Recent development of satellite data assimilation at JMA

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1. Outline of NWP systems at JMA

<table>
<thead>
<tr>
<th>Model</th>
<th>Global Model &amp; Analysis (GSM,GA)</th>
<th>Mesoscale Model &amp; Analysis (MSS,MA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal resolution (km)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Forecast range (initial time)</td>
<td>5th (00,06,12,18 UTC)</td>
</tr>
<tr>
<td></td>
<td>Data Assimilation (inner loop res.)</td>
<td>4D-Var (TL319)</td>
</tr>
<tr>
<td></td>
<td>Assimilation window</td>
<td>6h (-3 to +3 hours)</td>
</tr>
<tr>
<td></td>
<td>Radiance assimilation</td>
<td>RetTOV9.3</td>
</tr>
<tr>
<td></td>
<td>Cut off time</td>
<td>Early Analysis: 2527m</td>
</tr>
</tbody>
</table>

![Image](image1.png)

Satellite (to be) used in the operational global and mesoscale NWP system items in red were implemented in the operational system since ITSC17

<table>
<thead>
<tr>
<th>Satellite/Instrument</th>
<th>GA</th>
<th>MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAAs15,16,18,19, Aqua, Metop / AMSU-A</td>
<td>Radiance</td>
<td>Radiance</td>
</tr>
<tr>
<td>NOAA-18,19, Metop / MHS</td>
<td>Radiance</td>
<td>Radiance</td>
</tr>
<tr>
<td>(Aqua/AMSR, Metop/IRS)</td>
<td>Under development</td>
<td>Under development</td>
</tr>
<tr>
<td>TRMM/3B42</td>
<td>Radiance</td>
<td>Rain Rate</td>
</tr>
<tr>
<td>DMSP/16,17,18 / SSMIS</td>
<td>Radiance</td>
<td>Rain Rate</td>
</tr>
<tr>
<td>MTSAT-2, Meteosat-7,9, GOES-13,15</td>
<td>AMV</td>
<td>X</td>
</tr>
<tr>
<td>Aqua/Terra/MODIS</td>
<td>Ocean surface wind</td>
<td>Under development</td>
</tr>
<tr>
<td>Metop/ASCAT</td>
<td>Refractivity</td>
<td>Under development</td>
</tr>
<tr>
<td>Metop/GRAS</td>
<td>Refractivity</td>
<td>Under development</td>
</tr>
</tbody>
</table>

![Image](image2.png)

2.1 Exploit AMSU-A channels of 6, 7, 8 in the operational Global analysis (GA)

- AMSU-A channels of 6-8 have been assimilated additionally in coastal area since Nov 2010.
- Their qualities in coastal area, with surface emissivities fixed (0.9) in RTM calculations, were found to be similar to those in land area.
- The experiment in advance of the observation showed:
  - available data increased by 30-35% (Fig.1.1)
  - analyses field got closer to other centers’ ones (Fig.2.1.2)
  - forecast was improved especially in about 100-700hPa vertical layers

![Image](image3.png)

2.2 Radiance assimilation in the operational Mesoscale analysis (MA)

- Radiance data have been assimilated instead of retrievals since Dec 2010.
- A quality control used in GA was applied for the MA with several modifications:
  - 49m thinning distance within 180-250km in GA
  - extrapolating atmospheric profiles with U.S. standard atmosphere’s lapse rate above MSL top height (~400 Pa)
  - employ VarBC coefficients estimated in the latest GA
- Considerable improvements in the tropospheric analyses and short range forecasts (Fig 2.2.2)

![Image](image4.png)

3.1 Assimilation experiment of surface-sensitive microwave radiances with RetTOV-10 in the GA

- TEST run uses RetTOV-10.1, while CNTL run uses RetTOV-9.3. TEST employs also:
  - FASTEM-4 and climatological land surface emissivity, both supplied in RTTOV-10
  - Active assimilation of MHS channel 3-5 over land
  - Reduction of observation error inflation for AMSU-A ch6 over land
  - Use of hourly surface temperature from GSM as the first guess in RTM calc
  - Increase of TCWV over land, especially desert areas. It got closer to ground-based GPS observation than CNTL (Fig.3.1.1)
- Forecasts were improved not only in the troposphere, but also in the stratosphere (Fig.3.1.2)

![Image](image5.png)

3.2 Initial assessment of FY-3A/MWTS

- According to departure (Observed minus Background) statistics, its quality is almost equal or slightly better than AMSU-A (Fig 3.2.1).
- In data assimilation experiment, channel 2 and 3 were newly assimilated. Channel 1 was used to screen out cloud contaminated data. Improvements of temperature forecast for Southern Hemisphere were confirmed when compared to runs without FY-3A/MWTS (Fig.3.2.2).

![Image](image6.png)

3.3 AIRS & IASI clear radiance assimilation

- Cloud detection and Cloud top height estimation
  - 1. Window channel (AIRS ch850, 10.2μm) O-B threshold
  - 2. Difference of observed radiances (AIRS 10.2μm – 11.8μm) threshold
  - 3. The cloud top heights are estimated by Minimum Residual Method (Eyre and Menzel 1969) with two AIRS channels (13.4μm, 10.8μm)

![Image](image7.png)

3.4 Use of daily ozone product instead of climatological values for RTM calculation

- Use of daily ozone product instead of climatological values for RTM calculation
  - O-B of clear data forms Gaussian-like

![Image](image8.png)

3.5 AIRS assimilation experiment with these configurations performed well (Fig.3.5.5)

- Assimilation IASI almost equal configuration did not show improvement. Under investigation.

![Image](image9.png)

4. Future Plans

- Assimilate clear radiances of AIRS and IASI
- Implement RTTOV-10 into GA and MA, and exploit more land sensitive channels
- Further investigation of FY-3A/MWTS toward operational use. Also FY-3B
- Assimilate radiances affected by clouds and rain

![Image](image10.png)

<References>