Improving earthquake risk assessments for the reinsurance industry using remote sensing and socioeconomic data

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Outline

- Remote sensing classification
- Codes for damage assessment
- Characterization of buildings through mapping schemes
- Socioeconomic data

Data Sources

- Global Rural-Urban Mapping Project-Urban Extent: SEDAC
- Gridded Population of the World (GPW): SEDAC
- Landscan: Oak Ridge National Laboratory
- Global Impervious Surface Area (IMPSA): NOAA
- Visible Infrared Imaging Radiometer Suite (VIIRS): NOAA/NASA
- LandSat-8: USGS/NASA
- Global Human Settlement Layer (GHSL): JRC

Remote sensing "Homogenous zones"

Rural

High-rise

Dense Urban

Urban

Dense Res

Light Res
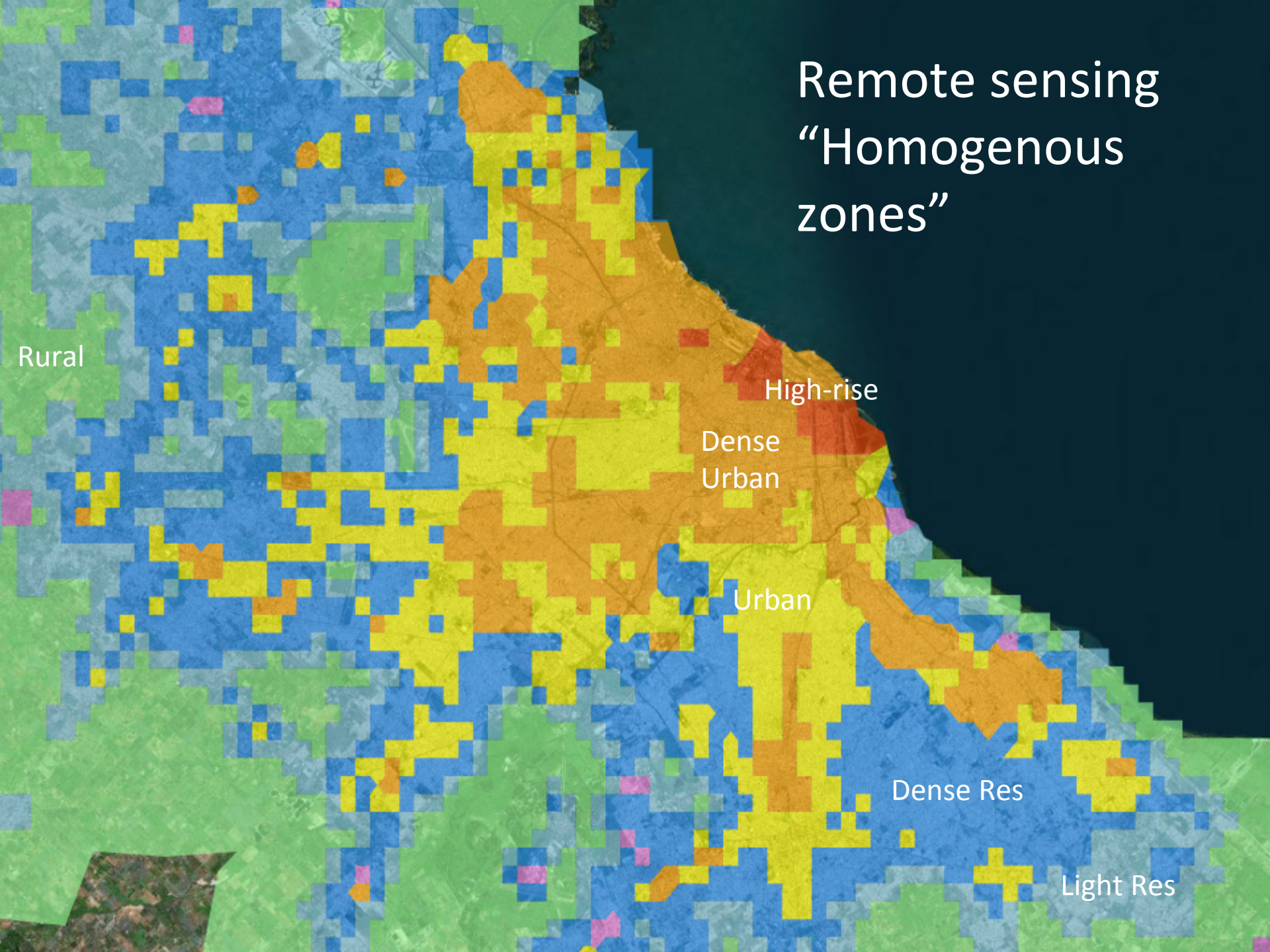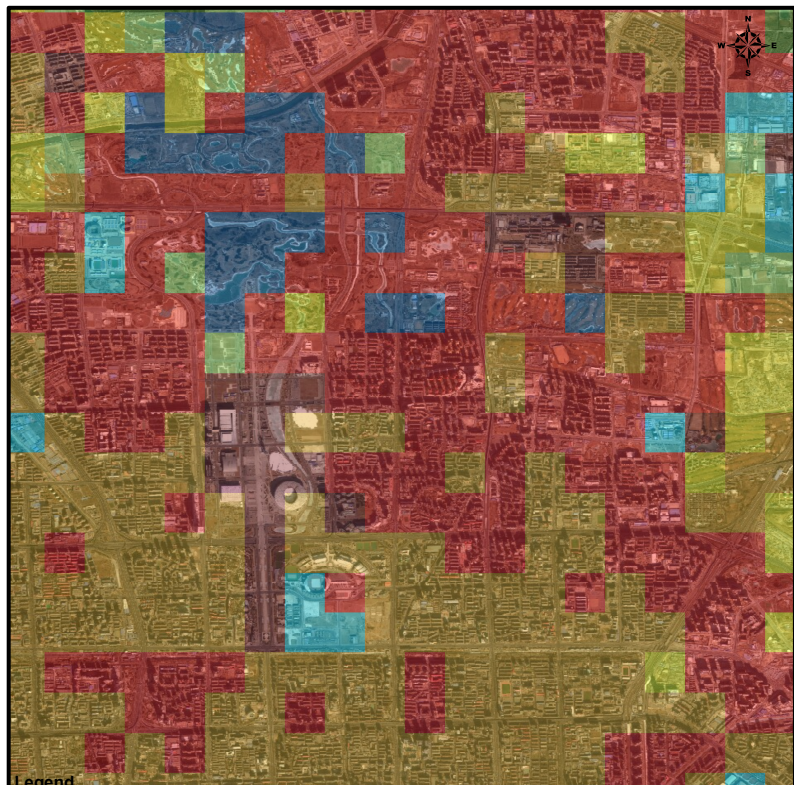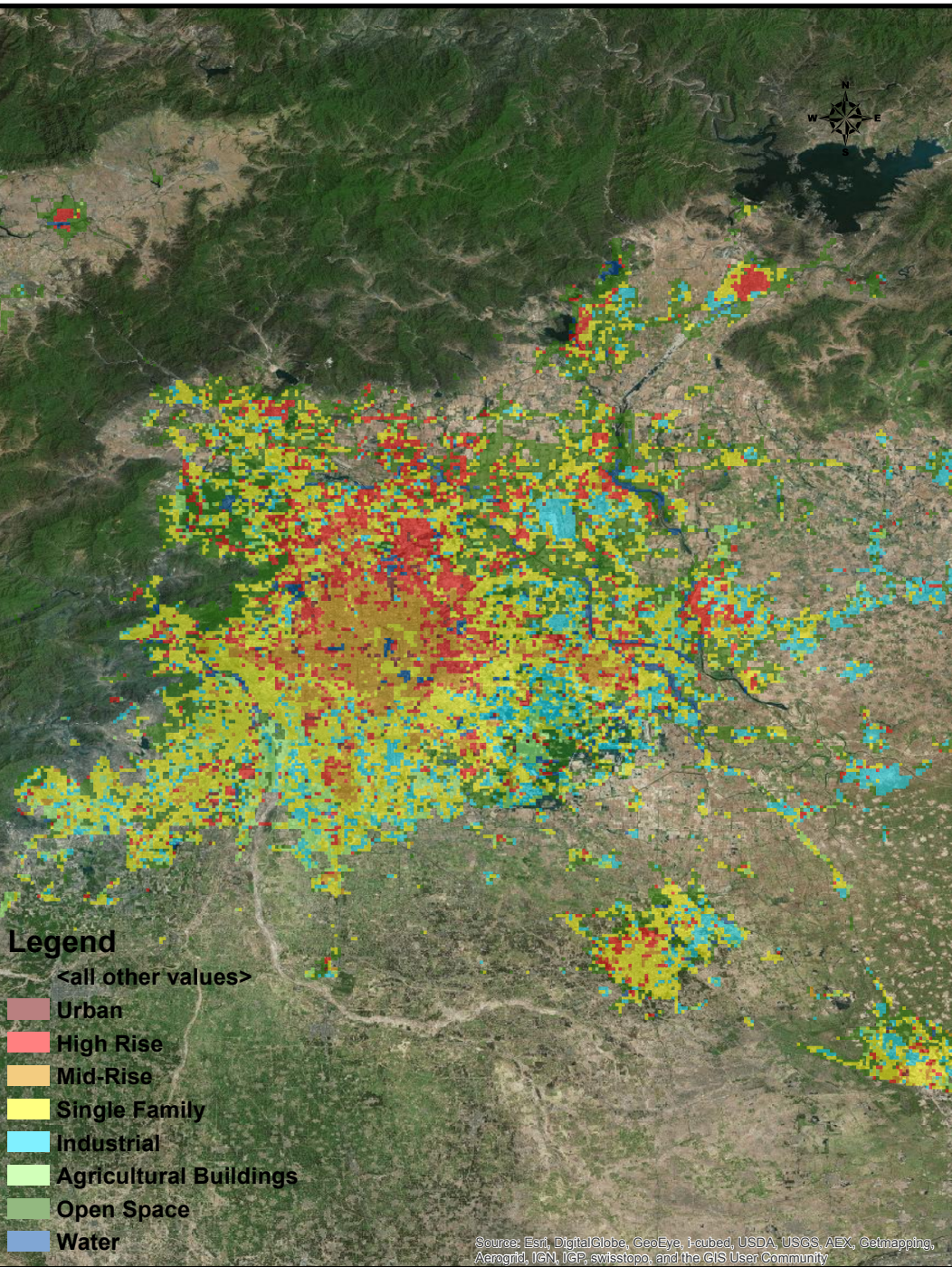
Legend

