Assimilation of KOMPSAT-5 GNSS-RO data in KMA global NWP model

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1. Introduction

✱ Background

- The GNSS-RO data has been used as an important data to improve the forecasting performance of global models in the Southern Hemisphere, ocean (Healy, 2008). In addition, it has been used to verify other observations because it is vertically highly accurate data (Anthes et al., 2008).
- The Korea Meteorological Administration (KMA) has been using GNSS-RO data for its numerical model since 2010. It has been already investigated that Korea Multi-Purpose Satellite-5 (KOMPSAT-5) GNSS-RO data gave a positive impact in the previous KMA operational model (25km).
  - Quality of KOMPSAT-5 data is as good as the COSMIC-1 data (Bowler, 2018).
- The KOMPSAT-5 was launched in 2013. Due to network limitation of the receiving ground station, there was a delay of about 12 hours in data collection, making it difficult to use in the numerical weather prediction model. Recently, KOMPSAT-5 data were collected from the National Meteorological Satellite Center with NOAA and the Korea Aerospace Research Institute (KARI), and through the Global Meteorological Network (GTS). It can be used for NWP model in real-time.

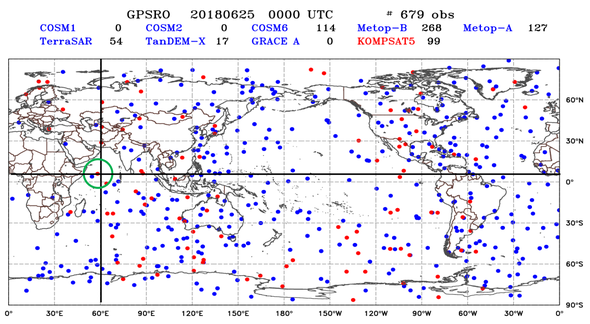
✱ Goal

- Evaluating the impacts of KOMPSAT-5 RO data in the current KMA operational model

2. KOMPSAT-5 RO data

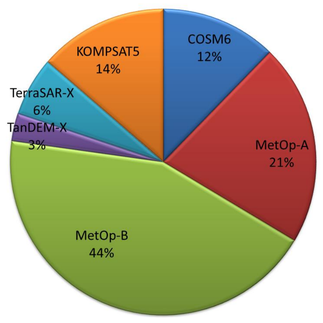
▣ Number of data

- Analysis period : 25th June~15th July, 2018



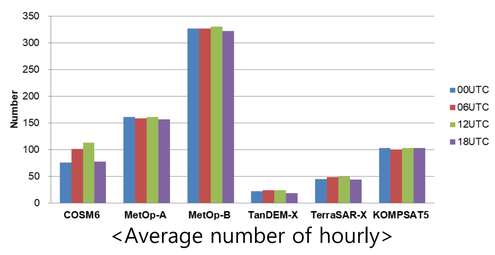
- The horizontal distribution of KOMPSAT-5 RO (red) and other satellite RO data (blue) at 00UTC 25th June, 2018

- On average, the KOMPSAT-5 RO data are accounted for about 14% of the total data.
- The amount of data used in data assimilation increased between 20% and 28% in every cycle, on average 23%.



<Average ratio of RO satellite>

- The KOMPSAT-5 has the third largest ratio of data after MetOP-A and B.



<Average number of hourly>

- The KOMPSAT-5 shows evenly an average number of 102 at 00, 06, 12, and 18UTC.

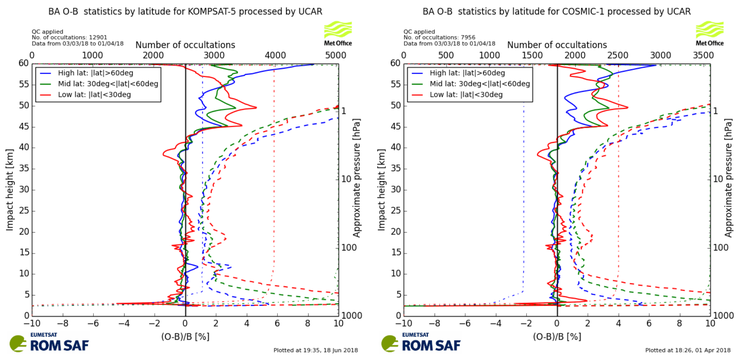
▣ Quality Control

- Using 1D-Var

	Description that assigns PGE values
reject (Final PGE>0.5)	Missing data
	Convergence test
	Initial cost function test
	Final cost function test
	Some levels rejected on 1D-Var
	Error in background data
	Valid values < 10 in profile
accept (Final PGE=0.1)	1D-Var success

<Checklist of quality control>

- To identify erroneous observation data
- To prevent that data from being assimilation

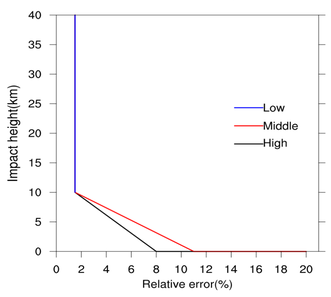


<Bias and standard deviation of (O-B)/B (from ROM SAF report 32) >

- The quality of KOMPSAT-5 data is similar to that the COSMIC-1.

