Understanding Exposure Data

This section will introduce some of the contributions of the METEOR project to exposure development science, including a discussion of metadata and the various levels. The audience will learn what they should do when they receive exposure data on a project, and how to tell “if it is any good.” Several of visuals of exposure overlaid with hazard data so that users can understand intuitively why, for example, crude exposure is not adequate for localized hazards.

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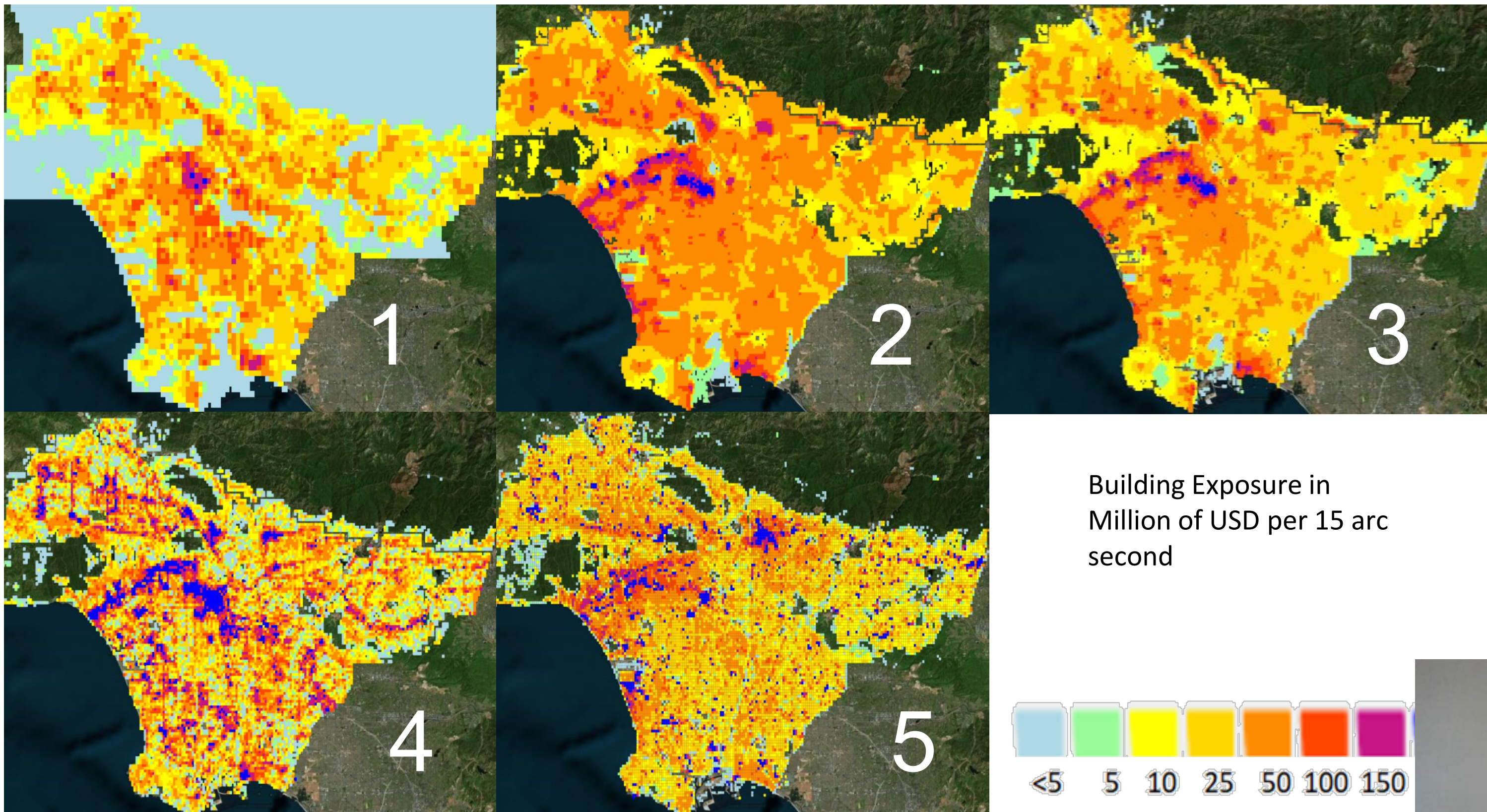
How to check your exposure data and ensure that it is fit for purpose?

- Levels of exposure data
- Resolution and scale of impact given the hazard
- Key parameters
- Understanding the metadata
- Validation
- Understanding the limitations

Levels of exposure data



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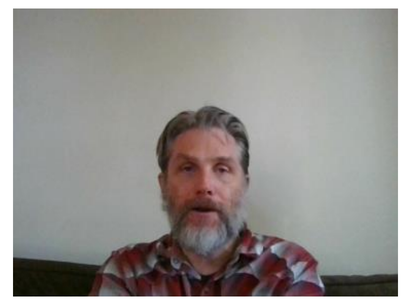
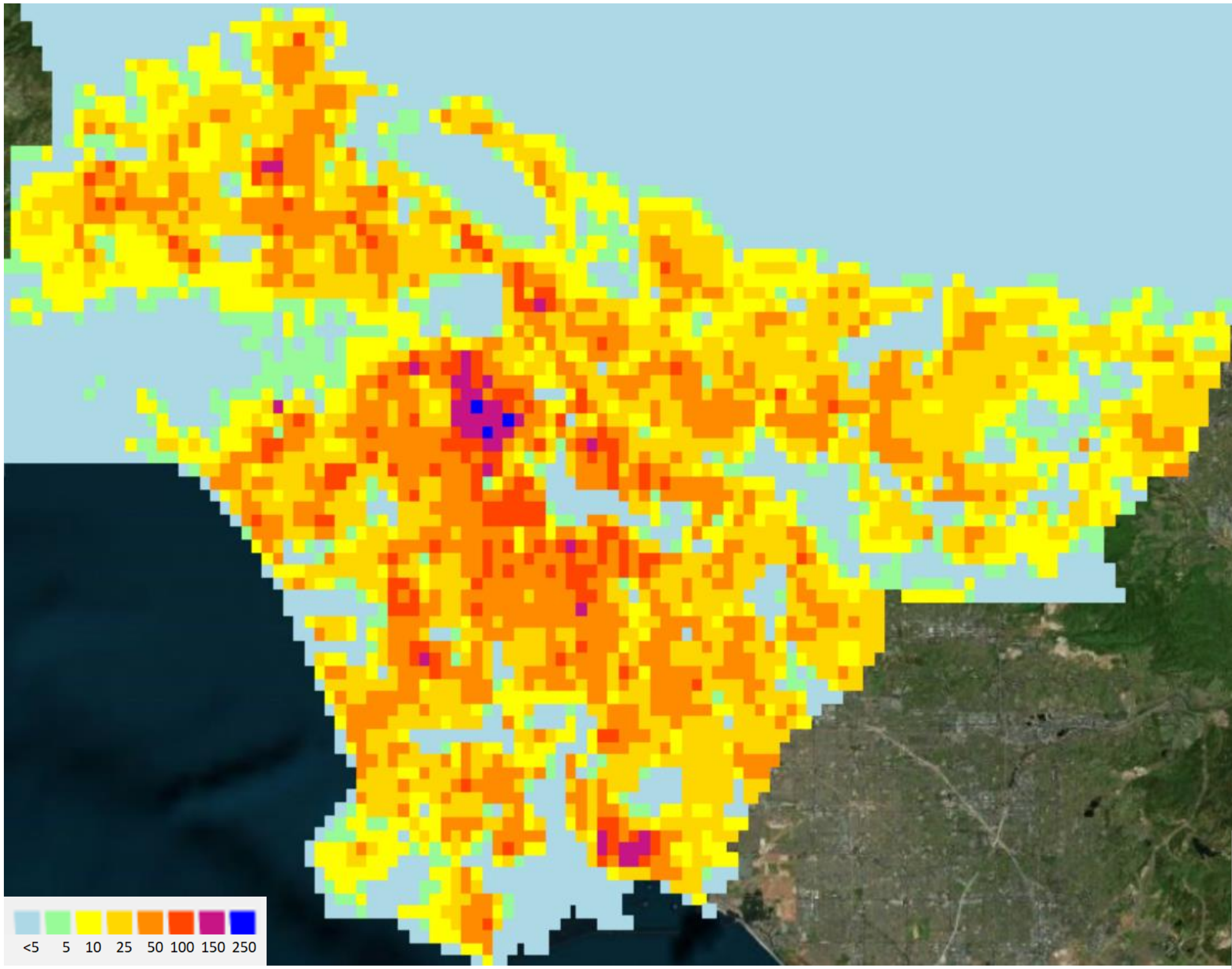
Level 1 Data for Los Angeles

Level 1 data was downloaded from GEM's OpenQuake site. For the US, OpenQuake provides data from FEMA P-366 (Jaiswal et al., 2017) and largely taken from HAZUS. It is less crude than it may be for many other countries, for the US, and may be more like a level 2 in most countries that said, the project team found there were significant differences between this dataset and the one developed for level 2, as described below. Most of the effort required was mapping the structural types to those used by the Seismicat software. There are no meaningful indications of building height or era of construction in this data set.



L1



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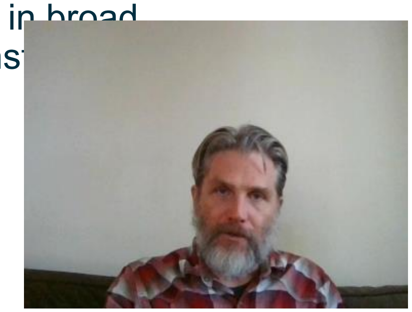
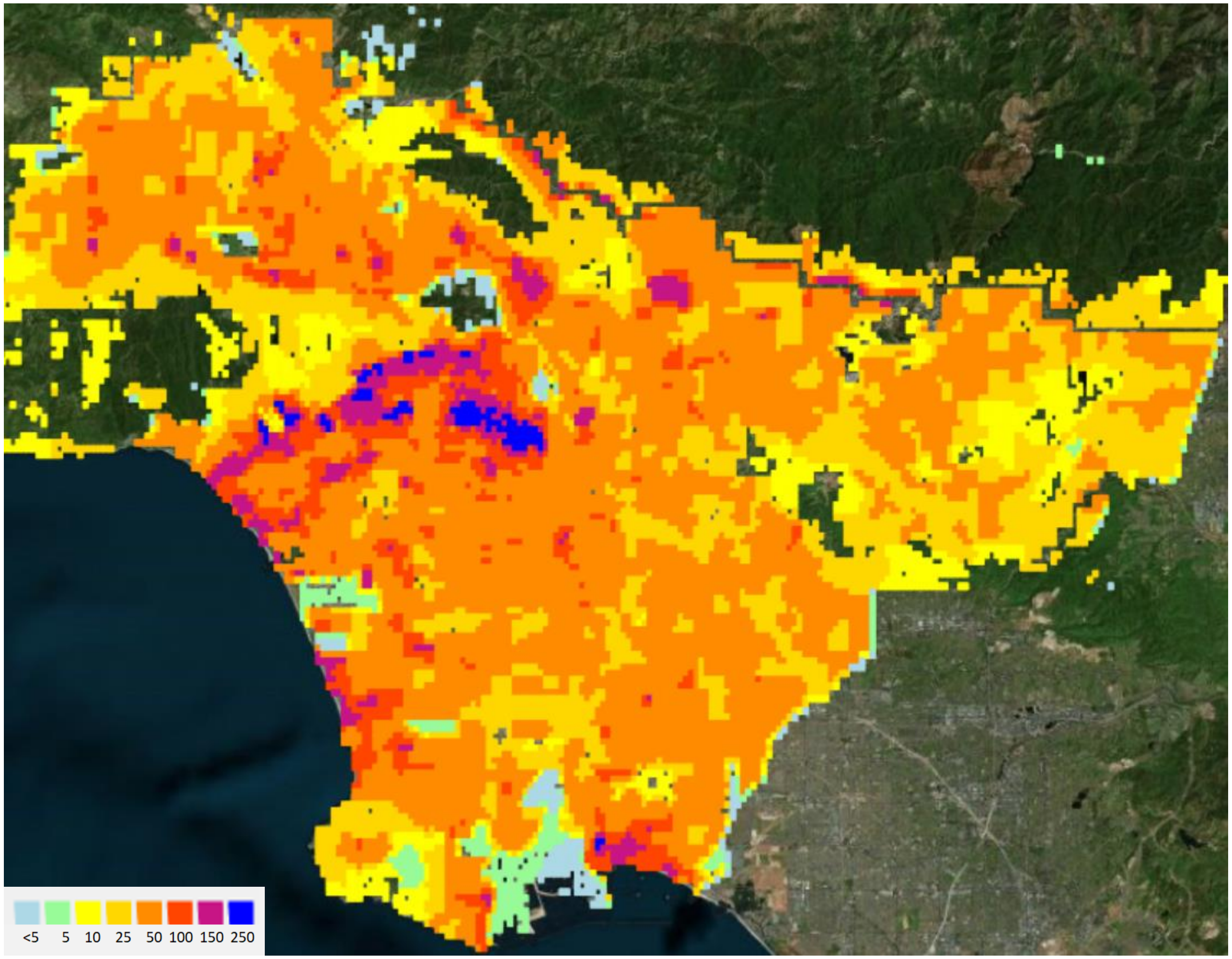
Level 2 Data for Los Angeles

