WUDAPT

World Urban Database and Access Portal Tools

—an International Collaborative Project for Climate Relevant Physical Geography Data for the World's Cities

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TJ15.4: Understanding Urban Growth and Climate Variability Impacts on Health, Adaptation, and Resilience: Part 3

WUDAPT.ORG

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Setting the Stage

- **Majortiy of Population in Urban areas, urban growth,** and rates of urbanization and industrialization differ geographically
- **Climate change is here**, significant changes but impacts and risks differ geographically
- **Fit-for purpose modeling**,
  - Scale (grid size) dependent science requires commensurate scale-dependent data inputs.
  - **Powerful tools for myriad of applications (including National WX readiness),**
  - Many are **open community-based** modeling systems. e.g.,
    - WRF (20,000 downloads worldwide) Mesoscale Wx modeling
    - CMAQ (7000 users) Community Multiscale Air Quality modeling

- **WUDAPT Goal: To provide data and infrastructure to support urban canopy model applications on worldwide bases; no such prior supporting database exists.**

WUDAPT

WORLD URBAN DATABASE AND ACCESS PORTAL TOOLS

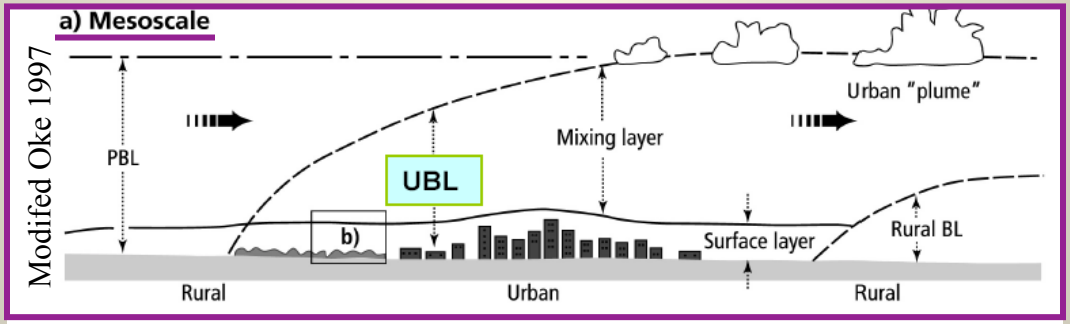
- **Acquire and make accessible** coherent and consistent descriptions and information on aspect of **FORM** and **FUNCTION** of cities relevant to climate studies on **WORLDWIDE** bases.

- **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.

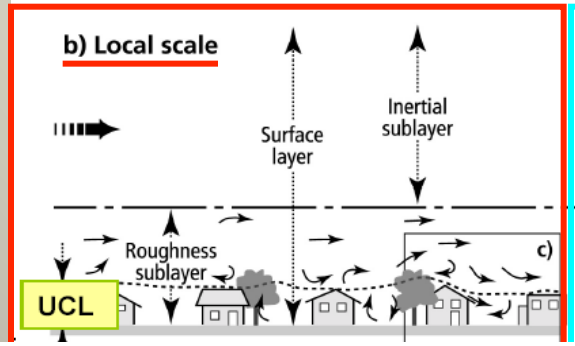
WUDAPT considers variety of Scales and Forms that impacts Meso-urban boundary layers, weather and climate simulations

