

World Urban Database and Access Portal Tools (WUDAPT)

Mapping Global Cities by Using a Common Language

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Prof. Johannes FEDDEMA , University of Victoria, Canada

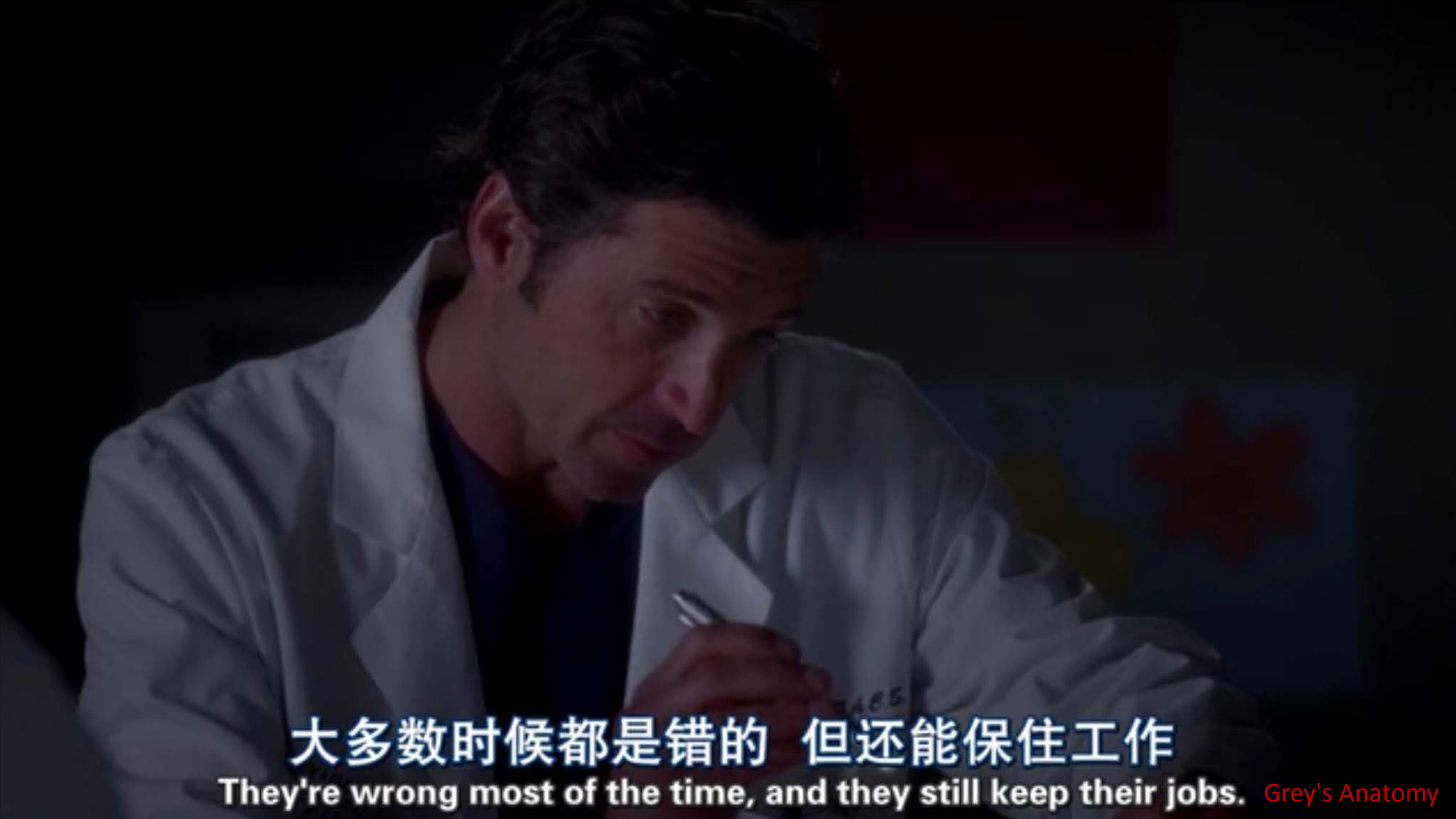
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我本以为这个风暴三天后才来的
I thought this storm was coming in three days.



你知道那些播天气预报的
You know weather guys.

A man with dark hair, wearing a white lab coat over a dark shirt, is looking down at a clipboard he is holding. He has a serious expression. The background is dark and out of focus, with some colorful shapes visible.

大多数时候都是错的 但还能保住工作

They're wrong most of the time, and they still keep their jobs. Grey's Anatomy

After Hurricane



Homes are damaged after Hurricane Irma struck in Philipsburg, on the Dutch Caribbean island of St. Martin on Sept. 6, 2017. Netherlands Ministry of Defense via AFP - Getty Images

More Unpredictable Weather Extremes....

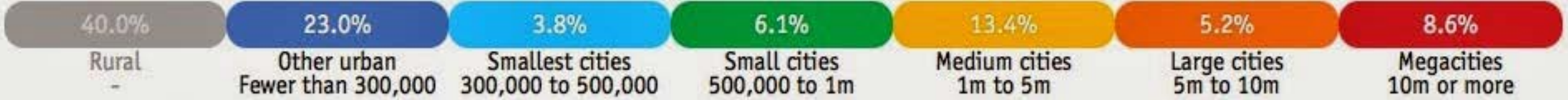


The most recent report from the Intergovernmental Panel on Climate Change (IPCC) notes **the dearth of information on urban areas.**

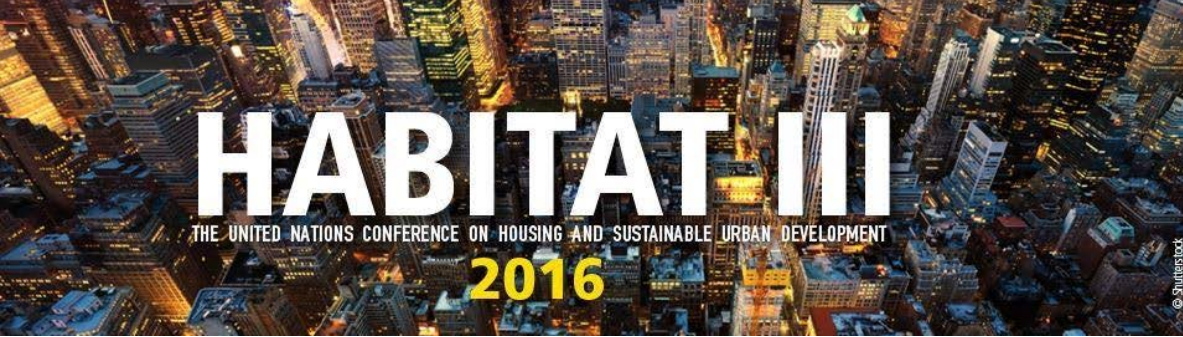
(The IPCC Special Report on Extremes, 2012)



Cities have the power to change the world,
but cities are as *vulnerable* as they are powerful.



2030



In HABITAT III,
WE DECIDE THE FUTURE
OF CITIES TOGETHER



New Urban Agenda

Quito Declaration on **Sustainable Cities and Human Settlements for All**

Quito implementation plan for the New Urban Agenda

Transformative commitments for sustainable urban development

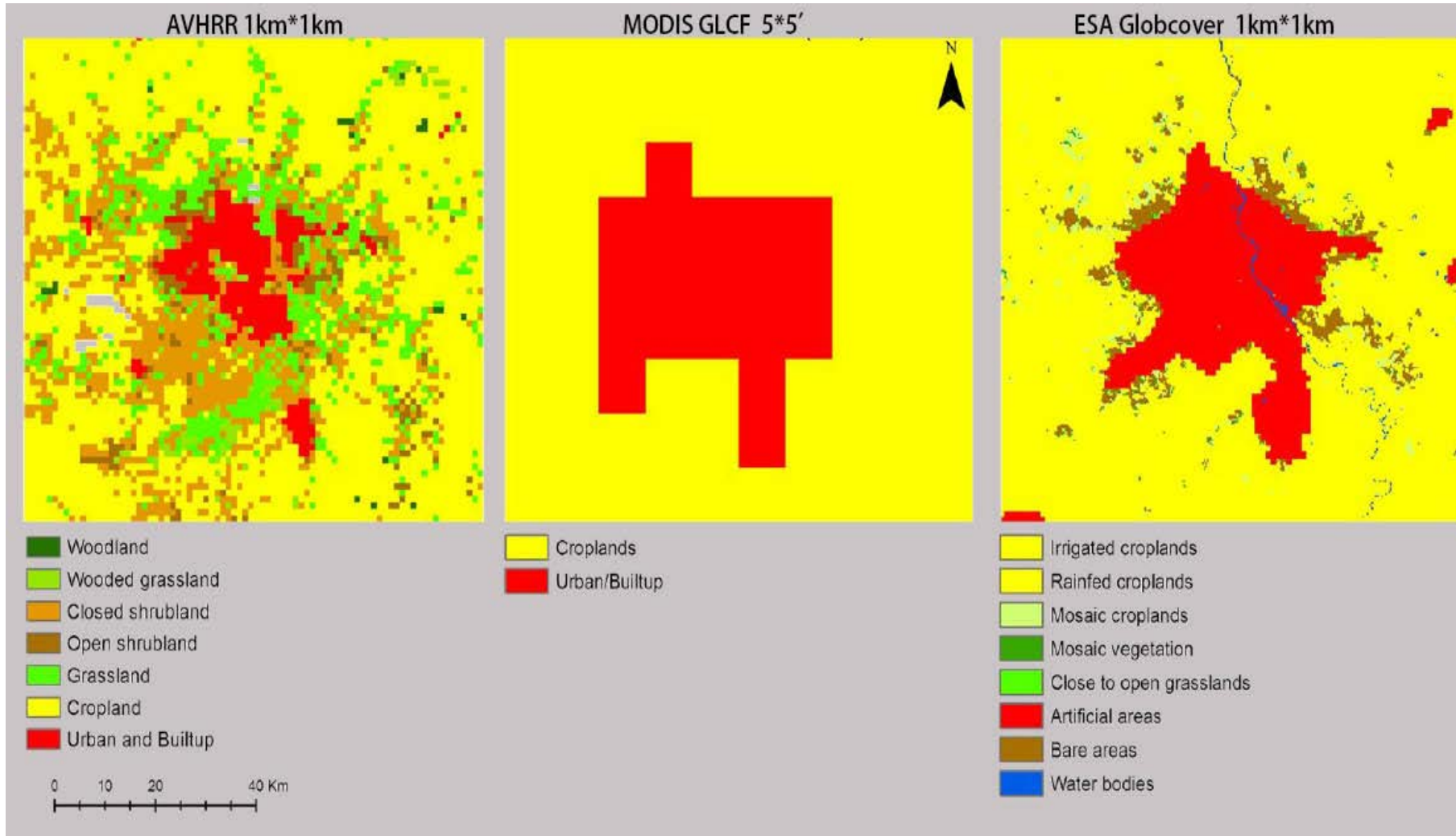
from: *social, economic and environmental dimensions*

How data science and analytics can contribute to sustainable development?



