WISE program: Observation, Modeling and Application for Urban Meteorology in Seoul

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(On behalf of Director Gangwoong Lee)
WISE / HUFS / KMA

차세대도시농림융합기상사업단
(Weather Information Service Engine)
Unfortunately,

WISE has not been doing any research on Air Quality until now!

History along with WMO
‘13: WISE submitted to 16th WMO CAS
‘14: Discussion with WMO GAW
‘15: with Dr. Alexander Baklanov
WISE program

- **Project period**: 2012~2019
- **Total budget**: US$85 million  (Assessed every year)
  - Actually received **half** of it from Gov. until now.
  - ’17 budget: US$5.5 million
- **Personnel**: Total 48  (43 researchers + 5 admin.)
- **Organization**
  - 3 Deps. of research + 1 Dep. of human resources
    - Modeling & Computer
    - Urban Observation
    - Application
    - Adm.

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KMA

HUFS  
Hankuk Univ. of Foreign Studies

WISE
Program components

① Observation

② Storm-scale NWP model

③ Application

- Flash flood
- Road weather
- Urban meteor.
- Urban ecology
- Dispersion of H.S.
- Renewable Energy
- Agroforestry

Public service

KMA
City of Seoul
Urban Traffic Information Center
Ministry of Agriculture
Finally, all observation sites have been installed late 2016. They are now running well!

Its total cost is approximately US$7 million.
Observation “Location”

Seoul metropolitan area
Pre-existing observation of KMA: 7 ASOS, 108 AWS, 2 radar, 1 rawinsonde
<table>
<thead>
<tr>
<th>Systems</th>
<th>Sensor or specification</th>
</tr>
</thead>
</table>
| **Surface energy balance obs. system (14 sites)** | Sites: rural, residential, commercial, industrial, apartment, river (1.5~18.5m)  
Sensor: T, RH, Wind, ↑↓ short/longwave radiation, CO₂/H₂O IR gas analyzer, sonic anemometer, Tsfc, rain gauge, Twater(2), IR thermometry (6), Large Aperture Scintillometer(1 set). Tsfc monitoring system(2 sets) |
| **Meteo. Obs. system for profile**          | Ceilometer (2): Wavelength: 910 nm / Backscatter by aerosol (up to 15 km, 10 m vertical resolution, 1-min temporal resolution), cloud bottom heights (3 level)  
Aerosol lidar (2): Wavelength: 532 nm (parallel, cross-polarized), 1064 nm / Backscatter by aerosol (up to 16 km, 3.75 m vertical resolution, 1-hr resolution), depolarization ratio, backscatter  
Radiometer (7): Water vapor (22~31 GHz, 7 channels), T (51~58 GHz, 7 channels)  
Tₜ for each channel, vertical profile of T, RH, liquid water content  
Wind lidar (6): Wavelength: 1532 nm, Wind speed and direction (up to 6,000 m, 100 m vertical resolution, 10-min interval) |
| **Applied meteo. Obs. system**              | Road (6): Wind, T, RH, Precip., Precip. detection, insolation, net radiometer, road temperature and status, salinity, water depth  
Water quality (2): Twater, pH, conductivity, dissolved oxygen, salinity, turbidity, chlorophyll-a, water depth  
Mosquito (3): Mosquito collector  
Greenhouse gas (1): CH₄ concentration, total radiation, diffuse radiation  
Agrometeo.(4): Shortwave/longwave radiation, T and RH, albedo, leaf wetness, soil moisture content, wind speed and direction, precipitation, Tsoil |

Transmitted by M2M
1) For Vertical Profiles

Ceilometer  Aerosol Lidar  Wind Lidar  Microwave Radiometer
Vertical Profiles

(Urban Boundary Layer Evolution)

(Ceilometer/Aerosol Lidar)

(Microwave Radiometer)

(Wind Lidar)
2) AWS + Surface energy balance system

- 3D Sonic anemometer
- CO$_2$/H$_2$O gas analyzer
- Wind speed/direction
- Net radiometer
- Thermal imagery
- Temperature/Humidity
- Rain gauge
- 10m
- 9m
- 8m
- 5m
- 2m
- surface
3) Mobile Road & Urban Meteo. Obs. System

- Wind speed/direction
- GPS
- Temp./Humidity
- Precipitation detection
- Precipitation
- Road condition
- insolation
- Net rad.
- Road water film thickness
- Remote sensing
WISE is providing observation data to KORUS-AQ

**Observation**

Urban Met. Observation
- Wind lidar, Radiometer
- Aerosol lidar, Ceilometer
- Surface energy balance
- Surface Met/KMA/SKP
- Applied Met.

