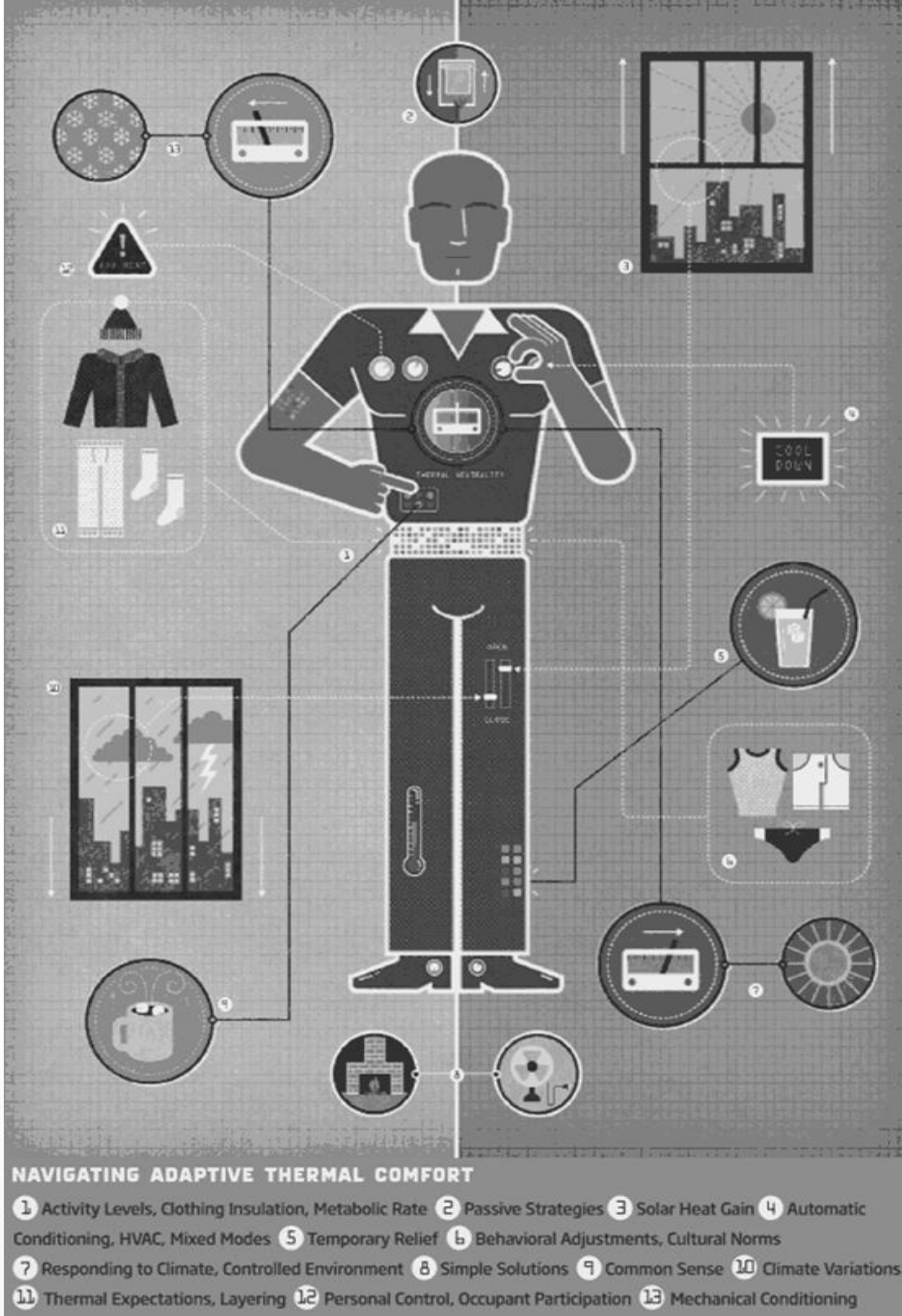
# Climate information - application for improved planning and management of cities

WISE project of KMA, Chaeyeon Yi




차세대도시농림융합 기상사업단 기상청 Korea Meteorological Administration 한국외국어대학교 Hankuk University of Foreign Studies

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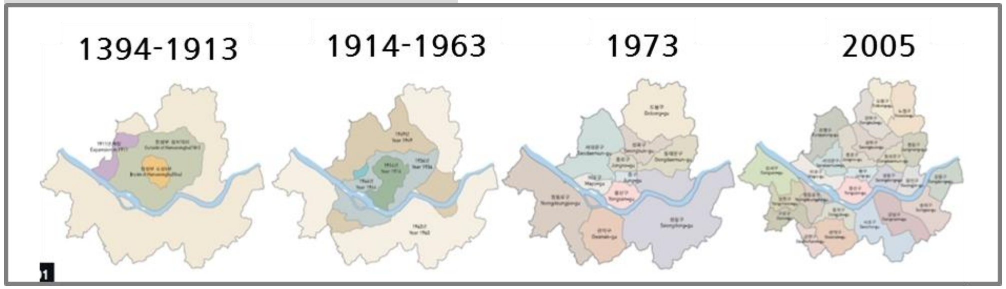
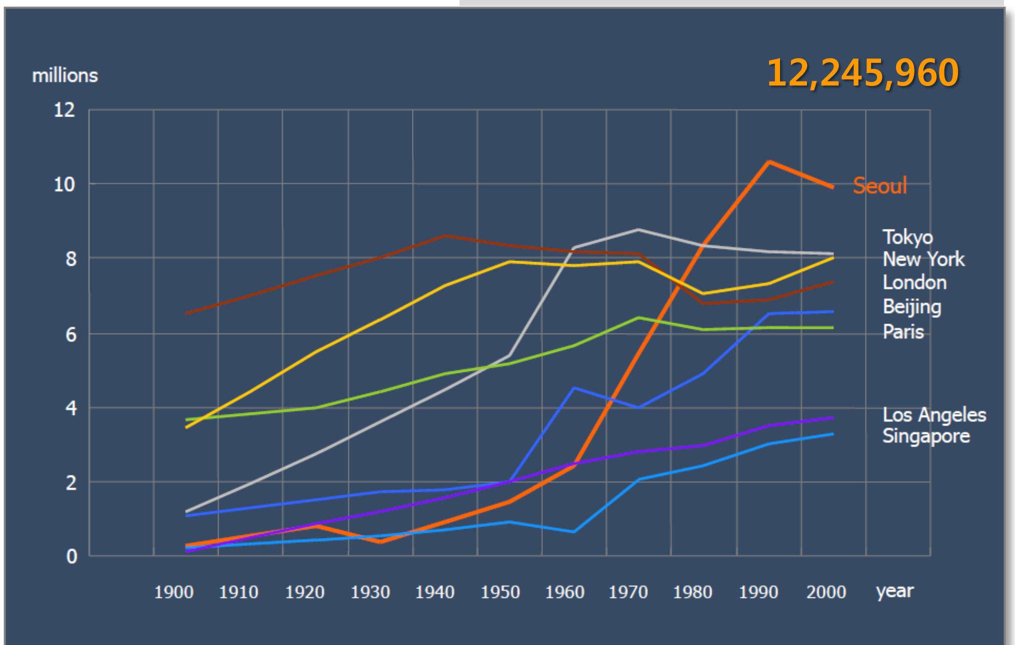
## Expansion of Seoul city and Climate

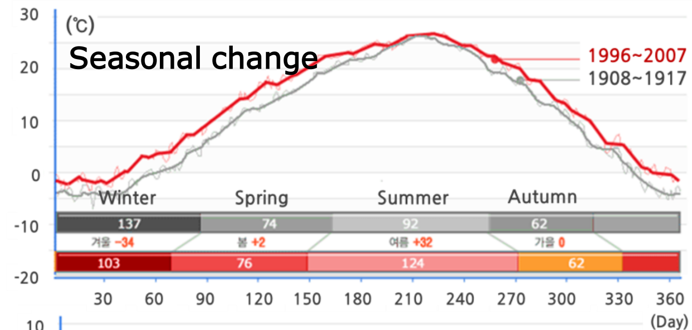
### Region Expanding

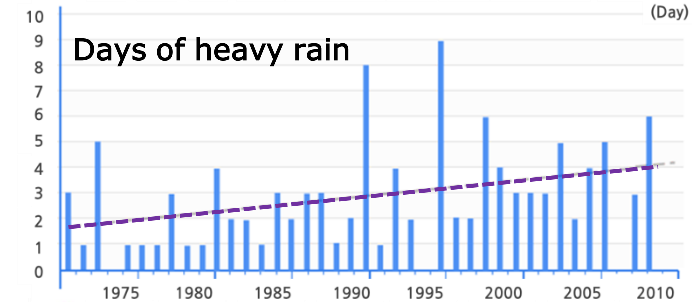


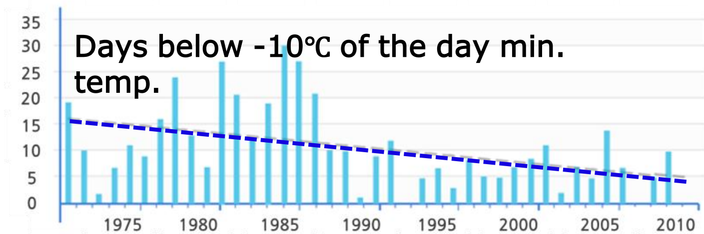

### High Population density

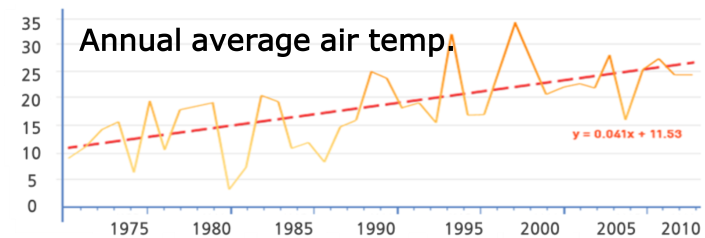



### Change of Seoul climate for 40



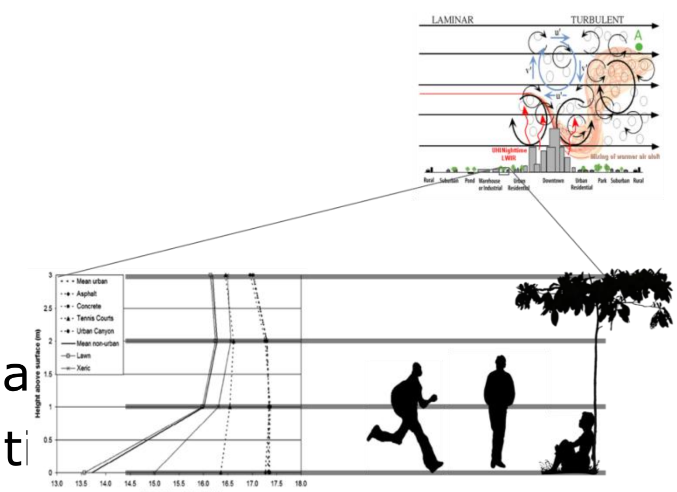
# 01 Urban climate studies in Seoul

## Major Urban Surface Properties (C.S.B. Grimmond *et al.*, 2010 )

| Surface properties | Purpose |
|---|---|
| Roughness length | Wind flow influence |
| Impervious surface fraction | Energy partition between Heat and moisture exchanges |
| Sky View Factor | Solar access and radiative cooling |
| Thermal admittance | Heating and cooling cycles of materials |
| Albedo | Heat absorption |
| Anthropogenic heat flux | Additional source of energy |

