城市模型及其规划设计响应

Applied Urban Models and Their Applications in Urban Planning & Design

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沈尧、沈振江、王江浩、吴康、杨东峰、张俊杰和赵怡婷等

城市模型及其规划设计响应

1 城市模型与规划支持系统

1.1 规划支持系统在城市规划中的应用探索
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1.4 囊括方法、软件和模型的规划支持系统框架体系
1.5 面向空间规划的微观模拟

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Applied Urban Models and Their Applications in Urban Planning & Design

1 Urban Models and Planning Support Systems

1.1 Planning support systems in urban planning
1.2 Beijing urban spatial development model families
1.3 Planner Agents: A toolkit for support planning a low carbon urban form
1.4 An applied planning support toolkit including quantitative methods, software and models in China
1.5 Urban micro-simulation for spatial planning

2 Big Models and Quantitative Urban Studies

2.1 Big models: Several fine-scale urban studies for the whole China
2.2 Automated identification and characterization of parcels (AICP) with OpenStreetMap and points of interest
2.3 Simulating urban expansion at the parcel level for all Chinese cities
2.4 Estimating population exposure to $PM_{2.5}$ in China
2.5 Bus landscapes: Analyzing commuting pattern using bus/metro smartcard data in Beijing
2.6 Four changes on quantitative urban studies in the big data era

3 Applications in Urban Planning & Design

3.1 Data augmented design (DAD): Planning & design in new data environment
3.2 Street urbanism
3.3 Evaluation of urban planning implementation: An analytical framework for Chinese cities and case study of Beijing
3.4 Evaluating the effectiveness of urban growth boundaries with human mobility data
3.5 Shrinking cities in China and the research agenda
3.6 Historical city plans in Beijing

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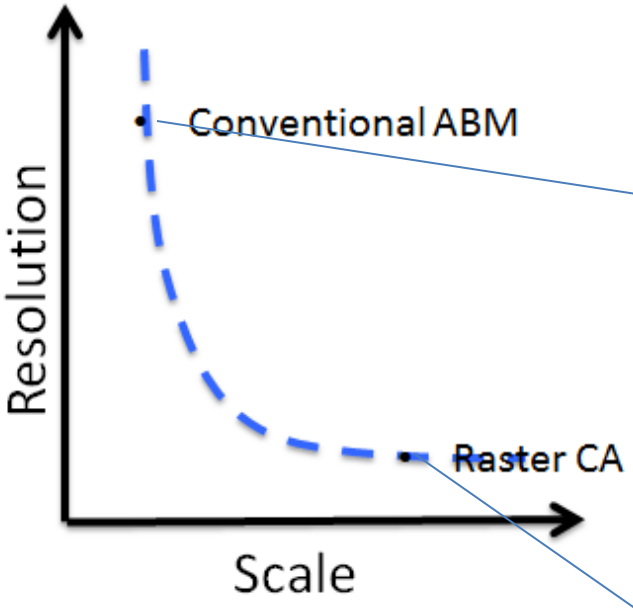
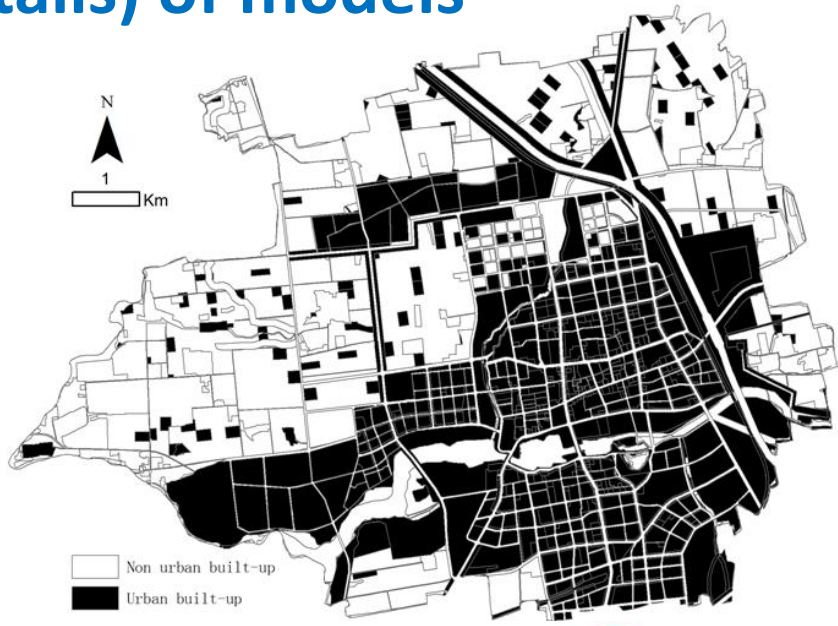
Research background

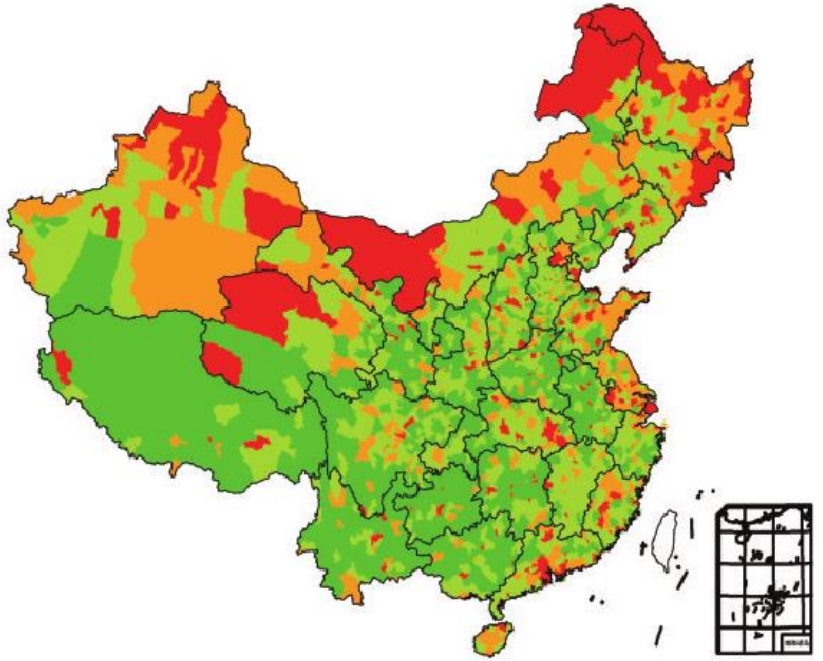
- Booming urban expansion in China
  - 46,751 km^2 (annual expansion rate 5.2% 2007-2012)
- Urban expansion simulation models developed for supporting decision making
  - 1 City or district level models
    - Almost all for big cities, e.g. Beijing, Shanghai, Guangzhou, Hangzhou, using grid cellular 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 km^2, a county

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



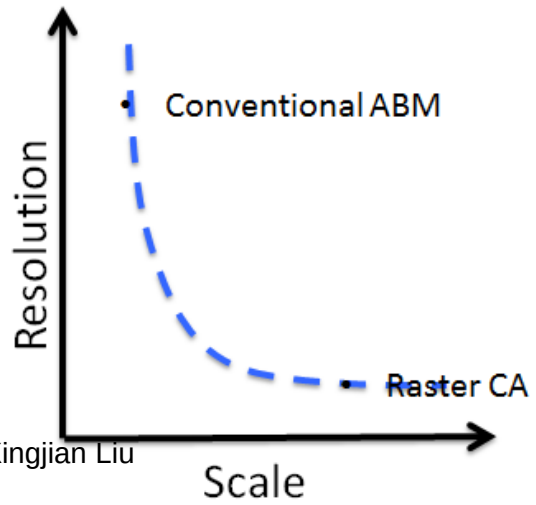


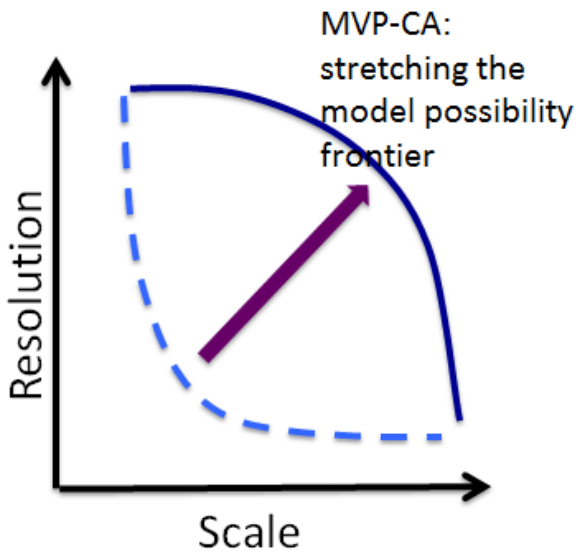
Existing urban expansion models



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.

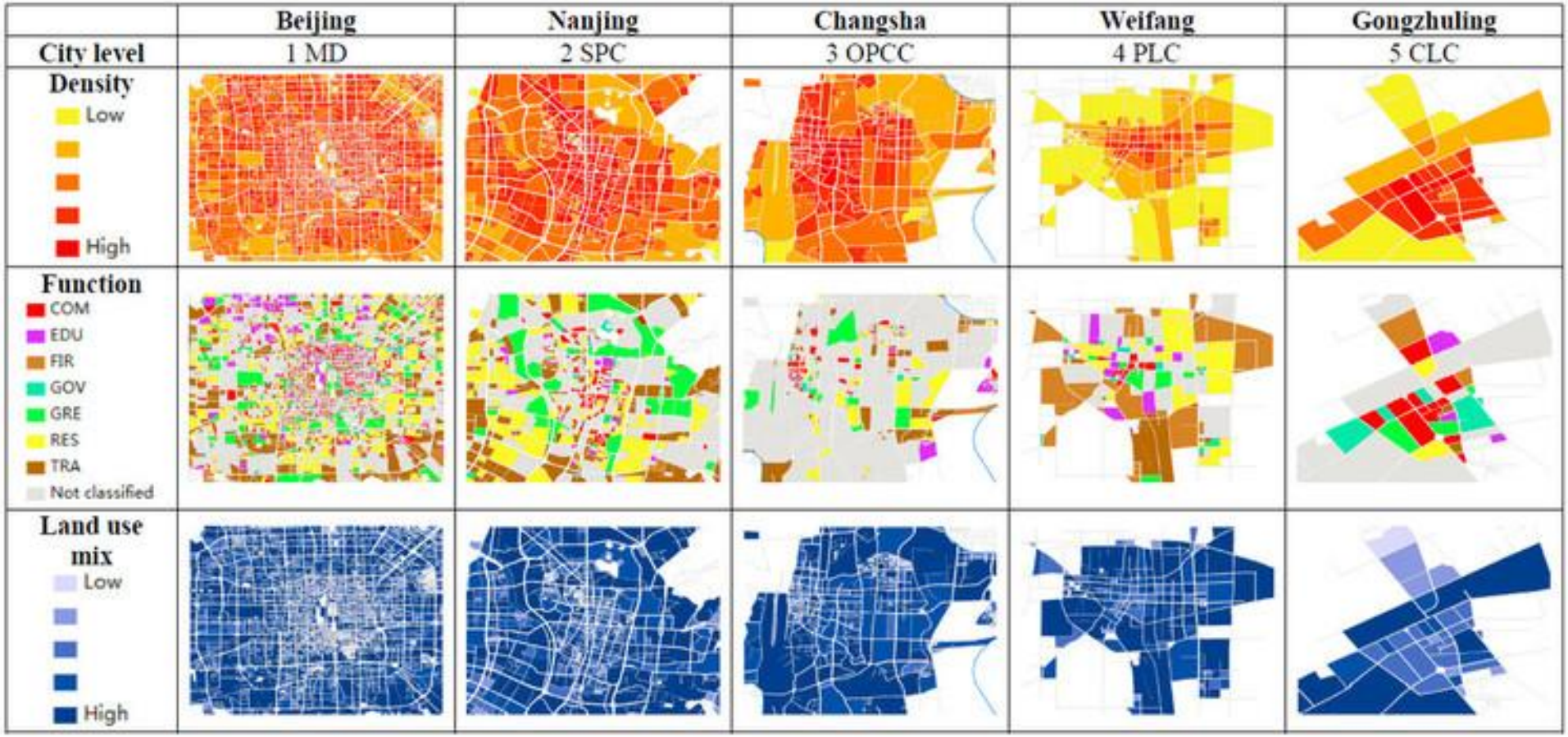
We do not have national-scale parcel maps in most of developing cities!