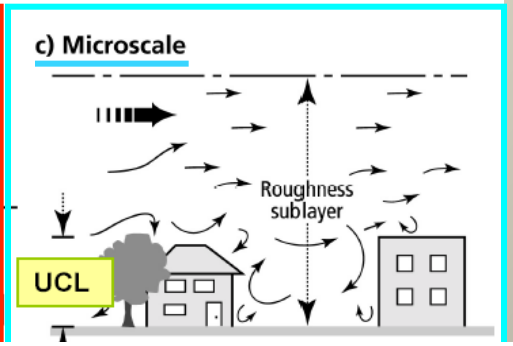
Slide courtesy of Grimmond


Chicago




Gothenburg



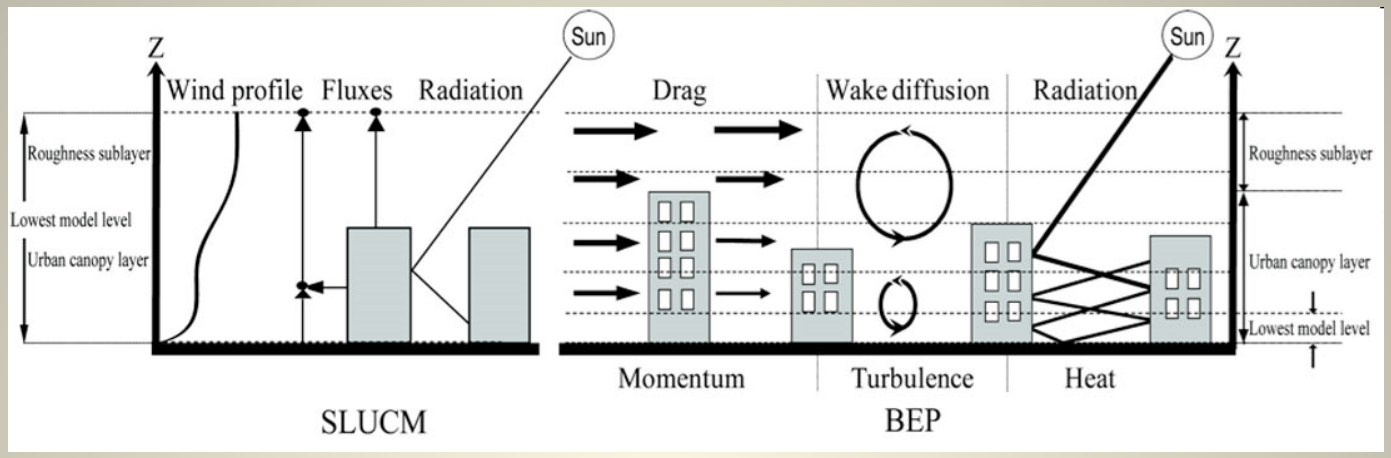



Bremen


Chicago

Scales

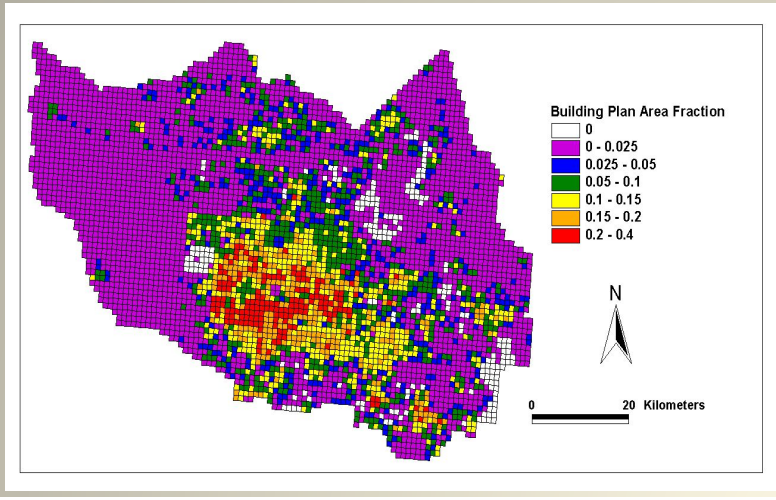
Models embody urban climate knowledge

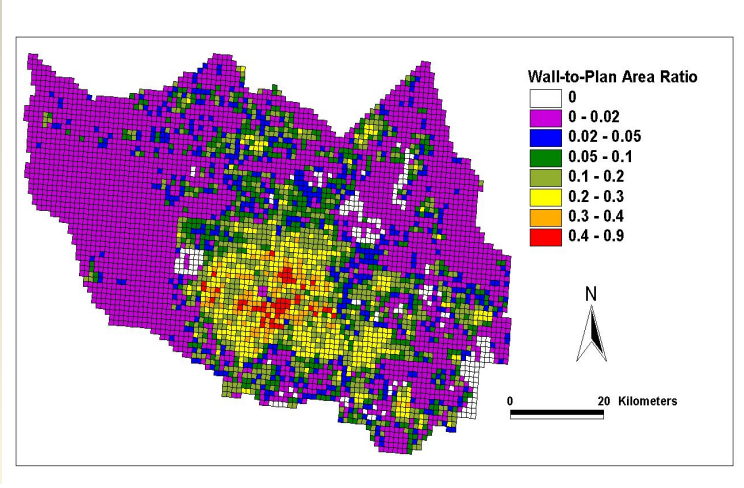


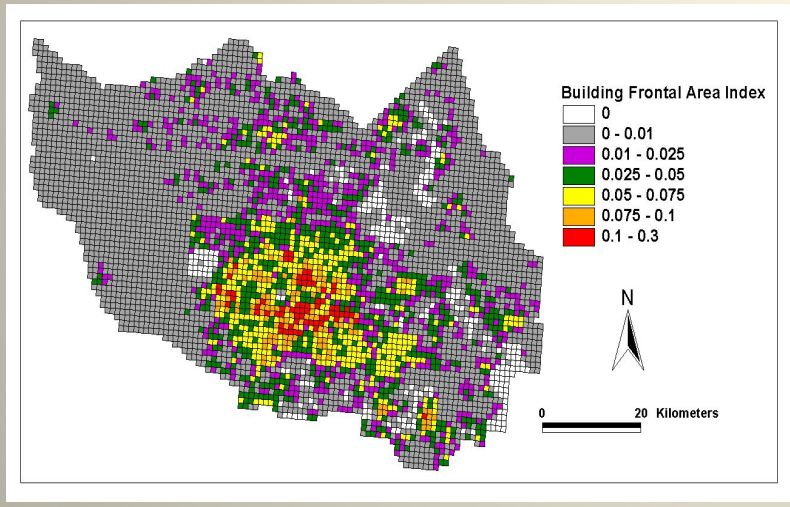
CANOPY UCPs	**BUILDING UCPs**	**VEGETATION, OTHER UCPs**
		Mean vegetation height
Mean canopy height	Mean Height	**Vegetation plan area density***
Canopy plan area density*	Std Dev of heights	**Vegetation top area density***
Canopy top area density*	Height histogram	**Vegetation frontal area density***
Canopy frontal area density*	Wall-to Plan area ratio	
Roughness Length	Height to width ratio	**Mean Orientation of Streets**
Displacement height	Plan area density*	Plan area fraction surface covers
Sky View Factor	Rooftop area density*	**% connected impervious areas**
	Frontal area density*	Building material fraction
*computed as a function of height (1-m increments)		

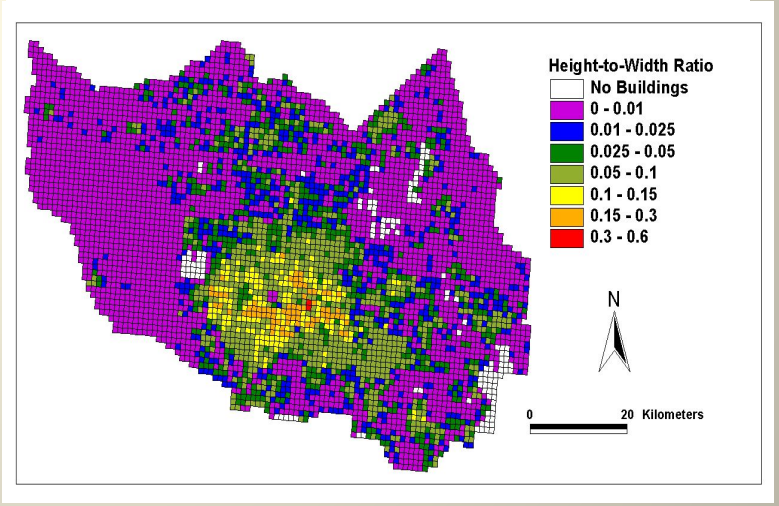
NUDAPT: Ching et al., BAMS 2009

Goal: Generate city-wide gridded UCPs for the world









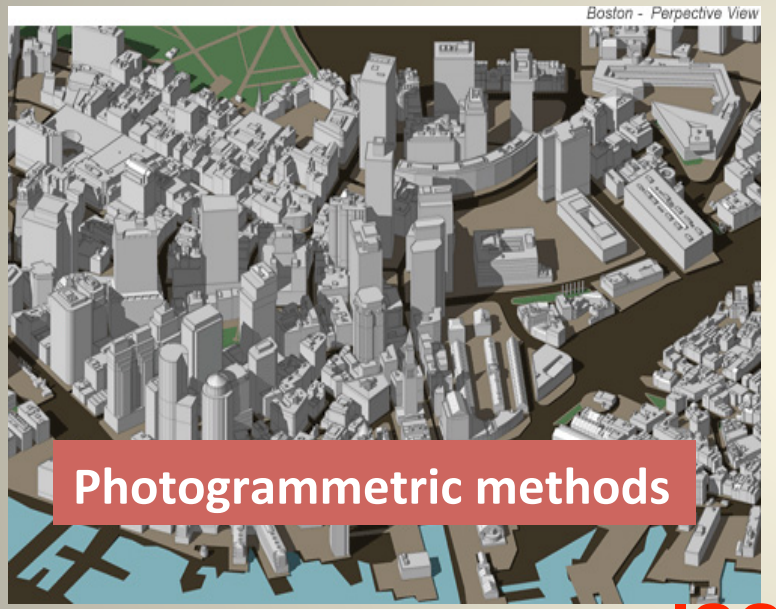
Urban Canopy Parameters per 1 km^2 cells.

