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 Model & Analysis (GSM,GA)	Meso-scale Model & Analysis (MSM,MA)	Local Forecast Model & Analysis (LFM, LA)
Horizontal /vertical res.	TL959 / 100 (up to 0.01hPa)	5km / 50 (up to 22km)	2km / 60 (up to 20km)
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 (15km)	3D-Var (5km)
Assimilation window	6h (-3 ~ +3 hours)	3h (-3 ~ 0 hours)	1h×3 (Rapid Update Cycle)
RTM for Radiance assimilation	RTTOV 10.2		(under development)
Cut off time	Early Analysis : 2h20m Cycle Analysis :11h50m(00,12UTC), 7h50m(06,18UTC)	50m	30m

Satellite data (to be) used in the operational assimilation systems.
Items in red were implemented in the operational system since ITSC18

Satellite/Instrument		GA	MA
1.Sounder	NOAA15,16,18,19, Aqua, Metop-A,B / AMSU-A	Radiance	
	NOAA18,19, Metop-A,B / MHS		
	(Hyper spectral IR sounders)	Under development	
2.MW Imager	TRMM/TMI	Radiance	Radiance, Rain Rate
	DMSP16,17,18 / SSMIS		
	GCOM-W / AMSR2		
3.VIS/IR Imager	MTSAT-2, Meteosat-7,10, GOES-13,15	Radiance	
		AMV	
	Aqua,Terra/MODIS, NOAA,Metop/AVHRR, LEO-GEO	AMV	X
4.Scatterometer	Metop-A,B/ASCAT	Ocean surface wind	Under development
5.GNSS-RO	Metop-A,B, COSMIC, GRACE-A, TerraSAR-X, C/NOFS	Bending angle	Under development

2. List of Upgrades

- MHS 3-5 over land, use of land surface emissivity atlas distributed with RTTOV 10.2 (GA&MA, Nov 2012) (M. Kazumori 2012)
- GNSS RO refractivity data from GRACE-A, TerraSAR-X and C/NOFS in addition to Metop-A and COSMIC with the implementation of new observation operators. (GA, Dec 2012) (H. Owada and K. Yoshimoto 2013)
- Switch from METEOSAT-9 to METEOSAT-10 AMV and CSR (GA, Feb 2013) (K. Yamashita 2014)
- Extension of MSM&MA lateral boundaries (Mar 2013) → ***2.3***
- LEO-GEO and AVHRR winds (GA, Jul 2013) (K. Yamashita 2014)
- AMSR2 onboard GCOM-W1, Japanese name: Shizuku (GA&MA, Sep 2013) (M. Kazumori and T. Egawa 2014) → ***2.1***
- Data from Metop-B (GA&MA for AMSU-A and MHS, GA for AVHRR-AMV, ASCAT and GRAS, Nov 2013) (M. Moriya et al 2014) → ***2.2***
- GNSS RO bending angle, AMSU-A 14ch, ground based GNSS zenith total delay were introduced in GA with the upgrades of GSM (GA, Mar 2014)

2.1 Introduction of GCOM-W1/AMSR2 (Japanese name:Shizuku)

- GCOM-W1 is a JAXA's earth observation satellite with the AMSR2 microwave imager on board. Because of its afternoon orbit, it fills gaps in microwave imager coverage by SSMISs onboard DMSP-F16, 17, 18, which have early morning or morning orbits.
- The results of OSEs conducted in advance for AMSR2 show a positive impact on rainfall prediction. Based on these outcomes, AMSR2 was introduced as part of the operational DA system in September 2013.

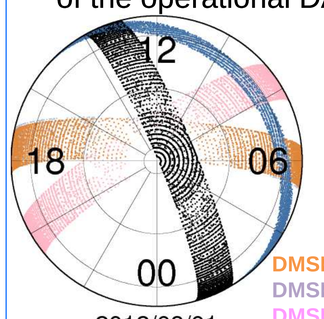


Figure 2.1.1. MW imager data coverage.GCOM-W1/AMSR2 data (black) fill the gaps. Note: DMSP-F16 and F17 had almost the same coverage as of summer 2012.