- 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

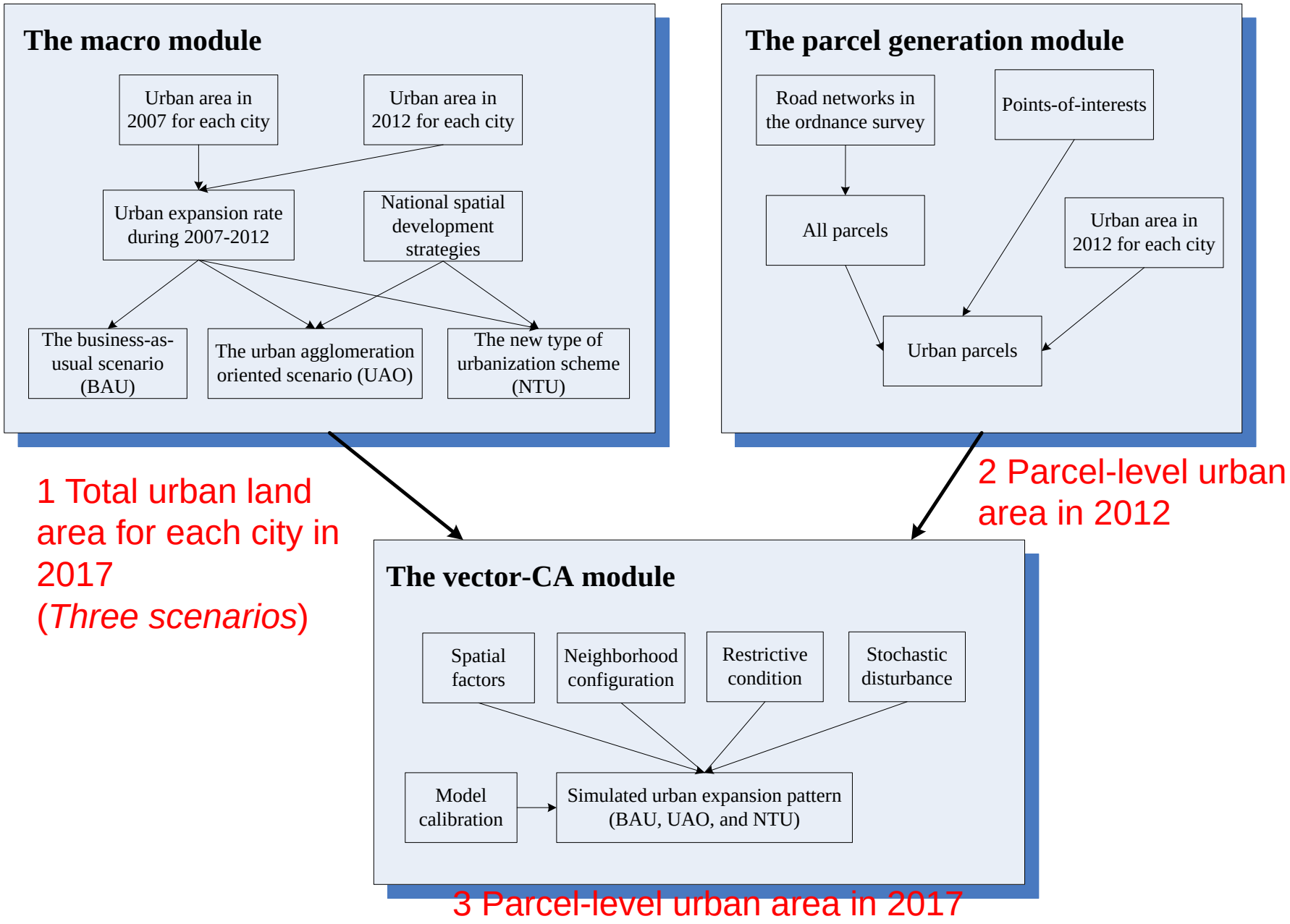
- **Automated identification and characterization of parcels (AICP) with OpenStreetMap and Points of Interest**
- **http://arxiv.org/abs/1311.6165**
- **Parcels and their attributes (urban function, density and land use mix) were generated for 297 Chinese cities**



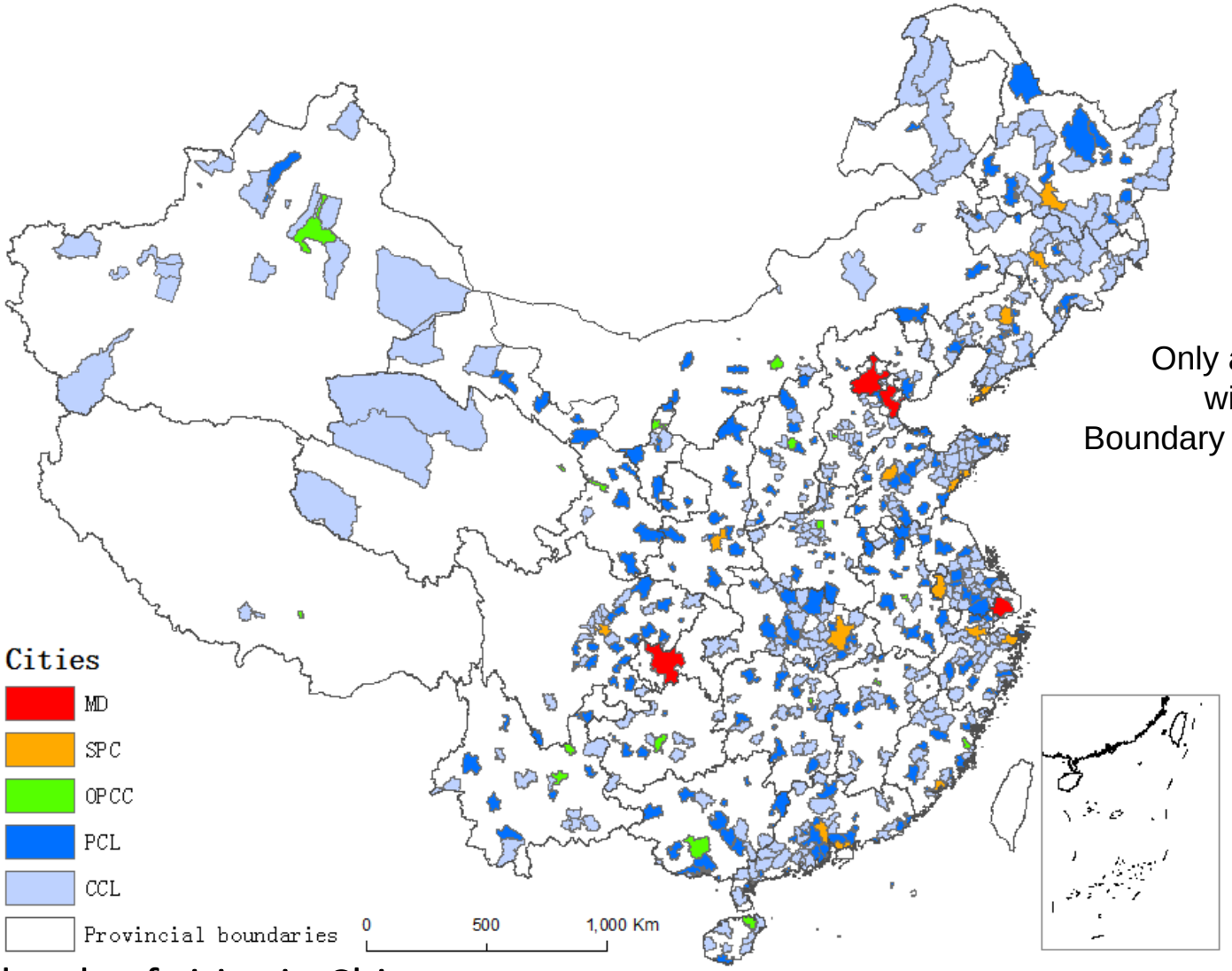
This study will

- 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 maga-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



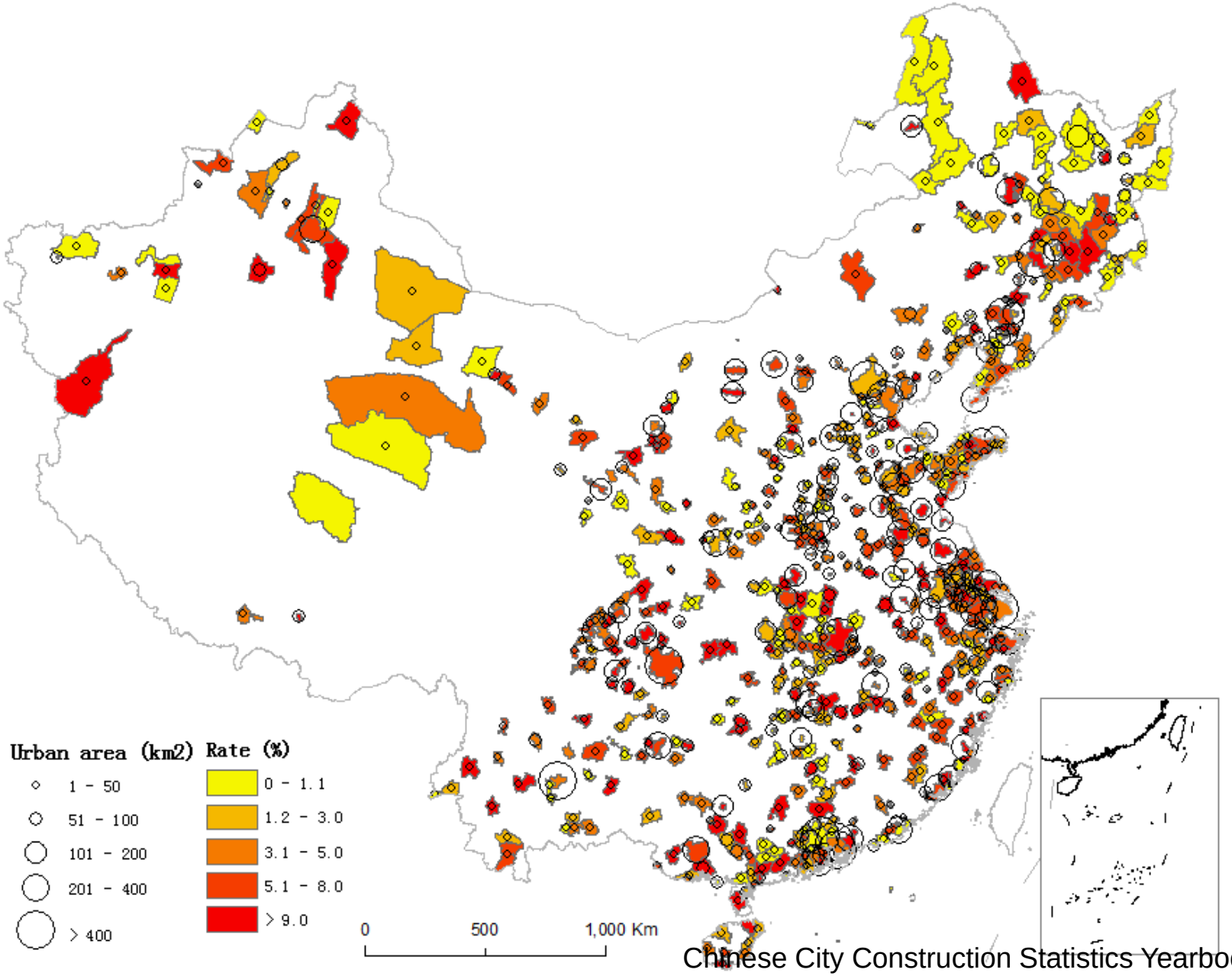
Administrative boundaries of 654 Chinese cities



Only a portion land within each city Boundary is developed.

