Modification and application of urban properties tool (UPT) in CLM5 input surface data

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Tool source: http://www.cgd.ucar.edu/iam/projects/thesis/thesis- urbanproperties-tool.html;

Outline

1. What is Urban Properties Tool ?

2. How to operate the UPT ?

3. Output results based on UPT

1.Introduction

1.1 why uses urban properties tool (UPT) ?

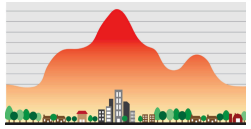
Air pollution

Water pollution

Urbanization

Food security

Urban island



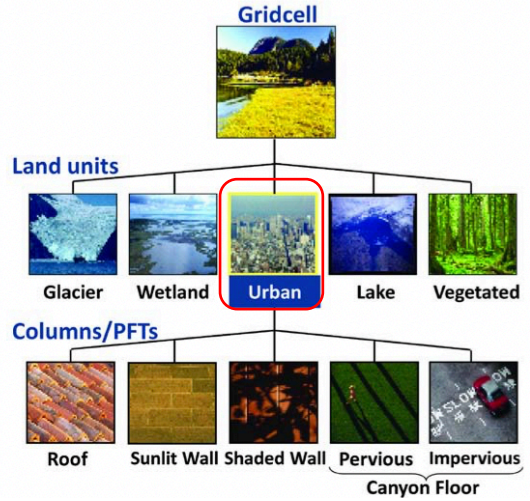
the effect of urbanization

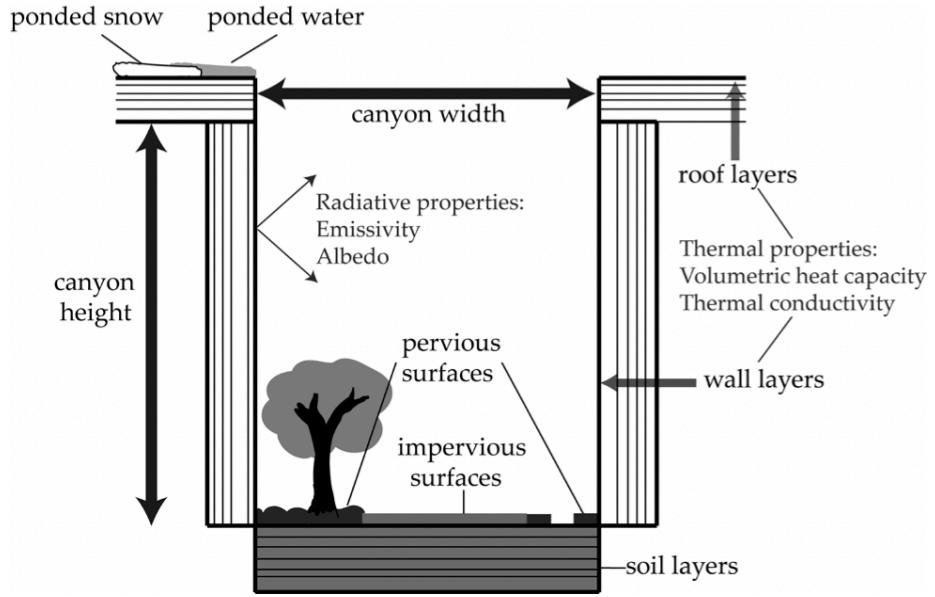
on climate change?

Global Urban Expansion (courtesy of Prof. Liu)

Evaluation method (climate model)

Community Land Model Urban (CLMU)





1.1 why uses urban properties tool (UPT) ?

Problem

1. The finest resolution accepted by the CLM tool that create surface datasets is 0.05° × 0.05 °.
2. Coupled with urban properties data.

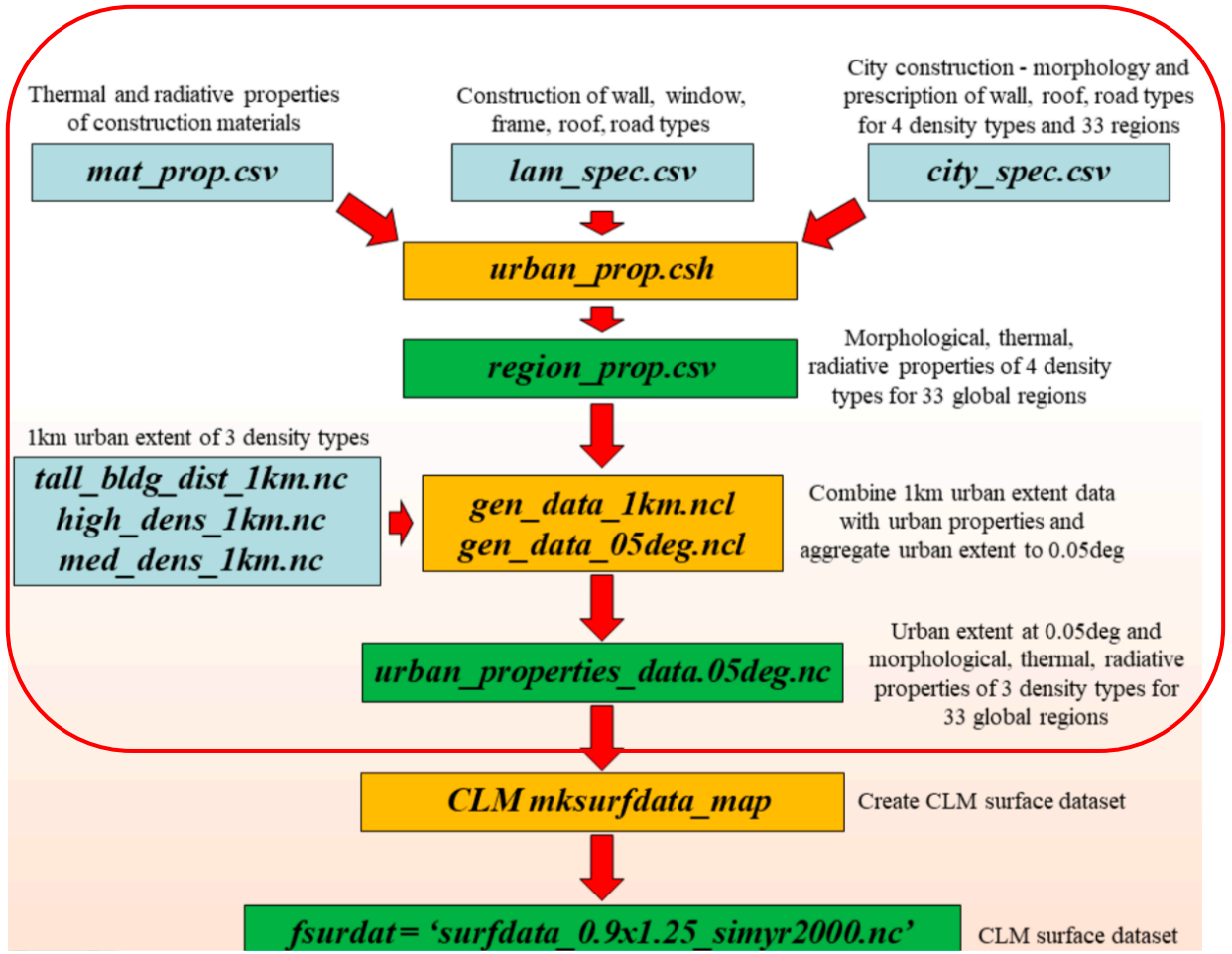
Objective

Modifying the urban percent data in the CLMU surface data based on the 1km ×1 km urban extent data provided by Prof. Liu.

Solution

1. **Urban properties tool (1km ×1km----→0.05° ×0.05 °)**
2. CLM *mksurfdata _map* tool (**0.05° ×0.05°----→0.9375° ×1.25 °**)

1.2 what is urban properties tool (UPT) ? ---- Tool structure



(Oleson et al., 2019)

Blue: Input files

Orange: Executable scripts

Green: Output files

Input files
- Urban extent
- Urban properties

- Present-day **urban extent** and **urban properties** are provided by the global urban dataset developed by ***Jackson et al.***(2010)

1.2 what is urban properties tool (UPT) ? ---- Global urban dataset

Global urban dataset provided by Jackson et al. (2010)

First step: Divide Earth's land surface into manageable regions (physical and cultural geography)

Second step: Determine spatial extent of four categories of urban intensity

Third step: produce a database of building and road properties for each regional category

1.2 what is urban properties tool (UPT) ? ---- Global urban extent

First step: Divide Earth's land surface into manageable regions (physical and cultural geography)

↓

Second step: Determine spatial extent of four categories of urban intensity

↓

Third step: produce a database of building and road properties for each regional category

Urban-rural boundaries

- Each of 33 regions to determine unique boundaries
- **Data source**: LandScan 2004 population densities (spatial resolution: 1km ×1km)
- **Criteria**: a lower limit of population density

1.2 what is urban properties tool (UPT) ? ---- Global urban extent

Urban density classes	Stories tall	Pervious fraction	Examples
Tall building density (TBD)	≥10	5~15% of plan area	\
High density (HD)	3<H<10	5~25%	Commercial, residential, or industrial areas
Medium density (MD)	1<H<3	20%~60%	Row houses or apartment
Low density (LD)	1 -2 story buildings	50%~85%	e.g. suburbs of the United States to urban agricultural parts of East Africa

- Intra-urban boundaries (e.g. between low and medium density) were based on **population density** and **observations of satellite imagery** in at least ten sample cities per region (i.e. validation cities).