Urban Data Challenges at Global Scale

Some examples of global scale data for the city of Delhi, India



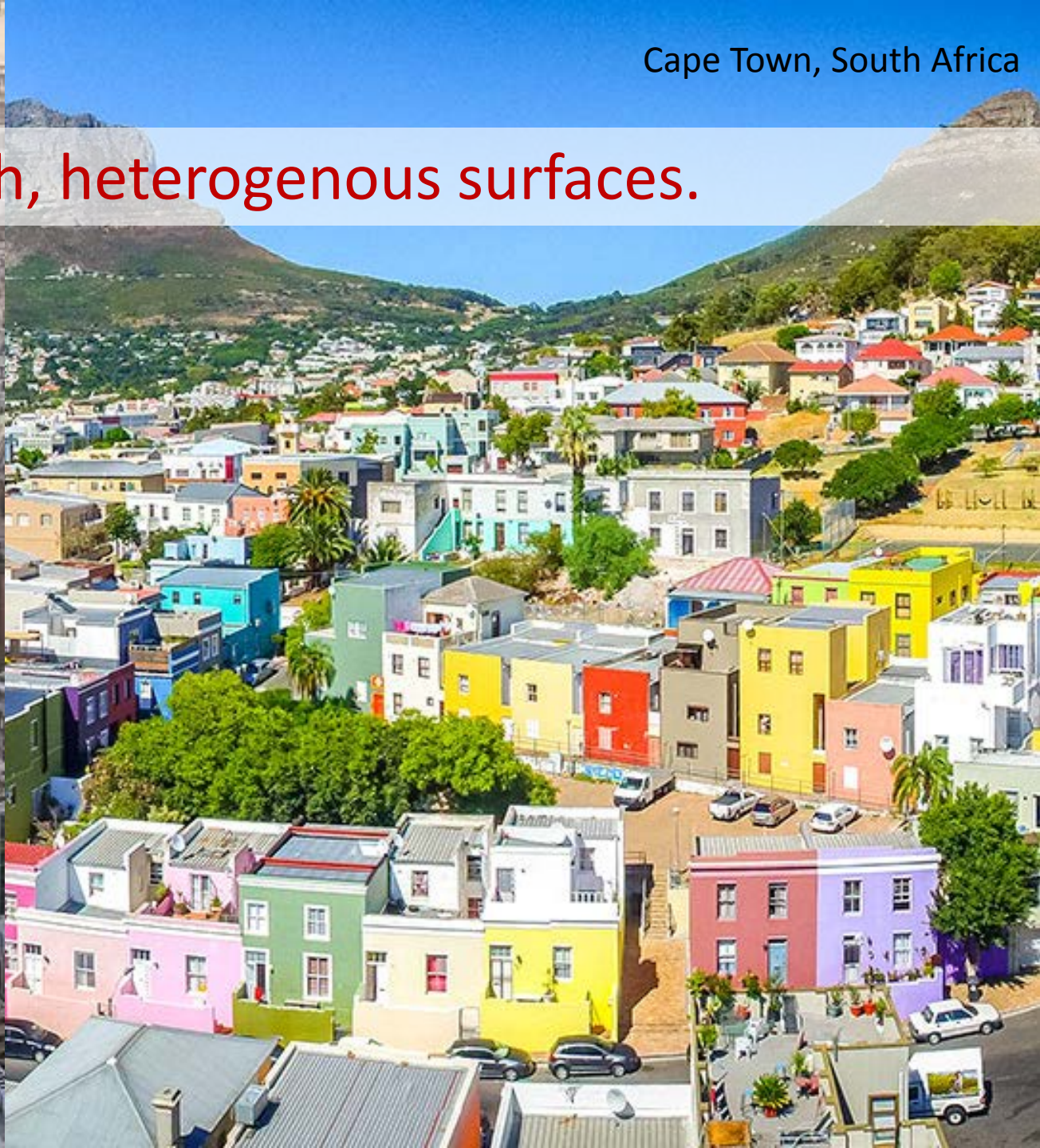
The Question is
how to make a cross-comparison among City A, City B, City C.....?



London

Cape Town, South Africa

Cities present very rough, heterogenous surfaces.



Facet



Building



Street Canyon



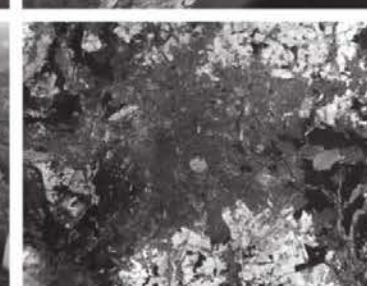
Block



LCZ or Neighbourhood



City



1 - 10 m

1 - 100
m²

10 - 100 m

10 -
10,000
m²1 - 1,000
cap

5 - 50 m

100 m - 1 km

1 - 100
ha100 - 10k
cap

1 - 10 km

1 - 100
km²1k - 100k
cap

10 - 100 km

100 -
10,000
km²100k - 10M
cap

The Missing Link

Scientific Community



Gap? Linkage?



Design Stakeholders



Meteorologists, Climatologists, Ecologists, Aerodynamists, Wind Engineers, Environmental Scientists, GIS and Remote Sensing Researchers, etc....

Town Planners, Architects, Landscape Architects, Governmental Officials, Policy Makers, etc..

The Missing Link & Need

Problems	Issues & Facts
Urban Data Availability & Accessibility	<ul style="list-style-type: none">• Few or no-data available globally on cities (Global South and rural / peri-urban areas especially in developing countries, regions and cities)
Censuses of Urban Data	<ul style="list-style-type: none">• No consensus of urban data for climate related studies (The dearth information of urban areas)
Data Standardization & Harmonization	<ul style="list-style-type: none">• No standard classification to represent land use and land cover of cities and surroundings landscapes (Densities, heights, functions and natural coverage for distinction)
Properties	<ul style="list-style-type: none">• Offer multiple properties on urban morphologies and landscapes (Morphologies, geometrics, thermal / physical information, surface cover...)
Applications	<ul style="list-style-type: none">• Applicable globally and transferable to each city (Transdisciplinarity for scientific research, urban planning, disaster & risk management, health impact analysis and response...)

'Local Climate Zone' Scheme

(Stewart & Oke, 2012)



Built types	Definition	Land cover types	Definition
1. Compact high-rise	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.	A. Dense trees	Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
2. Compact midrise	Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	B. Scattered trees	Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
3. Compact low-rise	Dense mix of low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	C. Bush, scrub	Open arrangement of bushes, shrubs, and short, woody trees. Land cover mostly pervious (bare soil or sand). Zone function is natural scrubland or agriculture.
4. Open high-rise	Open arrangement of tall buildings to tens of stories. Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	D. Low plants	Featureless landscape of grass or herbaceous plants/crops. Few or no trees. Zone function is natural grassland, agriculture, or urban park.
5. Open midrise	Open arrangement of midrise buildings (3–9 stories). Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	E. Bare rock or paved	Featureless landscape of rock or paved cover. Few or no trees or plants. Zone function is natural desert (rock) or urban transportation.
6. Open low-rise	Open arrangement of low-rise buildings (1–3 stories). Abundance of pervious land cover (low plants, scattered trees). Wood, brick, stone, tile, and concrete construction materials.	F. Bare soil or sand	Featureless landscape of soil or sand cover. Few or no trees or plants. Zone function is natural desert or agriculture.
7. Lightweight low-rise	Dense mix of single-story buildings. Few or no trees. Land cover mostly hard-packed. Lightweight construction materials (e.g., wood, thatch, corrugated metal).	G. Water	Large, open water bodies such as seas and lakes, or small bodies such as rivers, reservoirs, and lagoons.
8. Large low-rise	Open arrangement of large low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Steel, concrete, metal, and stone construction materials.	VARIABLE LAND COVER PROPERTIES	
9. Sparsely built	Sparse arrangement of small or medium-sized buildings in a natural setting. Abundance of pervious land cover (low plants, scattered trees).	Variable or ephemeral land cover properties that change significantly with synoptic weather patterns, agricultural practices, and/or seasonal cycles.	
10. Heavy industry	Low-rise and midrise industrial structures (towers, tanks, stacks). Few or no trees. Land cover mostly paved or hard-packed. Metal, steel, and concrete construction materials.	b. bare trees	Leafless deciduous trees (e.g., winter). Increased sky view factor. Reduced albedo.
		s. snow cover	Snow cover >10 cm in depth. Low admittance. High albedo.
		d. dry ground	Parched soil. Low admittance. Large Bowen ratio. Increased albedo.
		w. wet ground	Waterlogged soil. High admittance. Small Bowen ratio. Reduced albedo.

The World Urban Database and Access Portal Tools (WUDAPT)

The most recent report from the Intergovernmental Panel on Climate Change (IPCC) notes **the dearth of information on urban areas**. **The goal of the WUDAPT initiative** is to fill this demand.

Create LCZs with Landsat

Use freely available Landsat imagery to create a Local Climate Zone (LCZ) classification of your city



Create LCZ Training Areas

Follow the simple steps outlined here to create LCZ training areas for your city



Classify your City

Follow the step-by-step instructions to create an LCZ classification of your city



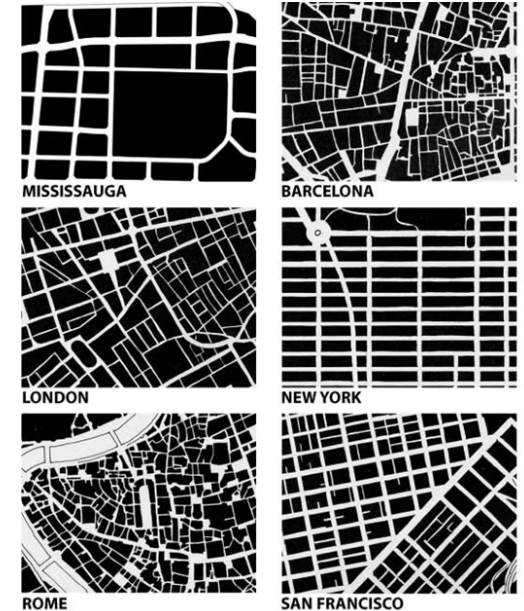
View LCZ maps

Access LCZ maps for different cities around the world using Geopedia

Two Objectives

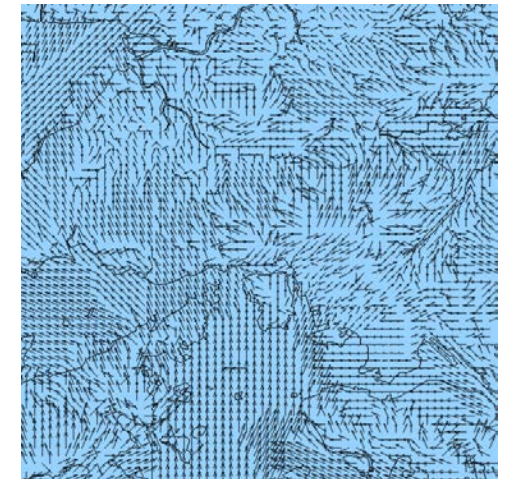
Objective 1

- **Acquire and make accessible** coherent and consistent descriptions and information in the aspects of **FORM** And **FUNCTION** of cities relevant to climate studies on **WORLDWIDE** basis.

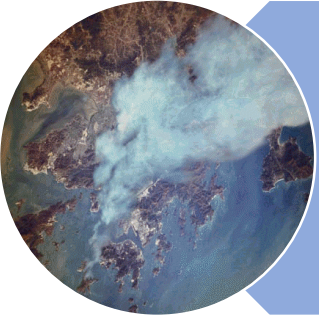


Objective 2

- **Build Portal (tools)** that will **EXTRACT** relevant urban parameters and properties for models and for model **APPLICATIONS** at appropriate scales for various climate, weather, Urban Planning purposes.



