Edge Debate 86: Urban Form, Density & Microclimate – 13th November 2018

Improving Urban Meteorological Information for the Building Scale

Sue Grimmond[1], Ting Sun[1], Fredrik Lindberg[2],
Jie Xiong[1,3,4], Denise Hertwig[1], Yihao Tang[1],Runming Yao[3,4]

[1] Department of Meteorology, University of Reading [2] Gothenburg University
[3] School of the Built Environment, University of Reading [4] Chongqing University

Acknowledgements: EPSRC LoHCool, Met Office/Newton Fund CSSP- China, NERC AirPro, Numerous co-authors of Papers mentioned

Meteorological data

- Typical Meteorological Year: used to run Building Energy Models
- Data sources
  - Observations
  - Future – Climate models

- Feedbacks
  - e.g. Temperature
  - Form and Function
- Wind fields

Interdependent energy relationships between buildings at the street scale

Julie Futcher[a], Gerald Mills[b] and Rohinton Emmanuel[c]

BRI

RESEARCH PAPER

Energy use and height in office buildings

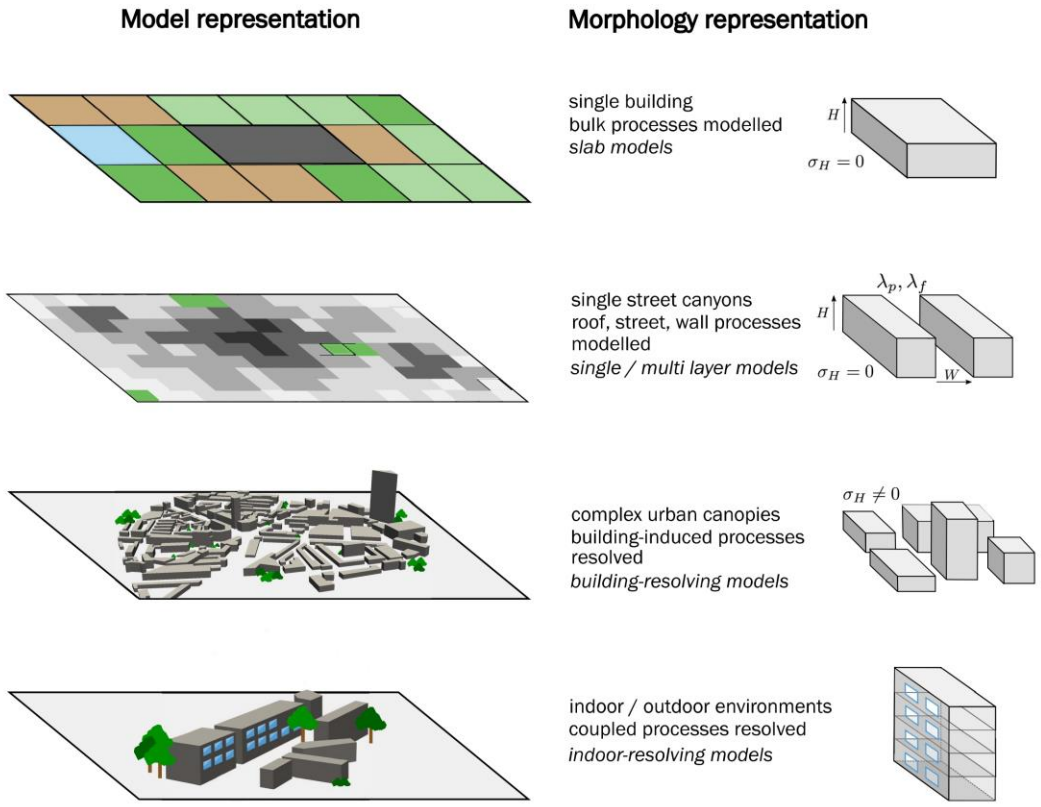
Daniel Godoy-Shimizu[a], Philip Steadman[a], Ian Hamilton[a], Michael Donn[b], Stephen Evans[a], Graciela Moreno[c] and Homeira Shayesteh[d]

Natural ventilation in cities: the implications of fluid mechanics

Jiyun Song[a,j], S. Fan[b], W. Lin[c], L. Mottet[d,j], H. Woodward[e], M. Davies Wykes[a], R. Arcucci[f], D. Xiao[d], J.-E. Debay[a], H. ApSimon[e], E. Aristodemou[g], D. Birch[c], M. Carpentieri[c], F. Fang[d], M. Herzog[h], G. R. Hunt[i], R. L. Jones[b], C. Pain[d], D. Pavlidis[d], A. G. Robins[c], C. A. Short[j] and P. F. Linden[a]

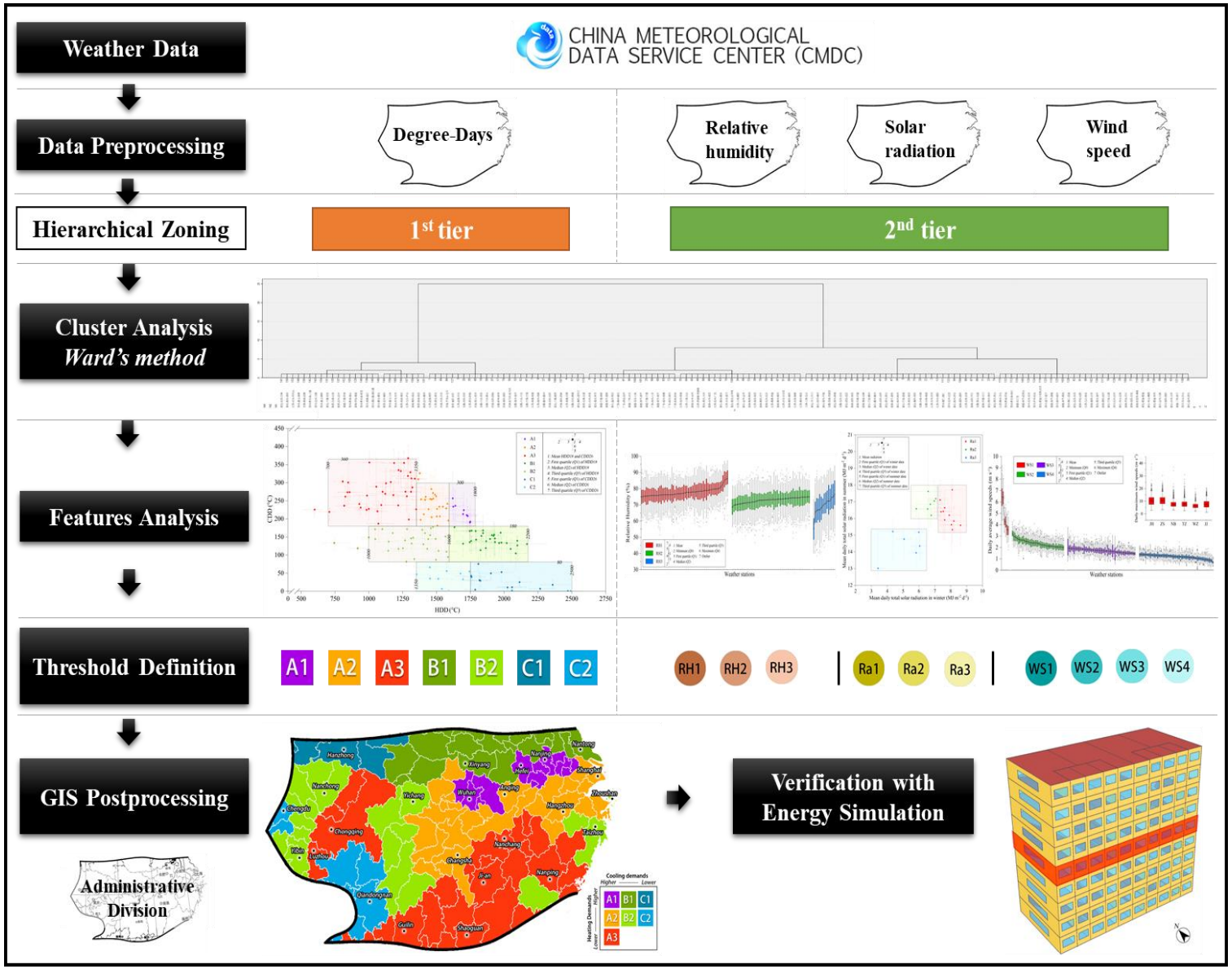
Challenges in the low-carbon adaptation of China's apartment towers