1.2 what is urban properties tool (UPT) ? ---- Global urban extent

First step: Divide Earth's land surface into manageable regions (physical and cultural geography)

↓

Second step: Determine spatial extent of four categories of urban intensity

↓

Third step: produce a database of building and road properties for each regional category

→

1km urban extent of 3 density types

tall_bldg_dist_1km.nc
high_dens_1km.nc
med_dens_1km.nc

1. High spatial resolution: 1km×1km
2. Including different urban intensities

1.2 what is urban properties tool (UPT) ? ---- Global urban properties

Global urban dataset provided by Jackson et al. (2010)

First step: Divide Earth's land surface into manageable regions (physical and cultural geography)

↓

Second step: Determine spatial extent of four categories of urban intensity

↓

Third step: produce a database of building and road properties for each regional category

Urban properties

Building morphological

building height to street width ratio, roof fraction, average building height and pervious fraction of canyon floor

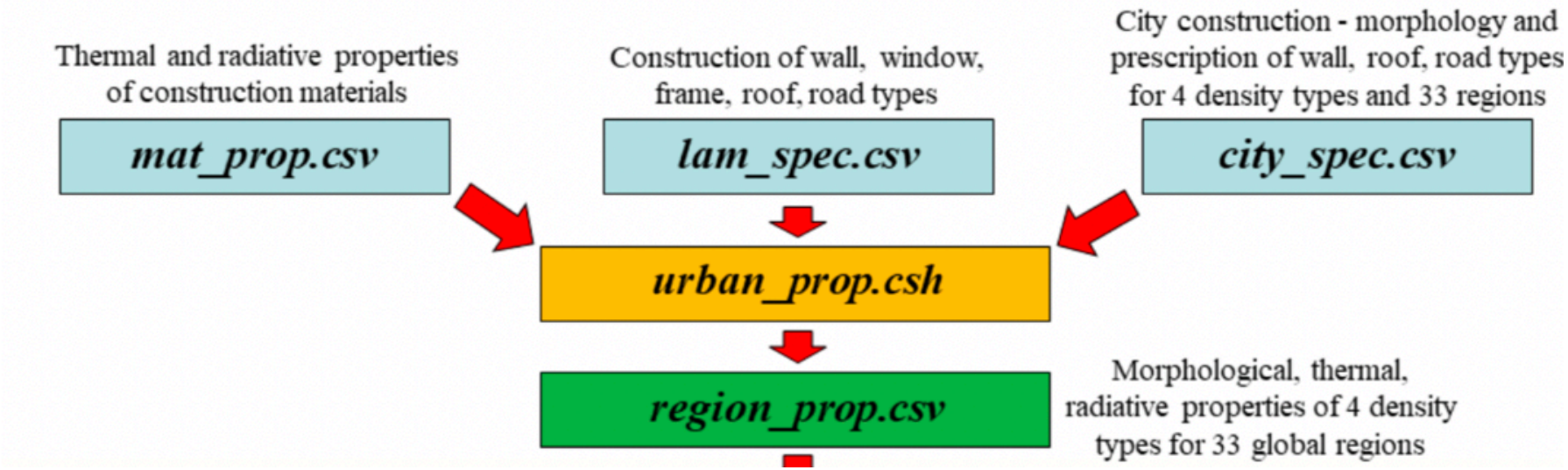
Thermal

thermal conductivity and heat capacity of materials making up roofs, walls, and roads

Radiative

e.g. albedo and emissivity

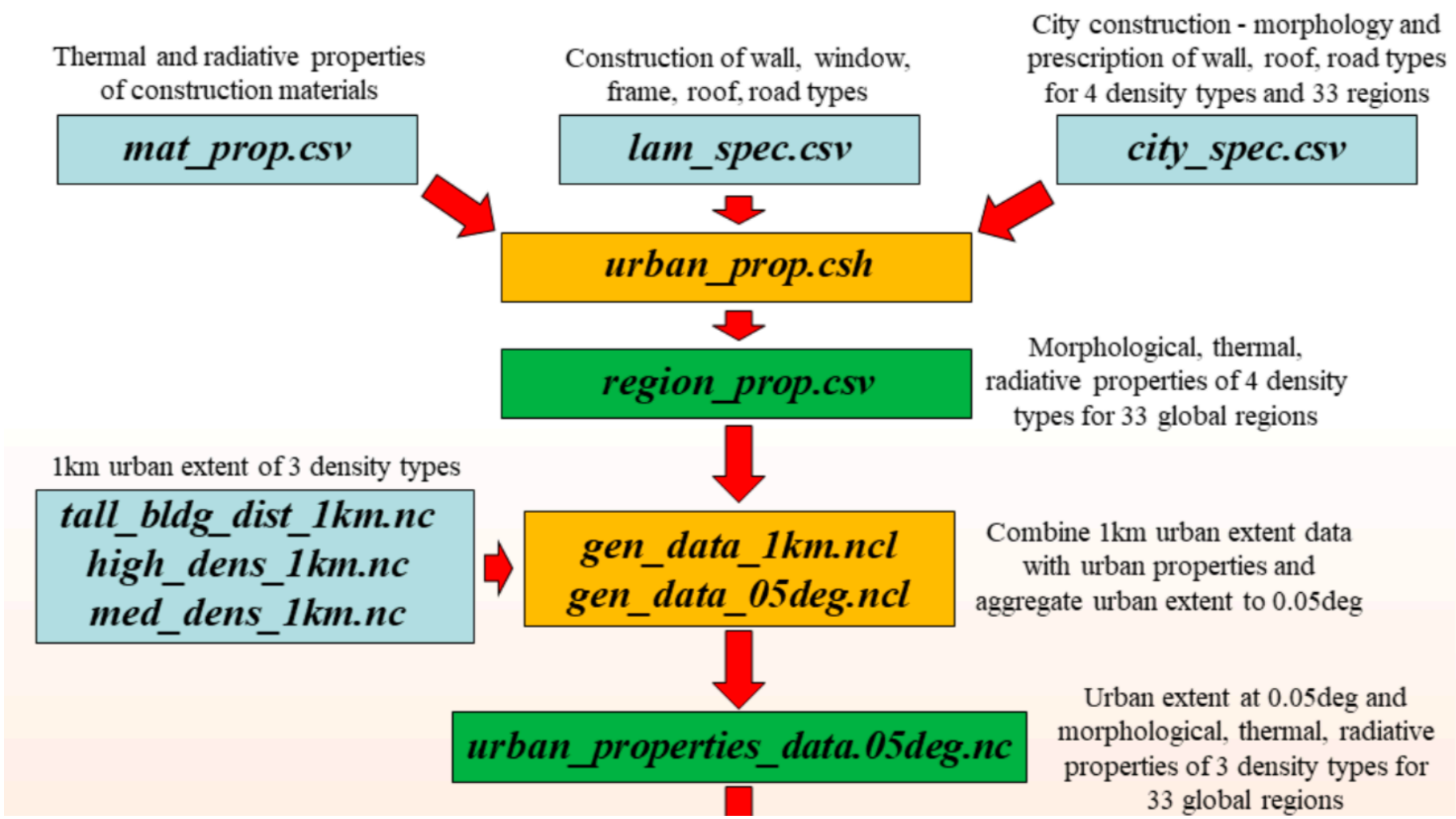
1.2 what is urban properties tool (UPT) ? ---- Global urban properties



- ***Mat_prop.csv:*** describe the fundamental thermal and radiative properties of materials typically used in urban construction.
- ***Lam_spec.csv:*** describe the construction of walls (including windows and frames), roofs, and roads
- ***City_spec.csv:*** assigns the wall, window, roof, and road types to each of the four urban density classes for thirty-three global regions.

