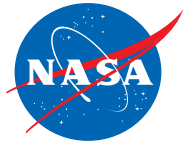

Center for International Earth Science Information Network
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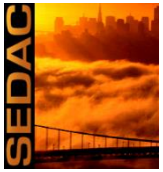


Gridded Population of the World, Version 4 (GPWv4): A Technical Review of the Development and Methods

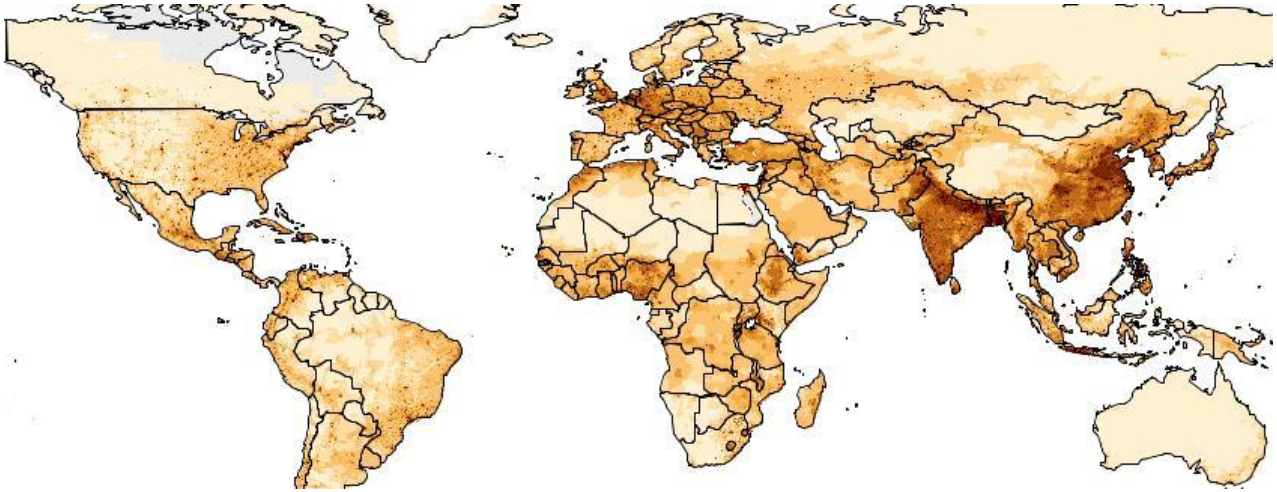
Erin Doxsey-Whitfield
Kytt MacManus
Susana B. Adamo

July 29, 2015
IGARSS – Milan, Italy

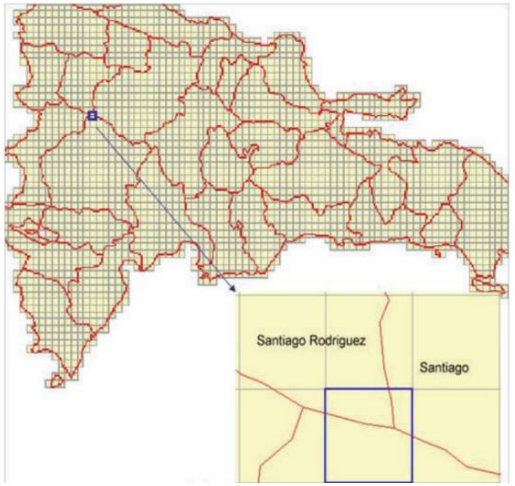
http://sedac.ciesin.columbia.edu

Gridded Population of the World

- Raster data product developed to provide a **spatially-disaggregated population surface** that is compatible with data sets from social, economic, and Earth science fields.
- Census population data are transformed from their native spatial units to a global grid of quadrilateral latitude-longitude cells (Balk et al. 2010)
- Free and openly available



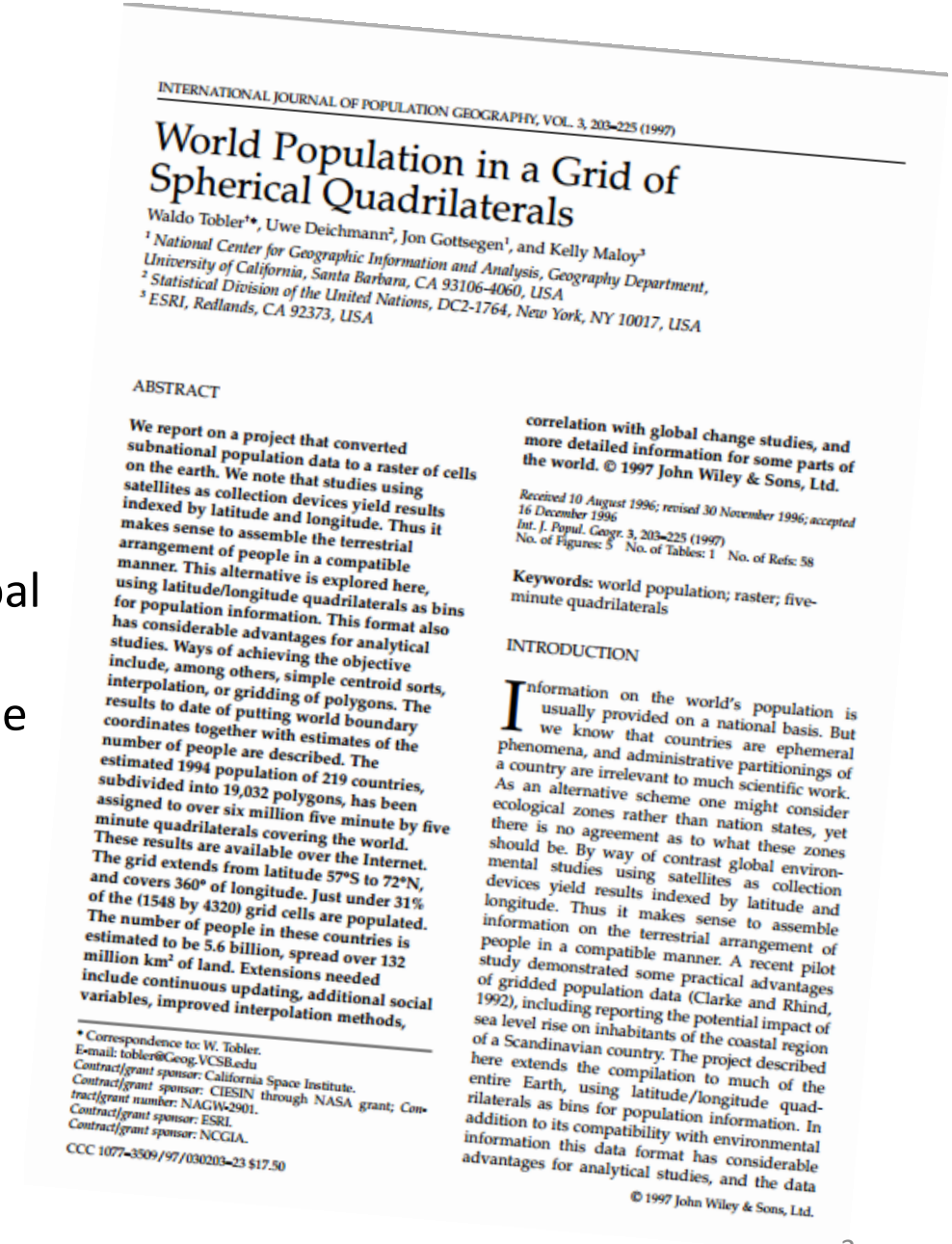
GPW version 3, 2000 population density



Transforming census units to a grid

History of GPW

- GPWv1 was an outgrowth of a Global Demography Workshop held at CIESIN in 1994
- Consensus that a consistent global database of population totals in raster format would be invaluable for interdisciplinary study (Deichmann et al., 2001)
- Produced by Waldo Tobler, Uwe Deichmann, Jon Gottsegen, and Kelly Maloy at the UC Santa Barbara



