The Response of Vertical Information Content in a 3D-Var Data Assimilation System

Szu-Chen Kuo[1], Chian-Yi Liu[1,*], Gin-Rong Liu[1]

[1]Center of Space and Remote Sensing Research, National Central University, Taiwan

[*]TEL: +886-3-422 7151 extn 57618   E-mail: cyliu@ncu.edu.tw

1.Objective

- Retrieved T/Q profiles have various uncertainties in PBL, troposphere, and stratosphere.
- Microwave (MW) sounder has coarse spatial and vertical resolutions, while hyperspectral IR sounder has the capability to improved spatial and finer vertical resolutions.
- Proper use of the vertical information contains from MW and hyperspectral IR sounding products may assist the NWP predictability.
- This study would like to evaluate the optimal use of both MW and hyperspectral IR sounding products in a 3D-var data assimilation system, in order to conducting a best method to apply satellite data in a regional scale NWP.

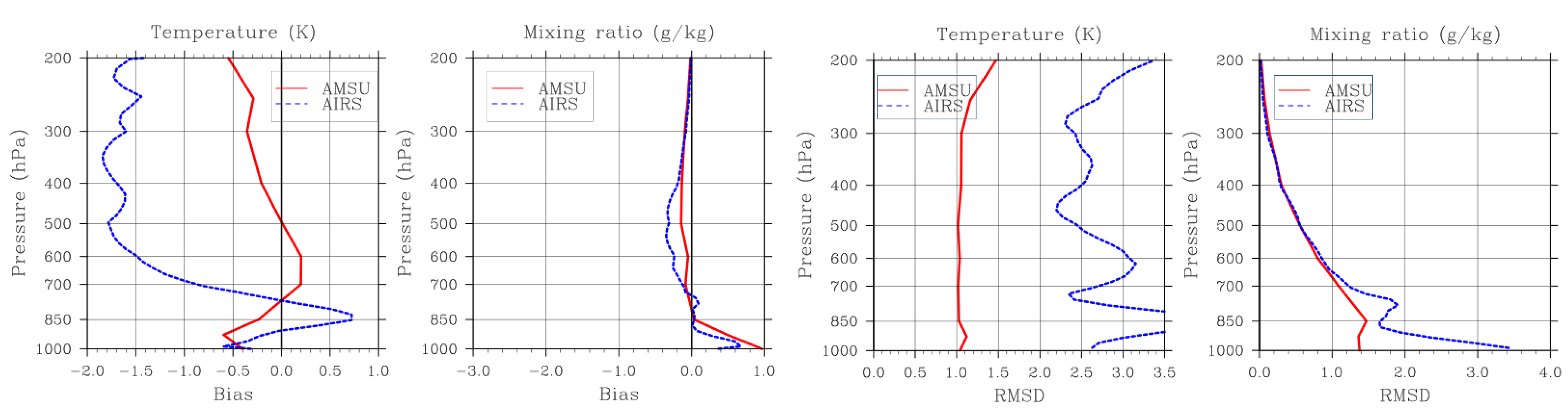

Figure1. (a) Bias of temperature (K). (b) Bias of mixing ratio (g/kg). (c) Root-mean-square deviation(RMSD) of temperature (K). (d) RMSD of mixing ratio (g/kg). Red line for AMSU and blue line for AIRs.

2.Experiment Design

- **Weather Research and Forecasting(WRF) V3.1.1**
  - Initial time: 2012/06/08 0000UTC~13 0000 UTC (6 days)
  - Initial: NCEP GFS ANL
  - Domain: 3 one-way nested domains
  - Resolution: vertical 31 levels, horizontal 45/15/5 km
- **WRF Data Assimilation (WRF DA) v3.1.1**
  - 3D-Var
  - Assimilation time: after each 6 h simulation
  - Time windows: ±3 hr
  - Cycling period: 2 days

	T/Q	T
200~300hPa	TQ_U	T_U
200~700hPa	TQ_M	T_M
200~925hPa	TQ_L	T_L

Table 2. The experiment setting

- **Experiment setting**
  - Assimilate variable: Temperature(T) and Mixing Ratio(Q) and T only
  - Assimilate layer: 200~300hPa, 200~700hPa and 200~925hPa

Physical Scheme	
Microphysics	WSM 5-class
Longwave radiation	RRTM
Shortwave radiation	Dudhia
Boundary layer	Yonsei University
Cumulus	new Kain-Fritsch

