

12. GIS Design for Feature Extraction

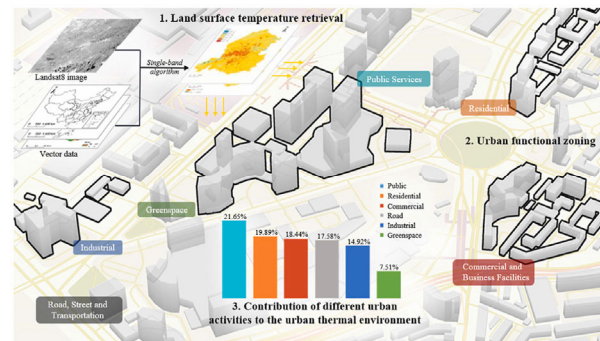
Urban Functional Zone as an example

GE3238 GIS Design and Practices
Geography@NUS
Chen-Chieh FENG

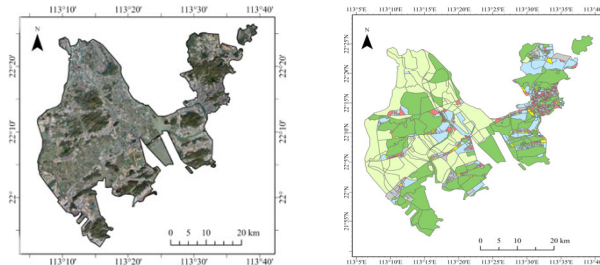
1

Objectives

- To look at GIS design for using geospatial technologies to retrieve **urban functional zone (UFZ)**
 - Technical: Classification or semantic segmentation
 - Problem set: Information retrieval and feature extraction



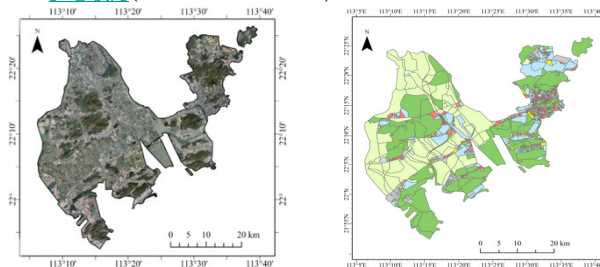
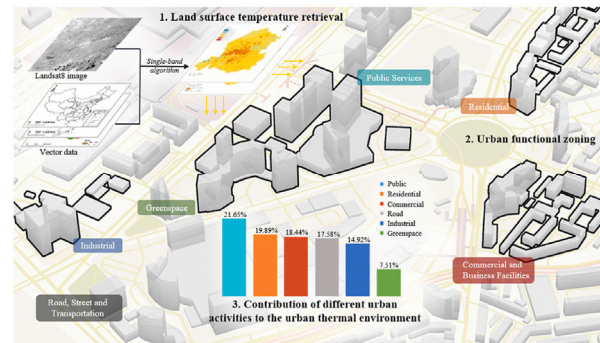
Source: https://ars.els-cdn.com/content/image/1-s2.0-S0360132322002426-ga1_lrg.jpg (last accessed 7 APR 2025)



2

Objectives (cont.)

- To look at GIS design for using geospatial technologies to retrieve urban functional zone (UFZ)
 - Focus on **data layers** and **fitness-for-use**



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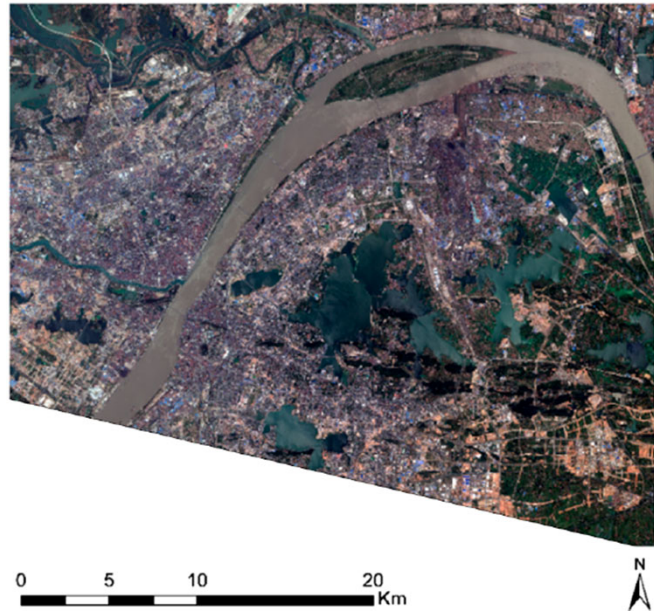
Land use/land cover (LULC) vs UFZ