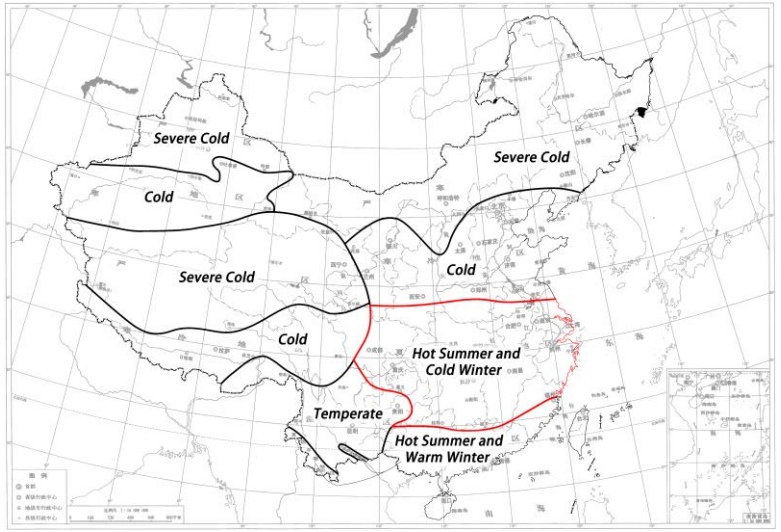
C. Alan Short[a], Jiyun Song[a,b], Laetitia Mottet[a,c], Shuqin Chen[d], Jindong Wu[d] and Jian Ge[d]



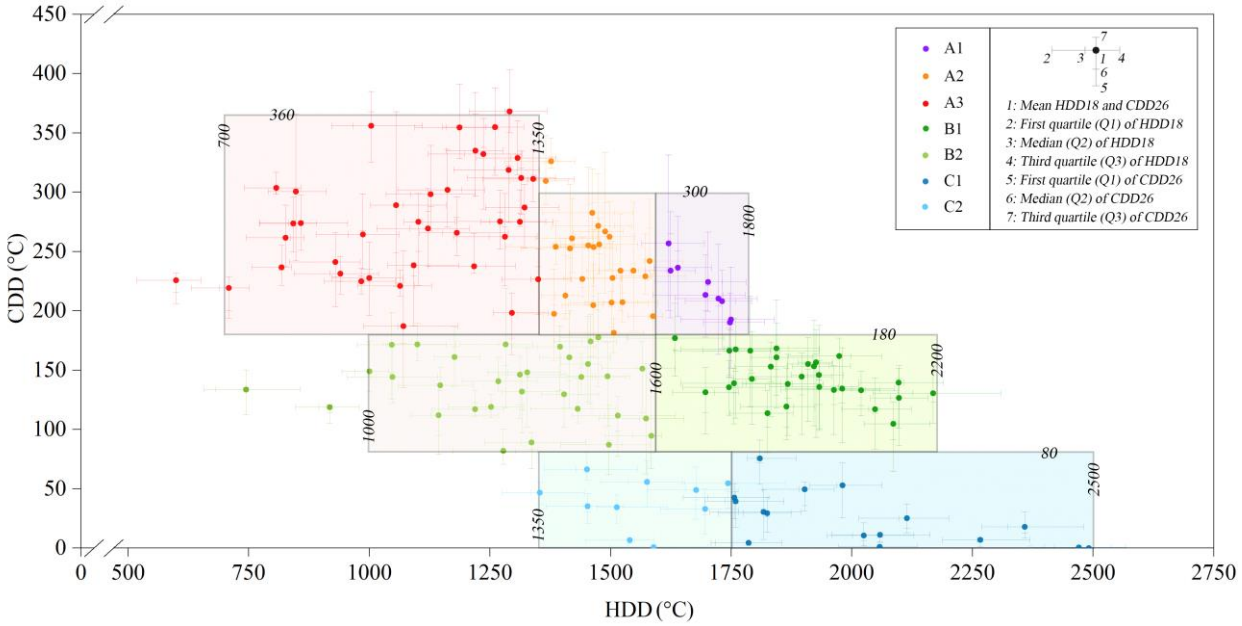
Hertwig et al. (in prep)

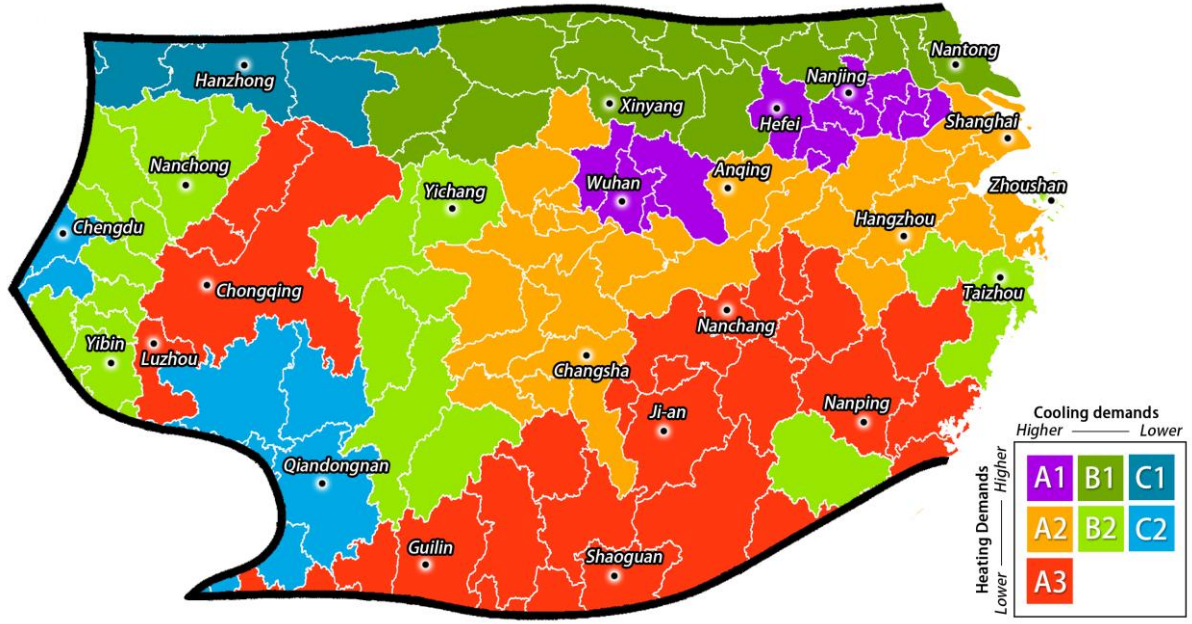
Hierarchical climatic zoning method for energy efficient building design

