Co-funded by
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GFZ
Helmholtz Centre
for Geosciences

Every Building on Earth

The
Global Dynamic Exposure
Model/Platform

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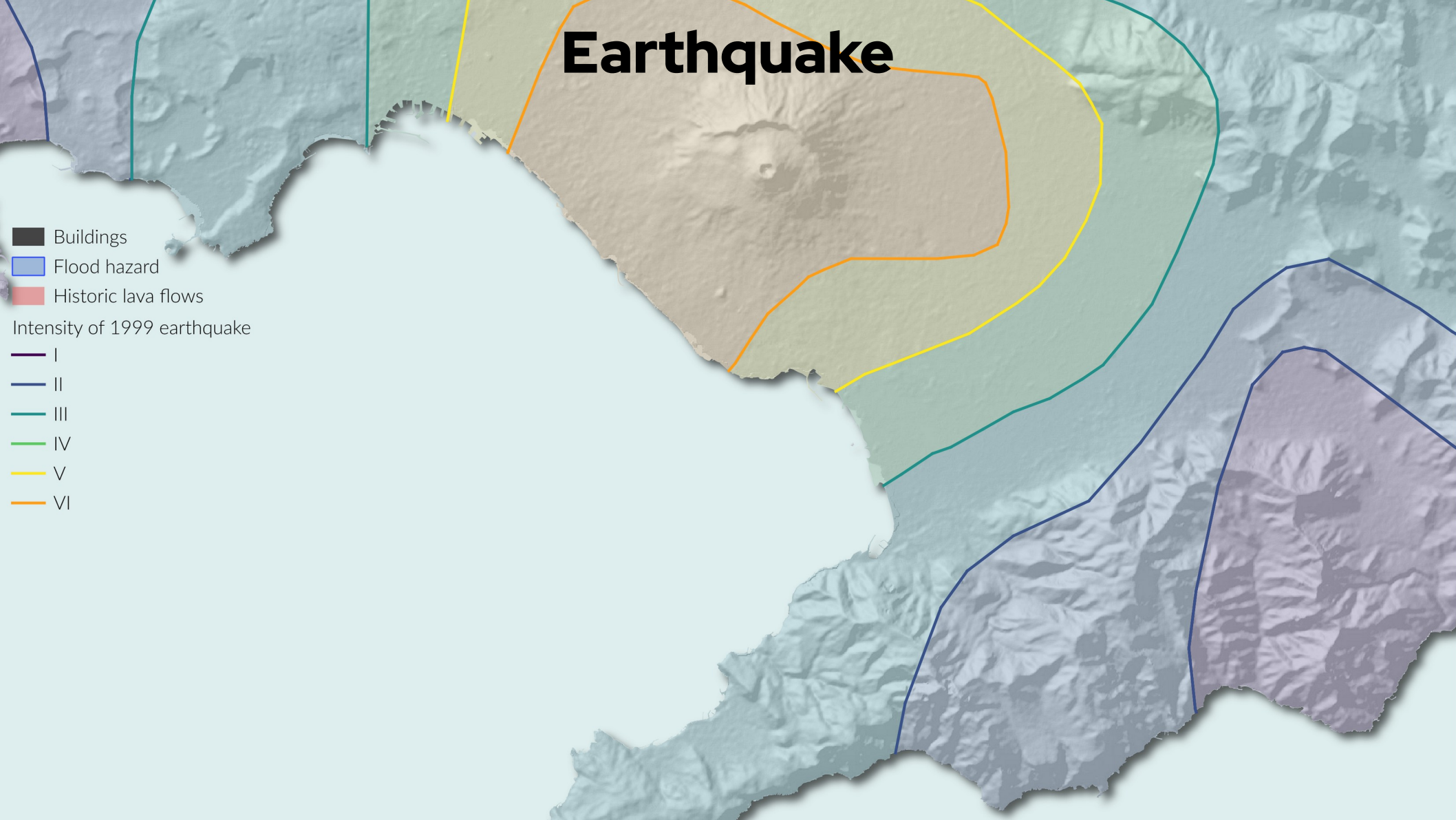
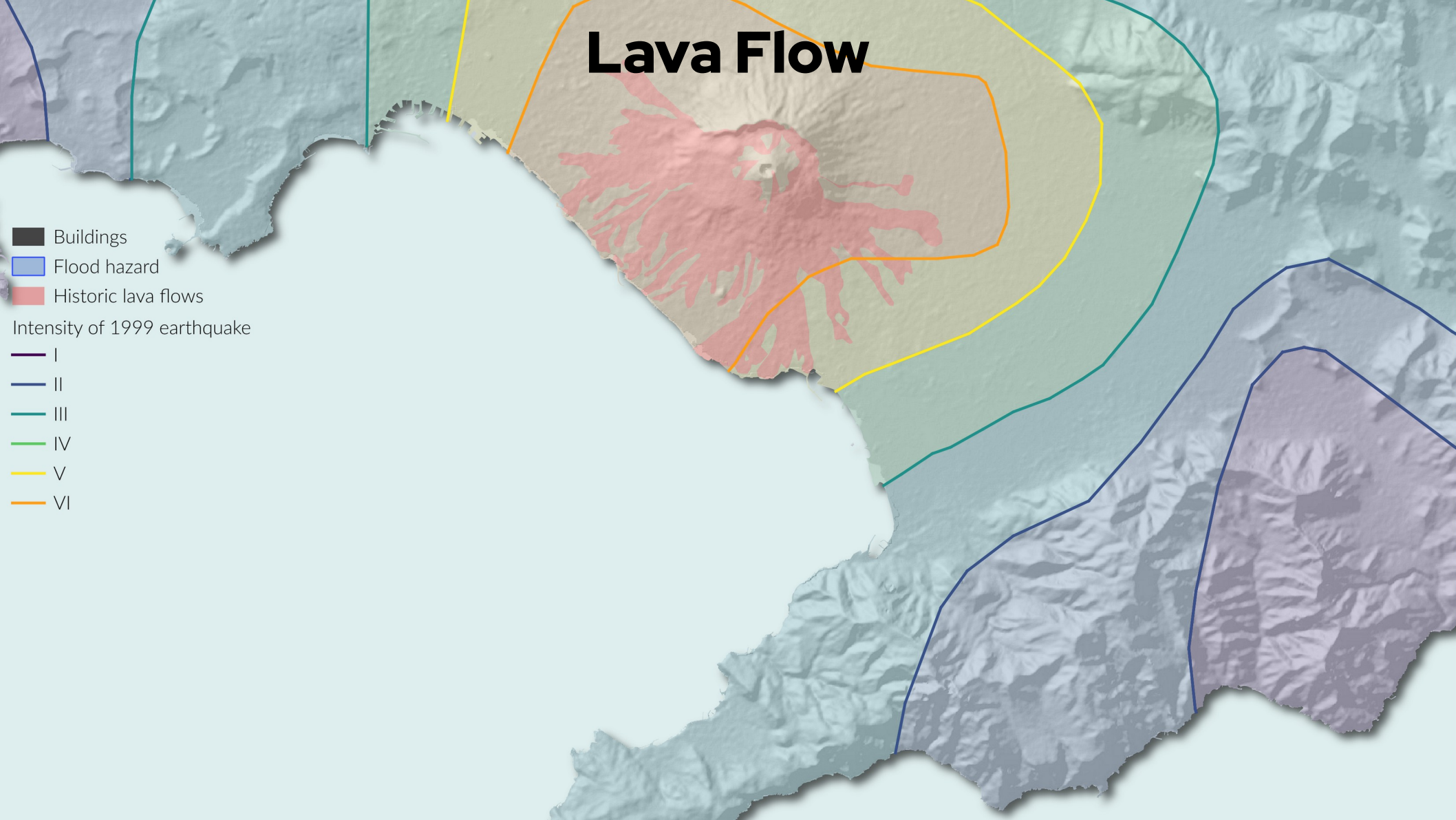
GFZ Potsdam

Vesuvius Area

Earthquake


Buildings
Flood hazard
Historic lava flows
Intensity of 1999 earthquake
I
II
III
IV
V
VI


Lava Flow
Buildings
Flood hazard
Historic lava flows
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I
II
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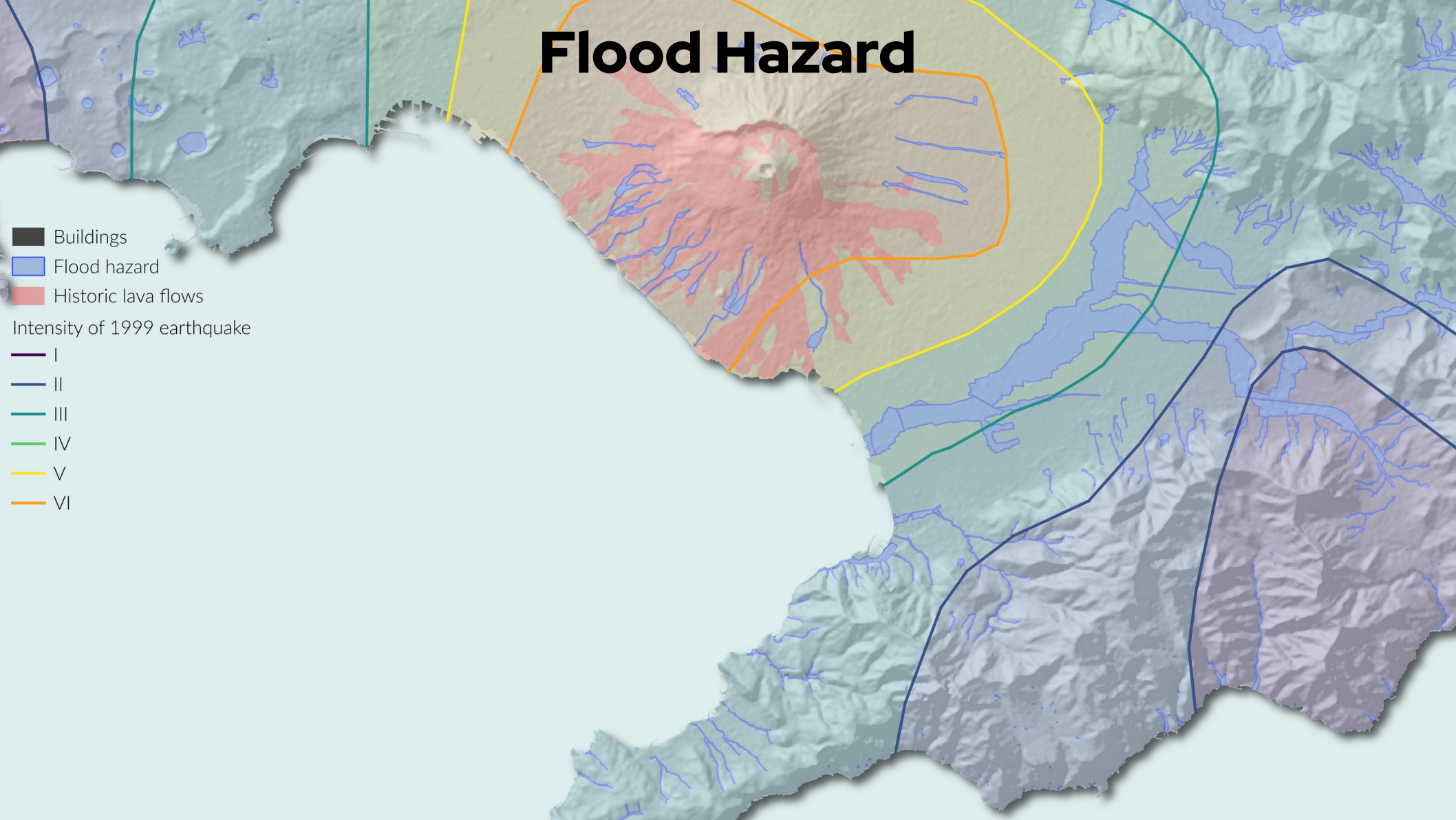
V
VI

