Current status and plan of the satellite data assimilation at Korea Meteorological Administration

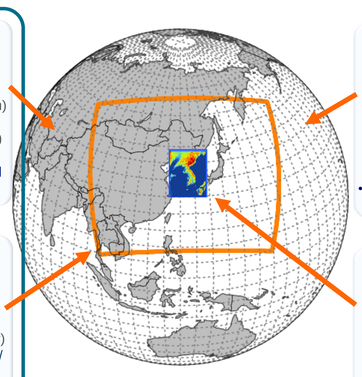
Sangwon Joo[1], Yoonjae Kim[1], Eun-Jung Kim[1], Jung-Rim Lee[1], Eun-Hee Lee, Hyun Mee Kim[2] , Youngchan No[3], and B.J. Sohn[3]
[1]Korea Meteorological Administration, [2]Yonsei University, [3]Seoul National University

Introduction

NWP system at KMA

GLOBAL
• Resolution N512L70 (UM) (~25km / top = 80km)
• Target Length 288hrs (00/12UTC) 87hrs (06/18UTC)
• Initialization : Hybrid Ensemble 4DVAR

E-ASIA
•UM 12kmL70 / WRF 10kmL40
• Target Length 87hrs/72hrs (6 hourly)
• Initialization : 4DVAR / 3DVAR



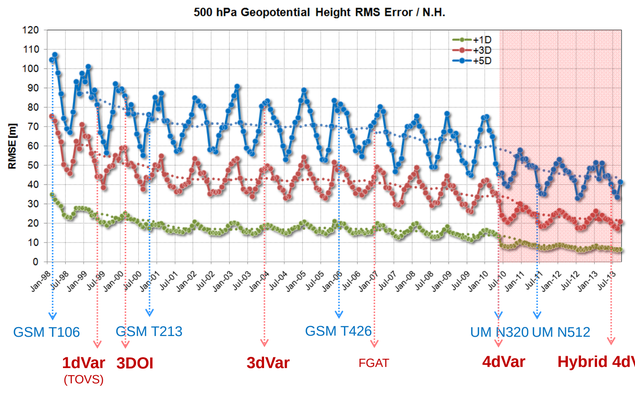
Global EPS
• Resolution N320L70 (UM) (~40km/ top =80km)
• Target Length 288hrs
• IC : GDAPS
• # of Members : 24
• Perturbation : ETKF, RP, SKEB2

LOCAL
• Resolution 1.5kmL70 (UM) (744×928 / top =39km)
• Target Length 36hrs
• Initialization : 3DVAR

Satellite data usage

Type	Variables	Thinning
PILOT	U, V	2hr 2min black list
Radiosonde/Dropsonde	U, V, T, (T-Td), Ps	70 levels, black list
Surface report (SYNOP, SHIP, BUOYs)	T, (T-Td), Ps, (U, V over water)	1 report /1hr, black list
Aircraft (AIREP, AMDAR)	U, V, T	80km*50hPa/2hr black list
ATOVS NIAA-15/18/19(no HIRS), METOP-A/B	AMSU-A: land(7-14), sea/low topo(+6), sea(+4,5) AMSU-B: land(3-5), HIRS: sea(2-8, 10-15)	154km(TR), 125km(ExTR)
AIRS	54(land), 160(ocean)	154km(TR), 125km(ExTR)
IASI	111(land), 183(ocean)	154km(TR), 125km(ExTR)
ASCAT	U, V at 10 meter over ocean	latitude limit
AMV (Meteosat, GOES, MTSAT, COMS)	U, V (IR, WV, VIS, SWIR channels)	100 hPa/2hr, 1hr/2 degree angle difference
MODIS, AVHRR polar wind	U, V	200km/100hPa/2hr
Wind profiler (NOAA, Europe, KMA, Japan)	U, V	1 report / 1hr black list
GPSRO (COSMIC, GRACE, GRAS)	Bending angle	10-60 km
COMS CSR	H (WV channel)	3hr

