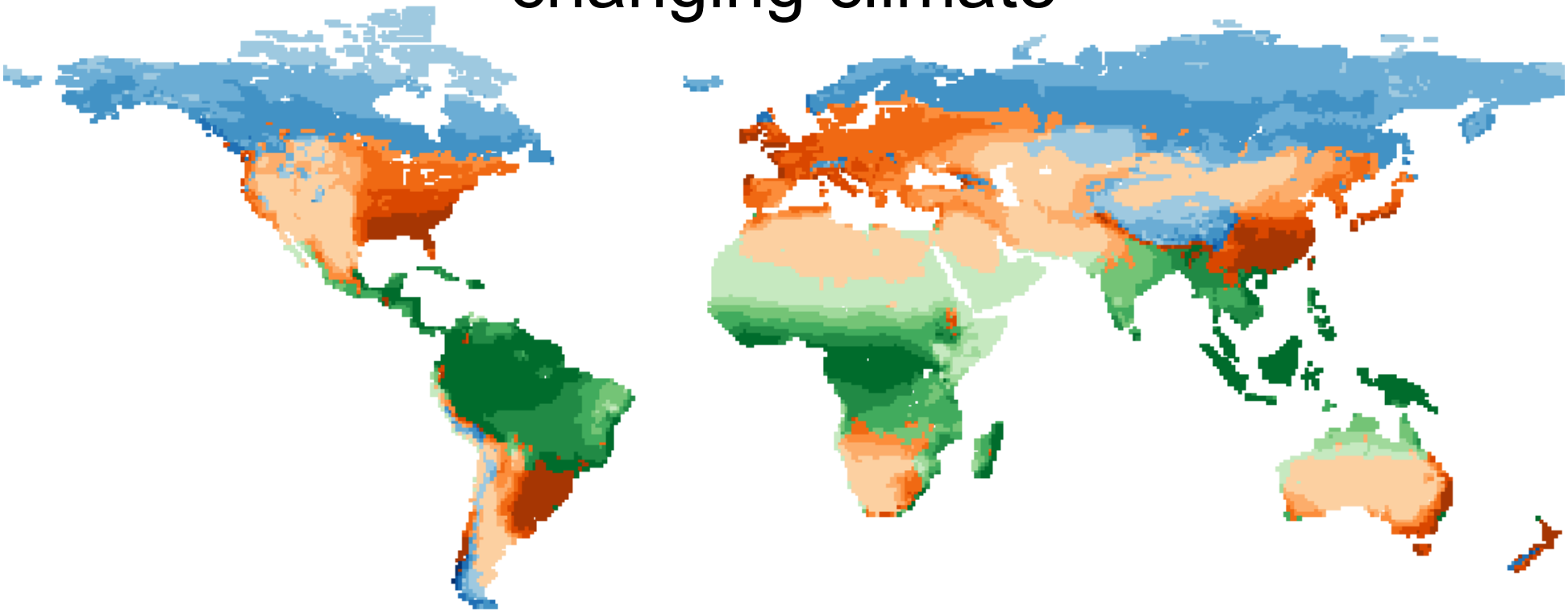
Implications of constant land unit boundaries for land use projection in a changing climate