INTERNATIONAL JOURNAL OF POPULATION GEOGRAPHY, VOL. 3, 203–225 (1997)

World Population in a Grid of Spherical Quadrilaterals

Waldo Tobler[1]*, Uwe Deichmann[2], Jon Gottsegen[1], and Kelly Maloy[3]
[1] National Center for Geographic Information and Analysis, Geography Department, University of California, Santa Barbara, CA 93106-4060, USA
[2] Statistical Division of the United Nations, DC2-1764, New York, NY 10017, USA
[3] ESRI, Redlands, CA 92373, USA

ABSTRACT

We report on a project that converted subnational population data to a raster of cells on the earth. We note that studies using satellites as collection devices yield results indexed by latitude and longitude. Thus it makes sense to assemble the terrestrial arrangement of people in a compatible manner. This alternative is explored here, using latitude/longitude quadrilaterals as bins for population information. This format also has considerable advantages for analytical studies. Ways of achieving the objective include, among others, simple centroid sorts, interpolation, or gridding of polygons. The results to date of putting world boundary coordinates together with estimates of the number of people are described. The estimated 1994 population of 219 countries, subdivided into 19,032 polygons, has been assigned to over six million five minute by five minute quadrilaterals covering the world. These results are available over the Internet. The grid extends from latitude 57°S to 72°N, and covers 360° of longitude. Just under 31% of the (1548 by 4320) grid cells are populated. The number of people in these countries is estimated to be 5.6 billion, spread over 132 million km² of land. Extensions needed include continuous updating, additional social variables, improved interpolation methods, correlation with global change studies, and more detailed information for some parts of the world. © 1997 John Wiley & Sons, Ltd.

* Correspondence to: W. Tobler.
E-mail: tobler@Geog.VCSB.edu
Contract/grant sponsor: California Space Institute.
Contract/grant sponsor: CIESIN through NASA grant; Contract/grant number: NAGW-2901.
Contract/grant sponsor: ESRI.
Contract/grant sponsor: NCGIA.
CCC 1077-3509/97/030203-23 $17.50

Received 10 August 1996; revised 30 November 1996; accepted 16 December 1996
Int. J. Popul. Geogr. 3, 203–225 (1997)
No. of Figures: 5 No. of Tables: 1 No. of Refs: 58

Keywords: world population; raster; five-minute quadrilaterals

INTRODUCTION

Information on the world's population is usually provided on a national basis. But we know that countries are ephemeral phenomena, and administrative partitionings of a country are irrelevant to much scientific work. As an alternative scheme one might consider ecological zones rather than nation states, yet there is no agreement as to what these zones should be. By way of contrast global environmental studies using satellites as collection devices yield results indexed by latitude and longitude. Thus it makes sense to assemble information on the terrestrial arrangement of people in a compatible manner. A recent pilot study demonstrated some practical advantages of gridded population data (Clarke and Rhind, 1992), including reporting the potential impact of sea level rise on inhabitants of the coastal region of a Scandinavian country. The project described here extends the compilation to much of the entire Earth, using latitude/longitude quadrilaterals as bins for population information. In addition to its compatibility with environmental information this data format has considerable advantages for analytical studies, and the data

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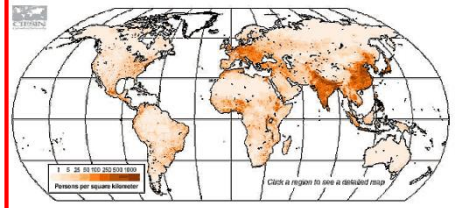
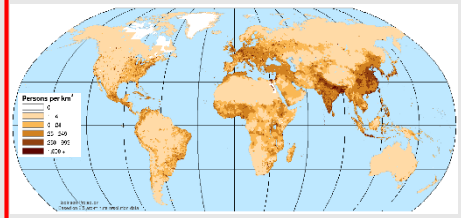
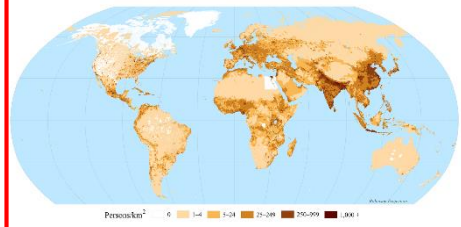
Development of GPW

	Publication Year	Years of Estimation	Grid Resolution	Number of Input Units (subnational geographic units)	Census variables	Population Density Grid
GPWv1	1995	1994	5 arc-minute (10 km)	19,000	Total Population	1994
GPWv2	2000	1990, 1995	2.5 arc-minute (5 km)	127,000	Total Population	 1995
GPWv3	2005	1990, 1995, 2000	2.5 arc-minute (5 km)	~ 400,000	Total Population	 2000
GPWv4	2015	2000, 2005, 2010, 2015, 2020	30 arc-second (1 km)	~ 12,500,000	Total Population, Sex, Age, Urban/Rural status	 2010