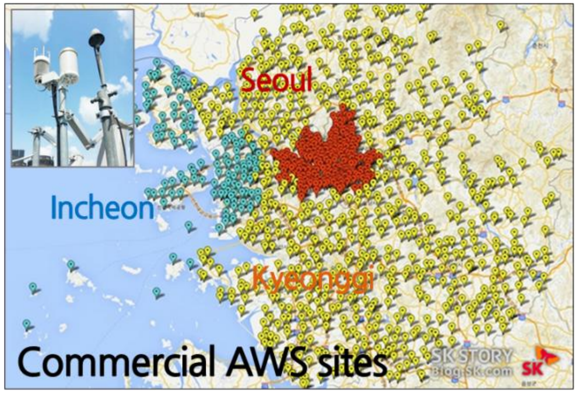
## Urban Climate Information - Applications

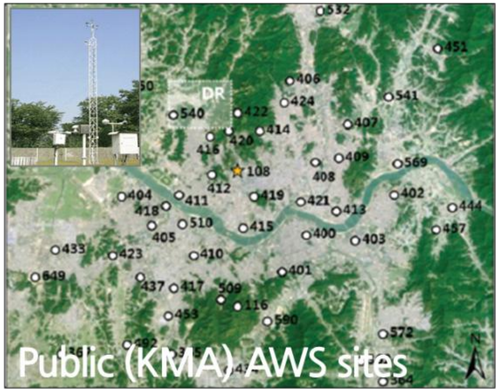
- Architectural design and urban planning
- Human comfort and health
- Forecasting urban weather, hazards and clima
- Practical applications of atmospheric informati

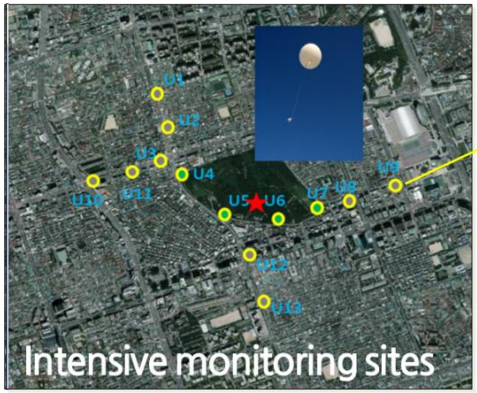


# 01 Urban climate studies in Seoul

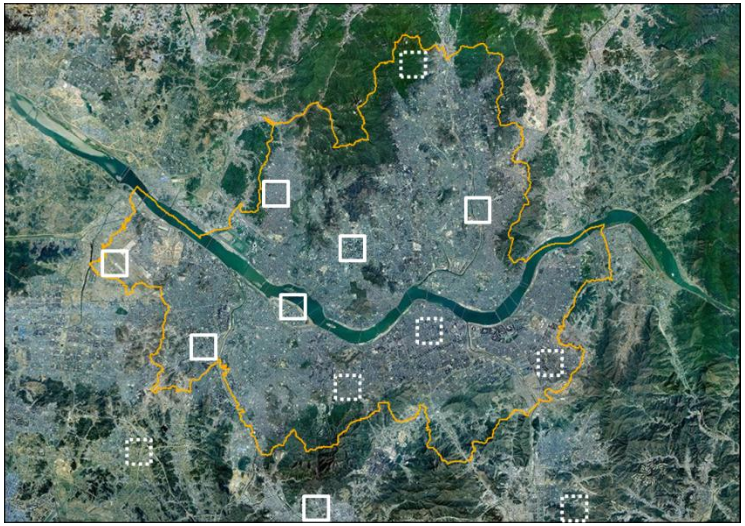
## Weather Monitoring Systems for Public and Commercial Services

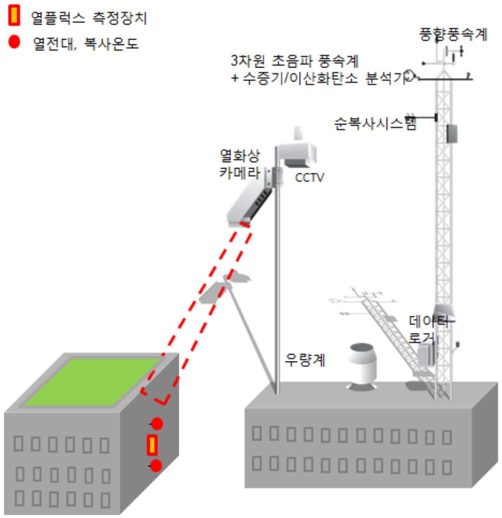


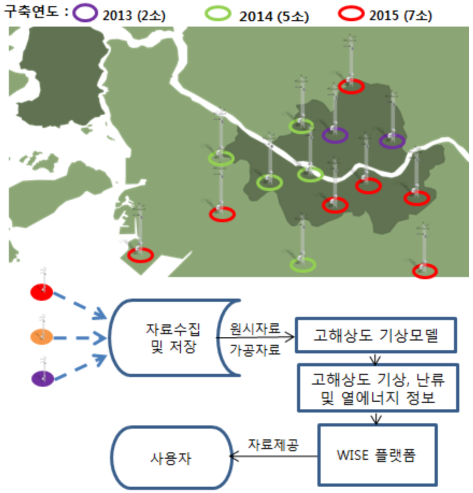




## Energy Balance Observing System of WISE



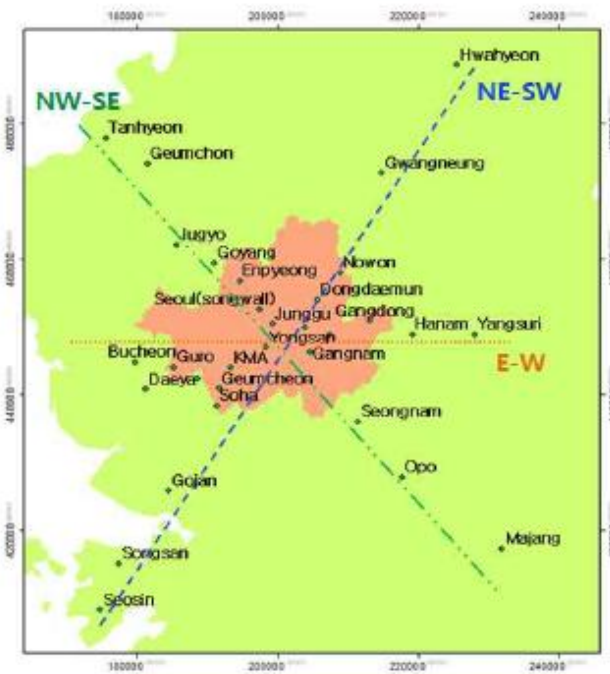


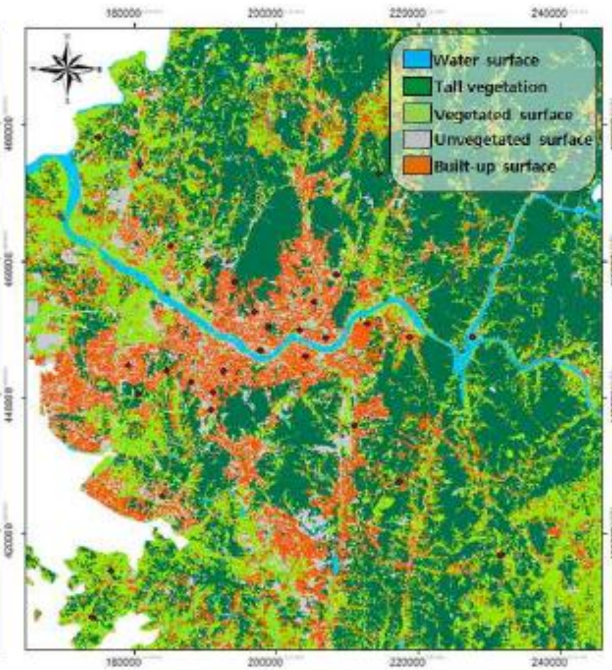



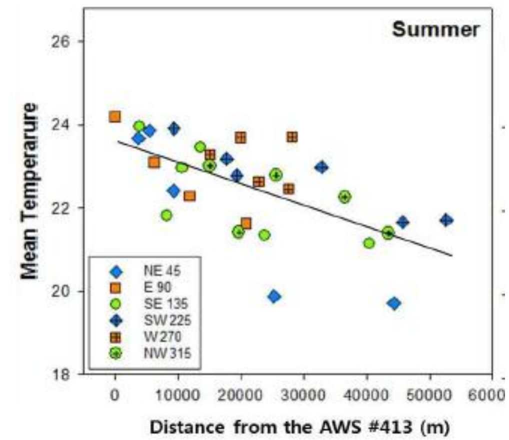
# 01 Urban climate studies in Seoul

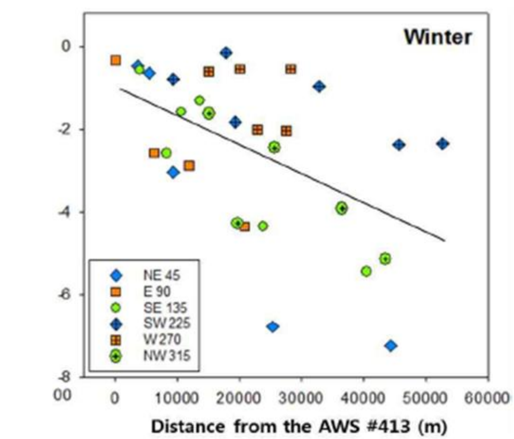
## Study to Find Factors Affecting the Heat Island Intensity

