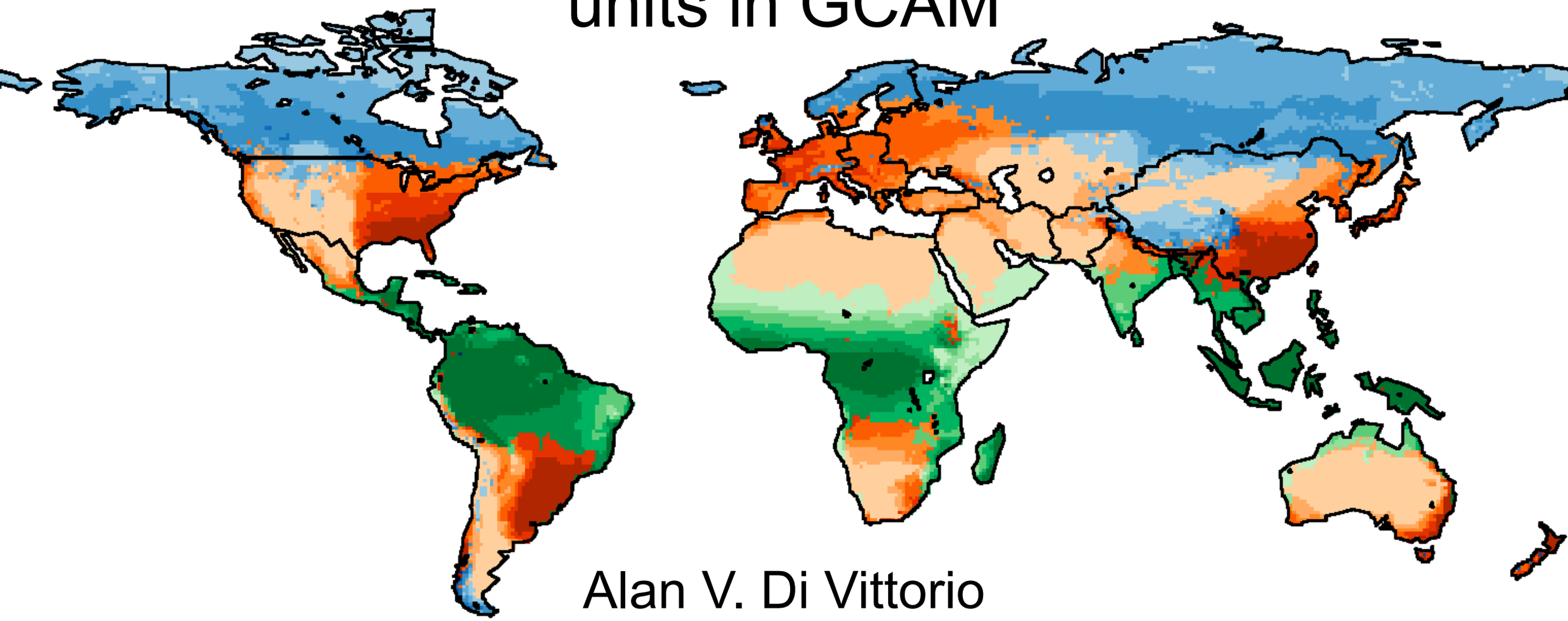
Uncertainty in land resource projection associated with static geographic land units in GCAM



Alan V. Di Vittorio

Lawrence Berkeley National Laboratory

Page Kyle and William Collins

IA/GCAM annual meeting
1-4 December 2015

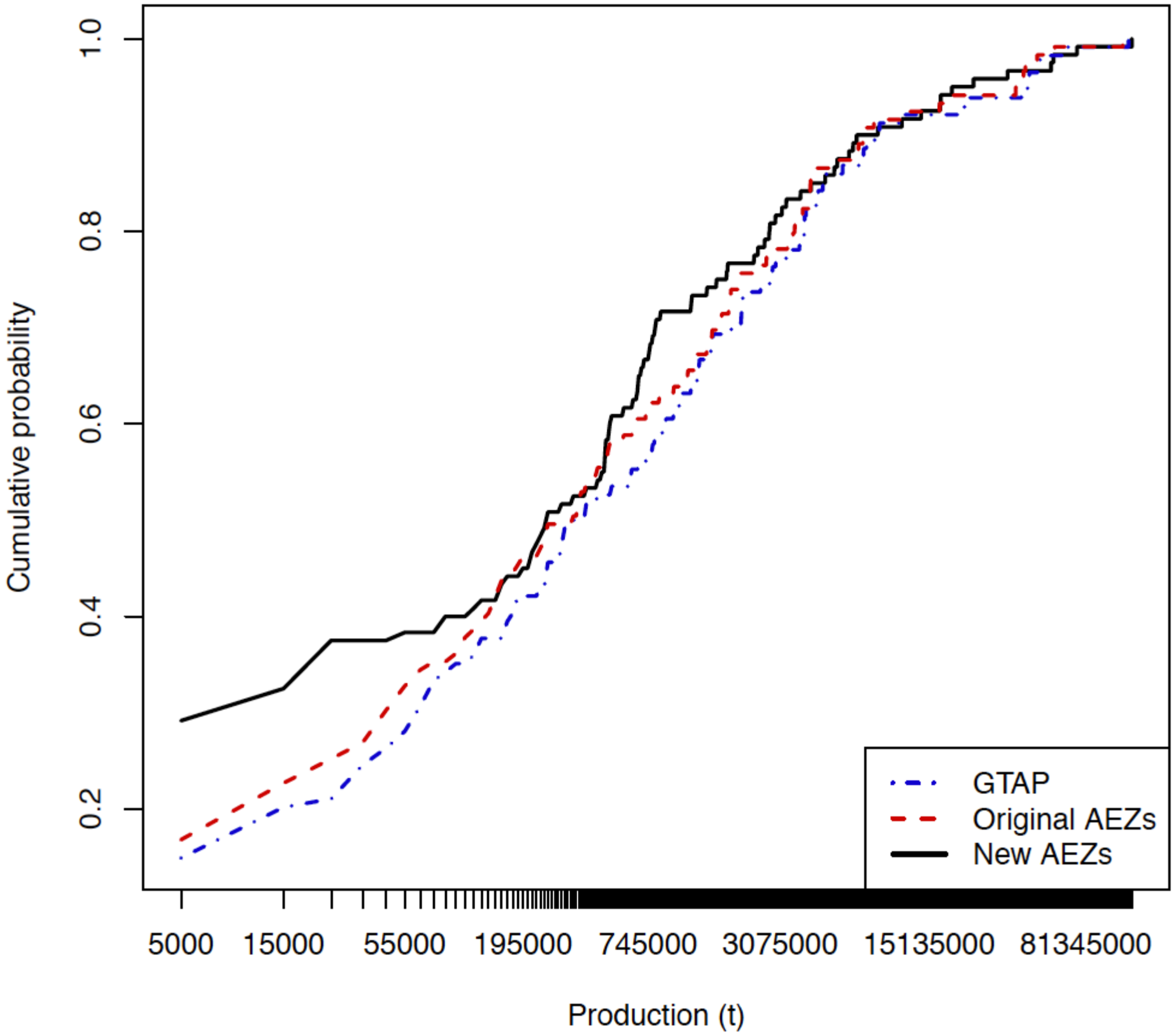
EARTH & ENVIRONMENTAL SCIENCES

CLIMATE & CARBON SCIENCES PROGRAM

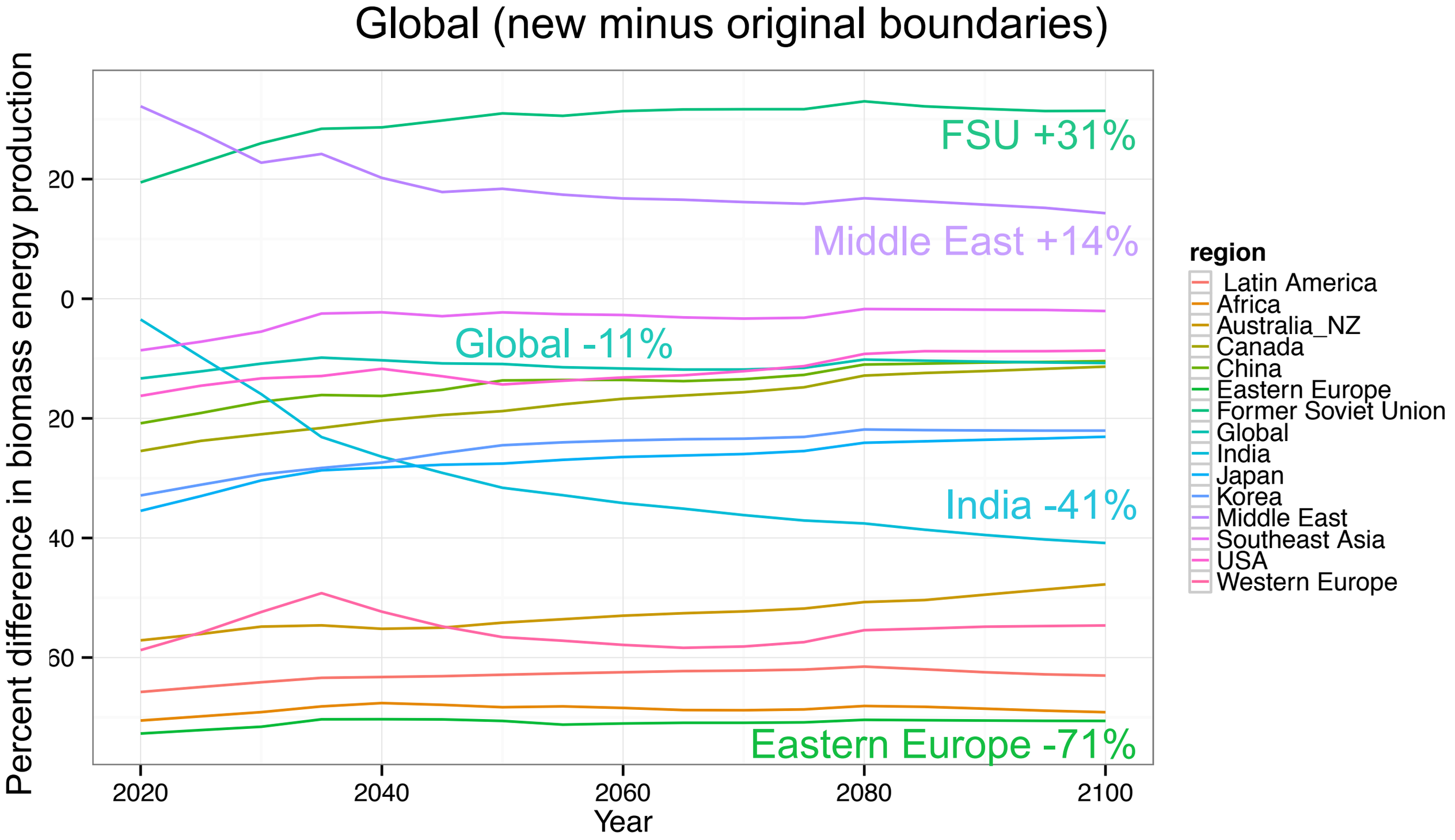
Pacific Northwest NATIONAL LABORATORY

BERKELEY LAB

Global distributions of Paddy Rice Production



Boundaries affect biomass energy production



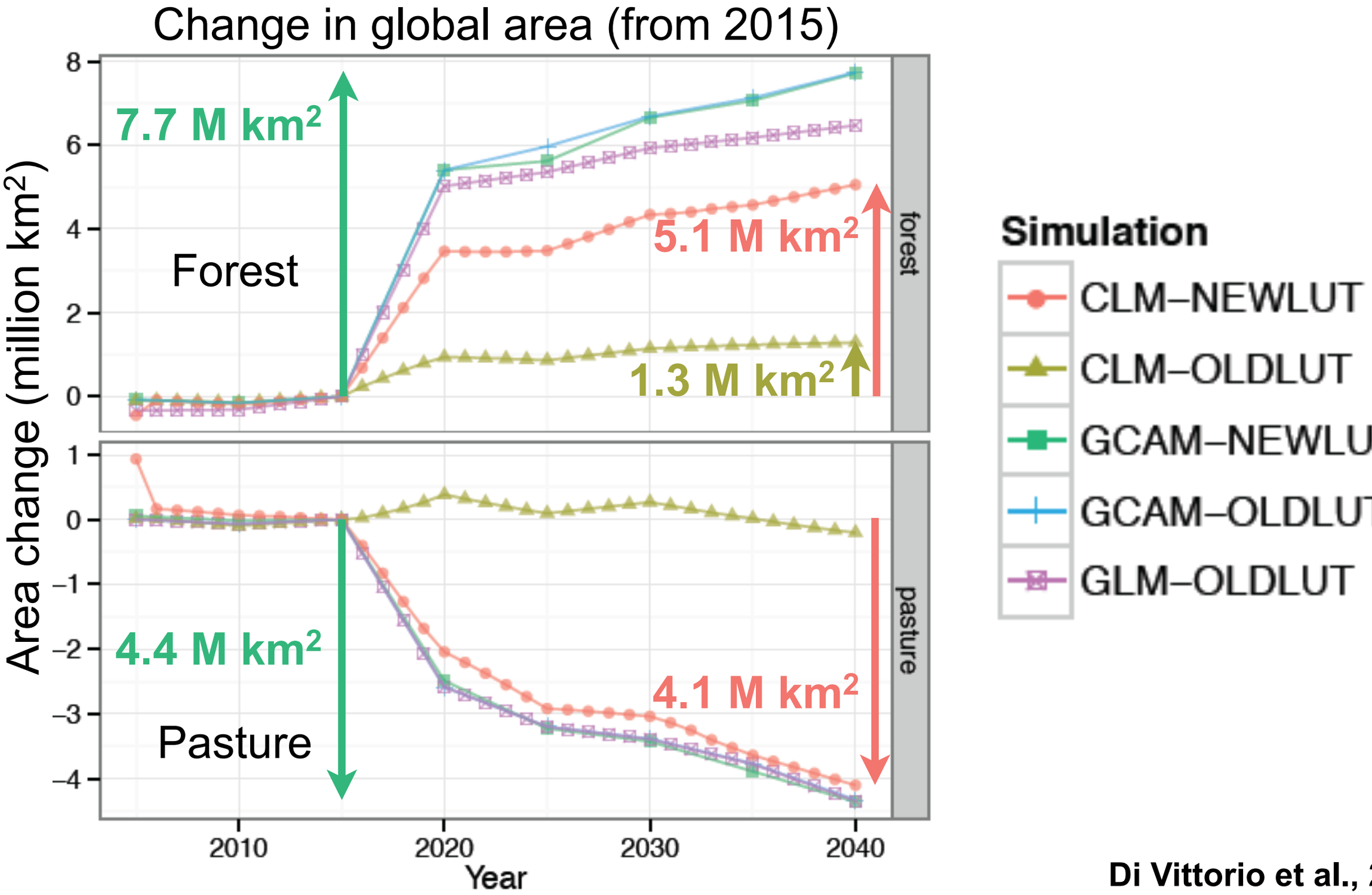
IAMs have different regions/land units

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

Model	Regions	Land units for 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