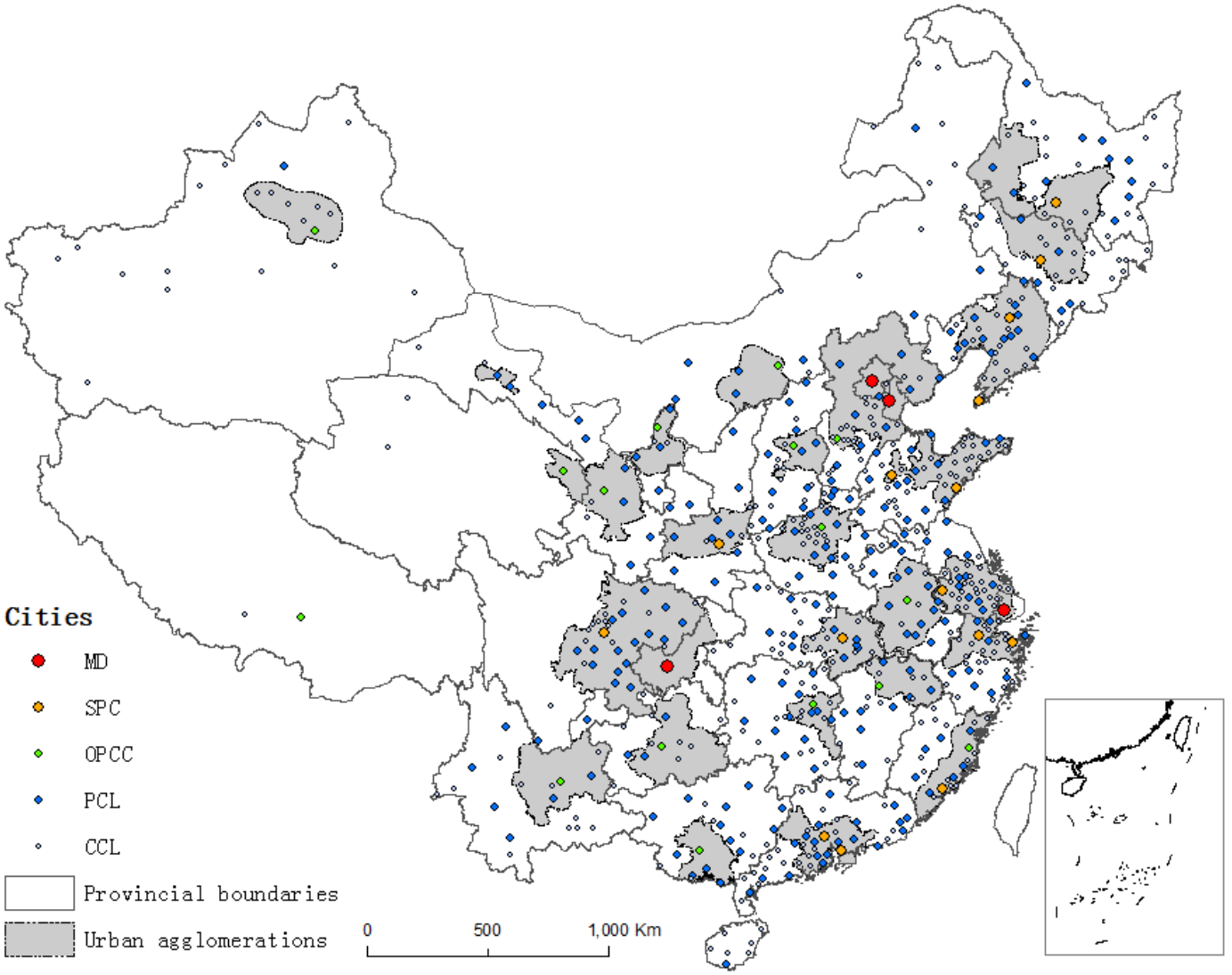
- Five levels of cities in China:
  - municipalities directly under the Central Government (MD, 4 cities), sub-provincial cities (SPC, 15), other provincial capital cities (OPCC, 17), prefecture-level cities (PLC, 250), and county-level cities (CLC, 368)

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



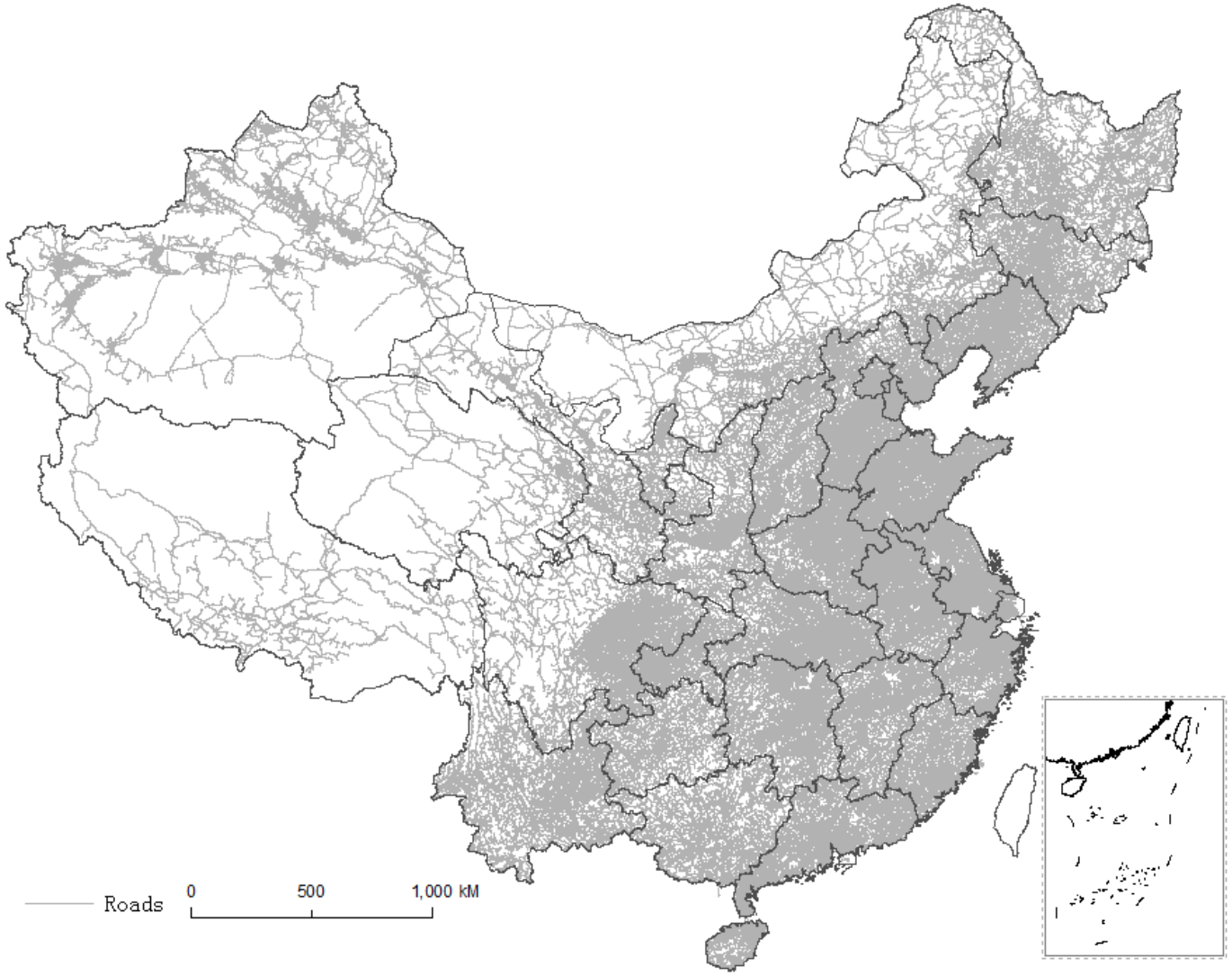
Chinese City Construction Statistics Yearbook 2012

Urban agglomerations (city regions) of China (23)



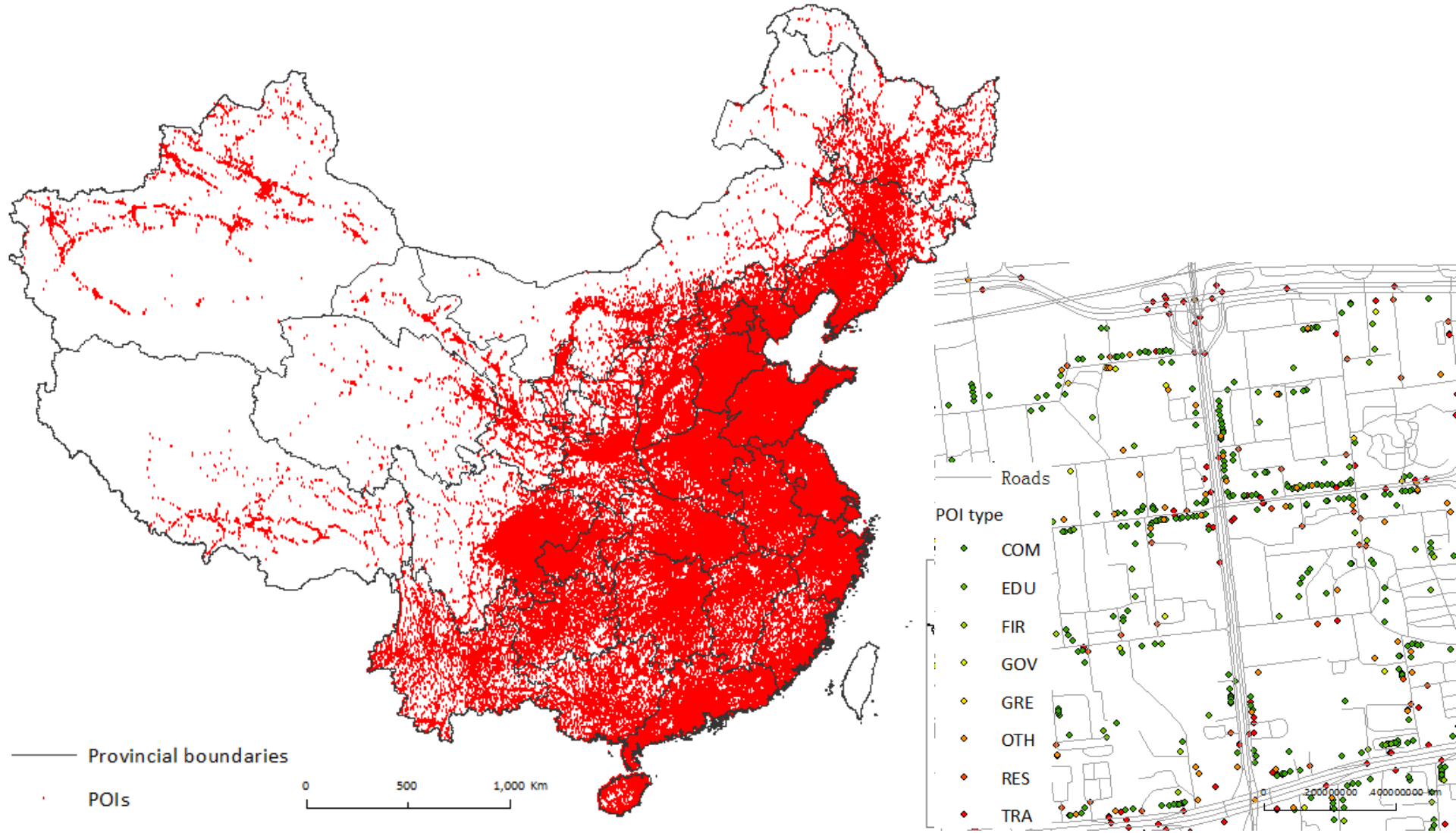
- Urban agglomerations in China are highlighted in the future urbanization in China (Wu et al, 2013)
- For setting simulation scenario

