8 May 2025

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Improved multiscale gridded Direct Human Forcing for ISIMIP4

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COMPASS

NaturalHazards.eu

Leibniz Association

ISIMIP requirement for exposure data

- Spatial consistency between gridded population, GDP and fixed assets (using the same population datasets)
- No break in timeseries between up-to-date historical data and SSPs
- Using new SSP scenarios from 2024
- Consistent spatial mapping of countries and regions (also with the land mask)
- Using the same data as ESMs

ISIMIP solution

Create a new, reproducible approach to generate multiscale exposure data

Framework

- Resolutions from 30” (≈1 km) and lower
- 1850-2100
- Five SSPs v3.1 (July 2024)
- Open Python code
- Harmonization in time and space

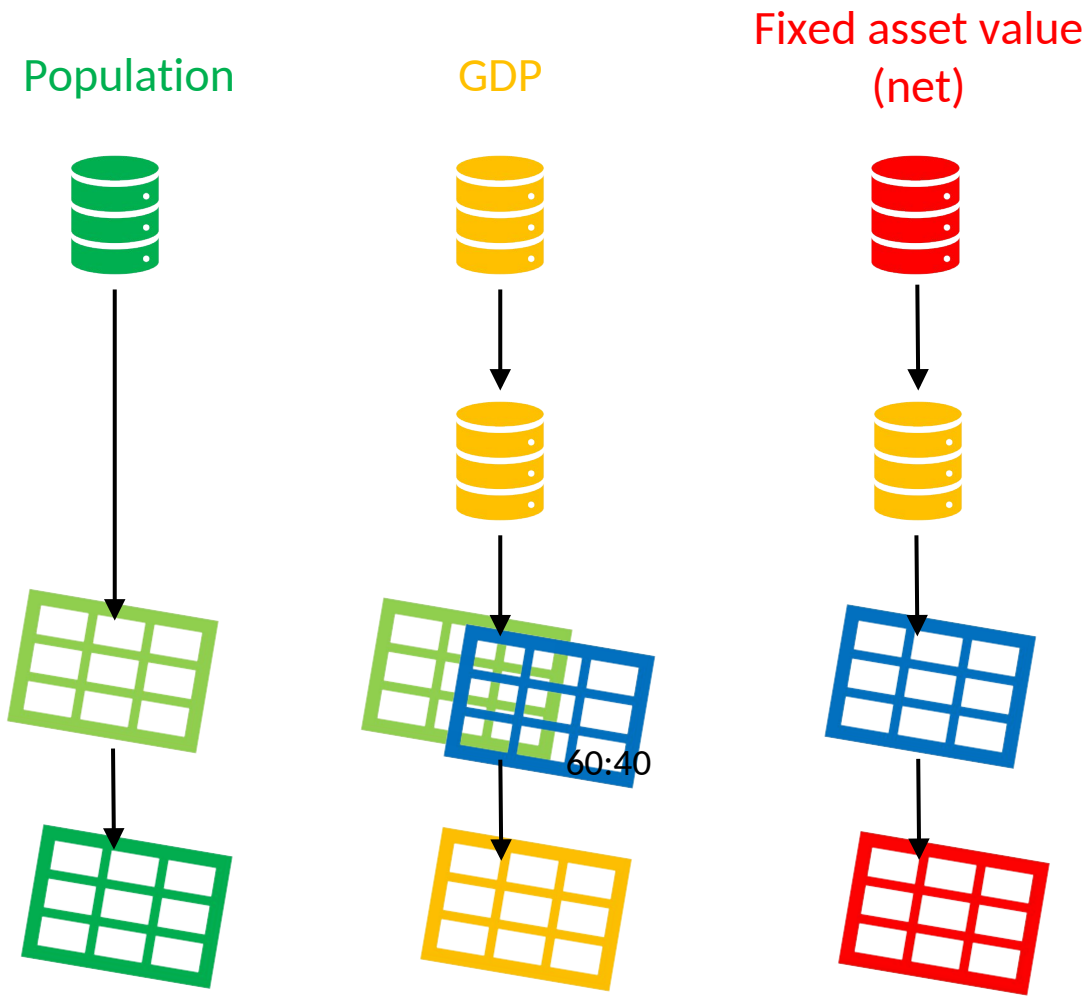
„Compound extremes attribution of climate change: towards an operational service” (COMPASS)

Funded by the European Union

compass-climate.eu

Deliverable 3.1 published March 2025 on Zenodo

Concept



Annual multisource (100+) data
1850-2023
SSP projections **2020-2100**

Annual multisource (120+) data
1850-2023 (if available)

External gridded data, 5/10-yearly
(Population, Build-up area)

Annual gridded exposure

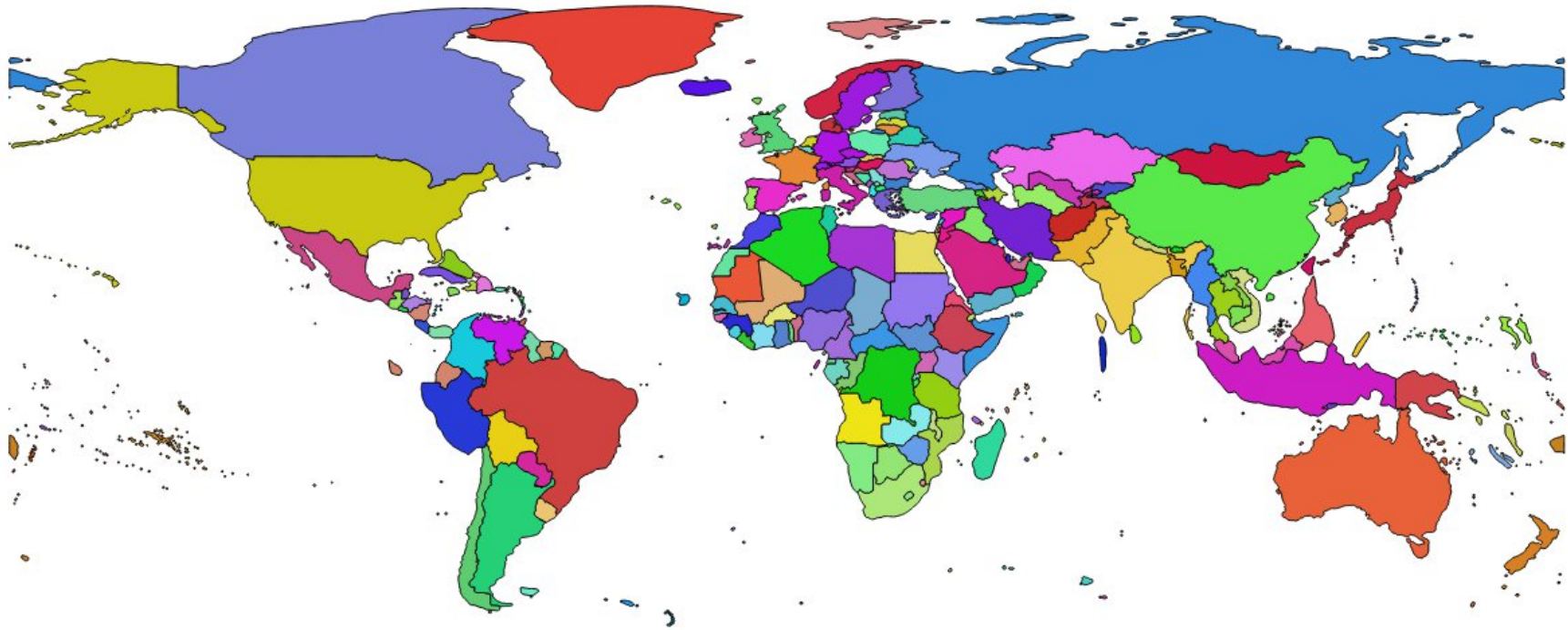
Countries & regions

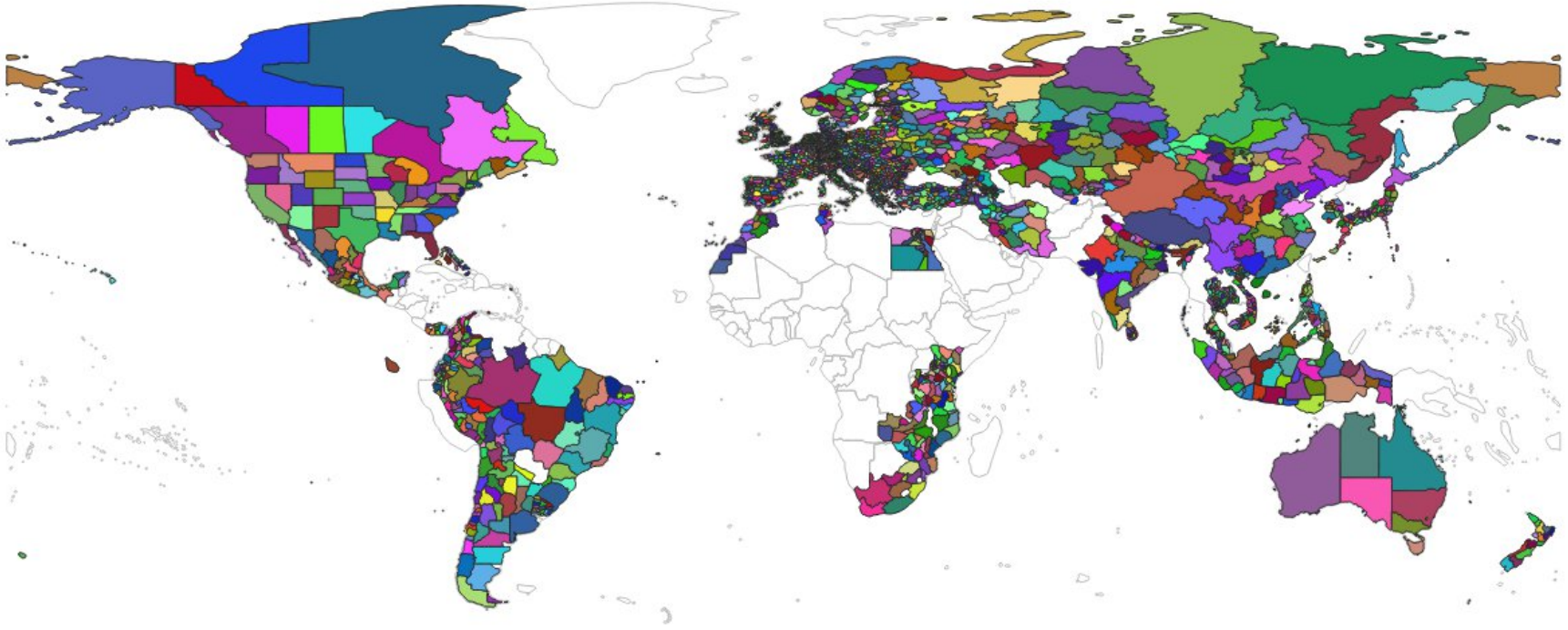
Consistent map adapted from HANZE and OpenStreetMap boundaries

248 national units

2652 subnational units (≈89% of global GDP)

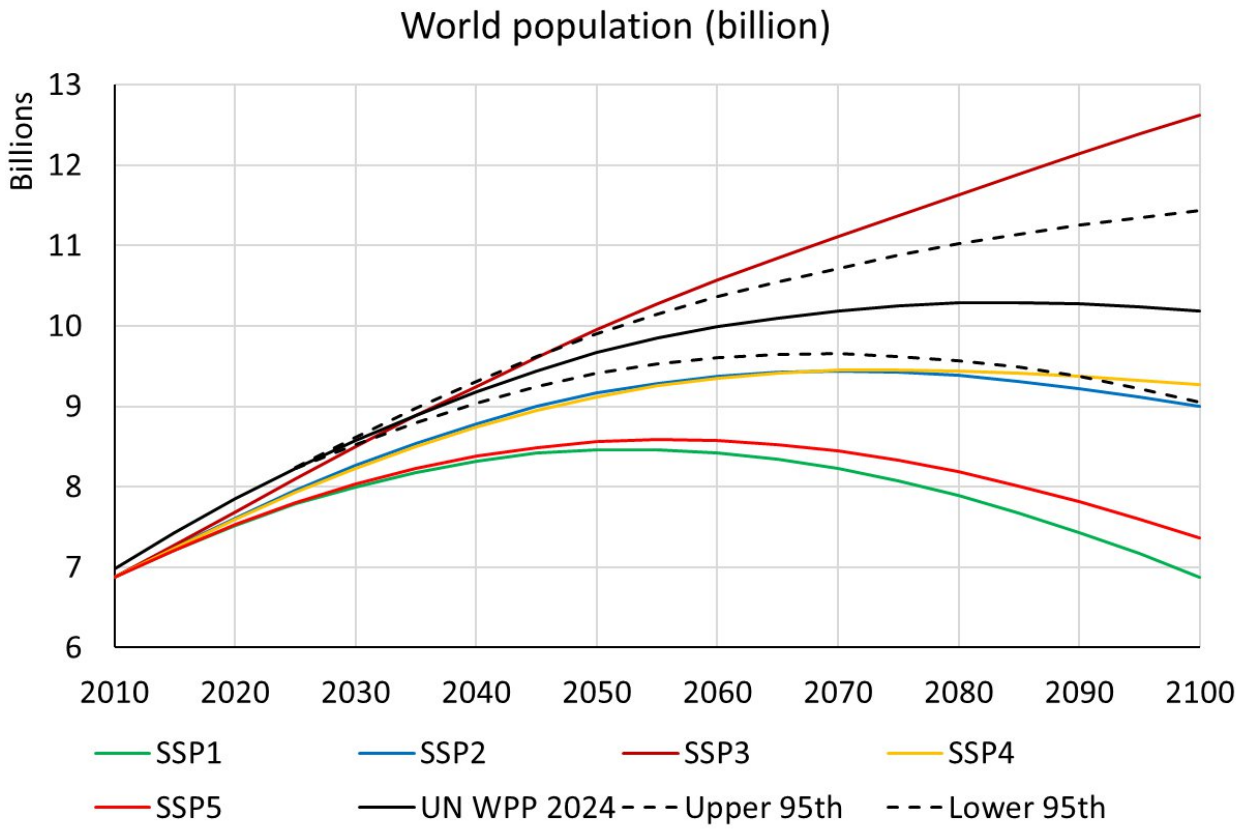
Historical data are adjusted to the same political divisions

