Impact of Assimilating Atmospheric Motion Vectors from Himawari-8 and Clear-Sky Radiance from FY-4A GIIRS on Binary Typhoons

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Introduction

From late August to early September 2020, three typhoons have continuously affected the region of northeastern China since 1949, which brought more than 100 mm of precipitation to this area. It was rare for such three consecutive typhoons to make direct landfall in this region. In this study, the second and third of the three consecutive typhoons are selected, which are Maysak and Haishen, respectively. The reason why a choice of these two typhoons is their generation time relatively close to each other with a more obvious feature of binary typhoons and stronger intensity with much extensive landfall precipitation than the first one Bavi.

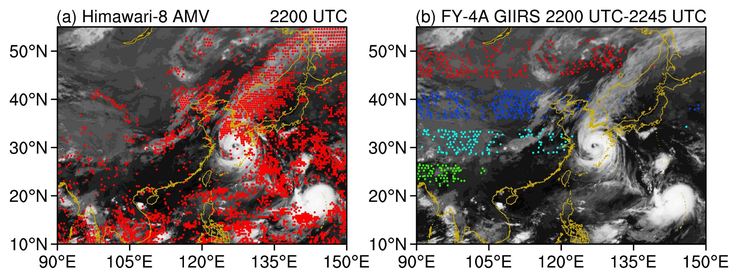

Fig. 2. The distribution of (a) hourly atmospheric motion vectors (AMVs) from Himawari-8 and (b) 15-minute interval radiance data from channel 06 of FY-4A GIIRS.

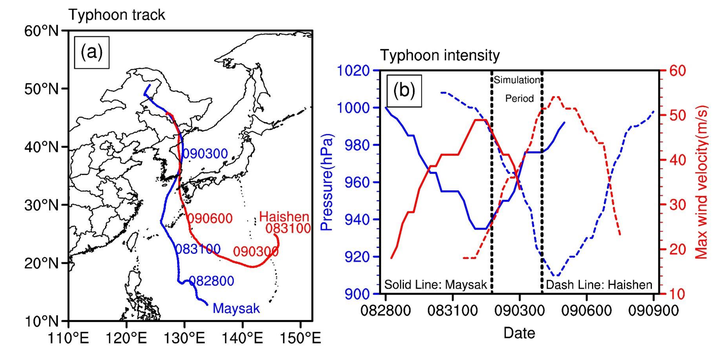

Fig. 1. (a) Moving tracks, (b) MSLPs and max wind velocities of binary typhoons from the NOAA best-track dataset.

The Geostationary Interferometric Infrared Sounder (GIIRS), as the first infrared hyperspectral instrument carried on the geostationary weather satellite FY-4A, can capture detailed atmospheric information with a high spectral resolution for this fixed observation area. The impact of high-frequency (15-min) assimilating atmospheric motion vectors (AMVs) from Himawari-8 and clear-sky radiance from FY-4A GIIRS on this rare case has been investigated based on the Weather Research and Forecasting Model (WRF) and three-dimensional variational (3D-Var) data assimilation system, which may provide guidance for monitoring and forecasting typhoons of assimilation from different satellite information in mid-to-high latitude regions in East Asia.

Experimental Design

In this work, 48 longwave channels covering the upper, middle, and lower troposphere of GIIRS are selected. The updated noise equivalent delta temperatures (NEDT) for GIIRS in August 2020 are recalculated in this work in Fig. 3, and some channels are removed. Relatively, the FOV approaching the north/south edge of each array (such as pixel numbers of 1, 32, 64, 96, and 128) has larger NEDTs than centers, and such FOVs have also been discarded in this work.

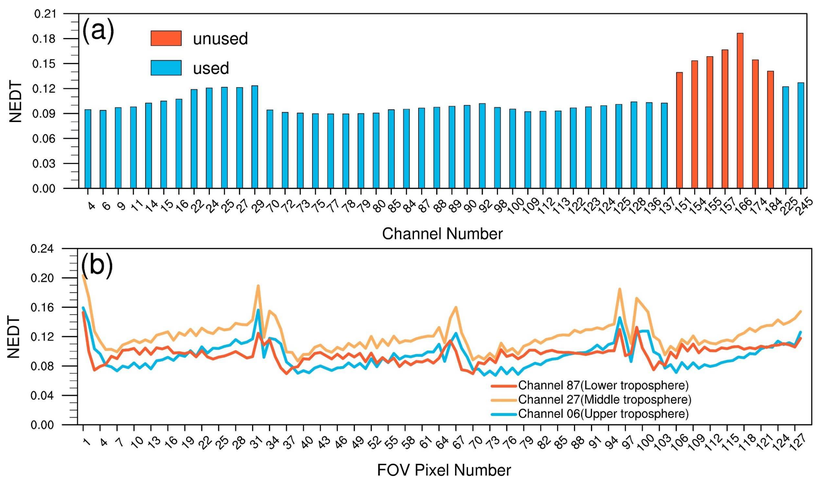

Fig. 3. The monthly averaged NEDT (units: K, background brightness temperature is set to 300 K) of different (a) channels and (b) FOV pixels from GIIRS in August 2020.

All the experiments are cyclically assimilated for 15 min from 2100 UTC on 1 September to 0300 UTC on 2 September, followed by 45-hour forecasts.