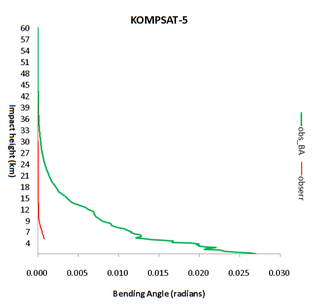
▣ Observation error

- Assumed latitudinal fractional errors and observation errors used for data assimilation in UM



- The uncertainty of above impact heights of 10km is 1.5%.
- KOMPSAT-5 RO data are utilizes from 5 to 40km vertical altitude.

<Assumed observation fractional errors for bending angle>



<Observed bending angle and observation error>

3. Numerical Model

▣ KMA NWP System

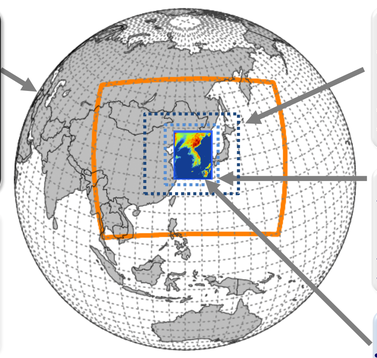
- In June 2018, the global model was updated with 10km resolution and so on.

❖ Numerical Model: UM v10.8
- Horizontal resolution: N1280(10km) L70
- Target length: 288hrs(00, 12UTC)

❖ Data Assimilation: Hybrid 4D-Var(4D-Var+MOGREPS-G)
- Horizontal resolution: N320(≈40km) L70
- Analysis time: 00, 06, 12, 18UTC

Global(GDAPS)
- Resolution N1280L70(UM) (10km / top = 80km)
- Target Length 288hrs (00/12UTC) 87hrs (06/18UTC)
- Initialization : Hybrid 4D-VAR

Global EPS
- Resolution N400L70(UM) (32km / top = 80km)
- Target Length : 288hrs
- Members : 49



Local(LDAPS)
- Resolution 1.5~4km L70(UM) (1188×1148 / top = 39km)
- Target Length : 36hrs
- Initialization : 3D-VAR

Local EPS
- Resolution 2.2km L70(UM) (460×482 / top = 39km)
- Target Length : 72hrs
- Members : 13

Very-short(KLAPS)
- Resolution 5km L40(WRF) (235×283 / top = 20km)
- Target Length : 12hrs
- Initialization : LAPS diabatic

▣ Experimental Design

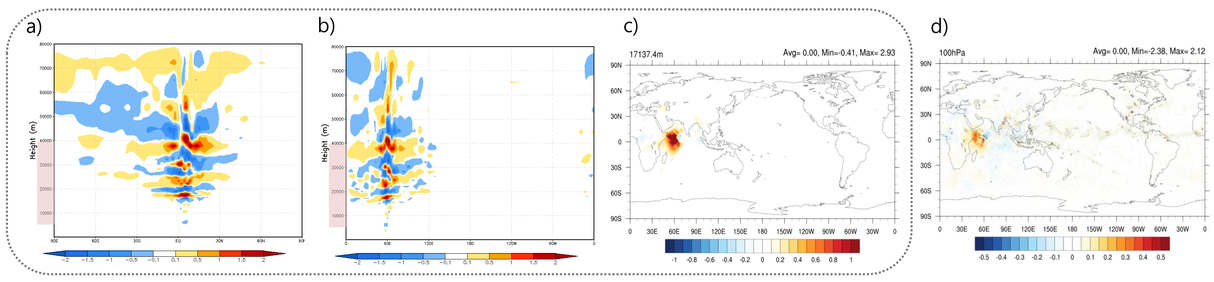
- Model: GDAPS
- Experiment Period: 25th June~15th July, 2018

	OPER	EXPR
Data	AHIClear, AIRS, AMSR, ATMS, ATOVS, COMSClear, CrIS, GOESClear, **GPSRO**, GroundGPS, IASI, MTSAPHIR, MWSFY3C, SEVIRIClear, Satwind, Scatwind Aircraft, Sonde, Surface	
GPSRO	COSMIC-1, MetOP, TanDEM-X, TerraSAR-X, GRACE-B	COSMIC-1, MetOP, TanDEM-X, TerraSAR-X, GRACE-B, **KOMPSAT-5**

