A23

Recent Development of ATOVS usage in Korea Meteorological Administration

Sang-Won Joo, Eun-Ju Lee, and Seung-On Hwang
Korea Meteorological Administration, Seoul, Korea

Introduction

History of (A)TOVS assimilation at KMA

2000: 1dVar for TOVS + 3dOI

2002: 1dVar for ATOVS + 3dOI

2004: Direct assimilation of ATOVS in 3dVar

What we want talk about today!

Method

3dVar Formulation

$$J(\eta) = \eta^{\mathrm{T}}\eta + (\mathbf{H}\eta - D)^{\mathrm{T}}\mathrm{R}^{-1}(\mathbf{H}\eta - D)$$

$$\eta = L^{-1}(x - x_b),\ B = LL^T$$

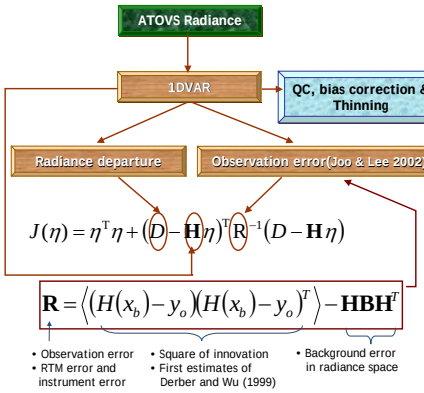
$$D = (y - H(x_b))$$

Inner loop (T63)

Outer loop (T213)

- Control variables: $\eta = L^{-1}[\delta\zeta, \delta D_u, \delta(T, P_s)_u, \delta \ln q]_s^{\sigma}$
- Model variables : $x_b = [\zeta, D, T, P_s, q]_s^{\sigma}$
- Observed variables : $y = [\phi, u, v, T, q]_g^p, P_s, T_s, u_s, v_s, q_s, Rad$

Direct Assimilation Algorithm



Details of the H operator for radiance

Scan angle and air mass bias correction is done before 3DVAR(Joo and Okamoto, 2000)

- Bias correction depends on the cloud condition and latitude
- No bias correction for the stratospheric channels

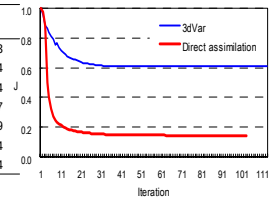
H operator is linearized in the background states and no update within the inner loop

Level 1d data of HIRS 1-8,10-15,AMSU-A 5-15 channels are used at the same time

Diagnostics

Adjoint check and Normalized Cost Function

Satellite sounding	$(Hdx)^T*(Hdx)$	dx^TH^THdx
1	0.025767163	0.025767163
2	0.514098014	0.514098014
3	0.744231604	0.744231604
4	0.864059397	0.864059397
5	0.758332559	0.758332559
6	0.557038524	0.557038524
7	0.146815814	0.146815814

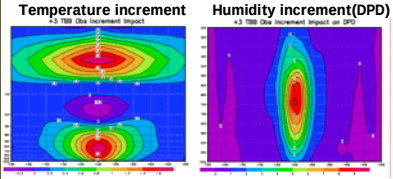


One point observation experiment

Put an ATOVS observation of which innovation is 3 deg in all channels at the point of 30N / 125E

Temperature increment

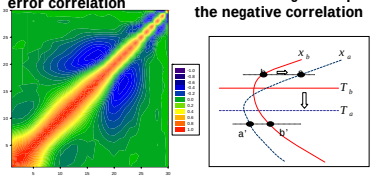
Humidity increment(DPD)



Temperature increments are positive except tropopause and humidity is decreased. It is what we expected!

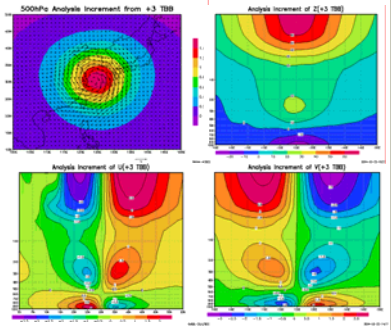
Background temperature error correlation

Schematic diagram explains the negative correlation



The negative temperature analysis increment near the tropopause is caused by the negative background error correlation of temperature.

Mass-wind relationship



Mass and wind balance is maintained by the linear balance equation and it makes the wind increment by the ATOVS assimilation in 3dVar.

Effect of fixed TL in basic state

In order to get the 3dVar results in a reasonable time, basic state of the **H** operator is not updated usually.

Is it true?

1dVar retrievals with and without H update are compared.