**Impact of the local surface characteristics and the distance from the center of heat Island to suburban areas on the night temperature distribution over the Seoul Metropolitan Area** (Yi et al., 2014)



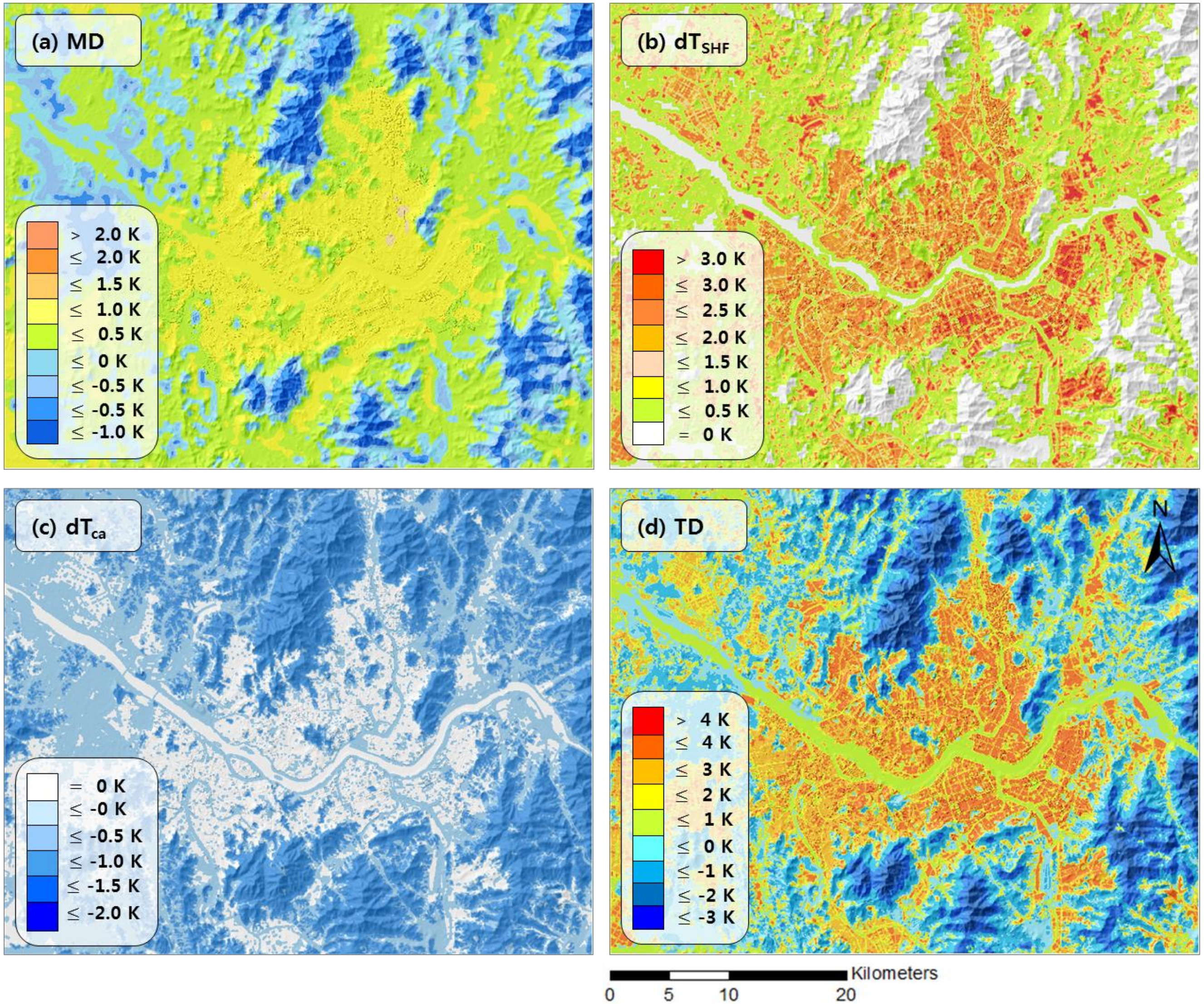




| Season | Radius | Model | $R^2$ | C(p) |
|---|---|---|---|---|
| Summer | 1km | $T = 17.61 + 1.41\ US + 3.43\ SVF$ | 0.74 | 1.70 |
| | 200m | $T = 18.77 + 47.62\ BS + 40.98\ BH + 4.11\ SVF - 0.038\ D$ | 0.72 | 5.42 |
| Winter | 1km | $T = -5.14 + 1.59\ US$ | 0.60 | 4.34 |
| | 200m | $T = -8.73 + 78.22\ BS + 61.48\ BH + 6.63\ SVF - 0.050\ D$ | 0.57 | 4.56 |

# 01 Urban climate studies in Seoul

## CAS (Climate Analysis Seoul) Workbench

**by National Institute of Meteorological Research & Technical Univ. of Berlin**




(a) Meso-scale temperature deviation (*MD*)

(b) Nocturnal sensible heat release by buildings ($dT_{SHF}$)

$$dT_{SHF} = c_{SHF} \cdot (f_{CSAR} - 1)$$
$$f_{CSAR} = 1 + 4 \cdot \sqrt{f_{BS}} \cdot \frac{h_B}{ds}$$

(c) Decrease in air temperature by local cooling ($dT_{ca}$)

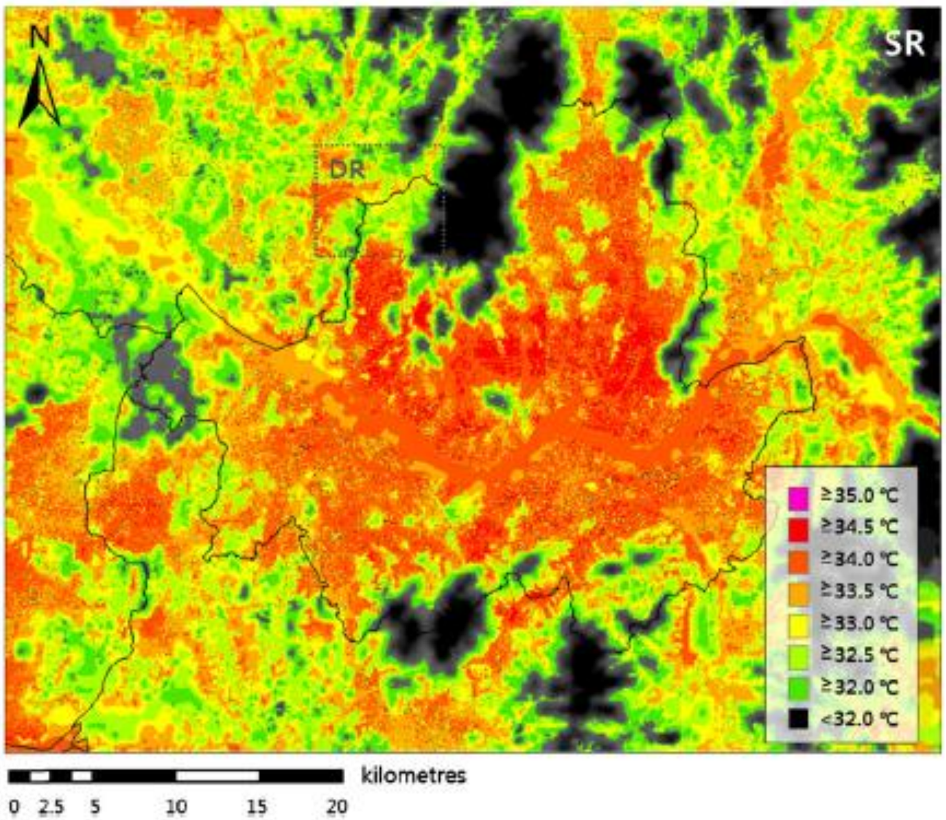
$$dT_{ca} = c_{ca} \cdot Q_{ca} = c_{ca} \cdot \begin{pmatrix} f_{TV} \cdot Q_{ca,TV} \\ +f_{VS} \cdot Q_{ca,VS} \end{pmatrix}$$

(d) Total air temperature deviation (*TD*)