GDPAS performance



Implementation plan

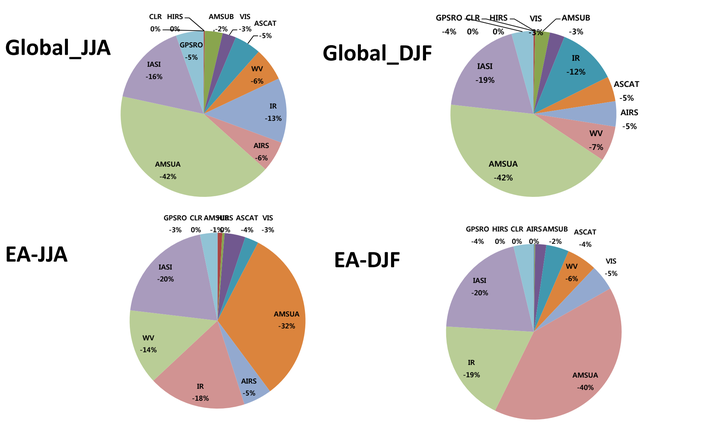
Year		2014	2015	2016	2017	2018
Super Com			3rd → 4th	4th		
GDAPS	UM	25km 70L	25km 70L	17km 70L	17km 90L	12km 85L
	EPS	40km 70L 24M		25km 70L 24M		
	DA	Hybrid 4dVar (60km 70L) Common ODB Observations: COMS Snow, GPS-ZTD, NPP, OSCAT, HR RAOB, ADM-Aeolus	Hybrid 4dVar (40km 70L) VarBC Observations: FY-3, GPM, AODs, GeoIR	Hybrid 4dVar (40km 70L)	Observations: Himawari-8	4D-ENS-VAR (25km 85L)
RDAPS	UM	12km 70L	12km 70L			
	DA	4dVar (32km 70L)	4dVar (32km 70L)			
LDAPS	UM	1.5km 70L	1.5km 70L		1km 70L	
	EPS	3km 70L 12M/24M	3km 70L 12M/24M	1km 70/90L 12M/24M	1km 70/90L 12M/24M	1km 70/90L 12M/24M
	DA	3km 70L 3dVar(3Ihr) Observations: Rain, COMS SST & Snow, GPS-ZTD	3km 70L 4dVar(1hr) Observations: GPM, HR AWS	3km 70L Hybrid 4dVar(1hr)	2km 70L 4dVar(1hr) Observations: Dual polarized doppler radar	3km 70L 4dVar(1hr) Observations: Dual polarized doppler radar

Satellite impact evaluation using FSO

$$\delta e = (\delta \mathbf{w}_t^{fa})^T \mathbf{C} (\delta \mathbf{w}_t^{fa}) - (\delta \mathbf{w}_t^{fb})^T \mathbf{C} (\delta \mathbf{w}_t^{fb})$$

$$\delta e_k \approx \delta y_k \left(\frac{\delta e}{\delta \mathbf{y}} \right)_k$$

$\delta \mathbf{w}_t^{fb}$: 24hour forecast error in a simplified forecast state initialised from an analysis
$\delta \mathbf{w}_t^{fa}$: the error initialised from the background state for that analysis
C : a diagonal inner-product matrix of moist energy norm
$\delta \mathbf{y}$: the vector of observation innovations
$\mathbf{e}_k$: an estimate of the contribution to the total impact of the k[th] observation



- The errors are measured by 24 hour forecast moisture energy norm in global model
- The FSOs are calculated routinely every day and monitored regularly to asses the impact of observations
- AMVs show a relatively important role over the East Asia and comparable to AMSU-A in winter season (See Eun-Jung's poster)

COMS CSR assimilation

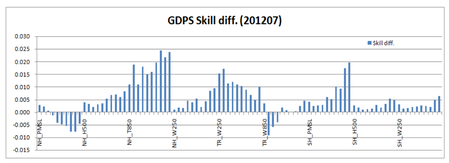
Impact of COMS CSR in global NWP

➢ Verification : NH(MSLP,H500,T850,W250)/ SH(MSLP,H500,W250) / TR(W850,W250)

Summer (2012.07.02~31)

Total Weighted Mean Skill

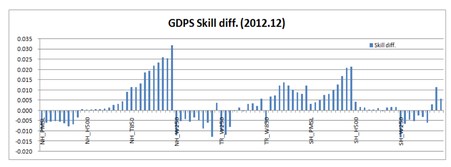
CNTL =	78.210
PS01 =	78.685
Test - Control =	0.475



Winter (2012.12.02~31)

Total Weighted Mean Skill

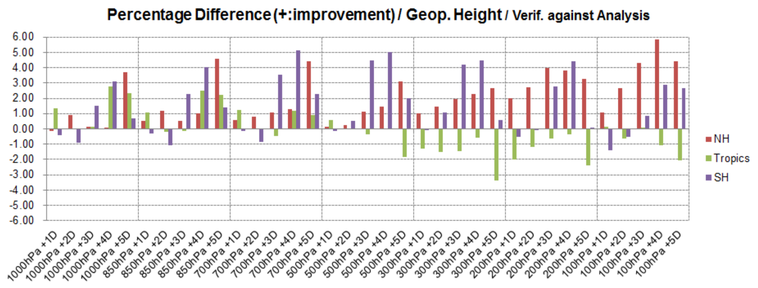
CNTL =	83.827
PS01 =	84.118
Test - Control =	0.291



NWP index are mostly improved

In general, COMS WV CSR improve the skill score.