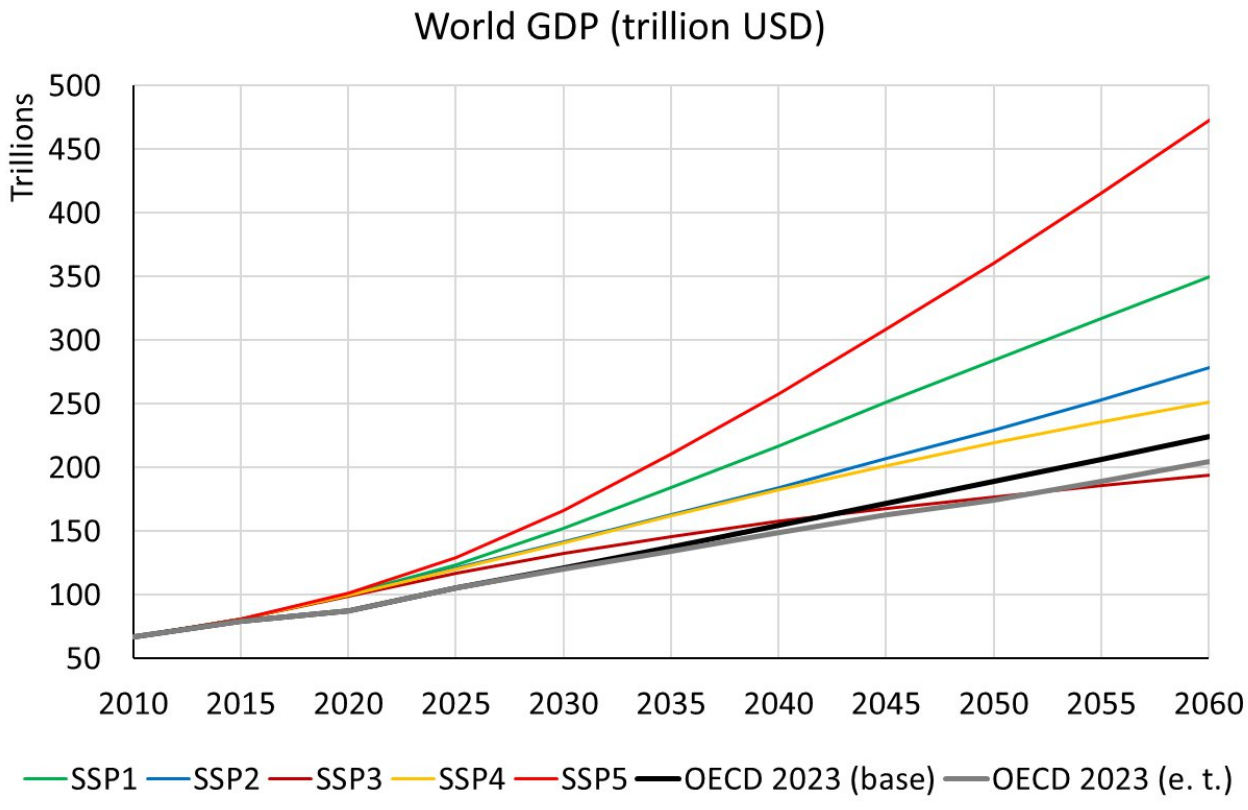




Harmonizing national timeseries

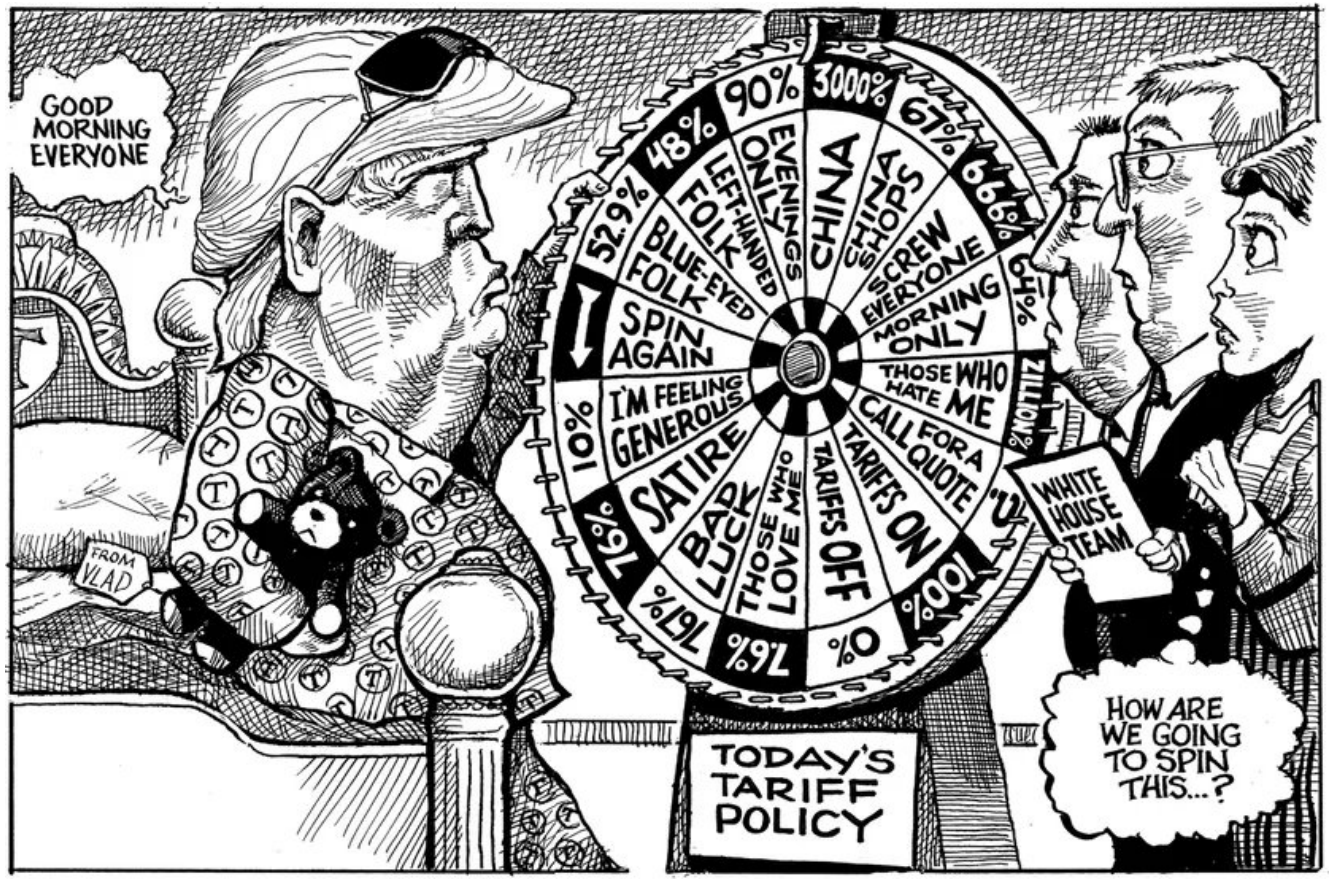
2013 SSPs vs most recent projections





SSP3: Regional rivalry. A revival of nationalism and regional conflicts pushes global issues into the background. Policies increasingly focus on questions of national and regional security. Investments in education and technological development are decreasing.

Harmonizing national timeseries



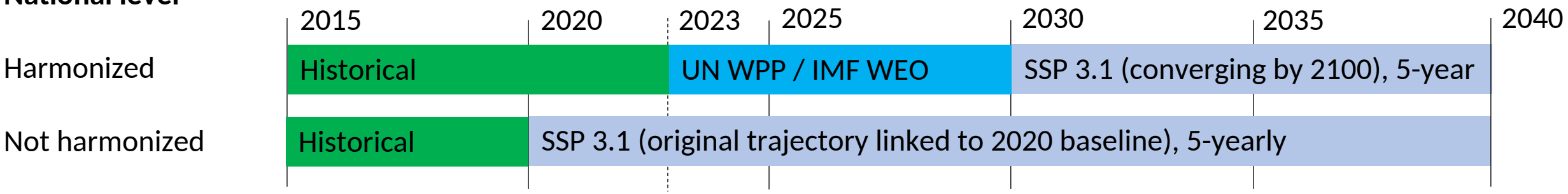
The Economist, 16.4.2025

Short-term variations does not invalidate long-term trajectories

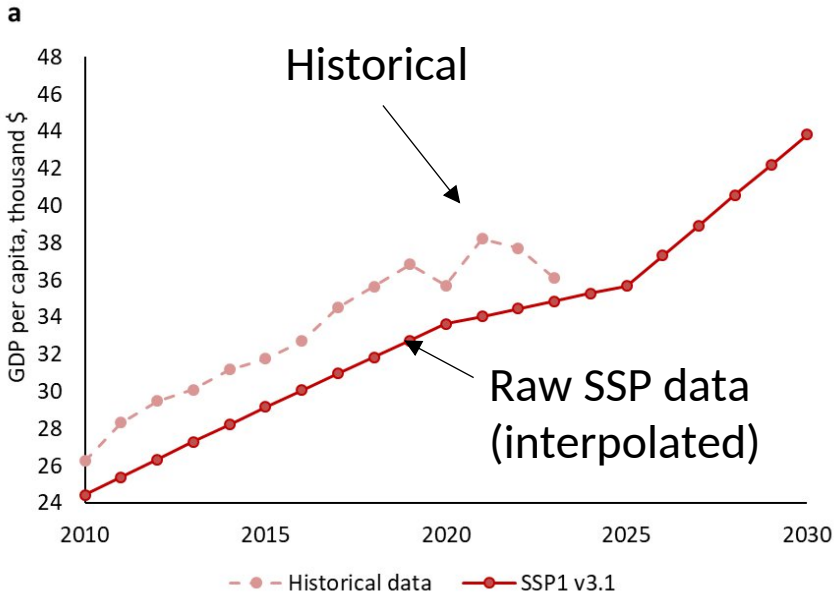
Not harmonized:
Historical and SSP data linked at base year (2020)
Harmonized:
Historical data and short-term projections used until 2030 and then slowly converging with SSPs by 2100

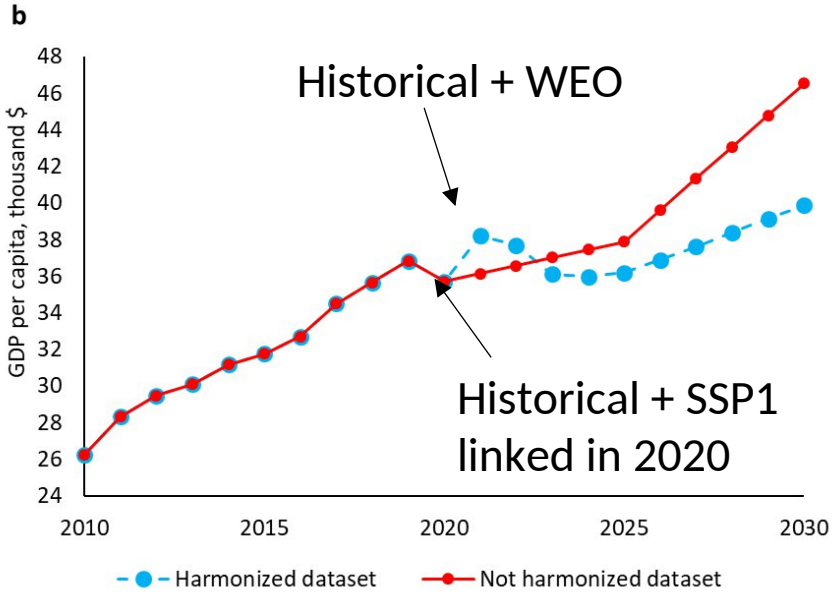
Harmonizing national timeseries

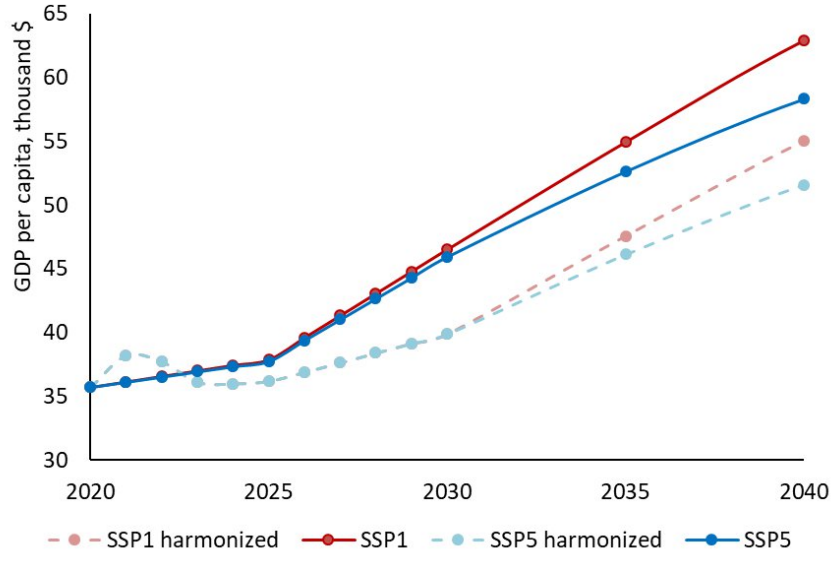
National level



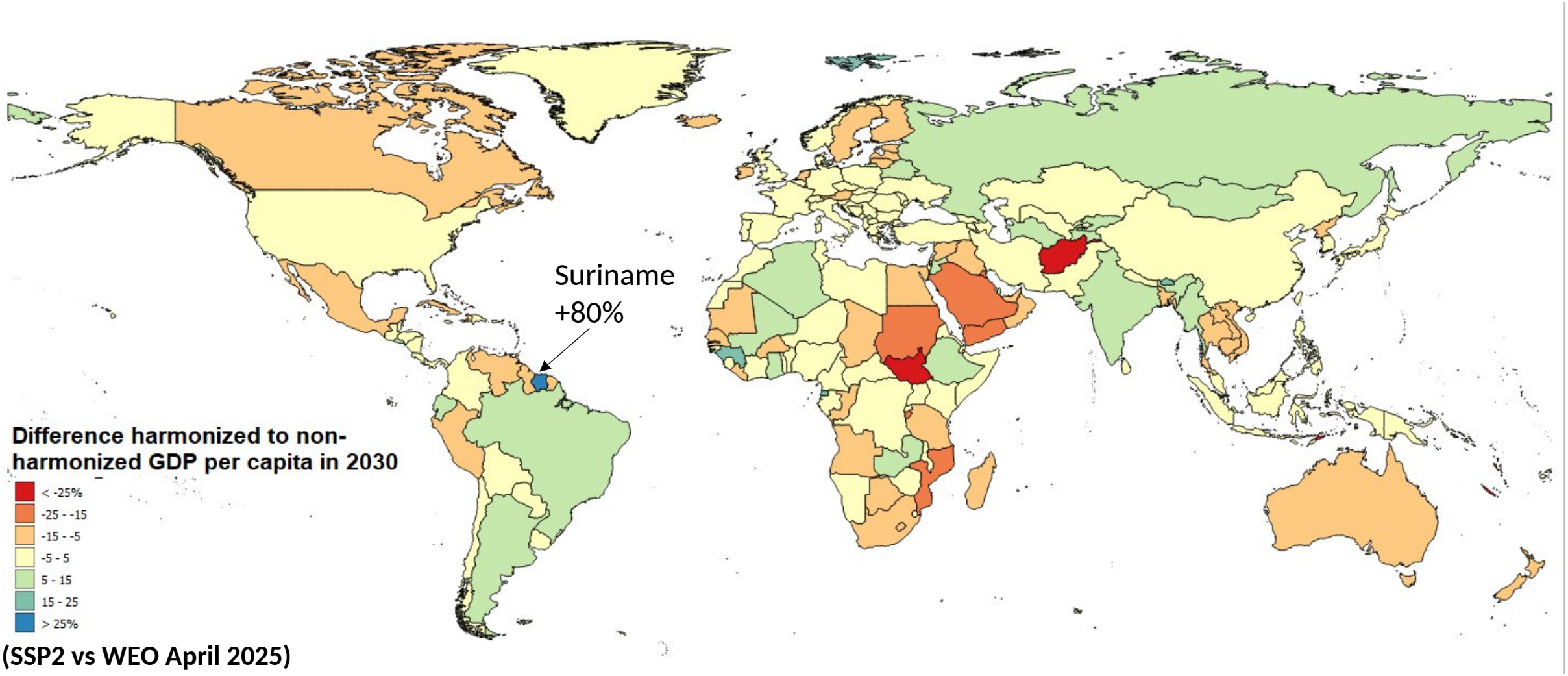
Estonia, GDP per capita, $2017 PPP





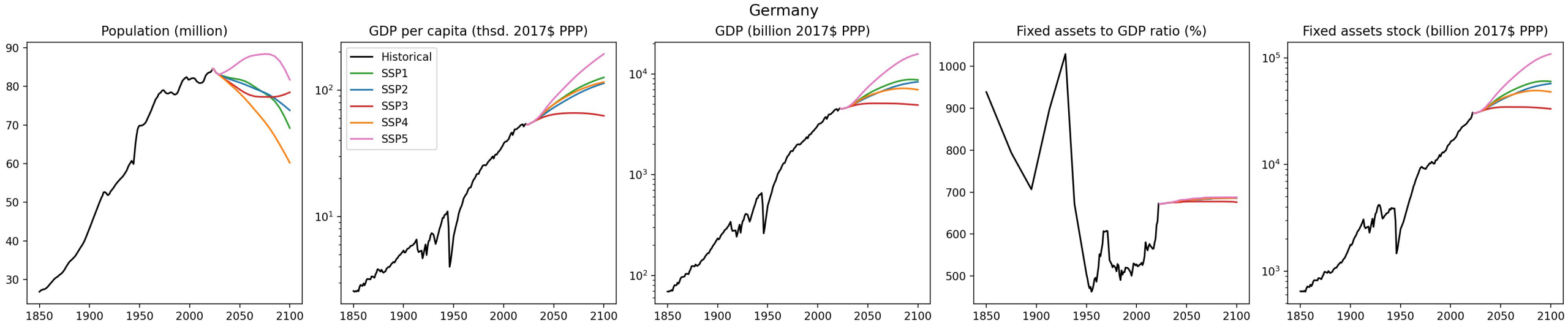


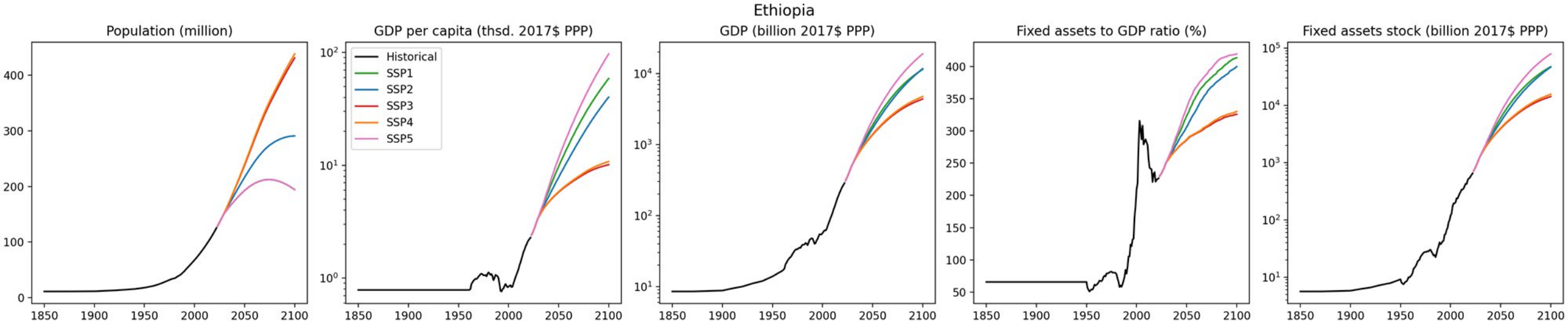
Harmonizing national timeseries



(SSP2 vs WEO April 2025)