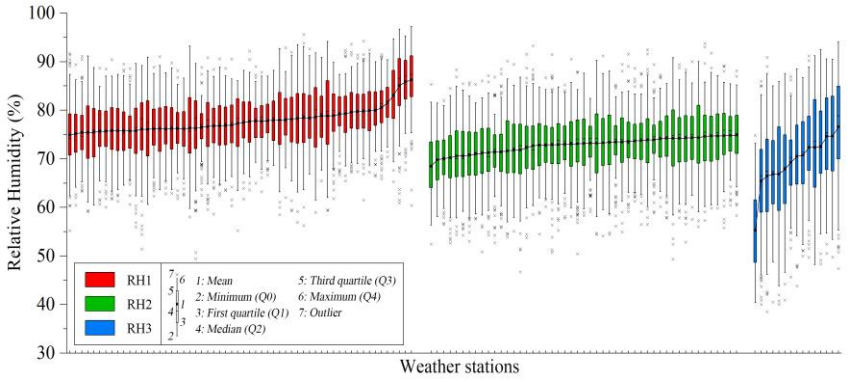


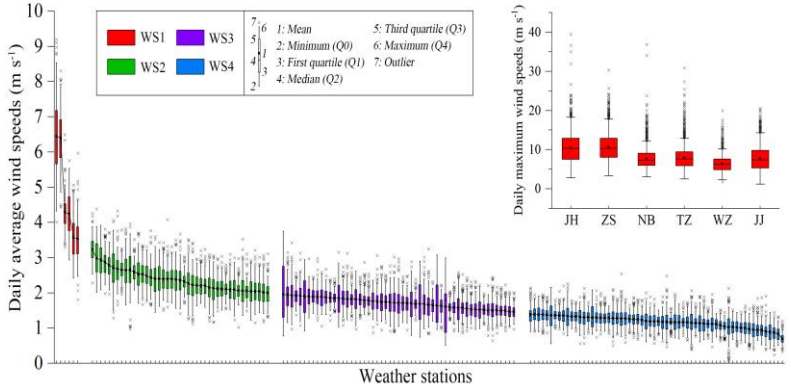


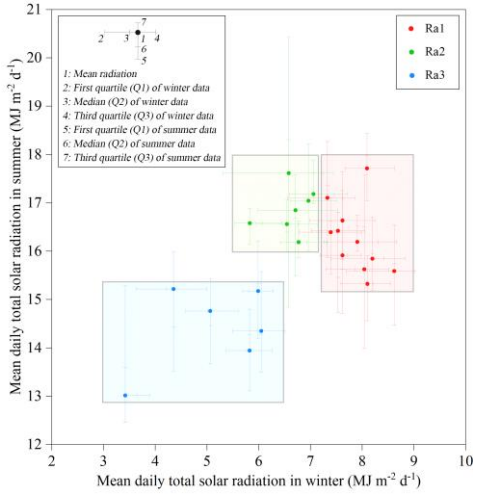
Xiong et al. (in review)





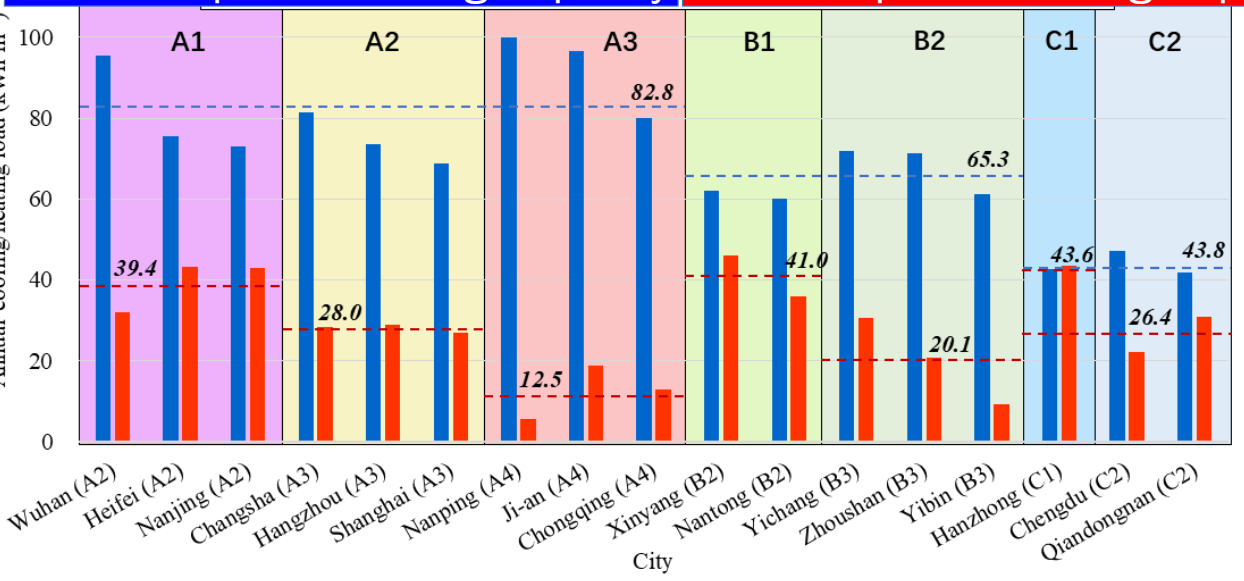


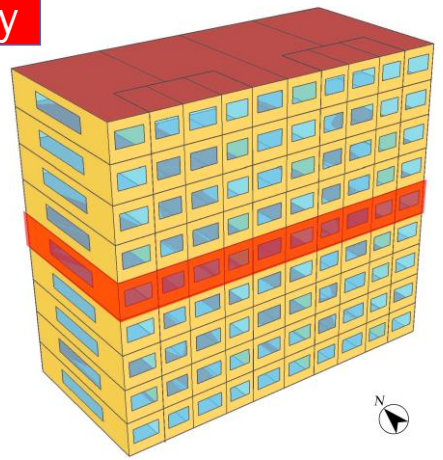


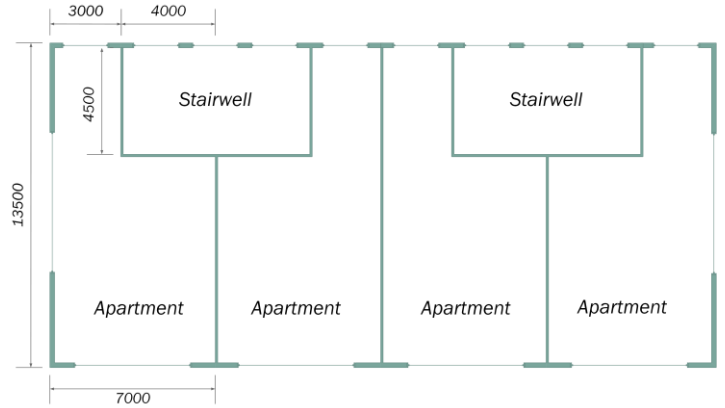


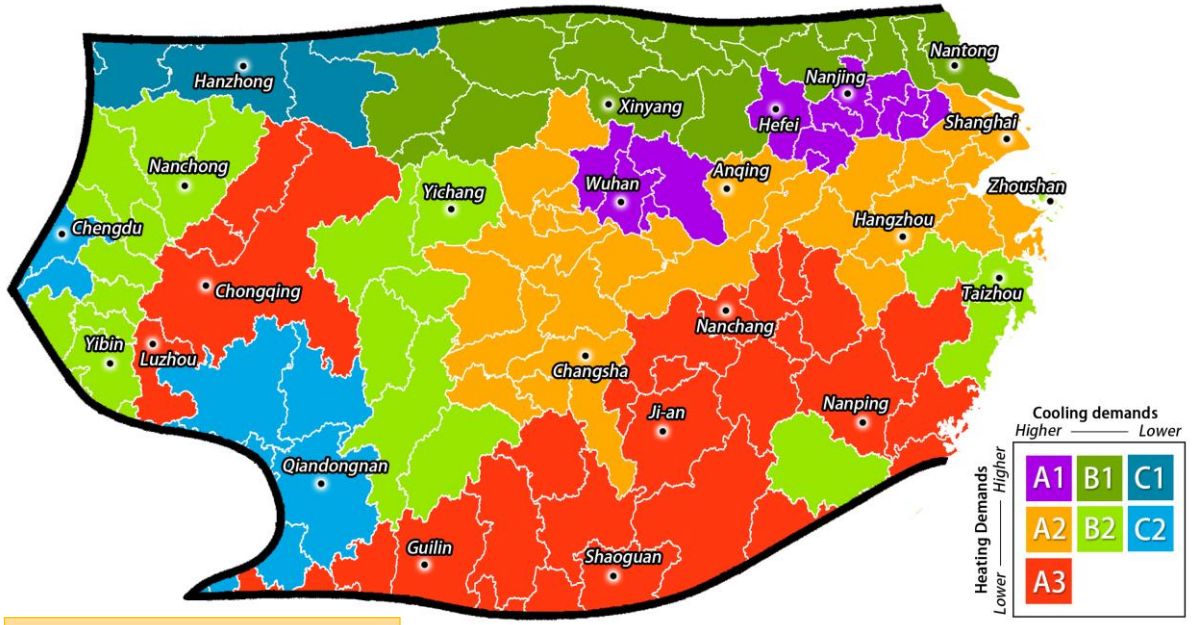
Xiong et al. (in review)