<all other values>

■ Urban

■ High Rise

■ Mid-Rise

■ Single Family

■ Industrial

■ Agricultural Buildings

■ Open Space

■ Water

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping,
Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Mapping Schemes (Indonesia example)

Building Counts and Floor Area (Sq M) by Land Use, Number of Stories and Structural Type

Zone Land Use	Basic Structural Type	Detailed Structural Type	Stories	# of Buildings	Total Sq Meters
Airport	Reinforced Concrete	Frame	1	20	15,000
Commercial	Masonry	Confined masonry	1	861	173,413
Commercial	Masonry	Confined masonry	2	270	173,616
Commercial	Masonry	Reinforced masonry	1	175	37,352
Commercial	Masonry	Unreinforced clay brick	1	2151	303,389
Commercial	Masonry	Unreinforced clay brick	2	97	35,452
Commercial	Masonry	Unreinforced, with reinforced concrete floors	2	97	41,191
Commercial	Reinforced Concrete	Frame	1	451	105,211
Commercial	Reinforced Concrete	Frame	2	296	387,201
Commercial	Reinforced Concrete	Shear wall	1	77	12,214
Commercial	Reinforced Concrete	Shear wall	2	146	57,050
Commercial	Timber/Wood	Open frame at grade	1	886	118,346
Commercial	Other	Other		171	173,692
Industrial	Masonry	Confined masonry	1	849	171,021
Industrial	Masonry	Reinforced masonry	1	849	181,263
Industrial	Reinforced Concrete	Frame	2	562	735,185
Industrial	Steel	Braced frame	1	280	134,875
Industrial	Steel	Braced frame	7	1	8,784
Industrial	Steel	Light frame (transverse-frame; longitudinal-steel rod tension-only bracing)	1	562	762,777
Industrial	Steel	Moment frame	1	280	58,204
Industrial	Steel	Moment frame	2	280	48,667