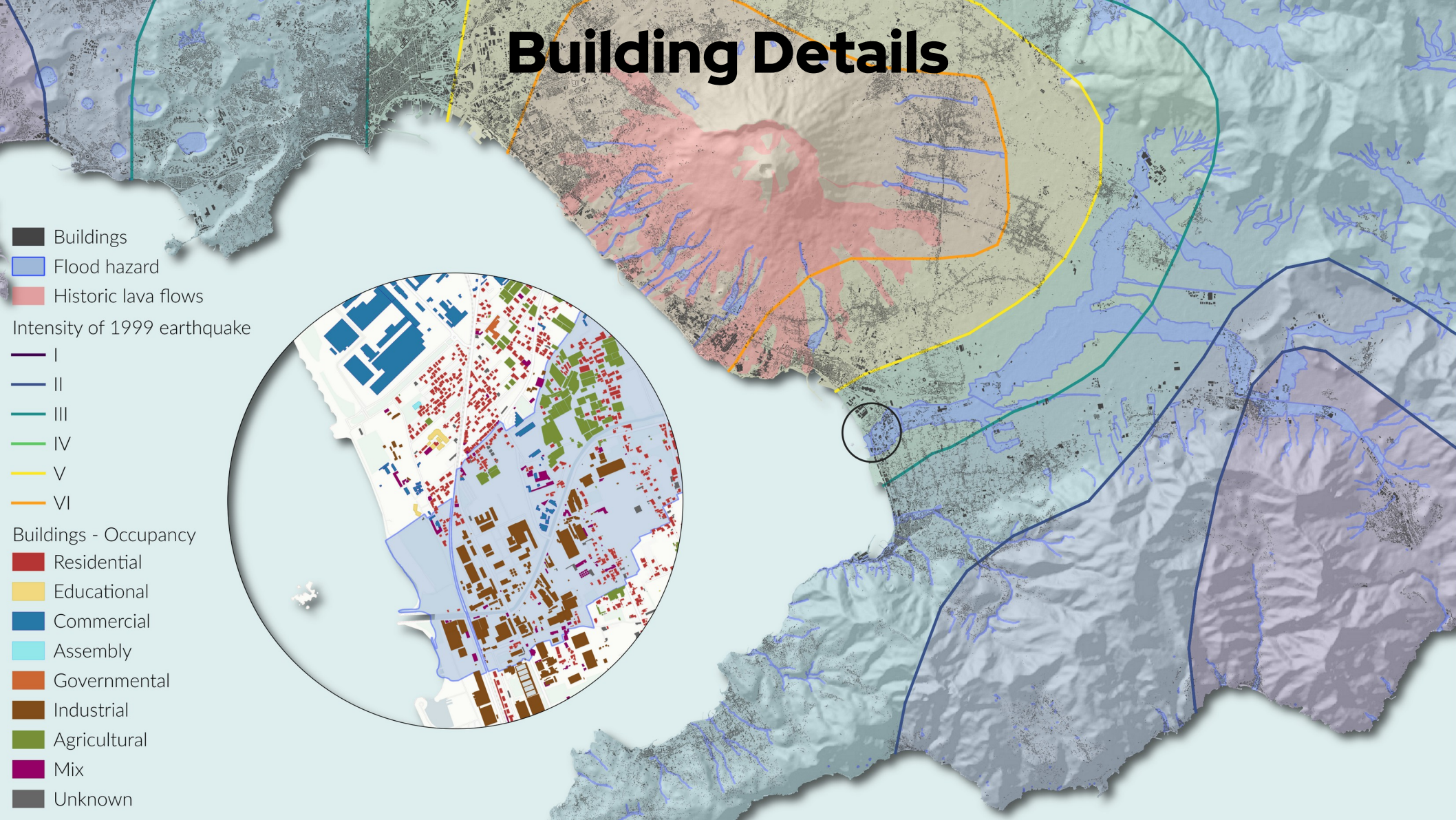
Flood Hazard



Buildings


Buildings
Flood hazard
Historic lava flows
Intensity of 1999 earthquake
I
II
III
IV
V
VI

Building Details



Knowing Every Building

Imagine we know every building worldwide

→ Exact location & size

→ Number of people inside

→ Type and vulnerability

→ Value

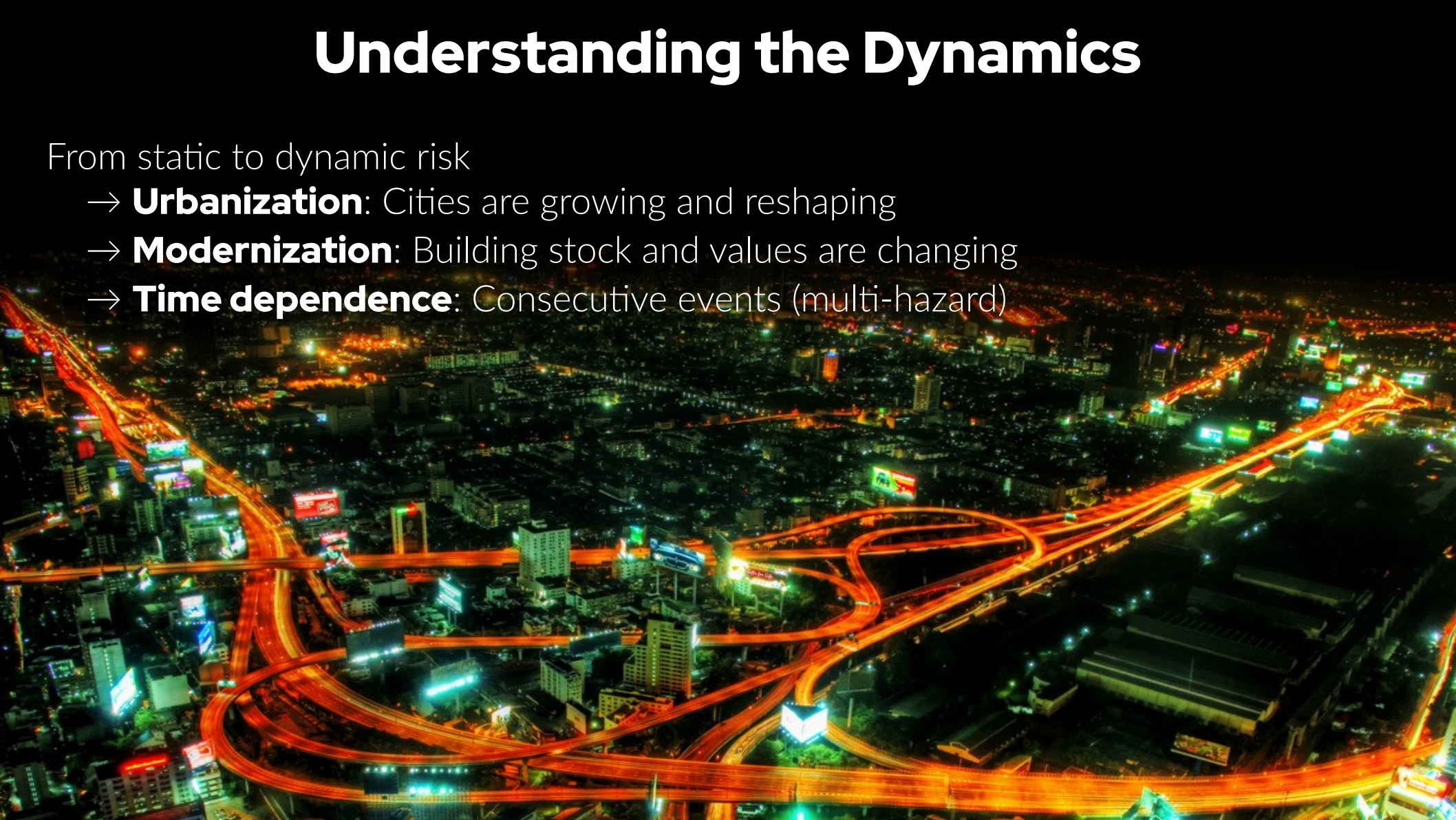
Understanding the Dynamics

From static to dynamic risk

→ **Urbanization**: Cities are growing and reshaping

→ **Modernization**: Building stock and values are changing

→ **Time dependence**: Consecutive events (multi-hazard)



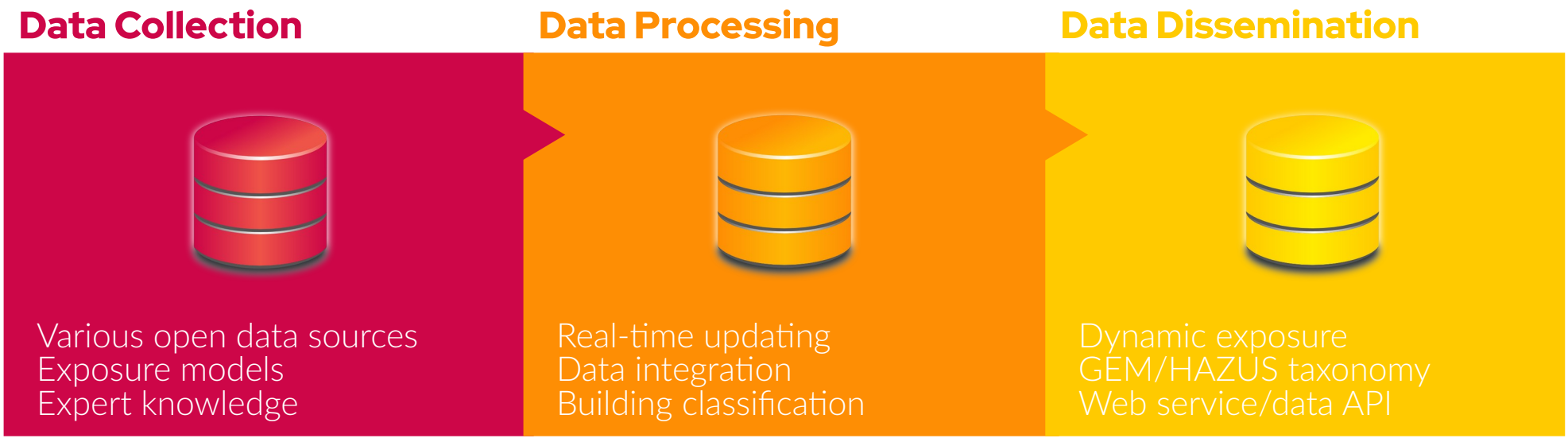
The Challenge

- **High-Resolution** exposure data globally
  → On the building-by-building level

- **Dynamic** exposure model for monitoring risk
  → Capturing urbanization

The Strategy

- **Crowd-sourced approach for data collection**
  → Developing a platform around the OpenStreetMap ecosystem
- **Integrating Standards**
  → Classical exposure models with standard taxonomies
- **Providing Dynamic Exposure**
  → Rule-based processing of each building separately



Rabotnik – Assembly Line

- Key component of the processing platform
- Rule-based processing of every updated building and tile
- Leads to probabilistic selection of structural information

Data Available

Data Available

Deterministic Estimates:

- Footprint size & location

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value

Data Available

Deterministic Estimates:

- Footprint size & location
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Probabilistic Estimates:

- Structural type
- Structural value
- Population

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value
- Population

- Building context

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value
- Population

- Building context
- Footprint shape

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value
- Population

- Building context
- Footprint shape
- Construction year

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value
- Population

- Building context
- Footprint shape
- Construction year
- Roof shape

Processing

→ Updating from OpenStreetMap every 60 seconds
→ Processing all changes
→ Algorithmically assessing all possible building properties

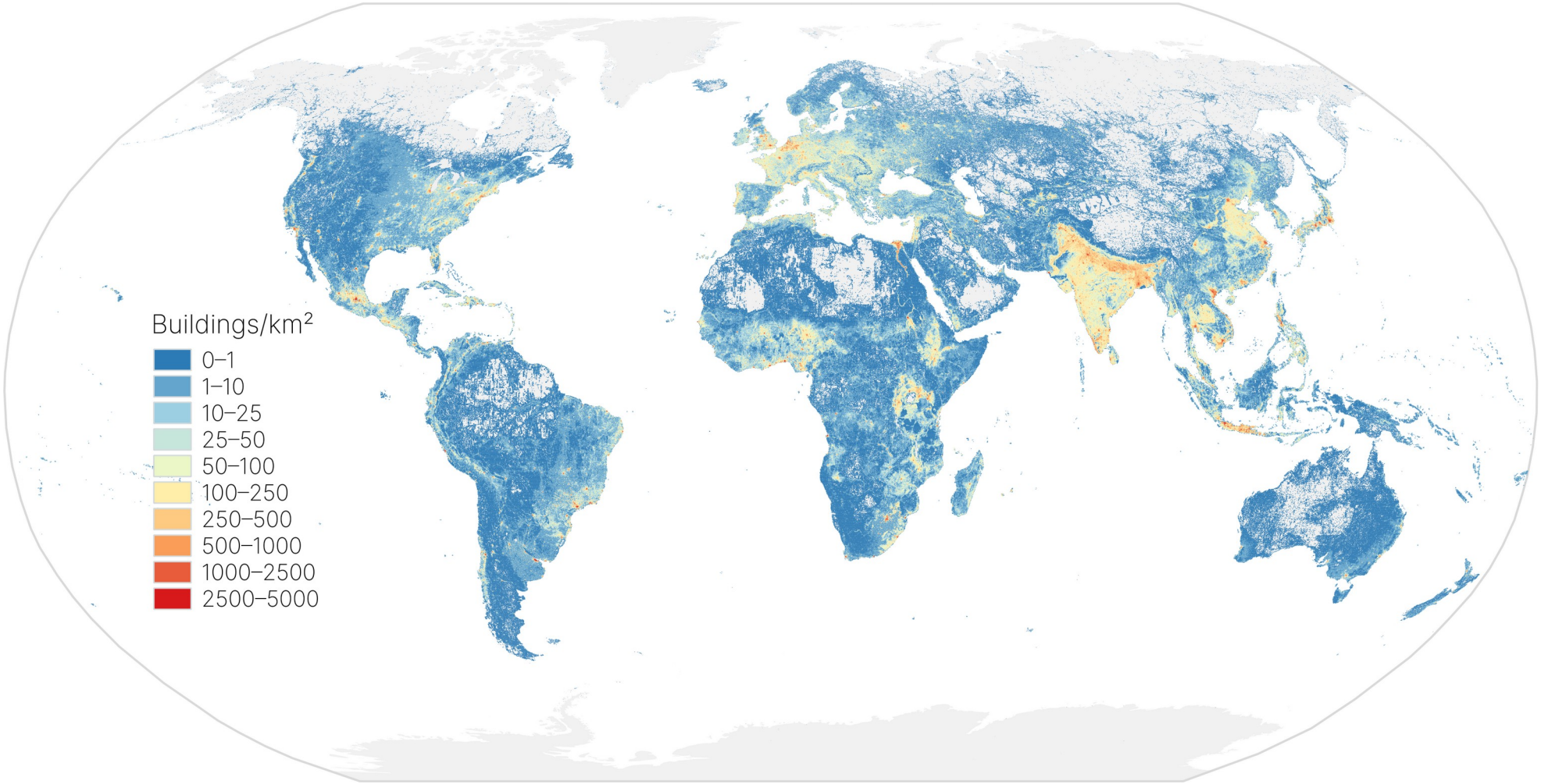
Global Dynamic Exposure

OpenBuildingMap today:

