The impact of assimilation of microwave radiance in HWRF on the forecast over the western Pacific Ocean

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1. Objective

Typhoons are among the most severe natural hazards that cause damage to property and loss of life in Taiwan. Developing a more accurate forecast model for typhoons could potentially help to improve the preparedness and to decrease damage. In the HWRF system, the initial condition is generated with an advanced vortex initialization and data assimilation system (GSI), which assimilates both satellite radiances and conventional observations (Gall et. al. 2013).

In this work we investigate the impact of incorporating the microwave observations of the AMSU-A and MHS radiances in HWRF for the prediction of typhoons over the western Pacific Ocean.

2. AMSU-A and MHS

AMSU-A and MHS observations provide more information under severe weather conditions over cloudy fields of view than the observations with infrared instruments because microwaves can penetrate non-precipitating clouds.

Table1. AMSU-A and MHS information.

	AMSU-A	MHS
Resolution	48 km @ nadir	16 km @ nadir
Channel	Channel 3~8: 50.3, 52.8, 53.6, 54.4, 54.9, 55.5 (GHz)	Channel 1~5: 89, 157, 183.31 ± 1, 183.31 ± 3, 190.31 (GHz)

3. Experiments and Bias Correction

An initial field is created for the model in two steps:

1. The original typhoon-like vortex in the background field from the Global Forecast System (GFS) analysis/forecast is removed and replaced with a new vortex reconstructed from information provided by the National Hurricane Center (NHC).
2. A 3DVAR data assimilation system is used to assimilate the observational data. The data assimilation system used in this work is the community Gridpoint Statistical Interpolation (GSI).

HWRF	GSI
Initial time: span from 2013 July 6 0600 UTC to July 9 1200 UTC, sampled every 6-hours Resolution: vertical 42 levels, horizontal 27/9/3 km	3D-Var Assimilation interval: 6 h Time windows: ±1.5 hr

In GSI, the bias in satellite observation is expressed as a linear regression of N state-dependent predictors, $P_i(x)$, with their coefficients β_i, which serve to modify the model of radiative transfer:

$$H(x, \beta) = H(x) + \sum_{i=1}^{N} \beta_i \cdot P_i (x) \qquad (1)$$

in which H is the radiative transfer model and x is the atmospheric state from the output of the weather forecast model. in the left side would produces the modified radiances. Vector β is obtained on minimizing the following cost function:

$$J(\beta) = 1/2 \, [\, y - H(x,\beta)]^T [\, y - H(x,\beta)] \qquad (2)$$

in which y is a satellite observation (Dee 2004).

