Development of a fine-scale Numerical Weather Prediction system for urban areas: Preliminary results

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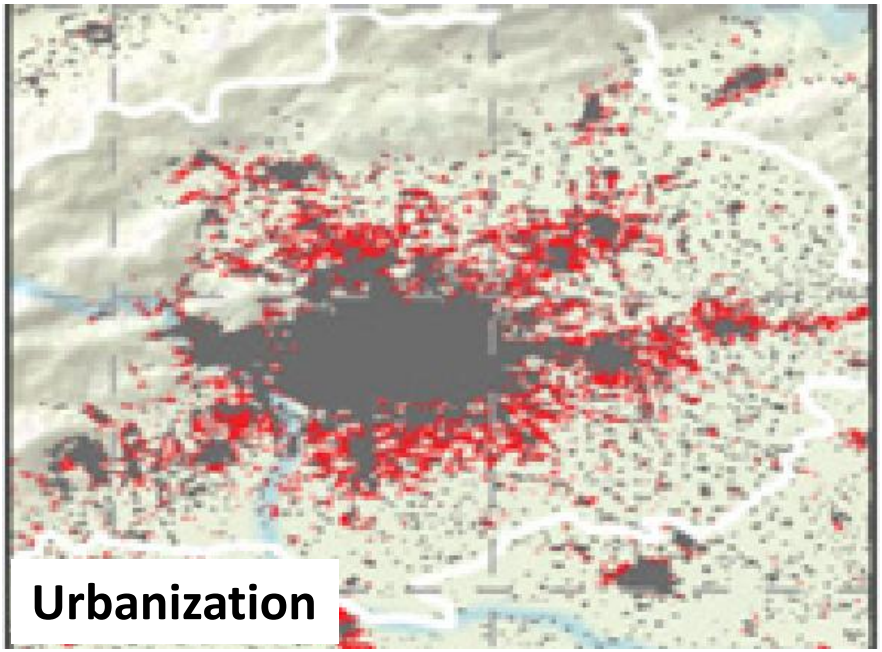
INTRODUCTION

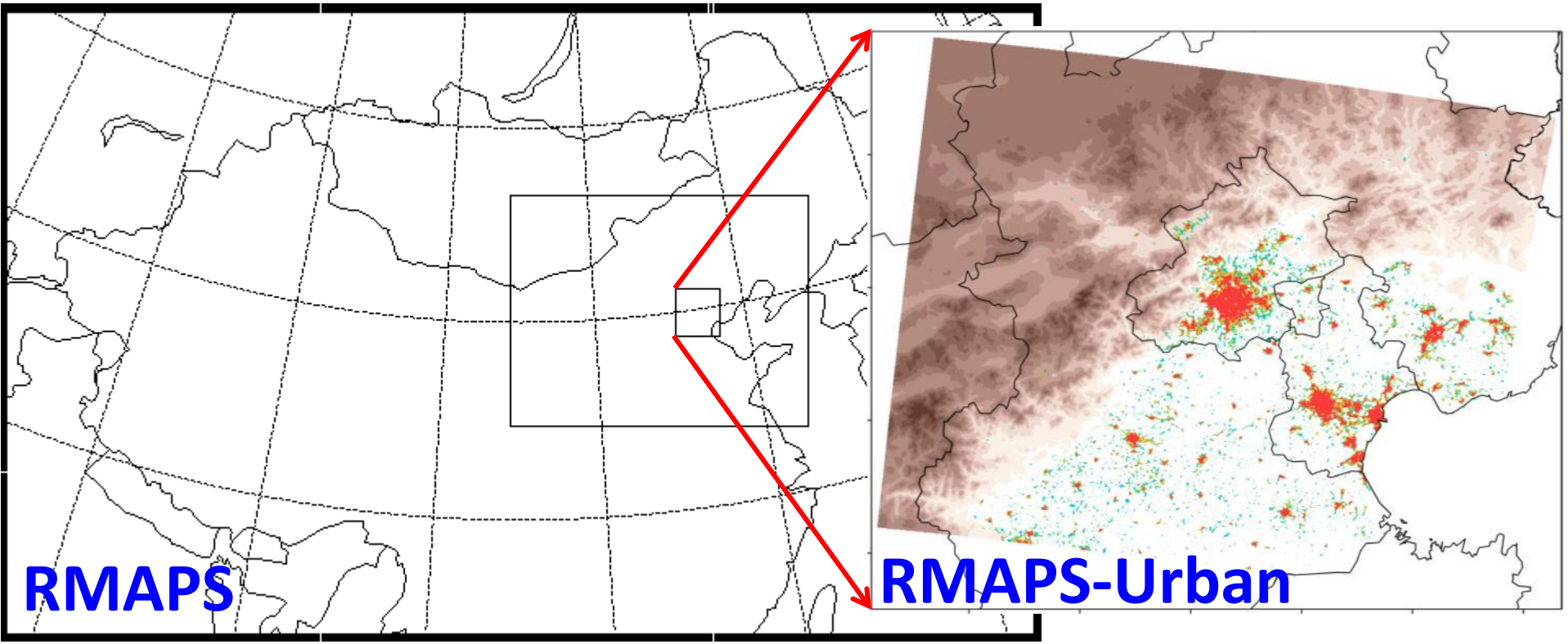
- Urbanization → Environmental problems (UHI & urban flooding)
- In order to improve high-impact weather forecast for urban areas
- A fine-scale NWP system (RMAPS-Urban), based on WRF model, is developed with horizontal grid spacing of 1 km



Urbanization

Urban flooding

- **RMAPS-Urban is nested into Rapid-refresh Multi-scale Analysis and Prediction System (RMAPS)**