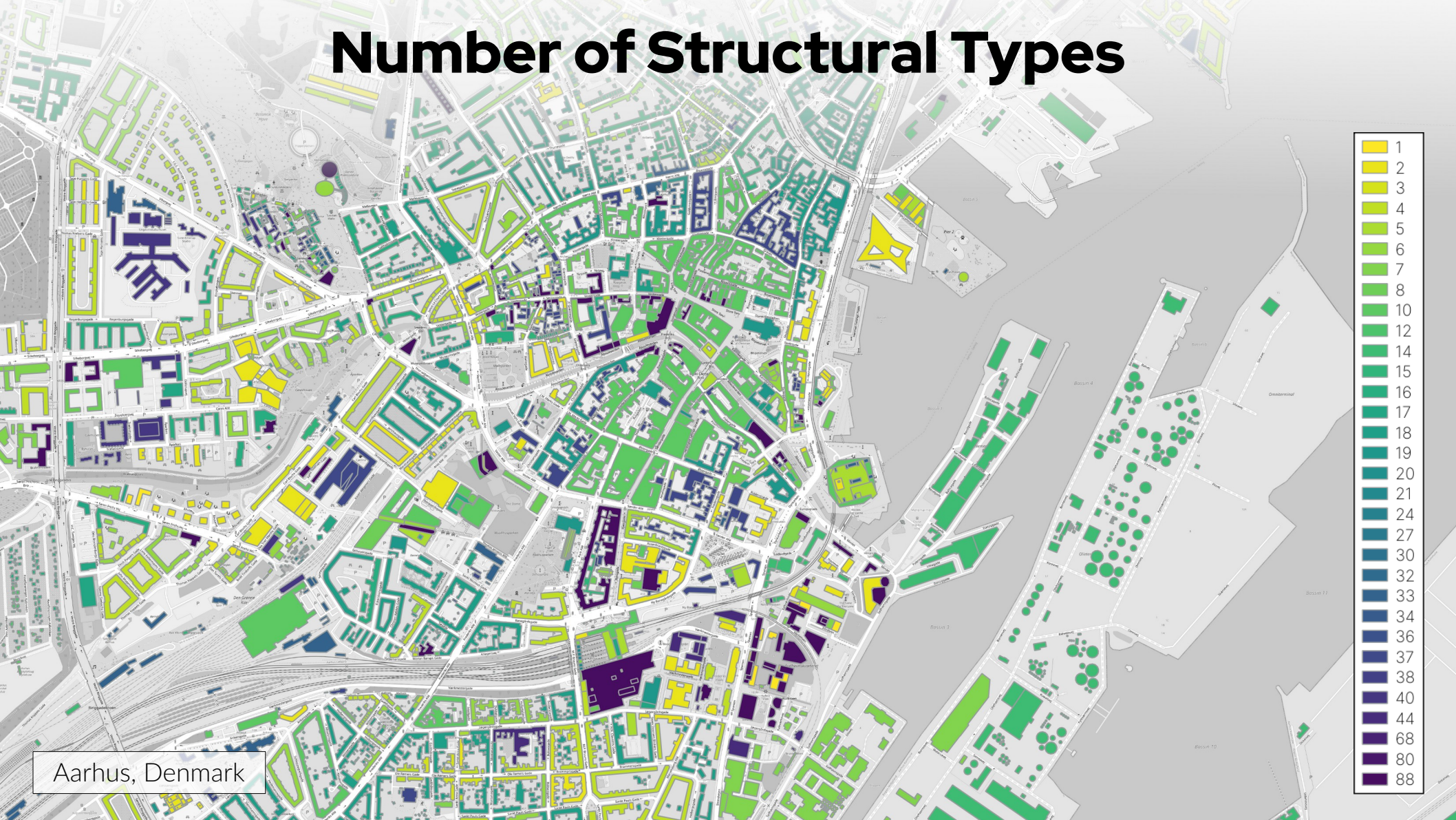
~2.7 billion building datasets

5+ million building footprints added every month (> **2** per second)

