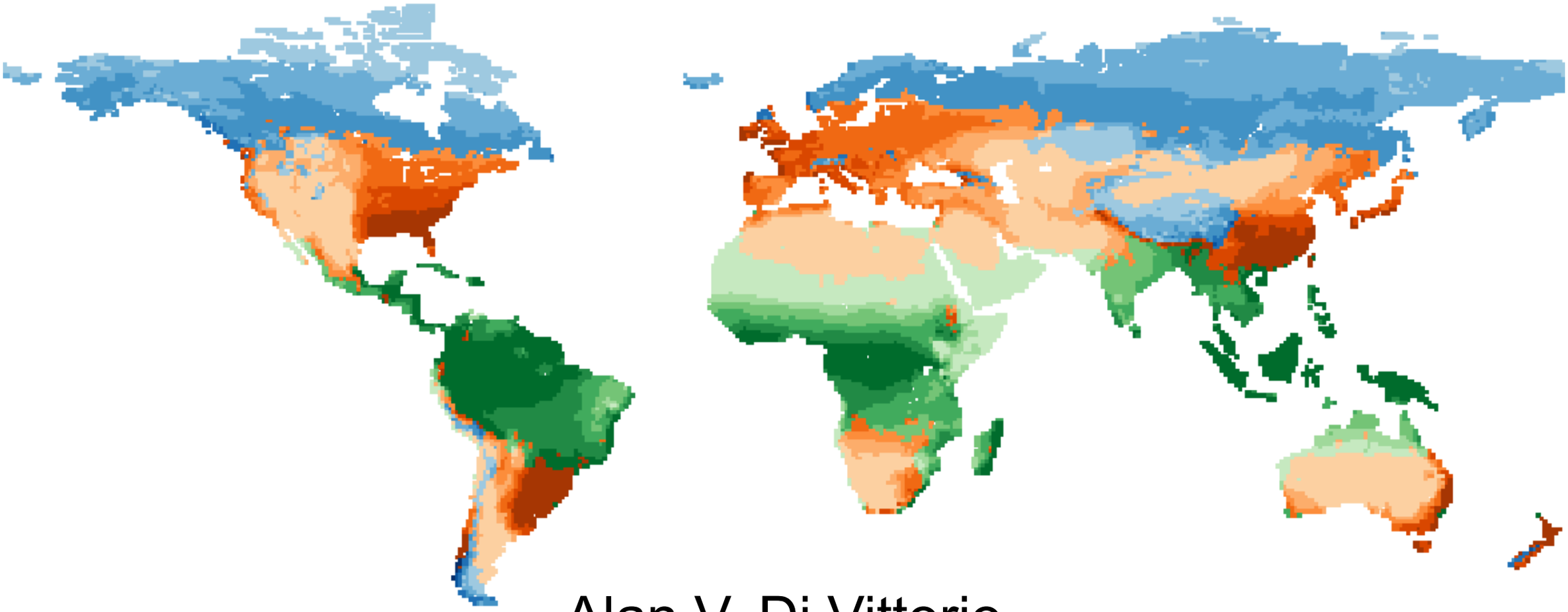
The effects of land unit boundaries on GCAM land use and land cover projection



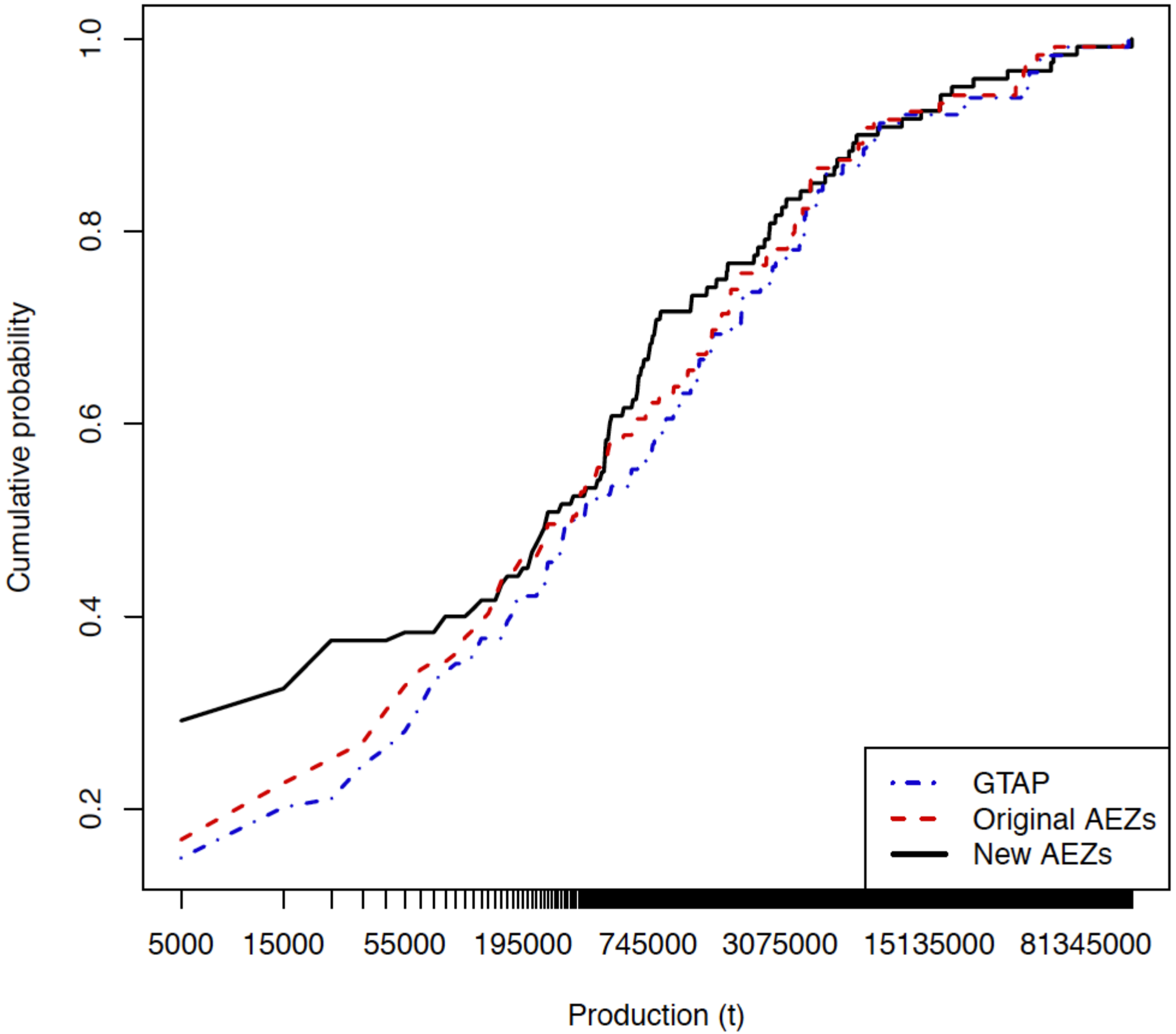
Alan V. Di Vittorio

Lawrence Berkeley National Laboratory

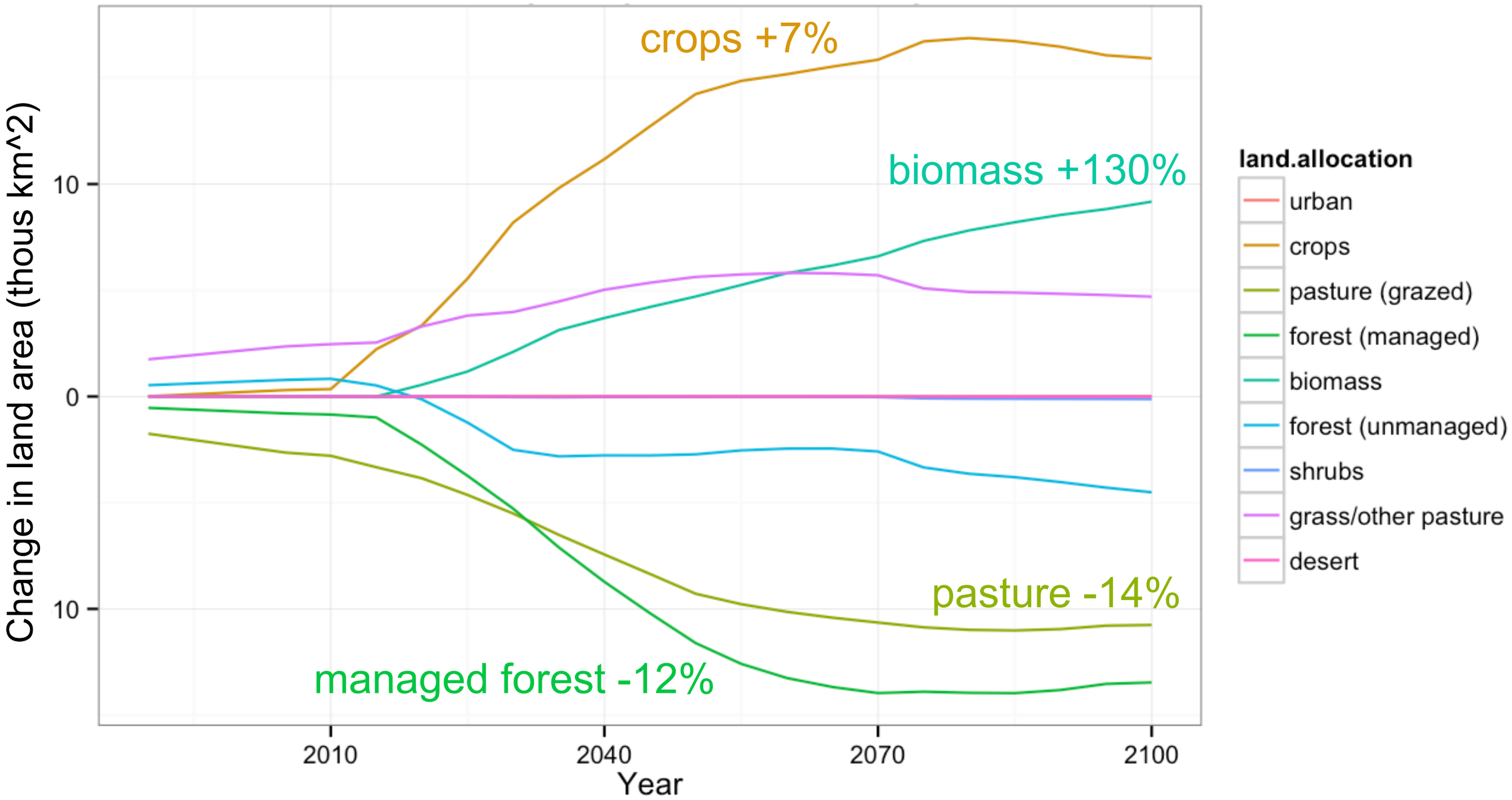
With special thanks to Page Kyle and Pralit Patel

IA/GCAM annual workshop
21 October 2014

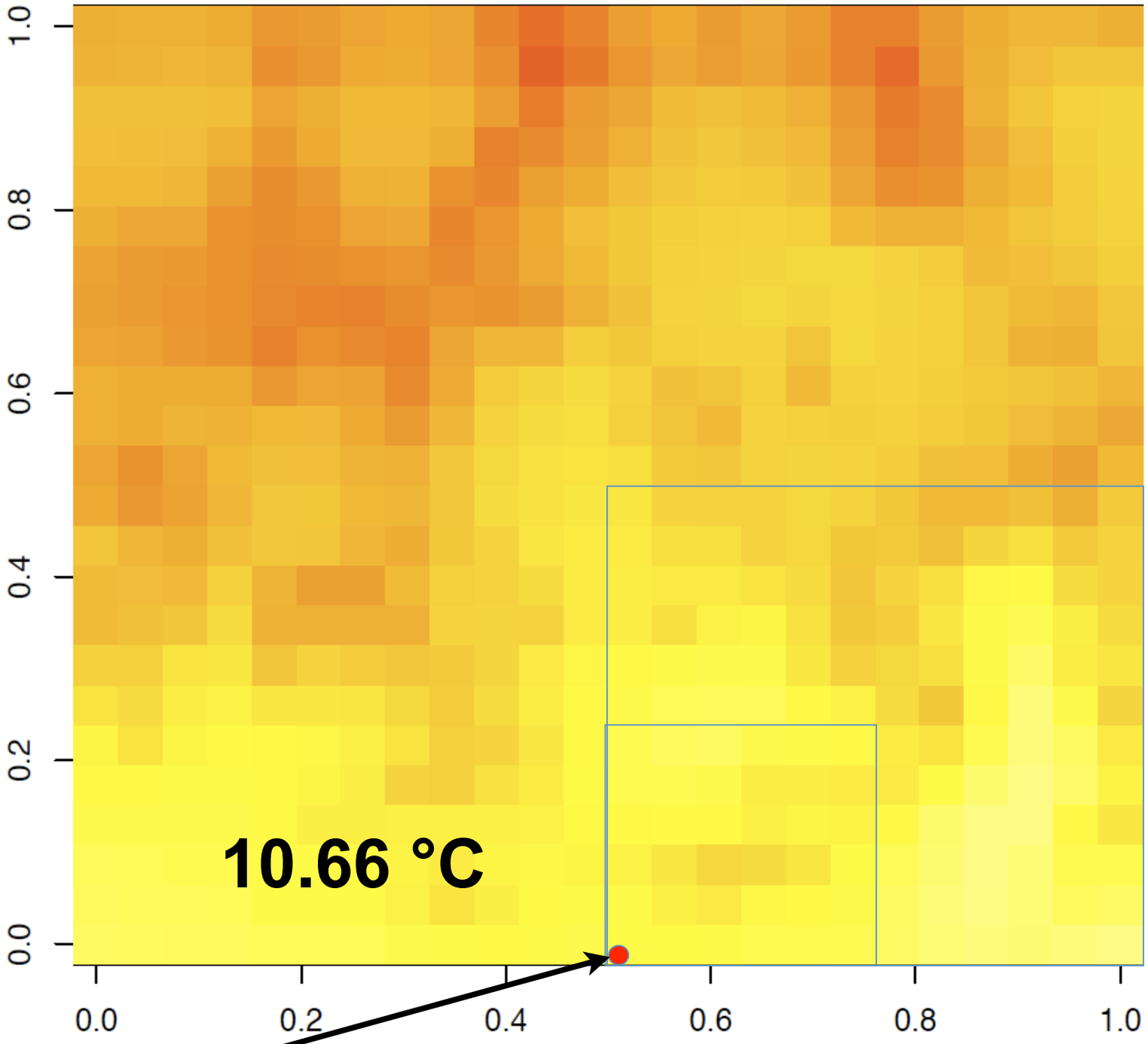
Global distributions of Paddy Rice Production



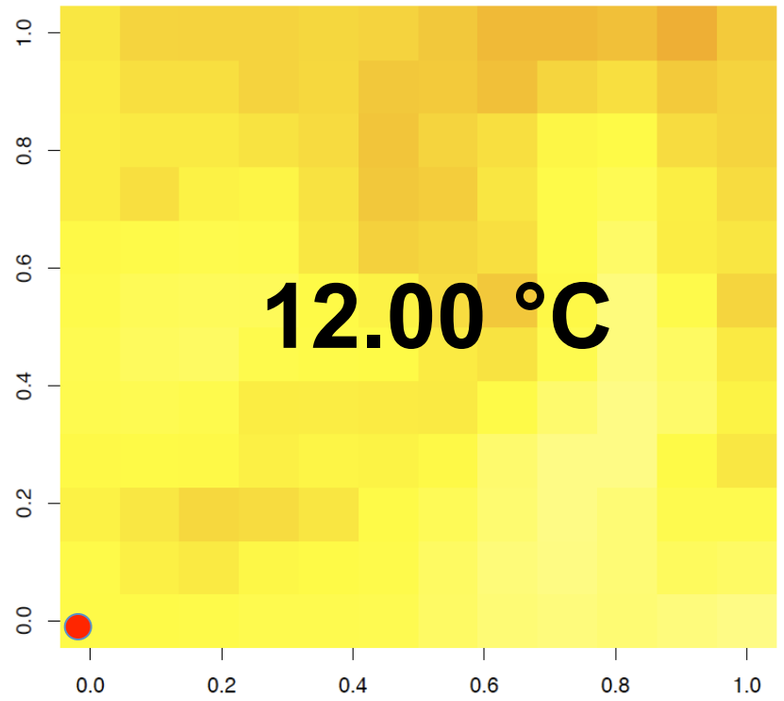
AEZ boundaries affect projected land use/cover



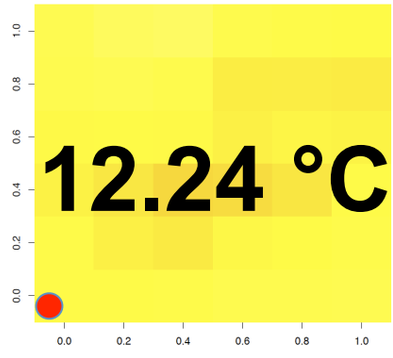
Different boundaries give different "local" estimates



1 degree (~100 km) per side



0.5 degree (~50 km) per side



0.25 degree (~25 km) per side

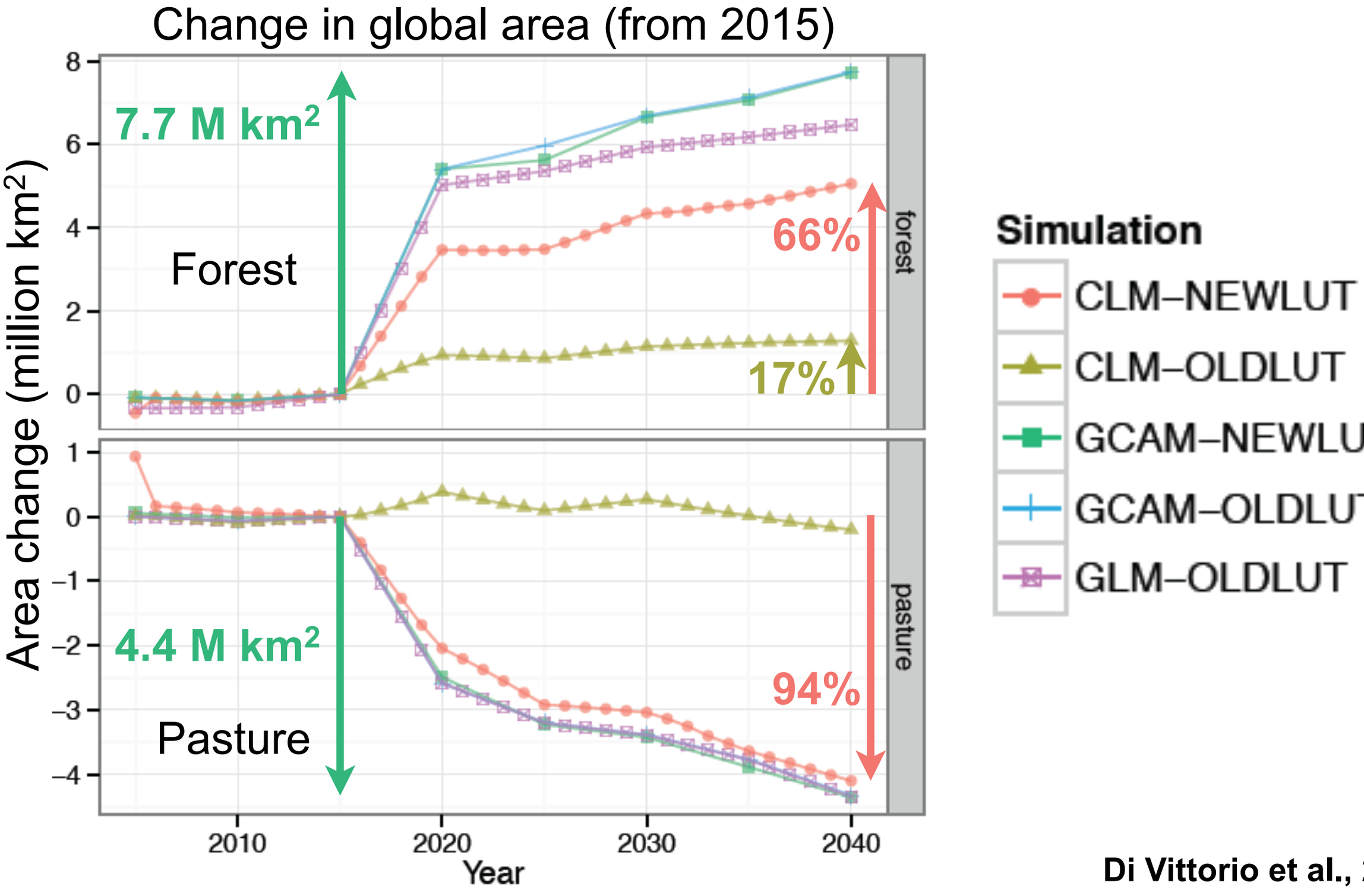
Temperature maximum, Jan. 1, 2003
Cell size is 2.5 minutes (~5 km)

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

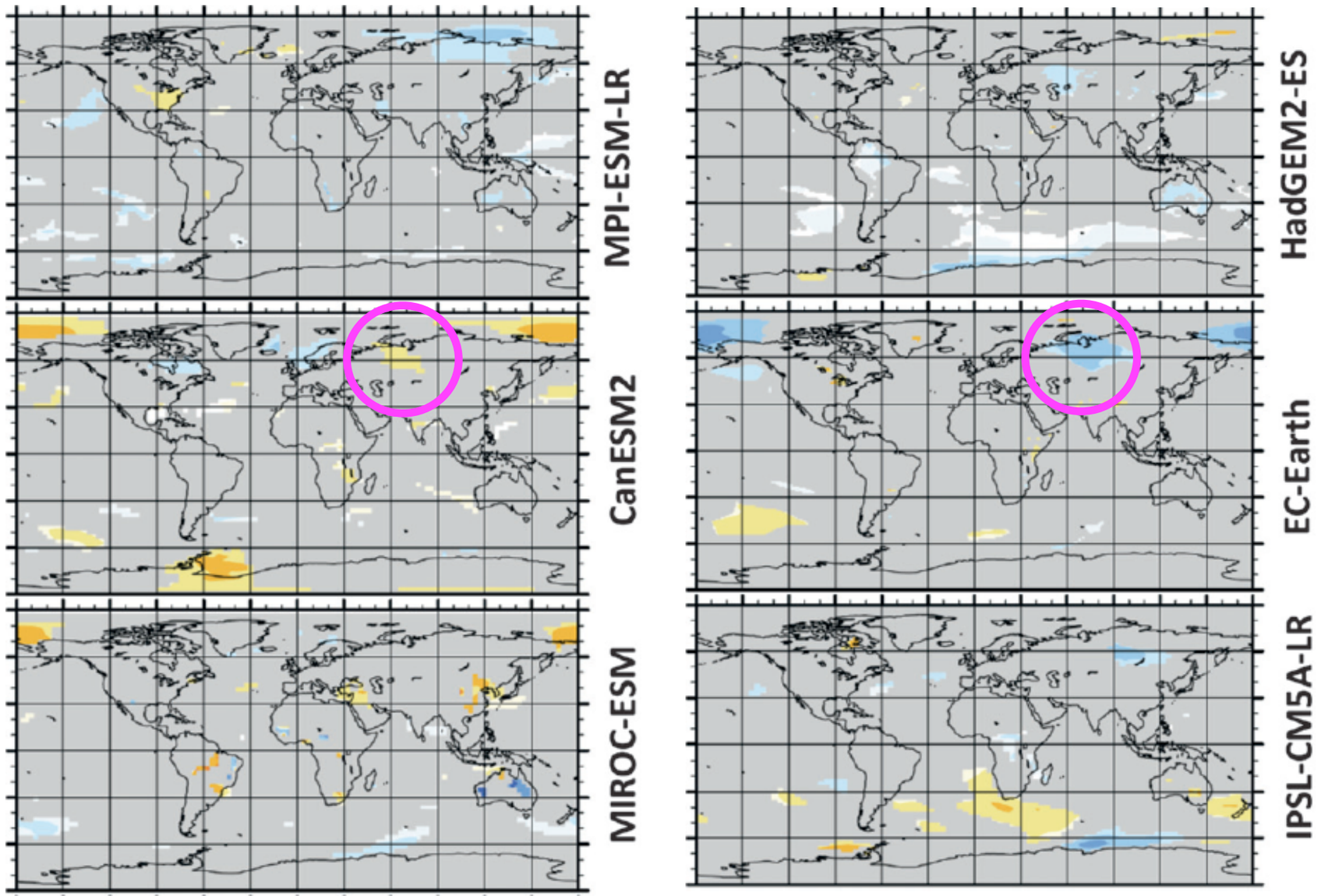
Land cover inconsistencies across IAMs and ESMs can alter the global carbon cycle