RMAPS:
D1: 9km, 649*400*50
D2: 3km, 550*424*50

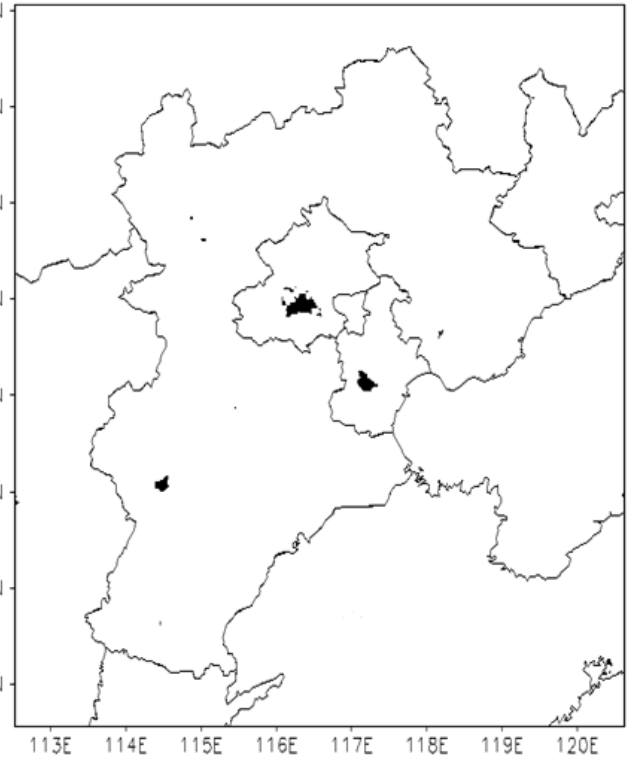
RMAPS-Urban:
Grid spacing: 1km
Grid number: 460*403*50

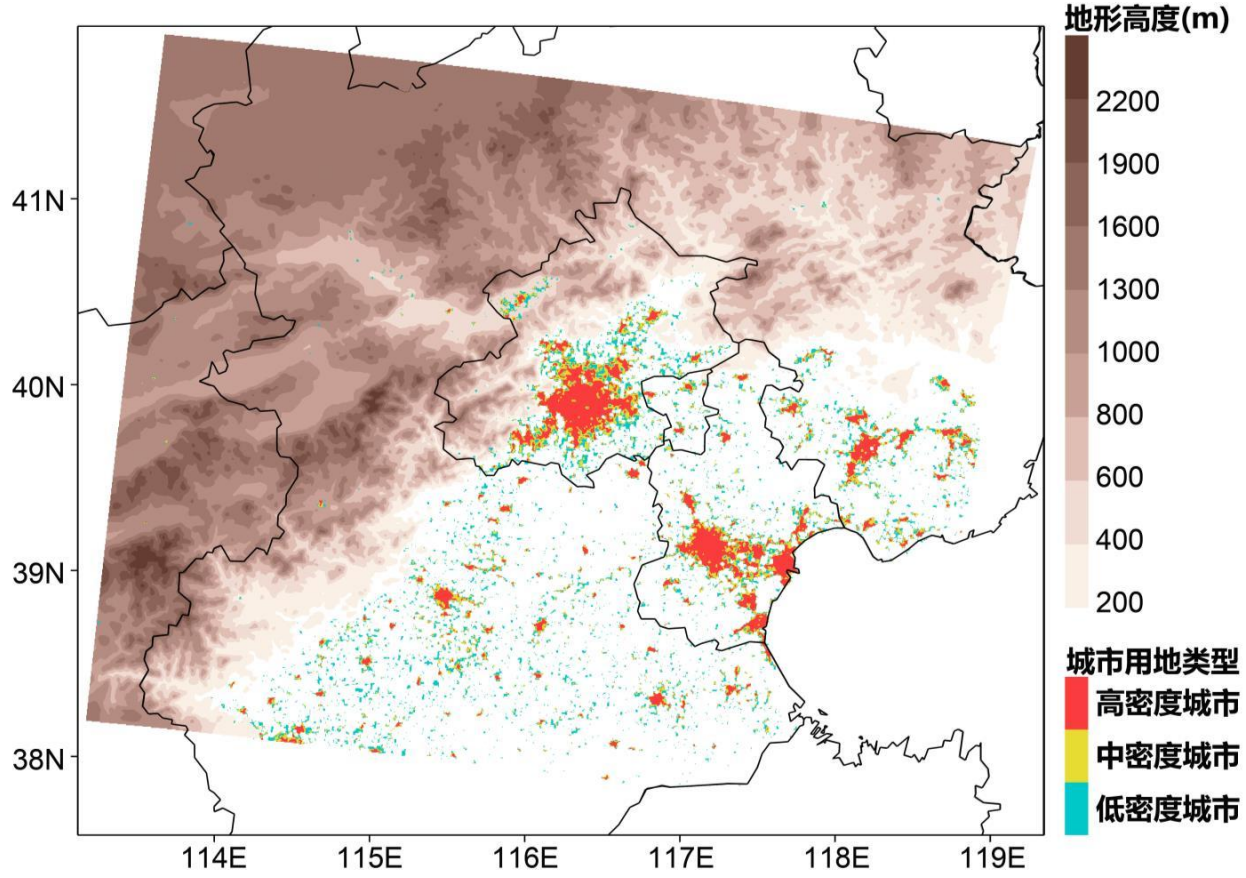
Main Features of RMAPS-Urban

1. **High-resolution urban data**
2. **Enhanced modeling of latent heat flux from urban surfaces**
3. **Fractal Dimension for urban heterogeneity**
4. **Sensible and latent heat from air conditioning system (BEM)**
5. **Aerosol impact on cloud micro-physics**
6. **Four-dimensional data assimilation (FDDA) of VDRAS data**
7. ***Real-time run***
8. **On going: Aerosol-radiation, PBL scheme, and applications**