Annual required Cooling Capacity | Annual required heating Capacity







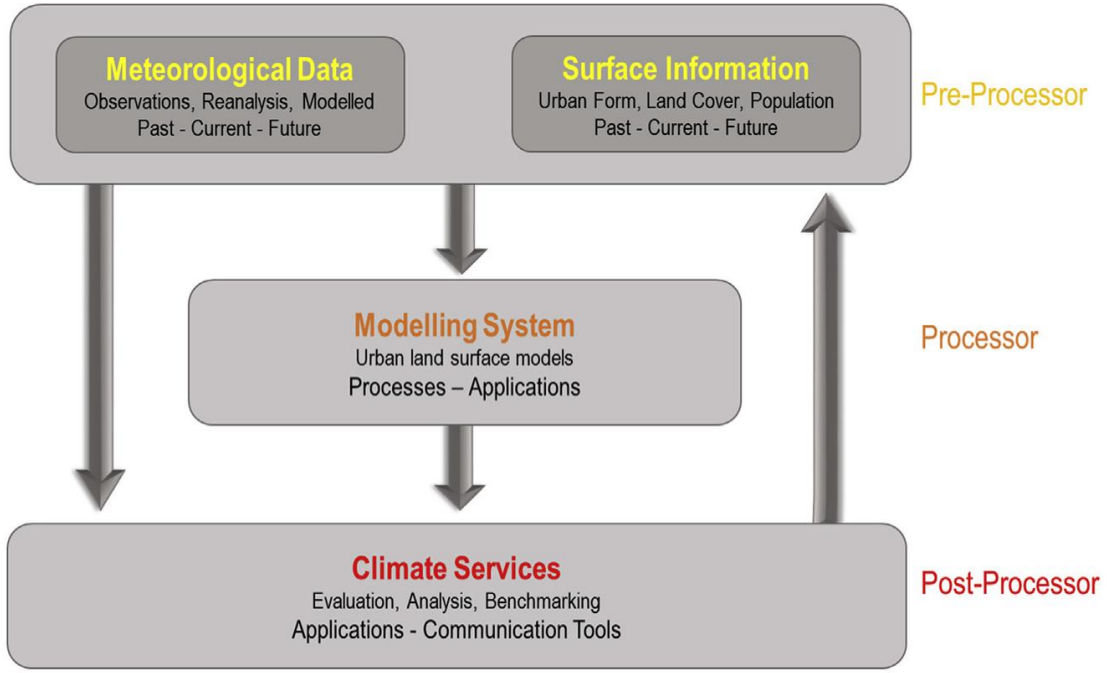


Xiong et al. (in review)

Sub-zone	Province	City	Humidity	Radiation	Wind	Cooling Load (kWh m^{-2})	Heating Load (kWh m^{-2})	Non-heating and cooling period (h)	Mean ± s.d. cooling load
A1	Hubei	Wuhan	RH1	Ra2	WS3	95.5	32.0	3044	82.8 ± 11.6
	Anhui	Hefei	RH2*	Ra1	WS2	75.6	43.3	3192	
	Jiangsu	Nanjing	RH2*	Ra1	WS2	73.1	43.0	3557	
A2	Hunan	Changsha	RH2	Ra2	WS2	81.5	28.2	3271	
	Zhejiang	Hangzhou	RH2	Ra1	WS2	73.6	28.8	3592	
	Shanghai	Shanghai	RH2	Ra1	WS2	68.9	27.0	4067	
A3	Fujian	Nanping	RH1	Ra1	WS4	100.0	5.7	5437	
	Jiangxi	Ji-an	RH1	Ra2*	WS3	96.7	18.8	4869	
	Chongqing	Chongqing	RH1	Ra3	WS4	79.9	12.9	3808	
B1	Henan	Xinyang	RH2	Ra1	WS2	61.9	46.1	4779	65.3 ± 5.8
	Jiangsu	Nantong	RH1	Ra1	WS2	60.1	35.9	5106	
B2	Hubei	Yichang	RH2	Ra3	WS4	72.0	30.7	3354	
	Zhejiang	Zhoushan	RH1	Ra1*	WS1	71.2	20.6	5475	
	Sichuan	Yibin	RH1	Ra3*	WS4	61.3	9.1	4248	
C1	Shanxi	Hanzhong	RH1	Ra2*	WS4	42.7	43.6	4833	43.8 ± 2.9
C2	Sichuan	Chengdu	RH1	Ra3	WS4	47.1	22.0	4462	
	Guizhou	Qiandongnan	RH1	Ra3*	WS3	41.7	30.8	5237	

Urban Multi-scale Environmental Predictor

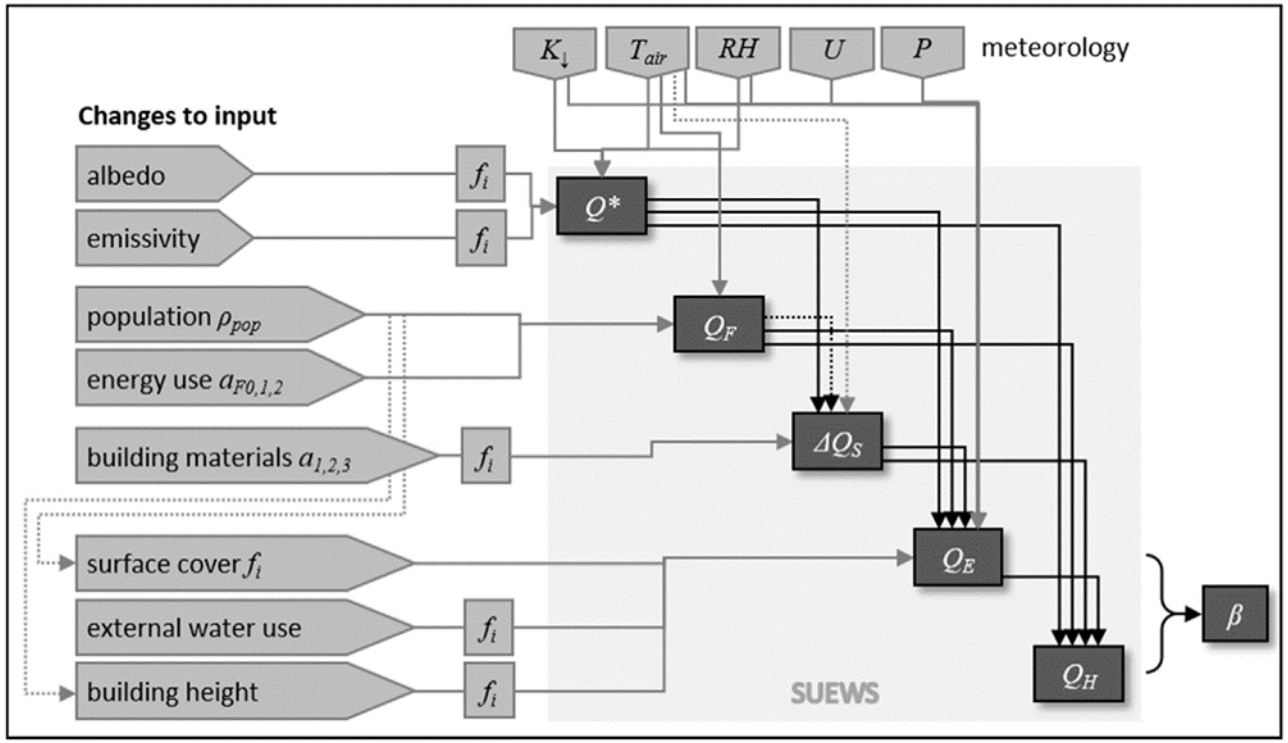
- Coupled modelling system: 1D and 2D models
- Street canyon to city scale (10^0-10^5 m)



