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E.g. Long Y, 2014, Automated identification and characterization of parcels (AICP) with OpenStreetMap and Points of Interest, Slides at Beijing City Lab, <http://www.beijingscitylab.com>

Simulating urban expansion at the parcel level for all Chinese cities

(AUM 2014, 1 April 2014)

Dr. Ying Long

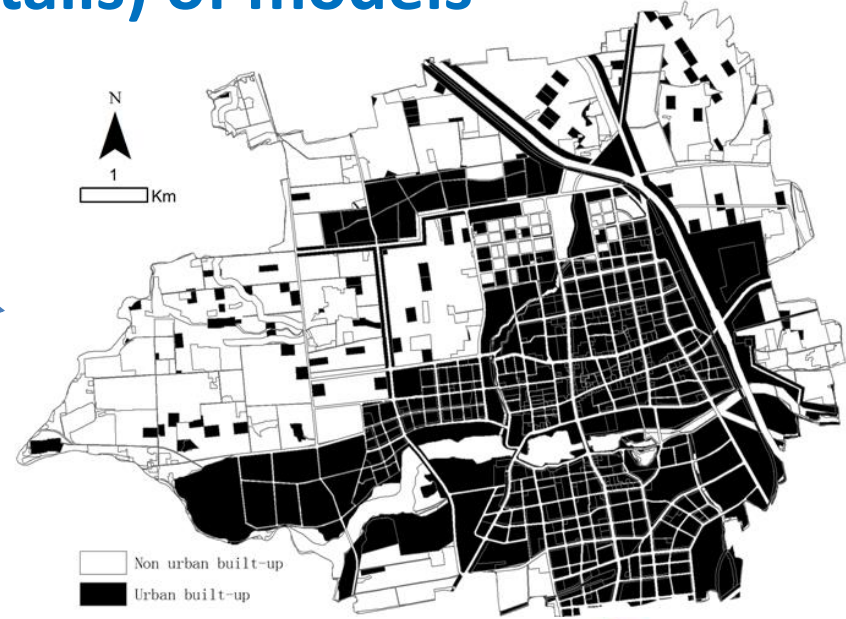
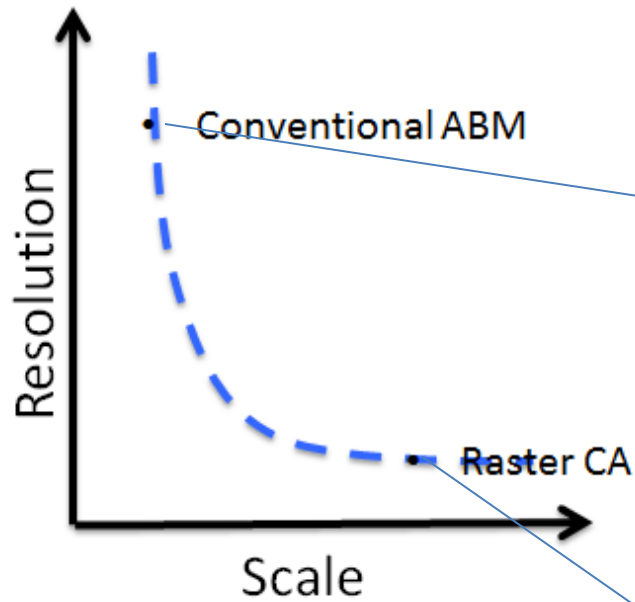
Beijing Institute of City Planning
Martin Centre, University of Cambridge

Collaborated with Dr. Kang Wu, Dr. Qizhi Mao, and Dr. Ying Jin

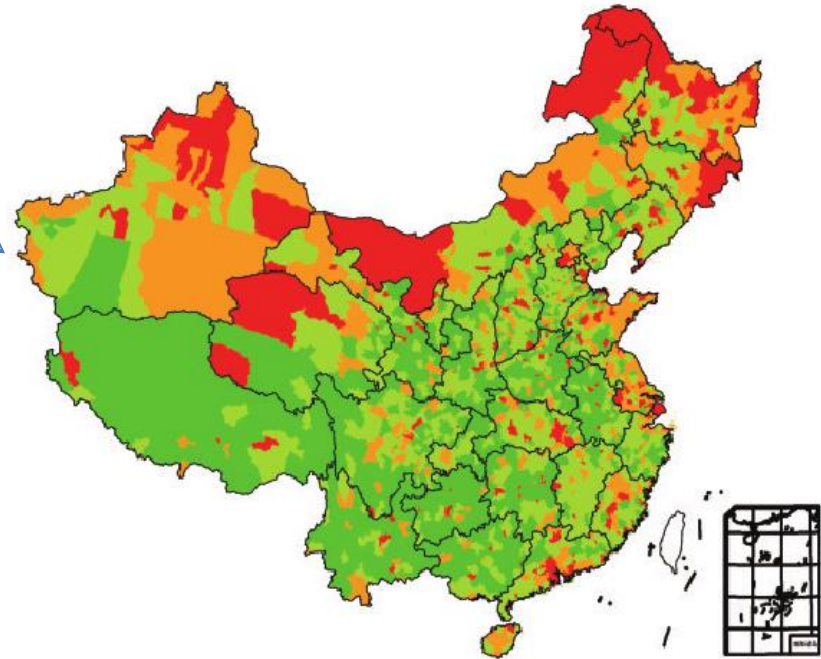
Research background

- Booming urban expansion in China
 - 46,751 km² (annual expansion rate **5.2%** 2007-2012)
- Urban expansion simulation models developed for supporting decision making
 - 1 City or district level models
 - **Almost all for big cities**, e.g. Beijing, Shanghai, Guangzhou, Hangzhou, using grid cellular automata (CA) models
 - V-BUDEM for Beijing using vector CA (see the poster of **Zhang and Long**)
 - 2 Regional or national models
 - Pearl River Delta, Beijing-Tianjin-Tangshan, Northern China
 - Associated with low spatial resolution e.g. several km², a county

Trade-offs between geographic scale (extent), sample size and resolution (details) of models

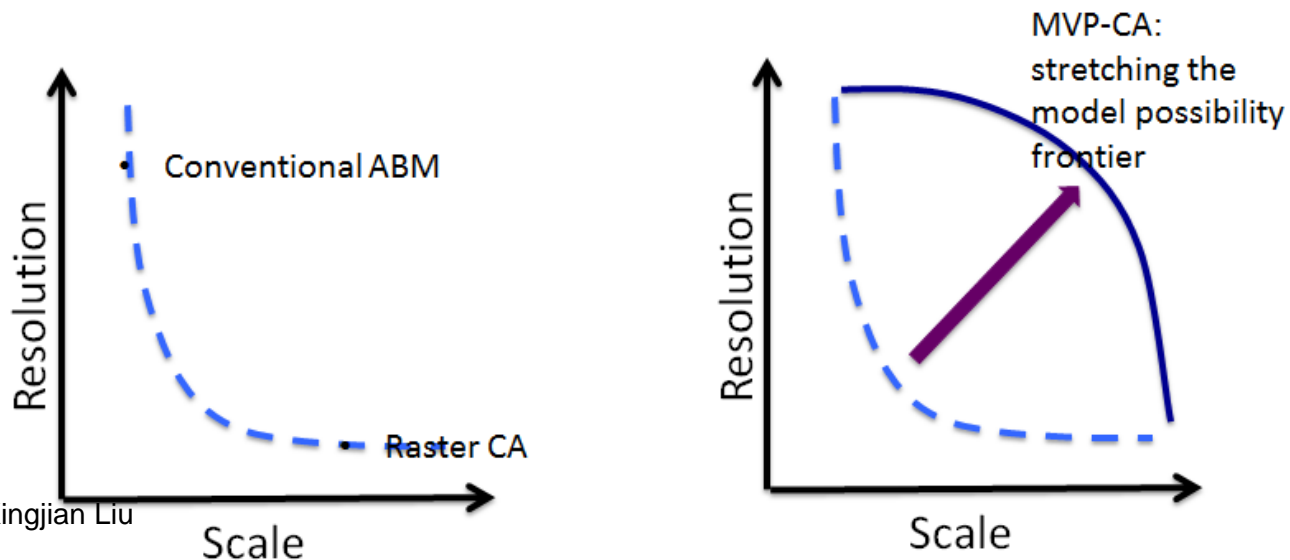


Existing urban expansion models



Research question

- Can we develop an urban expansion model for a super large geographical extent (e.g. **the whole China**), at a fine scale (e.g. **parcel/block**), for a short or mid term (e.g. **five years**)?



Courtesy of Dr. Xingjian Liu

- Every city, big or small, would have an urban expansion model in China
- To inform decision makers, developers, planners and local residents our simulation results

Why parcel/block?

- Raster CA models sensitive with the grid size
- Urban planning and management
 - Spatial plans, zoning, building permits
- Urban studies
 - Urban form and its impact (travel behavior, energy consumption, health, quality-of-life, etc.)

It is worth noting that the term **PARCEL** 地块 in this study, having no relationship with ownership, corresponds to a **BLOCK** in western world.



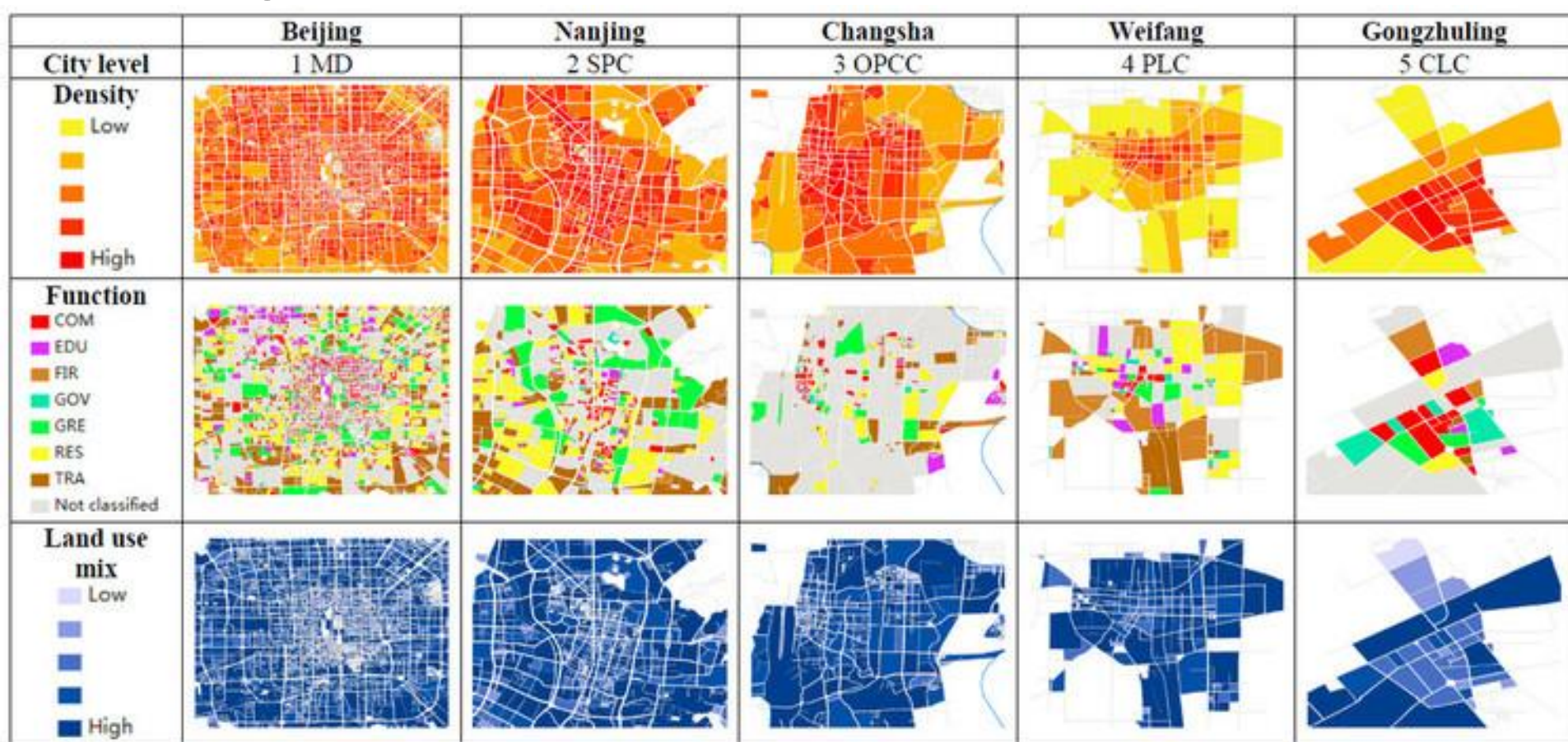
We do not have national-scale parcel maps in most of developing cities!

