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)

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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)

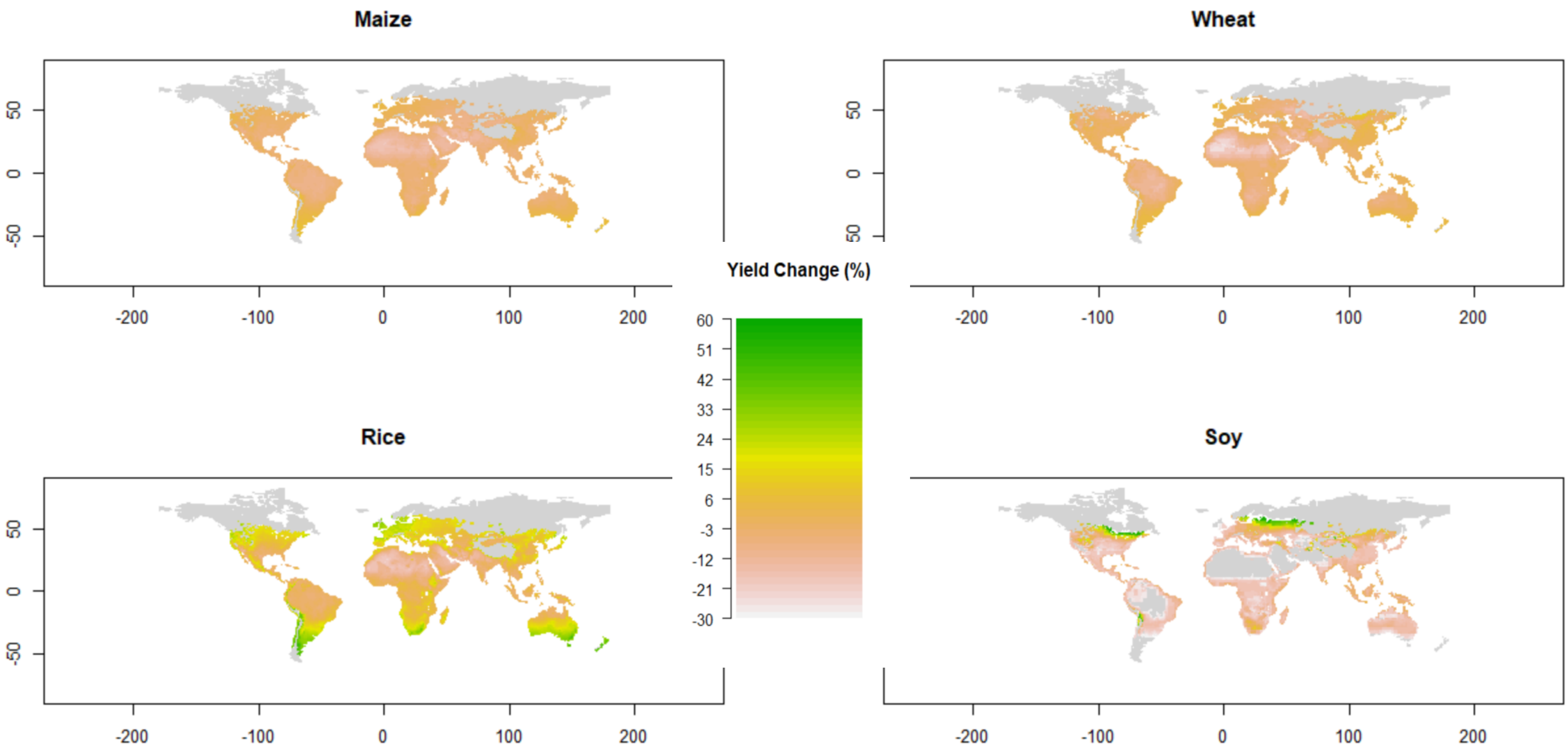
Meta-analysis of 1,010 estimates (53 different studies) of wheat, rice, maize, soybean yield changes in response to temperature change compiled for IPCC (2014)

- Variables include average growing season T, change in T, Precip, CO_2 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