5

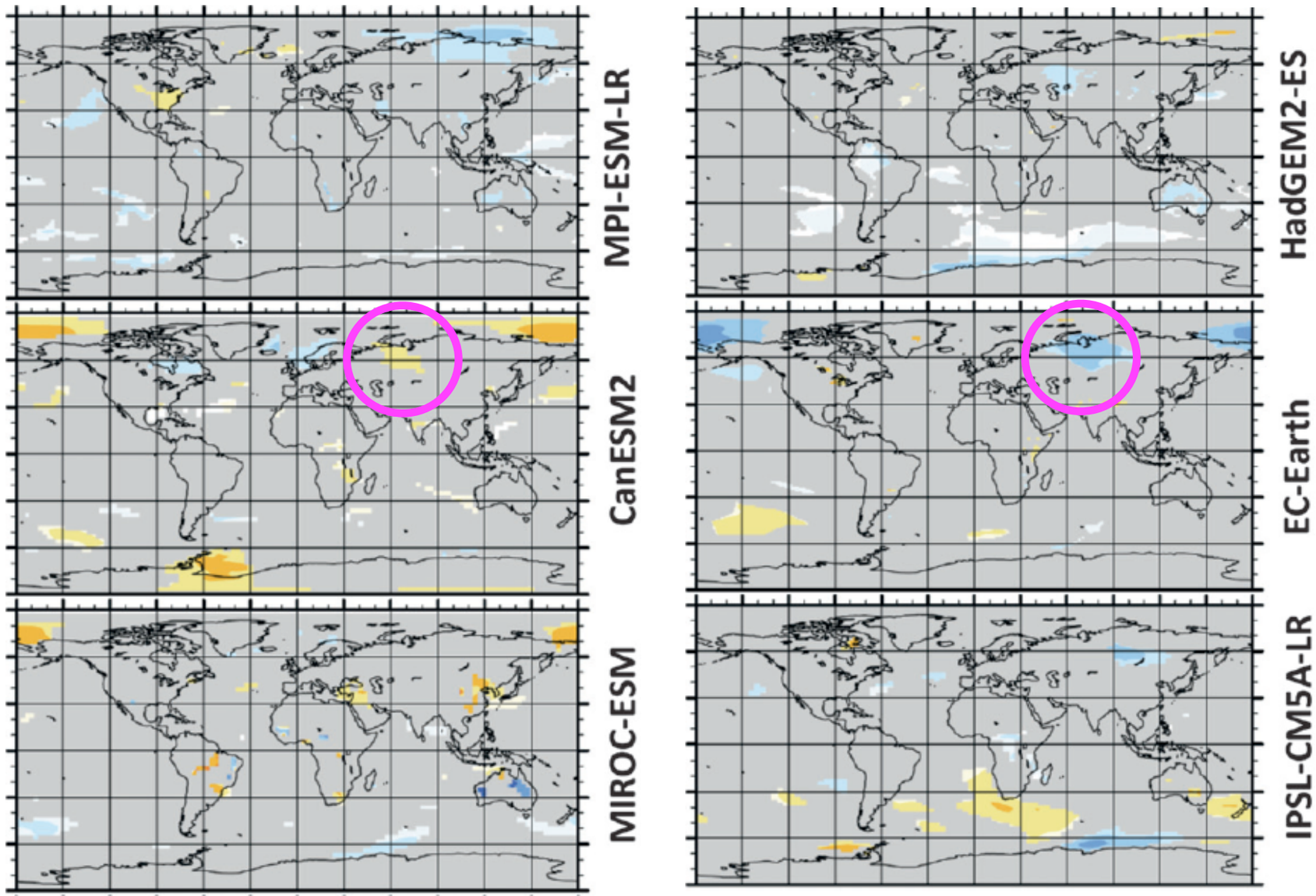
Land use/cover inconsistencies across IAMs and ESMs can alter the global carbon cycle



Di Vittorio et al., 2014

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

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



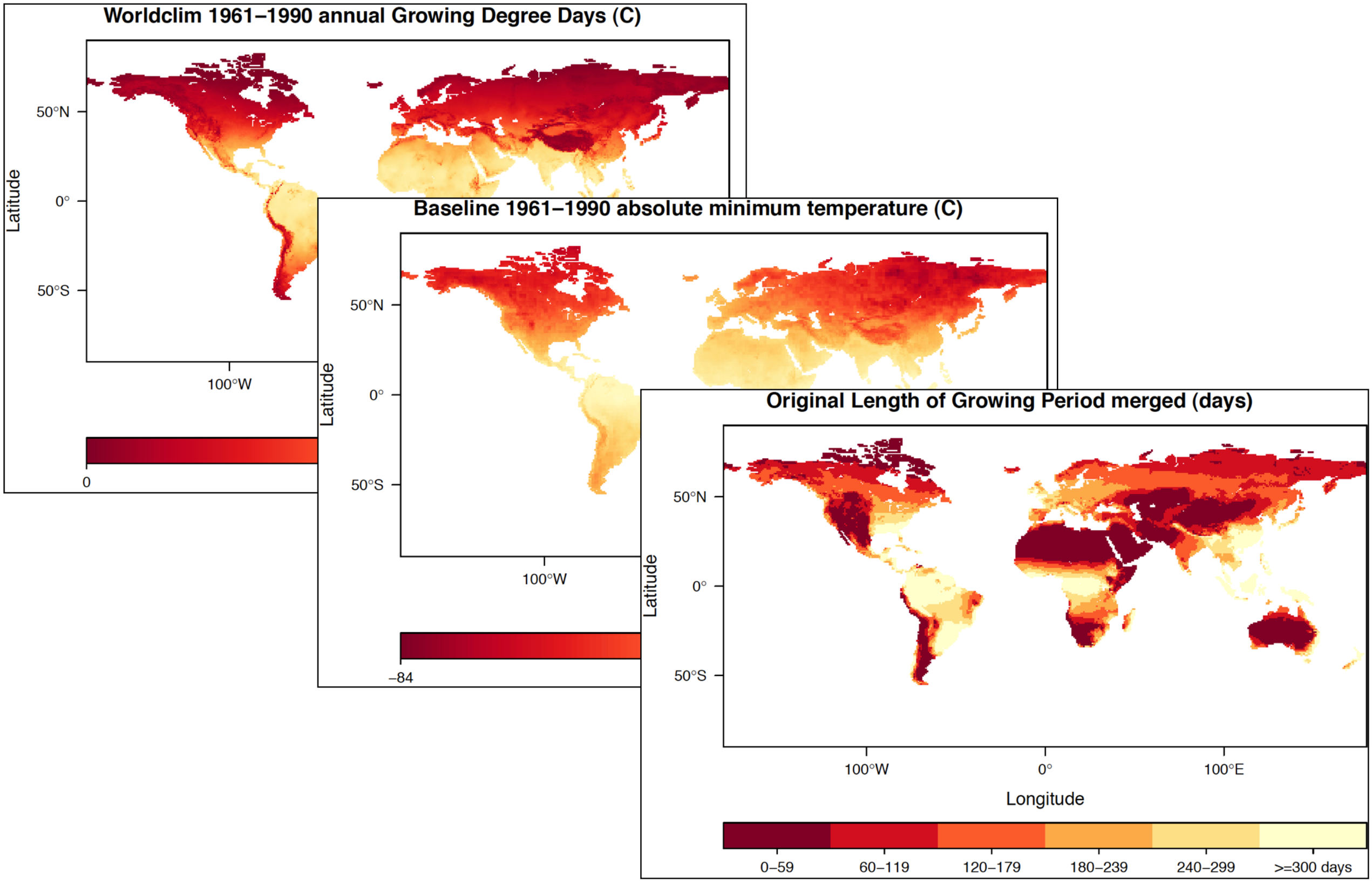
Temperature effect of RCP 8.5 land use change for 2071-2100 (Brovkin et al. 2013)

In the context of coupled whole earth system modeling

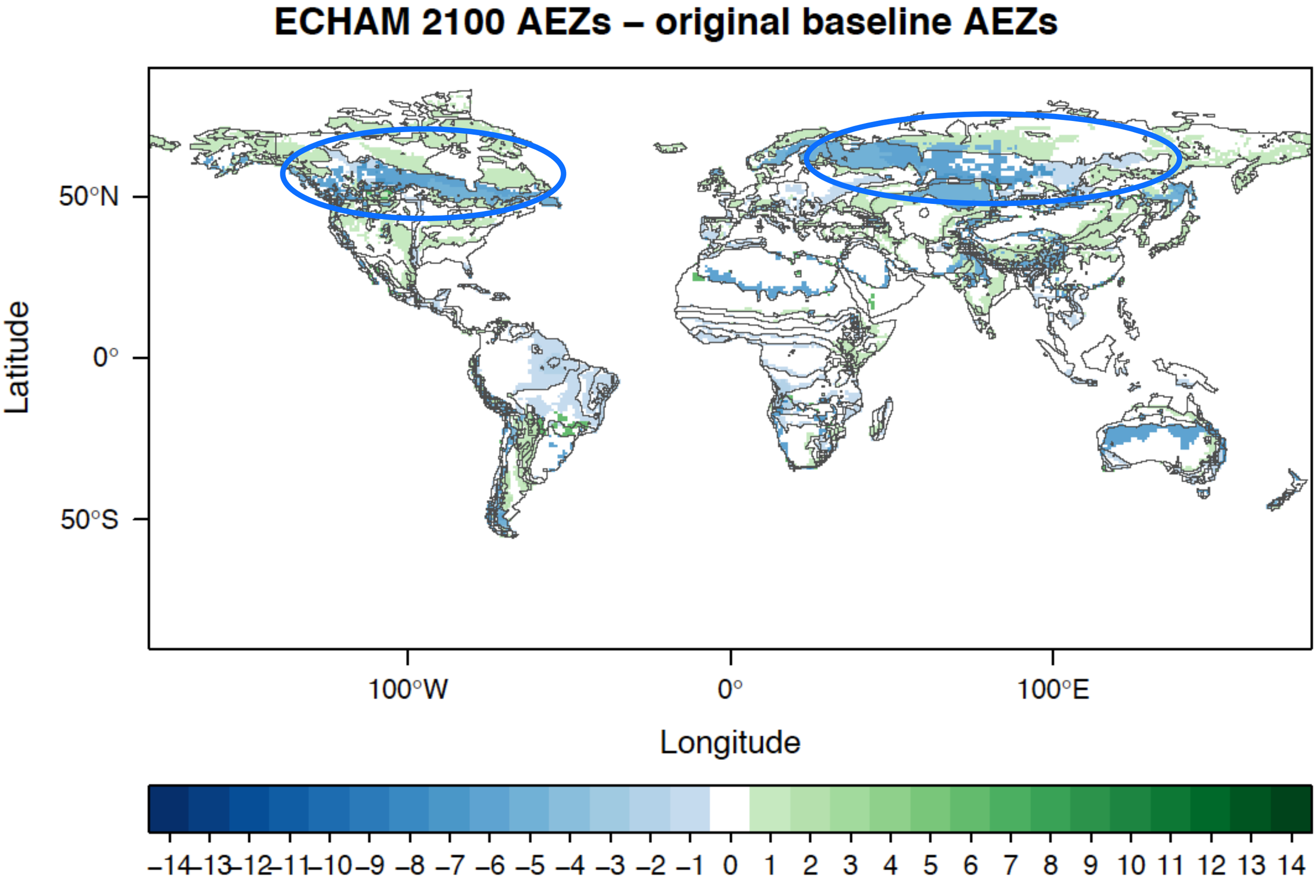
- How do we make robust projections of land resources in the context of projected climate change?

- **How do spatial boundaries influence land resource projections?**

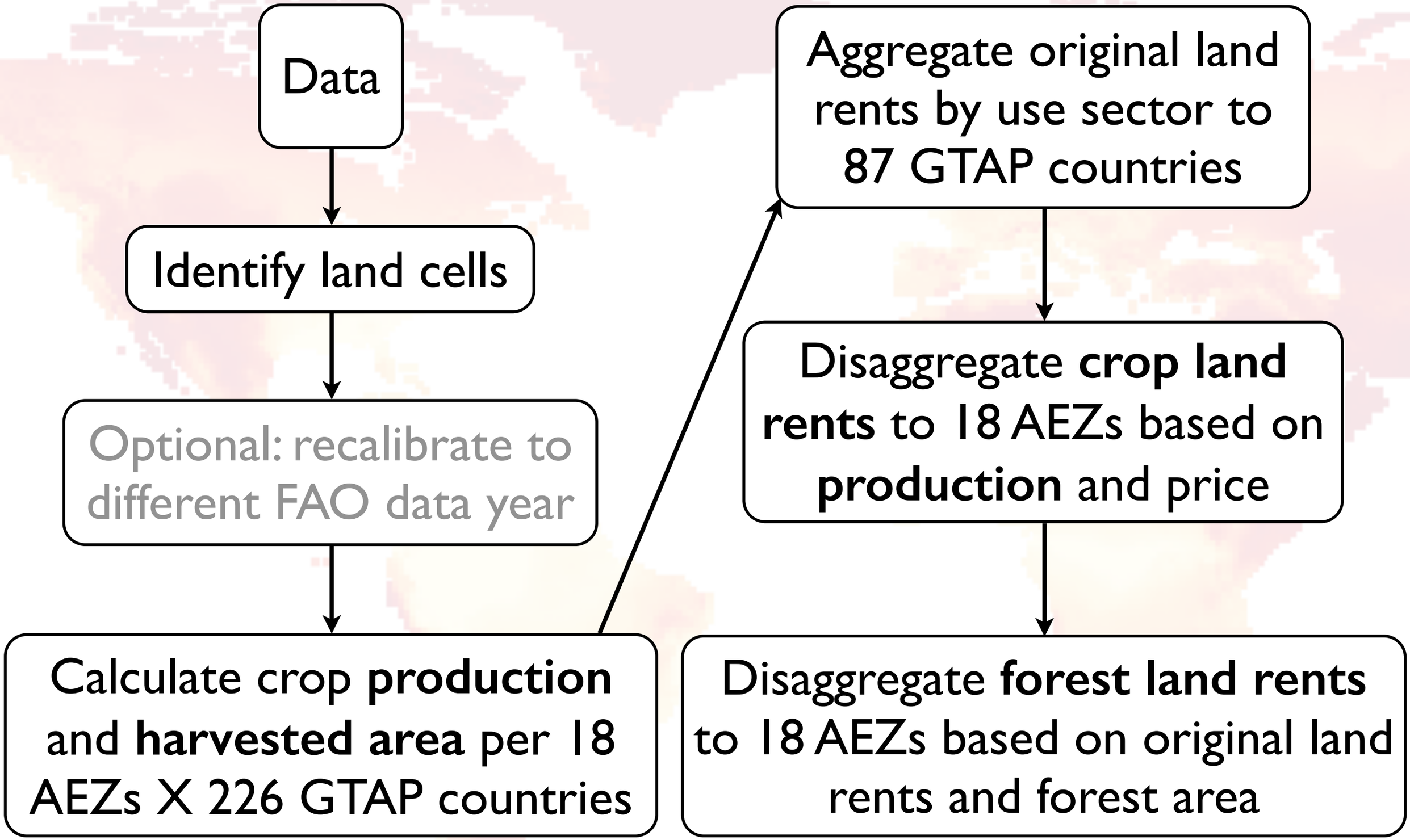
Agro-Ecological Zones (AEZs) are bio-climatically defined