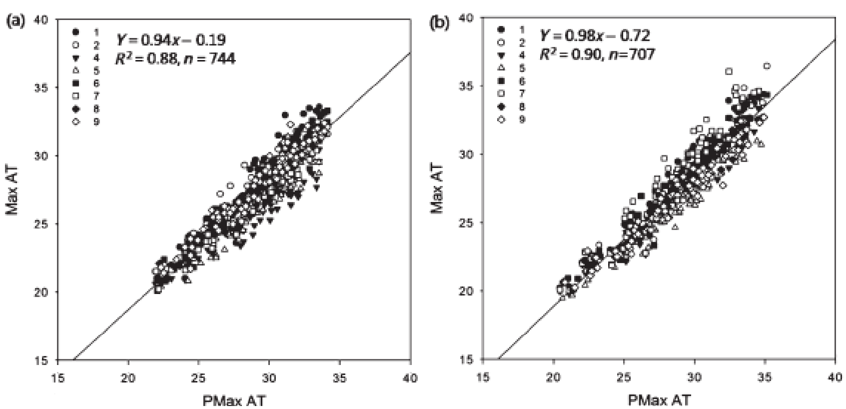
$$TD = MD + dT_{SHF} + dT_{ca}$$

## Comparisons between Observed and Estimated Temperatures

**Estimating spatial patterns of air temperature at building-resolving spatial resolution** (Yi et al., 2015)



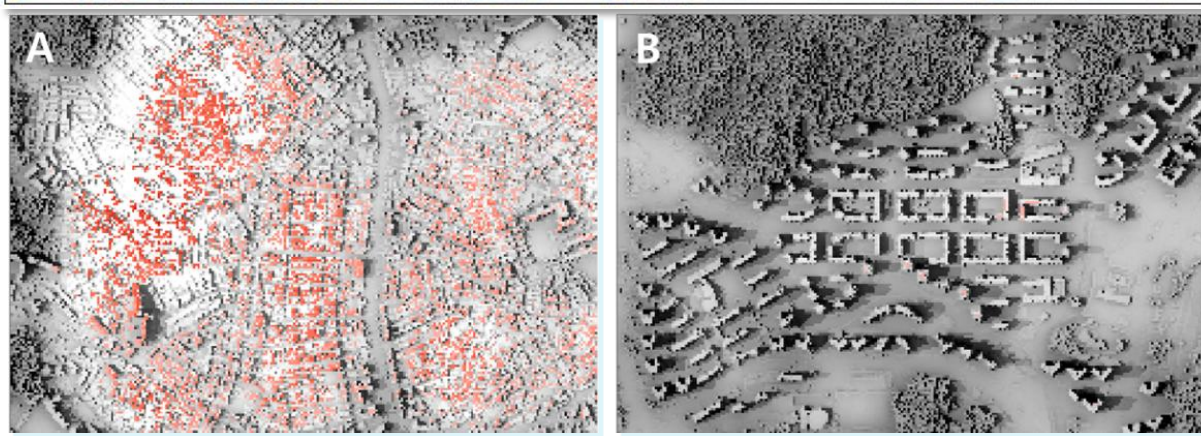

Maximum temperature distribution map of the Seoul based on the CAS workbench and an observed daily maximum temperature of 33 ◦C at the Seoul weather station (the threshold temperature for heat advisory in Korea)



# Study on Urban Bio-meteorology (Heat Stress) Analysis, BioCAS

**Bio-meteorological Climate impact Assessment System for building-scale impact assessment of heat-stress related mortality** **(Kim et al., 2013)**

**Old town** **New town**

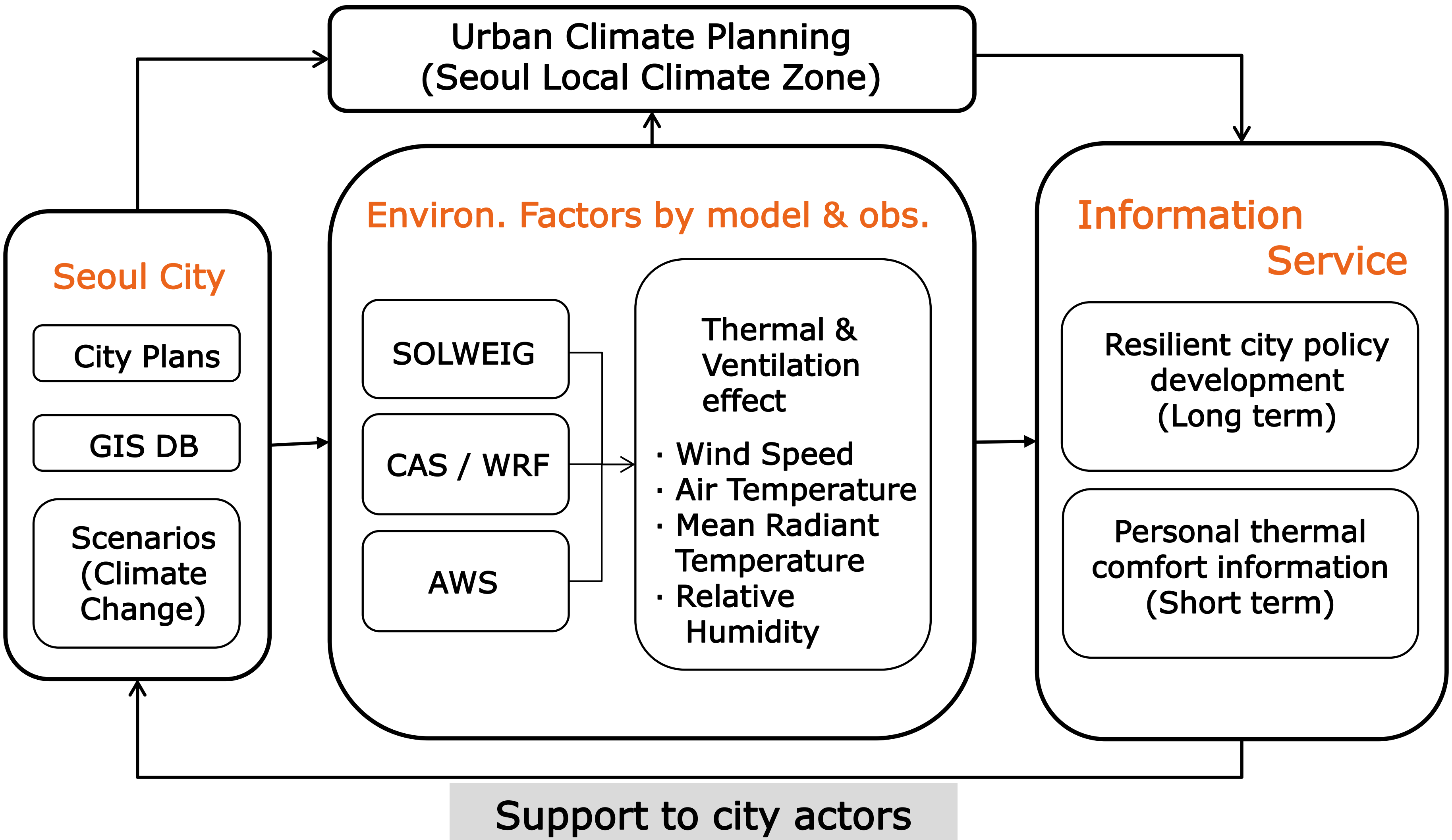



Estimated excess mortality rate, expressed as increase in daily mortality rate relative to the expected base mortality rate of the same day, during the heat event on August 5, 2012

| | min | max | mean | Std. dev. | Area: $r_{EM}>0$ |
|---|---|---|---|---|---|
| Old Town (A) | 0 | 0.51 | 0.02 | 0.069 | 14.3 % |
| New town (B) | 0 | 0.09 | ~0 | 0.001 | 0.1 % |

# 02 WISE Urban Climate Information Service

## Urban Climate Information System



# Urban Planning Processes in Korea

## Needs of urban climate information on the Urban Plan

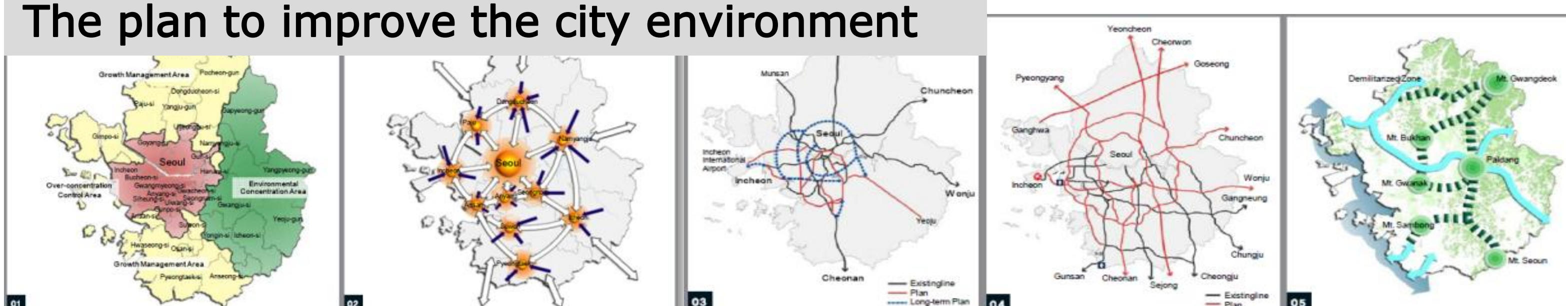
### City Planning Systems

- National Comprehensive Plan
- Arrangement Plan for the Capital Region
  - Regional Plan
- Seoul Master Plan
  - Downtown Development Plan
- Urban Management Plan
- Implementation Plan

### Three-tiered system of city planning

| | Goal |
|---|---|
| Seoul Master Plan | Basic Spatial Plan And Long-term Development Direction |
| Urban Management Plan | Concrete Development Procedure and Restrictions |
| Implementation Plan | Execution of Project |

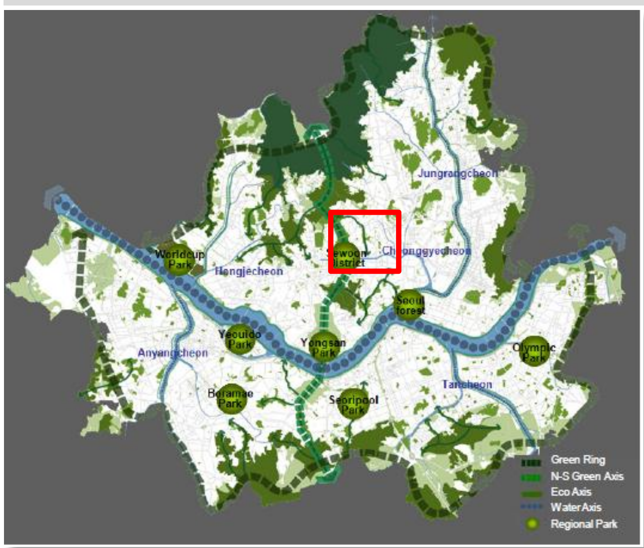
### The plan to improve the city environment