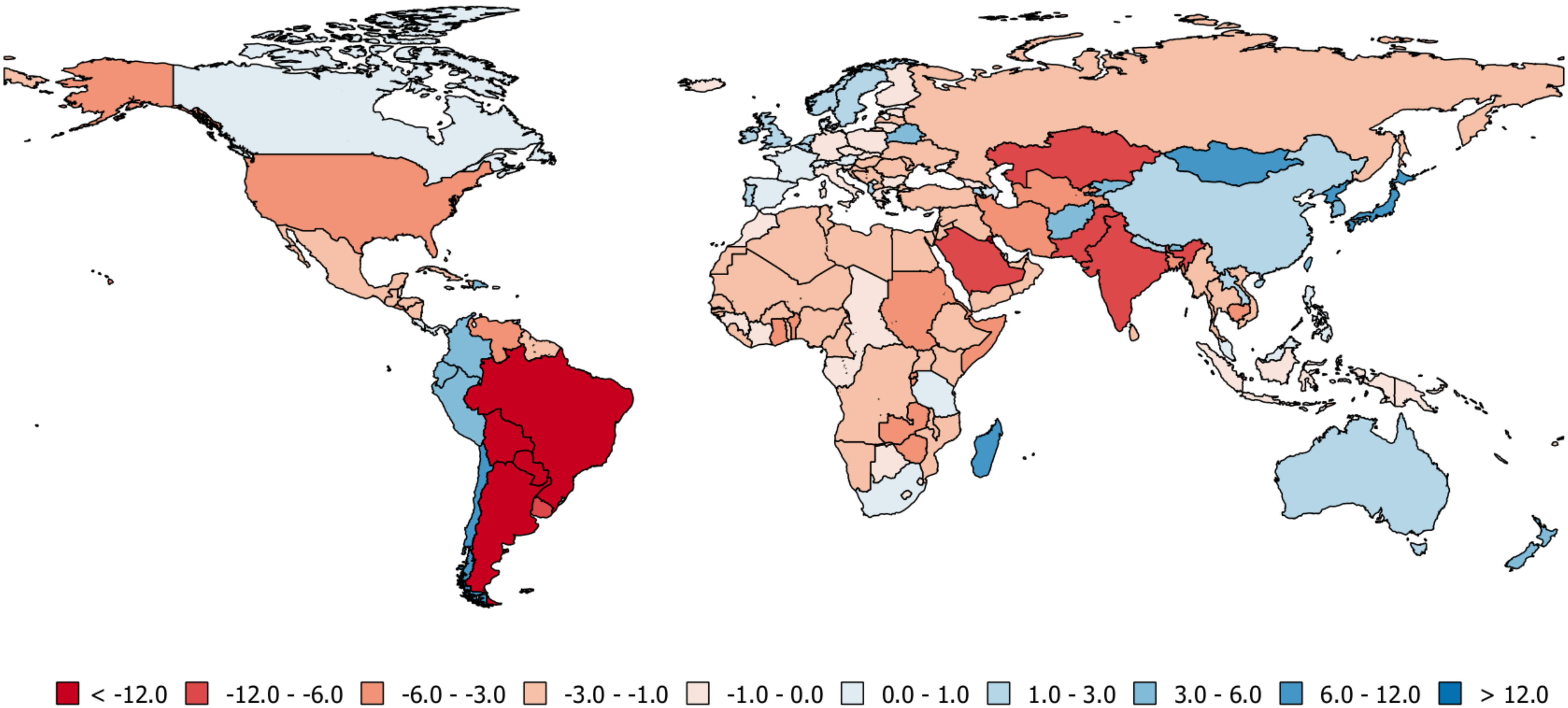
Sources of Geographic Disparities in Climate Impacts

- **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

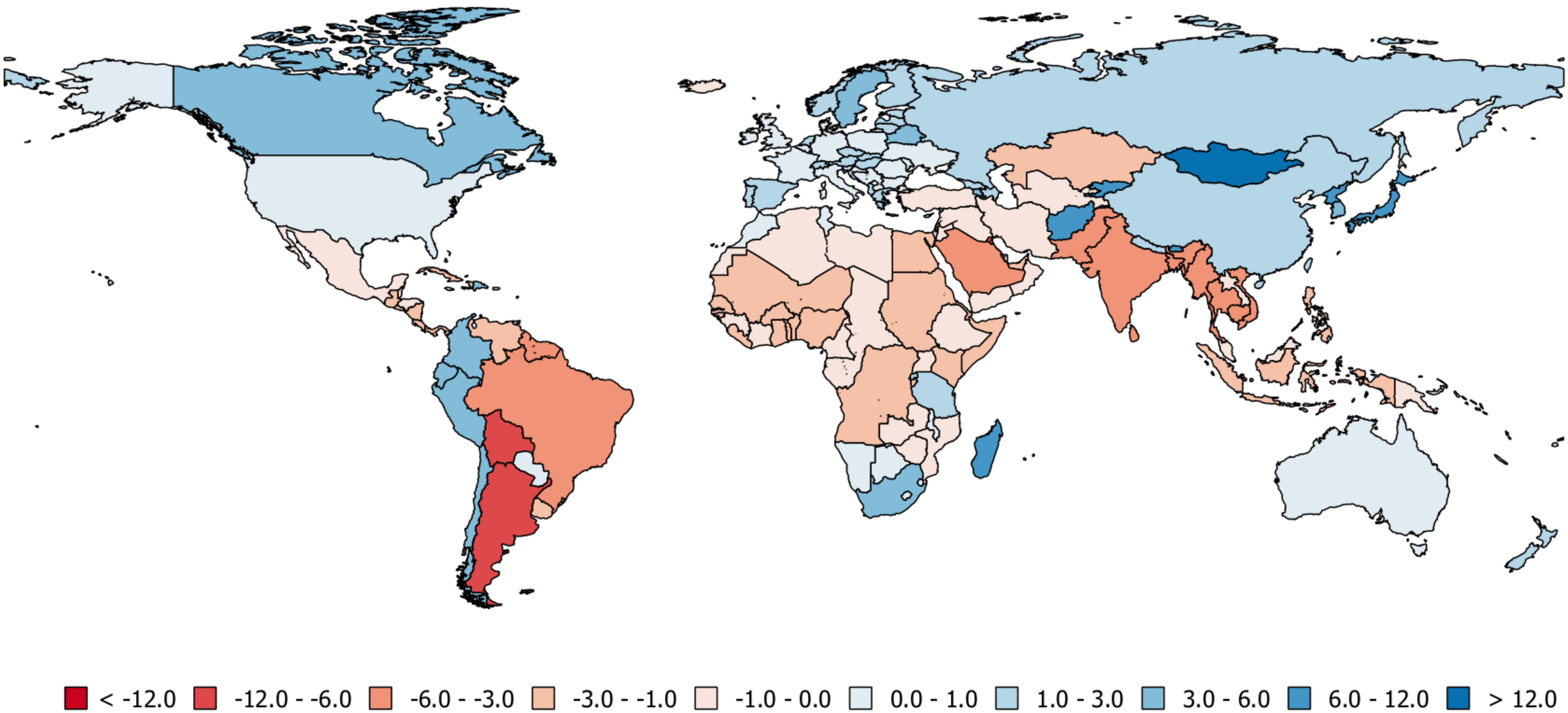
- E4**: Full Geography**
- E3: Remove impact of initial temperature:
  - Initial temperature set at mean value (neutralize starting temperature)
- E2: Remove pattern-scaling of temperature
  - Initial temperature set at mean value (neutralize starting temperature)
  - No pattern-scaling of temperature (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)