3 Levels of WUDAPT Products



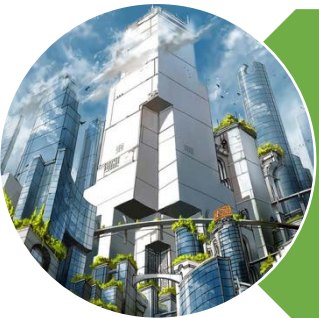
Level 0

- Cities are mapped using the Local Climate Zone scheme (Stewart & Oke, 2012). Each LCZ type is described in terms of the typical appearance of each in ground-based and aerial photographs and is linked to some urban parameter values.



Level 1

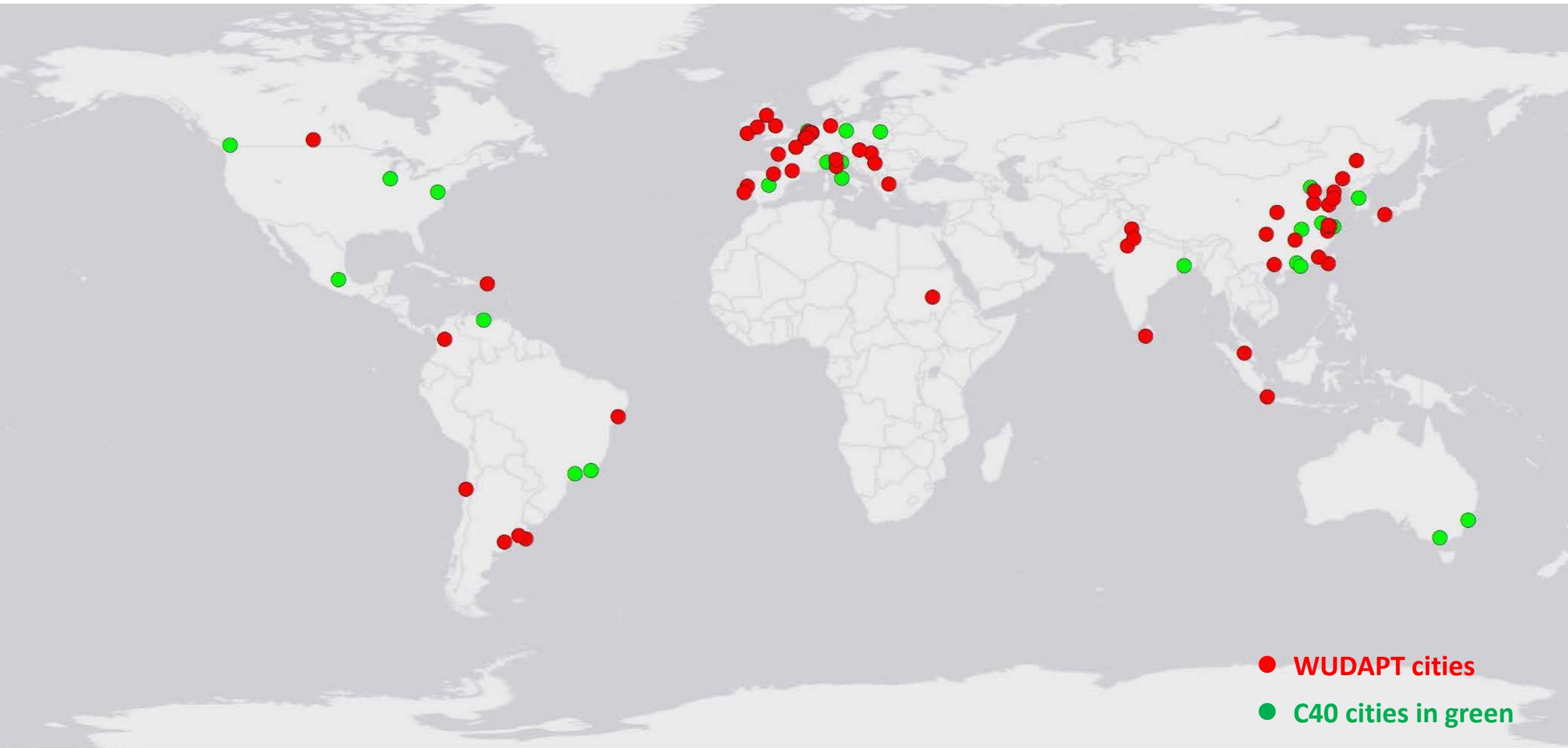
- The LCZ maps are used to sample urban landscapes to provide more information on the aspects of form and function in greater details.



Level 2

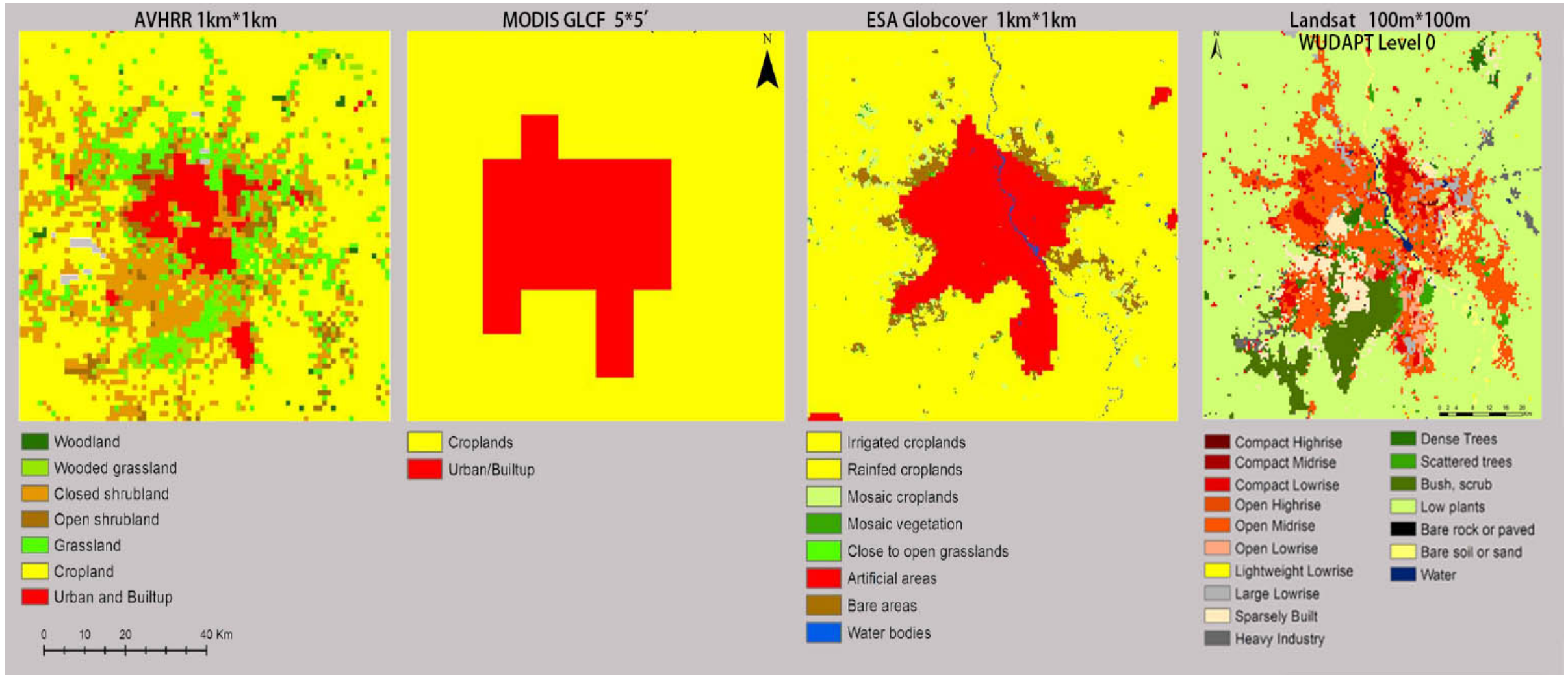
- This is the highest level and it refers to urban data gathered at a specified spatial scale (e.g. 250 m) across the entire urban area ('wall-to-wall' coverage).

More than 150 Cities involved (Jun. 2017)



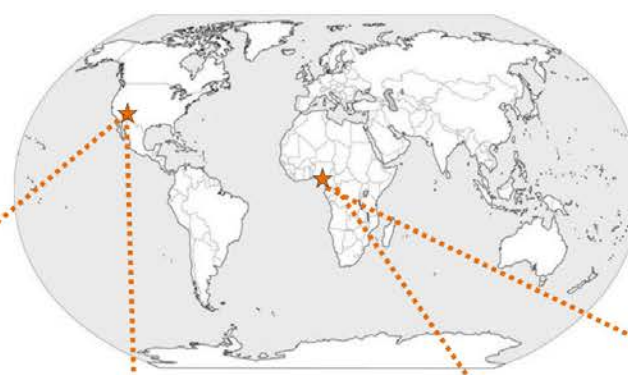
Urban Data Challenges

Some examples of global scale data sets compared to a WUDAPT level 0 map for the city of Delhi, India



Los Angeles USA

Akure NIGERIA



LCZ 1

LCZ 8

LCZ 6

LCZ D



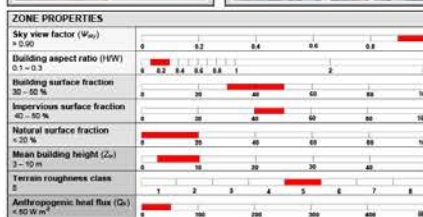
LCZ EXTENSIVE LOWRISE B7

ZONE DEFINITION: Flat, horizontal buildings 1-3 stories tall. Buildings extend outward not upward and are well-separated by open, paved surfaces. Sky view from ground level slightly reduced. Steel-framed concrete, stone, or metal structures; thin, flat roofs of metal, tar/gravel, or concrete. Natural surface cover sparse. Low space heating/cooling demand. Moderate-high traffic density.

PROBABLE FUNCTION: Light industrial (modern warehousing, wholesale districts, cargo ports, storage yards); commercial (shopping centres); institutional (airports).

ANTICIPATED LOCATION: City outskirts; city port (transportation hub/terminal).

CORRESPONDANCE: UC24 (Oke 2004); Do1, Do4 (Ellefsen 1990/1).



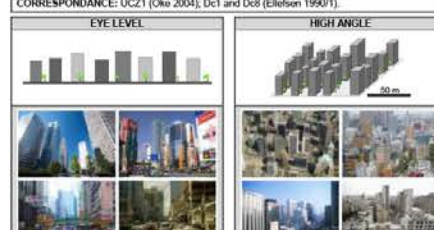
LCZ COMPACT HIGHRISE B1

ZONE DEFINITION: Irregular and compact skyline of highrise buildings >10 stories tall. Buildings close-set, free-standing. Sky view from street canyons significantly reduced. Streets paved (asphalt, concrete), geometric in layout. Buildings of heavy, solid construction (concrete, stone). Steel-caged, glass-skinned skyscrapers. Surface cover mostly impervious; limited tree or vegetative cover. High space heating/cooling demand. Heavy traffic flow.

PROBABLE FUNCTION: Commercial (offices, hotels); high-density residential (apartment towers) or institutional (major facilities or complexes).

ANTICIPATED LOCATION: Modern city centre (e.g., "downtown"); City periphery (highrise sub-centre, highrise sprawl).

CORRESPONDANCE: UC21 (Oke 2004); Do1 and Do8 (Ellefsen 1990/1).



