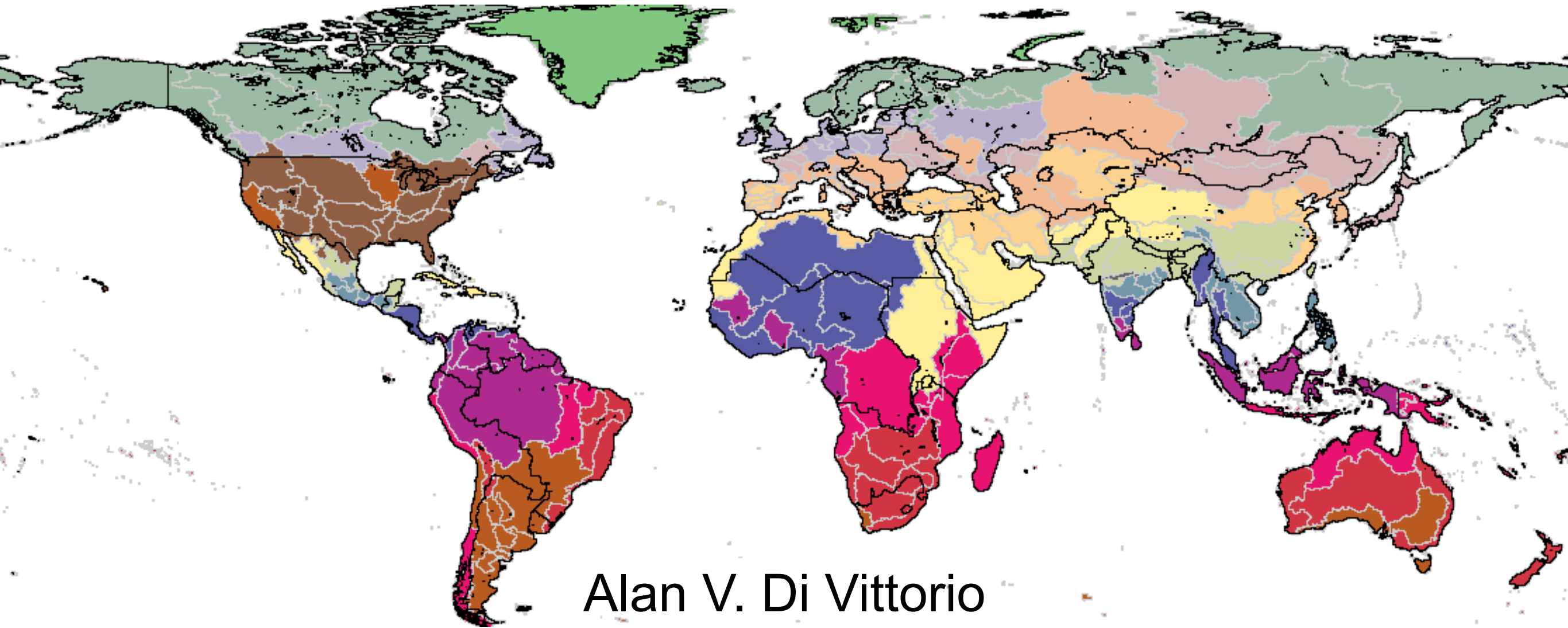


Moirai v3: a land data system for providing inputs to global models



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IA/GCAM annual meeting
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**EARTH &
ENVIRONMENTAL
SCIENCES**

CLIMATE & CARBON SCIENCES PROGRAM



Overview

- Land use and land cover data
- Why are these data important?
- Moirai: a system for spatial reconciliation of land use and land cover data

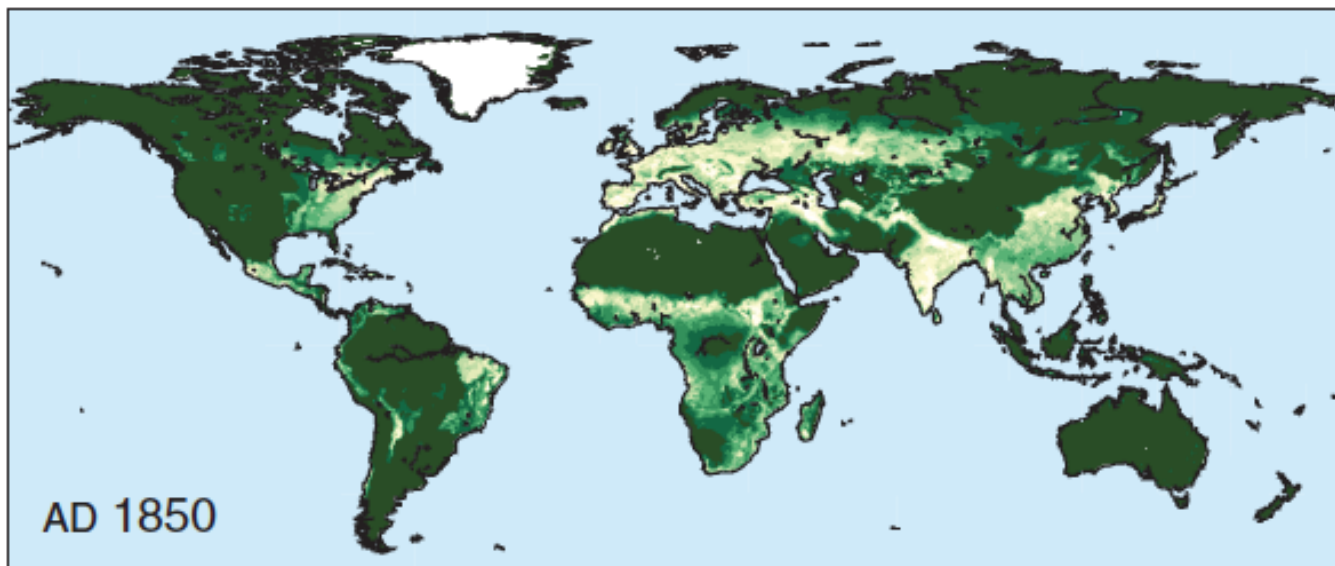
Global historical land use data

- Not much to choose from, and they have overlapping sources

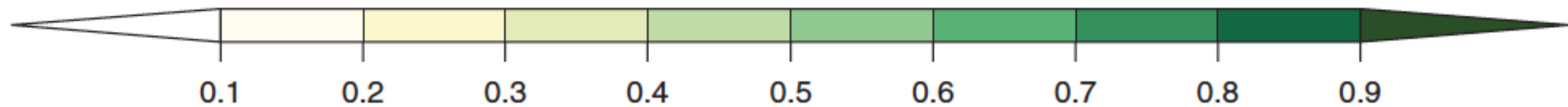
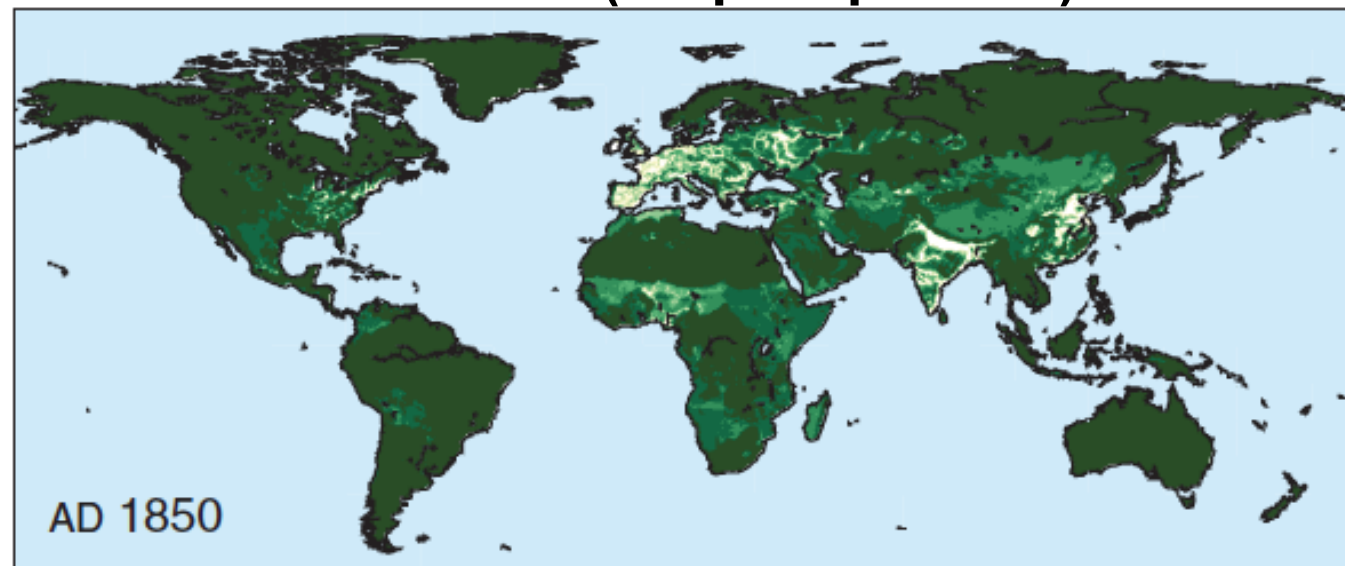
Data	Coverage	Source
KK10, land use	8000BP - 1850AD, 5 arcmin	Kaplan et al., 2011
SAGE cropland	1700-1992, half-degree	Ramankutty and Foley, 1999
Houghton, cropland and pasture	1850-2000, global	Houghton, 2010
HYDE 3.2, multiple land uses	10000BC - 2016, 5 arcmin	Klein-Goldewijk et al., 2017
Land Use Harmonization	850-2100, quarter-degree	Hurtt et al., in prep