In the following experiments, we tested the effects of using two sets of bias correction coefficients:
1. generated from the NCEP global modeling system
2. generated by the HWRF itself.
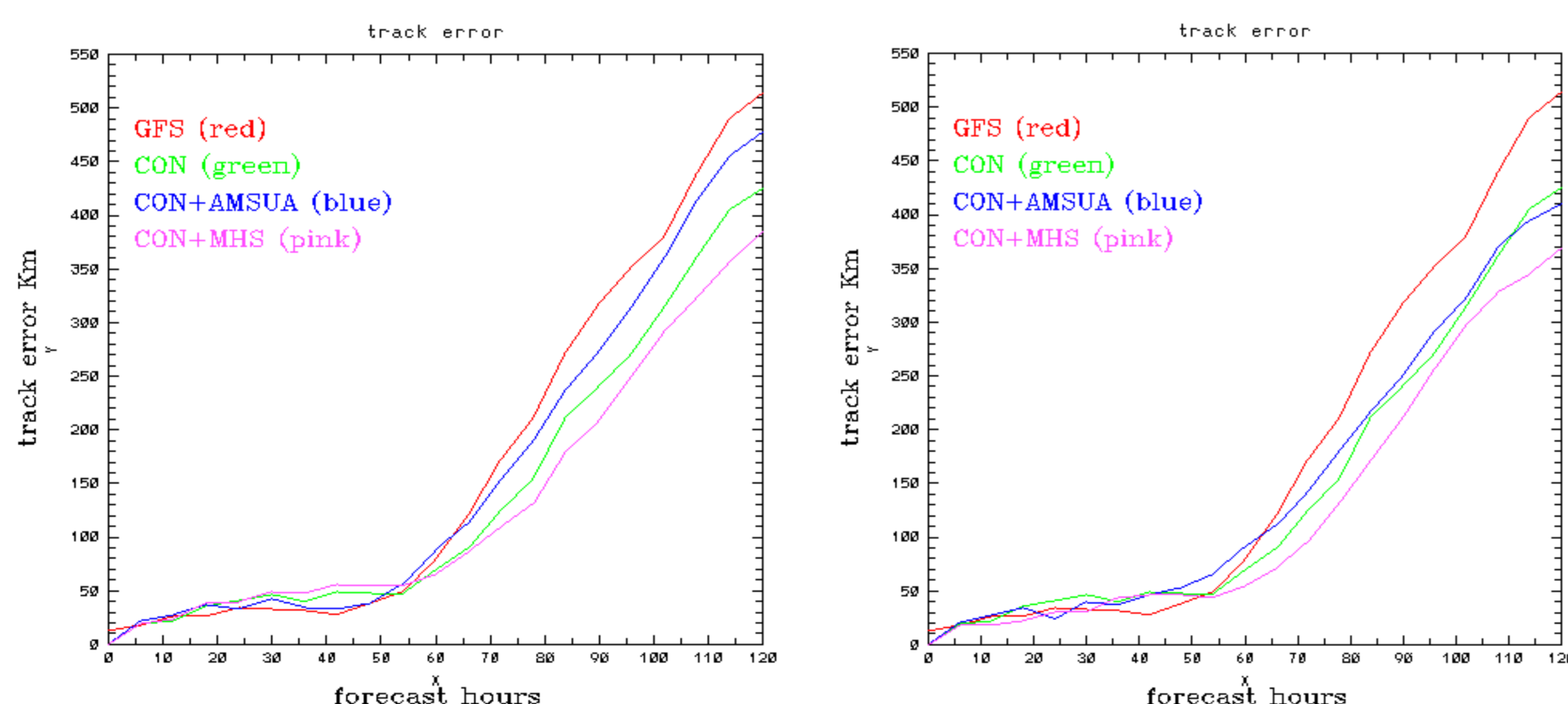
4. Result

Figure 1. Mean absolute errors in the forecast of the track for Typhoon Soulik. (a) Bias correction coefficients produced with the global model are used. (b) Bias correction coefficients generated with the mesoscale model itself are used.