Combined national timeseries (harmonized)





Documentation

Population: 1950-2023 from UN WPP 2024, unless otherwise noted
GDP per capita: 2011-2023 from UN NAMAD unless otherwise noted
GDP per capita: 1850-2010 from MPD2023 (Bolt and van Zanden 2024), interpolated where necessary, unless otherwise noted
Fixed assets: regression between GDP per capita and relative fixed assets unless otherwise noted

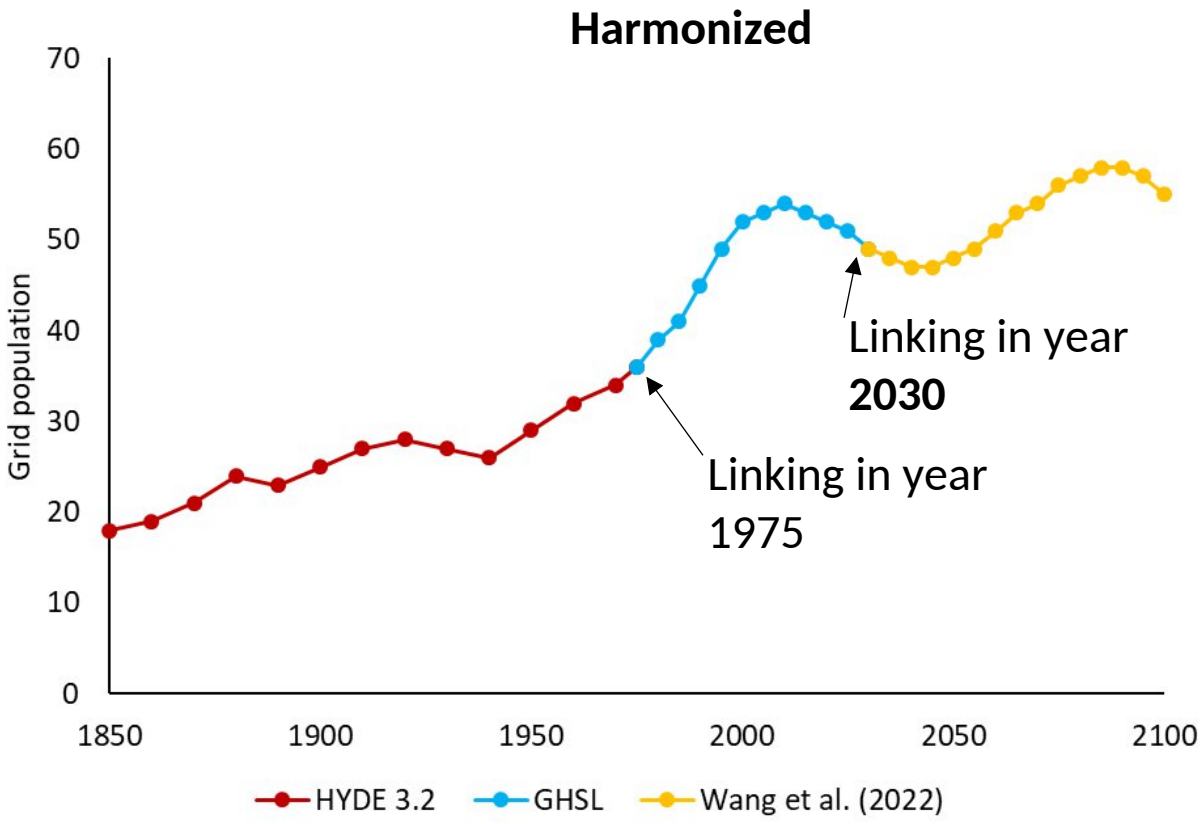
Name	Population source	Population note	GDP per capita	Fixed assets
Gambia	**1850-1900:** extrapolated from 1901 with backprojections of Frankema and Jerven (2014); **1901-1949:** 1901, 1911, 1921, 1931 censuses from United Nations (1955) and 1938-49 estimates from United Nations (1960); remainder interpolated and all adjusted to 1950 UN WPP2024 estimate	Pre-1901 census data cover only small part of the territory; accuracy of pre-1960 data highly questionable	**1850-1949:** extrapolated with estimates for Africa from Maddison (2003), assuming starting from regional GDP per capita in 1850	**1960-2019:** PWT 10.01
Germany	**1850-1918:** extrapolated from 1919 estimate for present-day and 1937 Germany using 1850-1918 timeseries from Bolt and van Zanden (2024) for 1913 territory revised to match 1937 borders using difference between 1913 and 1937 territory for 1910 census from Statistisches Reichsamt (1922); **1919-1945:** 1939 estimate for present-day Germany (United Nations 1960) annualized with 1919-44 timeseries from Bolt and van Zanden (2024) for 1937 territory; **1946-1949:** United Nations (1960) adjusted to 1950 UN WPP2024 estimate	Recalculation of pre-1939 population censuses to territory of pre-1990 West Germany not included due to lack of comparable data for East Germany	-	**1850-1949:** extrapolated from 1950 using reproducible tangible assets, interpolated from 1850, 1875, 1895, 1913, 1929, 1938 and 1950 estimates by Goldsmith (1985); **1950-1990:** extrapolated from 1991 with PWT 10.01; **1991-2023:** Destatis (2024)
Guatemala	**1850-1949:** 1850, 1870, 1900-1949 from Bolt and van Zanden (2024) adjusted upwards to the 1950 WPP2024 estimate; remainder interpolated	Historical censuses (first made in 1880) generally strongly underenumerated, except vastly overenumerated 1940 census	**1850-1919:** extrapolated with estimates for Latin America from MPD2023	**1950-2019:** PWT 10.01

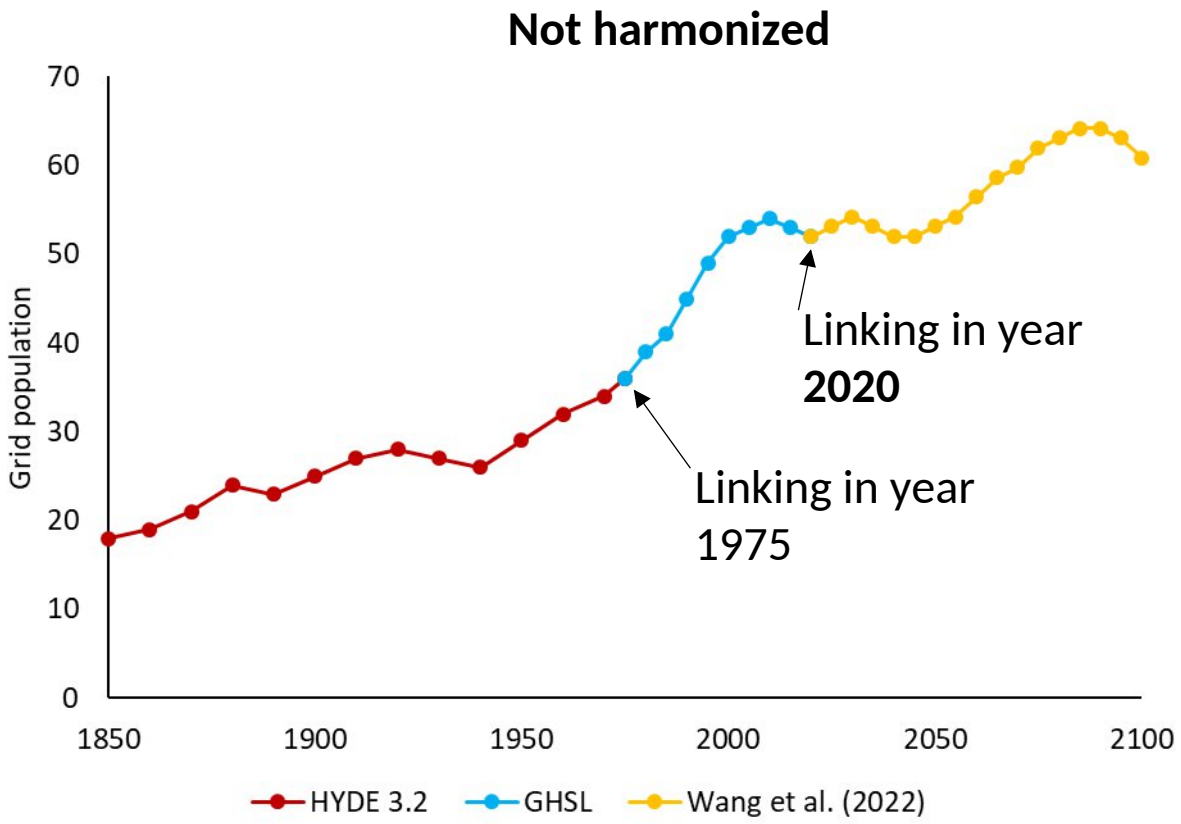
Downscaling

Historical | Historical + harmonization | Projections

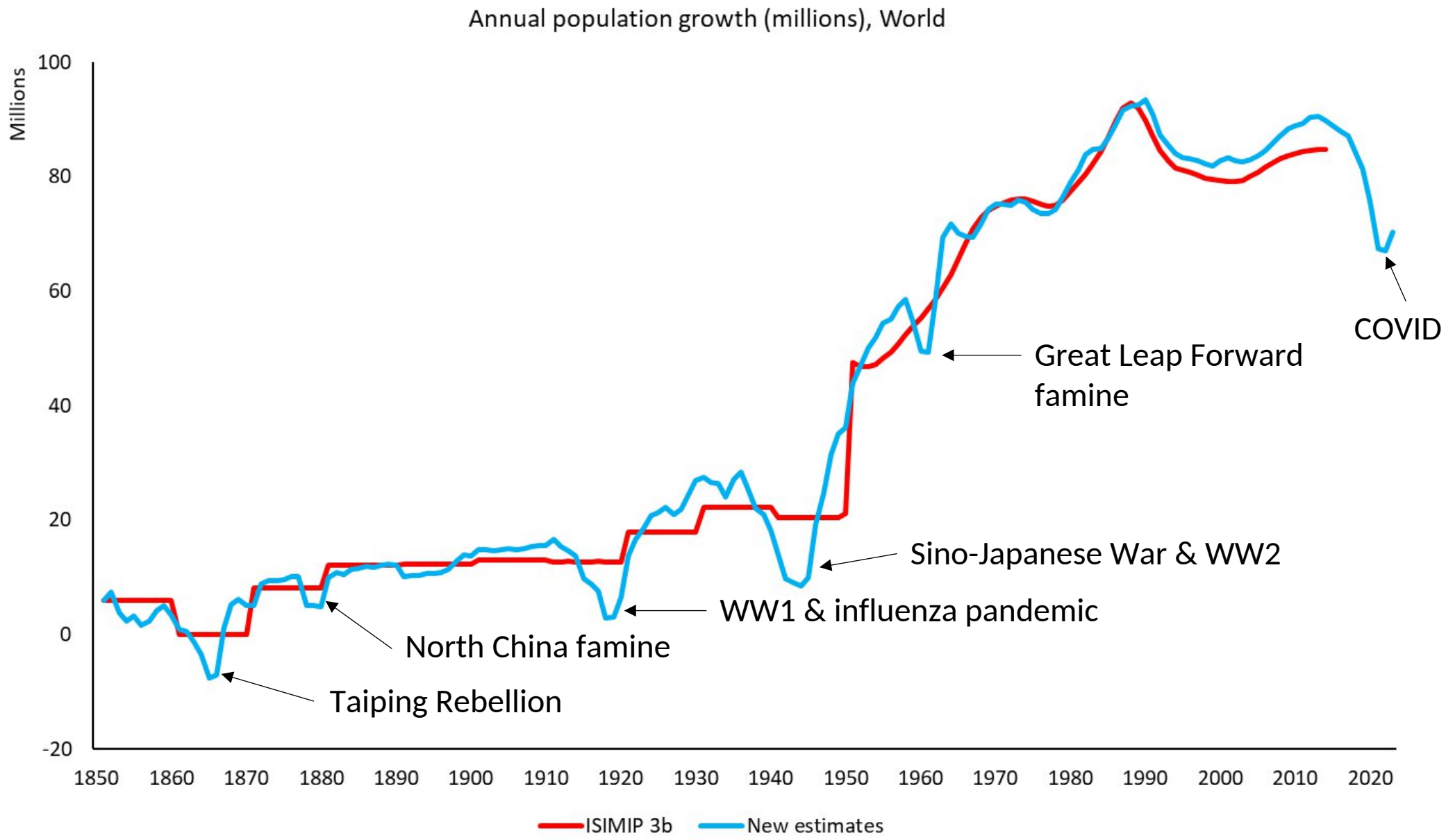
Dataset	Version	Resolution	Timesteps	Step	Variables
HYDE	3.2.1	5' (~9 km)	1850-1980	10	Population
GHSL **(baseline)**	R2023A	30'' (~1 km)	1975-2020 (2030)	5	Population, build-up surface
Wang et al.*	2022	30'' (~1 km)	2020 (2030)-2100	5	Population

* Temporary solution

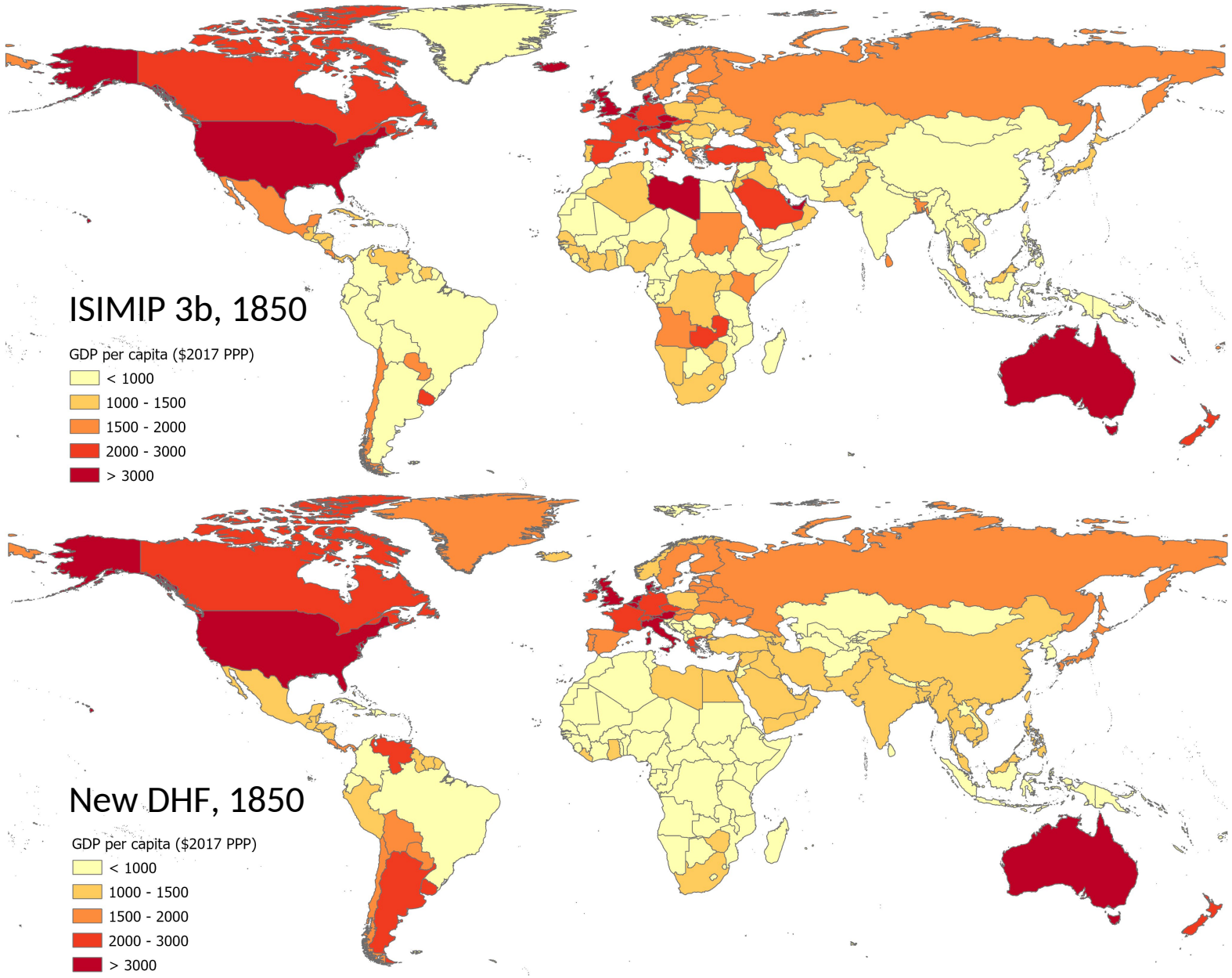


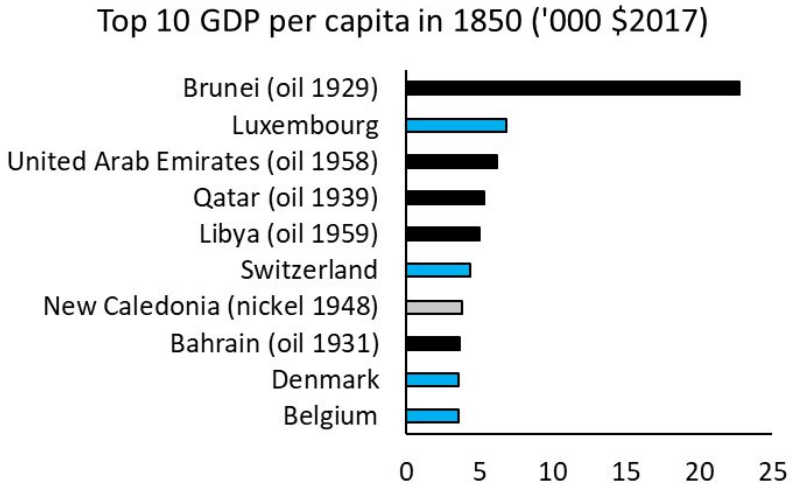


Improving historical population estimates (1850-2023)