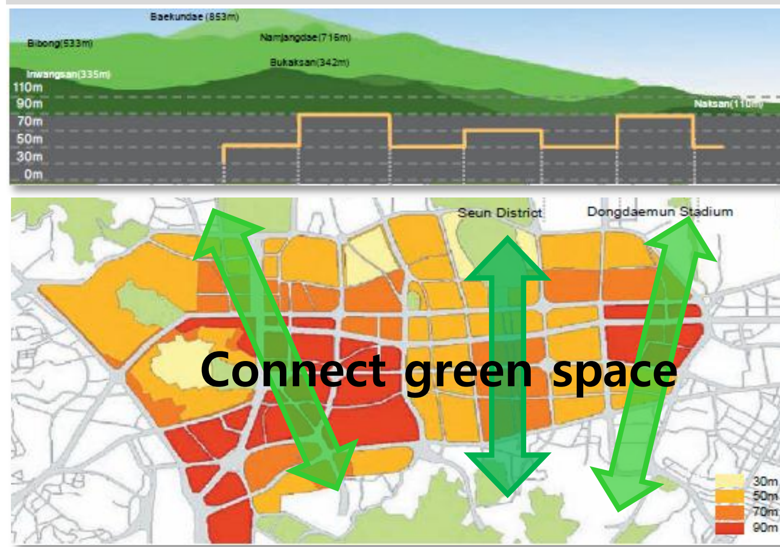
# Applied Technology Development of Seoul Master Plan

## Seoul Urban Plan Information System (http://www.urban.go.kr)

## Green network plan of Seoul




## Building height control and green network

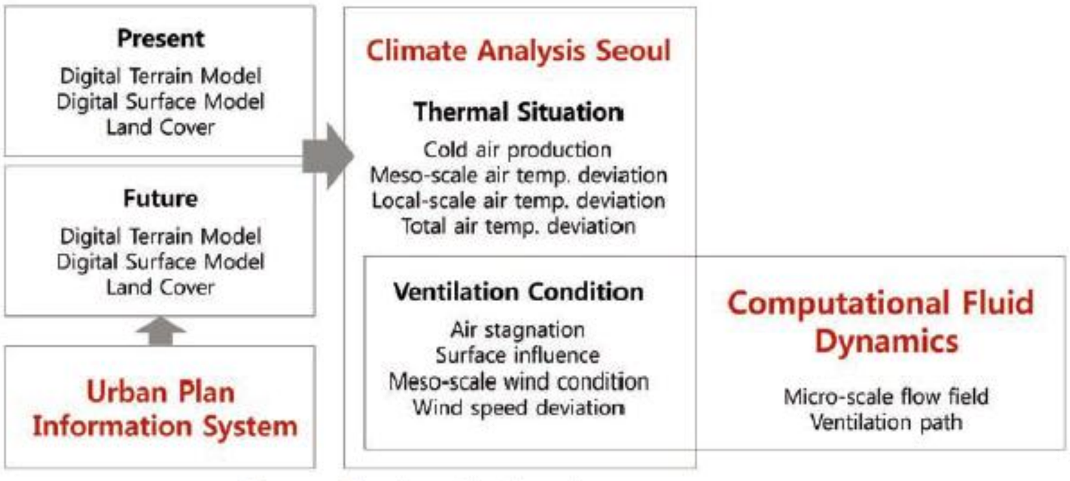


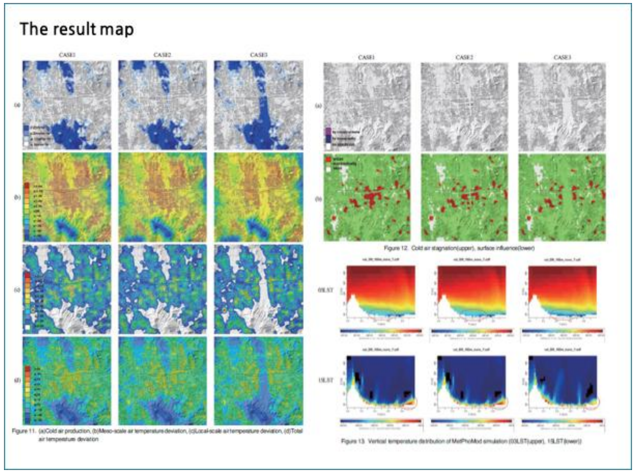

Source : Urban Renaissance Master Plan for Downtown Seoul, Seoul Metropolitan Government, 2007

# Applied Technology Development of Seoul Master Plan

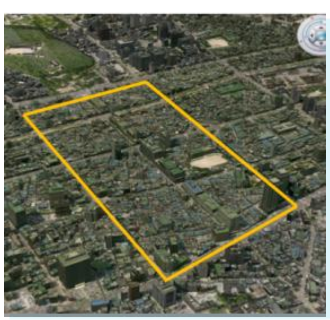
## Urban Climate Impact Assessment Reflecting Urban Planning Scenarios

(Kwon et al., 2015)