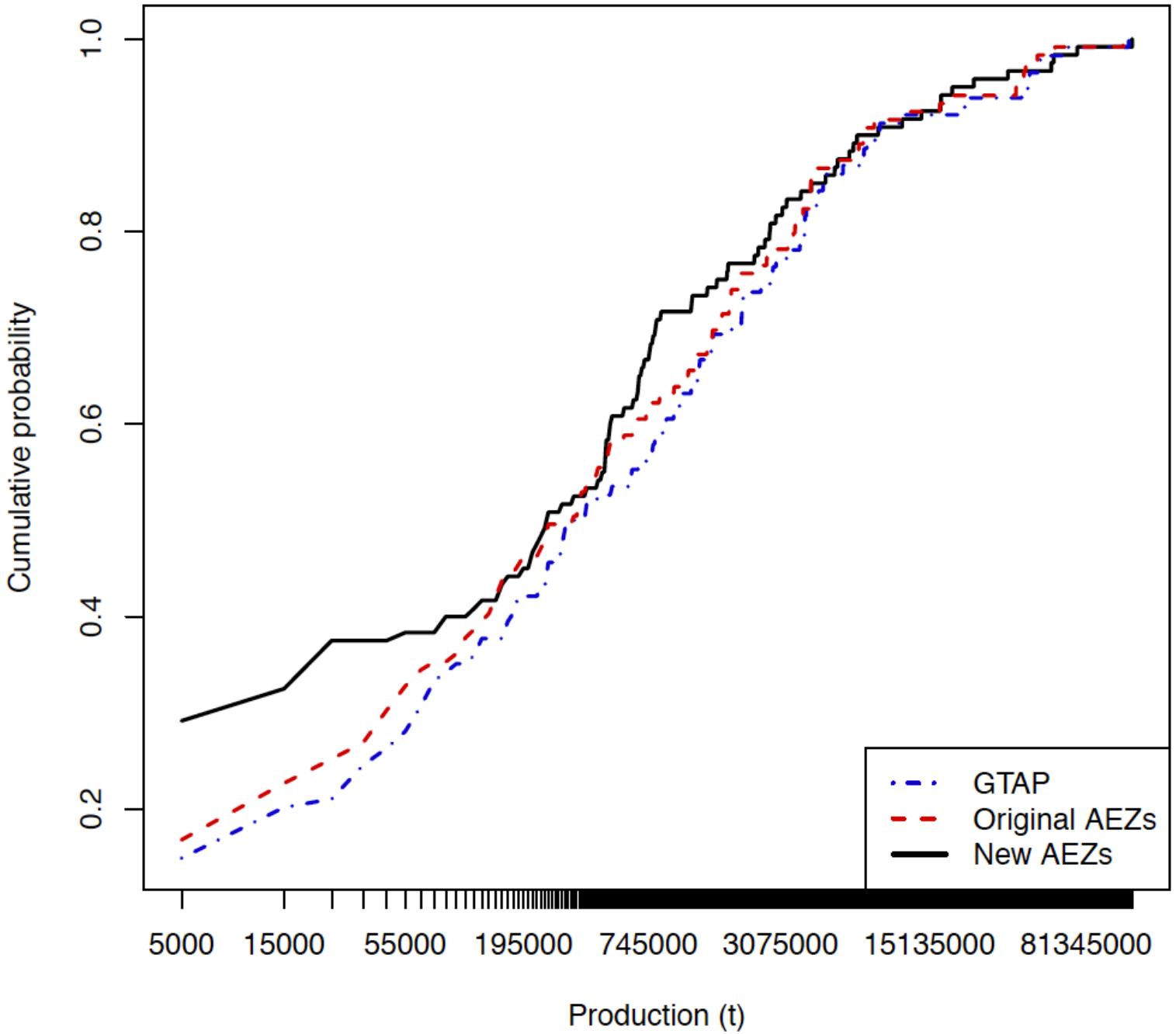
Alan V. Di Vittorio

Lawrence Berkeley National Laboratory

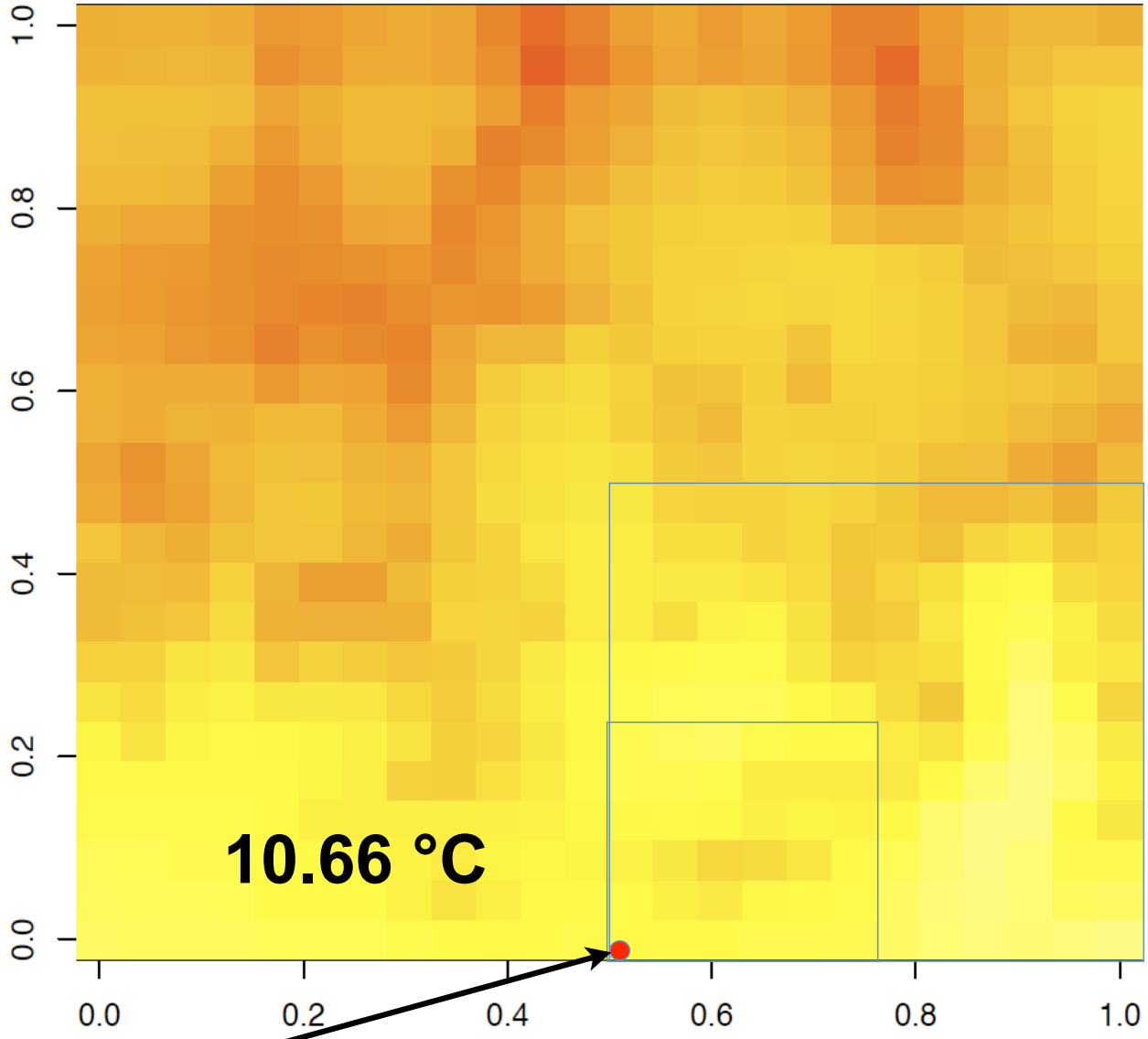
CESM annual workshop

19 June 2014

Global distributions of Paddy Rice Production

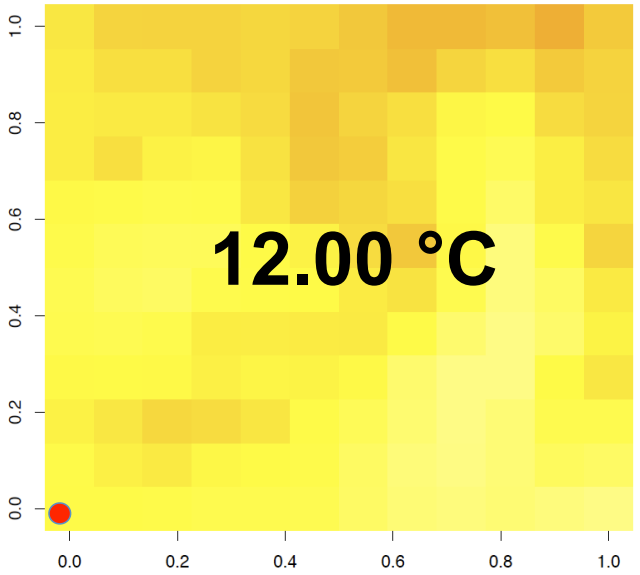


Different boundaries give different 'local' estimates

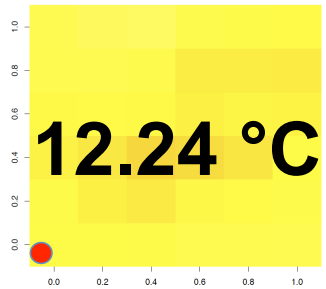


1 degree (~100 km) per side

12.66 °C



0.5 degree (~50 km) per side



0.25 degree (~25 km) per side

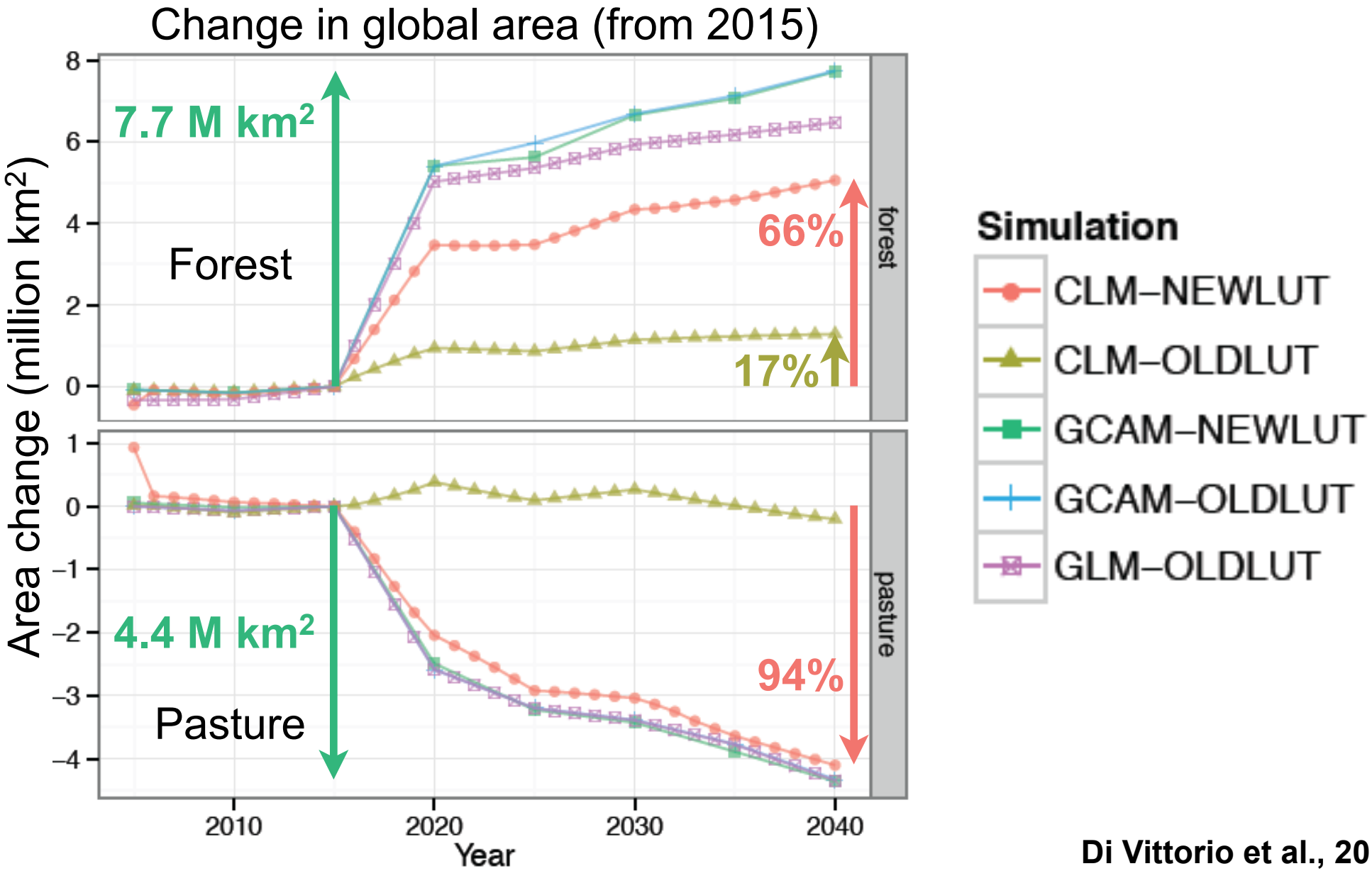
Temperature maximum, Jan. 1, 2003
Cell size is 2.5 minutes (~5 km)