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



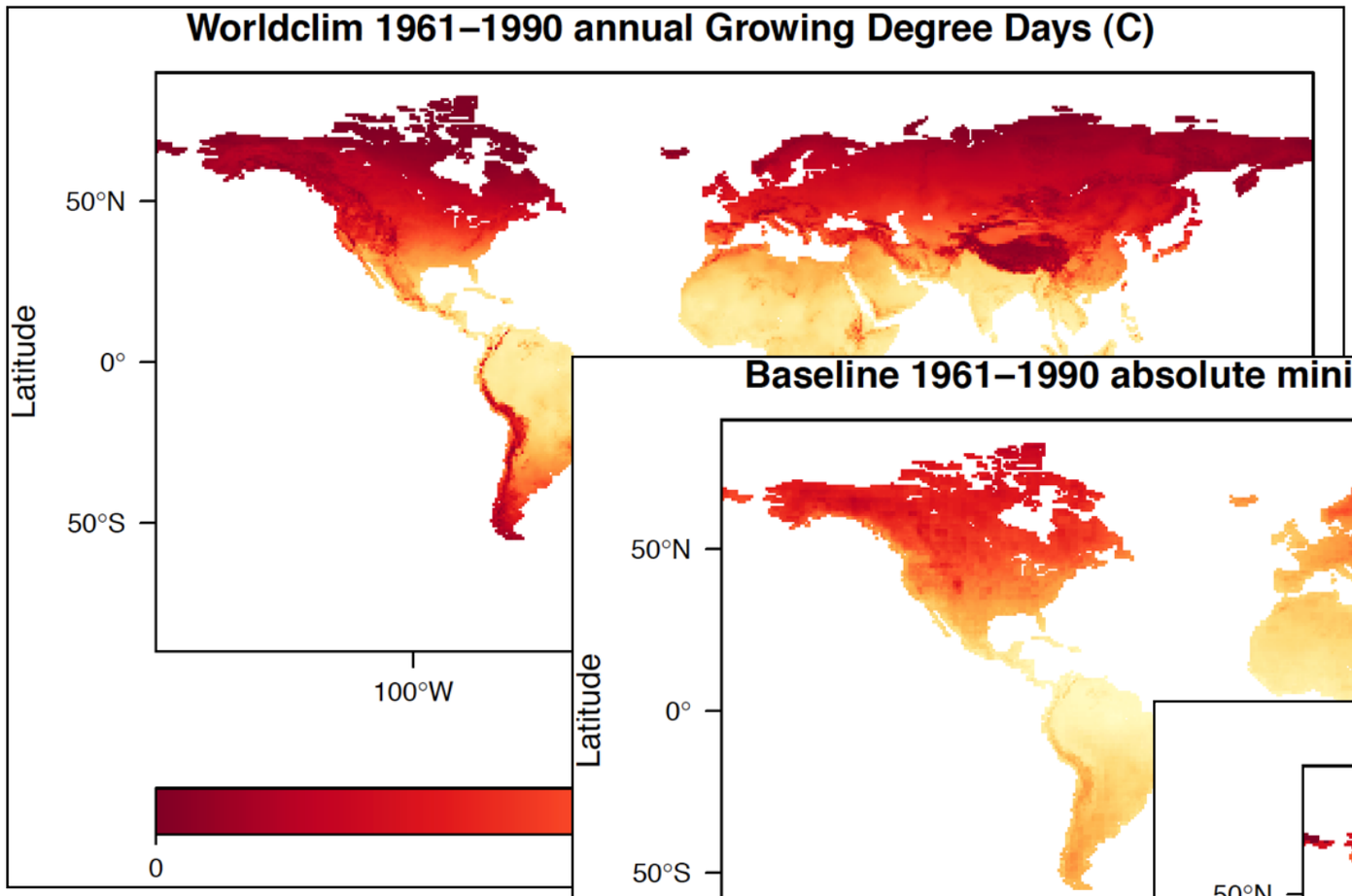
Temperature effect of RCP 8.5 land use change for 2071-2100 (Brovkin et al. 2013)

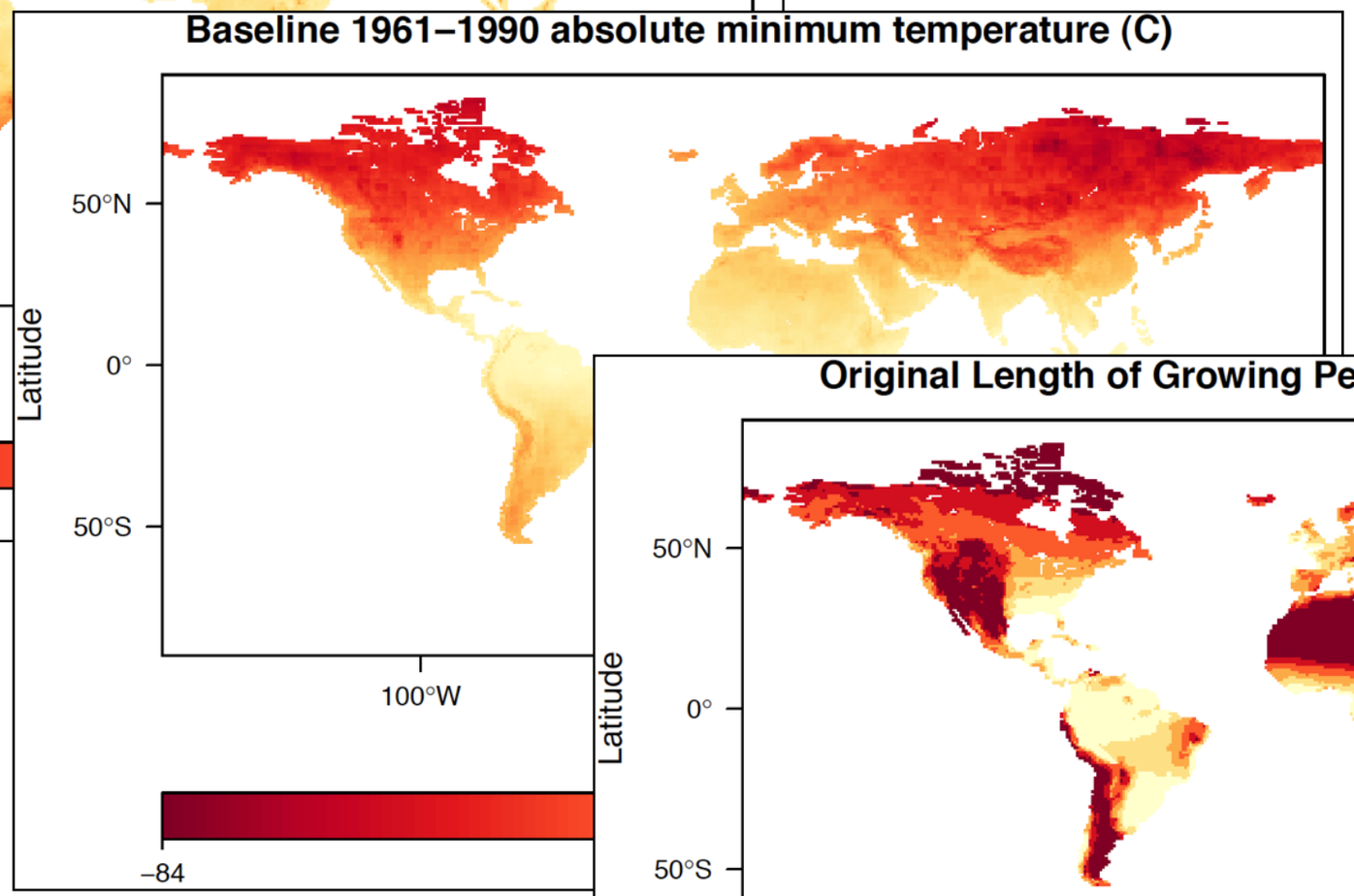
In the context of coupled whole earth system modeling

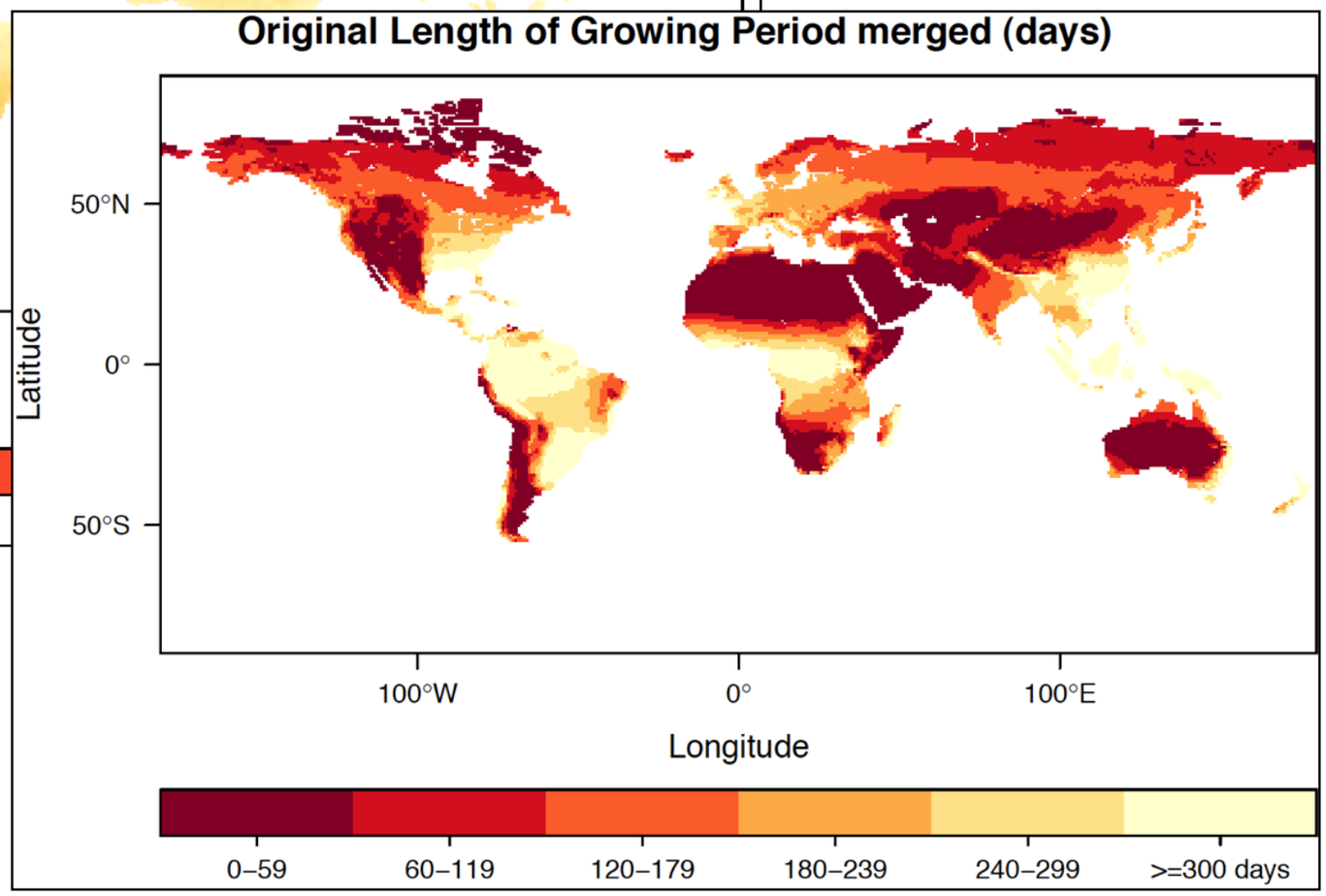
- How do we make robust projections of land use change in the context of projected climate change?

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

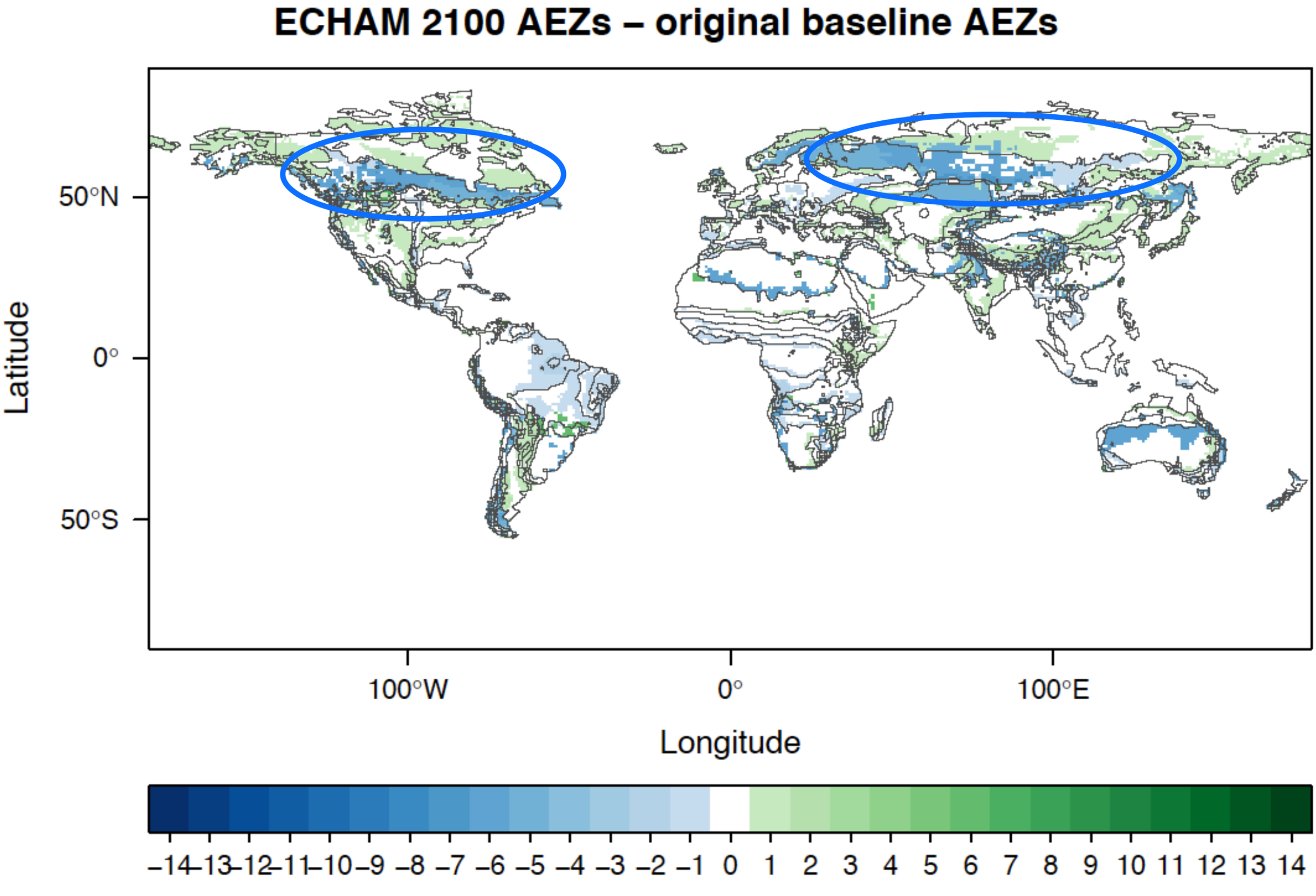
Agro-Ecological Zones (AEZs) are bio-climatically defined



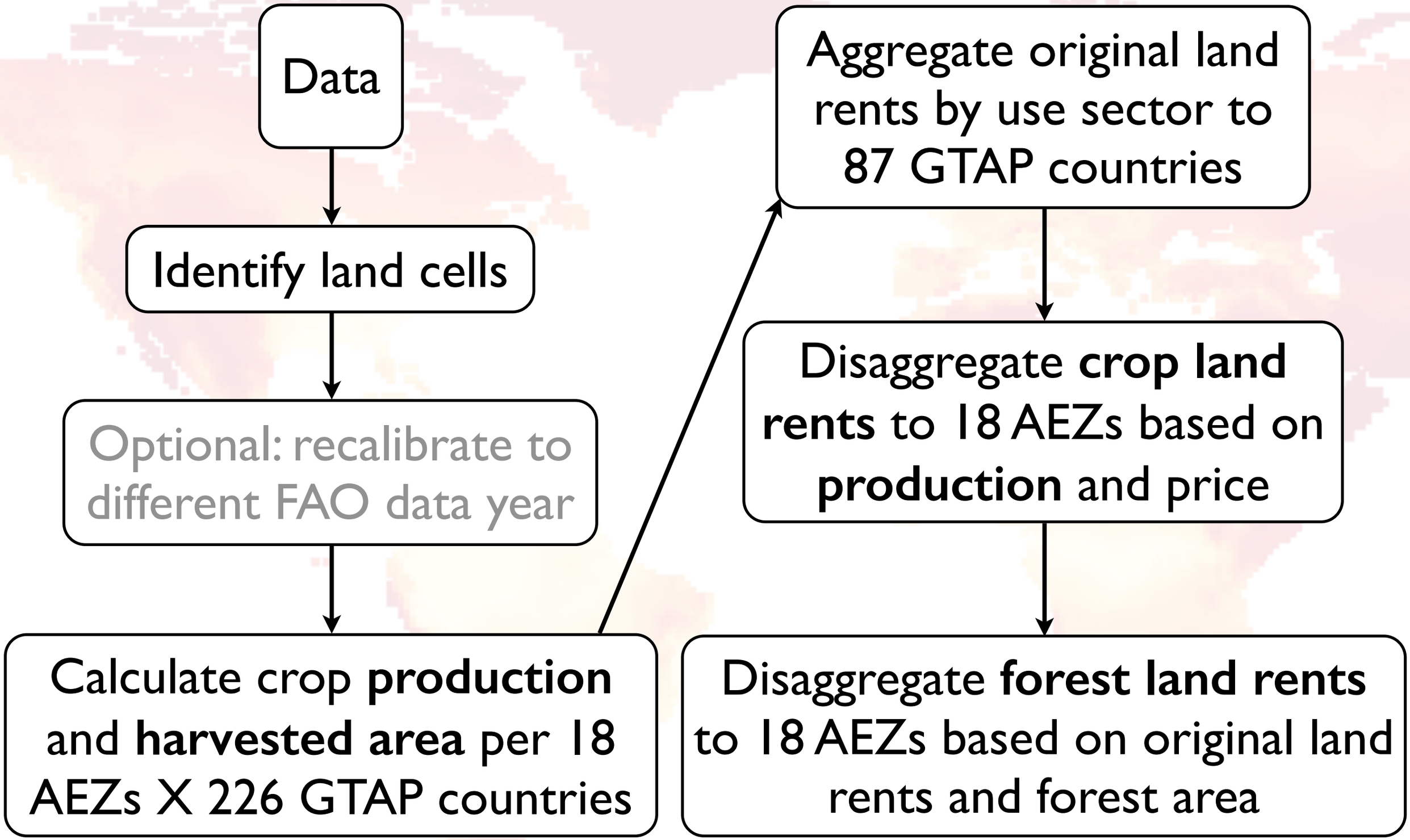




Current land units become heterogeneous



Workflow to create new AgLU crop and land rent inputs



Data required to create new AgLU crop and land rent inputs

Spatially explicit data

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

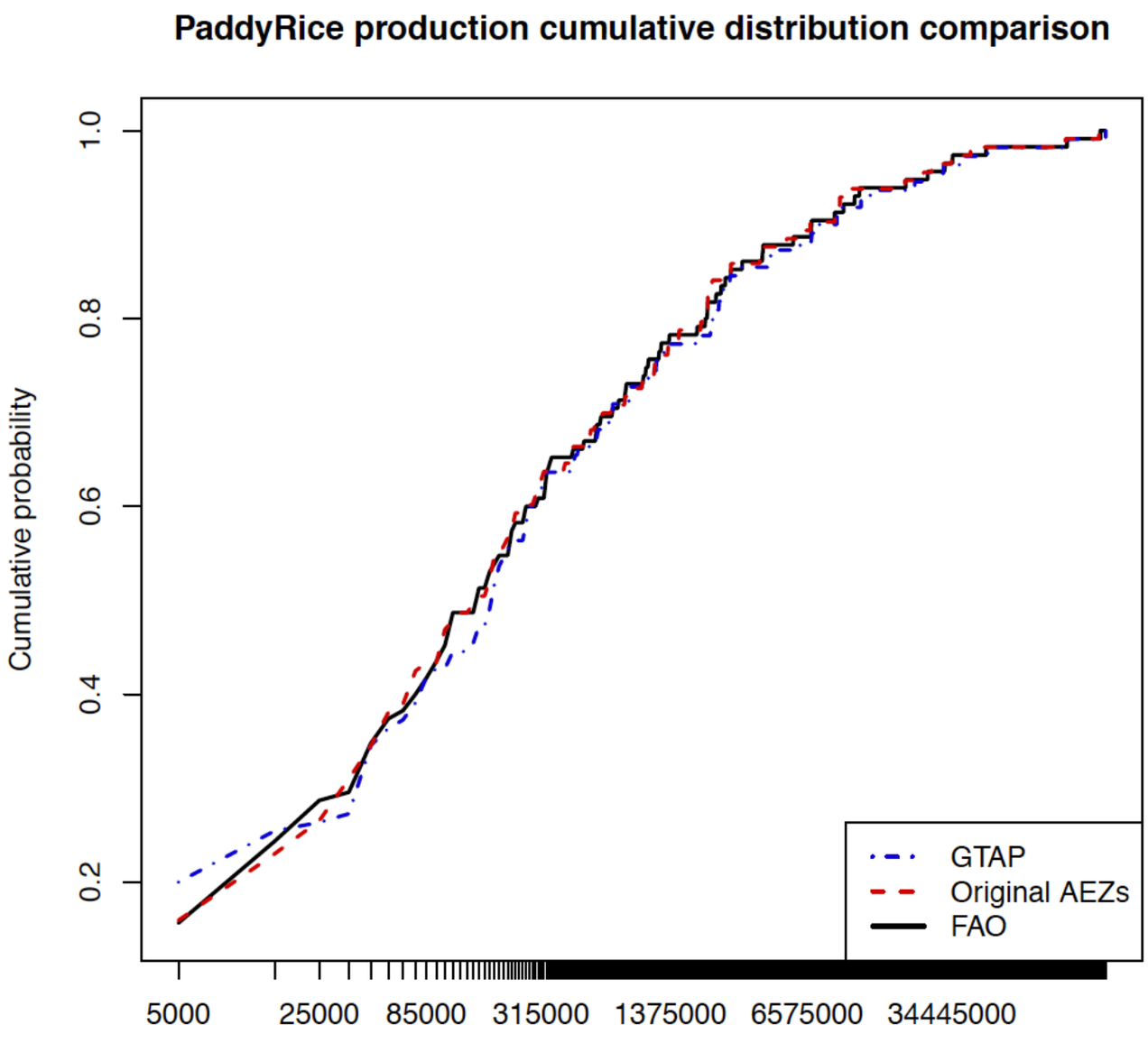
- SAGE data:
  - crop yield, area
  - cropland
  - pasture
  - land area
  - potential vegetation
- HYDE3.1 data:
  - urban
  - land area
- AEZ boundaries