(morphological properties are also assigned within this file)

1.3 urban properties tool (UPT) ---- output files



Outline

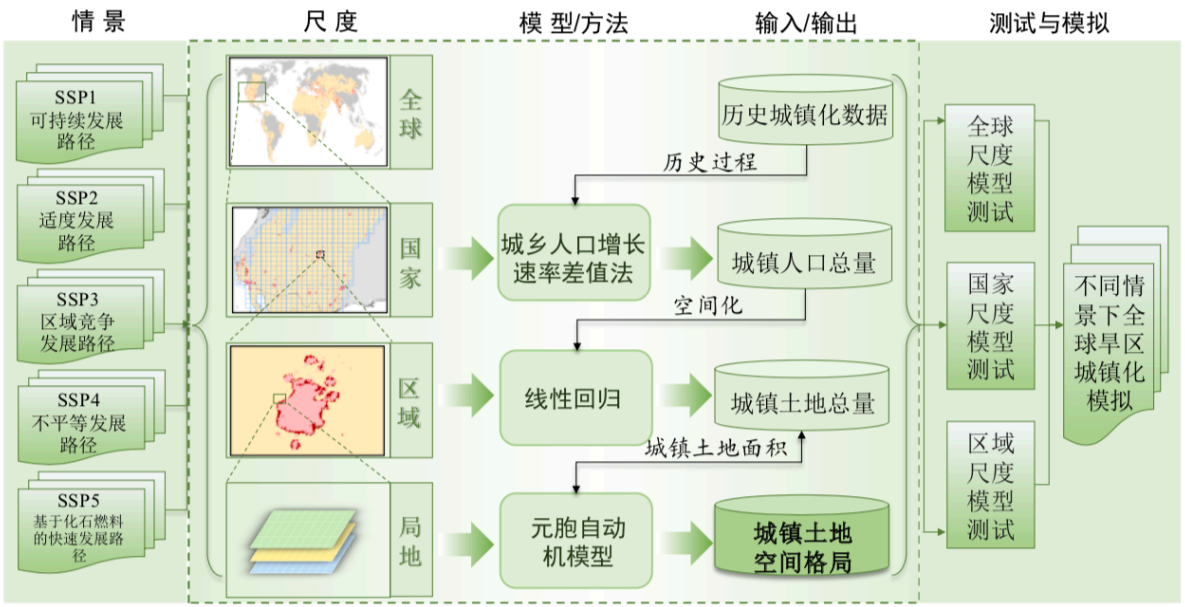
1 What is Urban properties tool ?

2. How to operate the UPT ?

3. Output results Based on UPT

2. Method

2.1 How to operate UPT ---- Data source



Data Information

A. Data format: **.tiff file**

B. Data period: 2020 - 2070 under different SSP scenarios

C. Resolution:

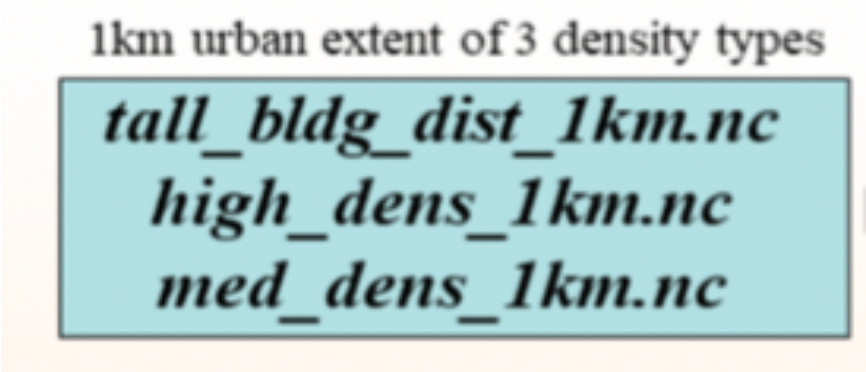
1km ×1km: Urban extent: binary system, 0/1

100km ×100 km: urban area per grid

2. Method

2.2 How to operate UPT ---- Data alignment

The input urban extent data requirements:



A. Data format: **.nc file**

B. Included Information:

Resolution: 1km ×1km (0.0083333°× 0.00833333°)

latitude: 180/0.008333333= 21600

longitude: 360/0.008333333 = 43200

TBD/HD/MD: binary system, 0/1

C. Three urban density: TBD/HD/MD

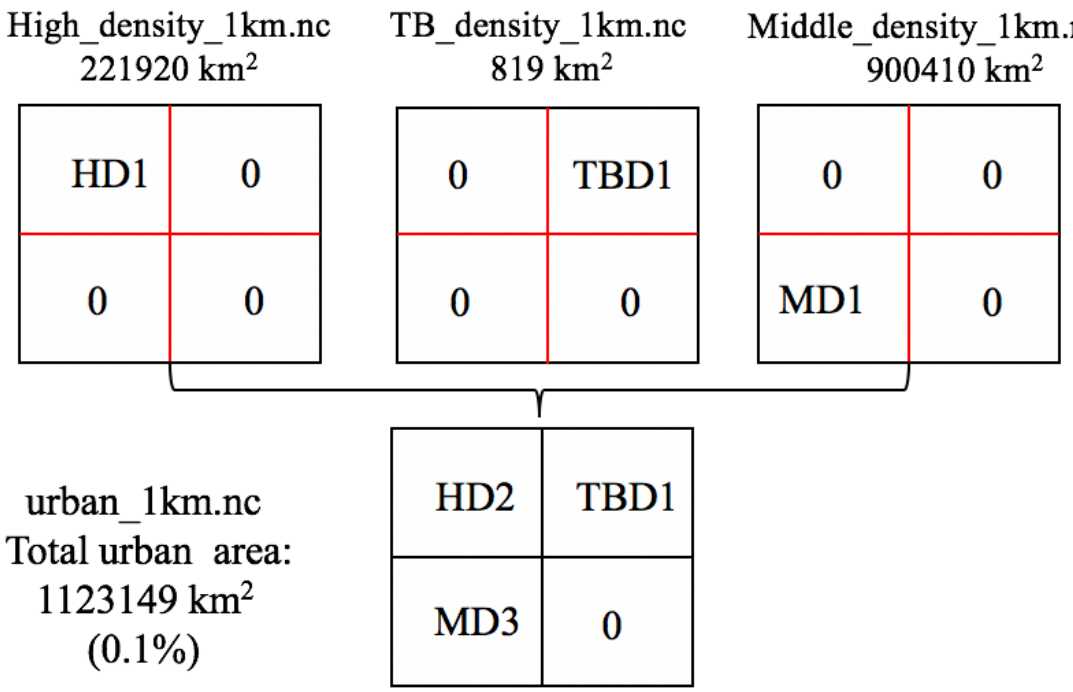
- Data Resample: based on Nearest Distance method;

First step: ArcMap function: **project raster** convert the geodetic coordinate into geographic coordinate (WGS,1984)

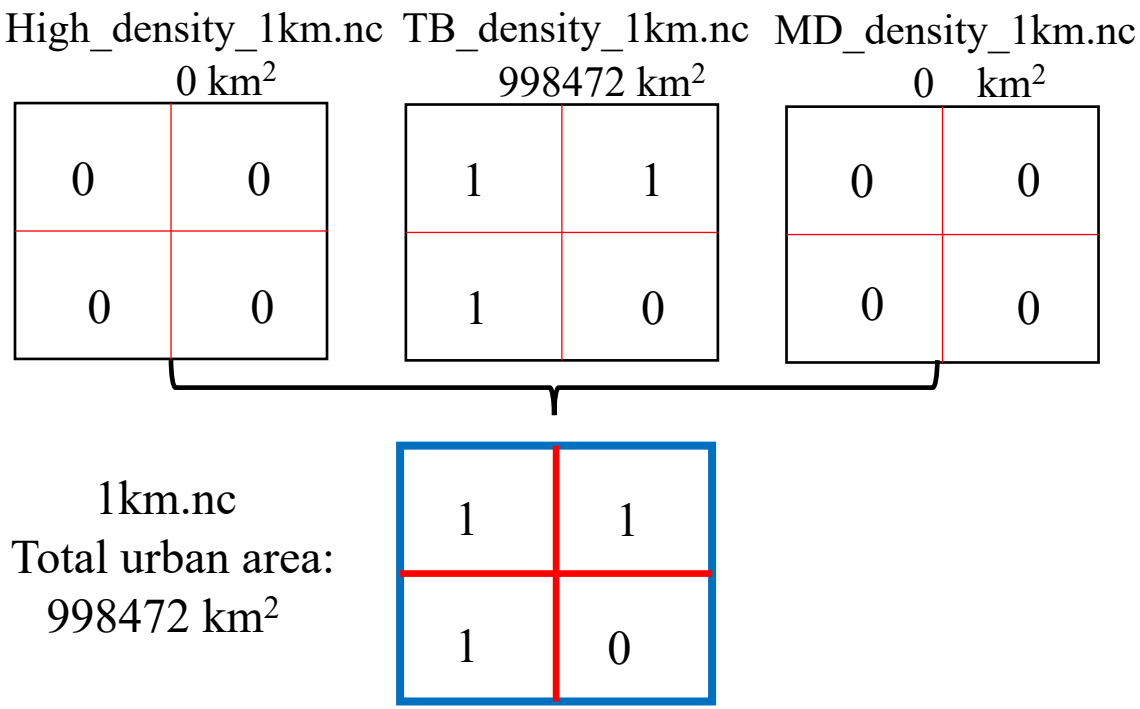
Second step: ArcMap function: **Resample** Re-grid based on the nearest neighbor method. All the intervals should be 0.008333333°

