts

- **Biophysical determinants (Direct effect)** of geographic disparities from climate change
- **Economic geography (Terms of trade)** – determines how these biophysical disparities translate into differential welfare outcomes; hardest hit countries:
 - Are net importers of commodities with rising world prices
 - Source their imports from relatively hard-hit suppliers
 - Compete in export markets with relatively favored suppliers
- **Policy interactions (Allocative efficiency)** – Final determinant of economic welfare is the interplay with policies

Economic geography: Overall impact of climate change on each individual country's ToT

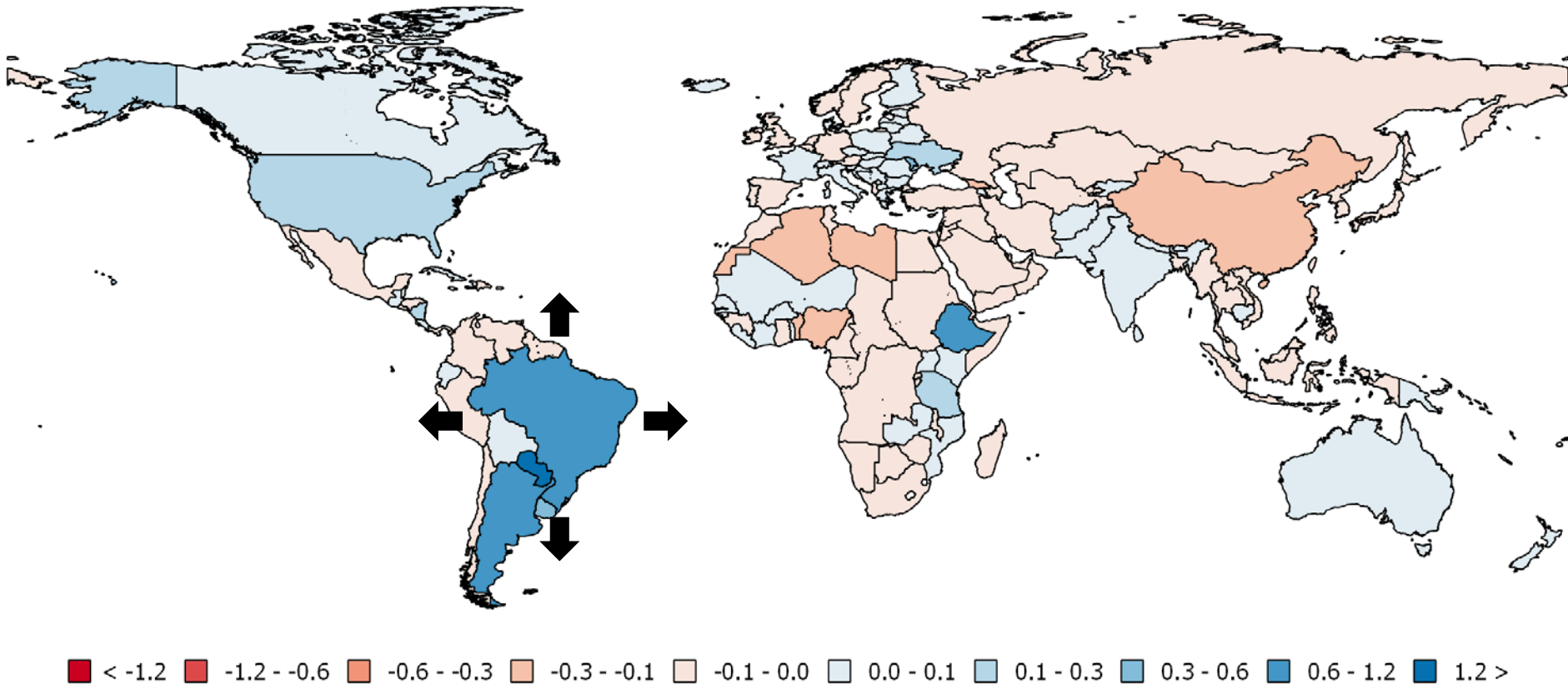


Terms of trade: Percentage change in index of export prices, relative to import prices (E4): 2 degrees C global mean T rise