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

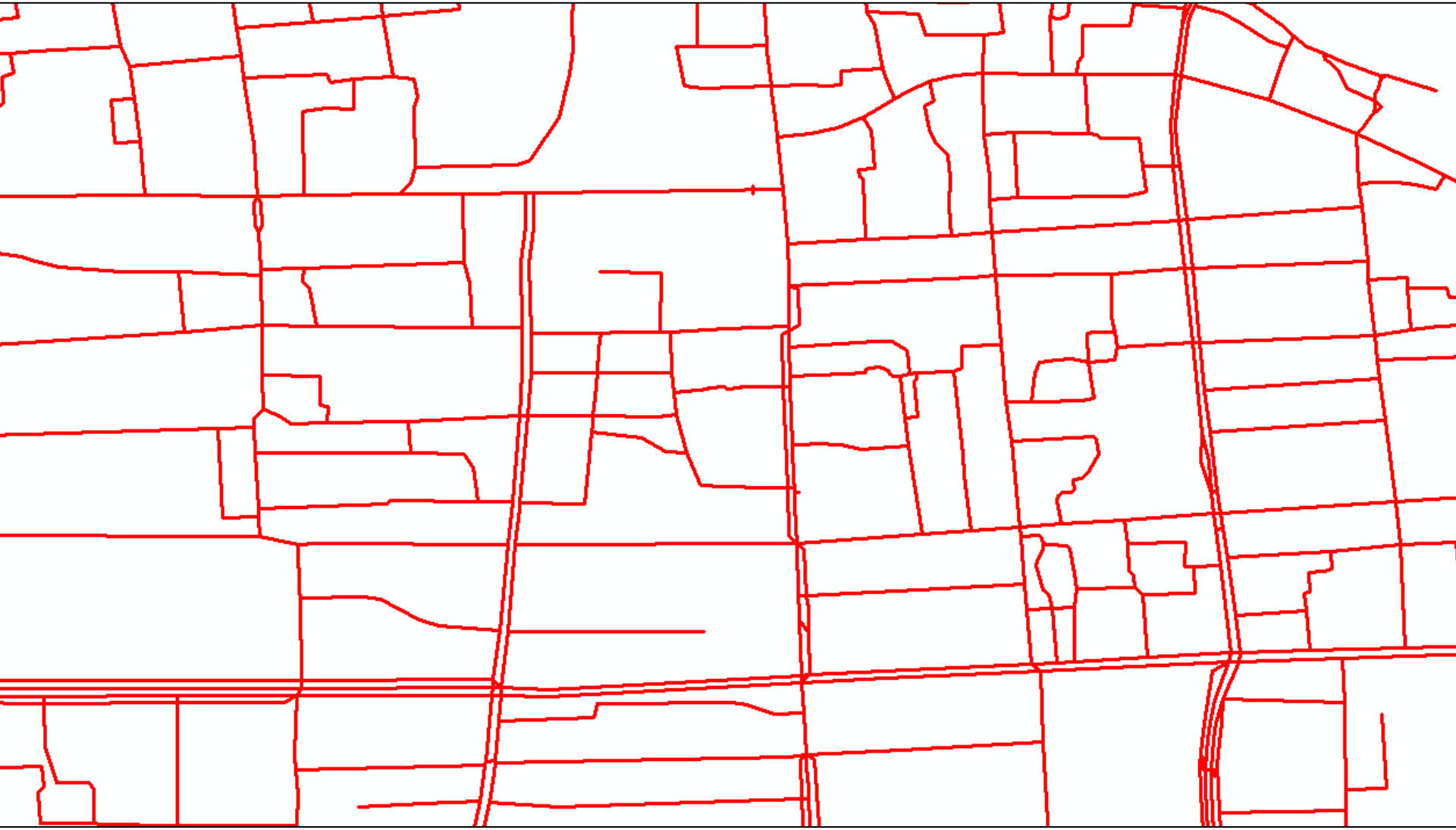
1 The macro module:

Three scenarios on city-level urban area totals in 2017

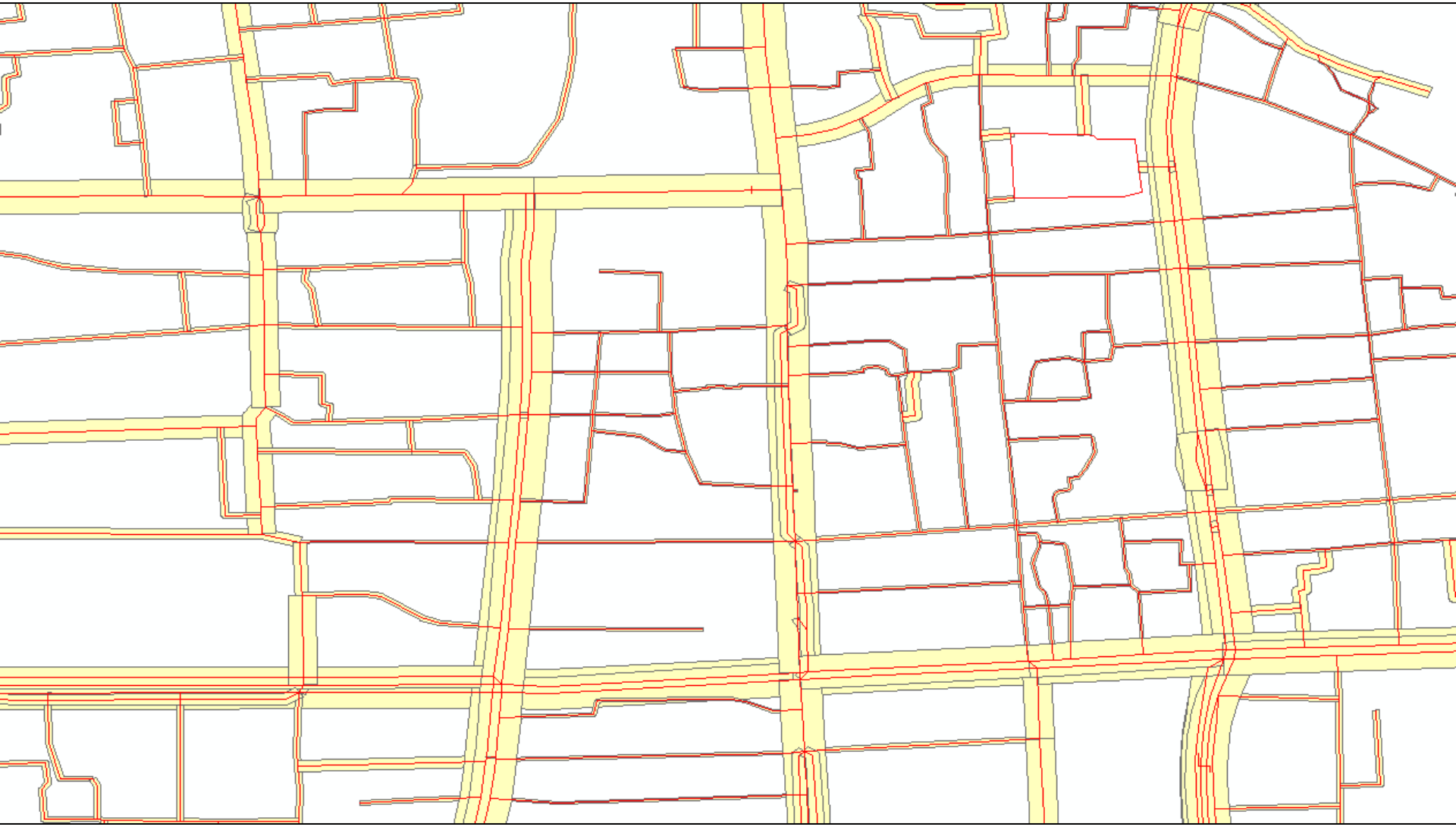
1. Business-as-usual (BAU):
   - Each city replicates its urban expansion rate during 2007-2012 (5.2% for the whole China)
2. Urban agglomeration oriented (UAO)
   - 355 cities in UAs: 5%
   - Other cities: 4%
3. New urbanization planning (NUP)
   - The larger a city is, the lower its expansion rate would be in the next five years
     - Urban area > 400 km^2 in 2012, 3.0%
     - Urban area 200-400 km^2, 4.0%
     - Urban area 100-200 km^2, 5.0%
     - Urban area < 100 km^2, 6.0%.
   - <u>This scenario is to be updated according to the new urbanization plan of China announced on March 16th, 2014</u>