1. High-resolution urban land-use dataset

- **Derived from Landsat-TM data (30m)**
- **Urban expansion: 7 times**

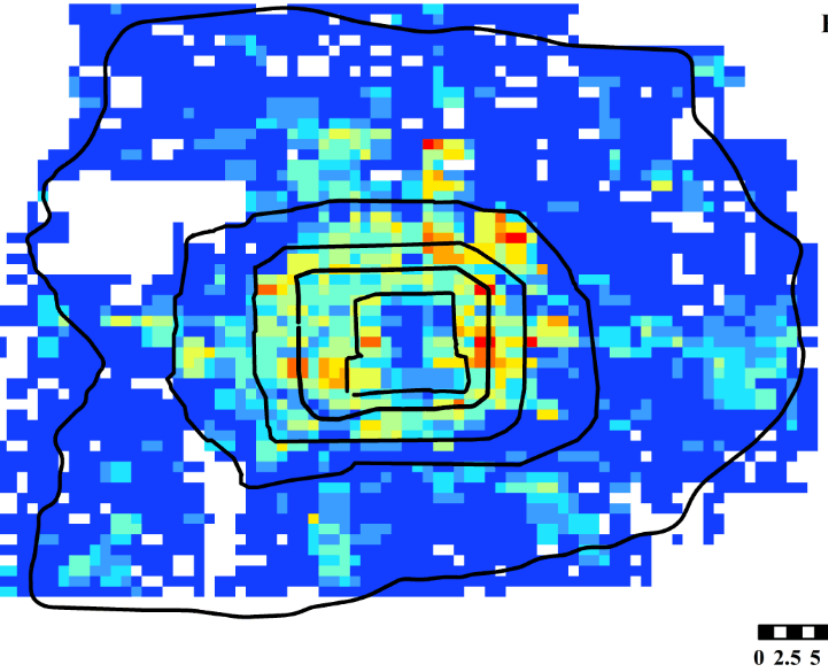




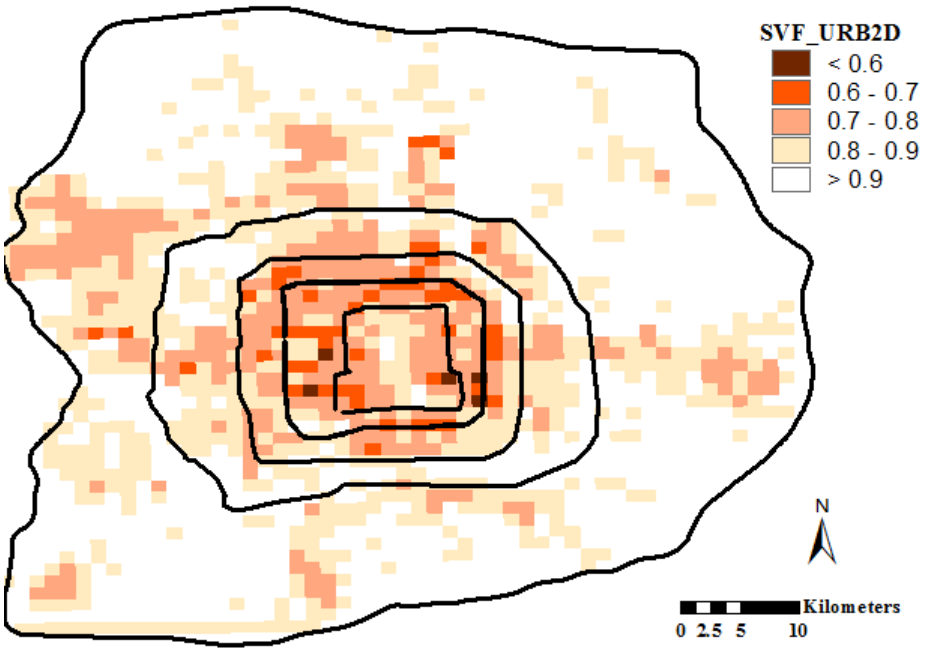
2-D Urban Canopy Parameters

- Derived from building morphological data
- Grid spacing: 1 km
- These data are tested in RMAPS-Urban now

Area Weighted Mean Building Height

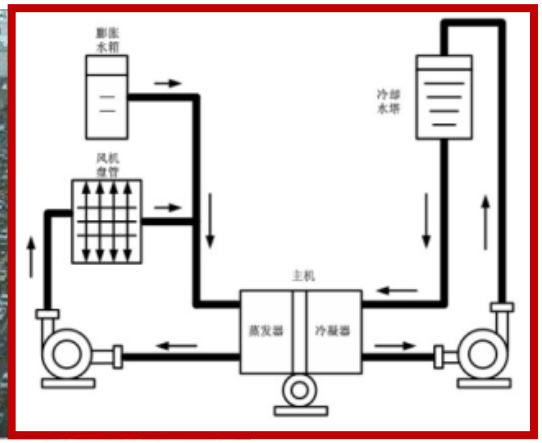


Sky View Factor (SVF)