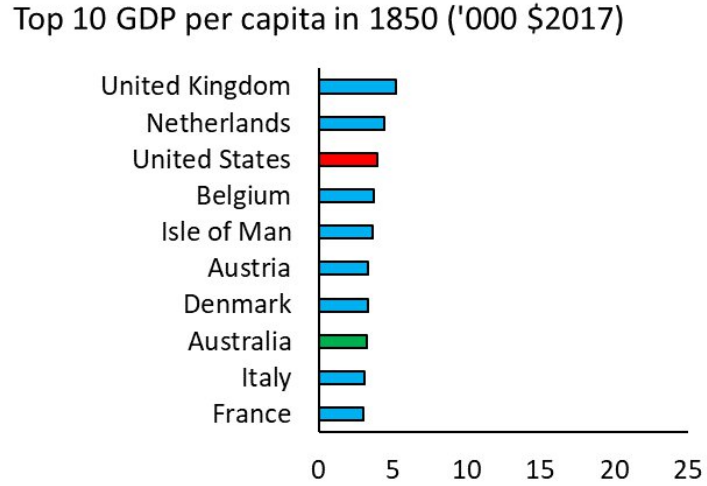


Improving historical GDP estimates





Nearly 1/3 of countries below subsistence level



No countries below subsistence level

Benefits of the new DHF

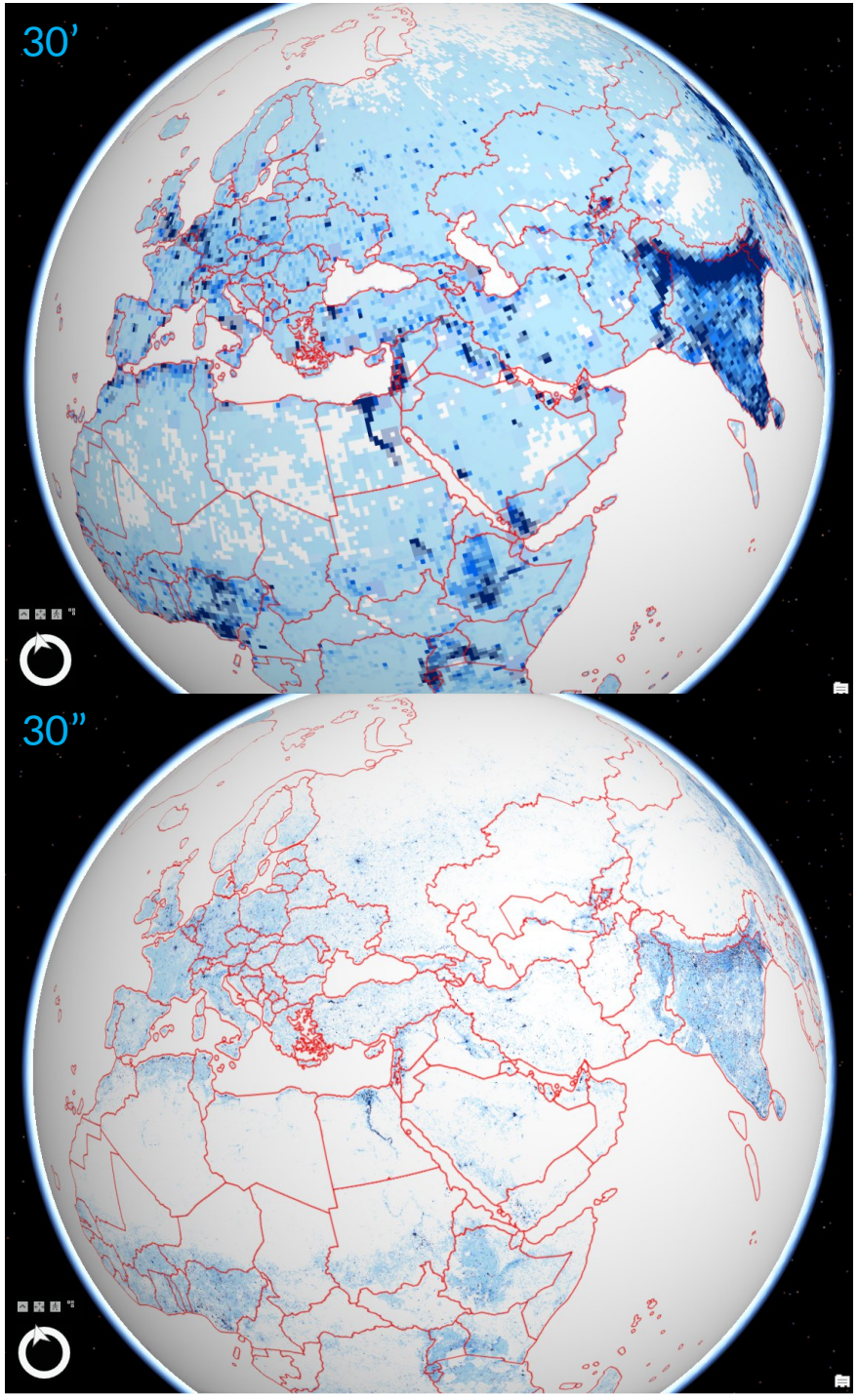
- Consistent merging of different datasets (spatial, temporal, thematic)
- Full input data documentation
- Explicit and reproducible methods
- Easy updating with latest historical data and short-term projections
- Fast generation of many target resolutions

Challenges

- Some quality issues (mainly related to HYDE data) not fully resolved
- Gap-filling and projecting subnational GDP
- GDP structure disaggregation

Next steps

- Additional layers (GDP per capita, population density)
- Further data updates and formatting for ISIMIP application
- Incorporating new SSP-based gridded datasets



Potsdam Institute for Climate Impact Research

THANK YOU!

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COMPASS

Funded by the European Union

„Compound extremes attribution of climate change: towards an operational service” (COMPASS)

compass-climate.eu

NATURAL HAZARDS

DFG Deutsche Forschungsgemeinschaft German Research Foundation

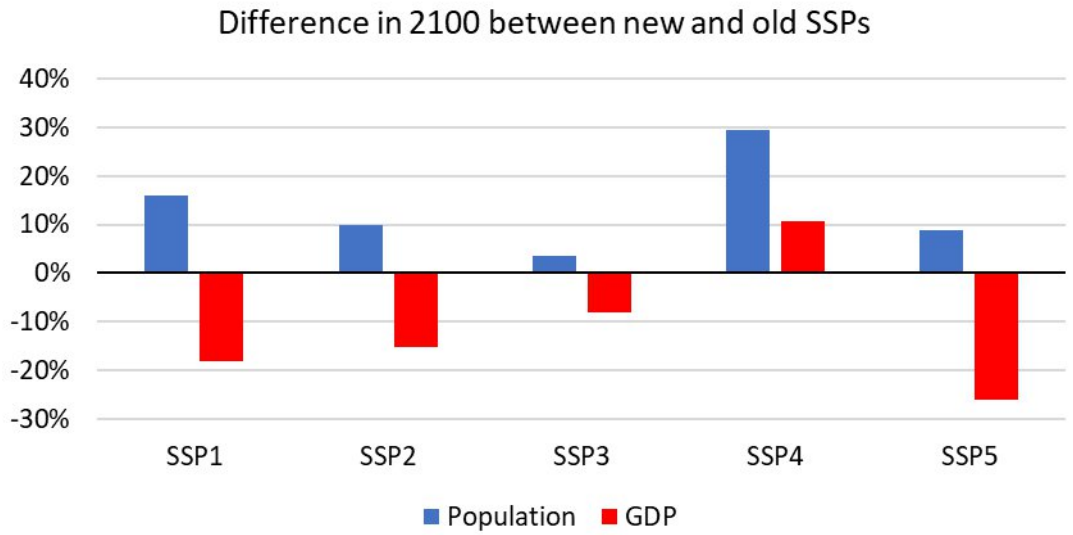
„Decomposition of flood losses by environmental and economic drivers” (FloodDrivers)