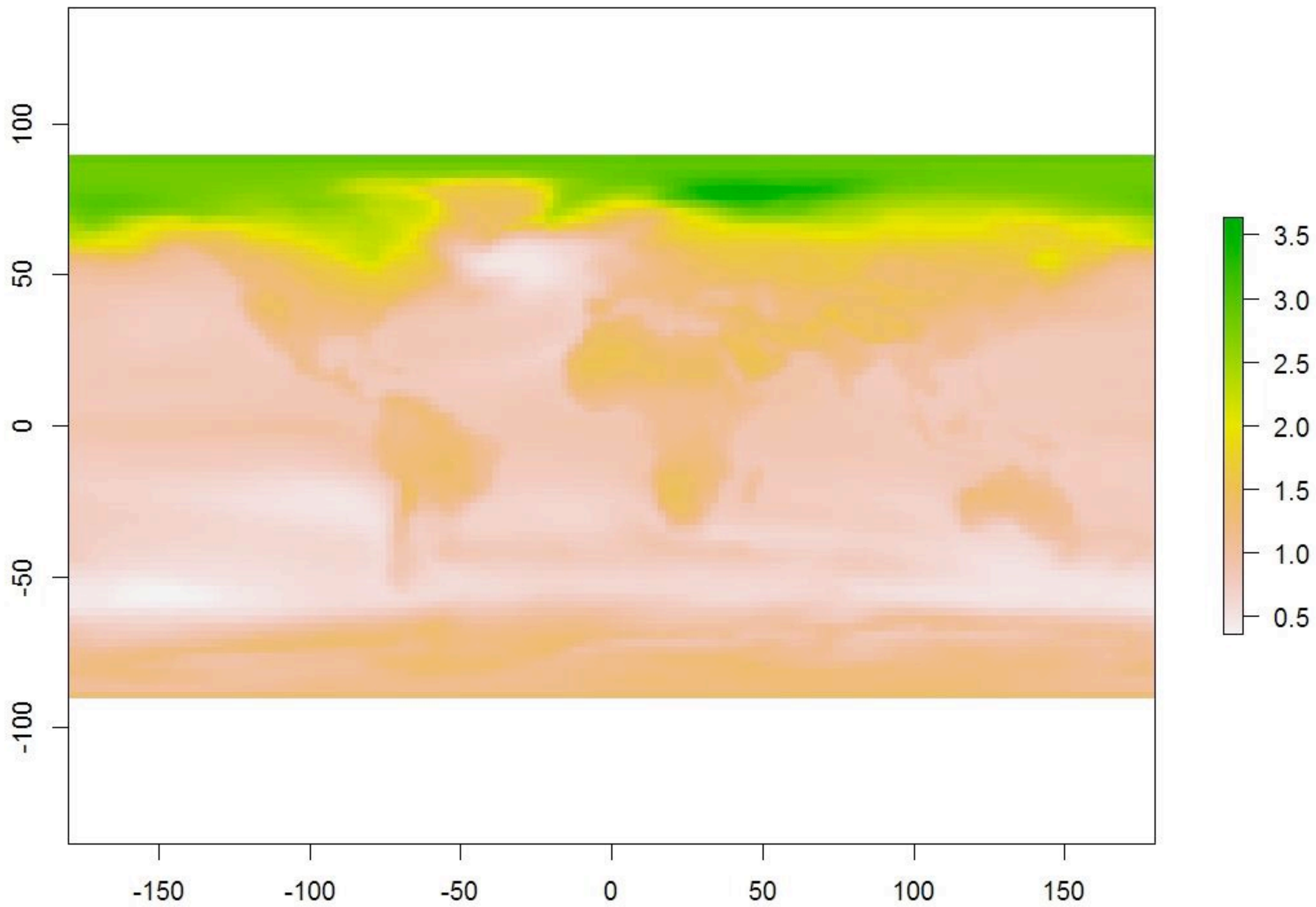
National welfare, normalized by output value for four crops
2 degrees C global mean T rise