IAMs have different regions/land units

- Unquantified spatial uncertainty confounds inter-model comparison and ensemble analysis

Model	Regions	Land units for use projection
IMAGE (RCP 2.6)	26	half-degree grid
MiniCAM (RCP 4.5)	14	GCAM: 151 land units
AIM (RCP 6.0)	24	half-degree grid
MESSAGE (RCP 8.5)	11	half-degree grid

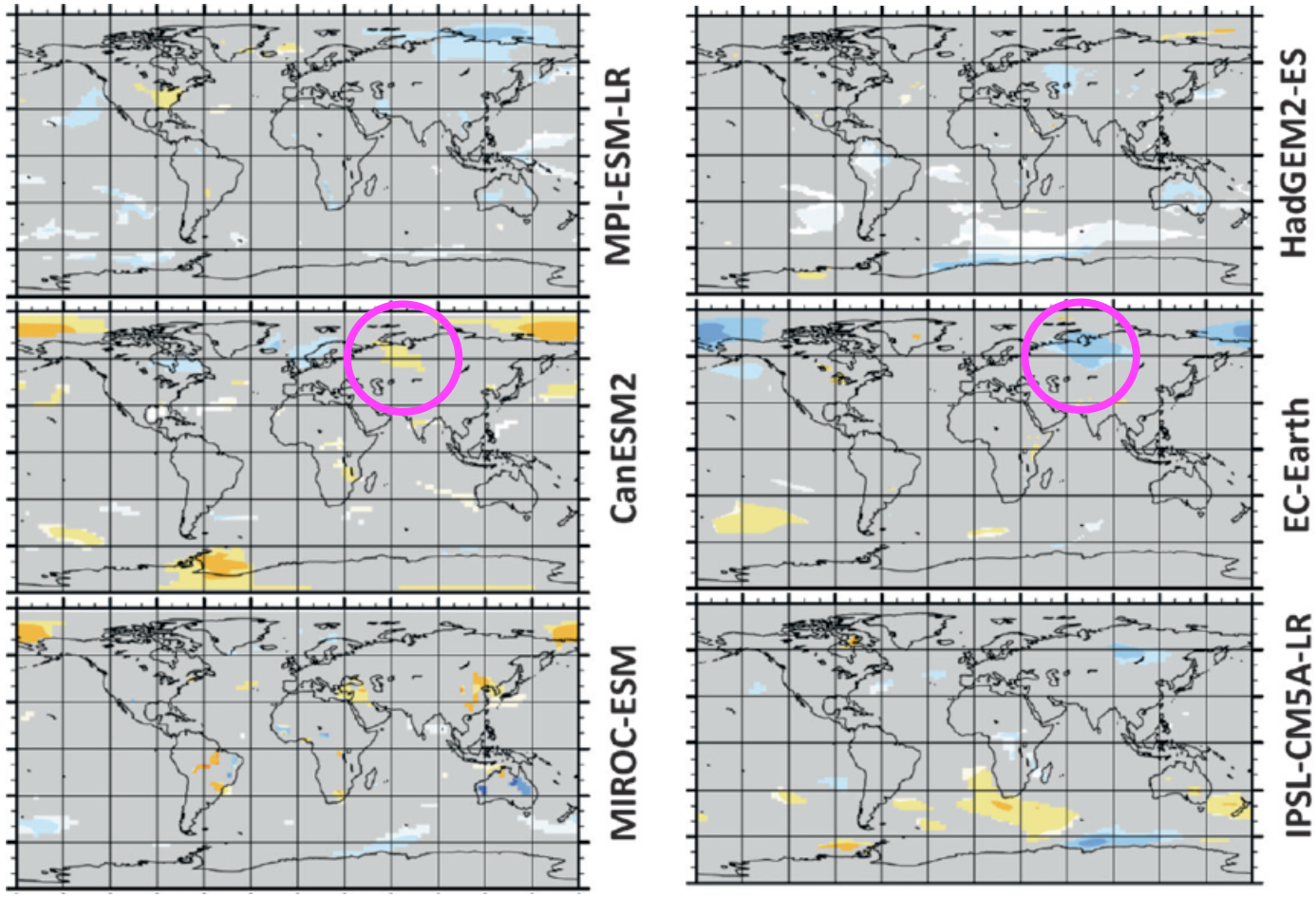
Land cover inconsistencies across IAMs and ESMs can alter the global carbon cycle



Di Vittorio et al., 2014

Different land use/cover representations in ESMs obscure land use change effects on regional climate

- Uncertainty chain:
  - IAM land use spatial uncertainty
  - Land use/cover translation
  - ESM land cover



Temperature effect of RCP 8.5 land use change for 2071-2100 (Brovkin et al. 2013)

How this relates to the SDWG

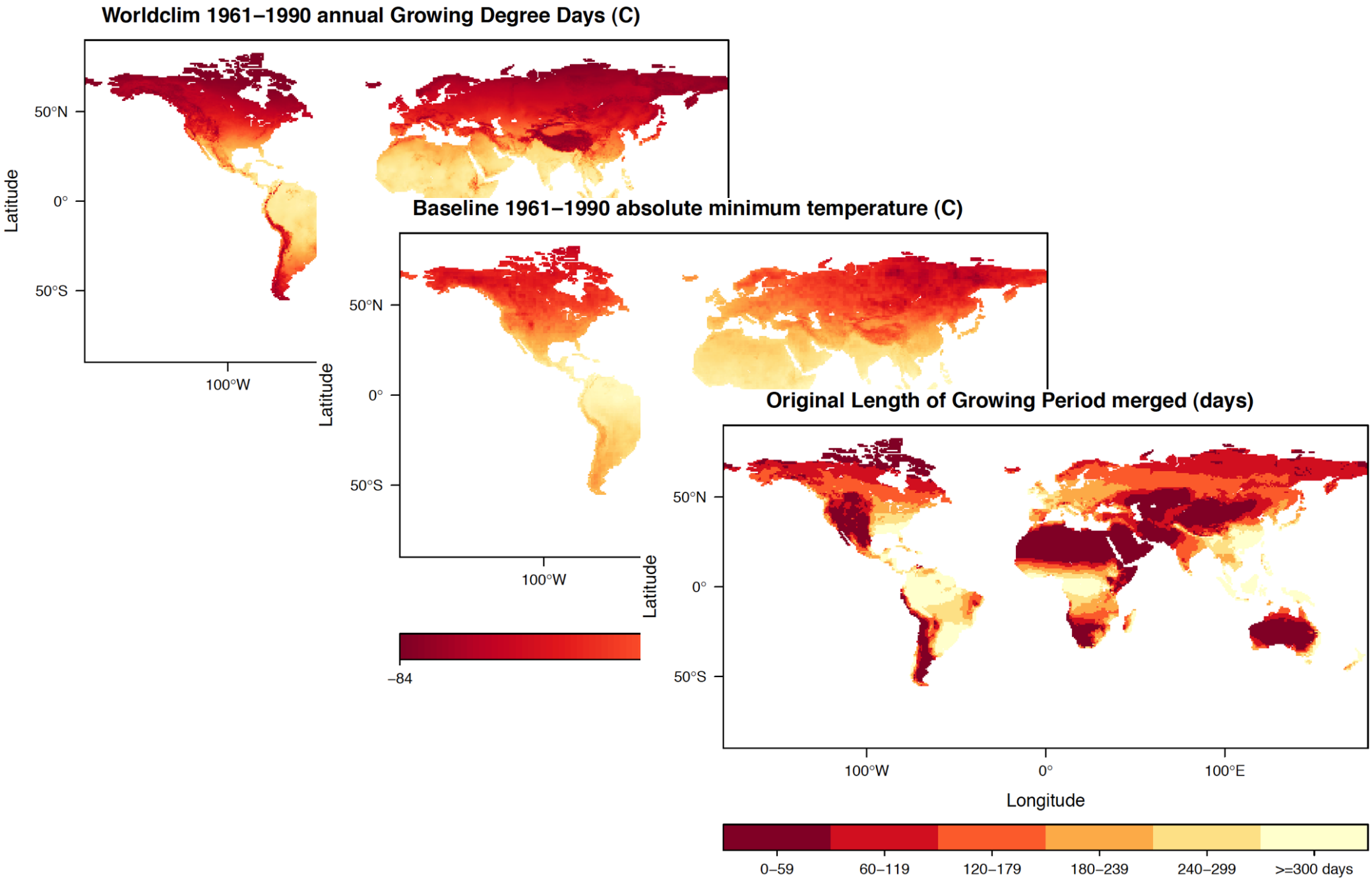
- **Fostering dialogue**
  - **Human** and **biophysical system** models need to **simulate the same earth**
- **Potential CESM developments**
  - **Land use and cover** that is **consistent** with **historical data** and **future projections**
  - More **complete** and **detailed agriculture** and **land management**