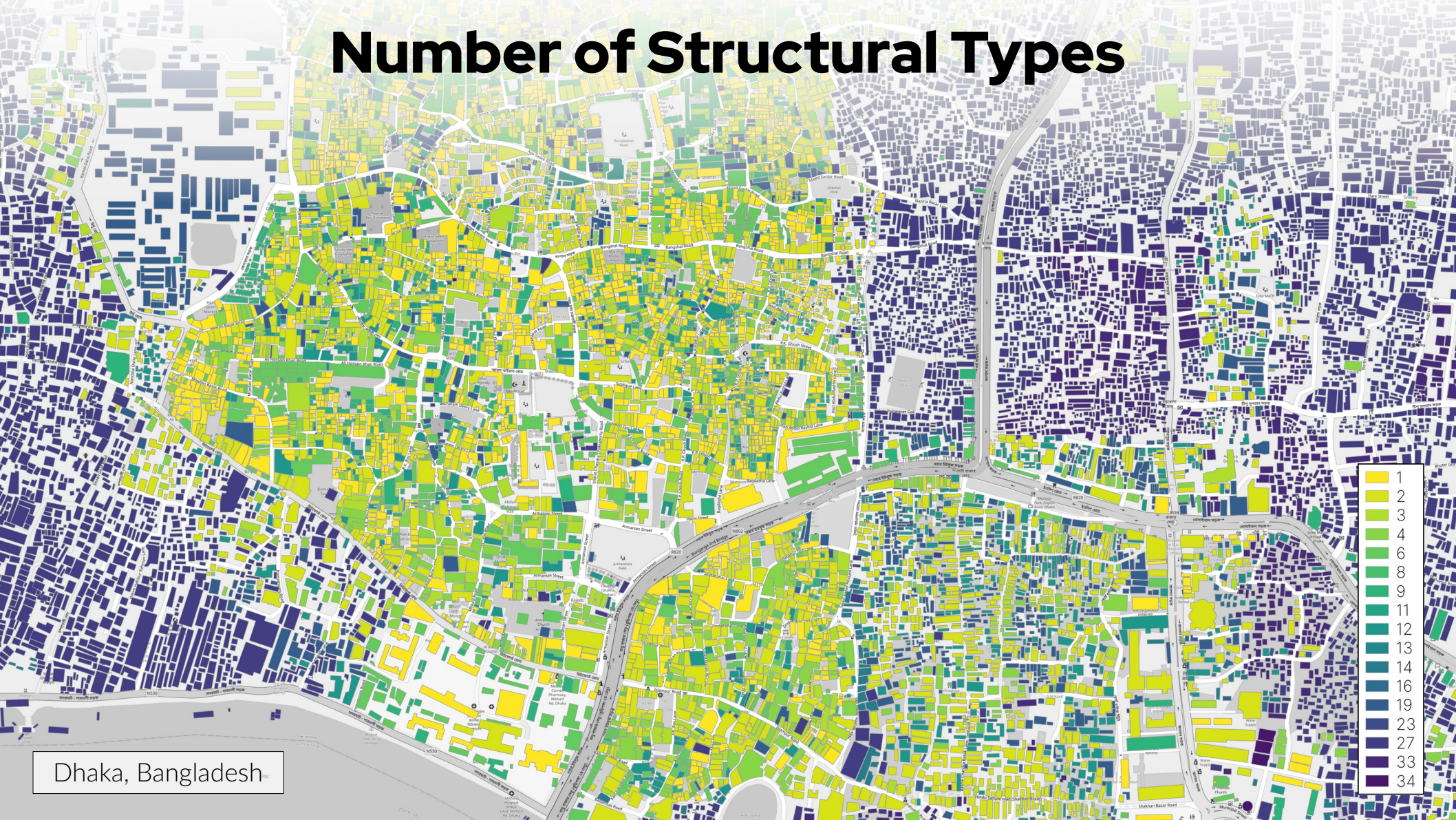
Number of Buildings



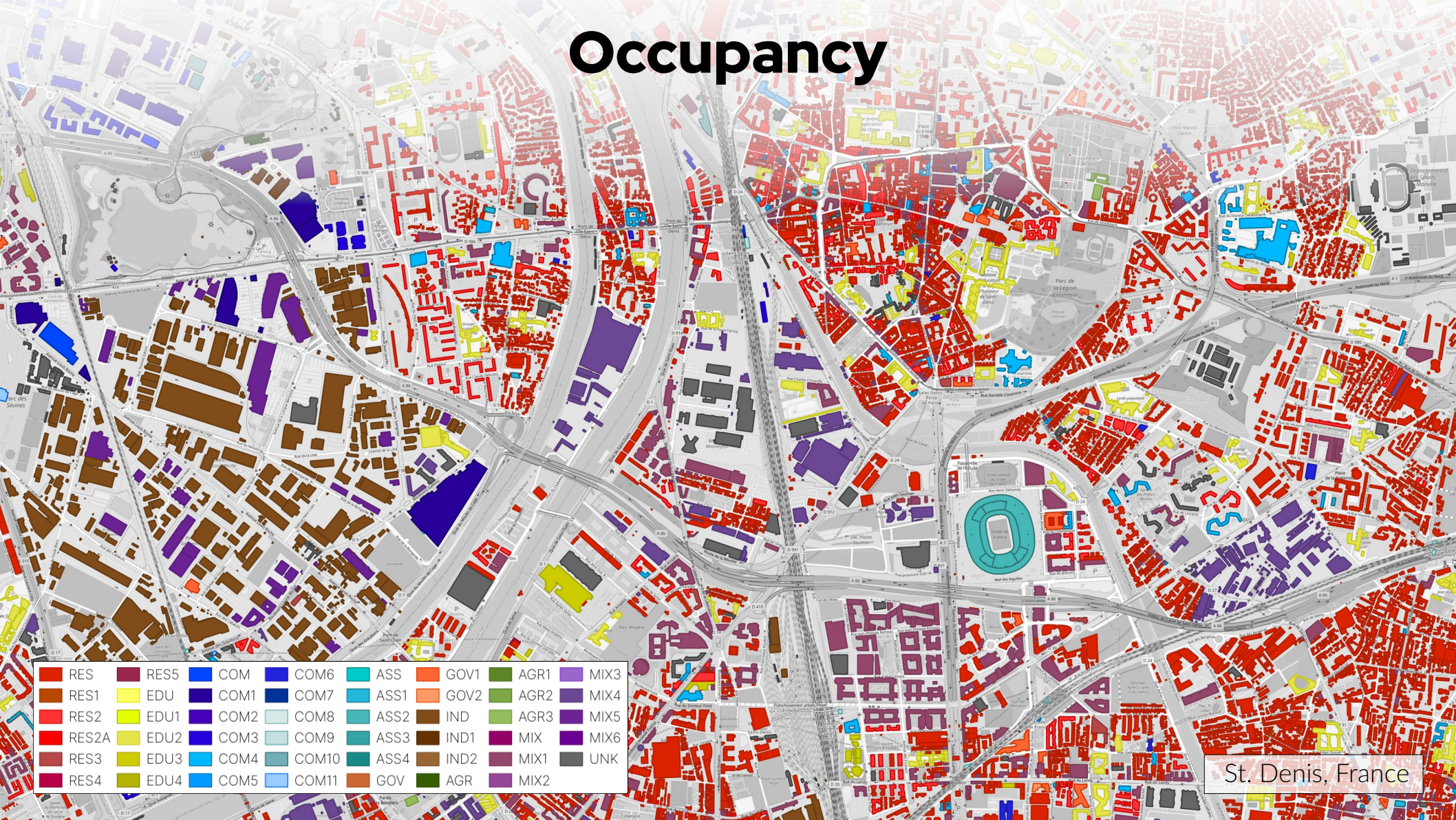
Number of Structural Types



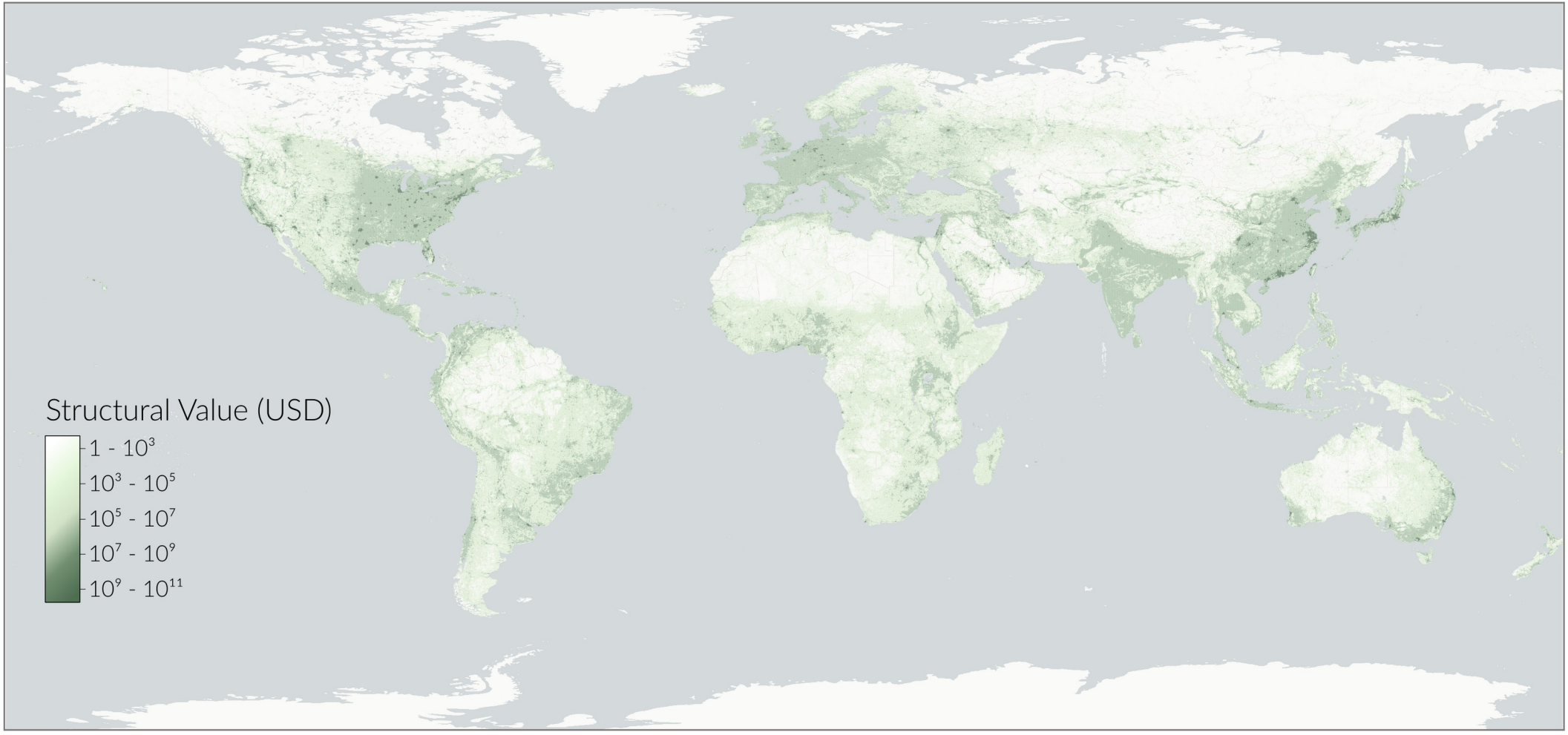
Number of Structural Types



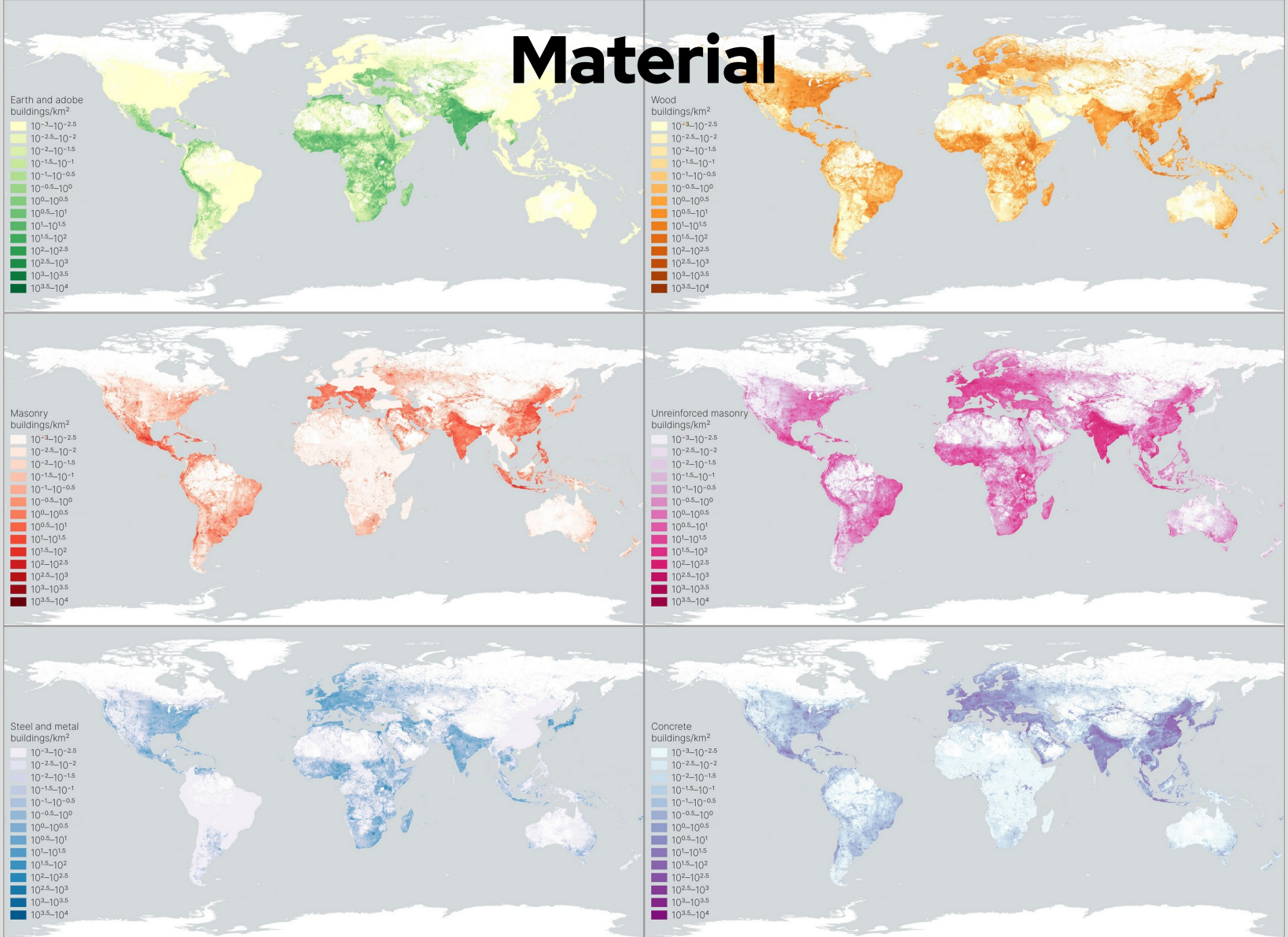
Occupancy


RES
RES1
RES2
RES2A
RES3
RES4
RES5
EDU
EDU1
EDU2
EDU3
EDU4
COM
COM1
COM2
COM3
COM4
COM5
COM6
COM7
COM8
COM9
COM10
COM11
ASS
ASS1
ASS2
ASS3
ASS4
GOV
GOV1
GOV2
IND
IND1
IND2
AGR
AGR1
AGR2
AGR3
MIX
MIX1
MIX2
MIX3
MIX4
MIX5
MIX6
UNK
St. Denis, France

Structural Value



Material


Earth and adobe
buildings/km²
10^{-3}–$10^{-2.5}$
$10^{-2.5}$–10^{-2}
10^{-2}–$10^{-1.5}$
$10^{-1.5}$–10^{-1}
10^{-1}–$10^{-0.5}$
$10^{-0.5}$–10^{0}
10^{0}–$10^{0.5}$
$10^{0.5}$–10^{1}
10^{1}–$10^{1.5}$
$10^{1.5}$–10^{2}
10^{2}–$10^{2.5}$
$10^{2.5}$–10^{3}
10^{3}–$10^{3.5}$
$10^{3.5}$–10^{4}
Wood
buildings/km²
10^{-3}–$10^{-2.5}$
$10^{-2.5}$–10^{-2}
10^{-2}–$10^{-1.5}$
$10^{-1.5}$–10^{-1}
10^{-1}–$10^{-0.5}$
$10^{-0.5}$–10^{0}
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10^{1}–$10^{1.5}$
$10^{1.5}$–10^{2}
10^{2}–$10^{2.5}$
$10^{2.5}$–10^{3}
10^{3}–$10^{3.5}$
$10^{3.5}$–10^{4}
Masonry
buildings/km²
10^{-3}–$10^{-2.5}$
$10^{-2.5}$–10^{-2}
10^{-2}–$10^{-1.5}$
$10^{-1.5}$–10^{-1}
10^{-1}–$10^{-0.5}$
$10^{-0.5}$–10^{0}
10^{0}–$10^{0.5}$
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$10^{1.5}$–10^{2}
10^{2}–$10^{2.5}$
$10^{2.5}$–10^{3}
10^{3}–$10^{3.5}$
$10^{3.5}$–10^{4}
Unreinforced masonry
buildings/km²
10^{-3}–$10^{-2.5}$
$10^{-2.5}$–10^{-2}
10^{-2}–$10^{-1.5}$
$10^{-1.5}$–10^{-1}
10^{-1}–$10^{-0.5}$
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10^{0}–$10^{0.5}$
$10^{0.5}$–10^{1}
10^{1}–$10^{1.5}$
$10^{1.5}$–10^{2}
10^{2}–$10^{2.5}$
$10^{2.5}$–10^{3}
10^{3}–$10^{3.5}$
$10^{3.5}$–10^{4}
Steel and metal
buildings/km²
10^{-3}–$10^{-2.5}$
$10^{-2.5}$–10^{-2}
10^{-2}–$10^{-1.5}$
$10^{-1.5}$–10^{-1}
10^{-1}–$10^{-0.5}$
$10^{-0.5}$–10^{0}
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$10^{0.5}$–10^{1}
10^{1}–$10^{1.5}$
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10^{2}–$10^{2.5}$
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$10^{3.5}$–10^{4}
Concrete
buildings/km²
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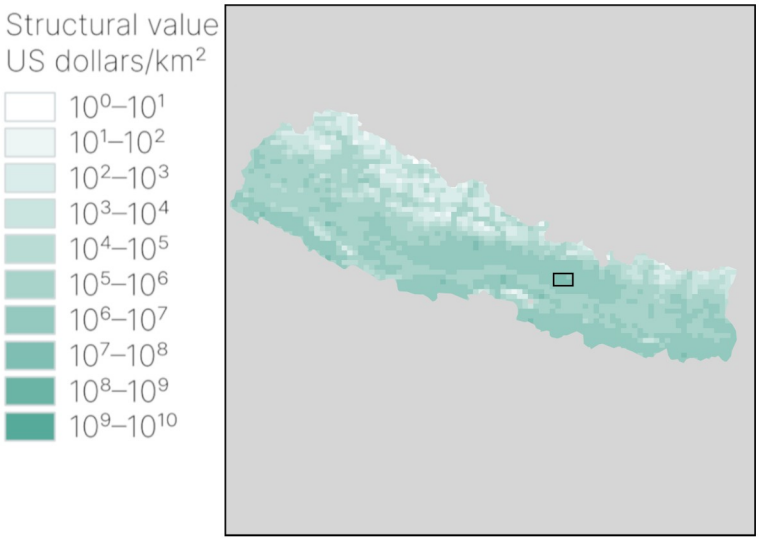
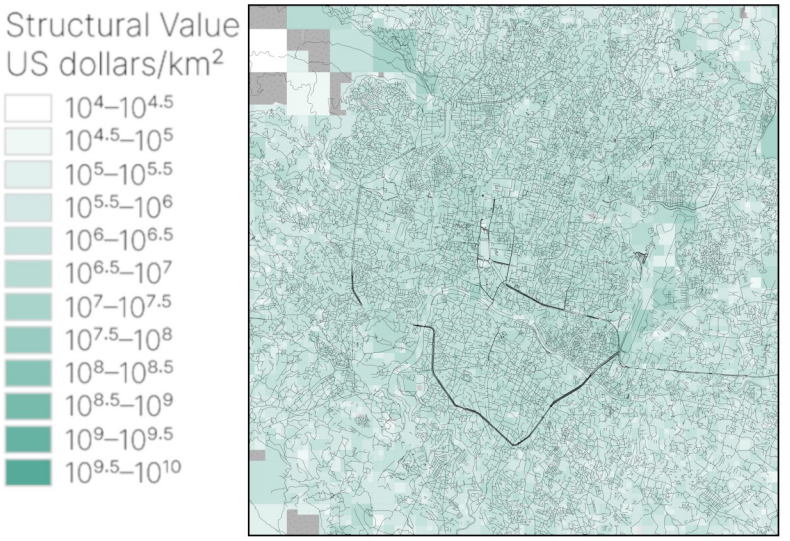
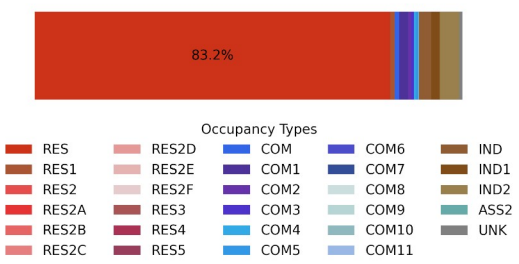
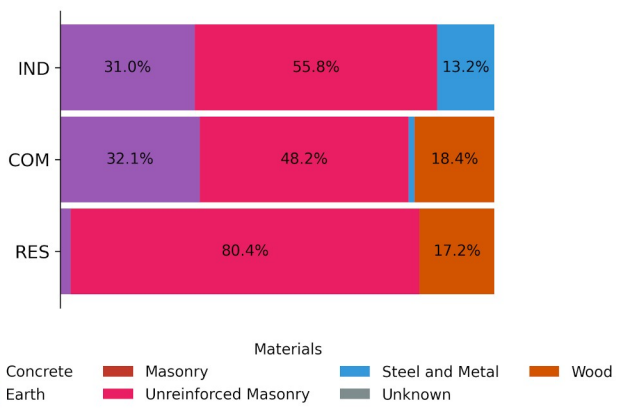
10^{-1}–$10^{-0.5}$
$10^{-0.5}$–10^{0}
10^{0}–$10^{0.5}$
$10^{0.5}$–10^{1}
10^{1}–$10^{1.5}$
$10^{1.5}$–10^{2}
10^{2}–$10^{2.5}$
$10^{2.5}$–10^{3}
10^{3}–$10^{3.5}$
$10^{3.5}$–10^{4}