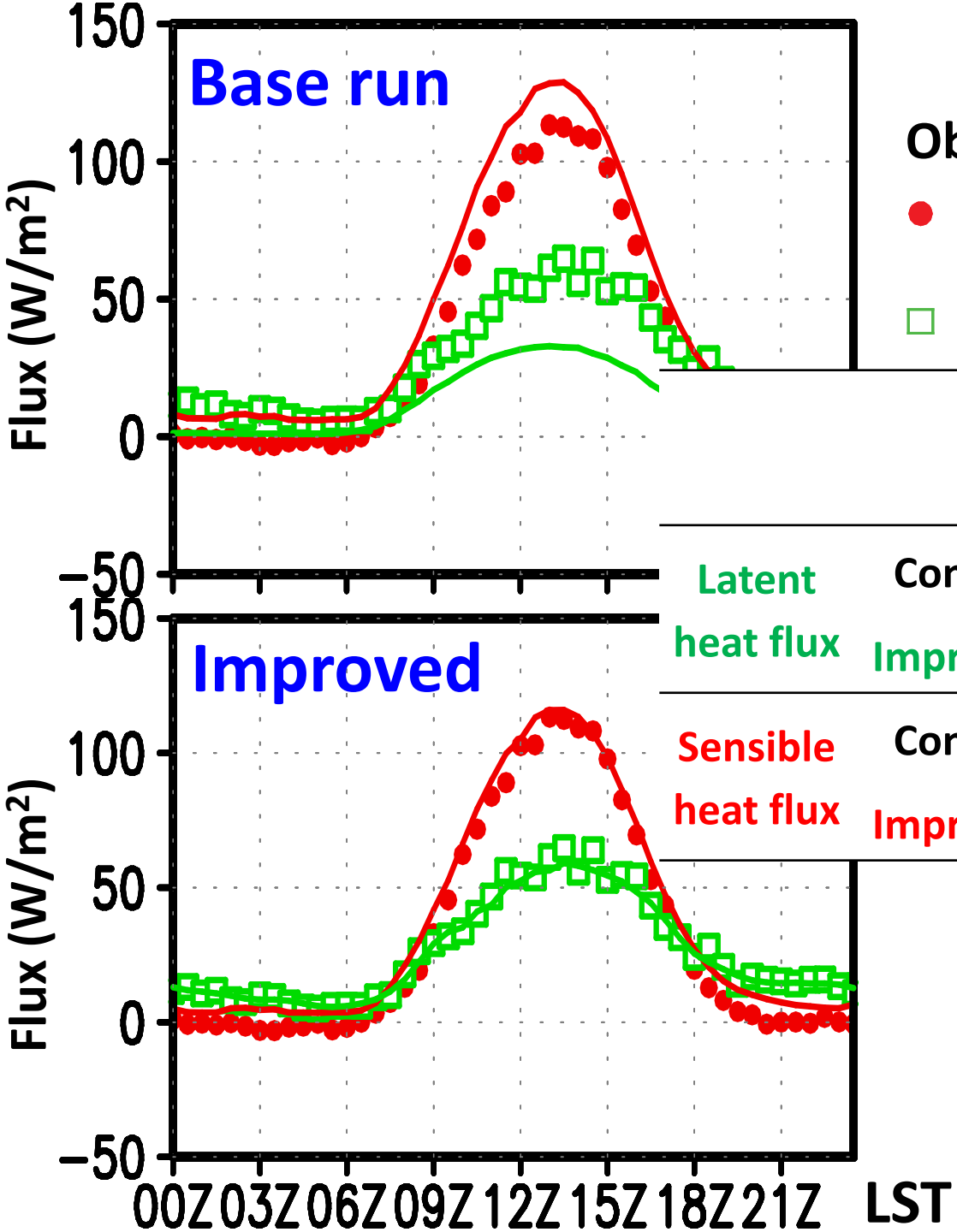


2. Enhanced modeling of latent heat flux from urban surfaces

① Urban irrigation
② Oasis effect for urban green areas (~1.5)
③ LH from impervious surface after rainfall (~1 day)
④ Anthro. LH: air conditioning, traffic



Miao & Chen, 2014; Yang et al. 2015



Obs — Modeling

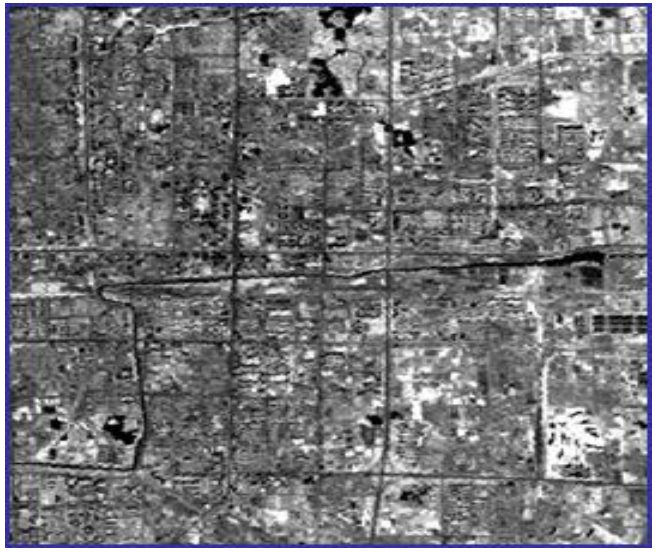
SH

LH

		BIAS (W/m²)	RMSEs (W/m²)	IOA
Latent heat flux	Control	-14.50	39.43	0.61
	Improved	-0.01	29.95	0.72
Sensible heat flux	Control	13.20	15.29	0.87
	Improved	7.18	14.67	0.87

3. Fractal Dimension (FD) for urban heterogeneity

- Landsat-TM data are used to derive FD



CBD: 2.9847

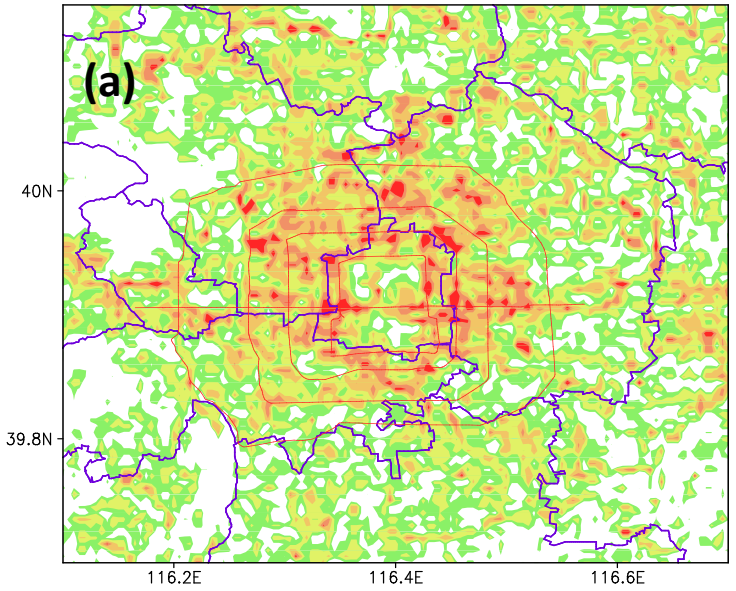
Residential area: 2.9054

- A higher FD means a more complex surface and higher fragmentation
- FD could be a reflection of urban morphological information