Contribution of ***initial temperature*** to welfare

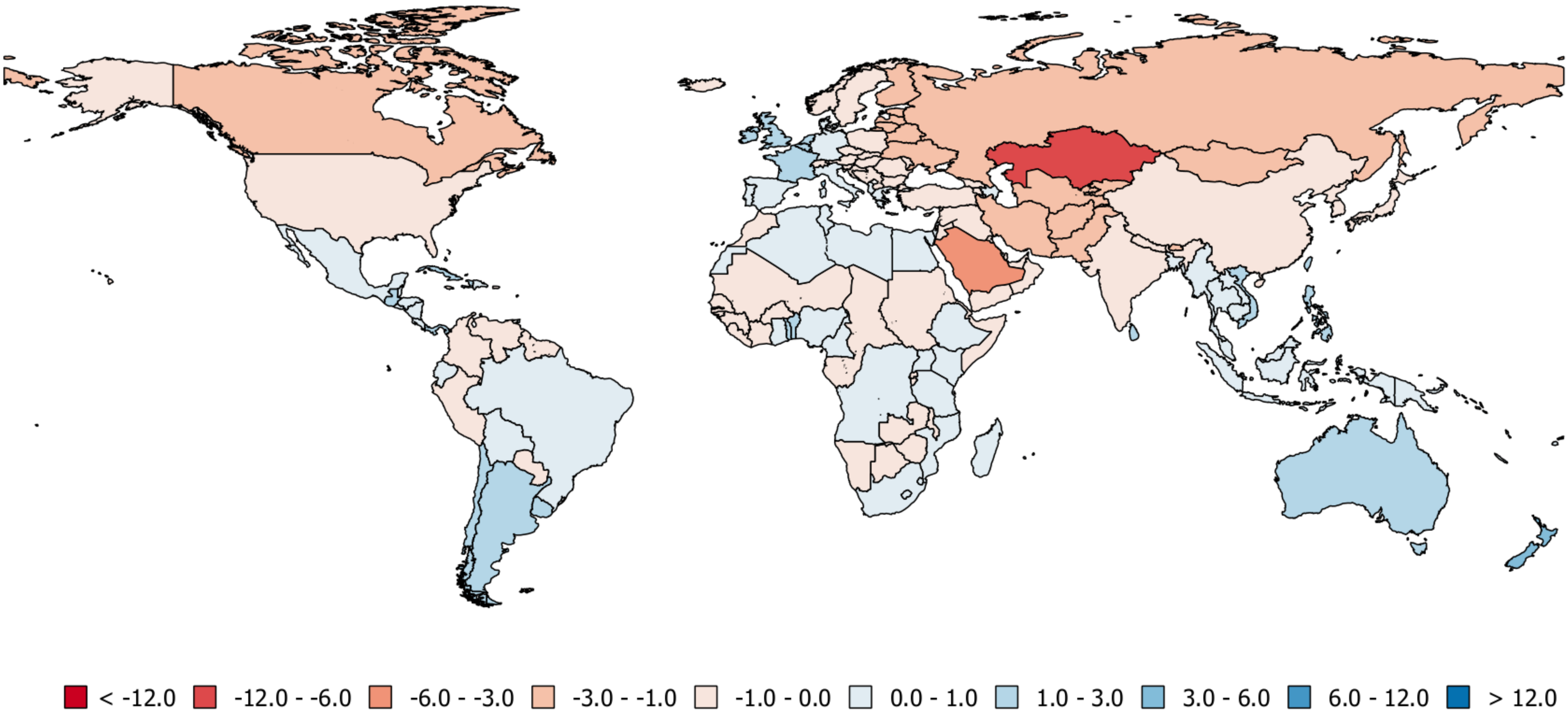


National welfare, normalized by output value for four crops: **E4 – E3**
2 degrees C global mean T rise