Q1 -- What is/are the difference(s)?

(Why do we care about UFZ?)

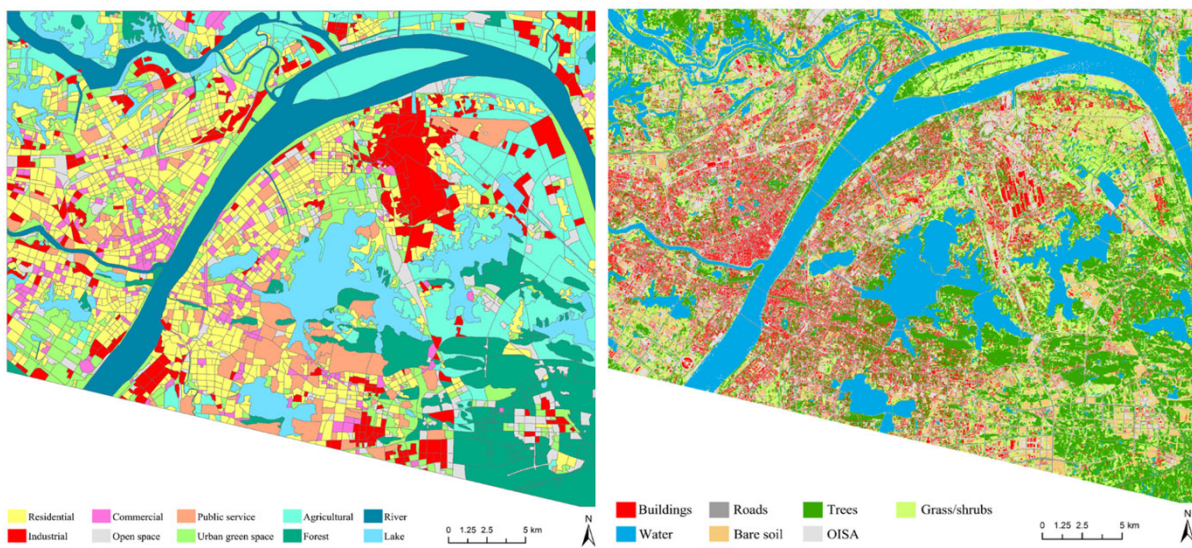
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- Remote sensing imagery
 - Commonly taken to be data input for further (geo-) spatial analyses
 - Data wrangling (see slide 8 for an example)
 - Information retrieval or feature extraction
 - UFZ is the information to be retrieved



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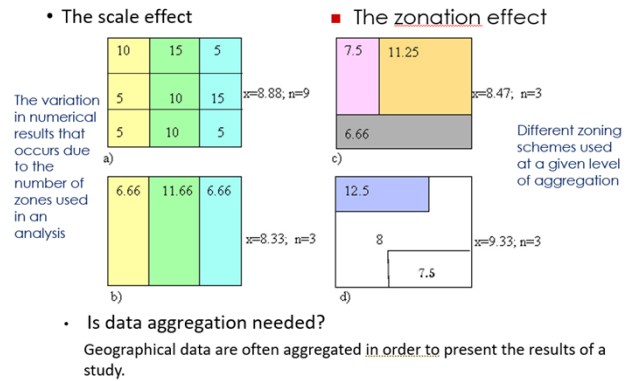
UFZ & Land Use/Land Cover (LULC) (cont.)