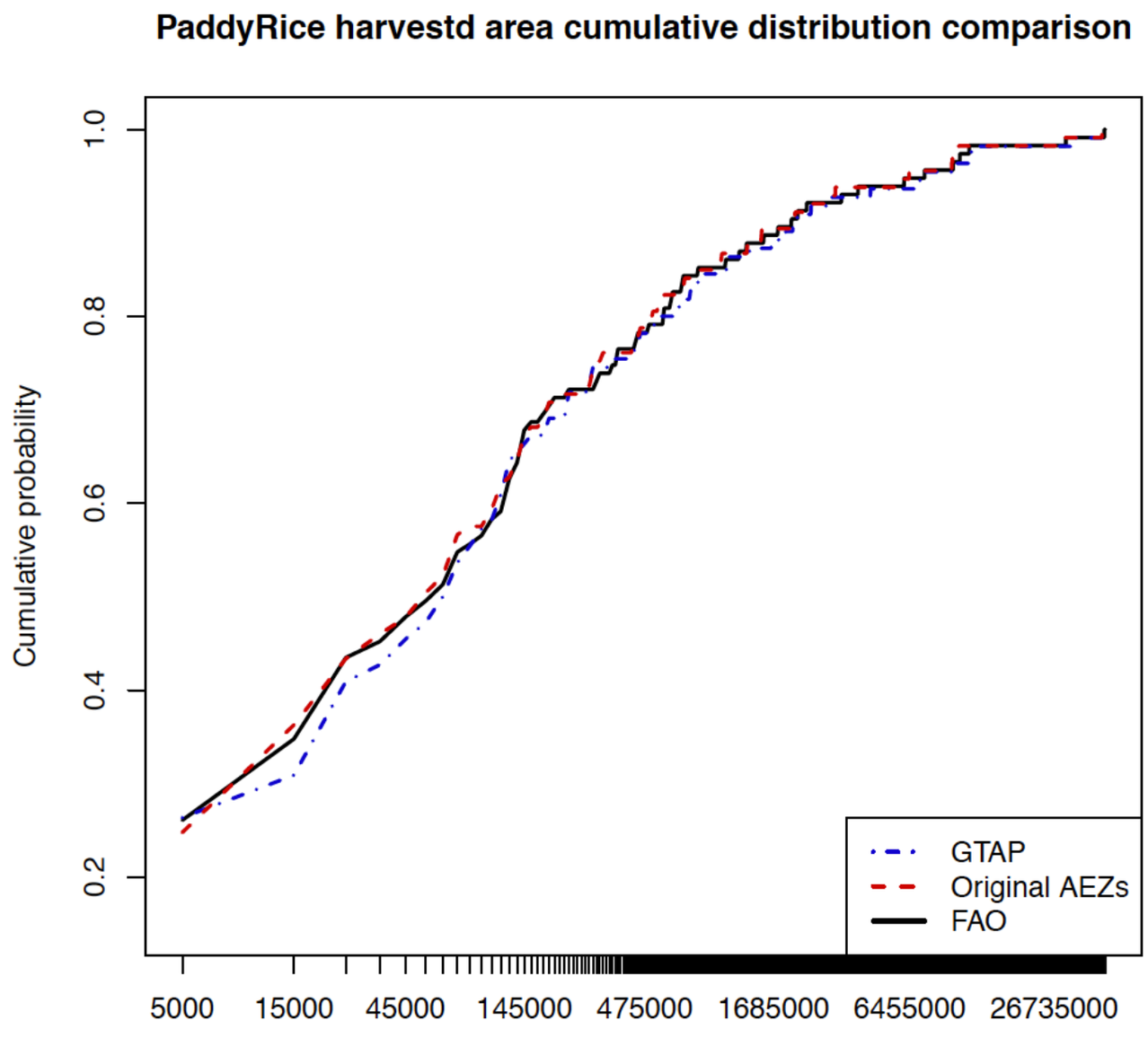
Tabular data

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

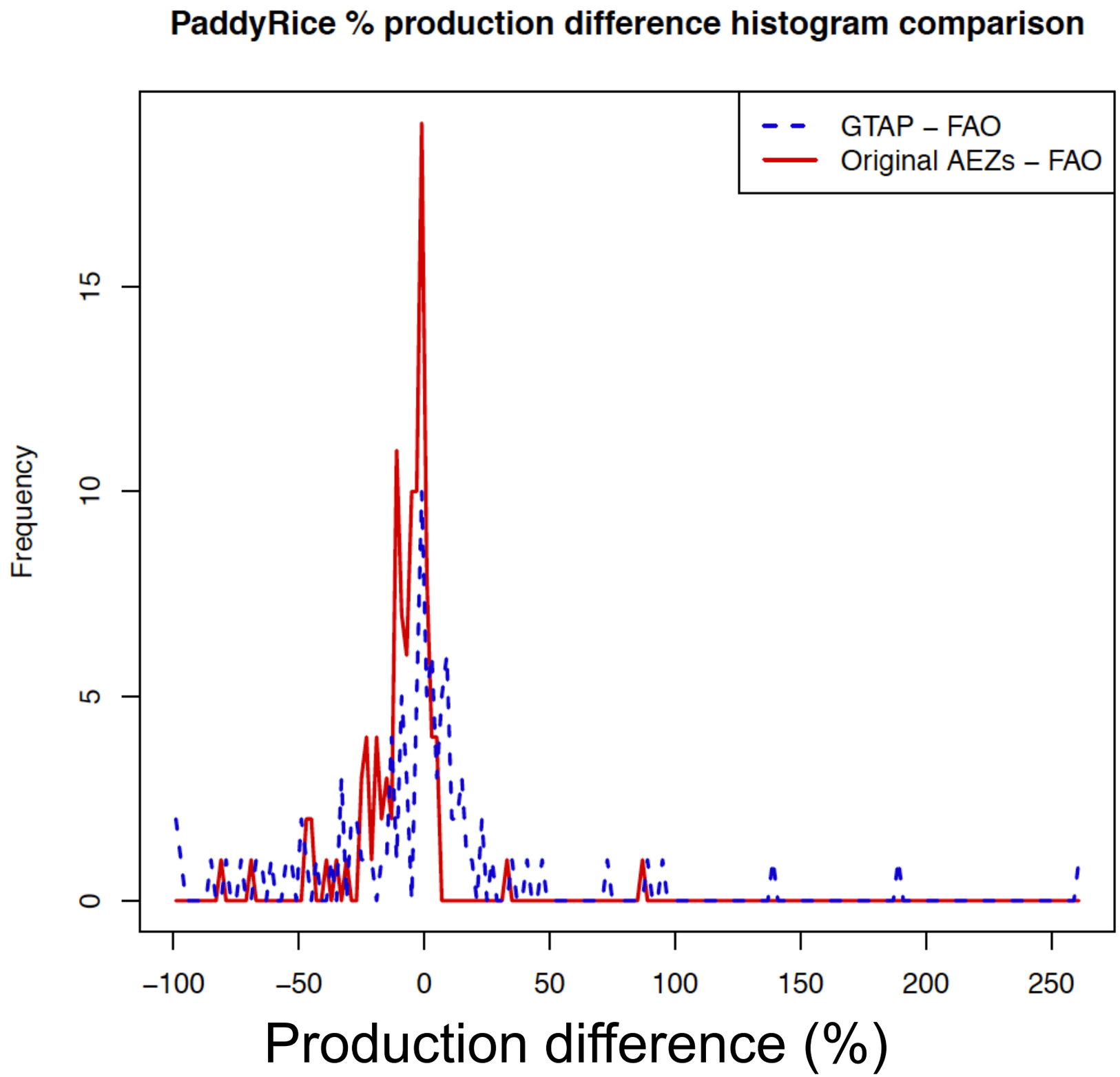
- GTAP (SAGE) crops
- GTAP use sector
- GTAP land rent
- FAO crops
- FAO crop production
- FAO producer prices
- FAO crop yield, area
  - for recalibration

Global distributions of Paddy Rice, by country

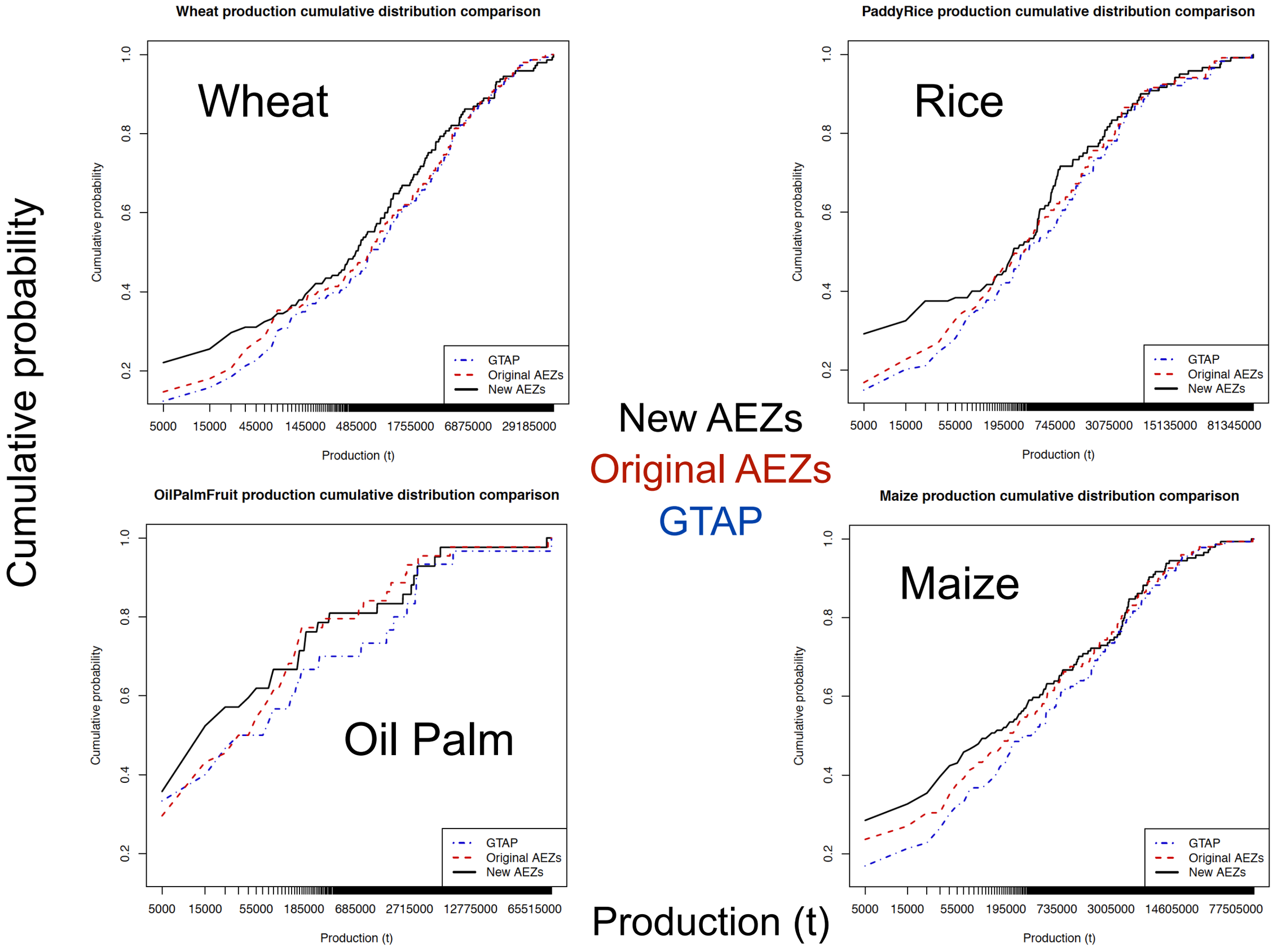




Distribution differences for Paddy Rice, by country



Each crop is uniquely affected by new land units



Cumulative probability

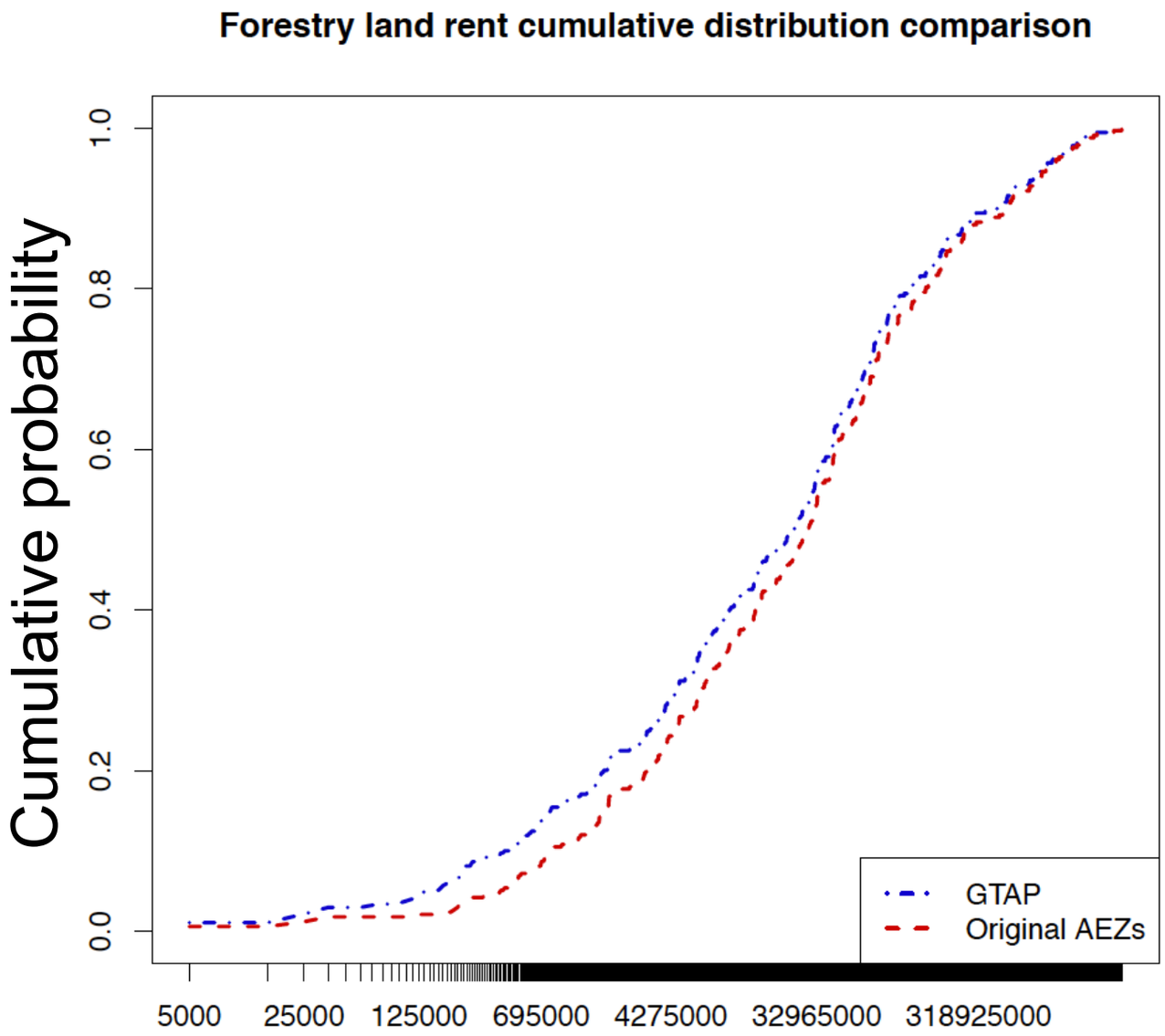
New AEZs

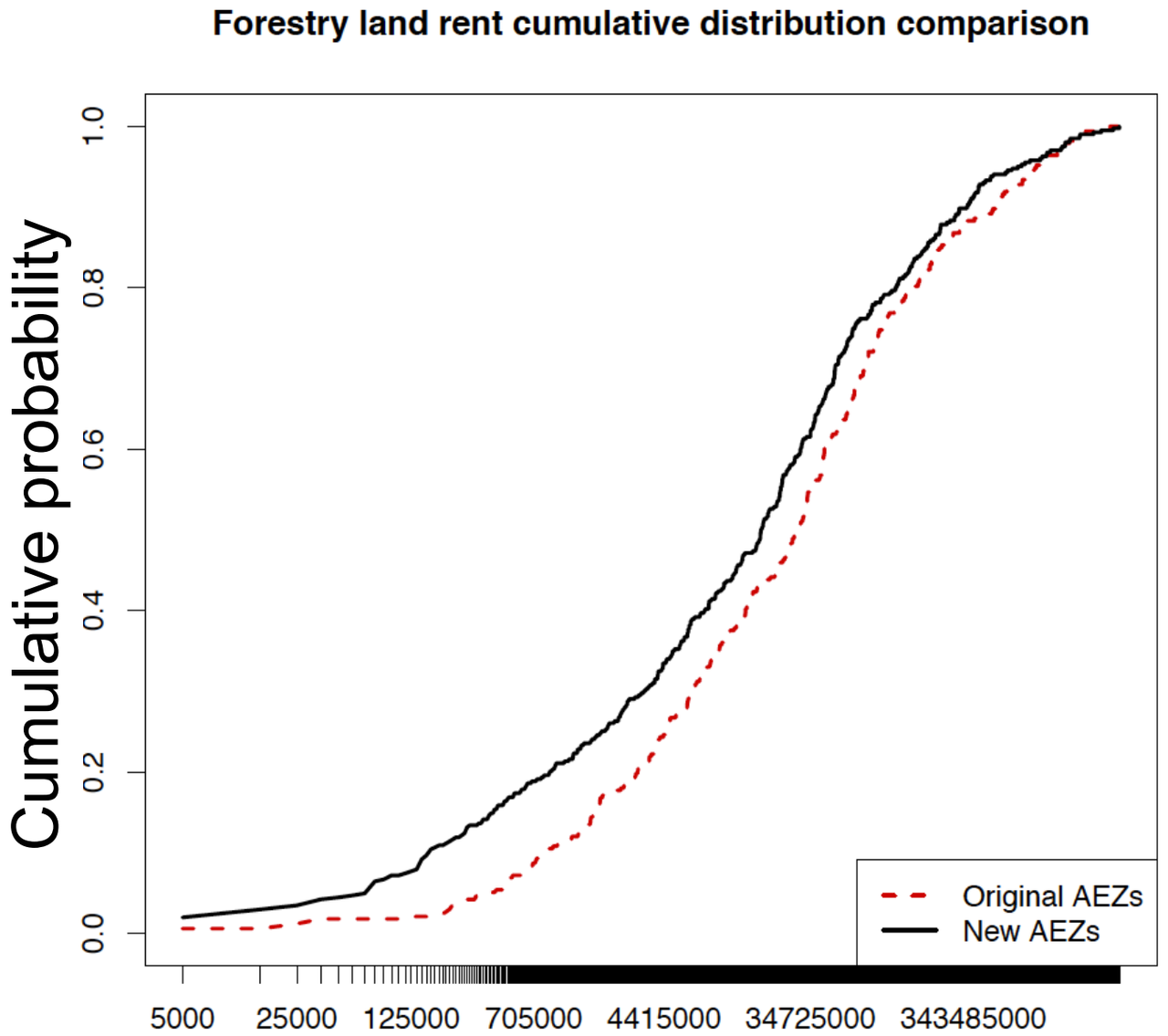
Original AEZs

GTAP

Production (t)

