Recent progress and perspective on the observation data use in JMA NWP

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Introduction

• The JMA is operating three kinds of deterministic NWP models with their specific DA systems.
  – The outputs are used for issuing official weather forecast and alert in Japan.

• The assimilated data volume has increased year to year and it contributes to the better initial condition analysis which leads to the better forecast.
  – The continuous effort* and the plan will be presented
    • * Several OSEs (observation system experiments) were conducted before new data introduction, generally.
Current NWP models at JMA

deterministic models only

GSM: Global Spectral Model
short- and medium-range forecast
TL959(0.1875deg.) / 100 Layers up to 0.01hPa
84-hours forecast at 00, 06, 18UTC, and
264-hours forecast at 12UTC

MSM: Meso Scale Model
Disaster reduction, short-range forecast
5km (4080x3300km) / 50 Layers up to 22km
39-hours forecast at 00,03,06,09,12,15,18 and 21UTC

LFM: Local Forecast Model
Disaster prevention, Aviation forecast
2km (3160x2600km) / 60 Layers up to 20km
9-hours forecast at every hour on the hour
Current DA systems at JMA
deterministic models only

GA: Global Analysis (4DVAR)
Model resolution: Outer: TL959L100 / Inner: TL319L100
Data cut off time
  for Early Analysis: +2h20m
  for Cycle Analysis: +11h50m(00,12), 7h50m(06,18)
Assimilation Window: -3h to +3h

MA: Mesoscale Analysis (4DVAR)
Model resolution: Outer: 5km / Inner: 15km
Data cut off time: +50min.
Assimilation Window: -3h to Analysis time

LA: Local Analysis (3DVAR Rapid Update Cycle)
Resolution: 5km
Data cut off time: +30min.
Assimilation Window: -30min. to +30min. x 4 times

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History of the assimilated data amount on JMA’s global NWP (2002.01-2014.07)

The assimilated data number shows the good correlation with the forecast RMSE at FT48 on Z500 after 2007 (when there is no major change on the DA scheme).
RECENT EXPERIMENTS FOR THE NEW DATA INTRODUCTION
LEO-GEO and AVHRR Polar AMVs

- LEO-GEO and AVHRR AMVs were introduced into JMA’s operational NWP system on 1 July 2013
  - New Data cover the latitudinal zone from approximately 60° to 70°
  - OSEs to evaluate the impact of the new AMVs using GSM-DA
    - Accuracy of analyses and forecasts is mostly improved in terms of various elements such as wind, temperature and humidity, evaluated against various observations including upper-air obs.
    - RMSEs of the most elements against initial fields are reduced up to 48 hours at tropics and beyond 48 hours in Southern Hemisphere.

Typhoon track error is reduced after FT=36 hours.
GCOM-W/AMSR2

- JAXA’s GCOM-W was launched in May 2012.
  - With a close collaboration between JMA and JAXA, the preliminary AMSR2 data had been provided from the early stage. It accelerated the data utilization development.

- Over East China Sea, the coverage of radar is very limited.
  - Since the radar data of surrounding countries are not available at present, satellite MW imager data is very important for detecting precipitation and humidity information.
  - The coverage had a gap on PM and it could be filled by AMSR2.
A sample case of the improvement on precipitation prediction in “2012 Kyushu-Hokubu-Gou (heavy rain event in northern Kyushu)”

<table>
<thead>
<tr>
<th>Without AMSR2</th>
<th>With AMSR2</th>
<th>Observation</th>
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<tbody>
<tr>
<td><img src="image1" alt="Without AMSR2" /></td>
<td><img src="image2" alt="With AMSR2" /></td>
<td><img src="image3" alt="Observation" /></td>
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</tbody>
</table>

Three-hour precipitation prediction for 18-21 UTC 11 July 2012 by JMA’s Meso-Scale Model initialized at 00UTC in the same day. AMSR2 data provide the better water vapor analysis over the upstream of Kyushu (East China Sea) and it caused the better precipitation prediction.

This OSE shows the importance of frequent monitoring of humidity over the upstream. And it also shows that our NWP model has a room for improving the processes relating to the humidity.
**Metop-B**

**AMSU-A, MHS, GRAS, ASCAT, AVHRR/AMV**

Coverage Map: 2013/07/10 00UTC without and with Metop-B

<table>
<thead>
<tr>
<th>MW-SOUNDER (AMSU-A)</th>
<th>MW-SOUNDER (AMSU-B/MHS)</th>
<th>SCATTEROMETER</th>
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<td>2013/07/10 00:00(UTC)</td>
<td>2013/07/10 00:00(UTC)</td>
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Metop-B
AMSU-A, MHS, GRAS, ASCAT, AVHRR/AMV

TROPICS

Wind speed error profiles of analysis and background against radio-sonde observation:
- O-B_{cntl}, O-B_{test}
- O-A_{cntl}, O-A_{test}

Average Typhoon Track Forecast Errors for August 2013
Ground-based GNSS(GPS)

The better (smaller) RMSE sequence on humidity analysis and forecast against radiosonde data were confirmed in the ZTD assimilation experiment in advance.