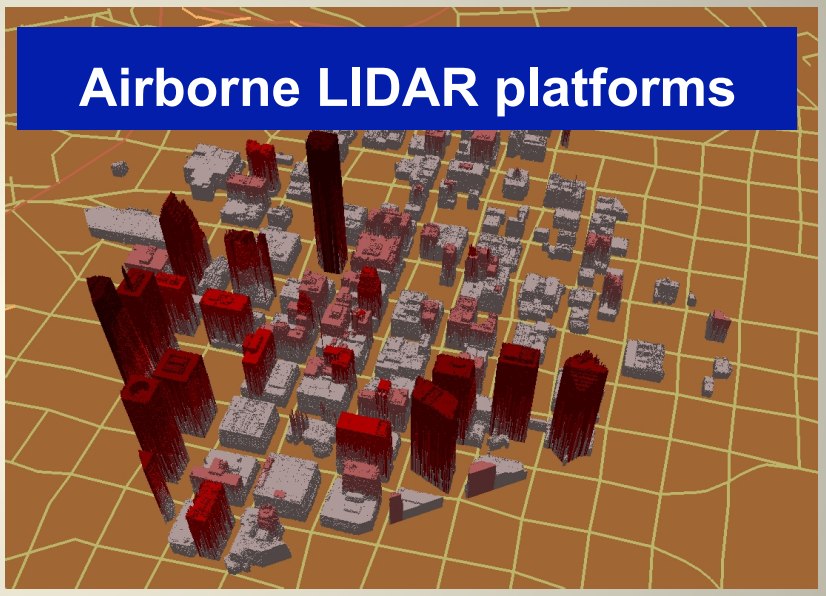
NOTE! Each grid cell has unique combination of gridded UCPs

NUDAPT: Ching et al., BAMS 2009

Task: Obtaining morphology data for world's cities

High resolution (meter scale) building data are technologically and operationally feasible to obtain; datasets are becoming increasingly more available and affordable. Such data provide the bases for advanced contemporary grid modeling and for each specific urban area.





ISSUES:

Data relatively expensive to obtain and process
Static (Cities evolve)
Material composition of morphology features needed
Limited areal coverage in current NUDAPT database

WUDAPT's acquisition STRATEGY is geared to be TIMELY & WORLDWIDE in converage

Increasing detail

Level 2

- Detailed description of urban landscape parameters at a scale suited to boundary-layer models
- Use of all available databases (e.g. building footprints)

Level 1

- More precise parameter values for each LCZ
- Focus on aspects of form (e.g. building heights, street width) and functions (e.g. building use).
- Sampling of LCZ using GeoWiki

Level 0

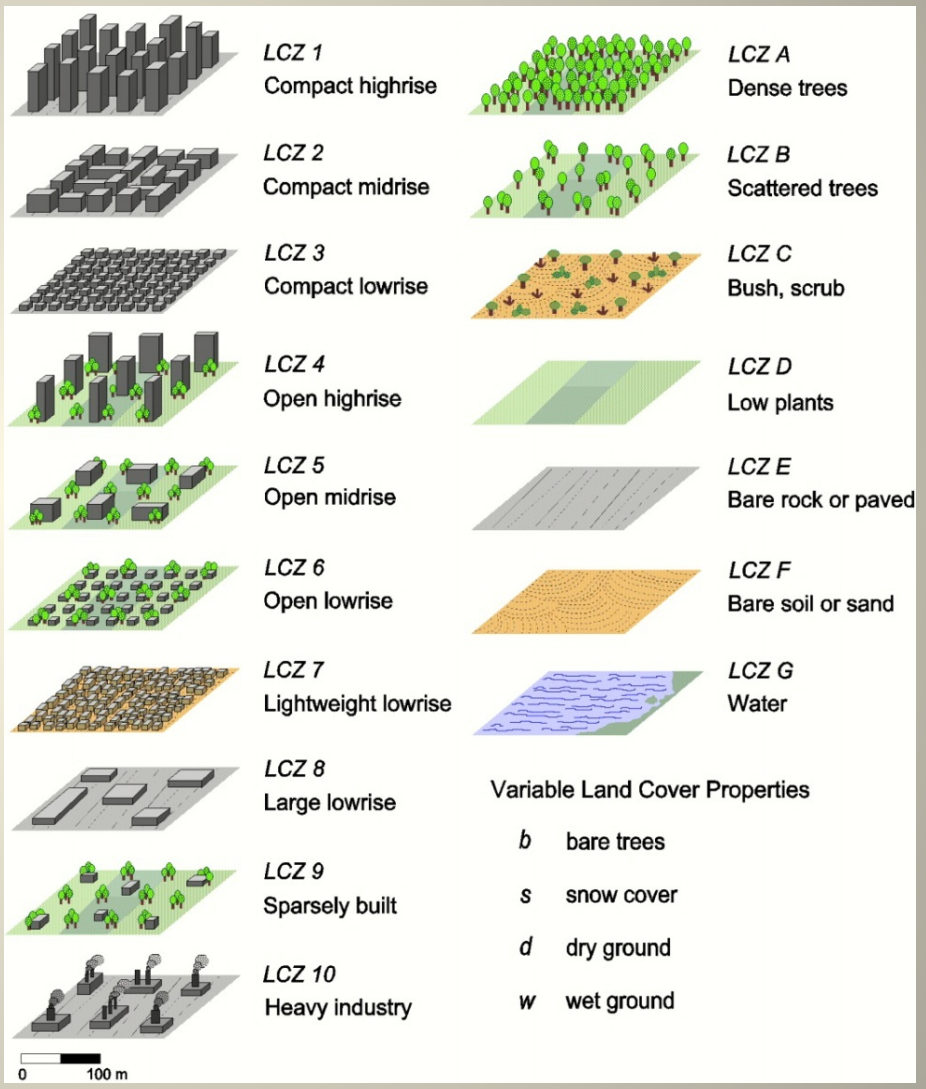
- Local Climate Zones (LCZ) along with parameter ranges
- Categorise city neighbourhoods into LCZ types
- Local experts provide training areas
- GoogleEarth, Landsat8 and Saga

Level 0 paradigm based on **LOCAL CLIMATE ZONES** (Stewart and Oke 2013)

Simple **urban and rural distinctions have little value** for describing urban and natural/managed landscapes and their effects.

