Applications of Microwave Satellite Data to KMA LDAPS

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Objectives

- Introducing satellite data for synoptic information around sparse data area
- Assimilation of moisture information to the convective-scale model

Observation current usage in LDAPS
- SONDE (temp, pilot, windprofiler), SURFACE (synop, ship, buoy, metar), AIRCRAFT (amdar), RADAR (radial velocity), SCATWIND (ASCAT)

Lack of available observation, needs of satellite DA
KMA Convective-scale Model

- **LDAPS** (**Local** Data Assimilation and Prediction System)

  - **Model**
    - UM **vn10.1k** (ENDGame)
  
  - **Area, resolution**
    - grid number: **1,598 (E-W) X 1,718 (S-N)**
    - resolution: **1.5 ~4 km (Variable grid)**, 70 levels
      - DA 3 km
  
  - **Forecast length (cycle)**
    - **36 hours** (3 hourly)
  
  - **DA system:** 3DVAR(FGAT) with IAU
    - surface, sonde, wind profiler, aircraft, radar,
      scatwind (current) ± 90 min cutoff time
    - **AMSU-B, ground GNSS, TC Bogus**
      will be added next operation
  
  - **In Operation** since July 2017
### AMSU-B Data

**ATOVS(MHS) on board NOAA-18, 19, METOP-A, B**

<table>
<thead>
<tr>
<th>Sensor</th>
<th>FOV [km] (at nadir)</th>
<th>Distance [km]</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIRS</td>
<td>10.0</td>
<td>42.2</td>
<td>IR Sounder</td>
</tr>
<tr>
<td>AMSU-A</td>
<td>47.6</td>
<td>52.7</td>
<td>MW Temp Sounder</td>
</tr>
<tr>
<td><strong>AMSU-B (MHS)</strong></td>
<td><strong>15.9</strong></td>
<td><strong>17.6</strong></td>
<td><strong>MW Humidity Sounder</strong></td>
</tr>
</tbody>
</table>

- **Full-resolution AMSU-B received directly from NMSC of Korea**
- **Channel 1, 2 – semi-window channels, affected from surface and ice phased cloud (using for QC)**
- **Channel 3, 4, 5 – near 183GHz H2O absorption line (Profiling the WV in troposphere)**

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**AMSU-B Weighting Fn.**

- DA
- QC
- Ch1,2
- Ch3
- Ch4
- Ch5

![AMSU-B LODB](image-url)
Analysis Increments Profiles of single AMSU-B with or without conventional data

- O-B<0 ➔ Humidity(+), Temp.(-)
- The impact of AMSU-B is decreased but charged over 90% of total increments over land.
- Over ocean and upper troposphere, the influence of AMSU-B is dominant.

→ We need accurate preprocess to get uncontaminated data.
Preprocess in OPS

Cloud Detection

- QC algorithm for detecting cloud-affected radiances is limited by MHS data itself

1. Detect Cirrus : reject CH4, 5

   Cloud Cost Fn. \( J_c = \frac{1}{2} \Delta T \cdot (HBH^T + R)^{-1}(\Delta T)^2 \)

   (\( \Delta T \) : O-B ch3,4,5 , H : TL Operator, B: BgErr Cov., R: ObsErr Cov.)

2. (EXP1) Detect rain : reject all

   Ocean \( SI = T_{b,1} - T_{b,2} - (a + b \times \theta) \) (\( \theta \) : latitude)

   - It is not working on land

2-1. Detect Rain over Land

   (EXP2) If cirrus detected, reject all channels

   (EXP3) Detect rain using Land SI*

* Qin & Zou (2016)-Development and Initial Assessment of a New Land Index for Microwave Humidity Sounder Cloud Detection
In cloudy area, the standard deviations ($\sigma$) of MHS channel become smaller and the TB1-$\mu$ are not lower than clear sky. → Land SI increased

The contaminated data show negative O-B signals at lower channel.

When remove it, the STD of departure become 1.59 to 1.55 at CH5 and the bias of departure closes to 0 at CH3 (-1.06 → -0.28)
When adding Land SI (EXP3), it shows improvements of main fields.

When rejecting all channel under cirrus (EXP2), it shows improvement of humidity fields at lower troposphere.

EXP3 shows better performance than EXP2 in humidity fields with total forecast time and all height.

Improvement Rate [%] = \left[1 - \frac{RMSE(\text{EXP})}{RMSE(\text{OPER})}\right] \times 100

+ : improved, - : degraded
Comparing the O-A, the change is biggest at CH3 after assimilating AMSU-B.

It influences strongly on humidity and GPH fields near 500 hPa.
Ground-based GNSS in local model

40 domestic sites will be used operationally in next local model

RH('16.7)

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<thead>
<tr>
<th>6 12 18 24 30 36</th>
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<th>6 12 18 24 30 36</th>
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Rain Equivalent Threat Score

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<tr>
<th>ETS(EXPR-OPER)</th>
<th>July</th>
<th>January</th>
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<tr>
<td>0.1mm</td>
<td>6~18H</td>
<td>6~18H</td>
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<tr>
<td>1mm</td>
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<td>7.2%</td>
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<td>5mm</td>
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<td>3.8%</td>
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<tr>
<td>12.5mm</td>
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<tr>
<td>15mm</td>
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<td>25mm</td>
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RMSE improvement rate(%)

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<tr>
<th>Height(hPa)</th>
<th>36H</th>
<th>30H</th>
<th>24H</th>
<th>18H</th>
<th>12H</th>
<th>6H</th>
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Rain Analysis Increment

3% improvement

Eun-Hee Kim
When assimilating AMSU-B and ground GNSS additionally, these add humid in troposphere.

Changes in the upper layer RH fields could affect the subsequent precipitation forecasts.
Summary and Future Plan

- KMA has been dedicating to assimilate satellite data to fill the gap at the data sparse area and provide the moisture information.

- By removing the cloud-affected radiances, the humidity and GPH field at 850~400hPa show better forecast performance.

- The skill score of precipitation forecast is improved but it is tend to overestimate the strong rainfall at the end of forecast.

- **Observation error** and new bias correction method

- Additional polar-orbiting satellite data - IASI, ATMS, GPSRO...
Thanks for attention.