Initial conditions matter

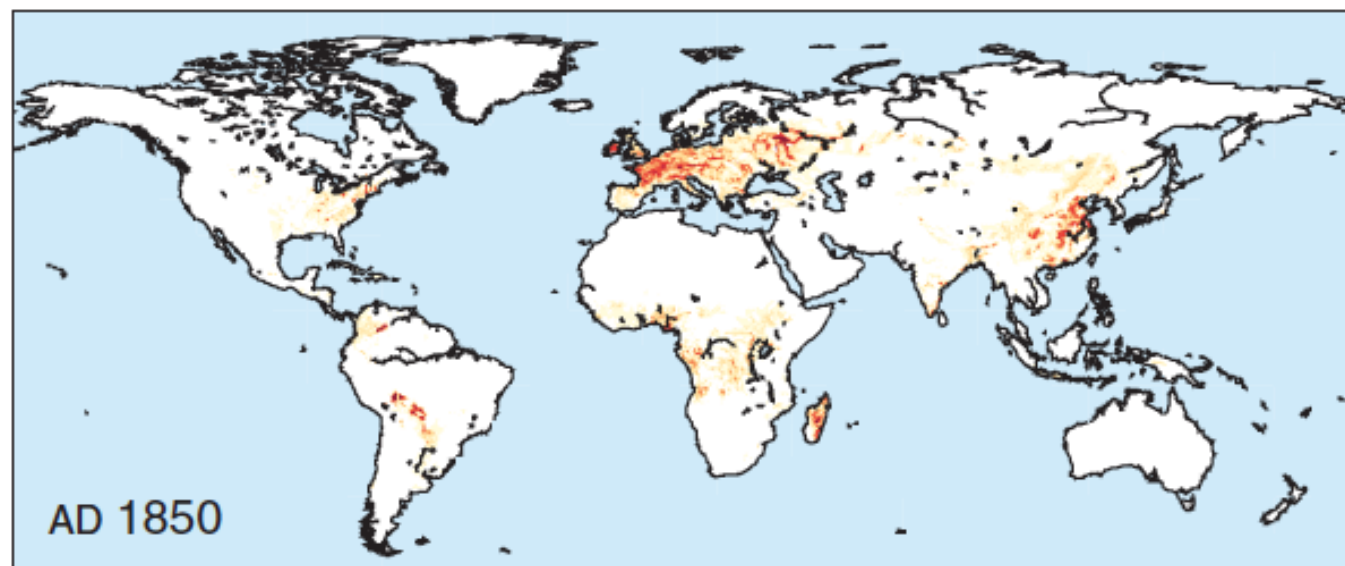
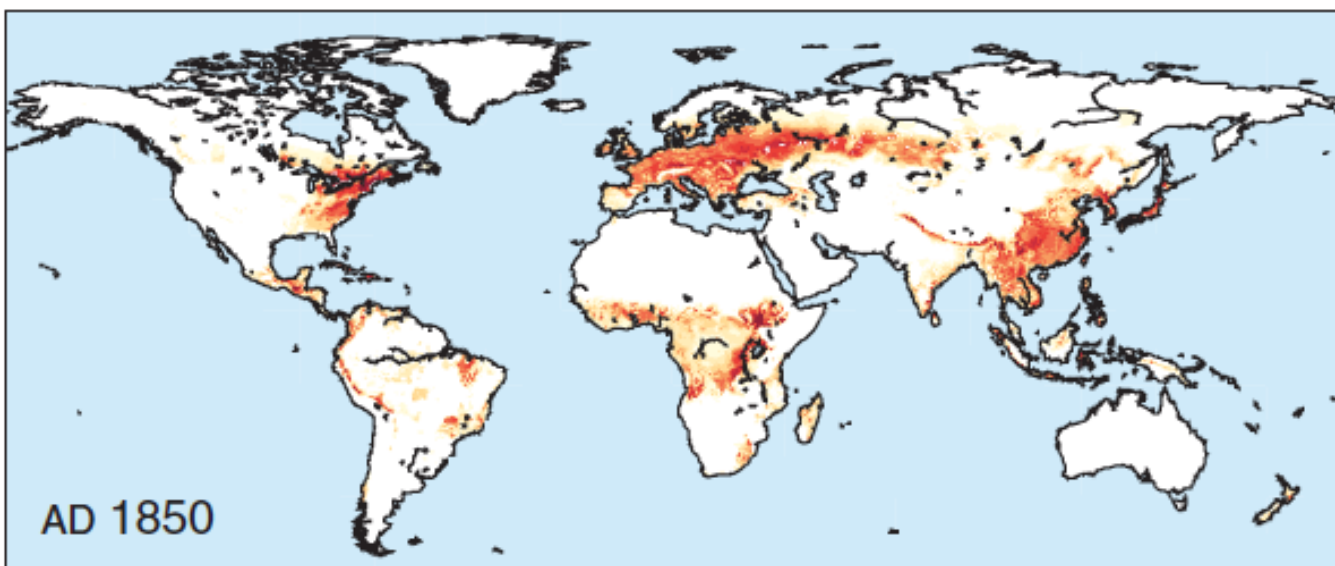
KK10 land use



HYDE 3.1 (crops + pasture)