Level 2 data was developed using the exposure data provided with HAZUS 4.2. HAZUS includes data from a variety of sources, but there are only a few key datasets and parameters used to create the default general building stock. The number of structures for residential development is based on the US Census, in this case 2010. The non-residential building stock is largely developed using data provided by a private company specializing in data provision- Dun and Bradstreet. Extending from building count to building size and replacement cost, HAZUS assumes a single model building type and size for each occupancy classification from the data collected by the census and Dun and Bradstreet. These estimates of building size do not have a distribution like the structural values, but only a single value. The replacement cost developed through the per square foot for each of these model building types provided by RS Means, in this case 2018. Unlike the level 1 data, the era of construction is provided through the census data. A height distribution is provided though the structural type in broad ranges but in practice is set to 100% low rise cons



L2



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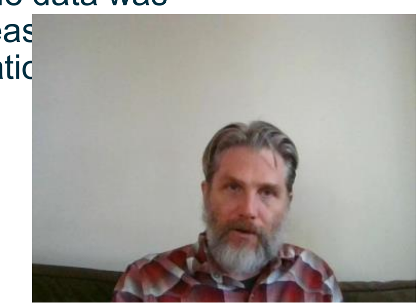
Level 3 Data for Los Angeles

Level 3 harnesses the capabilities of EO and applies them to the default Level 2 database. The process for developing this dataset was compiled by the project team on a previous project for NASA. As described in Section 2 above, development patterns were extracted from EO data and used to adjust the mapping schemes provided by HAZUS that are used to assign structural types and height. The general classes correspond to areas that are primarily industrial, rural, suburban, multi-family, or commercial business districts of various levels of density of building area. This allows for a more accurate assessment of the likely building type for a given retail structure that is identified in downtown Los Angeles as opposed to an unpopulated area, for example, or an industrial building identified by Dun and Bradstreet in a commercial business district. The distribution of model building types is also used as a key component in the valuation, using the Inhance “ITV”, or Insurance to value module (ImageCat, 2019[a]). This represents a simple EO-based enhancement of the default parameters provided in a national dataset to reflect local exposure. The era was also considered, using the HAZUS data from Level 2. The data was aggregated to 15 arc-seconds to make the results eas comparable between levels, and to reduce computatic



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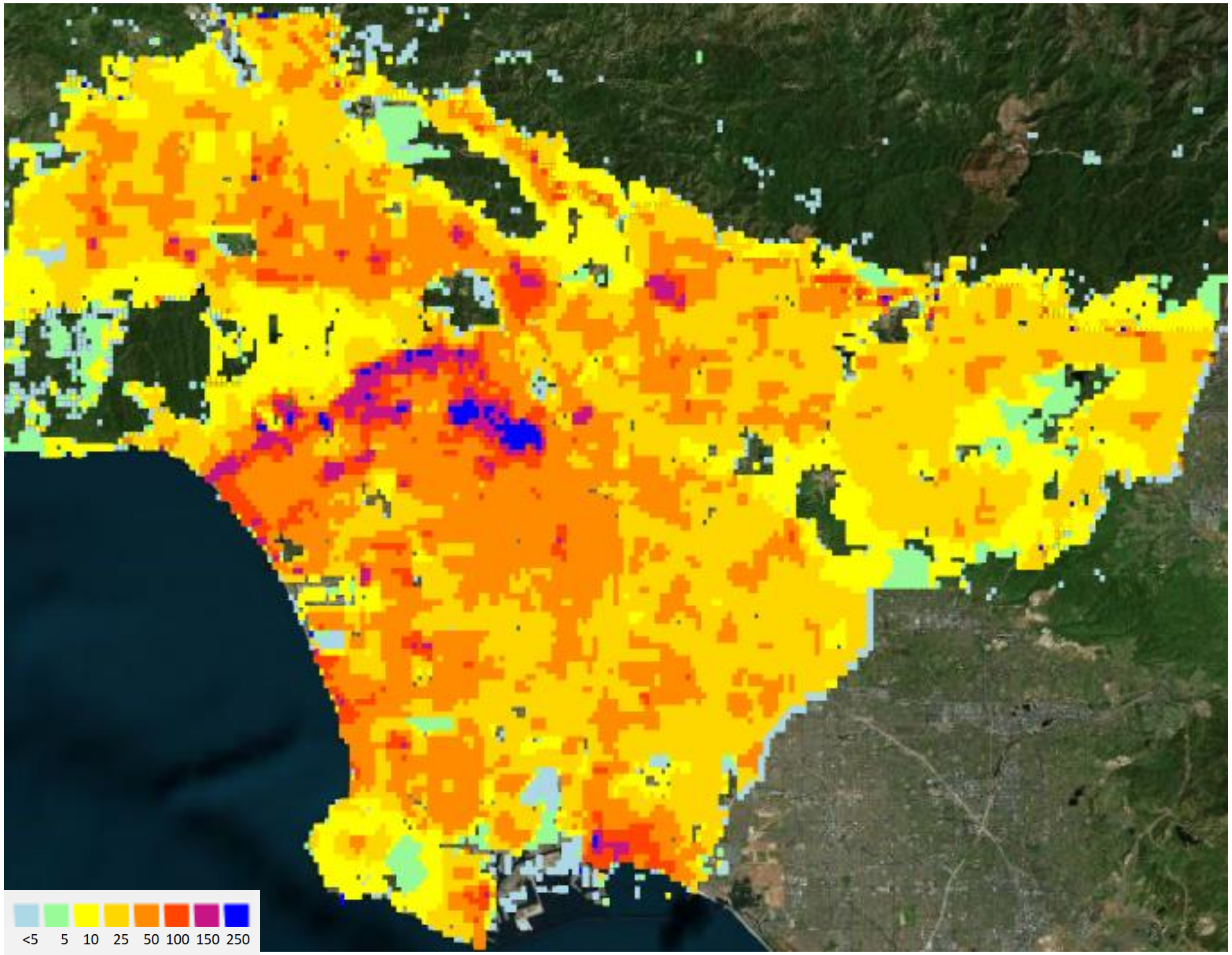
L3



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Level 4 Data for Los Angeles

Level 4 takes advantage of many of the key EO-based tools discussed above for Level 3, but supplements the process using EO-based building extraction. For this dataset, building footprints provided by Microsoft were used to develop the estimated number of buildings and the estimated square footage of building stock. Through visual inspection, 2,000 square feet of building footprint was determined to be an adequate delineation between residential and non-residential construction. These data were then aggregated into Based on the height distributions for the various development patterns discussed in level 3, the buildings were “extruded” to reflect the total square footage of building space rather than just the footprint. The non-residential square footage was then distributed into occupancy classes based on the aggregated HAZUS data from Level 2, and these occupancies were used to assign structural classes for each development pattern. As with Level 3, the Inhance ITV module was used to assign the replacement cost, and the HAZUS data was used to assign the era of construction. With the Level 4 data, only the era of construction is derived from the HAZUS data. The level 4 exposure represents the best solution possible with “empty footprint” data. That is, footprints extracted through EO building ext
attributes.

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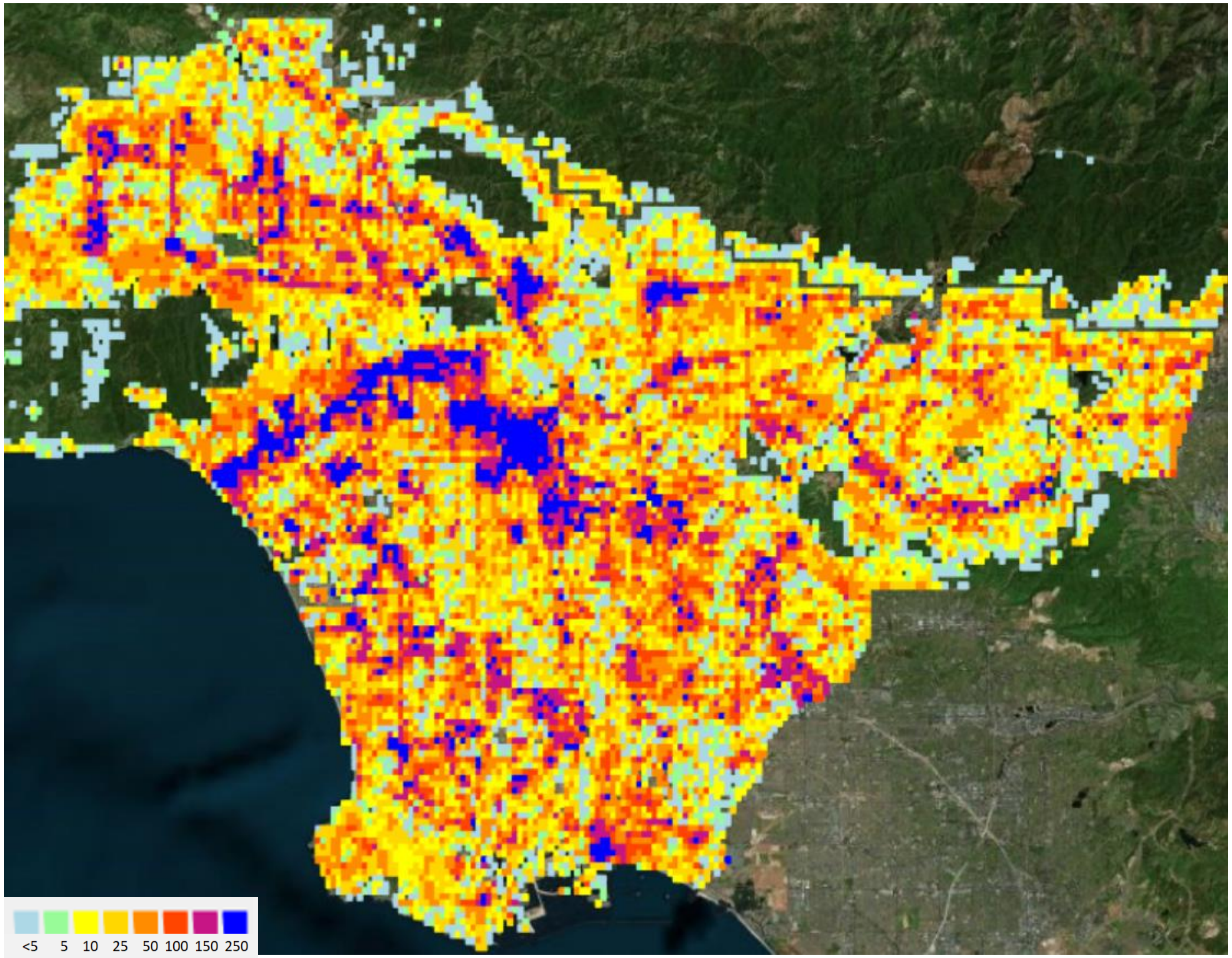
L4