The absence of a lexicon that is universal in nature has proved a major obstacle to compare results from city to city and allow communication urban climatologists.

The ***Local Climate Zone*** approach developed by Iain Stewart and Tim Oke builds on other approaches and provides a classification scheme for urbanised and natural landscapes that can be used to ***describe neighbourhoods*** within cities.



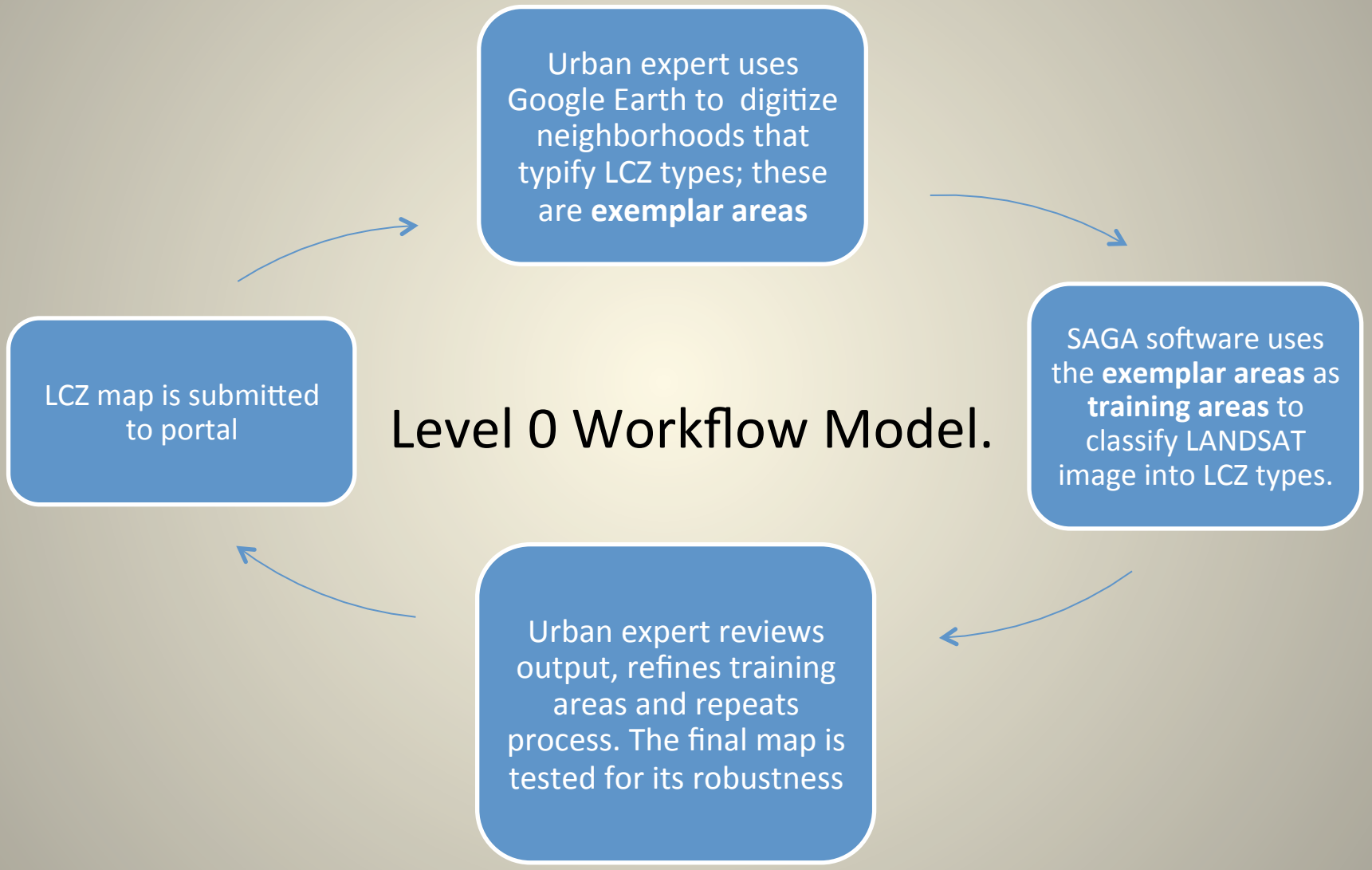
KEY to modeling!

Each LCZ type has associated **Tables with range** of **urban canopy parameter values**

LCZ Type	SVF	Canyon Aspect Ratio (H/W)	Mean Height (m)	Terrain Roughness Class	Building Surface Fraction	Impervious Surface Fraction	Pervious Surface Fraction	Surface Albedo	QF (Wm^{-2})
1	0.2- 0.4	>2	>25	8	40-60%	40-60%	<10%	0.10-0.20	50-300
2	0.3-0.6	0.75-2	10-25	6-7	40-70%	30-50%	<20%	0.10-0.20	<75
3	0.2-0.6	0.75-1.5	3-10	6	40-70%	20-50%	<30%	0.10-0.20	<75
4	0.5-0.7	0.75-1.25	>25	7-8	20-40%	30-40%	30-40%	0.12-0.25	<50
5	0.5-0.8	0.3-0.75	10-25	5-6	20-40%	30-50%	20-40%	0.12-0.25	<25
6	0.6-0.9	0.3-0.75	3-10	5-6	20-40%	20-50%	30-60%	0.12-0.25	<25
7	0.2-0.5	1-2	2-4	4-5	60-90%	<20%	<30%	0.15-0.35	<35
8	>0.7	0.1-0.3	3-10	5	30-50%	40-50%	<20%	0.15-0.25	<50
9	>0.8	0.1-0.25	3-10	5-6	10-20%	<20%	60-80%	0.12-0.25	<10
10	0.6-0.9	0.2-0.5	5-15	5-6	20-30%	20-40%	40-50%	0.12-0.20	>300
A	<0.4	>1	3-30	8	<10%	<10%	>90%	0.10-0.20	0
B	0.5-0.8	0.25-0.75	3-15	5-6	<10%	<10%	>90%	0.15-0.25	0
C	0.7-0.9	0.25-1	<2	4-5	<10%	<10%	>90%	0.15-0.30	0
D	>0.9	<0.1	1	3-4	<10%	<10%	>90%	0.15-0.25	0
E	>0.9	<0.1	<0.25	1-2	<10%	>90%	<10%	0.15-0.30	0
F	>0.9	<0.1	<0.25	1-2	<10%	<10%	>90%	0.20-0.35	0
G	>0.9	<0.1	N/A	1	<10%	<10%	>90%	0.02-0.10	0

