Spatiotemporal Distribution Characteristics of Precipitable Water in the Three Major Mountainous Regions of Xinjiang: Postprint

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Abstract

Using the level-2 retrieval data from the AIRS Standard Physical Retrieval Edition 6.0 dataset released by the National Aeronautics and Space Administration (NASA) from January 2003 to December 2015, this study investigates the spatiotemporal distribution characteristics of precipitable water over Xinjiang and its surrounding areas, particularly the three major mountain ranges, for the recent 13-year period. The results show that, in terms of spatial distribution, high-value areas of precipitable water are mainly concentrated in basin regions, especially the Tarim Basin and Junggar Basin, while the minimum value reaches 1.92 mm in mountainous areas; based on the 13-year average of all grid points for precipitable water in Xinjiang and its surrounding areas, the values are highest in summer and lowest in winter overall. In terms of temporal distribution, regional averaging was performed for the four study regions of Xinjiang and its surrounding areas, the Tianshan Mountains, the Kunlun Mountains, and the Altai Mountains, revealing that the annual variation in each region exhibits a single-peak pattern, with precipitable water gradually increasing from January to July and decreasing month by month from August to December; the overall interannual variation trend of precipitable water is consistent, showing an increasing trend from 2003 to 2010 and a decreasing trend from 2010 to 2015.

Full Text

Preamble

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ARID LAND GEOGRAPHY

1. Introduction

Xinjiang is located in an arid region of northwest China, characterized by dry climate, strong evaporation, and overall shortage of water resources. Therefore, water resources play a decisive role in sustainable development in Xinjiang. Total precipitable water vapor (TPWV) is the material basis for cloud and precipitation formation and an important component of water resources. Although previous studies on the spatial and temporal distribution of TPWV have yielded many results, research using AIRS data for water resource utilization and precipitation prediction in Xinjiang remains insufficient. In this study, the temporal and spatial characteristics of TPWV in Xinjiang were analyzed using the AIRS Standard Physical Retrieval Edition 6.0, level 2 inversion data from January 2003 to December 2015 released by NASA.

1.1 Study Area

The study area (Figure 1) includes Xinjiang and its surrounding regions, located between 34–50°N and 73–97°E. The region encompasses three major mountain systems: the Tianshan Mountains (42–50°N, 84–92°E), the Kunlun Mountains (35–39°N, 75–92°E), and the Altay Mountains (45–50°N, 84–92°E). The area also includes several basins: the Junggar Basin, the Turpan Basin, and the Tarim Basin. The Tianshan Mountains divide Xinjiang into northern and southern parts, with the Junggar Basin in the north and the Tarim Basin in the south. The region has a typical temperate continental arid climate with scarce precipitation and large temperature variations. The terrain is complex, with significant elevation differences. The multi-year average TPWV in Xinjiang is 8.19 mm, with an average annual precipitation of approximately 130 mm. The maximum TPWV reaches 14.74 mm in the Turpan Basin, while the minimum is 1.92 mm in the Kunlun Mountains.

The AIRS data used in this study has a spatial resolution of 1°×1° and covers the period from January 2003 to December 2015. The data quality is high, with retrieval errors within acceptable ranges. Previous studies have validated the accuracy of AIRS TPWV products over Xinjiang, confirming their reliability for regional water vapor analysis.

2.2 Data and Methods

The AIRS Standard Physical Retrieval Edition 6.0 level 2 data were obtained from NASA' s Goddard Earth Sciences Data and Information Services Center. The TPWV product was derived from infrared and microwave retrievals with a vertical resolution of approximately 1 km in the lower troposphere. The data were screened for cloud contamination using quality control flags, and only retrievals with "good" quality were retained for analysis.

The spatial distribution of TPWV was analyzed using geographic information systems to produce seasonal and annual climatologies. Temporal variations were

examined through monthly, seasonal, and interannual time series. Linear trend analysis was applied to quantify changes over the study period. The study area was divided into four sub-regions for detailed analysis: the entire Xinjiang region, the Tianshan Mountains, the Kunlun Mountains, and the Altay Mountains.

[Figure 3: see original paper]

Figure 3 Spatial distribution of multi-year average seasonal total precipitable water vapor in Xinjiang (2003–2015) /mm

The spatial distribution of TPWV shows clear patterns related to topography. High-value areas are concentrated in the basins, with the Turpan Basin showing the highest values. The distribution in the Junggar and Turpan Basins exhibits a decreasing trend from west to east across four distinct levels. In the Tarim Basin, TPWV decreases from west to east across three levels. Mountainous areas show a gradual decrease from piedmont zones to mountain peaks, though areas near basins maintain relatively higher TPWV values compared to interior mountain regions.

Seasonal variations are pronounced, with summer showing the highest TPWV values across all regions. The maximum summer TPWV occurs in the Turpan Basin (26.4 mm), while the maximum autumn value also appears there (14.11 mm). Winter minima are observed across all sub-regions, with the lowest values in the Kunlun Mountains (2.16 mm). Spring maxima appear in the Tarim and Junggar Basins (13.69 mm and 13.24 mm respectively). The differences in TPWV amounts among regions are smallest in winter, followed by spring and autumn, and largest in summer.

[Figure 5: see original paper]

Figure 5 Interannual variations of multi-year average of total precipitable water vapor in Three Mountain Areas of Xinjiang and total study areas (2003–2015) /mm

Interannual variations show consistent patterns across all sub-regions, with an upward trend from 2003 to 2010 followed by a downward trend from 2010 to 2015. Xinjiang and its surrounding areas, the Tianshan Mountains, and the Kunlun Mountains peaked in 2010 with values of 8.92 mm, 10.47 mm, and 7.07 mm respectively. The Altay Mountains peaked earlier in 2008 at 8.26 mm. Minimum values in 2015 were 7.37 mm, 8.81 mm, 5.13 mm, and 6.81 mm for the respective regions. The overall trend indicates a slight decline in atmospheric water vapor content during the latter half of the study period, consistent with observed precipitation patterns in the region.

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