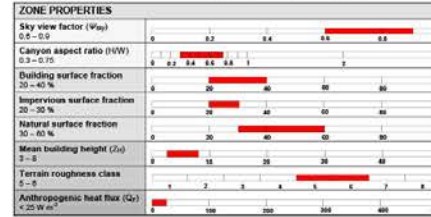
LCZ OPEN-SET LOWRISE B6

ZONE DEFINITION: Small, lowrise buildings 1-3 stories tall, detached but close-set. Buildings separated by natural surfaces and set along medium-width streets, often in grid pattern. Construction materials of wood, brick, stone, concrete, or tile. Low space heating/cooling demand. Low-moderate traffic flow.

PROBABLE FUNCTION: Medium-density residential (single- or multi-family housing); commercial (small retail shops).

ANTICIPATED LOCATION: Central or "suburban" housing tracts. Commuter towns. Rural towns.

CORRESPONDANCE: UC25 (Oke 2004); Do3 (Ellefsen 1990/1).

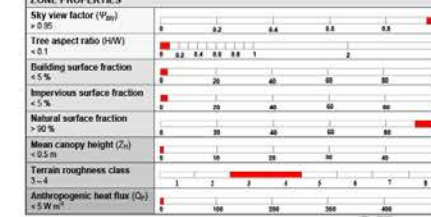
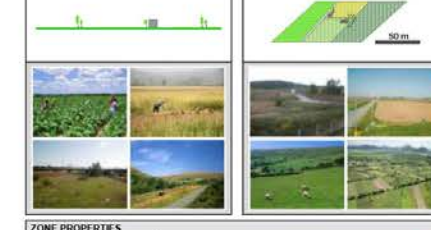


LCZ LOW PLANT COVER N4

ZONE DEFINITION: Low, uniform crops or fields. Grassy landscape (grasses, forbs, shrubs). Plant canopy height < 2 m. Sky view unobstructed. Fields demarcated by roads, fences, hedge lines. Few if any scattered buildings, trees. Space heating/cooling demand negligible. Light traffic density.

PROBABLE FUNCTION: Agricultural (e.g., vegetables, grains, pasture). Undeveloped.

CORRESPONDANCE: UC27 (Oke 2004).



WWW.WUDAPT.ORG



Collaboration Partners & Supporters



The Chinese University of Hong Kong

Core Teams



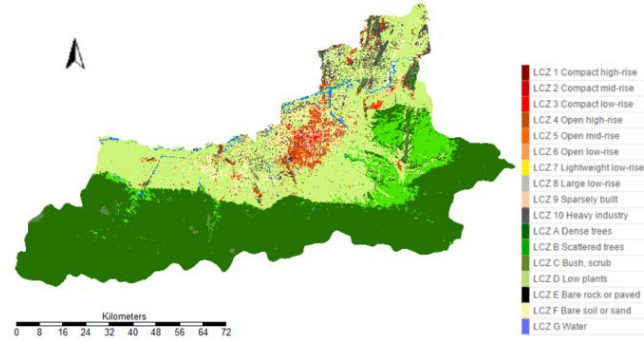
CUHK team's work and efforts

WUDAPT: Major Cities in China

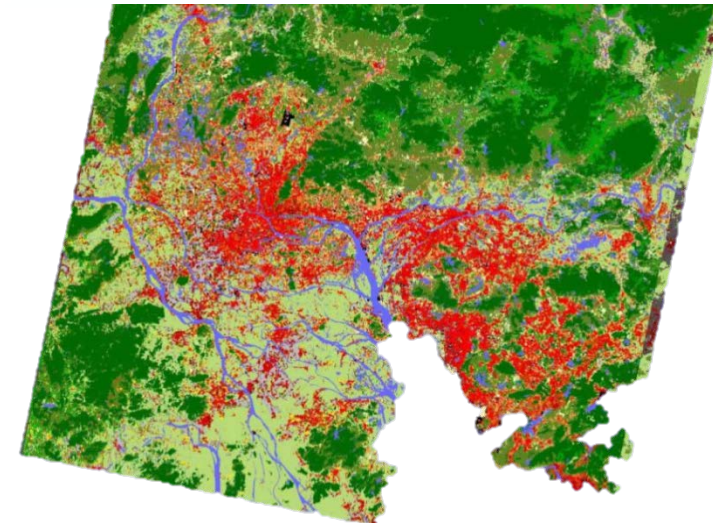
Beijing
Shanghai
Wuhan
Guangzhou
Changsha
Dalian
Guangzhou
Hangzhou
Jinan
Nanjing
Qingdao
Shanghai
Shenyang
Tianjing
Xi'an
Xiamen

.....

When you later work on urban climate study in China,
you don't need to worry about its urban morphological data.



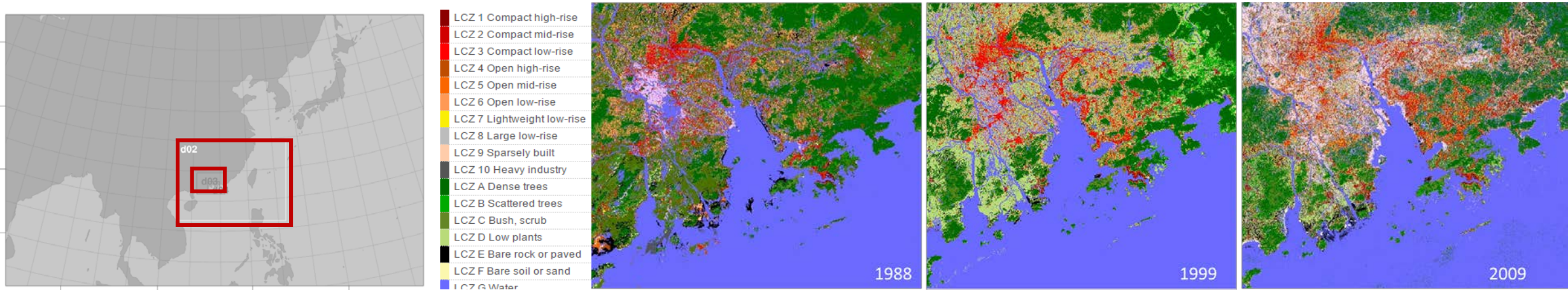
LCZ 1 Compact high-rise
LCZ 2 Compact mid-rise
LCZ 3 Compact low-rise
LCZ 4 Open high-rise
LCZ 5 Open mid-rise
LCZ 6 Open low-rise
LCZ 7 Lightweight low-rise
LCZ 8 Large low-rise
LCZ 9 Sparsely built
LCZ 10 Heavy industry
LCZ A Dense trees
LCZ B Scattered trees
LCZ C Bush, scrub
LCZ D Low plants
LCZ E Bare rock or paved
LCZ F Bare soil or sand
LCZ G Water



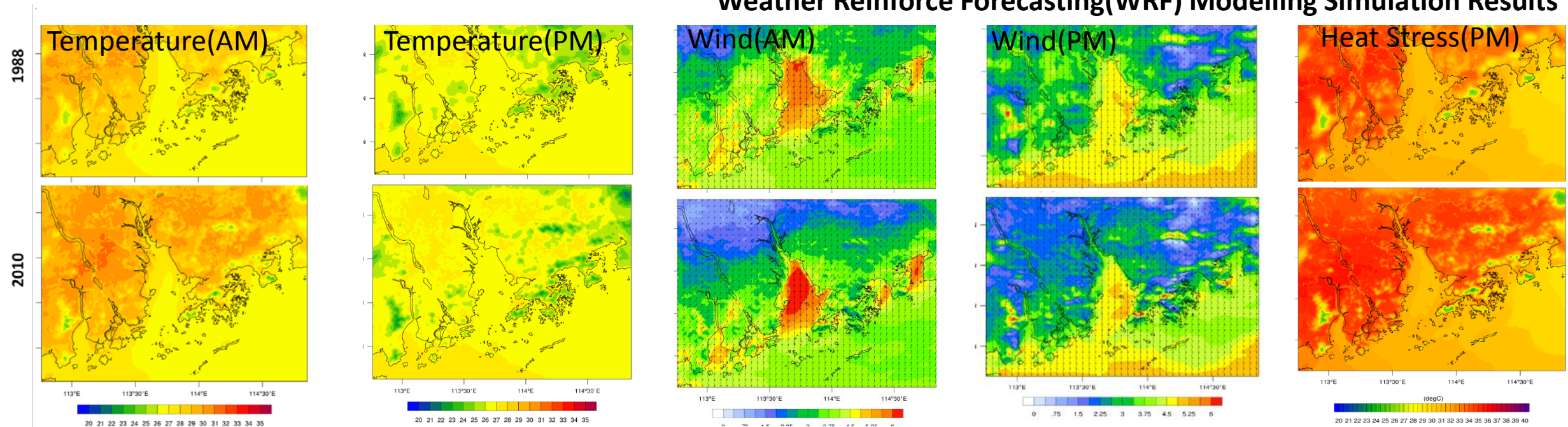
By Jun 2016, we have finished the LCZ mapping work for 57 all provincial capital cities and major economic big regions.

Historical Urban Data Bay Area Of Hong Kong-Macau-Guangdong

pure urbanization impact on local urban climate (1980-2010)



Weather Reinforce Forecasting(WRF) Modelling Simulation Results

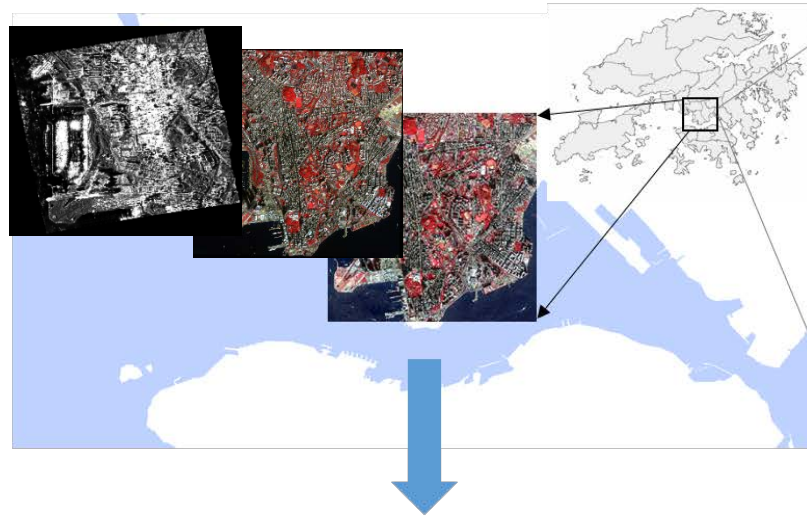




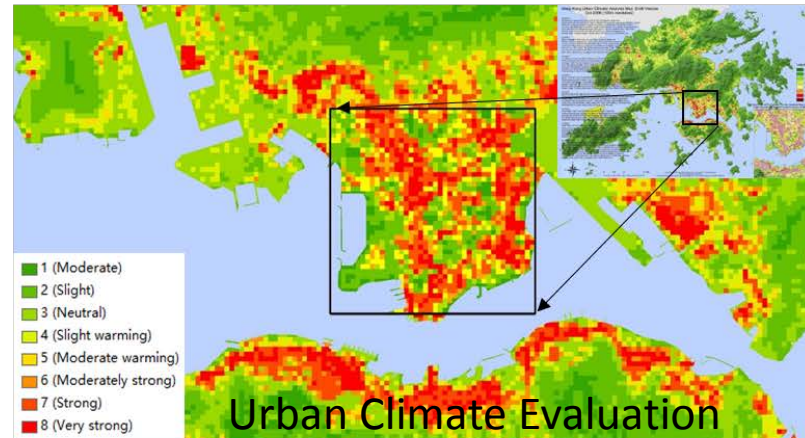
3-D Urban Morphological Data by Adopting Multi-source Satellite Images