2.2 How to operate UPT ---- Data alignment

CLMU provided by Jackson et al. (2010)



Data provided by Pro. Liu



2. Method

2.3 How to operate UPT

Input data:

(1)mat_prop.csv

(2)Lam_spec.csv

(3)City_spec.csv

(4)Region_spec.csv

(5)Tall_bldg._dist_1km.nc

(6)High_dens_1km.nc

(7)Med_dens_1km.nc

(8) urban_region.nc

→ Gen_data_1km.ncl → **output data: Urban_properties_1km.nc**

→ Gen_data_05deg.ncl → **output data: Urban_properties_05deg.nc**

Outline

1 What is Urban properties tool ?

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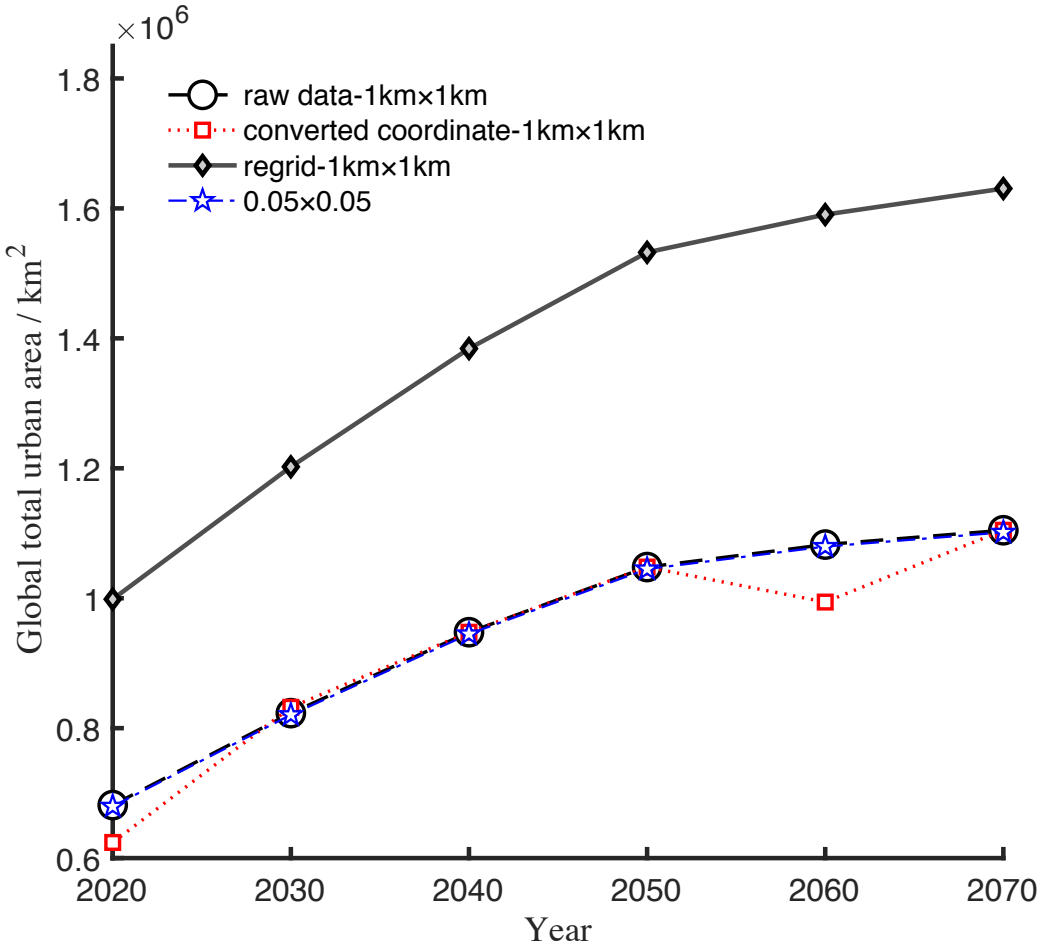
3. Results

3.1 Error produced by data alignment

- Comparison of Global urban total area among different processed methods



Raw data
(1km × 1km)

↓

Converted coordinate system
(geodetic - - -▸ geographic)

↓

Resample: 0.0083°
(based on nearest distance)

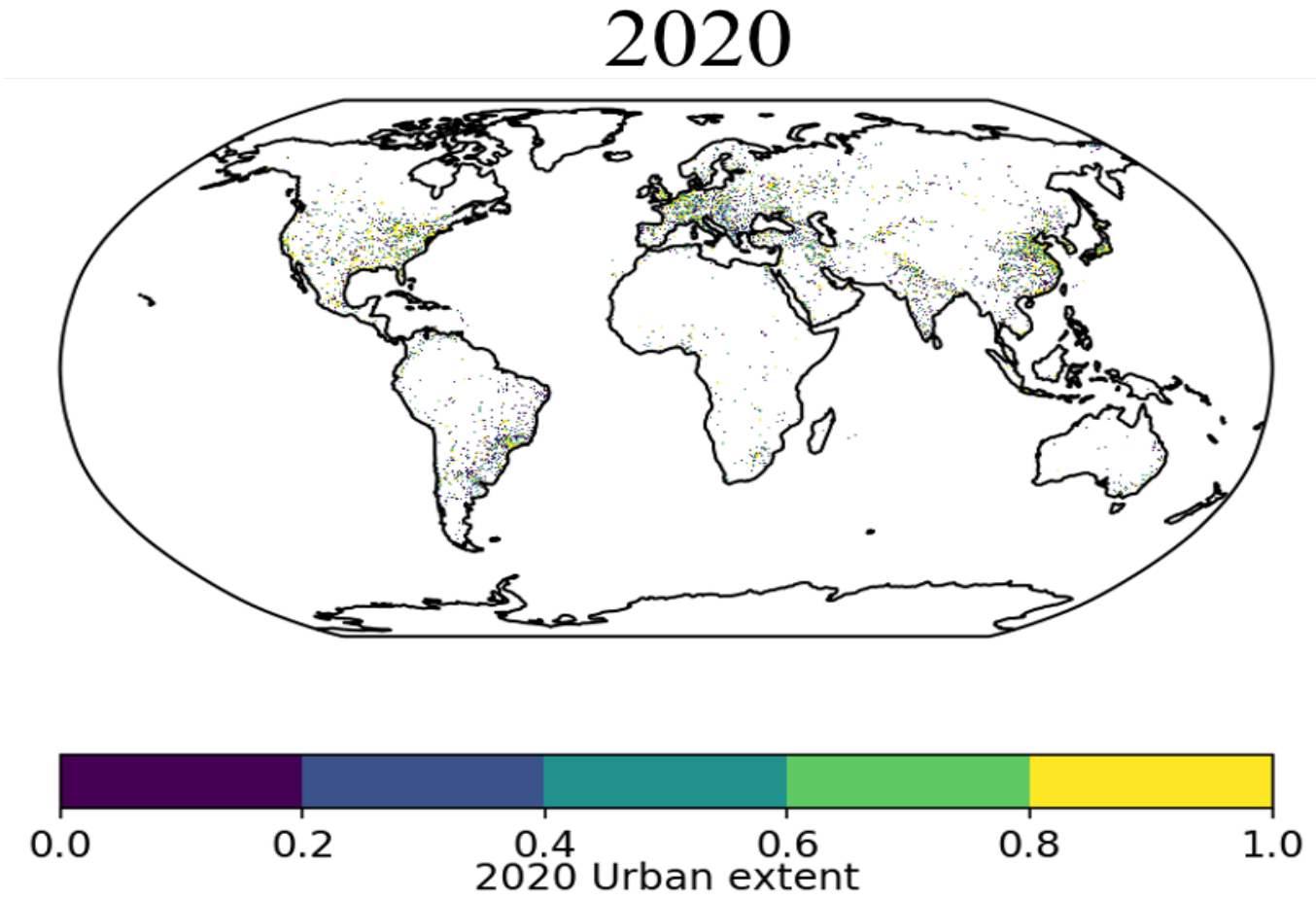
↓

0.05°×0.05°
(UPT)