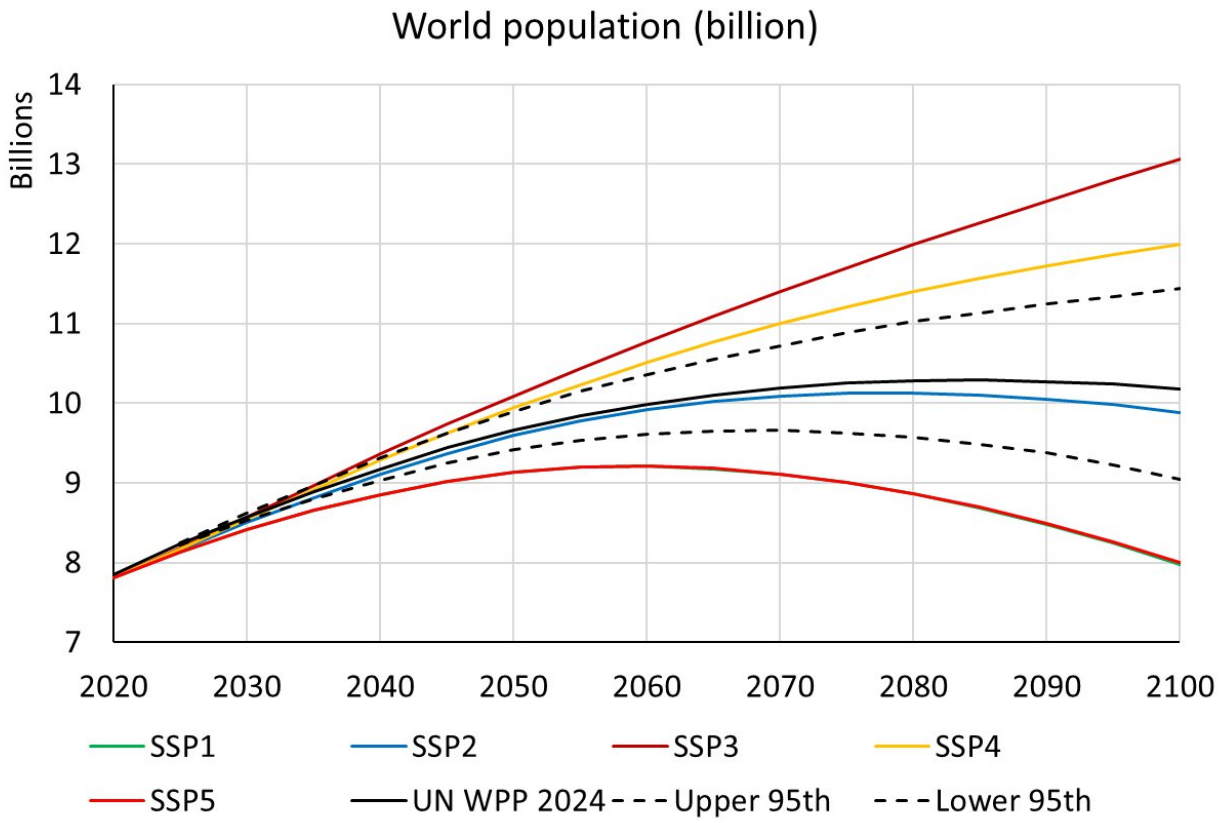
NaturalHazards.eu

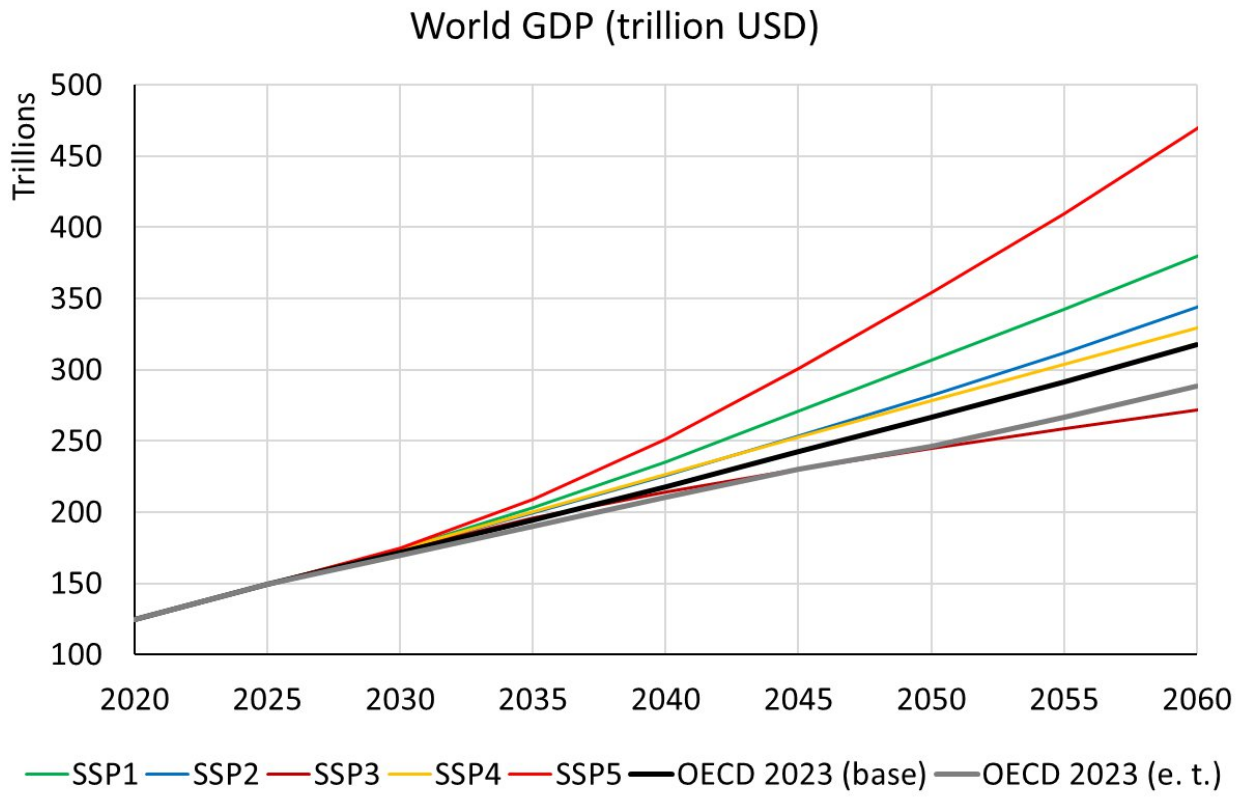
Leibniz Association

Supporting slides

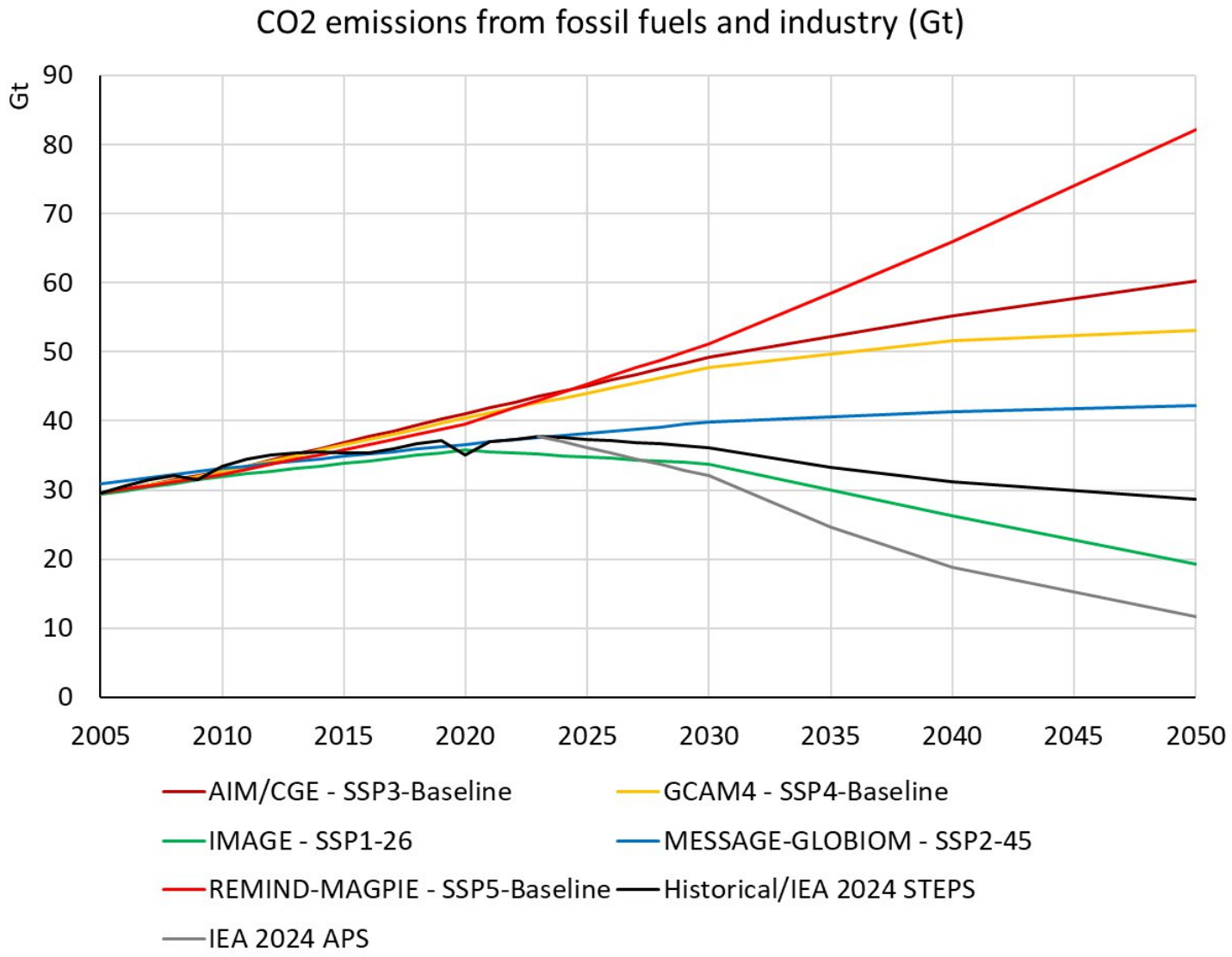
2024 SSPs


Difference in 2100 between new and old SSPs
40%
30%
20%
10%
0%
-10%
-20%
-30%
SSP1
SSP2
SSP3
SSP4
SSP5
Population
GDP


World population (billion)
Billions
14
13
12
11
10
9
8
7
2020
2030
2040
2050
2060
2070
2080
2090
2100
SSP1
SSP2
SSP3
SSP4
SSP5
UN WPP 2024
Upper 95th
Lower 95th


World GDP (trillion USD)
Trillions
500
450
400
350
300
250
200
150
100
2020
2025
2030
2035
2040
2045
2050
2055
2060
SSP1
SSP2
SSP3
SSP4
SSP5
OECD 2023 (base)
OECD 2023 (e. t.)

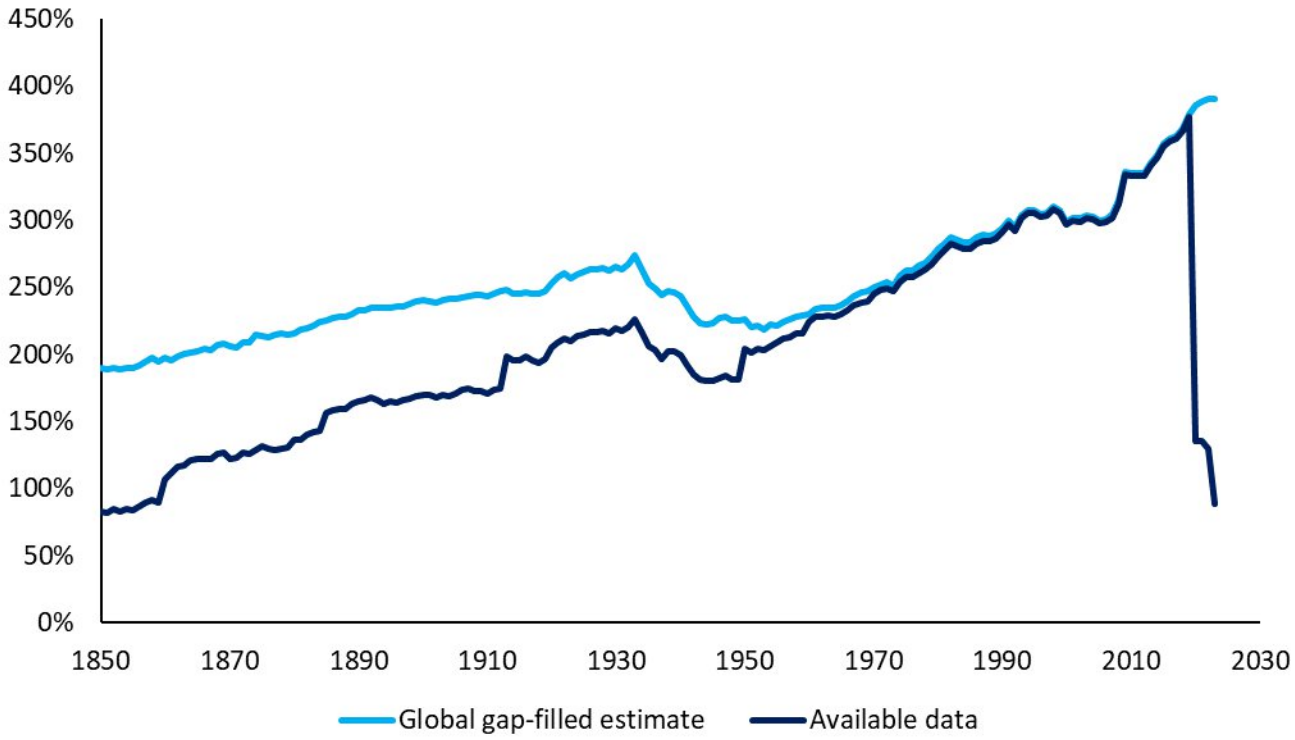
2013 SSP emissions



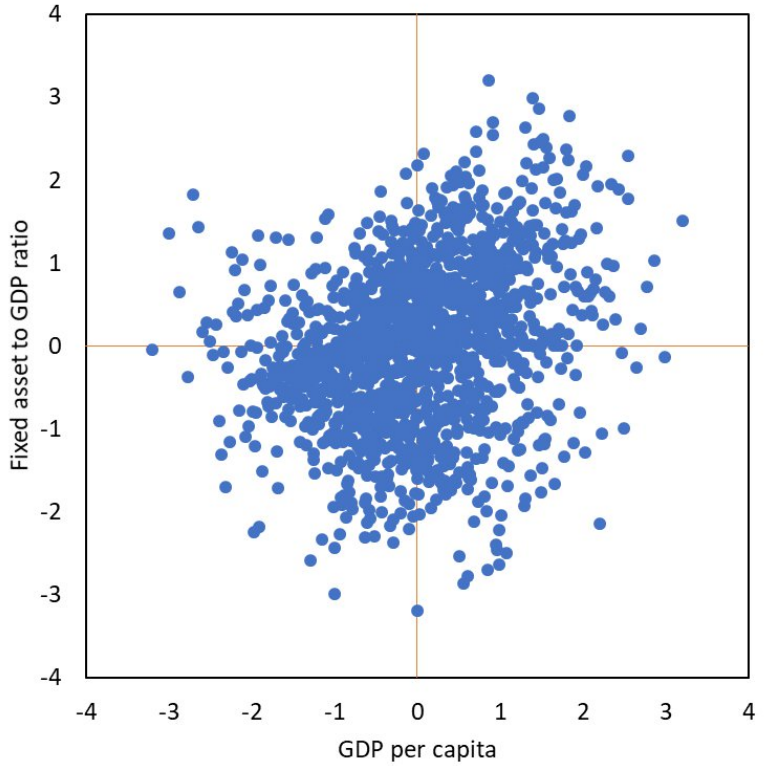
Fixed asset estimation

- Global fixed asset data is limited, especially on gross (rather than net) stock
- Gap-filling with GDP per capita with a Frank copula

Global net fixed asset stock relative to GDP, 1850-



Net fixed asset stock ratio and GDP per capita



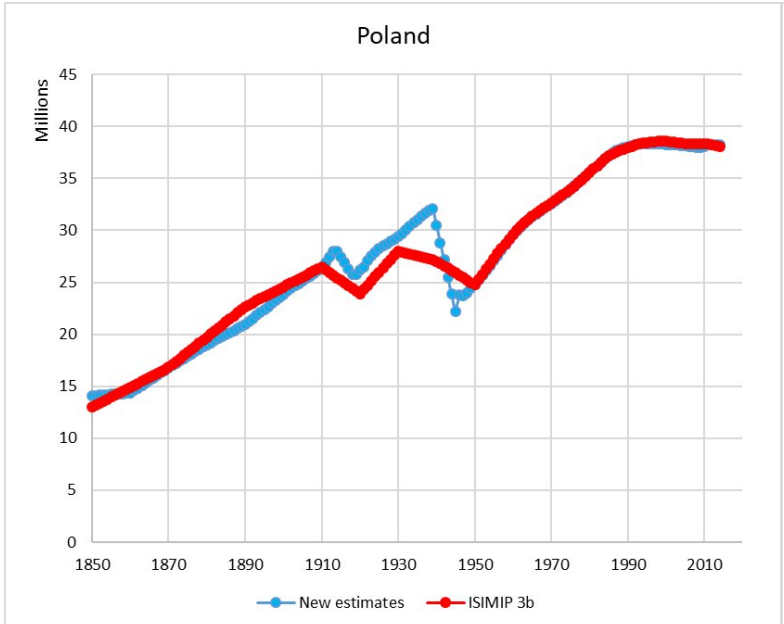
Datasets

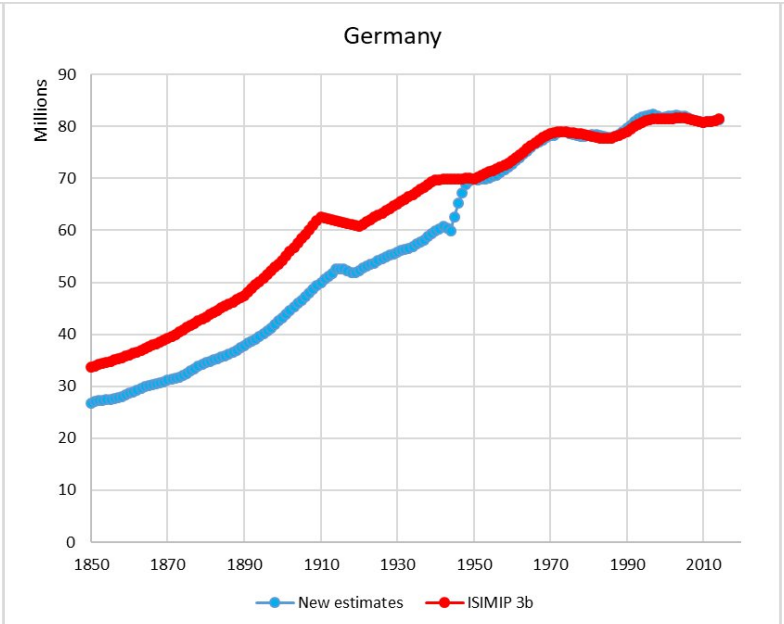
Historical | Historical + harmonization | Projections

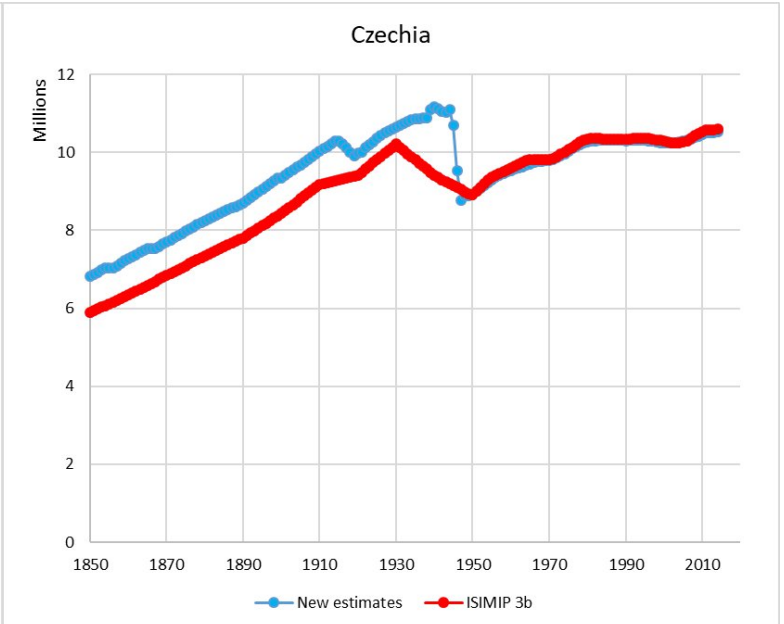
Dataset	Version	Resolution (used here)	Timesteps (used here)	Step (yrs)	Variables	Updates
National *						
MPD	2023	Country	1850-2010	1	GDP, population	Irregular
UN NAMAD	Jan 2025	Country	1970-2022	1	GDP	Annual
PWT	10.01	Country	1950-2019	1	Fixed assets, GDP	Irregular
UN WPP	2024 Rev.	Country	1950-2029	1	Population	Biannual
IMF WEO	Oct 2024	Country	1980-2029	1	GDP	2x per year
SSP	3.1.0	Country	2020-2100	5	GDP, population	Irregular
Gridded						
HYDE	3.2.1	5’ (~9 km)	1850-1980	10	Population	Irregular
GHSL	R2023A	30’’ (~1 km)	1975-2030	5	Population, build-up surface	Annual
Wang et al.	2022	30’’ (~1 km)	2020-2100	5	Population	None?