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

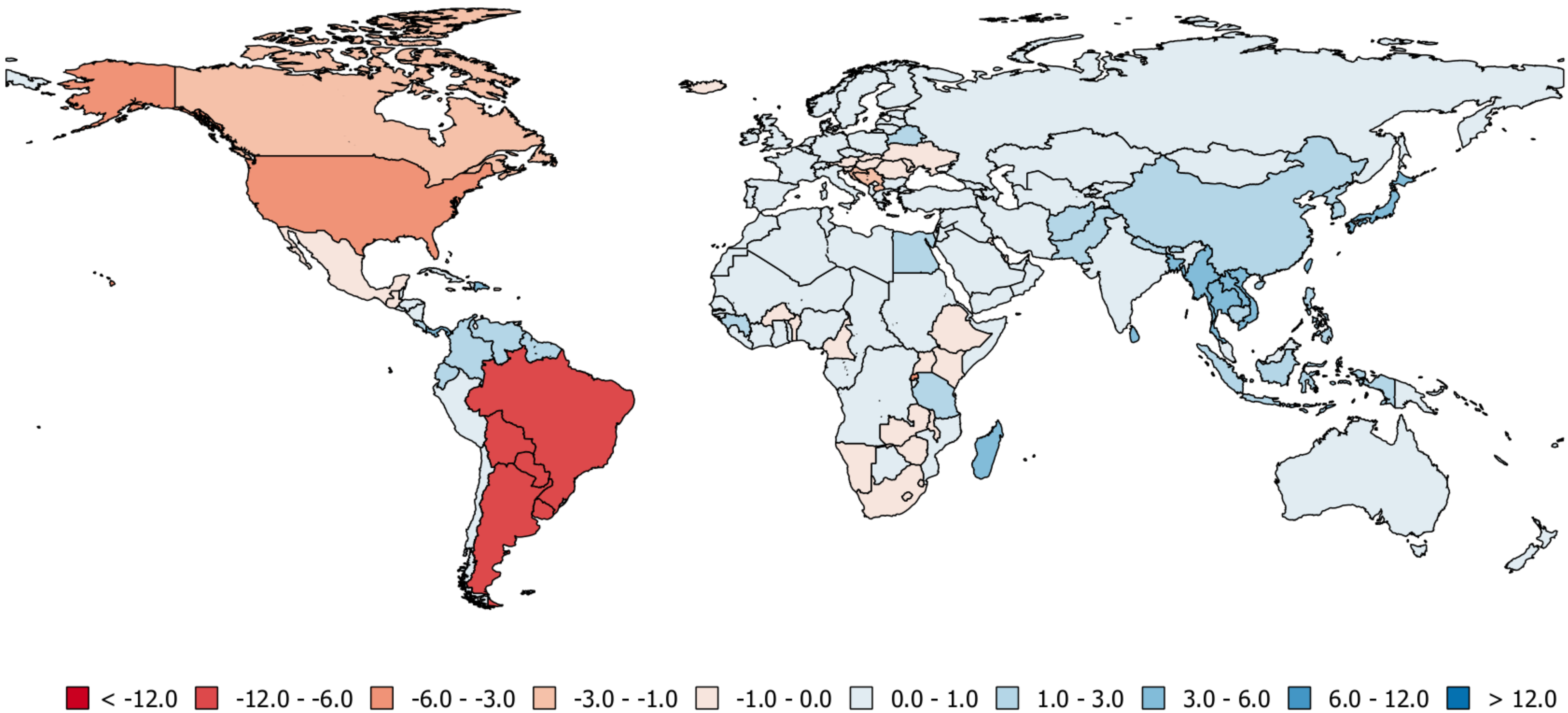


Contribution of ***pattern-scaling*** to welfare



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

Contribution of ***crop composition*** to welfare

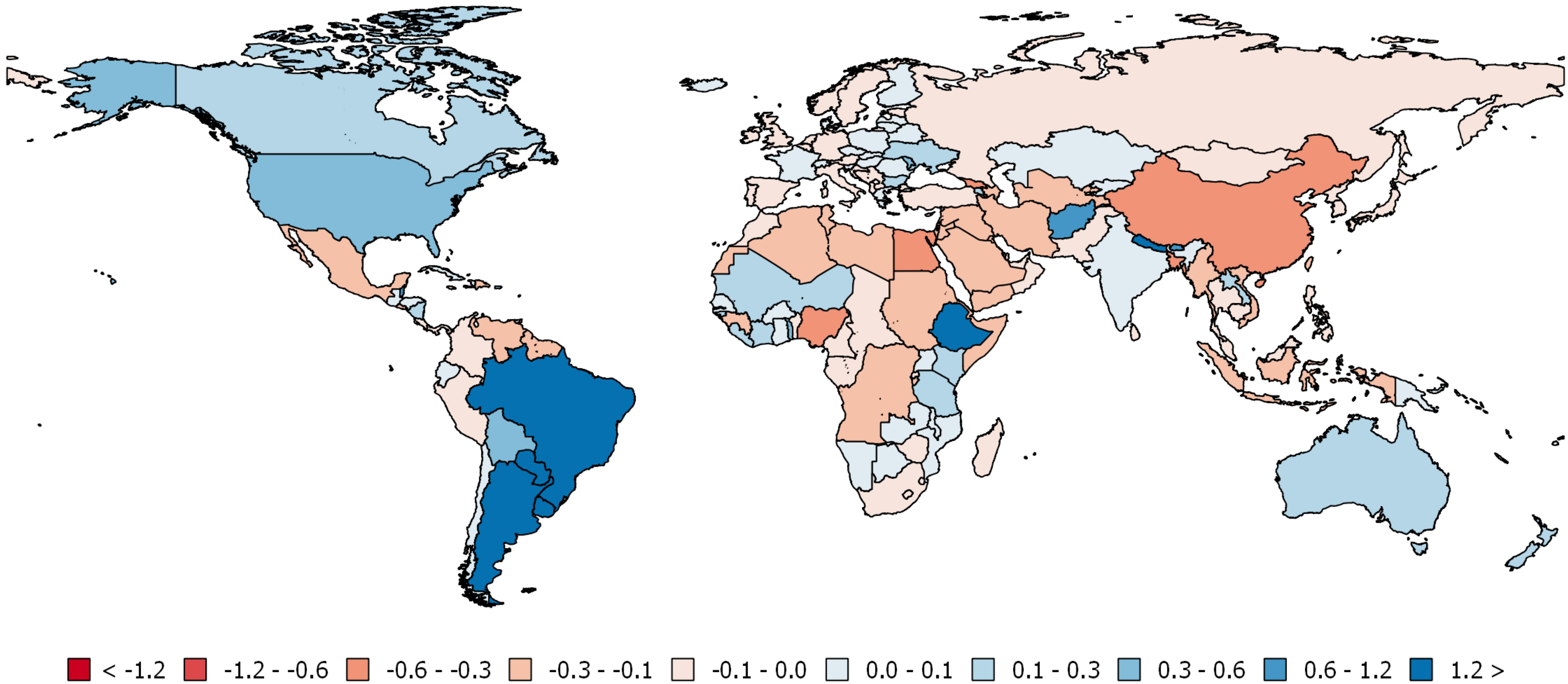


National welfare, normalized by output value for four crops: E2 – E1
2 degrees C global mean T rise

Sources of Geographic Disparities in Climate Impacts

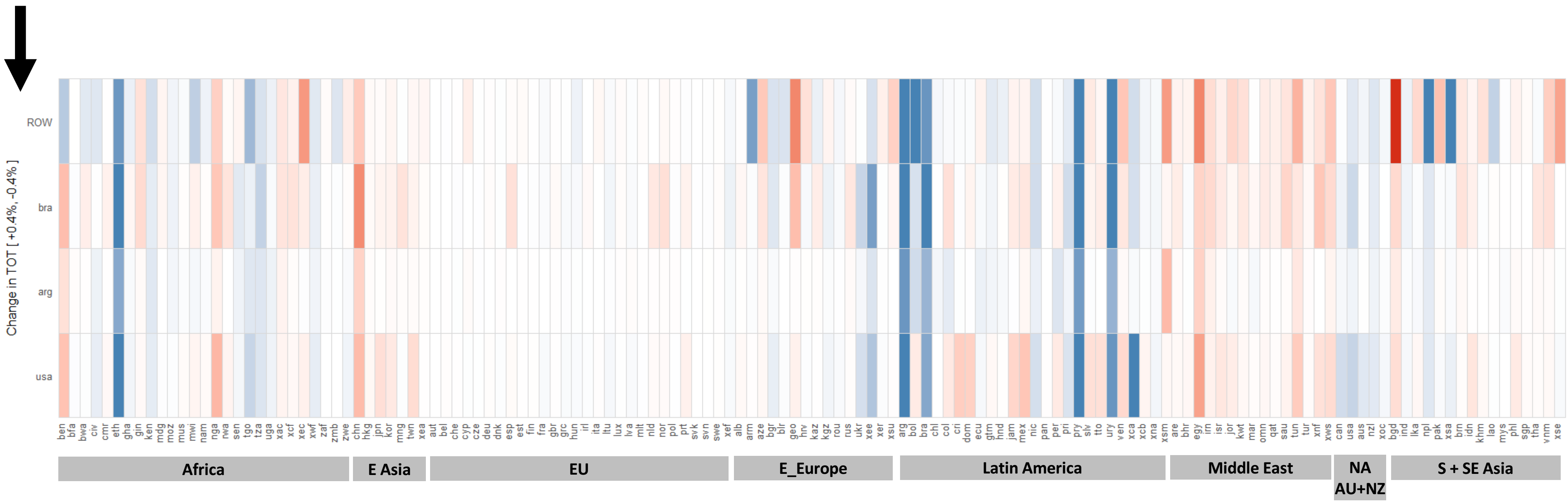
- **Biophysical determinants (Direct effect)** of geographic disparities from climate change
- **Economic geography (Terms of trade)** – determines how these biophysical disparities translate into differential welfare outcomes; hardest hit countries:
    - Are net importers of commodities with rising 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