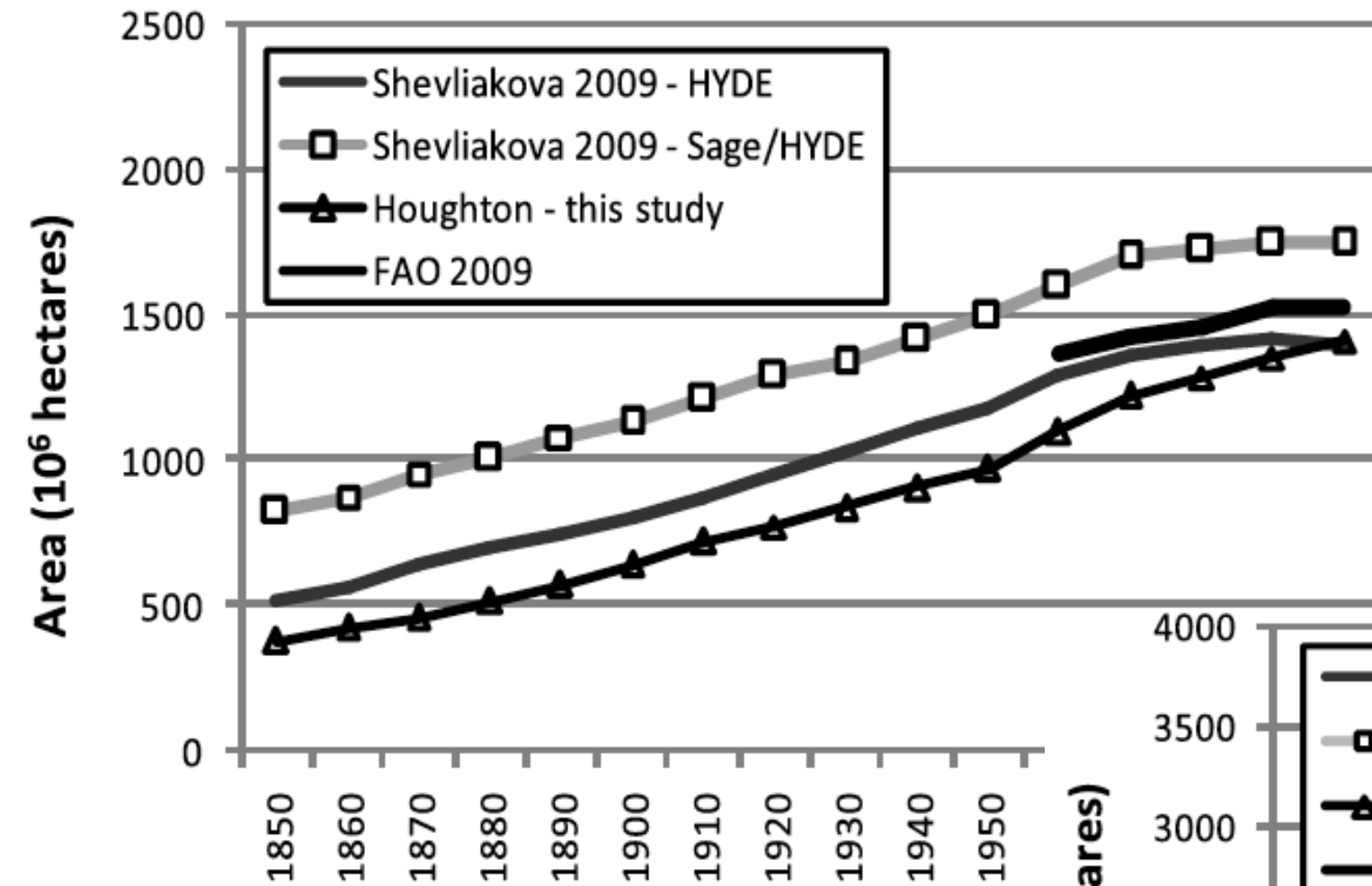


Fraction of gridcell under natural vegetation

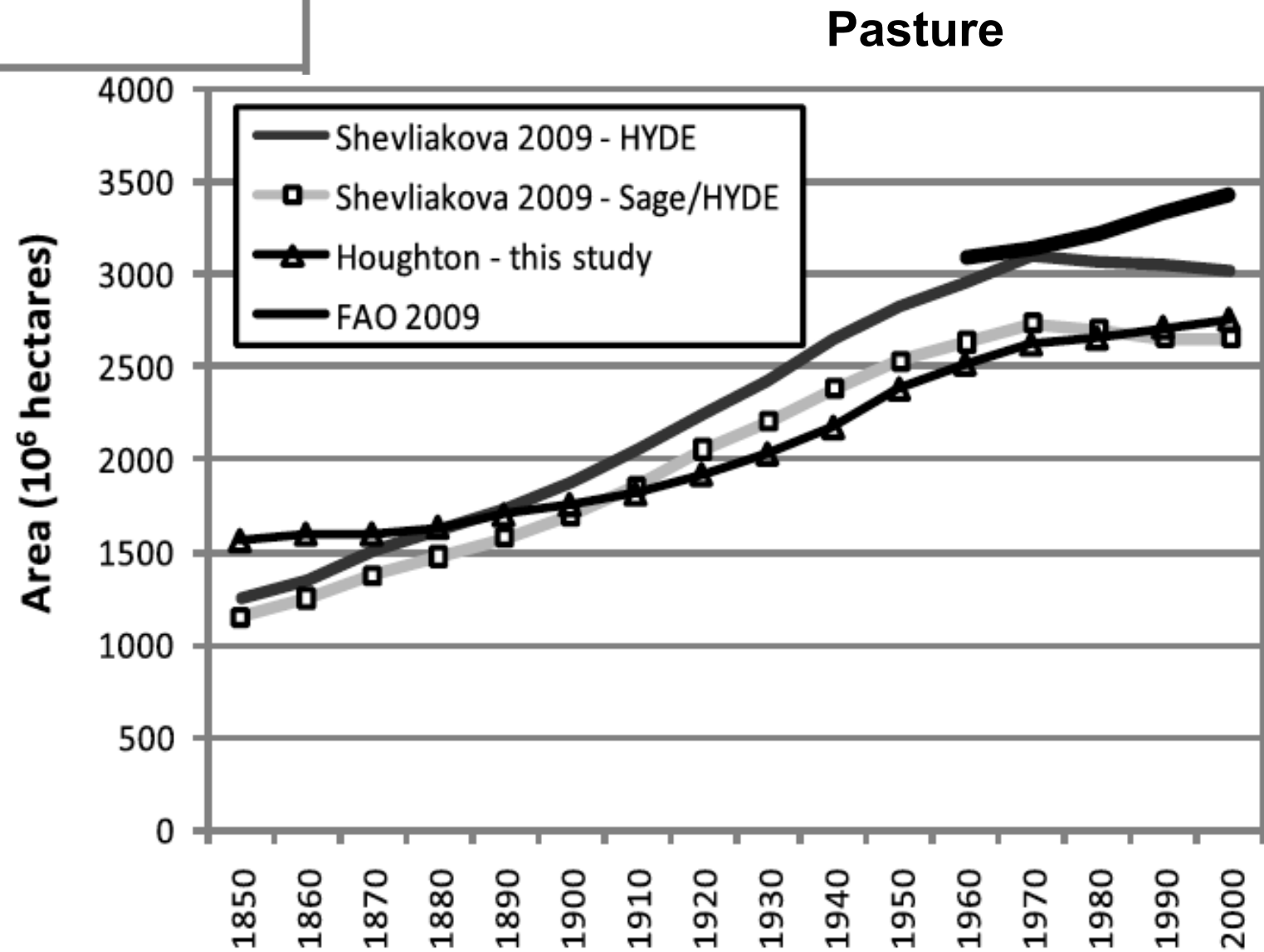


Net carbon loss (kg m^{-2}) = natural vegetation – ALCC scenario

Considerable uncertainty



Cropland



Pasture