Global distributions of forest land rent, by GTAP land unit



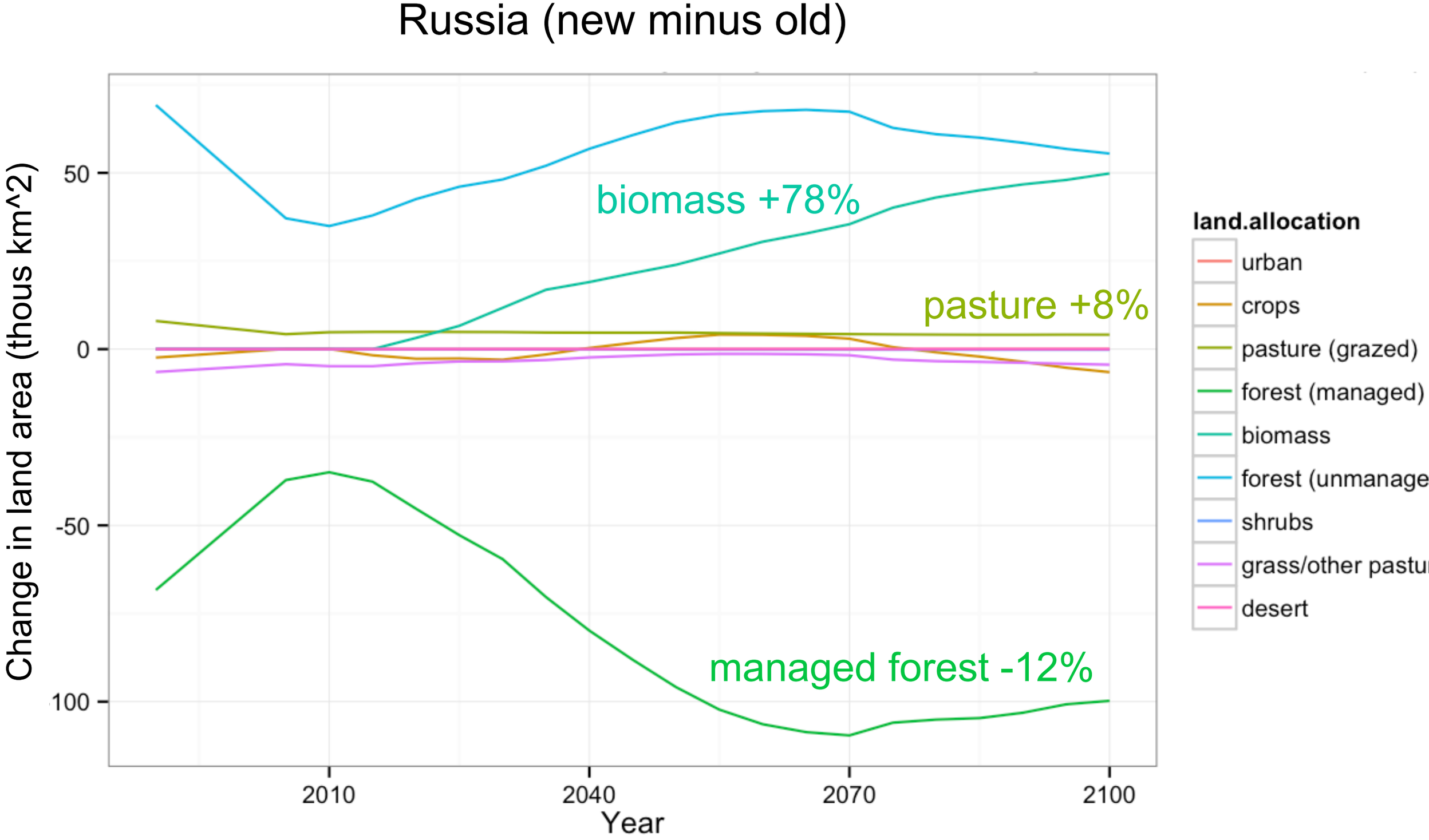


New AEZs

Original AEZs

GTAP

AEZ boundaries affect projected land use/cover



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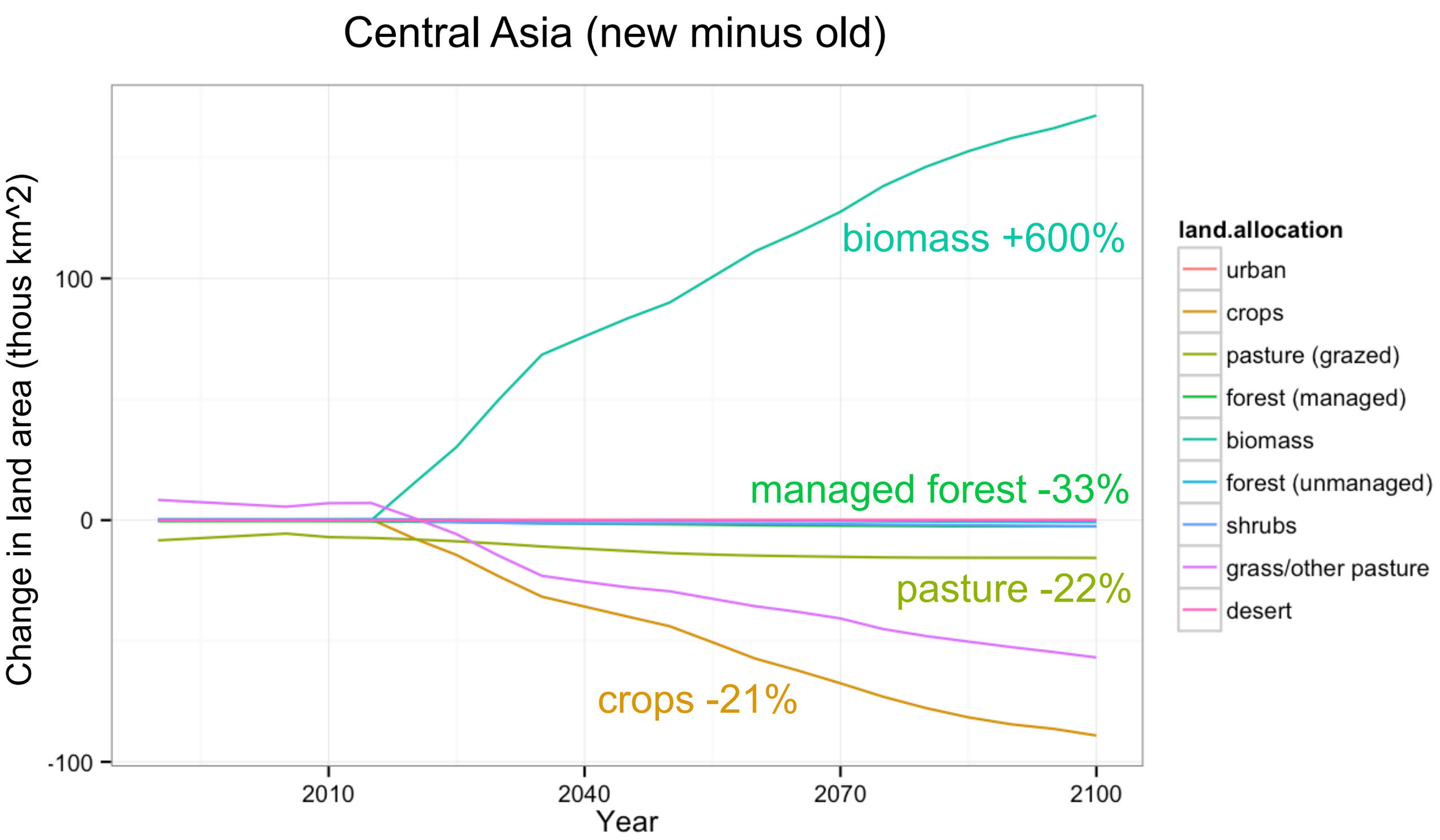

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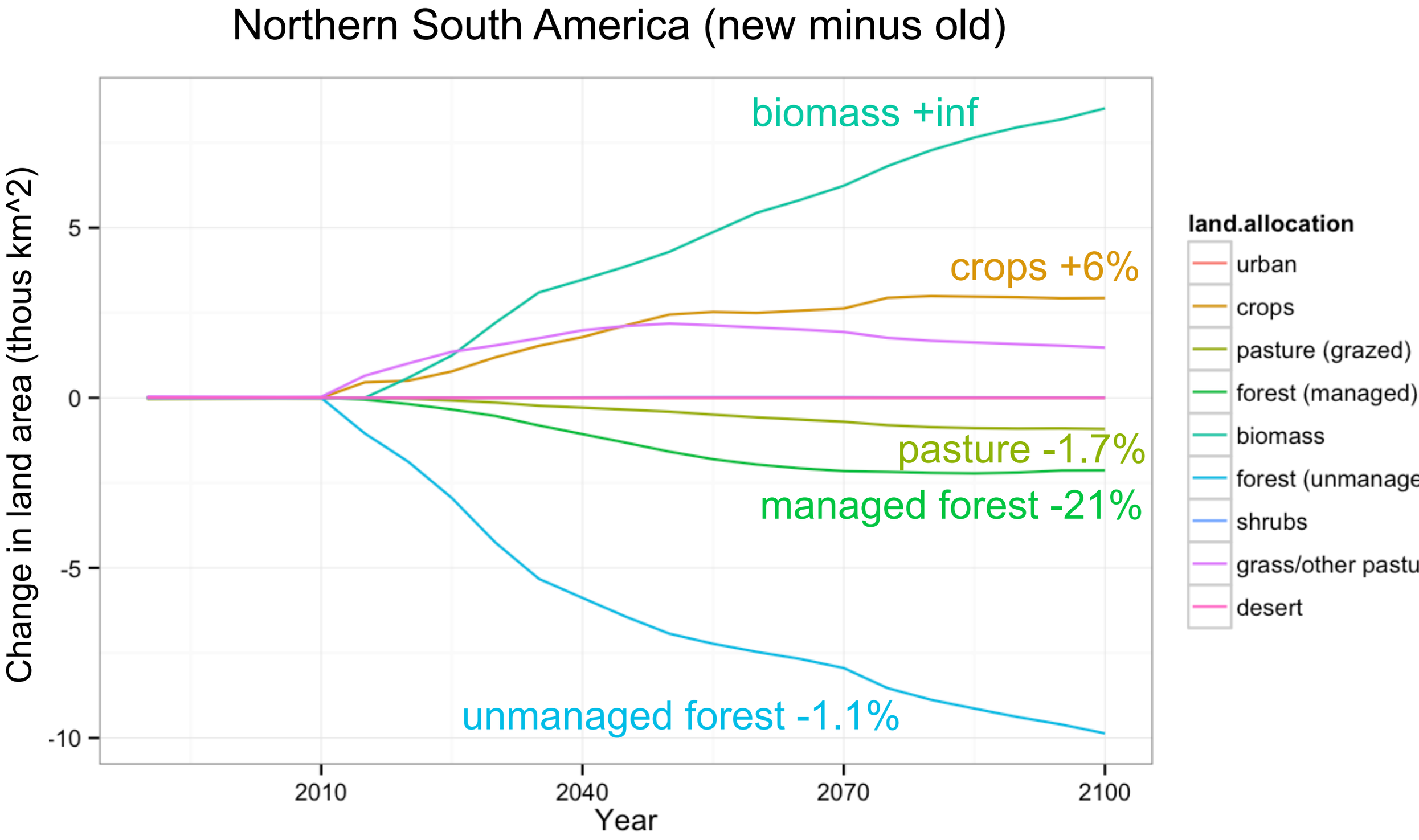

Summary

- 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, harvested area, and forest land rent are different between the original and new land units

- Regional land use/cover distributions are different between the original and new land units

- Feedbacks: climate, impact, and land use

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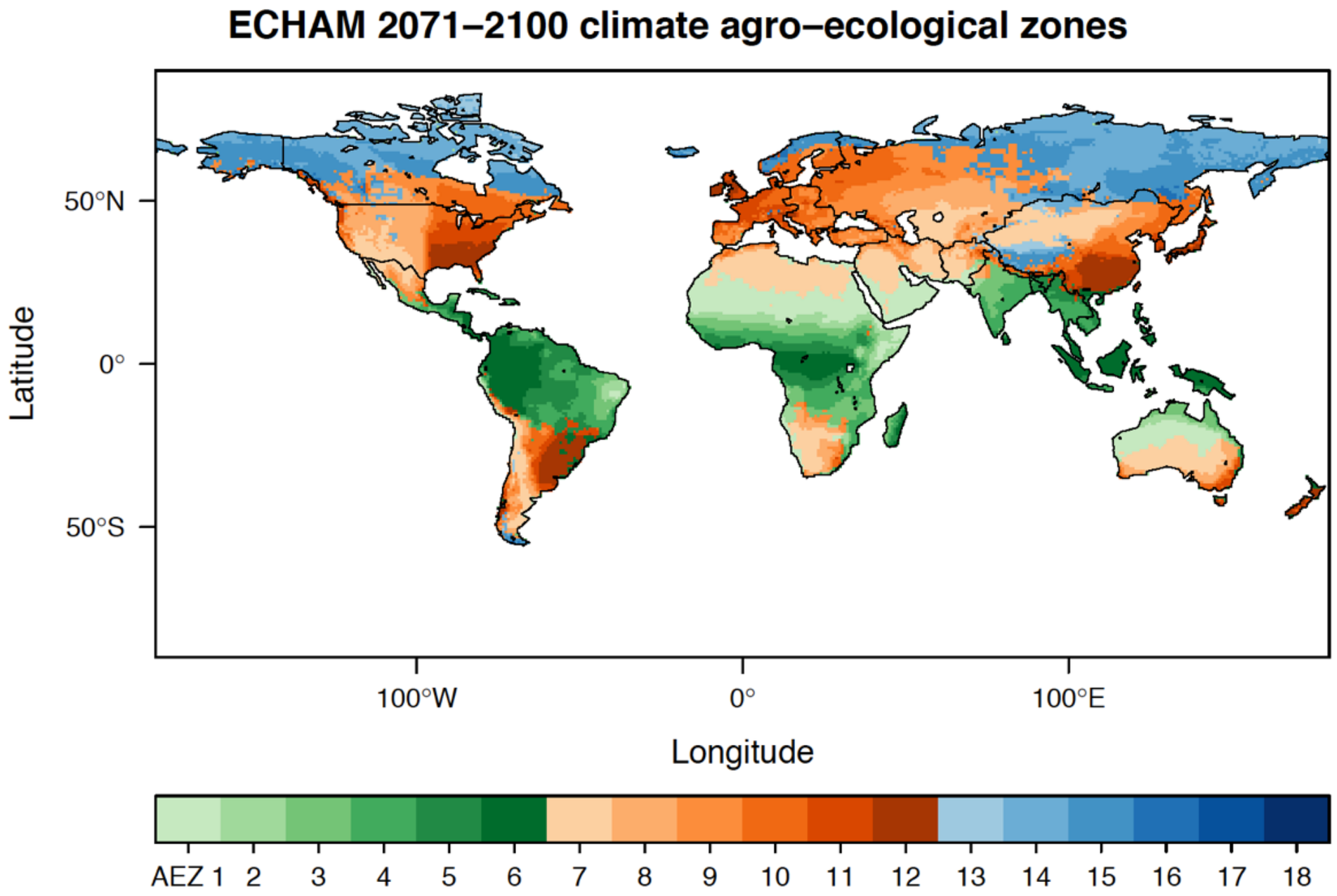
Opportunities

- Optimize GCAM land units
- New spatial land delineation
  - AgLU coincides with water module?
  - AEZ x watershed?
- Facilitate spatial data consistency across global models

Questions?

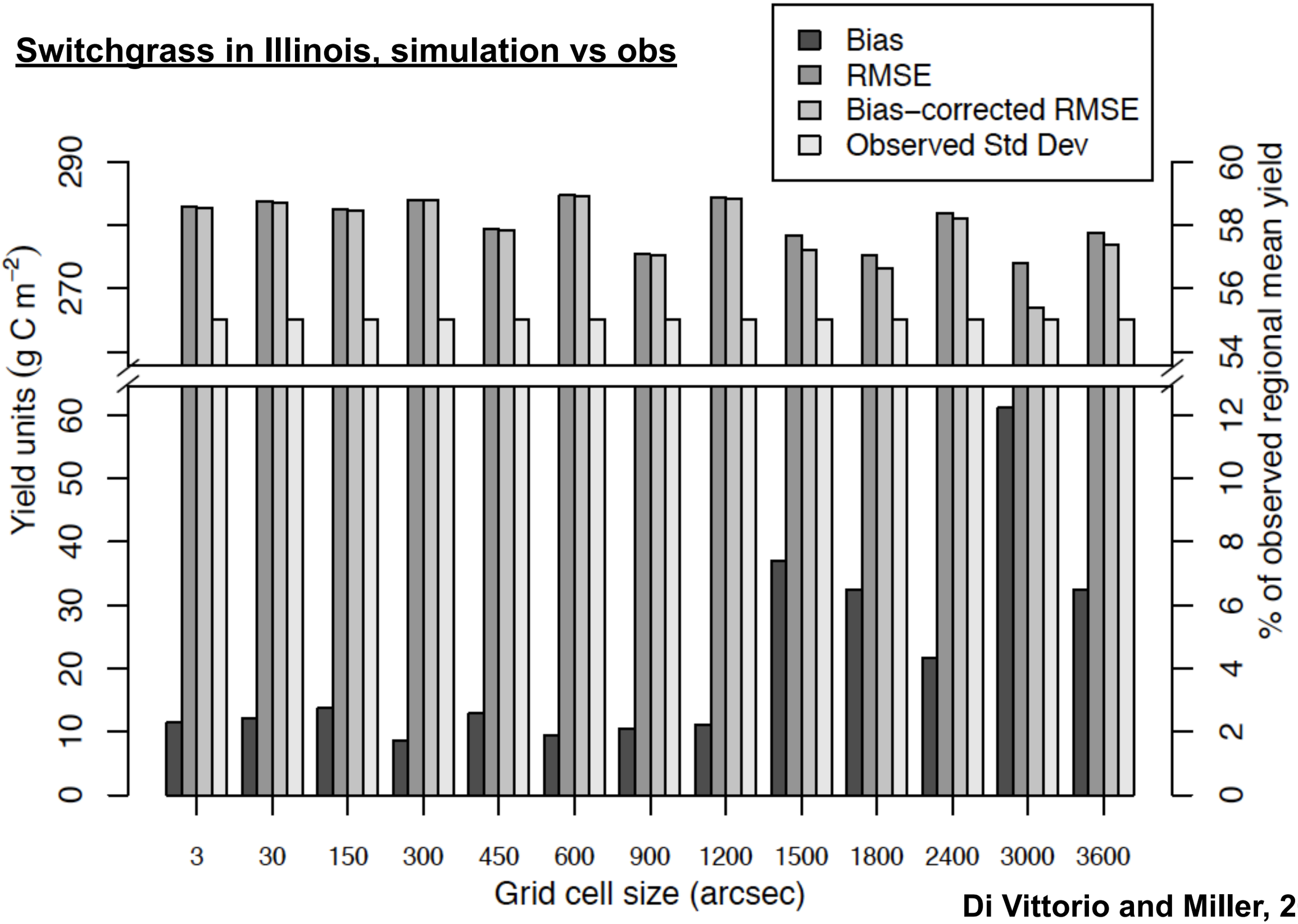


This work is supported by the Director, Office of Science, Office of Biological and Environmental Research of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 as part of their Integrated Assessment Research Program.

3

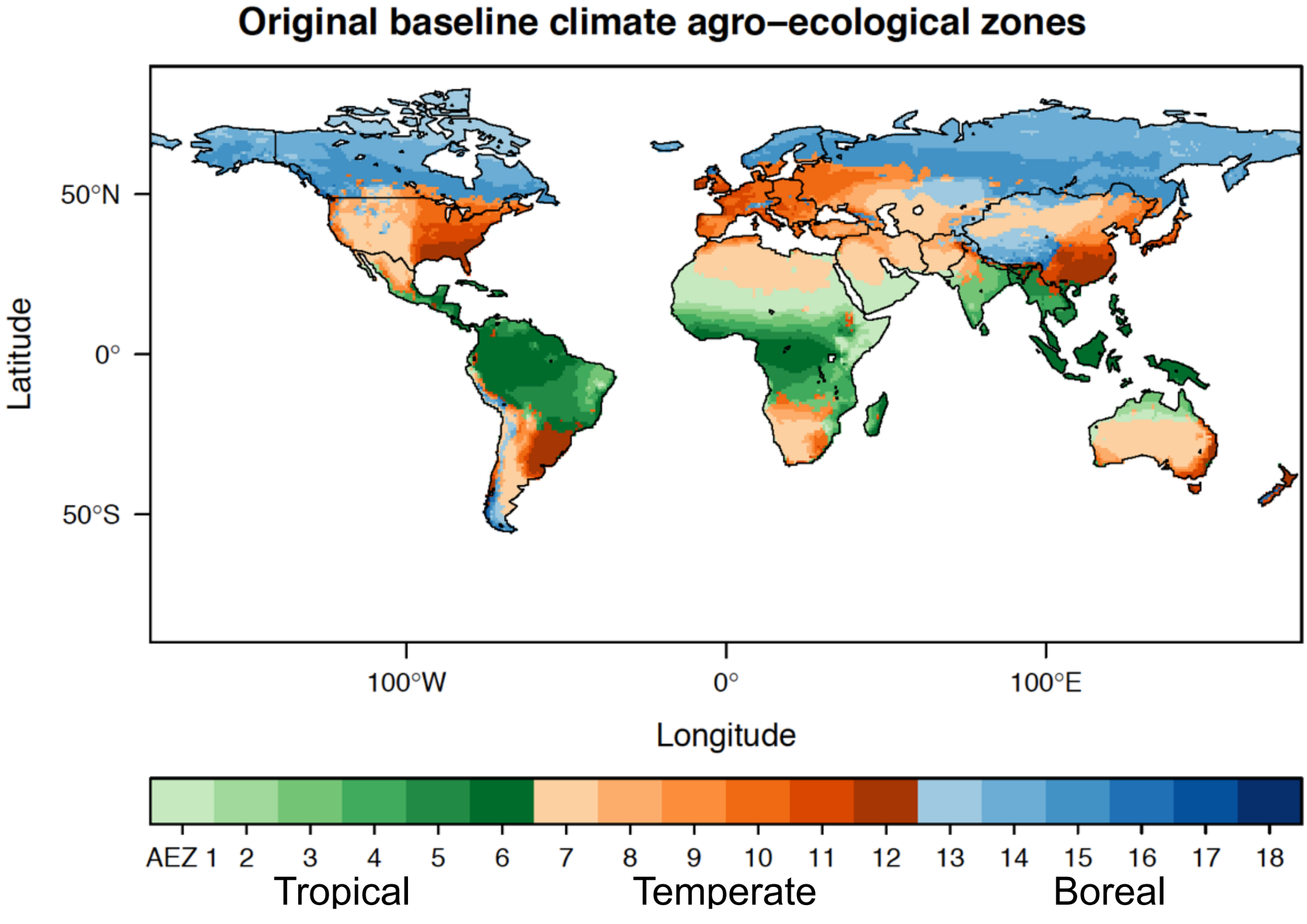
Different resolutions have different biases