Mapping schemes linked to homogenous zones

Adjust modifiers

Results*

* Adjust mapping schemes, observations, and zones as needed, repeat

Guarding against too many classes
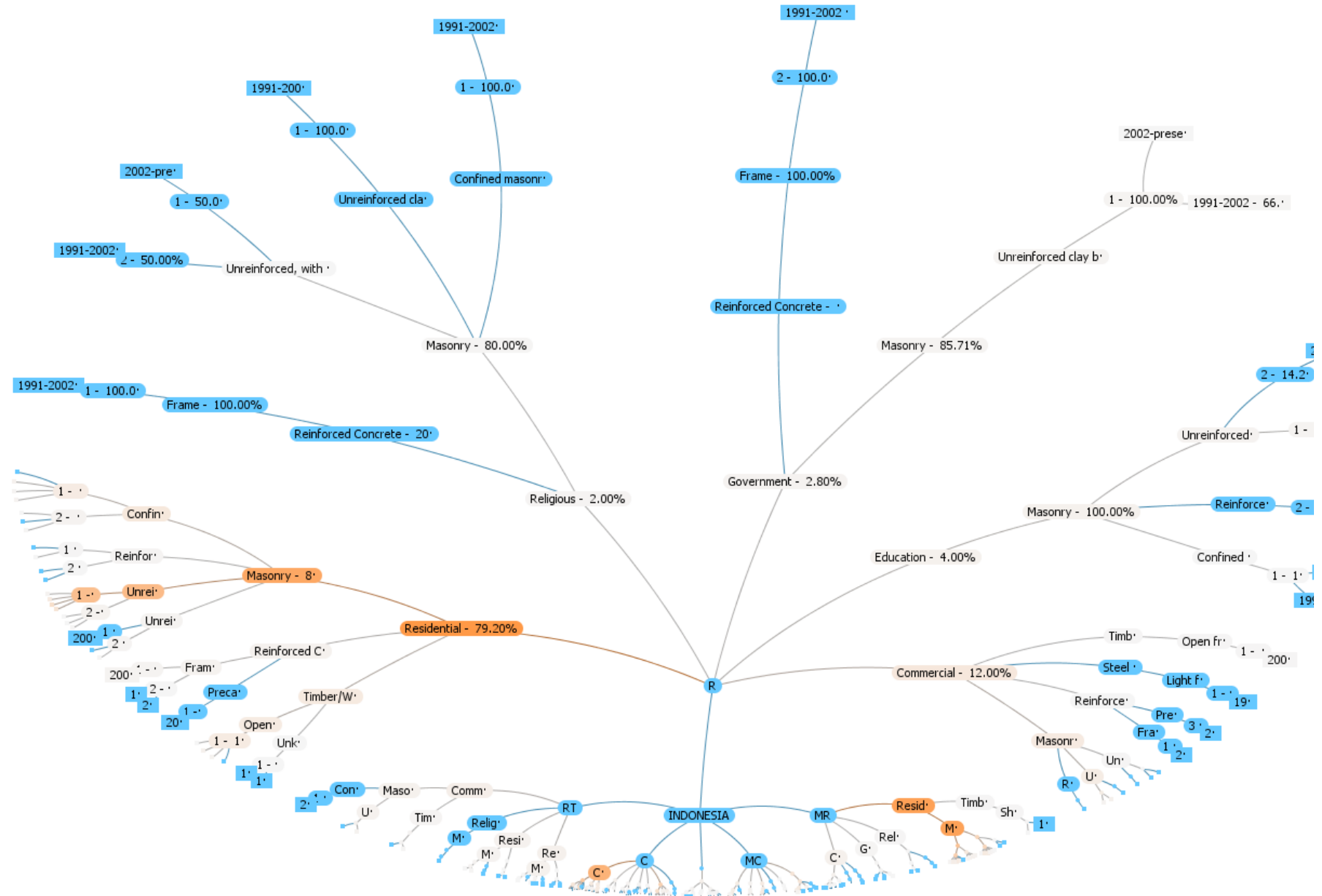
Applied Technology Council (ATC) Codes

- Categories for modeling damage from earthquakes

- Developed in the U.S.