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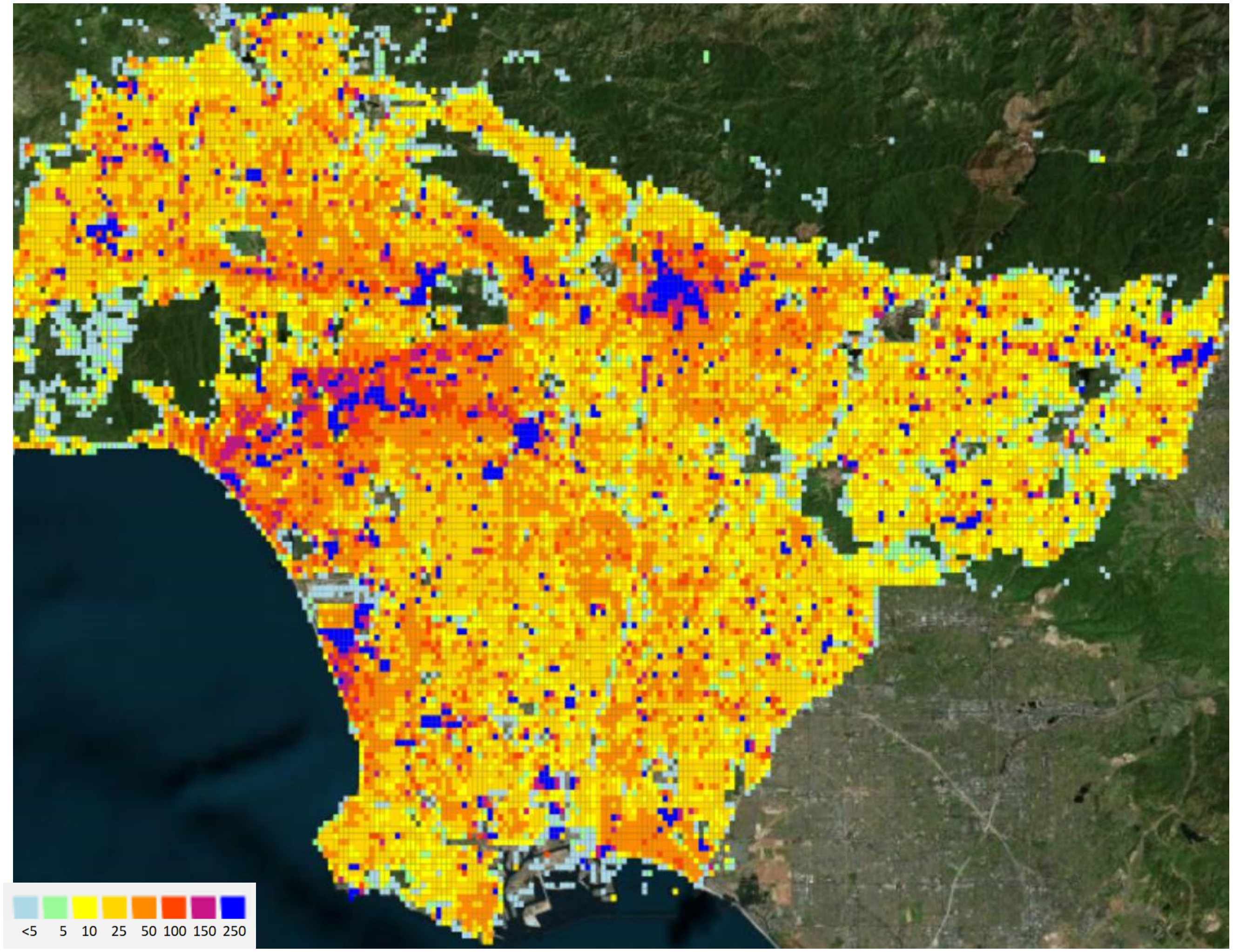
Level 5 Data for Los Angeles

For Level 5, the Los Angeles tax assessor data was acquired by the Los Angeles tax assessor and processed in a manner discussed above. This source of data is completely independent of levels 1 to 4. Although it is more detailed, it may not always be more accurate and was compiled for a purpose other than tax assessment. For each record, a fire code is used to indicate flammability or material type, and given this structure type, height, the use code, and the era of construction a more detailed structural assessment is assumed. This process was modelled on an internal memo completed by Hope Seligson during the preparation of *Data Standardization Guidelines for Loss Estimation Population Inventory Databases for HAZUS MR-1* (ImageCat and ABS, 2006) but was tailored to meet the vulnerability codes of Seismicat. The tax assessor provides the building height in ranges. Late in the development of the exposure data, a building footprint database was discovered that was derived from Lidar data and included height in feet. This was used to assign a height in stories. All other parameters were obtained directly from the dataset. There were no efforts made to adjust the data to account for missing buildings that may not be inventoried by the tax collector or adjust the assessments to reflect a more accurate replacement cost. The result is that key facilities such as ports and airports appear to be missing.

L5



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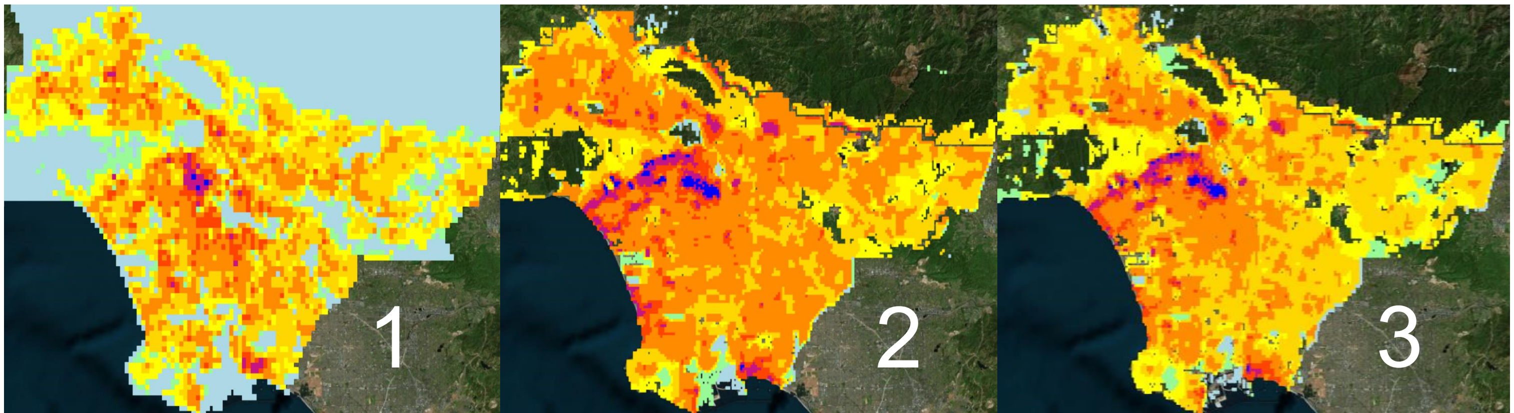
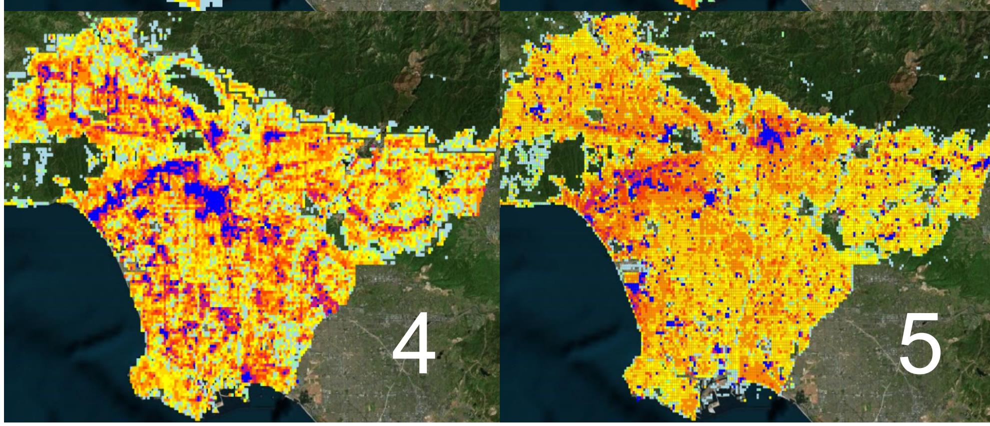
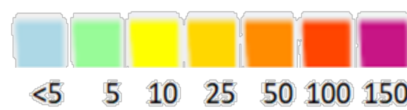
Levels of exposure data





Building Exposure in Million of USD per 15 arc second



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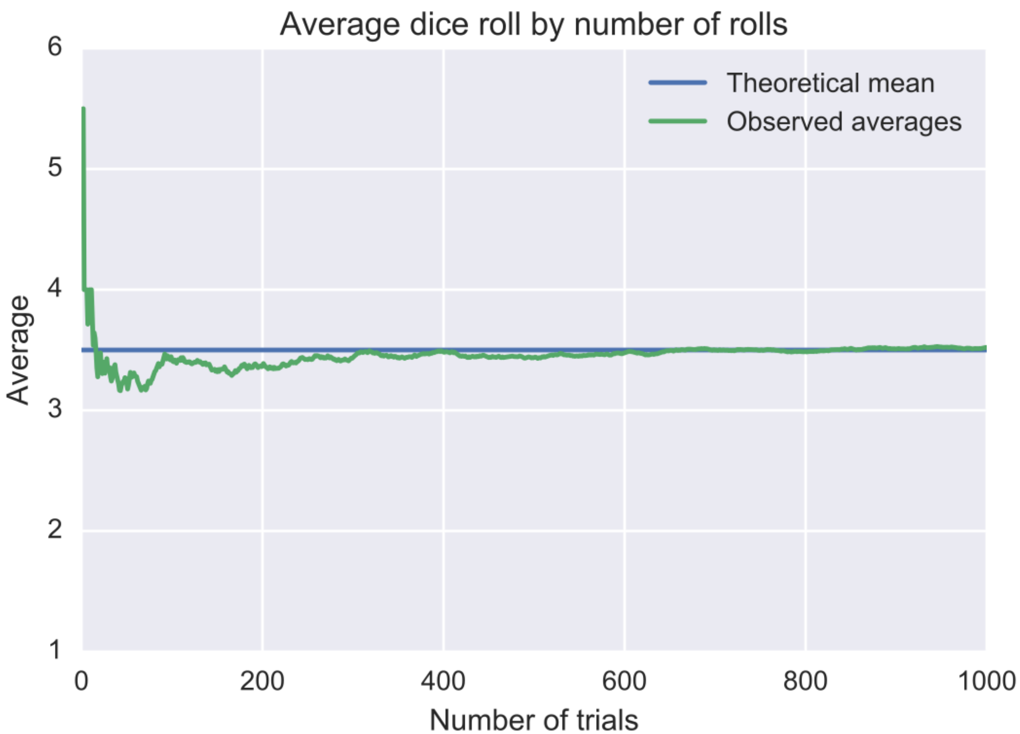
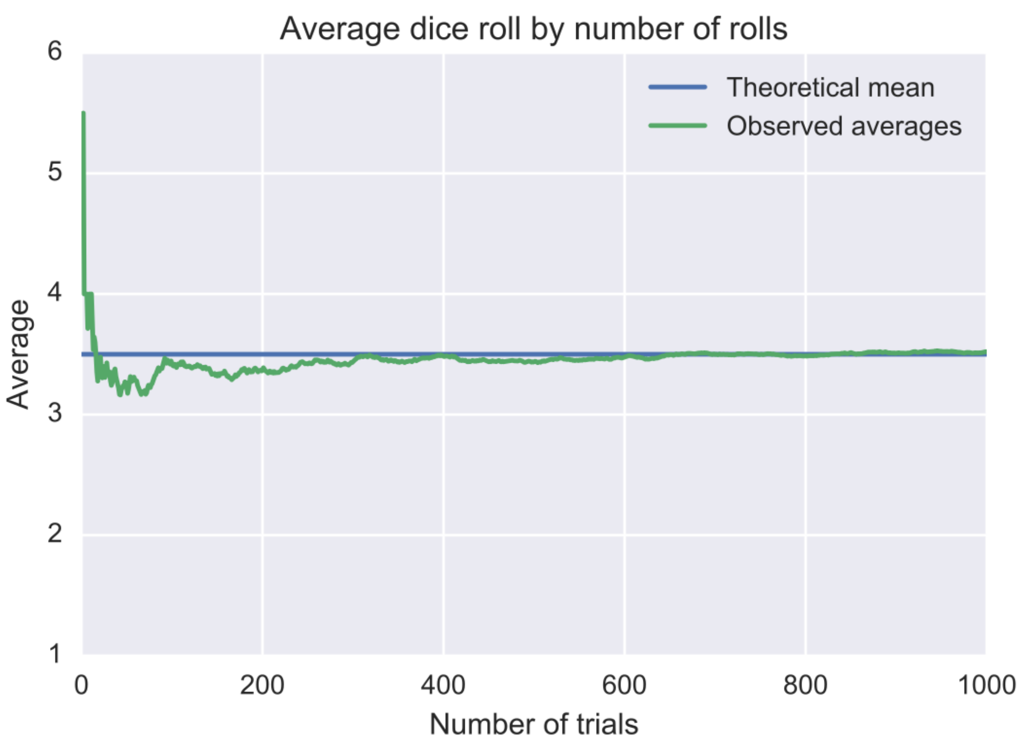
“Law of large numbers”