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

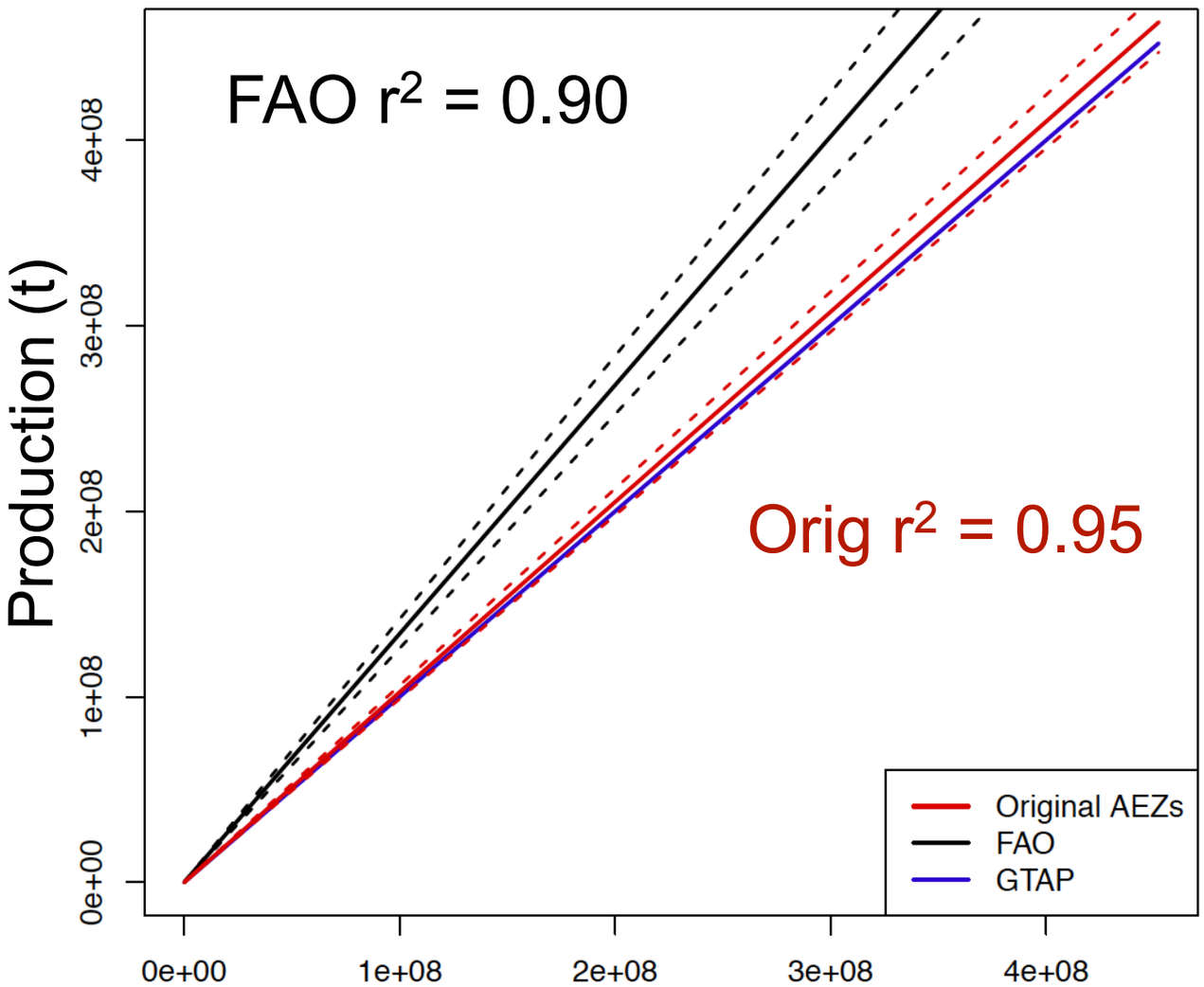
Tabular data

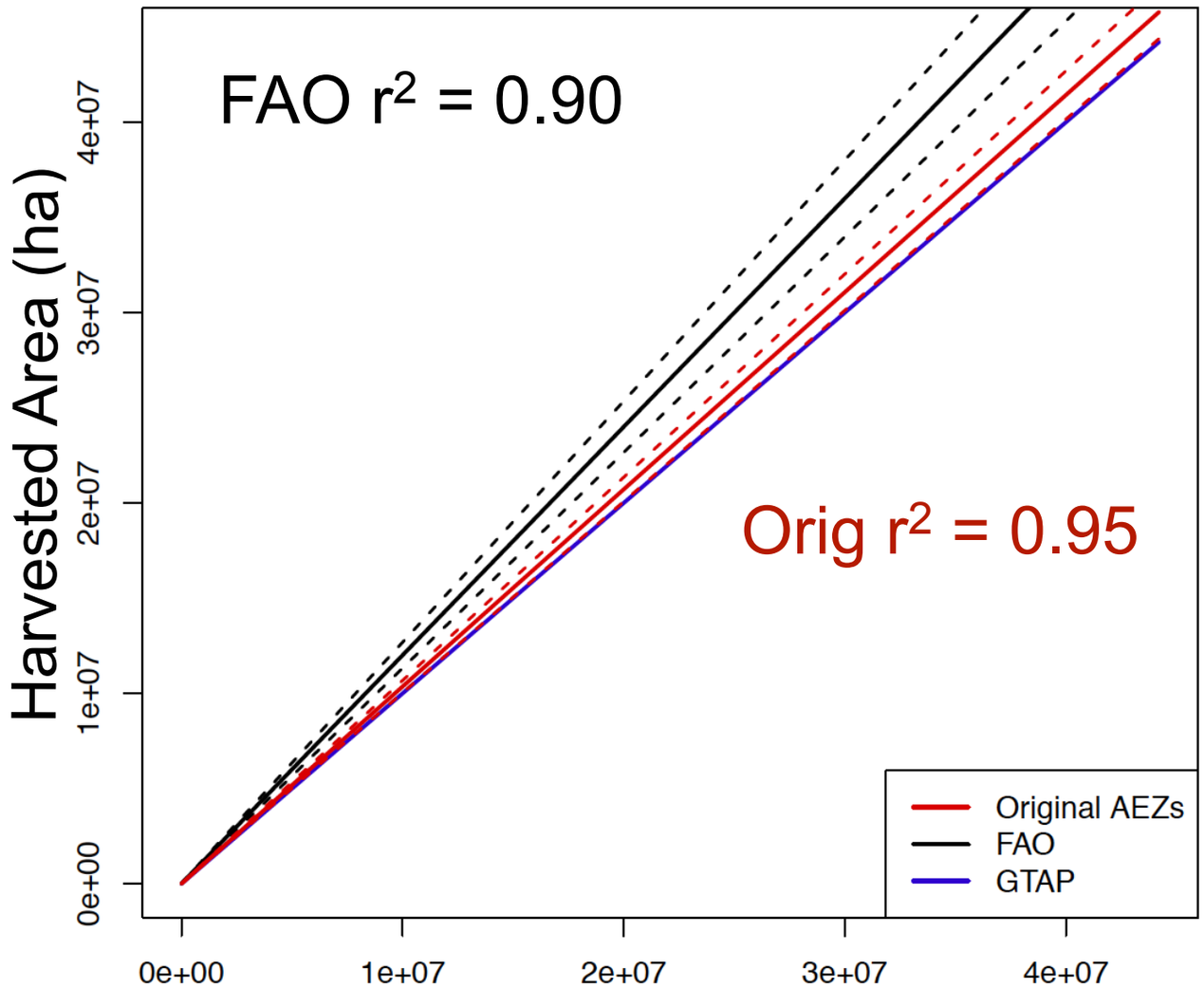
- GTAP countries (226, 87)
- FAO countries (241)

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

Validation: Mean of crop regressions against GTAP data

Country level comparison

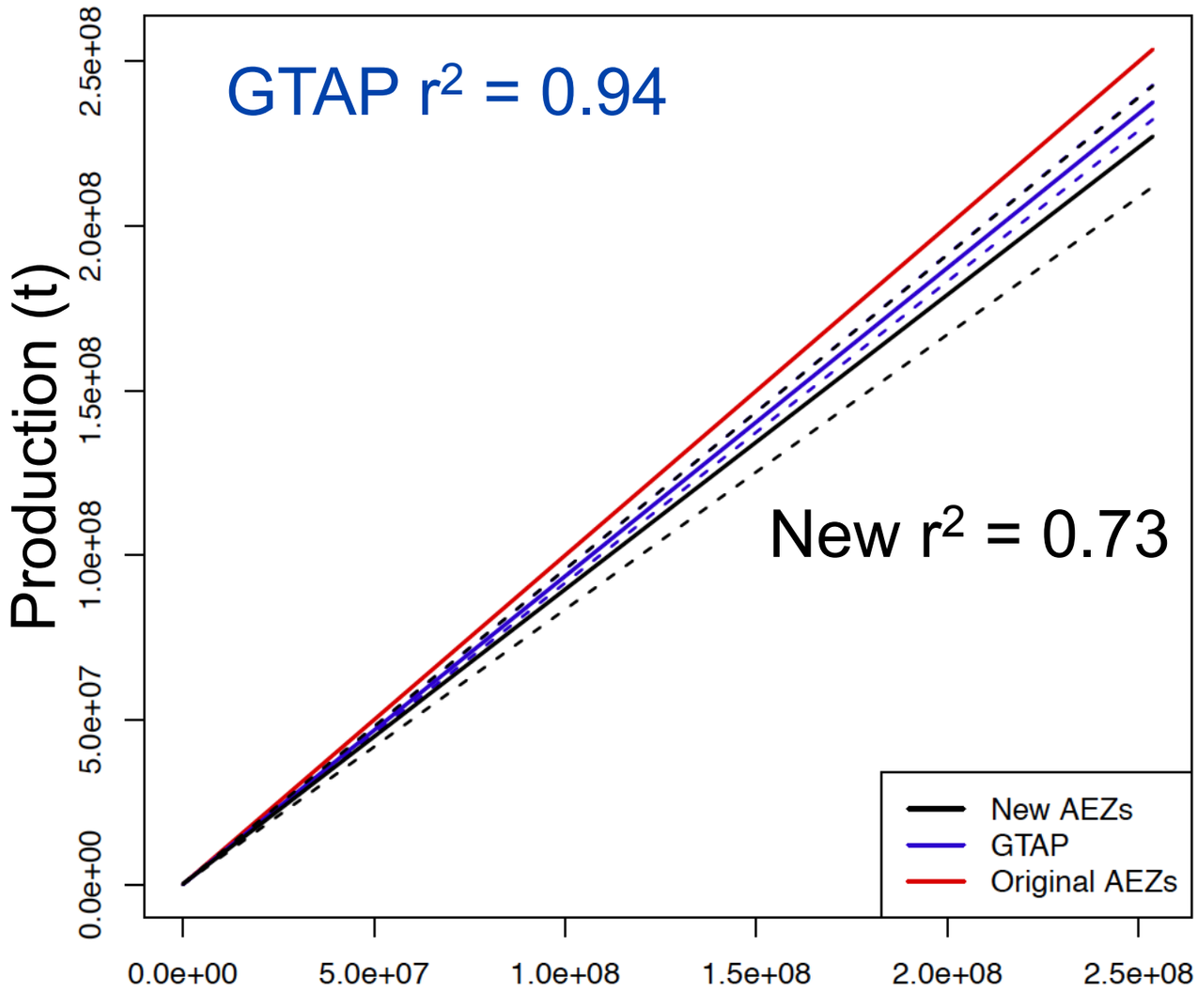


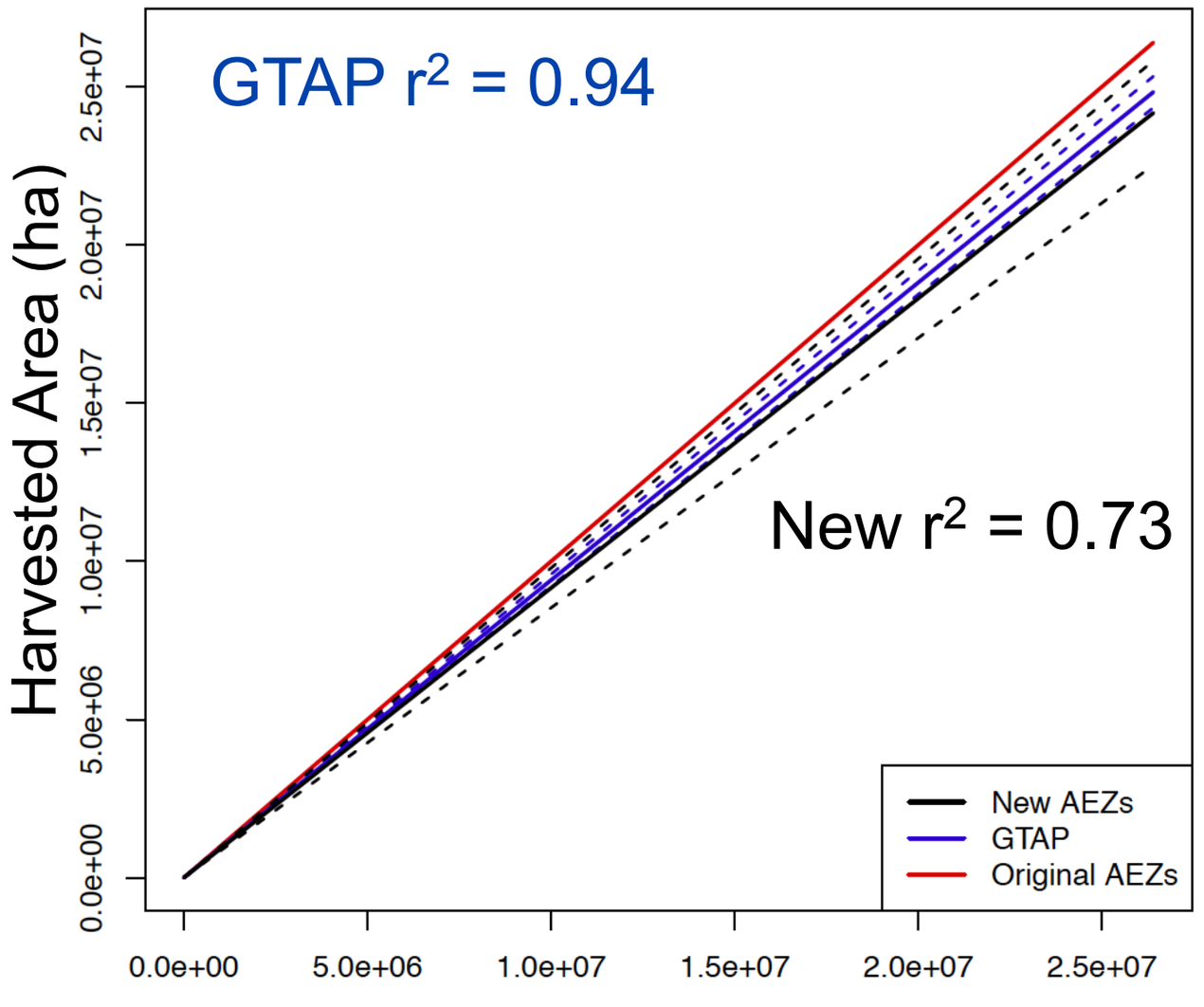


86 crops with n >= 20 countries

Geographic shift of initial conditions: Mean of crop regressions against Original AEZs