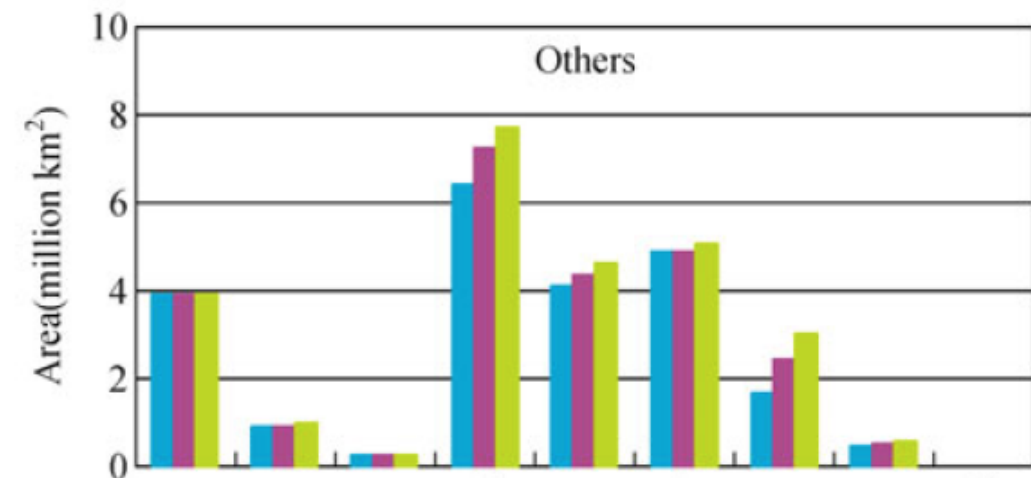
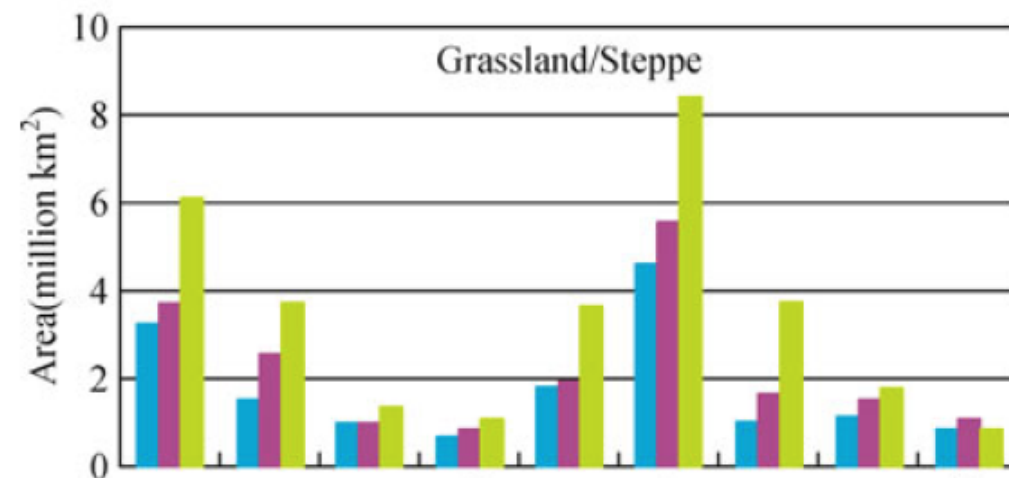
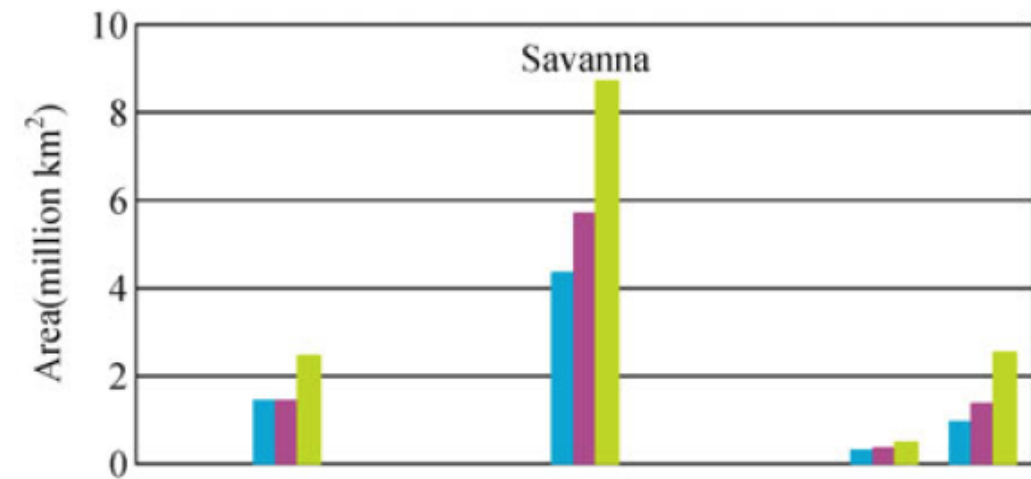
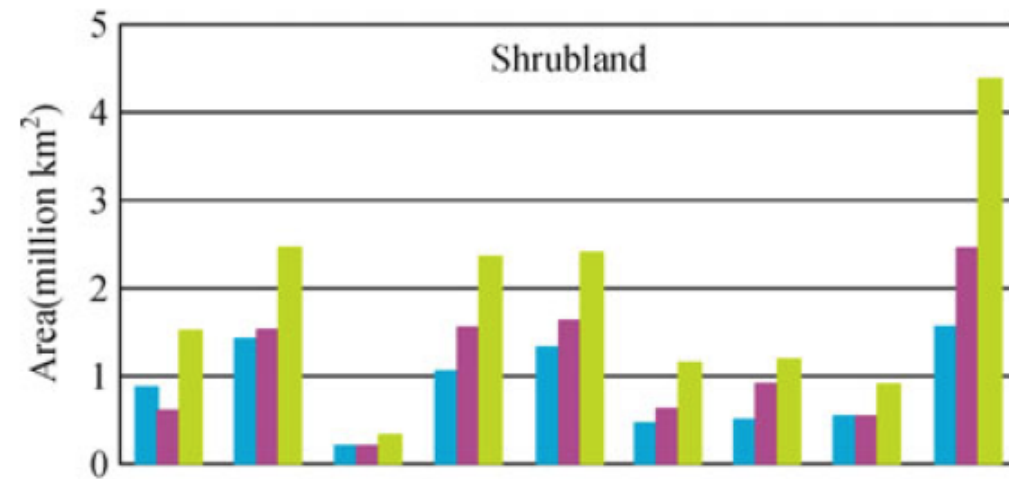
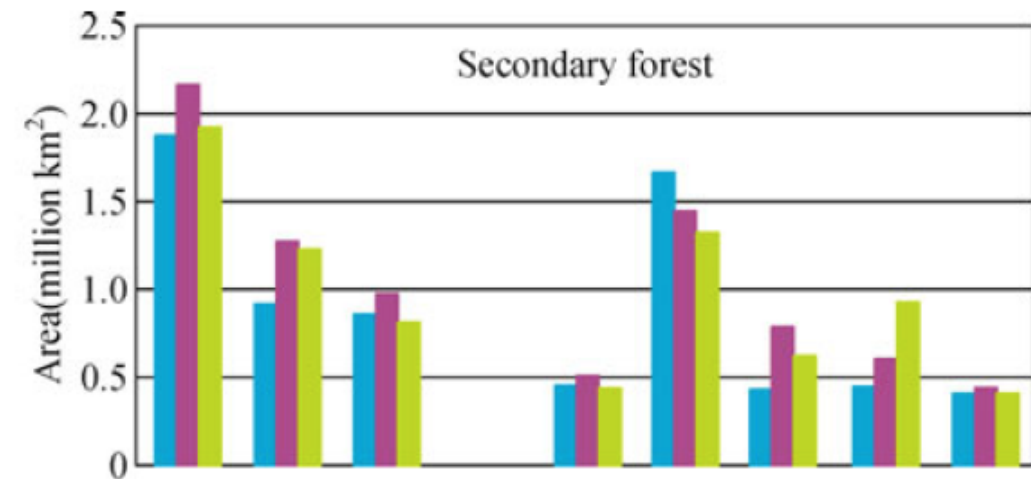
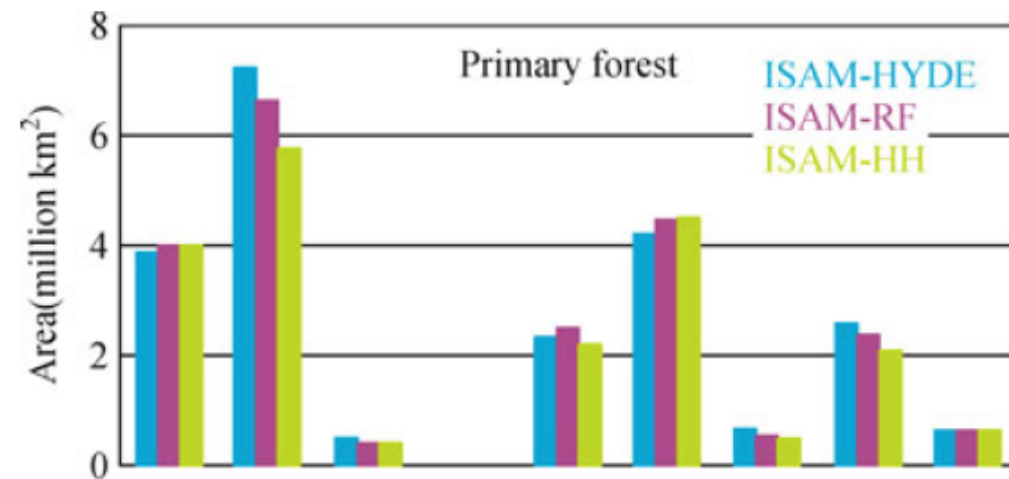
Houghton, 2010