Mean error: **0.3%** between 1km×1km and 0.05°×0.05°(SSP5_2020)

3. Results

3.2 Spatial distribution of global urban extent



3. Results

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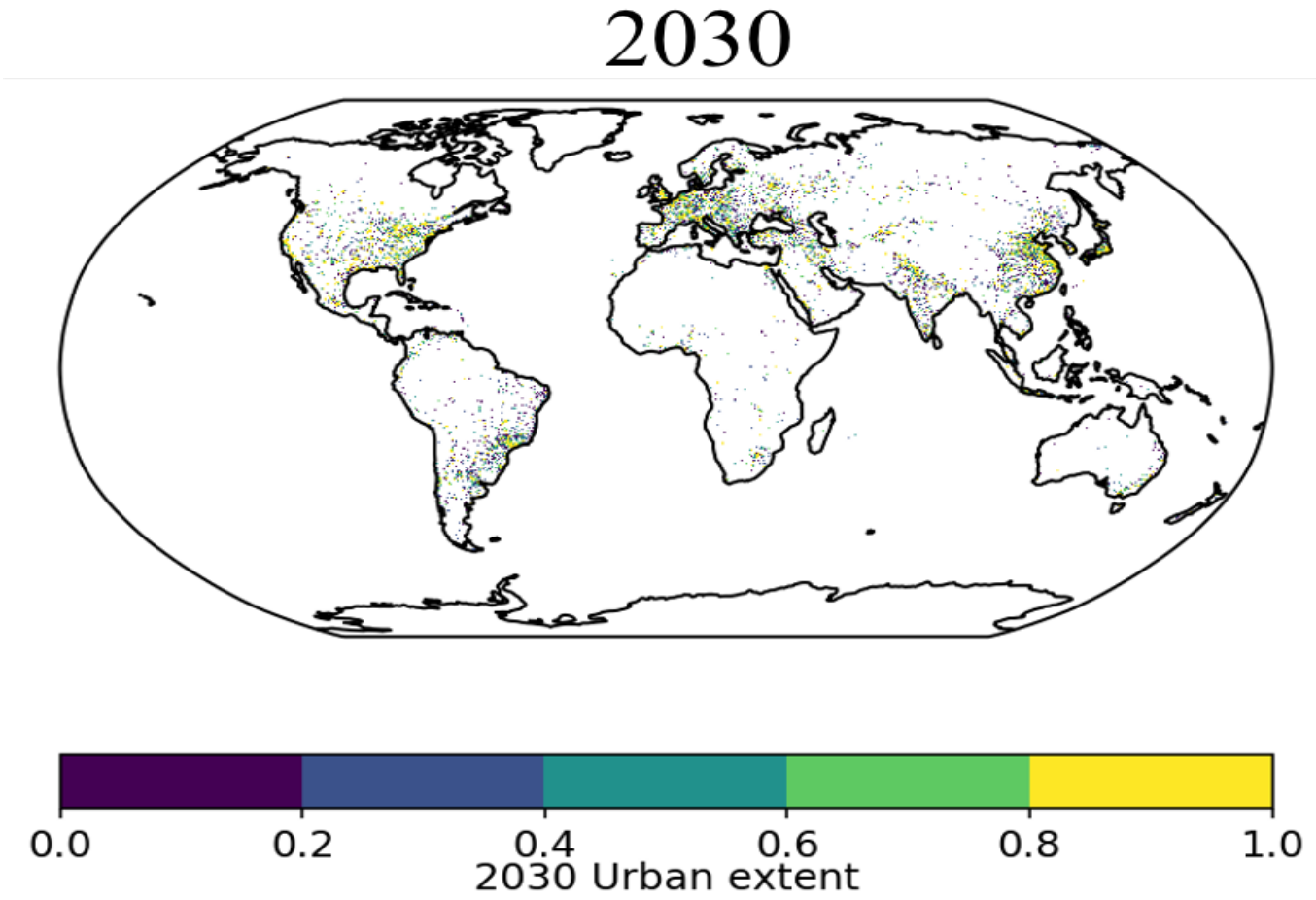

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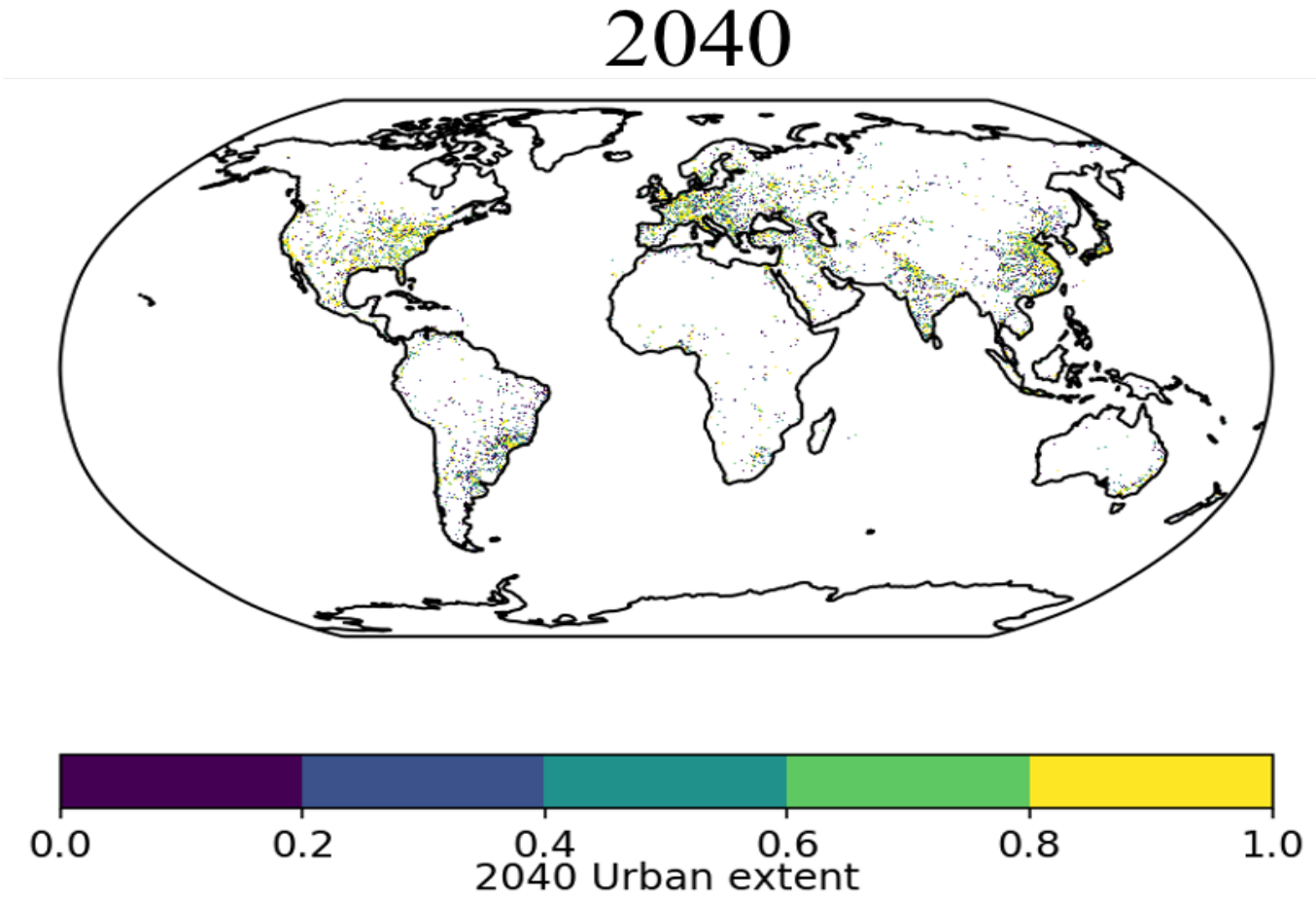