Switchgrass in Illinois, simulation vs obs

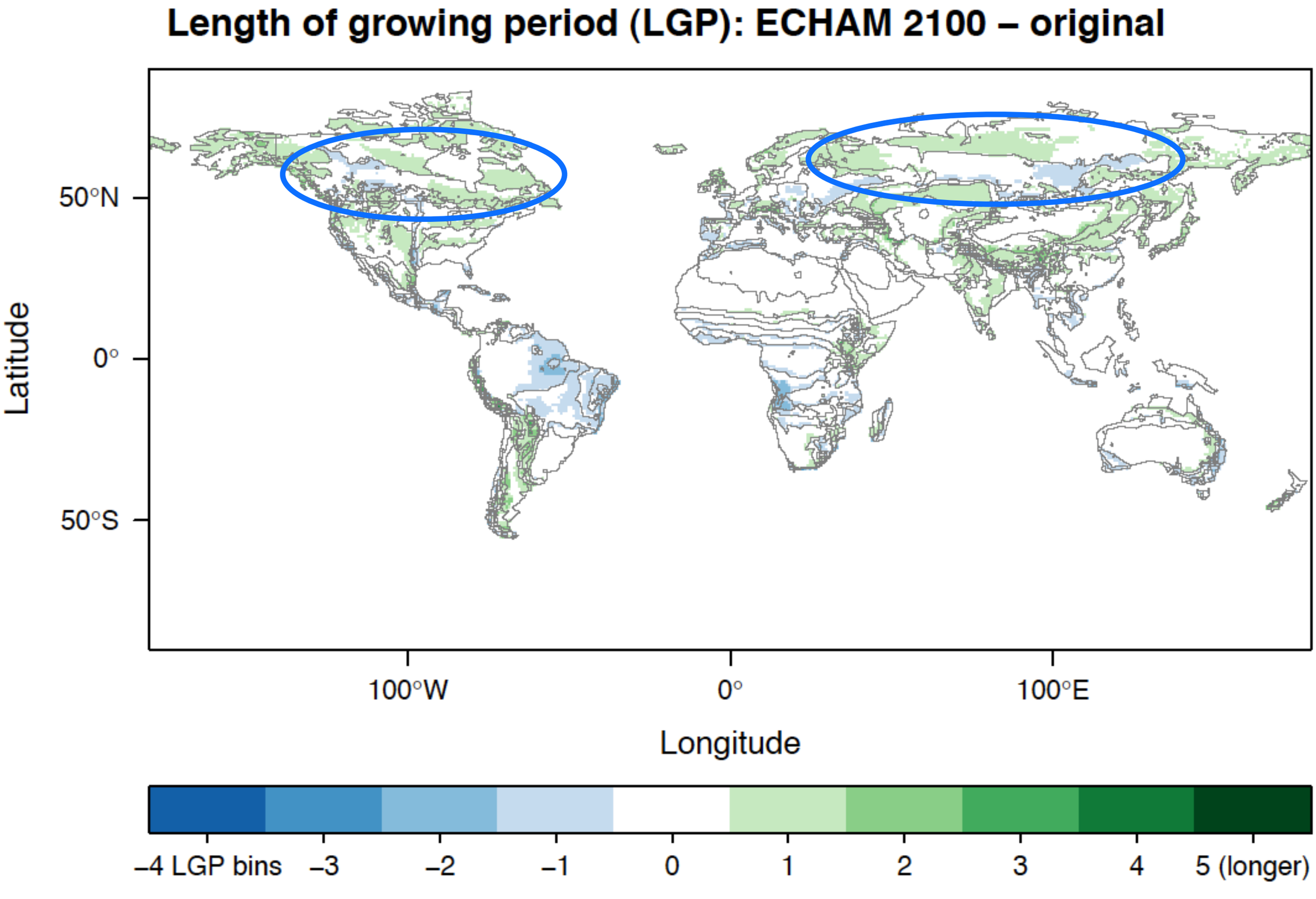


Di Vittorio and Miller, 2014

Land use distribution assumes uniform vegetation productivity within zones

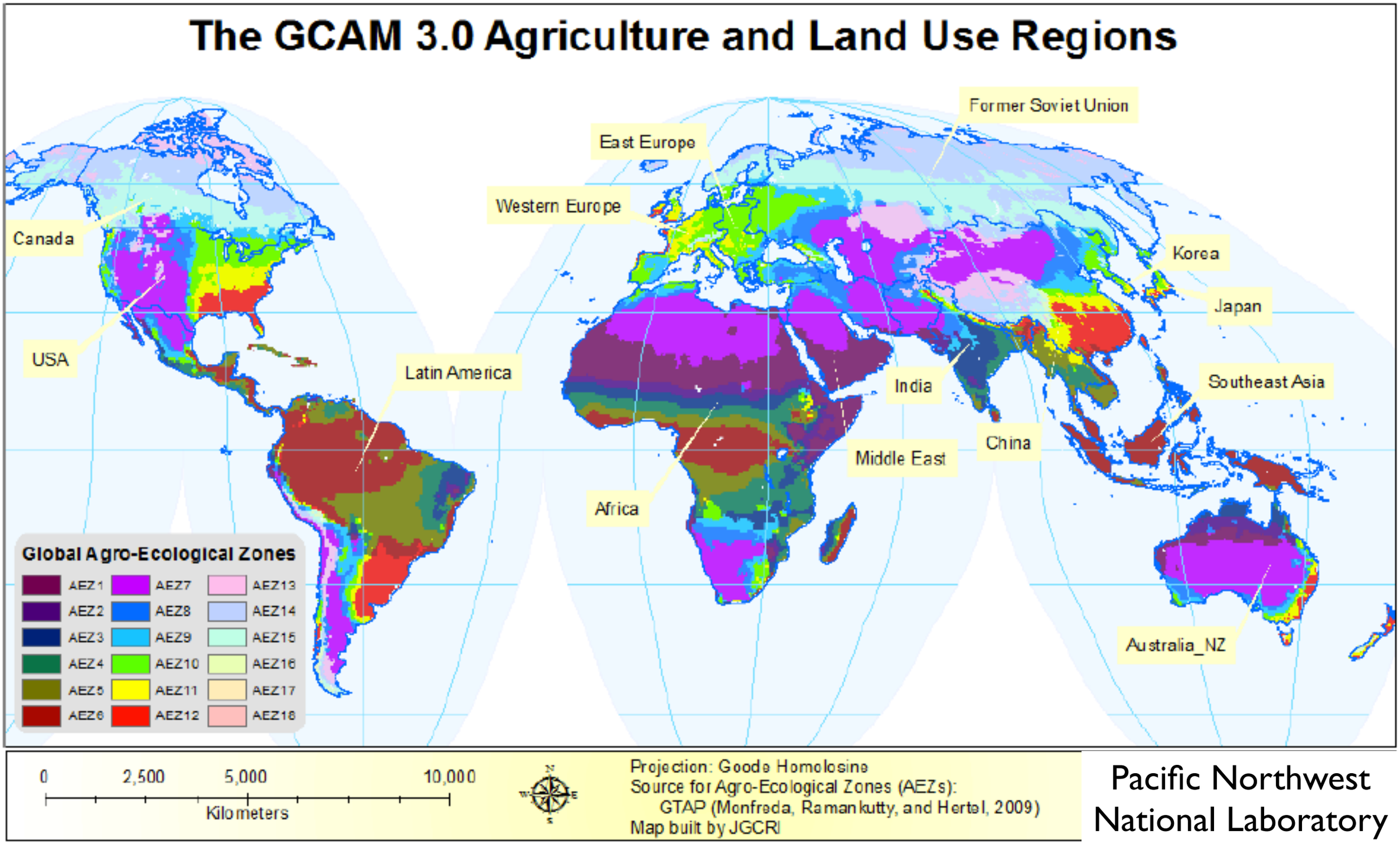


Current land units become heterogeneous



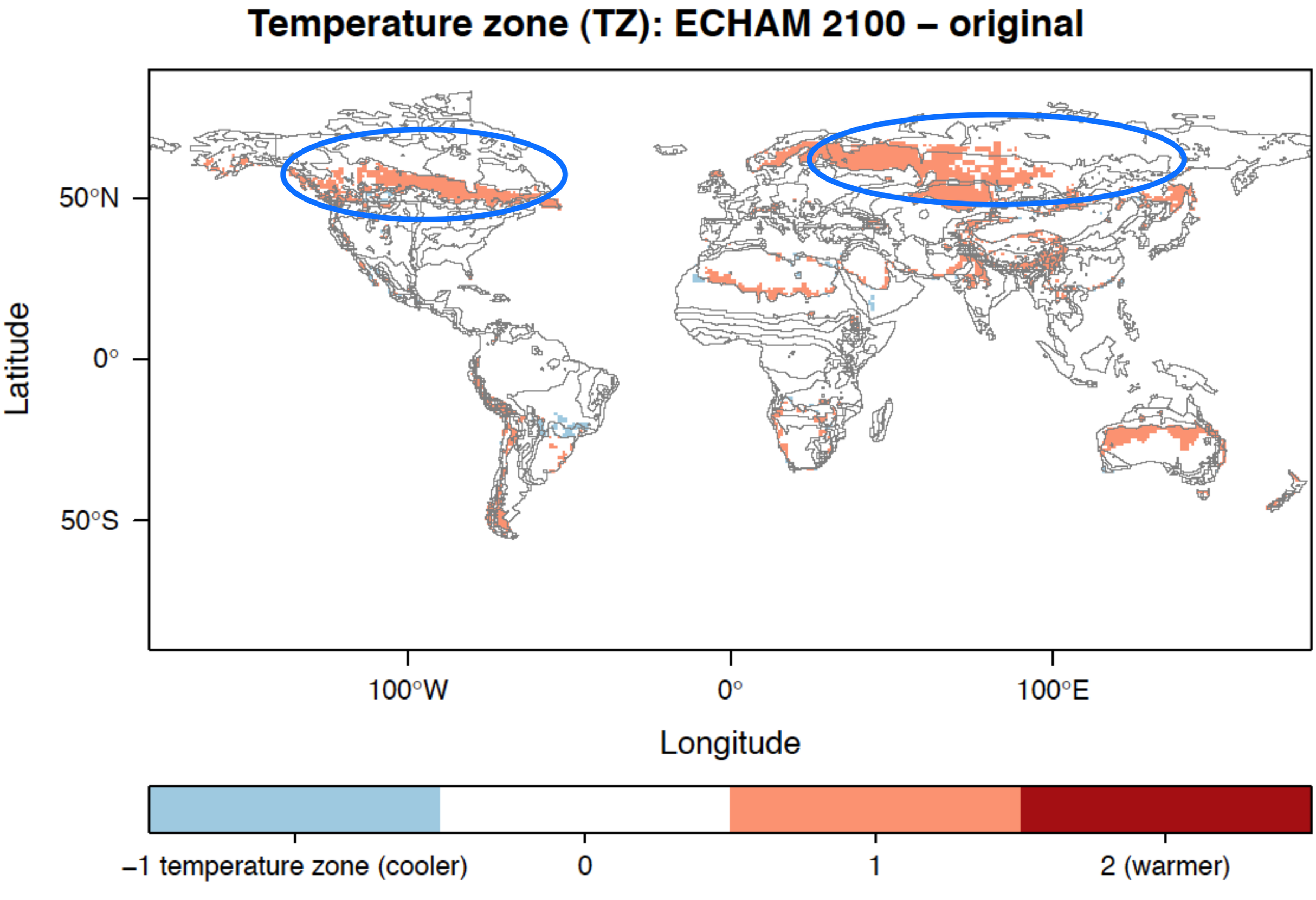
Land use distribution assumes uniform vegetation productivity within zones

- **Do projected Agro-Ecological Zones alter land use trajectories?**



Pacific Northwest National Laboratory

Current AEZs become heterogeneous



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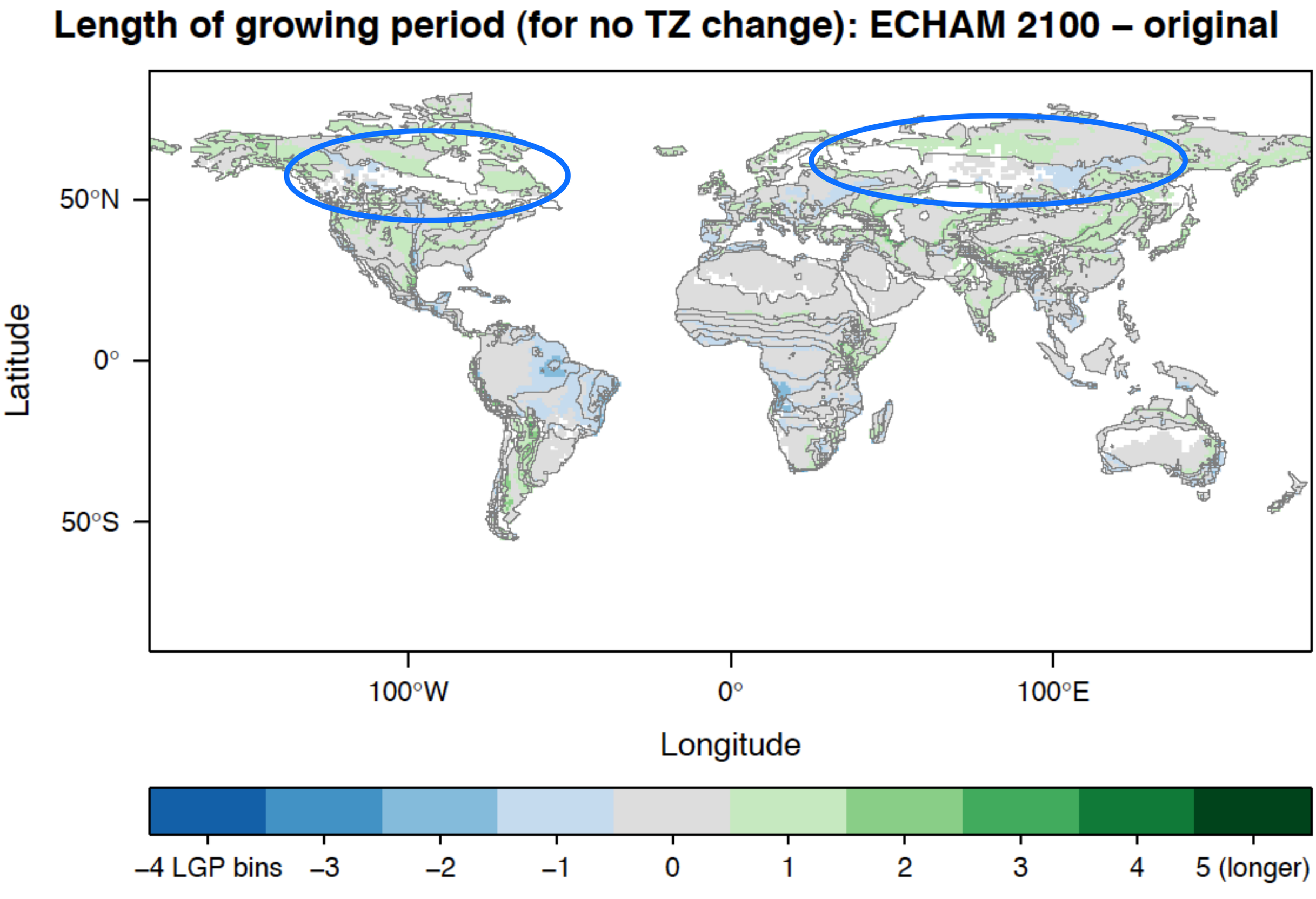
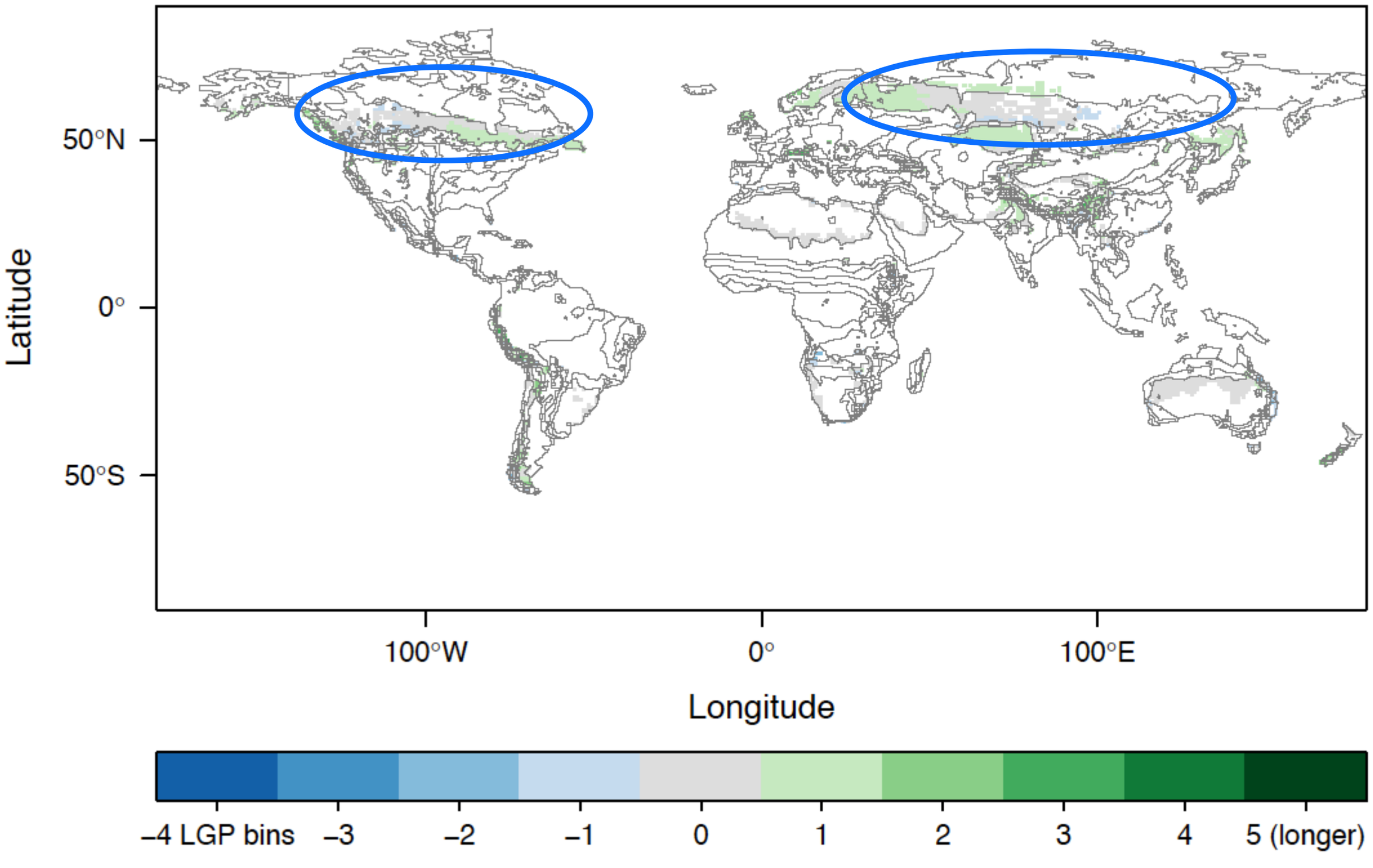
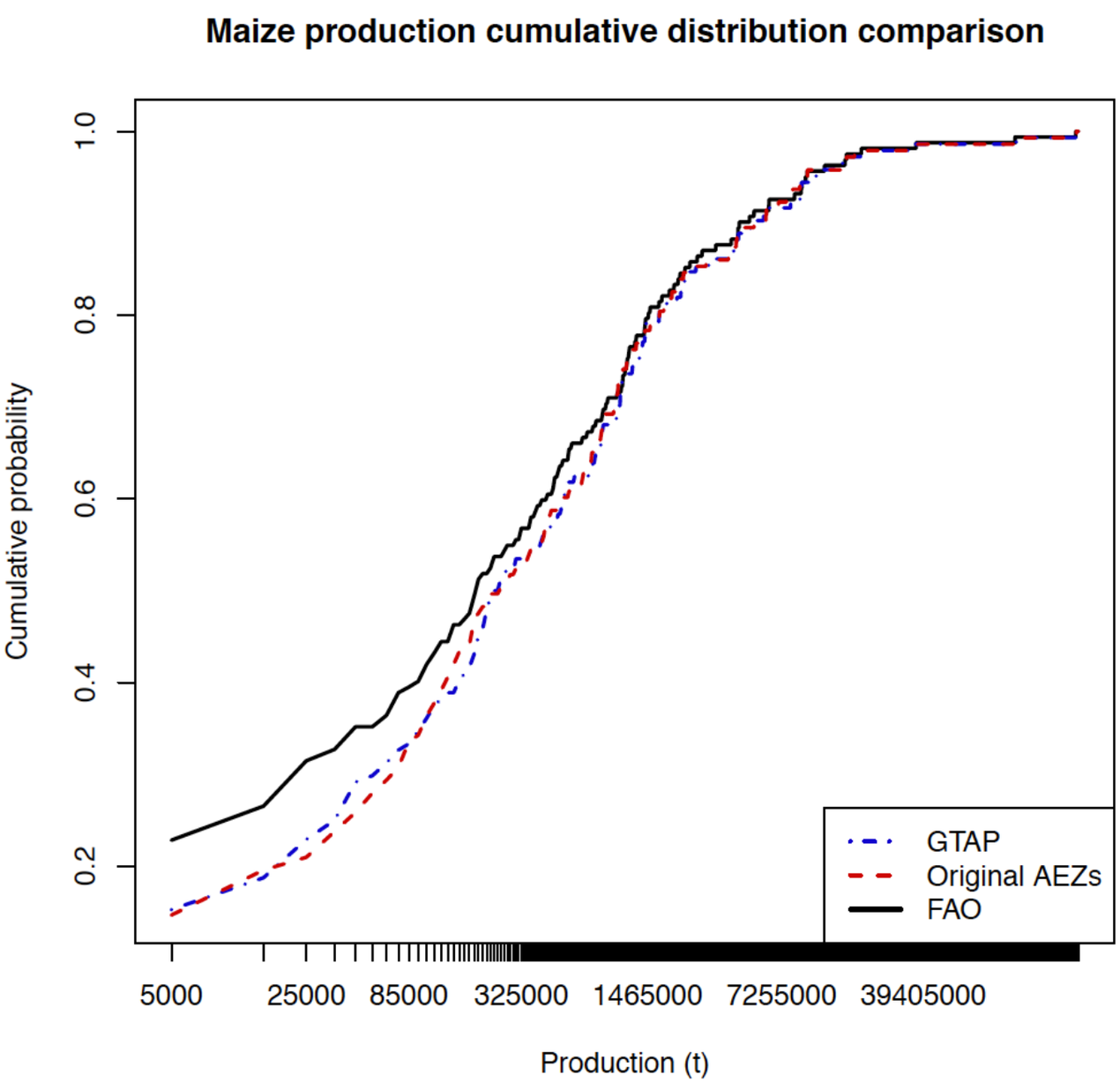


