

Improving rainfall forecast by assimilating all-weather atmospheric product from Himawari-8 multispectral infrared imaging

*Takaya Yamashita¹, Hironobu Iwabuchi¹, Junshi Ito¹, Shin Fukui²

1. Graduate School of Science, Tohoku University, 2. Meteorological Research Institute

Geostationary satellites can capture disturbances with a wide range of spatiotemporal scales. Assimilating rich information efficiently from such satellite observations may improve weather forecast. Many studies have made efforts to assimilate all-sky infrared radiances to utilize the rich information in clouds in recent years. Still, assimilating data affected by thin upper cloud is difficult because of issues in the reproducibility of hydrometeors in forecast models and the representativeness of radiative transfer models used as observation operators. Recently, a statistical method is proposed to estimate temperature, humidity, and their uncertainties in all-weather conditions from infrared multispectral imaging in Himawari-8 using machine learning. This method can estimate three-dimensional distributions of temperature and humidity stably and accurately even in cloudy areas by using spatial distribution features of clouds and water vapor in infrared images and spectral characteristics. This atmospheric product enables us to assimilate observations of many infrared bands even below cloud top. In this study, we conducted an observing system experiment for a heavy rainfall case in western Japan in July 2018 to investigate the feasibility of assimilating the product.

To clarify whether assimilation below cloud top is effective in heavy rainfall forecast, we conducted three experiments: one assimilating no observation, another assimilating the product only above cloud top, and the other assimilating the product over the entire domain including below cloud top. Below the cloud top is defined as the area where the air temperature from the product is higher than the brightness temperature in band 13 of Himawari-8. We used the Japan Meteorological Agency's (JMA) nonhydrostatic model and performed numerical simulation that covers Japan and its surrounding area with a 5 km resolution giving JRA-55 as the lateral boundary conditions. The atmospheric product was assimilated at 100 km spacing every hour using the local ensemble transform Kalman filter. Numerical experiment was performed from July 1 to 8. We evaluate the accuracy of rainfall forecast with equitable threat score (ETS) for 3-hour precipitation using the radar-raingauge analyzed precipitation from the JMA as a reference.

ETS in the experiment assimilating entirely including below cloud top is the highest of the three experiments. When a threshold value of ETS is 10 mm per 3 hours, ETS is about 0.1 higher than without assimilating the product, and about 0.05 higher than in assimilating the product only above cloud top. The position of Baiu front was corrected by assimilating above cloud top through thermal wind balance, suggesting that assimilating the proposed product exerts a positive influence on the forecast of horizontal wind. By assimilating the product entirely including below cloud top, the spatial distribution of infrared brightness temperature becomes closer to the observation compared to assimilating above cloud top only. The assimilation of the proposed products including below cloud top has significant advantages in rainfall forecast.

Keywords: geostationary satellite, satellite retrieval, satellite data assimilation, observing system experiment