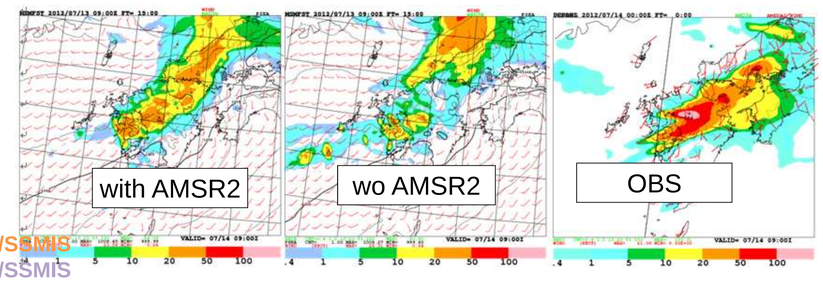
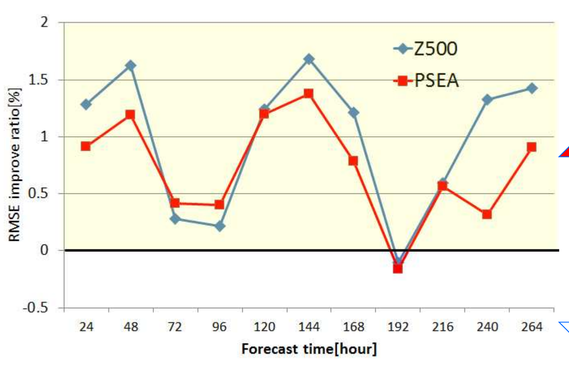


Figure 2.1.2. Comparison of the 3-hour accumulated rainfall forecast for 00 UTC on July 14, 2012. The forecast time is 15 hour. "OBS" panel is the rainfall distribution estimated from radar observations and rain gauges. The units are mm/3hr.

2.2 Introduction of data from Metop-B

- Data from Metop-B (AMSU-A, MHS, AVHRR AMV, ASCAT and GRAS) have been assimilated operationally in global NWP system since Nov 2013.
- The results of an OSE conducted for the payloads of Metop-B showed a positive impact on geopotential height and typhoon track forecasts.



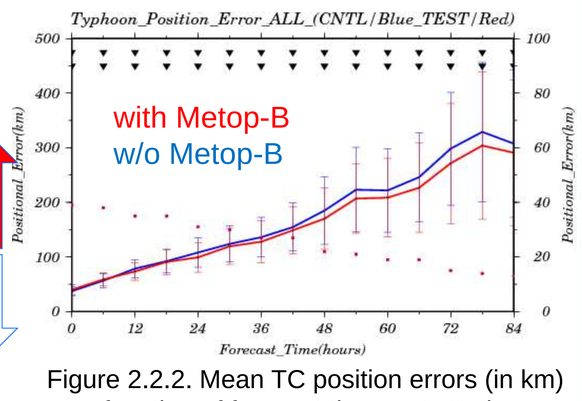


Figure 2.2.1. Improve rates of Z500(blue) and PSEA(red) 42days and globally averaged RMSE scores when Metop-B(AMSU-A, MHS, AVHRR AMV, ASCAT and GRAS) were added to Global NWP system.

Figure 2.2.2. Mean TC position errors (in km) as a function of forecast time up to 84 hours in summer 2013. The red and blue lines indicate errors of forecasts with and without Metop-B data, respectively. The dots correspond to the vertical axis on the right, which represents the number of verification samples.

2.3 Extension of MSM&MA lateral boundaries

- Forecast and analysis region of MSM&MA were expanded in March 2013, which aims 1) improve forecast accuracy near the lateral boundary 2) give more proper boundary conditions to LFM.
- Experiments, conducted prior to the implementation, showed that expanded MSM&MA improves precipitation forecast accuracy. It was found that the increased satellite data usage by the expansion contributed to the improvement.