GPWv4 Workflow

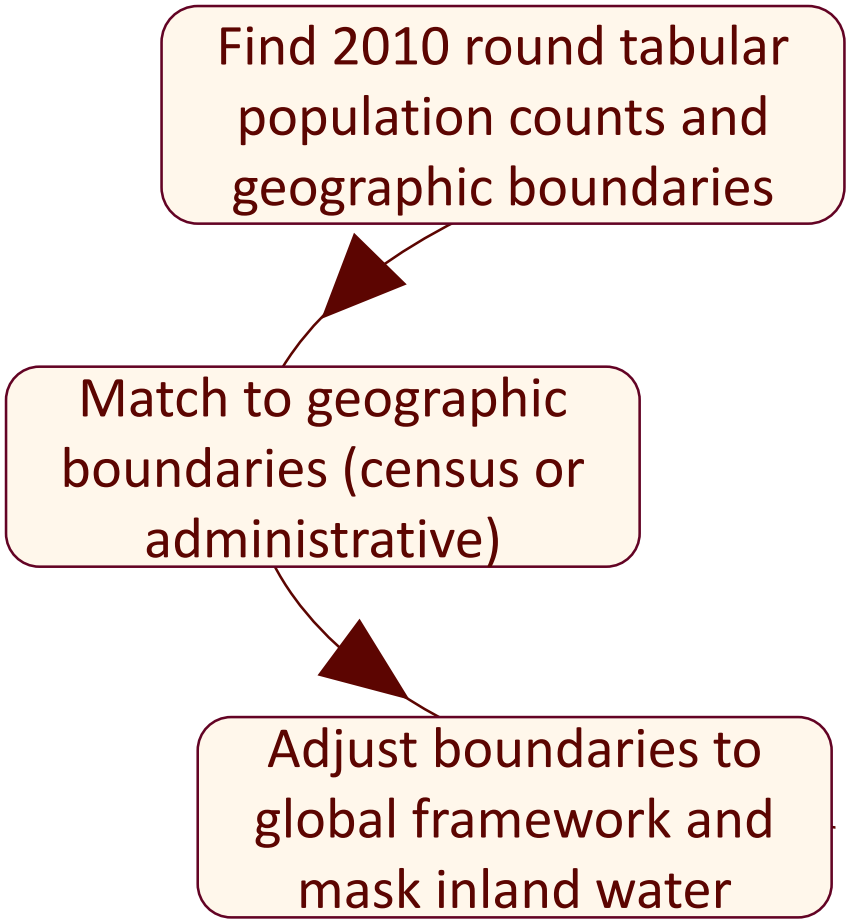
Find 2010 round tabular population counts and geographic boundaries

GPWv4 Workflow

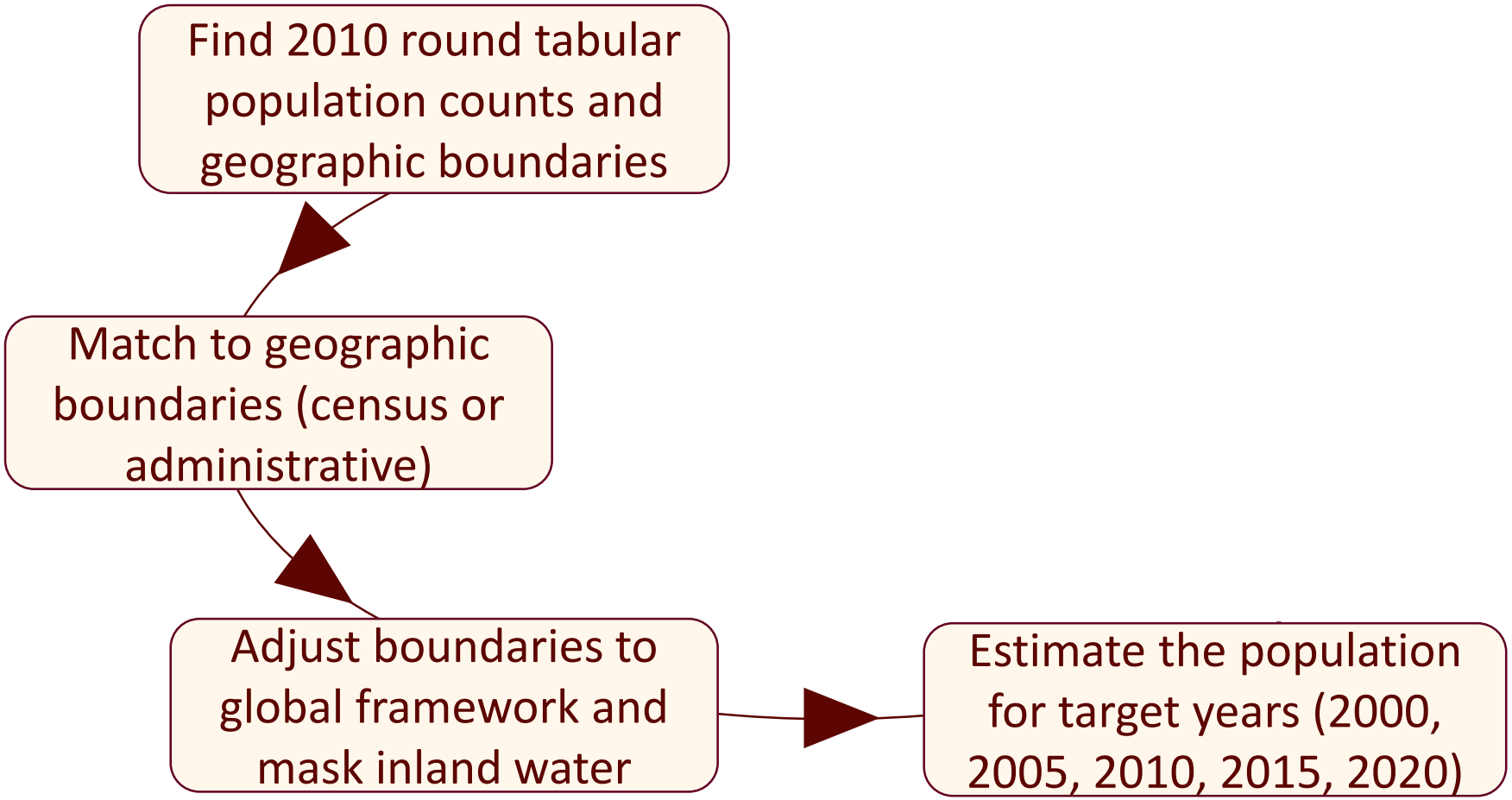
Find 2010 round tabular population counts and geographic boundaries

Match to geographic boundaries (census or administrative)