In the context of coupled whole earth system modeling

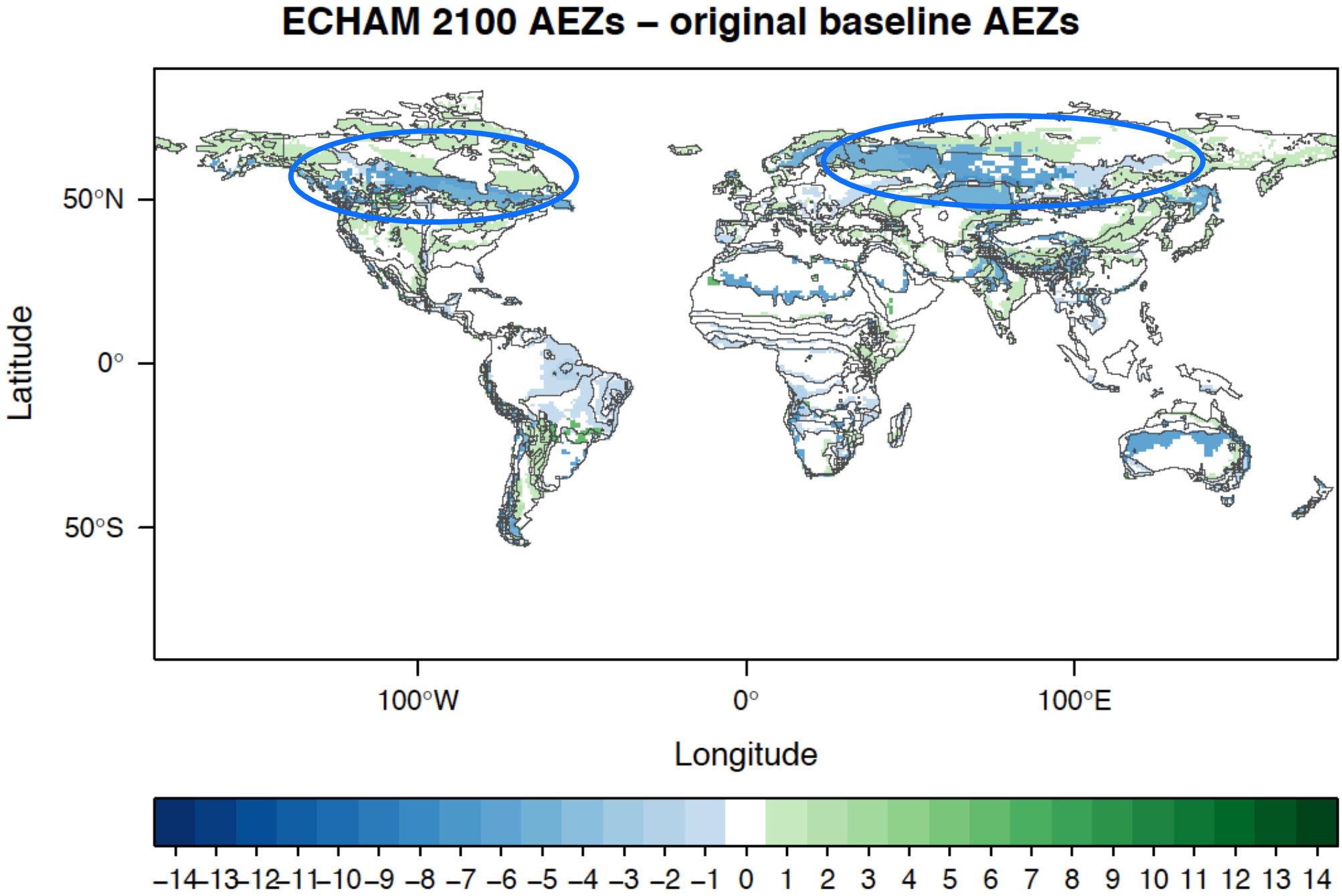
- How do we make robust projections of land use change in the context of projected climate change?

- **How do spatial boundaries influence projected land use?**

Agro-Ecological Zones (AEZs) are bio-climatically defined



Current land units become heterogeneous



Data required to create new AgLU crop and land rent inputs

Spatially explicit data

- VMAP0 countries (246)
- AEZ countries (160)