Now decompose the impacts: How do individual climate impacts in these regions



Differentially affect the ToT of all regions

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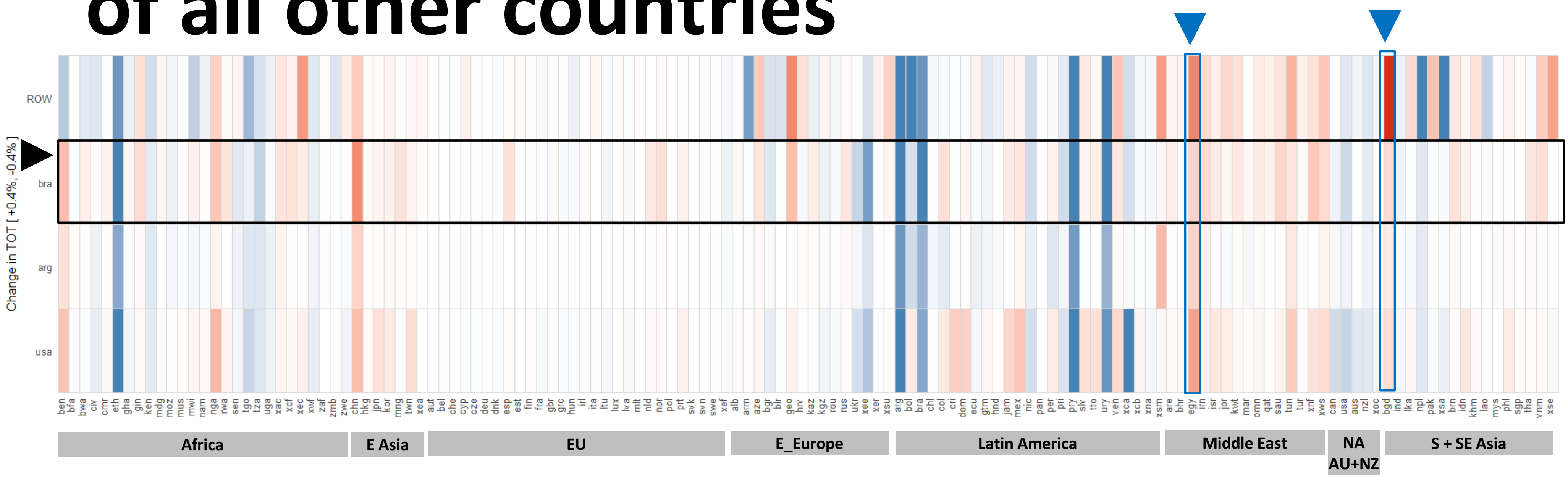
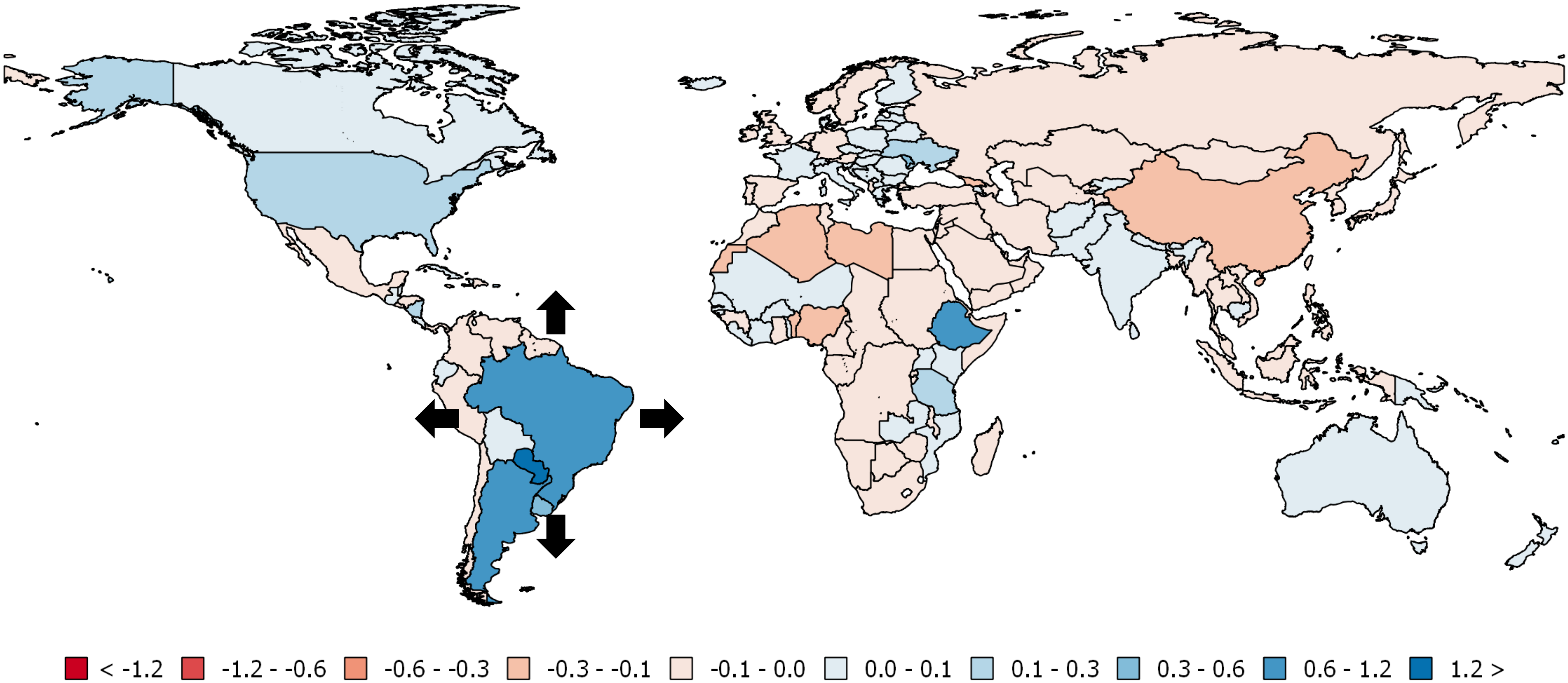
How climate impacts in Brazil affect ToT of all other countries