- Some overlaps in categories

- Permanent Dwelling (single family housing)
- Permanent Dwelling (multi-family housing)
- Temporary Lodging
- Group Institutional
- Housing Retail Trade
- Wholesale Trade
- Personal and Repair Services
- Professional, Technical and Business Services
- Health Care Service Entertainment and Recreation
- Parking Heavy Fabrication and Assembly
- Light Fabrication and Assembly
- Food and Drugs Processing
- Chemicals Processing
- Metal and Minerals Processing
- High Technology
- Construction
- Petroleum
- Agriculture
- Mining
- Religion and Nonprofit
- General Services
- Emergency Response Services
- Education
- Highway
- Railroad
- Air
- Sea/Water
- Electrical
- Water
- Sanitary Sewer
- Natural Gas
- Telephone & Telegraph
- Communication (Radio and TV)
- Flood Control
- General Commercial
- General Industrial
- Miscellaneous
- Multi-Family Dwelling- Homeowners Association
- Multi-Family Dwelling- Condominium Unit Owner
- Gasoline Service Station
- Restaurants
- Casinos
- Acute Care Services Hospitals
- Hotels - Large Hotels - Small and Medium
- Rental – General Commercial
- Colleges and Universities

Socioeconomic Data

- Used to weight mapping of ATC codes to land cover classes

- Using census data on employment in industry (by categories)

- Census categories are mapped to ATC codes (multiple apply in some cases)

- Work in progress!

L600	Table 6 Total employed population by industry and thrice industrial ratio by county（people, %）
L600001	Total Population of Age 16 and Over
L600002	Total Employed Population by Industry
L600003	Sub-Total Employed Population in Agricultural Industry
L600004	Sub-Total Employed Population in Mining Industry
L600005	Sub-Total Employed Population in Manufacturing Industry
L600006	Sub-Total Employed Population in Production and Supply of Electric Power, Gas and Water Industry
L600007	Sub-Total Employed Population in Construction Industry
L600008	Sub-Total Employed Population in Storage and Postal Industry
L600009	Sub-Total Employed Population in Transportation, Computer Services and Software Industry
L600010	Sub-Total Employed Population in Information Transfer, Wholesale and Retail Trade Industry
L600011	Sub-Total Employed Population in Hotel and Restaurants Industry
L600012	Sub-Total Employed Population in Financial Industry
L600013	Sub-Total Employed Population in Real Estate Industry
L600014	Sub-Total Employed Population in Leasing and Business Services Industry
L600015	Sub-Total Employed Population in Scientific Research and Polytechnic Services and Geological Prospecting Industry
L600016	Sub-Total Employed Population in Water Conservancy, Environment and Public Facilities Management Industry
L600017	Sub-Total Employed Population in Resident and Other Services Industry
L600018	Sub-Total Employed Population in Education Industry
L600019	Sub-Total Employed Population in Health Care, Social Security and Social Welfare
L600020	Sub-Total Employed Population in Culture, Sports and Entertainment Industry
L600021	Sub-Total Employed Population in Public Administration and Social Organizations
L600022	Sub-Total Employed Population in International Organizations
L600023	Percentage of Population in Primary Industry to Total Employed Population
L600024	Percentage of Population in Secondary Industry to Total Employed Population
L600025	Percentage of Population in Tertiary Industry to Total Employed Population