- Poor developed digital infrastructure
 - Big cities
 - Beijing, one of the most technologically advanced and rapidly developing cities in the erstwhile Third World –dated in 2010 (parcel density limited to six ring road)
 - Medium- and small-sized cities:
 - Not well prepared / digitalized
- Institutional barriers (according to our interview with over 50 professionals)
 - Parcel maps are confidential/classified, and constrained within plan bureaus and official planning institutes like BICP
 - Foreign and private planning consultancies, **NO**
 - Professors and students in universities, **NO**

We NEED create parcels by ourselves.

AICP: a previous study on using open data

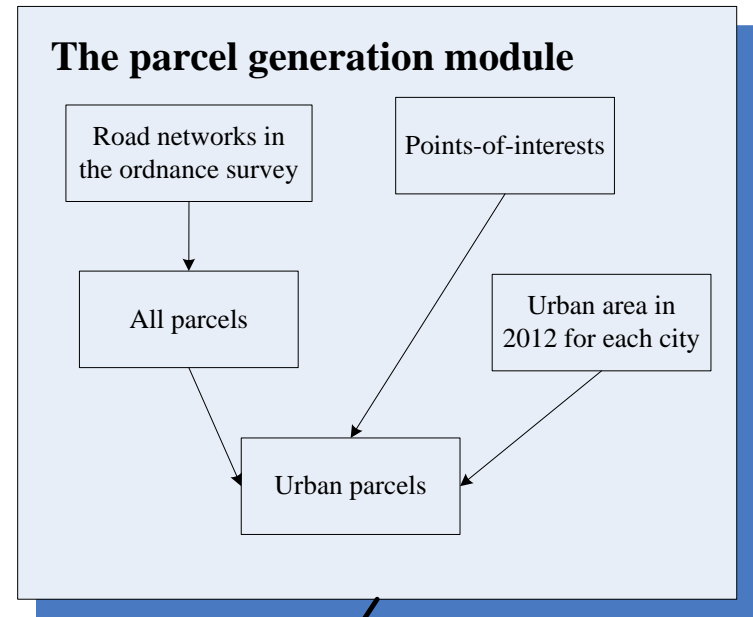
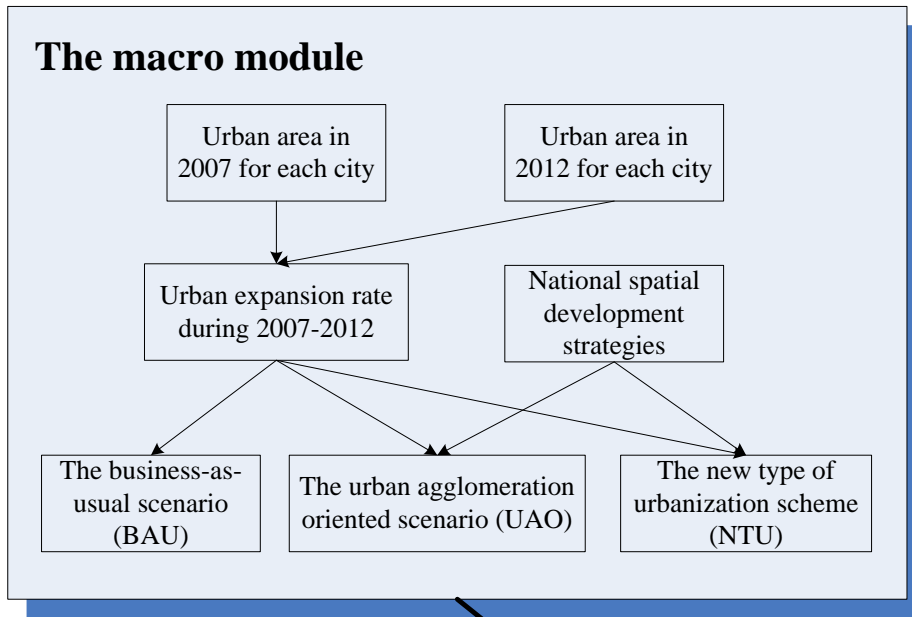
- Automated identification and characterization of parcels (AICP) with **OpenStreetMap** and Points of Interest
- <http://arxiv.org/abs/1311.6165>
- Parcels and their attributes (urban function, density and land use mix) were generated for 297 Chinese cities



This study will

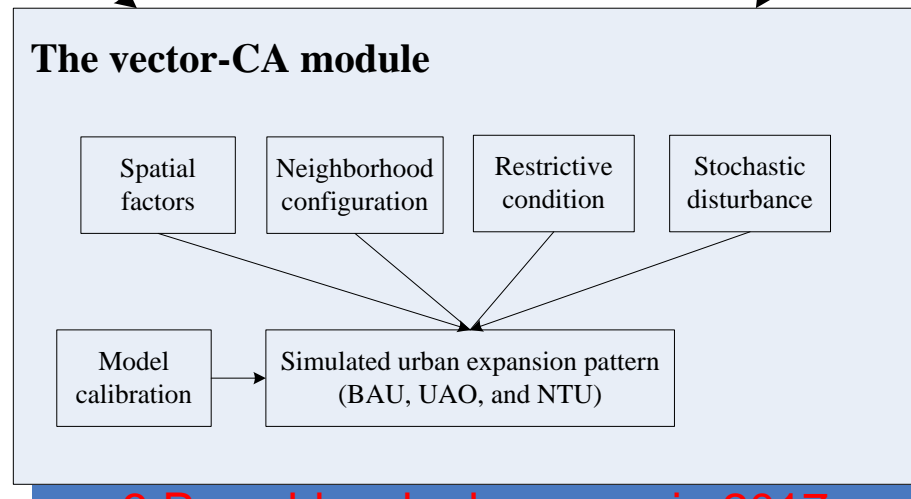
- Extend the existing framework of AICP by replacing OSM road network by the **ordnance survey roads**
 - To generate 2012 parcels for all Chinese cities (297→655)
- Develop a mega-vector-parcels cellular automata model (**MVP-CA**) for simulating urban expansion of China
 - 2012-2017
 - 654 cities

The structure and flow diagram of MVP-CA



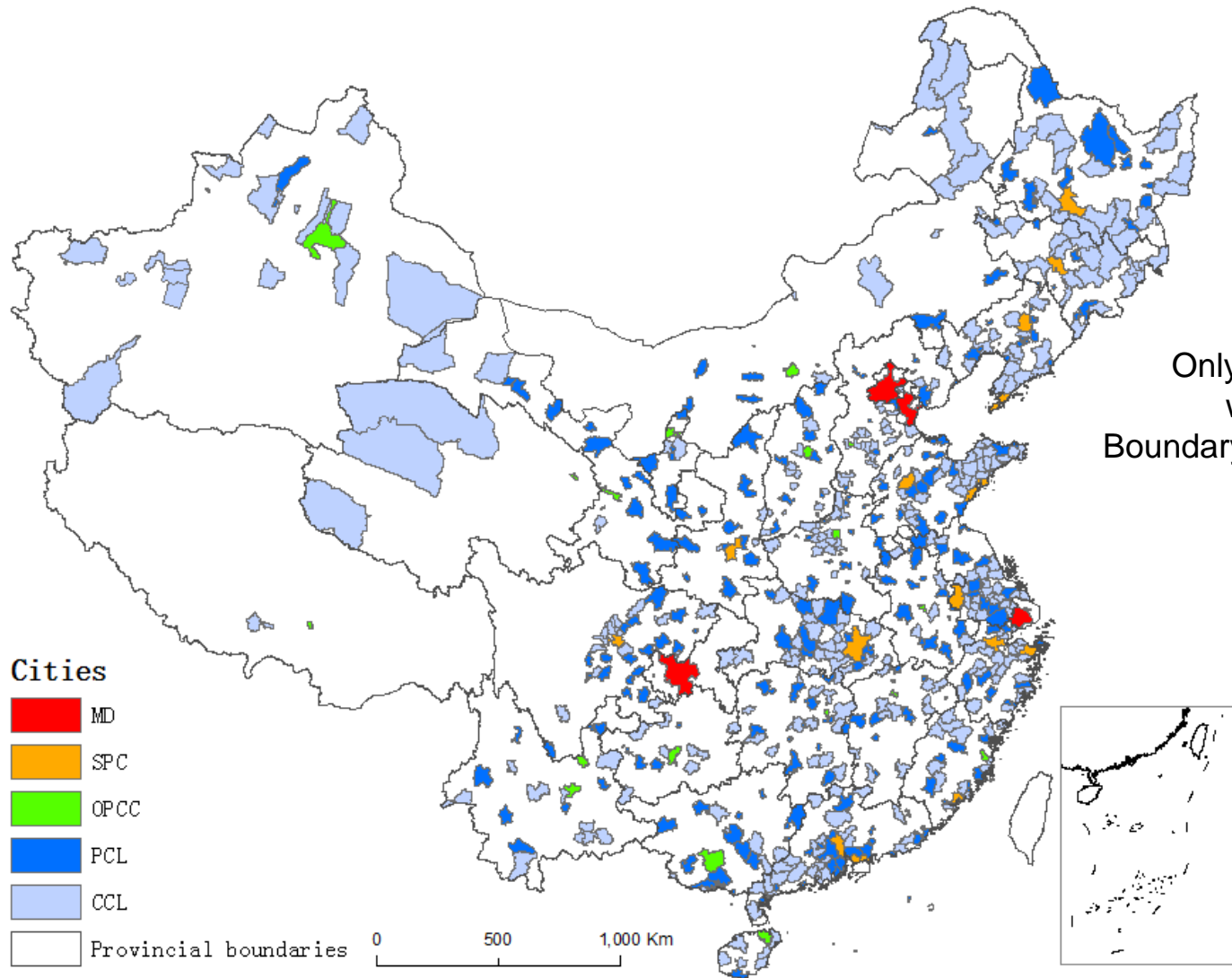
1 Total urban land area for each city in 2017
(Three scenarios)

2 Parcel-level urban area in 2012



3 Parcel-level urban area in 2017

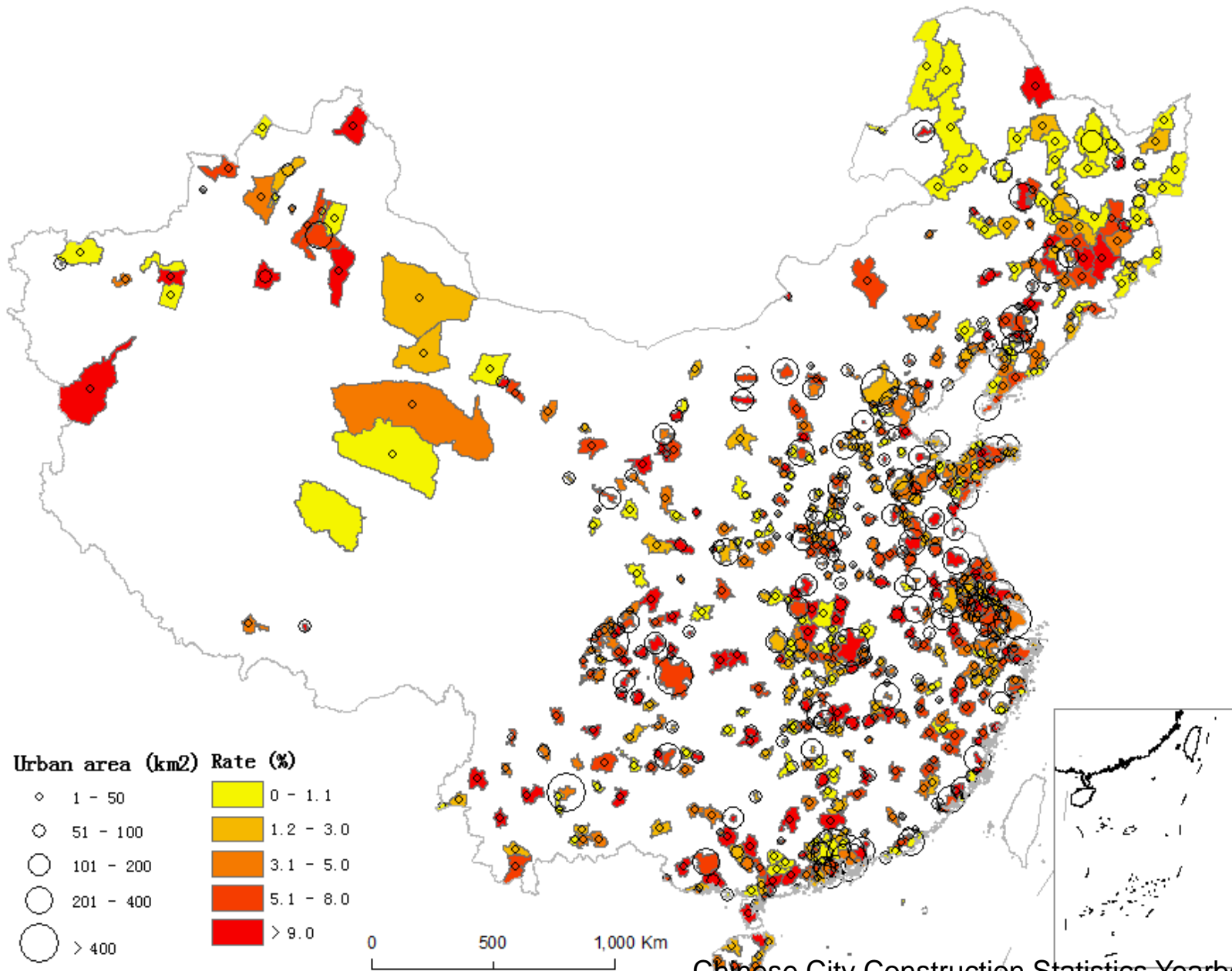
Administrative boundaries of 654 Chinese cities