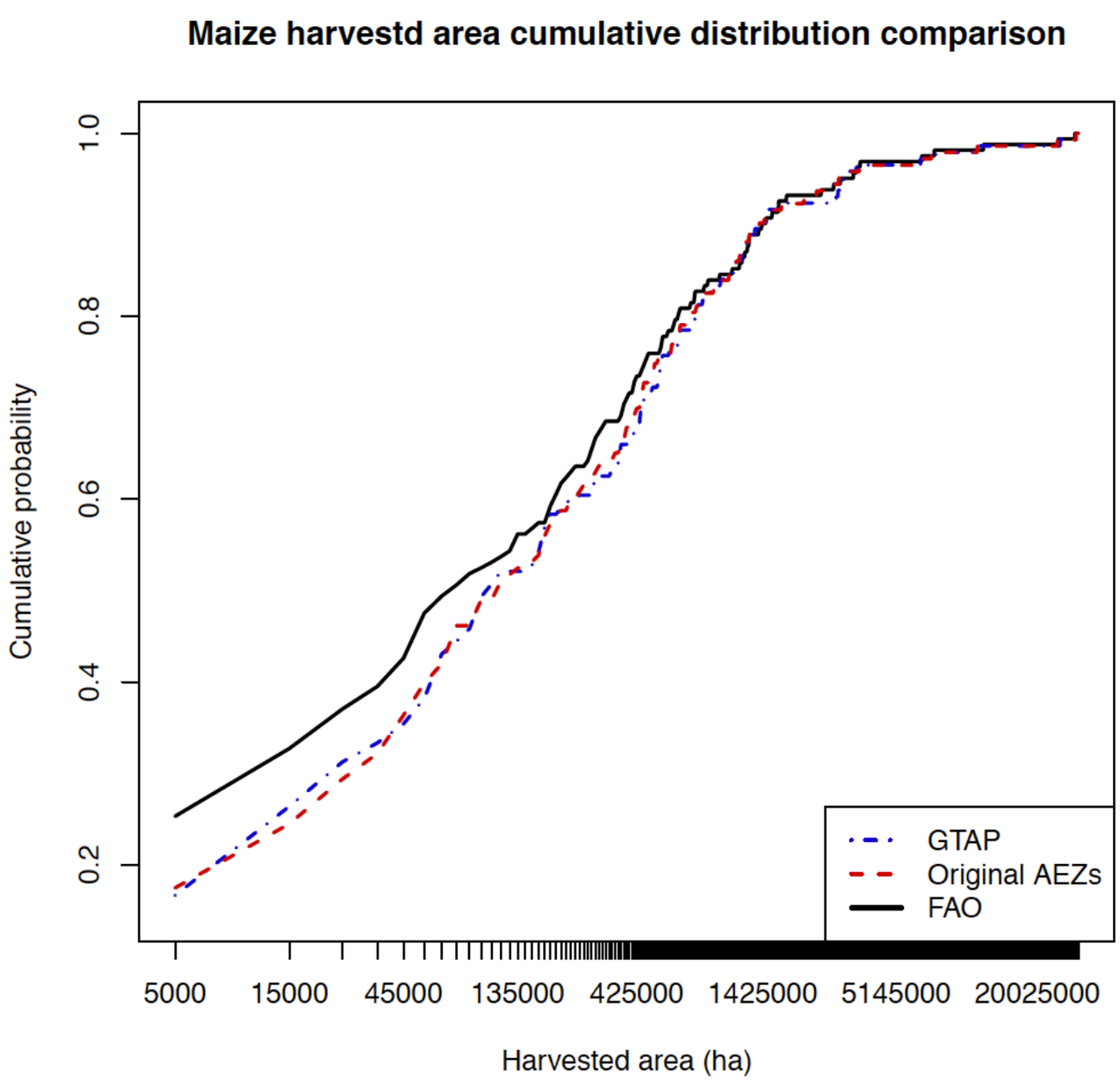
Current AEZs become heterogeneous

Length of growing period (for +1 TZ change): ECHAM 2100 – original

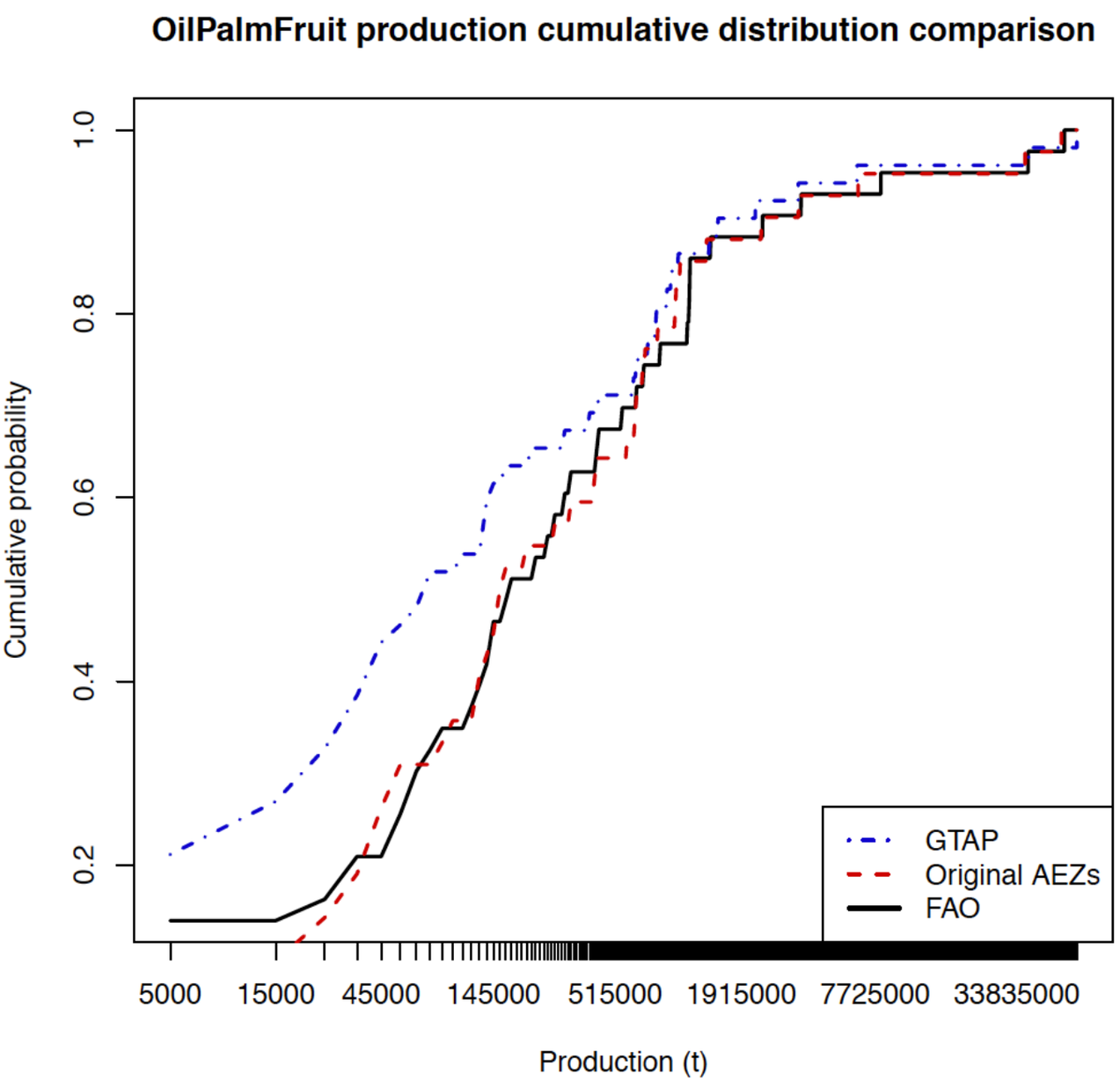


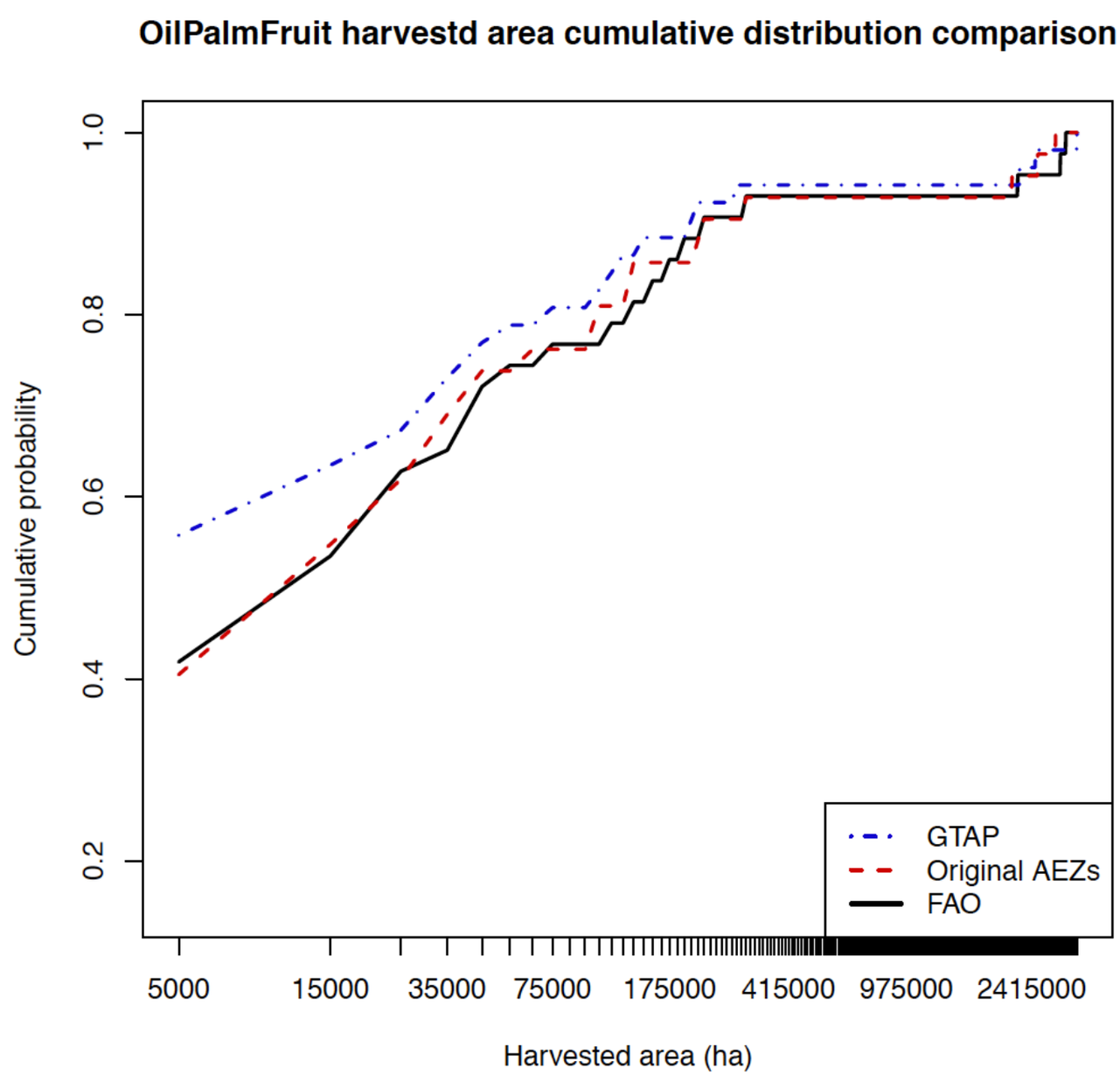
Global distributions of Maize, by country



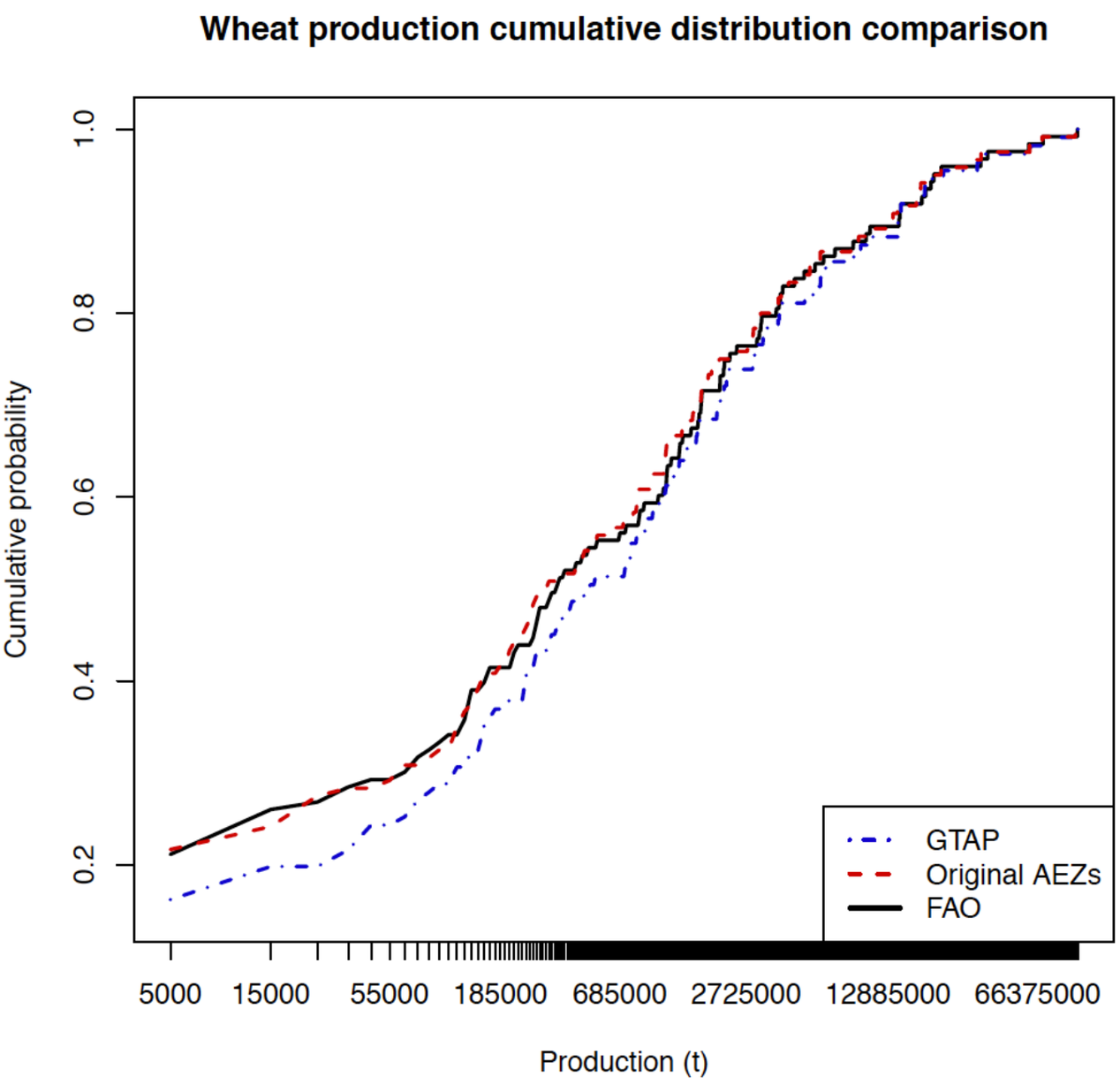


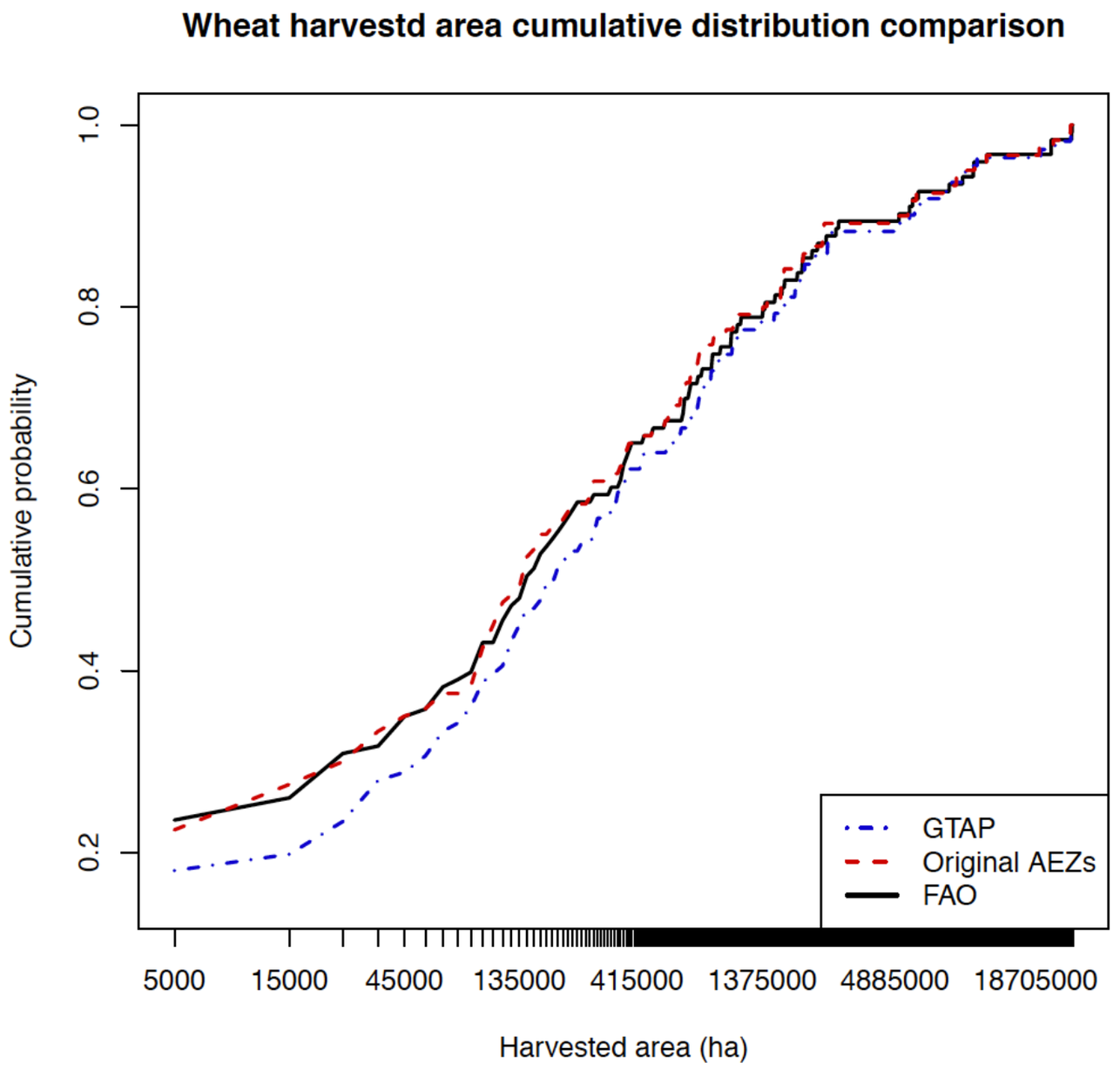
Global distributions of Oil Palm Fruit, by country



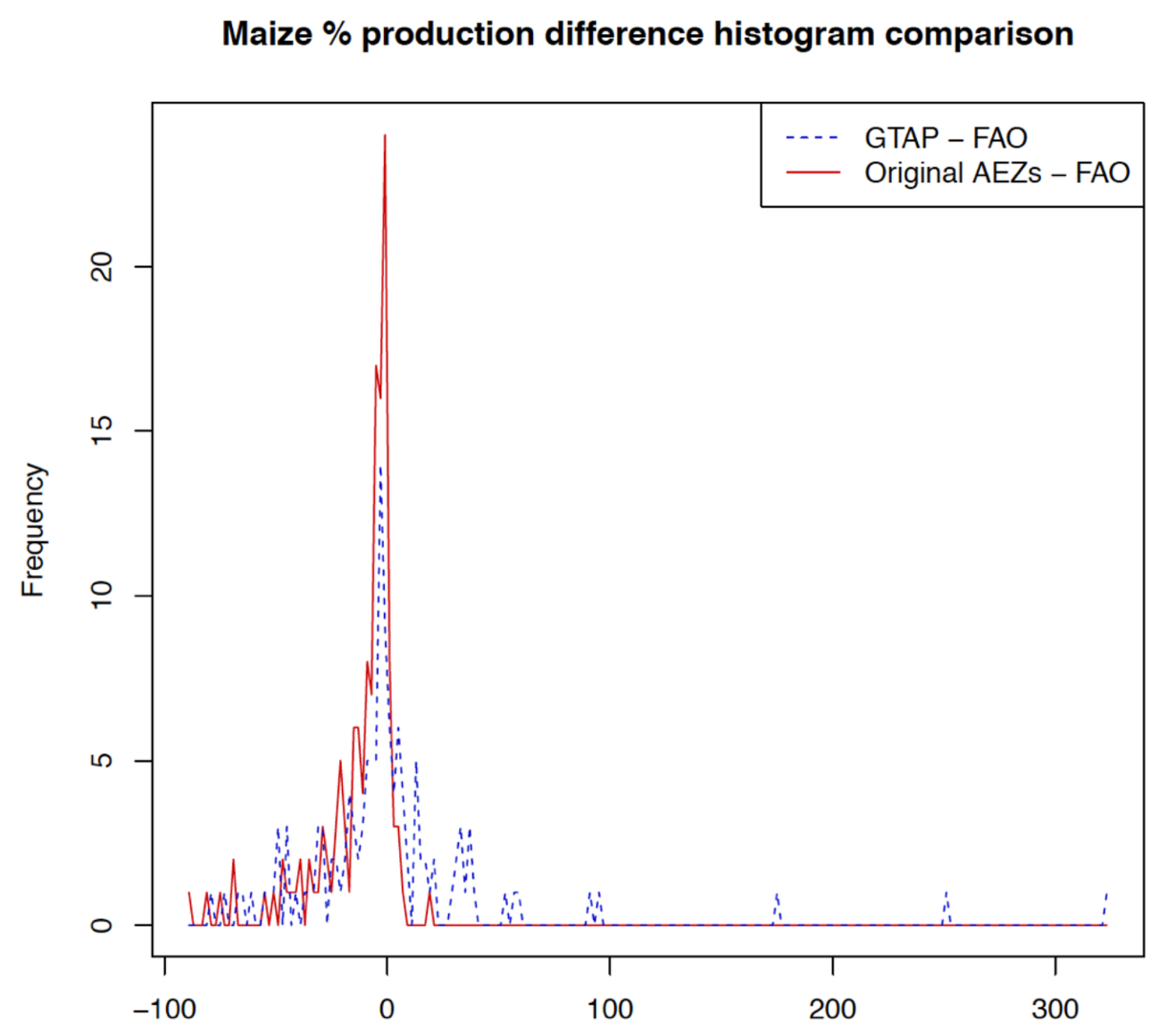


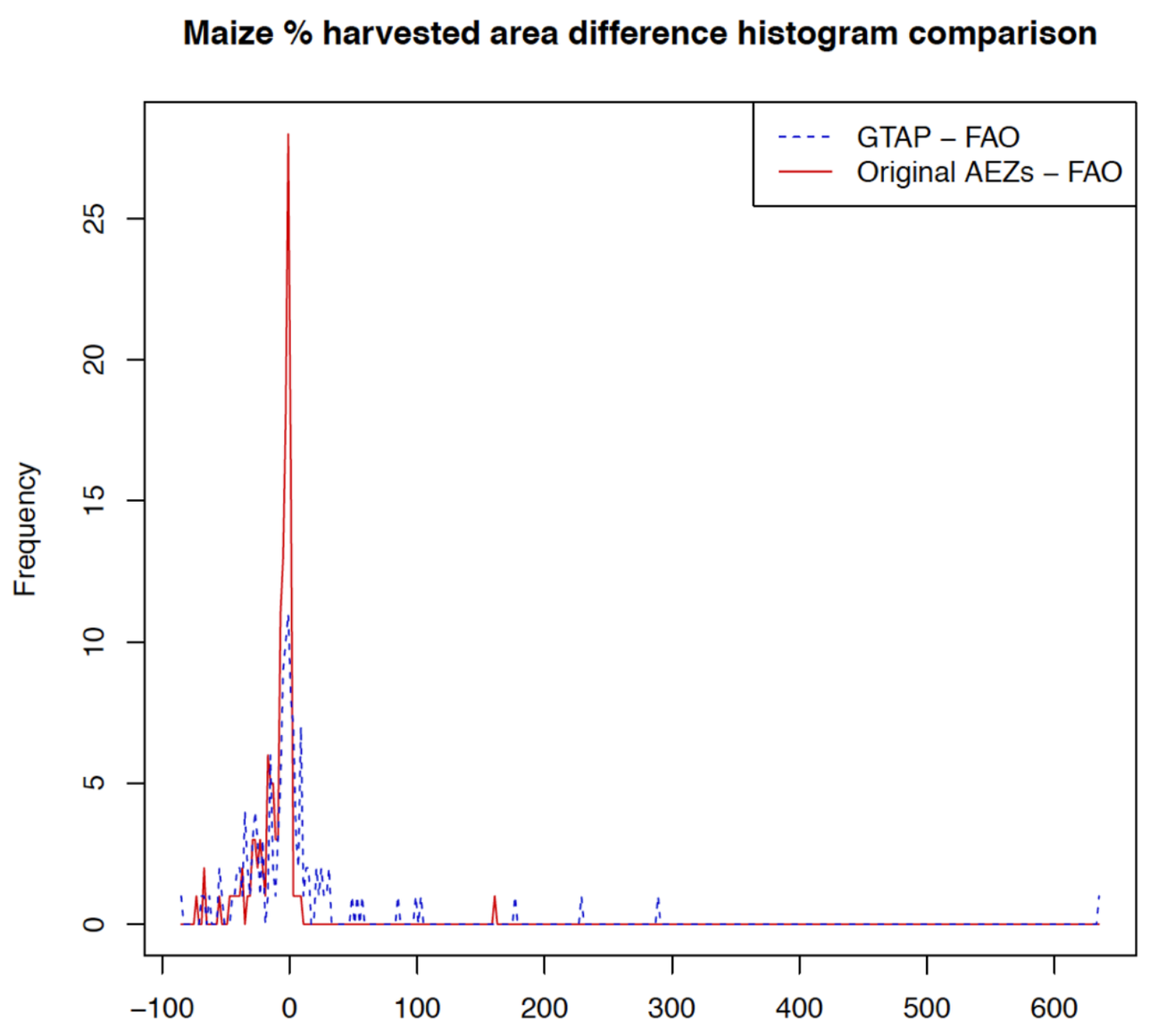
Global distributions of Wheat, by country





