Bias Correction of Satellite Data in GRAPES-VAR

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Outline

- Status of GRAPES-3DVAR
  - Main components of GRAPES
  - Usage of satellite data in GRAPESVar
- Improvement of satellite data assimilation
  - Bias Correction
  - Error Tuning
- Impact on Analysis and Forecast
  - Global Model
  - Typhoon Forecast
- Discussions and Ongoing Work
Main components of Chinese new generation NWP system

Global/Regional Assimilation and Prediction System

- GRAPES-Var
- GAPRES-Global
- GRAPES-Meso
Data usage of GRAPES-Var

Conventional data
- TEMP
- SYNOP
- SHIPS
- AIREP

Remote sensing data
- ATOVS
- AMV
- Weather Radars

Assimilated directly
**ATOVS From Regional to Global Since Oct. 2005**

- Global l1b data from NOAA/NESDIS
- Local received HRPT data from NSMC

**PREPROC**
- ATOVS Level 1C data
- ATOVS Level 1D data

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**NOAA16/17 AMSUB CH4 2005080118(-3h~3h) Local received**

**NOAA16/17 AMSUB CH4 2005080118(-3h~3h) From NESDIS**

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**Typhoons Origin**
Satellite Data Assimilated In GRAPES in Nov. 2005

2xAMSU-B (NOAA-16/17) Winds from 5 GEOS (Met-5/7 GOES-9/10/12)

NOAA16/17 AMSUB

NOAA15/16 AMSUA

2xAMSU-A (NOAA-15/16) Winds from FY2C

GTS AMVs

FY2C AMVs
Preprocessing of Satellite Data in GRAPES-Var

- Quality control (by NSMC)
- Thinning
  - Error Correlation (Not represented in the obs. covariance)
  - To reduce data volume

- Observational error Assignment
  - Statistics of the Innovations
  - Tuning of the Error Setting

- Bias correction
  - Global Model
  - Regional Model
Bias Correction Scheme in Practice: Harris and Kelly (2001)’s scheme

Scan Bias: \( s = \langle d_j(\theta) - d_j(\theta = 0) \rangle \)

Air Mass Bias: \( b = H(x_b) - y - s \)

Least Square

\[
b = Ap + c
\]

\( p \) (predictors) \( b \) : Air Mass Bias

Solution

\[
A = bp^T(p^p^T)^{-1}
\]

\[
c = b - Ap
\]

Predictors:
- Scan Bias
  - Latitude Band Average
- Air Mass Bias
  - Thickness between 1000-300hPa
  - Thickness between 200-50hPa
  - Surface temperatures
  - Integrated water vapor
AMSUA Bias: $H(xb) - Yo$

Ch5-Ch10: Cold Bias of Obs.

Ch1-Ch4 and Ch11-Ch15: Warm Bias of Obs.
Estimation of std. of AMSUA Error
**AMSUB Bias of H(xb)-Yo**

**Bias**

Bias of H(xb)-Yo for AMSUB Channels 1 to 6 for NOAA16 and NOAA17.

**Std.**

STD of innovations for AMSUB Channels 1 to 6 for NOAA16 and NOAA17.

NOAA16

NOAA17
**Tuning of Obs. Error**

- **Step 1**: Tuning of Obs. Error based on Innovation Statistics

\[
\mathbf{\mathbf{\varepsilon}^o_{\text{sound}}} , \mathbf{\mathbf{\varepsilon}^o_{\text{synop}}} , \ldots , \mathbf{\mathbf{\varepsilon}^o_{\text{amsu}}} , \ldots , \mathbf{\mathbf{\varepsilon}^o_{\text{type}_N}}
\]

- **Step 2**: Tuning of Different Observations

\[
J(\alpha) = J(\mathbf{\varepsilon}^o_{\text{sound}}, \alpha \mathbf{\varepsilon}^o_{\text{amsu}}) \Rightarrow J = \frac{p}{2}
\]
5.8323  5.4066  2.6716  0.9650  0.3840
0.2217  0.2326  0.4030  0.3273  0.3387  0.6327
1.3265  2.2177  3.3642  4.8095
NOAA16

AMSUB Channels

STD of Innovations

6.5990  4.6569  3.5632  3.0555  2.8246

6.7829  4.6709  3.6053  3.0412  2.7886

NOAA17

AMSUB Channels

STD of Innovations

6.5990  4.6569  3.5632  3.0555  2.8246

6.7829  4.6709  3.6053  3.0412  2.7886
Impact of Bias Correction

- On Analysis Increments
- On Forecast
  - Global Model
    - Verification against its own analysis (15 days)
    - ACC: Anomaly Correlation Coefficient
    - Typhoon Track Forecast
  - Regional Model
dxa: T, q
Average of 2005080112—2005081512
15 days
dxa: T, q
Average of 2005080112—2005081512
15 days

500hPa dT(nebc) Unit:K

500hPa dT(bc) Unit:K

500hPa dq(nebc) Unit: Kg

500hPa dq(bc) Unit: Kg
$500\text{mb ACC}$

$(2005080112-2005081012, 144\text{h Forecast})$

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<th>2</th>
<th>3</th>
<th>4</th>
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dxₐ: T, q
Average of 2005080112—2005081512
15 days
200hpa Analysis Increments

200hPa $dT(bc)$ Unit:K

200hPa $dT(bc+tuning)$ Unit:K

200hPa $dq(bc)$ Unit:g/Kg

200hPa $dq(bc+tuning)$ Unit:g/Kg
Bias Correction For Assimilation of ATOVS in GRAPES: Impact on Typhoon Forecast

- Global Model (One Case: MATSA)
- Regional Model (One Case: RANANIM)
GRAPES Global Model: 2005080112(UTC), 120h Forecast

Different Initial Value only
- N: NCEP Analysis
- G: GTS
- S: GTS+AMSU+BC
- O: Obs.
Animation of 700hpa humidity
144h Forecast GRAPES Global Model
with Assimilation of AMSU+BC
NOAA16: AMSUA-ch5, 200408126

warm core
Ch5, 6, 7, 8

**Innovation of AMSUA (NOAA 16)**

*Ch5-Ch8*
Ch5, 6, 7, 8

After Q.C.  
With B.C
Distribution of innovation of effective obs.

Dashed line: without B.C

Solid Line : with B.C.
No AMSU
AMSU
AMSU+BC
2004081206, UTC
Precip. Forecast During Rananim Landfall, 24h

Arrows: 10m Wind Vectors
Shaded 6-hour Accumulated Rainfall
Precip. Forecast During Rananim Landfall, 30h

Arrows: 10m Wind Vectors
Shaded 6-hour Accumulated Rainfall
**GRAPES-3DVAR is Moving to a New Stage**

- Operational implementation
- Refinement

**Bias Correction and Obs. Error Tuning**

- VERY Important
- Preliminary results is promising
- Need More Work

**Positive Impact of Satellite Data Assimilation**

- Global Medium Forecast
- Typhoon Forecasts
- Other Verifications is Ongoing (Precip., etc.)
Ongoing Work

- Thinning (Resolution of Obs., Analysis and Model)
  - Global Model
  - Regional and Mesoscale Model
  - Constant Distance Thinning

- Bias Correction
  - Predictors
  - Parameter Estimation Method
  - Bias Model
  - Treatment of Coast (No Options in RTTOV)

- Observation Error Setting and Online Tuning
  - Interaction with Q.C.
  - Diagnosis of $E(J_{min}) = p/2$ (Talagrand, 1999; Chapnik, 2006)
Thank you for Attention