Mapping Census to ATC

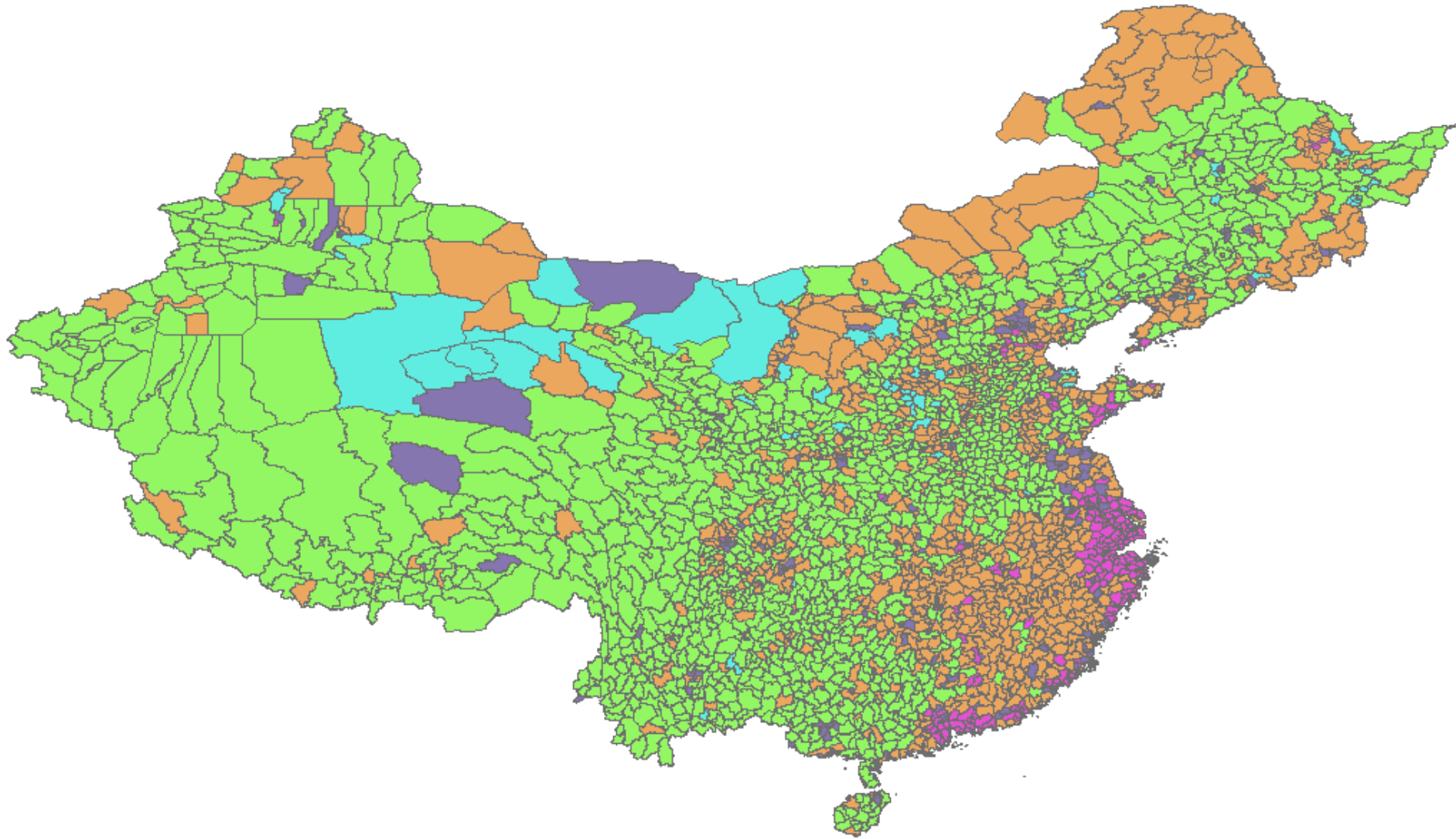| ATC Occupancy Description	Census 2010 Industry Mapping
Retail Trade	Information Transfer, Wholesale and Retail Trade
Wholesale Trade	Storage and Postal
Personal and Repair Services	Resident and Other Services
Professional, Technical and Business Services	Real Estate; Transportation, Computer Services and Software; Financial; Leasing and Business Services; International Organizations; Scientific Research and Polytechnic Services and Geological Prospecting
Health Care Service	Health Care, Social Security and Social Welfare
Entertainment and Recreation	Culture, Sports and Entertainment
Light Fabrication and Assembly	Manufacturing
Construction	Construction
Agriculture	Agriculture
Mining	Mining
General Services	Water Conservancy, Enivronment and Public Facilities Management; Public Administration and Social Organizations
Education	Education
Electrical	Production and Supply of Electric Power, Gas and Water
Restaurants	Hotels and Restaurants