QGIS

OSGeo Project

SUEWS Surface Urban Energy and Water Balance Scheme

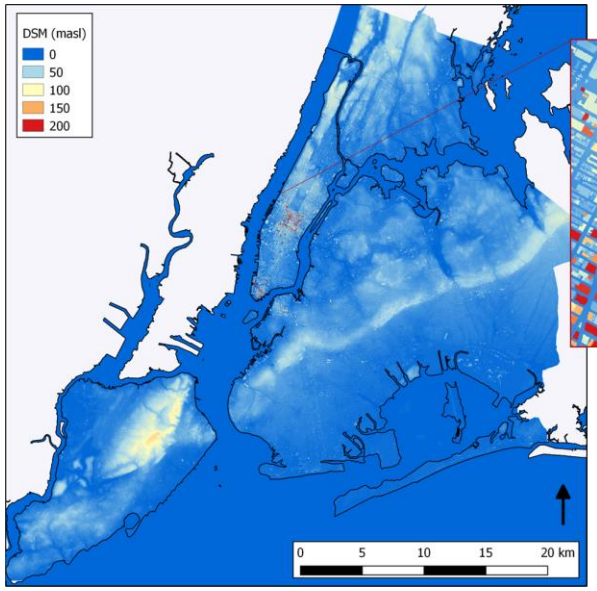


Lindberg et al. 2018: *Environmental Modelling & Software* 99, 70-87

Ward and Grimmond 2017: *Landscape and Urban Planning* 165, 142–161

New York City: Spatial data

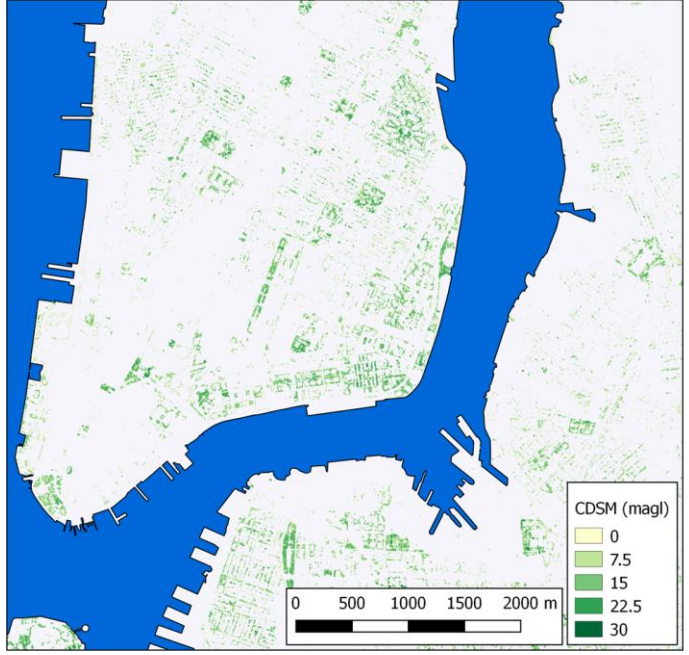
Lindberg et al. 2018



Digital Surface Model (DSM)

Raster grid: buildings and ground (m agl)

DSMGenerator in UMEP: DEM
vector building footprints + height data
4 m pixel resolution



Canopy Digital Surface Model (CDSM).

vegetation raster (m agl)

Derived based on Lindberg and Grimmond (2011; UES)

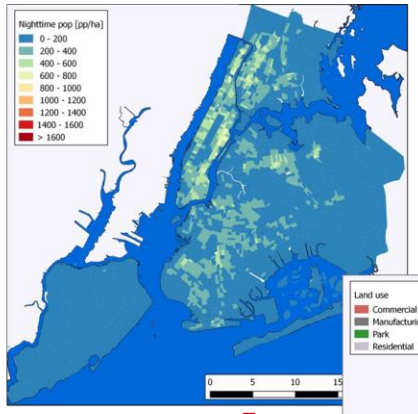
4 m pixel resolution

Land Cover

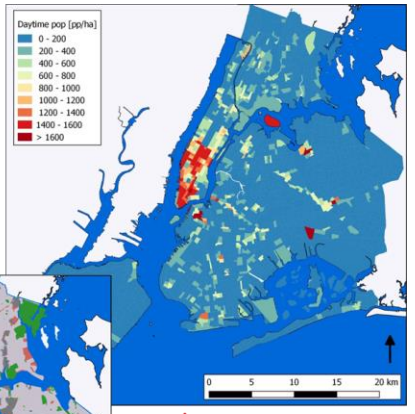
Raster grid 7 LC-classes.

Derived: **Land Cover Reclassifier** in UMEP

4 m pixel resolution



Nighttime



Daytime

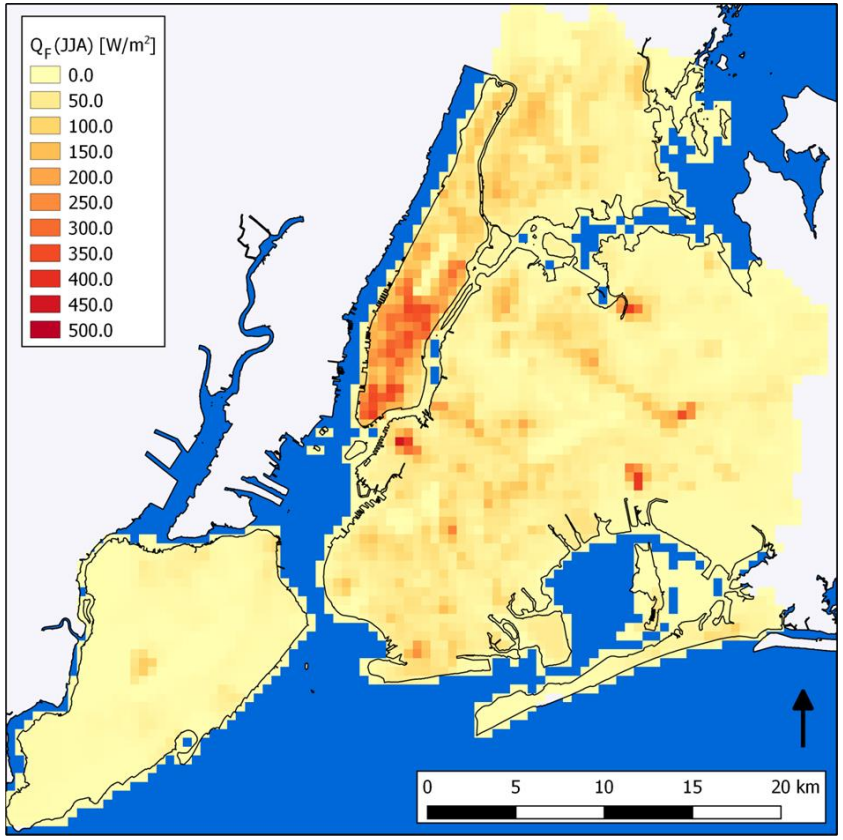
Population density

Census Tract
vector dataset: residential population.
Land use: derive daytime population

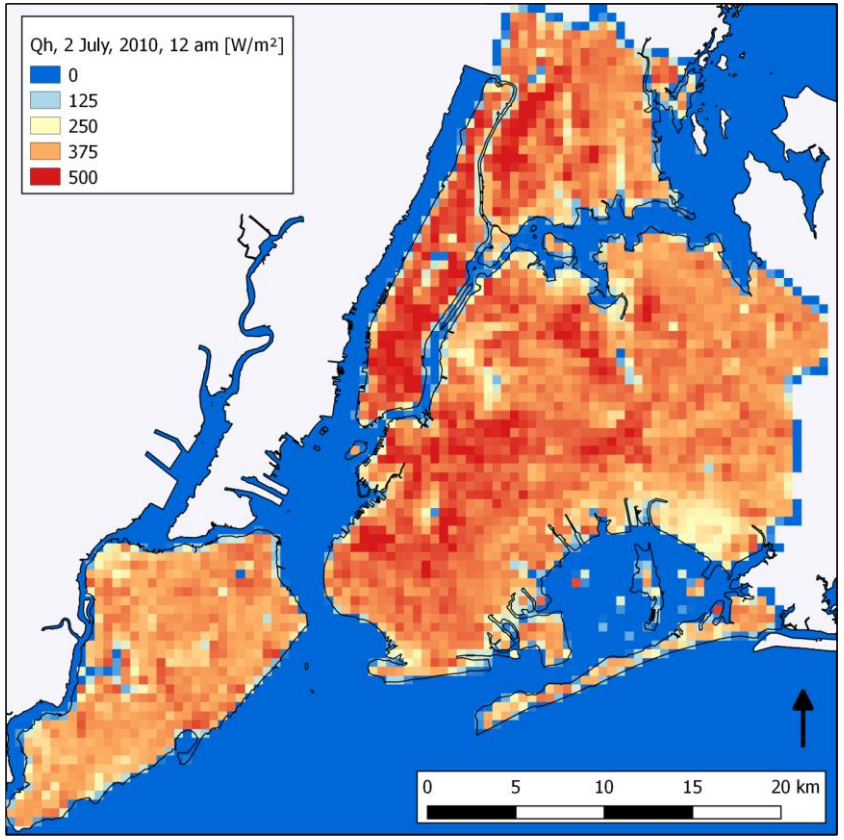
Land use

Information on commuters outside of the 5 boroughs are also included (USCB)