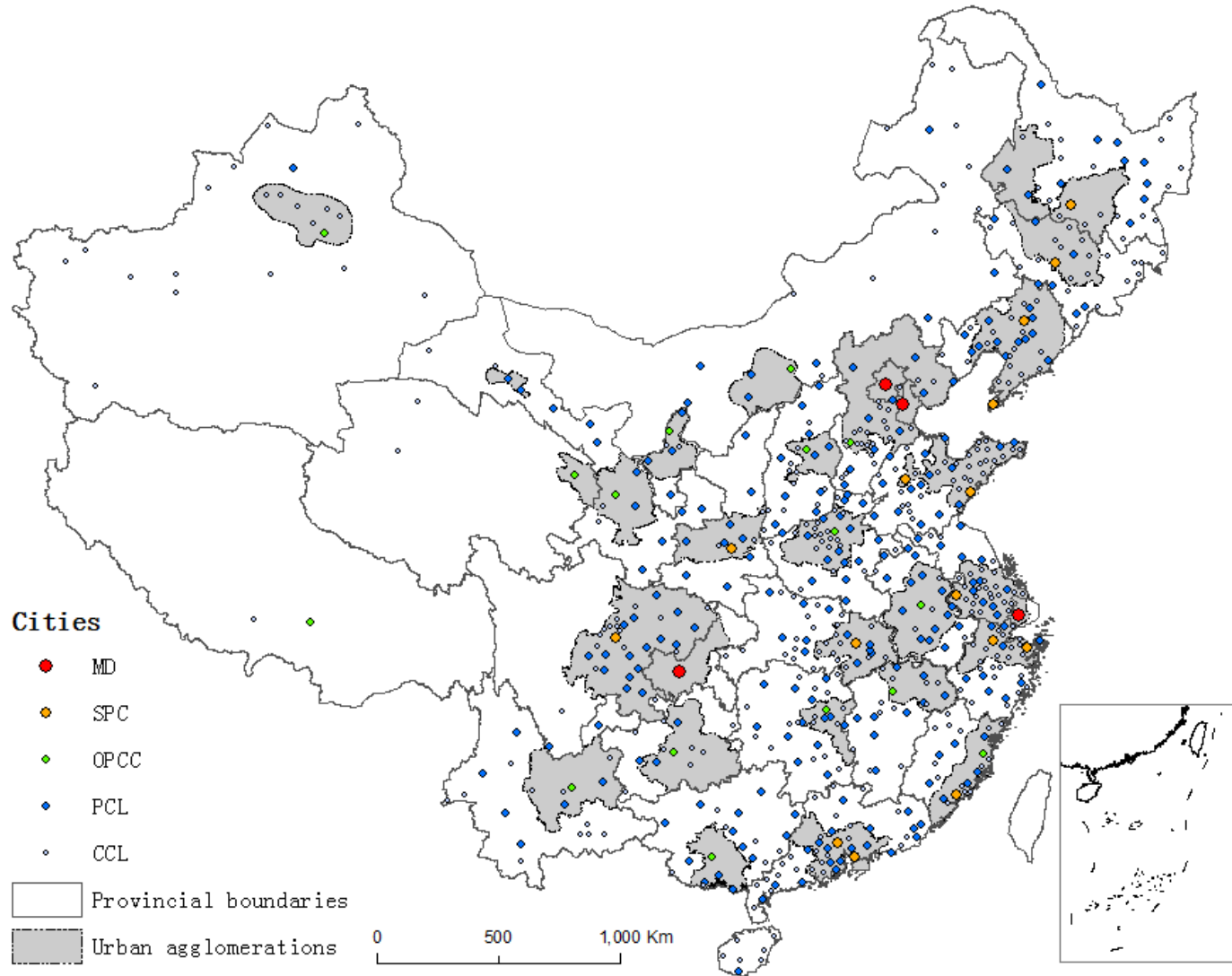
- Five levels of cities in China:

- municipalities directly under the Central Government (**MD**, 4 cities), sub-provincial cities (**SPC**, 15), other provincial capital cities (**OPCC**, 17), prefecture-level cities (**PLC**, 250), and county-level cities (**CLC**, 368)

City size of each city in terms of total urban area in 2012 and the urban expansion rate during 2007-2012

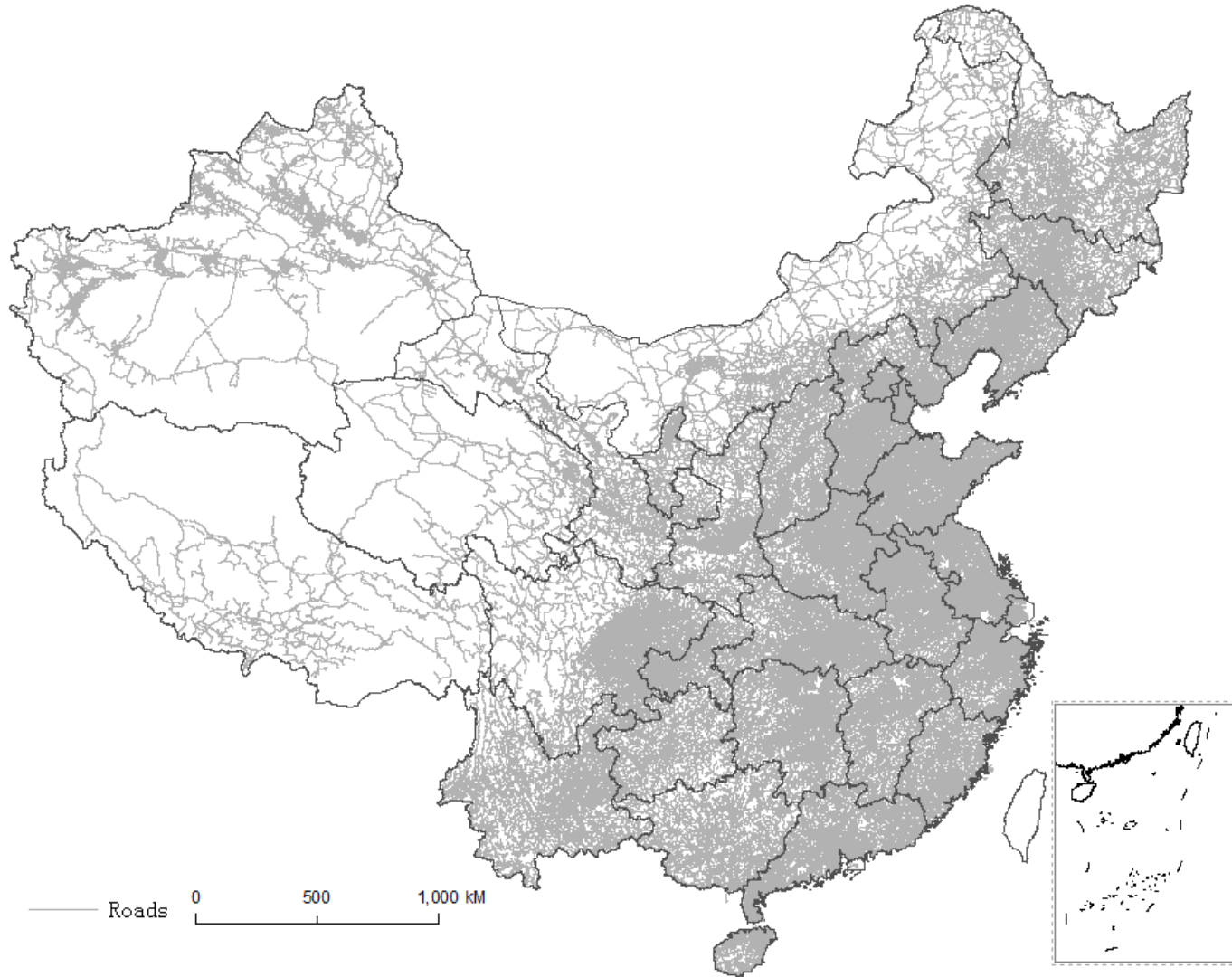


Urban agglomerations (city regions) of China (23)



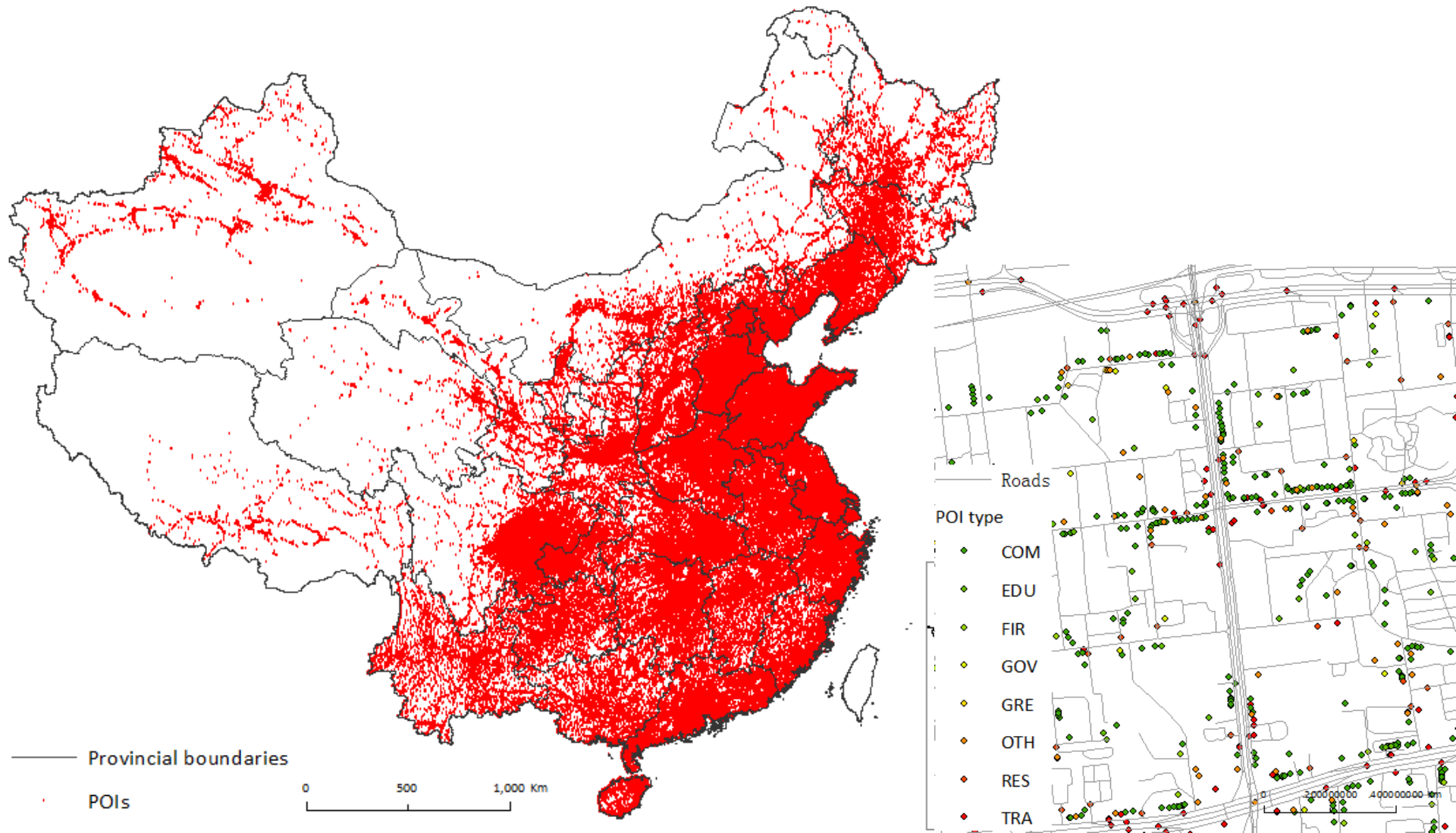
- Urban agglomerations in China are highlighted in the future urbanization in China (Wu et al, 2013)
- For setting simulation scenario