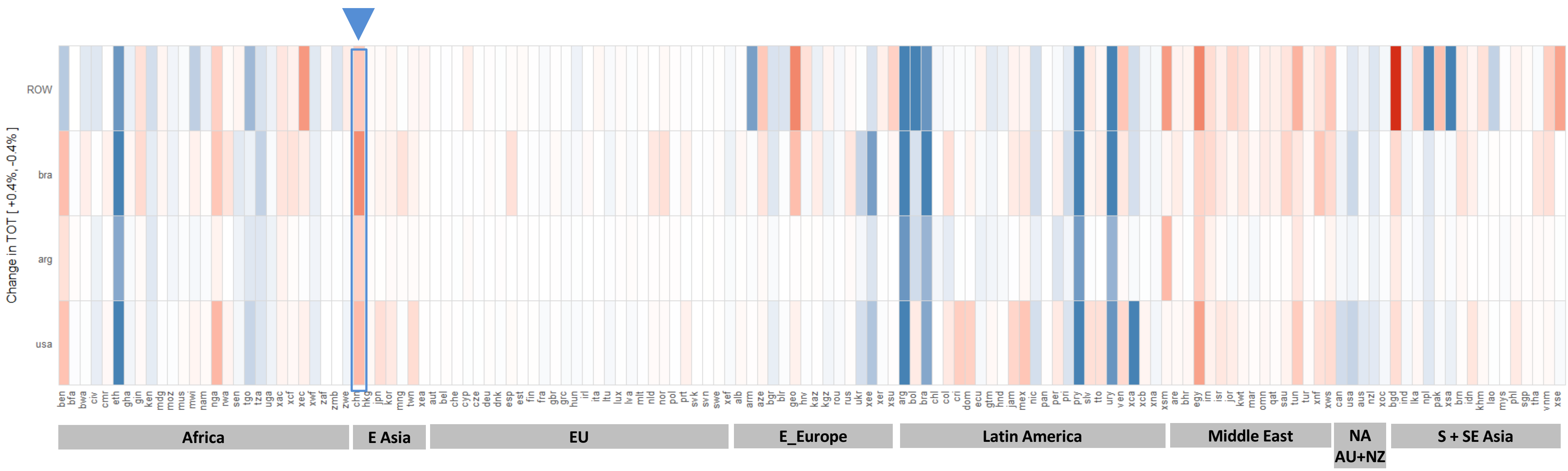
This is a row in our decomposition table

How climate impacts in Brazil….