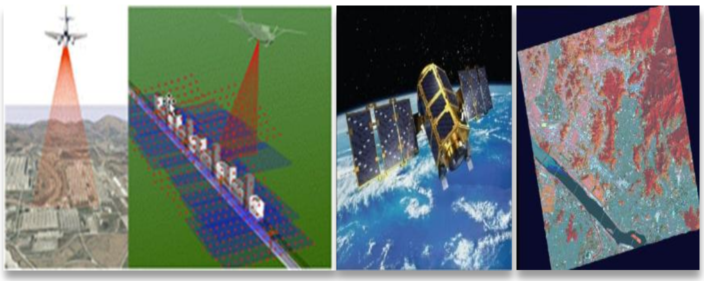

District Development Plan → UPIS → Input of CAS

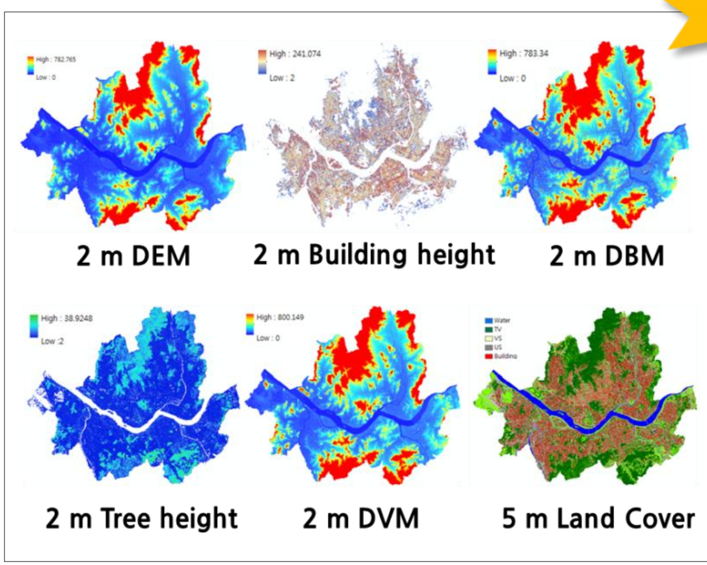


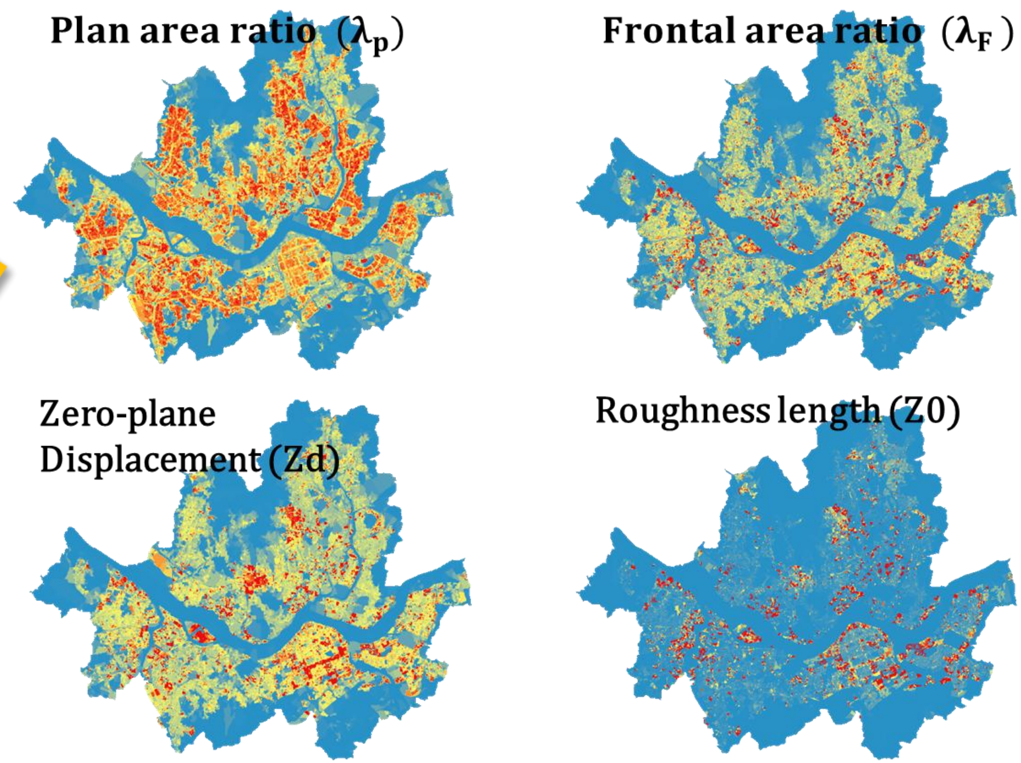
## Urban Surface Properties Development

### A Study on the Roughness Length Spatial Distribution in Relation to the Seoul Building Morphology (Yi et al., 2015)

From Aerial LiDAR and Satellite data



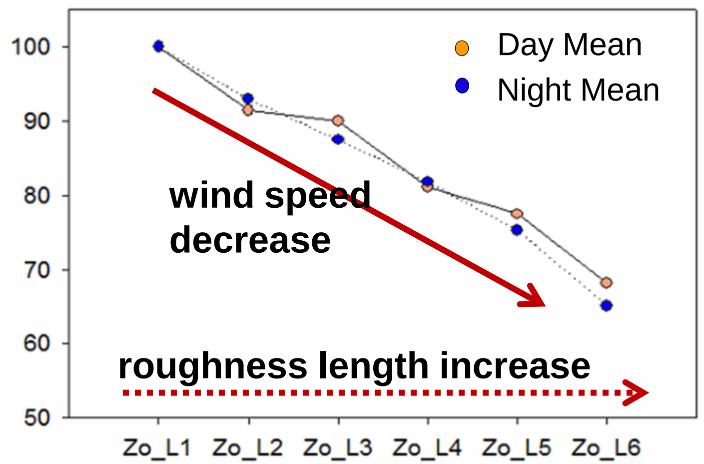


# Relations between Roughness Length class rate and AWS wind speed

**AWS wind speed decreased as the roughness length class rate(%) increased**

**Roughness length class rate(%)**

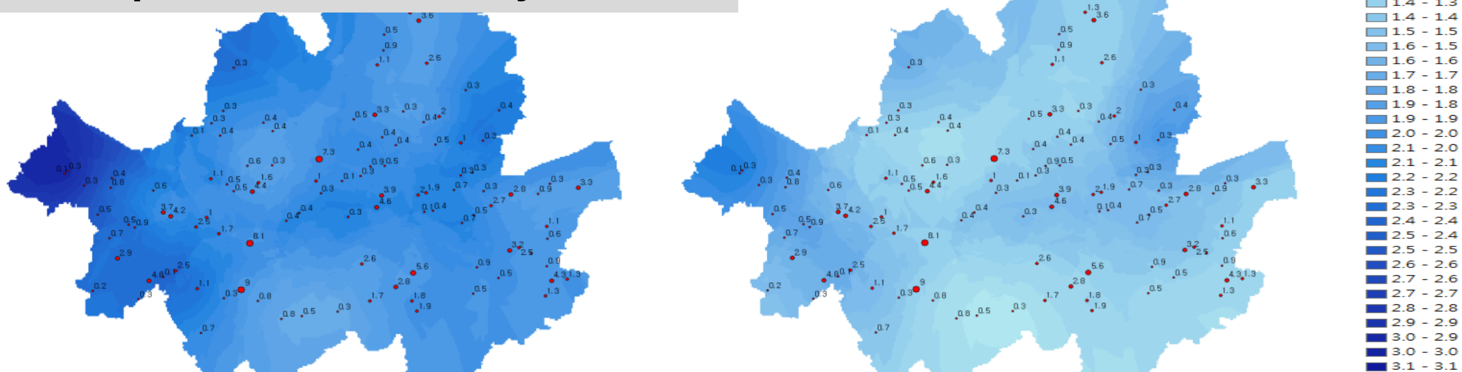



AWS Classification Table

| Class | Range | Count |
|---|---|---|
| Z0_L1 | ~0.5 | 44 |
| Z0_L2 | 0.5~1.0 | 25 |
| Z0_L3 | 1.0~2.0 | 14 |
| Z0_L4 | 2.0~4.0 | 16 |
| Z0_L5 | 4.0~8.0 | 7 |
| Z0_L6 | 8.0~16.0 | 2 |
| Z0_L7 | 16.0~32.0 | 0 |
| Z0_L8 | 32.0~ | 0 |

- Date : July ~ Sep., 2013 (92 days)
- AWS No: 161 AWSs
- Condition : wind speed < 2m/s cloud cover < 30%

**Wind speed distribution by AWSs**

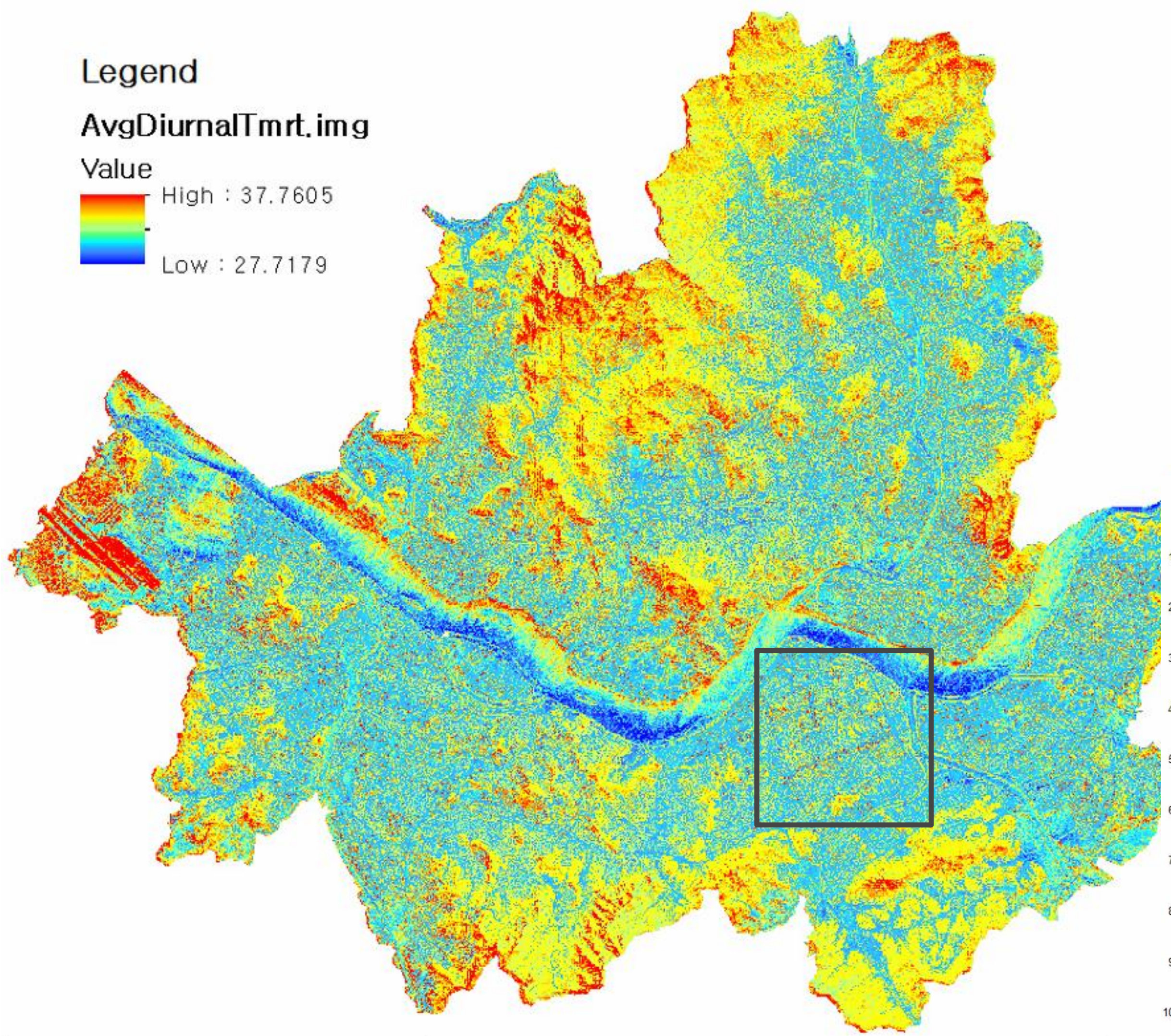


* Kriging Interpolation **Day(06:00~19:00)** **Night(20:00~05:00)**

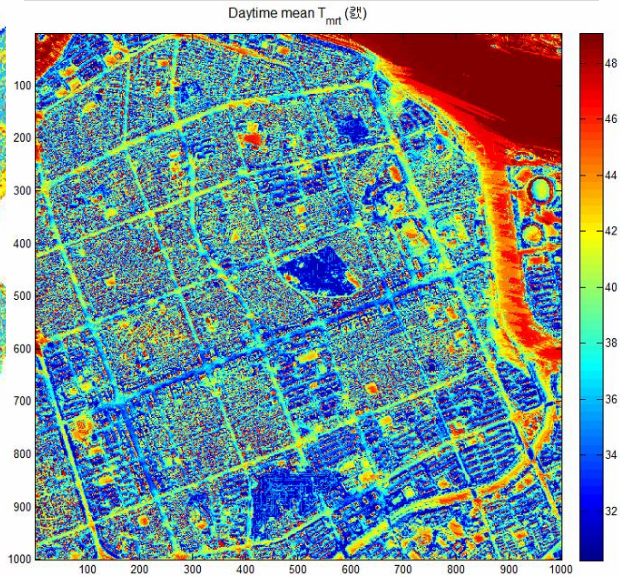
# 02 WISE Urban Climate Information Service