Ordnance roads of China in 2012



- 6.03 million road segments of 2.62 million kilometers

Points-of-interest in 2012



- **Five million** POIs gathered from and geocoded by business cataloging websites
 - **9 categories**, including commercial, transport, government, education, residence, green space, etc

1 The macro module:

Three scenarios on city-level urban area totals in 2017

1. Business-as-usual (BAU):

- Each city replicates its urban expansion rate during 2007-2012 (5.2% for the whole China)

2. Urban agglomeration oriented (UAO)

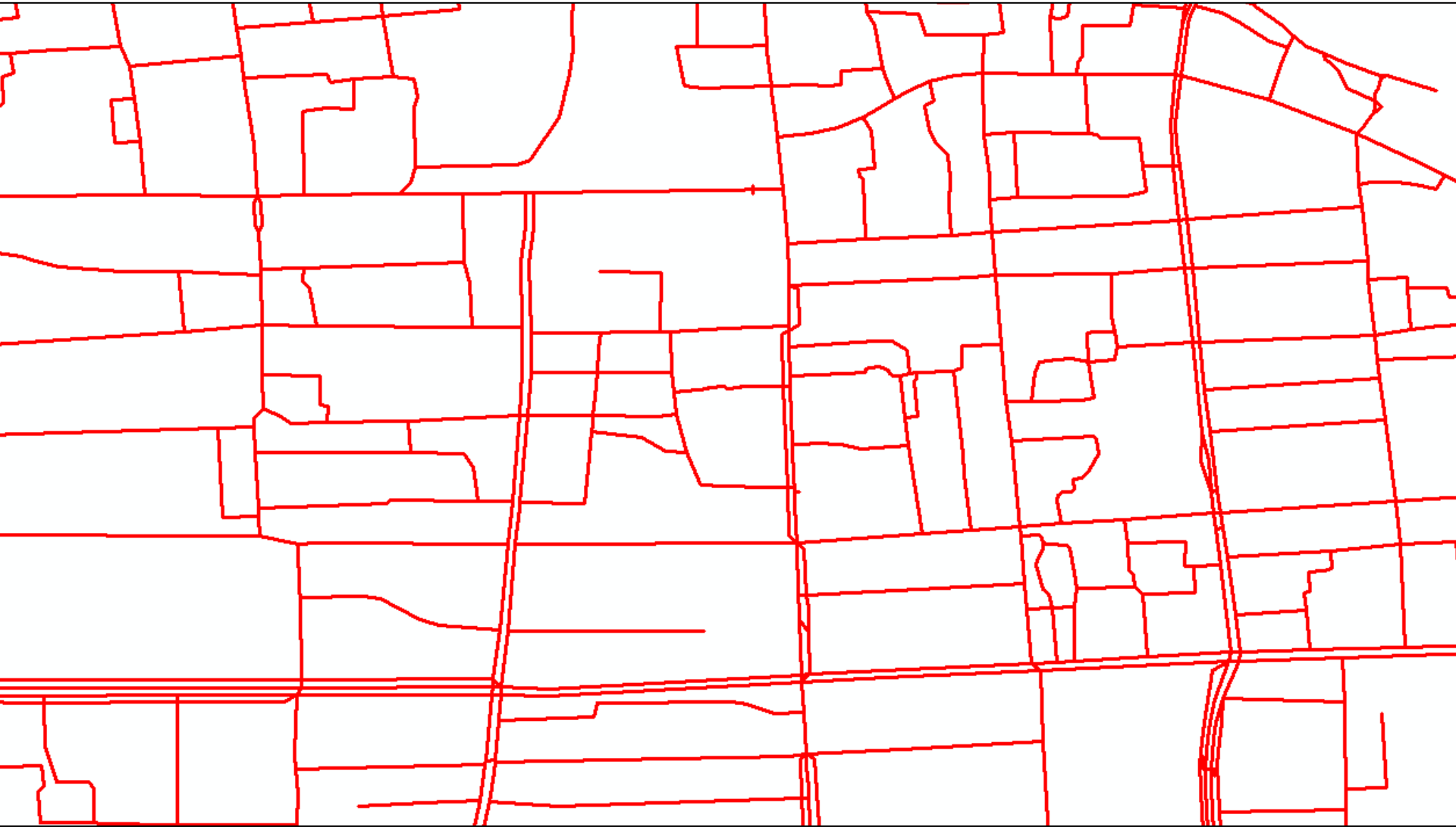
- 355 cities in UAs: 5%
- Other cities: 4%

3. New urbanization planning (NUP)

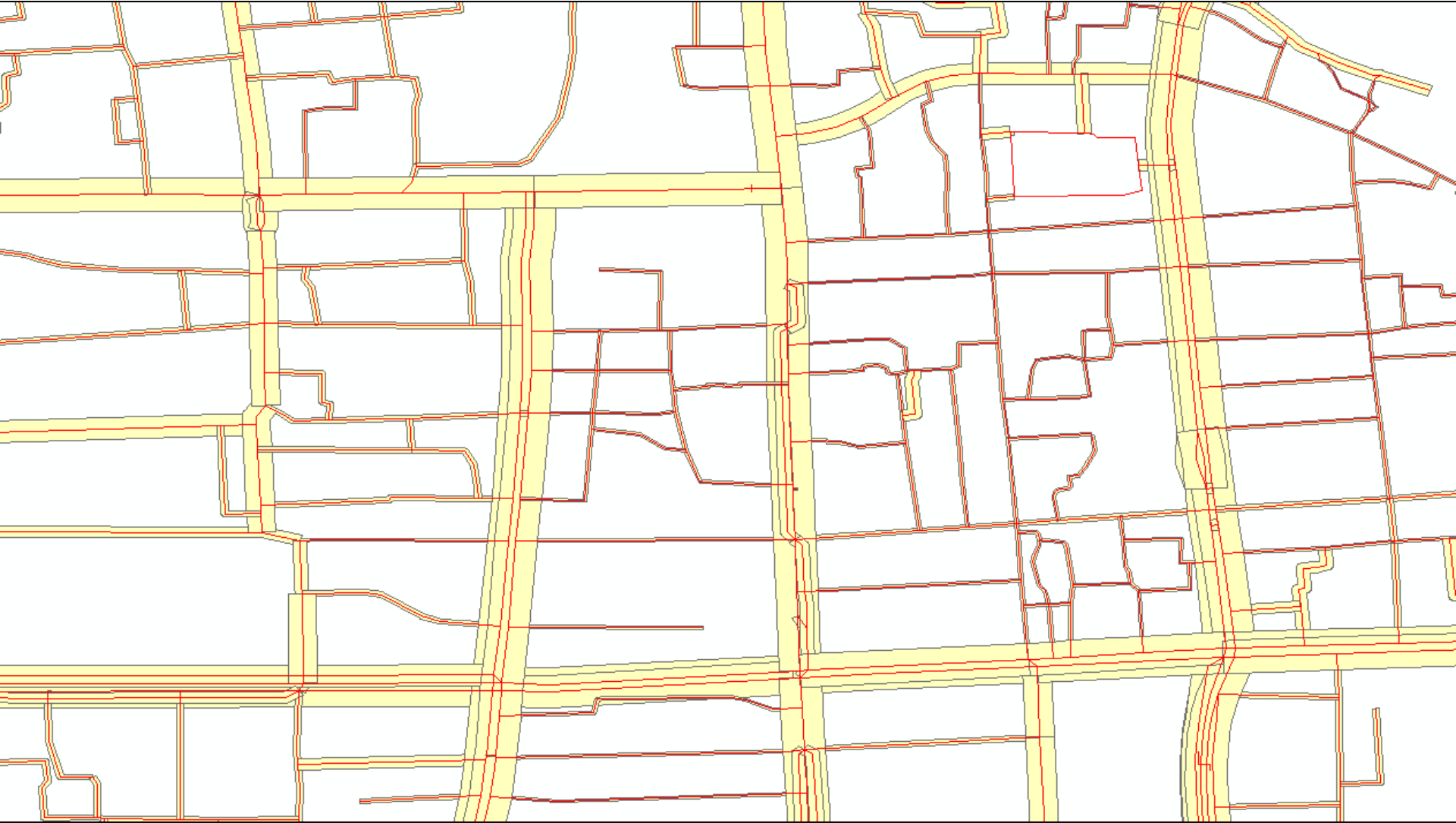
- The larger a city is, the lower its expansion rate would be in the next five years
 - Urban area > 400 km² in 2012, 3.0%
 - Urban area 200-400 km², 4.0%
 - Urban area 100-200 km², 5.0%
 - Urban area < 100 km², 6.0%.
- This scenario is to be updated according to the new urbanization plan of China announced on March 16th, 2014

