Recent Development of ATOVS usage in Korea Meteorological Administration

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Introduction

History of (A)TOVS assimilation at KMA
2001: 1dVar for TOVS + 3dOI
2002: 1dVar for ATOVS + 3dOI
2004: Direct assimilation of ATOVS in 3dVar

Method

3dVar Formulation
\[ J(\eta) = \eta^T \mathbf{a} + \mathbf{B} \eta \mathbf{D} \mathbf{R}^{-1} (\mathbf{H} \eta - \mathbf{H}) \]
inner loop (180)
outer loop (1213)
• Control variables: \( \eta = [z, D, T, P, q]^T \)
• Model variables: \( x_0 = [z, D, T, P, q]^T \)
• Observed variables: \( y = [\phi, u, v, T, P, q, \text{Rad}] \)

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)

Background temperature error correlation
Schematic diagram explains the negative correlation

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

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.

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

Direct Assimilation Algorithm

ATOVS radiance

QC bias correction & Thinning

 Observations error correction (Lo et al. 2007)

\[ R = \left((H(x_0) - y_0)^T H(x_0) - y_0^T \right)^{-1} H \mathbf{B} H^T \]

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

Adjoint check and Normalized Cost Function

<table>
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<th>Satellite sounding</th>
<th>( \text{min}^2 )</th>
<th>( \text{max}^2 )</th>
<th>( \text{avg}^2 )</th>
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<th>Corr Coef</th>
<th>Reg Coef</th>
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Problems in stratosphere

• 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.
• The warm bias is corrected in the stratosphere.
• However 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 : DGV + Bias correction is applied in the stratospheric channels depending on the latitude

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.