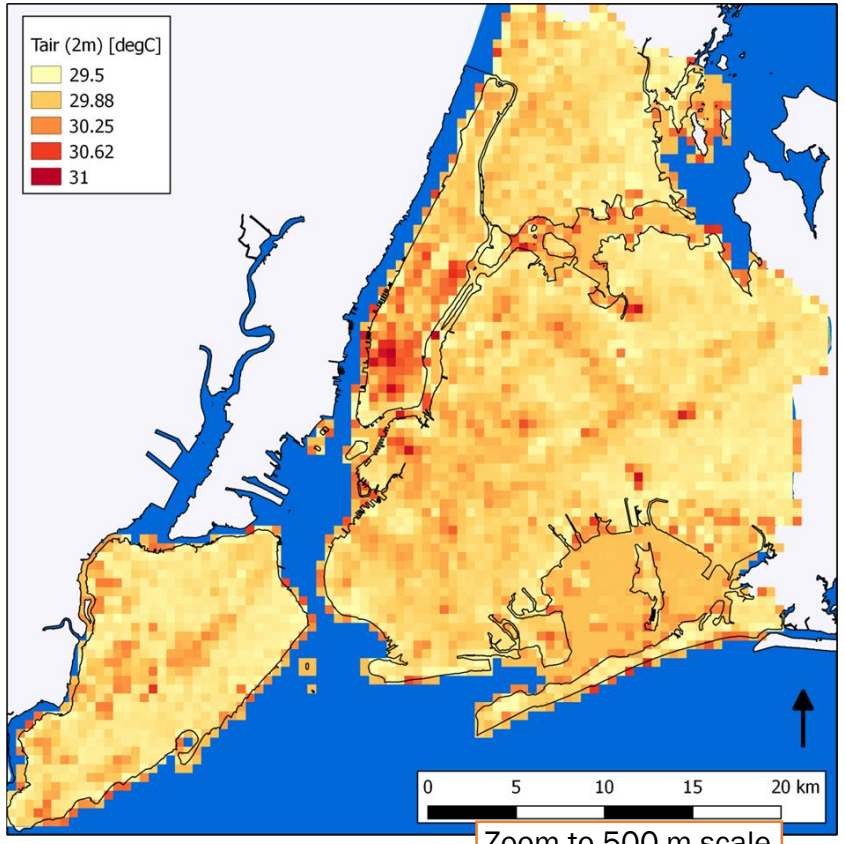
Anthropogenic Heat Fluxes



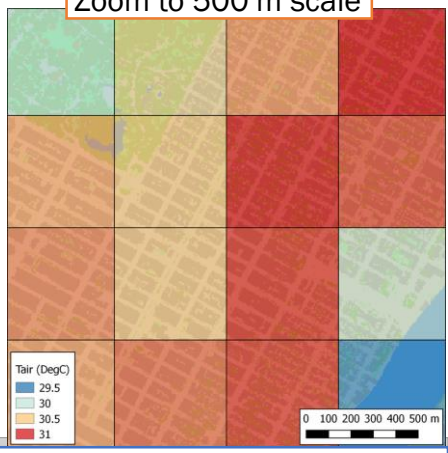
Turbulent Sensible Heat fluxes



Air Temperature



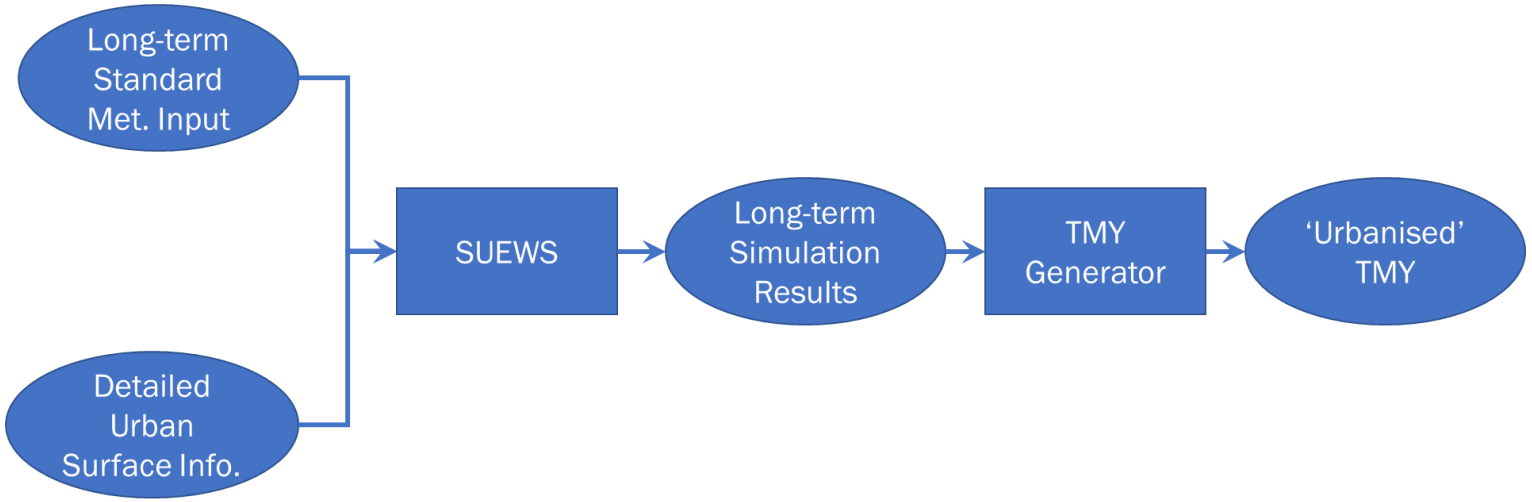
Zoom to 500 m scale

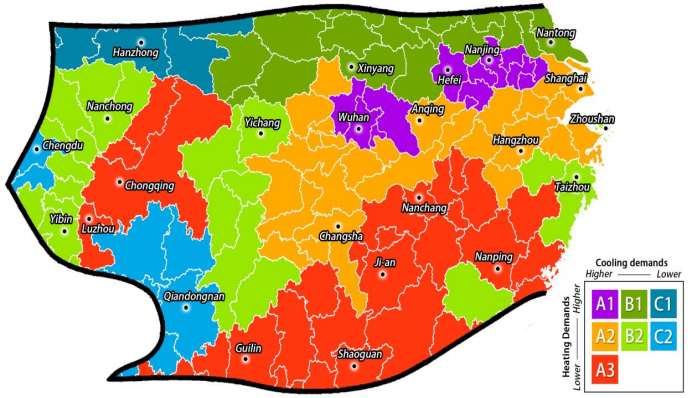


Lindberg et al. 2018

Average air temperature during a heat wave event 6 to 8 July