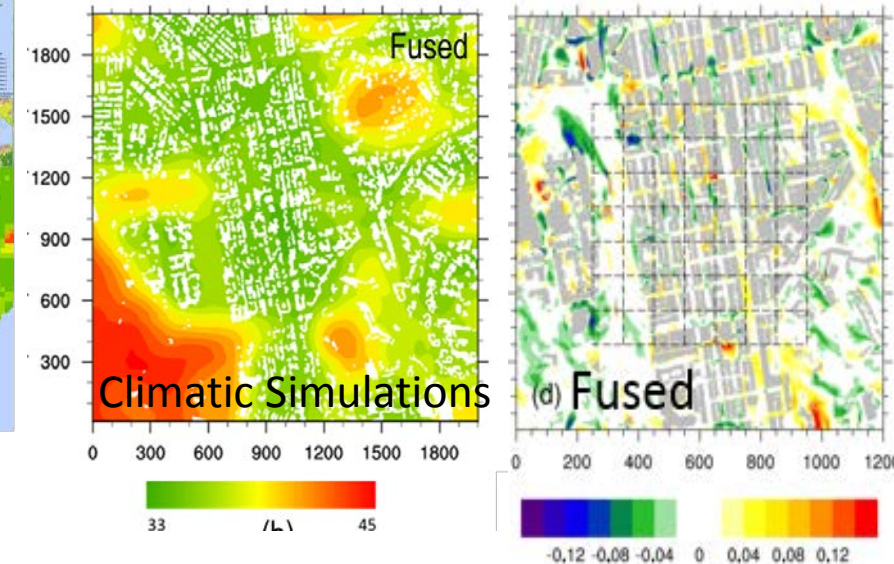
- Patented technology
- High accuracy (70-90%)
- Low-cost;
- Fast development ;
- Large coverage;
- Easy to update and manage;
- Suitable for weather and climate modellings



Satellite-derived building morphology using our approach



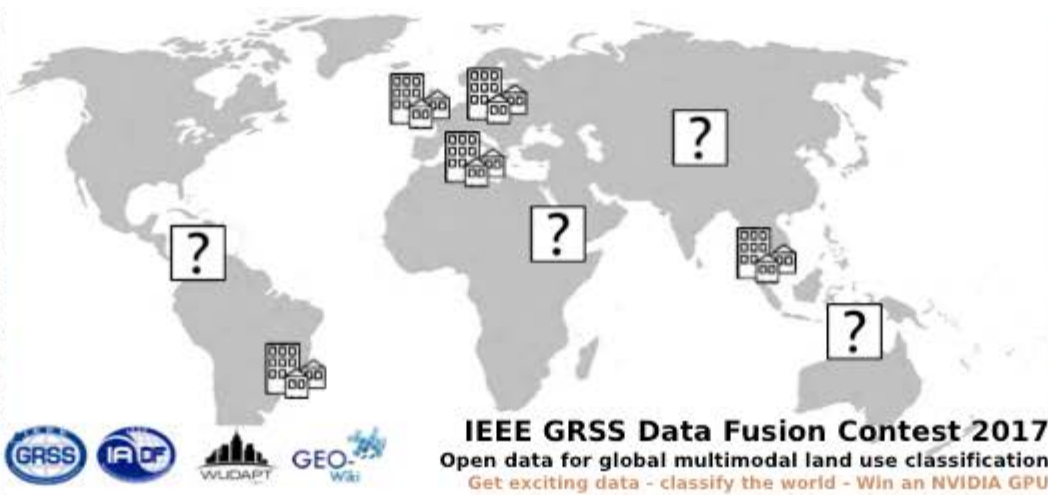
Urban climatic map using satellite data





2017 IEEE GRSS Data Fusion Contest

Open data for global multimodal land use classification



The 2017 IEEE GRSS Data Fusion Contest was organized by the IADF TC in collaboration with [WUDAPT](http://www.wudapt.org/) and [GeoWiki](http://www.geowiki.org/).
Over **800 Submissions** were received!

We are Top 4!

Authors: Yong Xu, Fan Ma, Deyu Meng, Chao Ren, Yee Leung

(The Chinese University of Hong Kong and Xi'an Jiaotong University, China)

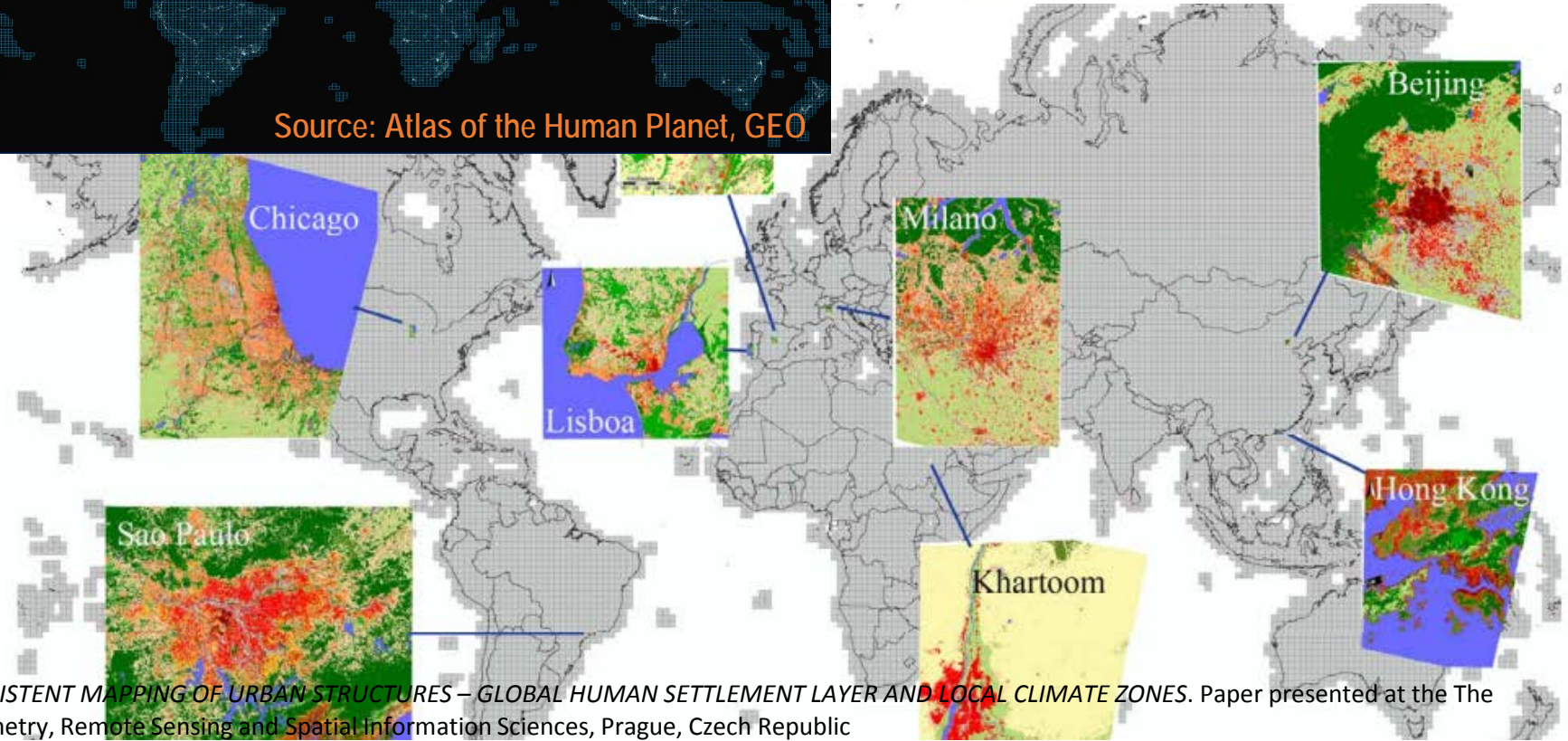
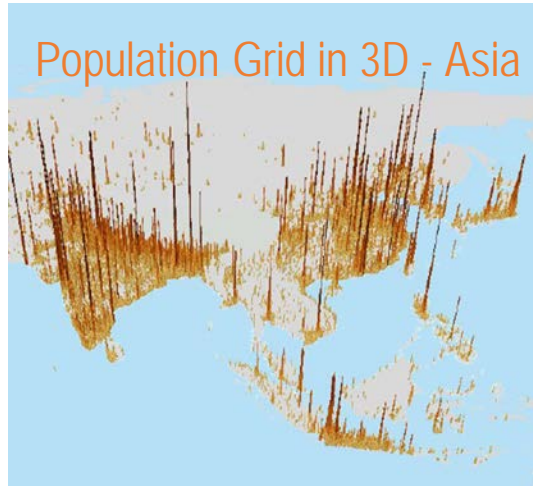
<https://www.grss-ieee.org/community/technical-committees/data-fusion/2017-ieee-grss-data-fusion-contest-results/>

Other on-going Collaborations and Applications

'Atlas of the Human Planet'

On-going Projects & Collaborations

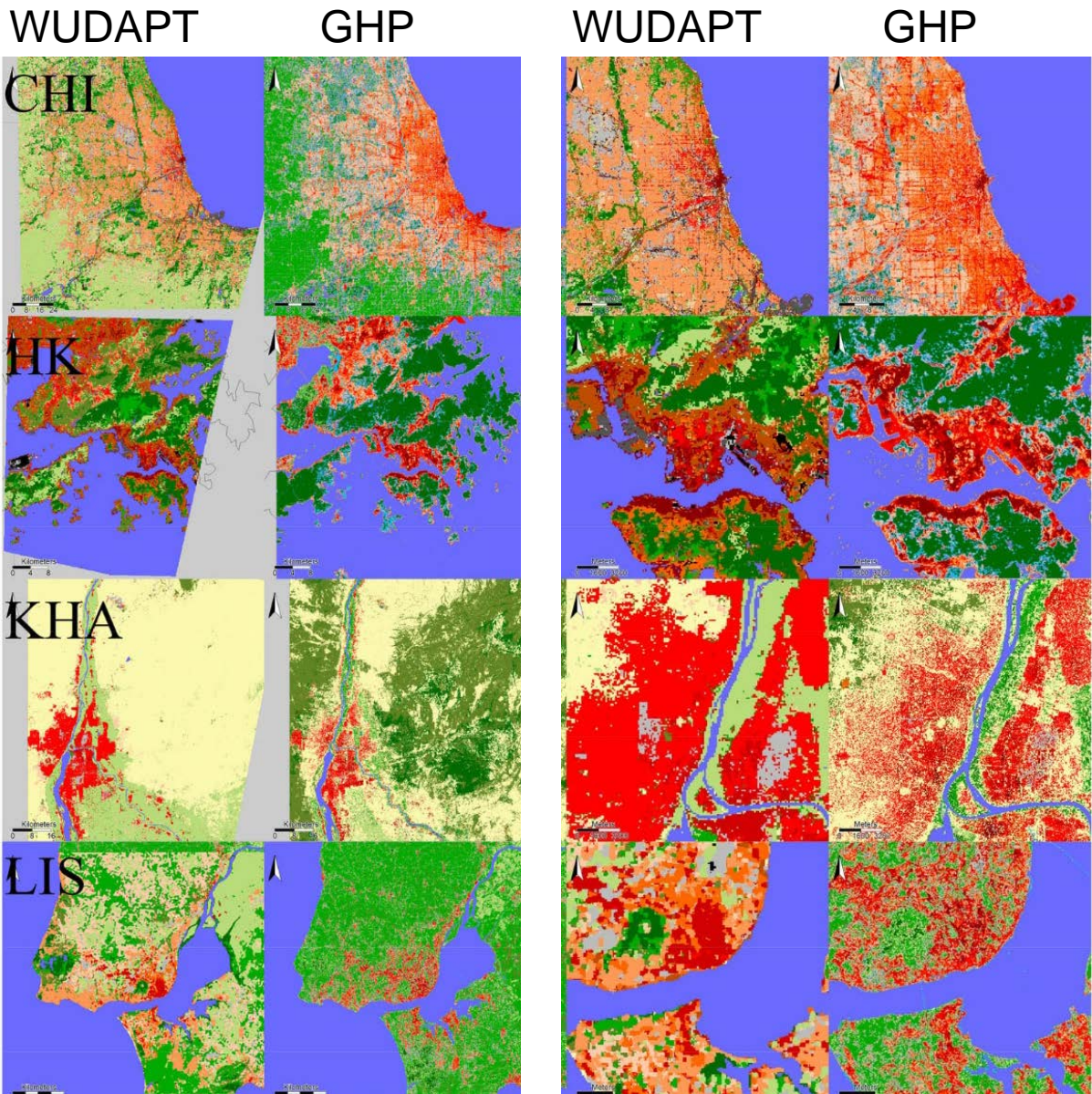
Collaboration with GEO, European Commission