MRT

## Seoul Mean Radiant Temperature using SOLWEIG

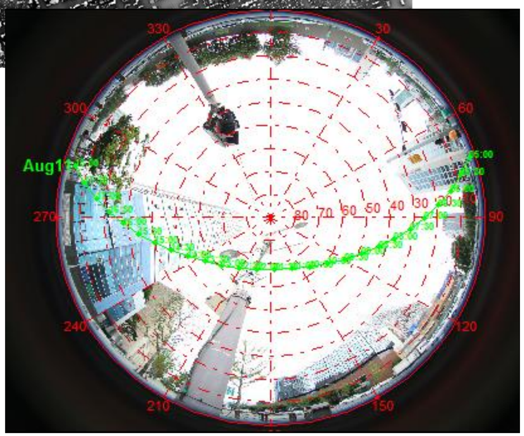



Average Daytime
MRT
Resolution: 20m / 4m

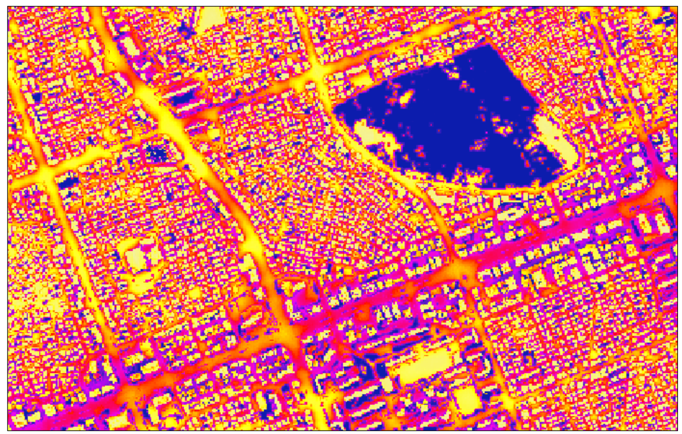


# Evaluation of Sky View Factor - calculations methods for enhancement

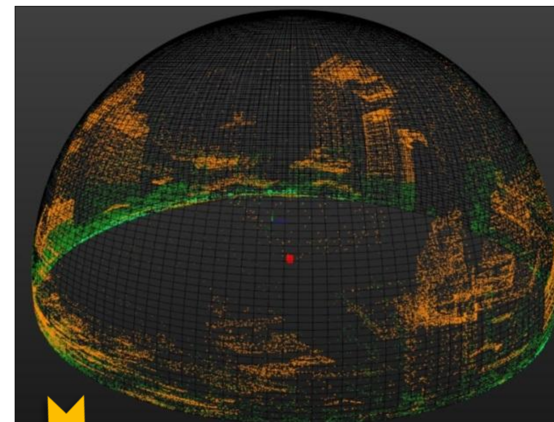
1. Fish-eye photography based calculation (1D, observation sites)
2. SOLWEIG model using DBM, DVM Grid (2D, Lindberg et al., 2008)
3. Three-dimensional point cloud based calculation (2D, An et al., 2014)



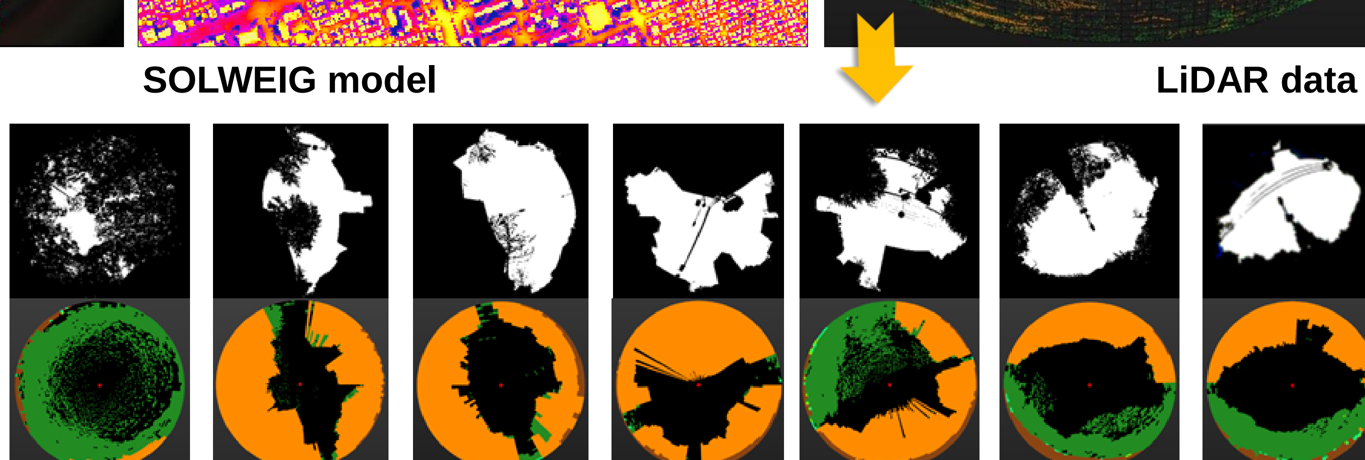
Fish-eye



SOLWEIG model



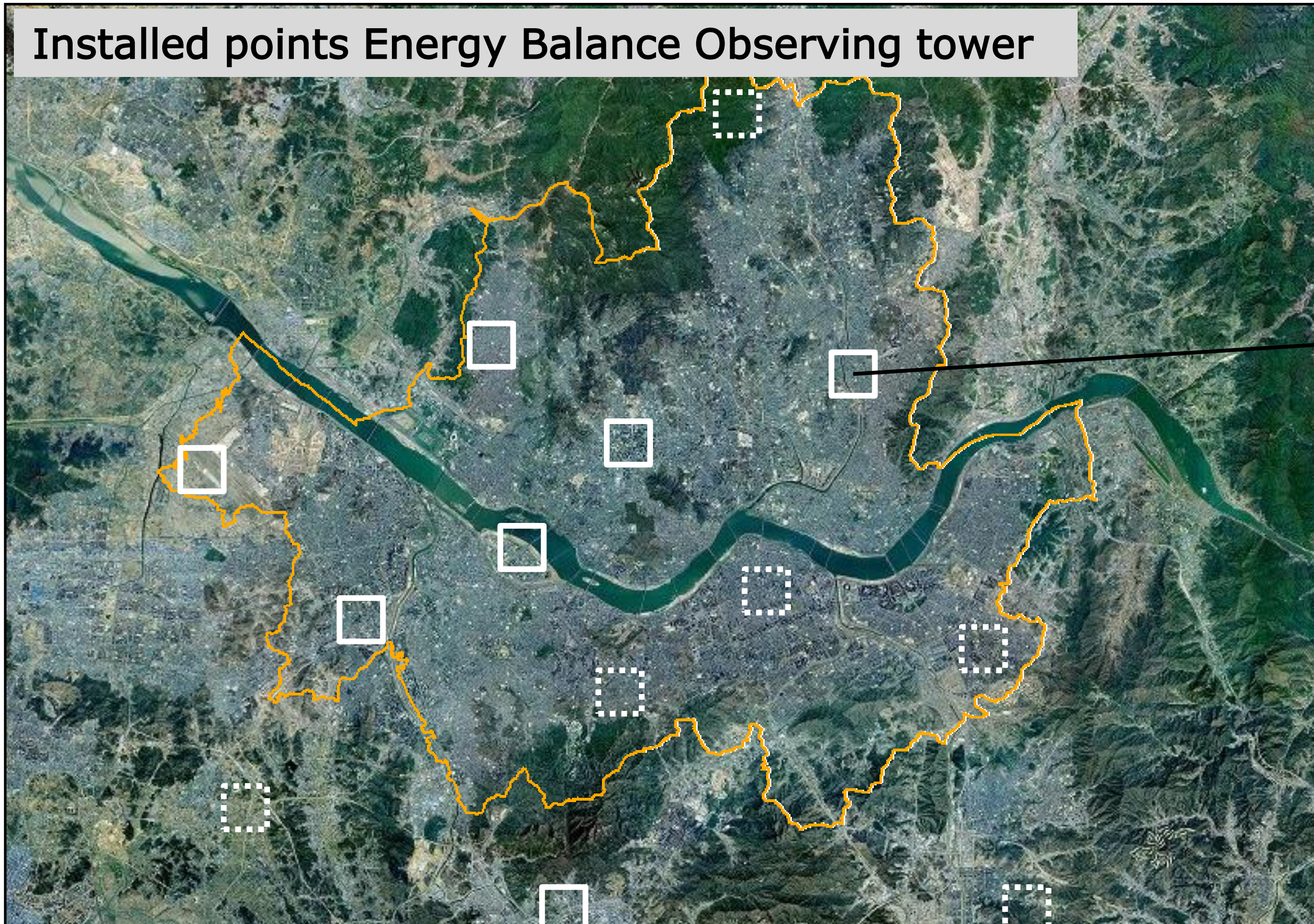
LiDAR data

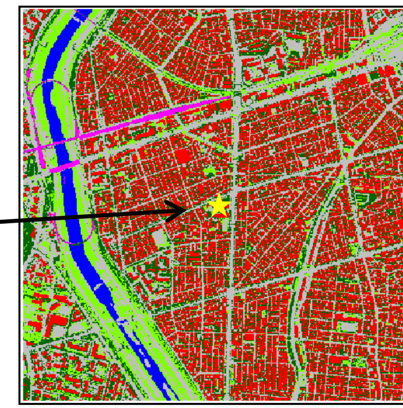


# 02 WISE Urban Climate Information Service

## Flux Observation and Validation of the radiation flux

Net radiometer, Infrared thermometers, Sonic wind and temp., $H_2O/CO_2$ gas analyzers, Humidity, Anemometer and wind direction

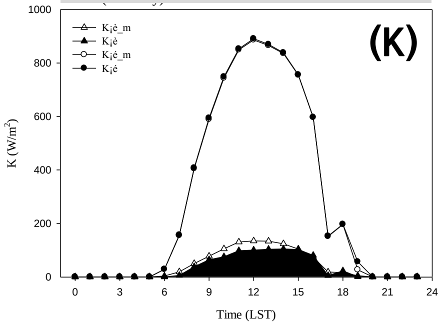


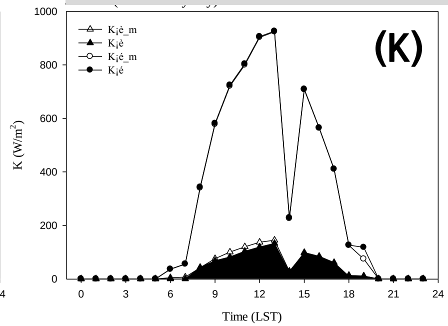



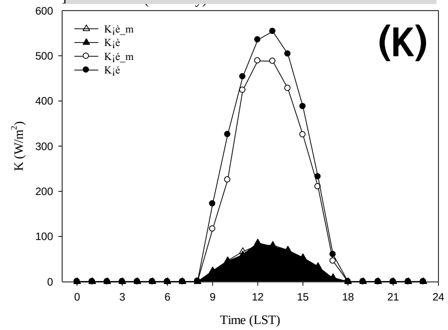
MRT

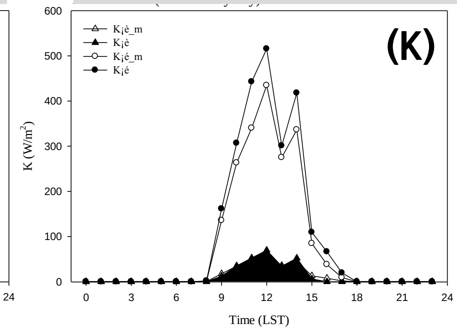
# Validation of Radiation Flux from SOLWEIG