**Data acquisition / Quality Check**

- Metadata
  - Real-time data acquisition system
  - Real-time quality check system (Automated quality check)

**Data Assimilation**

**Met/Application Model**

**Platform**

HH 00m
- Obs. (Field)

HH 05m
- Acquisition (To Server)

HH 10m
- QC (At Server)
Station Metadata

(Muller et al., 2013; Song et al., 2014)
Real-Time Data Display and Check
2 Storm-scale NWP model
Advanced Storm-Scale Analysis and Prediction Sys. (ASAPS) 1-km resolution, up to 6-hr forecast, every hour

Predicting severe weather on Seoul and metropolitan area to support meteorological prediction information to application models

LAPS (from NOAA)

WRF (from NCAR)
Operational on KMA Cray supercomputer
Application for Public Service

- Flash flood
- Road weather
- Urban meteor.
- Urban ecology

Not Serviced yet!
1. Flash flood
Urban flash flood (only for the city of Seoul)

Observation & NWP forecast

- AWS
- QPE/QPF from Radar
- NWP model (ASAPS)

Run-off and flooding Forecast model

Land / Hydraulic structure

- Digital map (2m)
- Land Cover
- Soil map
- Pumping / Undercurrent
- Pipe linenet
- Manhole

83 drainage areas in Seoul

Gangnam
### Risk matrix (tentative proposal)

For the impact-based forecast

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Area (km²) that depth of flooding is higher than 0.5m</th>
<th>Take action</th>
<th>Be prepared</th>
<th>Be aware</th>
<th>Not severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 60%</td>
<td>High</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>≥ 40%</td>
<td>Medium</td>
<td>1</td>
<td>6</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>≥ 20%</td>
<td>Low</td>
<td>4</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 1%</td>
<td>Very Low</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Low</td>
<td>0.01 - 0.1</td>
<td>0.1 - 0.2</td>
<td>0.2 &lt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>0.01 - 0.1</td>
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</table>
Prediction system for Inundation Area in Seoul
2. Road Weather
1) Road Condition

**Observation & NWP forecast**

Heat balance model for road Temp.

- Guess
- Sensible & Latent heat
- Geothermal heat
- Net radiation
- Radiation from cars
- Friction heat of tires
- Sensible heat of cars
- Estimation of T on road

**Road condition (wet, dry, ice, snow)**

Water balance model / Machine running

**Service map**

forecast
2) Road Hydroplaning (water film thickness)

Observation (AWS) → interpolation → Estimation of precipitation on roads → Hydroplaning zone

Precipitation

Road geometry
(wide, # of lanes, height, cross-fall, vertical grade etc)
OBD (Future work)

- To collect Temp. and Pres. in real-time basis from OBD (On-Board Diagnostics) installed in moving cars.
- It can be used to provide real-time Temp. in urban area, and to evaluate the estimated Temp. on roads.
Climate Analysis Seoul (CAS)

Urban microclimate analysis model (10m-resolution)
which is able to analyze urban spatial characteristics in detail.

Surface structure (GIS)
Slope, dx/dz, dy/dz, Hollow depth,
Aspect Ratio, Building(Vegetation) Height,
Volume, Density,
Complete Surface Area Ratio,
Fractional Coverage of Land cover

CAS: by National Institute of Meteo. Science (NIMS) and Technical University of Berlin
Ex 1) Urban Heat Wave

- Building-Resolving air Temperature (BRT) forecast

Heat risk map

(Risk Matrix)

(Seoul)
Ex 2) Cool roof

Production of Surface Microclimatological / Micrometeorological Data (Wind, Humidity, Air/Radiation Temp., etc)

Weather Impact forecasts
Urban policy support
Public service
4. Urban Ecology
MAPS (Mosquito Activity Prediction System)

Forecast using meteorological observation/prediction data and ecological environment

- Mosquito collector: 50 by City of Seoul, and 3 by WISE
- Method: Random forest (Machine Learning)

Category:
- Comfortable
- Concerned
- Beware
- Uncomfortable
Thank you for listening!