GEMS capacity building training programme

Enkhbaatar DAVAANYAM

Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia

2024.01.19
### Schedule of Training

<table>
<thead>
<tr>
<th>Hour/Day</th>
<th>0900-0930</th>
<th>0930-1000</th>
<th>1000-1030</th>
<th>1020-1110</th>
<th>1110-1130</th>
<th>1130-1230</th>
<th>1230-1330</th>
<th>1330-1630</th>
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</thead>
<tbody>
<tr>
<td>08/01/24</td>
<td>PREP</td>
<td>Registration</td>
<td>Opening &amp; Photo session</td>
<td>INVITED TALKS GISTDA (Dr. Pakorn Petchprayoon) - NIER (TBD)</td>
<td>BREAK</td>
<td>INVITED TALK</td>
<td>Air pollution monitoring w remote sensing (Prof. Jhoon Kim)</td>
<td>LUNCH</td>
</tr>
<tr>
<td>09/01/24</td>
<td>SESSION</td>
<td>Intro to Pandora (Prof. Hanlim LEE)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>DOAS (Prof. Hanlim LEE)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>SESSION</td>
</tr>
<tr>
<td>10/01/24</td>
<td>PREP</td>
<td>SESSION</td>
<td>DOAS (Prof. Hanlim LEE)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>DOAS (Prof. Hanlim LEE)</td>
<td>LUNCH</td>
<td>BREAK</td>
</tr>
<tr>
<td>11/01/24</td>
<td>SESSION</td>
<td>GEMS data validation and correction with Pandora (Prof. Ukkyo Jeong)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>GEMS data validation and correction with Pandora (Prof. Ukkyo Jeong)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>SESSION</td>
</tr>
<tr>
<td>12/01/24</td>
<td>SESSION</td>
<td>GEMS data validation and correction with Pandora (Prof. Ukkyo Jeong)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>GEMS data validation and correction with Pandora (Prof. Ukkyo Jeong)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>SESSION</td>
</tr>
<tr>
<td>13/01/24</td>
<td>SESSION</td>
<td>Surface level concentration estimation - nonlinear method (Prof. Jungho Im)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>Surface level concentration estimation - nonlinear method (Prof. Jungho Im)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>SESSION</td>
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<tr>
<td>14/01/24</td>
<td>SESSION</td>
<td>Surface level concentration estimation - nonlinear method (Prof. Jungho Im)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>Surface level concentration estimation - nonlinear method (Prof. Jungho Im)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>SESSION</td>
</tr>
<tr>
<td>15/01/24</td>
<td>PREP</td>
<td>SESSION</td>
<td>Surface level concentration estimation - Linear method (Prof. Jinho Yoon)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>Surface level concentration estimation - Linear method (Prof. Jinho Yoon)</td>
<td>LUNCH</td>
<td>BREAK</td>
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<tr>
<td>16/01/24</td>
<td>SESSION</td>
<td>Surface level concentration estimation - Linear method (Prof. Jinho Yoon)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>Surface level concentration estimation - Linear method (Prof. Jinho Yoon)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>Self Study</td>
</tr>
<tr>
<td>17/01/24</td>
<td>SESSION</td>
<td>Source identification/transboundary (Prof. Cheolhee Kim)</td>
<td>BREAK</td>
<td>SESSION</td>
<td>Source identification/transboundary (Prof. Cheolhee Kim)</td>
<td>LUNCH</td>
<td>BREAK</td>
<td>SESSION</td>
</tr>
<tr>
<td>18/01/24</td>
<td>PRESENTATION or Additional Lecture</td>
<td>BREAK</td>
<td>PRESENTATION or Additional Lecture</td>
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</tbody>
</table>
Air pollution
• There are primarily two reasons for this: (1) in the winter months, continuous heating is required in residential and commercial sectors, which increases the total emissions from heating boilers in the city and at the power plants, and (2) the problem is further exacerbated by lower mixing layer heights (lower than 200 m) coupled with geography surrounded by mountains, which restrict the vertical and horizontal dispersion of pollutants in the winter months (Guttikunda et al., 2013).

• Guttikunda (2007) states that five tons of coal and three cubic meters of wood is consumed by a household on average annually.

• The under clear skies and weak synoptic winds, Siberian high-pressure systems dominate over the area, which produce persistent temperature; emitted pollutants are trapped in the boundary layer, causing severe air pollution problems in Ulaanbaatar (Ganbat et al., 2016).