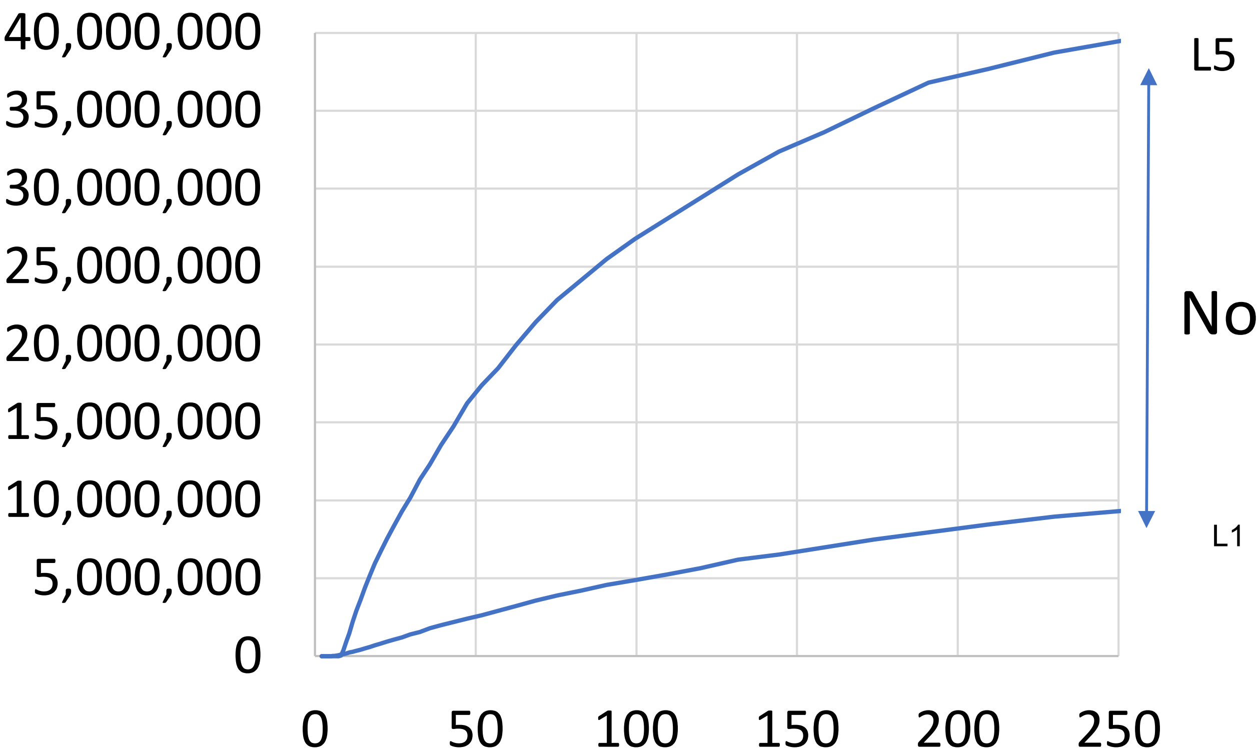


Whoops!


Average dice roll by number of rolls
Theoretical mean
Observed averages
Average
Number of trials
1
2
3
4
5
6
0
200
400
600
800
1000

Why the law of large numbers is problematic when considering exposure data

- Exposure data is often very sensitive to a few numbers
  - Replacement Cost
  - People per household
  - Average dwelling size
  - Exchange rate
- Buildings are seldom actually sampled
- Census data often has bias



Nobody knows

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To characterize uncertainty by level of data…

- 5 levels of data
- Collect all 5 for Los Angeles County
- Run them through a probabilistic risk assessment
- See how far the results a
  what difference does it r

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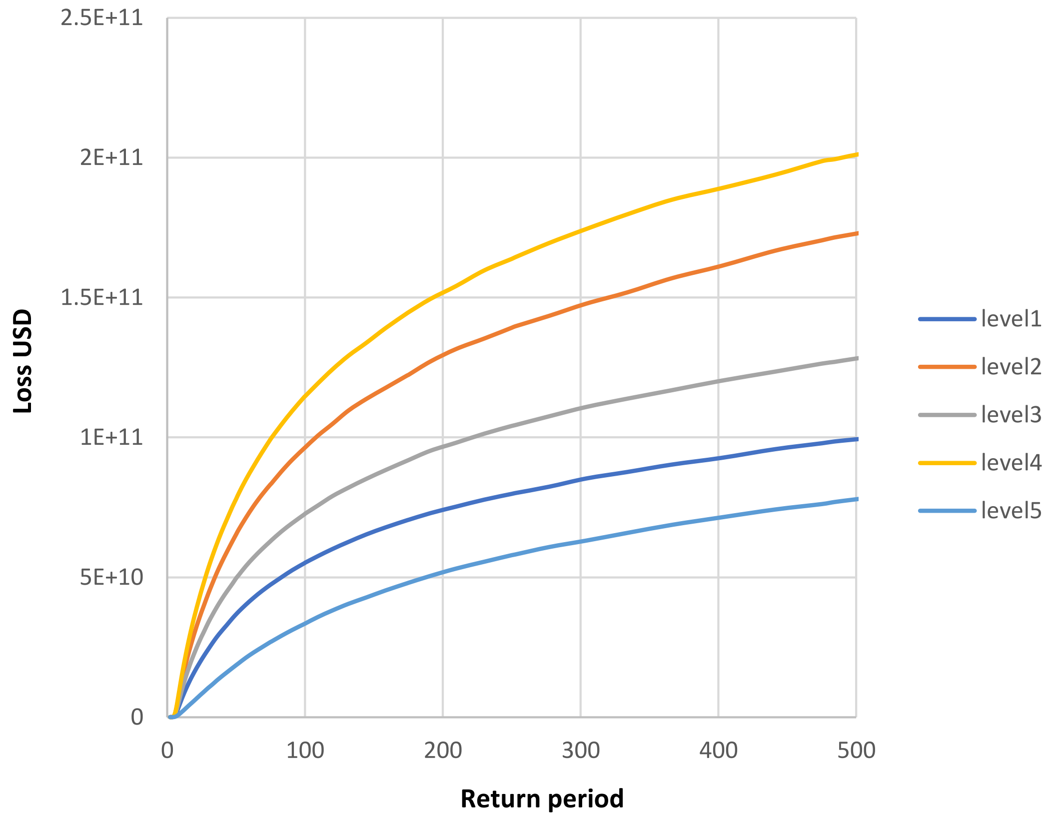

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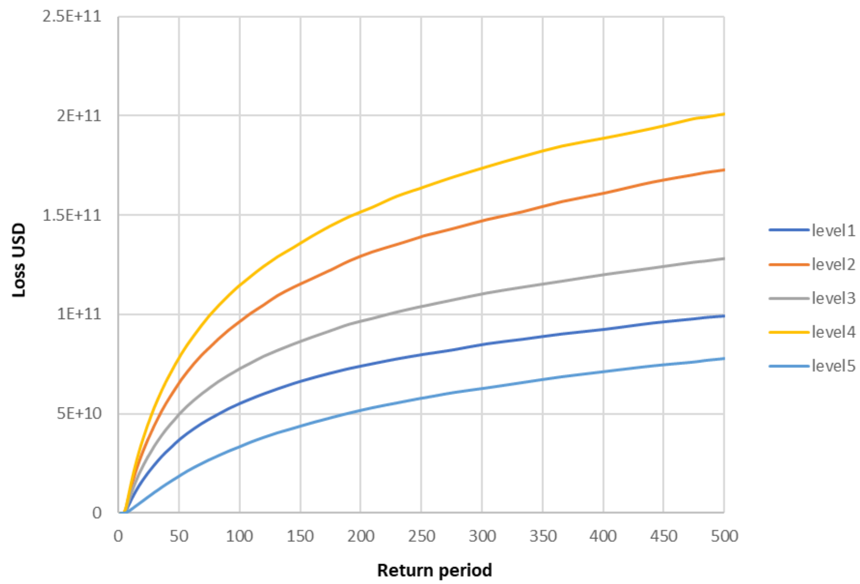
Detrended for differences in area, per buildings and replacement cost



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Key, often ignored factors

- Persons per household
- Living area per household
- Rebuilding cost
- Exchange rates

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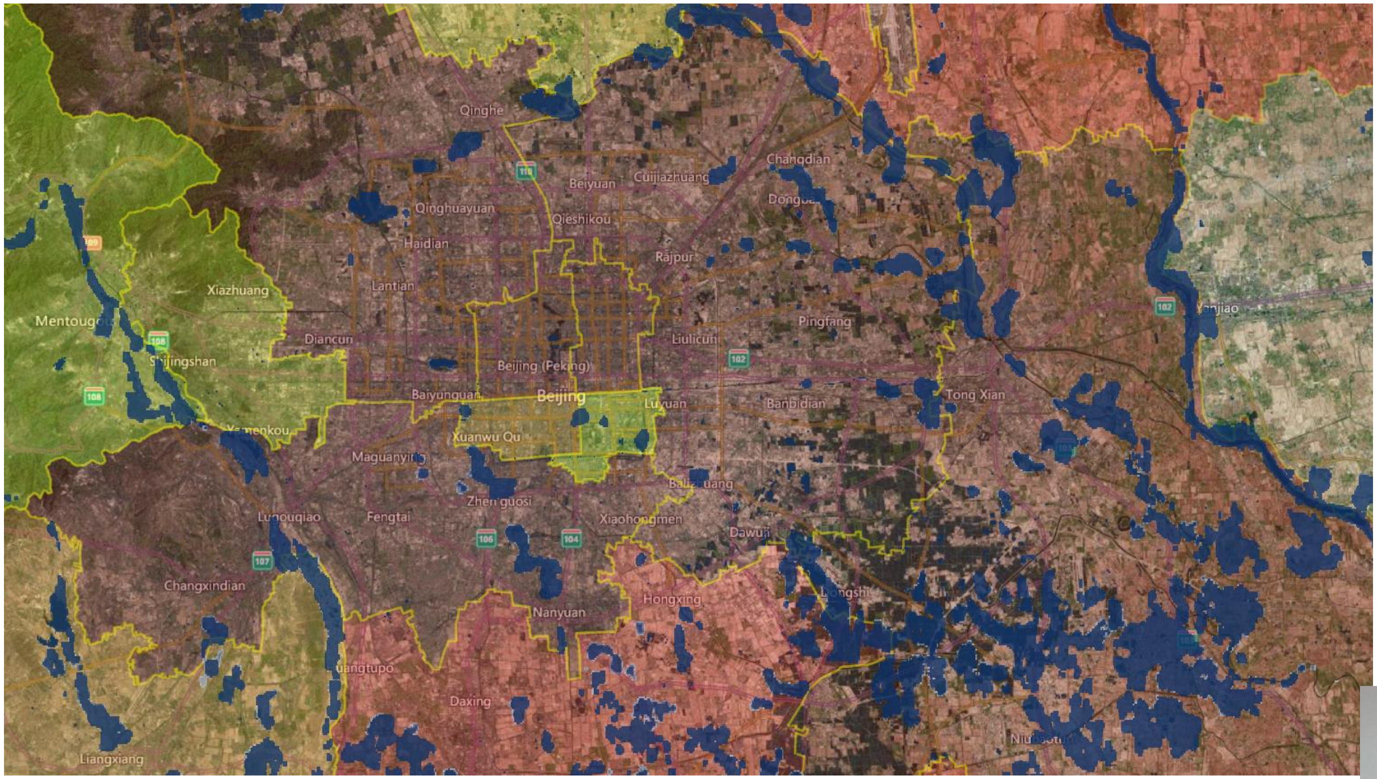
Introduces more uncerta
than hazard and vulnera