For each City, LANDSAT scenes are compiled

The Urban Expert is someone who knows the city under study.
All of the tools developed are free to use.



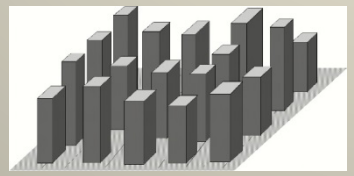
Example: CLASSIFYING LCZs

LCZ 1: Compact high-rise

Sendai, JAPAN

Visual Clues
Few if any trees
Little or no green space
Tightly packed buildings
10+ stories tall

Diurnal temperature range: **small** medium large

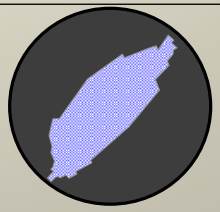


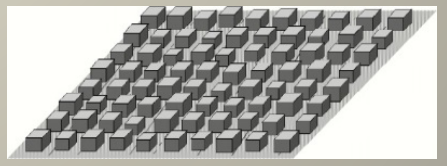
LCZ 3: Compact low-rise

Medellin, COLOMBIA

Visual Clues
Few if any trees
Little or no green space
Tightly packed buildings
1 – 3 stories tall

Diurnal temperature range: small **medium** large





Source:
Iain Stewart.

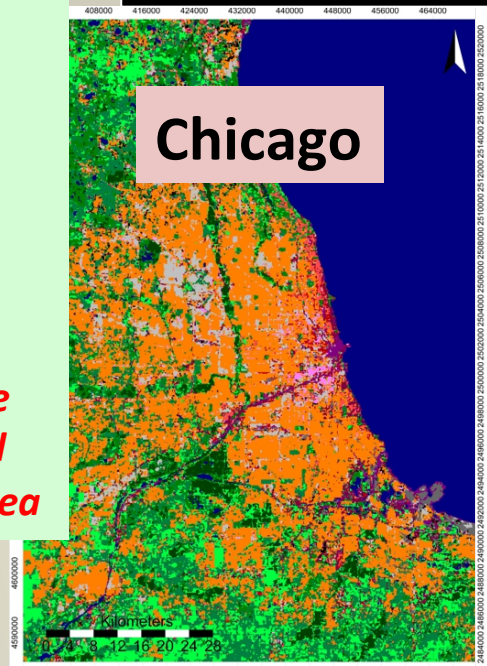
16 cities WUDAPT Level "0" generated at 2014 Workshop in Dublin Ireland

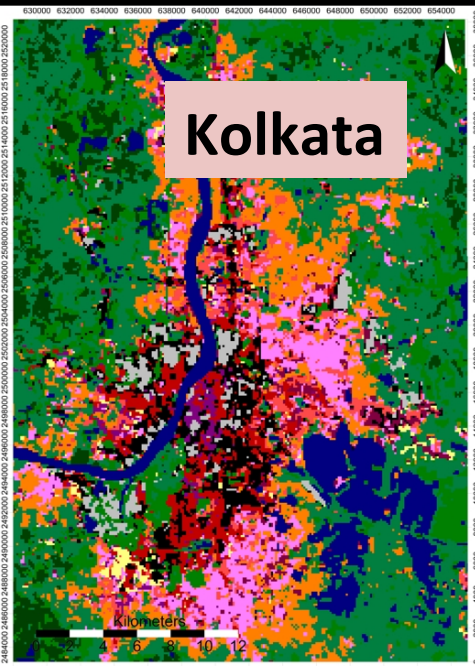
Rich diversity and complex distributions of climate zones observed within each city

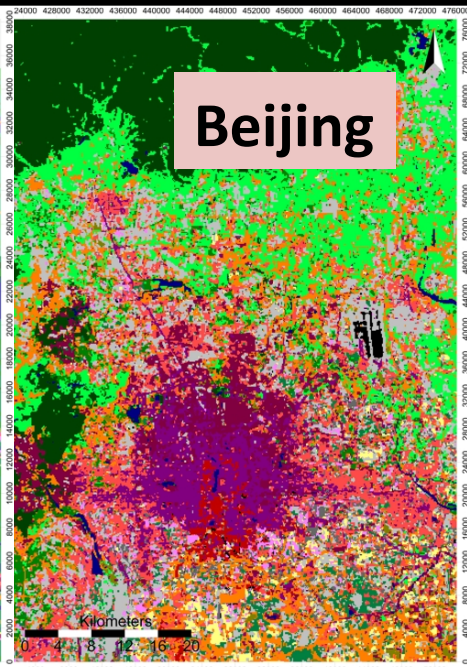
LCZ signature palate different and unique to each city

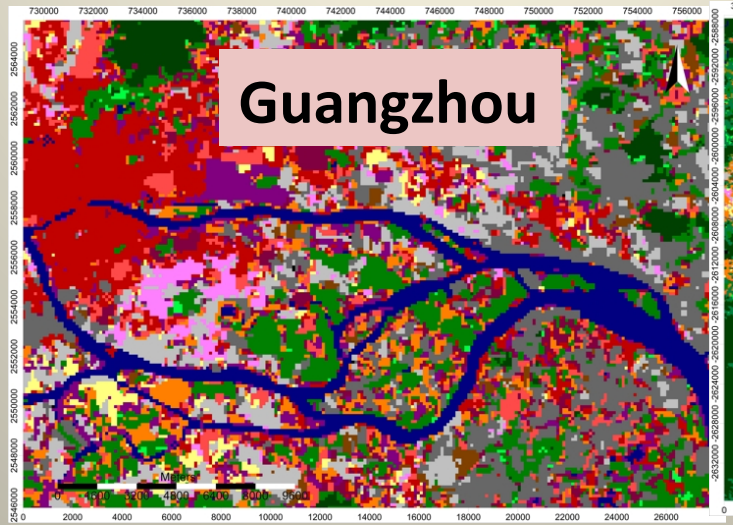
Distributions of "Form and Function" modeling parameters produce unique climate and meteorological responses to each urban area