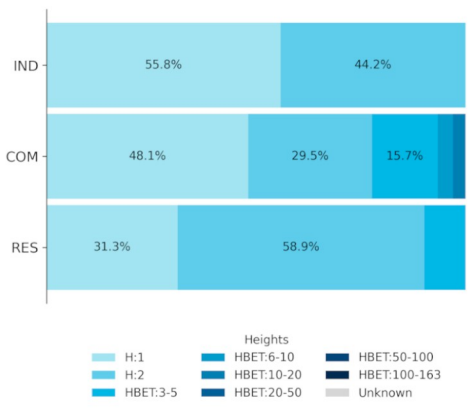
Country Summary – Nepal



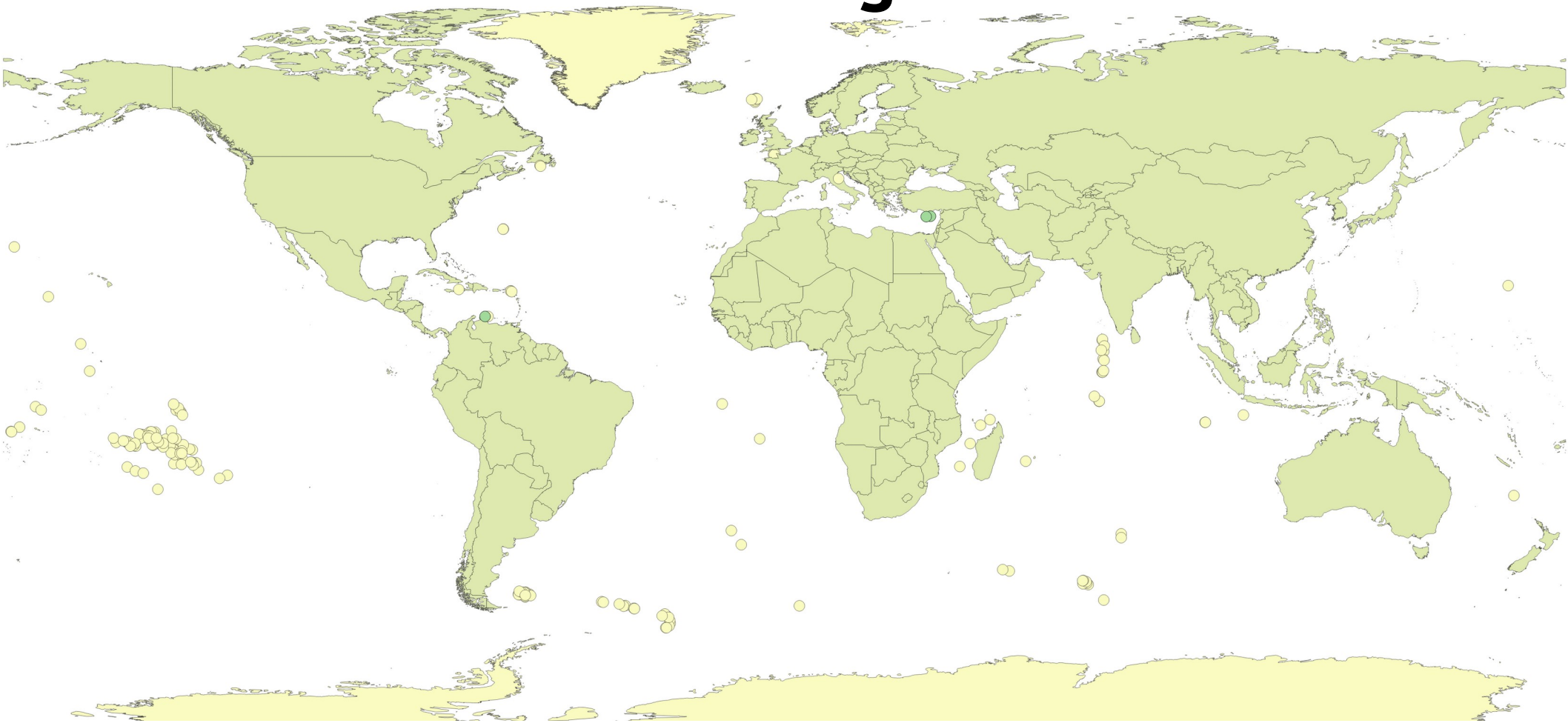








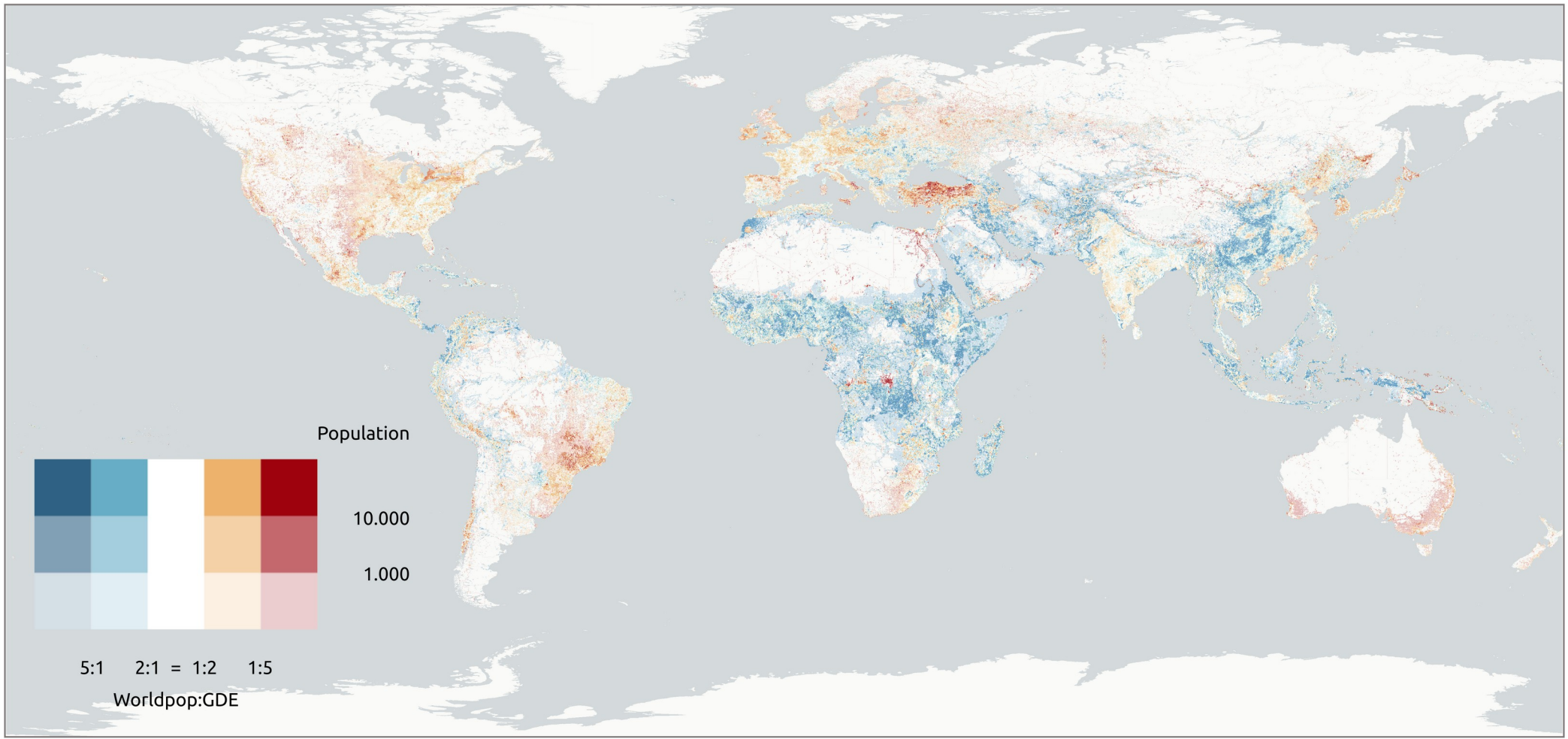
Coverage



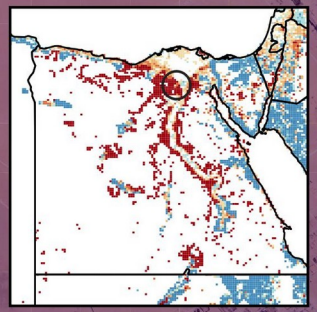
Fully covered with structural information (using structural information from neighboring country)

Covered without structural information (only buildings and population distribution)

