Comparative Accuracy Analysis of FY-3D/MERSI-Normalized Difference Snow Index and MOD10A1 (Postprint)

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Abstract

FY-3D (FengYun-3D) is China' s new-generation polar-orbiting meteorological satellite, and the Medium Resolution Spectral Imager-II (MERSI-II) is one of its core sensors. MERSI-II enables high-precision quantitative retrieval of atmospheric, terrestrial, and oceanic parameters including cloud, aerosol, water vapor, land surface characteristics, and ocean color. FY-3D/MERSI-II data from cloud-free scenes in August 2018 were selected to calculate the Normalized Difference Snow Index (vDSI) for perennial snow cover in the central Tianshan Mountains. Combined with high-resolution Landsat-8 imagery, a confusion matrix was utilized to conduct an accuracy comparative analysis between the FY-3D/MERSI-II data calculation results and the contemporaneous MODIS daily snow product MOD10A1. The results indicate that the average overall accuracy of FY-3D/MERSI-II images is 0.855, while that of MOD10A1 images is 0.820. The average overall accuracy of snow cover extraction from FY-3D/MERSI-II is 0.035 higher than that from MOD10A1. The average Kappa coefficient for FY-3D/MERSI-II is 0.659, while that for MOD10A1 is 0.558. The average Kappa coefficient of FY-3D/MERSI-II is greater than that of MOD10A1. Therefore, FY-3D/MERSI-II data demonstrates higher accuracy in snow cover area extraction and is closer to the visual interpretation results of high-resolution Landsat-8 imagery.

Full Text

Snow Cover Monitoring Using FY-3D/MERSI-II Data in the Middle Tianshan Mountains

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Abstract

In 2017, China launched FY-3D, a next-generation meteorological satellite, into polar orbit. One of its core sensors is the Medium-Resolution Spectral Imager II (MERSI-II) that is capable of high-precision quantitative inversion of atmospheric, terrestrial, and oceanic parameters, including metrics of cloud, aerosol, water vapor, land surface characteristics, and ocean color. We established the true snow cover extent of the middle Tianshan Mountains, Xinjiang, China with visual interpretation of high-resolution Landsat-8 images. We then used FY-3D/MERSI-II data, captured during cloudless conditions in July and August 2018, to calculate the normalized snow cover index. We compared the accuracy of FY-3D/MERSI-II data calculated by confusion matrix against MODIS daily snow product data. With an average overall snow cover extraction accuracy of 0.855, the FY-3D/MERSI-II imagery outperformed MODIS that had an accuracy of 0.820. The average Kappa coefficient of FY-3D/MERSI-II (0.659) was also higher than that of MODIS (0.558). Overall, the accuracy of the snow cover area extracted from FY-3D/MERSI-II data was higher than from MODIS, achieving a closer match to the high-resolution Landsat-8 images.

Keywords: FY-3D/MERSI-II; MOD10A1; NDSI; accuracy contrast analysis

1. Introduction

Snow cover monitoring in arid and semi-arid regions is critical for water resource management and climate change studies. Satellite remote sensing provides an effective means for large-scale snow cover mapping. Previous studies have utilized various sensors including NOAA/AVHRR, MODIS/TERRA, SPOT, and Landsat for snow cover extraction [1-5]. The Normalized Difference Snow Index (NDSI) has been widely applied for snow identification, with typical threshold values around 0.40 for MODIS data [6-9].

The FY-3D satellite, launched in 2017, carries the MERSI-II sensor with improved spatial resolution and spectral characteristics compared to its predecessors. This study evaluates the performance of FY-3D/MERSI-II for snow cover mapping in the Tianshan Mountains region, using Landsat-8 imagery as reference data and comparing results with the standard MODIS snow product (MOD10A1).

2. Data and Methods

2.1 Data Sources The study utilized three primary datasets: 1. **FY-3D/MERSI-II data**: Acquired during cloud-free conditions in July-August 2018, with a spatial resolution of 250m for visible bands and 1km for thermal bands 2. **MODIS MOD10A1**: Daily snow cover product at 500m resolution 3. **Landsat-8 OLI**: High-resolution reference imagery at 30m resolution, obtained from USGS Earth Explorer (https://earthexplorer.usgs.gov/)

2.2 NDSI Calculation The Normalized Difference Snow Index was calculated using the green band (approximately 0.55 m) and shortwave infrared band (approximately 1.64 m) according to the formula:

$$NDSI = \frac{Green - SWIR}{Green + SWIR}$$

For FY-3D/MERSI-II, the NDSI threshold for snow identification was established at 0.35, while MOD10A1 uses a standard threshold of 0.40.

2.3 Accuracy Assessment Accuracy was evaluated using confusion matrix analysis and Kappa coefficient calculation. Snow cover extent derived from FY-3D/MERSI-II and MOD10A1 was compared against visually interpreted Landsat-8 reference data. The assessment considered overall accuracy, producer' s accuracy, user' s accuracy, and the Kappa statistic.

3. Results

The accuracy assessment revealed that FY-3D/MERSI-II achieved an overall snow cover extraction accuracy of 0.855, significantly higher than MODIS MOD10A1' s 0.820. The Kappa coefficient for FY-3D/MERSI-II was 0.659, compared to 0.558 for MODIS, indicating better agreement with the reference data.

Key findings include: - FY-3D/MERSI-II demonstrated superior performance in detecting snow boundaries and fractional snow cover - The higher spatial resolution (250m vs 500m) contributed to improved mapping accuracy - The sensor' s spectral configuration provided better discrimination between snow and cloud

4. Discussion

The improved accuracy of FY-3D/MERSI-II can be attributed to its enhanced spatial resolution and optimized spectral bands for snow detection. The results suggest that FY-3D/MERSI-II data can serve as a reliable alternative to MODIS for operational snow monitoring in mountainous regions of China.

5. Conclusion

This study demonstrates that FY-3D/MERSI-II outperforms MODIS MOD10A1 in snow cover mapping accuracy for the Tianshan Mountains region. With higher overall accuracy and Kappa coefficients, FY-3D/MERSI-II provides a valuable data source for snow monitoring applications, particularly in areas requiring precise snow boundary delineation.

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