- MHS observations leads to slightly decreased forecast errors for the track.
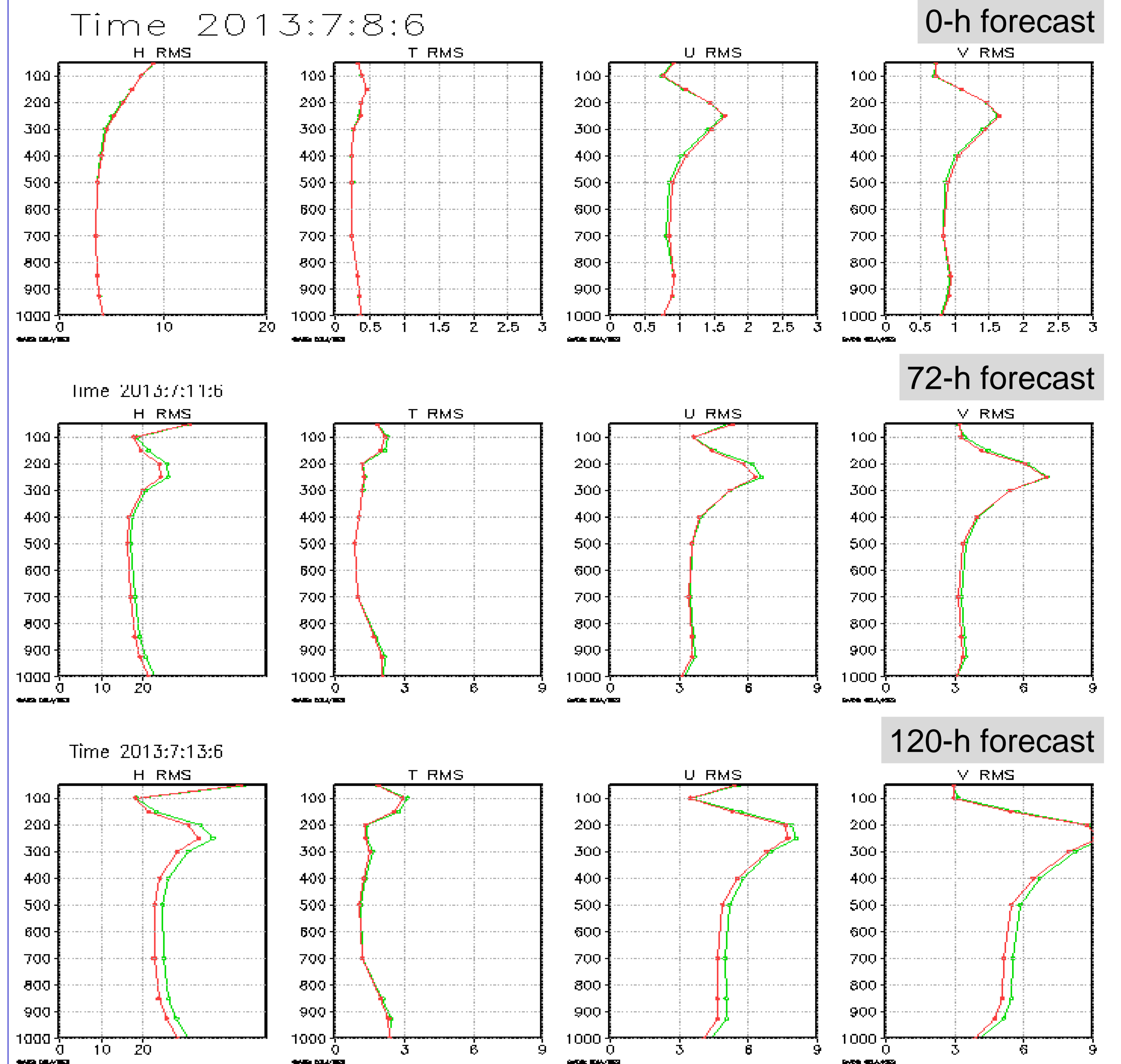- The bias correction coefficients from the HWRF system have more benefit.

Figure 2. Root-mean-square error over the domain bounded by 0 N-50 N and 100 E-150 E. Left to right are the errors in geopotential height, temperature, and u and v components of velocity. Green indicates the control run, and red the run with assimilated MHS data.