GCAM land unit comparison

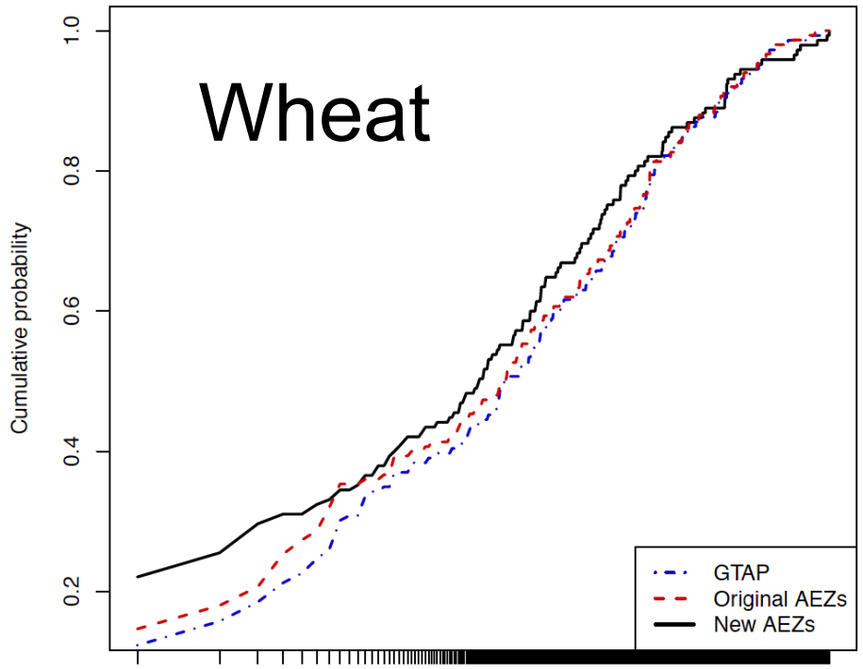


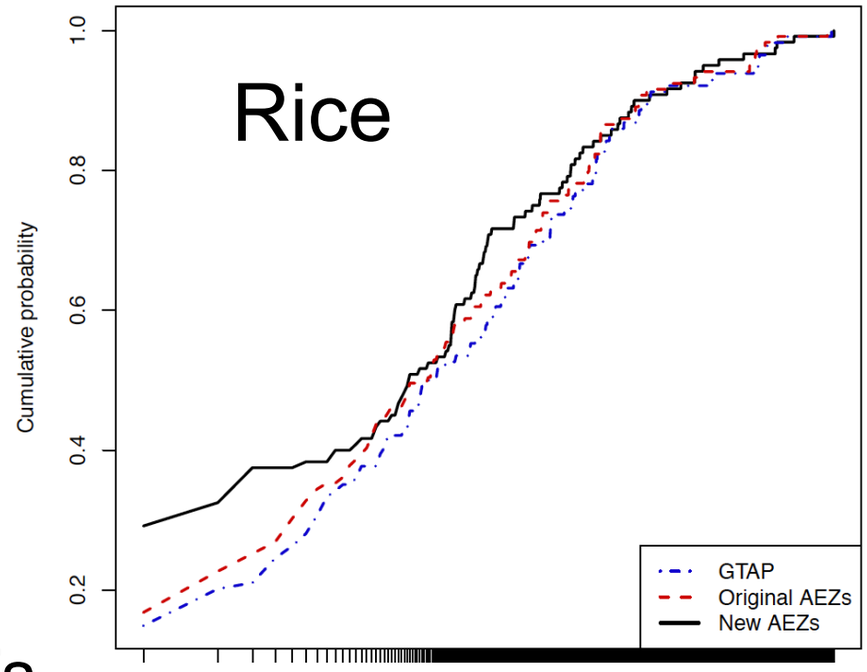


117 crops with n >= 20 land units

Each crop is uniquely affected by new land units

Cumulative probability

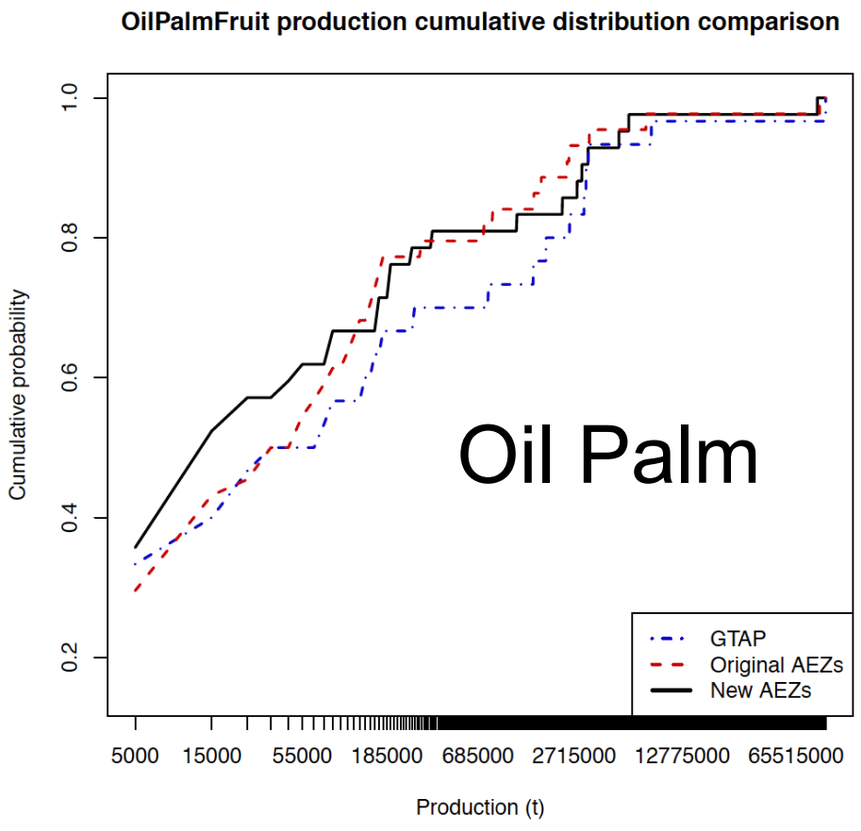


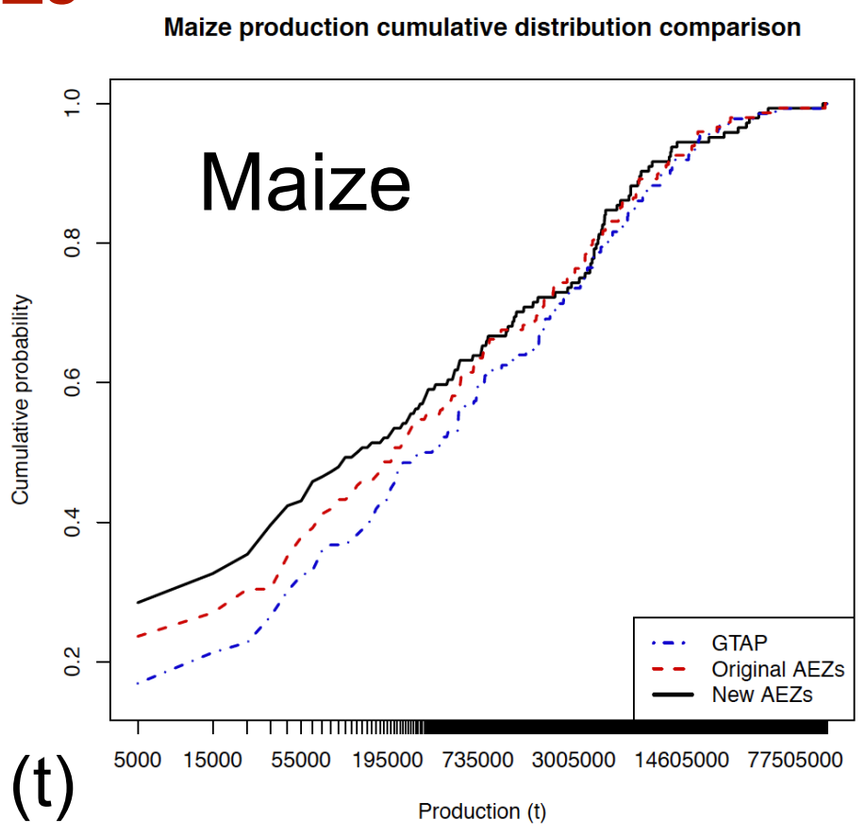


New AEZs

Original AEZs

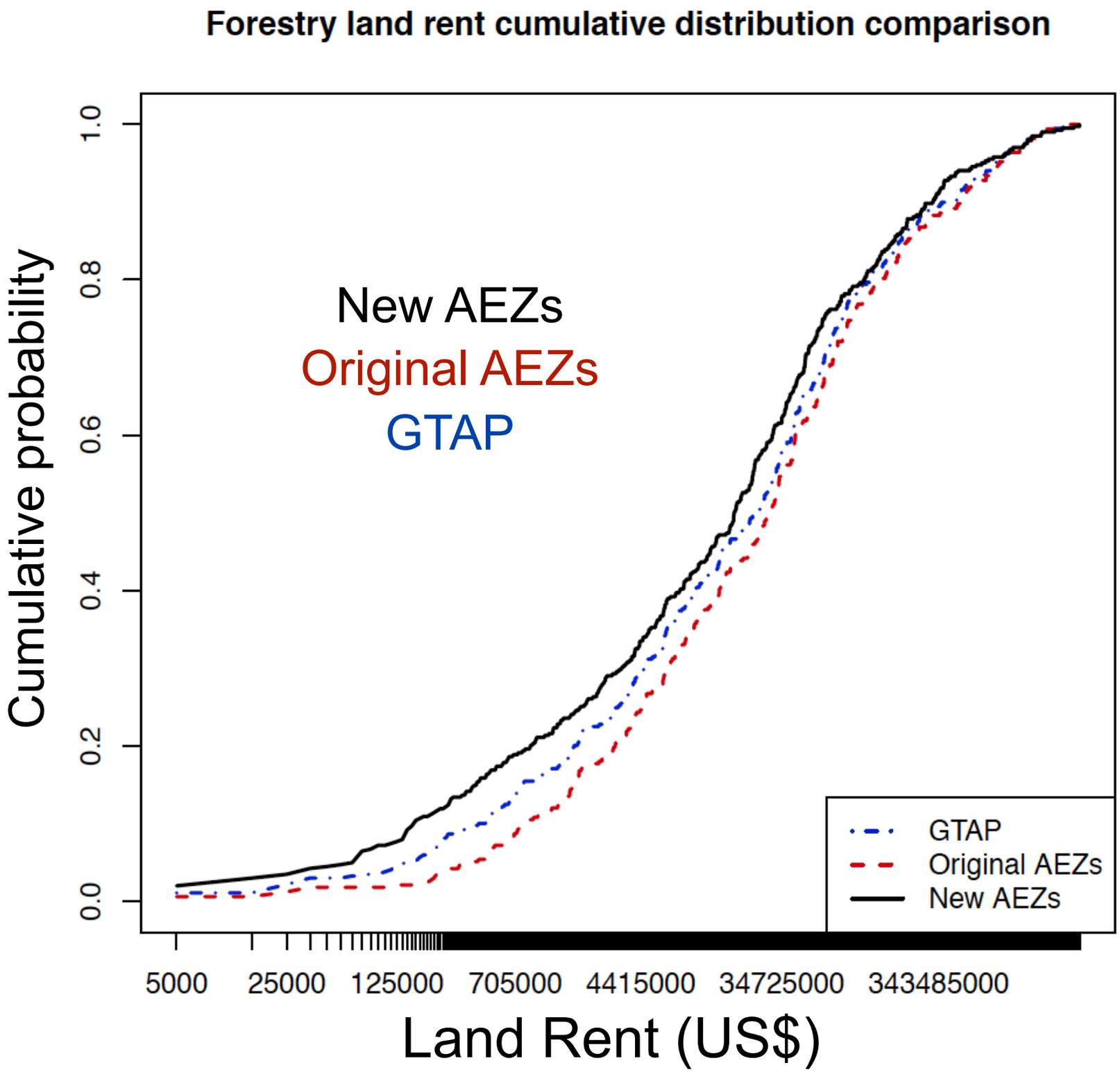