Distribution differences for Maize, by country





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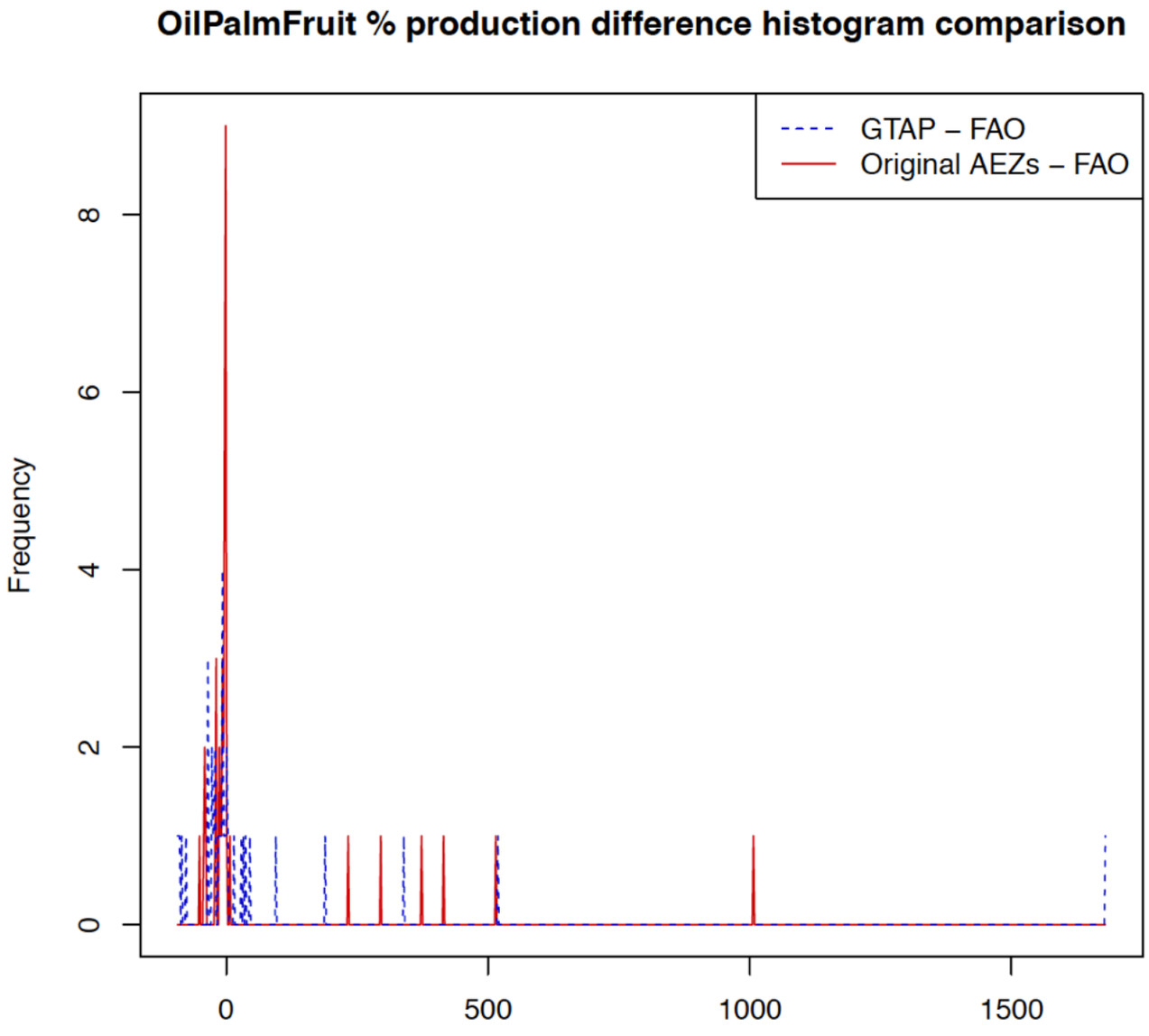
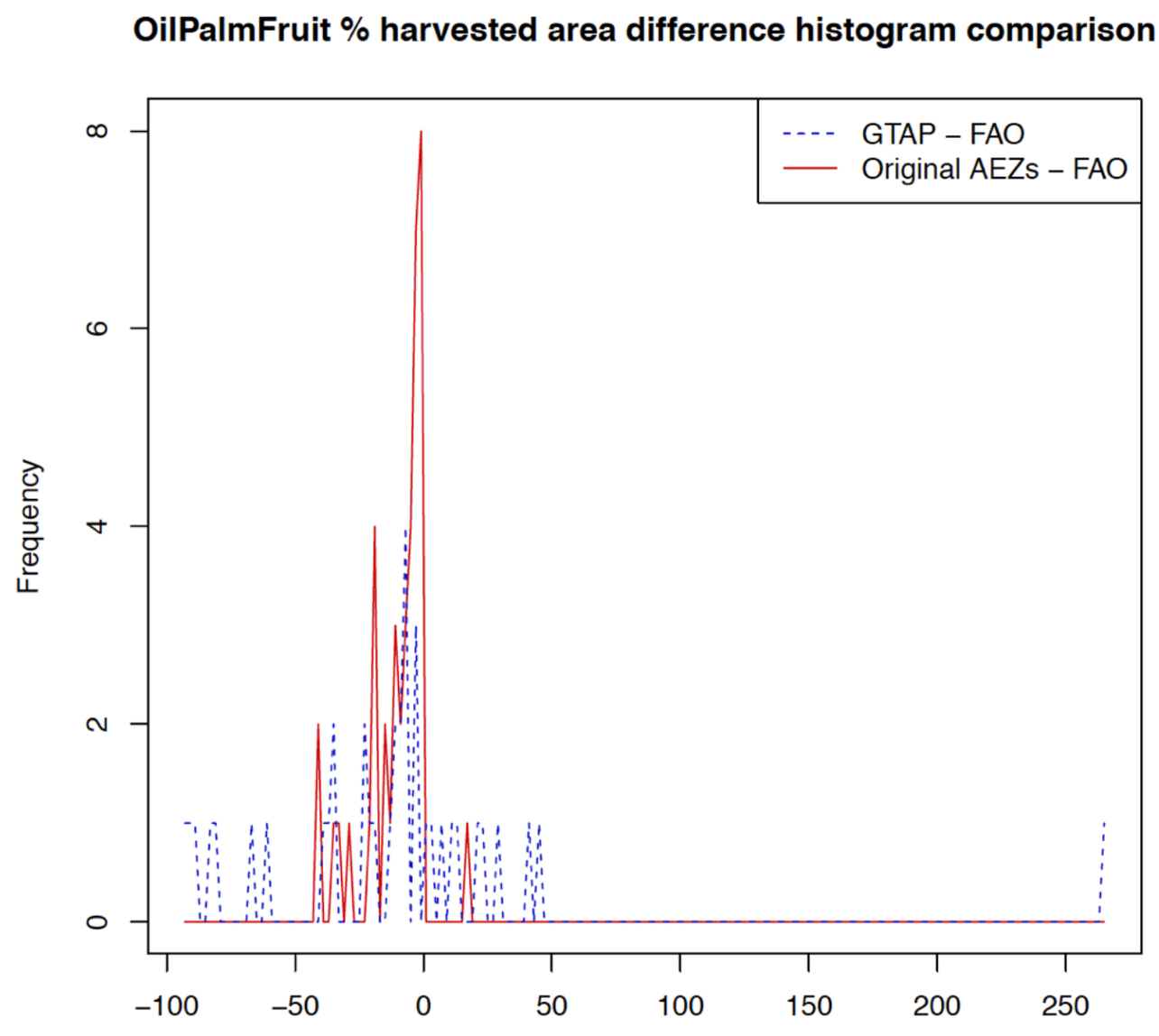
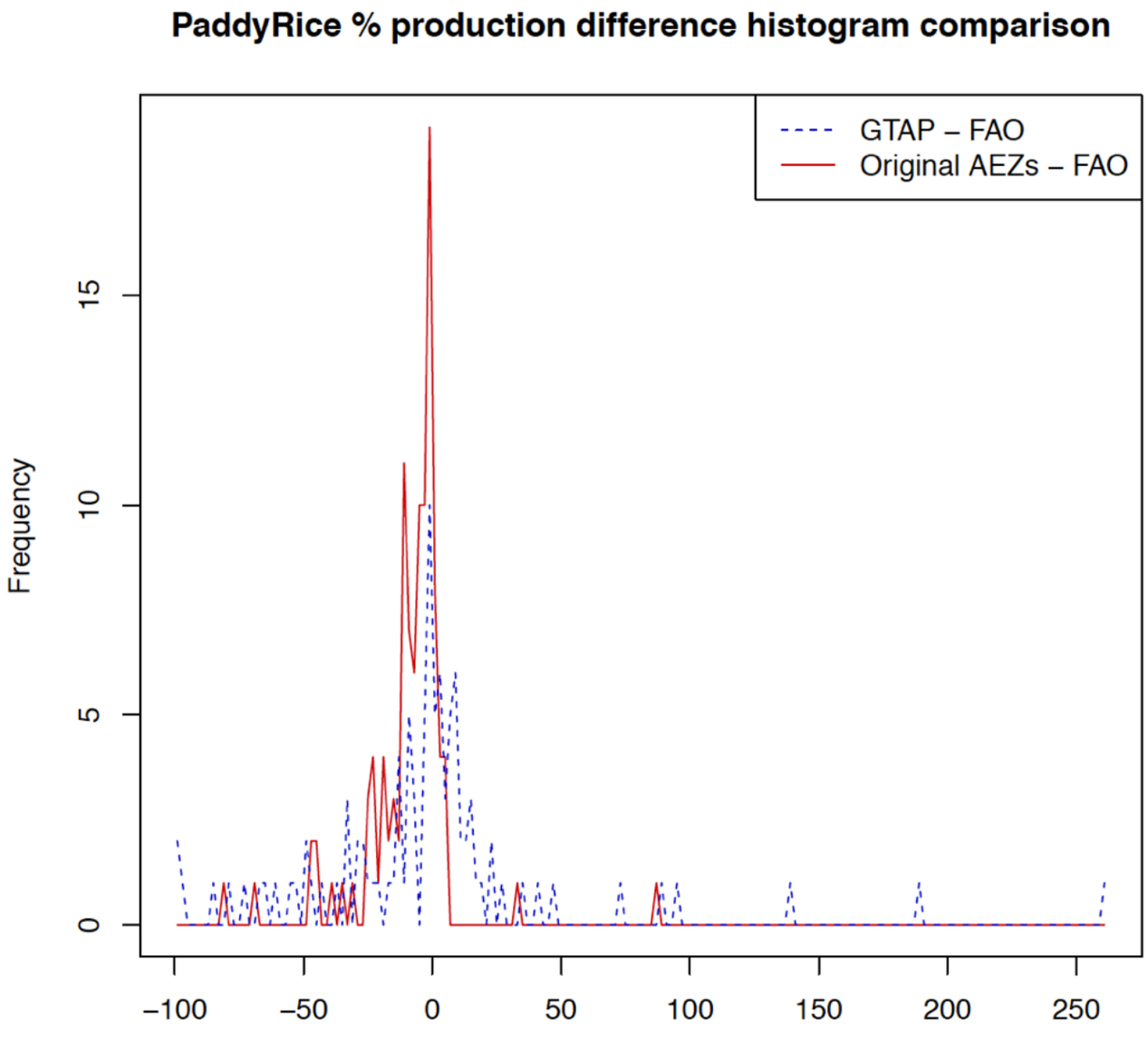


Production difference (%)



Harvested area difference (%)

Distribution differences for Paddy Rice, by country



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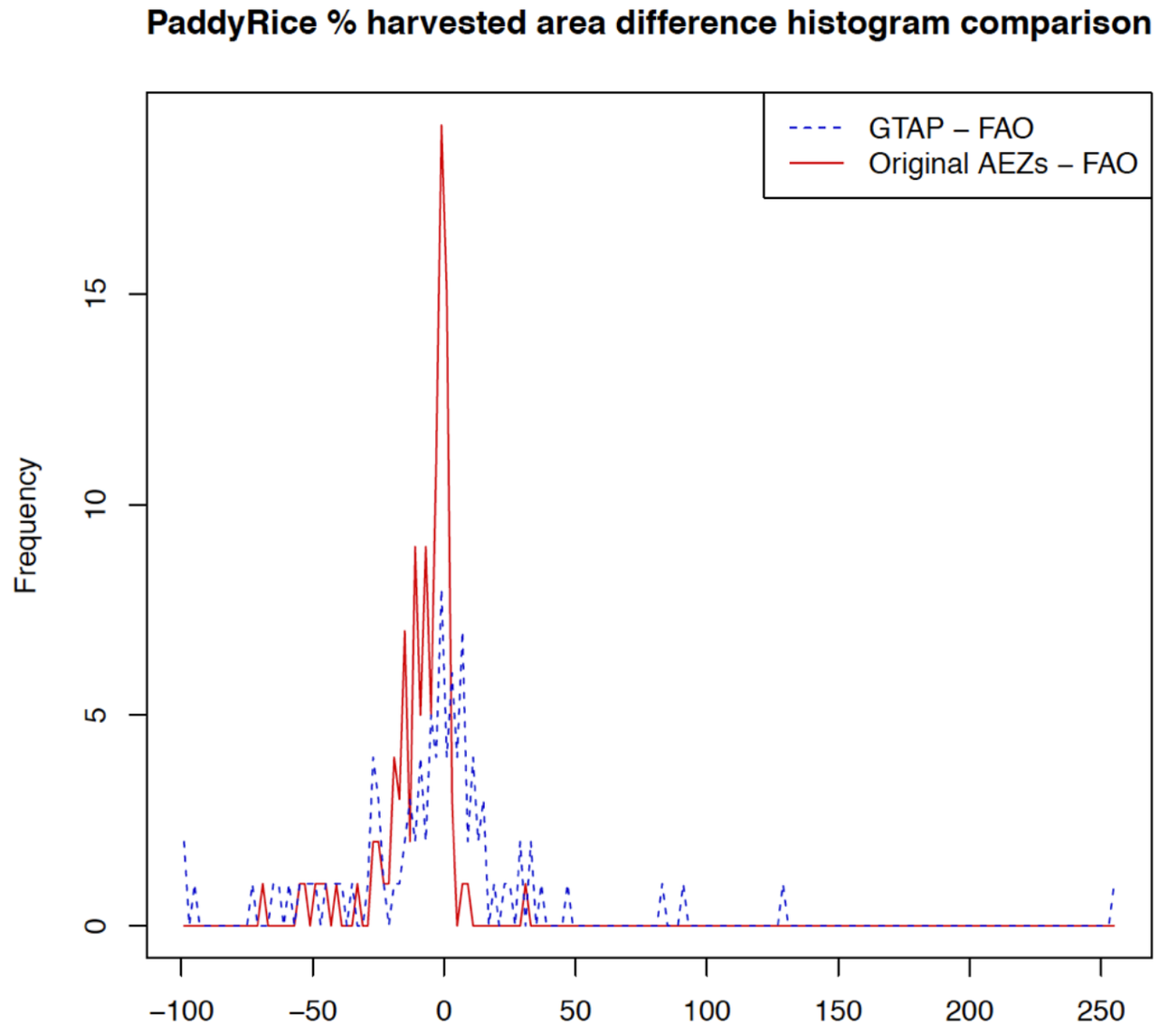
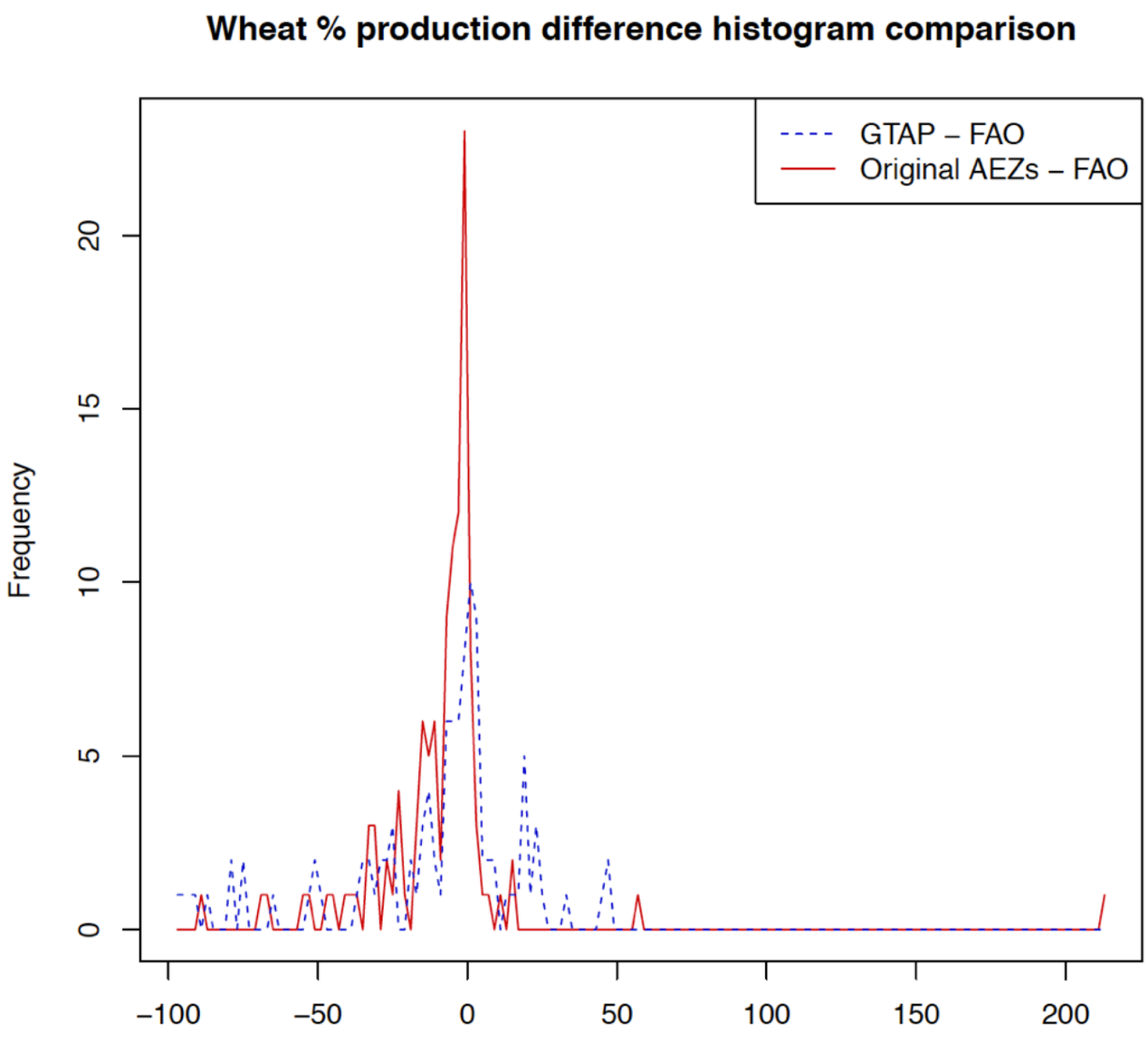
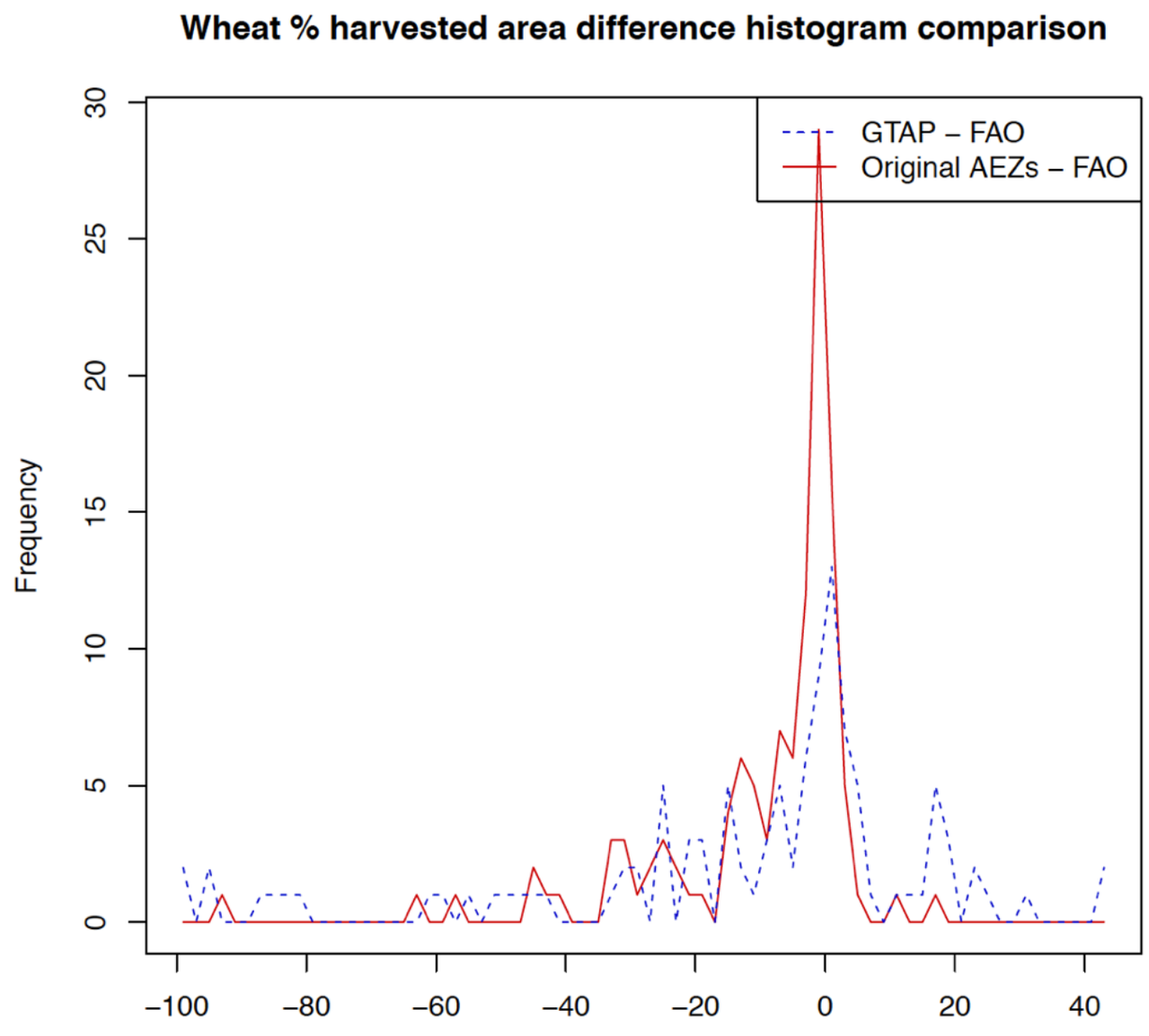


