Recent developments in satellite data assimilation at JMA

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1. Outline of NWP systems at JMA

Specifications of JMA's forecast model and data assimilation systems

Model	Global Spectral Model & Analysis (GSM,GA)	Meso-scale Model & Analysis (MSM,MA)	Local Forecast Model & Analysis (LFM, LA)
Horizontal res. / Vertical levels (top)	TL959 / L100 (up to 0.01hPa)	5 km / L48 (up to 22 km)	2 km / L58 (up to 20 km)
Forecast range (Initial time)	84h (00, 06, 18UTC) 264h (12UTC)	39h (3 hourly)	9h (1 hourly)
Data Assimilation (inner loop horizontal res.)	4D-Var (TL319)	4D-Var (15 km)	3D-Var (5 km)
Assimilation window	6h (-3 ~ +3 hours)	3h (-3 ~ 0 hours)	1 h × 3 times (Analysis cycle)
RTM for Radiance assimilation	RTTOV 10.2		(under development)
Cut off time	Early Analysis: 2h20m Cycle Analysis: 11h50m (00, 12UTC), 7h50m (06, 18UTC)	50 min	30 min

Satellite data used in the operational assimilation systems.
Items in red were implemented in the operational system after ITSC19

Satellite/Instrument		GA	MA	LA
Sounder	NOAA15, 18, 19, Aqua, Metop-A, B / AMSU-A	Radiance		Under development
	NOAA18, 19, Metop-A, B / MHS			
	Megha-Tropiques / SAPHIR	Radiance	Under development	
	Aqua / AIRS, Metop-A, B / IASI	Radiance	Under development	
MW Imager	GCOM-W1 / AMSR2	Radiance	Radiance, Rain rate	
	DMSP-F16, 17, 18 / SSMIS			
VIS/IR Imager	MTSAT-2, Meteosat-7, 10, GOES-13, 15	Radiance		
		AMV		AMV
	Aqua, Terra / MODIS, NOAA, Metop / AVHRR, LEO-GEO	AMV	—	—
Scatterometer	Metop-A, B / ASCAT	Ocean surface wind	Under development	Under development
GNSS-RO	Metop-A, B, COSMIC, GRACE-A, TerraSAR-X, C/NOFS	Bending angle	Under development	Under development

2. List of Upgrades

- Introduction of Aqua/AIRS and Metop-A, B/IASI (GA, Sep. 2014) (Okagaki 2015) → ***2.1***
- Introduction of new NWP model "ASUCA" into LFM and LA, introduction of AMVs (LA, Jan. 2015) (Aranami et al. 2015)
- Introduction of Megha-Tropiques/SAPHIR (GA, Jun. 2015) (presented in 1p.04 by M. Kazumori)
- Improvement of ASCAT utilization (GA, Oct. 2015) → ***2.2***

<References>

- K. Aranami, K., T. Hara, Y. Ikuta, K. Kawano, K. Matsubayashi, H. Kusabiraki, T. Ito, T. Egawa, K. Yamashita, Y. Ota, Y. Ishikawa, T. Fujita, and J. Ishida, 2015: A new operational regional model for convection-permitting numerical weather prediction at JMA. *CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling.*, 45, 5.05–5.06.
- Okagaki, A., 2015: Assimilation of IASI and AIRS radiances at JMA. *CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling.*, 45, 1.17–1.18.

2.1 Introduction of Aqua/AIRS and Metop/IASI

- Clear radiances from the Metop/IASI and the Aqua/AIRS have been operationally assimilated into GA since Sep. 4, 2014.
- Long-wave temperature sounding channels (around 15 μm) were selected as assimilation targets to improve the accuracy of the temperature field in analysis. There are 69 selected channels for IASI and 76 for AIRS. For AIRS, 9 channels around 4.4 μm are added only in the nighttime.
- The impact of IASI and AIRS assimilation was evaluated through a pre-operational experiment, in which the RMS of FG departure from AMSU-A and MHS was reduced and errors of short-range forecasting for 500-hPa geopotential height were also reduced significantly.