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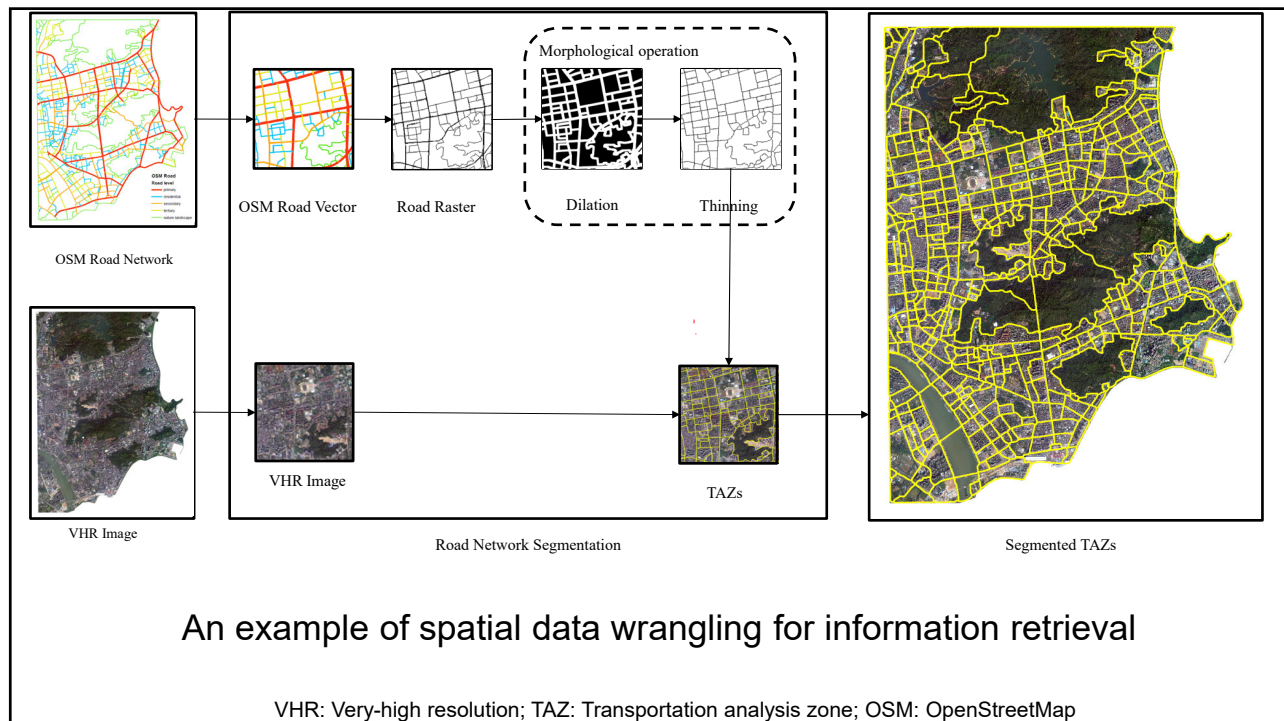
What Kind of Spatial Unit?

- Administration, e.g., planning area, subzone?
- Block demarcated by roads?
- Any other region types?



The Effects of MAUP (Modifiable Areal Unit Problem)

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How about Capturing Human Activities?

Q2 -- What is the readily available dataset that captures human activities?

(What layers + attributes to include in your design)
(What about their fitness-for-use?)

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The screenshot shows the OpenStreetMap Wiki page for "Points of interest". The page is in English and includes a sidebar with navigation links, a main content area with a definition of a point of interest (POI), and a list of examples. The URL at the bottom is https://wiki.openstreetmap.org/wiki/Points_of_interest.

Visit the main page

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Points of interest

Deutsch English español français português suomi русский українська فارسی 한국어 中文 (简体) 日本語

Points of interest - Other languages

Other languages...