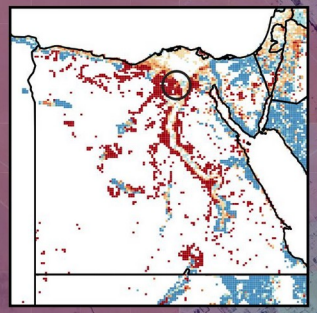
Validation



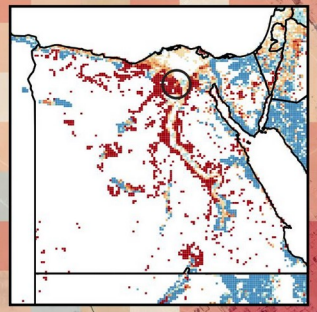
Worldpop



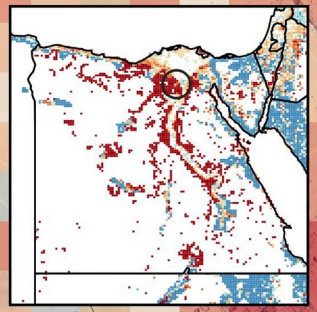
Global Dynamic Exposure



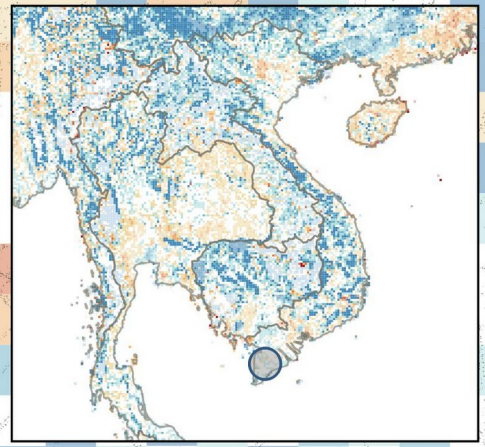
Difference



Buildings

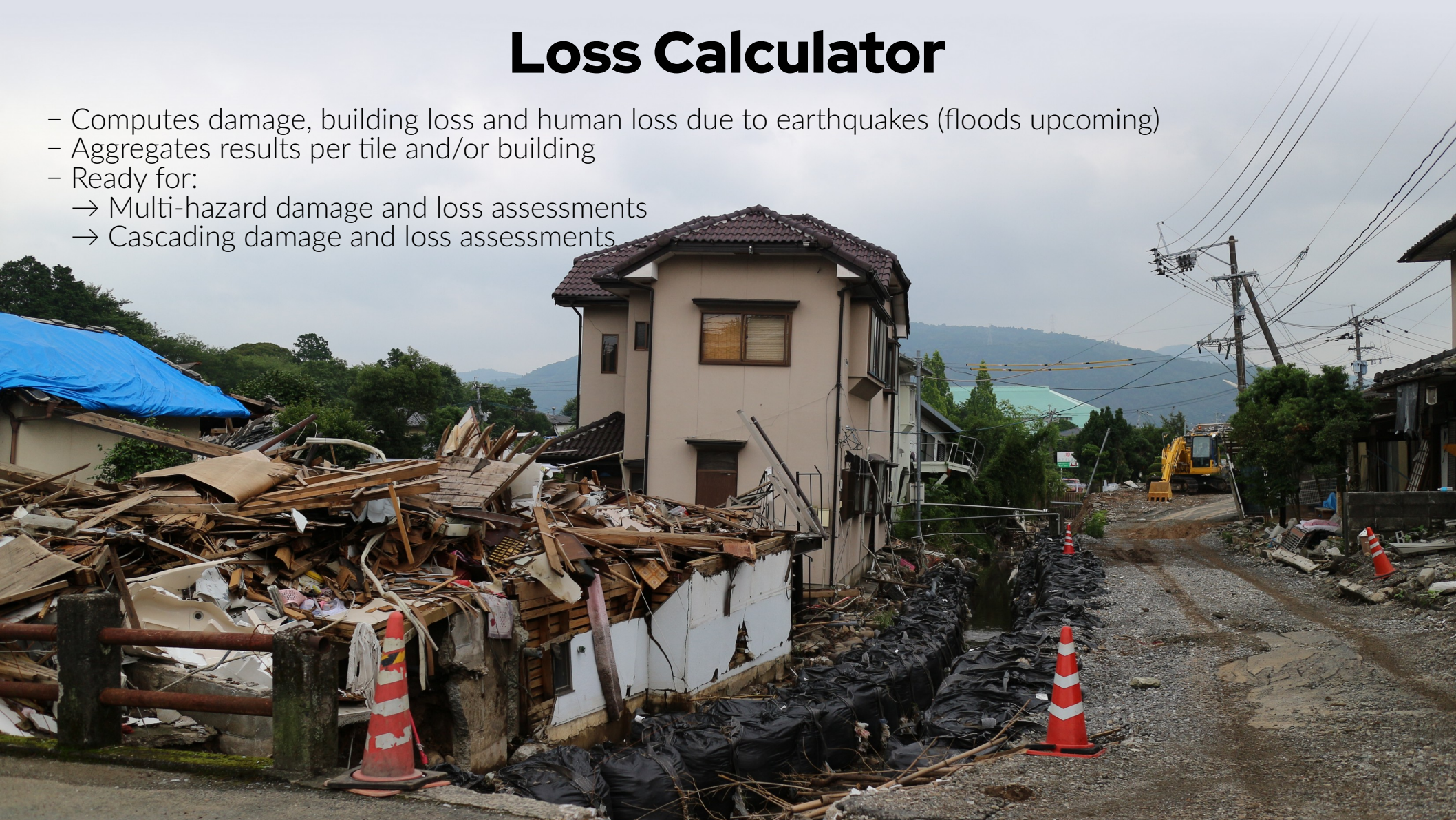


Vietnam

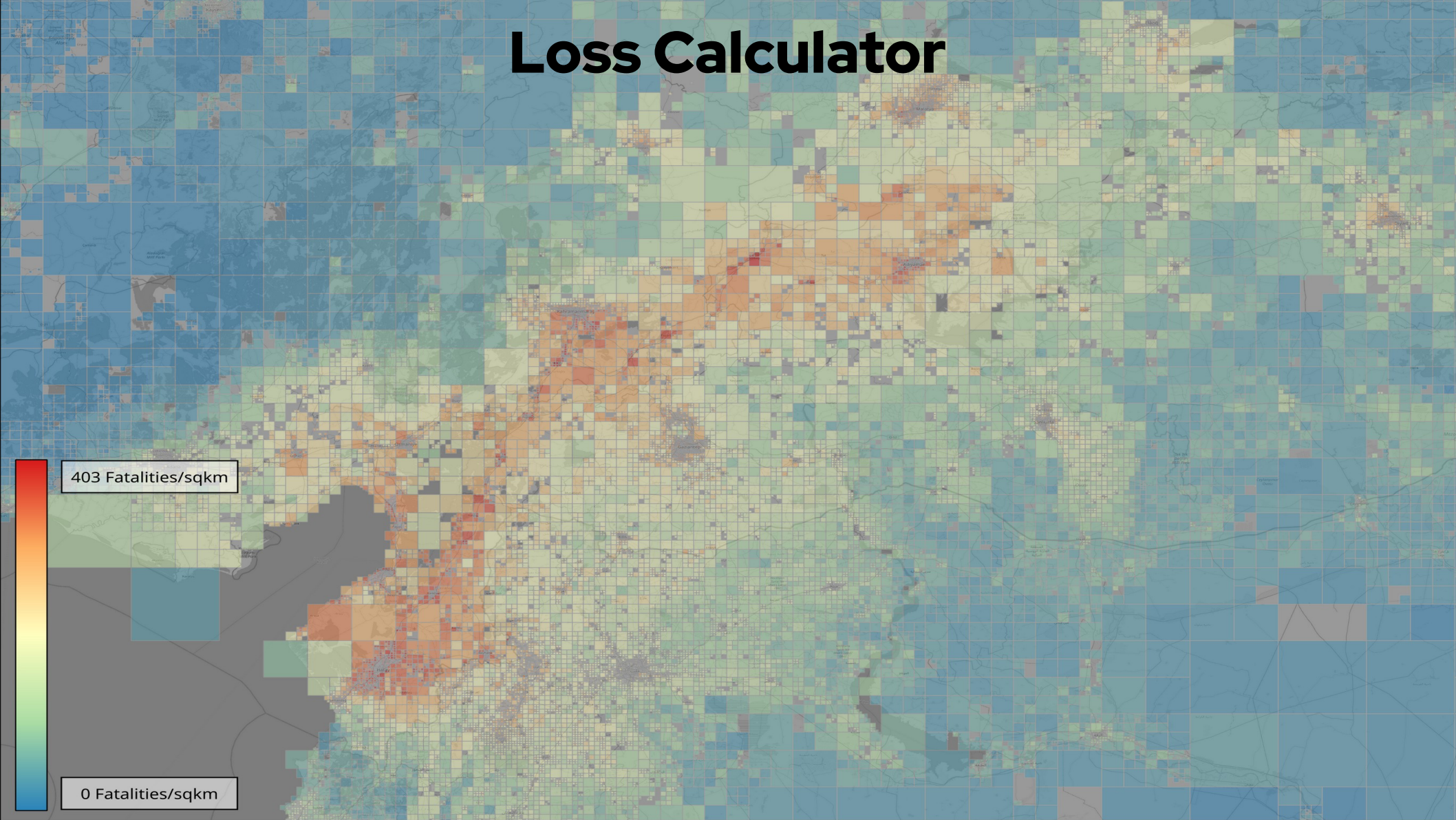


Loss Calculator

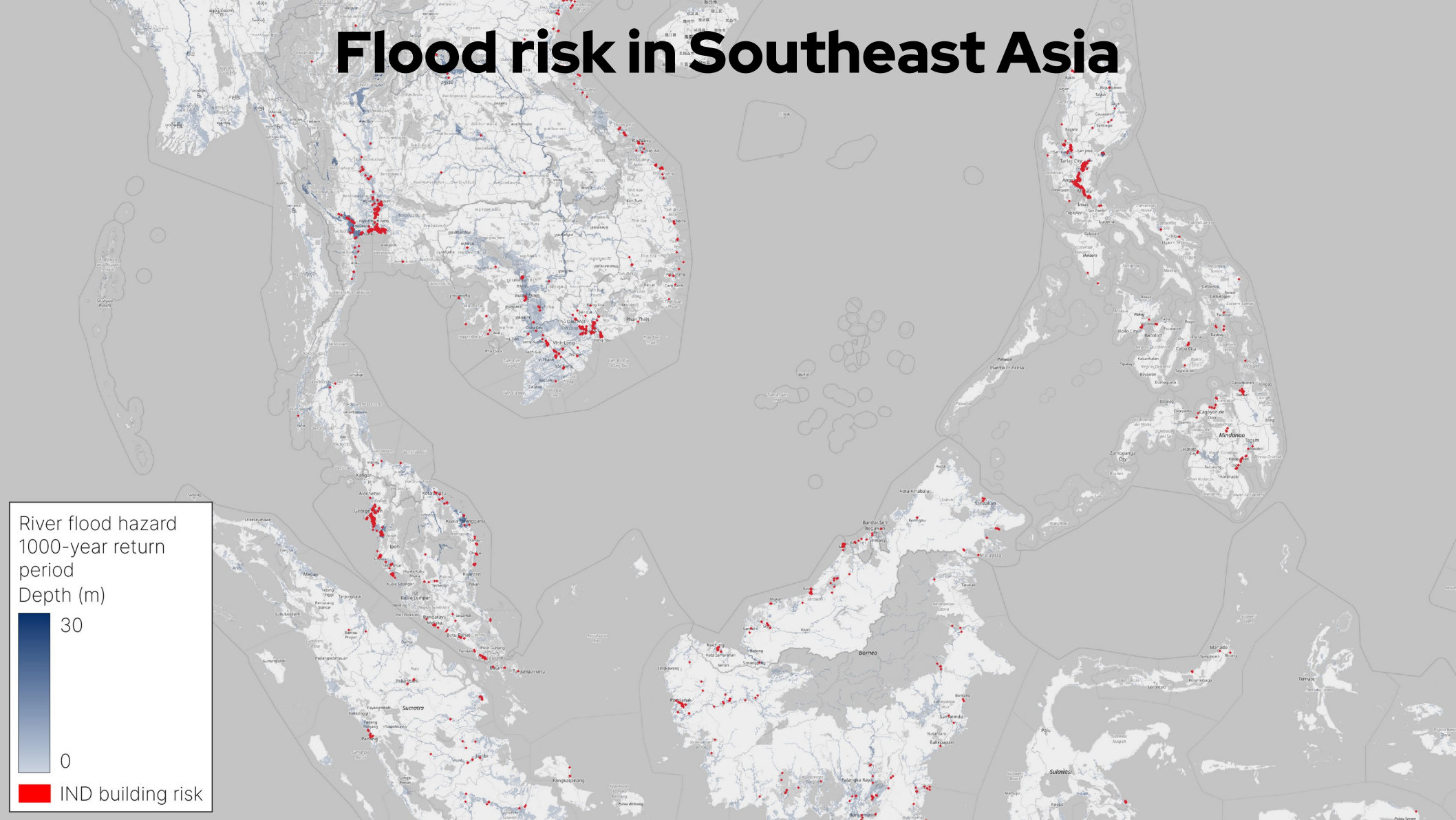
- Computes damage, building loss and human loss due to earthquakes (floods upcoming)
- Aggregates results per tile and/or building
- Ready for:
  → Multi-hazard damage and loss assessments
  → Cascading damage and loss assessments