2 The parcel generation module (AICP):

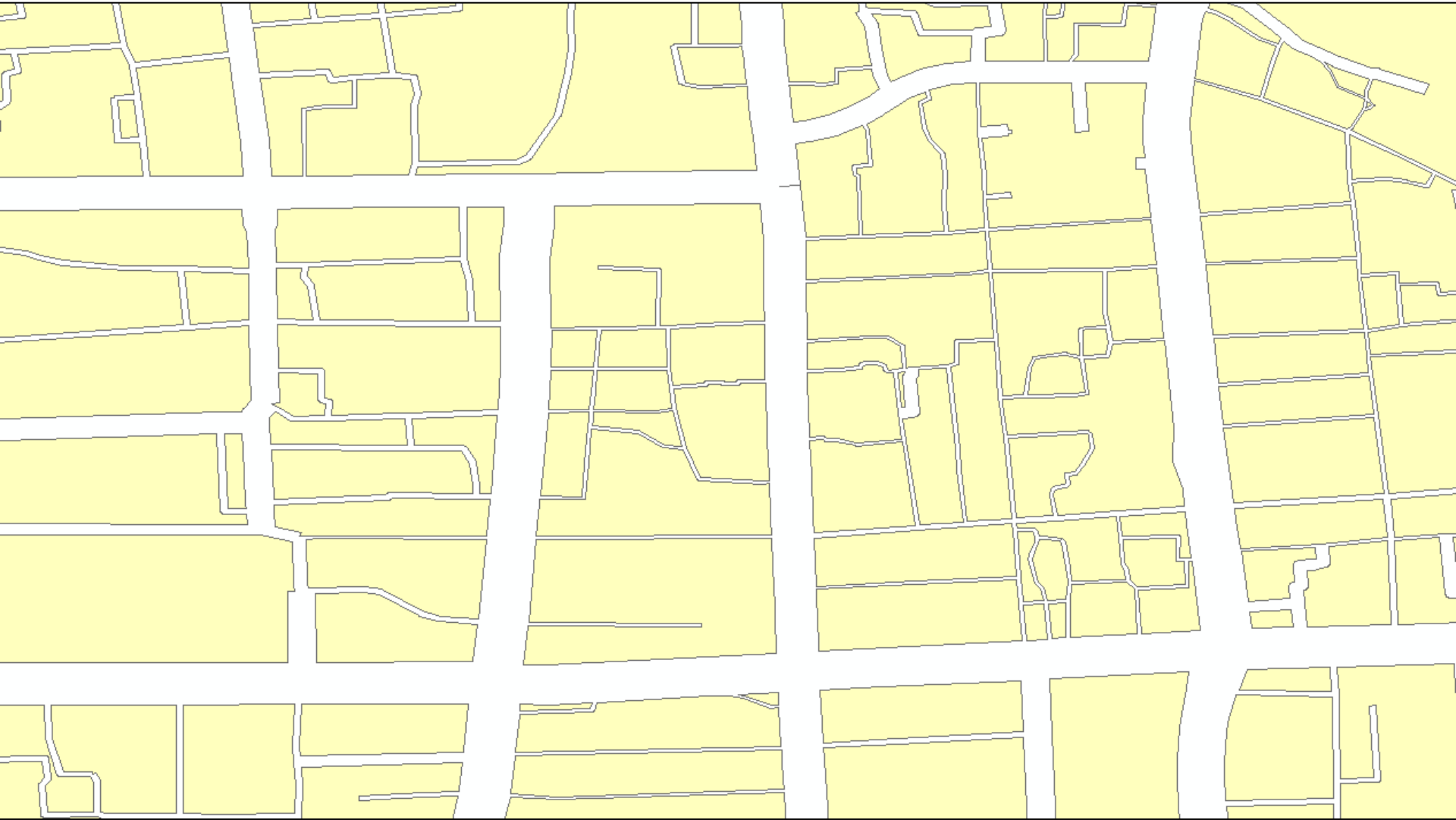
(1) delineating parcel boundaries



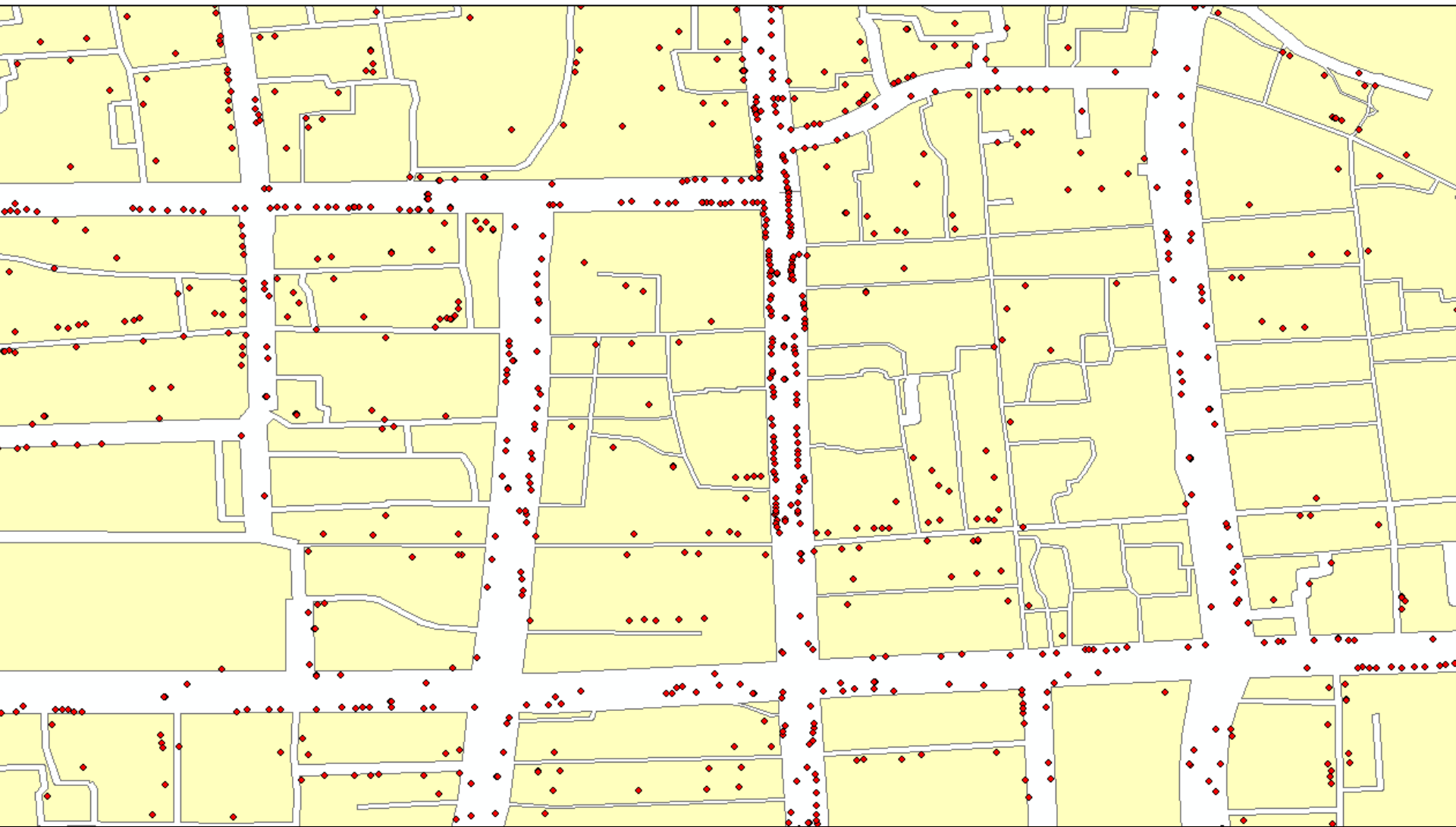
(2) Delineating parcel boundaries



(3) Delineating parcel boundaries



(4) Calculating POIs density for all generated parcels



(4) Calculating POIs density for all generated parcels

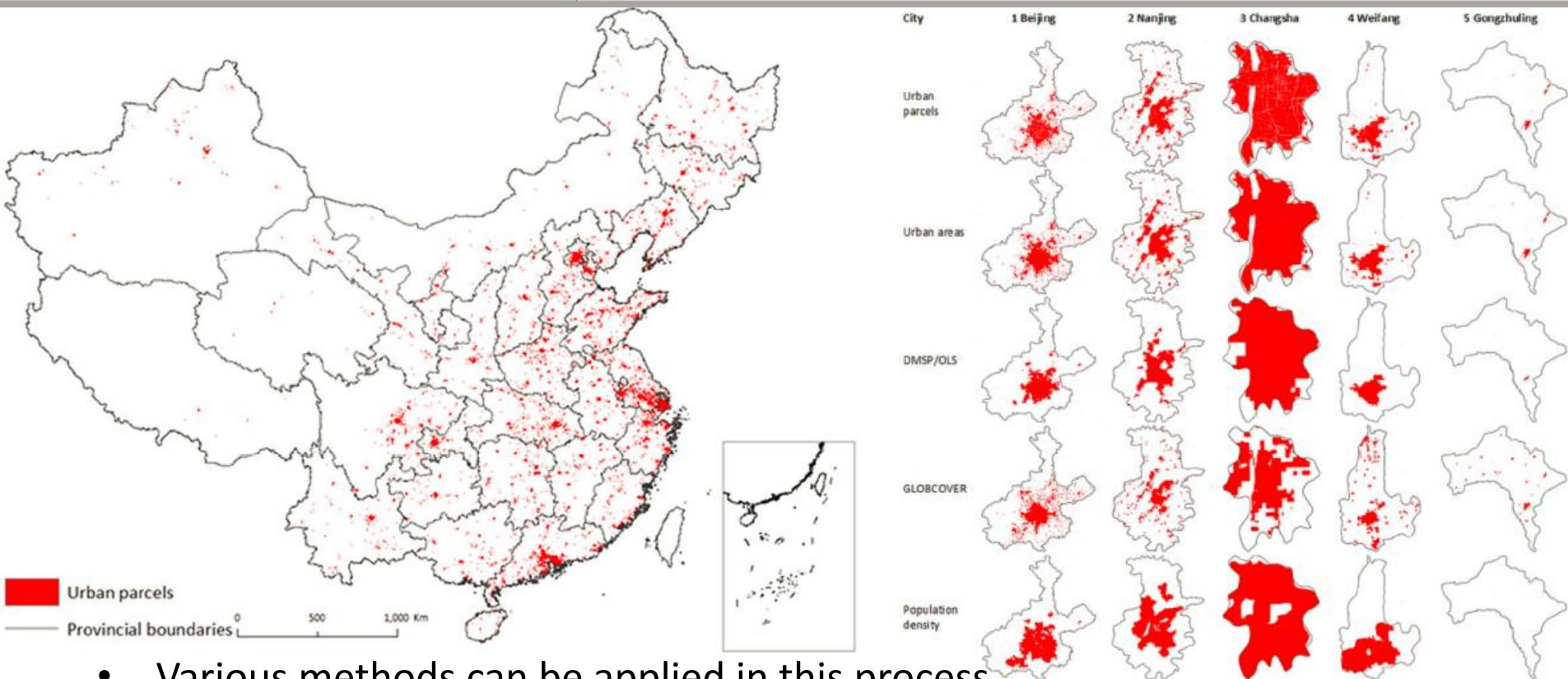


(6) Inferring urban parcels in 2012

MAPPING URBAN BUILT-UP AREAS WITH ROAD NETWORK AND POINTS OF INTEREST USING VECTOR CELLULAR AUTOMATA

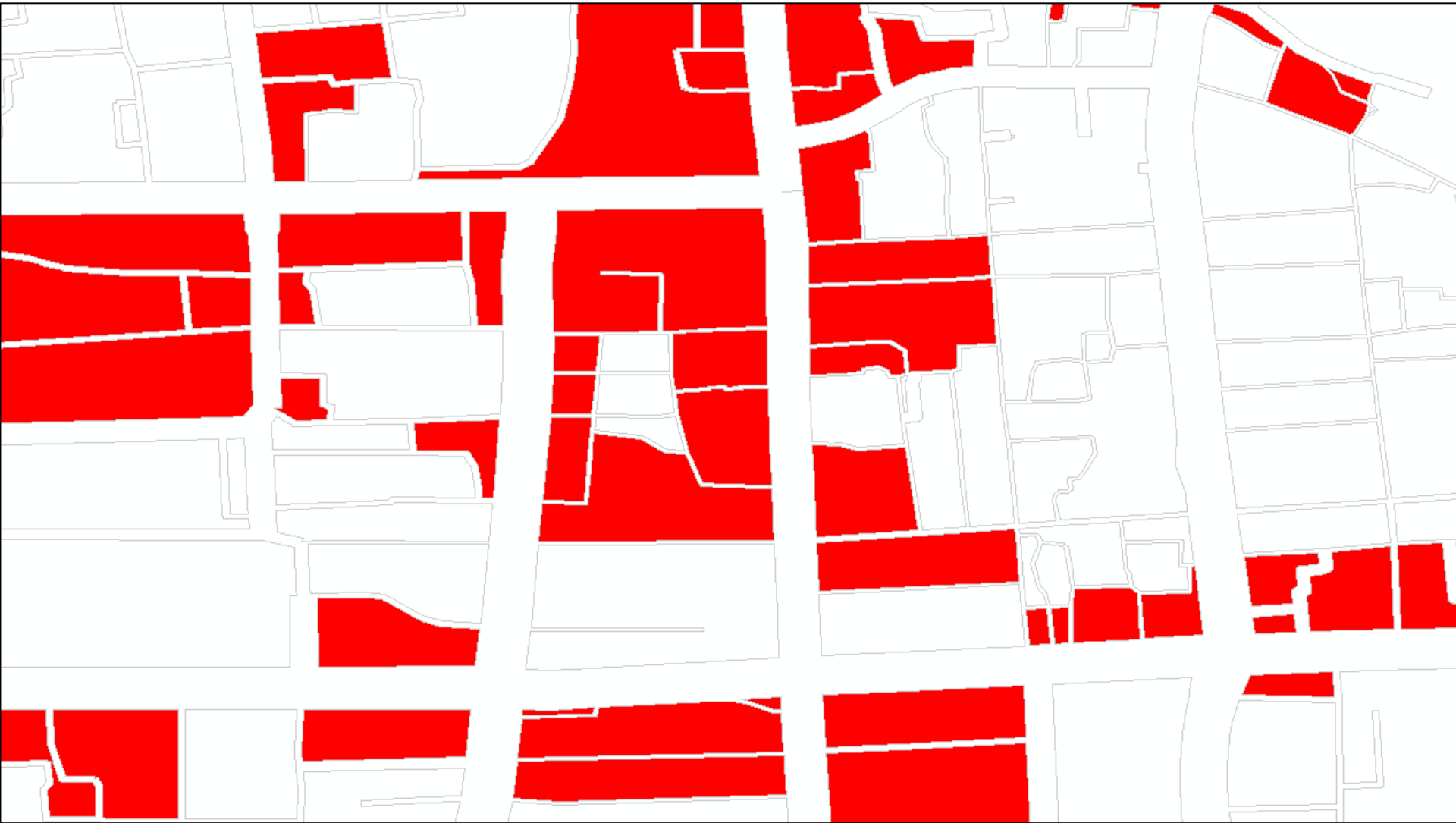
A Parcel-based Perspective of A Large Geographical Area

Yao SHEN (The Bartlett, University College London, UK) & Ying LONG (Beijing Institute of City Planning China & Department of Architecture, University of Cambridge UK)