2 The parcel generation module (AICP):

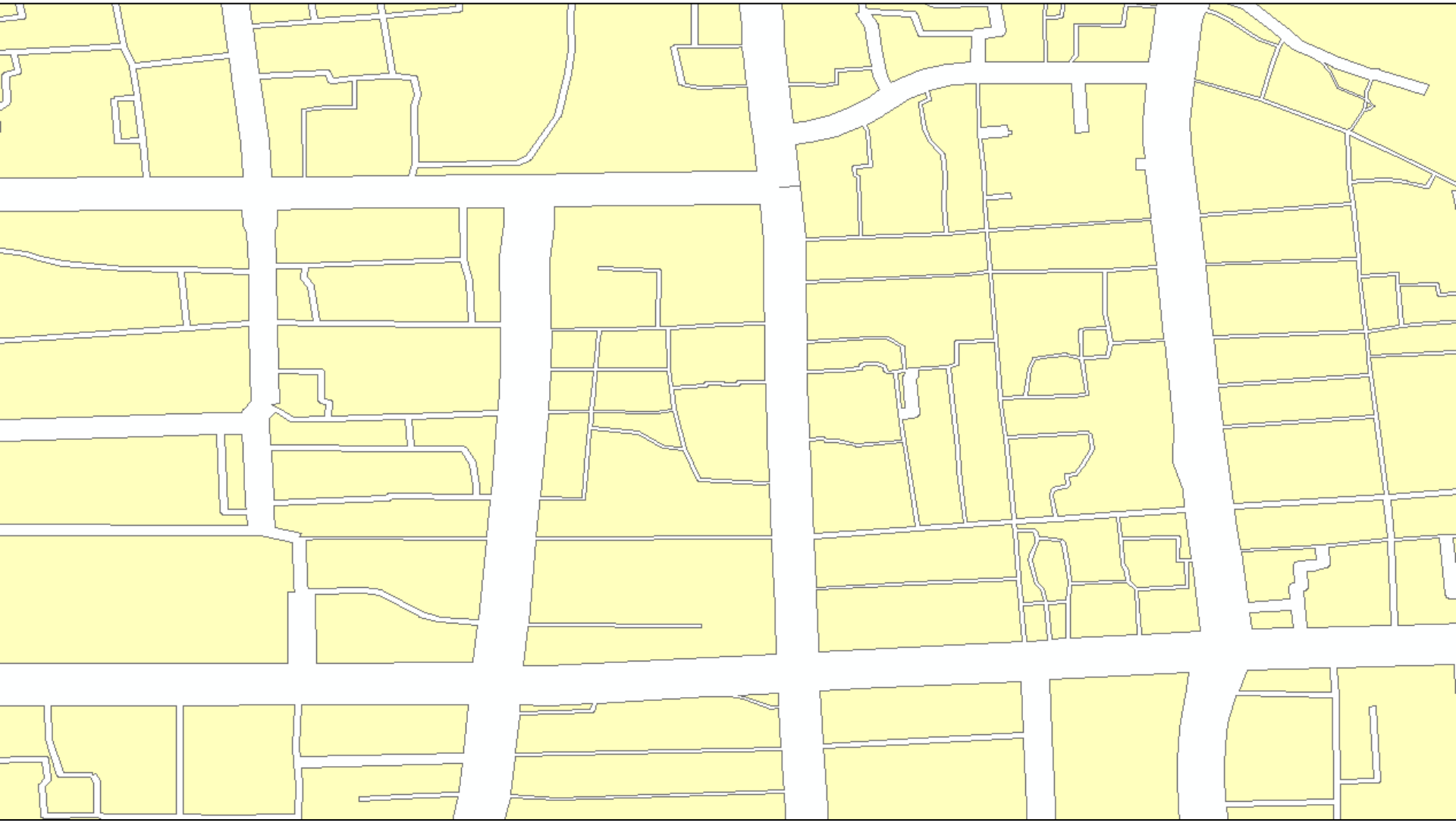
(1) delineating parcel boundaries



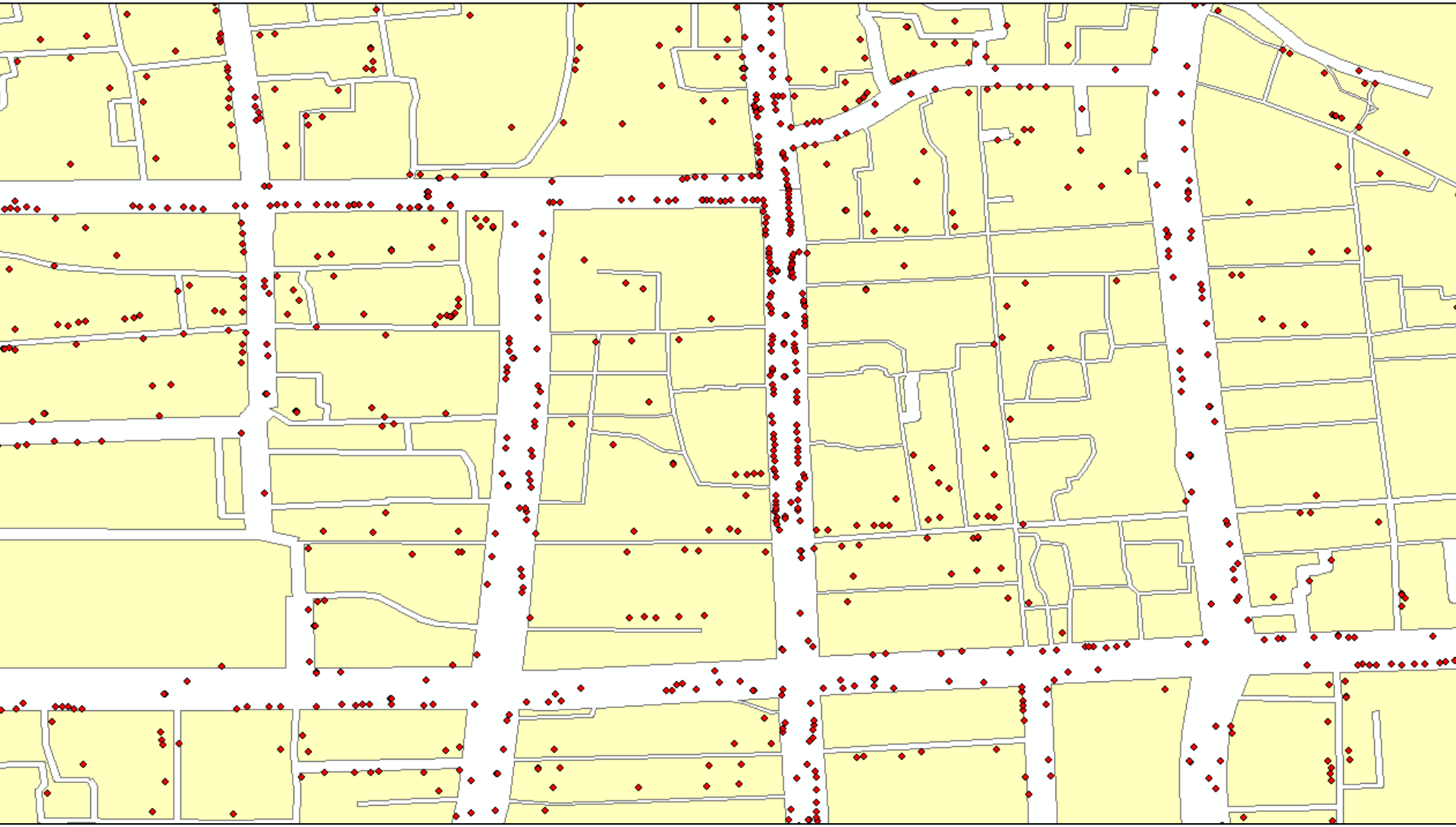
(2) Delineating parcel boundaries



(3) Delineating parcel boundaries



(4) Calculating POIs density for all generated parcels



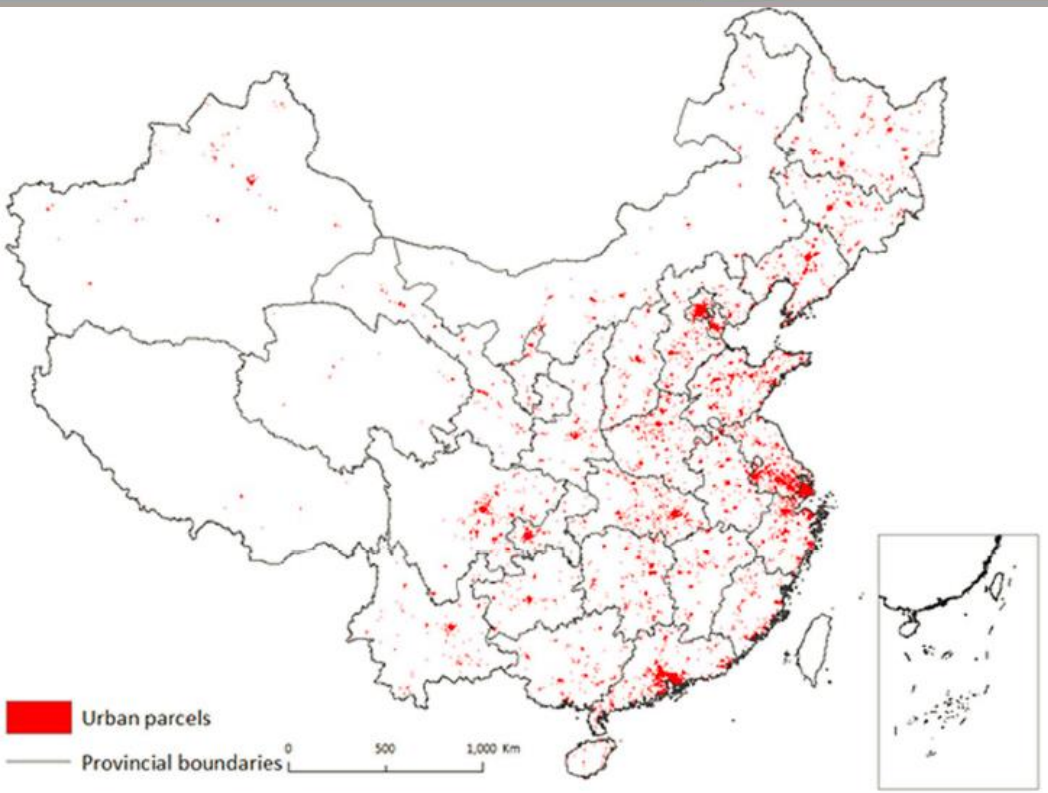
(4) Calculating POIs density for all generated parcels

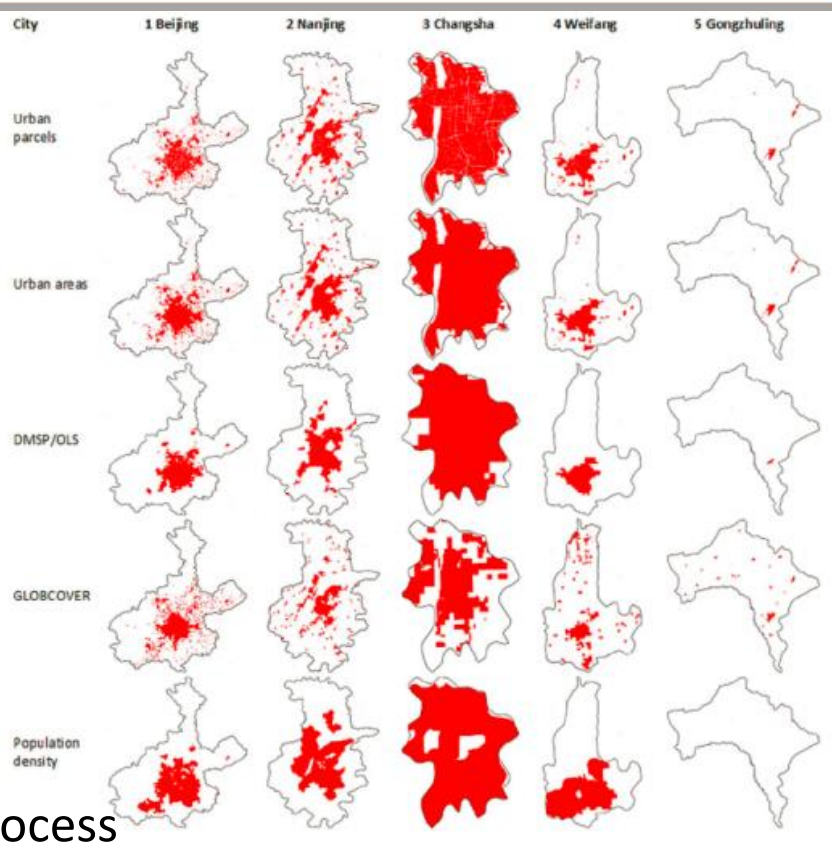
(6) Inferring urban parcels in 2012

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)



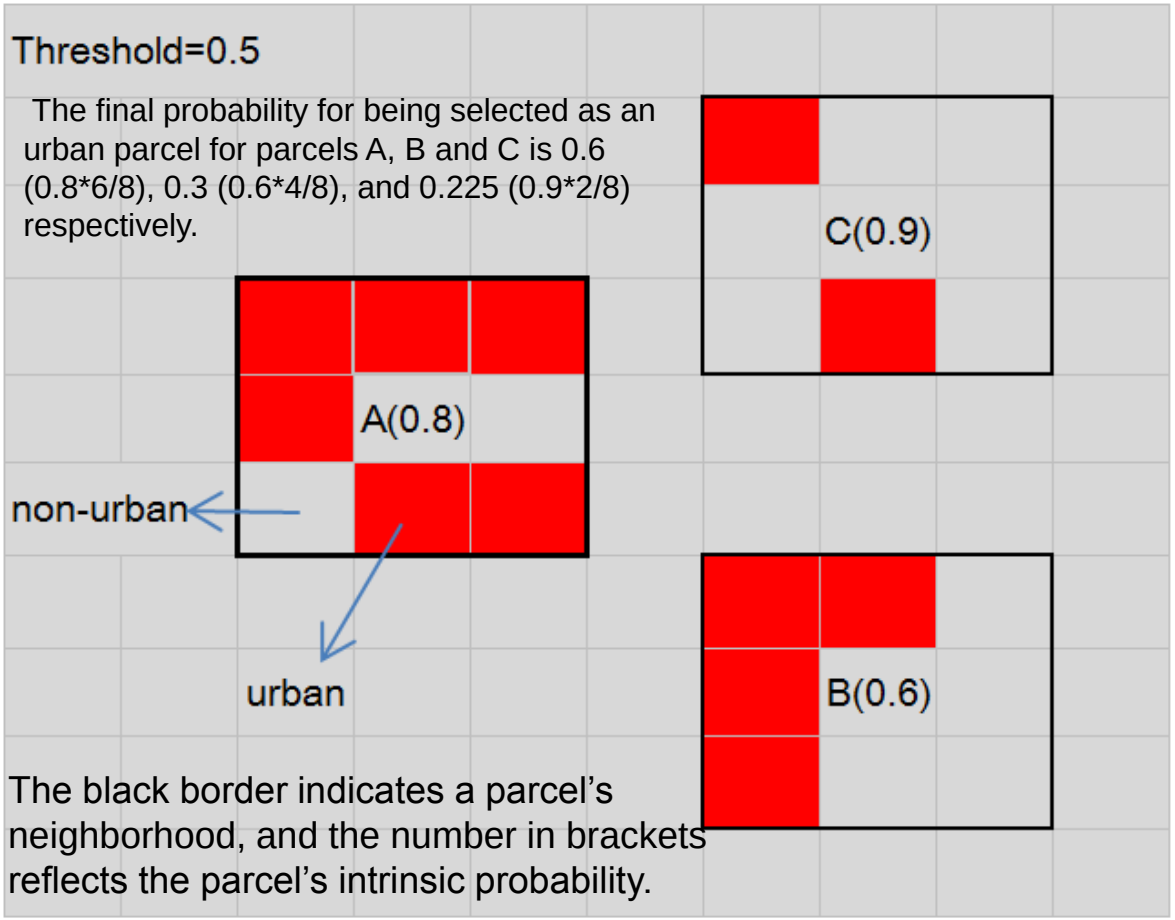


- Various methods can be applied in this process
  - Benchmarking road junction density and population density, referring to other LUCC products