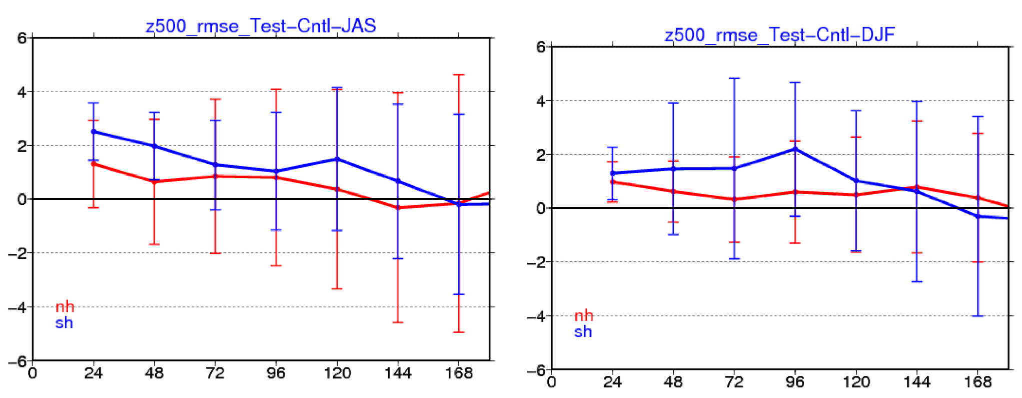

Figure 2.1.1 Normalized differences of RMS [%] in forecast errors for 500-hPa geopotential height verified against initial fields as a function of forecast range [hours]. Positive values correspond to reduced RMS with IASI and AIRS assimilation. Left: JAS period; Right: DJF period. Red lines show verification results for the northern hemisphere (20˚N–90˚N), and blue lines show those for the southern hemisphere (90˚S–20˚S). Error bars show a 95% confidence interval.

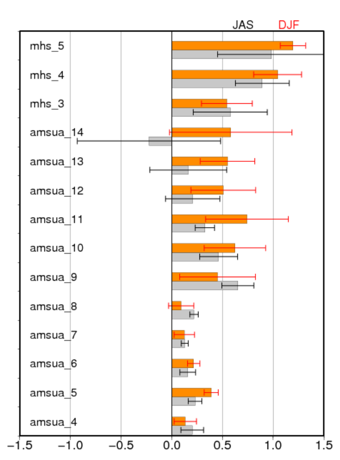

Figure 2.1.2 Normalized difference of RMS [%] in FG departure for AMSU-A and MHS. Gray bars show the JAS period, and red bars show DJF. Positive values correspond to reduced RMS with IASI and AIRS assimilation. Error bars show a 95% confidence interval.

2.2 Improvement of ASCAT utilization

- High wind speed data of ASCAT had not been used due to positive bias of the JMA's global model. JMA's global NWP system was upgraded in Mar. 2014 and its wind speed biases were reduced in this time.
- In Oct. 2015, upper limit was changed from 15 m/s to 25 m/s to use more high wind speed data of ASCAT and the observation error inflation in the region with higher latitude than 30˚S was done away with.

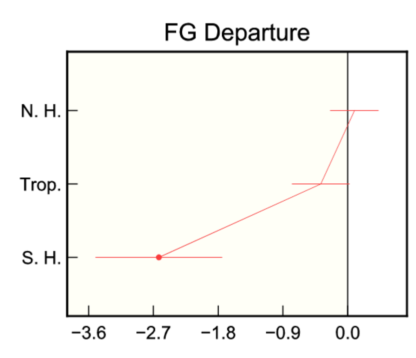

Figure 2.2.1 Normalized difference of STDDEV [%] in FG departure for the sea surface pressure observation. Negative values correspond to reduced STDDEV with Improvement of ASCAT utilization. Error bars show a 95% confidence interval.

3. Future Plans

3.1 Use of Suomi-NPP/ATMS (Details are presented in 11.04)

- Assimilation experiments for ATMS without AMSU-A and MHS showed statistically significant positive impacts on short range forecast against initial fields, though experiments with AMSU-A and MHS showed moderate impacts. Examinations and evaluations are in progress.