Bechtel, B., et al. (2016). *TOWARDS CONSISTENT MAPPING OF URBAN STRUCTURES – GLOBAL HUMAN SETTLEMENT LAYER AND LOCAL CLIMATE ZONES*. Paper presented at the The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Prague, Czech Republic

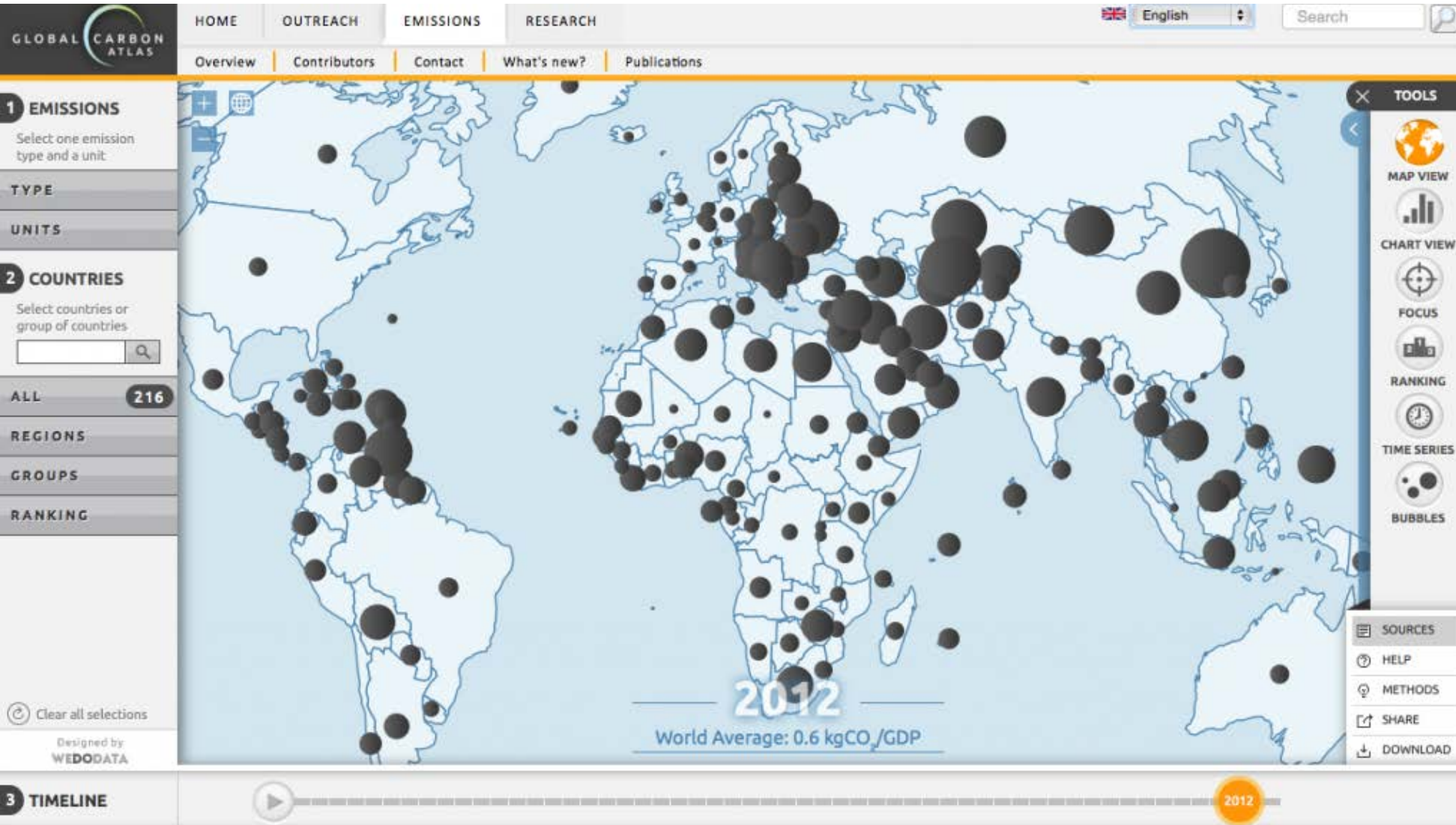
'Global Human Settlement Layer (GHSL)' vs WUDAPT Data

ID	LABEL NAME	ID2	LCZ NAME
0	no data	-	not available
1	Other	-	
2	Ice and permanent snow	-	
3	Bare soil and rocks	F	bare soil or sand
4	Shrubs and Grassland	C	bush, scrub
5	Mosaic Croplands and Forest	B	scattered trees
6	Rain Cropland	D	low plants
7	Irrigated Cropland	D	low plants
8	Forest	A	dense trees
9	Occasionally water / land-water interface	-	
10	Surface Water	G	Surface Water
11	Roads		
12	Built-up with highly reflecting roof	8	large lowrise
13	Very light built-up	9	sparsely built
14	Light built-up	6	open lowrise
15	Medium built-up	5	open midrise
16	Strong built-up, lowrise	3	compact lowrise
17	Strong built-up, midrise	2	compact midrise
18	Strong built-up, highrise	1	compact highrise
19	Strong built-up, very highrise	-	
	not available	7	lightweight lowrise
		4	open highrise
		10	heavy industry
		E	bare rock or paved



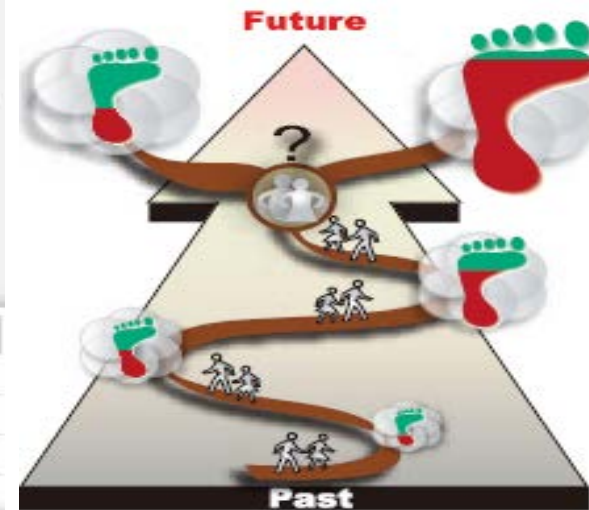
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'Global Carbon Atlas Project'



New focus

- Building a modest database on cities' carbon emission and of key drivers
- Examining alternative urban designs



Urban Development Path and Carbon Balance Decisions

'Healthy City Development for Latin American Cities'



LAC-URBAN HEALTH
Urban Health Network for Latin America and the Caribbean



'Digital Belt & Road' Initiative

On-going Projects & Collaborations

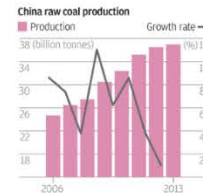
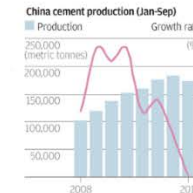
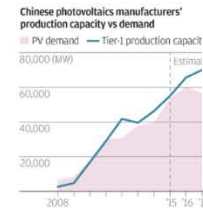
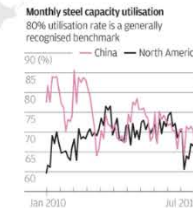