A **point of interest (POI)** for short is a term used in cartography (and therefore in reference to maps or geodatasets) for the choice to represent a particular feature using an icon that occupies a particular point. The idea is that, as opposed to linear features like roads or areas of landuse, some features might be suited to being indicated as a point in a particular context; for example, if one wanted to send a letter, it would be relevant to see all the post offices and mailboxes nearby, and if they are all represented by an envelope icon, it is easy to see. There are five factors^[1] that distinguish high-quality POI data: freshness, coverage, consistency, ease of use and customization.

Three caveats:


- A POI does not necessarily have to be stored as a point in a geodatabase (see #in OSM for details particular to us); it merely is represented as a point in the user interface (for example, in the [standard tile layer](#)).
- Do not take the 'of interest' part too literally; a feature might be quite ordinary, such as the postboxes mentioned above, and only in the context of the map user wanting to mail something does it become "interesting". As such, POIs are often `amenity=*`.
- The flavours of usage of the term may vary between users of satellite navigation systems (SATNAVs), [geocachers](#), and GIS users, but the gist is basically as defined above.

Some example of types of POI:

- Churches, schools, town halls, distinctive buildings
- Post offices, shops, postboxes, telephone boxes

https://wiki.openstreetmap.org/wiki/Points_of_interest

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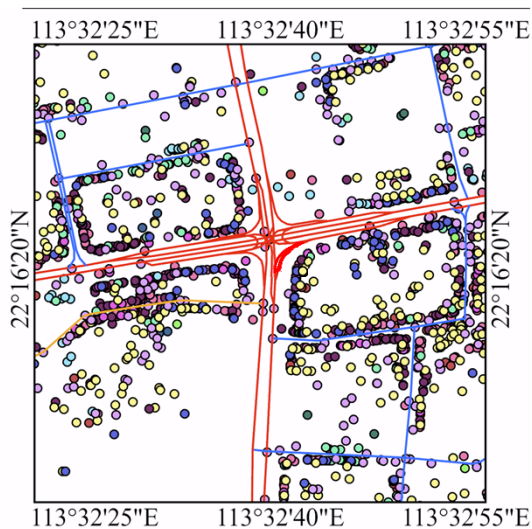
Please visit ti

Please visit ti

Feature_De signation_ Code	Feature_Designatio n_Name	Feature_Designation_Description	Collection_Guidance	Feature_Class
ADM1	first-order administrative division	"a primary administrative division of a country, such as a state in the United States"	Center of Feature (changes to primary name or designation require BGN/FNC approval)	A - Administrative Regions
ADM2	second-order administrative division	a subdivision of a first-order administrative division	Center of Feature	A - Administrative Regions
ADM3	third-order administrative division	a subdivision of a second-order administrative division	Center of Feature	A - Administrative Regions
ADM4	fourth-order administrative division	a subdivision of a third-order administrative division	Center of Feature	A - Administrative Regions
ADMD	administrative division	"an administrative division of a political entity, undifferentiated as to administrative level"	Center of Feature	A - Administrative Regions
	administrative	a building that houses one or more functions of		

https://geonames.nga.mil/geonames/GNSHome/services.html

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Any concerns with
using POIs?

POIs (14 classes)

- | | |
|-----------------------|-------------------------|
| • Company | • Public service |
| • Factory | • Recreational service |
| • Food and beverage | • Residential building |
| • Public organization | • School |
| • Health facility | • Science and education |
| • Hospital | • Shop |
| • Living service | • Transportation |

Fig 2 of Wang et al (2023) – <https://www.mdpi.com/2072-4292/15/3/730>

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Describing Human Activities (again)?

Q2 -- What is the readily available dataset that describe
human activities?