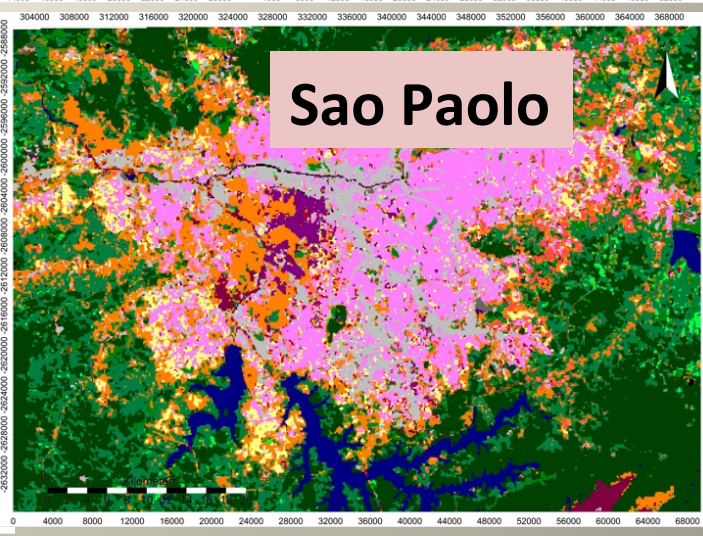
LCZ Classes- Each urban area is unique











LCZ Classes

Each city displays a different (UNIQUE) characteristic distribution of LCZ classes

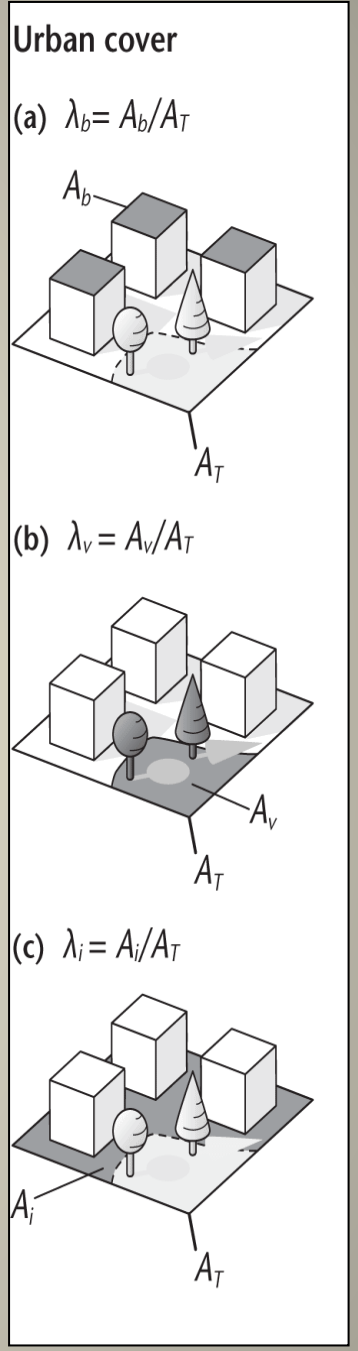
LCZ	Bei	Chi	Col	Dub	Kol	Kua	Mil	Sao	Van
Compact high-rise	18.2	7.4	1.5	2.3	4.5	8.2	0.0	9.0	3.6
Compact mid-rise	5.7	2.4	28.7	8.5	14.1	2.2	20.2	1.2	0.8
Compact low-rise	2.8	3.9	13.3	3.6	14.6	18.6	0.2	11.3	9.5
Open high-rise	17.9	6.0	6.2	0.1	7.9	15.7	5.6	6.0	10.4
Open mid-rise	14.4	3.5	9.8	5.3	7.6	10.0	18.8	4.3	5.9
Open low-rise	12.4	30.9	28.1	31.5	12.4	14.4	13.2	25.3	22.2
Lightweight low-rise	6.0	0.0	0.9	0.0	0.6	0.6	0.0	4.3	0.0
Large low-rise	14.9	13.0	11.5	44.7	9.2	10.6	19.9	18.8	14.8
Sparsely built	4.1	19.7	0.0	0.0	29.1	13.7	22.1	16.7	32.8
Heavy industry	3.8	13.3	0.0	4.0	0.0	6.0	0.0	3.1	0.0
Kappa	0.90	0.91	0.64	0.82	0.62	0.73	0.84	0.82	0.89
Total area	3406	3479	338	2396	622	1406	1630	4141	1408

A preliminary comparison of the LCZ make-up of 12 cities (Bei – Beijing, Chin; Chi – Chicago, US; Col – Colombo, Sri Lanka; Dub – Dublin, Ireland; Kol – Kolkata, India; Kua – Kuala Lumpur, Malaysia; Sao – Sao Paolo, Brazil and; Van – Vancouver, Canada. The kappa value is a measure of accuracy and Total Area is expressed in terms of satellite cell number (each cell is 120m on a side).