Table 1 Experimental Design

Experiment name	Assimilation Data		
	GTS	Himawari-8 AMV	FY-4A GIIRS
Exp. CTL	Yes	No	No
Exp. HM8	Yes	Yes	No
Exp. H8F4	Yes	Yes	Yes

Results

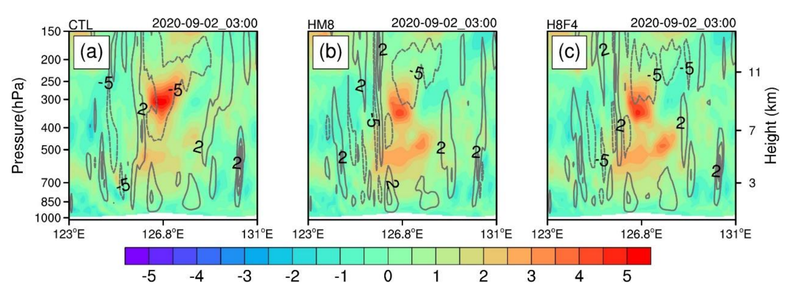

Fig. 4. Vertical distribution of anomalous temperature (shaded, units: K) and vertical wind (contours, unit: 10 m·s-1) in (a) Exp. CTL, (b) Exp. HM8 and (c) Exp. H8F4 at 0300 UTC on 2 September 2020 along 31.5° N latitude.

With the added enhancement of the warm anomaly near 500 hPa in Exp. HM8 and Exp. H8F4, it corresponds more with the vertical distribution of thermal anomalies in the decay period of Maysak. Dominated by the downward motion anomalies near the warm core structure at middle and upper levels and upward anomalies on both sides of Maysak throughout almost all which indicates that the overestimation of typhoon intensity occurs in Exp. CTL. Two satellite assimilation experiments show much benefit at a longer forecast time for Maysak and Haishen (Fig. 5).

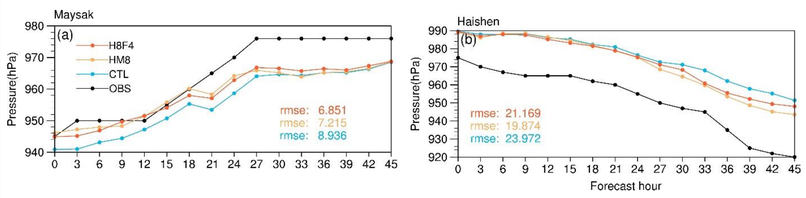

Fig.5. The 45-hour MSLP forecast of (a) Maysak and (b) Haishen from 0300 UTC on 2 September 2020.

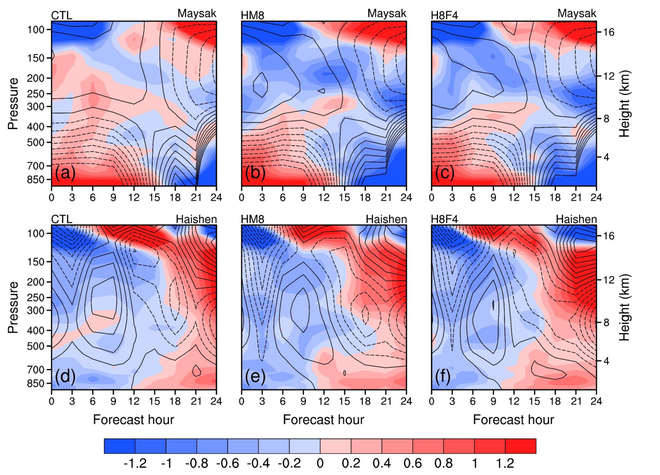

Fig.6. Vertical transects of anomalous temperature (shaded, units: K) and geopotential height (contours, units: gpm) averaged over 200 km from the center of Maysak (top panel, in (a) Exp. CTL, (b) Exp. HM8, and (c) Exp. H8F4) and Haishen (bottom panel, in (d) Exp. CTL, (e) Exp. HM8 and (f) Exp. H8F4.

A detailed vertical distribution of temperature and geopotential height anomalies can be captured (Fig. 6). As for the landfall precipitation brought by Maysak, it shows more accurate simulated results in Exp. H8F4 (Fig. 7).

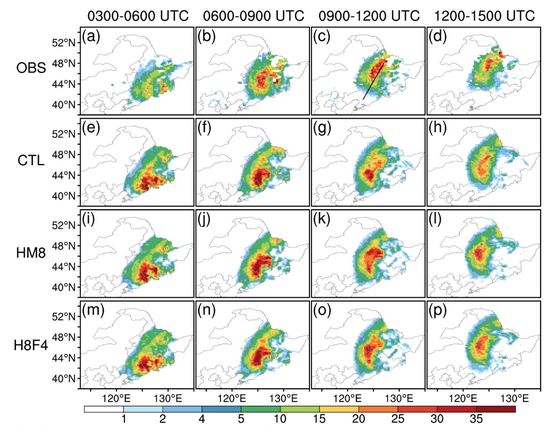

Fig.7. Spatial distribution of 3-hour accumulated precipitation (shaded, units: mm).

Summary and Future Work

The study indicates that the dynamic adjustment is obvious from assimilated hourly AMVs information, but it still needs to be combined with the 15-min FY-4A thermal field adjustment, which is essential for better forecast simulations of minimum sea level pressure (MSLP) and landfall precipitation with detailed typhoon structure. Meanwhile, the performance of three hourly landfall precipitation by Maysak is evaluated with better spatial distribution and higher equitable threat scores (ETS) for the large threshold (20 mm), resulting from wet bias reduction by much drier water vapor conditions in the analysis and more precise forecasts of relative humidity, water vapor transportation, and its divergence. Developing GIIRS IR sounder radiance assimilation into all skies is currently being tested with plans to extend to future work.

Acknowledgments

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