(Recall the consideration on *what layers to include?*)

(What about their *fitness-for-use?*)

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Mobility Data

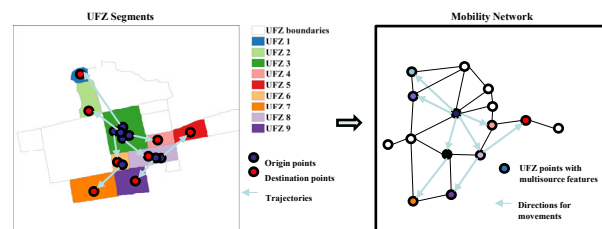
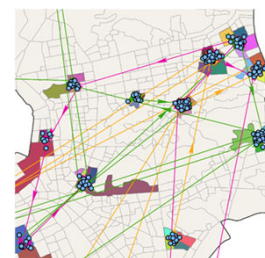
- Common types
 - Taxi data
 - Tap-in and tap-out data
 - GPS tracks
 - Mobile phone data
 - Bike sharing data
 - ...
- Fitness-for-use?



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Mobility Data

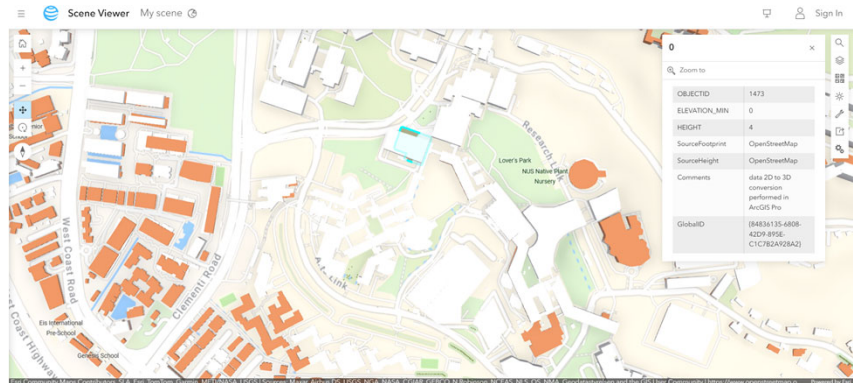
- Why do we consider mobility data for UFZ classification?
 - “Trajectories ... are **one of the indicators for human activities associated with socioeconomic characteristics of UFZs**”
 - For example, consider where most people go in the morning and evening



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Height Information

- Building height



<https://www.arcgis.com/home/item.html?id=b5a6788bf3a141d489f36487162252af> (last accessed 7 APR 2025)

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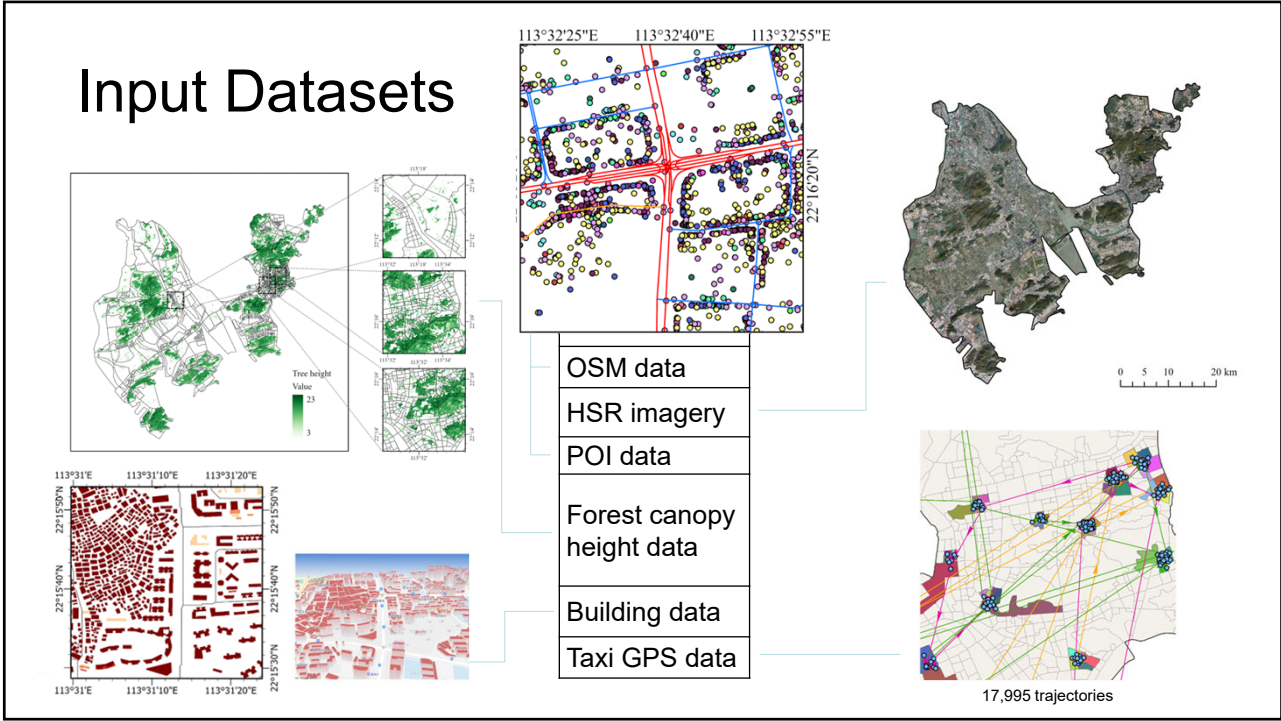
Height Information