Long-term simulation-based TMY results

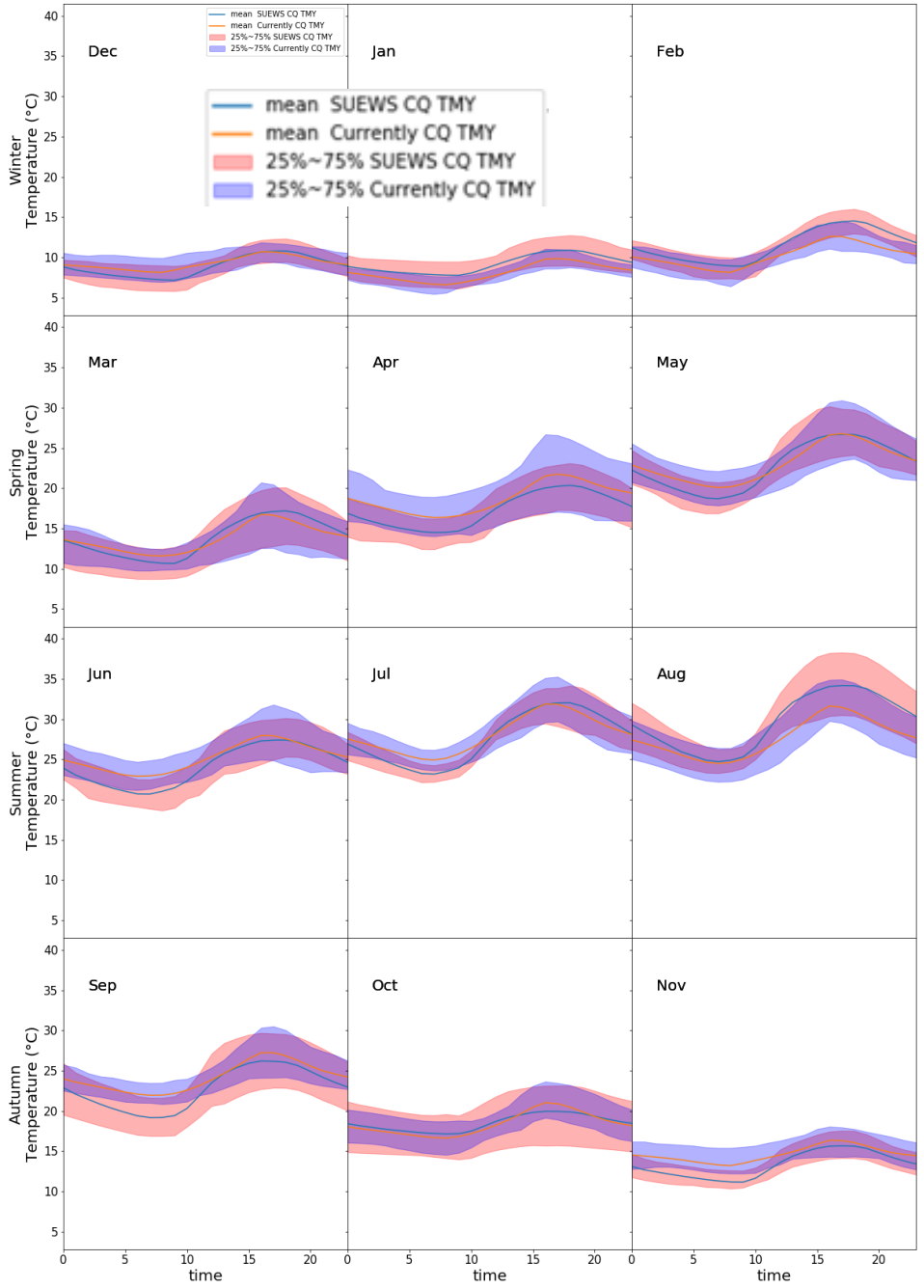




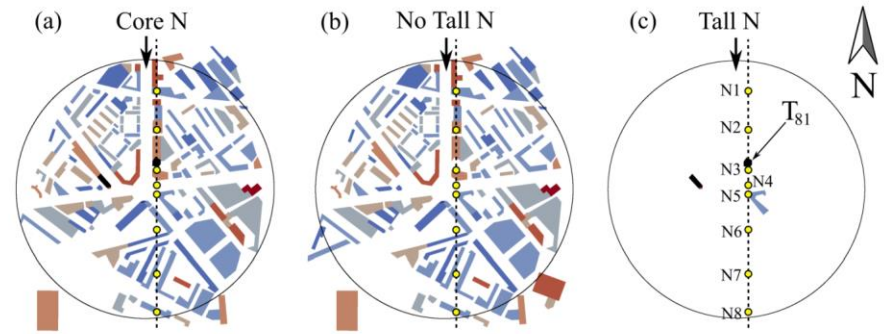
- **Chongqing**

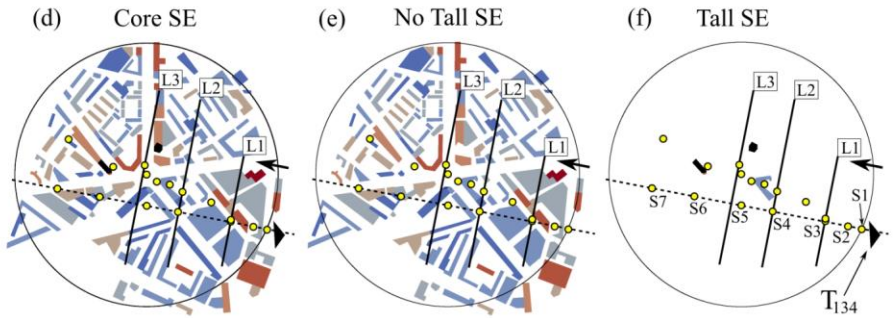
- Differences in T_a between existing and SUEWS-based TMY
- Higher August T_a informed by SUEWS

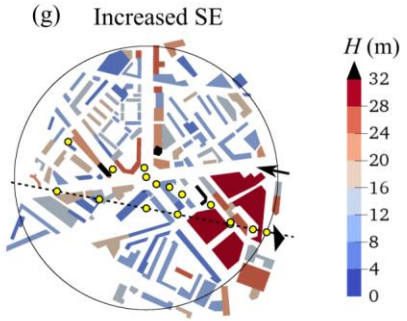
Sun et al. in prep.