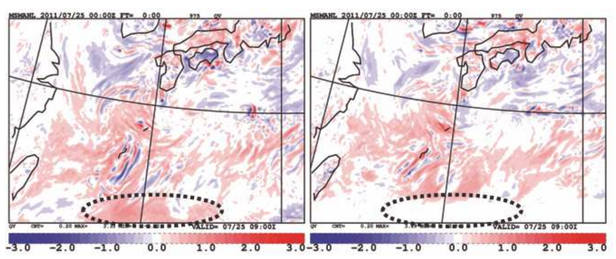


Figure 2.3.1 Humidity increment(g/kg) on 975hPa isobaric plane, 00UTC, 25 July 2012. Left) expanded MSM&MA system, Right)old system. Analyzing more water vapor in initial field, the expanded system predicts heavy rainfall well, which were observed in southern Kyusyu at 26 July.

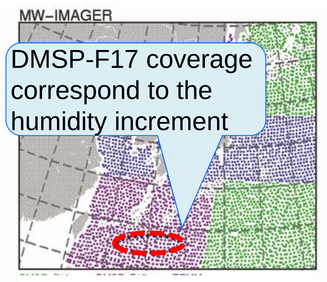


Figure 2.3.2. Coverage of Microwave imager at the analysis time of Figure X.1. Purple dots show DMSP-F17.

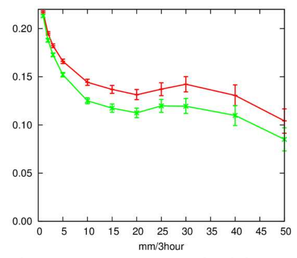


Figure 2.3.3. Equitable threat scores for precipitation forecast. for 22 Jul~15 Aug ,2011. Red) expanded MSM&MA system, Green) old system

3. Future Plans

- Towards the use of S-NPP/ATMS, AAPP v7 filter and QC for residual striping pattern are being examined.

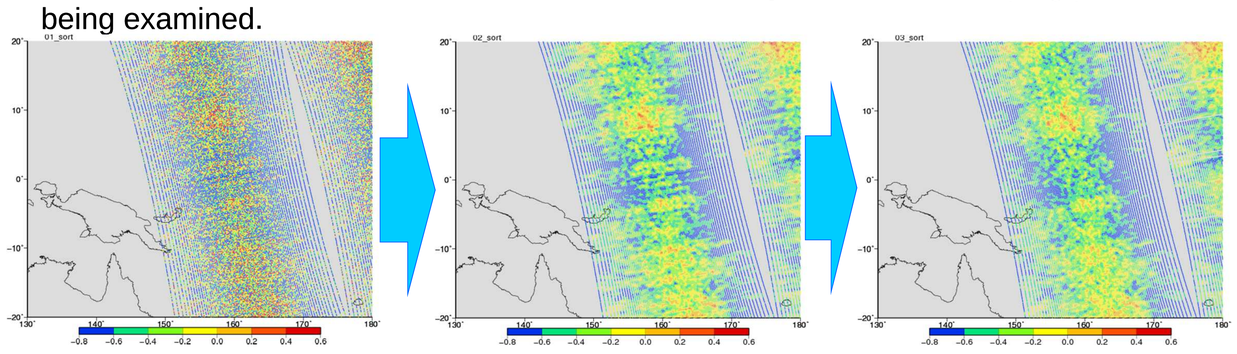


Figure 3.1. First guess departure (observation minus first-guess) for ATMS channel 12 in a 6hour period. left)original data; center)AAPP v7 filter was applied; right)A prototype filter for residual striping was applied

- Use of AIRS and IASI clear radiances
- Initial assessment of GPM/GMI, S-NPP/CrIS
- Assimilation of cloud / rain affected radiances

<References>

- M. Kazumori 2012. Assimilation experiments involving surface-sensitivity microwave radiances in JMA's global data assimilation system. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model.
- M. Kazumori and T. Egawa 2014. Assimilation of GCOM-W1/AMSR2 radiance data in the JMA NWP systems. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model. *Submitted.*
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- H. Owada and K. Yoshimoto 2013. Recent Updates on the Usage of GNSS RO Data in JMA's Operational Global Data Assimilation system. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model.
- K. Yamashita 2014. Introduction of LEO-GEO and AVHRR Polar Atmospheric Motion Vectors in the JMA Operational Global NWP System. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model, *Submitted.*