- Building height

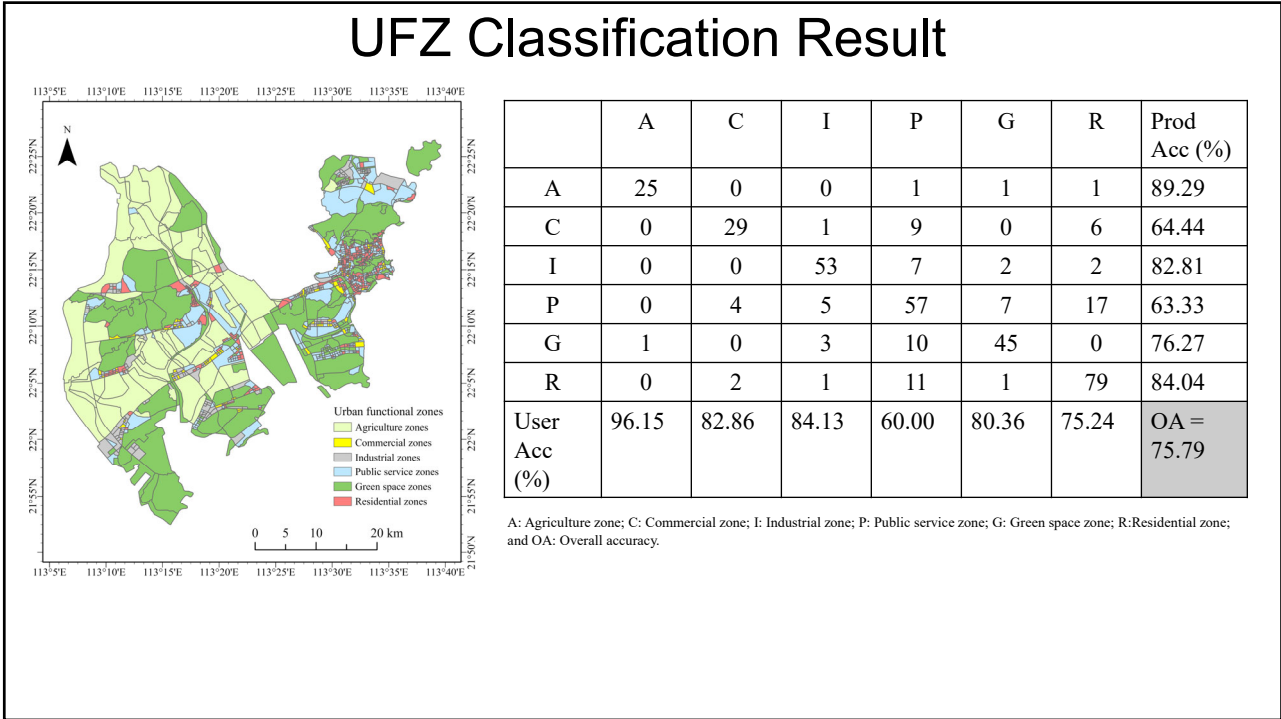
- Canopy height



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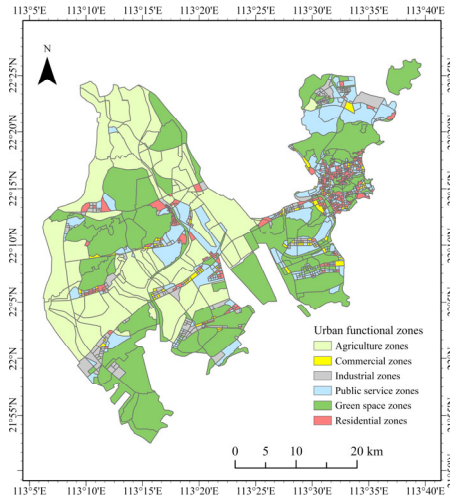


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UFZ Classification Result

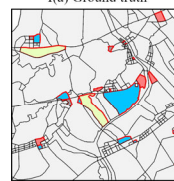
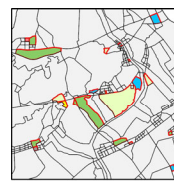
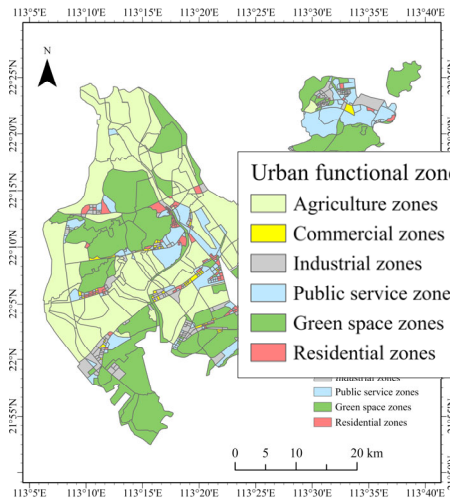


	A	C	I	P	G	R	Prod Acc (%)
A	25	0	0	1	1	1	89.29
C	0	29	1	9	0	6	64.44
I	0	0	53	7	2	2	82.81
P	0	4	5	57	7	17	63.33
G	1	0	3	10	45	0	76.27
R	0	2	1	11	1	79	84.04
User Acc (%)	96.15	82.86	84.13	60.00	80.36	75.24	OA = 75.79

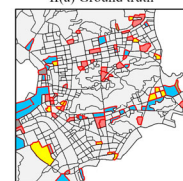
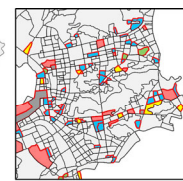
A: Agriculture zone; C: Commercial zone; I: Industrial zone; P: Public service zone; G: Green space zone; R: Residential zone; and OA: Overall accuracy.

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UFZ Classification Result



I(b) Our model



II(b) Our model

	A	C	I	P	G	R	
User Acc (%)	96.15	82.86	84.13	60.00	80.36	75.24	OA = 75.79

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What Does the Evaluation Tell You?

- The accuracy will never reach 99.9%!
- Do not look only at overall accuracy; Look also at individual categories
 - It is expected the spatial distribution of misclassification differs by category
- Is there additional data layers to be considered? What is the rationale?
 - Alternatively, do any of the data layers introduce noises?

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Summary

- UFZ classification as an example of information retrieval through classification (semantic segmentation)
 - Define the scope: Extraction of urban functional zone
 - Key concept: Human activities
 - Spatial unit: Transportation analysis zone (Why not pixel-based?)
 - Data wrangling: Dilution and thinning
 - Classification algorithm: out-of-scope for this lecture
 - Evaluation: Error matrix as a start; accuracy by category
 - Interpretation: Focus on implications

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