Table 1. Physical scheme to the WRF model

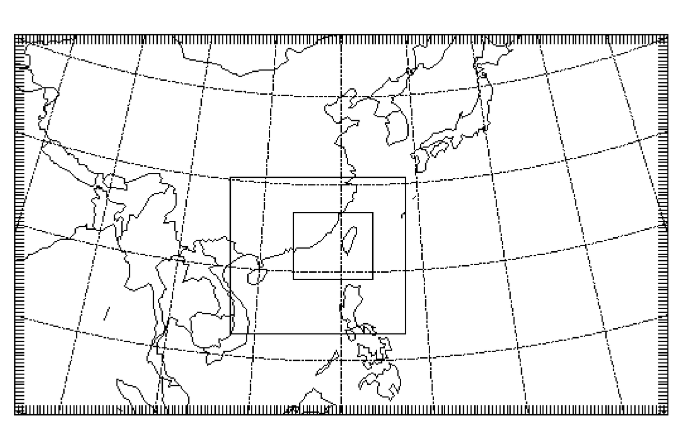

Figure 2. Three nested domains

3. Synoptic Description

- South part of Taiwan was encountering a southwesterly monsoon in 2012/06/10.
- A Mai-Yu front was passing through the northern Taiwan in the nighttime of 2012/06/11.
- There were two severe weather systems which caused heavy precipitation in Taiwan.