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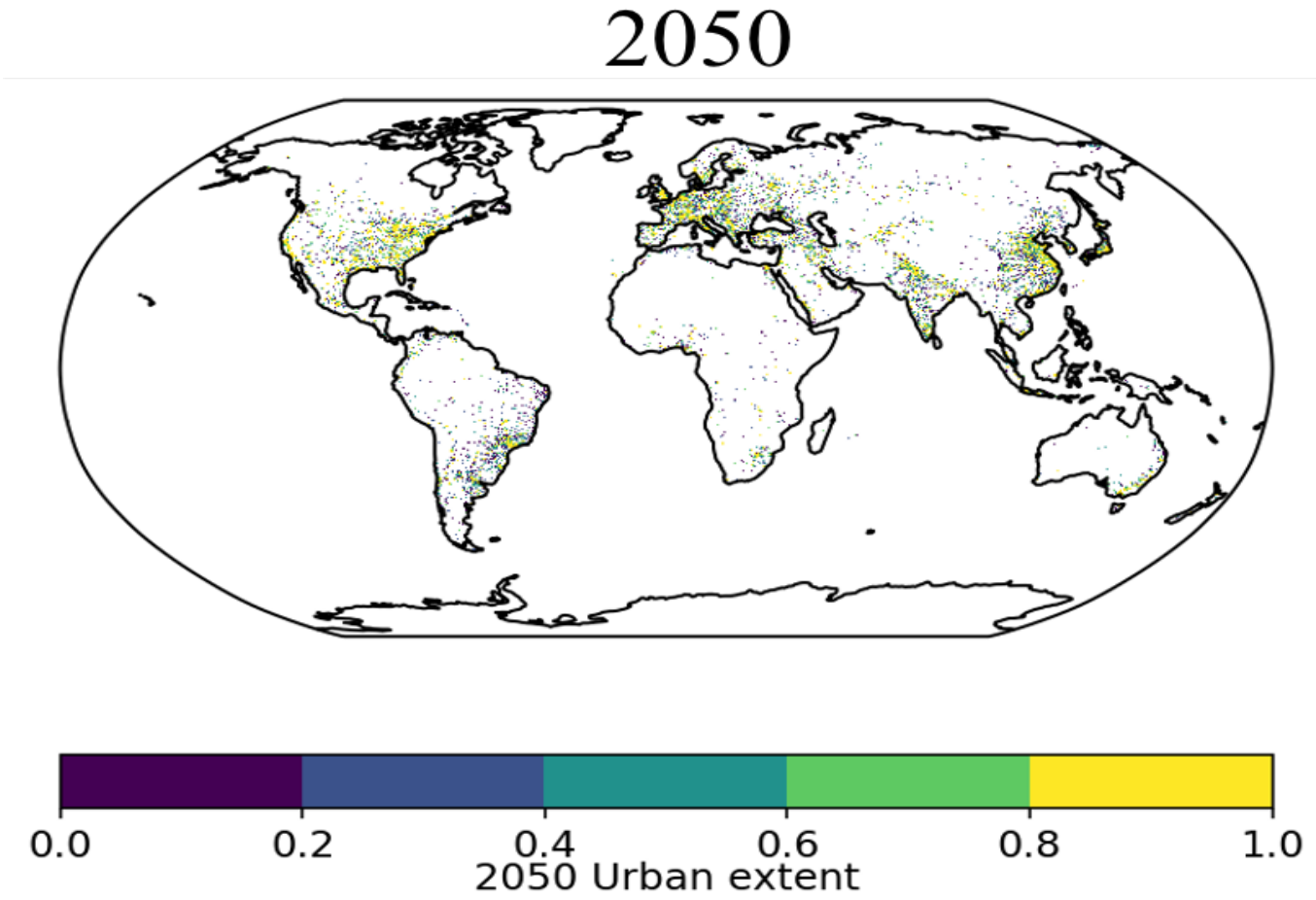

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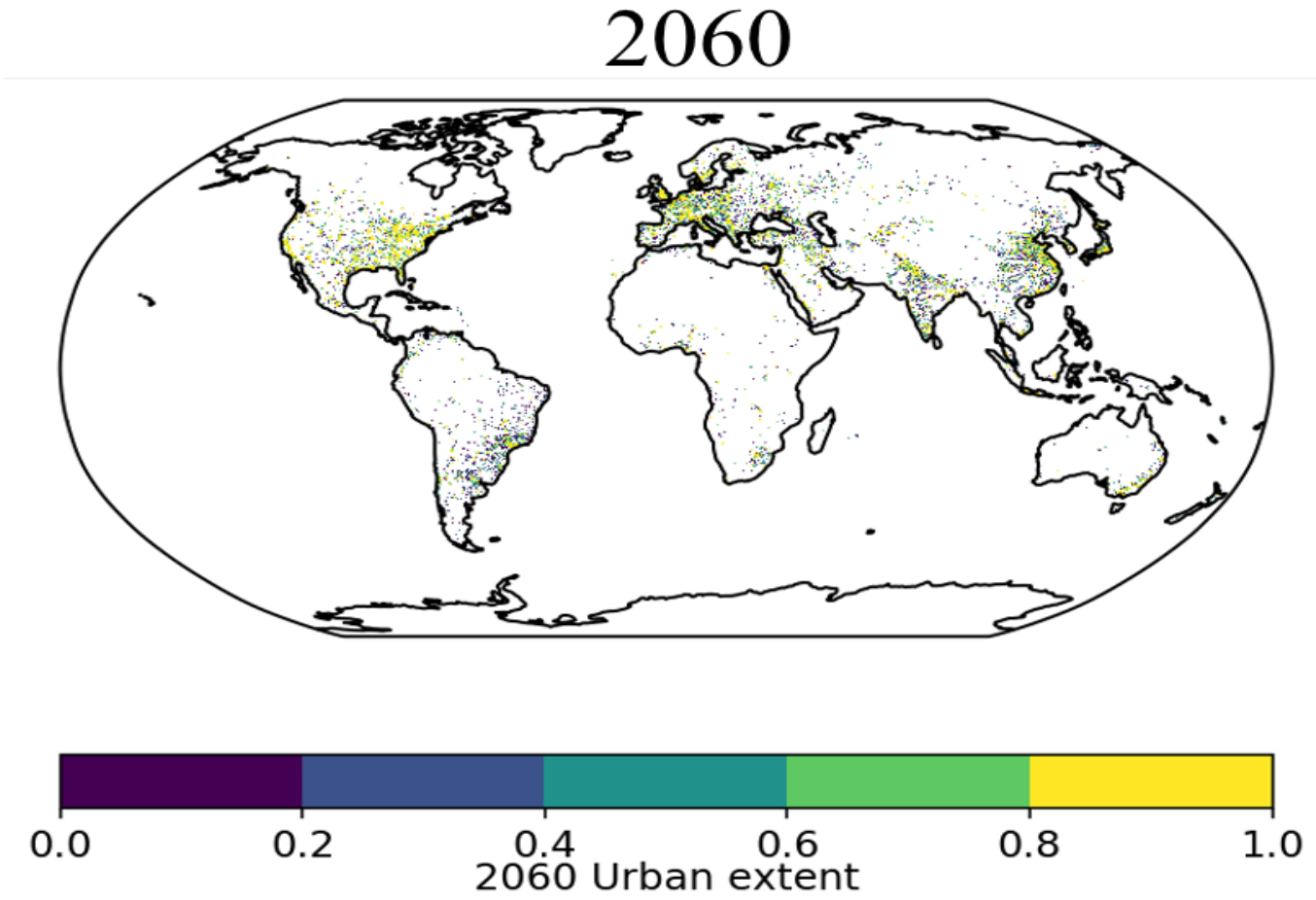