Li, Miao, and Chen, 2014

Fractal Dimension → **Building Index**
Fractional Impervious Surface → **Land Use Index** } **UCM**

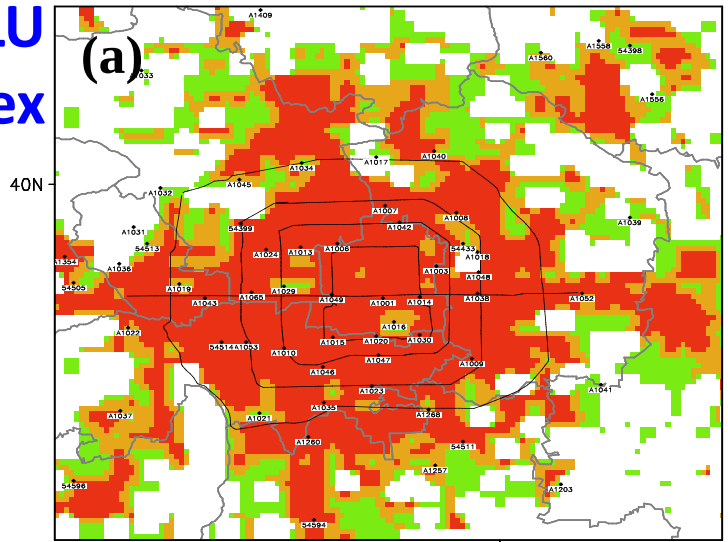
to better characterize the heterogeneity of urban morphological characteristics

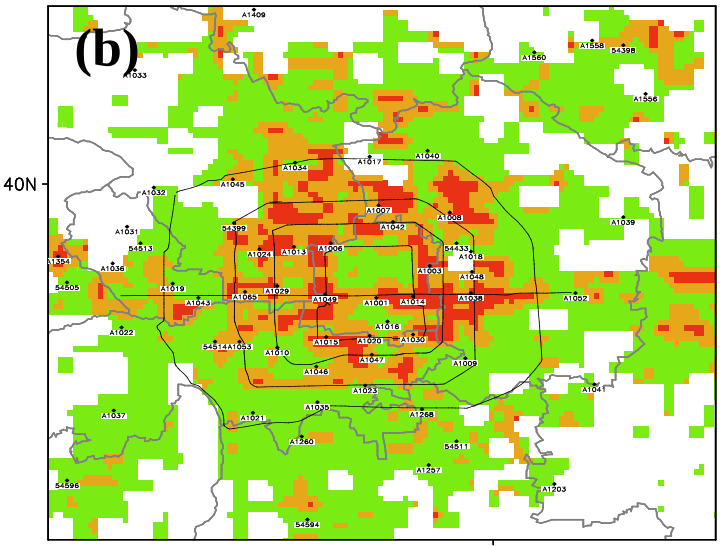


Fractal Dimension

2.9
2.8
2.7
2.6
2.5

LU Index





Building Index

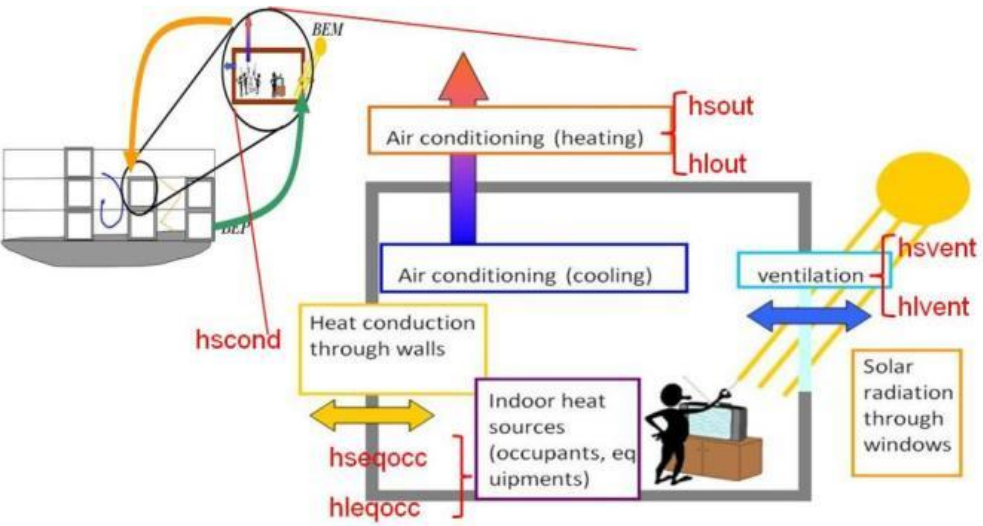
Low
Medium
High

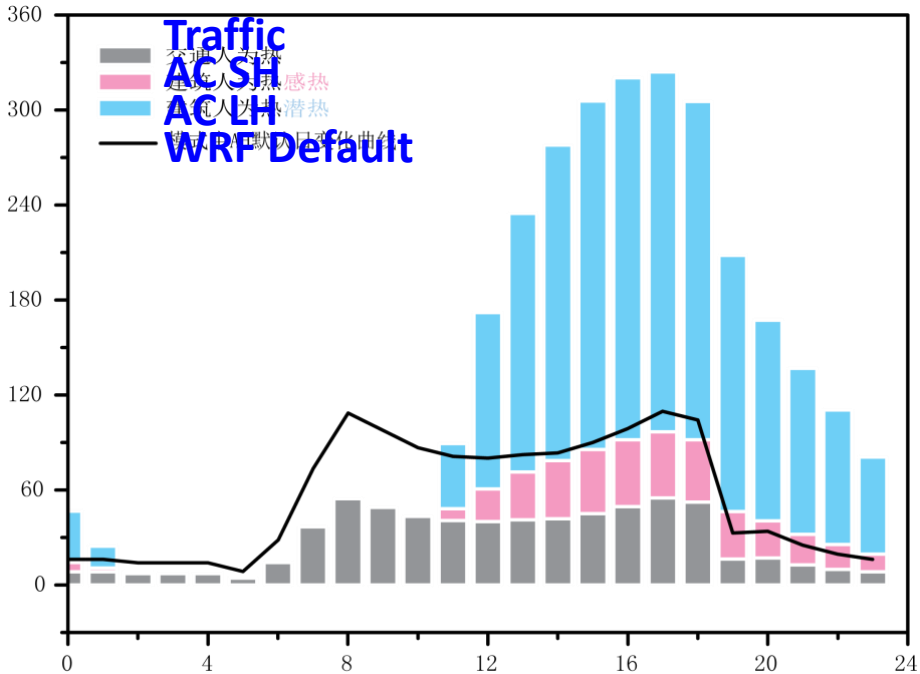
4. Sensible and LH from air conditioning system