• The atmospheric pollution in winter is one of the most serious environmental problems that threaten the public health of citizen, and effect on the infant mortality in recent 10-15 years in Ulaanbaatar (Oyunchimeg et al., 2005).
VARIOUS SOURCES OF AIR POLLUTION IN ULAANBAATAR

2016 Air pollution source inventory results

Small coal stoves
<10kW 216,000
11-100kW 2,829

Gers

Mobile source: 339,626 vehicles

Industrial stoves >101kW 158
Power plants 3

Ger area is the largest effect on ambient air quality in Ulaanbaatar city during heating season

- Small heating stoves, 80%
- Mobile sources, 10%
- Large sources, 6%
- Other sources, 4%
Site information of Pandora instruments

Ulaanbaatar is capital city of Mongolia which is urban area. Dalanzadgad is developing city of the Mongolia which is suburban area.

Population

- Ulaanbaatar (capital city)
- Dalanzadgad (rural)

DZ station installed 2022.05.12
PGN generating data from March 2023.

UB station installed 2022.07.25. Broken 2022.11.02

Dalanzadgad (Pandora 217)
Geographical coordinate of the site
( Roof top of the building )
- LAT: 43.5772
- LON: 104.4180555
- HEIGHT: 1462 a.s.l

Ulaanbaatar city (Pandora 216)
Geographical coordinate of the site
- LAT: 47.92038333
- LON: 106.9118222
- HEIGHT: 1303.34 a.s.l
Dalanzadgad station P217 Time series plots for NO2, HCHO, and SO2 (2022/06/01-2023/09/30)

- CH2O
- NO2
- SO2

Quality flag 0, 1, 2, 10

Quality flag 11, 12
Comparison of the Pandora data with GEMS

![Graph comparing Pandora and GEMS data with moles per square meter on the y-axis and January 2023 on the x-axis.]
Comparison of the Pandora data with GEMS

Hourly time series measurements of Pandora Vs GEMS, SO2, January 2023, Dalanzadgad P217 site

Scatterplot of GEMS and PANDORA measurements data, Dalanzadgad January 2023

\[ y = 0.1578x + 5.0292 \]
\[ R^2 = 0.1715 \]
Data of the DZ P217 Pandora instruments
Comparison of the Pandora data with GEMS and AERONET

2022 Aug-2023 June

2023 MAY

Month

days
Low-lying temperature inversion

Remember Ideal Gas Law:

\[ PV = nRT, \quad \text{or} \quad \rho = \frac{P}{RT} \]
ADAM3-Haze  High Resolution (27km) ADAM3 for Ulaanbaatar

Development history of ADAM

2001: Launching ADAM development
2002: Test run at KMA Intranet
2005: Posting at KMA Hompage
2006: Test run at KMA's supercom
2007: ADAM operation
2008: Improvement of vegetation effect
2009: Launching UM-ADAM development
2010: UM-ADAM operation (2 days → 3 days)
UM-ADAM2 operation (Four-seasons)
2011: UM-ADAM2 (N512) operation
2014: Launching ADAM-Haze development
2015: ADAM-Haze operation
Applying optimal interpolation
2016: Improvement of emission inventory

In 2017, ADAM-HAZE was installed at NAMEM in Mongolia.

- The initial conditions processor ICON
- The boundary conditions processor BCON
- The Meteorology-Chemistry Interface Processor MCIP
- The CMAQ Chemistry-Transport Model CCTM

CMAQ Modeling System Flow Chart

Meteorological Field
- Temperature, Wind, Rain, ...

Modeling Domain
- $\Delta C = \text{AdvDiff} + R - S_i + E_i$

Boundary Concentration
- Global Simulation
- Parent Domain

Emission Data
- $\text{NO}_x$, $\text{SO}_x$, $\text{VOC}$, $\text{PM}$, ...

Atmospheric Concentration
- $\text{O}_3$, PM$_{2.5}$, ...