Global historical land use and cover data

- Usually developed as needed from **unique land cover sources** and not made publicly available

Examples	Coverage	Source
MPI-ESM/JS-BACH	800-1992, half-degree	Pongratz et al., 2008
ISAM land model	1765-2005, half-degree	Meiyappan and Jain, 2012
LCC uncertainties in CESM/iESM	1850-2005, half-degree	Di Vittorio et al., 2018
Carbon and LULCC uncertainties	1850 - 1990, half-degree	Peng et al., 2017

Considerable uncertainty in land cover

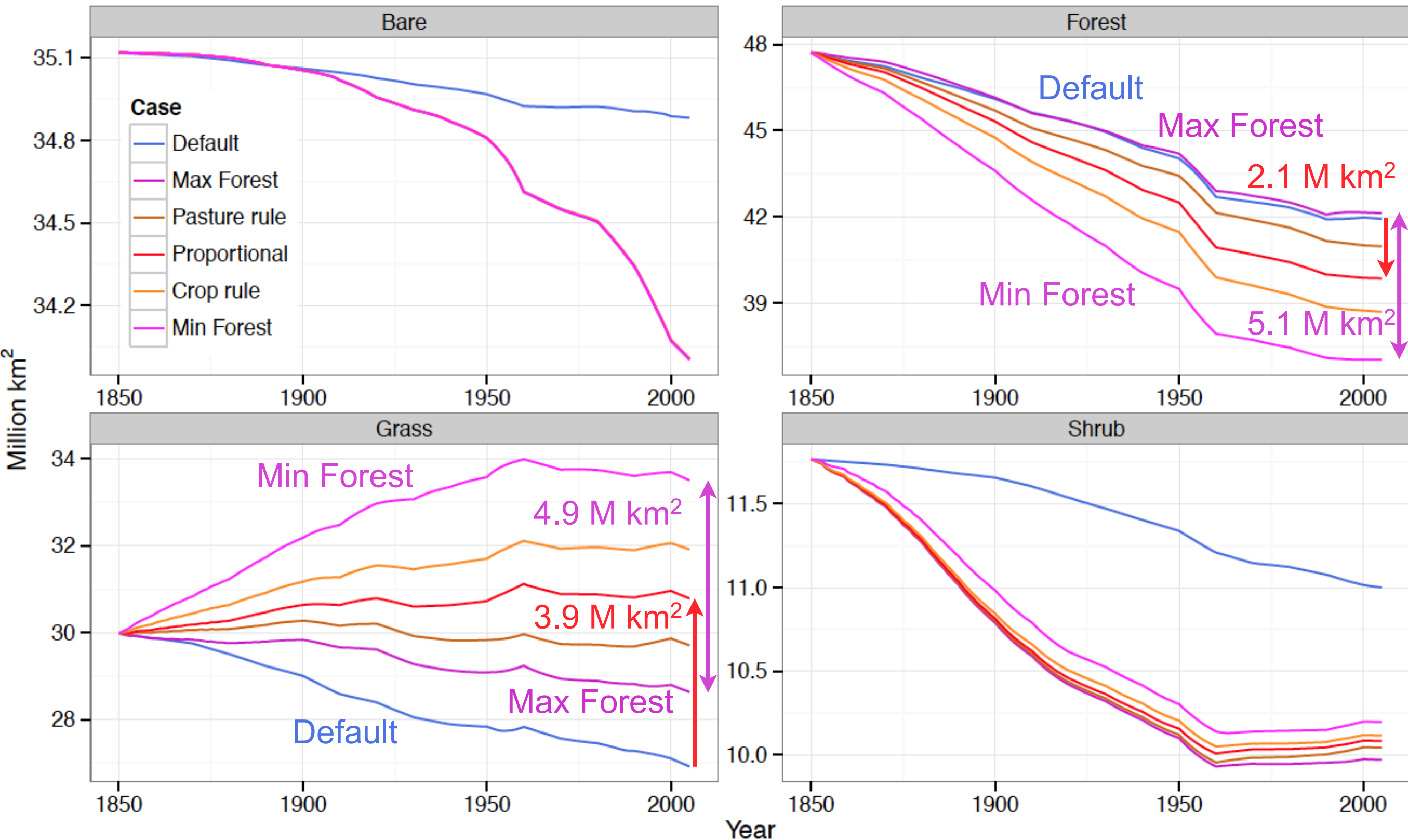


2005

Considerable uncertainty in land cover

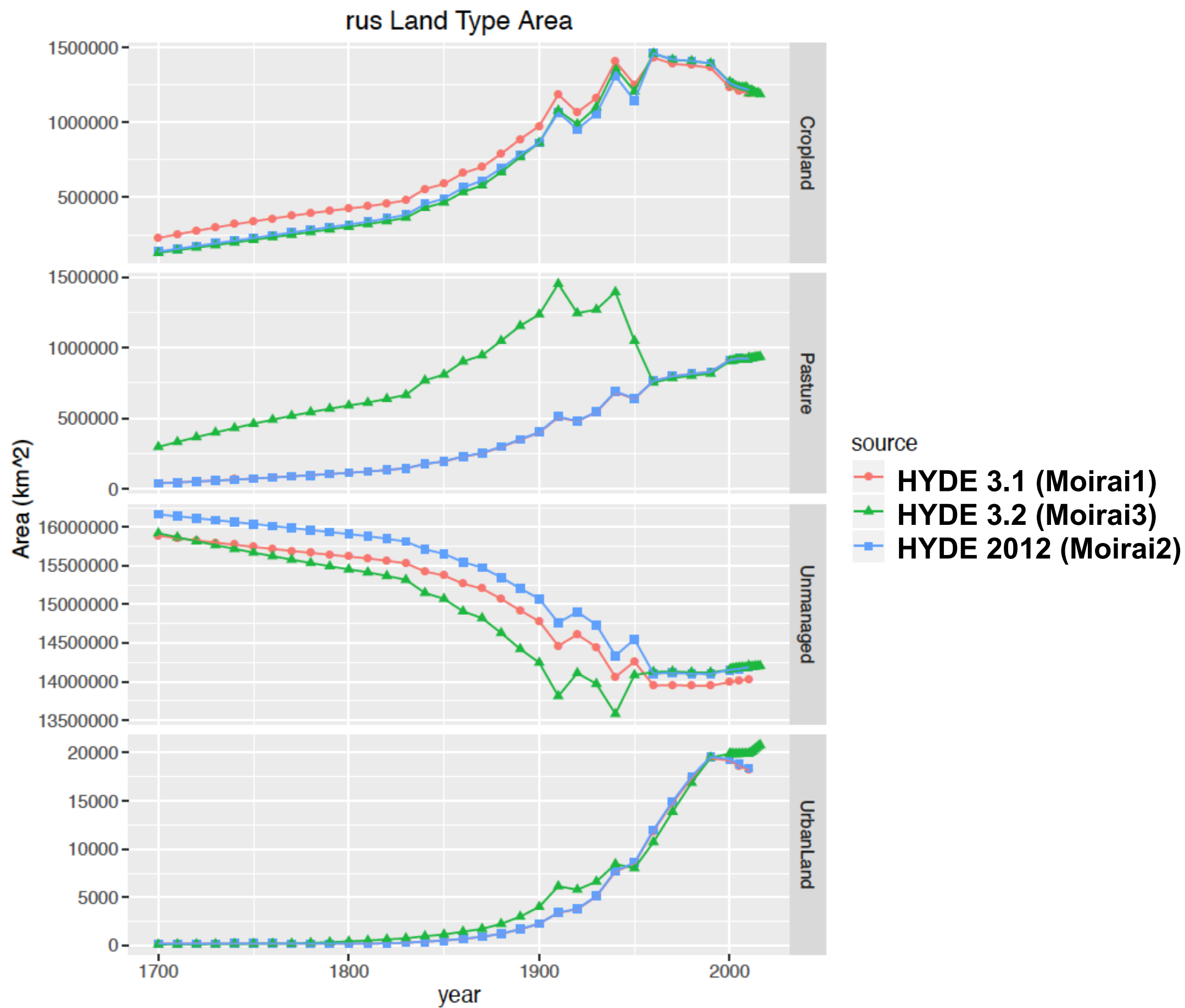
RCP4.5, CMIP5 LUH, CESM

Global area



Di Vittorio et al., 2018

Land use/cover uncertainty in Moirai



Why does this matter?

- Each land representation is a unique Earth that yields unique analysis and modeling results
- Both initial conditions and trajectories significantly affect economic, carbon, and climate projections
- Problematic when used for scenario-based Earth system modeling or multi-model comparisons

Moirai data inputs

Spatially explicit data

- VMAP0 countries (234)
- User Geographic units
- Land cover data
- SAGE data:
 - 175 crop yield, area
 - cropland extent
 - potential vegetation
 - land area
- MIRCA2000 irrigated area
- Crop water footprint
- HYDE3.2 data:
 - agriculture and urban
 - land area
- Original AEZ boundaries
- Protected area

Tabular data

- GTAP regions (87)
- FAO countries (235)
- GTAP land rent
- GTAP use sector list
- FAO crop list for mapping
- FAO crop production
- FAO producer prices
- FAO crop yield, area
 - for recalibration
- GCAM country to region
- Land use/cover mapping
- Potential vegetation carbon density
 - vegetation and soil
- USD-year conversion

Workflow for crop and land rent outputs

Data Reconciliation!

Optional: recalibrate crop data to FAO data year (1995-2014)

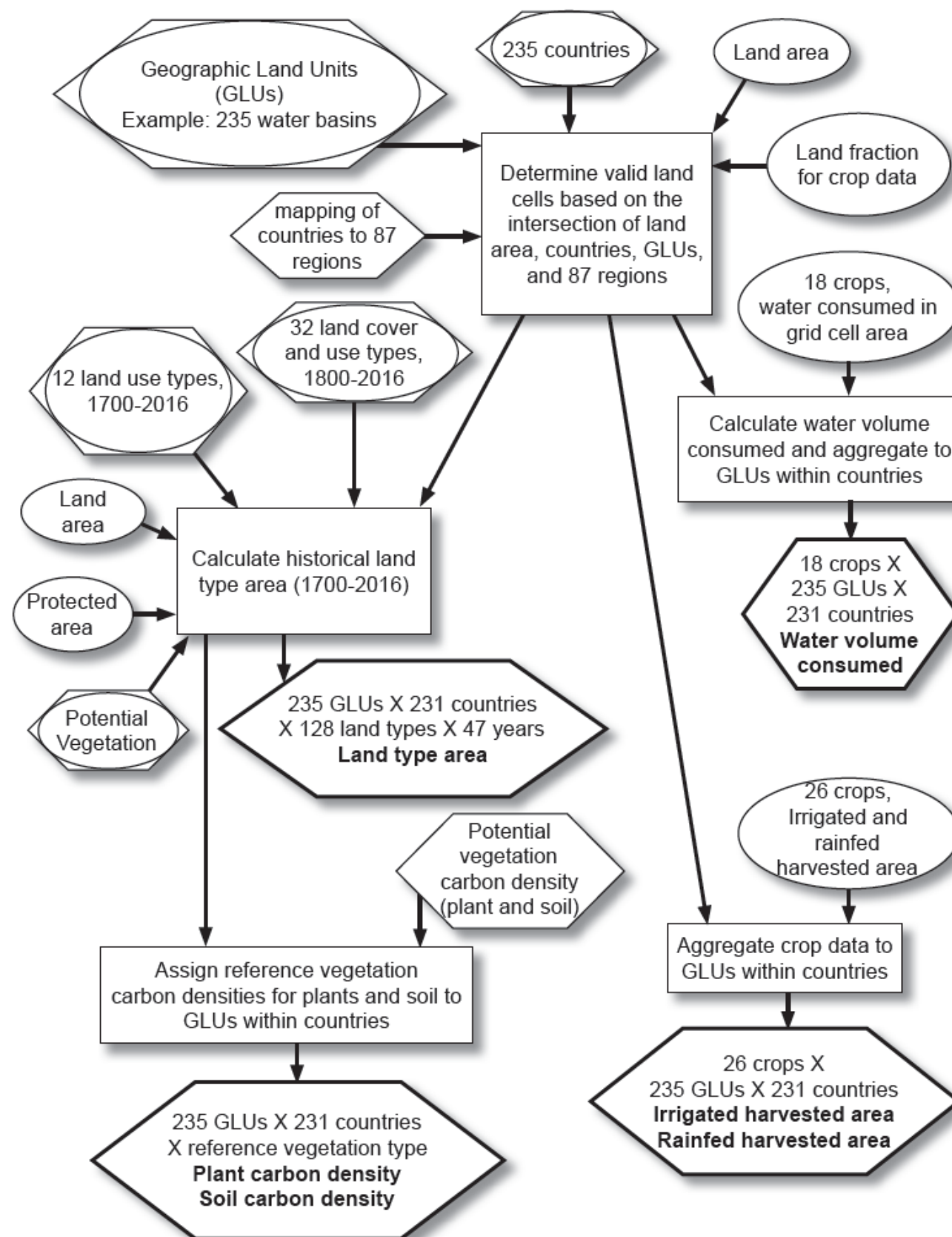
Determine areas of forest and pasture in Original 18 AEZs

Disaggregate forest land rents to 235 GLUs X 87 regions based on original land rents and forest area

Calculate crop production and harvested area per 175 crops X 235 GLUs X 231 countries

Disaggregate ag sector land rents to 235 GLUs X 87 regions based on production and price

Workflow for additional outputs



Workflow for additional outputs

Data Reconciliation!