Impact of monthly update of bias correction

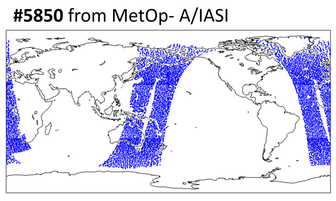


- Due to the drift of the bias correction values of the COMS, the bias correction coefficients are updated in December and applied.
- Most forecast scores show positive impact due to the update of the bias correction. (See Jung-Rim's poster for details)

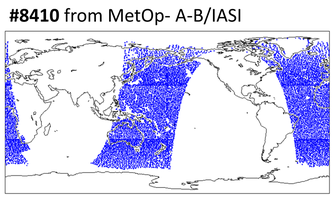
Metop-B assimilation

Metop-B data coverage

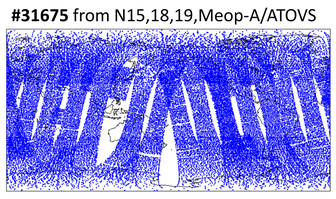
#5850 from MetOp- A/IASI



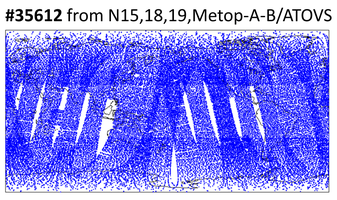
#8410 from MetOp- A-B/IASI



#31675 from N15,18,19,Meop-A/ATOVS

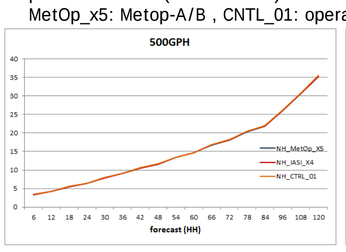


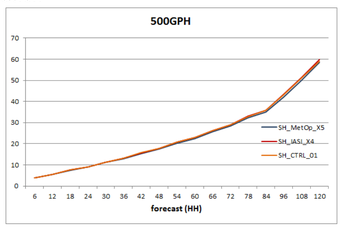
#35612 from N15,18,19,Metop-A-B/ATOVS



Impact of Metop-B data in global NWP

period: 1 month (2013.7.1.~31)
MetOp_x5: Metop-A/B , CNTL_01: operation





5 day forecast GPH RMSE at 500 hPa

	Operation	MetOp-B
N.H.	35.81 (m)	35.24 (m)
S.H.	59.135 (m)	58.415 (m)

- With additional MetOp-B/ATOVS and IASI, the performance of global NWP is slightly improved.

Summary & Plans

Summary

- FSOs are operationally used to evaluate the impact of satellite data in global NWP
- MetOp-B and COMS CSRs are successfully assimilated to improve the NWP performance 2013.

Plans

- ATOVS observation error was tuned with the linear estimate in parametric space and it showed positive impact. The tuned error will be implemented in operation after long term evaluation.
- IASI channels selection will in evaluated in operation mode and will be implemented in operation system.

ATOVS observation error tuning

Define: $\delta \mathbf{B} = \delta s^b \mathbf{B} \quad \delta \mathbf{R}_i = \delta s_i \mathbf{R}$

B Background error cov. R Observation error cov.

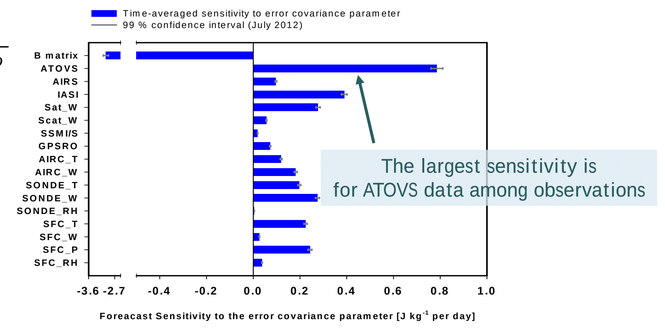
δs_i^o , δs_b error covariance parameter for observation and background

$$\delta e = e(B + \delta B, R + \delta R) - e(B, R)$$

$$\approx \delta e_b + \sum_i \delta e_i^o = \left\langle \left(\frac{\delta e}{\delta s_b}, \frac{\delta e}{\delta s_i^o} \right), (\delta s_b, \delta s_i^o) \right\rangle$$