中国科学院
CHINESE ACADEMY OF SCIENCES

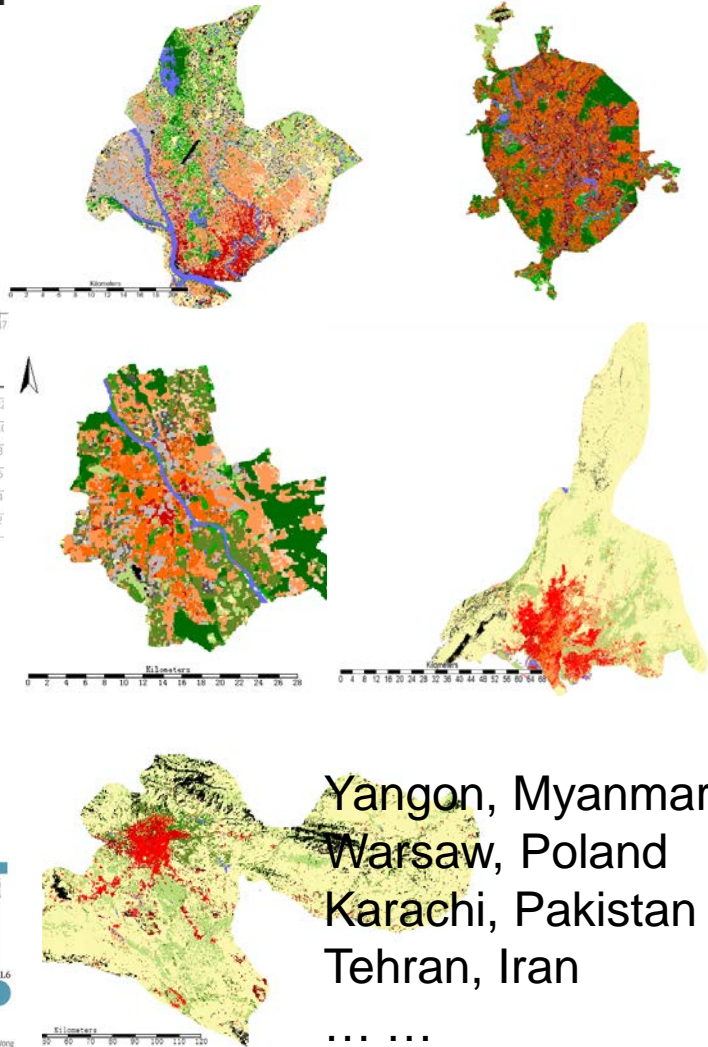
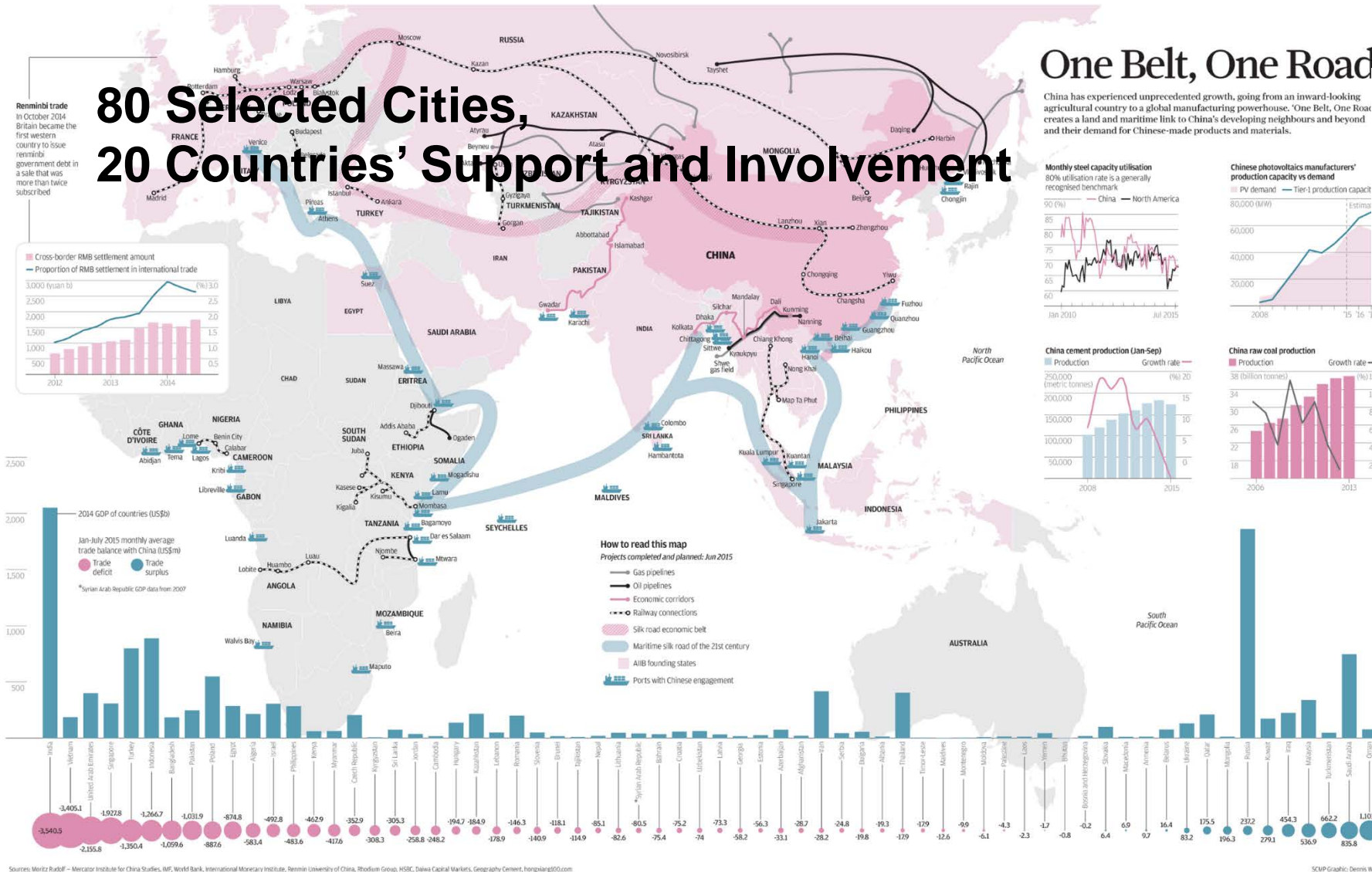
Collaboration with the Chinese Academy of Sciences

One Belt, One Road

China has experienced unprecedented growth, going from an inward-looking agricultural country to a global manufacturing powerhouse. 'One Belt, One Road' creates a land and maritime link to China's developing neighbours and beyond and their demand for Chinese-made products and materials.



80 Selected Cities, 20 Countries' Support and Involvement



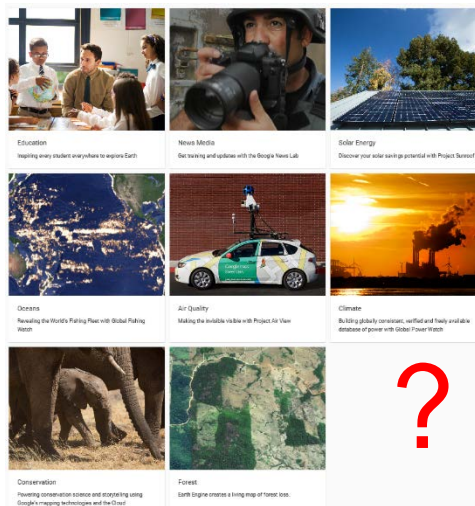
Collaboration between **WUDAPT** and **Google** Earth Engine

The Development of Global WUDAPT Level 0 Data

WUDAPT's innovative method, technologies and expertise + Google (data mining+ satellite images resources+ online system)

A Special Project of Google Earth Outreach

Google Earth Outreach



A New Urban Database in Google Earth Engine Catalog



Landsat
4, 5, 7, and 8



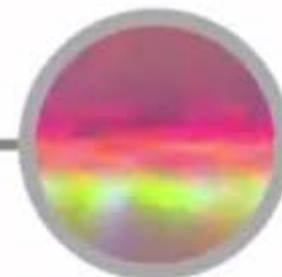
MODIS
Daily, NBAR, etc.



Terrain
SRTM, NED, etc.



Land Cover
GlobCover, NLCD, etc.



Atmospheric
NOAA NCEP, etc.

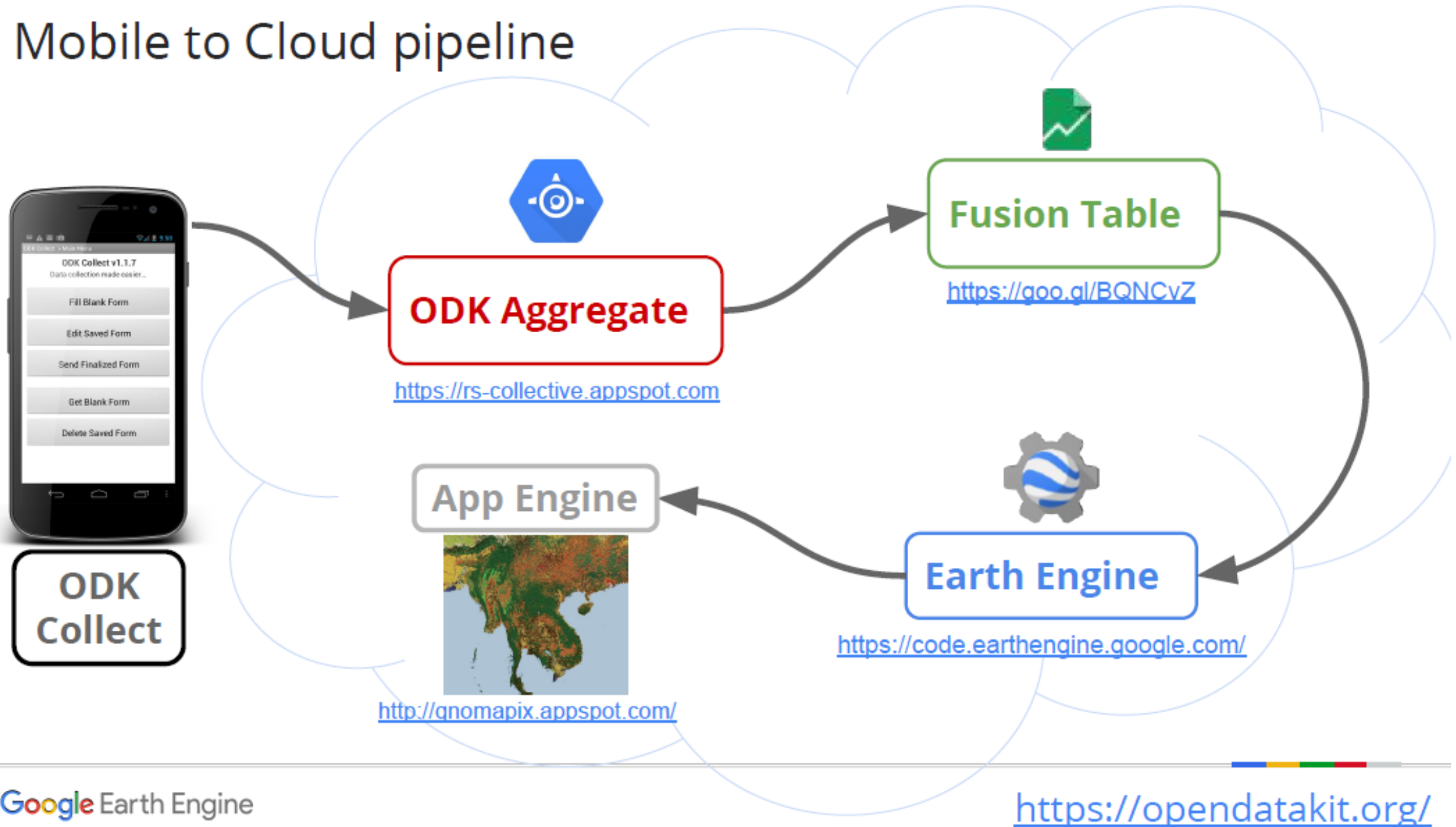
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Urban Morphology

The Development of Global WUDAPT Level 1+2 Data

Mobile to Cloud pipeline



GeoODK (Field-based app)

