Operational use of Suomi NPP ATMS radiance data in JMA's global NWP system

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1. Introduction

- Since 29 Mar. 2017, microwave radiance data from the Advanced Technology Microwave Sounder (ATMS) of the Suomi National Polar-orbiting Partnership (S-NPP) spacecraft have been assimilated operationally into the global Numerical Weather Prediction (NWP) system run by the Japan Meteorological Agency (JMA).
- In this poster, we briefly describes related data quality control and the impacts of the assimilation.

2. Specification of JMA's global NWP system

Data Assimilation

- Outer model: TL959L100 (horizontal reso. 20 km, top 0.01 hPa)
- Inner model: TL319L100 (horizontal reso. 55 km, top 0.01 hPa)
- 6-hr assimilation window, incremental 4D-Var
- Radiative Transfer Model: RTTOV-10.2

Forecast Model

- TL959L100 (horizontal reso. 20 km, top 0.01 hPa)
- 84-hr forecast at 00, 06, 18UTC, 264-hr forecast at 12UTC

3. Quality Control (Cloud screening and bias correction)

- The same approaches used for AMSU-A/MHS quality control (Okamoto et al. 2005) are applied.
- QC: Rain, CLW, Land/Sea, Sea Ice, Altitude
  - Over ice-free sea
    - CLW: NESDIS CLW algorithm (Weng, et al. 2002)
    - Rain detection: ObsTBB(ch16) – ObsTBB(ch17) > 3(K) or CLW >= 300 (g/m2)
    - Cloud detection: CLW >= 100 (g/m2)
- Observation errors: Estimated from O-B statics. (Table 1)
- Thinning: 250 km distance
- Bias correction: Scan position bias correction (static) and Variational bias correction (VarBC) (Sato 2007, Ishibashi 2009)
- AAPP FFT-based filter is applied to achieve noise performance similar to that of AMSU-A.
- Edge data on FOV number at 1, 2 and 95, 96 are not assimilated due to their anomalous biases.

ATMS:ch	Clear			Cloudy	Rainy
	Sea	Land	Sea Ice		
6	0.2 × 1.5	–	–	–	–
7	0.2 × 1.5	0.2 × 1.8 (1500 m <= altitude)	0.2 × 1.8	–	–
8	0.2 × 1.5	0.2 × 1.5 (2500 m <= altitude)	0.2 × 1.5	0.2 × 1.5	–
9	0.2 × 1.5	0.2 × 1.5 (5000 m <= altitude)	0.2 × 1.5	0.2 × 1.5	–

ATMS:ch	Clear	Cloudy	Rainy
18	2.0 × 4.5	–	–
19	2.5 × 4.5	–	–
20	3.0 × 4.5	–	–
21	3.5 × 4.5	–	–
22	4.0 × 4.5	–	–

Table 1. Observation errors and inflation factors used in the ATMS data assimilation. The units are degree K. The channels with blank cells are not assimilated. (Obserr × Inflation factor)

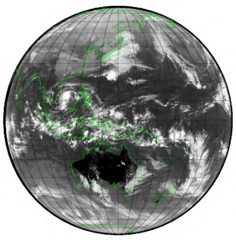


Figure 1. Himawari-8 IR (18 Nov. 2017, 03UTC)

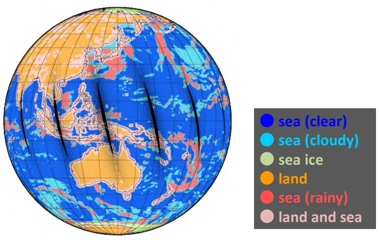


Figure 2. S-NPP ATMS QC parameters used to filter data (17 Nov. 2017, 21UTC - 18 Nov. 2017, 09UTC)

4. Observing System Experiments (OSE)

Design of experiments

- **Control**: Same as JMA operational global DA system as of Dec. 2016
- **Test**: Control + ATMS radiance (clear-sky)
- Period: One month for summer 2015 (August, 2015 sum) and winter 2015-2016 (January 2016 win)

Results

- Improved fits in FG departure of various observation types.