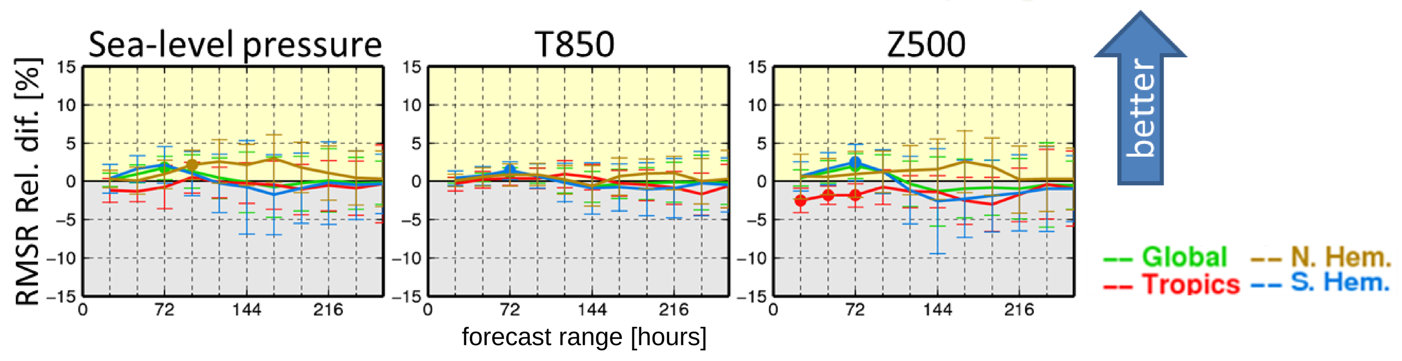

Figure 3.1.1 Normalized differences of RMS [%] in forecast errors for sea-level pressure, 850-hPa temperature, and 500-hPa geopotential height verified against initial fields as a function of forecast range [hours]. Positive values correspond to reduced RMS with ATMS assimilation.

3.2 Use of FY-3B/MWHS and FY-3C/MWHS2

- FY-3B/MWHS and FY-3C/MWHS2 have along-scan bias. The scan bias correction coefficients was calculated individually for each channel, and scan position. Quality controls for the assimilation system (e.g. cloud screening) are under development.

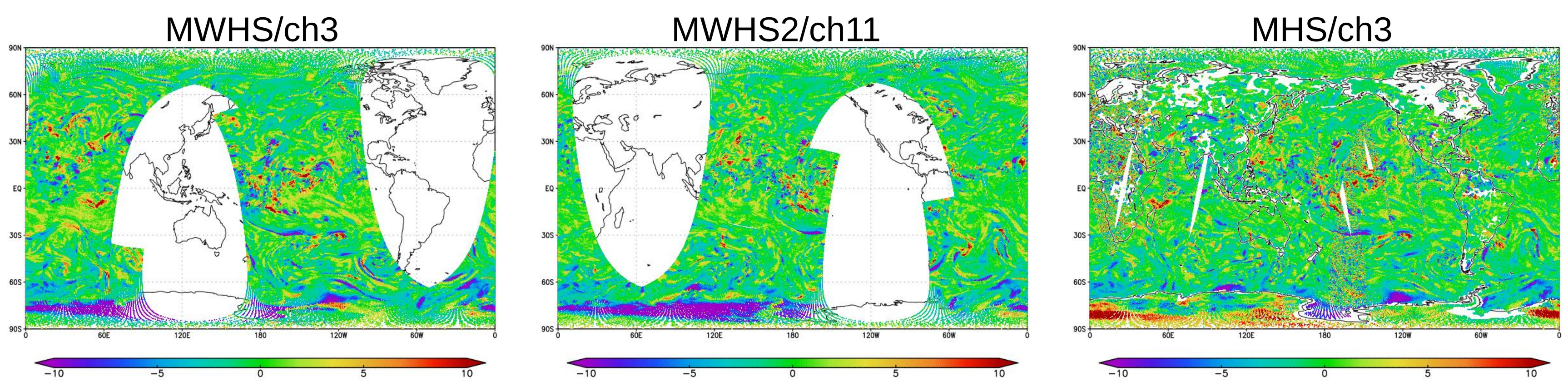

Figure 3.2.1 FG departure after the scan bias correction for MWHS/ch3, MWHS2/ch11, and MHS/ch3 (183.31±1.0 GHz) in a 6-hour period.