Determine land type area for **128 land types** X 47 years X 235 GLUs X 231 countries

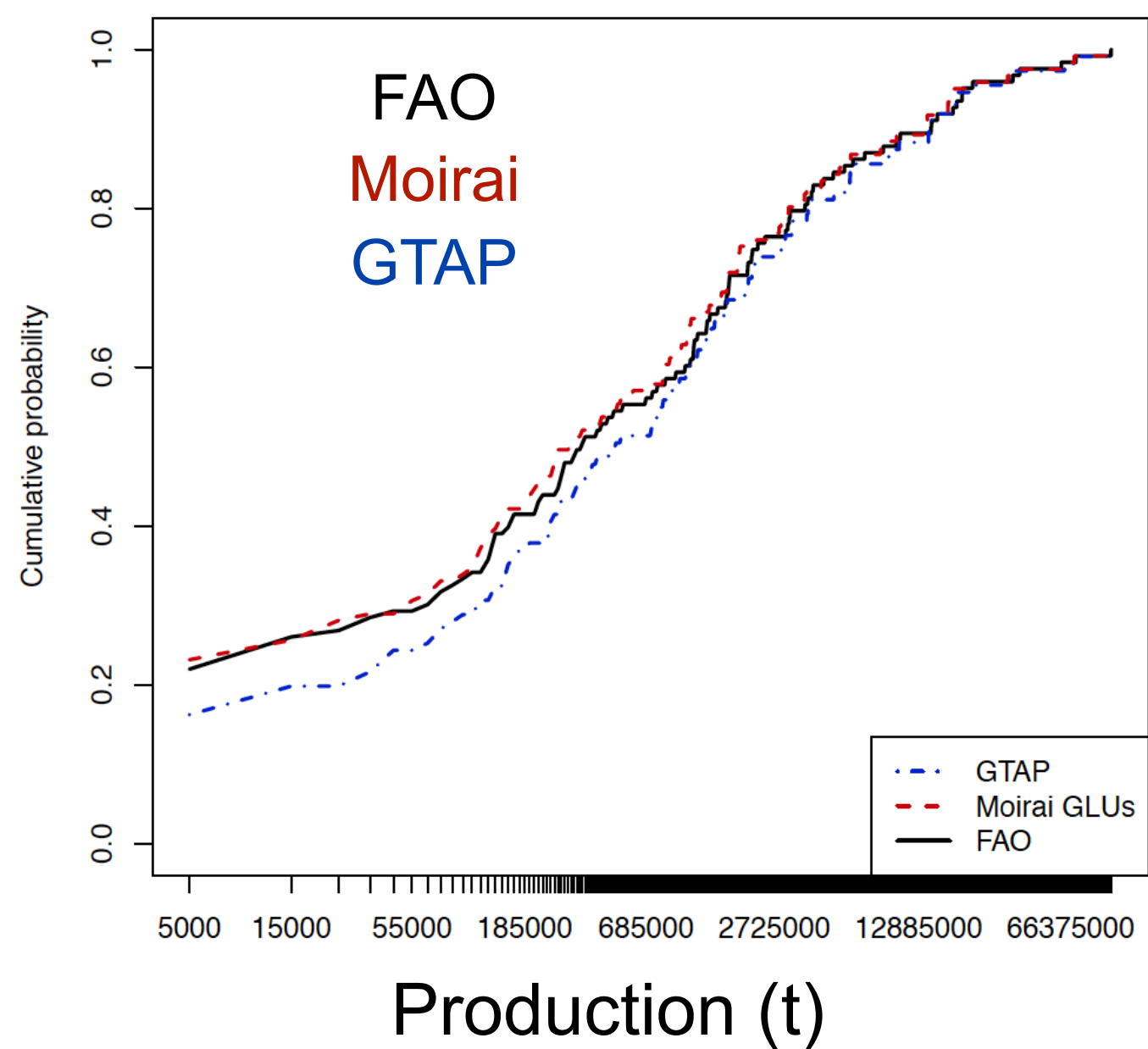
Determine plant and soil carbon density for **32 unmanaged land types** X 235 GLUs X 231 countries

Determine water volume consumed for **18 crops** X 235 GLUs X 231 countries

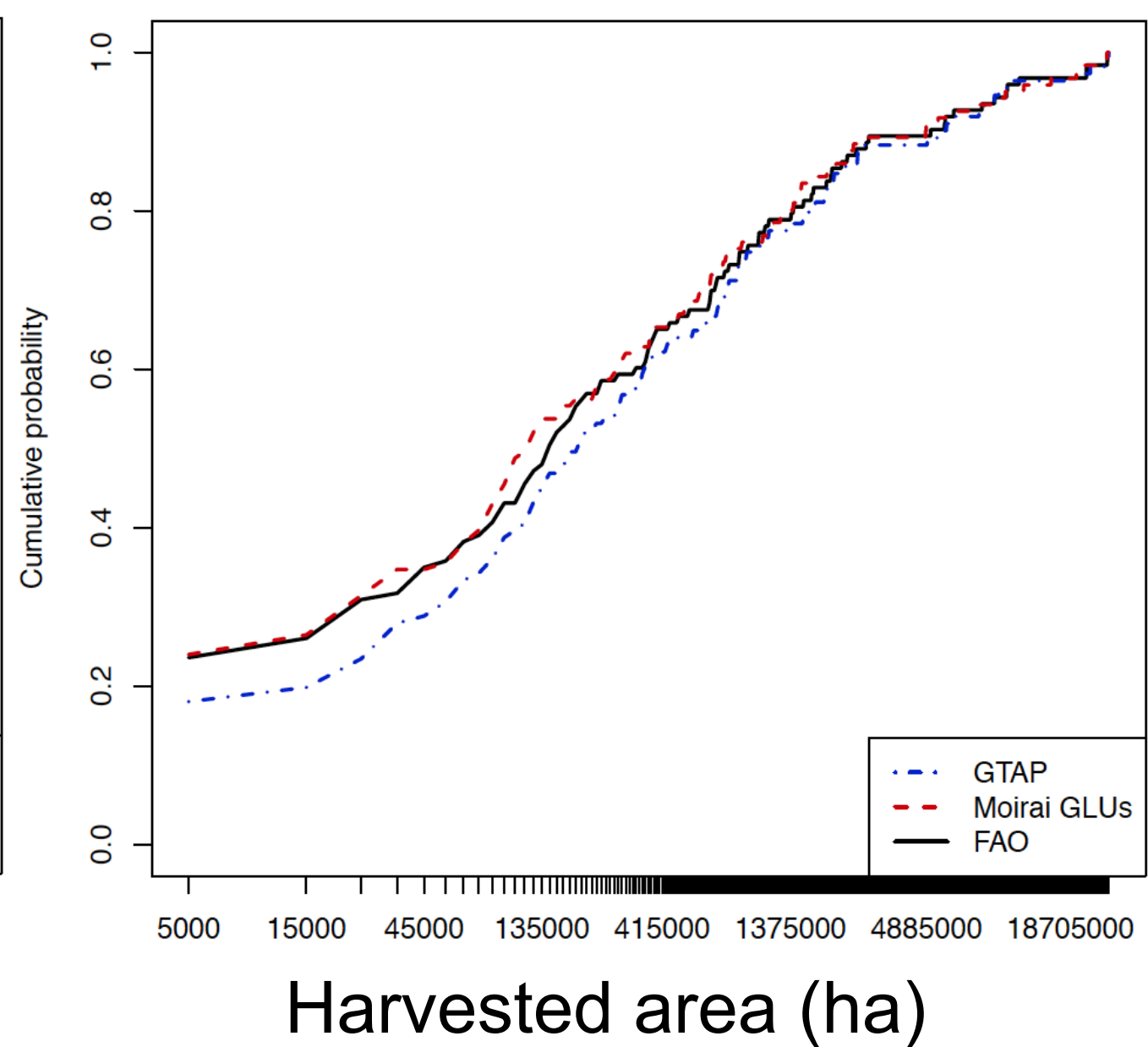
Determine irrigated and rainfed harvested areas for **26 crops** X 235 GLUs X 231 countries