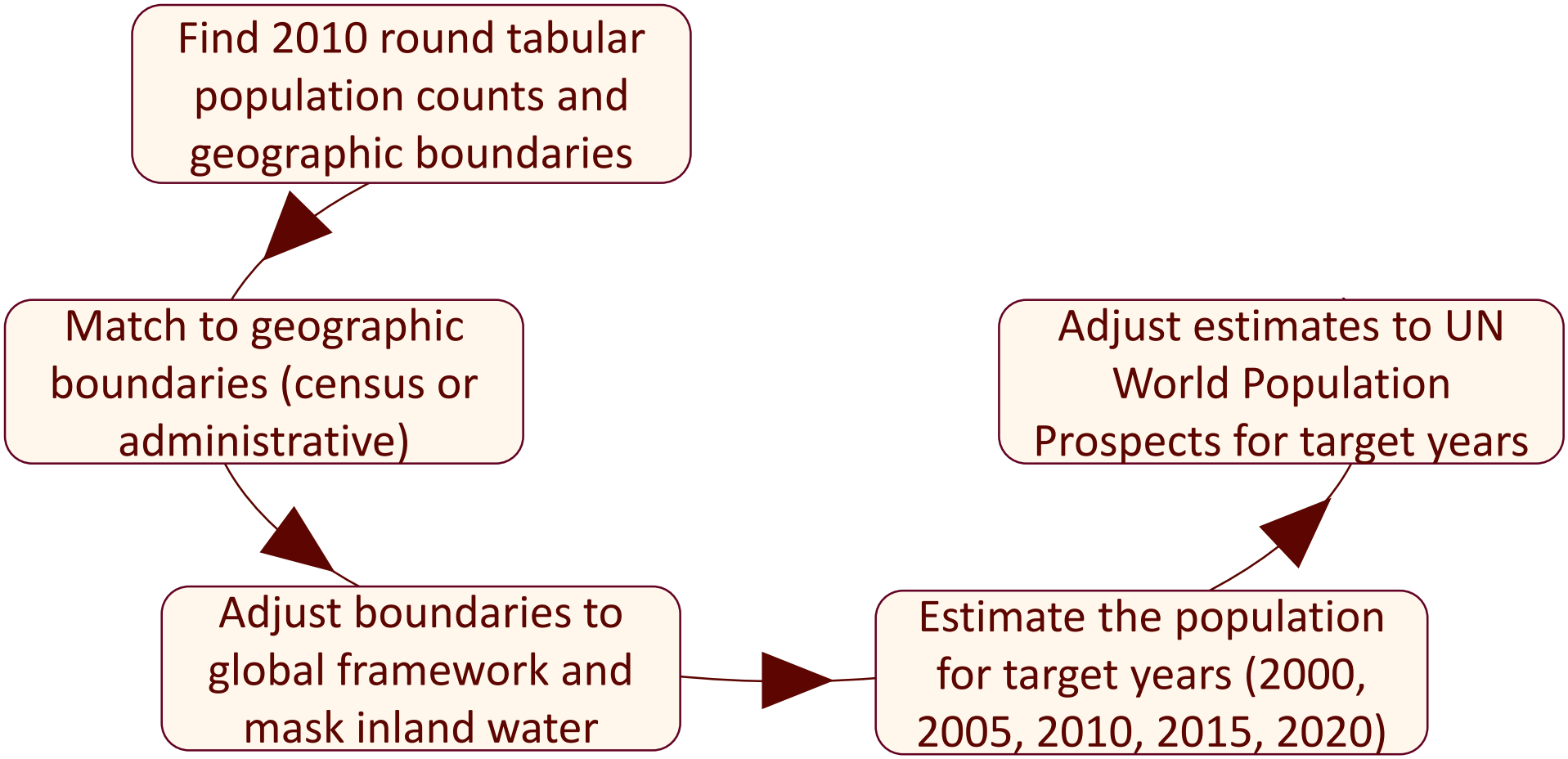
GPWv4 Workflow



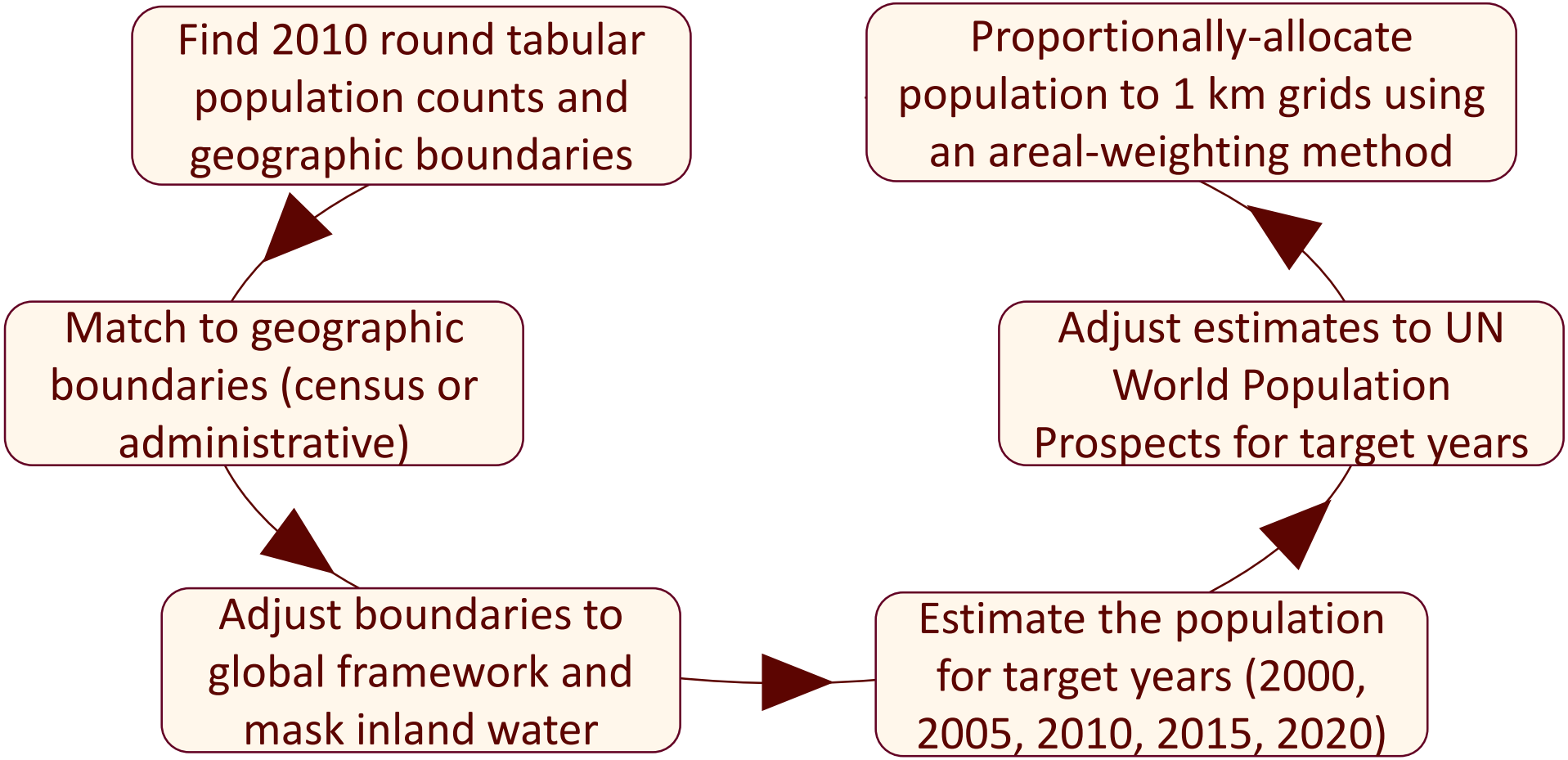
GPWv4 Workflow



GPWv4 Workflow

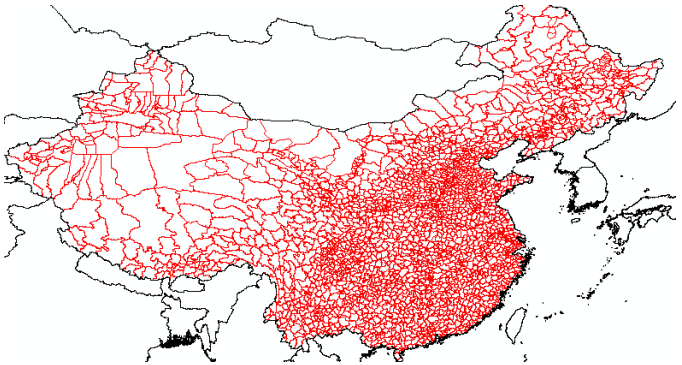


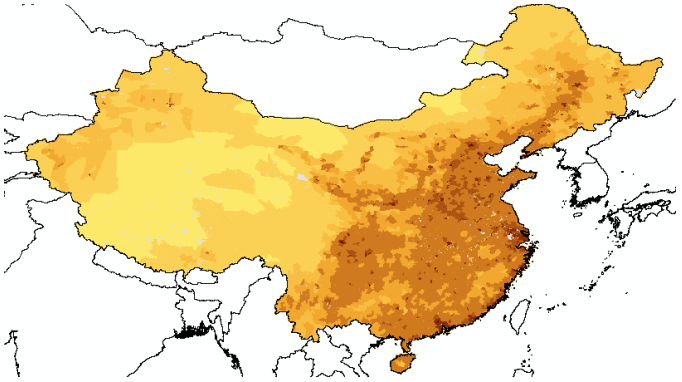
GPWv4 Workflow



GPW is minimally-modeled

- GPW uses the areal-weighting method
  - Uniformly distributes population based on land area
  - Does not incorporate ancillary data (e.g. land use/land cover, transportation networks, elevation, etc.)
- Maintains fidelity to input data
- The accuracy of GPW pixel estimates is directly related to the size of the input census units