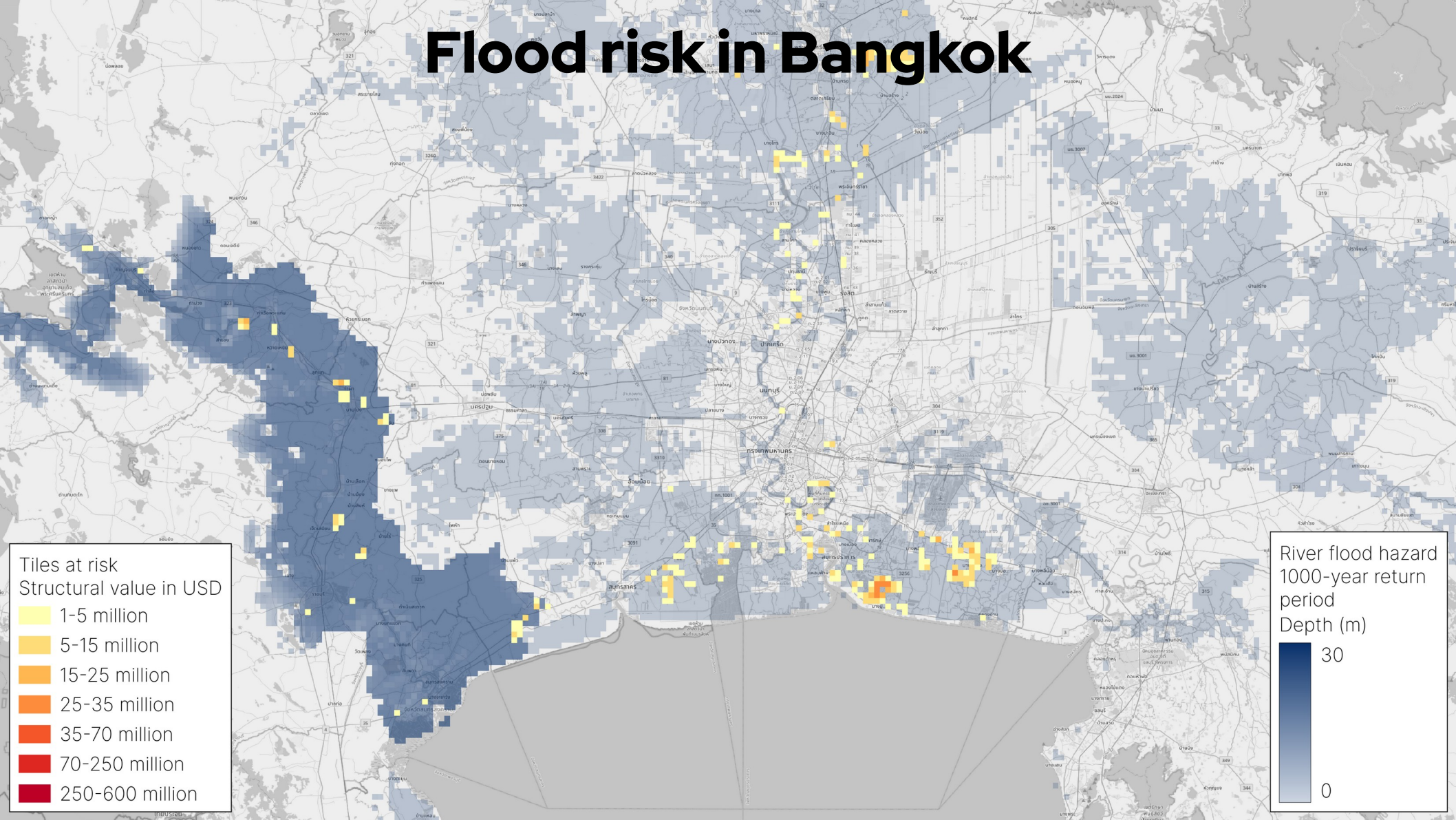
Loss Calculator



Flood risk in Southeast Asia

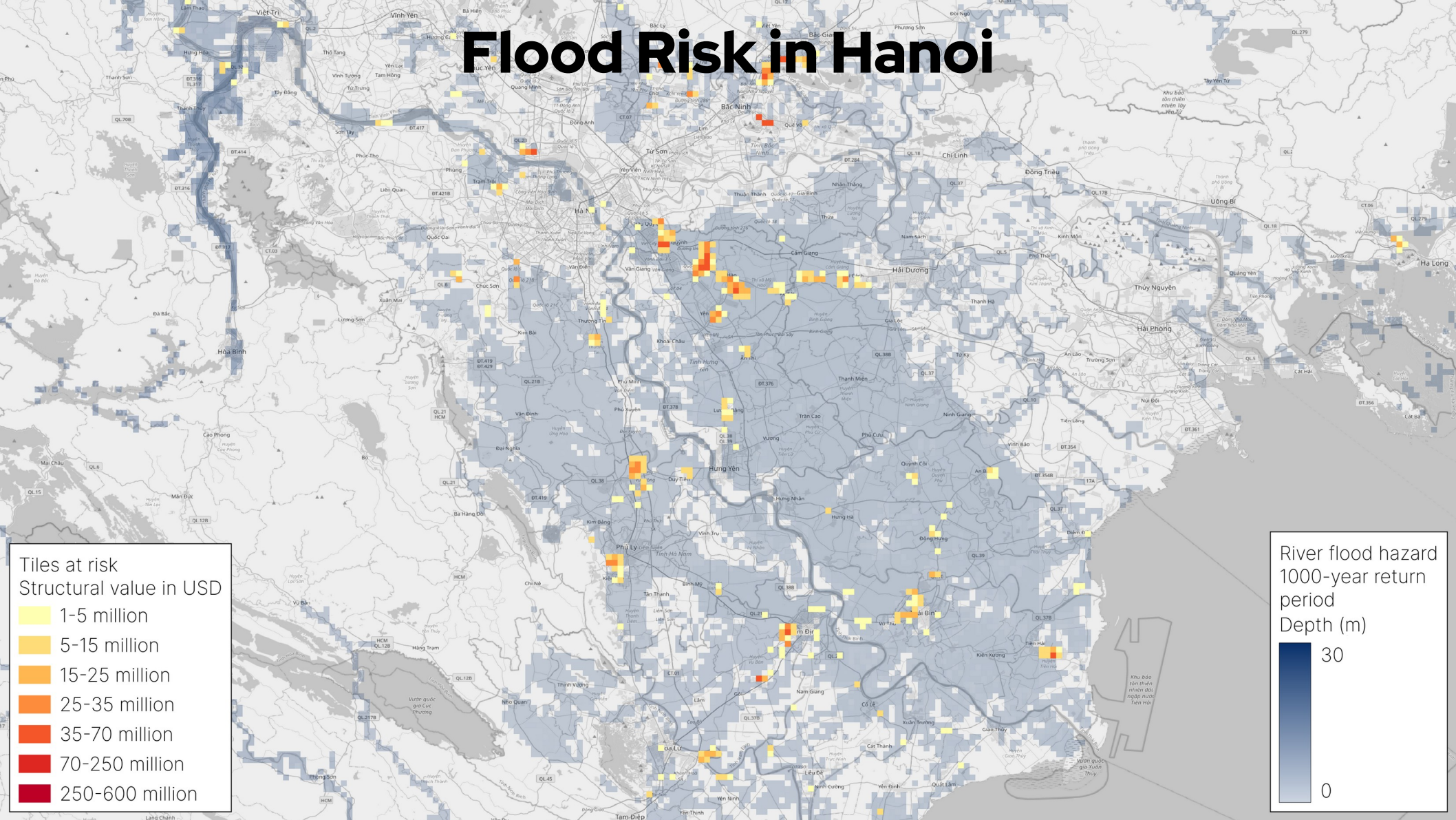


Flood risk in Bangkok

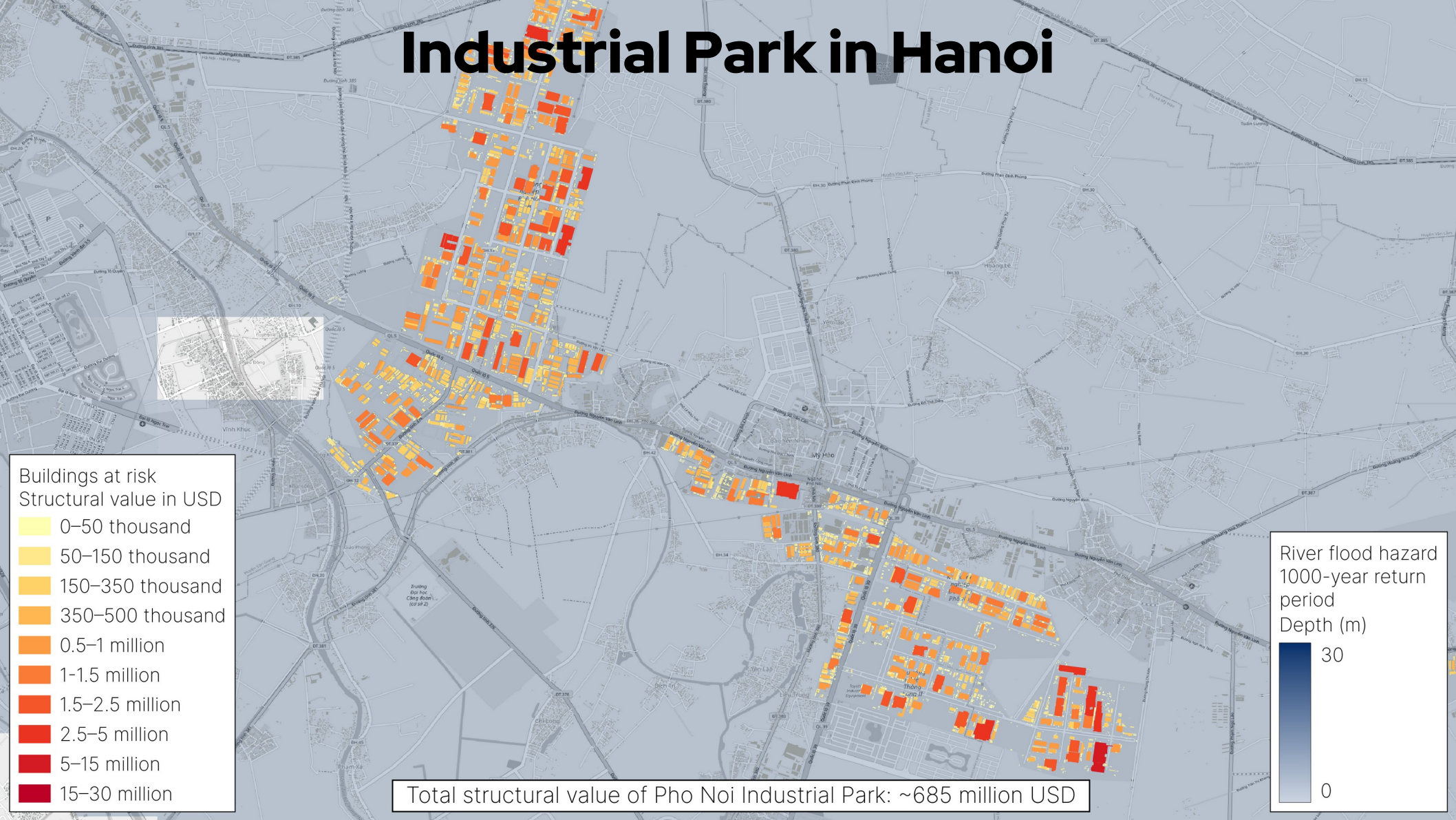


Industrial park in Bangkok

Flood Risk in Hanoi

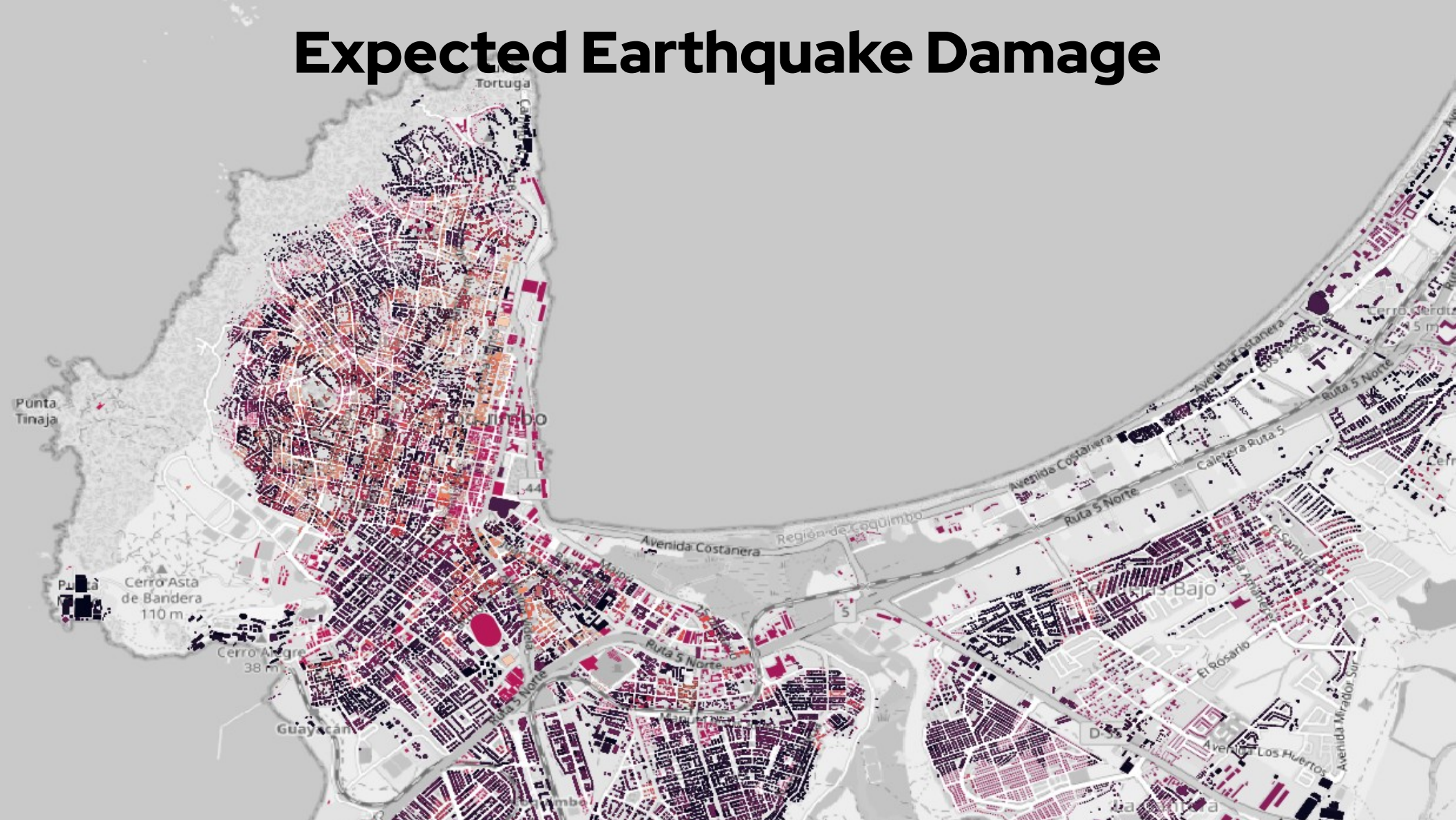


Industrial Park in Hanoi

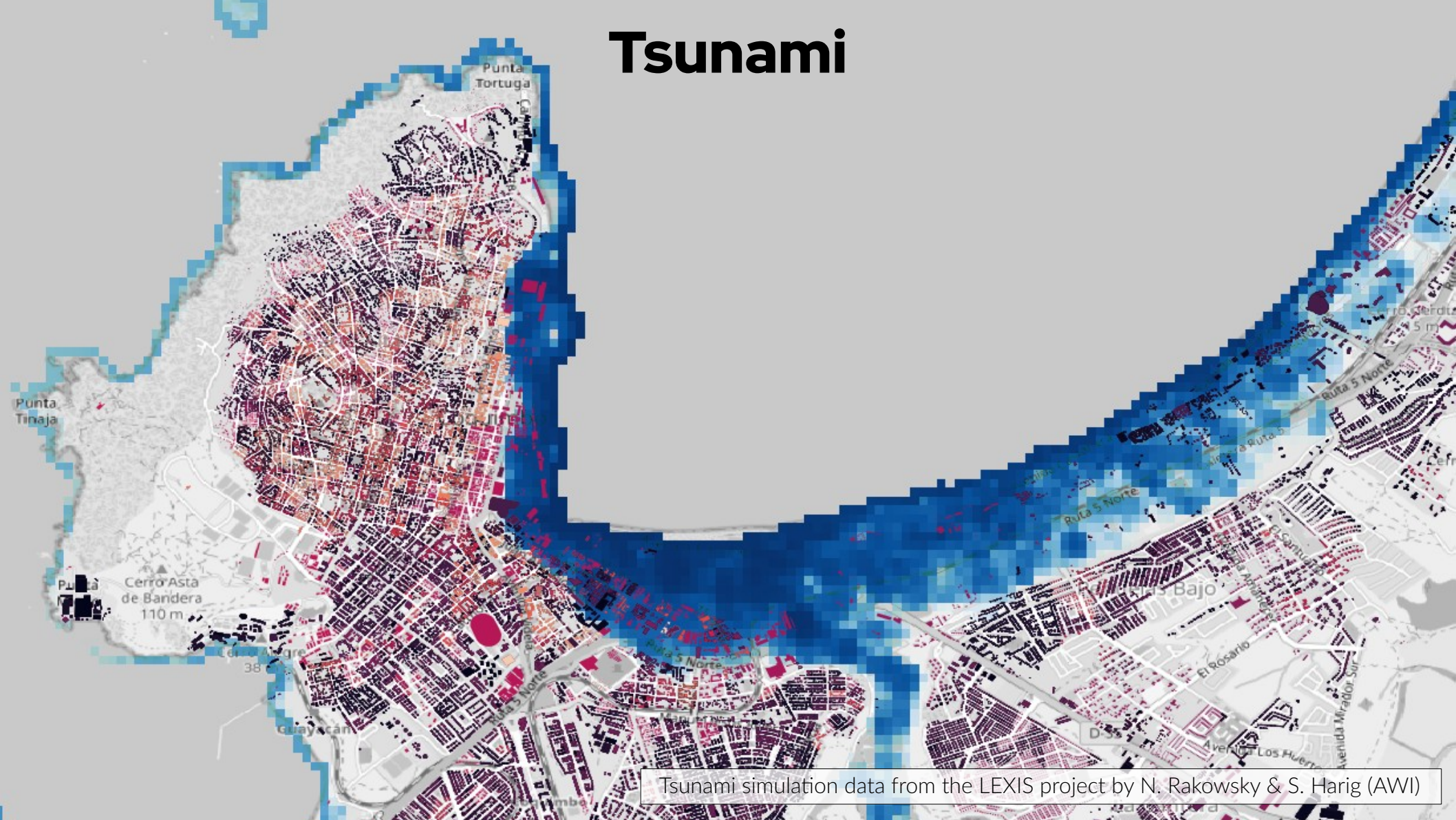


Coquimbo, Chile 2015

Expected Earthquake Damage



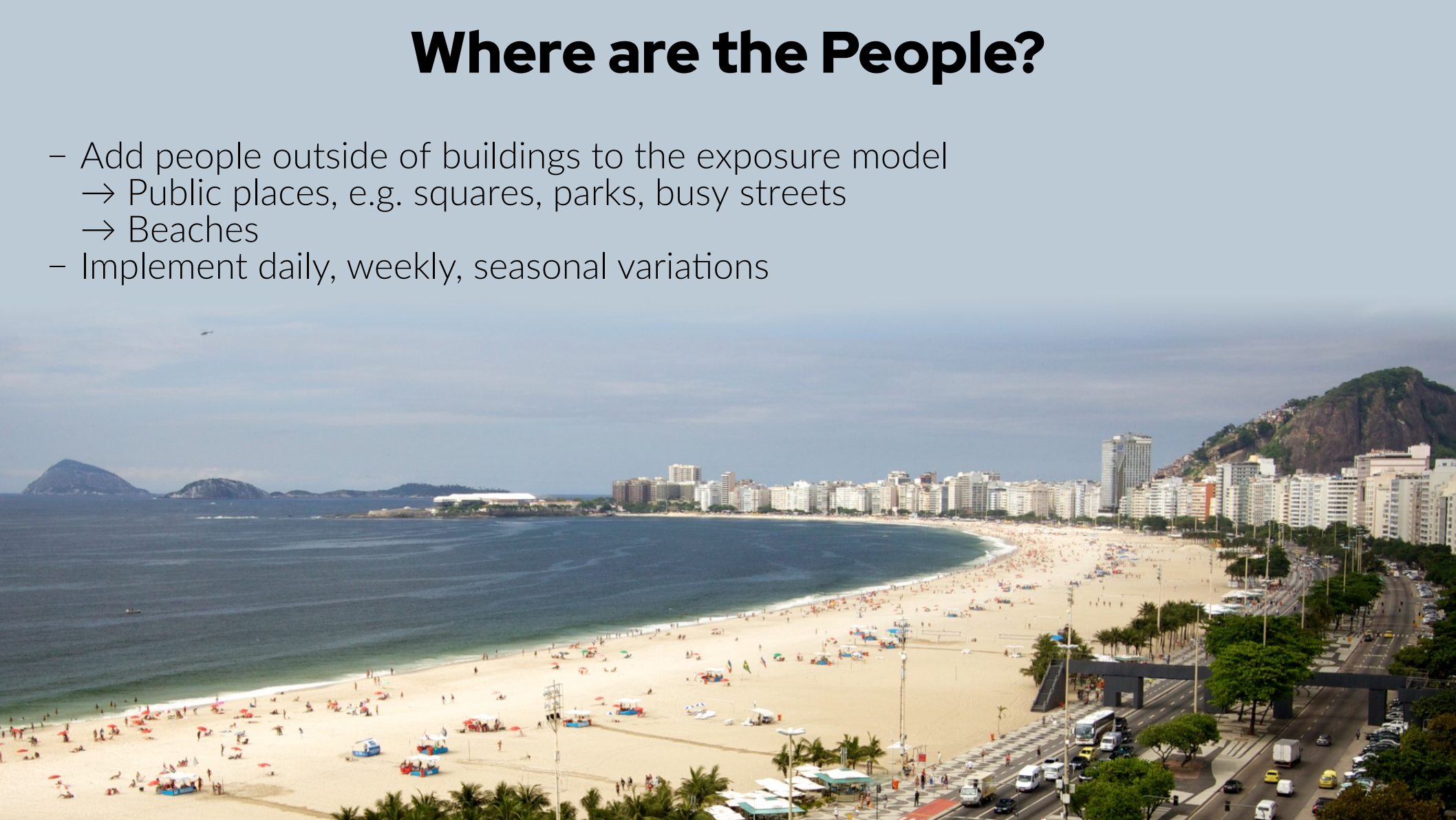
Tsunami



Tsunami simulation data from the LEXIS project by N. Rakowsky & S. Harig (AWI)

Where are the People?

- Add people outside of buildings to the exposure model
  → Public places, e.g. squares, parks, busy streets
  → Beaches
- Implement daily, weekly, seasonal variations

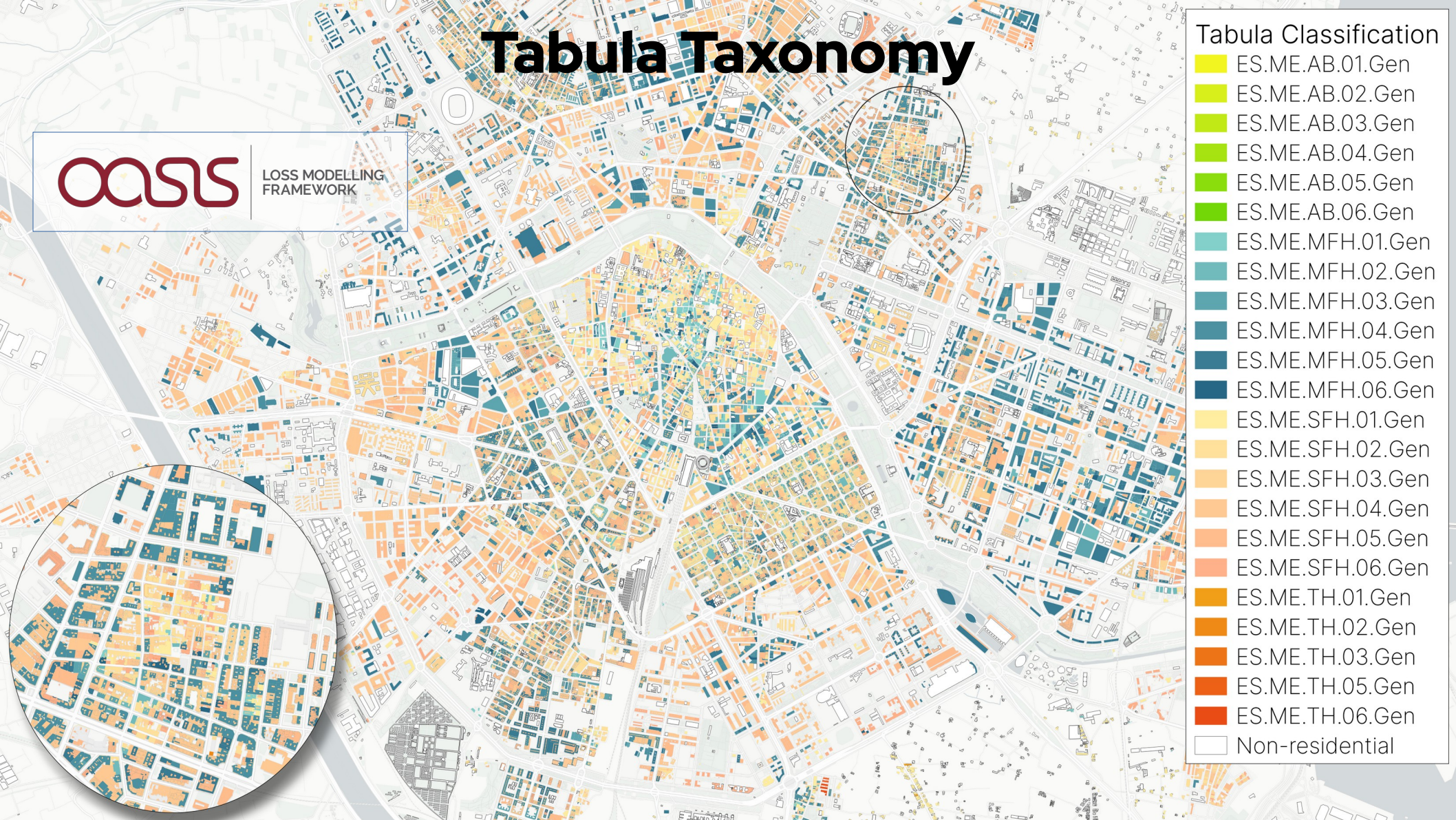