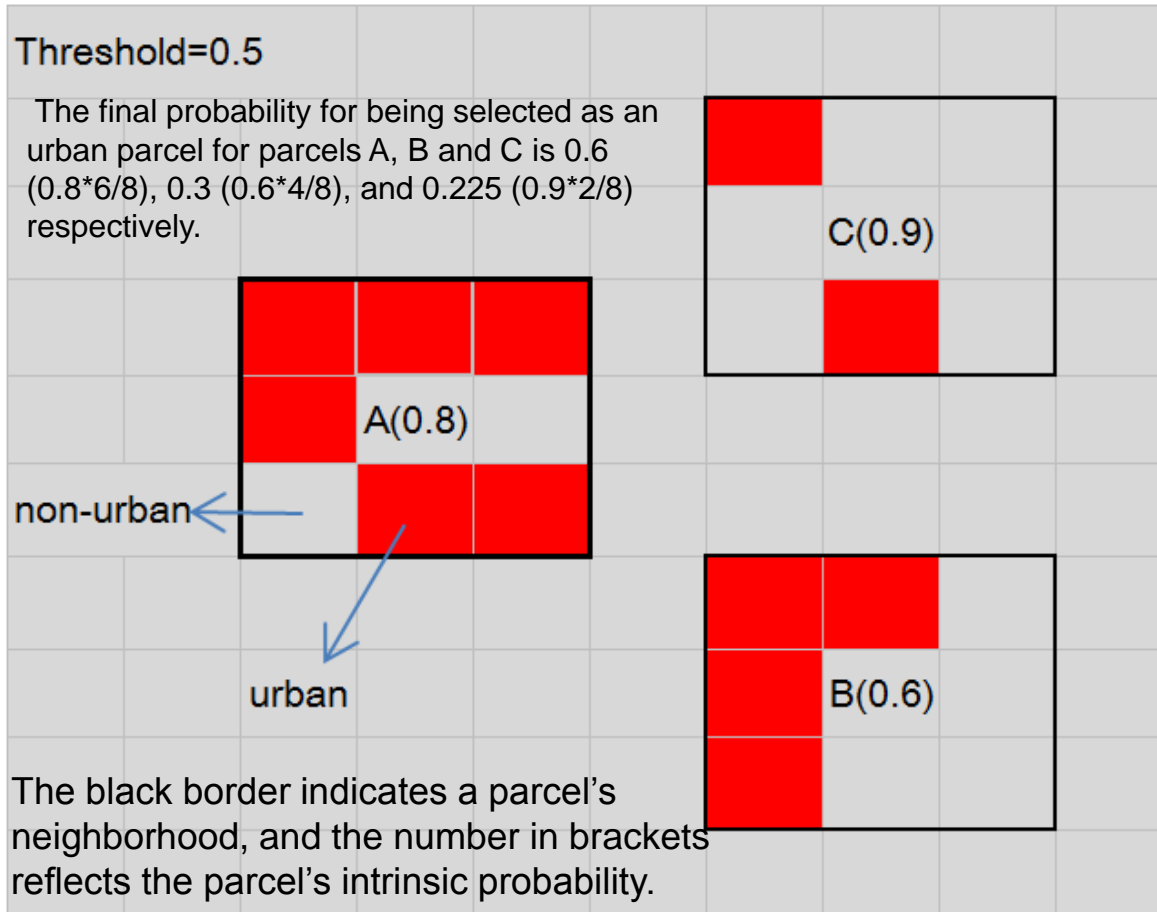
- Various methods can be applied in this process
 - Benchmarking road junction density and population density, referring to other LUC products

(7) Selected urban parcels in 2012



3 The vector CA module

Selecting urban parcels using vector cellular automata



$$P_{ij}^t = (P_l)_{ij} \times (P_\Omega)_{ij} \times con(\cdot) \times P_r$$

$$(P_l)_{ij} = \frac{1}{1 + \exp[-(a_0 + \sum_{k=1}^m a_k c_k)]}$$

$$\sum con(S_{ij}^t = urban)$$

$$(P_\Omega)_{ij} = \frac{\sum con(S_{ij}^t = urban)}{n}$$

$$con(cell_{ij}^t = suitable)$$

$$P_r = 1 + (-\ln g)^b$$

$$S_{ij}^{t+1} = \begin{cases} Urban & \text{for } P_{ij}^t \succ P_{thd} \\ NonUrban & \text{for } P_{ij}^t \leq P_{thd} \end{cases}$$

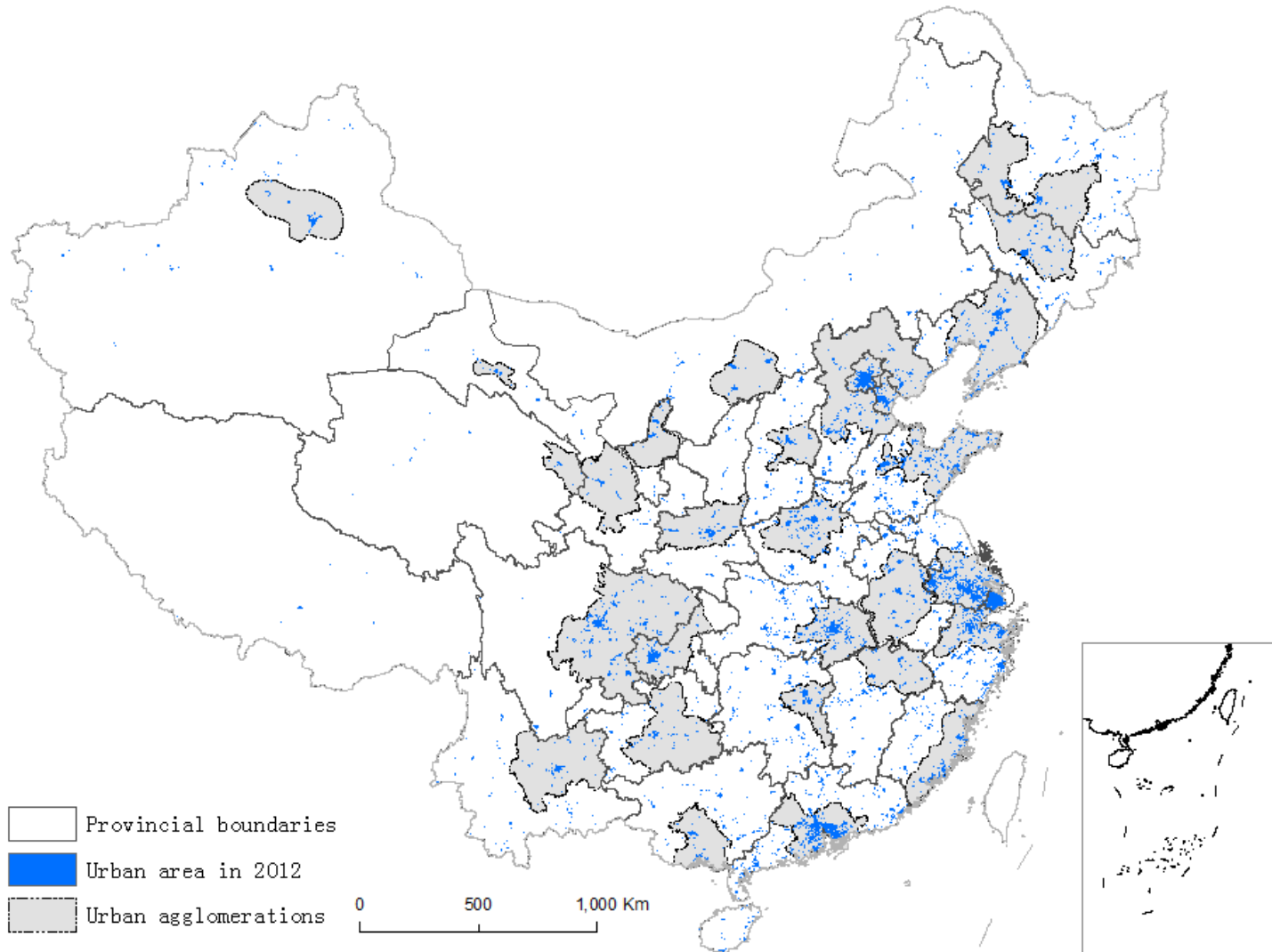
- One vector cellular automata model for each city
- Neighborhood configuration: 500 m radius of each parcel
- Constraints: **size, compactness, distance to city centers, and POIs density** (parameters calibrated using the Beijing parcels)
- Overall accuracy = 83.2%

3 The vector CA module

Simulated urban expansion (in blue)