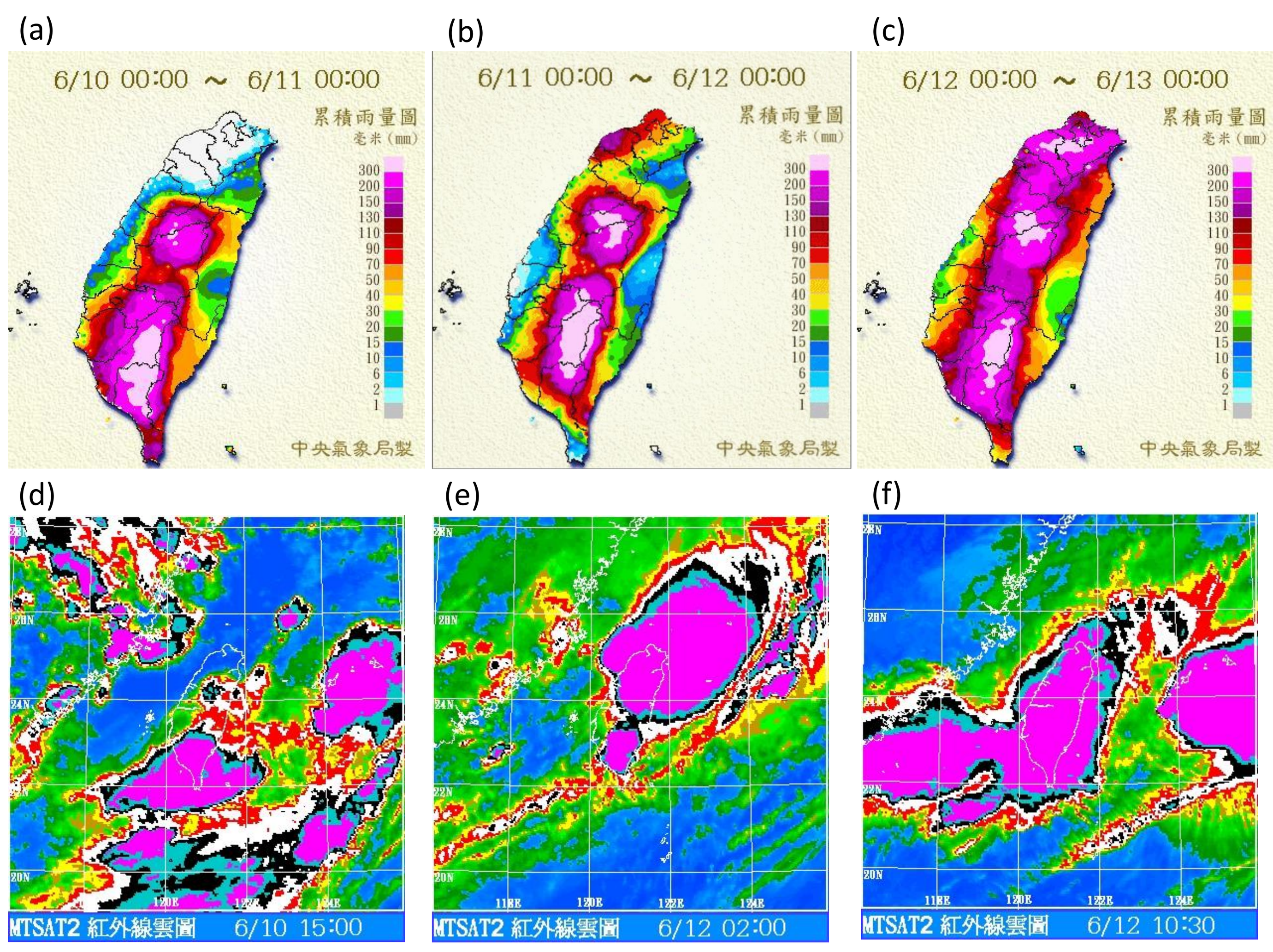

Figure 3. The accumulation rainfall distribution from 2012/06/10~06/12 and the associated IR window channel imagery from MTSAT on 10 June and 12 June 2012. (From CWB)

4.Result

- **Impact on Moisture Forecast : Relative Humidity at 850 hPa**
  - At the first 30 hour, except the AIRS TQ_L, the RMSD of other experiment are about 10%
  - The most important is that the RMSD of AMSU at different assimilate level are all smaller that the control run
  - The RMSD of AMSU is smaller than AIRS, AIRS TQ_L have larger RMSD than AMSU TQ_L.
  - Assimilating TQ and T seem have identical forecast performance, however, after 48-hour and beyond, using AMSU has improved skill than AIRS.

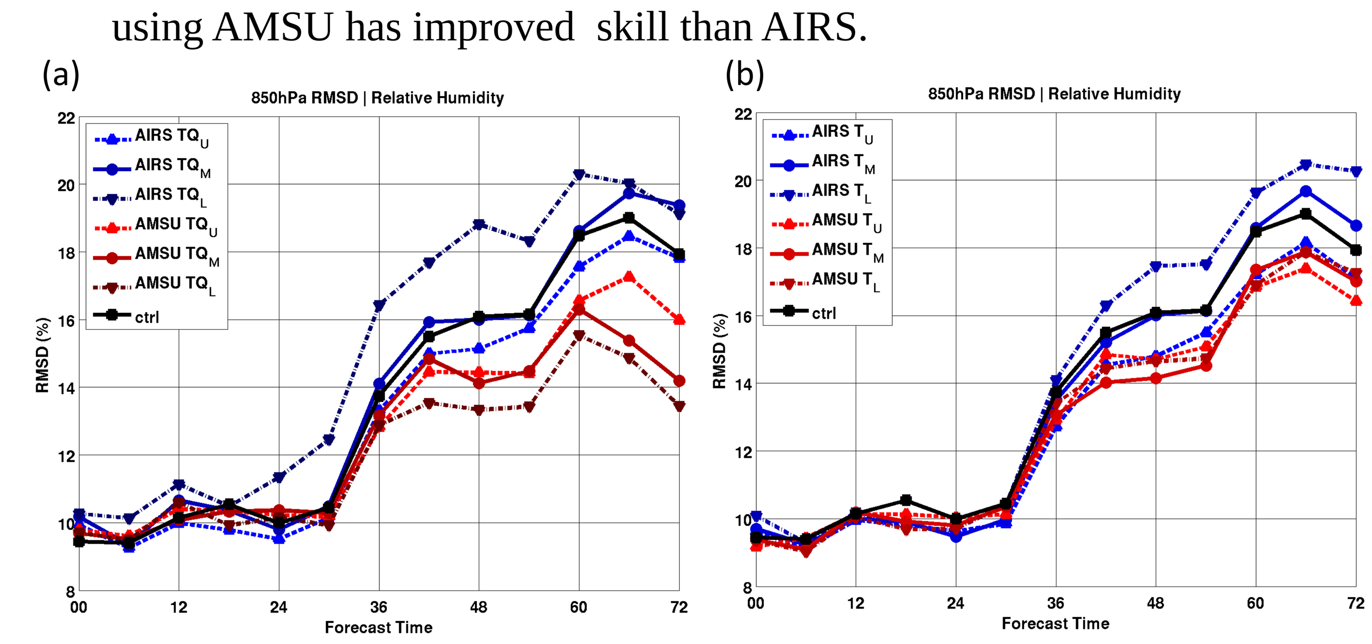

Figure 4. Compare different instrument and assimilate level of RMSD to relative humidity. (a) for T and Q (b) for T. Red line for AMSU, blue for AIRS and black is control run. Different brightness of color mean different assimilate level. Horizontal axis mean the forecast hour, and the vertical axis is the RMSD.