Exposure for Multi-Hazard

Exposure for Multi-Hazard

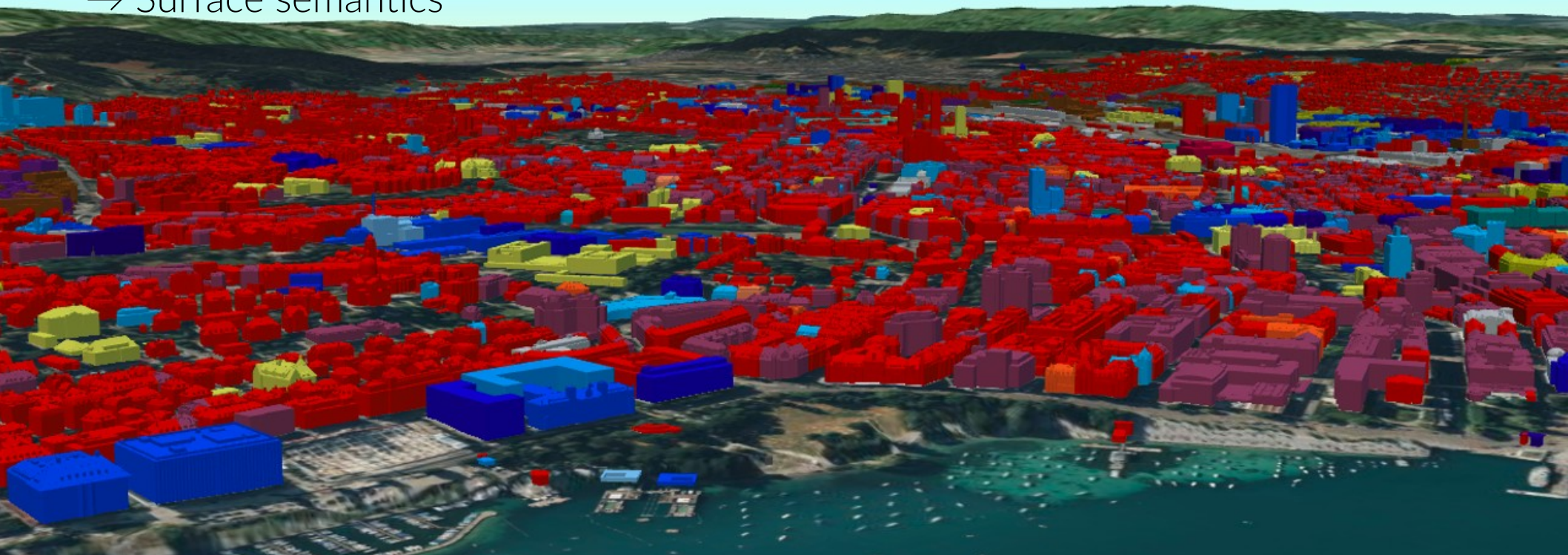
Exposure for Multi-Hazard

Tabula Taxonomy



3D Buildings

- To be provided by the EU for up to 500 cities in the member states
- Further data coming from the Japan Plateau dataset, USA, etc.
- Contains:
  → Up to LoD2.2 details
  → Surface semantics



The Way Forward

- Bringing the model to market while keeping it free for humanitarian/research use
- Update the model constantly and continue the research to improve the model
- Increase the coverage of 2.5D and 3D building data and add new datasets
- Employ AI techniques to increase the coverage of properties

Thank You

Contact: ds@gfz.de

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