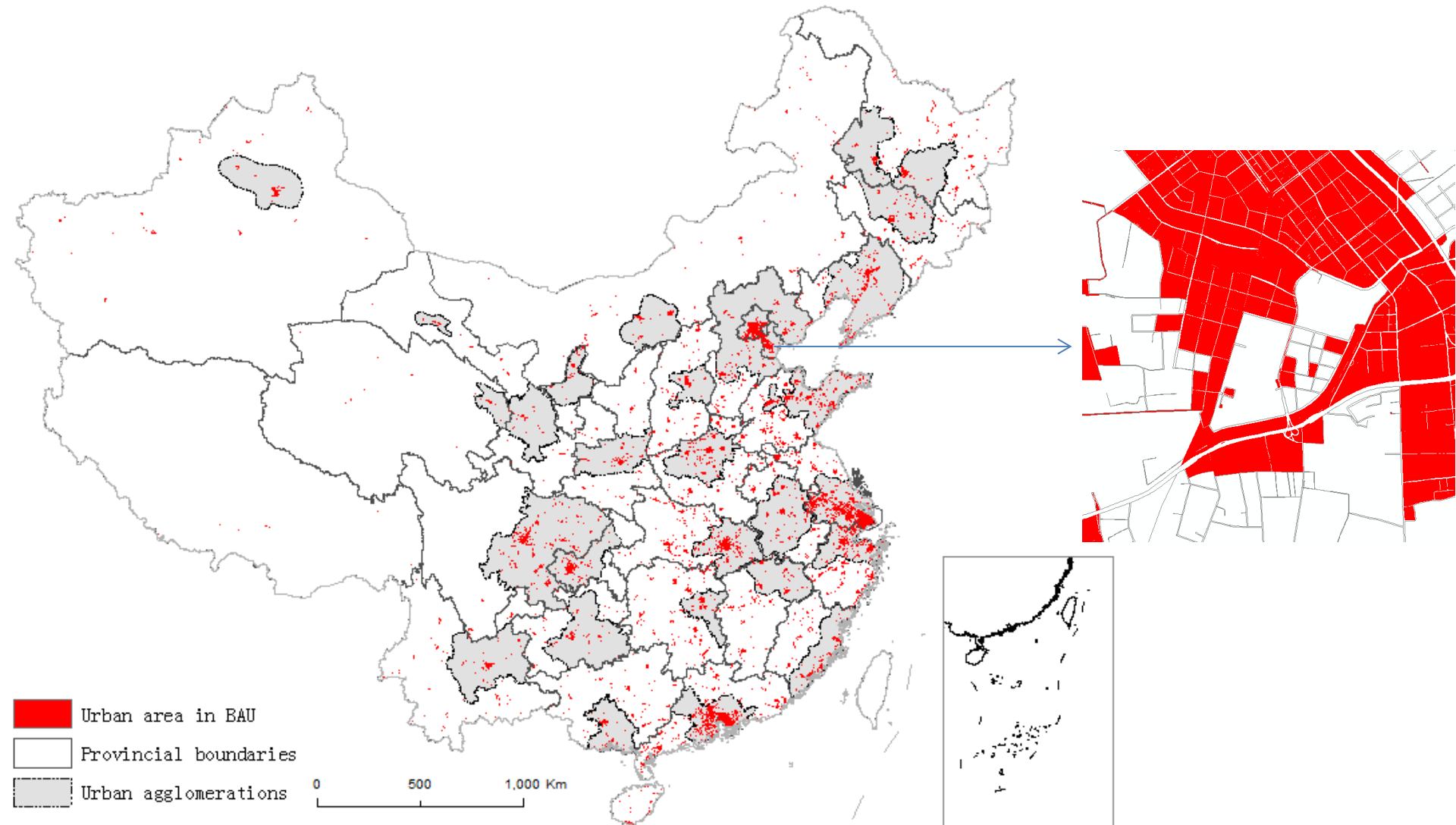


Urban areas of all Chinese cities in 2012



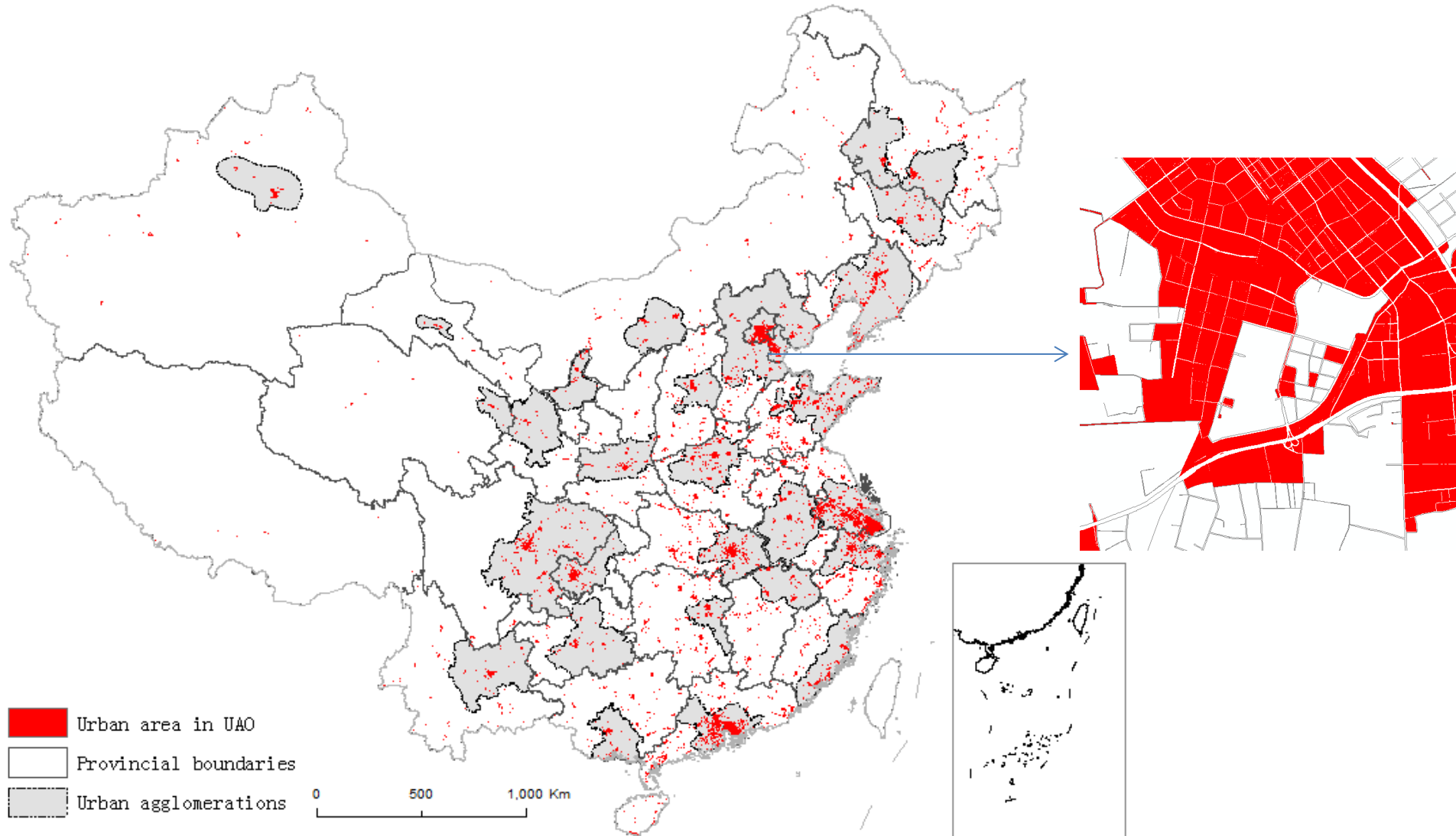
- There are totally **761,152 urban parcels** (among all **1.2 million parcels**) for all 654 Chinese cities and with a total land area 46,751 km² (the average urban parcel size is 6.1 hectares, **200 m*300 m**)

Simulation results: BAU



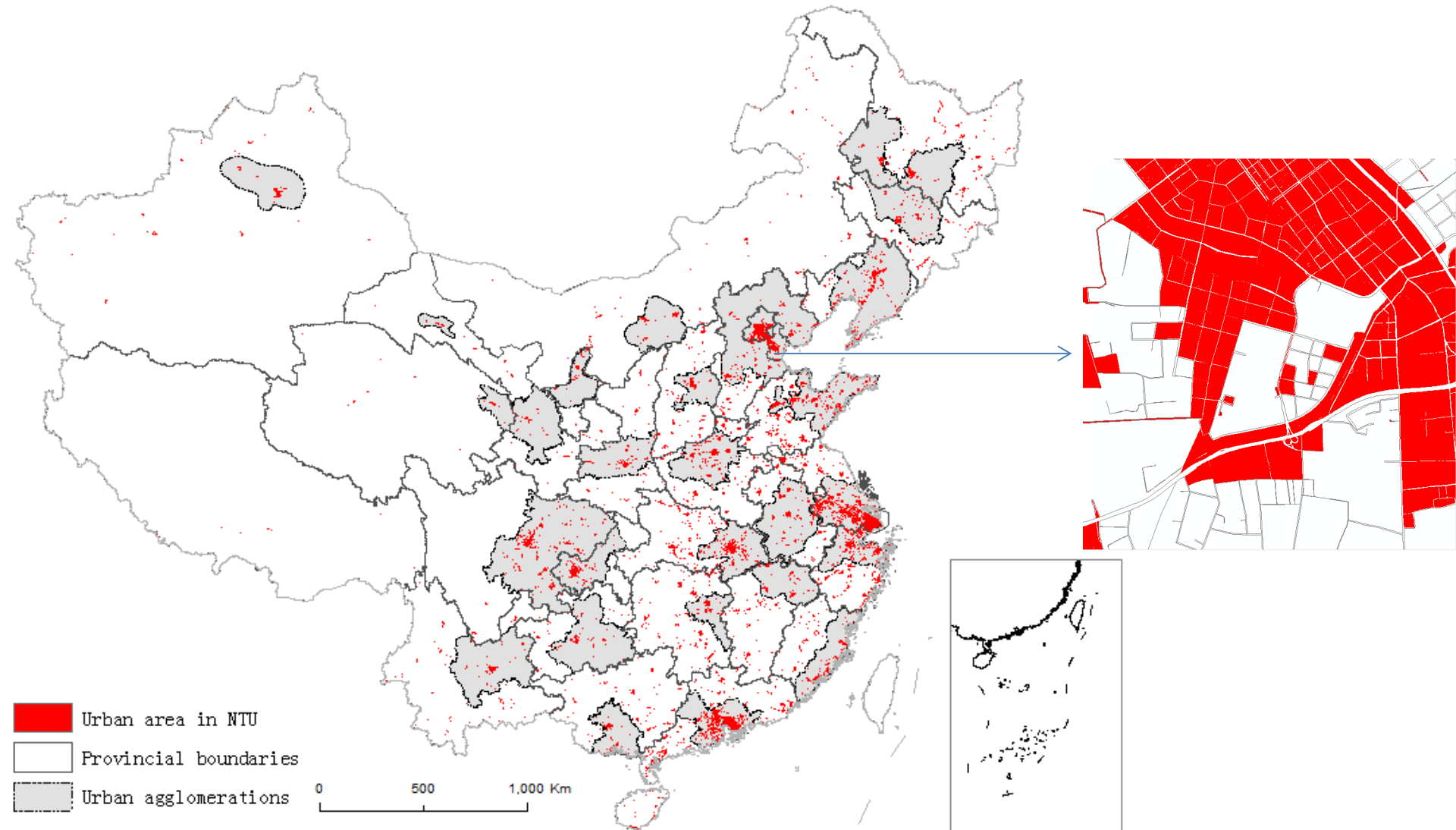
- Total urban land areas estimated by BAU are 62,835 km² in 2017, increased by 34.4% compared to 46,751 km² urban land in 2012.

UAO



- Total urban land areas of UAO are 58,394 km² in 2017, increased by 24.9% compared to urban land in 2012, while 4,441 km² less than BAU.

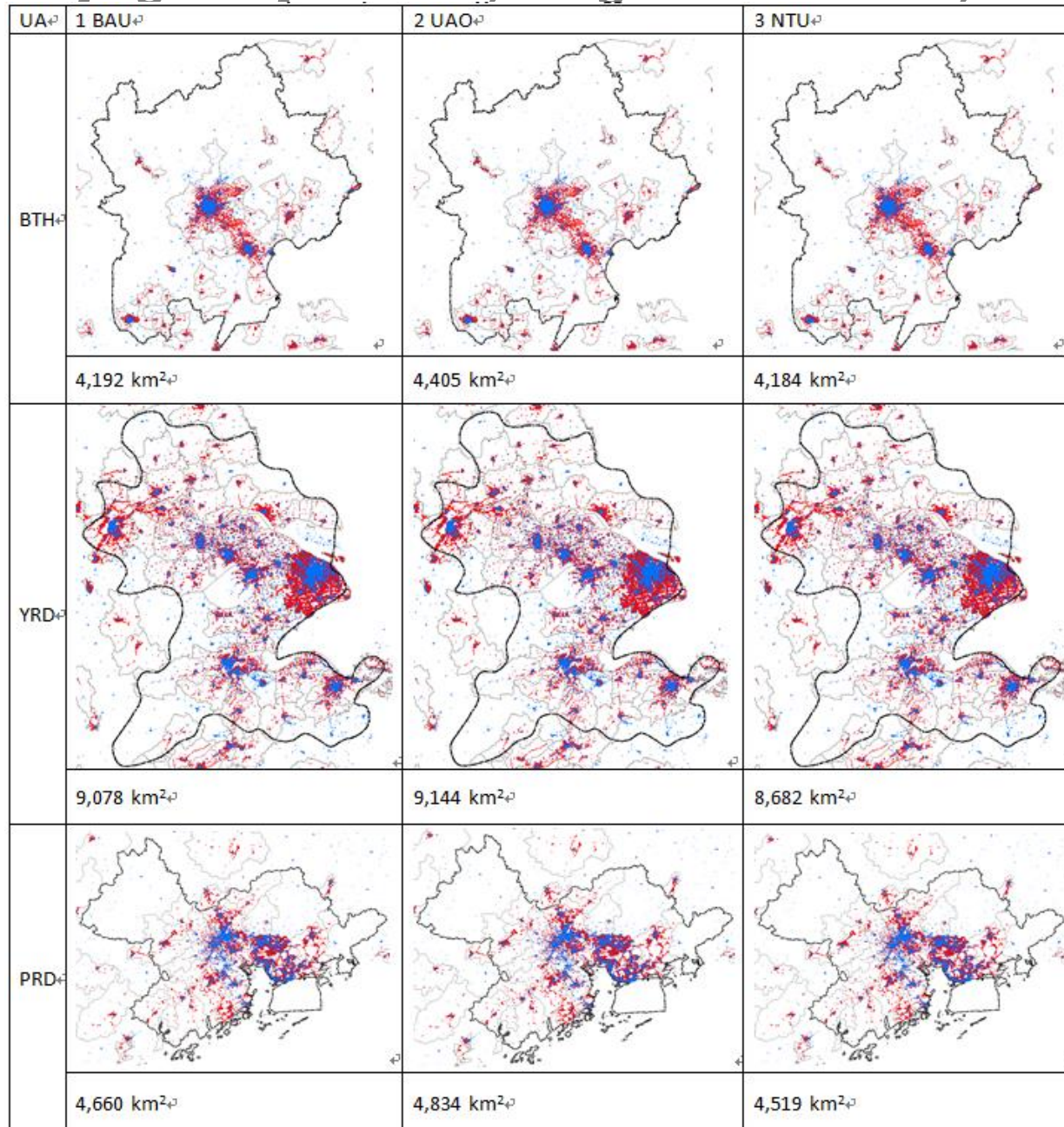
NUP



- The total urban land areas of NUP are 58,930 km² in 2017, increased by 26.1% compared to urban land in 2012, while decreased 3,905 km² in comparison with BAU.