Primary
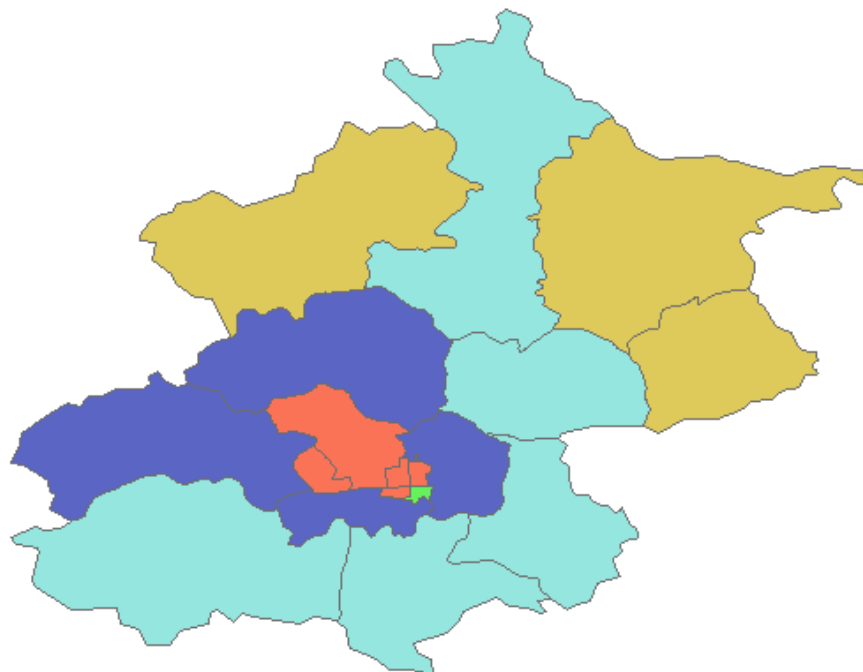
Secondary
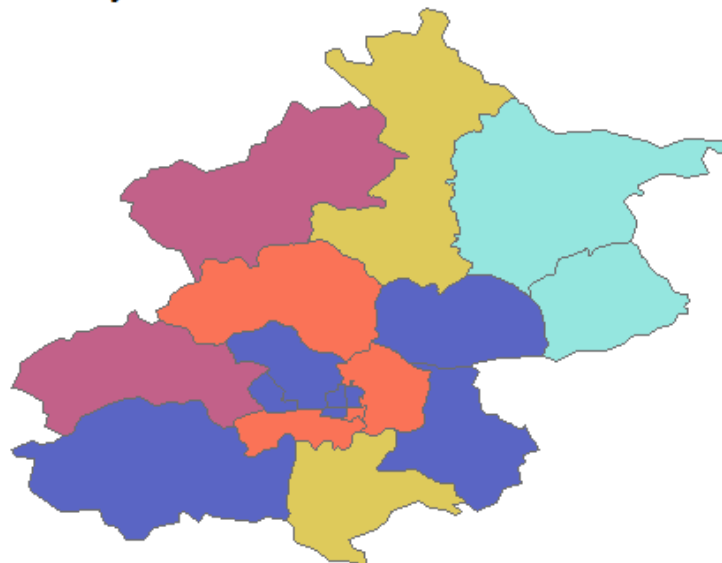
Tertiary
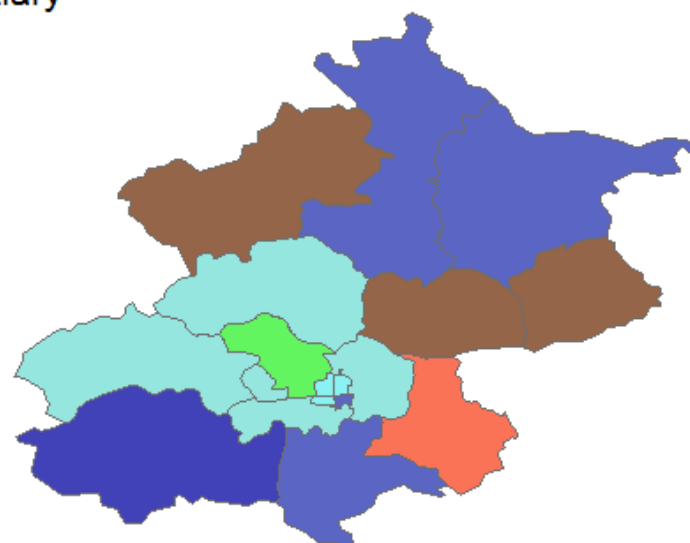
ATC Codes

- 5 Retail Trade
- 6 Wholesale Trade
- 7 Personal & Repair Services
- 8 Prof, Tech & Business
- 13 Light Fabrication & Assembly
- 18 Construction
- 20 Agriculture
- 23 General Services
- 25 Education
- 47 Restaurants