(7) Selected urban parcels in 2012

3 The vector CA module

Selecting urban parcels using vector cellular automata



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

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

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

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

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

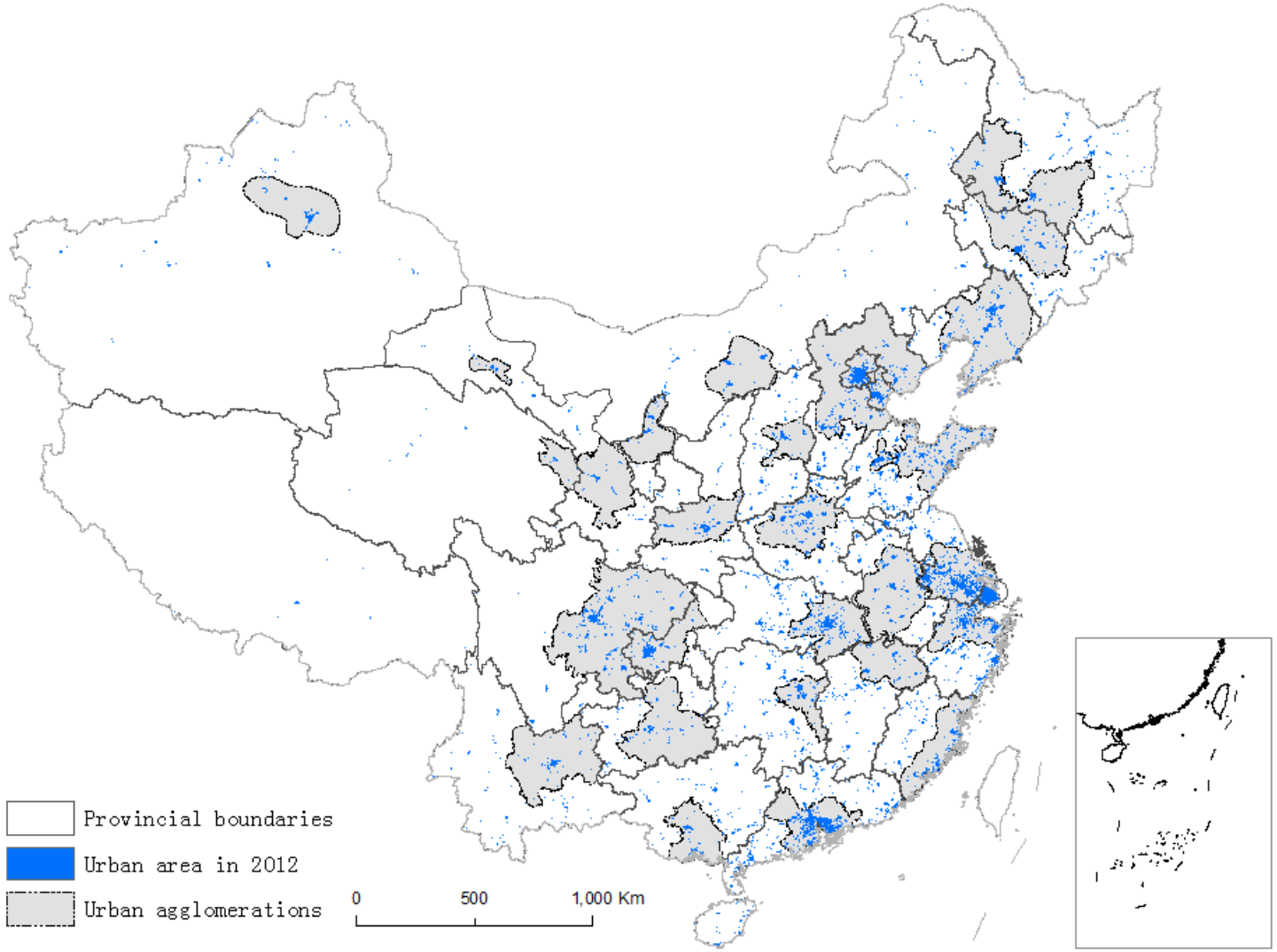
$$S_{ij}^{t+1} = \begin{cases} Urban \text{ for } P_{ij}^{t} \succ P_{thd} \\ NonUrban \text{ for } P_{ij}^{t} \pounds P_{thd} \end{cases}$$

- 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

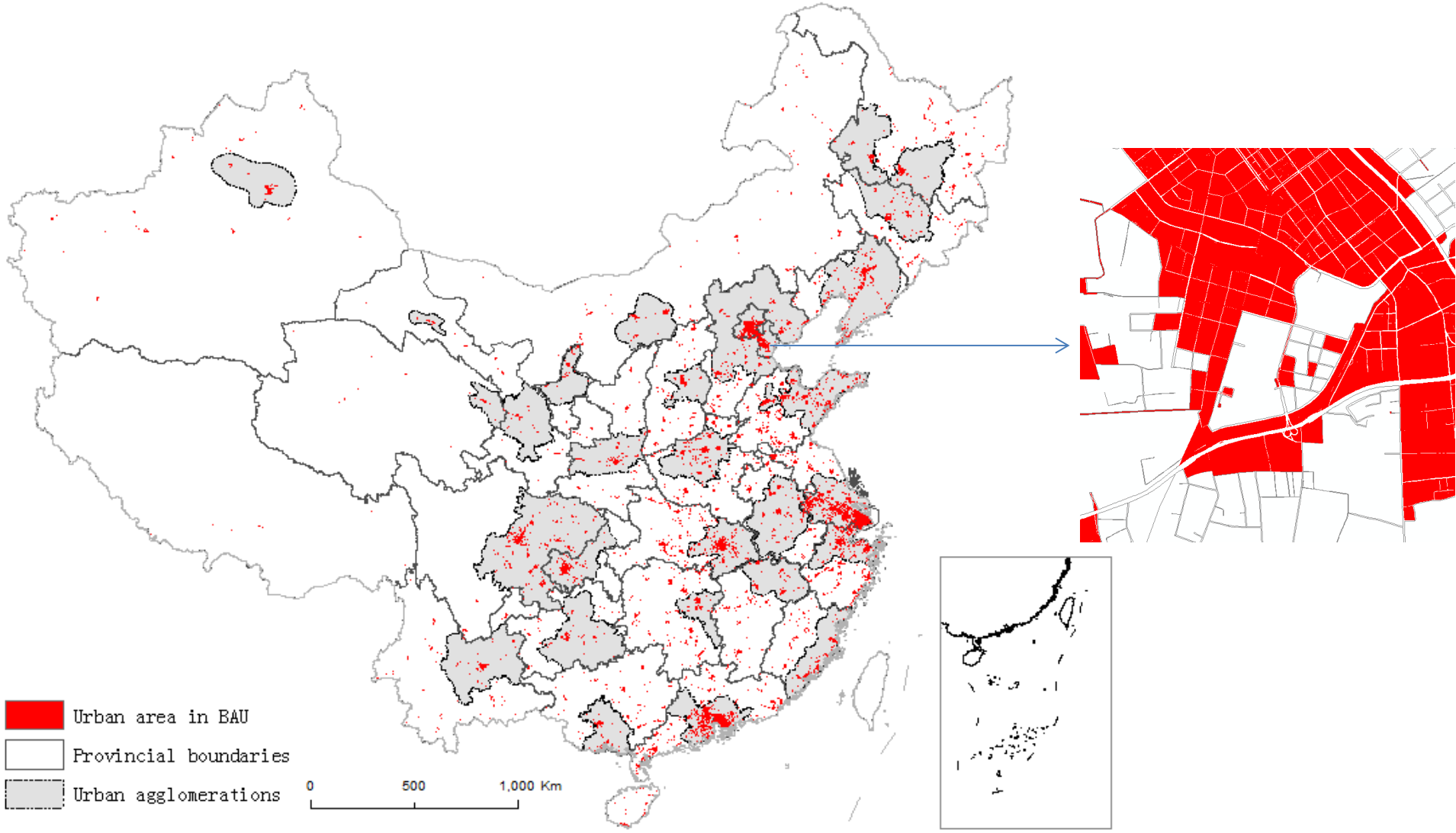
Simulated urban expansion (in blue)

Urban areas of all Chinese cities in 2012



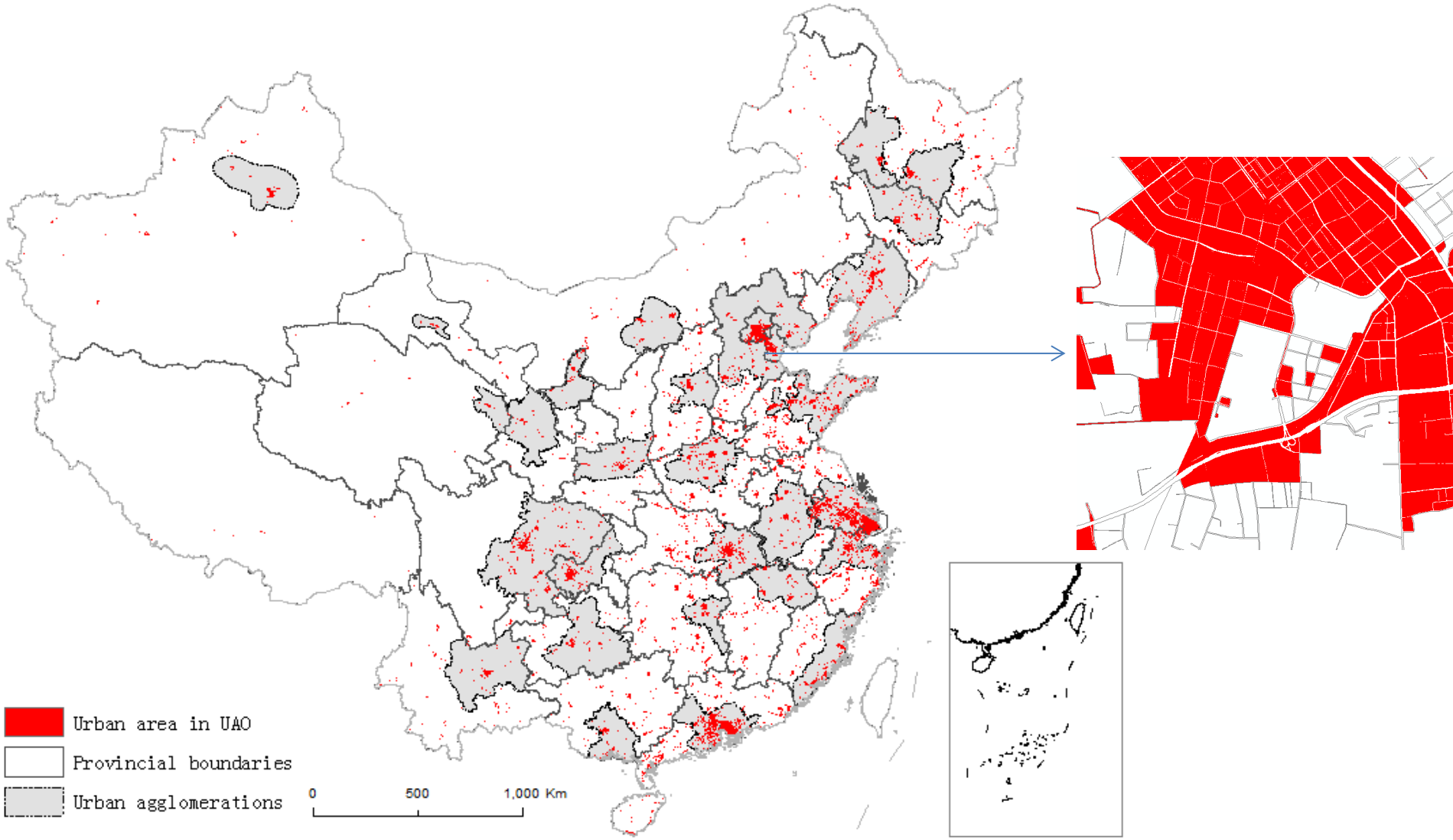
- There are totally 761,152 urban parcels (among all 1.2 million parcels) for all 654 Chinese cities and with a total land area 46,751 km^2 (the average urban parcel size is 6.1 hectares, 200 m*300 m)