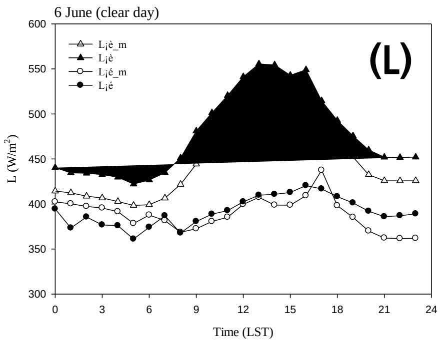
| Clear day, 6th June | Semi-Cloud day, 26th June | Clear day, 13th Dec. | Semi-Cloud day, 19th Dec. |
|---|---|---|---|

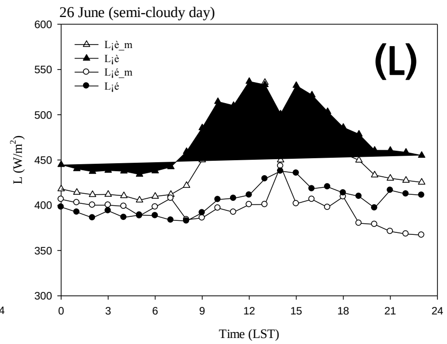


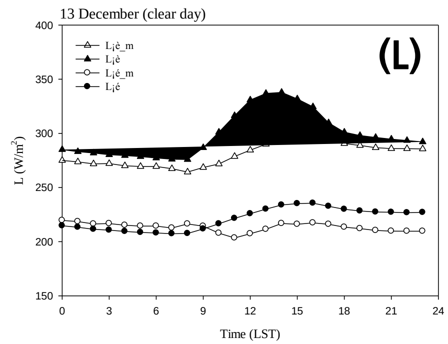



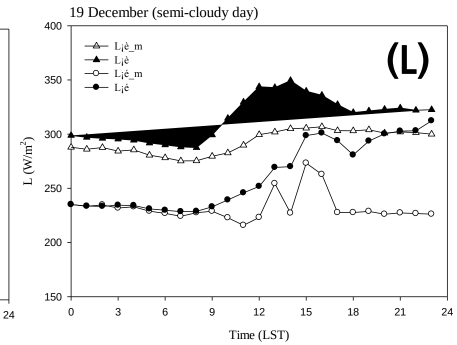



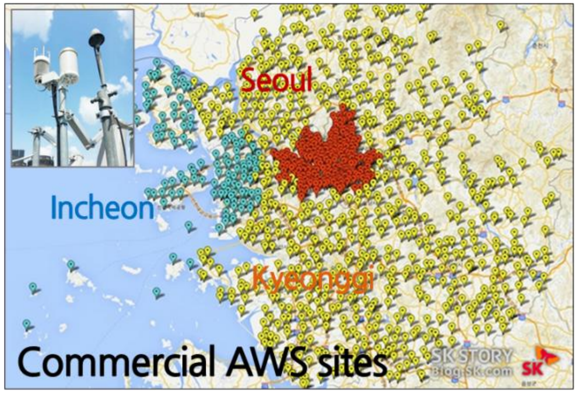



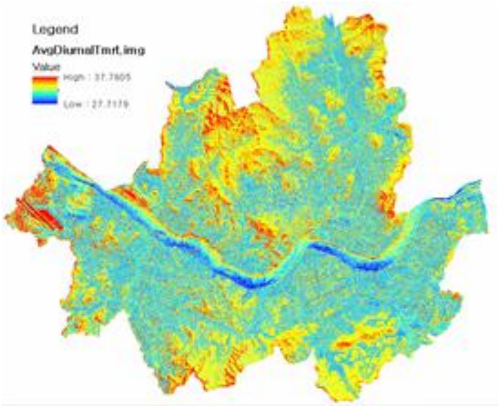




Model vs. measured hourly data of all the shortwave (n=96) and longwave (n=96) fluxes

| Kup | Kdown | Lup | Ldown |
|---|---|---|---|
| $y = 0.88x + 0.63$ | $y = 1.02x + 7.56$ | $y = 1.03x + 13.64$ | $y = 0.92x + 36.11$ |
| $R^2 = 0.97$ | $R^2 = 0.94$ | $R^2 = 0.98$ | $R^2 = 0.93$ |

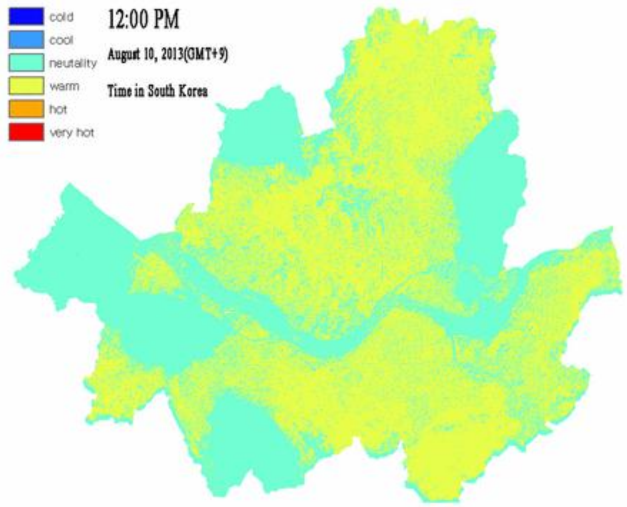
# Spatial and Temporal Variation of Thermal Comfort in Seoul (August 10, 2013)




**AWS (264 sites in Seoul)**
- Wind Speed
- Relative Humidity
- Air Temperature

**SOLWEIG Model**
- MRT




**Analysis model**
Monteiro and Alucci (2009)
Temperature Equivalent Perception(TEP)
TEP= -3.777 + 0.4828*AT + 0.5172*Tmrt+0.0802*RH-2.2322*WS

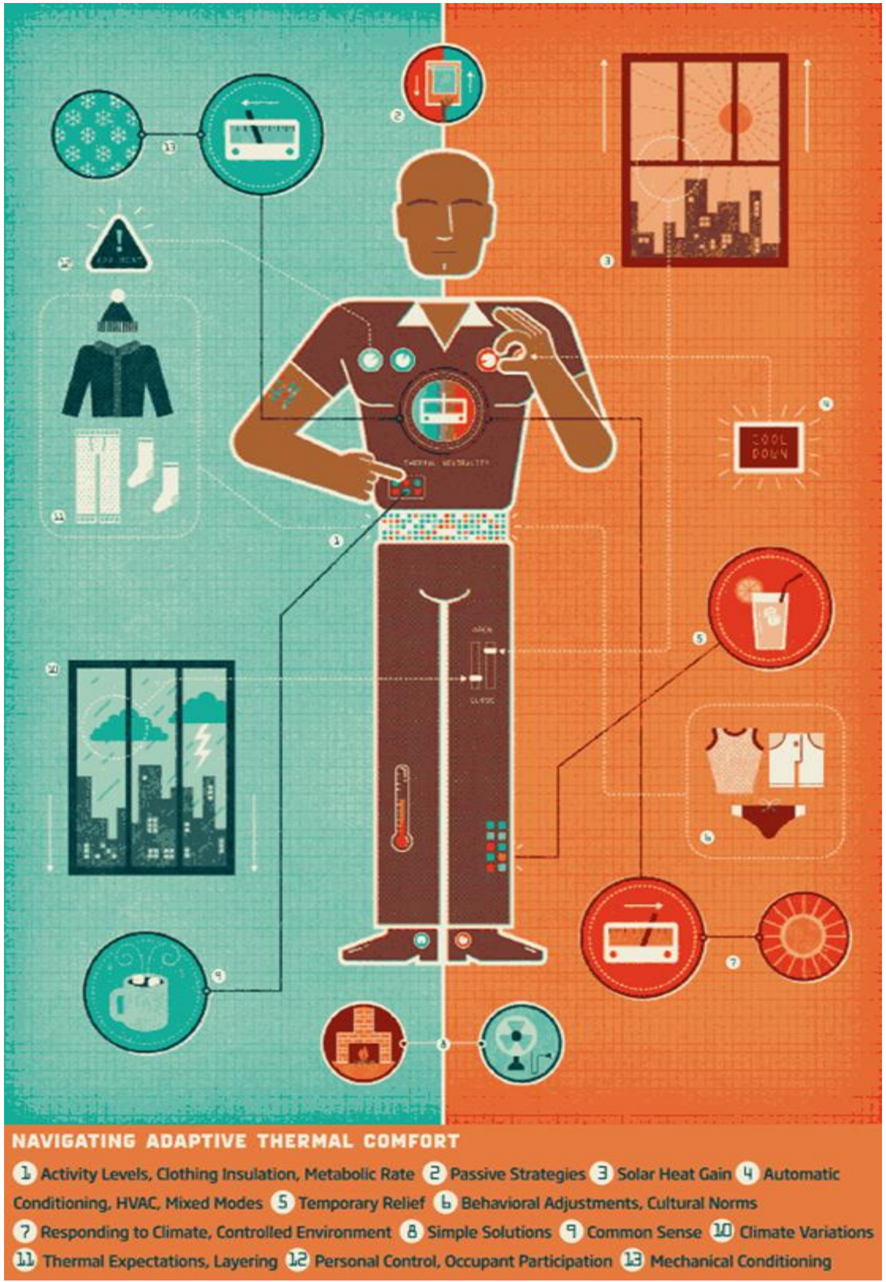
# 03 Conclusion

1. Comprehensive support system for long-term city planner was developed using UPIS, CAS, CFD

→ Provides climate information for future urban planning

2. A prototype thermal comfort information system for short-term support of the citizens was developed using AWS, SOLWEIG

→ Provides information for supporting the current citizen act

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