- MHS improve forecast at 72 h evidently, especially in the geopotential height.
- At 96 and 120 h, this decreased error becomes even more significant in the geopotential height and it also becomes evident in the velocity fields.
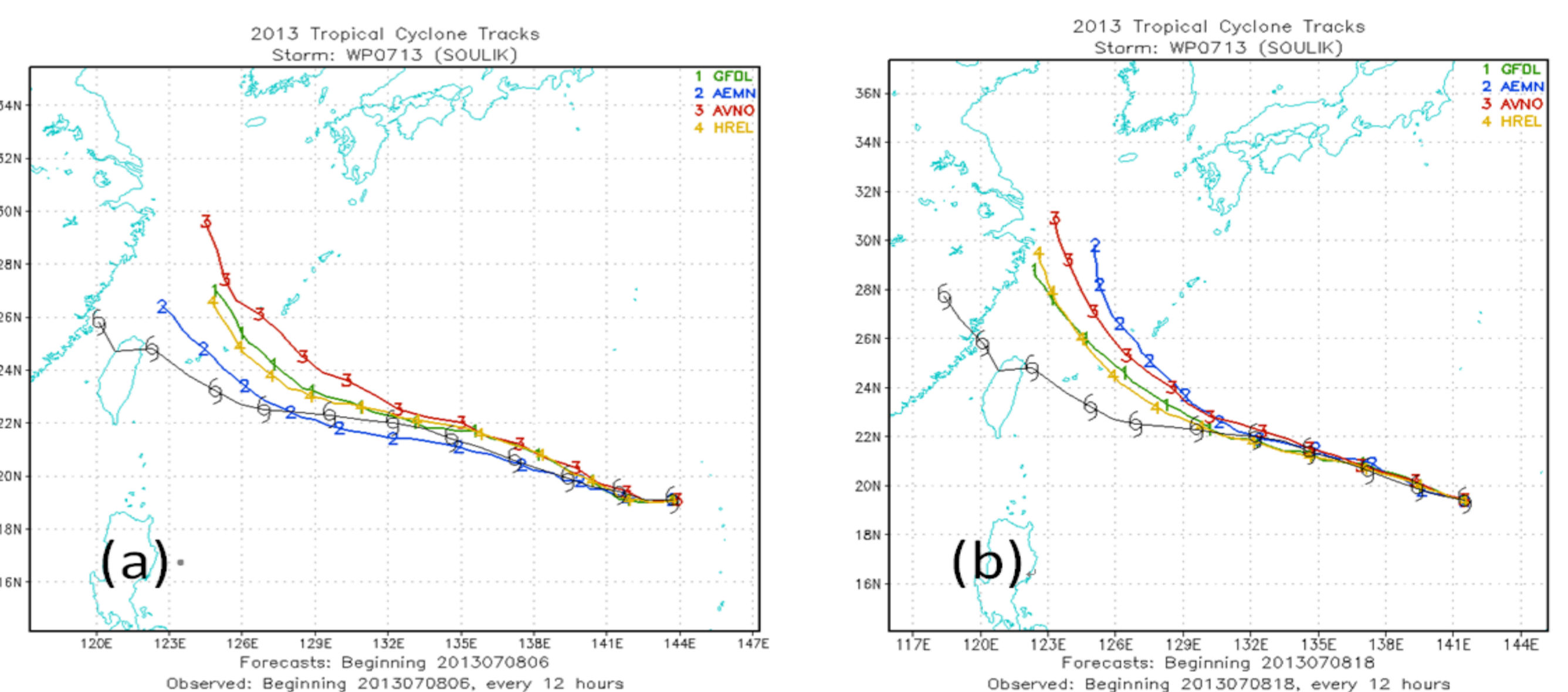

Figure 3. Comparison of typhoon tracks. The black line with typhoon markers indicates the best track (observation); green marks the control run; blue and yellow indicate the runs with the AMSU-A and MHS data, respectively. The red line is the GFS forecast. (a) The case with initial time at 2013 July 8 0600 UTC. (b) The case with initial time at 2013 July 8 1800 UTC.

- The reason that the AMSU-A data have a negative impact on the forecast in selected cases is still under investigation.
- Because HWRF requires TCvital data to initiate the simulation, the usable period to create the bias correction coefficients decreased.
- A possible explanation of the mixed effects of the AMSU-A data is that the generation of the bias correction coefficients for AMSU-A might require more time to spin up than the case for MHS.

7. Summary and Future Work
- MHS data had an overall positive effect in improving the forecast of the track and the meteorological fields associated with a typhoon.
- The bias correction coefficients generated from HWRF itself are superior to those generated from the global model in assisting to improve the outcome of assimilating the radiance data.
- Our AMSU-A experiments is still strongly influenced by statistical noise. More simulations might be needed in future work to clarify the impact of the AMSU-A data on the high-resolution HWRF forecast of typhoons.

References

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