Resolution and scale of impact given the hazard



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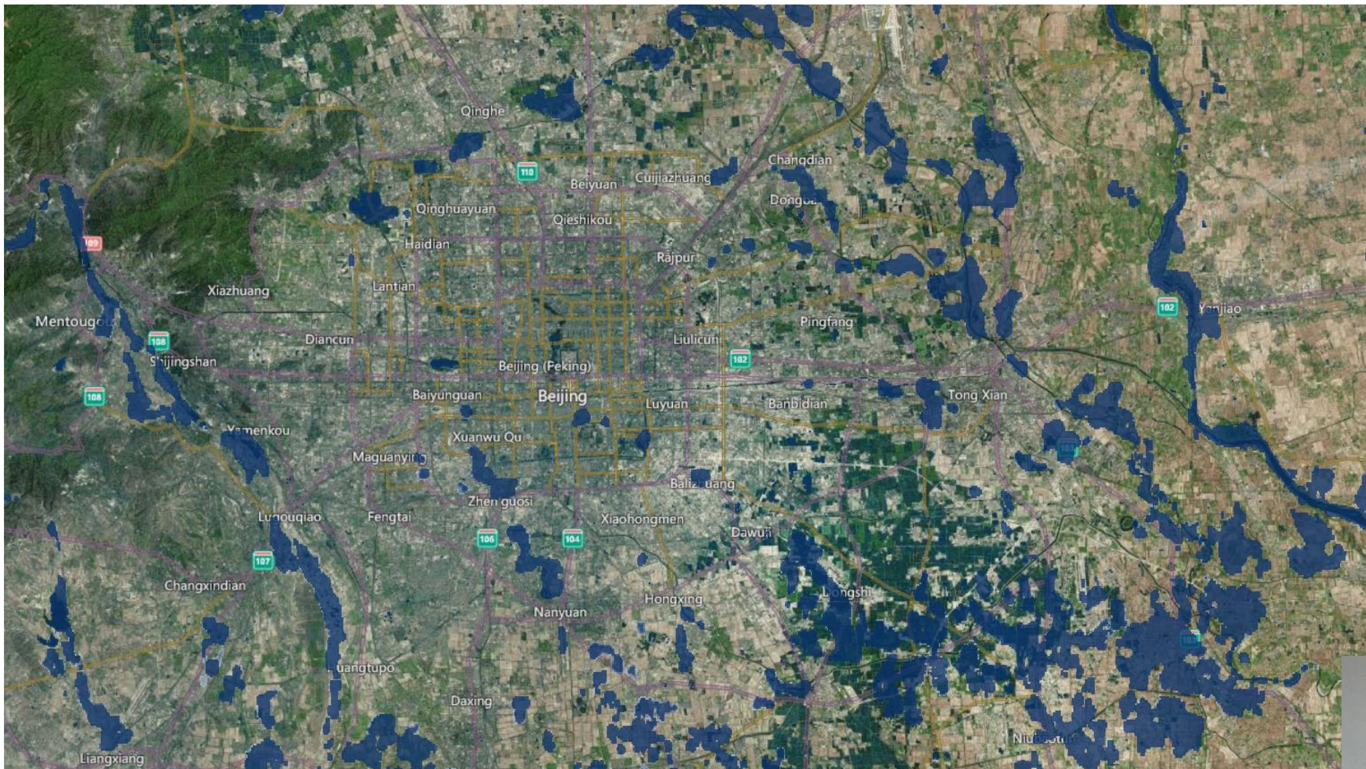
Resolution and scale of impact given the hazard



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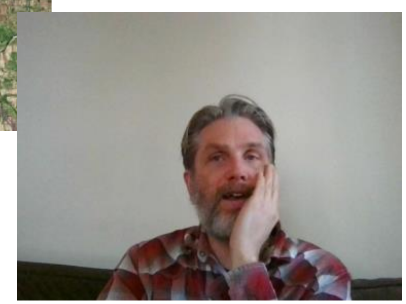
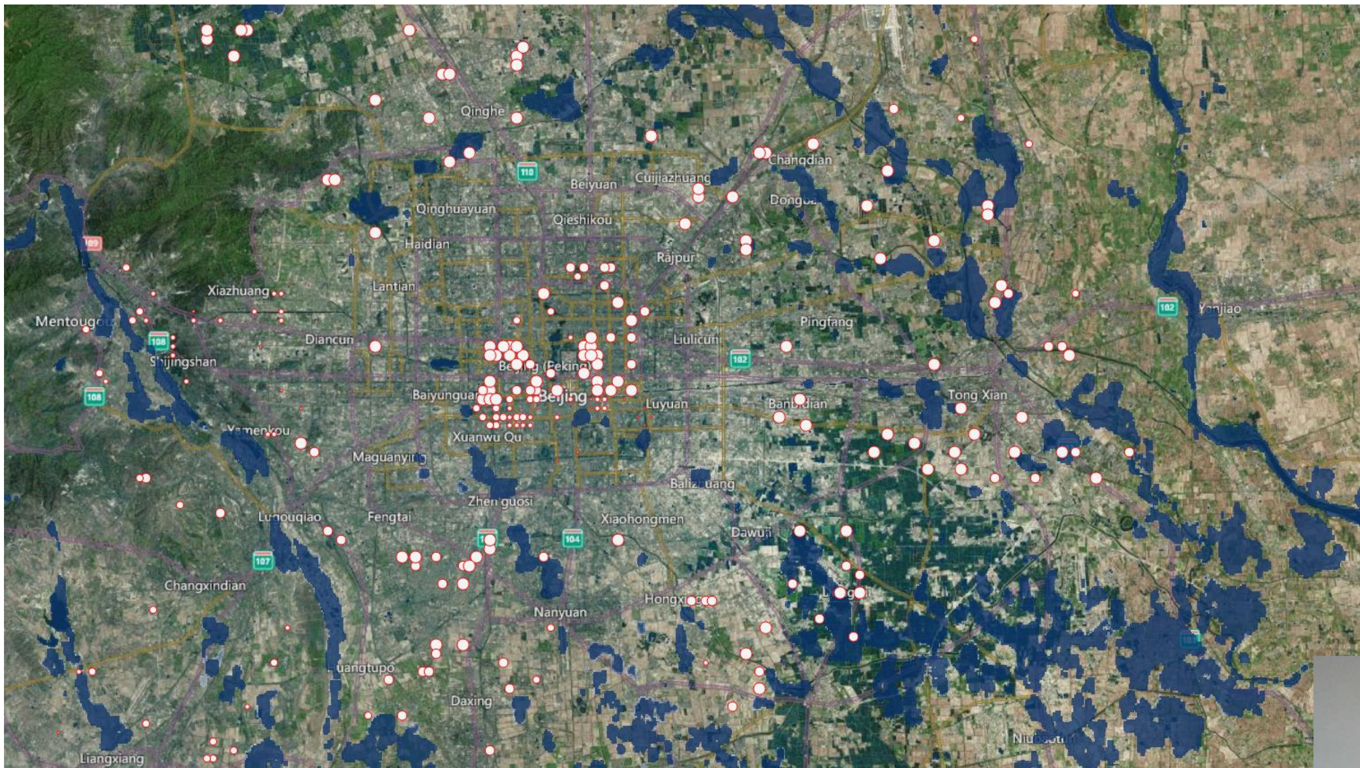


Resolution and scale of impact given the hazard



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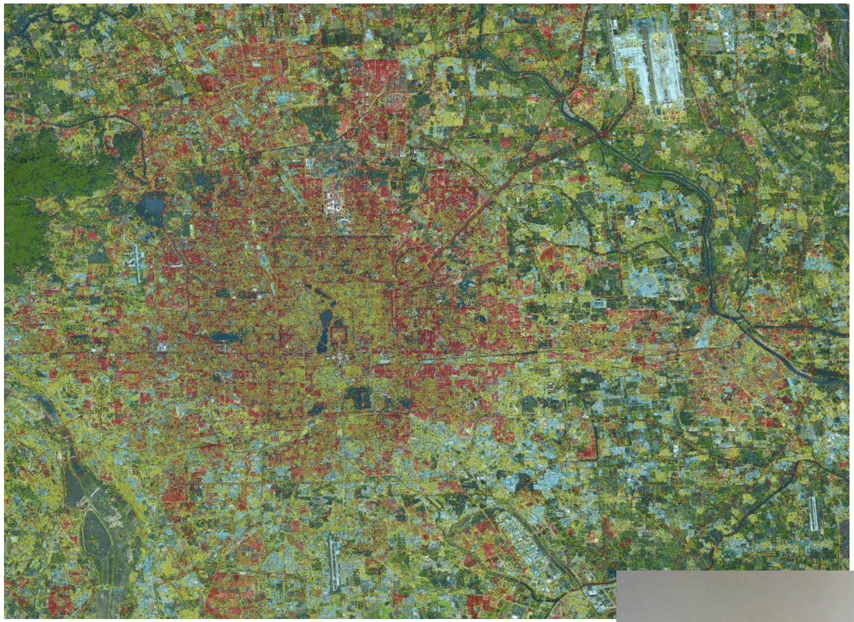
Resolution and scale of impact given the hazard



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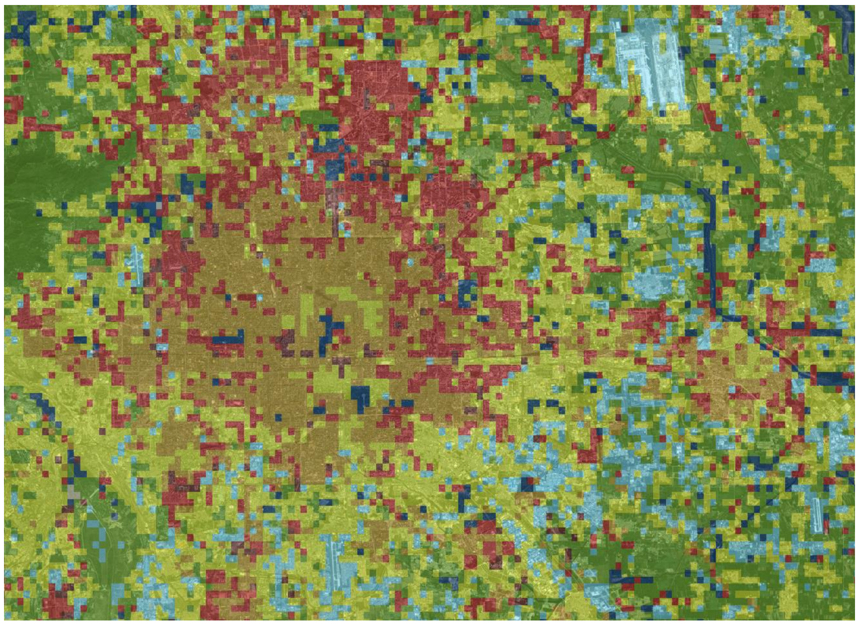
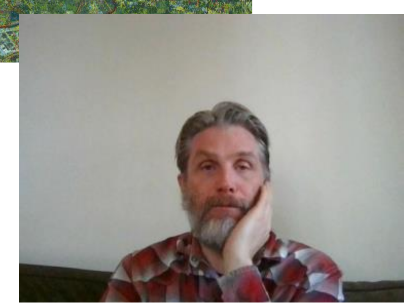
Resolution and scale of impact given the hazard