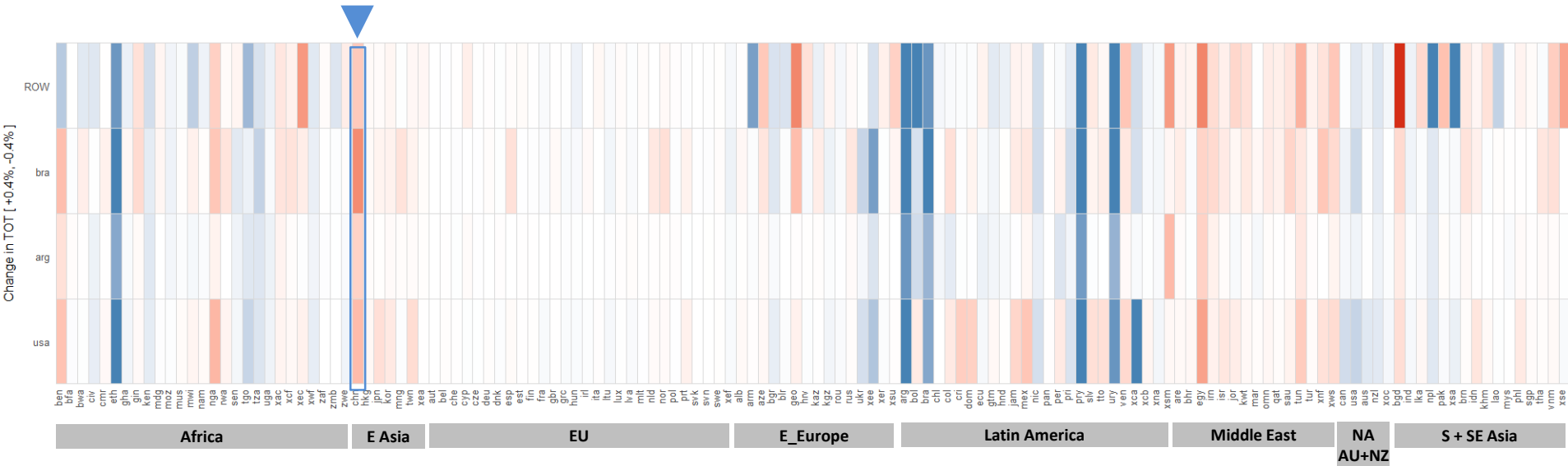
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How climate impacts in Brazil....



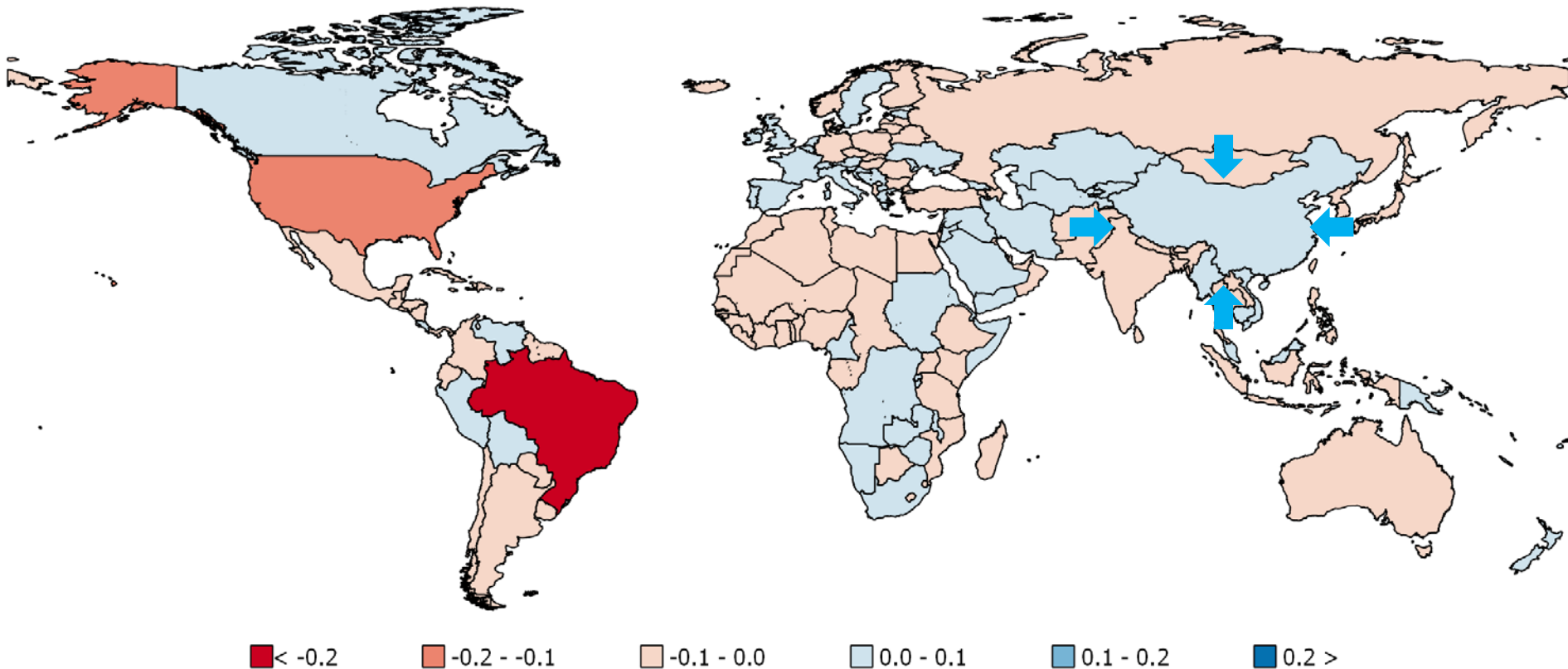
Affect ToT worldwide

How climate impacts worldwide affect China's ToT....



