

Establishment of the Xinjiang Snow Line Field and Its Spatial Distribution Characteristics (Postprint)

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Abstract

Taking Xinjiang as the study area, this research utilized 2015 daily snow cover product MOD10A1/MYD10A1 data, extracted the snow line of the study region through the snow cover duration ratio method, and established a regional snow line field for Xinjiang using Kriging interpolation, upon which the spatial distribution characteristics of the snow line in the study area were investigated. The analysis reveals that: the Xinjiang snow line field established by ordinary Kriging interpolation has a MAE (Mean Absolute Error) of 4.49 m and an RMSE (Root Mean Square Error) of 48.93 m, with errors meeting the accuracy requirements of this study; from the perspective of the entire study area, snow line elevation exhibits a pattern of low in the north and high in the south, high in the west and low in the east, with values ranging from 3,000-5,600 m, showing typical characteristics of longitudinal and latitudinal zonality, while the snow line field is densely distributed in the south and sparse in the north; from the perspective of local regions, snow line elevation in the Tianshan Mountains is high in the south and low in the north, high in the east and low in the west, in the Kunlun Mountains it is high in the middle and low on both sides, and in the Altai Mountains it decreases sequentially from northwest to southeast; snow line distribution varies significantly across different regions, its internal distribution is complex, and snow line elevations are interlaced with high and low values.

Full Text

Based on GIS: Establishment of the Xinjiang Snow Line Field and Its Distribution Characteristics

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Abstract: This paper takes Xinjiang as the study area, using daily snow products MOD10A1/MYD10A1 data from 2015. Through the snow duration ratio method, the snow line was extracted, and the Xinjiang snow line field was established using kriging interpolation. Based on this, the spatial distribution characteristics of the snow line were studied. Analysis shows that the ordinary kriging interpolation method for establishing the Xinjiang snow line field yields a Mean Absolute Error (MAE) of 4.49 m and a Root Mean Square Error (RMSE) of 48.93 m, which satisfies the accuracy requirements of this study. From analysis of the study area, snow line elevations show that the northern area is lower than the southern area, the western area is higher than the eastern area, with values ranging between 3000–5600 m, demonstrating typical zonal longitude and latitude distribution characteristics. The snow line field distribution is densely populated in the south and sparse in the north. From local area analysis, the Tianshan Mountains snow line shows the north is lower than the south and the east is higher than the west. The Kunlun Mountains snow line shows high in the middle and low on both sides, with the west higher than the east. The Altay Mountains snow line decreases from northwest to southeast. The snow line distribution differences are substantial, its internal distribution is complex, and snow line elevation height varies significantly.

Keywords: Xinjiang; Snow line field; GIS; Snow duration ratio method

1. Study Area

Xinjiang is located in the arid region of northwestern China (73°18'–96°69' E, 33°86'–48°50' N), covering an area of 1.66×10^6 km², accounting for approximately one-sixth of China's total land area [9]. The region is characterized by an extremely arid climate with low precipitation; annual precipitation in some areas is less than 150 mm, and the average annual precipitation across the region is only 789×10^3 m³, representing about 3% of the national total [10]. Glaciers in Xinjiang account for approximately one-sixth of the country's total

glacier area and volume [11], making the region a critical water resource area in China [12-13]. The snow line is a key indicator for studying glacier changes and climate change in this region.

2. Data Sources

The following datasets were employed in this study:

1. **MODIS Snow Products:** Daily snow cover data (MOD10A1, MYD10A1) from 2001-2015 were obtained from NASA's Earth Observing System Data Gateway (covering tiles h23v04, h23v05, h24v04, h24v05, h25v04, and h25v05).
2. **Landsat Data:** 30 m resolution Landsat imagery from 2005, 2010, 2014, and 2015 was acquired from the USGS GloVis portal (<http://glovis.usgs.gov/>) for validation purposes.
3. **Topographic Data:** 90 m resolution SRTM Digital Elevation Model (DEM) data was used for elevation information.

3. Methods

3.1 Snow Line Extraction The snow duration ratio method was applied to extract the snow line from MODIS data [15]. This method identifies the snow line based on the temporal frequency of snow cover during the ablation period.

3.2 Spatial Interpolation Ordinary kriging interpolation was used to generate a continuous snow line field surface. The interpolation was performed on a grid system with the following parameters: - Grid resolution: 10×10 - Elevation range: 3000-5600 m - Validation period: 31 days for primary analysis, with additional tests using 34-day and 24-day periods [16-17]

The interpolation accuracy was assessed using independent validation points, yielding a MAE of 4.49 m and RMSE of 48.93 m, which meets the study requirements.

3.3 GIS Processing All spatial analyses were conducted in ArcGIS 10.2. The processing workflow included: - Data reduction and grid generation using the ET GeoWizards extension - Overlay and intersect operations using ArcToolbox - Extraction of elevation values and snow line attributes to .dbf format for statistical analysis - Application of an elevation threshold of 1500 m to mask non-glaciated areas

[Figure 1: see original paper] shows the distribution of grid points before data reduction, while [Figure 2: see original paper] displays the points after reduction. [Figure 3: see original paper] presents the final smoothed snow line contour map for the Xinjiang region in 2015.

4. Results and Analysis

4.1 Spatial Distribution Characteristics The Xinjiang snow line field exhibits clear spatial patterns: - **Latitudinal variation:** Snow line elevations decrease from south to north, with the southern area higher than the northern area. - **Longitudinal variation:** Snow line elevations decrease from west to east, with the western area higher than the eastern area. - **Elevation range:** The snow line occurs between 3000–5600 m across the region.

At elevations of 3000–3300 m, the snow line gradient is $0.77 \text{ m} \cdot \text{km}^{-1}$. At 4500 m, the gradient increases to $4.67 \text{ m} \cdot \text{km}^{-1}$. Above 5600 m, the gradient decreases to $4.53 \text{ m} \cdot \text{km}^{-1}$, indicating complex topographic controls.

4.2 Mountain Range Variations **Tianshan Mountains:** The snow line shows a pattern of being lower in the north than in the south, and higher in the east than in the west. The average elevation is approximately 5100 m, with a gradient of $1.47 \text{ m} \cdot \text{km}^{-1}$ around 4300 m.

Kunlun Mountains: The snow line is characterized by high elevations in the middle and lower elevations on both sides, with the west higher than the east. The distribution is complex due to the extensive mountain system and varied climate conditions.

Altay Mountains: The snow line decreases progressively from northwest to southeast, showing a distinct directional trend.

4.3 Accuracy Assessment The interpolation accuracy was evaluated using three different validation periods: - 31-day period: MAE = 4.49 m, RMSE = 48.93 m (74.2% of points within acceptable range) - 34-day period: 76.5% of points within range - 24-day period: 83.3% of points within range

The error analysis demonstrates that the kriging interpolation method provides reliable results for establishing the regional snow line field [18].

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- [15] [Citation reference for snow duration ratio method]
- [16] [Citation reference for kriging interpolation method]
- [17] [Citation reference for validation methodology]
- [18] [Citation reference for error analysis]

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

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