GTAP



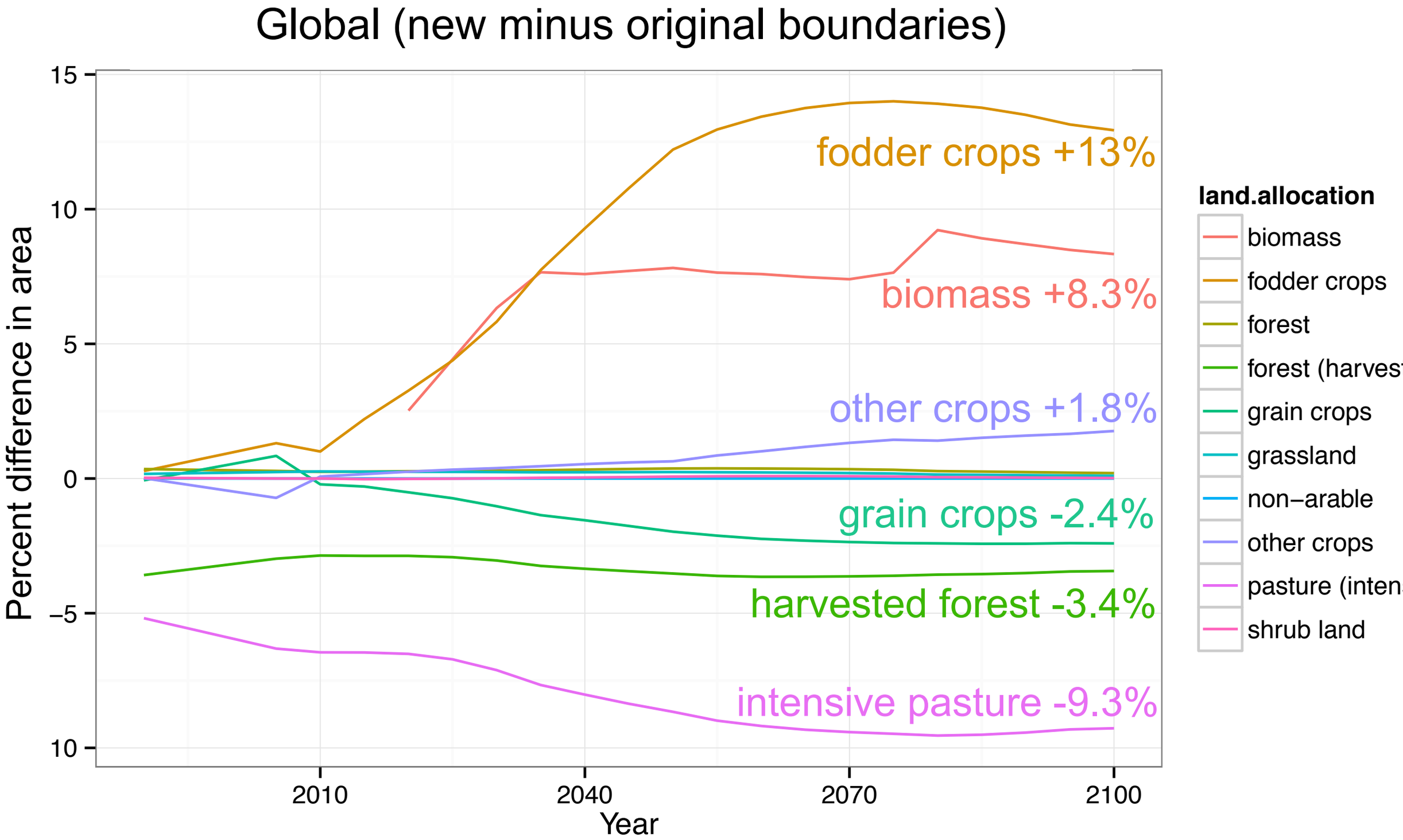


Production (t)

Global distributions of forest land rent, by GTAP land unit



Boundaries affect projected land use/cover



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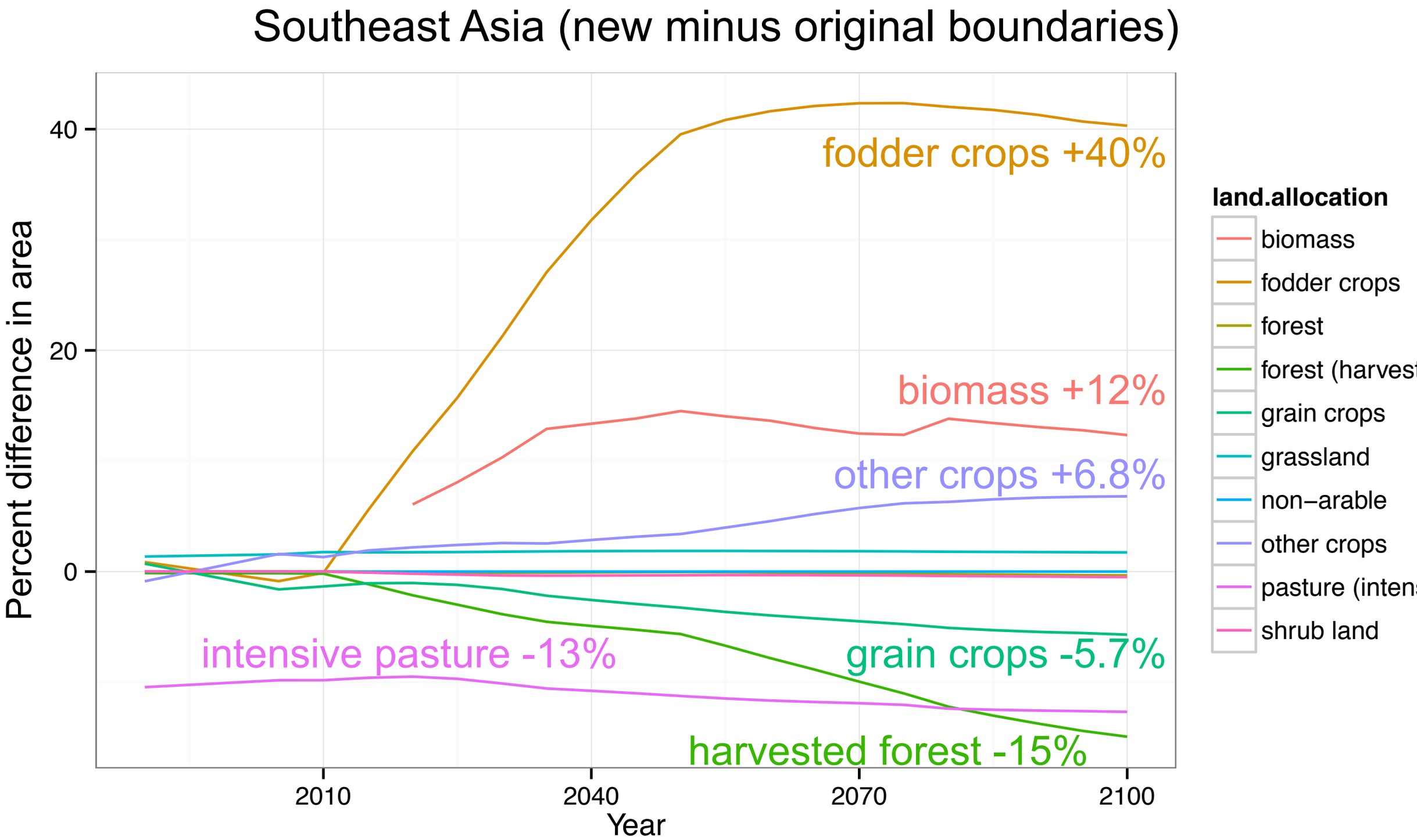
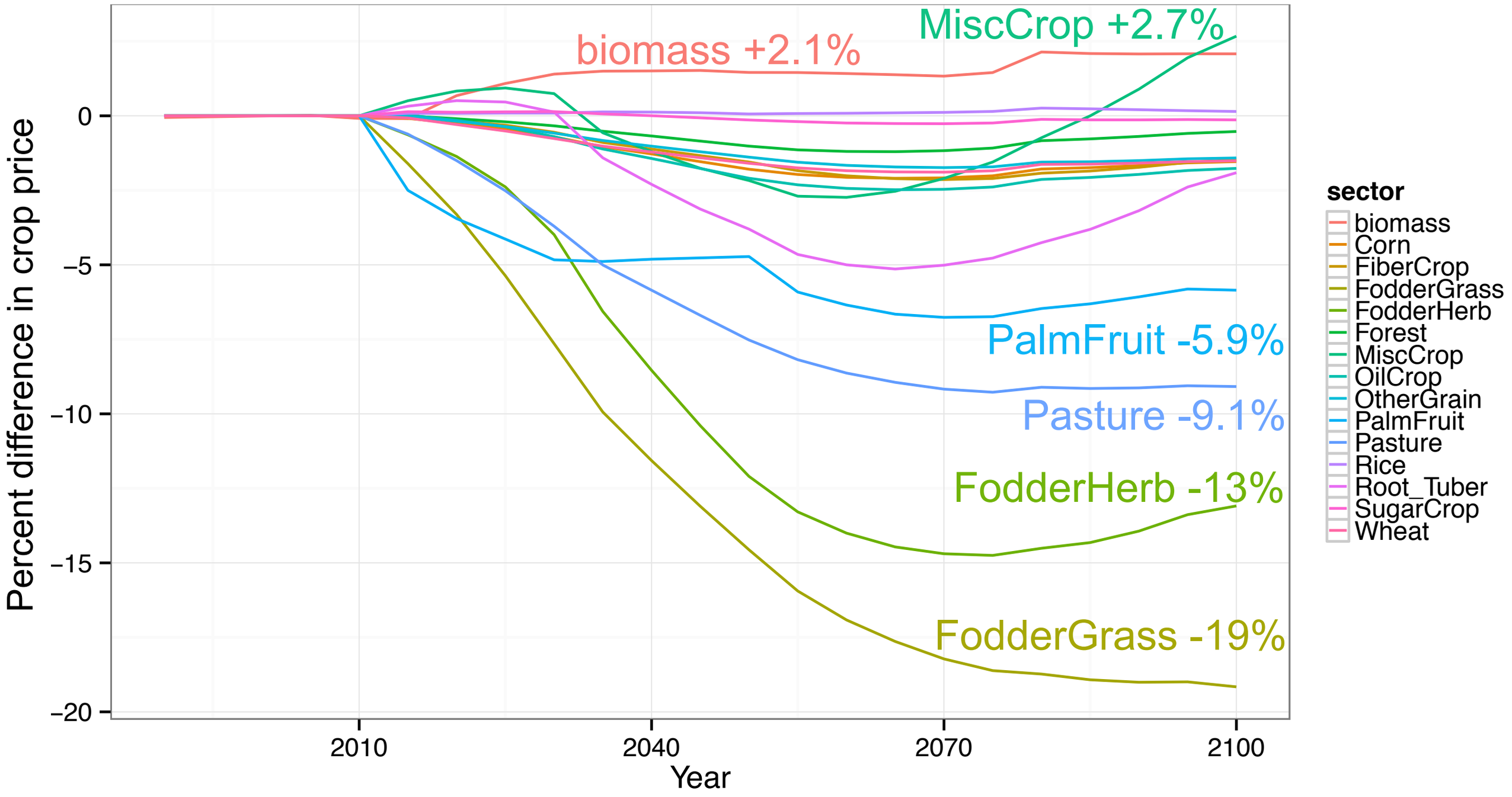
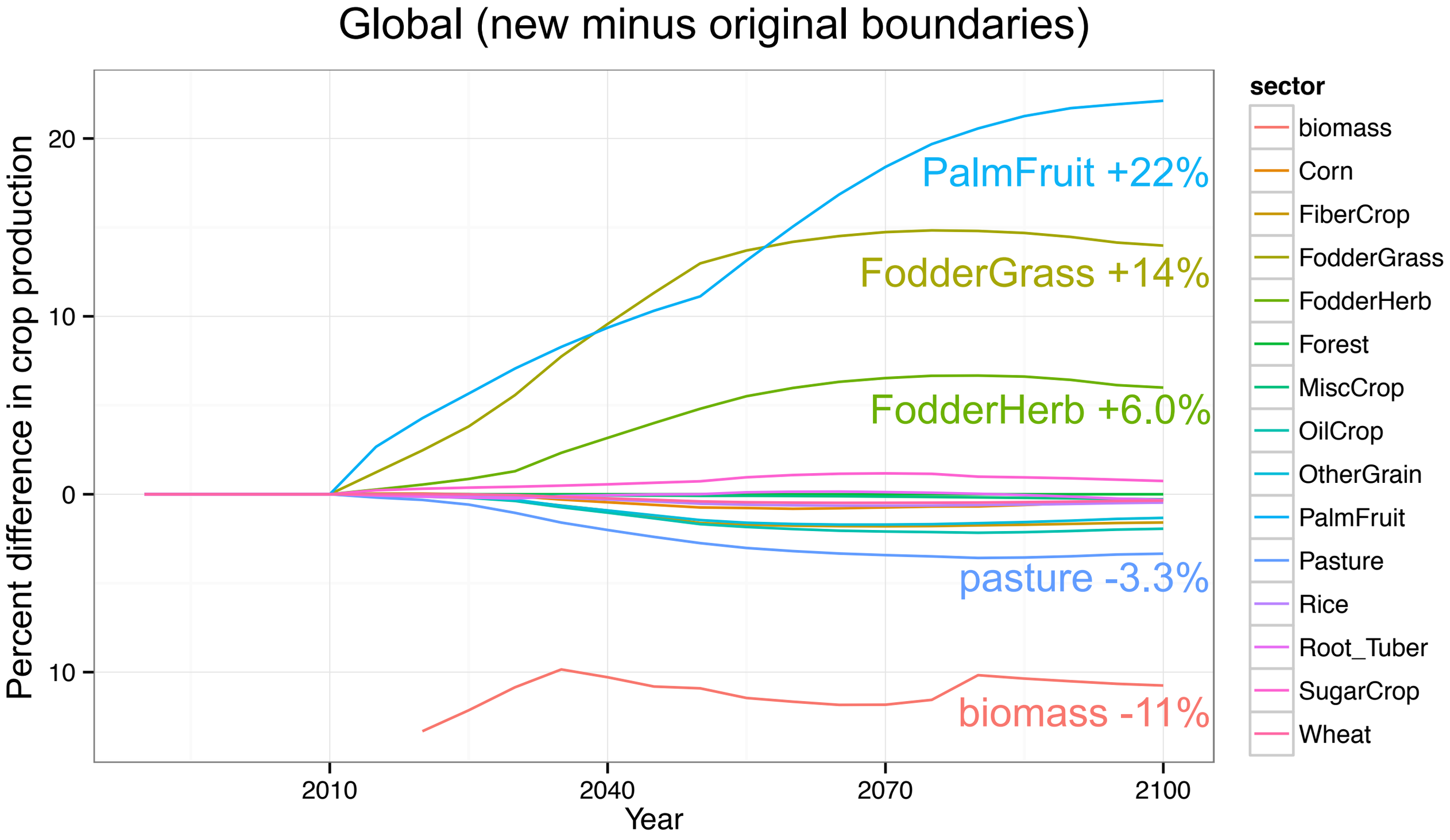