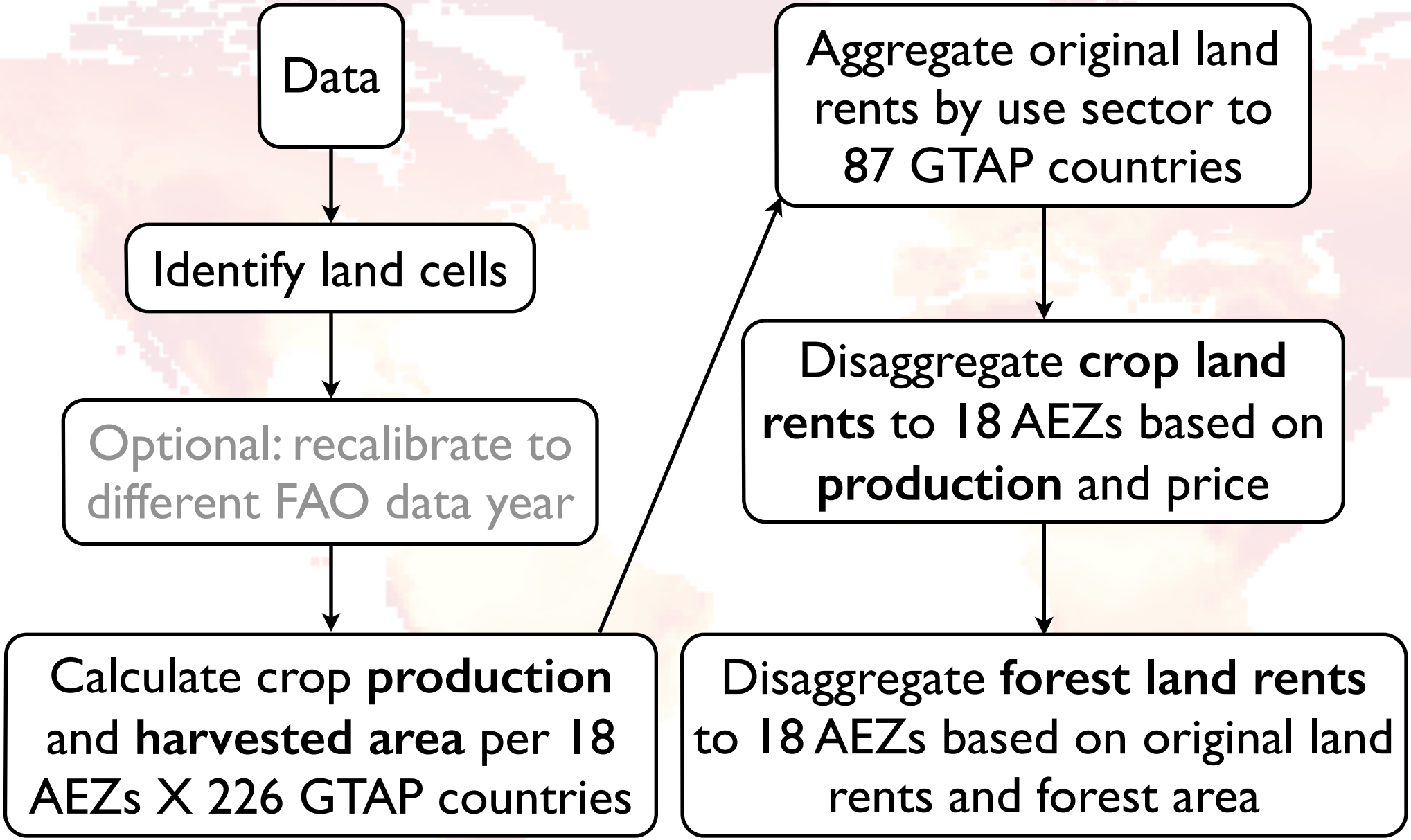
- SAGE data:
  - crop yield, area
  - cropland
  - pasture
  - land area
  - potential vegetation
- HYDE3.1 data:
  - urban
  - land area
- AEZ boundaries

Tabular data

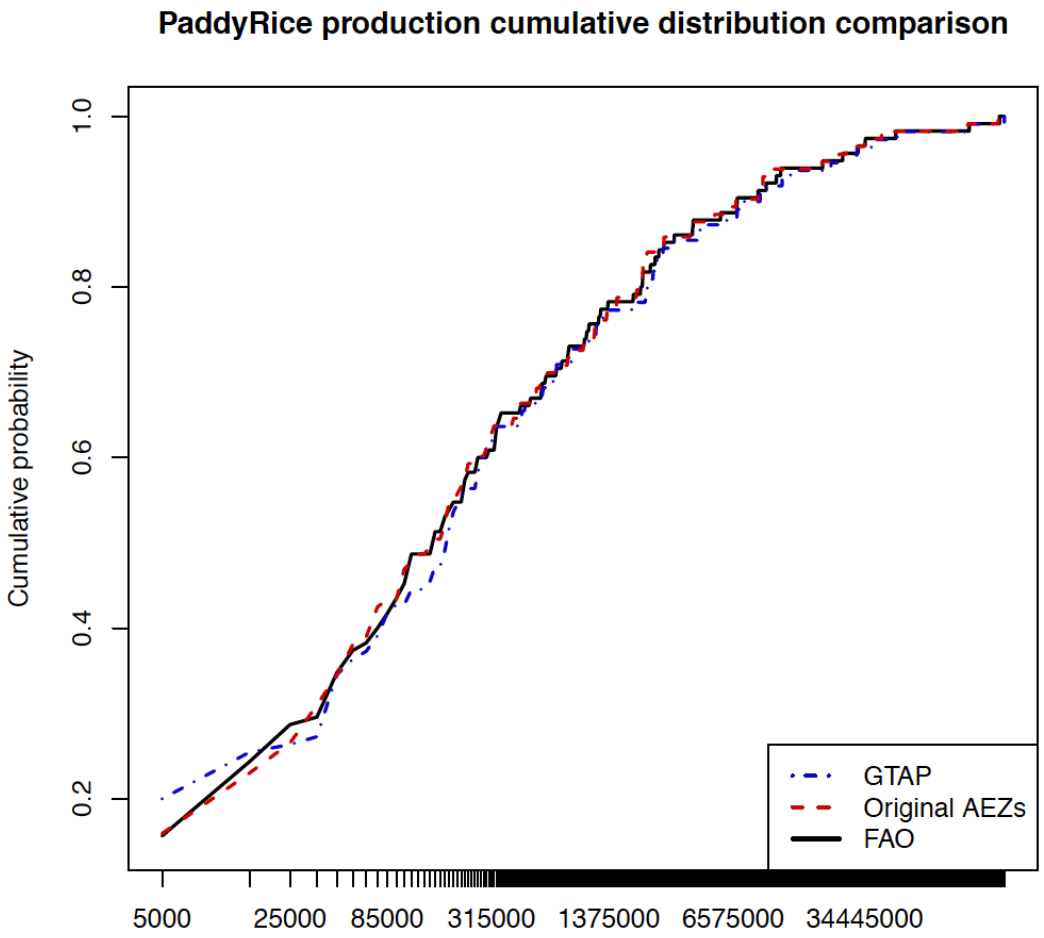
- GTAP countries (226, 87)
- FAO countries (241)

- GTAP (SAGE) crops
- GTAP use sector
- GTAP land rent
- FAO crops
- FAO crop production
- FAO producer prices
- FAO crop yield, area
  - for recalibration

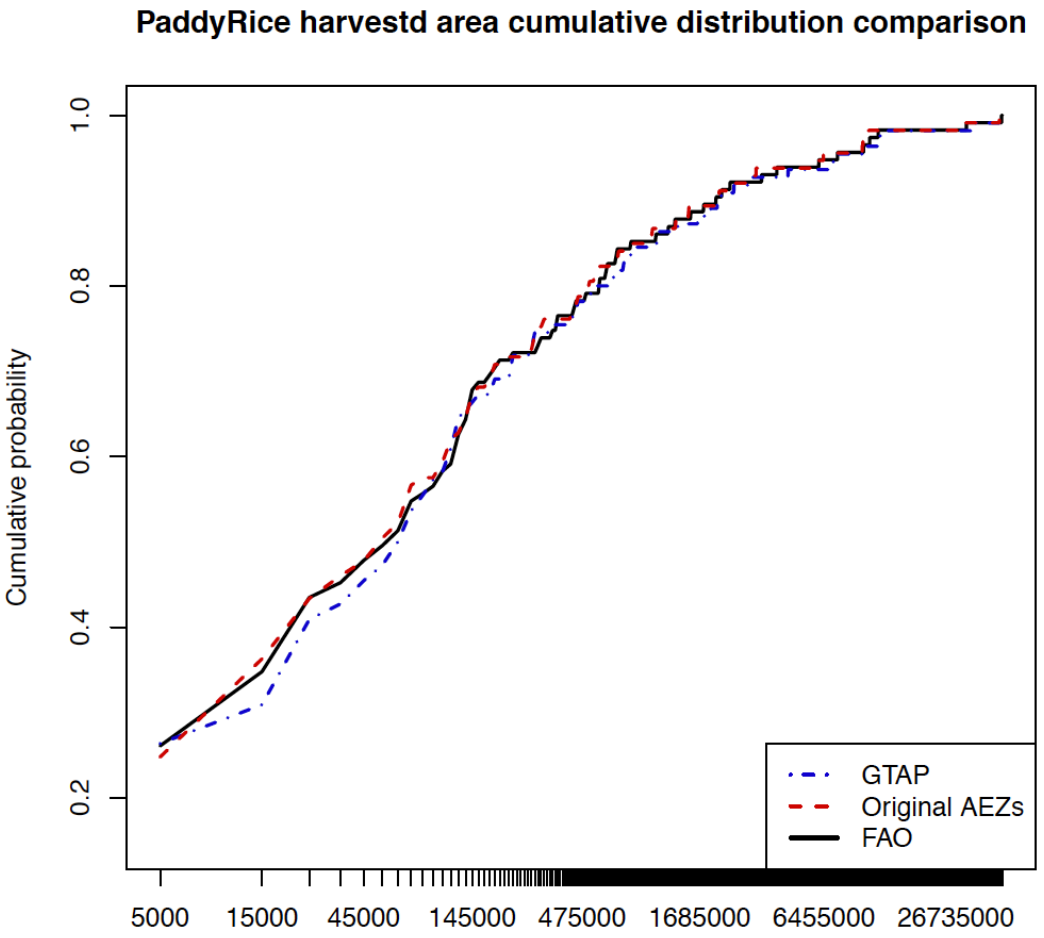
Workflow to create new AgLU crop and land rent inputs