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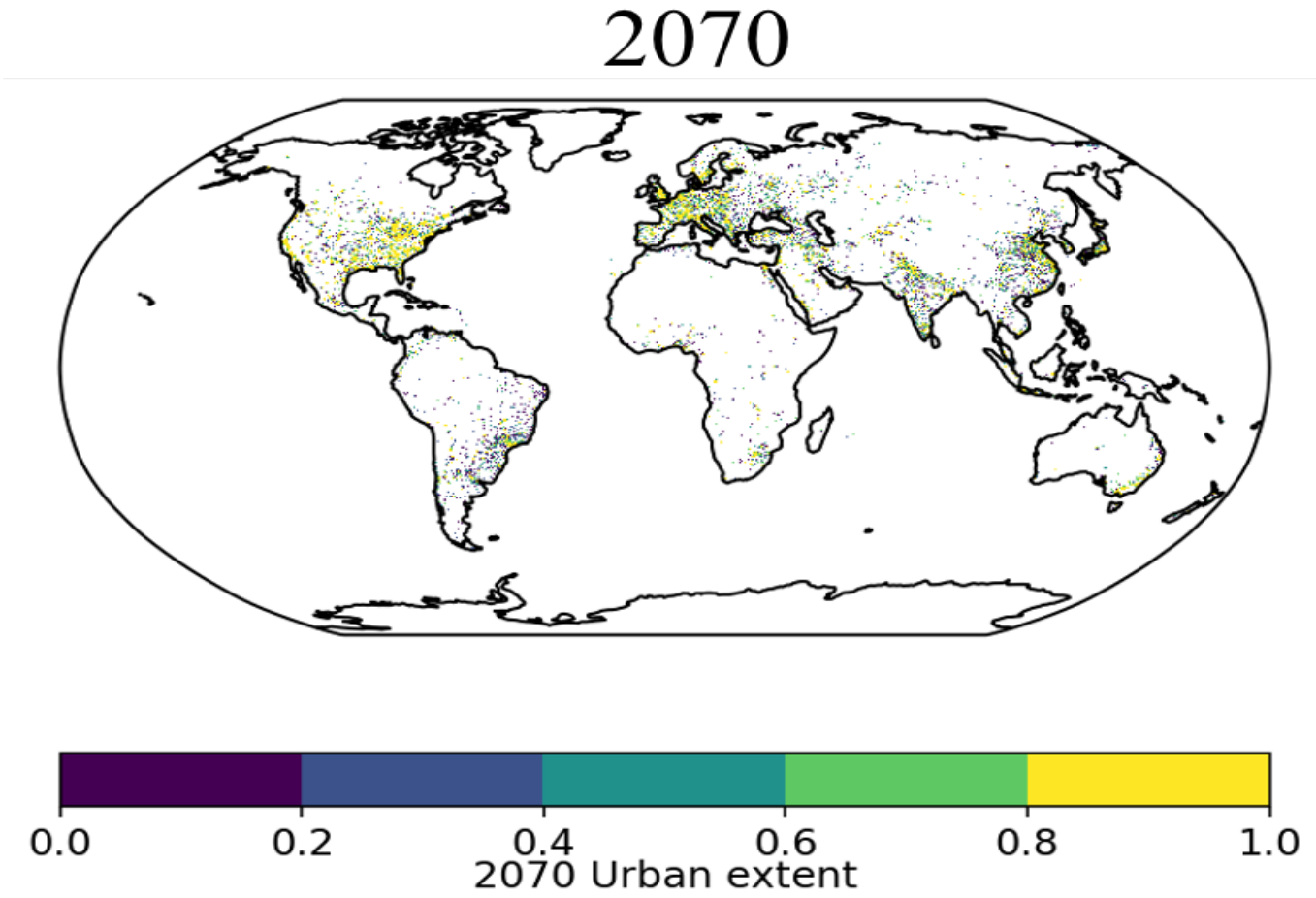
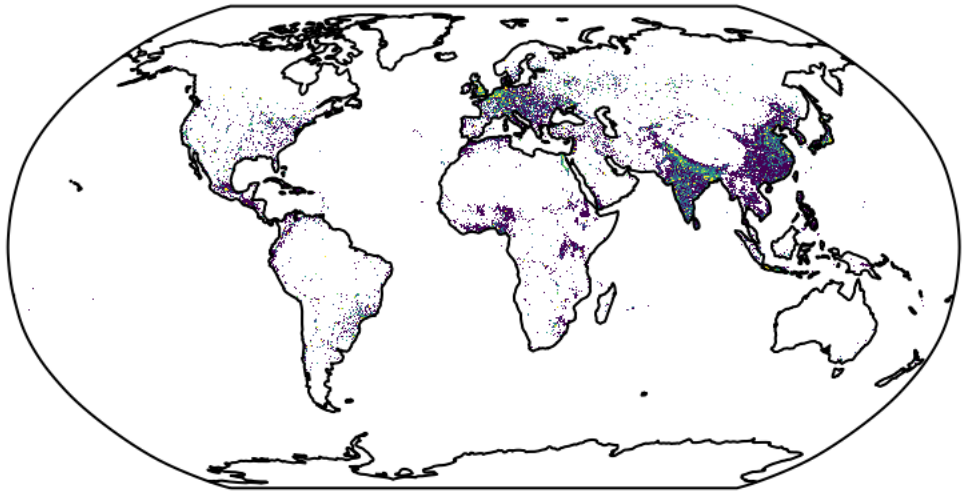
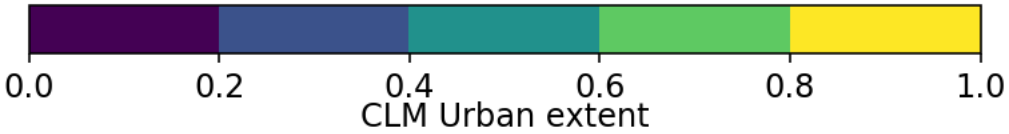


3. Results

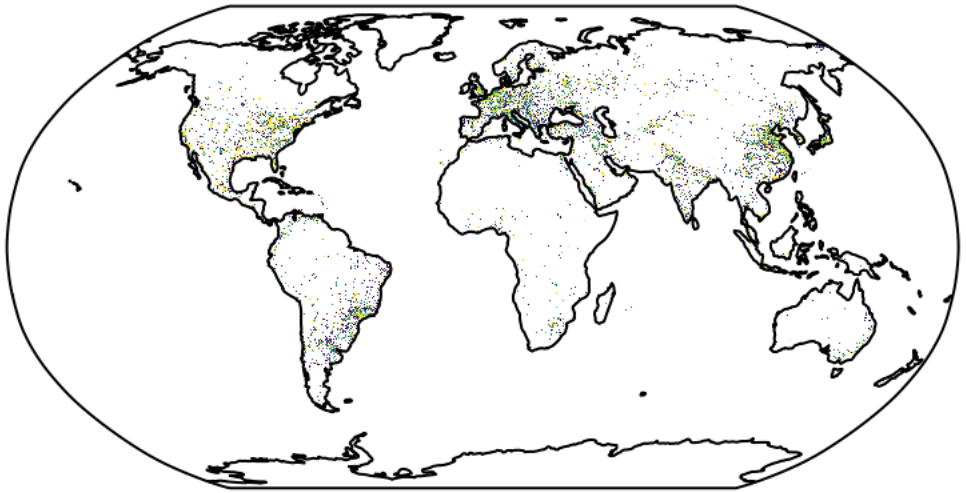
3.3 Comparison between CLM urban and data-SSP5 2020

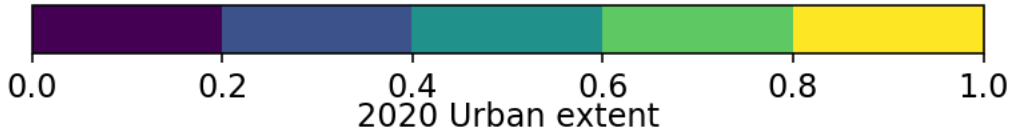
Data source: Jackson et al. (2010)





Data source: courtesy of Prof. Liu





	CLM	SSP5_2020
1km ×1km	1123149 km^2	681584 km^2
0.05°×0.05°	**835820 km^2**	**679630 km^2**