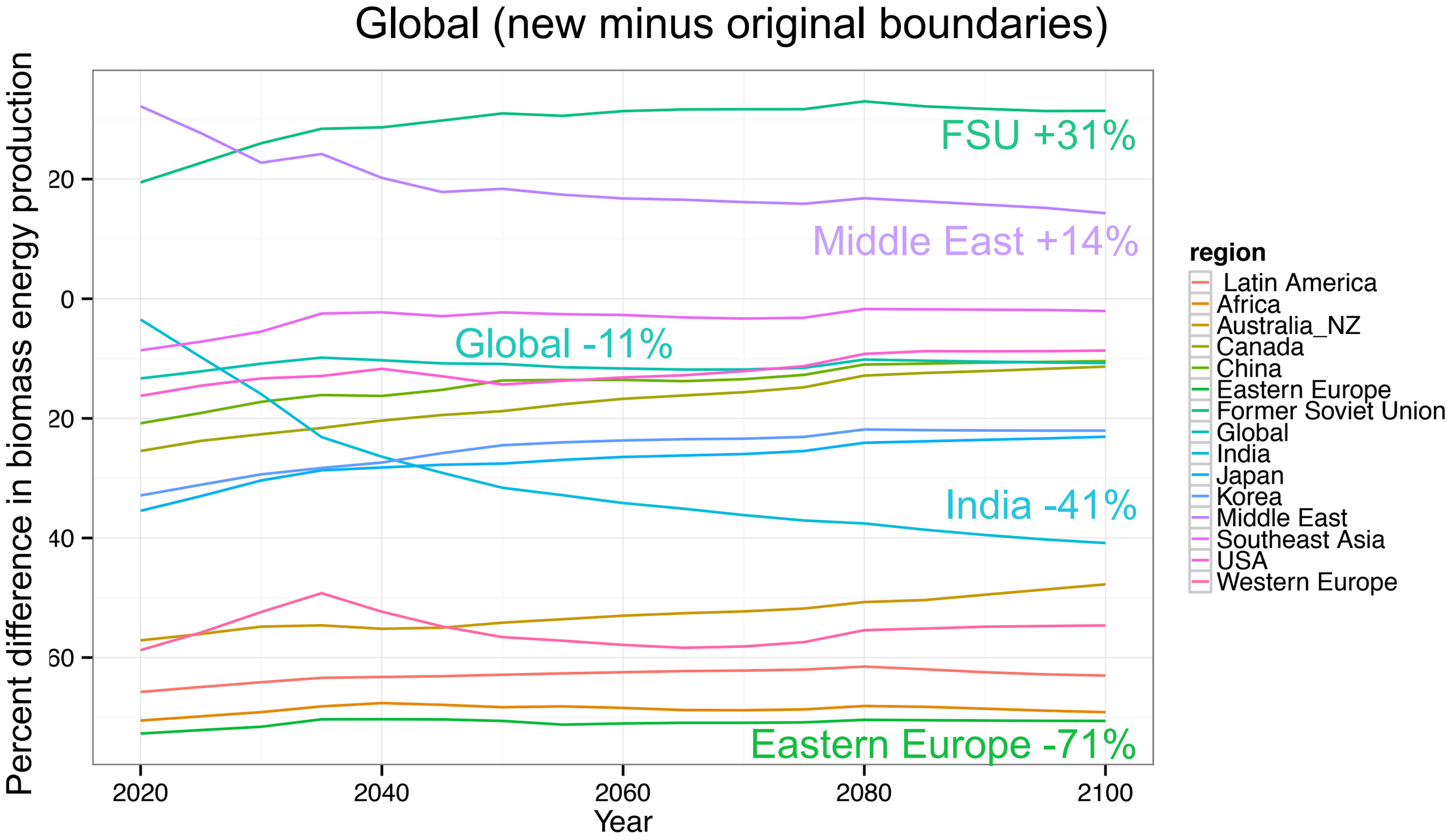
Boundaries affect crop price



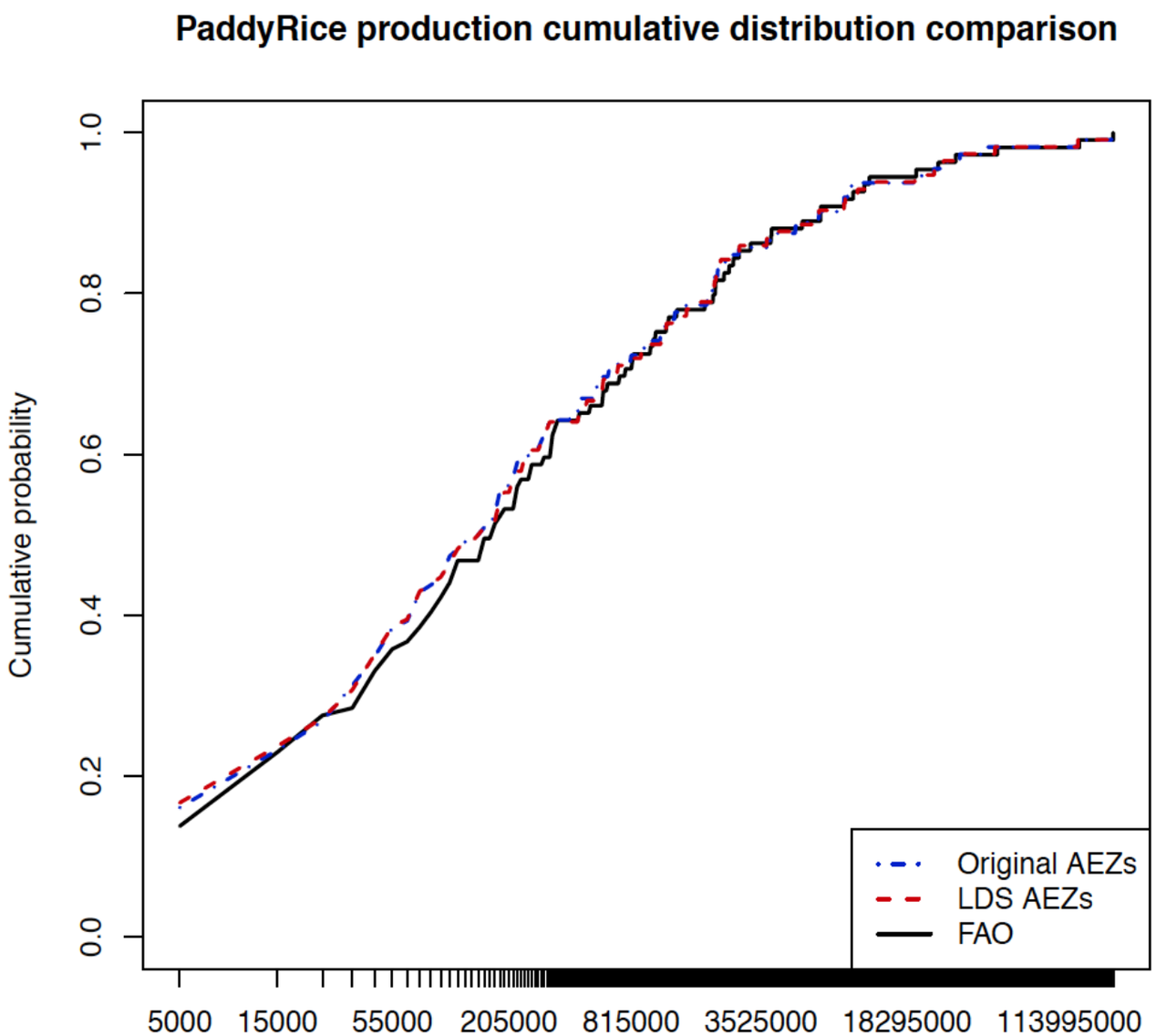
Boundaries affect projected crop production



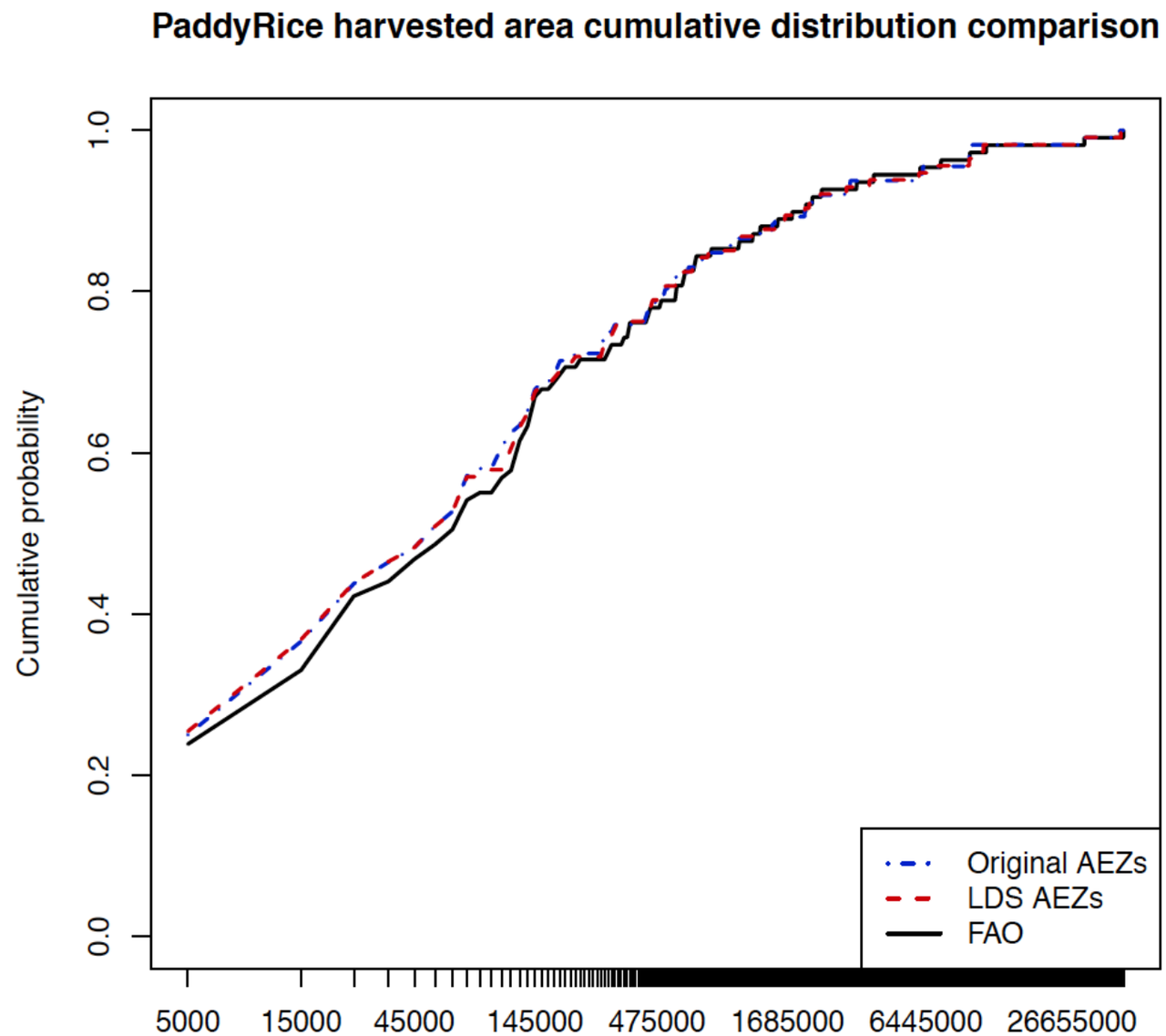
Boundaries affect biomass energy production



Validation (water basins): global distributions of Paddy Rice, by country



Production (t)



Harvested area (ha)

Summary

- AEZ-based land units do not consistently meet homogeneity assumption for land use projection
  - Negative implications for averaging climate impacts for feedback studies

- Boundary and initial conditions are different between the original and new land units

- Substantial regional and global differences in projected land use/cover, crop production/prices, bioenergy production/use

- Spatial uncertainty and feedbacks: climate, impact, and land resources
  - Geography matters!

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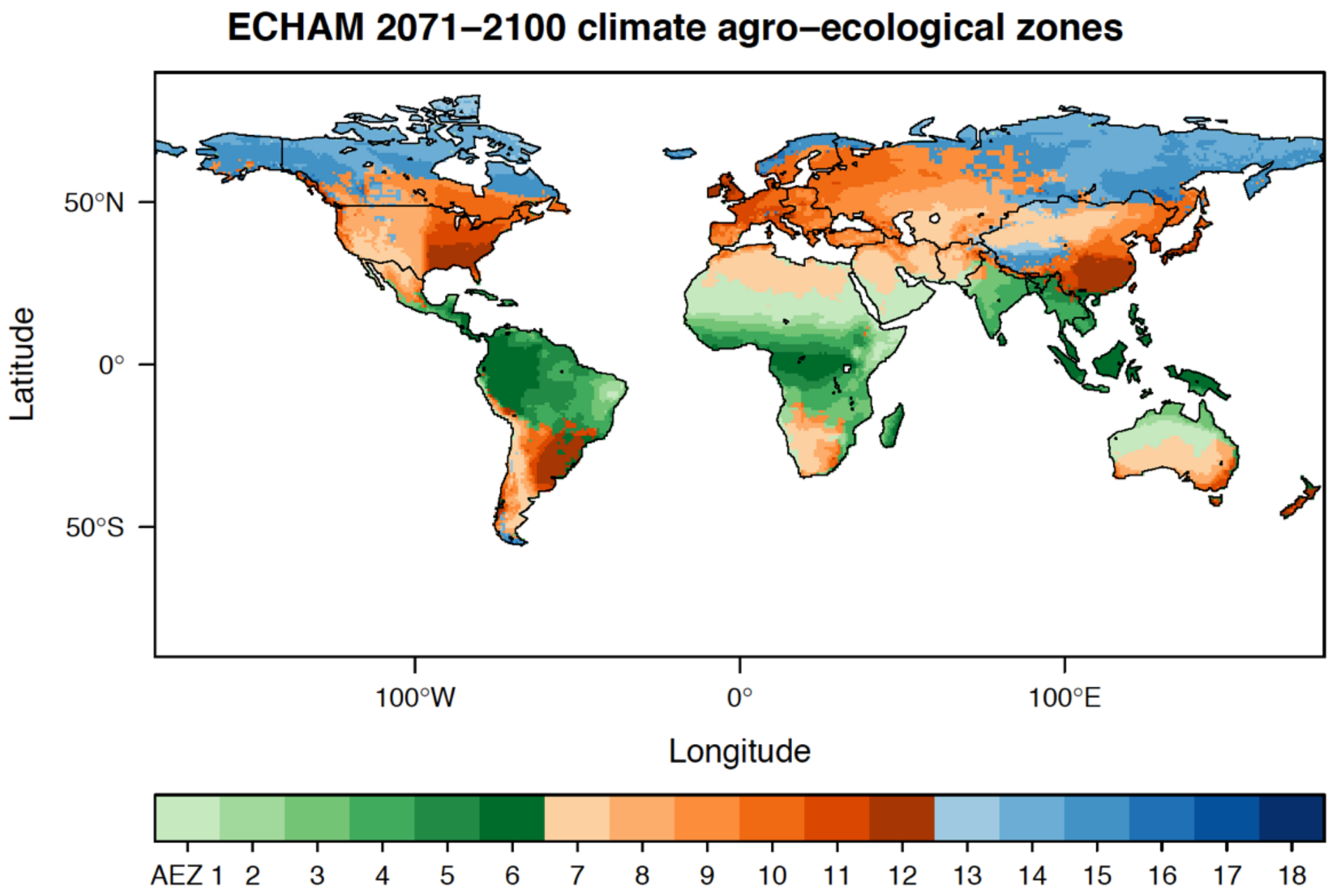
Opportunities