Global distributions of Rice, by country

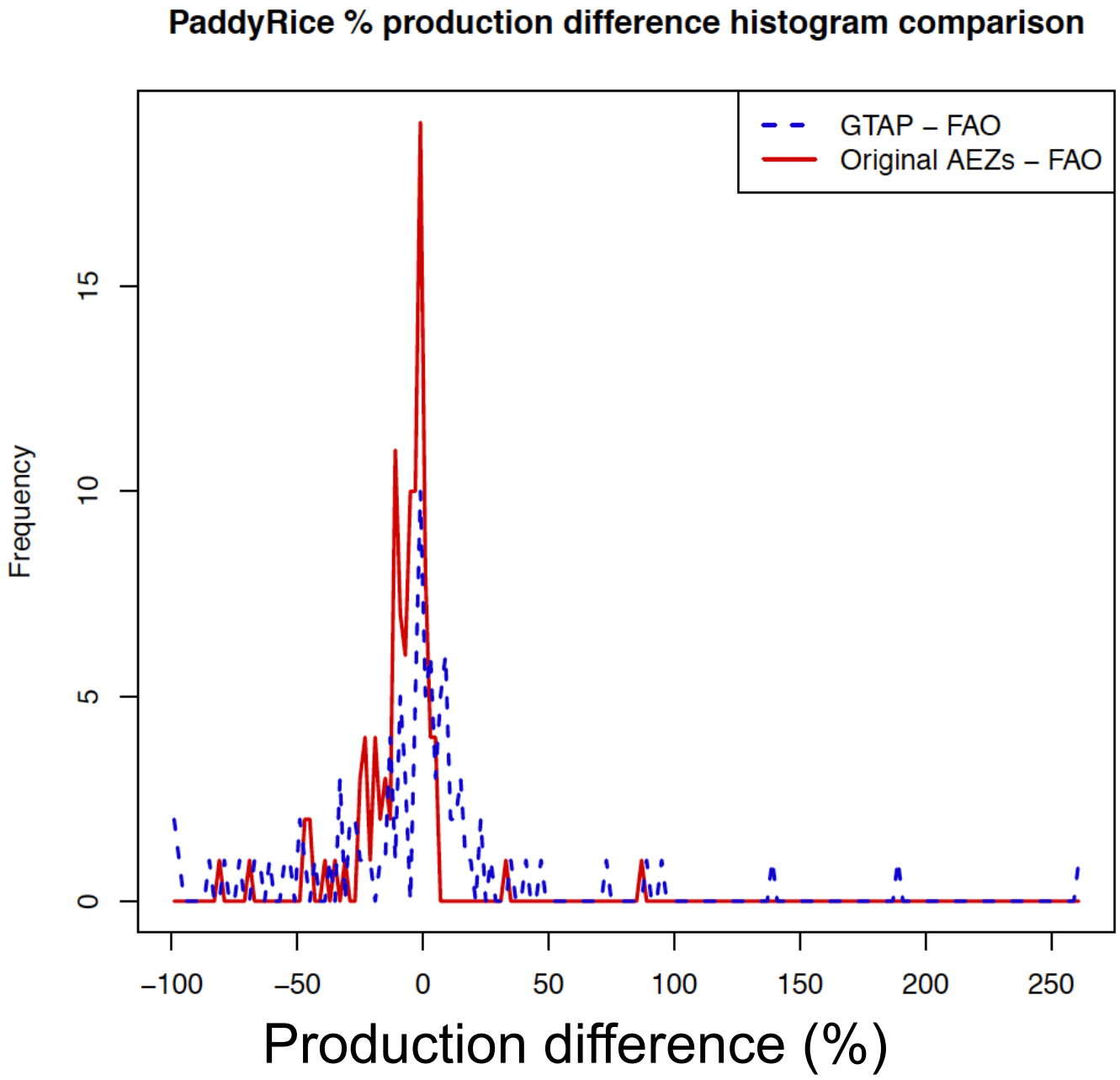


Production (t)



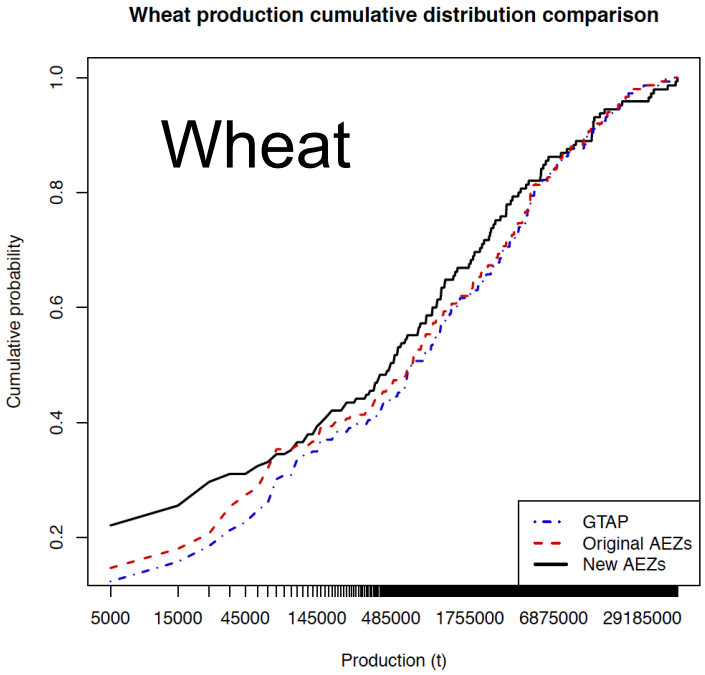
Harvested area (ha)

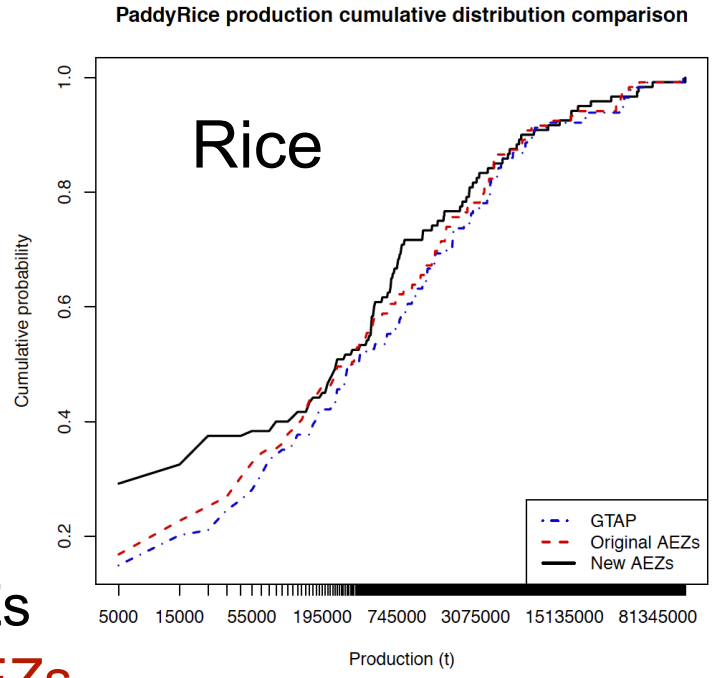
Distribution differences for Paddy Rice, by country