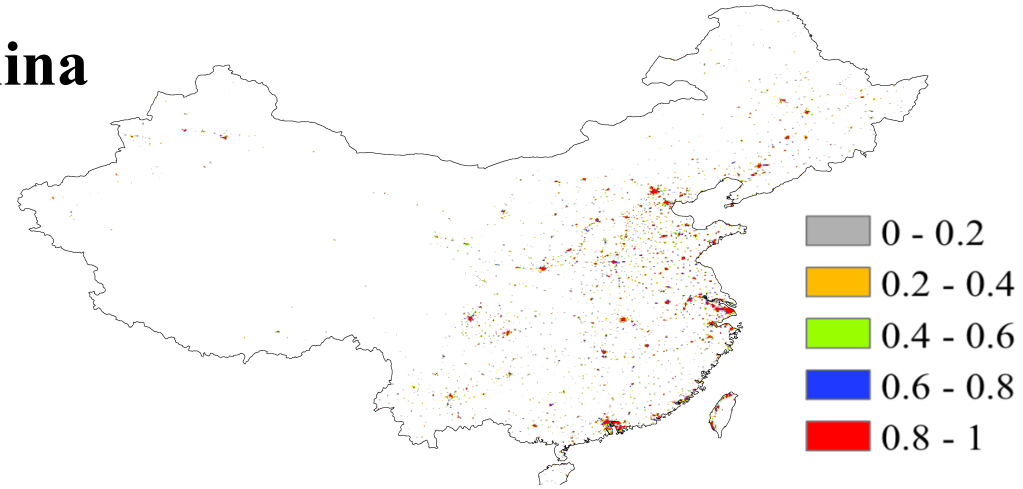
3. Results

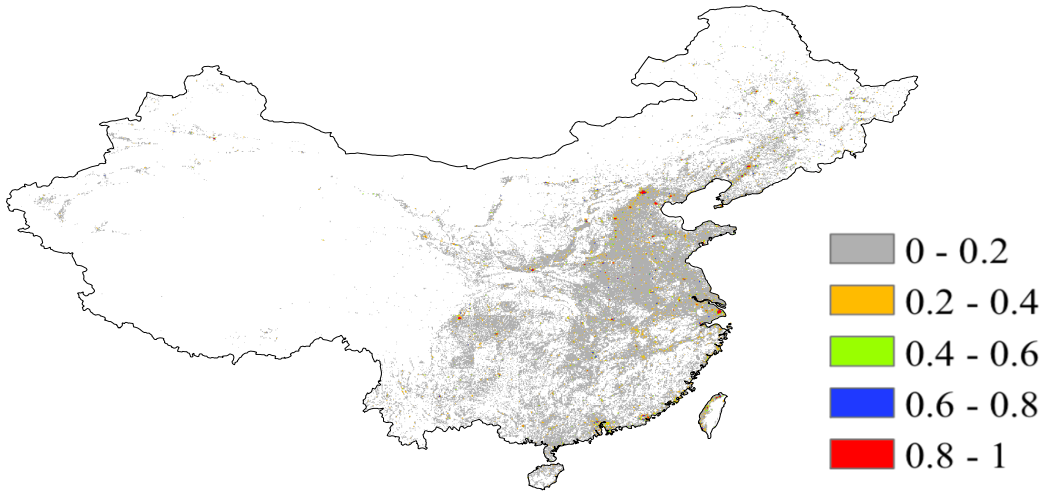
3.3 Comparison between CLM urban and data-SSP5 2020

SSP52020

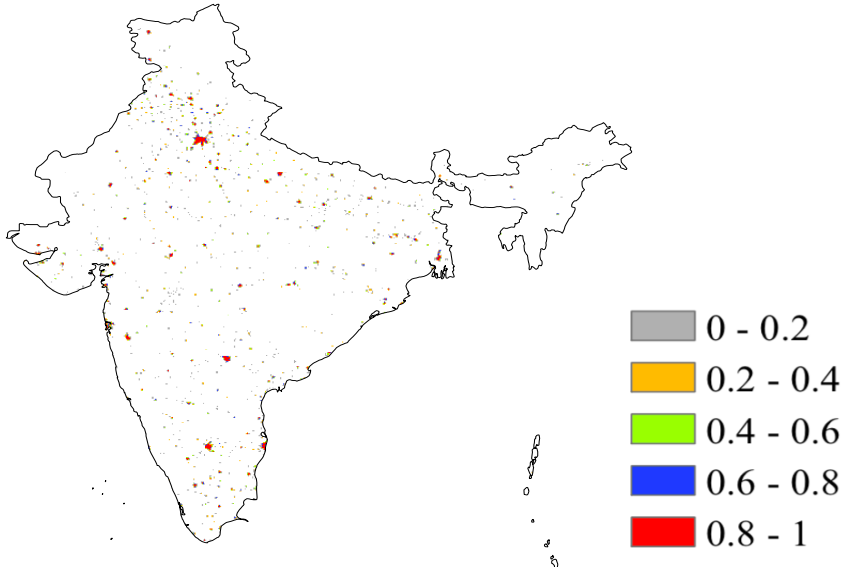
CLMU

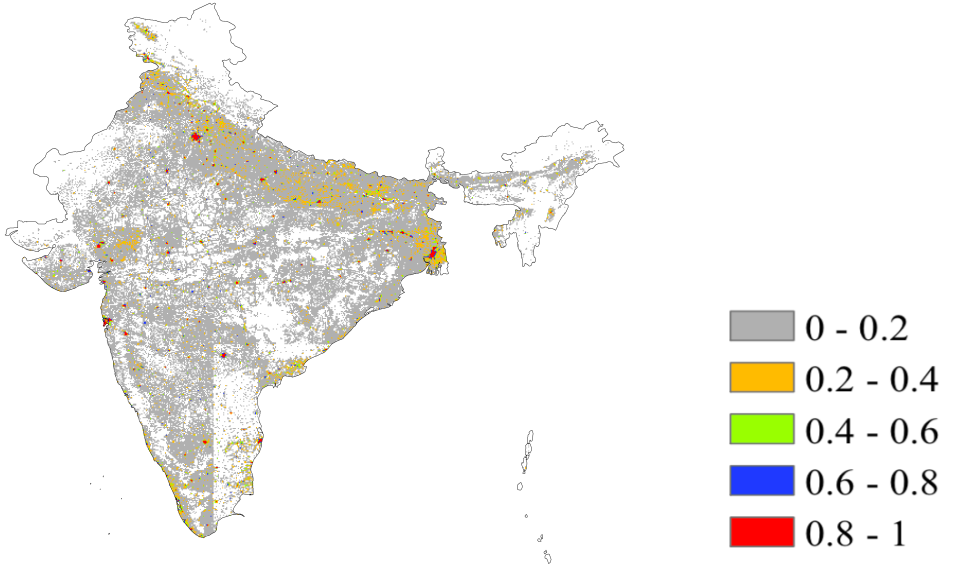
China





India





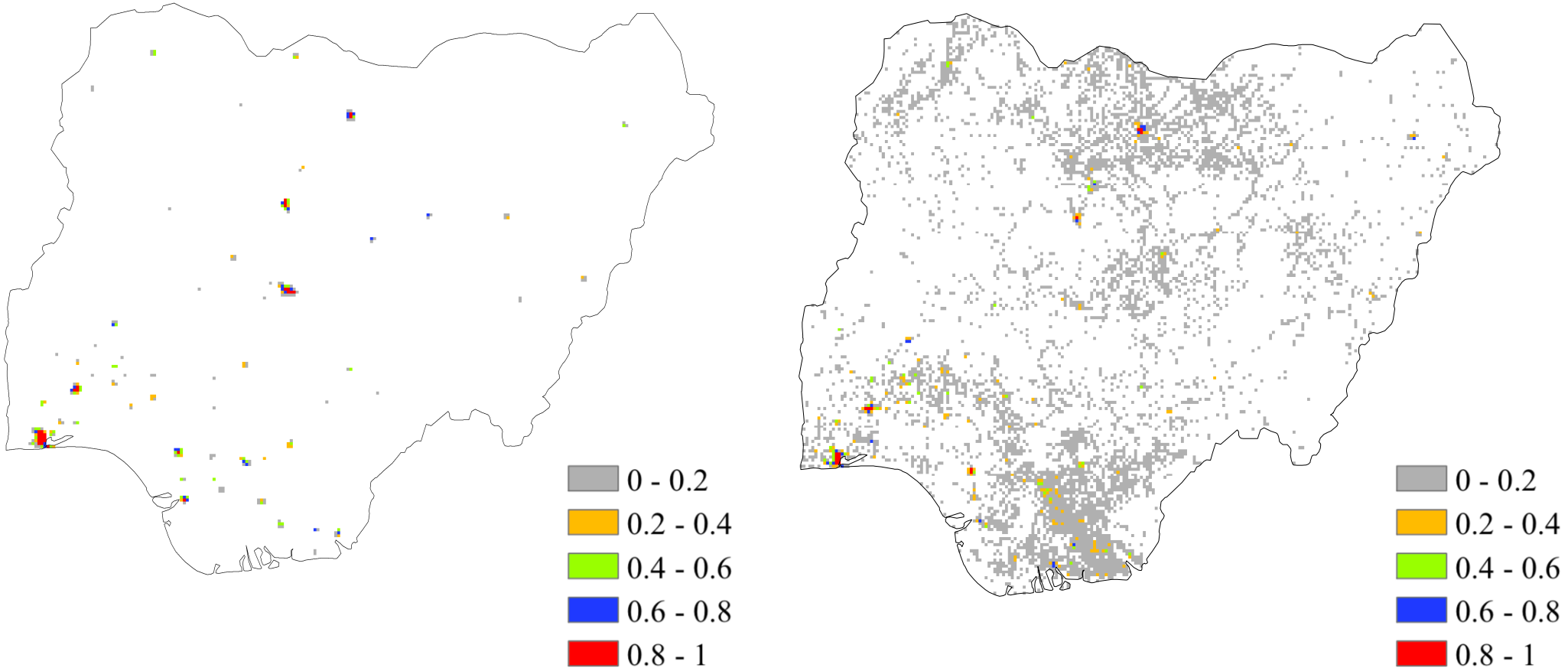
3. Results

3.3 Comparison between CLM urban and data-SSP5 2020

SSP52020

CLMU

Nigeria



Next steps:

- Adjust Global urban extent dataset provided by Prof. Liu to meet the CLM input data requirements

- Put the urban dataset at a resolution of $0.05^{o} \times 0.05^{o}$ into the CLM surface data using the *mksurfdata _map* tool

Any advice is welcomed !