CMAQ (Community Multiscale Air Quality model)
Comparison of the ADAM model and GEMS data (2023.05.18)

HIMAWARI

ADAM-Haze

GEMS

(2023.05.18 03:00 UTC)

(2023.05.18 06:30 UTC)

(2023.05.18 03:00 UTC)

(2023.05.18 06:00 UTC)
Comparision of the ADAM model and Pandora data

\[ y = -0.1053x + 0.2173 \]

\[ R^2 = 0.0121 \]
Comparison of the NO2 Ulaanbaatar’s Pandora data P216 with P217
Comparison of the SO2 Ulaanbaatar’s Pandora data P216 with P217

![Graph showing the comparison of SO2 levels between DZ Pandora 217 and UB Pandora 216 from September 2022 to October 2022. The x-axis represents the date, and the y-axis represents the number of moles per square meter.]
Comparison of the NO2 Ulaanbaatar’s Pandora data with ground measurement
Comparison of the SO2 Ulaanbaatar’s Pandora data with ground measurement
Estimation surface concentration PM2.5

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Variables (Abbrev.)</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-situ</td>
<td>AirKorea (S.Korea)</td>
<td>Final Aerosol Layer Height (AILH)</td>
<td>Point</td>
<td>Hourly</td>
</tr>
<tr>
<td></td>
<td>CNEMC (China)</td>
<td>Final Aerosol Optical Depth (354, 443, 550 nm) (AOCD)</td>
<td>3.5 x 8 km</td>
<td>6 – 10 / day</td>
</tr>
<tr>
<td></td>
<td>NIES (Japan)</td>
<td>Normalized Radiance (354, 388, 412, 443, 477, 550 nm) (NR)</td>
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<tr>
<td>Satellite</td>
<td>GEMS</td>
<td>UV Aerosol Index (JURAI)</td>
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<td>VIS Aerosol Index (VISAI)</td>
<td></td>
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<tr>
<td></td>
<td>VIIRS</td>
<td>Normalized Difference Vegetation Index (NDVI)</td>
<td>1 km</td>
<td>16 days</td>
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<td></td>
<td>SRTM</td>
<td>Digital Elevation Model (DEM)</td>
<td>90 m</td>
<td>-</td>
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<tr>
<td>Satellite</td>
<td>GHSL</td>
<td>Total built-up surface (Built)</td>
<td>1 km</td>
<td>5 years</td>
</tr>
<tr>
<td>Numerical Model</td>
<td>KIM</td>
<td>Temperature (Temp.)</td>
<td>12 km</td>
<td>8 / day</td>
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<td></td>
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<td>Dewpoint temperature (Dew)</td>
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<td></td>
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<td>Relative humidity (RH)</td>
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<td>Wind speed (gust, 3 h maximum) (MaxWS)</td>
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<td>Calculated accumulated StackMaxWS (1, 3, 5, 7 days)</td>
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<td>Planetary boundary layer height (PBLH)</td>
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<td>Pressure (P)</td>
<td></td>
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<td></td>
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<td>Total precipitation (3 h accumulation) (AP3h)</td>
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<tr>
<td>Auxiliary</td>
<td></td>
<td>Day of year converted to sine function (DOY)</td>
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<td>-</td>
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<tr>
<td></td>
<td></td>
<td>Hour of day converted to sine function (HOD)</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td>NASA SEDAC</td>
<td>Population density (PopDens)</td>
<td>30 arc second (~ 1 km)</td>
<td>5 years</td>
</tr>
<tr>
<td></td>
<td>GPWv4</td>
<td>Road density (RosedDens)</td>
<td>8 km</td>
<td>-</td>
</tr>
</tbody>
</table>

KIM model -> WRF model

Combine the ocean models with the land models

For ocean:
- Dependent variable: (Measured PM2.5, Concentrations)
- Independent variable: (Sea level, Bathymetry, Currents)
- Ground-based PM2.5 and PM2.5 concentrations over the ocean

For land:
- Dependent variable: (Measured PM2.5, Concentrations)
- Independent variable: (Land use information variables, DEM, NDVI, Built, Population density, Road density)
- Ground-based PM2.5 and PM2.5 concentrations over the land (urbanized areas)

[^1]: Land use information variables: DEM, NDVI, Built, Population density, Road density
UVI index in Dalanzadgad

A marked increase in the incidence of skin cancer in fair-skinned populations worldwide is strongly associated with excessive UV radiation exposure from the sun and possibly artificial sources such as sunbeds. Current evidence indicates that personal habits in relation to sun exposure constitute the most important individual risk factor for UV radiation damage.

2023/06/09-2023/07/03
UVI GEMS

2023/06/09-2023/07/03

Solarmeter 6.5 UV Index Meter

Winter 2023/01/05

00:45 UTC
01:45 UTC
02:45 UTC
03:45 UTC
04:45 UTC
05:45 UTC
06:45 UTC
07:45 UTC
08:45 UTC

Summer 2023/06/27

R2=0.71
Thank you very much for attention