Each crop is uniquely affected by new land units

Cumulative probability

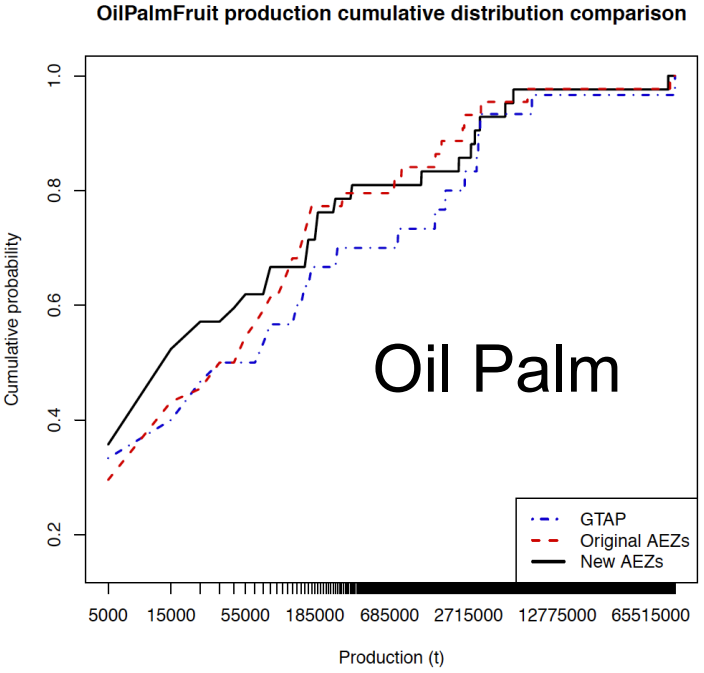


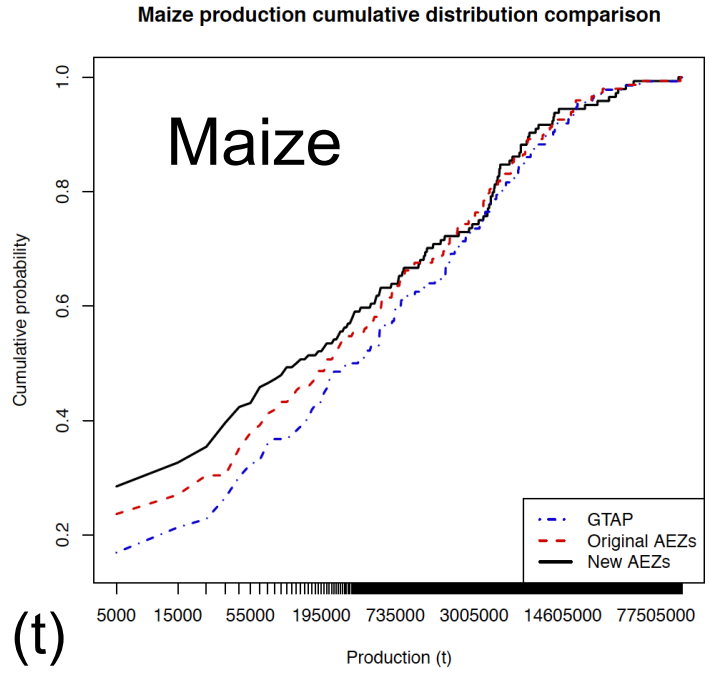


New AEZs

Original AEZs

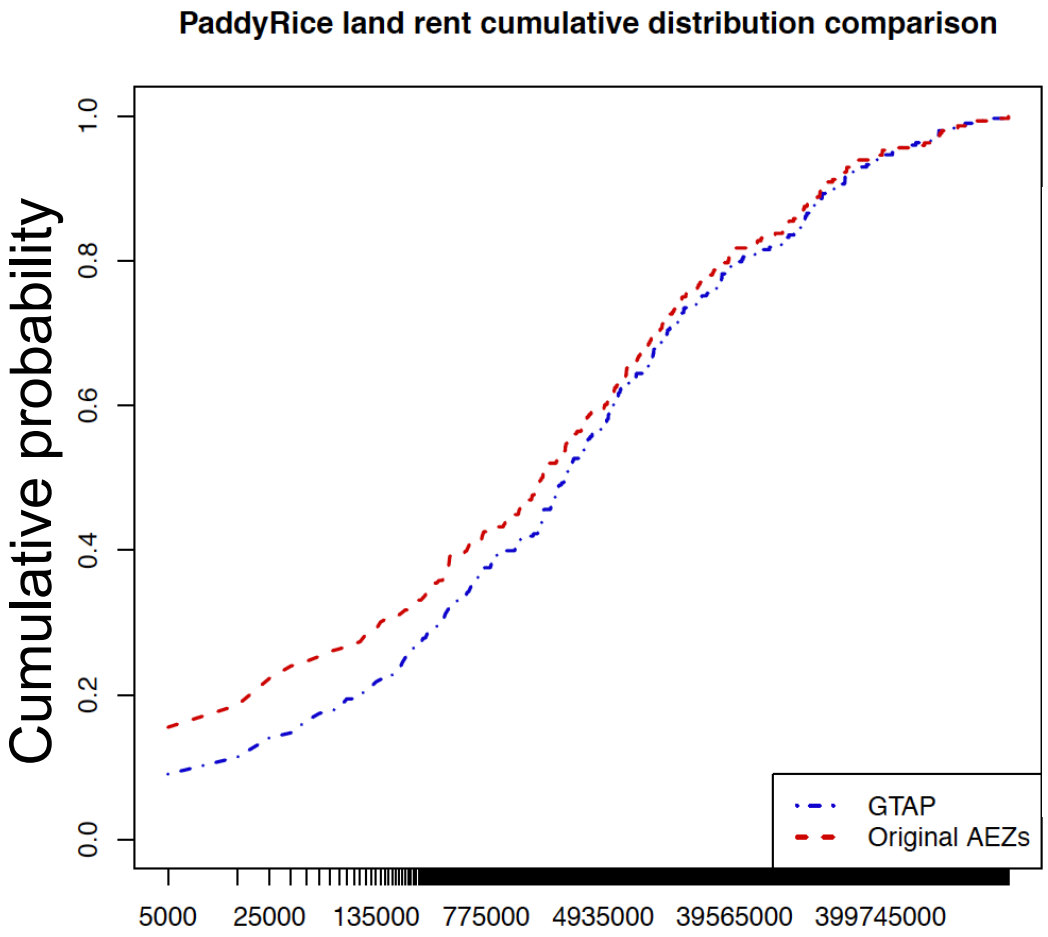
GTAP

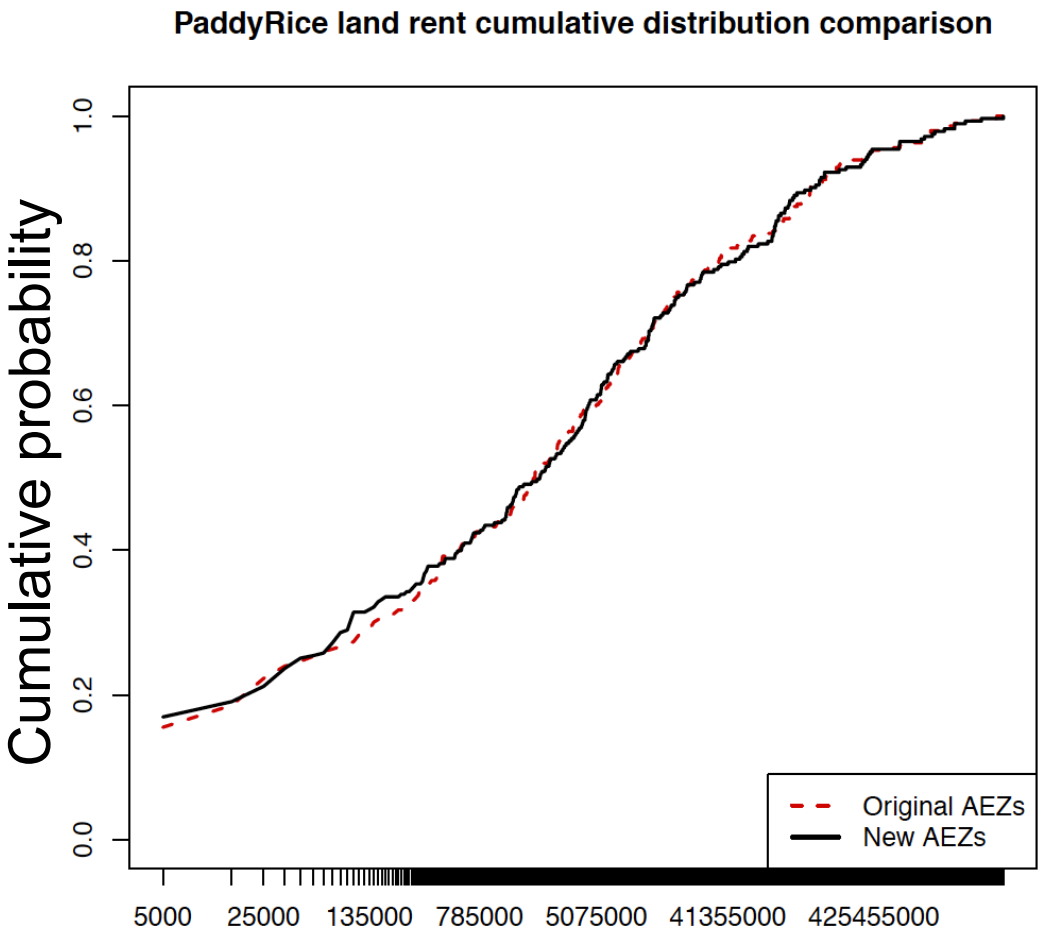




Production (t)

Global distributions of Rice land rent, by land unit





Land Rent (US$)

New AEZs

Original AEZs

GTAP

Land Rent (US$)

Summary

- AEZ-based land units do not consistently meet homogeneity assumption for land use projection
- New software performs better than GTAP with respect to FAO data: Reproducibility?
- Global distributions of crop production and harvested area are different between the original and new land units
- Unique crop responses to land units, technology, or climate will affect land use projections
- Feedbacks: climate, impact, and land use

Summary

- AEZ-based land units do not consistently meet homogeneity assumption for land use projection
- New software performs better than GTAP with respect to FAO data: Reproducibility?
- Global distributions of crop production and harvested area are different between the original and new land units
- Unique crop responses to land units, technology, or climate will affect land use projections
- Feedbacks: climate, impact, and land use

Summary

- AEZ-based land units do not consistently meet homogeneity assumption for land use projection
- New software performs better than GTAP with respect to FAO data: Reproducibility?