Dublin: Level 0 (LCZ) and 1 (Geowiki)

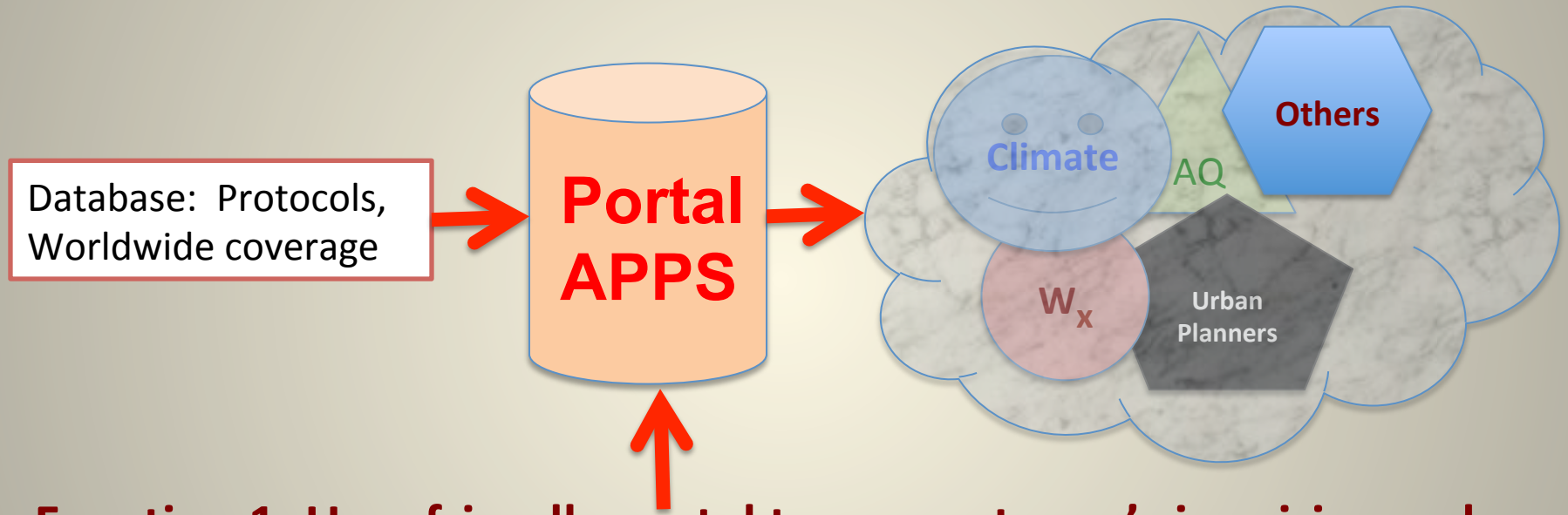
LCZ	Level 1 data experiment			Stewart & Oke 2012		
	λ_V	λ_b	λ_I	λ_V	λ_b	λ_I
Compact high-rise	10.5	42.4	47.1	<10	40-60	40-60
Compact mid-rise	11.3	43.9	43.7	<20	40-70	30-50
Compact low-rise	17.6	36	45.1	<30	40-70	20-50
Open high-rise	25.9	24.3	48.9	30-40	20-40	30-40
Open mid-rise	39.1	19.8	36.8	20-40	20-40	30-50
Open low-rise	39.4	22.2	38.1	30-60	20-40	20-50
Sparsely built	62.3	11.5	24.9	60-80	10-20	<20

The plan fraction (%) of vegetation (λ_V), buildings (λ_b) and impervious (λ_I) surface for the Dublin urban area based on a Geowiki application and the ranges from Stewart and Oke (2012)



Conceptual Design Functionalities of WUDAPT

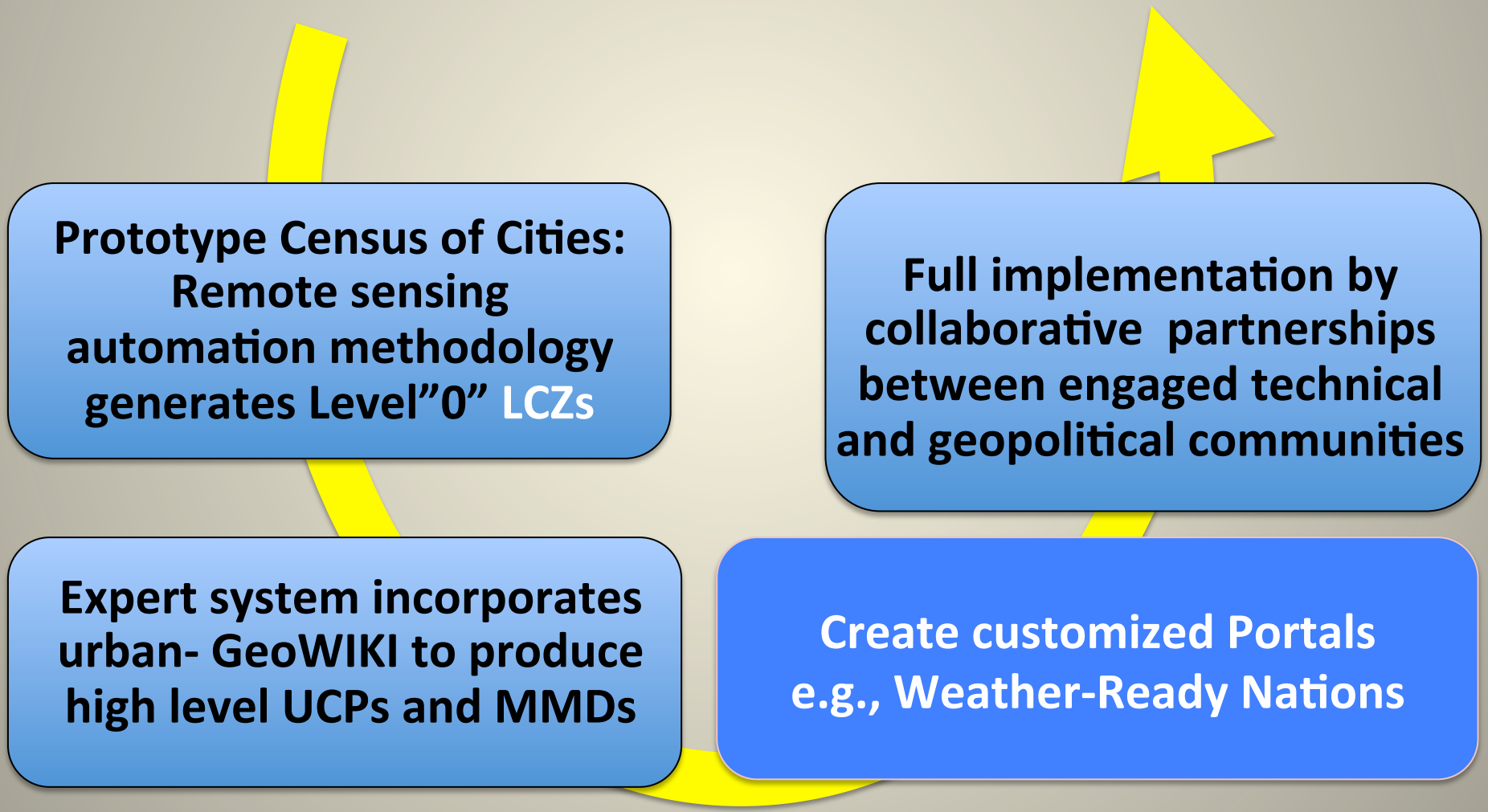
- **Open source** community framework
- **Worldwide coverage** of urban areas, all climate zones