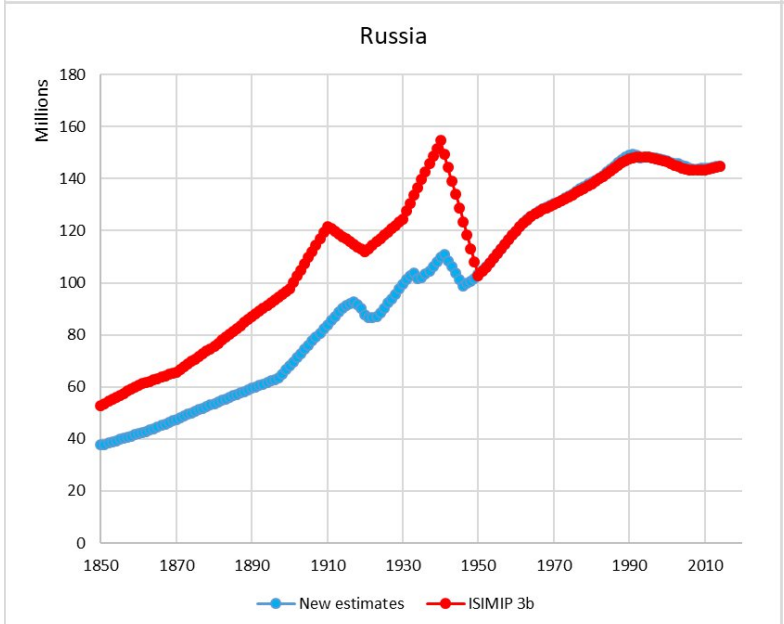
* 104 sources of historical data used in total so far

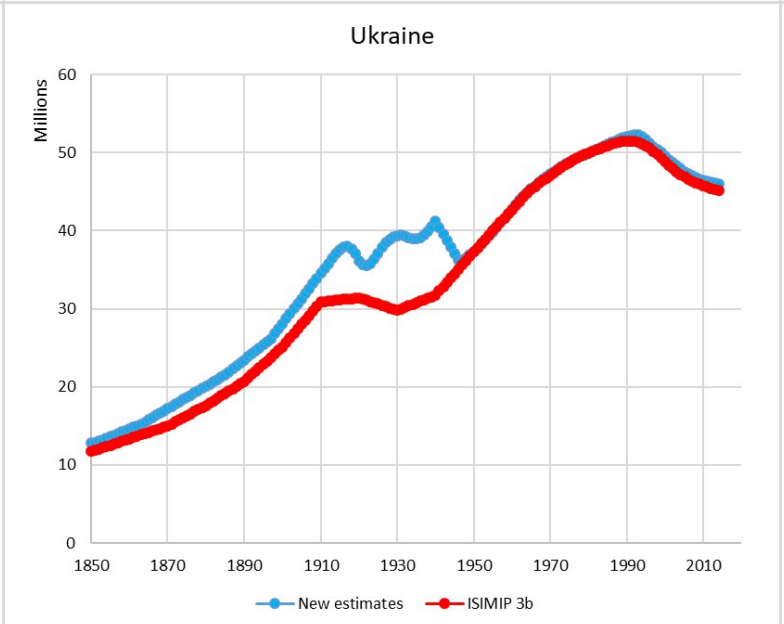
Correcting historical population estimates (present-day territories)

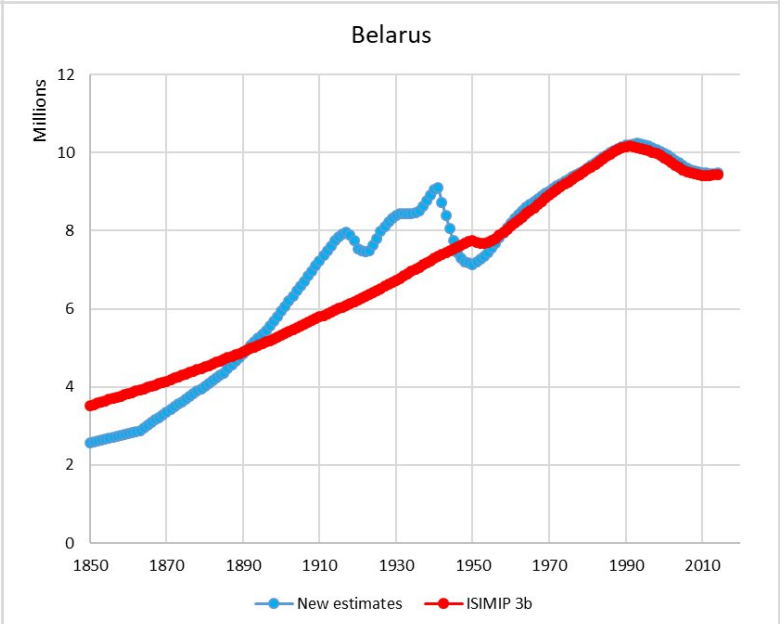




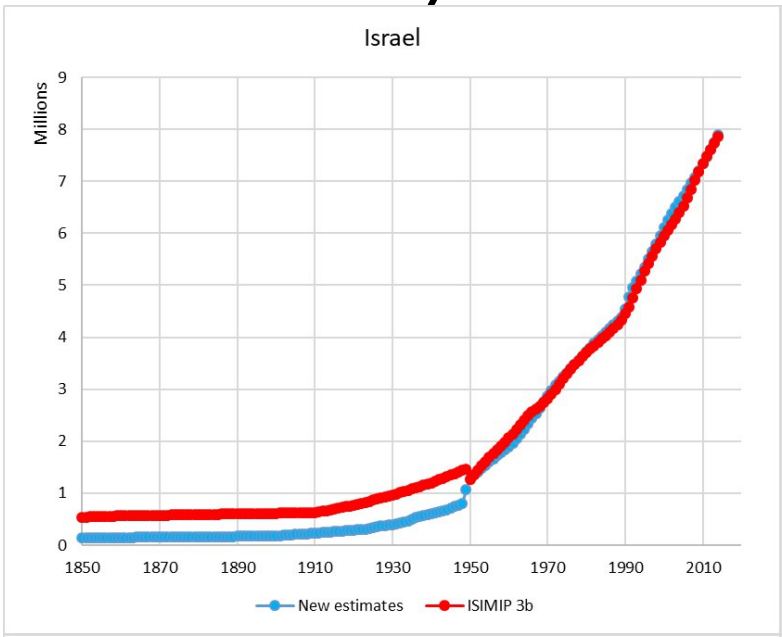


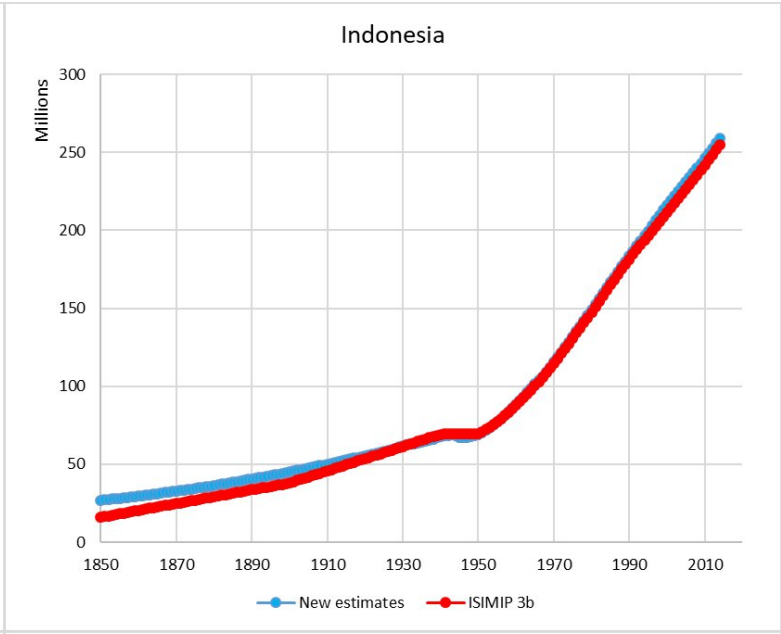


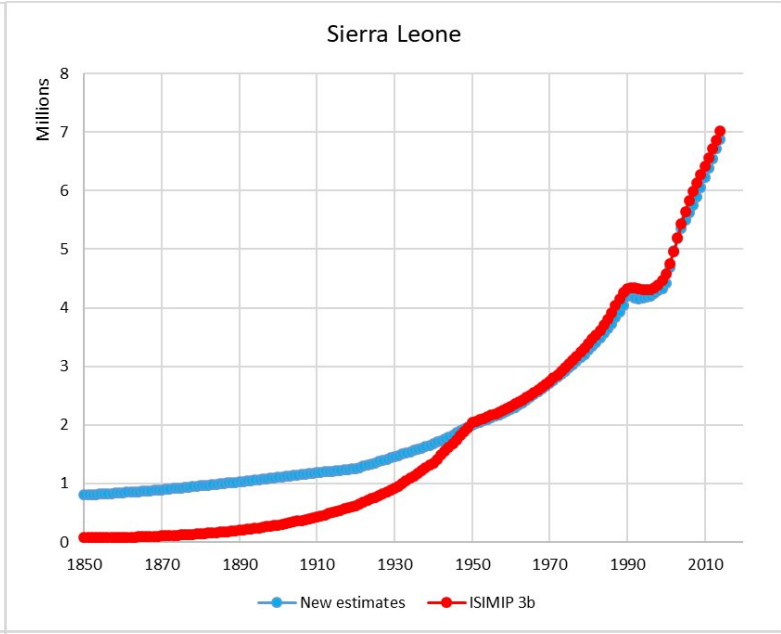


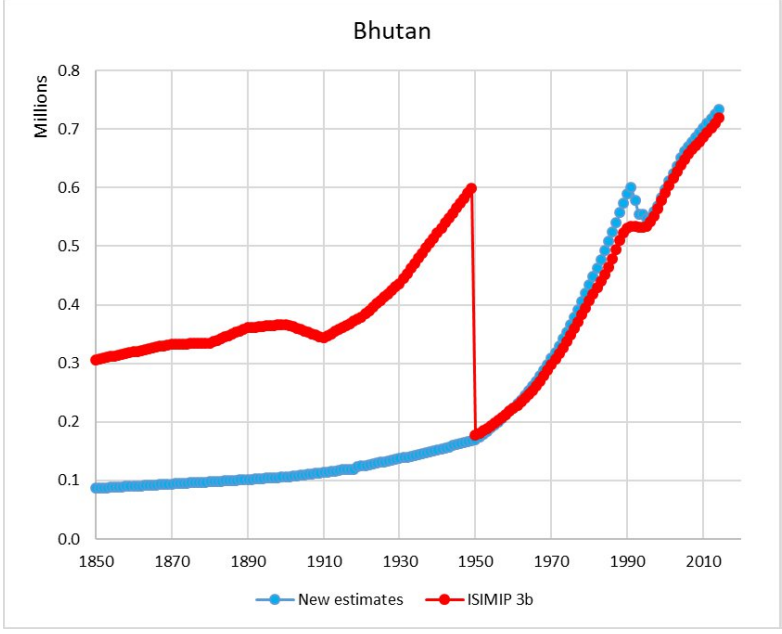


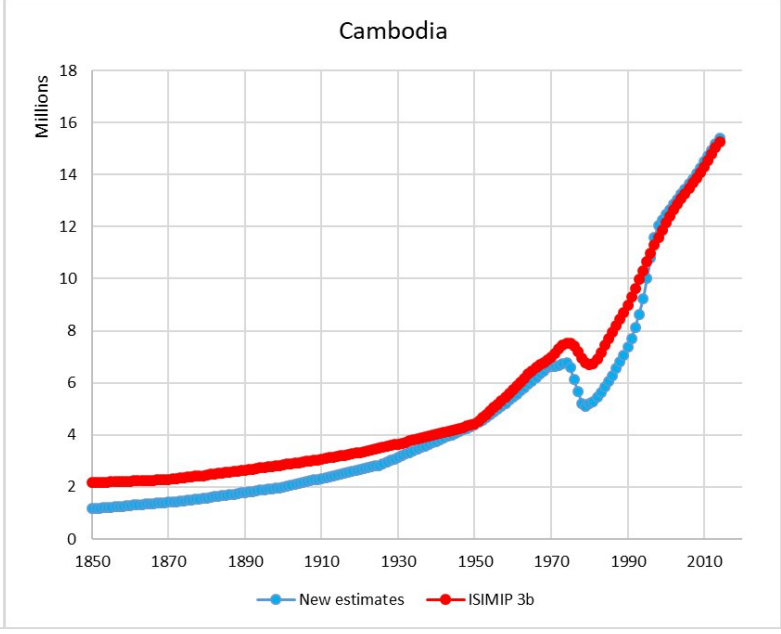
Correcting historical population estimates (present-day territories)