- Global distributions of crop production and harvested area are different between the original and new land units
- Unique crop responses to land units, technology, or climate will affect land use projections
- Feedbacks: climate, impact, and land use

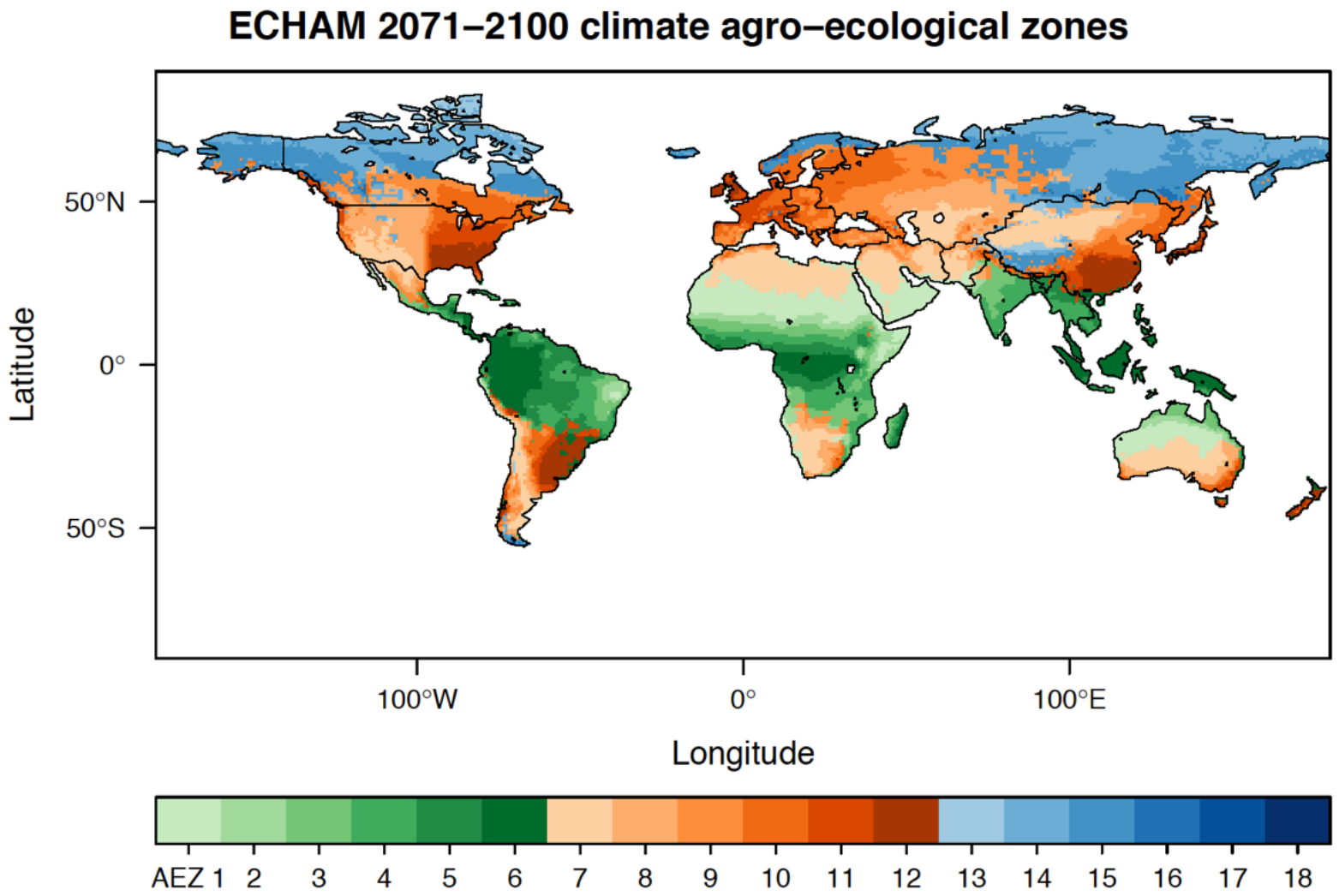
Summary

- AEZ-based land units do not consistently meet homogeneity assumption for land use projection
- New software performs better than GTAP with respect to FAO data: Reproducibility?
- Global distributions of crop production and harvested area are different between the original and new land units
- Unique crop responses to land units, technology, or climate will affect land use projections
- Feedbacks: climate, impact, and land use

Summary

- AEZ-based land units do not consistently meet homogeneity assumption for land use projection
- New software performs better than GTAP with respect to FAO data: Reproducibility?
- Global distributions of crop production and harvested area are different between the original and new land units
- Unique crop responses to land units, technology, or climate will affect land use projections
- Feedbacks: climate, impact, and land use

Questions?



This work is supported by the Director, Office of Science, Office of Biological and Environmental Research of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 as part of their Integrated Assessment Research Program.