Simulation results: BAU



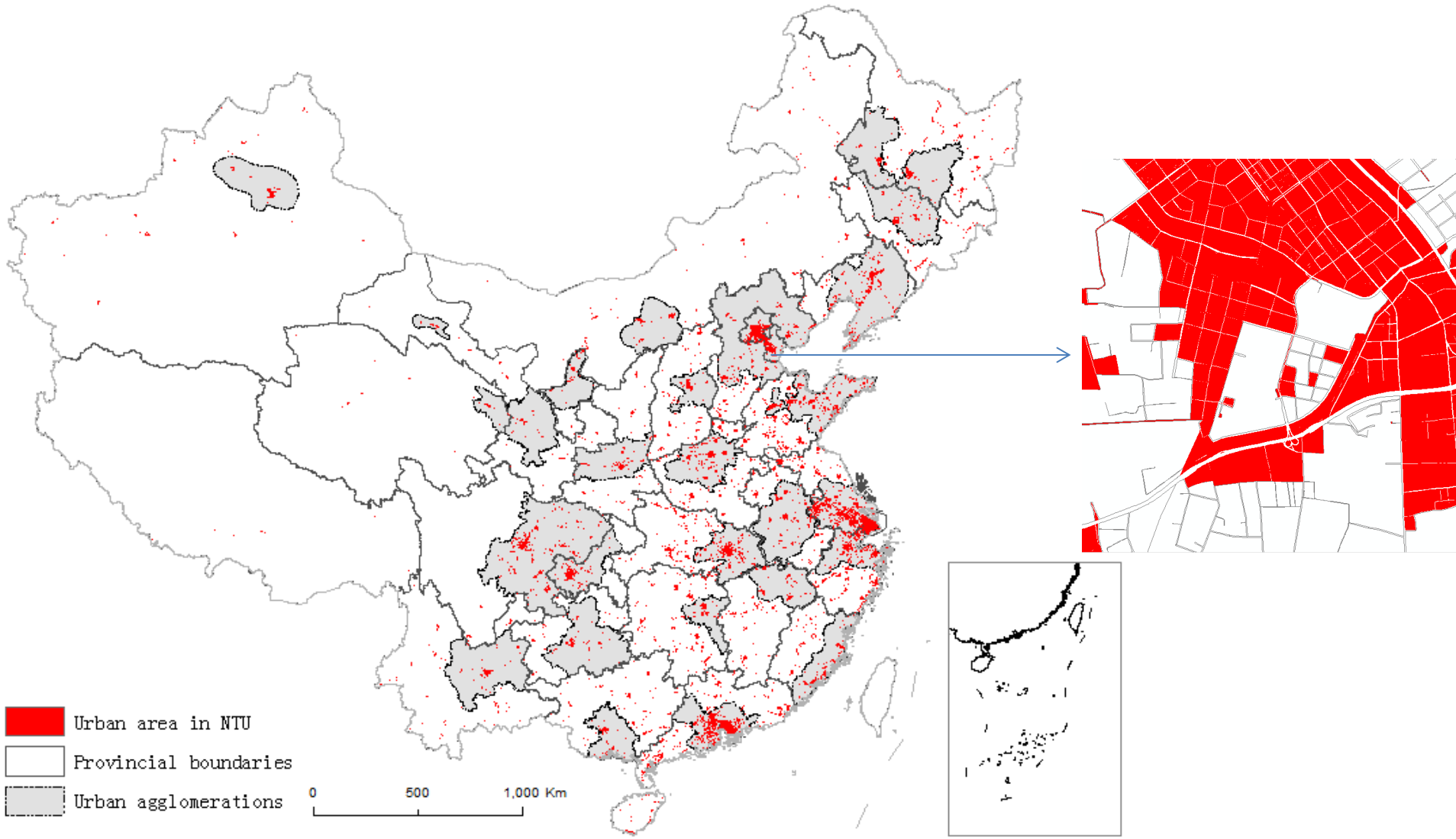
- Total urban land areas estimated by BAU are 62,835 km^2 in 2017, increased by 34.4% compared to 46,751 km^2 urban land in 2012.

UAO



- Total urban land areas of UAO are 58,394 km^2 in 2017, increased by 24.9% compared to urban land in 2012, while 4,441 km^2 less than BAU.

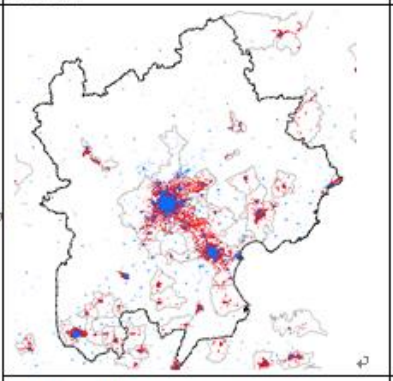
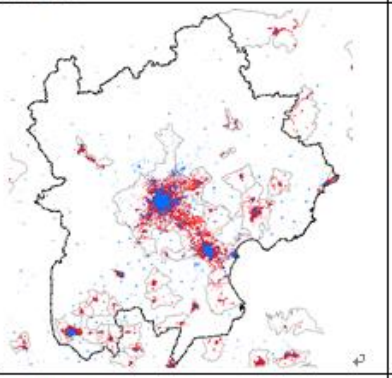
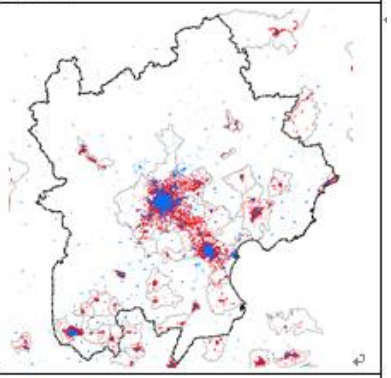
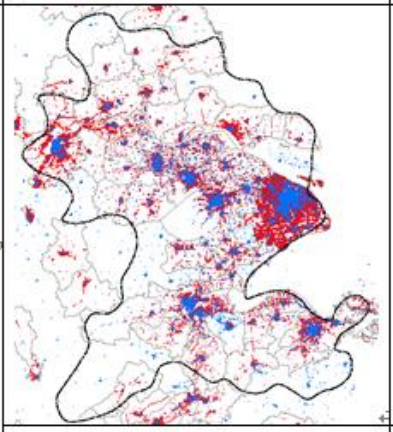
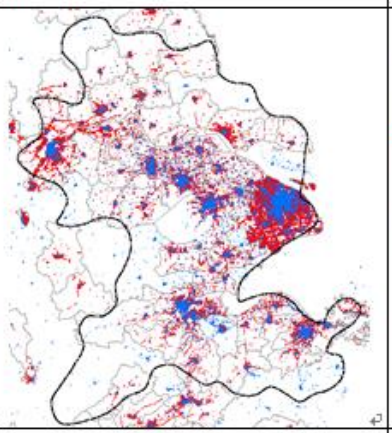
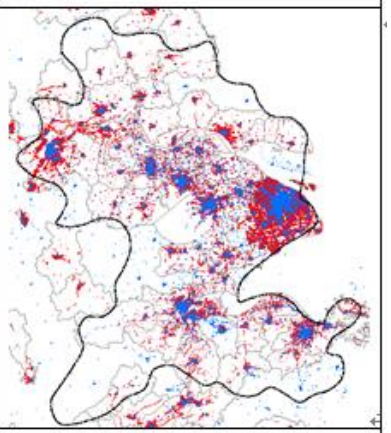
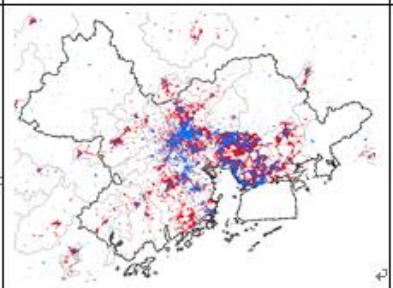
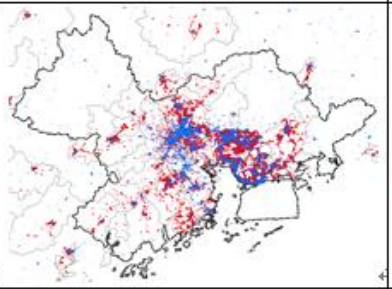
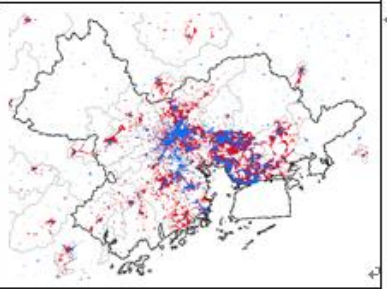
NUP



- The total urban land areas of NUP are 58,930 km^2 in 2017, increased by 26.1% compared to urban land in 2012, while decreased 3,905 km^2 in comparison with BAU.

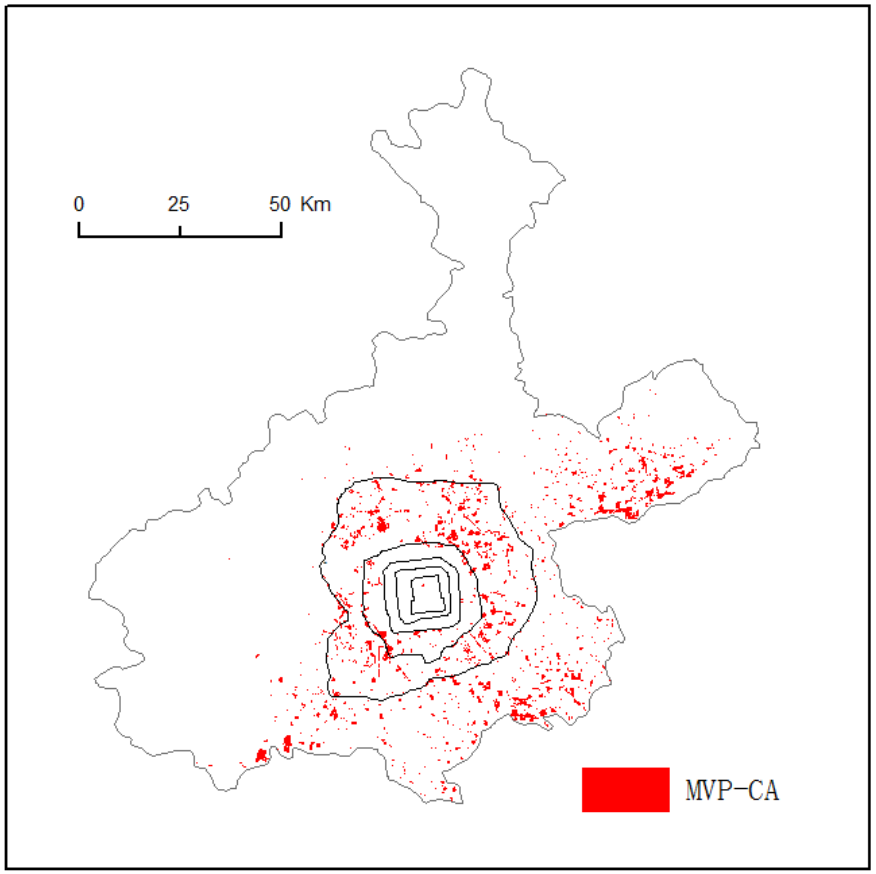
Urban expansion patterns in typical city regions