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

Wheat production cumulative distribution comparison

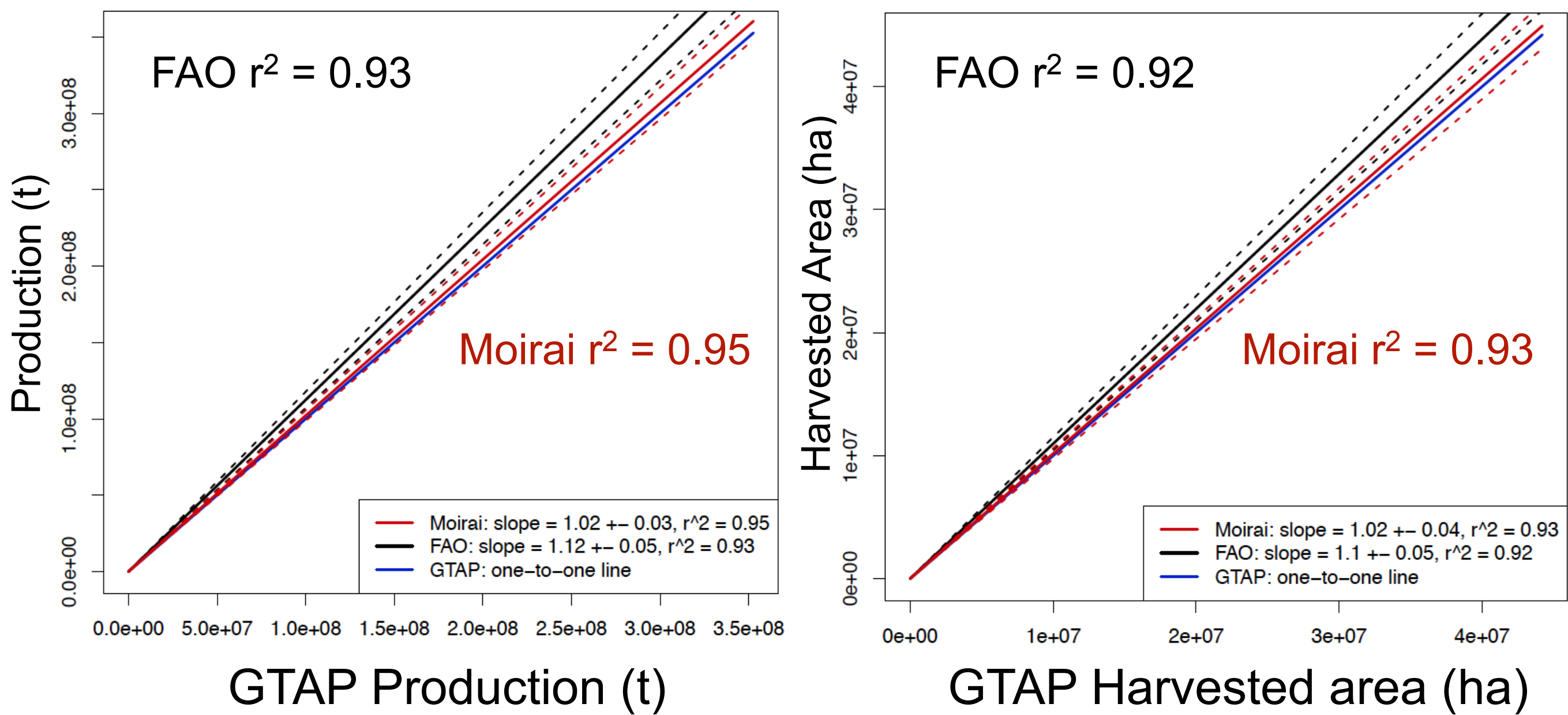


Wheat harvested area cumulative distribution comparison



Validation: Mean of crop regressions against GTAP data

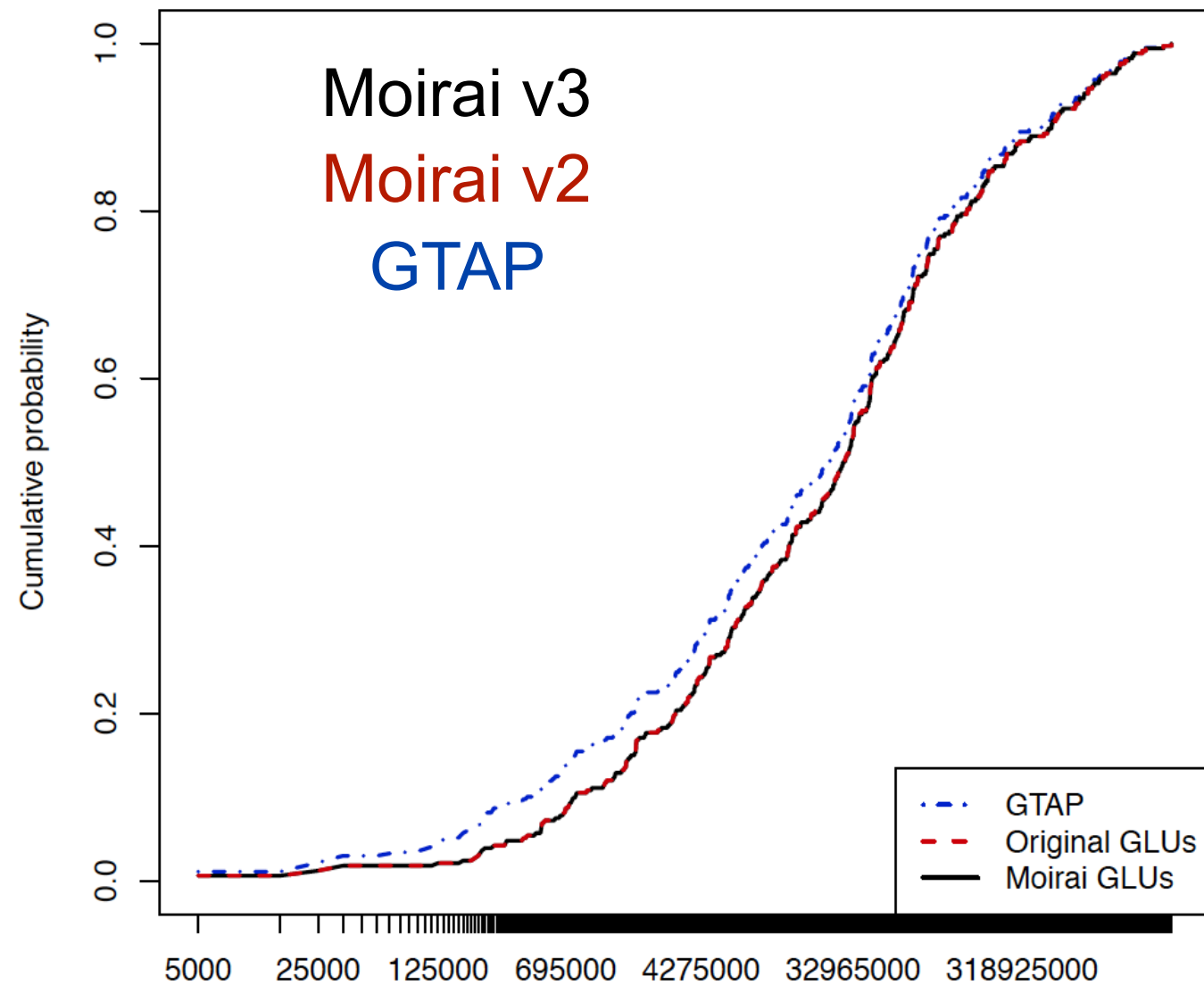
Country level comparison



88 (FAO) and 93 (Moirai) crops with $n \geq 20$ countries

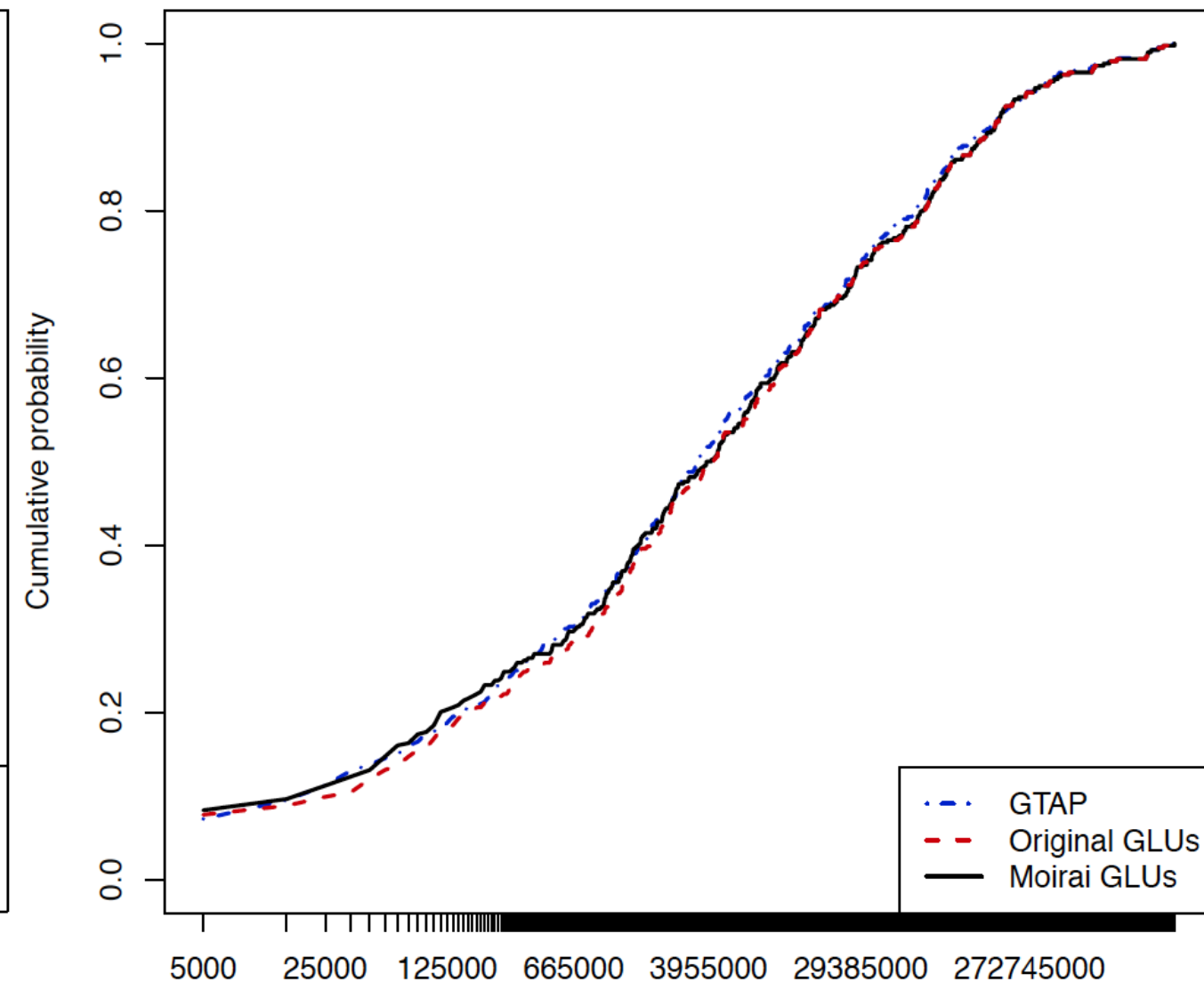
Validation (Original AEZs): land rent distributions, by GTAP land unit

