Brightness Temperature Estimation from Ground-Based Microwave Radiometer Observation by Machine Learning

Poster Number : 122

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1. Background

Recently, localized observations of water vapor have become a prevalent topic, so we have developed a ground-based microwave radiometer(MWR), named KASMI (as presented by Minowa et al., in 2025)*, which passively observes atmospheric radiation across 44 channels ranging from 18 to 26 GHz. This device estimates precipitable water vapor and vertical profiles of water vapor density using machine learning techniques.

In general, radiometers require semi-annual calibration with liquid nitrogen to ensure accurate brightness temperature observations. However, we have developed a machine learning method that estimates brightness temperature that eliminates the need to calibrate MWRs using liquid nitrogen.

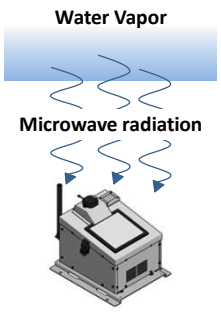


Fig. 1 Image of a ground-based microwave radiometer

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2. Method and Data

The vaguely visible radiometer is almost life-sized.
The actual item is on display at the exhibition hall (Booth: 443).

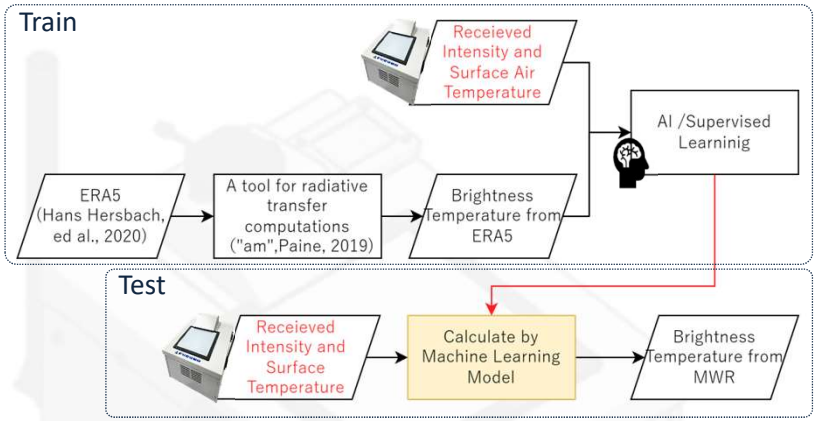


Fig. 2 Signal Processing Flowchart of MWR.

We developed a supervised machine learning model using **Principal Component Analysis (PCA)** and **multiple regression analysis**.

Since rain causes errors in MWR observations, quality control was performed by removing data for 8 hours before and after the time rain was observed by the rain sensor attached to KASMI in both training and evaluation.

Table 1 The conditions for the observation data.

Items for observation	Conditions
Date	Train: 28 May 2024 ~ 30 April 2024, Test: 1 May 2024 ~ 31 May 2024
Place	Meteorological Research Institute (36.05° N 140.13° E)
Reference	RPG-HATPRO-G5(RPG) (5ch pairs with differences below 0.1 GHz) and brightness temperature derived by ERA5 (44ch)

3. Results

Scatter plots of brightness temperatures estimated from KASMI compared with those of ERA5 and HATPRO are shown in Figs. 3a,b, suggesting a strong positive relationship between the data of KASMI and that of both ERA5 and HATPRO.

Brightness temperature obtained by KASMI shows some outliers compared to that by ERA5 and HATPRO. It has been noted that the presence of cloud water affects the accuracy of MWR observations. In order to confirm the accuracy when the effect of cloud water is excluded, we also validated the data from the infrared radiometer attached to HATPRO with cloud base temperature of less than 0°C (Fig. 3c, d). This result indicates that the machine-learned brightness temperature in this study has high estimation accuracy in the absence of cloud water.

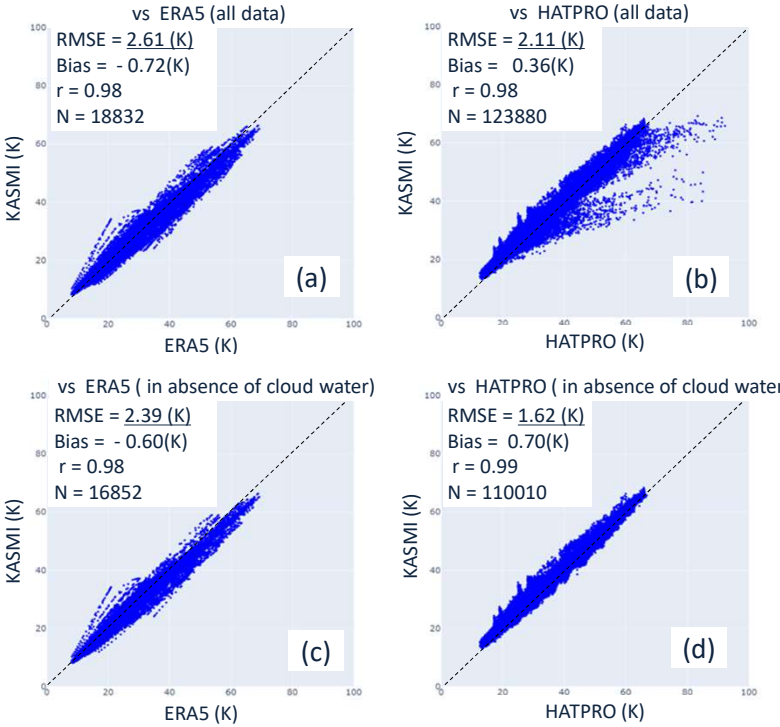


Fig. 3 Comparison of KASMI-derived brightness temperature with those of ERA5 and HATPRO.

4. Case study

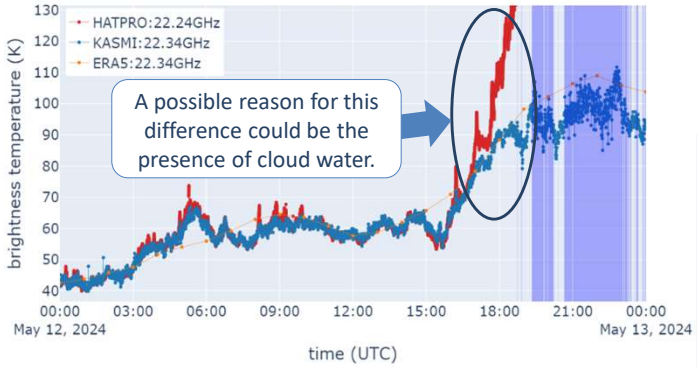


Fig. 4 Time series of brightness temperature on 12 May 2024. Blue shade indicates the rainy condition observed by a rain sensor attached with KASMI.

Through the case study, we validated the machine learning method using KASMI by investigating the outliers in Fig. 3 (b). The brightness temperature from KASMI tended to show similar temporal patterns to that from ERA5 and HATPRO, as shown in Fig. 4.

5. Conclusion

KASMI's brightness temperature could be estimated with accuracy comparable to ERA5 and HATPRO in absence of cloud water. Applying this method potentially allows for accurate brightness temperature estimation remotely or even on ships, by updating the machine learning models without the need for calibration with liquid nitrogen.

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