- **Impact on Temperature Forecast : Temperature at 500 hPa**
  - For TQ_M in AIRS and AMSU, the RMSD are the smallest one, for TQ_L AMSU is better than AIRS, but for TQ_U the result was inversely.
  - For 500hPa T variable the RMSD in all experiment are smaller than the control run.
  - When assimilate T only, the RMSD are larger than assimilate TQ, but at 300hPa the result are improved.

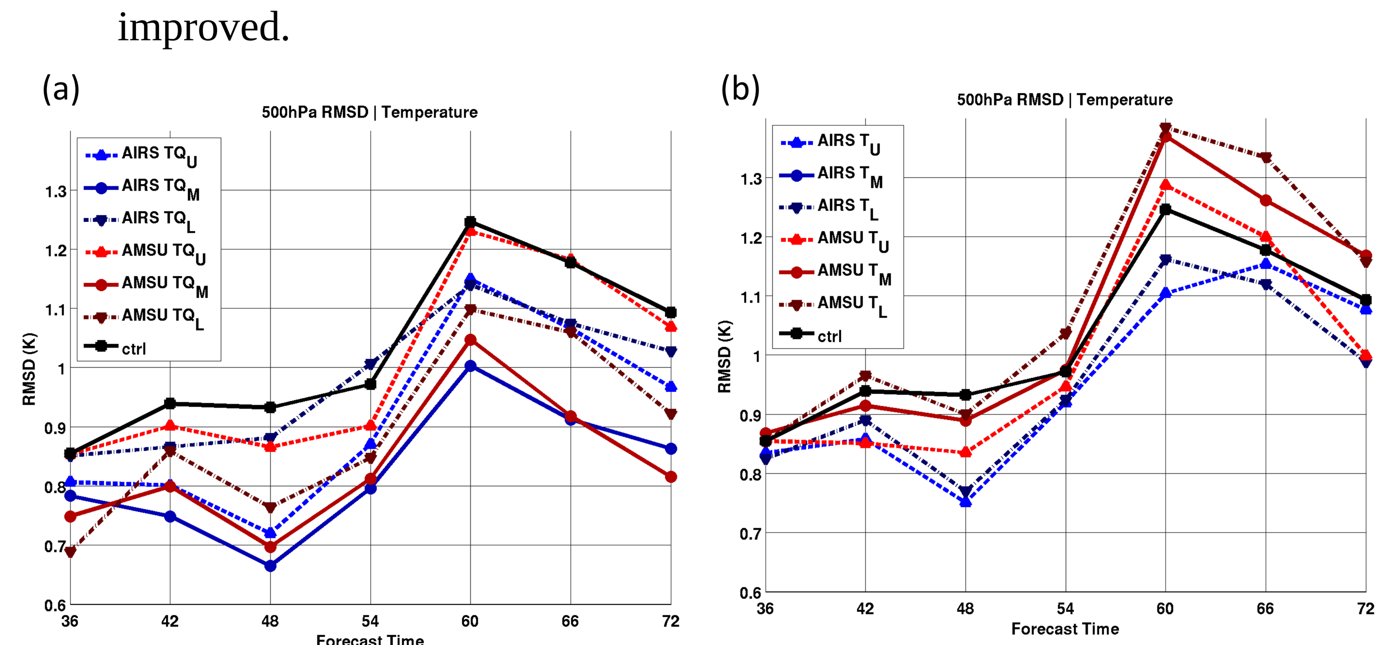

Figure 5. Compare different instrument and assimilate level of the RMSD to temperature. (a) for T and Q and (b) for T. Red line for AMSU, blue for AIRS and black is control run. Different brightness of color and marker mean different assimilate level. Horizontal axis mean the forecast hour, and the vertical axis is the RMSD.

