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Postprint: Adaptability Study of Ground-Based Microwave Radiometer Retrieval Products in Eastern Qinghai Province

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Abstract

Using radiosonde observation data at 08:00 and 20:00 BT and collocated MP-3000A microwave radiometer retrieval data at Xining station in eastern Qinghai Province in 2013, the vertical distribution characteristics of atmospheric temperature and relative humidity in this region were analyzed, the retrieval performance of the microwave radiometer was discussed, and bias correction was performed for months with large temperature deviations. The results show that:

From the perspective of altitude, the microwave radiometer retrievals of temperature and humidity in the lower layer are significantly better than those in the upper layer. The annual mean temperature correlation coefficient between microwave radiometer retrievals and radiosonde observations shows a basically decreasing trend with increasing altitude, with the maximum at the surface (0.988) and the minimum at 10 km above ground (0.529), which passed the significance test at the 0.01 level. However, the annual mean relative humidity correlation coefficient only passed the significance test at the 0.01 level below 3.0 km. From a seasonal perspective, the microwave radiometer retrievals of temperature and humidity agree significantly better with radiosonde data in spring, summer, and autumn than in winter. The temperature correlation coefficients in spring, summer, and autumn all passed the significance test at the 0.01 level. The relative humidity correlation coefficients in spring, summer, and autumn passed the significance test at the 0.01 level from the surface to 2.0 km, while in winter they passed the test below 0.5 km. The correction equation was applied to perform bias correction for months with large temperature deviations, and the results were satisfactory.

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Full Text

Preamble

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2 Data and Methods

The vertical distribution characteristics of temperature and relative humidity in the Xining region were analyzed using radiosonde data (at 08:00 and 20:00 BT) and corresponding MP-3000A microwave radiometer observations from 2013. The inversion effect of the microwave radiometer was evaluated, and temperature corrections were applied for months with large deviations.

2.1 Data Source

The study utilized MP-3000A microwave radiometer data collected at Xining Station in eastern Qinghai Province during 2013. Radiosonde observations served as reference data for comparison. The microwave radiometer performed continuous atmospheric profiling with observations recorded at 08:00 and 20:00 daily. The effective detection range extended from the surface to 10 km altitude, with vertical resolutions of 50 m below 500 m, 100 m between 500 m and 2 km, and 250 m between 2 km and 10 km. A total of 58 observation levels were processed, with data integrated over 24-hour periods.

2.2 Instruments and Methods

The MP-3000A microwave radiometer is a ground-based, multi-channel passive remote sensing instrument operating at frequencies of 22-30 GHz and 51-59 GHz, enabling retrieval of atmospheric temperature and humidity profiles. The instrument' s retrieval algorithm employs a neural network method trained with historical radiosonde data. For this study, microwave radiometer observations at 08:00 and 20:00 were matched with concurrent radiosonde profiles. The comparison analysis focused on the 0-10 km altitude range, with particular attention to the lower troposphere (2-5 km) where the instrument demonstrates optimal performance.

2.3 Statistical Analysis

2.3.1 Correlation and Error Metrics Statistical parameters including correlation coefficient, mean bias, and root-mean-square error (RMSE) were calculated to quantify agreement between microwave radiometer and radiosonde measurements. Significance testing was performed at the 0.01 confidence level. The analysis examined both annual mean conditions and seasonal variations across spring, summer, autumn, and winter.

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3 Results and Analysis

3.1 Temperature Profile Comparison

The correlation coefficient for annual mean temperature showed a decreasing trend with altitude, ranging from 0.988 at the surface to 0.529 at 10 km. Temperature retrieval accuracy was superior in the lower atmosphere, with correlation coefficients exceeding 0.90 below 2 km. Seasonal analysis revealed significantly better agreement during spring, summer, and autumn compared to winter, when correlation coefficients remained above 0.85 up to 1.5 km but decreased more rapidly at higher altitudes.

[Figure 6: see original paper] *Correlation coefficient, mean variation and root-mean-square error of relative humidity between radiosonde and microwave radiometer at Xining Station at 08:00 and 20:00 in 2013*

The fitted temperature curves demonstrated that microwave radiometer data required bias correction, particularly for months showing large systematic deviations. The correction equation effectively reduced these biases, improving retrieval accuracy.

[Figure 7: see original paper] *Fitted curve of temperature between radiosonde and microwave radiometer at 08:00 and 20:00, 2013*

3.2 Relative Humidity Profile Comparison

For relative humidity, correlation coefficients below 3 km passed significance tests at the 0.01 level for annual mean conditions. In spring, summer, and autumn, significant correlations ($p < 0.01$) extended from the surface to 2 km, while in winter, significant correlations were limited to below 1.5 km. The RMSE analysis indicated that humidity retrieval accuracy was height-dependent, with larger errors occurring above 5 km.

Specific height intervals showed distinct patterns: - **0-1.3 km**: Strong correlation ($r > 0.80$) with low RMSE - **1.3-5.5 km**: Moderate correlation ($0.60 < r < 0.80$) with increasing RMSE - **5.5-8.0 km**: Weak correlation ($r < 0.60$) and high RMSE - **Above 8.0 km**: Poor agreement due to instrument limitations

The 20:00 observations generally showed better correlation than 08:00 observations, particularly for humidity profiles in the 1.8-3.5 km layer where correlation coefficients exceeded 0.85 ($p < 0.01$).

3.3 Correction Methodology

A piecewise linear correction was applied to temperature profiles based on the fitted curves. The correction equations varied by altitude range and season, accounting for systematic biases identified in the comparison analysis. For months with large temperature deviations (typically winter months), the correction improved agreement with radiosonde data by 15-20% in the lower troposphere.

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Abstract: The vertical distribution characteristics of temperature and relative humidity (RH) in Xining region were analyzed using the data of radiosonde (at 08:00 and 20:00, BT) and the corresponding MP-3000A microwave radiometer over Xining in eastern Qinghai Province in 2013. The inversion effect of the microwave radiometer was discussed, and the correction of temperature in the months with high deviation was made. The results are as follows: The inversion of low-layer temperature and RH from the microwave radiometer was obviously superior to that of high layer. The correlation coefficient of annual mean temperature was in a decrease trend with the increase of height. The maximum value (0.988) occurred at the surface layer, and the minimum one (0.529) at 10 km height from the ground. The correlation coefficient of annual mean RH below 3 km height passed a significance test at 0.01 level; In spring, summer and autumn, the matching of temperature and RH between microwave radiometer and radiosonde was significantly better than that in winter. The correlation coefficients of temperature passed a significant test at 0.01 level in the three seasons. The correlation coefficients of RH in the three seasons were passed the significance test from the ground surface to 2 km height, but the correlation coefficient of RH in winter was passed below 1.5 km; The correction equation was used to correct the bias in the months with large temperature deviation, and the effect was good.

Keywords: microwave radiometer; radiosonde; temperature; relative humidity; correction; Qinghai Province

Note: Figure translations are in progress. See original paper for figures.

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