According to the ratio of various air conditioning types,

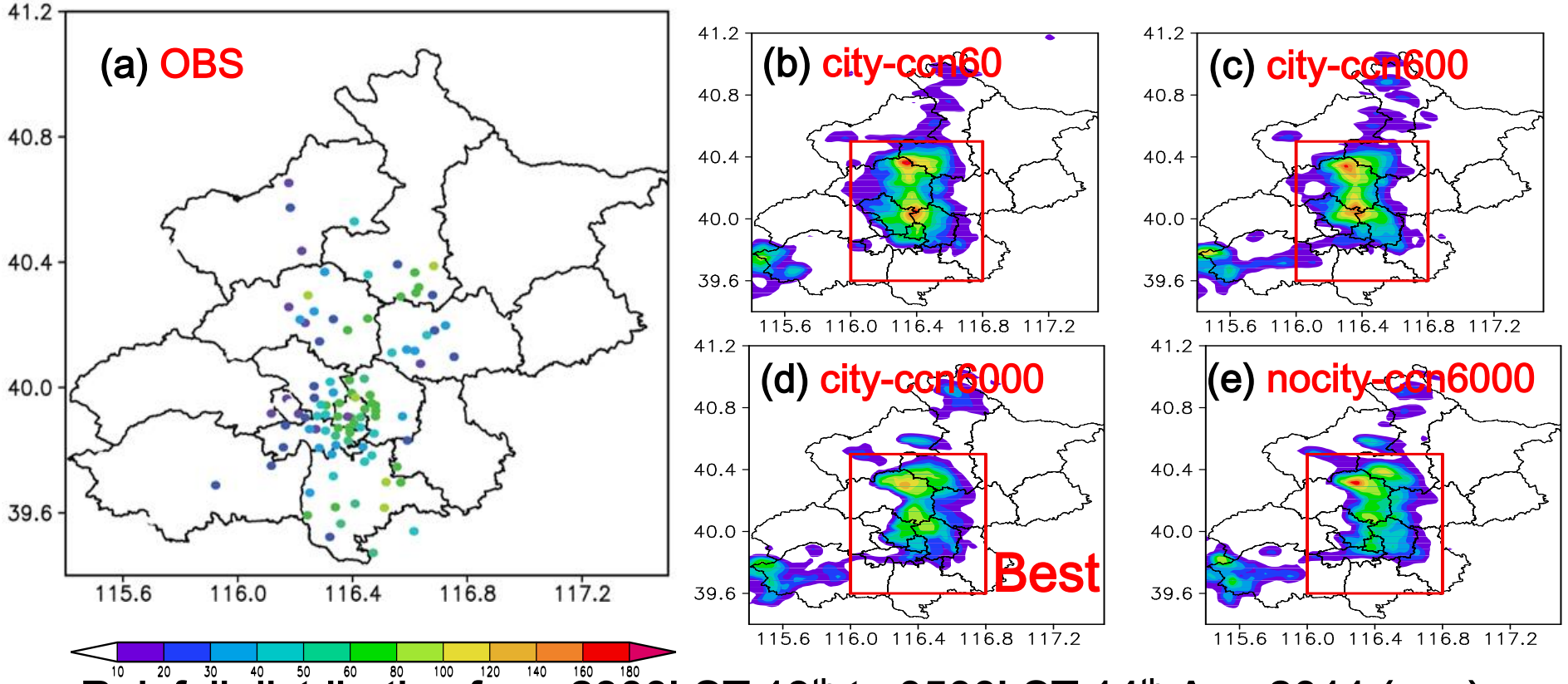
In Build Energy Model (BEM), consider the release of sensible and latent heat from air conditioning system.

Type of AC system	SH (W/m^2)	LH (W/m^2)
Air cooled (COP=3.5)	62.2	0.0
Water Cooled (COP=4.3)	7.3	50.9
TOTAL	12.7 (22%)	45.9 (78%)





5. Effects of CCN concentration (MP: Thompson)



Rainfall distribution from 2300LST 13th to 0500LST 14th Aug 2011 (mm)

Threat score of precipitation

	Experiment	Precipitation grades (mm)					
		<1	1~10	10~25	25~50	>50	
No pollution	city-ccn60	0.308	0.628	0.263	0.108	0.447	
Light Pollution	city-ccn600	0.205	0.698	0.263	0.189	0.263	
Medium Pollution	**city-ccn6000**	**0.359**	**0.651**	**0.263**	**0.243**	0.237	**Best**
	nocity-ccn6000	0.462	0.233	0.053	0.216	0.263	