- Spatially align GCAM water and land modules
  - Energy-Water-Land Nexus questions

- Integrated land use and land cover data analysis and projection

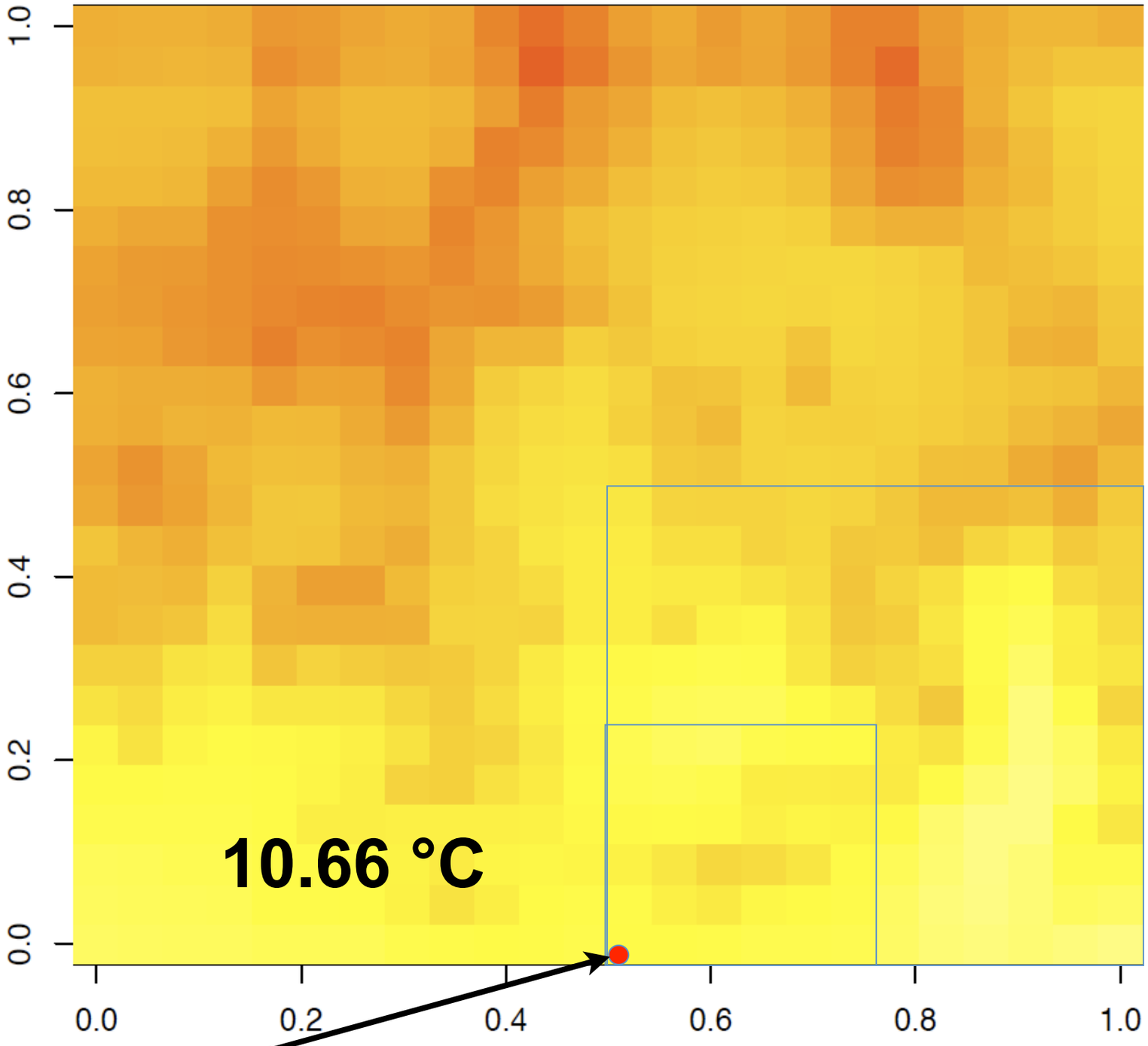
- Facilitate spatial data consistency across global models

Questions?

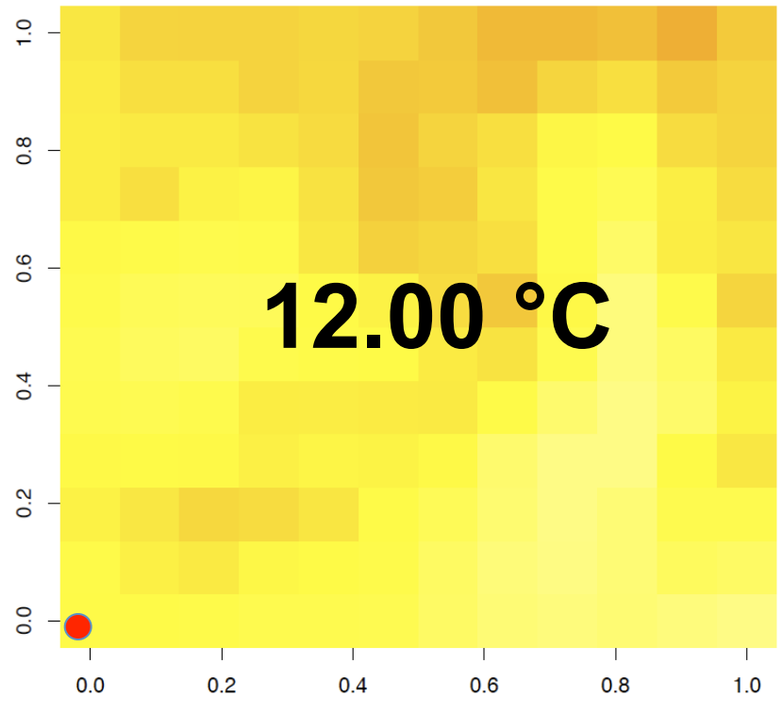


This work is supported by the Director, Office of Science, Office of Biological and Environmental Research of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 as part of their Integrated Assessment Research Program.

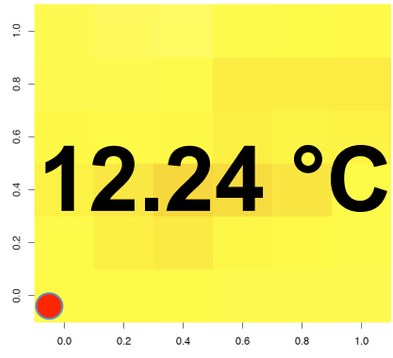
Different boundaries give different "local" estimates