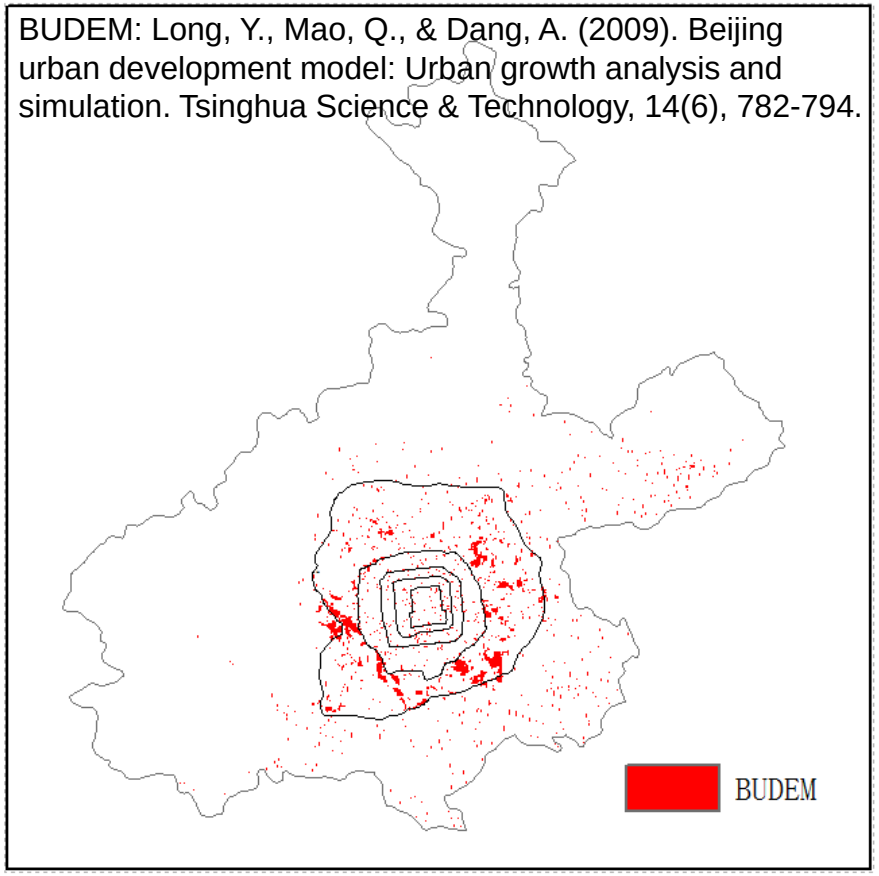
Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta

UA	1 BAU	2 UAO	3 NTU
BTH			
	4,192 km²	4,405 km²	4,184 km²
YRD			
	9,078 km²	9,144 km²	8,682 km²
PRD			
	4,660 km²	4,834 km²	4,519 km²

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

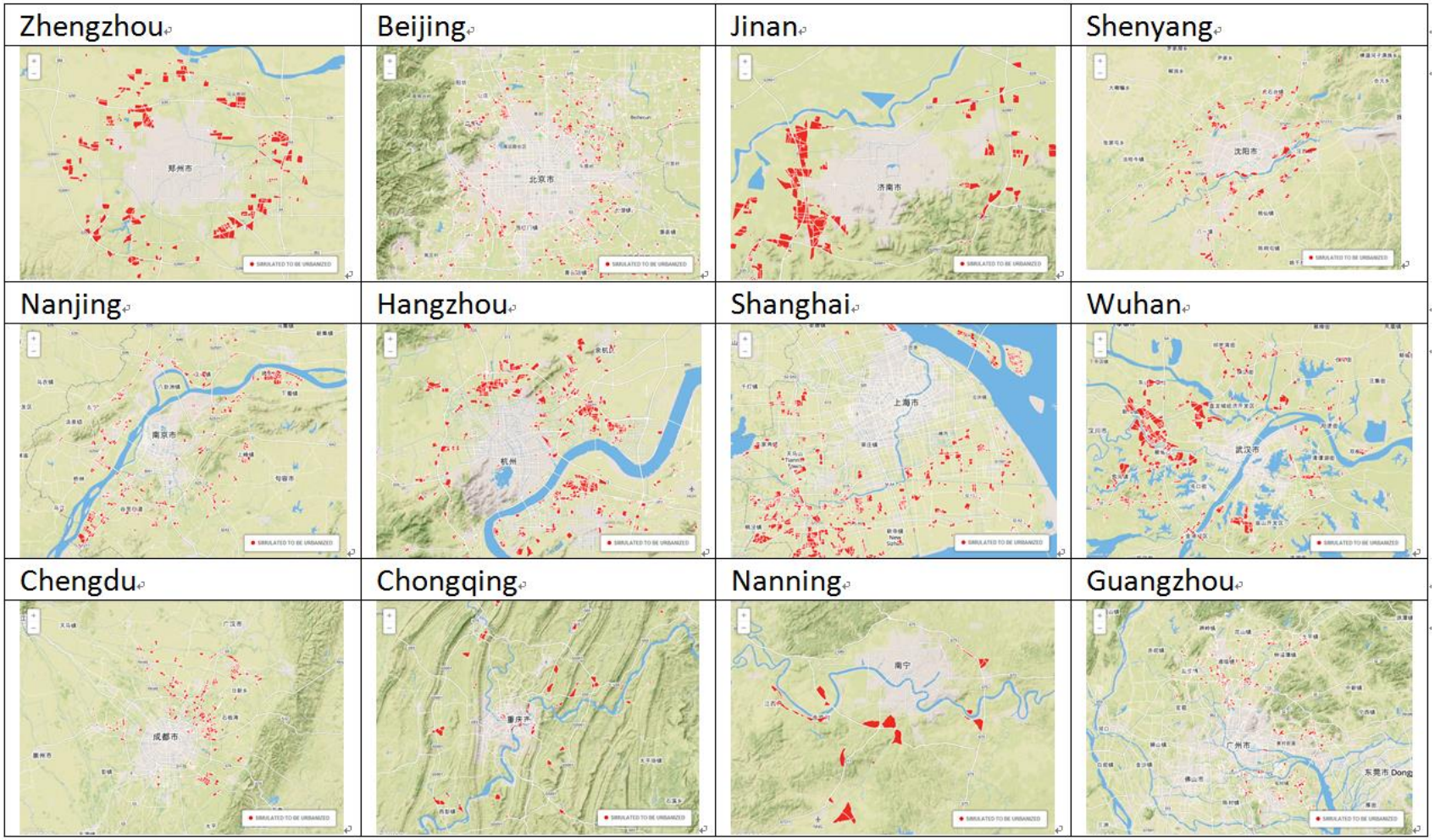
Validation: Comparing the BAU scenario with a 500m-raster-CA model BUDEM in the city of Beijing





- Expanded areas in both models exhibit similar patterns according to the visual judgement.
- The overlaid area shared by both patterns was 119 km^2 (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/

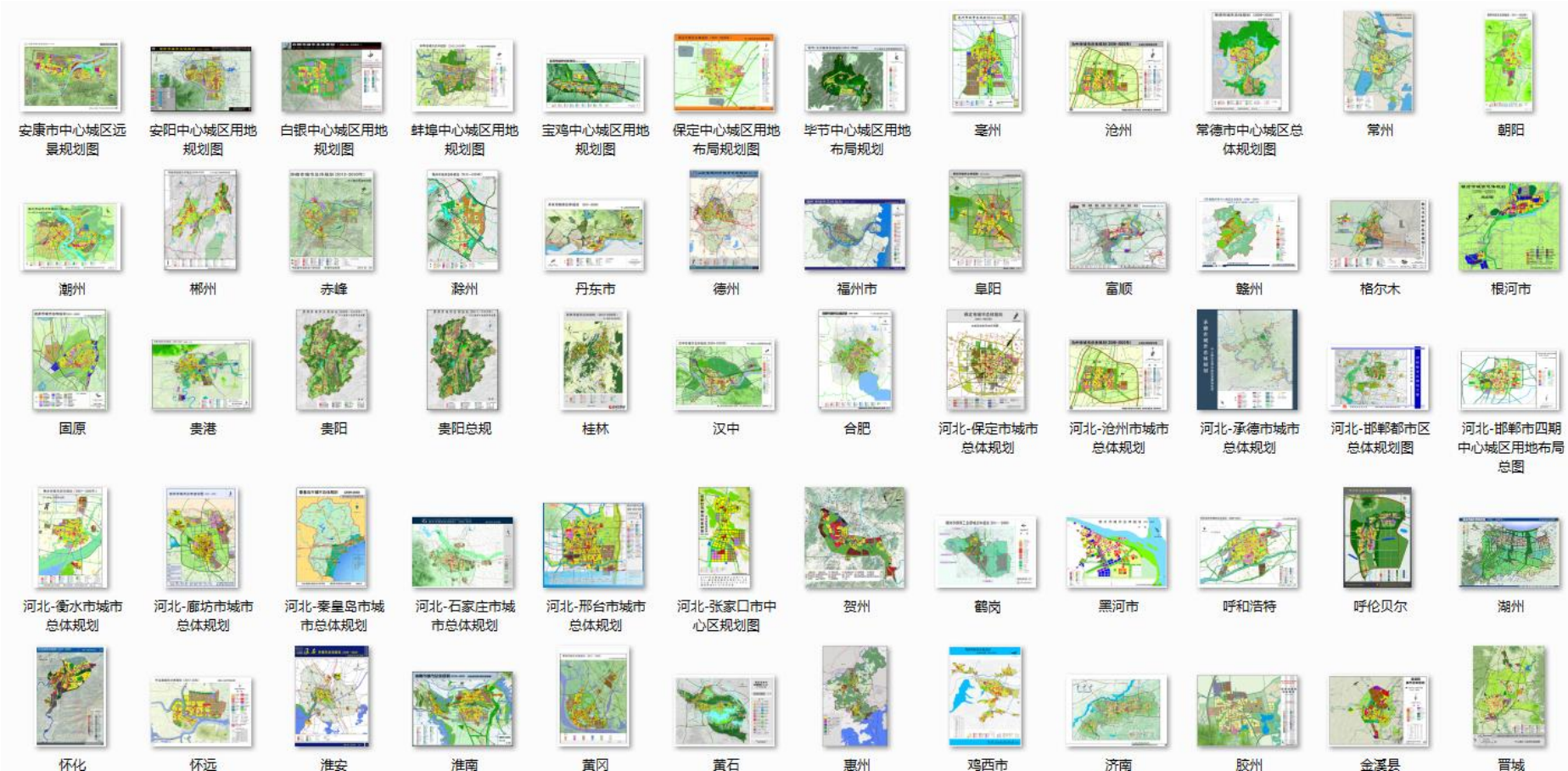
Potential applications

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



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未来更新将在BCL网站公布，敬请关注。

这套课件为龙瀛及其合作者近年来在城市模型领域研究的部分合集，包括传统的城市模型、基于大数据的城市模型、大模型这一城市与区域研究新范式，以及最近的面向规划设计应用的初步探索。

这些PPT在不同的学术会议和论坛上做过发表，时间和精力有限，并没有专门针对此课件进行调整。课件内容难免有不完善之处，欢迎将意见和建议致信到longying1980@gmail.com