Higher resolution boundaries in eastern China lead to more accurate population distributions

Improvements to GPWv4

1. Increased resolution of input census units

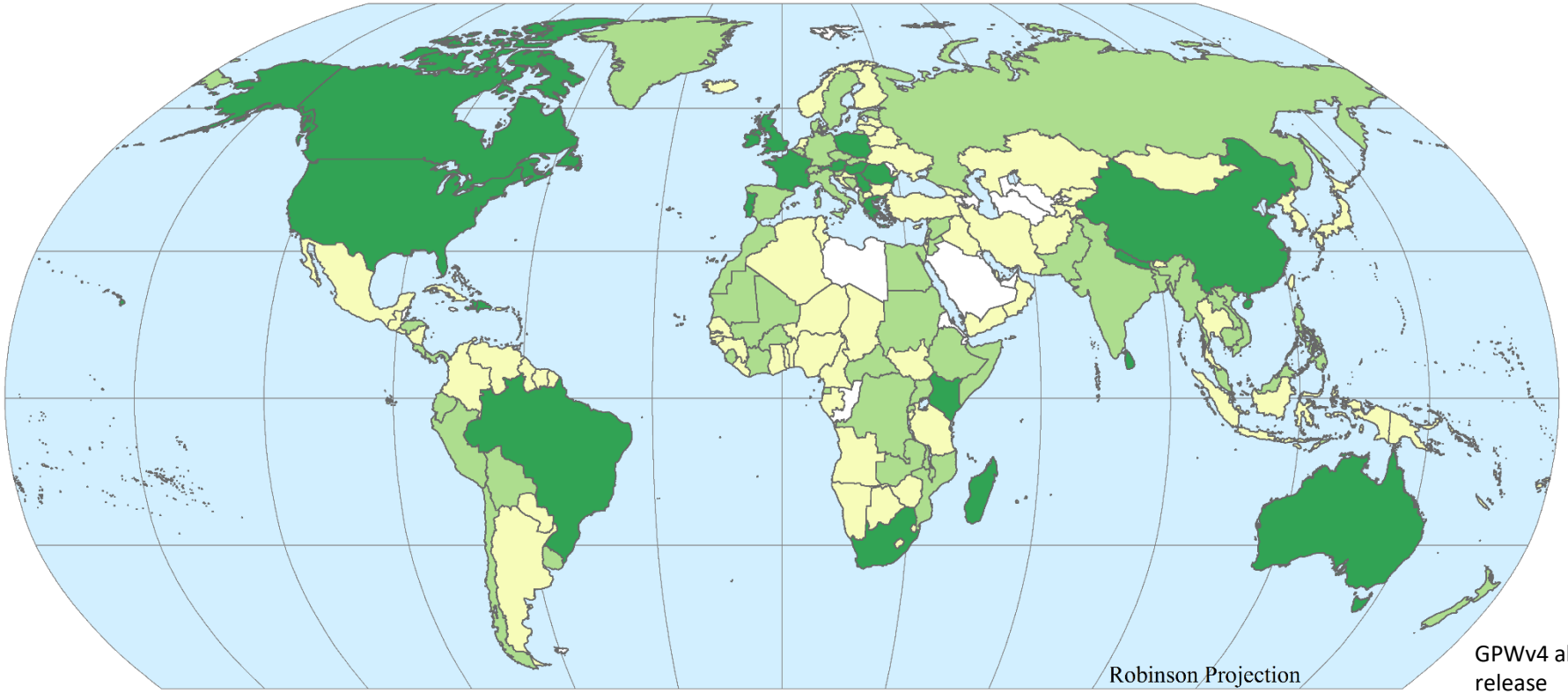
2. Addition of gridded census variables

1 Increased resolution of input census units

Number of Input Census Units

	GPWv3	GPWv4
Global	399,747	12,497,563

GPWv4 Administrative Level



GPWv4 alpha release

2 Addition of gridded census variables

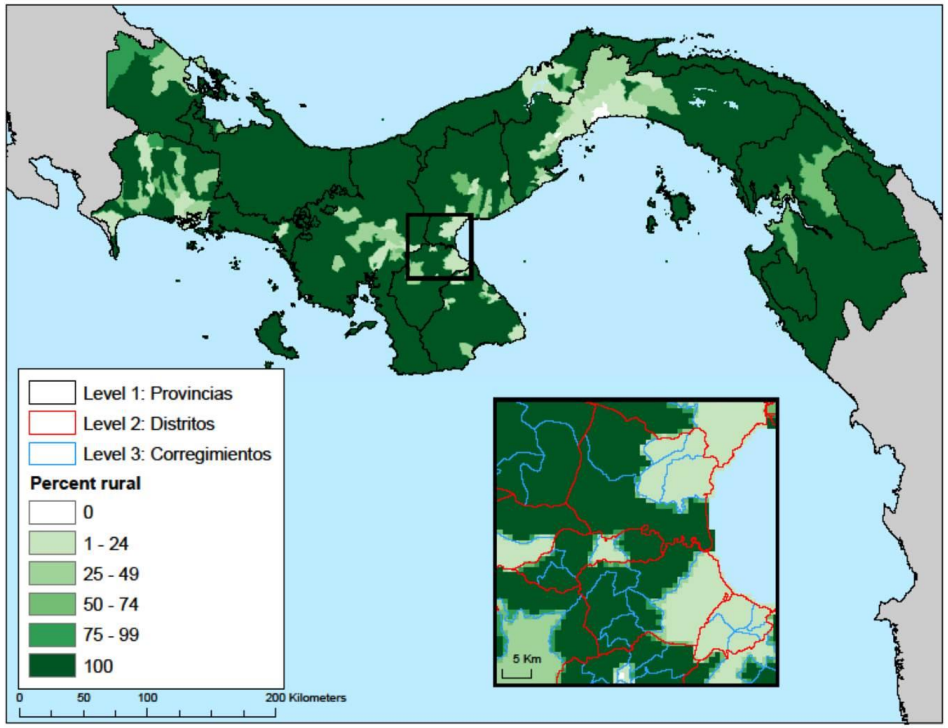
Demand to include demographic information in global population grids