More Accurate



Higher Resolution



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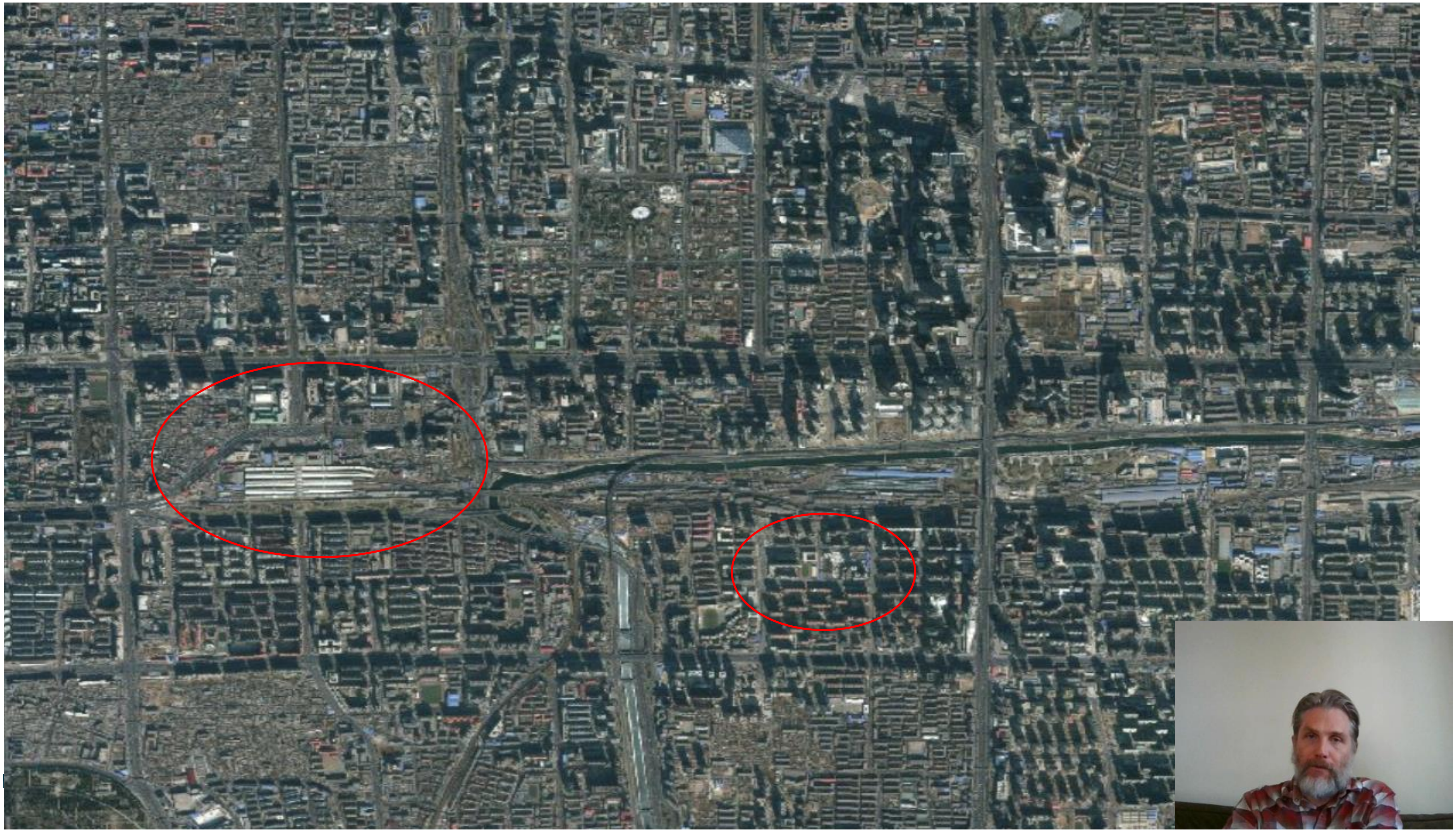
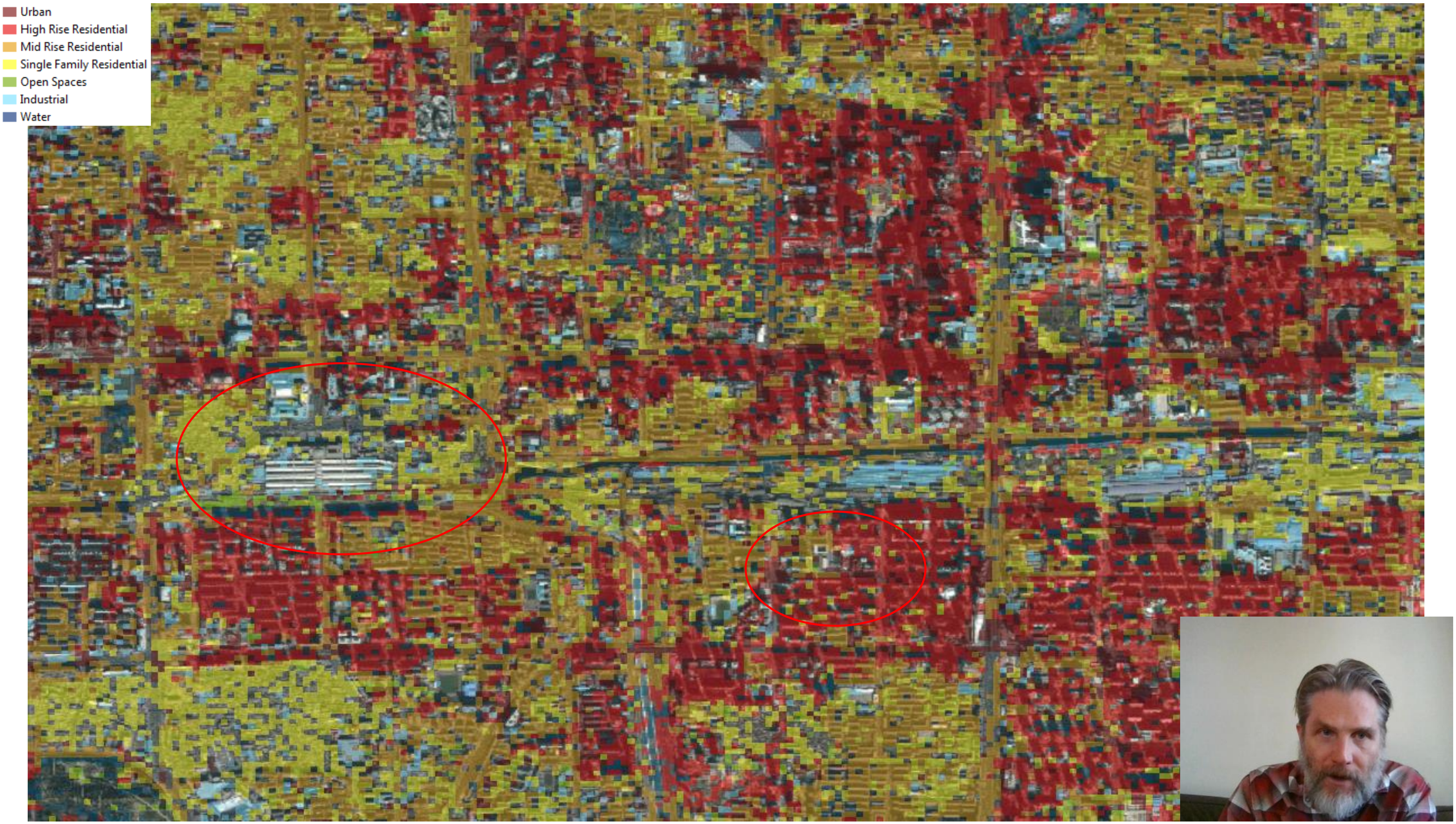
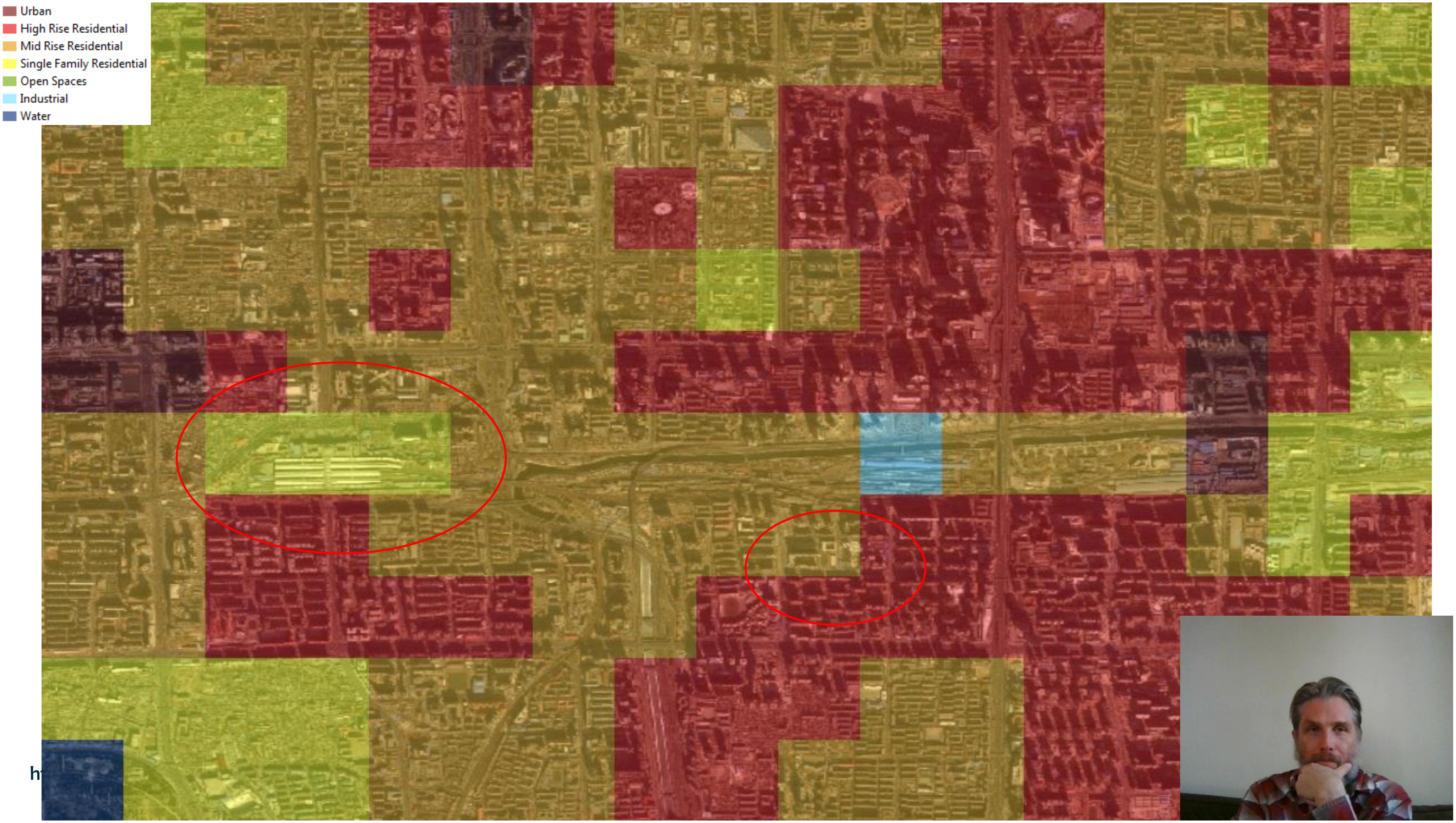


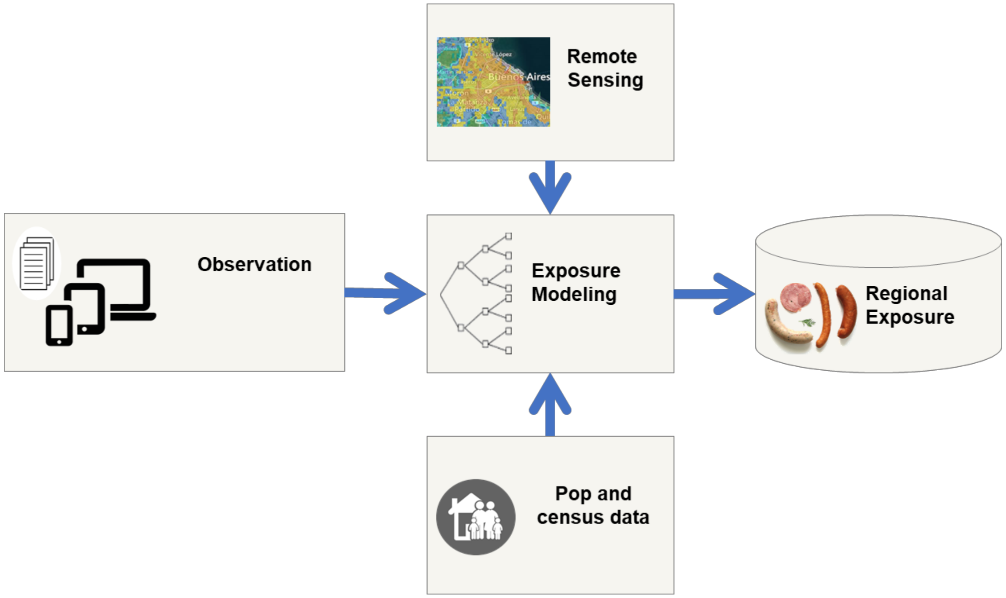


Urban
High Rise Residential
Mid Rise Residential
Single Family Residential
Open Spaces
Industrial
Water


Urban
High Rise Residential
Mid Rise Residential
Single Family Residential
Open Spaces
Industrial
Water

Understanding the metadata

- Source
- Vintage
- Key contacts
- Resolution- final and base data
- Methods



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A language for the science of exposure development

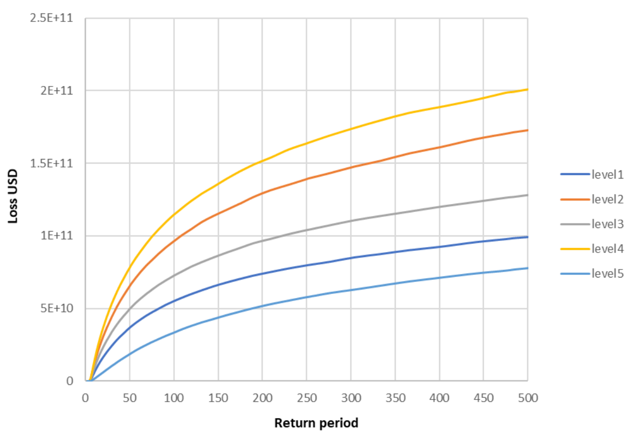
- Illuminate the process- Develop robust methods of representing exposure assumptions with respect to vintage, progeny, resolution, and limitations- particularly when fusing multiple datasets collected over a considerable period of time.
- Acknowledge the uncertainty- Establish methods of characterizing the uncertainty of exposure datasets through the incorporation of modeling techniques. It is particularly important that end users unde
uncertainties in key factors such as locati
taxonomy, and replacement cost before c

Validation

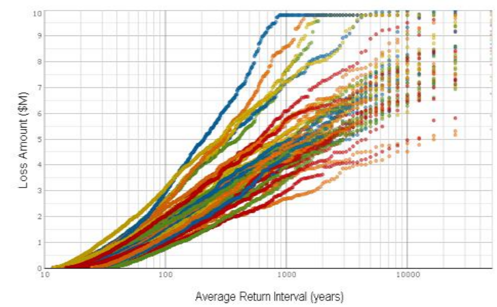
		Very High Urban			High Urban			Urban			HD Residential			Residential			Rural		
		PAGER	EO GED	Observed	PAGER	EO GED	Observed	PAGER	EO GED	Observed	PAGER	EO GED	Observed	PAGER	EO GED	Observed	PAGER	EO GED	Observed
Colombia	Wood	0.1	0	0	0.1	0	0	0.06	0	0	0.06	0	0	0.29	0	0	0.25	0	0
	Steel	0	0	0.08	0	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0	0
	RC Low	0.5	0.1	0.05	0.5	0.1	0.04	0.46	0.05	0.01	0.46	0.1	0.02	0.04	0.1	0.01	0.1	0	0
	RC Mid	0	0.25	0.1	0	0.05	0.03	0.05	0.1	0.03	0.05	0.05	0.04	0	0	0.02	0.05	0	0
	RC High	0	0.2	0.26	0	0.05	0.03	0	0.05	0.03	0	0	0.02	0	0	0.02	0	0	0
	Masonry	0.35	0.45	0.51	0.35	0.8	0.9	0.4	0.8	0.92	0.4	0.85	0.94	0.32	0.85	0.95	0.2	0.85	0.99
	Adobe	0.05	0	0	0.05	0	0	0.02	0	0	0.02	0	0	0.35	0.05	0	0.4	0.15	0
	RMSE	0.57	0.2		0.73	0.12		0.69	0.15		0.7	0.12		0.78	0.15		0.93	0.21	
	X^2	98.8	17.3		84.4	4.16		76.1	7.77		73.2	7.88		101	16.9		132	16.1	

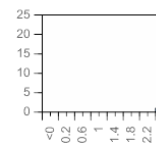
Confusion matrix results from the moderate and high resolution land use modeling.