- **Impact on the forecast capability : Relative humidity at 850 hPa**
  - Assimilating TQ, for 24hr forecast AIRS has more capability than AMSU, for 72hr AMSU has better forecasting capability.
  - AIRS has better forecast capability when assimilate T only than TQ.
  - When assimilate TQ AMSU has better forecast capability than T only

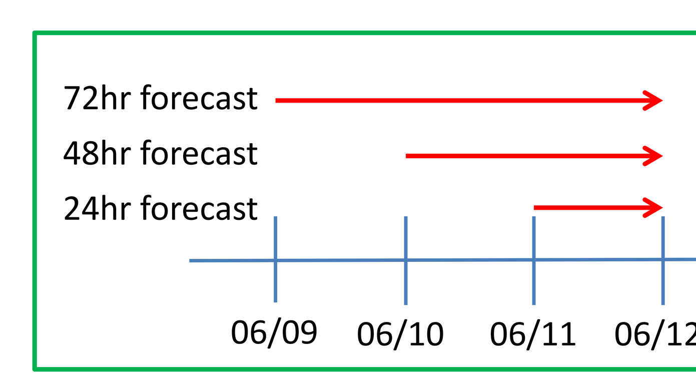

Figure 6. Time series for the impact on the forecast capability testing. Different forecast hour to 06/12.

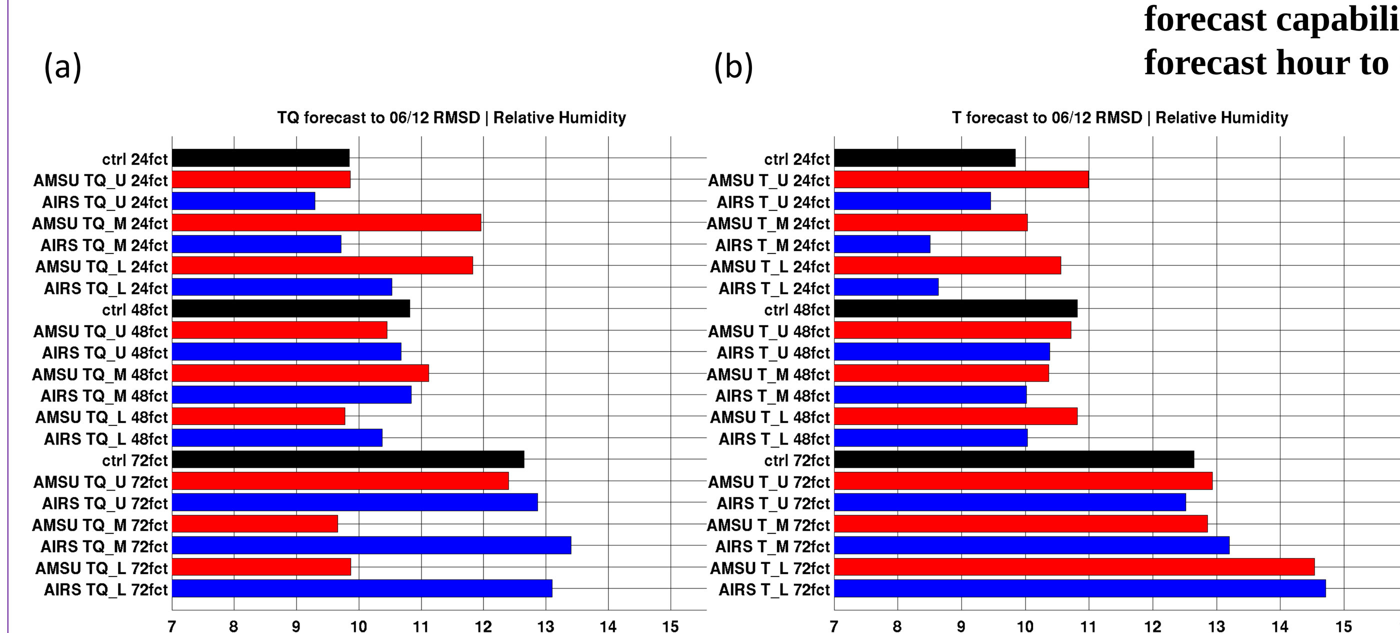

Figure 7. Compare different forecast capability to the 6/12. (a) assimilate T and Q (b) assimilate T only. Red for AMSU, blue for AIRS and black is control run.

5.Summary

- For relative humidity, AMSU usually have smaller RMSD, we estimate that AMSU is a MW instrument thus it's less sensitive to water vapor than the IR instrument of AIRS.
- AIRS assist temperature forecasting better than AMSU in all experiment setting.
- AIRS has better forecast capability in early forecast hour, and AMSU has better forecast capability in the latter forecast hour. Comparing the use of TQ ad T, we found the most different are in the 72hr forecast when assimilate AMSU data.

6.Reference

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