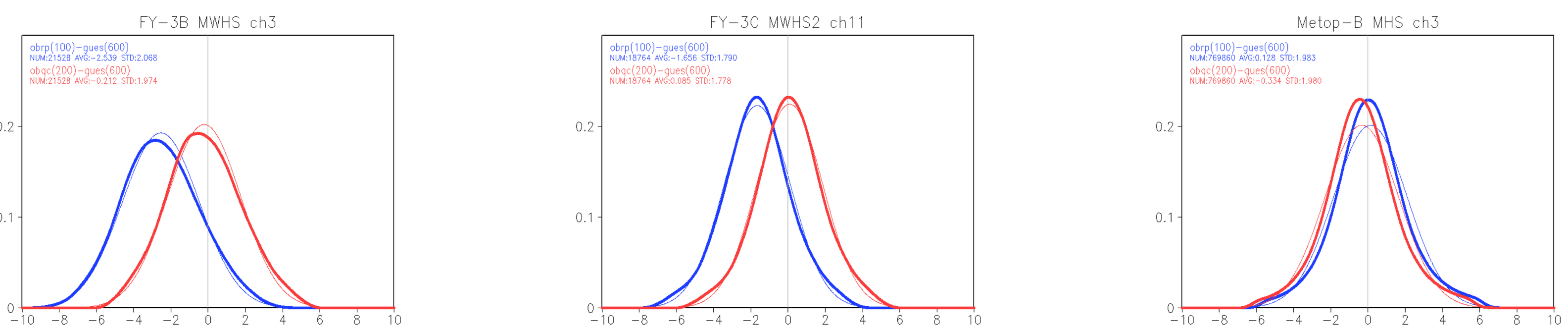

Figure 3.2.2 Histogram plot of FG departure after the tentative quality control for MWHS/ch3, MWHS2/ch11, and MHS/ch3.

3.3 Use of DMSP-F19/SSMIS

- We have just started to assess the data.

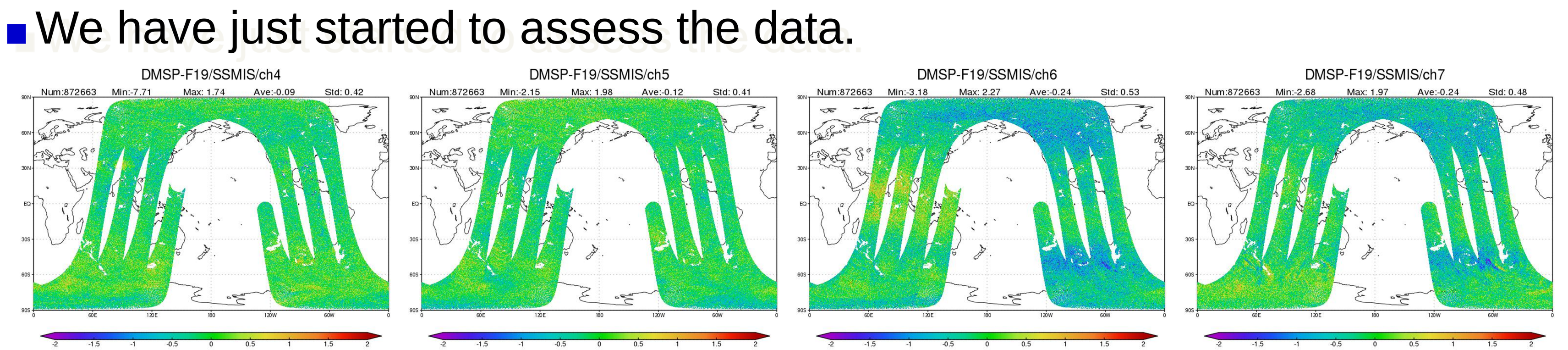

Figure 3.3 FG departure for DMSP-F19/SSMIS ch4–7.

3.4 Other plans

- Use of Suomi-NPP/CrIS, Himawari-8/CSR, AMV, GPM-core/GMI, FY-3B/MWRI, FY-3C/MWRI, and so on.
- Assimilation of cloud/rain affected radiances.
- Use of GNSS-RO data in MA.
- Use of radiance data in LA.