Assimilation Experiments of MTSAT Rapid Scan Atmospheric Motion Vectors

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1. Introduction

The MTSAT-1R(Multi-functional Transport Satellite), a geostationary satellite of the Japan Civil Aviation Bureau (CAB) and the Japan Meteorological Agency (JMA), began rapid scan operations in 2011. It has been providing images of Japan and its neighboring area (latitude/longitude range from 20˚N/120°E to 50˚N/150°E) as frequently as five minutes during daytime in summer for the purpose of monitoring severe convective weather or volcanic ash plumes that could possibly affect the air traffic. The Meteorological Satellite Center (MSC) of JMA has produced Rapid Scan Atmospheric Motion Vectors (RS-AMVs), which are wind vectors derived from three consecutive rapid scan images tracking spatial distribution features of clouds and water vapor. RS-AMVs are expected to capture atmospheric motions in smaller space and time scale than hourly AMVs that are obtained from images at longer intervals currently in operationally use. The study intends to show the advantages of assimilating RS-AMVs in better forecasting mesoscale phenomena such as local heavy rainfall.

2. Outline of Experiments

Assimilation experiments utilizing RS-AMVs were performed over a heavy rainfall case that occurred in the western part of Japan on August 13th in 2012. The four-dimensional variational data assimilation system (JNoVA) with a resolution of 5 km in horizontal and 40 levels in vertical, based on JMA non-hydrostatic model (JMA-NHM), was used in the experiments. In the test experiment (TEST), RS-AMVs were assimilated at every ten minutes in a 3-hour timeslot window for nine hours during daytime (from 0000 to 0900 UTC), while other observations such as surface, upper-air, aircraft, satellite, wind profiler, radar, and GPS data were assimilated hourly. Then using the analysis at 09 UTC as initial values and JMA Global Spectral Model forecasts as boundary conditions, a 15-hour forecast was performed from 0900 UTC initial time with a resolution of 2 km (350 x 350 grid points) and 60 levels. On the other hand, RS-AMVs were not assimilated in the control experiment (CNTL), but a 15-hour forecast was conducted in the same manner.

3. Results

The convective cloud band corresponding to the synoptic front that stretched over the Japan Sea and its coast area was slowly moving to the south at 0000 UTC on August 13th. Five-minute interval rapid scan images clearly showed that the inflow bands of low cumulus clouds over the East China Sea off the west coast of Kyushu moved up toward the front from the south-west (Fig. 1). Associated with these cloud motions, south-westerly winds were obtained as lower AMVs in the area where the cumulus clouds were tracked, while many upper AMVs representing jet streaks were calculated in the vicinity of the front. Figure 2 gives the distribution of the upper and lower RS-AMVs that were assimilated during 0000 – 0900 UTC off the west of Kyushu, which indicates a divergence at upper levels (the red circle in the Fig. 2) and inflow at low levels. The analysis values at 0900 UTC of TEST increased from those of CNTL in surface wind speed and convergence (Fig. 3 (a)) as well as in water vapor near surface level (Fig. 3 (b)) in the area mentioned above. These changes may result in the intensification of the front system over the Japan Sea and increase in amount of rainfall forecast at 1200 UTC off the coast of Chugoku and Kyushu (Fig. 3 (c)).

4. Conclusion

Although the results are so far preliminary, RS-AMVS may have some positive impact on forecasts of the timing and the intensity of a heavy rainfall because of their high resolution and possibility to track clouds more accurately especially at low levels. In order to utilize RS-AMVs more effectively in Numerical Weather Prediction, there should be improvement in assimilation techniques for data quality control, data thinning or estimation of observational errors as well as development of AMV retrieval algorithms that is more suitably designed for high-resolution rapid scan observations.

Acknowledgement

This research was supported by JST, CREST.

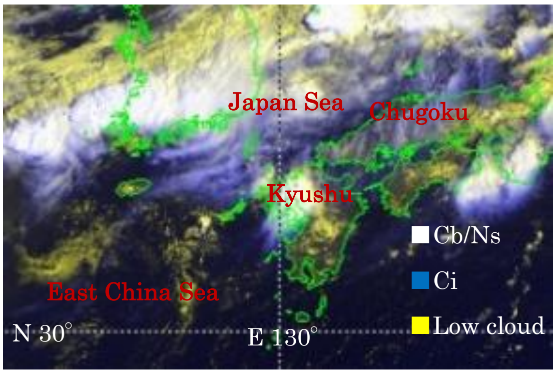


Figure 1. IR/VIS combined imagery by MTSAT at 0005 UTC on August 13th in 2012.

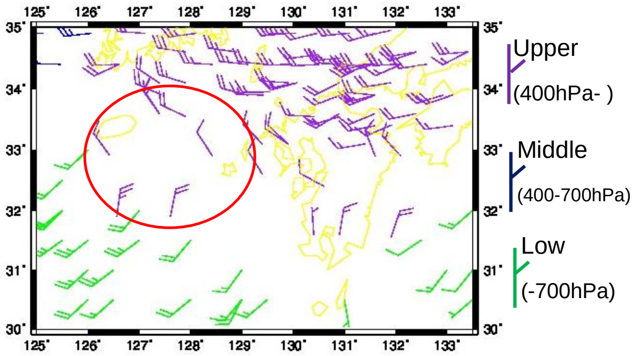
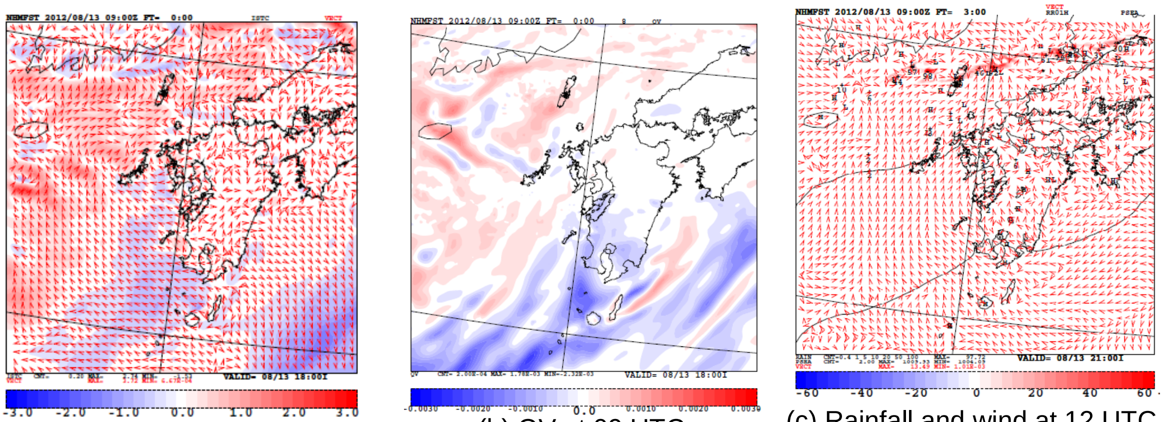


Figure 2. RS-AMVs assimilated in TEST (00-09 UTC). The red circle indicates a diversion spot in the upper-air.



(a) Wind at 09 UTC

(b) QV at 09 UTC

(c) Rainfall and wind at 12 UTC

Figure 3. Differences of analysis and forecast between TEST and CNTL (TEST minus CNTL) near surface level. (a) Analysis of wind speed [m/s] (color shading) and wind vector (arrows) at 09 UTC, (b) analysis of water vapor mixing ratio [kg/kg] (color shading) at 09 UTC, (c) forecast of rainfall [mm/h] (color shading) and wind vectors (arrows) at 12 UTC (FT=03).