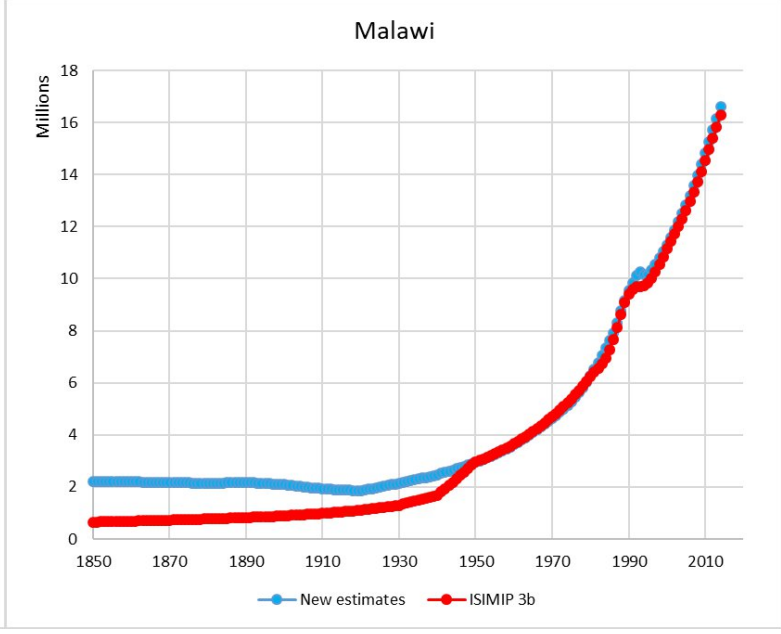




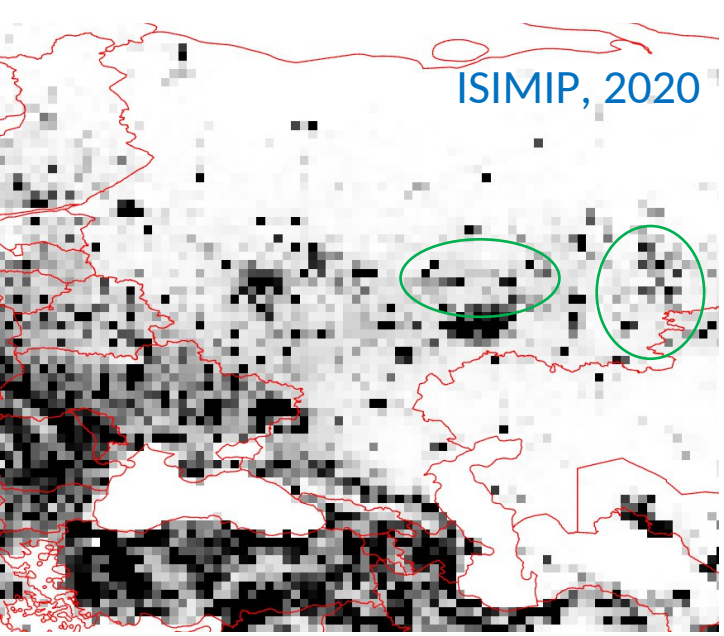


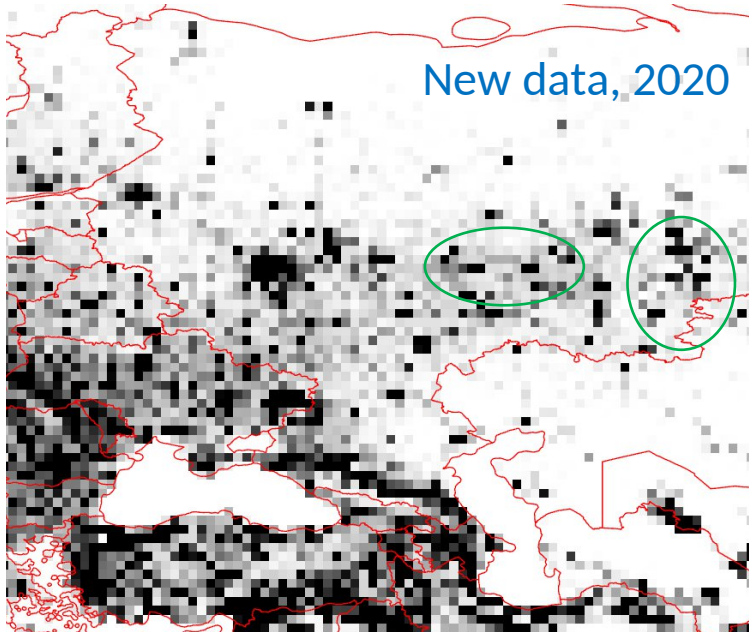


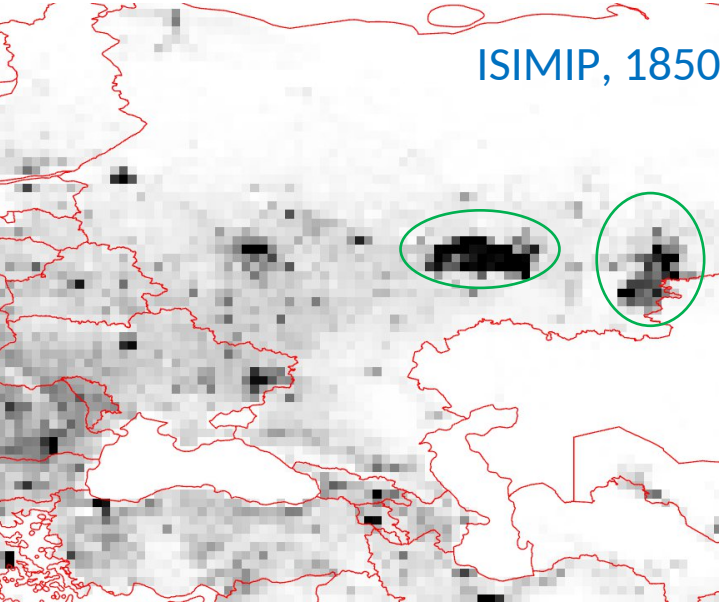


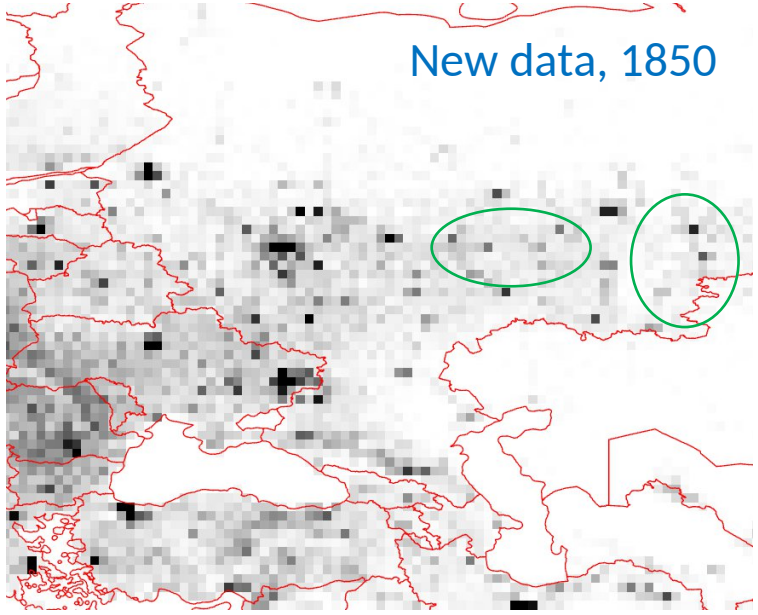


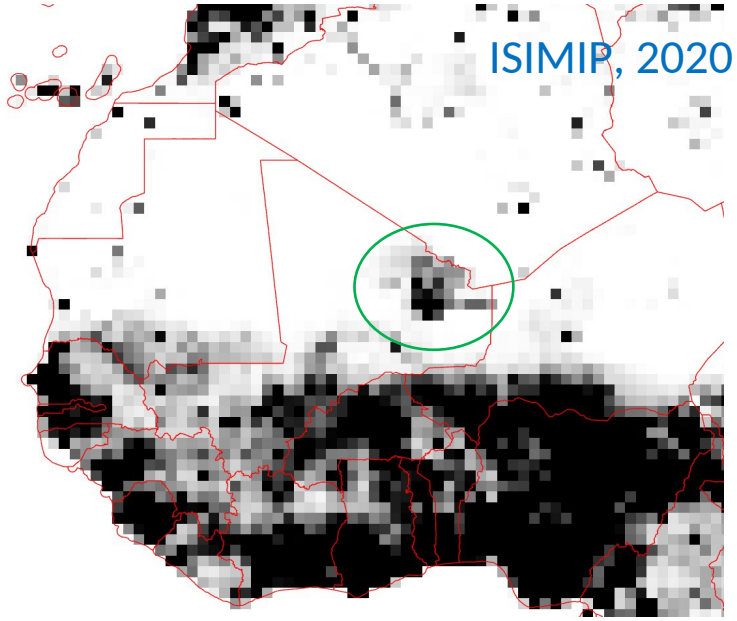
Correcting historical population estimates

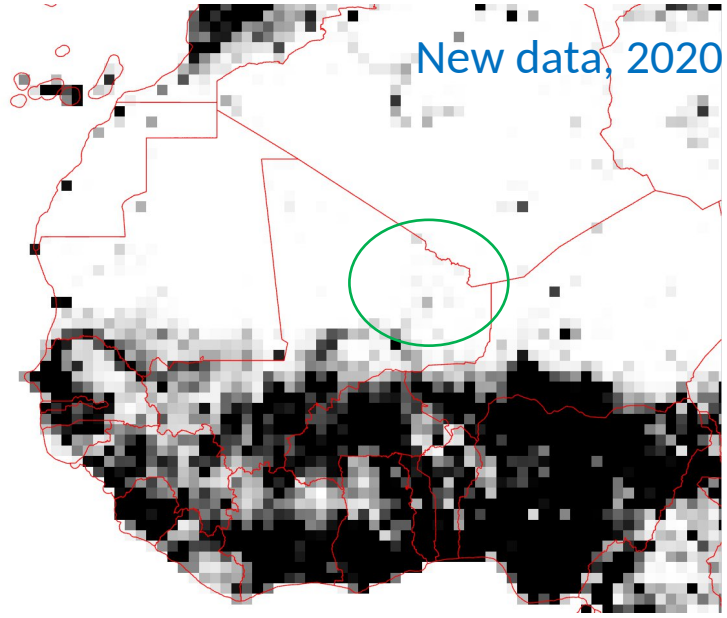




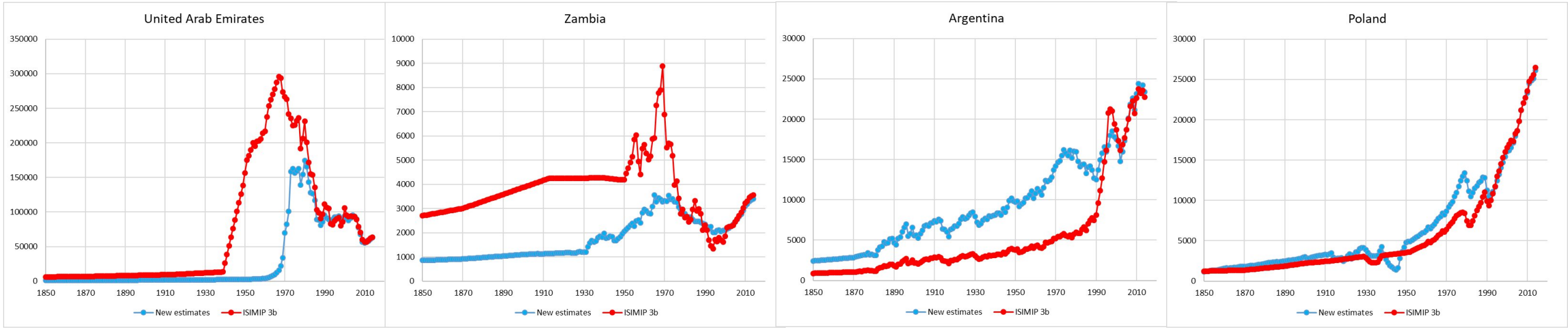


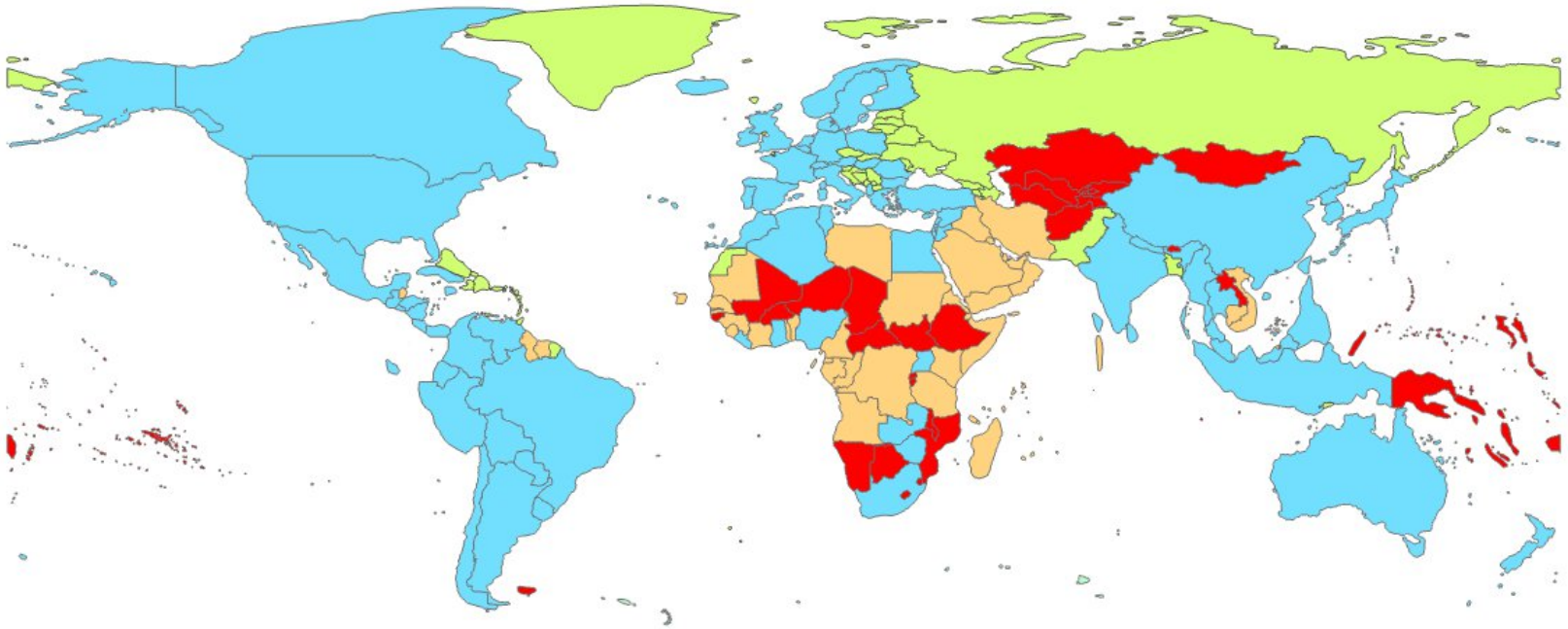






Adjusting historical GDP/capita estimates





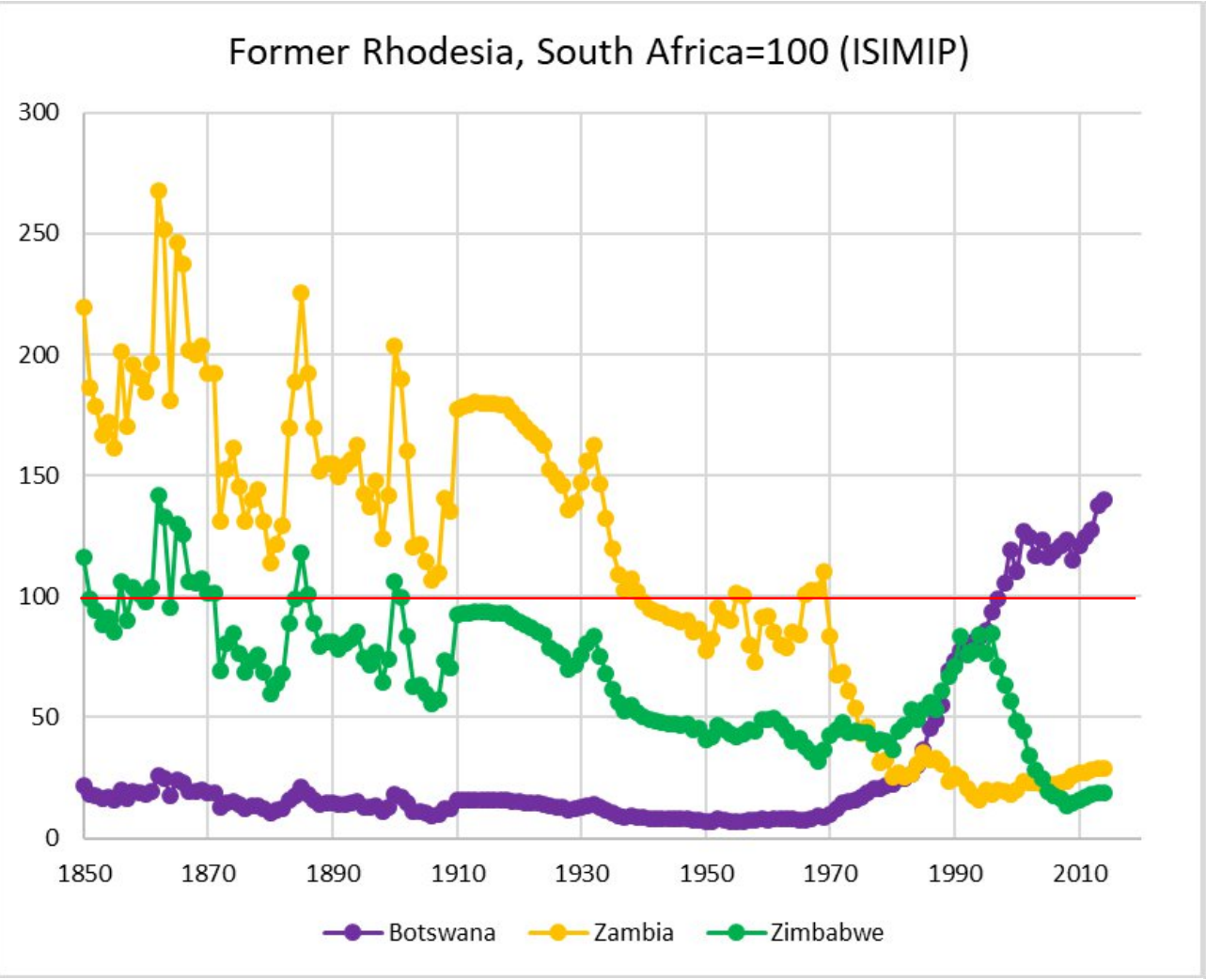
National timeseries (full/primarily)