Crowdsourcing Data Collection Tools

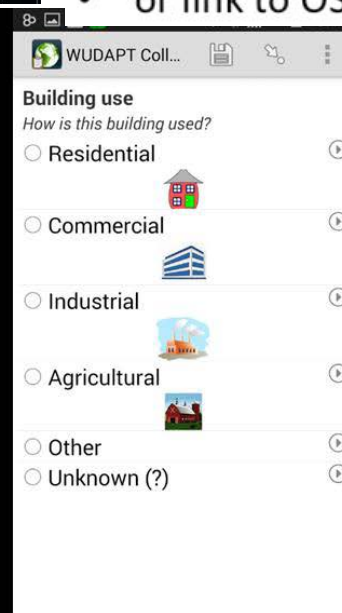
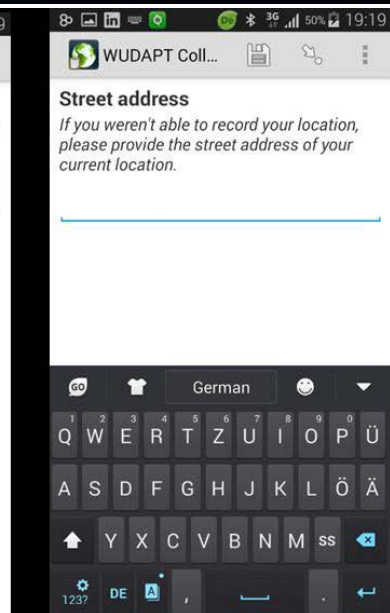
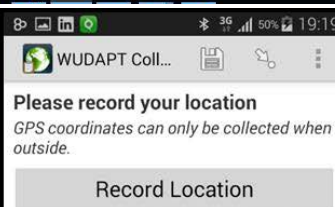
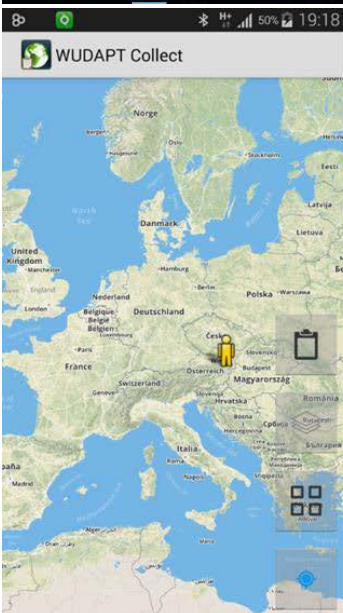
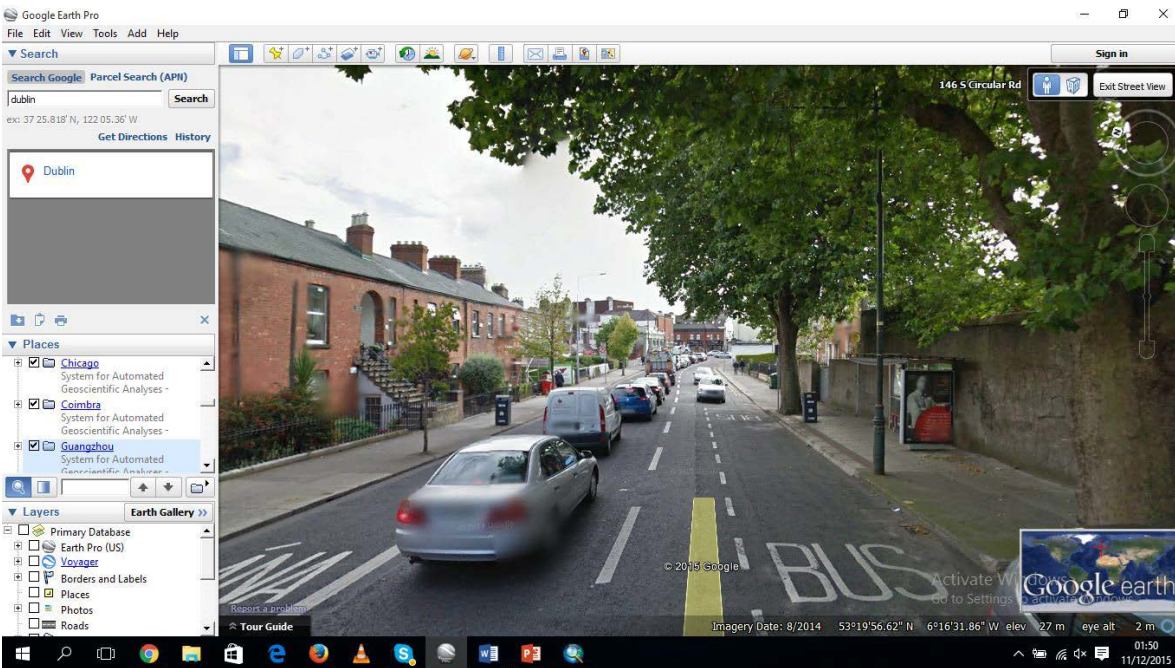
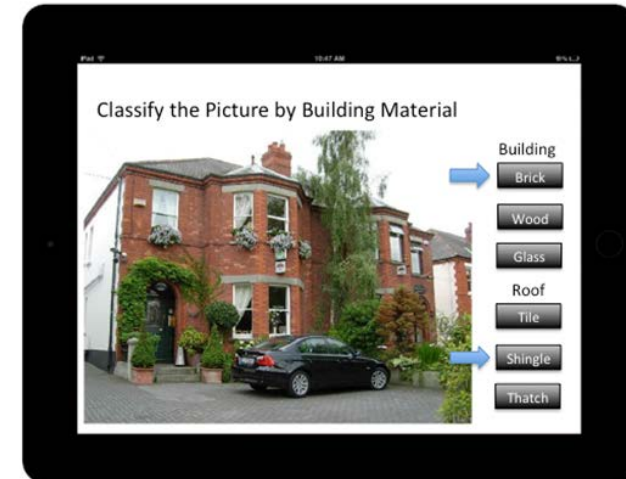
- Geo-Wiki / LACO-Wiki
- Geopedia
- Geo-Wiki Pictures
- Cropland Capture / Picture Pile
- FotoQuest Go
- GeoODK
- Bespoke website for entering data
- or link to OSM

- Q:
- How City specific?
 - Vegetation type?
 - Building age?
 - Socio Economic?



App to Gather Information from Photos: Type 1

- Geotagged pictures from different sources (e.g. Flickr, crowdsourcing, Streetview)
- User would identify building materials and roof types
- Automatic translation to UCPs for each LCZ
- App could also be used to take pictures and classify buildings and roof materials



The Development of Historical Urban Data using Google Earth Timelapse Technology

Carnegie Mellon
CREATE Lab



TIMELAPSE

Watch the world change over the course of nearly three
decades of satellite photography

Pictured: The megacity of Dubai grows in the desert, from 1984 to today

Roadmap of WUDAPT Global Initiative Project



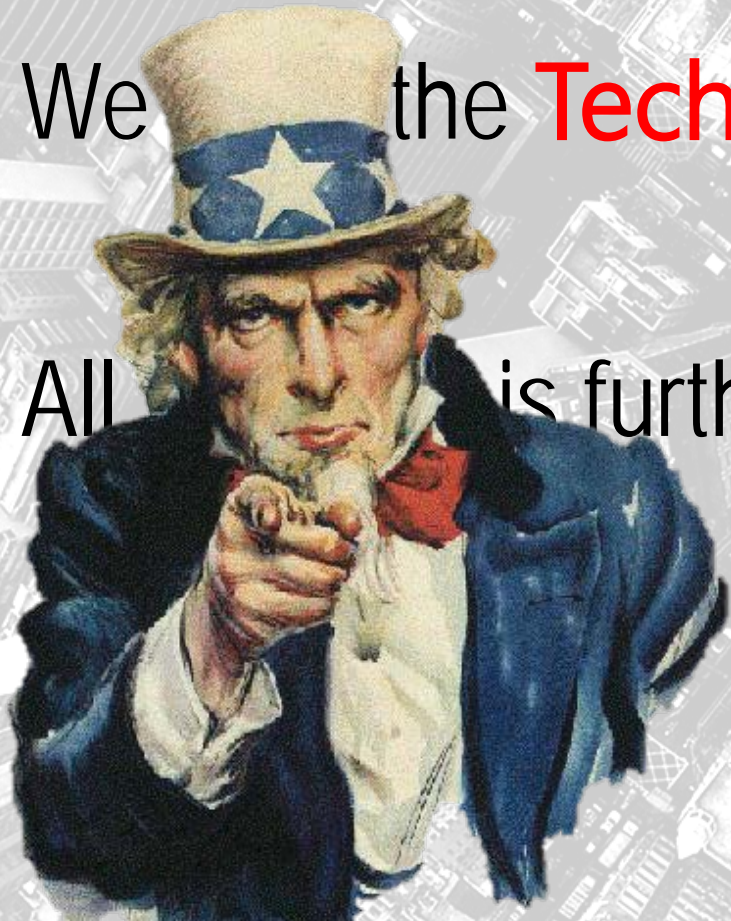
Data Science in Time, Data Science in Space

We have an **Idea**.

We have the **Technology** and we have the **Team**

All we need is further **Collaborations** and **Resources**

Will **YOU** join us?





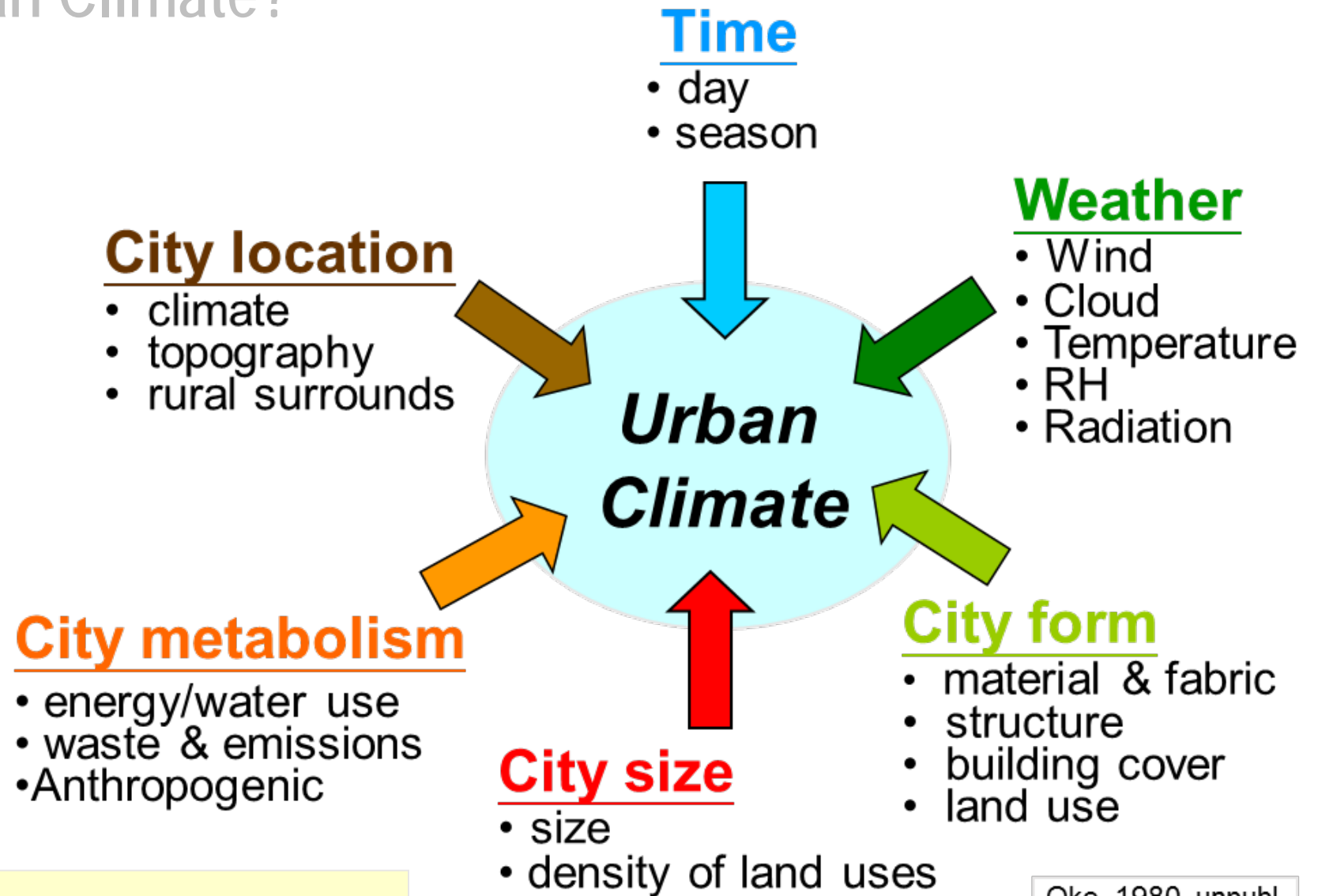
www.wudapt.org

Thanks. Any Questions?

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What influences Urban Climate?



‘Fixed’ – Location

‘Modulators’ – Time, Weather

‘Manageable’ (policy, **planning**, design) – **Size**, **Form**, Metabolism

Oke, 1980, unpubl.