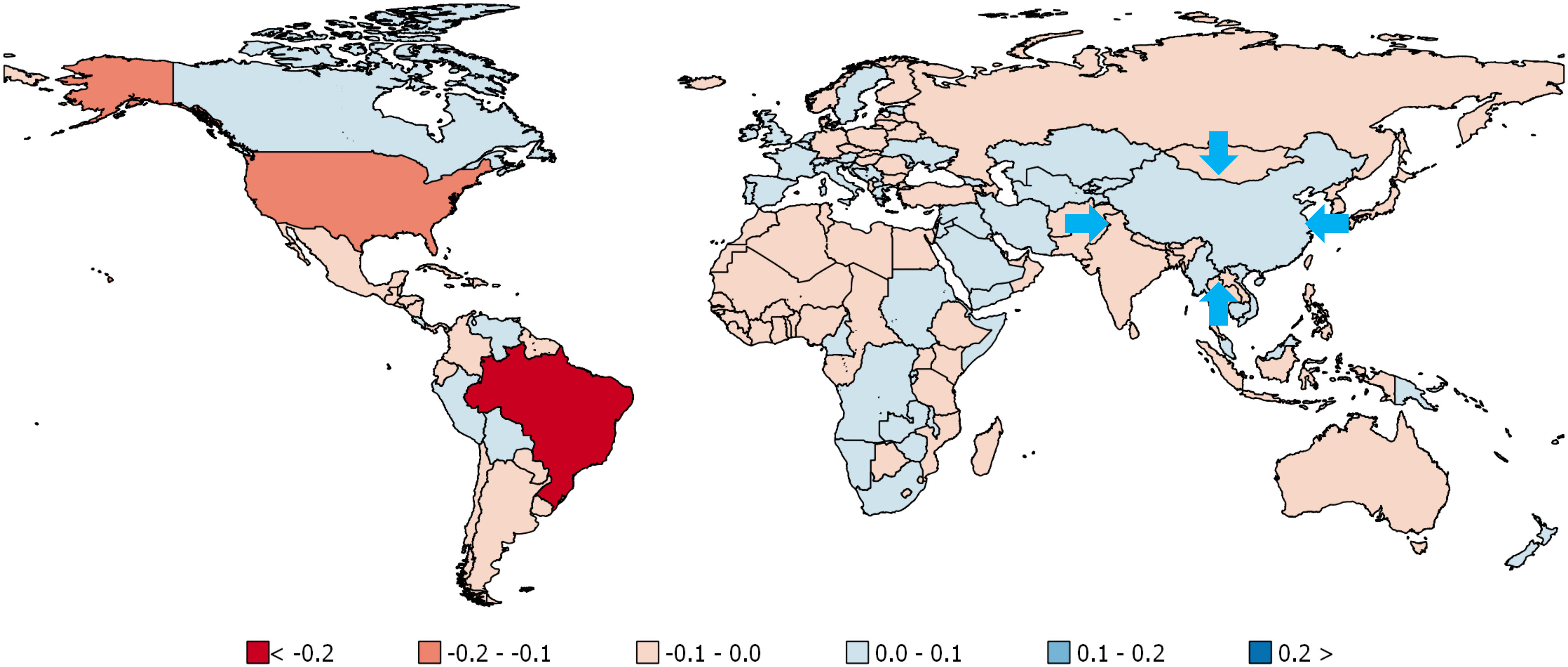
Affect ToT worldwide

How climate impacts worldwide affect China’s ToT….



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

How climate impacts worldwide

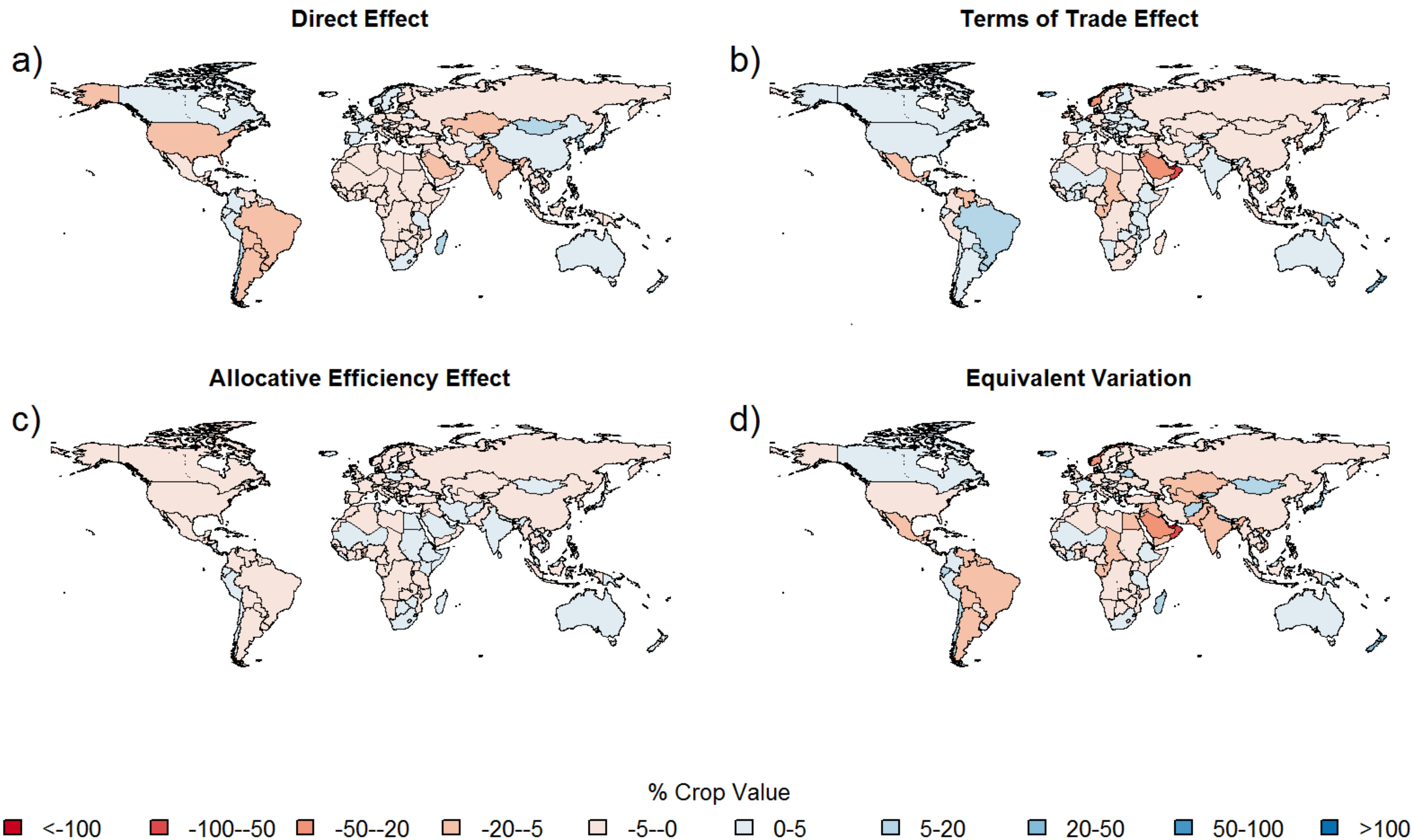


Affect China’s ToT…

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