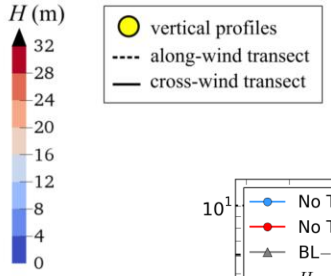


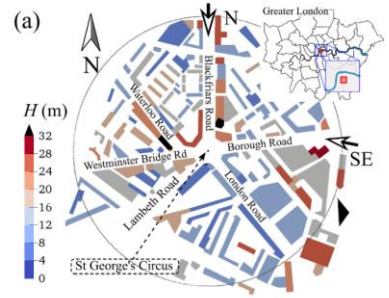
London (Magic site) – wind fields

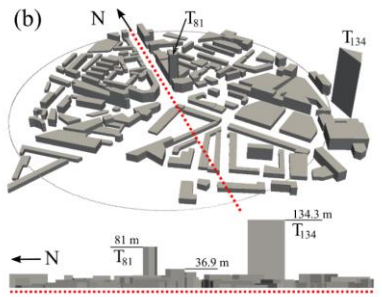


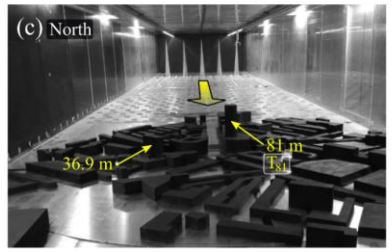


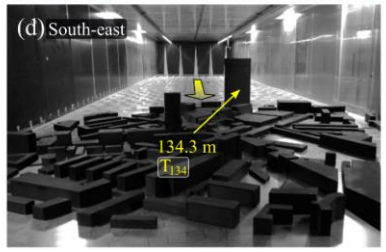


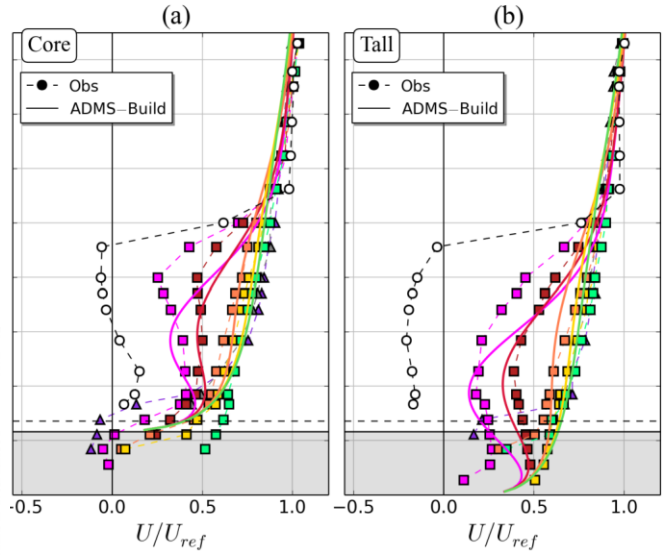


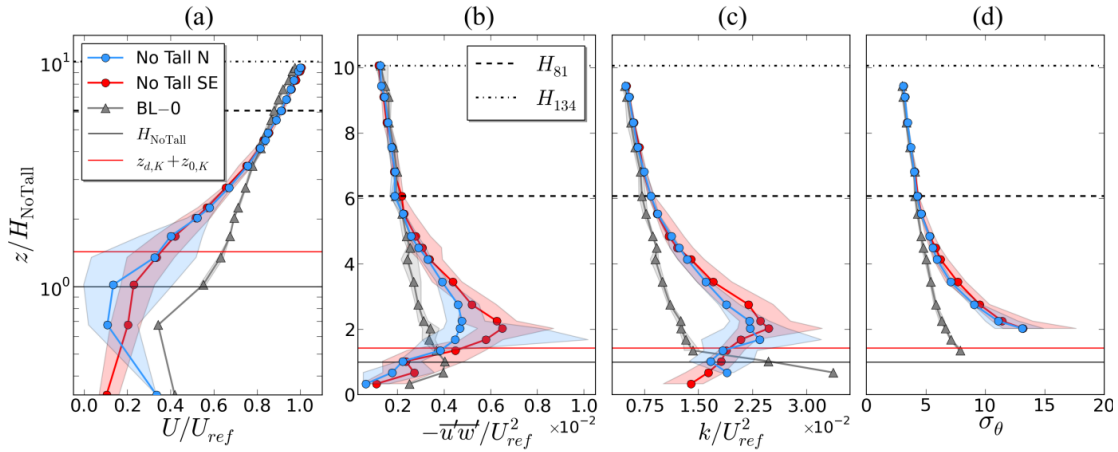


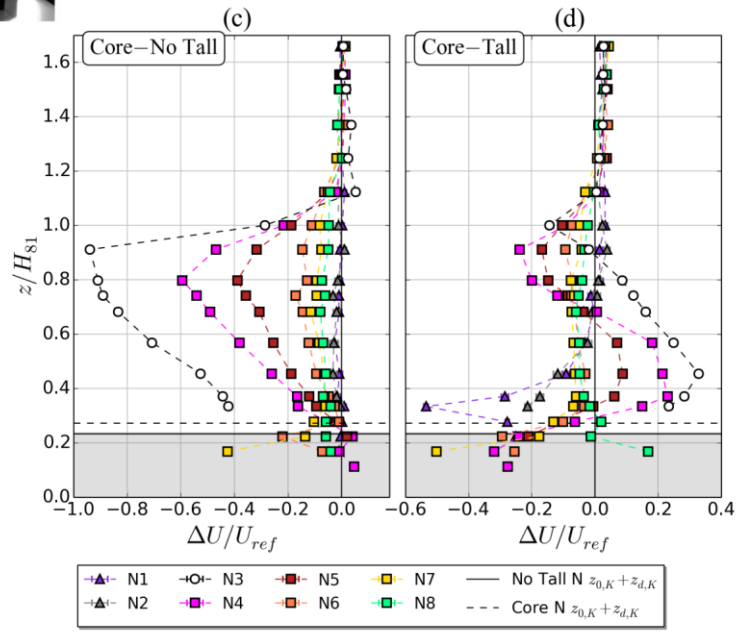








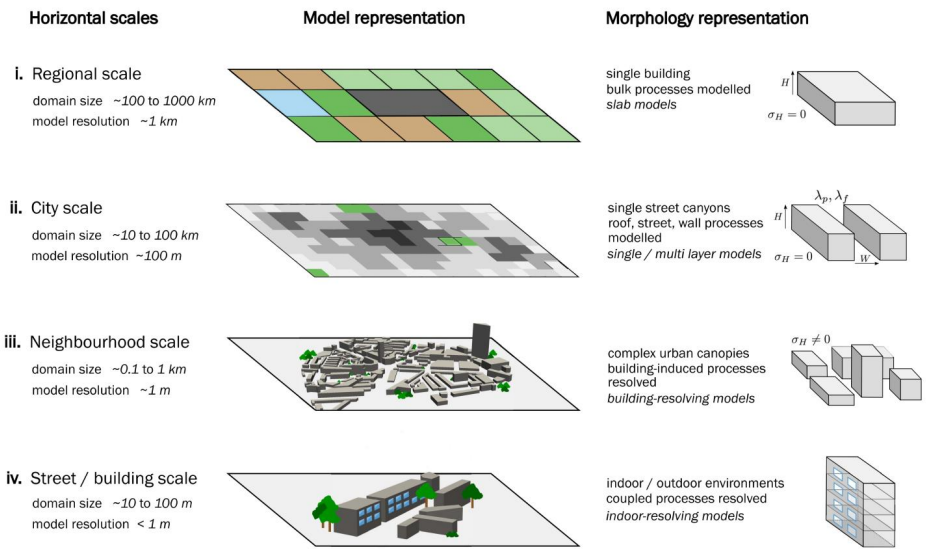


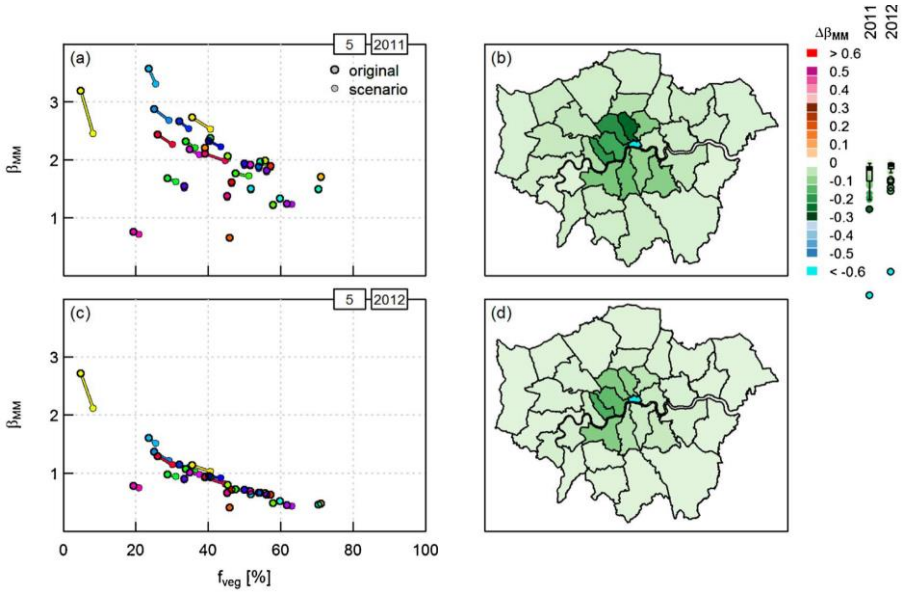


Hertwig et al. (In review)

Final Comments

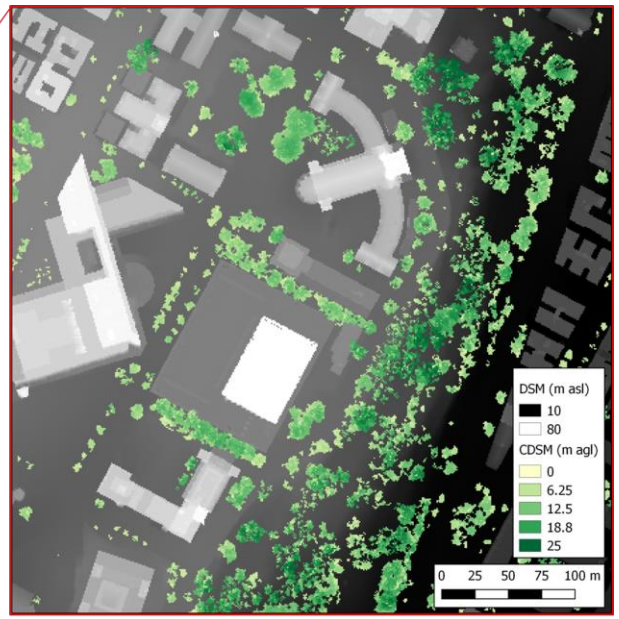
- Feedbacks between urban form and function - improve the TMY data
  - Potential for changes at a range of scales
- Meteorological models – still need improvements
  - Wind speed around tall buildings
    - Realistic settings
- Tools – that are usable for research and practitioners (e.g. UMEP)
  - e.g. Public Health in NY
  - London –future planning





Base input information for SOLWEIG modelling

- DSM
- CDSM
- Ground Cover
- Met-forcing data



2 pm DOY 190, 2010

Mean radiant temperature