Forestry land rent cumulative distribution comparison



Forestry land rent (USD)

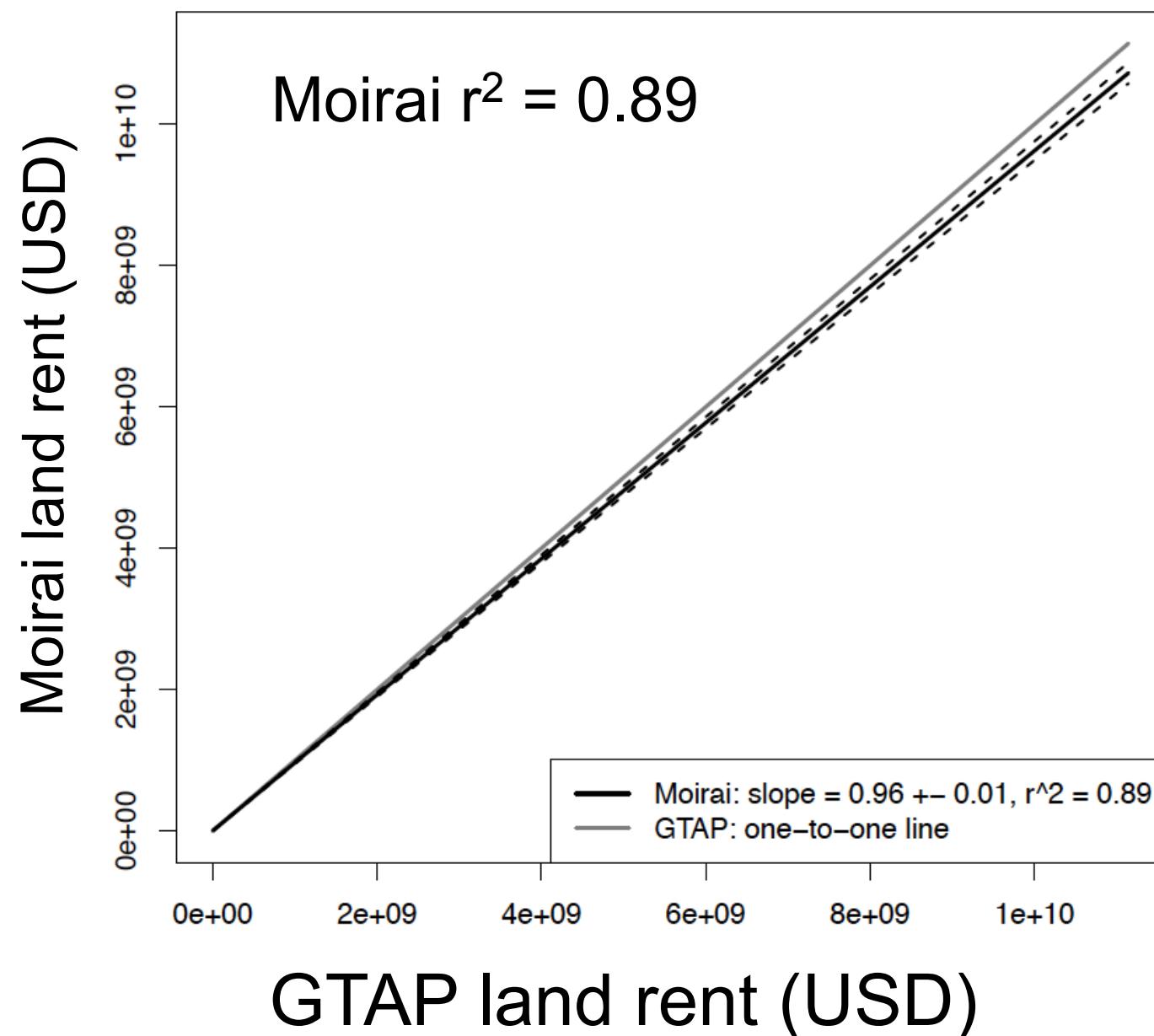
Wheat land rent cumulative distribution comparison



Wheat land rent (USD)

Validation: Mean of land rent regressions against GTAP data

GTAP land unit level comparison



12 use sectors

Summary

- Global land use data are sparse, and vary considerably
- Lack of integrated land use and land cover data and analyses is a major problem for the global change science community
- Moirai is only a first step toward resolving this problem
- Working toward an open source release of Moirai and its input data

Summary

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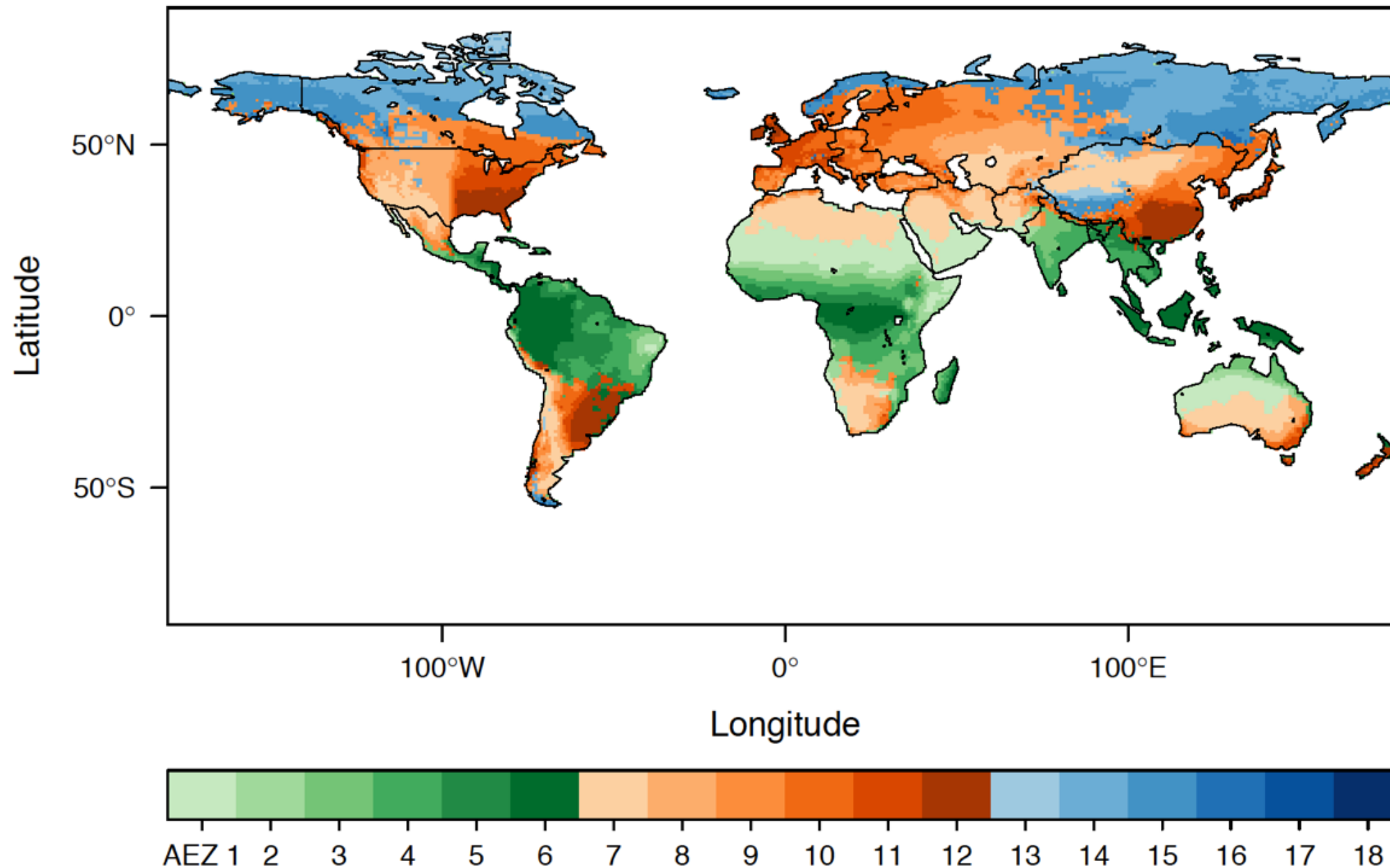
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Summary

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- Lack of integrated land use and land cover data and analyses is a major problem for the global change science community
- Moirai is only a first step toward resolving this problem
- Working toward an open source release of Moirai and its input data, including a manuscript

Questions?

ECHAM 2071–2100 climate agro-ecological zones



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