This is a *column* from our decomposition table....

How climate impacts worldwide

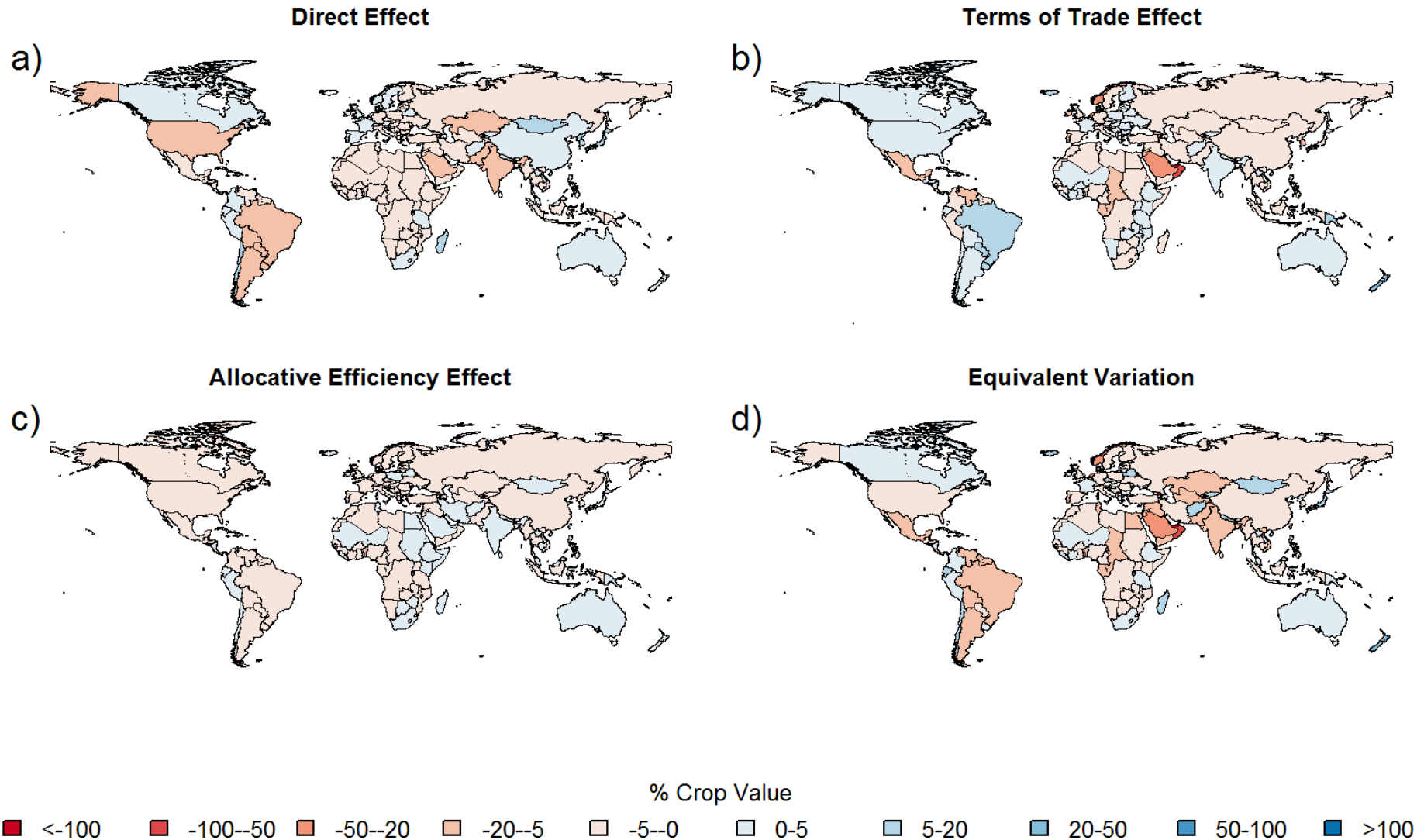


Affect China's ToT...

Sources of Geographic Disparities in Climate Impacts

- **Biophysical determinants (Direct effect)** of geographic disparities from climate change
- **Economic geography (Terms of trade)** – determines how these biophysical disparities translate into differential welfare outcomes
- **Policy interactions (Allocative efficiency)** – Final determinant of economic welfare is the interplay with policies:
 - If induced changes in output lead to an expansion of subsidized industries (e.g., agriculture in China), this is another source of loss

Overall impact of climate change on regional welfare (E4) - % of Crop Value



Conclusions

- **Geographical distribution of welfare** impacts due to climate change in agriculture **depends on both biophysical and economic factors**
- Absent biophysical differences across the world, there is no role for variations in economic geography – interaction is key
- We build into our analysis potential changes in trade patterns in response to climate shocks; however historical ties play a key role
- Most vulnerable regions may consider **building new trade ties to enhance resilience to climate change**

Thanks to my collaborators!



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Overall impact of climate change on regional welfare (E4) - % of Regional Income