GPWv4 will include detailed global grids for:

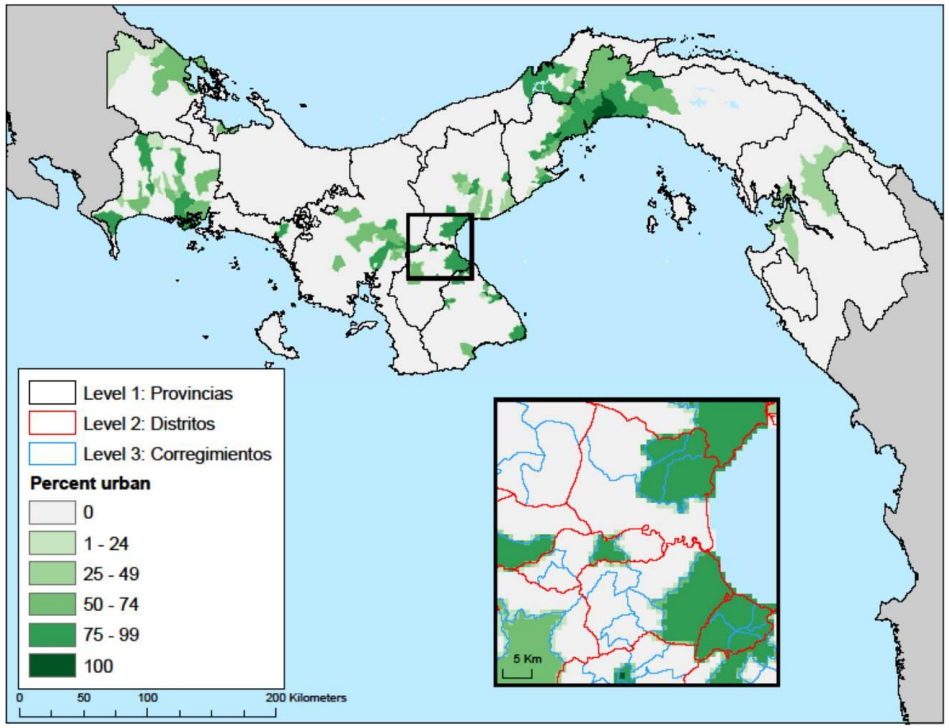
- Sex
- Age (single year or 5-year age groups)
- Urban/Rural status

2 Addition of gridded census variables

% Rural population, 2010, Panama



% Urban population, 2010, Panama



Improvements to GPWv4

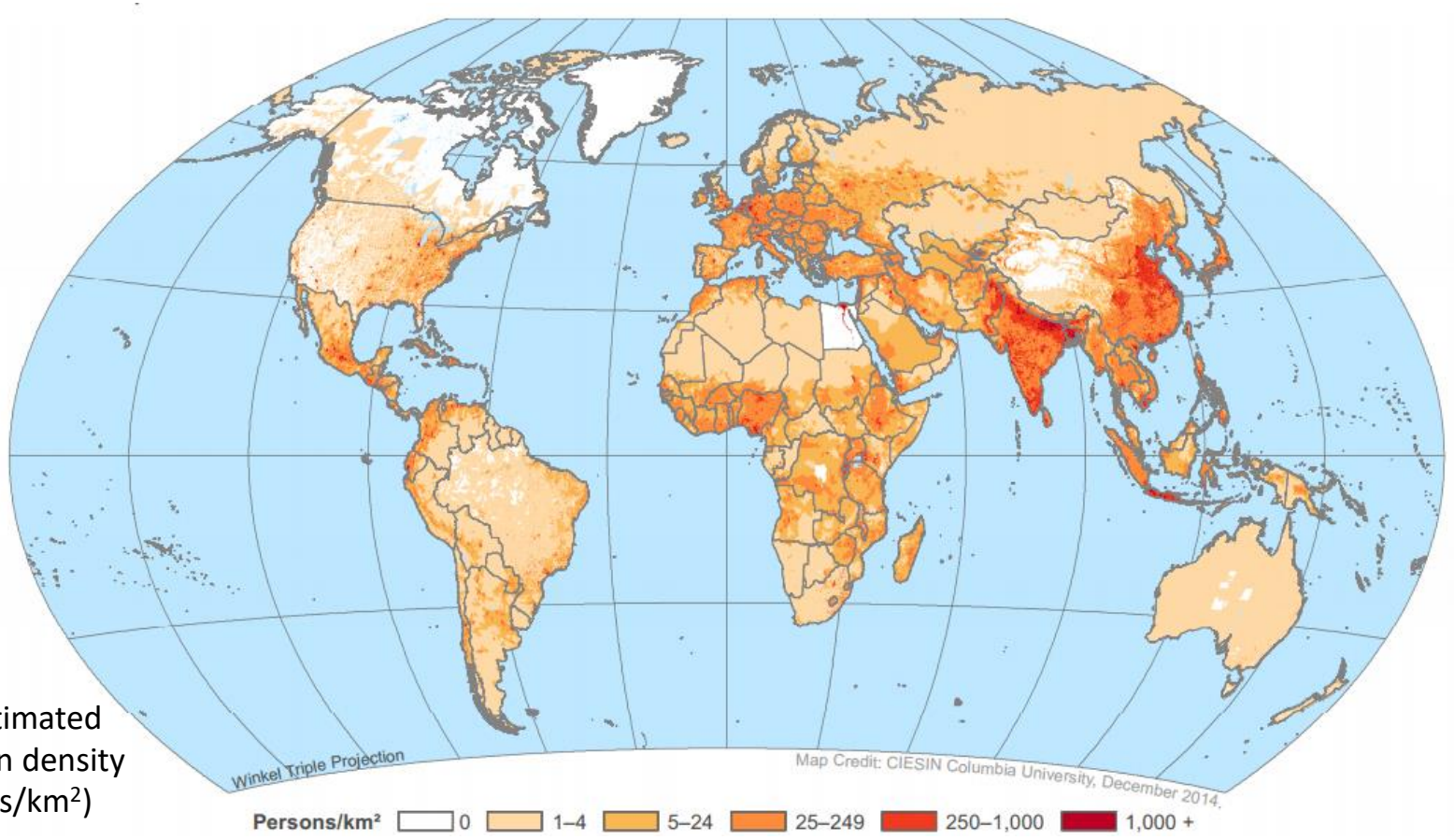
1. Increased resolution of input census units
   - Increases the accuracy of the data product
2. Addition of gridded census variables
   - Extends the applicability of GPWv4