	MMH Observatioins							
LS8_Spuervised	Agriculture Buildings	High Rise Residential	Industrial	Mid Rise Residential	Open Spaces	Single Family Residential	Urban	Water
Agricultural Buildings	6		1					
High Rise Residential	1	23		11	2	2	25	
Industrial			27					
Mid Rise Residential		3	1	18		3	16	
Open Spaces	2			1	12			1
Single Family Residential	2		14	1		17	2	
Urban		1					6	
Water								2



High Density Residential





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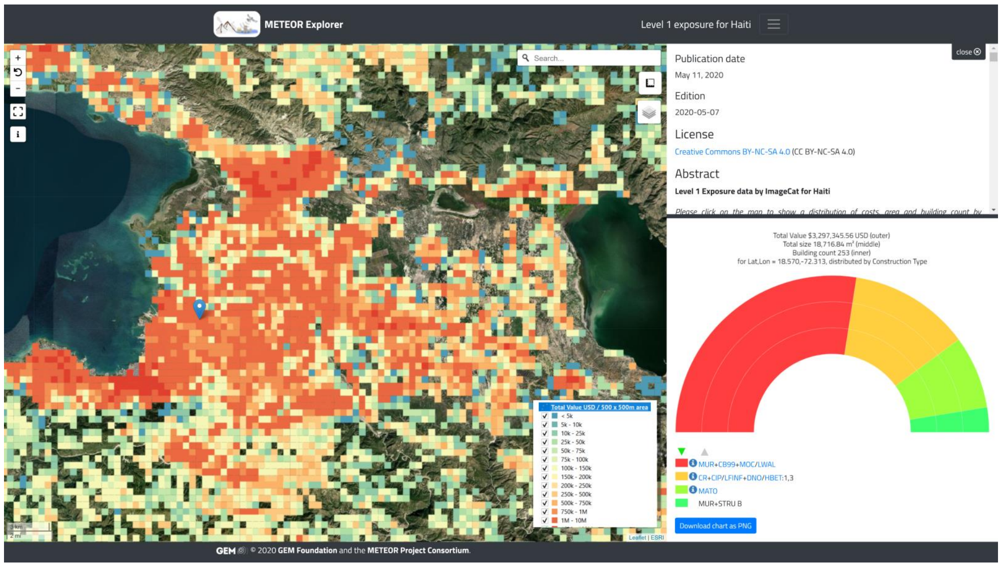
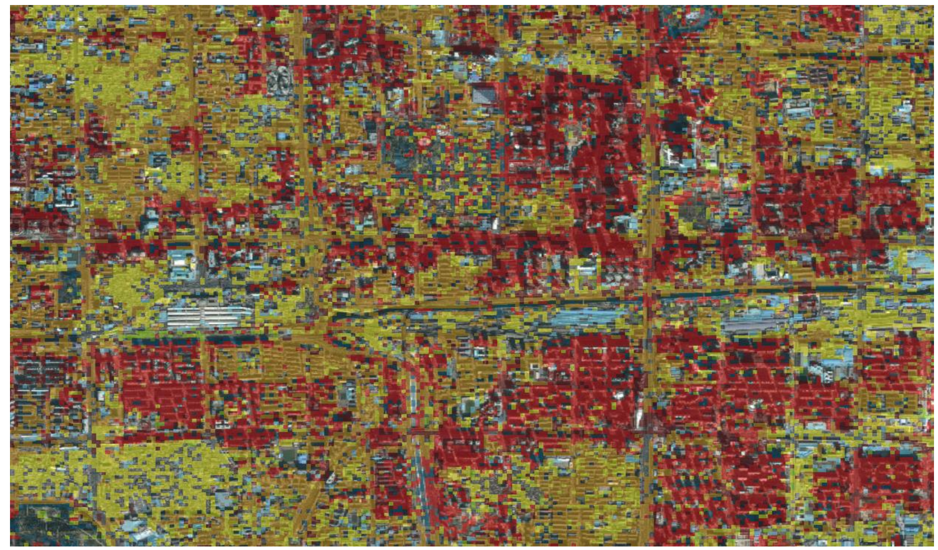
LOOK at the data and UNDERSTAND where it came from





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Earthquake Safe Communities in Nepal

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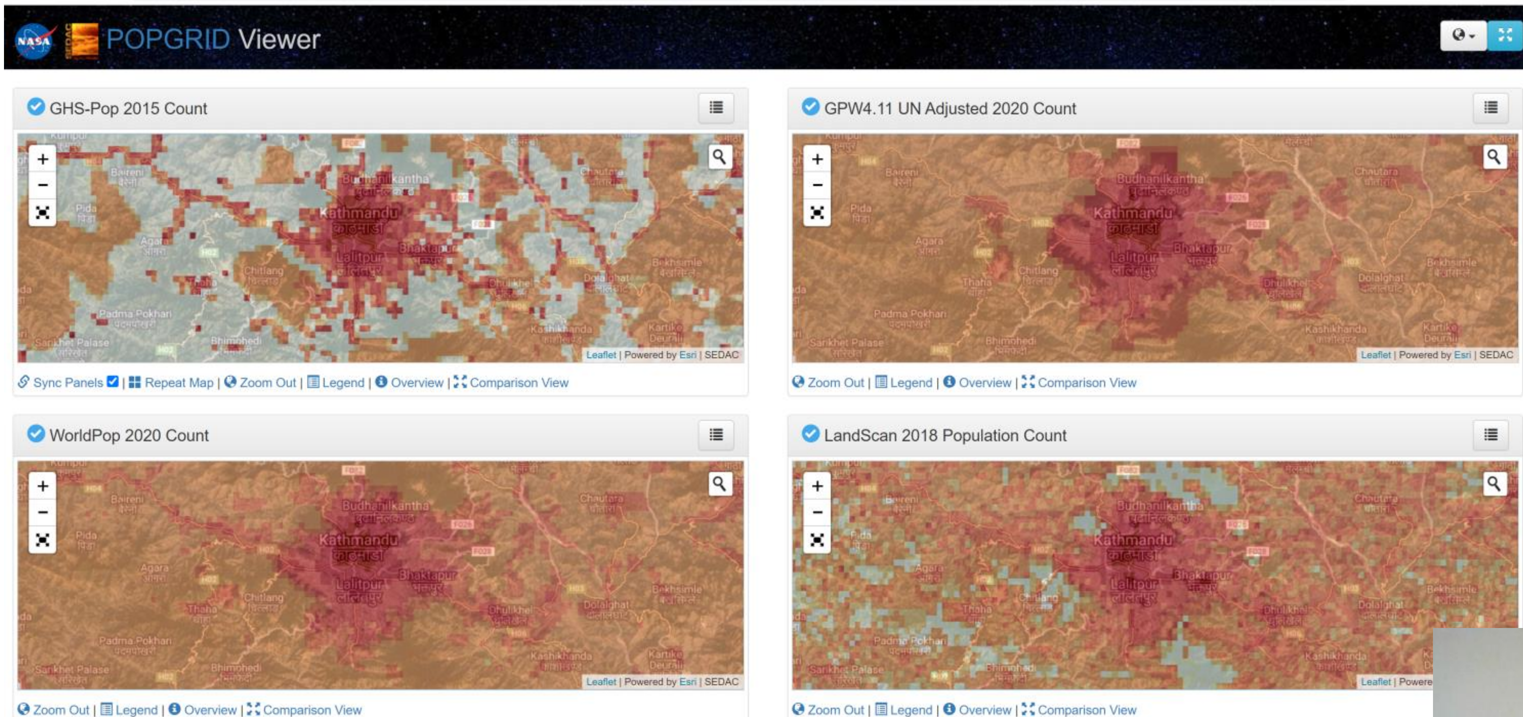
Understand the limitations



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How much does it cost to build this hut?

Does it matter?