→ The ZTD assimilation was started March 2014

Issue: The available data are very limited now. JMA has a plan to disseminate the Japanese data and hopes to the other countries to do so.
THE CURRENT PARALLEL RUN
Aqua/AIRS and Metop-A,B/IASI to be assimilated in this month

- Assimilate Only Clear Sky Radiances
- Channel Selections: AIRS 85 CHs, IASI 69 CHs.
- OSEs using Global NWP system reveals that the forecasts are improved, especially for the beginning of forecast period.

|O-B| stats of the other observations

worse  better  better  worse

August 2013
January 2014
The estimated assimilated data amount with starting AIRS & IASI assimilation

- JMA is starting the advanced IR sounder data assimilation for the global NWP.
  - AIRS on Aqua
  - IASI on Metop-A and -B
- It will make a “big jump” on the sequence of the assimilated data amount.

The data volumes were estimated using the parallel run data in 3 Aug. 2014.
THE CURRENT DEVELOPMENTS
The current developments

• The observations will be assimilated
  – S-NPP/ATMS, CrIS (the DA system is under development)
  – Megha-Tropiques/SAPHIR (the DA system is under development)
  – GPM/GMI,DPR (the preliminary data are being received & evaluated)
  – Himawari – the next JMA’s GEO satellite (waiting for the launch and the data)
  – Chinese FY-3 MW[TH]S (under discussing the real time data delivery)
  – For Meso-Scale Model
    • High elevation VAD winds from JMA Doppler Radars (under conducting OSE)
      – Low elevation radial winds and reflectivity data are being assimilated
    • Scatterometer (under conducting OSE)
    • RO bending angles (the DA system is under development)
  – For Local Forecast Model
    • AMV & satellite radiance data (the DA system is under development)

• The observations needs to be demonstrated
  – Ground based remote sensing data (Radar & GNSS-ZTD) of the neighboring countries
Remote sensing data utilization

- JMA is assimilating Japanese ground-based remote sensing data (WPRs, Doppler radars (Doppler velocity and reflectivity), and ground based GNSS), operationally. Toward the better forecast, introduction of such data in the neighboring countries (e.g. Korea) is important.
  - And it is believed that the JMA data also beneficial to the forecast in Korea especially when south-easterly winds are dominant (e.g. typhoons are located around the East China Sea).

The demonstration of the remote-sensing data exchange, quality standardization, and its utilization is one of the themes in the regional WIGOS project.

> Real time data exchange is the following step
Summary

• The assimilated data volume has increased year to year and it contributes to the better initial condition analysis which leads to the better forecast.
  – The continuous efforts are being made
  – Several developments are undergoing

• The ground-based remote-sensing data exchange is one of the hot topics.
  – To promote the exchange framework, the utilization demonstration is needed for convincing the operators.
Back Up
## Observations assimilated at JMA

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<th>Kind</th>
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<th>UV</th>
<th>RH</th>
<th>IPW</th>
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<th>Doppler Velocity</th>
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**G:** Global Analysis; **M:** Meso-scale Analysis; **L:** Local Analysis

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SLIGHT DEGRADATION OVER SH AND ITS POSSIBLE CAUSE
The assimilated data number shows the good correlation with the forecast RMSE at FT48 on Z500 after 2007 (when there is no major change on the DA scheme).
Available data distribution of SHIP/BUOY

- Large difference was found over SH.
- The colors show:
  - B:SHIP/G:BUOY/R:Drifter

Short term SHIP/BUOY data denial experiment was conducted for Nov. 2011 (in 2012)
- Forecast degradation was confirmed
- This situation might cause the forecast degradation over S.H. around 2012-2013
SHIP & BUOY OSEs

• Introduction
  – JMA has been using SHIP & BUOY Ps data for long time and the thinning distance is 50km. But, Is this optimum?

• Settings for this preliminary study
  – Used low res. system (TL319 forecast with TL159 4D-Var)
  – Forecast cases: 12UTC on 1 – 10 Nov. 2011 (very short!)

• OSEs:
  – Cntl: 50km thinning; Test1: SHIP & BUOY Ps data denial;
  – Test2: 500km thinning; Test3: 200km thinning;

Note: ASCAT data is assimilated with 50km thinning in all the test.
The OSE result

- Test 1 and 2 showed the clear degradation of the forecast skill, especially on the short range (~FT96) forecast.
- Test 3 showed the better forecast skill than Cntl mostly.
  - Statistical study showed the observation error correlation length are about 200km
- Comment for this result
  - These results suggested that the current JMA NWP systems need the marine Ps data with the density of one per around 200x200km².
  - at least on the low res. system.
Mean Absolute Innovation Difference against CNTL

In the test 1 and 2, the larger mean absolute innovations of $P_{\text{MSL}}$ are found around mid-ocean. It suggests 6-hours forecast error is larger in this test over there.

$\Rightarrow$ Degradation of the forecast quality

In the test 3, the larger mean absolute innovations of $P_{\text{MSL}}$ are hardly found.

$\Rightarrow$ No Degradation of the forecast quality

The smaller mean absolute innovations are found around the North America and northern part of Atlantic Ocean. The reason must be the longer thinning distance. (i.e. fewer assimilated site).
Total assimilated SHIP & BUOY data

Cntl: 50km

Test2: 500km

Test3: 200km

Strong inhomogeneity

Total on 5deg. grid box.

第10回数値予報システム評価会合（22 Jan. 2014）