GPWv4 Data Collection

- Population Density
- Population Count
- Land Area

- Data Quality Indicators:
  - Water Mask
  - Data Context
  - Mean Admin Unit Area

- National Identifier Grids
- Centroids



2010 estimated population density (persons/km^2)

Many gridded pop products

1994 → GPWv1

2015 → GPWv4, GRUMP, LandScan, WorldPop, Geostat…

Different products for different uses

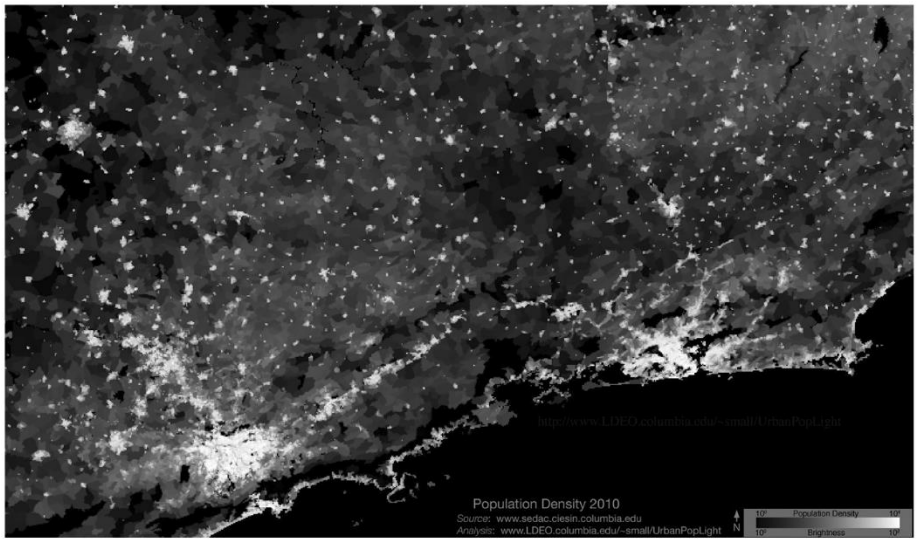
	Coverage	Resolution	Population	Method	Ancillary data used	Method consistency
GPWv4	Global	1km	Residential	Areal-weighting	None	Globally consistent
GRUMP	Global	1km	Residential	Dasymetric mapping	Nighttime lights, settlement points	Globally consistent
LandScan	Global	1km	Ambient	Dasymetric mapping	Roads, slope, elevation, land cover, urban boundaries, nighttime lights	Varies by country
WorldPop	Africa, Asia, Central and South America	100m - 1km	Residential	Dasymetric mapping	Land cover, settlement boundaries, roads, nighttime lights, health facility locations	Varies by country
Geostat	Europe	1km	Residential	Aggregation of microcensus; disaggregation and spatial modelling	Land cover, roads	Varies by country

Additional GPWv4 Modeling

- GHSL
  - Integration of GPW and GHSL via a joint project with JRC
- VIIRS
  - Day-Night band from the joint NASA-JAXA Suomi NPP satellite
  - Relationship between high resolution census data (population density) and emitted lights
  - Use relationship to reallocate population in areas of low resolution census data

