Assimilation of radiance data at JMA: recent developments and prospective plans

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## NWP models of JMA (Nov.2007～)

<table>
<thead>
<tr>
<th>Model</th>
<th>Global Model (GSM)</th>
<th>Meso-scale Model (MSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resolution</strong></td>
<td>TL959 (20km)/60(0.1hPa)</td>
<td>5km/50 (21.8km)</td>
</tr>
<tr>
<td>H/V(top height)</td>
<td>*Before Nov.2007: TL319(60km)/40(0.4hPa)</td>
<td></td>
</tr>
<tr>
<td><strong>Forecast range</strong></td>
<td>84h (00,06,18UTC)</td>
<td>15h (00,06,12,18UTC)</td>
</tr>
<tr>
<td>(Initial time)</td>
<td>216h (12UTC)</td>
<td>33h (03,09,15,21UTC)</td>
</tr>
<tr>
<td><strong>Target</strong></td>
<td>1～7 day forecast</td>
<td>Disaster prevention information</td>
</tr>
<tr>
<td></td>
<td>Aeronautical forecast</td>
<td></td>
</tr>
<tr>
<td><strong>Data Assimilation</strong></td>
<td>4D-Var (TL959/T159 or 20km/80km)</td>
<td>4D-Var (10/20km)</td>
</tr>
<tr>
<td>(outer/inner loop)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Window Length</strong></td>
<td>6h</td>
<td>6h</td>
</tr>
<tr>
<td><strong>Radiance Assimilation</strong></td>
<td>RTTOV7, VarBC</td>
<td>X (T/TCWV/rain retrieval)</td>
</tr>
</tbody>
</table>

*4D-Var (TL959/T159 or 20km/80km)*

*Data Assimilation*:
- RTTOV7, VarBC
- 4D-Var (TL959/T159 or 20km/80km)
- 4D-Var (10/20km)

*Target*:
- 1～7 day forecast
- Aeronautical forecast
- Disaster prevention information
Satellite data assimilated

- **Sounders**
  - Radiance from NOAA15~18/AMSU-A,-B,MHS, Aqua/AMSU-A, Metop/AMSU-A,MHS in GDAS
  - Including AP-RARS and EARS
  - Temperature retrieval from NOAA15-18 and Metop/ATOVS in MDAS

- **Microwave Radiometers (MWRs)**
  - Radiance from DMSP/SSMI, TRMM/TMI and Aqua/AMSR-E in GDAS
  - Total Column Water Vapor (TCWV) and Rain Rate retrieval in MDAS

- **Scatterometer**
  - Ocean surface wind vector from QuikSCAT/SeaWinds in GDAS & MDAS

- **GPS-RO (Radio Occultation)**
  - Refractivity from CHAMP in GDAS

- **AMV (Atmospheric Motion Vector)** from Aqua+Terra/MODIS in GDAS

- **Geostationary satellites**
  - AMV from MTSAT-1R, Meteosat7,9, GOES11,12 in GDAS & MDAS
  - CSR (clear sky radiance) from MTSAT-1R in GDAS

GDAS : Global Data Assimilation System
MDAS : Meso-scale Data Assimilation System
Operationally assimilate less cloud affected radiances of SSM/I, TMI and AMSR-E in GDAS since May 2006
- V.Pol only
- VarBC

**test1:** Improve QC and BC
- Stricter cloud screening & addition of total column cloud liquid water predictor in VarBC
- Small but consistent positive impact on the forecast of T850

**test2:** Add SSMIS+test1
- 19V, 22V, 37V, 92V
- Neutral impact from SSMIS window ch
AIRS assimilation (ongoing development)

- Assimilate radiances 54ch/324ch over the sea
  - Channel selection using Entropy Reduction (Rodgers 2000)
  - Detect cloud-affected radiances based on McNally and Watts (2003)
    - Comparison with CloudSat showed performance enough for QC (in poster)
  - Bias correction scheme is the same as ATOVS except predictors in VarBC
    - \( T_{\text{bobs}}, 1/\cos\theta, \text{const} \)

- Positive impact on analysis but neutral or negative on forecast
  - reduces model biases of temperature and moisture.
AIRS radiance assimilation

- Degrades forecast skills of the lower tropospheric temperature
- Possibly caused by the conflict of analysis increment with model trend

Time sequence of RMSE of 1- & 5-day forecasts verified against the initials

**RMSE Z500  N.H.**
- Test: 7.422  Control: 7.461
- Average: 7.422

**RMSE T850  Trp**
- Test: 0.543  Control: 0.529
- Average: 0.539
Other topics on Poster 6.9

- Metop/ATOVS impact
- AP-RARS & EARS impact
- Clear Sky Radiances (CSRs) of WV-ch from geostationary satellites
  - 1 geo vs. 5 geo
- AIRS radiance assimilation
  - CloudSat comparison
- Plans
End
Metop/AMSU-A & MHS assimilation

- Assimilate radiances in GDAS
  - Less cloud-affected, less land-surface-dependent radiances
  - Implement a static scan-dependent Bias Correction (BC) and adaptive air-mass dependent BC
    - Variational BC (VarBC) applied to air-mass BC

- Significantly positive impacts on forecasts, especially, of the geopotential height

- Moreover, great benefits of early and stable data dissemination

Forecast Improvement Rate wrt RMSE for 1-9 day forecasts

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>72</th>
<th>144</th>
<th>216</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psea</td>
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<td>T850</td>
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<tr>
<td>Z500</td>
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<tr>
<td>Wsp850</td>
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<tr>
<td>Wsp250</td>
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</tbody>
</table>

Test : using Metop, cntl : no Metop

--- Global  --- N. Hem.
--- Tropics  --- S. Hem.

- Statistically significant
EARS impacts on forecasts

Forecast Improvement Rate  average over 6/11-7/6 2007

Temperature improvement rate
FT=24 (left) and 120 (right)
5 Geo.Sat. WVch CSRs added

- Increase humidity in the mid- to upper troposphere, and even in the lower troposphere in dry areas
- Make analysis/guess closer to RAOB around 500hPa in RH and to AMSU-B&MHS channel 3 in TB
- Positive impact on forecast, especially at day 1 to 3
- 5 geo.sat. CSR assimilation has greater positive impact than one (MTSAT-1R)

Monthly averaged TCWV diff. by WV-CSR assimilation

Time sequence of TB O-B STD