Operational Use of the ATOVS radiances in global data assimilation at the JMA

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Recent Progress of Satellite Data Assimilation in JMA

Global data assimilation

- Sep 25 2001: implementation of 3D-Var global data assimilation
- May 6 2003: use of QuikScat sea surface wind data
- May 6 2003: use of Meteosat high-density atmospheric motion Wind data
- May 28 2003: start of operational direct assimilation of NOAA15&16 ATOVS radiance + new cumulus parameterization scheme

Previous Status
- Retrievals use
  - NESDIS retrieved thickness
  - GMS-5 moisture data

Current Status
- Radiances use
  - NESDIS Level 1D TBB (HIRS/3, AMSU-A)
  - NESDIS Level 1C TBB (AMSU-B)

Less Conversion Error
Processing of ATOVS radiances

1D-Var as Pre-processor
- Thinning
- Quality Check
- Bias Correction
- Channel Selection
- Obs Error Assignment

Global Analysis with 3D-Var
- RTTOV-6
- Incremental 3D-Var(Inner T106L40)
- Model Top 0.4hPa

Global Spectral Model(T213L40)

\[ J = (x-x_p)^T B^{-1} (x-x_p) \]
\[ + (y-H(x))^T R^{-1} (y-H(x)) \]

- X: analysis variables
  - T & lnQ at 41 levels of GSM and Tskin
- Y: observation
  - HIRS/AMSUA/AMSUB TBB from NESDIS BUFR
  - AMSUA is mapped to HIRS
- H: observation operator
  - RTTOV-6 (Saunders et al., 2000)
**Thinning**

- **Constant distance**
  - 250km (HIRS/AMSA)
  - 180km (AMSUB)
- **Priority is given to**
  - clear radiances
  - satellite closer to analysis time

**Change of distribution of available data**

Temperature (thickness) retrieved by NESDIS

Use of data on Land in the upper air.
**JMA TBB Bias Correction scheme**

\[ \text{BIAS}_j(n) = a_{j0} + \sum_{i=1}^{5} a_{ji}(n)X_{ji}(n) \]

**BIAS** = \(<\text{TBobs} - \text{TBcal}>\)  
*global mean and 1-Year averaged dataset*

**TBobs**: Observed TBB (Collocated with RAOB within 2 degree & 90 min)

**TBcal**: Calculated from profiles of RAOB

**RAOB are used due to the presence of a model bias**

**Guess is used to complement the lack of the upper stratosphere temp. & moist.**

**Predictors X**

- AMSU-A Ch5  Calculated TBB
- AMSU-A Ch7  Calculated TBB
- AMSU-A Ch10 Calculated TBB
- TPW (Total Precipitable Water from first guess)
- **Surface Temperature** (JMA SST Analysis)

The coefficients were defined every scan position.
(There are 56 scan position due to level 1D data mapped to HIRS Spot)

Not bias-correct AMSU-A12-14, AMSU-B, HIRS11-12 due to large model bias
Complicated Scan Bias of Level 1D data

Effect of Mapping to HIRS Spot

From: 2003/06/27
To: 2003/06/30

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Cycle Experiments

**Period**
- 2001 December
- 2002 July

**Model**
- JMA Global Spectrum Model : T213L40
- Assimilation system : 3D-Var with RTTOV-6

**Setting**
- **CNTL** ATOVS Retrievals assimilation
- **TEST** ATOVS radiance assimilation
  - NOAA15, NOAA16, HIRS/3, AMSU-A, AMSU-B
Change of Analysis Increment

Temperature (Zonal mean)

Moisture 850hPa (Specific Humidity)

Spread vertically!!

Globally!!

CNTL

TEST

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Analysis Impact for Temperature

Zonal Averaged Monthly Mean July 2002

Verification against RAOB Temperature BIAS Error

Smooth!!

Decrease of Bias!!
Analysis Impact for Humidity

Effect of ATOVS moisture channels

\(\text{HIRS/3:ch10, ch11, ch12 \& AMSU-B:ch3, ch4, ch5}\)

Validation against SSM/I TPW

Large impact on Total precipitable water in tropics was found.

Humidity field is close to SSM/I observation and became realistic!!
Forecast Impact

500hPa Geopotential Height
Verification against RAOB

CNTL
TEST

N.H.
Tropics
S.H.

Positive Impact!!
Forecast Score Z500 (against Initial)

RMSE of 500hPa geopotential height improved especially in former part of Forecast time.

Impact is remarkable on Southern Hemisphere in 24hour forecast!!
Case Study: Typhoon Track Prediction

500hPa geopotential height

Forecast of strength of subtropic high pressure affects forecast of typhoon track prediction.

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Comparison with Other NWP Center

- JMA: Direct assimilation ATOVS radiances
- JMA: Retrievals assimilation
- ECMWF
- UKMO
- NCEP
- CANADA

Improvement of 24hour forecast is remarkable!!

RMSE of Global 500hPa Height

Dec 2001

FT=120

FT=72

FT=24

Jul 2002
Summary and Ongoing Work

• Since 28 May 2003, JMA has started direct assimilation of ATOVS radiances in global 3d-Var operationally.

• In the experiments, analyzed temperature and humidity field were verified and became realistic.

• For forecast skills, very positive impact was found, especially, in tropics and southern hemisphere at short term forecast. But, the improvement in northern hemisphere was not large.

Moreover, to improve forecast skills,
• we have some plans and are going to.
  – Use level 1B data,
  – Revise TBB bias correction scheme,
  – Use NOAA 17 (HIRS,AMSU-A,AMSU-B)
  – Upgrade radiative transfer model (RTTOV-6 ---> RTTOV-7)
  – Use other new satellite data SSM/I,TRMM,AMSE,AIRS etc.