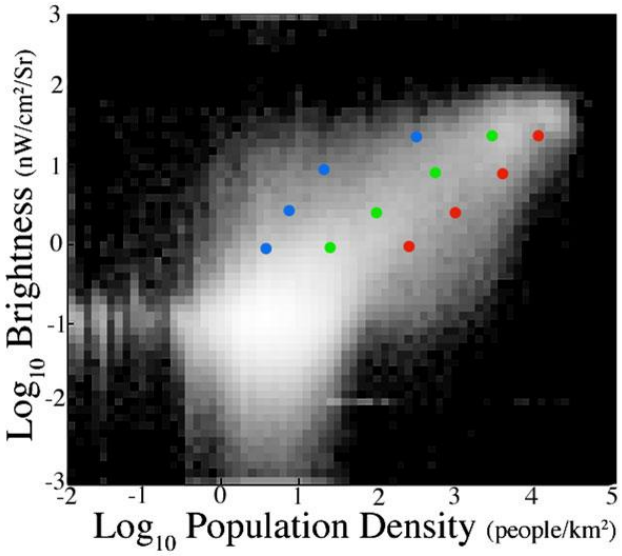
Population-Light Relationship

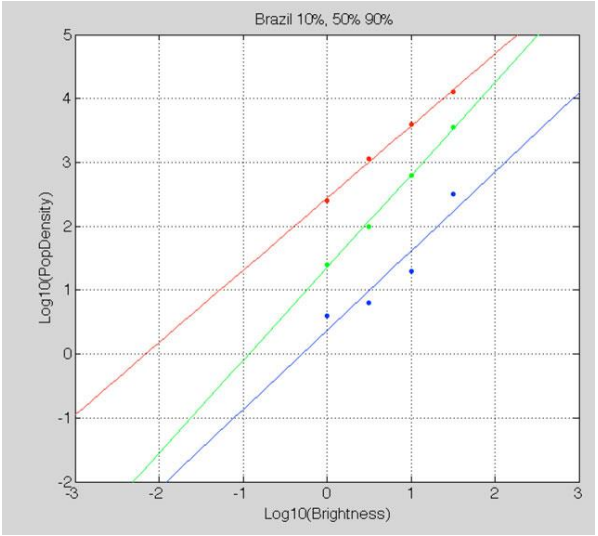
GPWv4 population density



VIIRS brightness

Scatterplot

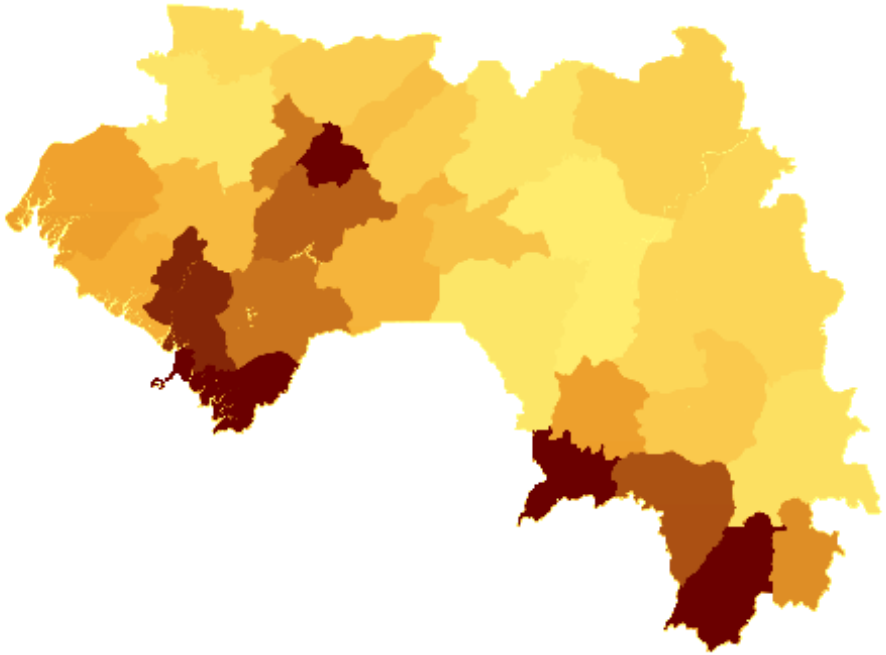




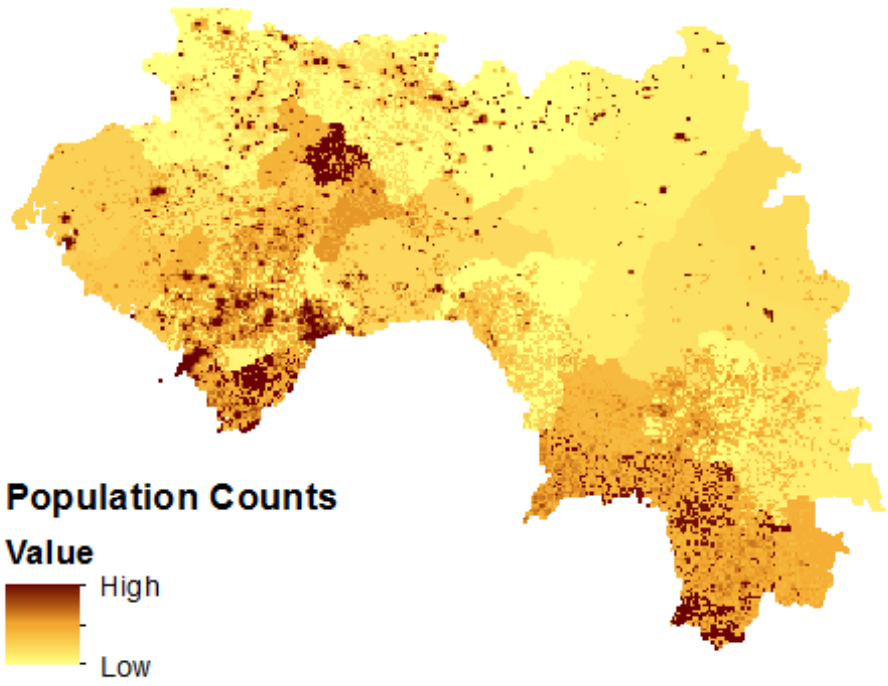
Linear transfer functions

VIIRS Test Case: Guinea

Proportional Allocation (GPWv4)



VIIRS Reallocation



Overall, GPW is a census-based global population grid that is:

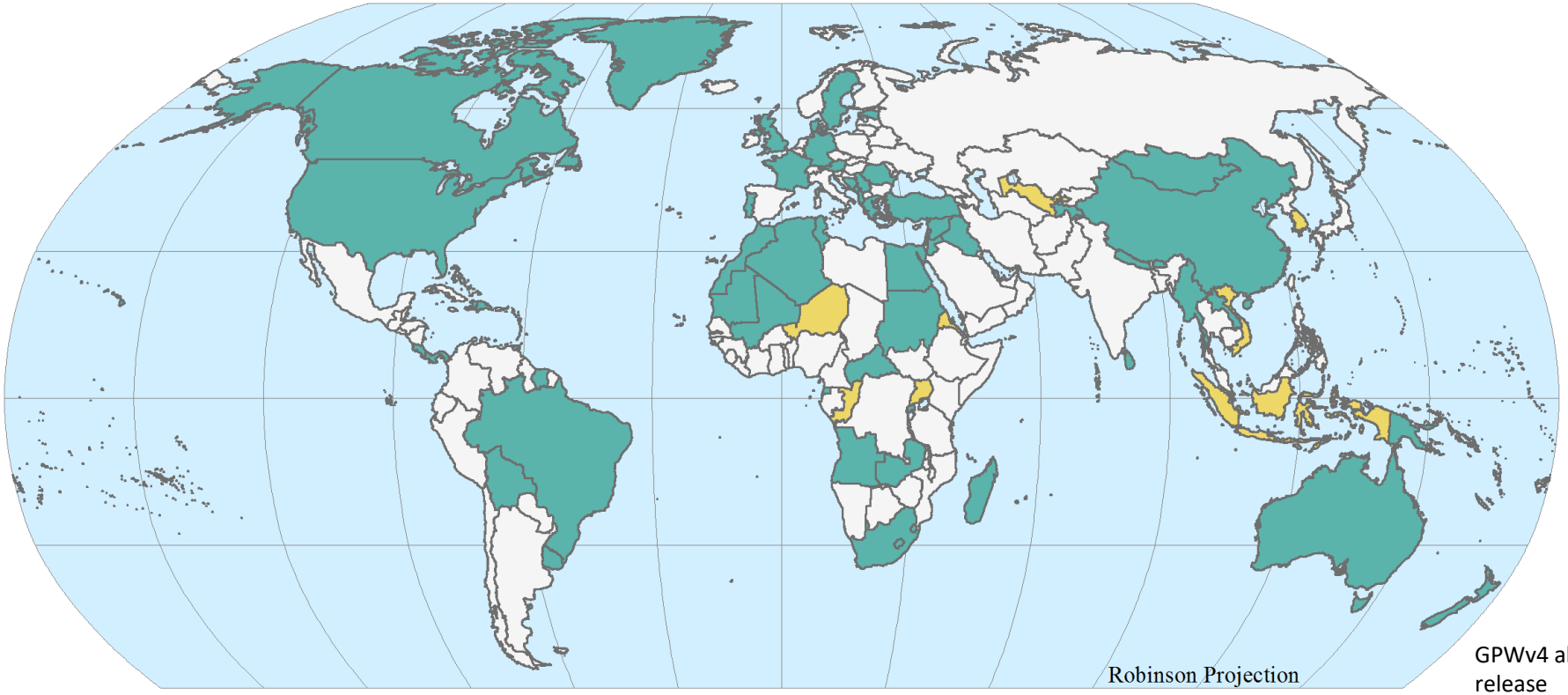
- **Free and open source**
- **Well-documented**
- **Transparent**
- **Highly used**
- **Widely applicable**

How to access data:

- **GPWv3: http://sedac.ciesin.columbia.edu/data/collection/gpw-v3**
- **GPWv4: Email gpw@ciesin.columbia.edu to request alpha data**

Erin Doxsey-Whitfield
edwhitfi@ciesin.columbia.edu

Improvements in Input Data Resolution



GPWv4 alpha release

Lower resolution than GPWv3
11 countries

Same as GPWv3
132 countries

Higher resolution than GPWv3
98 countries