Land Cover By Census Unit

Most Common Class

- ☐ Unclassified
- ☐ Mid-Rise
- ☐ Open Space
- ☐ Single Family
- ☐ Industrial
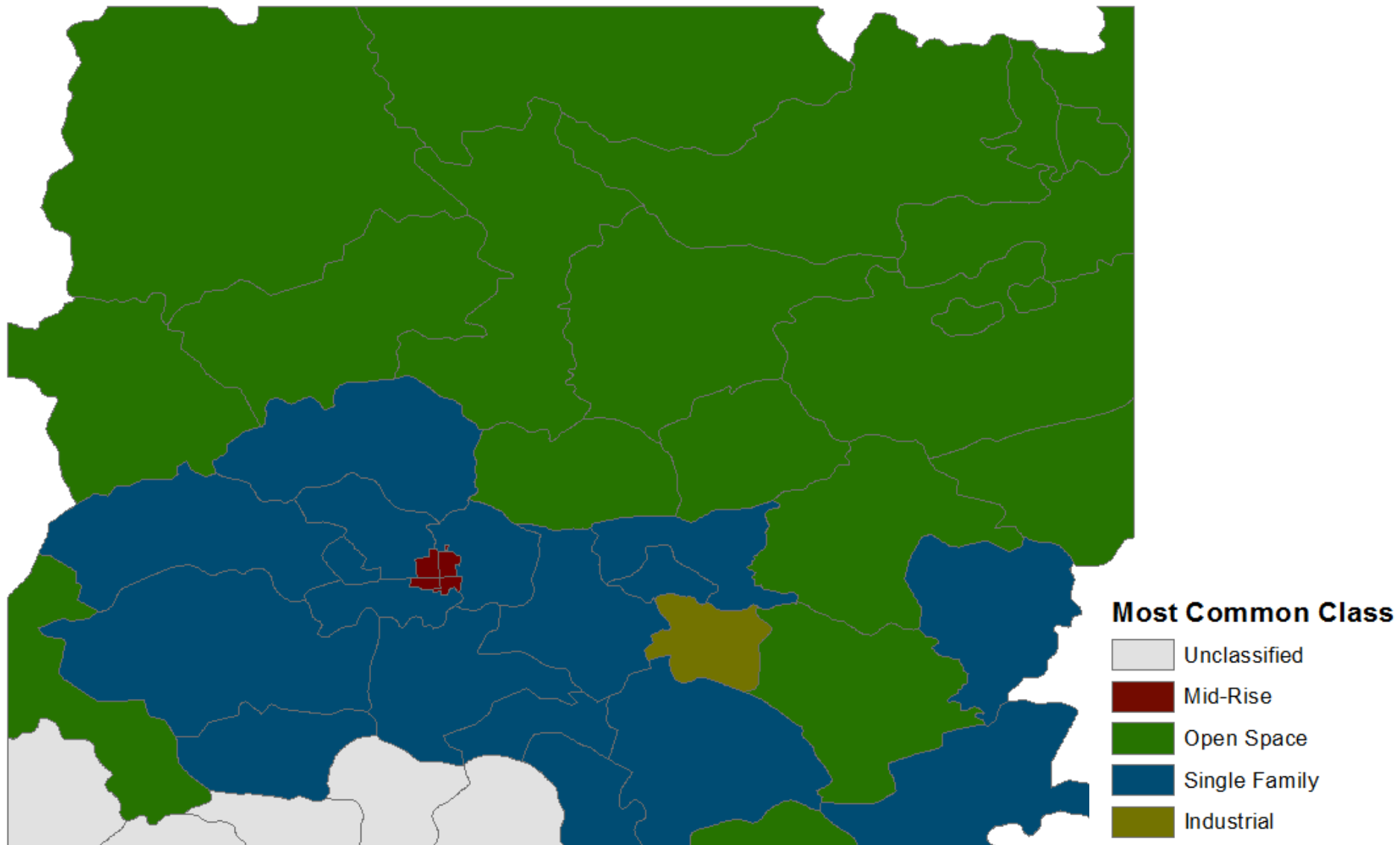
Clustering with K-Means

Remaining Work

- Round out mapping of Census data to ATC codes
  - Use demographic census where appropriate
- Complete validation
  - Merge k-means and other statistical groupings with land cover as sensitivity analysis
- Apply weights to land cover categories to produce estimates at the pixel level

Thanks!

Questions?

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