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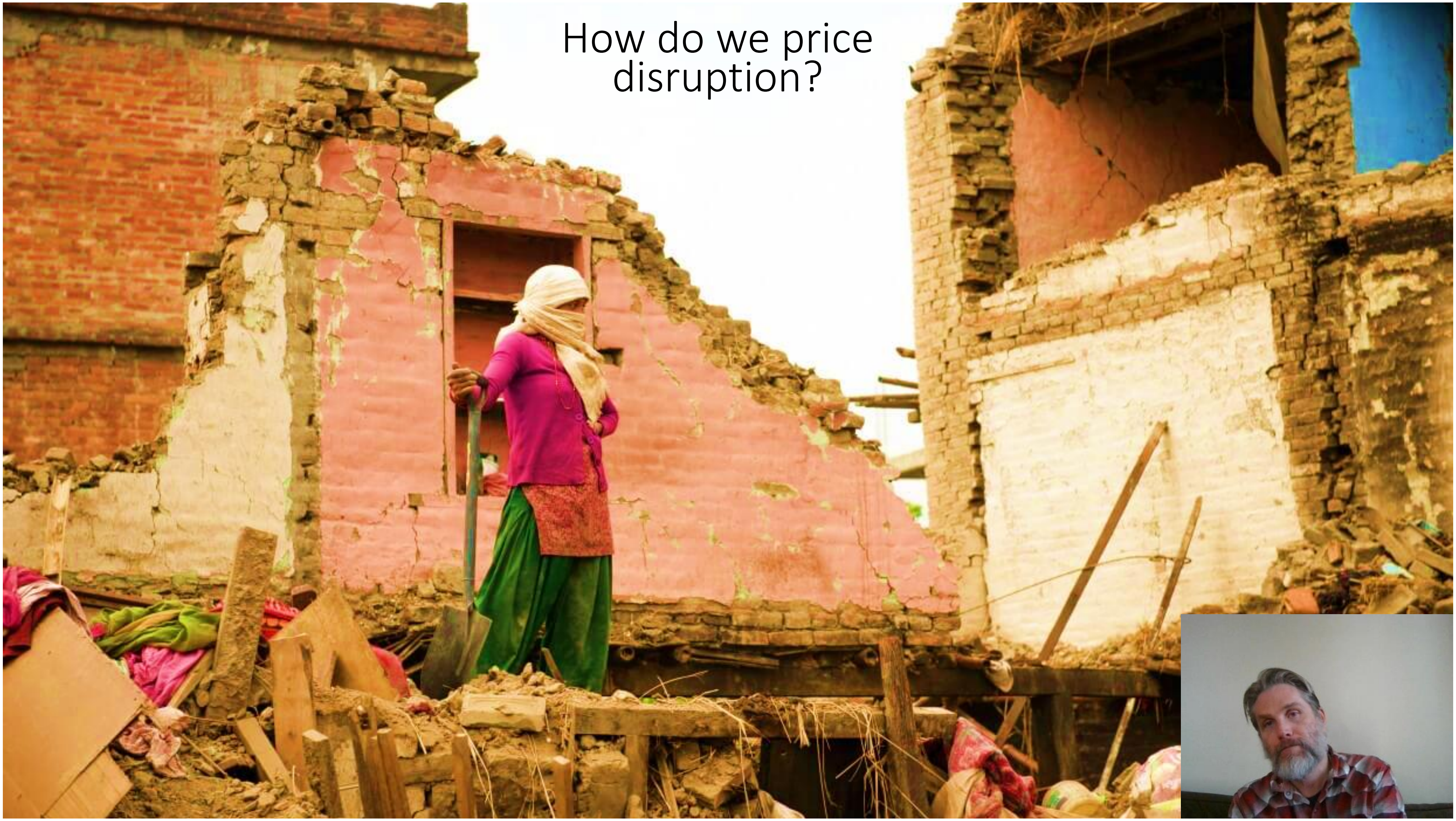
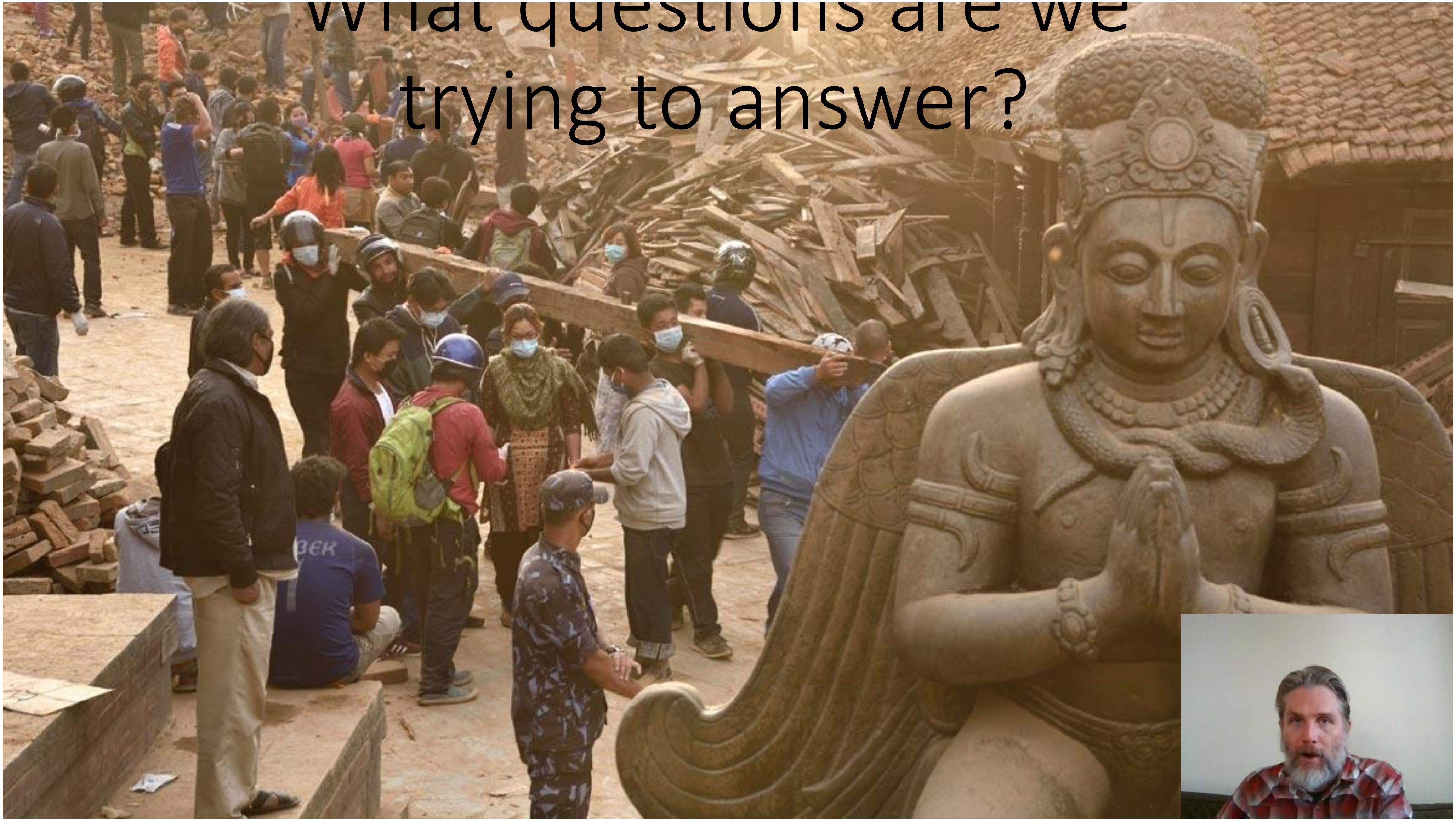
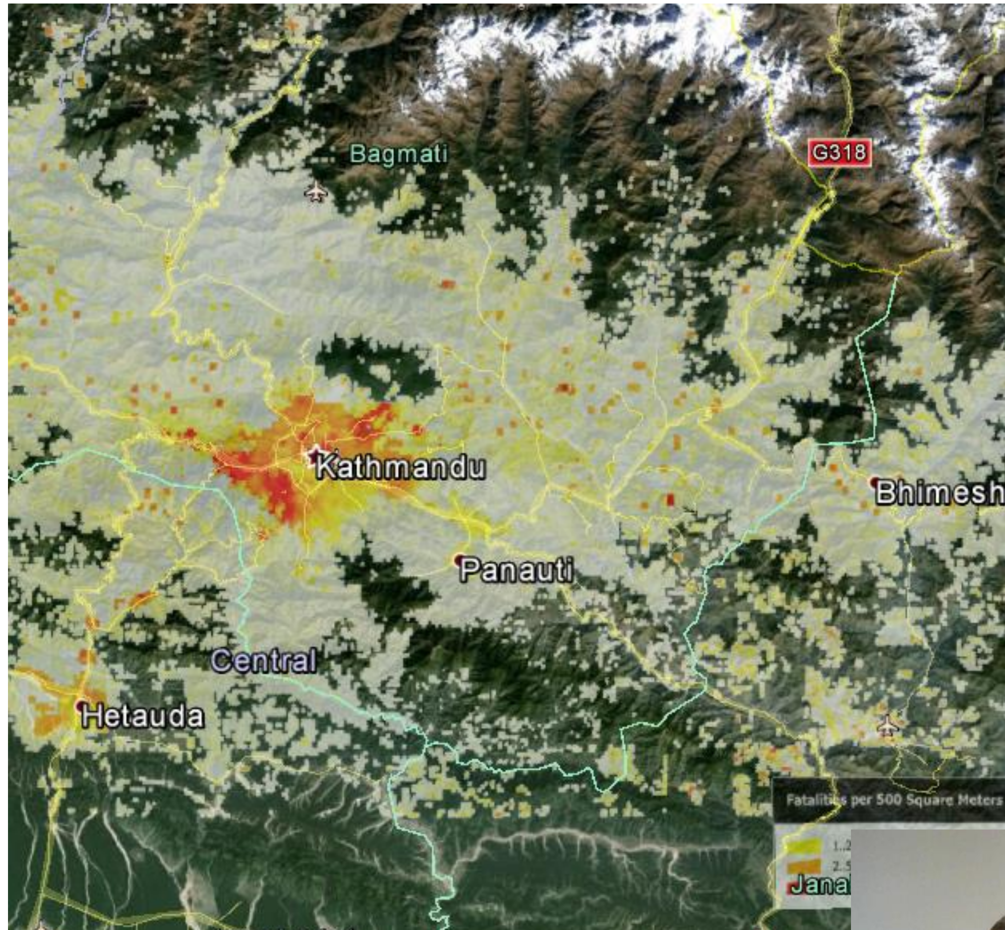
How do we price disruption?

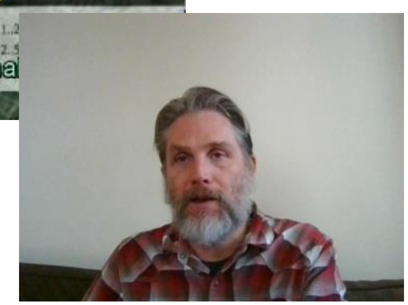


What questions are we trying to answer?



- Fatalities estimated throughout the area
- Total number of fatalities estimated by this method ranges from: 9,000 to 22,000, with a mean estimate of 16,000.
- Fatalities build on estimates of destroyed buildings- with “collapse” and the percentage of fatalities derived at a 15 arc second grid level
- Results build on ImageCat exposure and damage inferred from remote sensing





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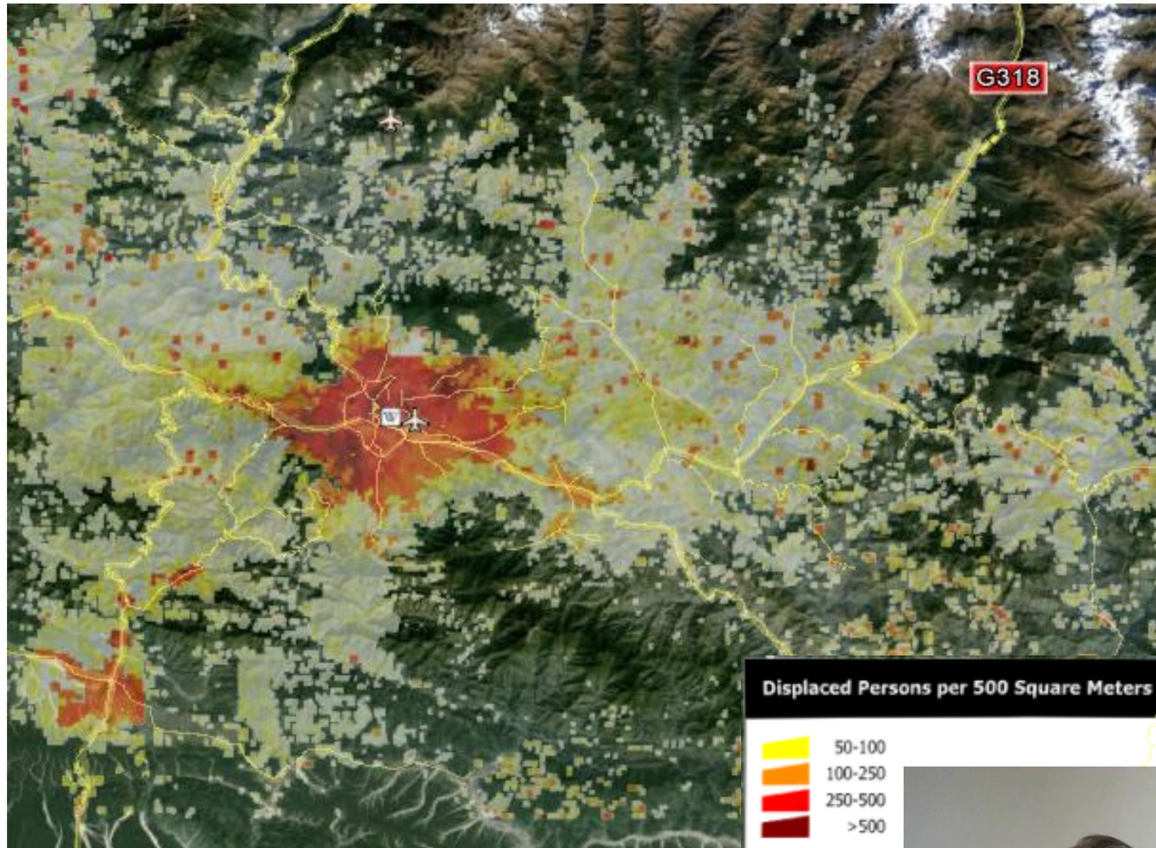
- Displaced persons estimated throughout the area
- Total number of extensively damaged or destroyed buildings estimated by this method ranges from: 225,000 to 450,000
- Displaced persons are derived from the estimated population associated with extensively damaged or destroyed buildings. Fatalities are accounted for
- Additional products produced for UNICEF, including proximity to shelters, and apportionment to estimates of children and the elderly
- Results build on ImageCat exposure and damage inferred from remote sensing



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Is it cost effective to retrofit certain types of buildings regionally?

Where should we focus retrofitting efforts?

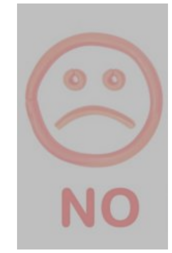
Are building codes cost effective, and where?

What might happen after…

- A hundred-year flood
- A large earthquake
- A volcano

There has just been a large earthquake…

- What are the likely impacts?
- Where is likely to have been effected the most?
- How should we deploy resources?



- Is it cost effective to retrofit *<u>this</u>* building?
- Which buildings fell down? Which homes are flooded?
- Exactly how many buildings fell down?

Thank You.

Email: ckh@imagecatinc.com

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