Fixed basic state of H is acceptable

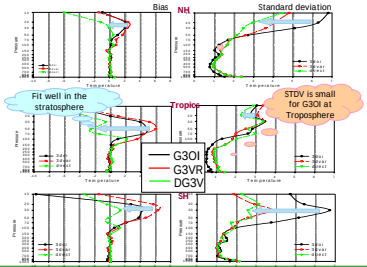
Variable	Corr Coef	Reg Coef Intercept	Reg Coef Slope	Variable	Corr Coef	Reg Coef Intercept	Reg Coef Slope
SFC T	1	0.481	0.998	SFC q	1	0.022	0.998
1000 T	1	0.624	0.998	1000 q	1	0.027	0.997
925 T	1	0.569	0.998	925 q	1	0.035	0.993
850 T	1	0.315	0.999	850 q	0.999	0.033	0.987
700 T	1	0.003	1	700 q	0.999	0.049	0.983
600 T	1	-0.31	1.001	600 q	0.999	0.06	0.985
500 T	1	-0.837	1.003	500 q	0.998	0.069	0.985
400 T	1	-1.426	1.005	400 q	0.992	0.06	0.982
300 T	0.998	-1.384	1.005	300 q	0.993	0.017	0.987
250 T	0.999	-0.274	1.001	MSLP	1	0.683	0.999
200 T	1	0.395	0.998	SFC U	1	-0.032	1.001
150 T	1	-0.445	1.002	SFC V	1	-0.007	1.001
100 T	1	0.086	1				
70 T	1	0.141	0.999				
50 T	1	0.103	1				
30 T	1	0.033	1				
20 T	1	0.011	1				
10 T	1	-0.005	1				

RESULTS

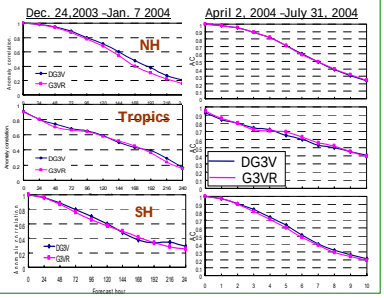
Experiments

- DG3V : Direct assimilation + 3dVar
- G3VR : 1dVar + 3dVar
- G3OI : 1dVar + 3dOI

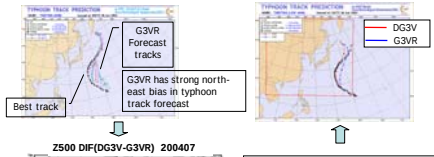
RAOB fit of analysis(2003121400-122818)

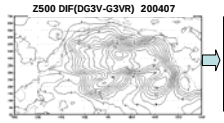


Forecast verification against its own analysis

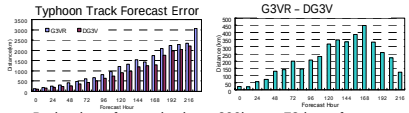


Typhoon Track Forecast Error / TY0406,07,08,10

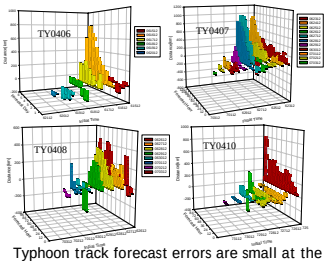




ATOVS assimilation makes the north pacific high stronger and then corrects the north-east bias of typhoon track forecast.



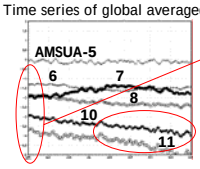
Reduction of error is about 200km at 72 hour forecast.



Typhoon track forecast errors are small at the initial stage of typhoon development !

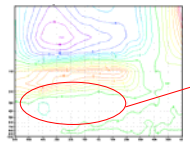
Problems in stratosphere

Time series of global averaged Innovation



- KMA global model has strong warm bias in the stratosphere.
- In order to correct the warm bias, the ATOVS stratospheric channel data is assimilated without bias correction.
- However the negative innovation of stratospheric channels are increased.

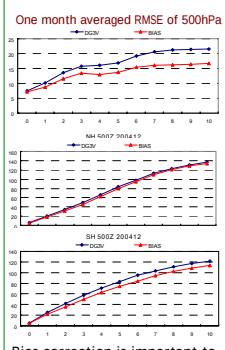
Zonal averaged T diff (DG3V-G3OI)



- The warm bias is corrected in the stratosphere.
- However, the warm bias is strongly increased from 300 to 100hPa.
- It is caused by the negative vertical temperature error correlation in 3dVar.
- The bias correction should not apply selectively.

New experiments BIAS is performed to solve the problems in the stratosphere
BIAS : DG3V + Bias correction is applied in the stratospheric channels depending on the latitude

One month averaged RMSE of 500hPa



Bias correction is important to improve forecast skill !

Summary & Plans

Summary

- Direct assimilation of ATOVS improves forecast performance and it becomes operation at KMA in August 2004.
- Typhoon forecast errors are reduced by the ATOVS direct assimilation and it is assumed to be caused by the better analysis of the north pacific high.
- Careful investigation is needed to correct model bias by using the ATOVS data because of the vertical error correlation of model error

Plans

- FGAT for ATOVS direct assimilation
- ATOVS level 1C data assimilation in the Unified 3dVar which was developed to run the global and regional application with the same code.