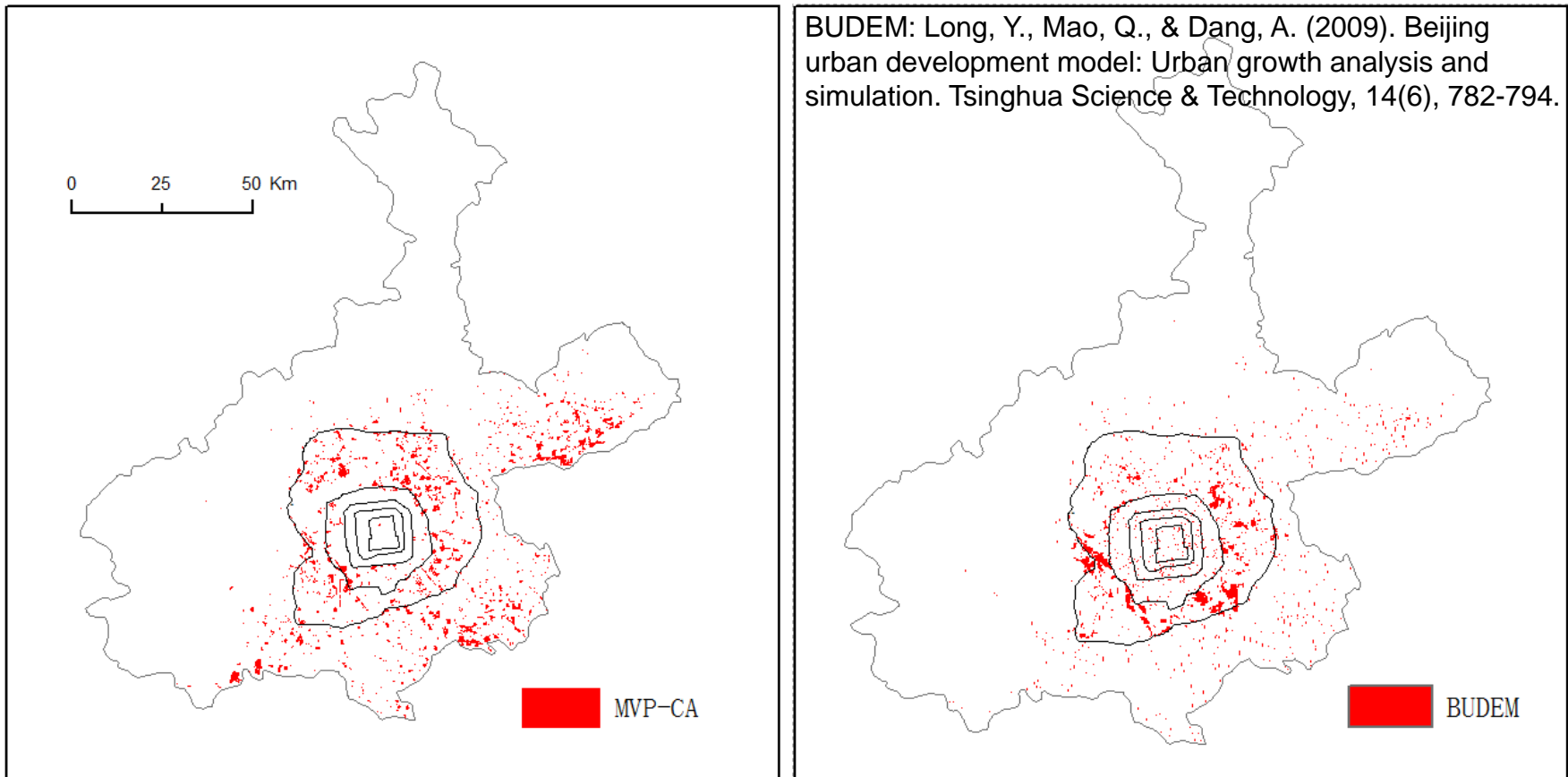
Urban expansion patterns in typical city regions

Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta



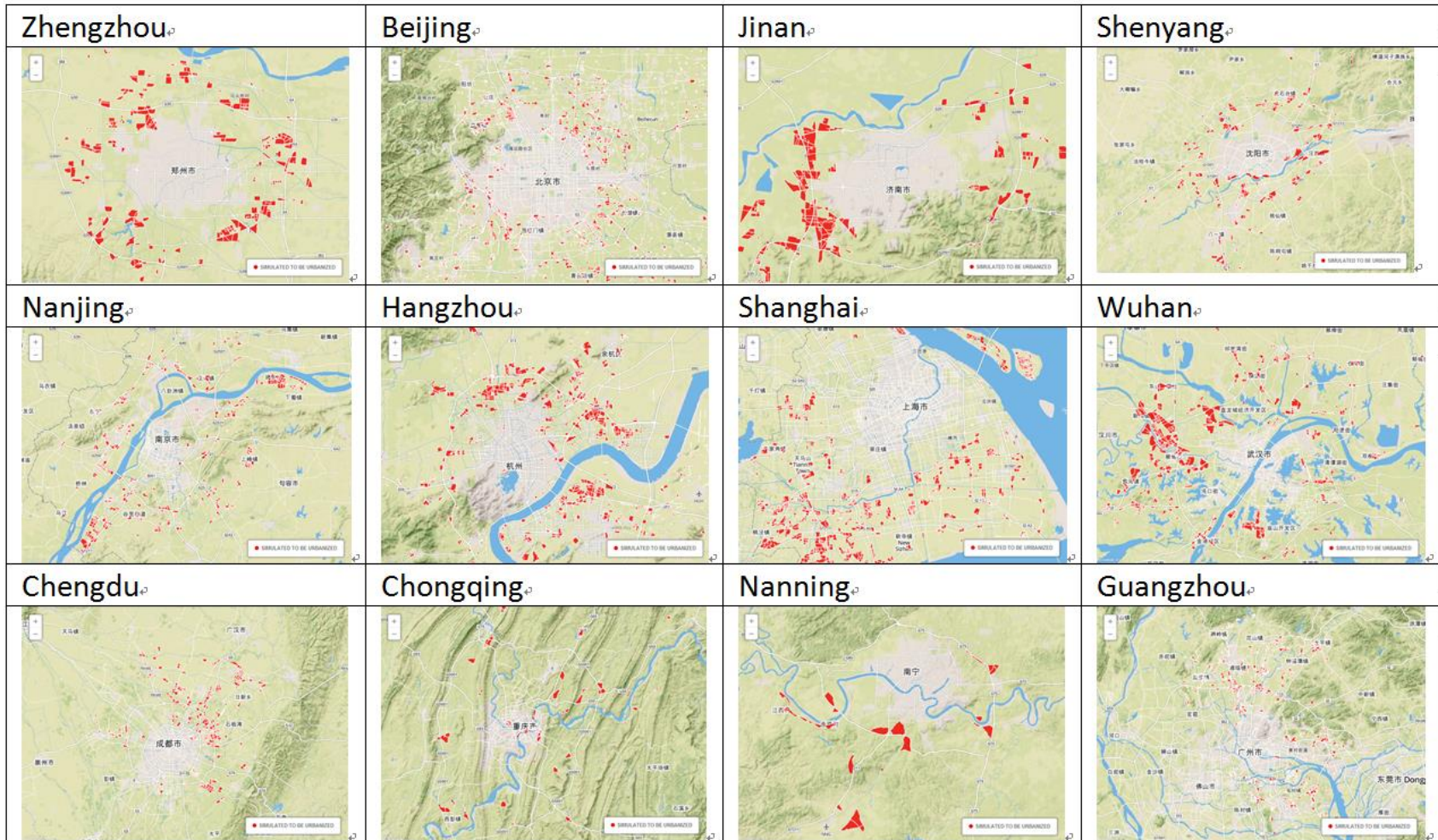
Red denotes simulated urban expansion during 2012-2017 and **blue** denotes existing urban land in 2012.

Validation: Comparing the BAU scenario with a 500m-raster-CA model BUDEM in the city of Beijing



- Expanded areas in both models exhibit **similar patterns** according to the visual judgement.
- The overlaid area shared by both patterns was 119 km² (**68.4% of the total expansion**)
- The simulated pattern for long term is not realistic due to developed large parcels when MVP-CA is adopted to predict for a longer time.

Validation: By online browsers on the released simulation results at CartoDB (an online WebGIS)



- 76 comments for 12 cities received at Sina Weibo. Most of them are **positive** “Happy to see my city’s future development”
- Some potential simulation bias due to being **lacking of planning intervention** in MVP-CA

Concluding remarks

- A data-driven and straightforward model for simulating urban expansion in a super large geographical scale in the parcel level.
- Datasets on existing urban areas and expanded parcels shared online for both practitioners and researchers.

20 Expanded parcels during 2012-2017 by MVP-CA

2014

"The BCL voice on future urban development of China"

Expanded 43,247 parcels during 2012-2017 in the business-as-usual simulation scenario (BAU) for 654 Chinese cities **(the preliminary results)**, by Dr Ying Long, Dr Kang Wu, and Dr Qizhi Mao.

Details are available in our arXiv paper (also available in the BCL "Data released" channel), <http://arxiv.org/abs/1402.3718>

Welcome cite: Long, Y., Wu, K., & Mao, Q. (2014). Simulating urban expansion in the parcel level for all Chinese cities. arXiv preprint arXiv:1402.3718.

Download: <https://www.dropbox.com/s/05id7nhn5i5qcwi/DT20.zip>

Data format: ShapeFile

<http://longy.jimdo.com/data-released-1/data1-20/>

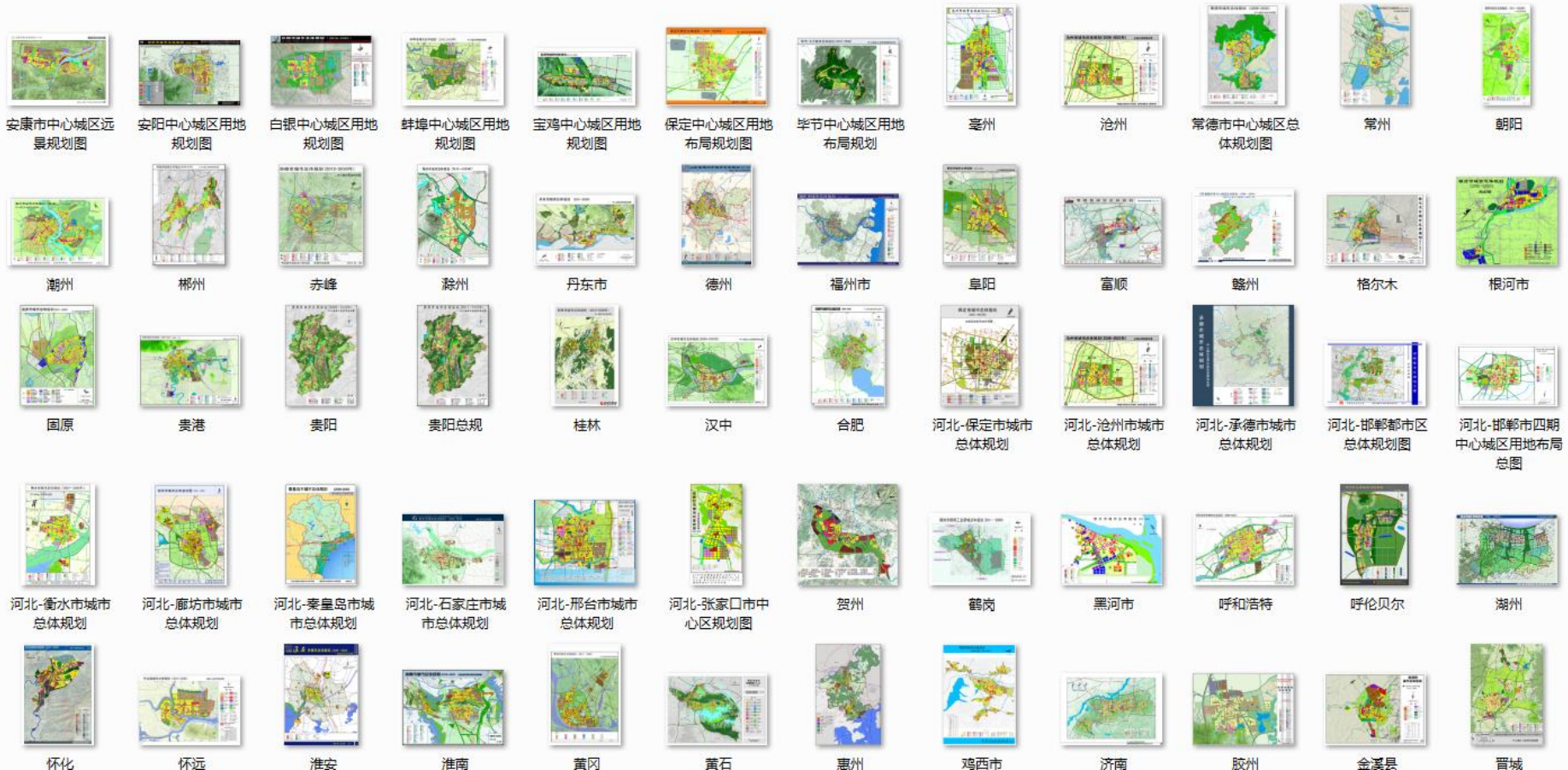
Potential applications

Results shared online to promote applications

1. Evaluating national spatial development strategies via linking macro policies to local developments.
 - Visualized at a fine scale using MVP-CA
2. Informing decision makers, developers, planners and local residents on simulated local developments
 - “Parcels” make more sense to them
3. Evaluating urban expansion impact based on simulated results
 - E.g. environment, ecology and social impacts

Next steps

1. Gathering master plans of Chinese cities **as a constraint** in MVP-CA
2. Model calibration using **national-wide datasets** rather Beijing
3. Parcel subdivision equipped for **subdividing large rural parcels**



Thanks for your attention!

Paper: <http://arxiv.org/abs/1402.3718>

Data 20 at Beijing City Lab: <http://longy.jimdo.com/data-released-1/data1-20/>