Courtesy of Daescu and Todling (2010)

$\frac{\delta e}{\delta s_i^o}$



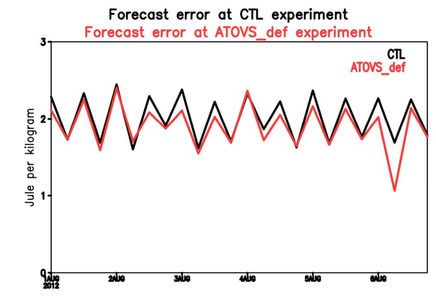
The largest sensitivity is for ATOVS data among observations

δs_i^o

July 2012

	B matrix	ATOVS	IASI	AIRS	SAT_W
July	0.3000	-0.7238	-1.0467	-0.3746	-0.5235
	SCAT_W	GPSRO	SSMI/S	SONDE_T	SONDE_W
July	0.2183	-0.6425	-2.0419	-0.9712	-0.4131
	SONDE_RH	SFC_P	SFC_T	SFC_W	SFC_RH
July	-0.9745	-0.7905	-0.5636	-0.7638	0.2676
	AIRC_T	AIRC_W	~ Tuning variable not used for DA system		
July	-0.3410	-1.2261			

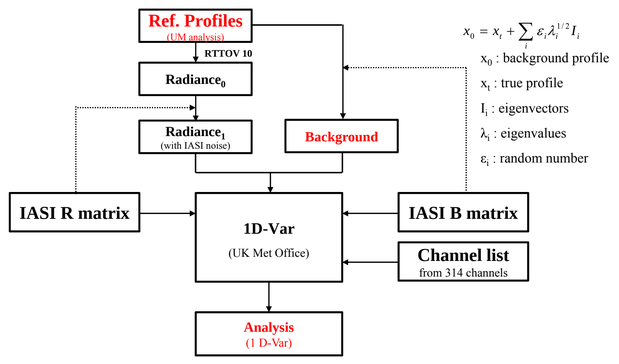
3 hour forecast errors in moist energy norm



- The ATOVS observation error is large and its reduction diminish forecast error in terms of moisture energy norm (See Hyun Mee Kim's presentation for details)

IASI Channel selection

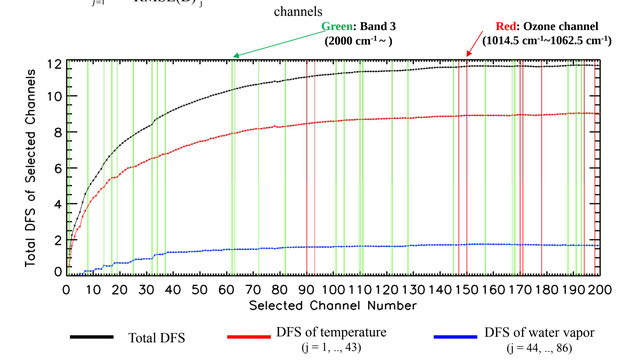
Methodology to select beneficial channels



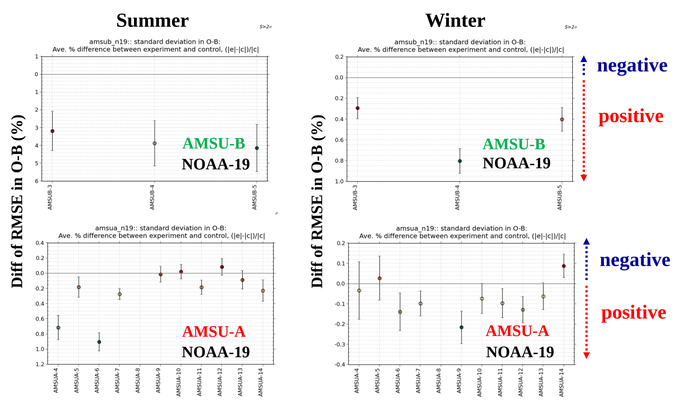
Selected channels using DFS

$$DFS_i = \sum_{j=1}^{N} [1 - \frac{RMSE(A)_{i,j}}{RMSE(B)_j}] w_j$$

- Most of information is from CO_2 channels.
- Band 3 and ozone channels are not included in UKMO 183 channels



Impact of new channel selection(200) compared to the operation(183)



- With the new selection of IASI channels, the ATOVS fits are improved (See Youngchan No's presentation for details)