1 degree (~100 km) per side



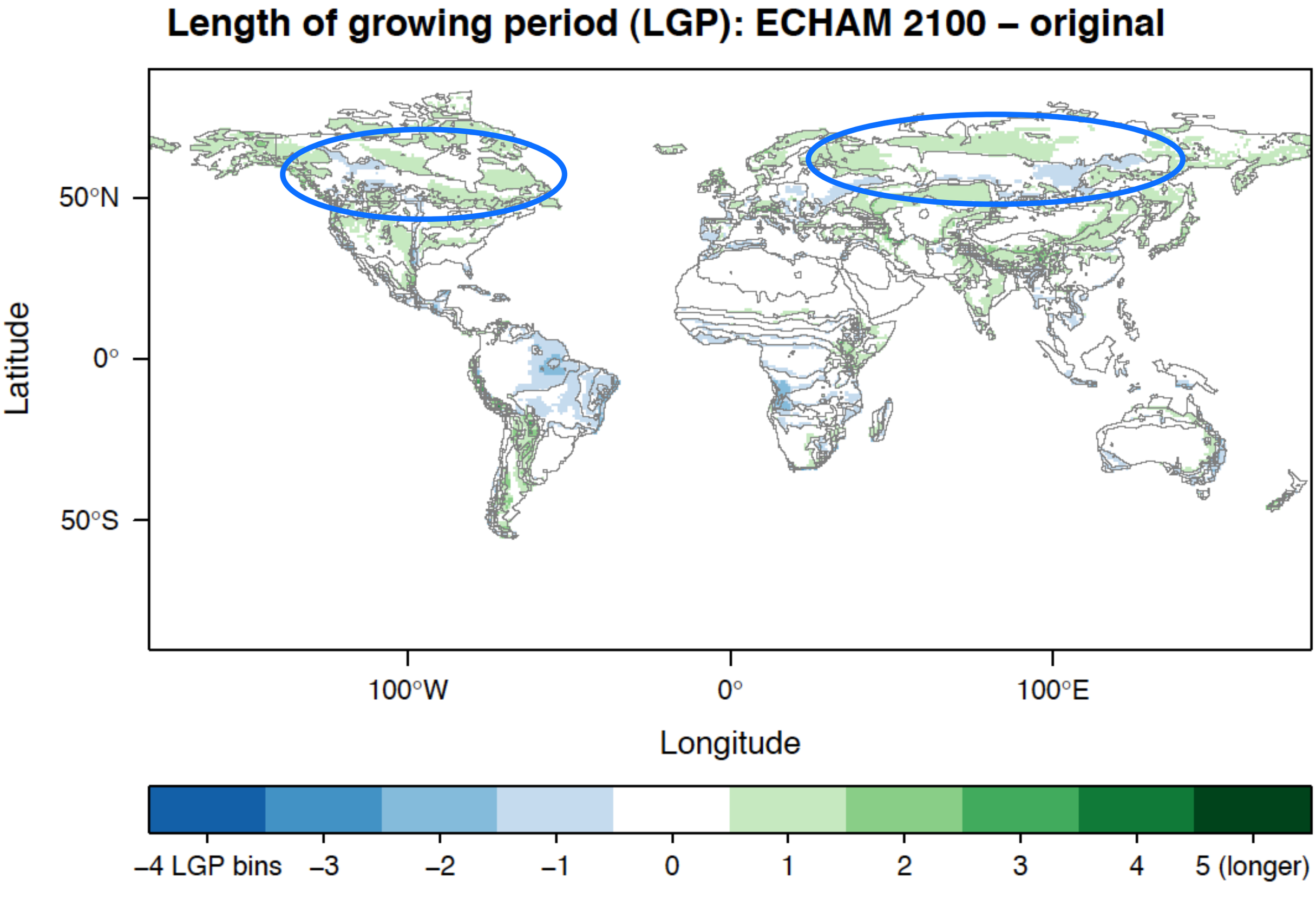
0.5 degree (~50 km) per side



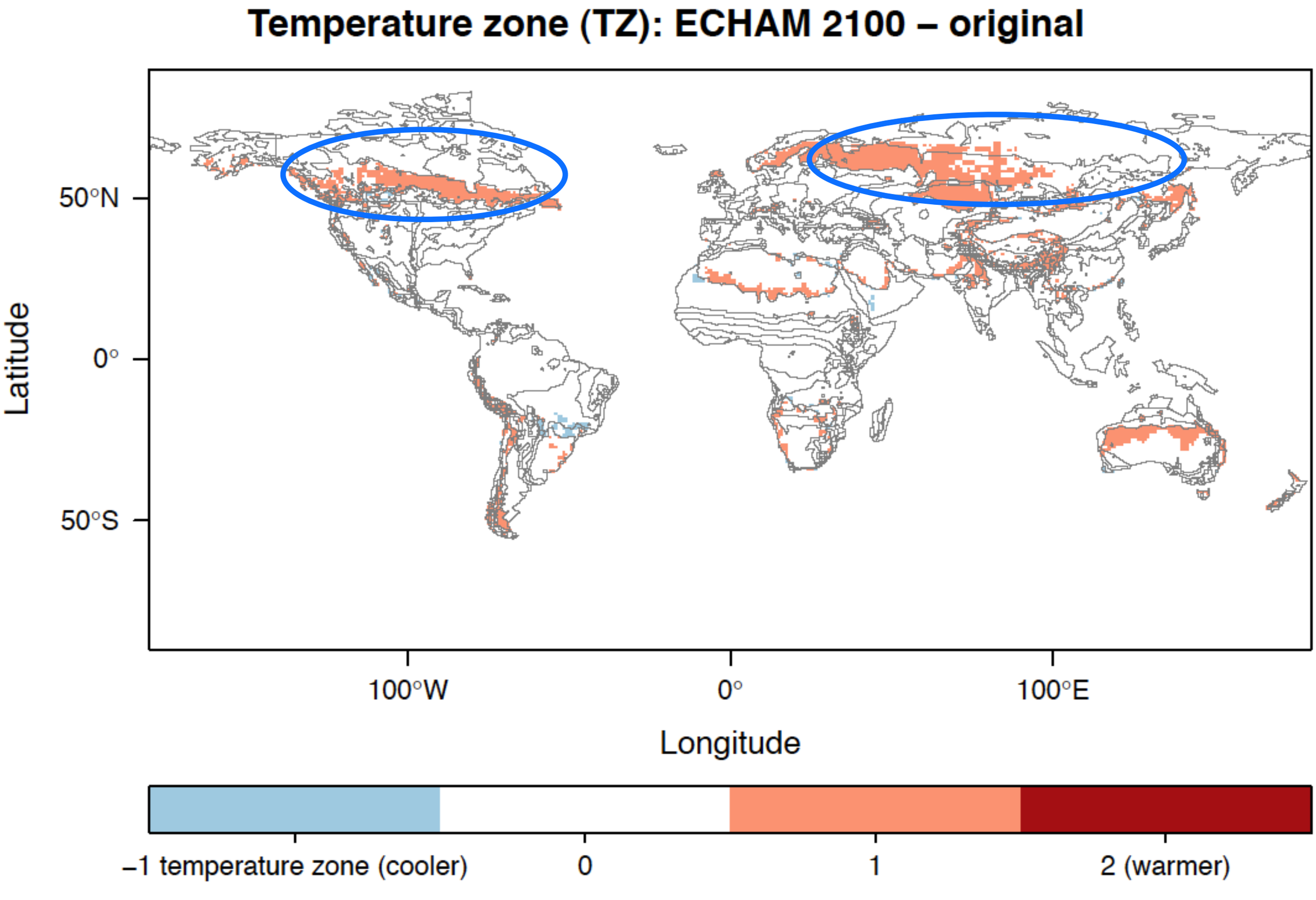
0.25 degree (~25 km) per side

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

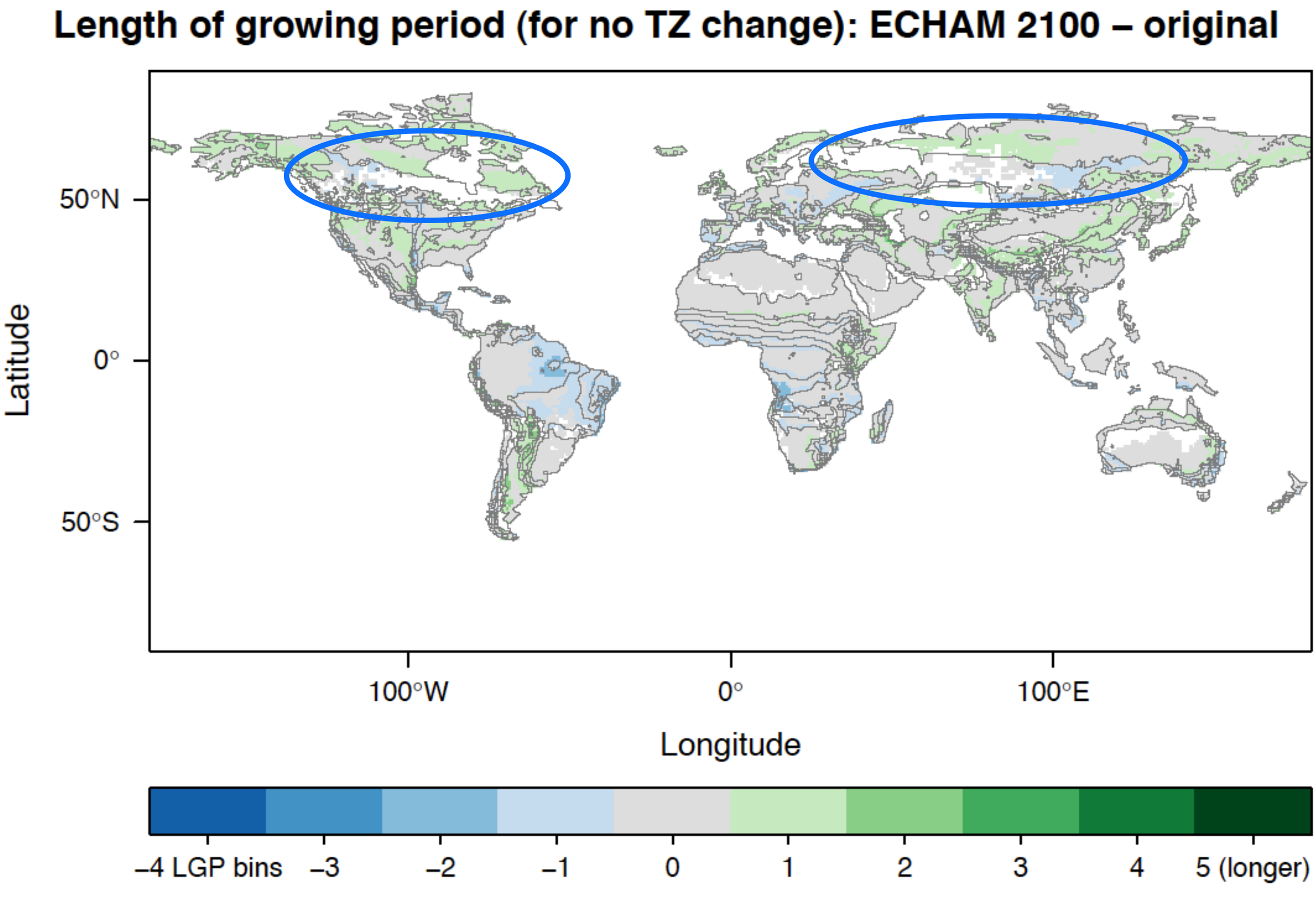
Current land units become heterogeneous



Current AEZs become heterogeneous



Current AEZs become heterogeneous



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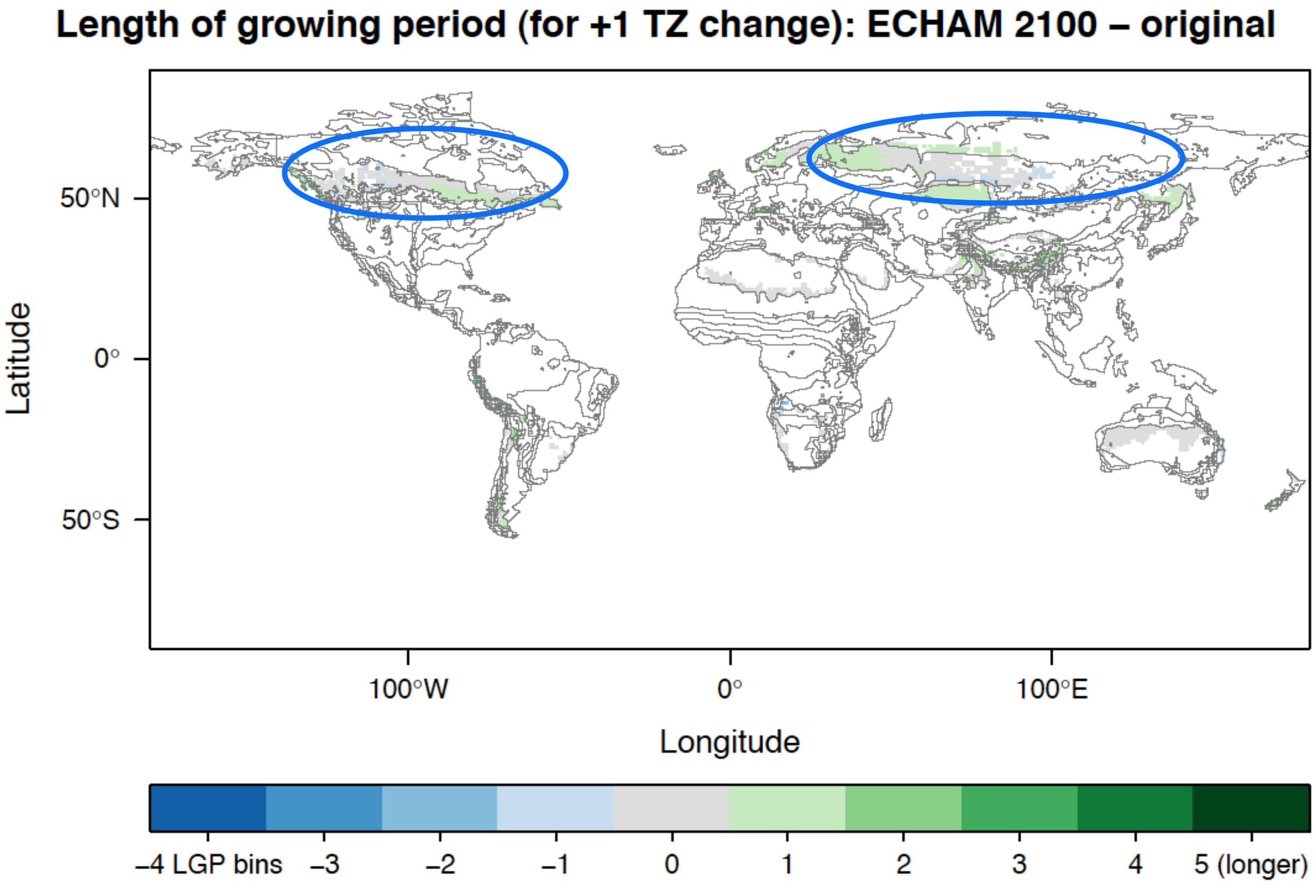

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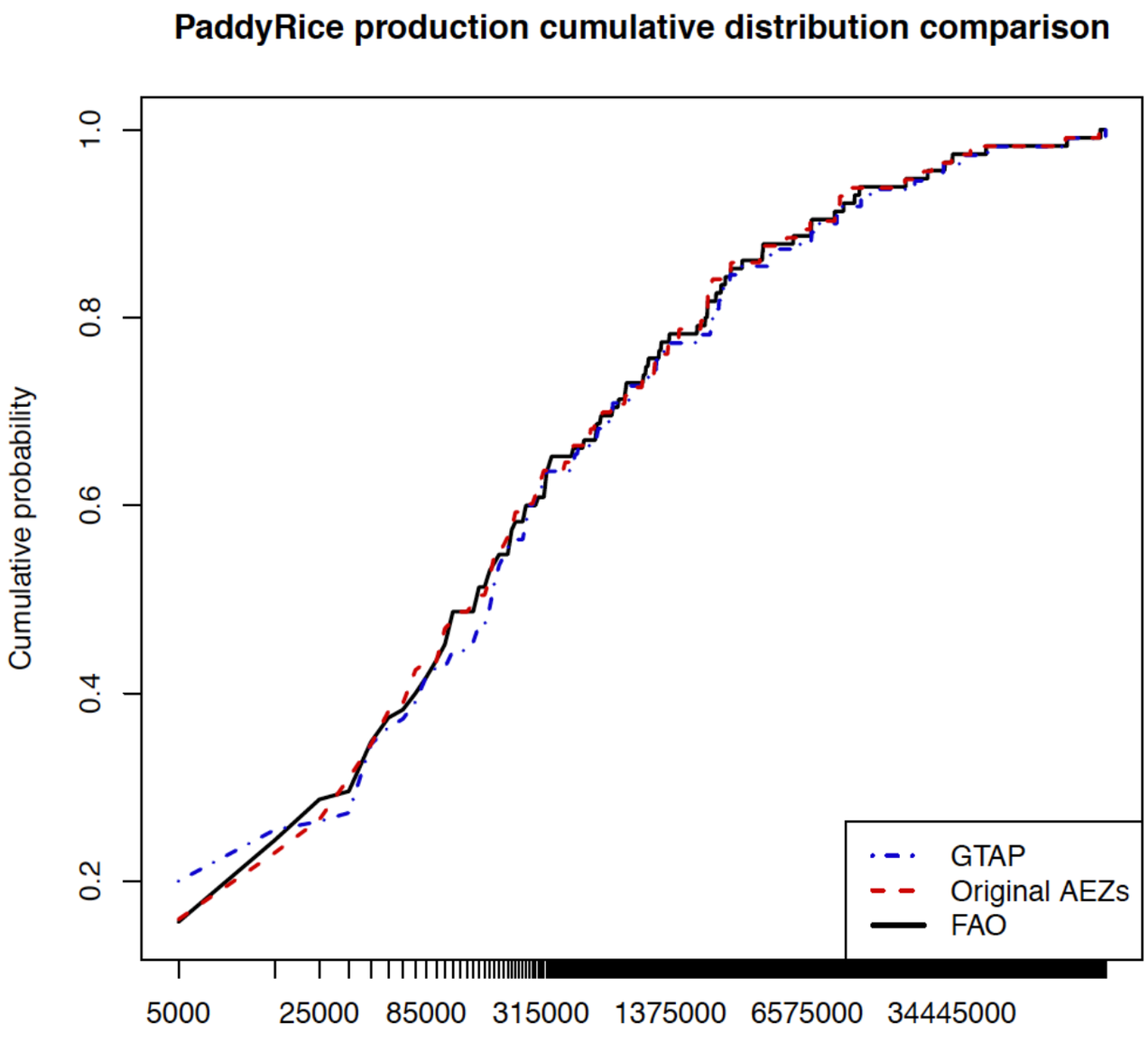
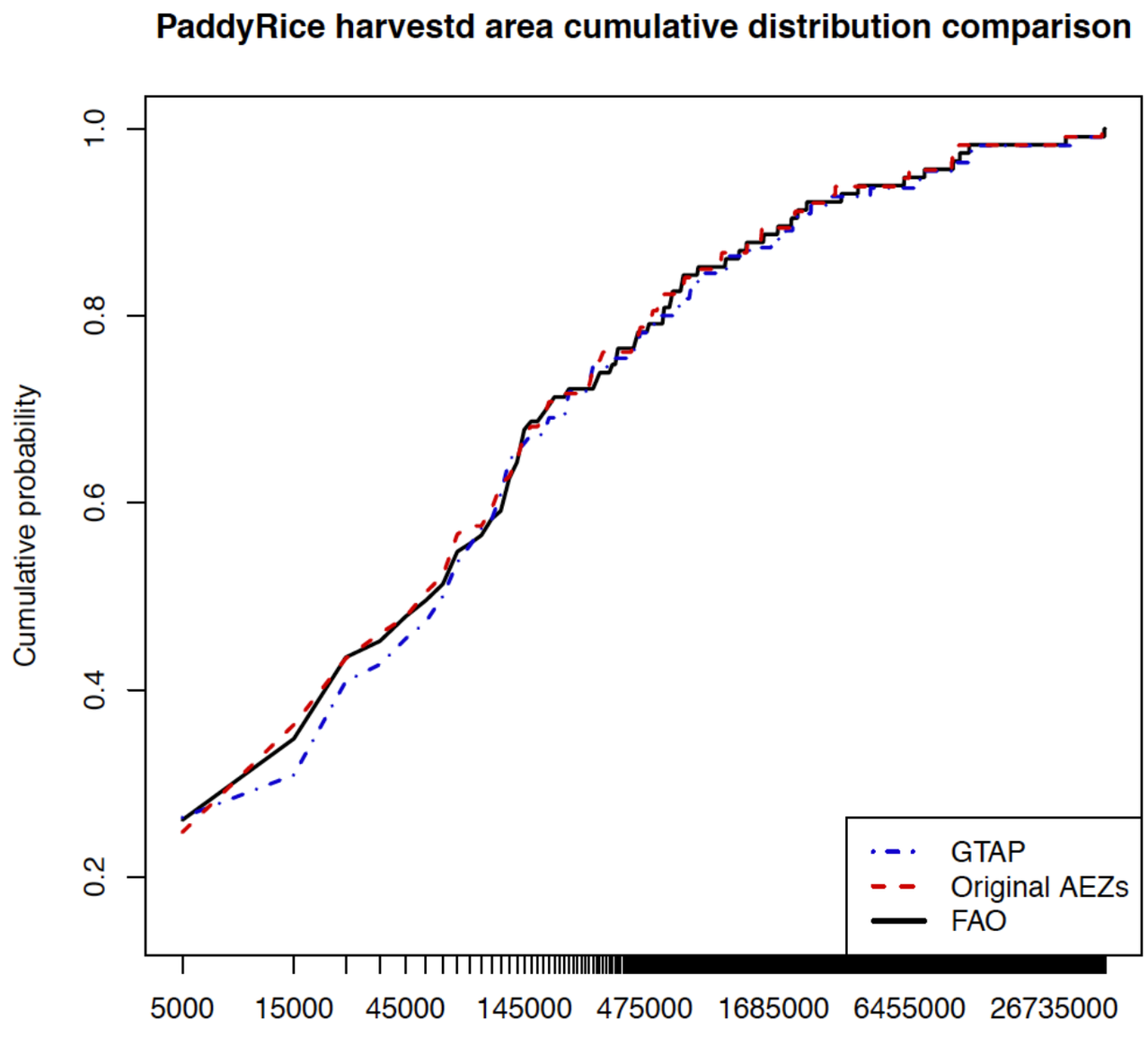


Production (t)



Harvested area (ha)

Distribution differences for Paddy Rice, by country