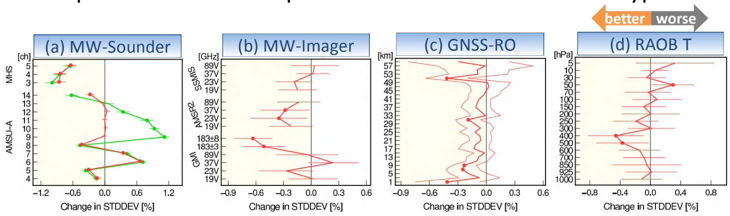


Figure 3. Normalized changes in the STDV of FG departures from (a) AMSU-A and MHS, (b) SSMIS, AMSR2 and GMI, (c) GNSS-RO, (d) radiosonde temperature observation (2015 sum). Negative values represent improvement. In panel (a), the green line represents results of a preliminary test using ATMS stratospheric channels (ch10-15). The ch 10-15 are not used in the operation（See Section 5).

- Positive impacts for the prediction of geopotential height and temperature, especially in the Southern Hemisphere.

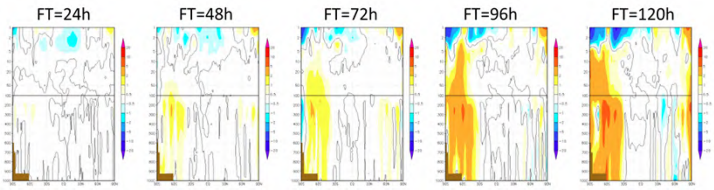


Figure 4. Zonal mean of RMSE differences between Control and Test for forecasting of geopotential height (2015 sum). Positive values (Orange shade) indicate improvement. Verification is against the own analysis.

- Positive impacts for typhoon track prediction.

5. Development

Use of stratospheric channels (ch10-15)

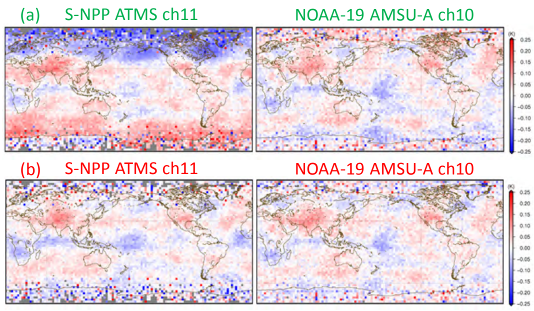
- Preliminary experiments using ATMS stratospheric channels (ch10-15) showed increasing STDV of FG departure from AMSU-A. (Fig. 3)
- We found different characteristics between corresponding ATMS and AMSU-A channels' FG departure in high latitudes after VarBC.
- Choice of VarBC predictors for ATMS T-ch affects the performance of the bias correction. Use of thickness as the predictor improved the consistency between ATMS T-ch and AMSU-A.
- Considering the change of the predictor for microwave temperature sounding channels from IWLR to thickness.

$$IWLR = \sum_{k=1}^{top-1} (T_{k+1} - T_k)(\tau_{k+1} - \tau_k)$$

IWLR : Integrated Weighted Lapse Rate

T_k : temperature (layer level = k)

τ_k : transmittance (layer level = k)



ATMS T-ch VarBC air-mass predictor

(a) IWLR (Zhu ,et al. 2014)

(b) thickness (Harris ,et al. 2001) (300-850 hPa, 50-200 hPa, 5-50 hPa)

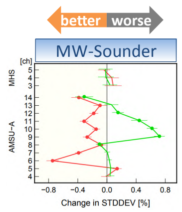


Figure 5. FG departure for S-NPP ATMS ch11 and NOAA-19 AMSU-A ch10 between 21 Jul. 2015 00UTC and 31 Aug. 2015 18UTC. (a) Same setting as of operation (May. 2017) but add ATMS ch10-15. (b) Same setting as (a) but change VarBC predictors of ATMS (IWLR -> thickness)

Figure 6. Normalized changes in the STDV of FG departures from AMSU-A and MHS for the same setting as Fig.4. (a) green line, (b) red line.

6. Summary

Operational use of clear-sky ATMS radiance since 29 Mar. 2017

- Tropospheric channels (ch6-9, ch18-22) are assimilated.
- Positive impacts for the fits in FG departure of various observation types.
- Considering the change of the VarBC air-mass predictor for microwave temperature sounding channels from IWLR to thickness.

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