4. Impact of KOMPSAT-5 RO data

▣ Single observation

- Impact of KOMPSAT-5 RO single observation on the analysis and forecast field

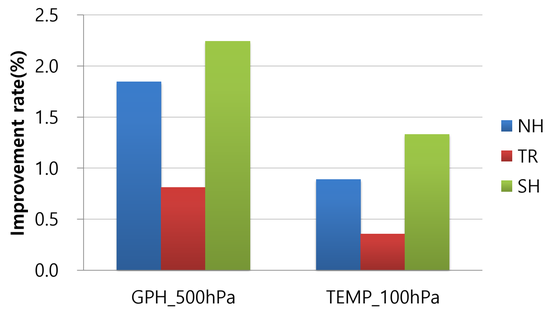


<**Analysis increment** of (a) vertical cross section at 60E, (b) vertical cross section at 5N, (c) horizontal at 100 hPa, and (d) **3 hour forecast** of temperature (theta) in first cycle (2018062500UTC)>

- The effect of the KOMPSAT-5 RO data is shown to be large at the altitude which data were used (5~40 km).
- It is shown that the analysis increment of temperature at 100 hPa is large at the corresponding position even in the 3 hours forecast field.

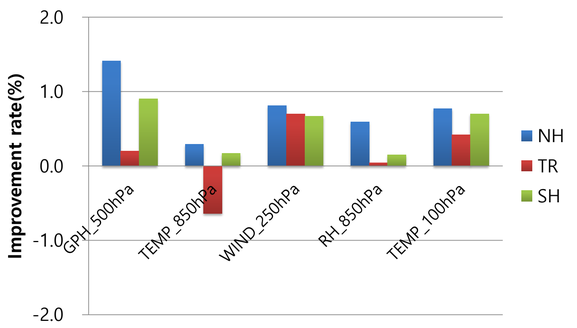
▣ Experiment

- Verification period: 1st July~15th July, 2018
- Improvement rate against ECMWF(T+00~T+120)

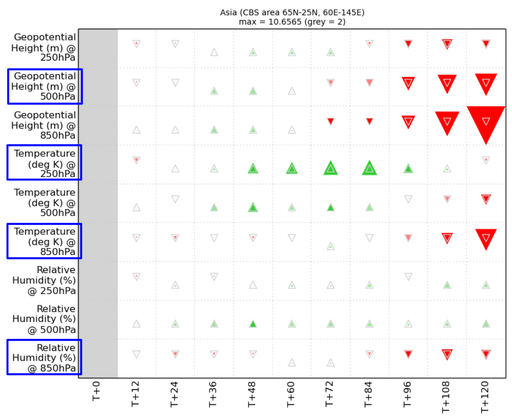


- The improvement rate of 1~5-days average forecast error compared to ECMWF for each variable and area.
- It shows a positive impact on geopotential height at 500 hPa and temperature at 100 hPa.
- In particular, the rate of improvement in the Southern Hemisphere is the largest.

- Improvement rate against OPER(T+72)



- Mostly positive impact except temperature at 850 hPa in the Southern Hemisphere.



<Root Mean Square Error(Forecast-Analysis), between 20180701 and 20180714 in Asia>

- The geopotential height at 500 hPa, temperature and relative humidity at 850 hPa have a positive effect until 3- days forecast and then declined.
- The temperature at 250 hPa has improved forecast performance in mid-prediction (48-96 h).

5. Summary & Future Works

▣ Summary

- When using KOMPSAT-5, the data volume is increased by more than 20%.
- The assimilation of KOMPSAT-5 RO data have a positive impact on geopotential height (2.2%) and temperature (1.3%), on 1~5 day forecast in the Southern Hemisphere.

▣ Future Works

- Analyzing the characteristics of observation error and quality of GNSS-RO data in KMA global model
- Investigating the impacts of KOMPSAT-5 RO data and improving observation error and quality on KMA's next generation NWP (Korean Integrated Model, **KIM**)

References

Anthes, R. A., and Coauthors, 2008: The COSMIC/FORMOSAT-3 Mission: Early results. *Bull. Amer. Meteor. Soc.*, **89**, 313–333.
Bowler, N. E., 2018: An initial assessment of the quality of RO data from KOMPSAT-5. *ROM SAF Report 32*, 18pp.
Healy, S. B., 2008: Forecast impact experiment with a constellation of GPS radio occultation receivers. *Atmos. Sci. Lett.*, **9**, 111–118.

Acknowledgments

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