Harvested area difference (%)

Distribution differences for Wheat, by country



Production difference (%)



Harvested area difference (%)

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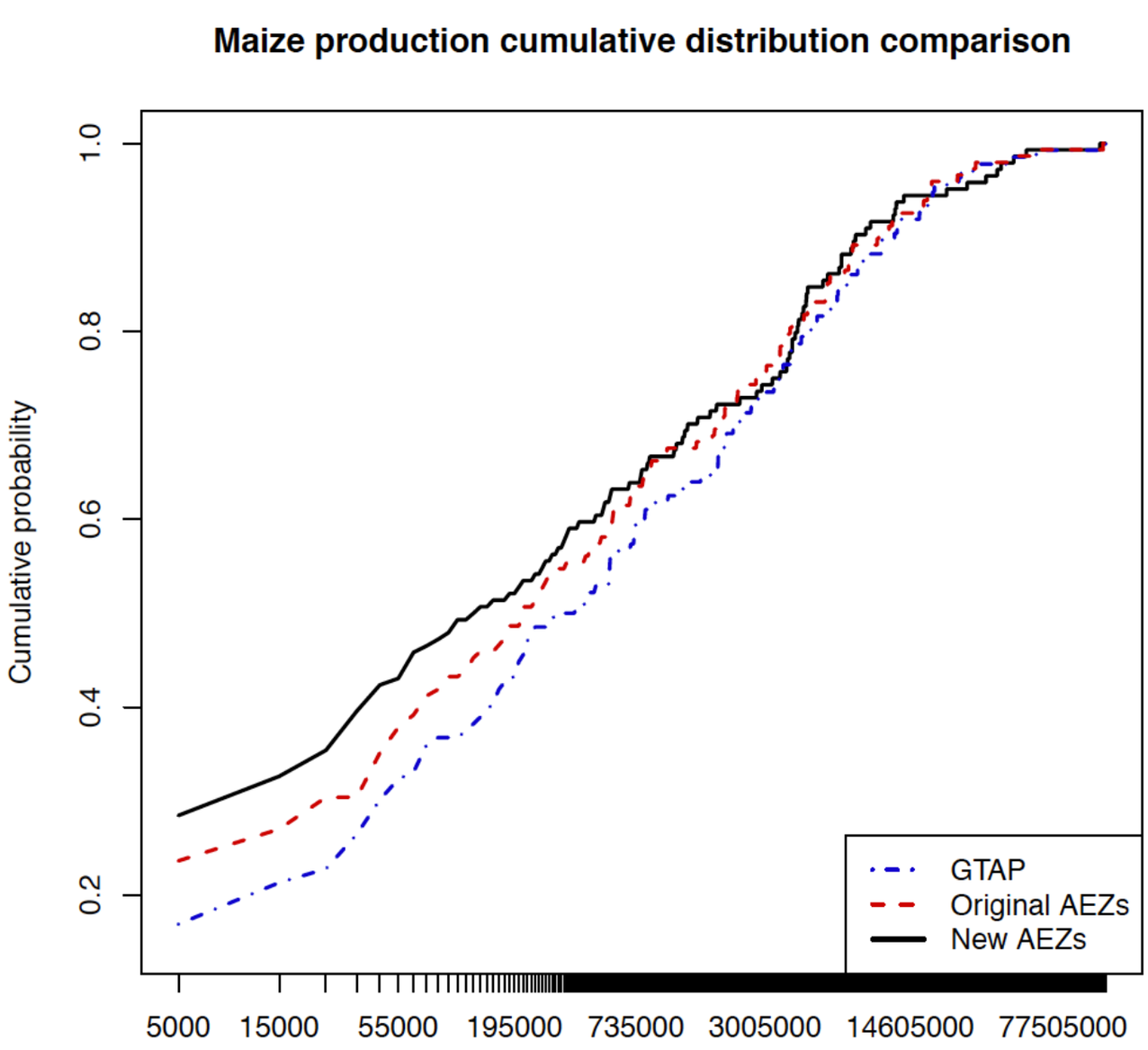
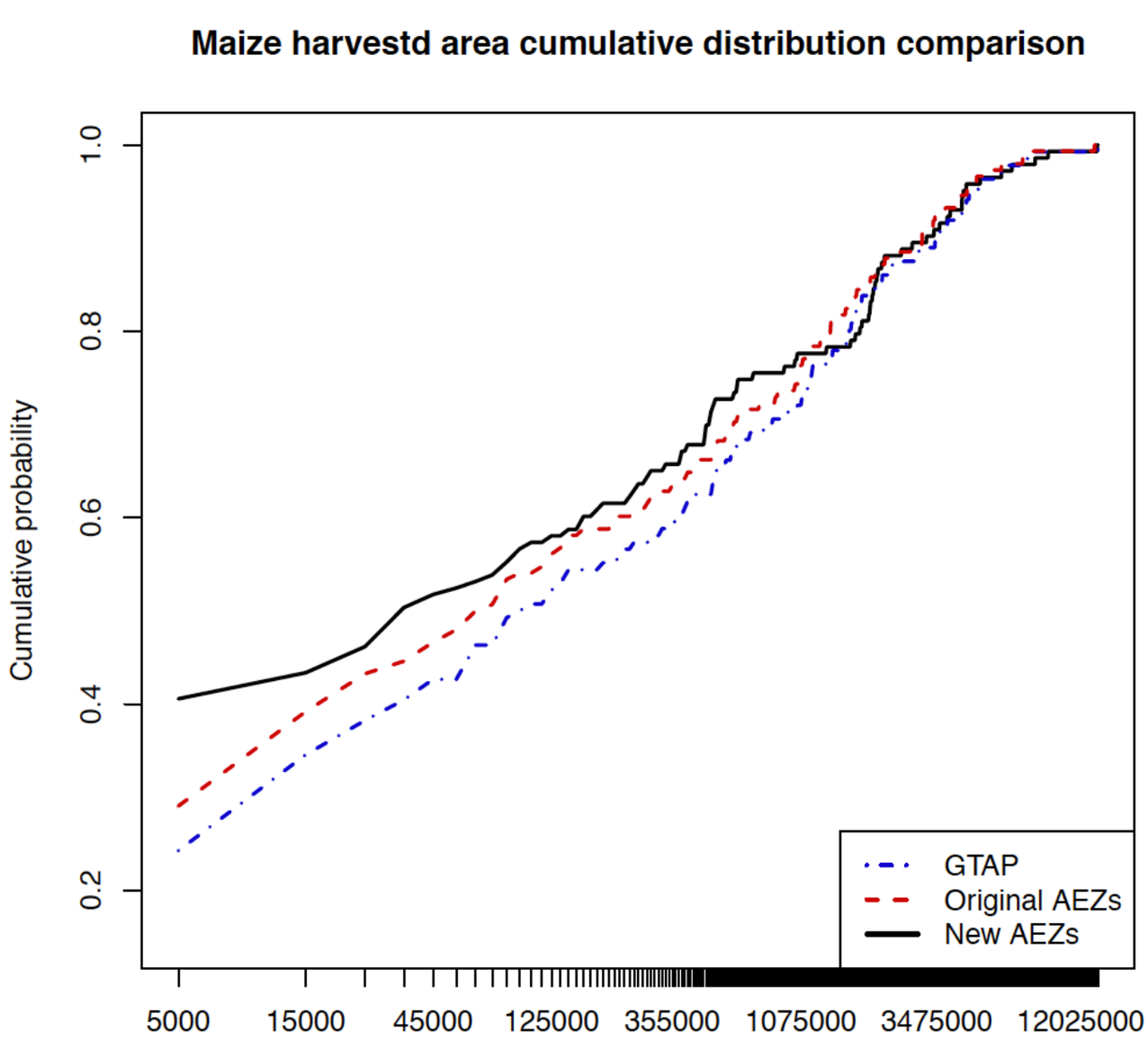
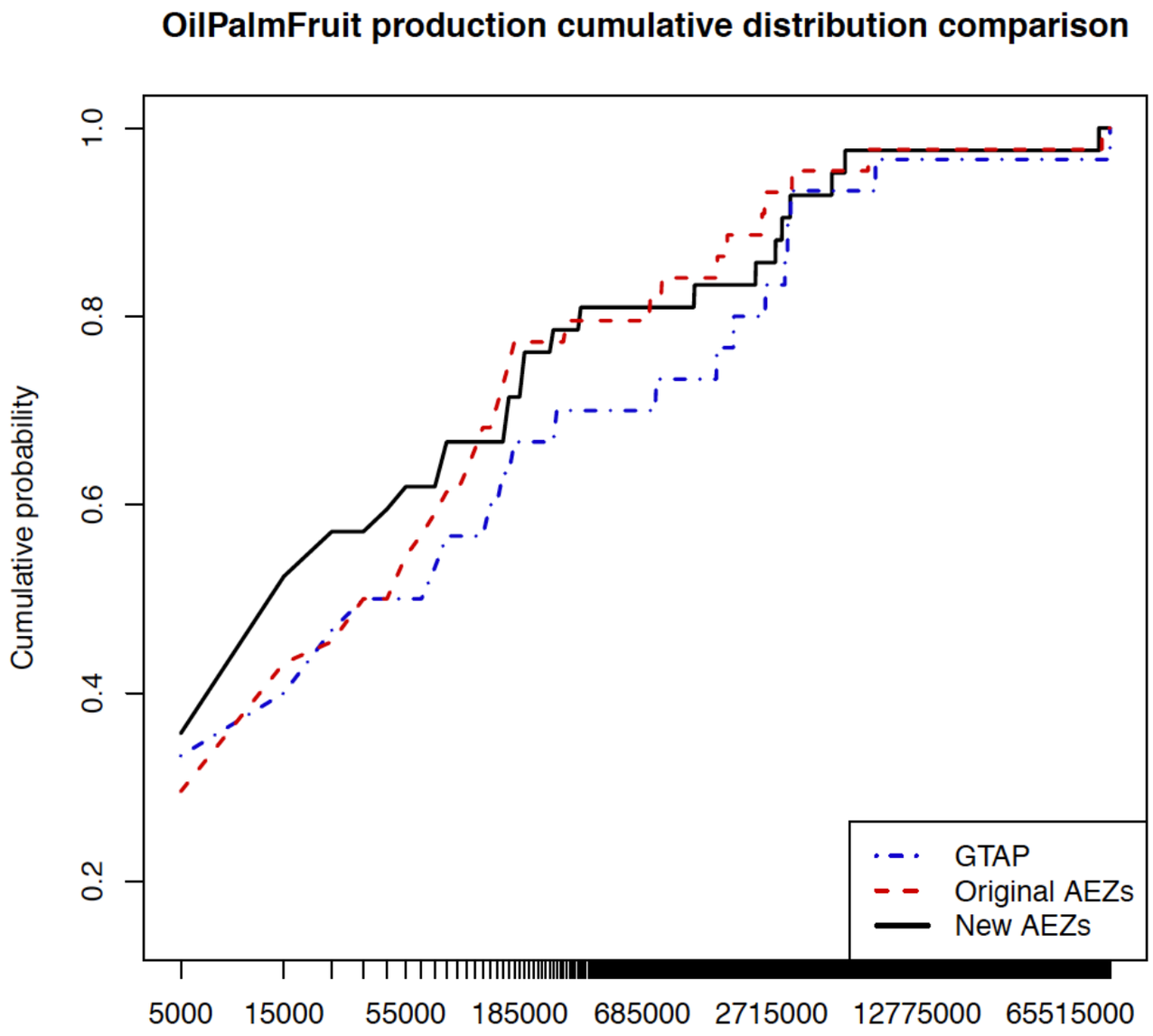


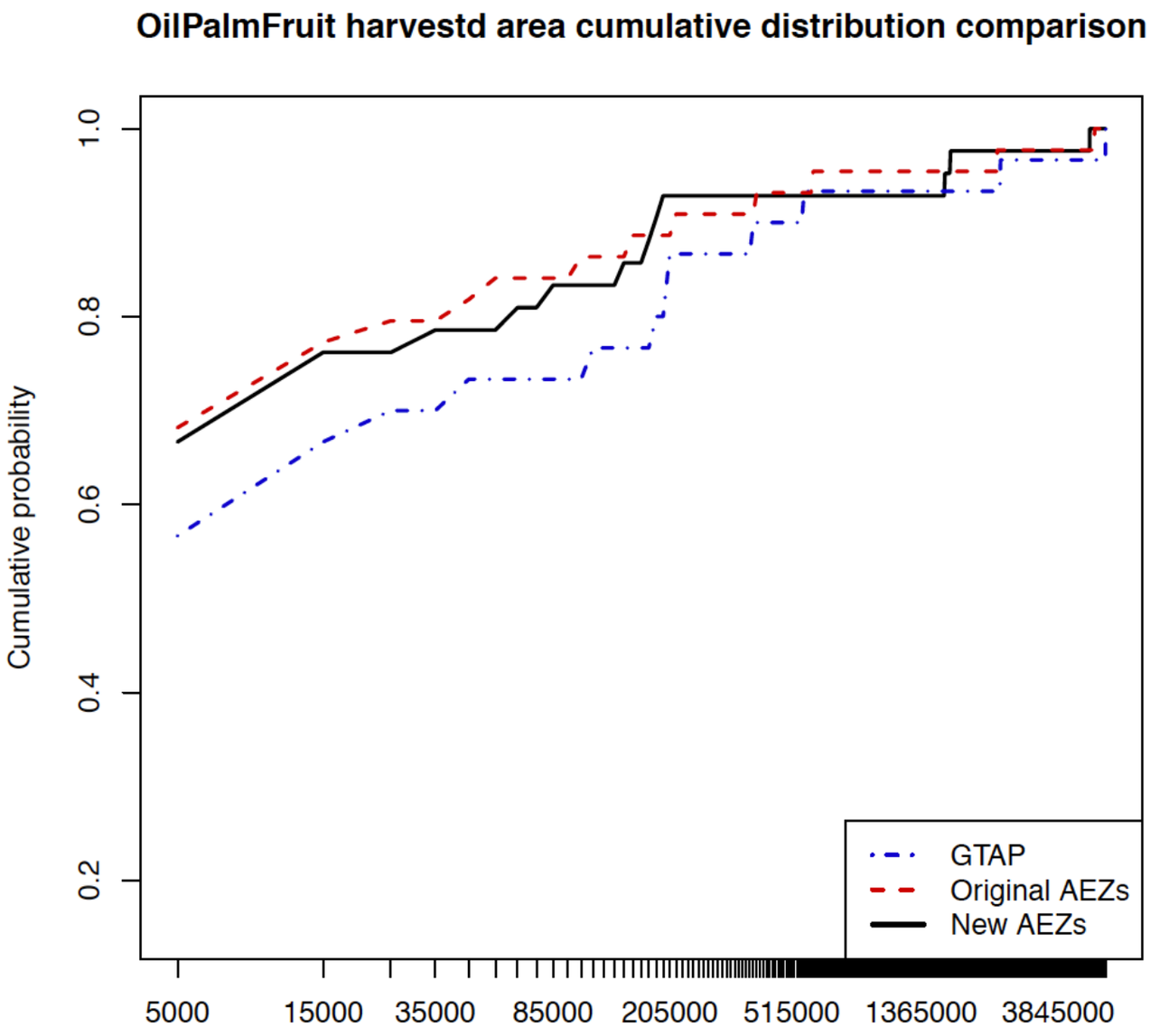
Production (t)



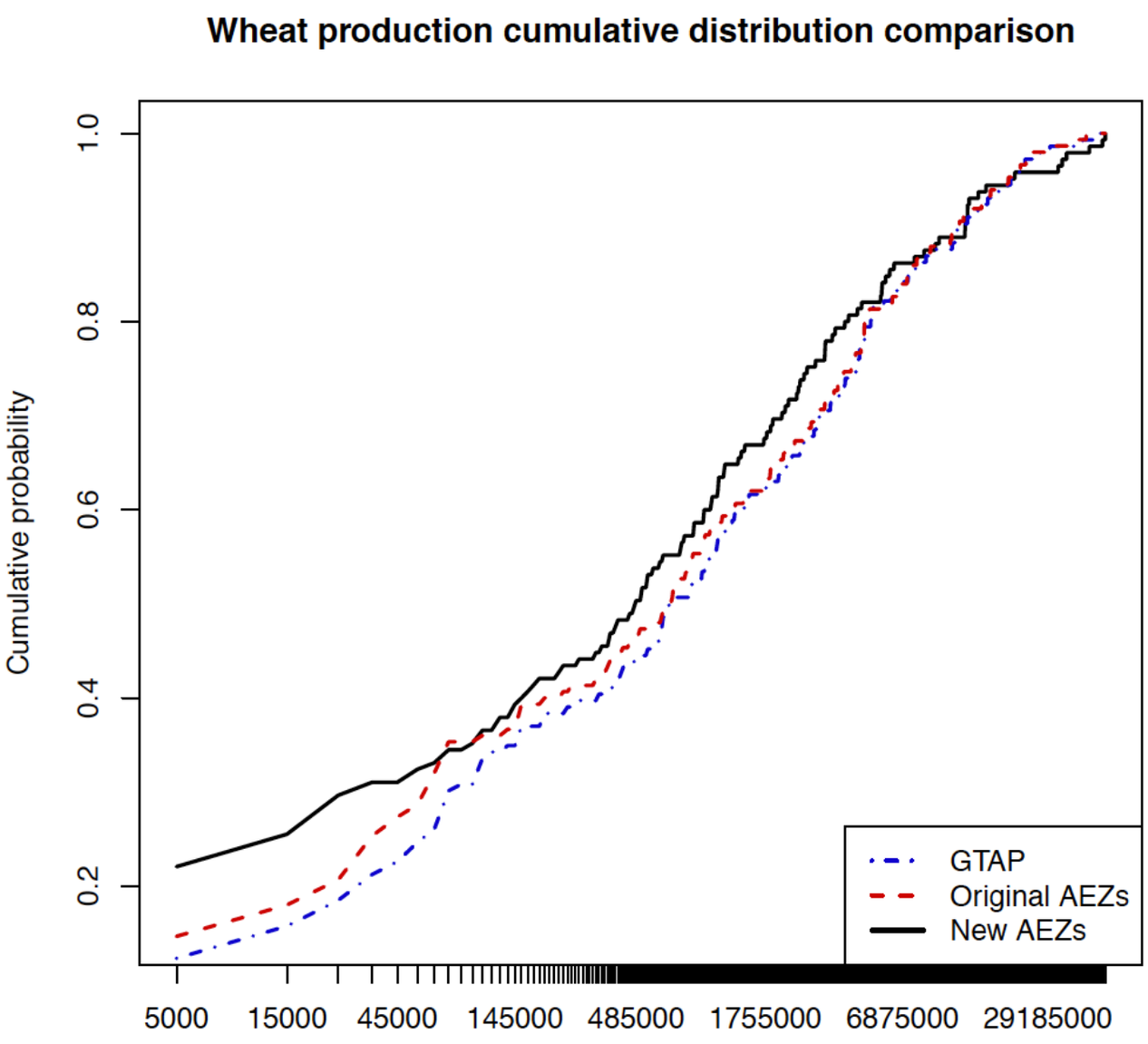
Harvested area (ha)

Global distributions of Oil Palm Fruit, by land unit

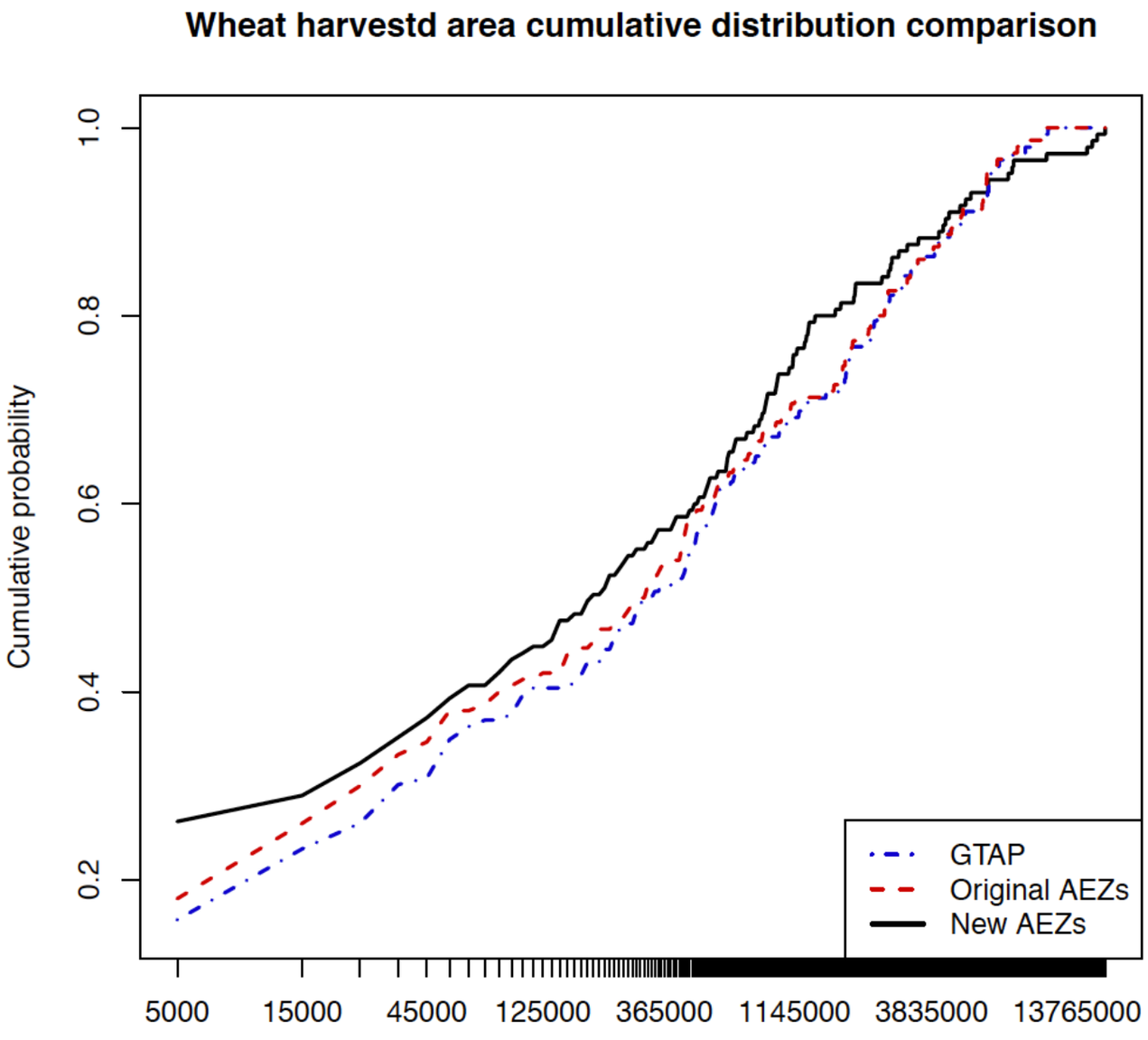




Global distributions of Wheat, by land unit



Production (t)



Harvested area (ha)