- **Function 1: User friendly portal to support user's inquiries and search inclusive of structured and unstructured information and supporting metadata- Ingestible to variety of user communities**
- **Function 2: Custom applications keyed to addressing variety of community needs**

WUDAPT's critical elements

Prototype Census of Cities and Collaborative Partnerships



Proof of Concept: Example of a WUDAPT Portal:

Processing WUDAPT Level "0" data to running WRF –Urban the case for Madrid, Spain

LCZ maps obtained by WUDAPT

120m Resolution

Closest pixel value

Fortran

Using *Stewart ID & Oke TR, 2012* supplement for Urban Fraction, Building & Roads Width and Heights

Using *Stewart ID, Oke TR & Scott E, 2014* for Building & Roads Heat Capacity and Thermal Conductivity

LCZs Values are 31-40 (31=LCZ1) Other classes 1-30 are from MODIS

New Land Use Index in WPS

333m Resolution

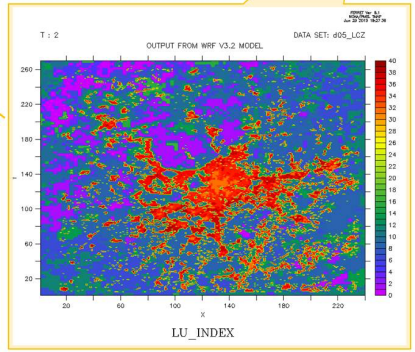
URBPARM.TBL

Running the WRF model

Statistical verification

LCZs dependent results

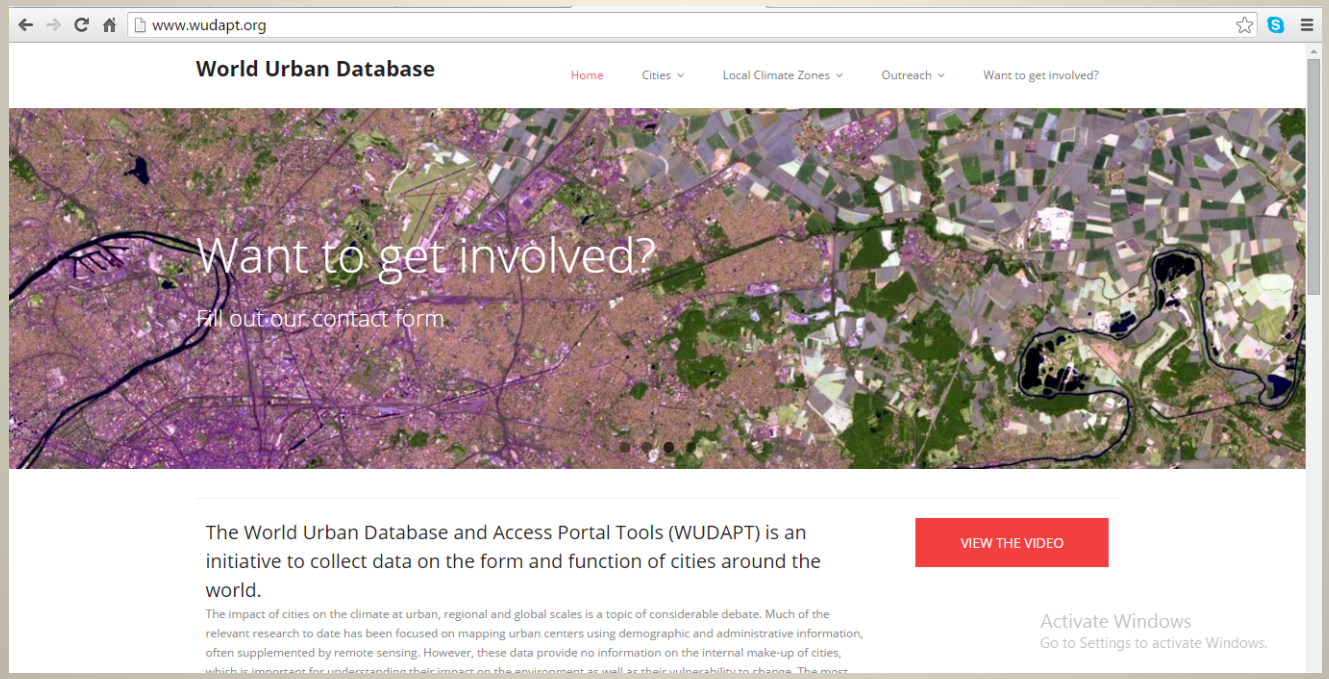
Needing supplementary datas for BEP-BEM (Roughness length, Capita/floor, Surface emissivity, Windows coverage ratio, AC system datas)
Assuming *Martilli A & Salamanca F , 2002/2010* values for now



Land Use of Madrid in WPS (Brousse O., 2015)

WUDAPT Developmental path

- 2011: ASI workshop in Hong Kong – initial discussion on the potential for a global database on cities.
- 2012: ICUC8 in Dublin furthered discussion on the urban data needs of the urban climate community.
- 2014: First workshop in Dublin on developing a protocol for creating WUDAPT
- 2015: Second Workshop in Toulouse
- 2015: Third workshop in Hong Kong



The WUDAPT project is outlined on www.wudapt.org. This site allows you to join the project and provides up-to-date information on its status.

Summary and Conclusions

- A global database of cities is needed that captures the character of urban landscapes and for modeling. It needs to be created quickly, given the pace of urbanization in Asia and Africa.
- The Level "0" approach described appears to be robust and the initial characterisation of large global cities will proceed using Landsat imagery. Work in progress currently on about 50 cities.
- Next step will be to gather more detailed information on cities using other techniques, including crowd-sourcing and using available data sources (e.g. based on building typologies, Google Streetview, open street map, etc.) Methodology developments now underway.
- Demonstrated Proof of concept using WUDAPT to run WRF (W2W!!

- **WUDAPT developed by and for the urban climate community and the results will be accessible for climate research and myriad of applications including national weather readiness, intraurban heat stress advisories**.

- **Momentum is building. Please Support and Join us.**