6. FDDA of VDRAS data

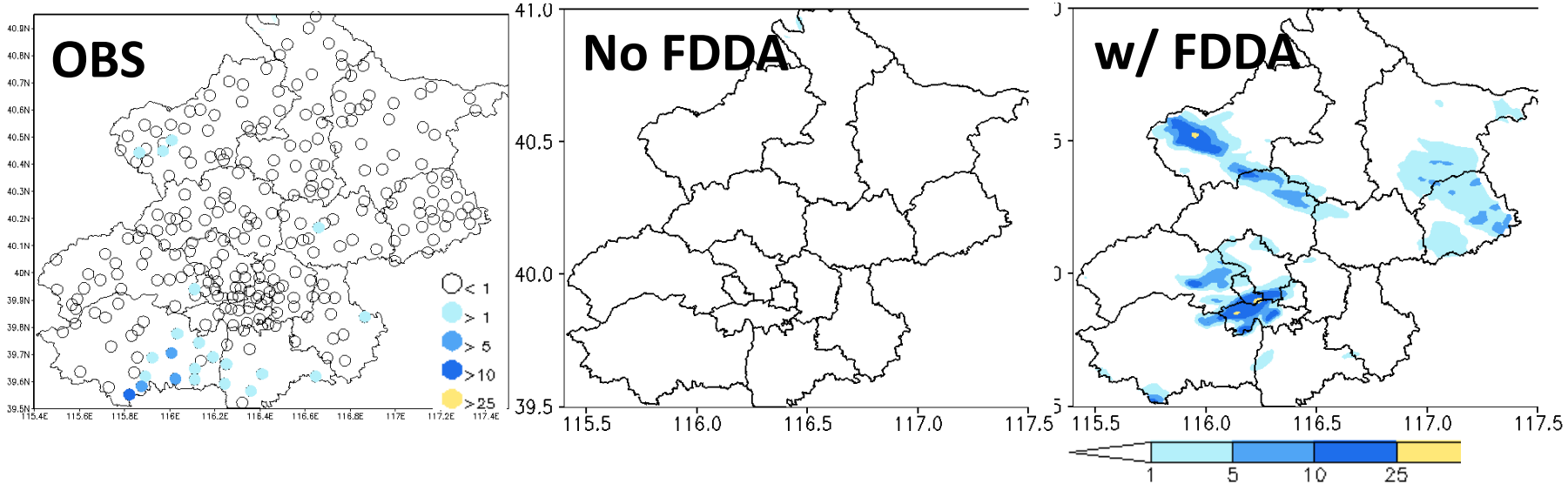
Outputs from Variational Doppler Radar Assimilation System (VDRAS) are used with the aid of Four-Dimensional Data Assimilation (FDDA):

$Dx/Dt = \ldots\ldots + GW\,(x_{obs} - x_{model})$

x=T, U, V, Q, P …… GW: nudging factor

Case	20130815	20140625	20140704	20140719
No FDDA	False Negative	Rain starts late	Wrong start time	False Negative
W/ FDDA	Rain starts late	Rain starts at correct time	Rain starts at correct time	Rain starts at correct time

20140625 1500LST



7. RMAPS-Urban real-time runs from this summer

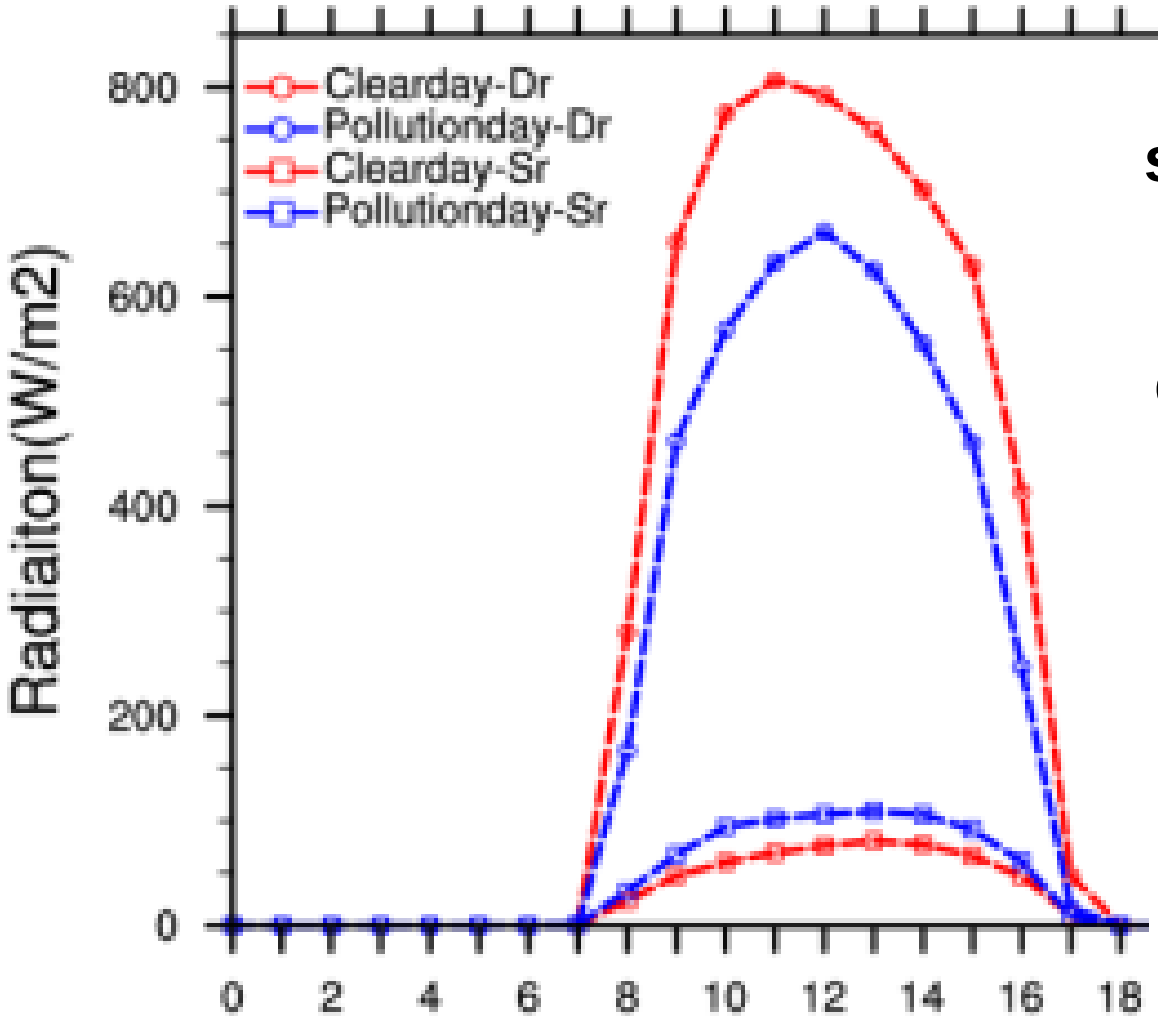
From: 2015-06-25-06_00 UTC
Rapid refresh: every 3-hr
Main features:

Data	**Urban land use data from Landsat TM** **Building morphological data** **CMA CLDAS products** **VDRAS products** **RMAPS products**
Land surface data assimilation	**uHRLDAS**
Atmospheric data assimilation	**FDDA of VDRAS products**
Urban land surface and boundary layer	**Improved BEP+BEM** ***TTE PBL***
Aerosol effects	***Radiation*** **Cloud micro-physcis**
Forecast range	**0-24 hrs**
Grid spacing	**1 km**
Products	**Surface, rainfall, PBL** **Urban canopy variables** **Building energy consumption**

Italic **denotes on-going.**

8. On going: Aerosol-radiation, PBL scheme, and applications

Observed air pollution impacts on surface radiation budget



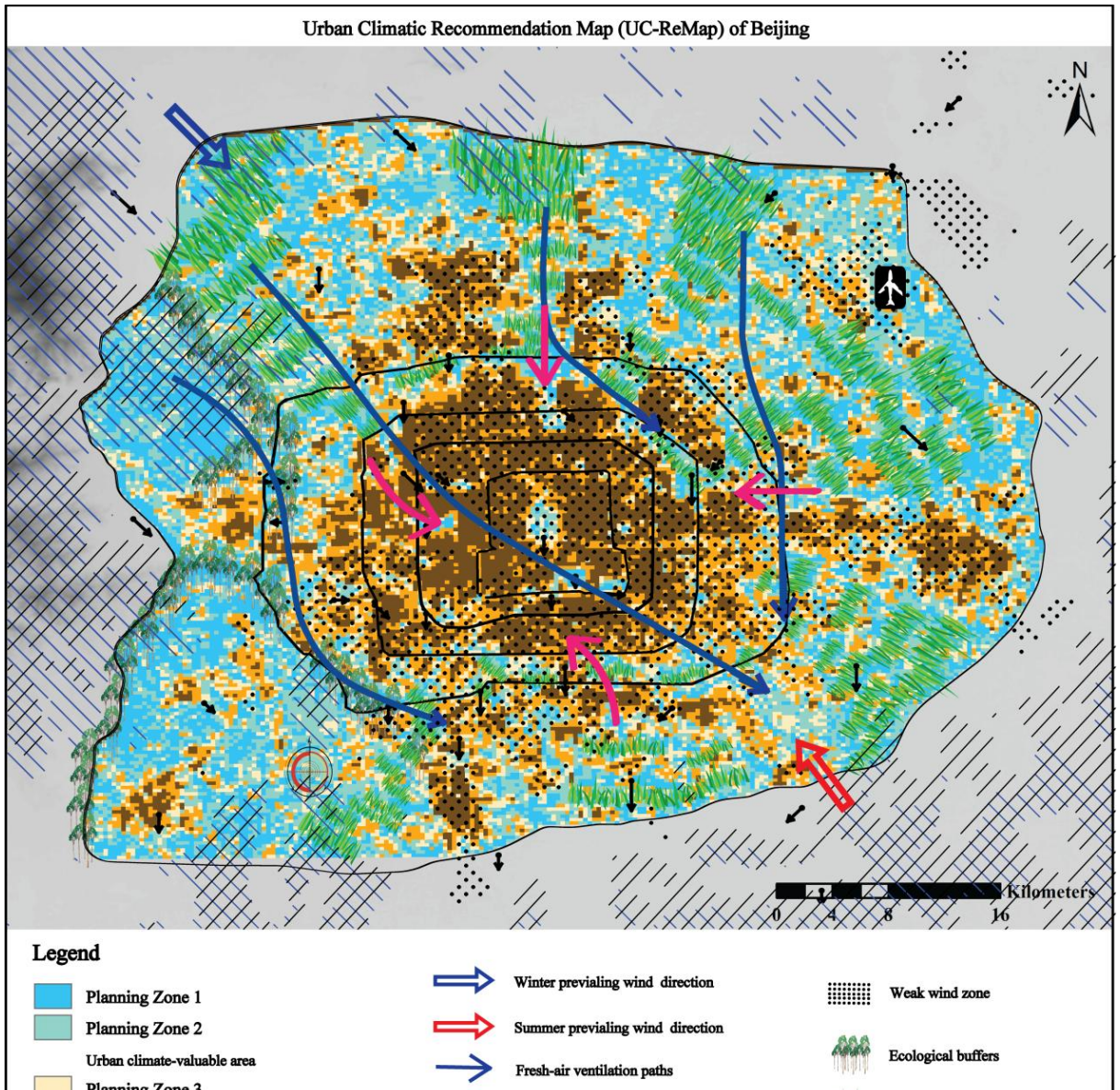
The direct (o) and scattered (□) downwind shortwave radiation observed at Beijing Observatory: clear-sky vs. polluted day

Next:

- Numerical simulation of aerosol impacts on PBL structure
- PBL scheme: TTE

8. On going: Aerosol-radiation, PBL scheme, and applications

Application of RMAPS-Urban: UCMap for Beijing



- GIS-based assessment
- Observation analysis
- Numerical simulation

Urban Climatic Recommendation Map (UC-ReMap) for Beijing

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6. Four-dimensional data assimilation (FDDA) of VDRAS data
7. *Real-Time run (1-km, 3-hr refresh)*
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Thank you!

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