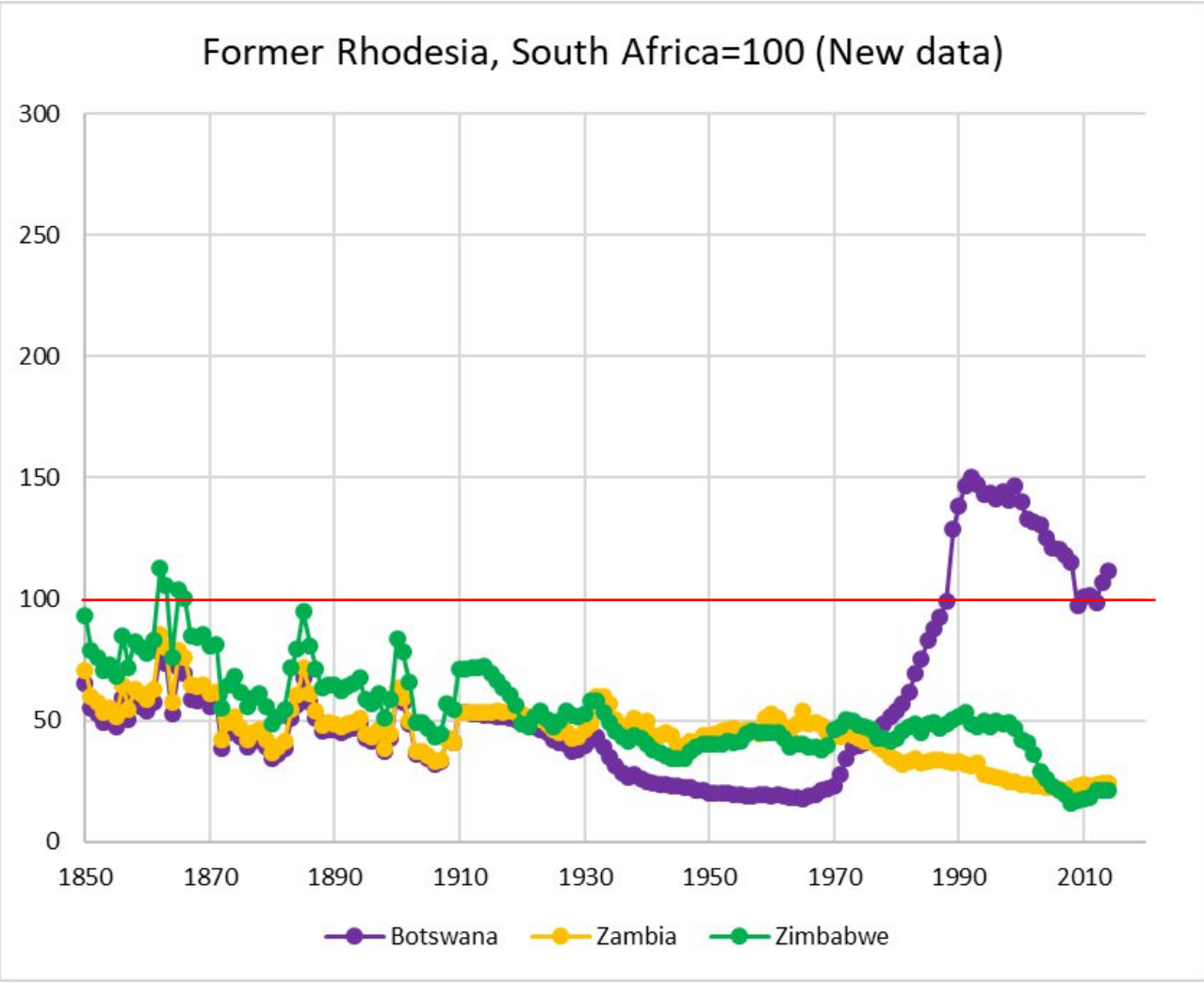
Disaggregated/transferred

Converge to regional estimates

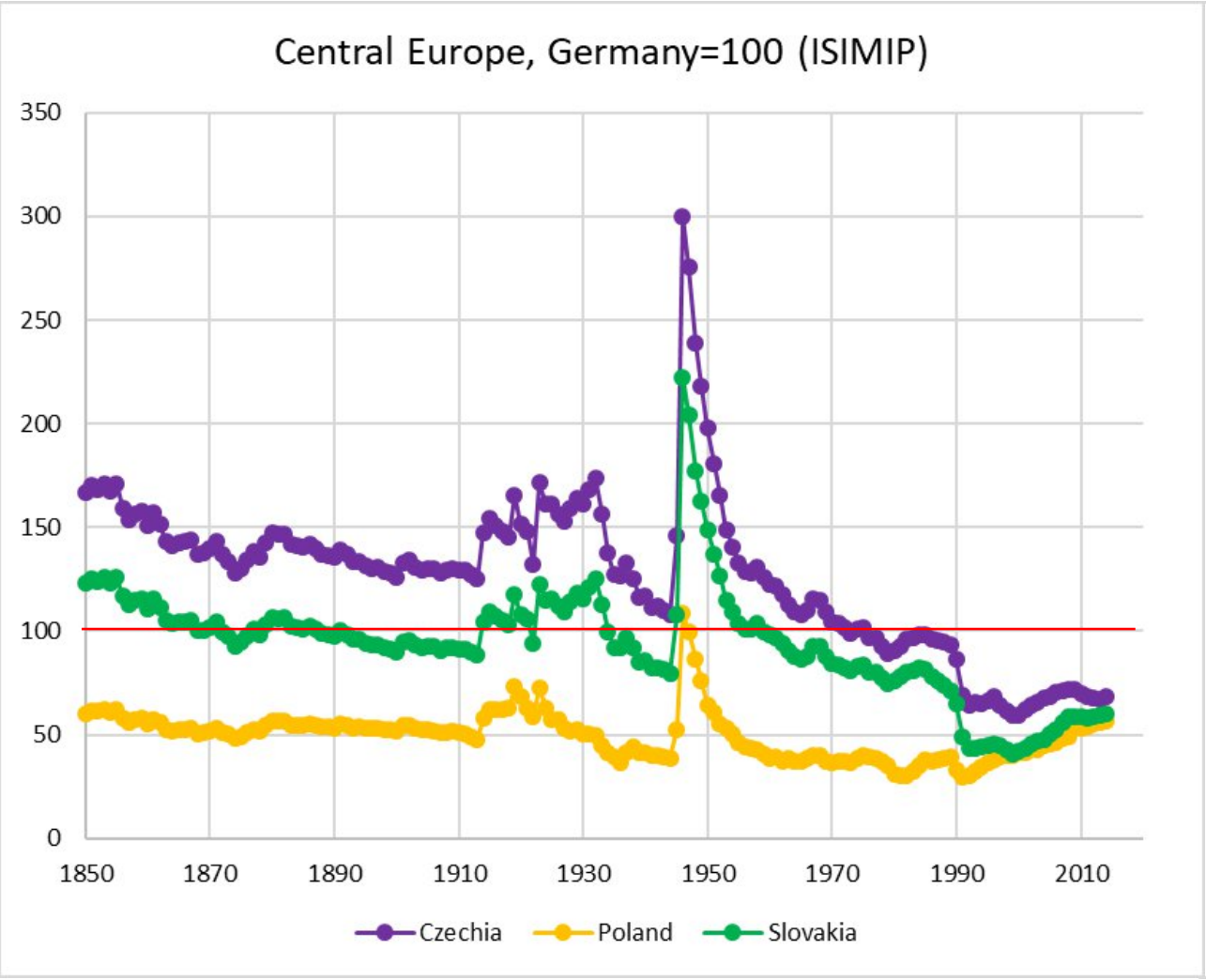
Start at subsistence level

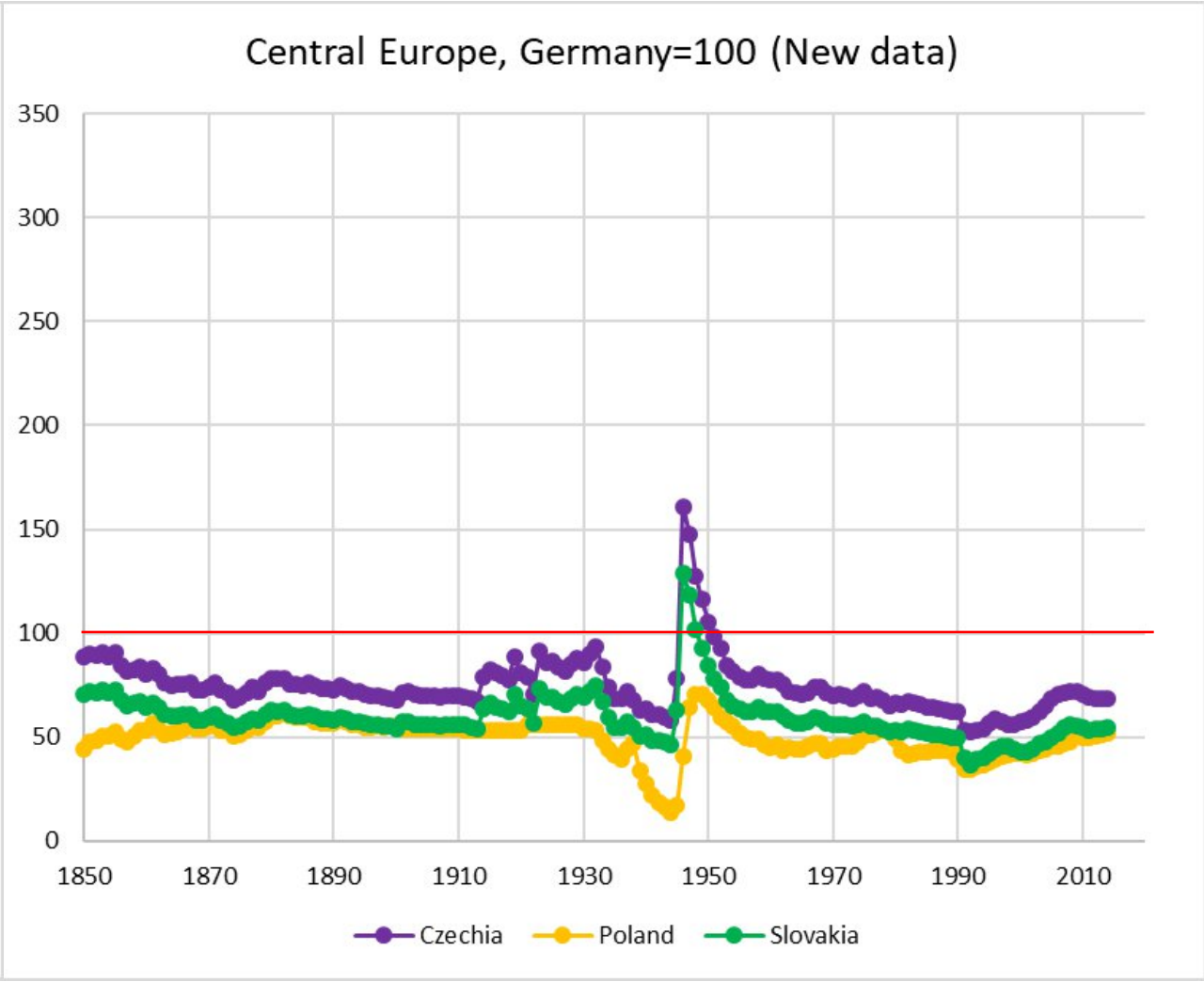
Adjusting historical GDP/capita estimates



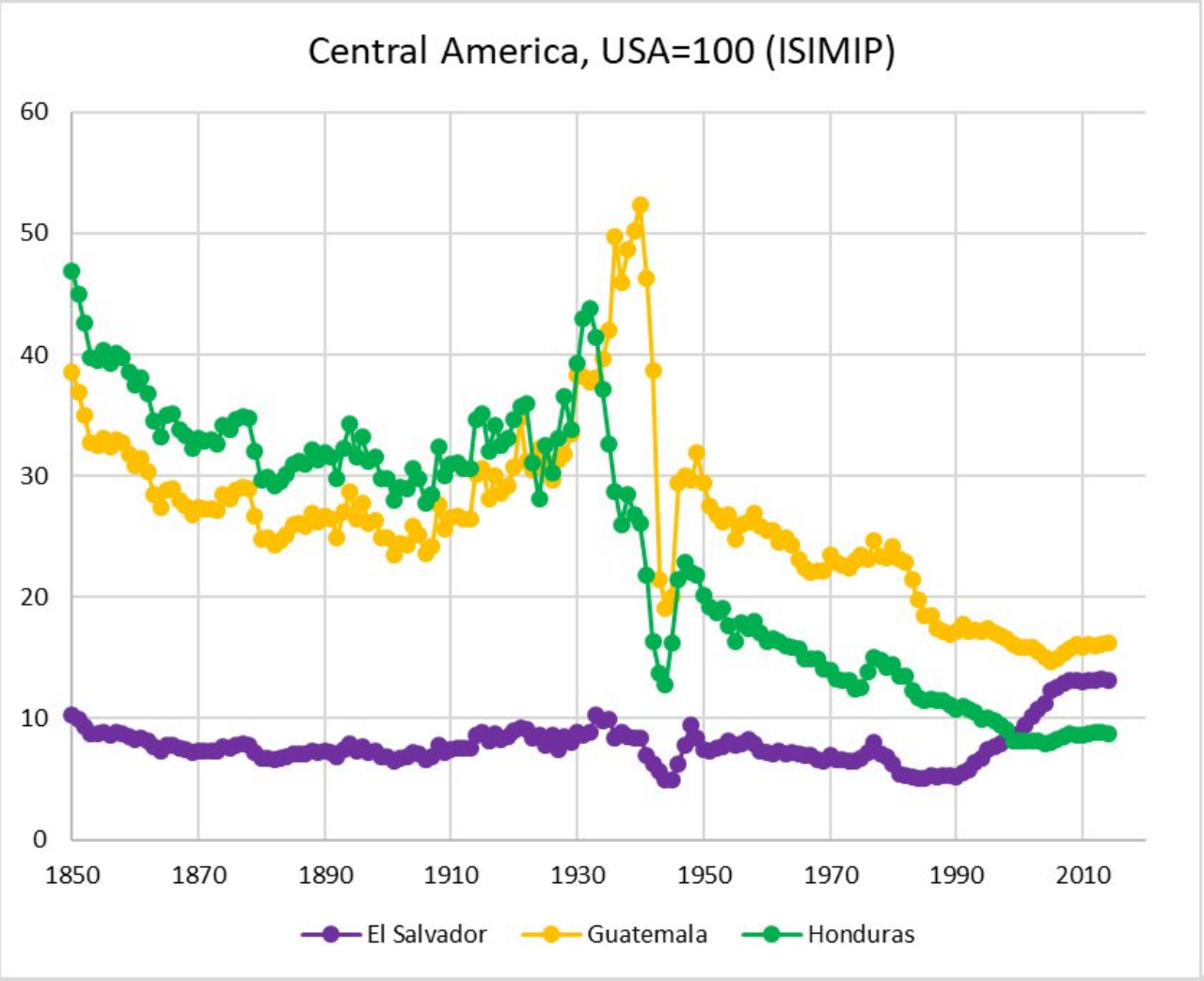


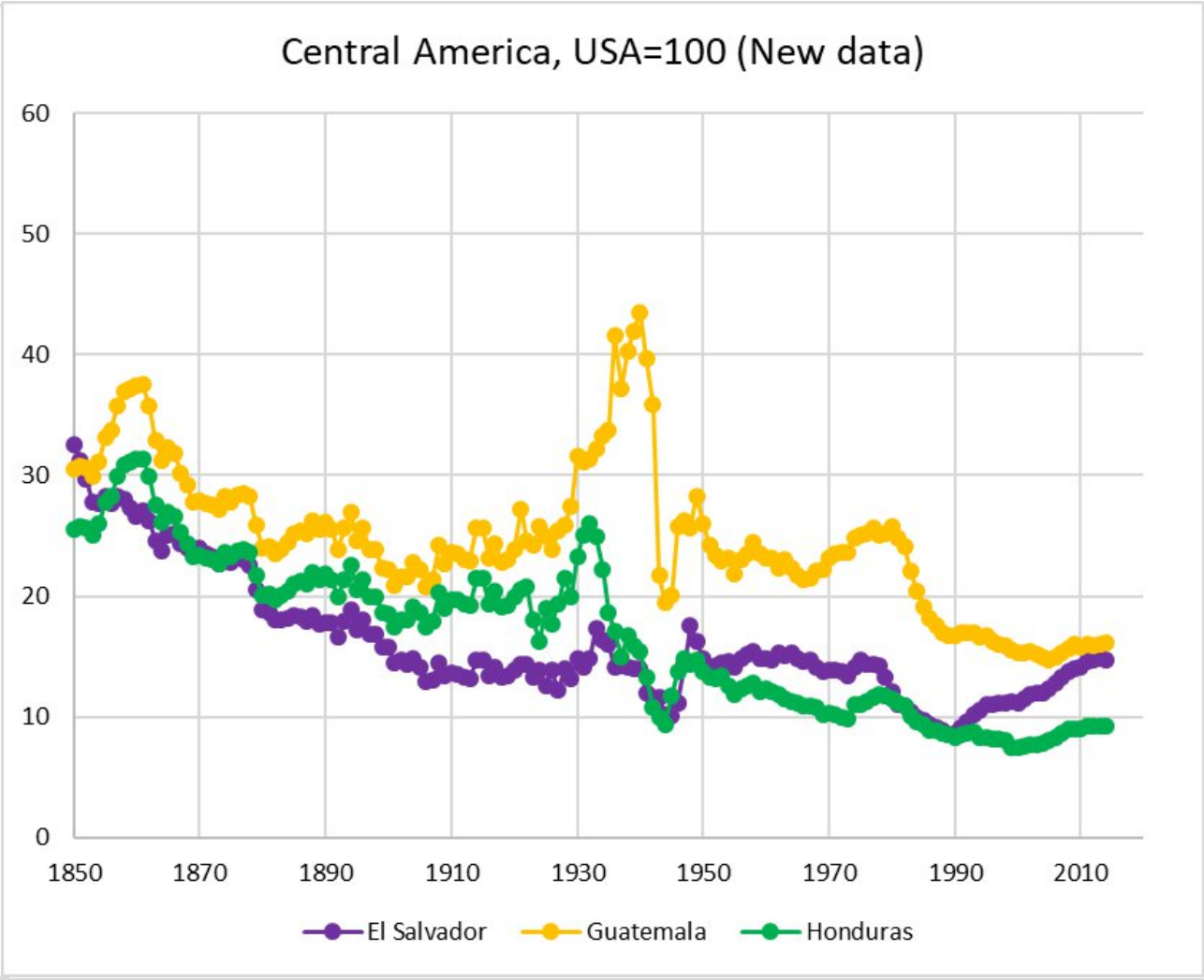
Adjusting historical GDP/capita estimates





Adjusting historical GDP/capita estimates





Adjusting historical GDP/capita estimates