AN IMPROVED METHOD FOR MAPPING DEBRIS-COVERED GLACIERS WITH SATELLITE MULTISPECTRAL IMAGE DATA AND DIGITAL ELEVATION MODEL

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1. INTRODUCTION

Automated glacier mapping from satellite multispectral image data is hampered by debris cover on glacier surfaces. There are amounts of 841 glaciers in China and the total area is 4338 km^2 based on the China Glacier Inventory which the data source are topographic maps derived from aerial photographs taken in the 1960-70s. In the China Glacier Investigation Project, high resolution multispectral satellite images, such as Landsat TM, ASTER, SPOT, are the main data source. Supraglacial debris exhibits the same spectral properties as lateral and terminal moraines, fluvioglacial deposits, and bedrock outside the glacier margin, and is thus not detectable by means of multispectral classification alone. Previous studies [1] related to quantitative assessments of glacier change (area/length) applied manual delineation of debris-covered glaciers, mostly by on-screen digitizing. It is very time-consuming and labour intensive for studying a larger number of glaciers. For this reason, more than 20 years has been used to complete whole China Glacier Inventory (CGI)[2].

Paul[3] has developed a multisource method for mapping supraglacial debris which include satellite multispectral image data ASTER and digital elevation model, and successfully applied to map two glaciers in SWISS Alps. However, whether the method can be applied in all debris-covered glaciers which include marine type, continental type, sub-continental type in China is uncertain. The criteria need to be tested and improved.

2. TEST OF CRITICAL SLOPE

In this article, different critical slope angles were tested from debris-covered glacier tongues cross sections for 10 glaciers from three type glaciers based on the digital elevation model (DEM) on 90m resolution, CGI layer and Aster images. It seemed there are no one unified critical slope even in one type glaciers. However, to most of glaciers, 24 can get well results. The curves of 10 cross sections for debris-covered glacier tongues also indicate that most slope of continental type glacier is less than that of marine type.

3. DATA AND METHOD

We applied our combined analytical approach with TM data from 31 August 1998, and the DEM from Shuttle Radar Topography Mission (SRTM)-derived products, and some holes in SRTM were filled by 1:250 000 topographic map. The vector of CGI of the study area was extracted. The improved multi-source method were developed and applied in Keqikaer glacier, which located in source of Akesu River, western of China.

4. RESULTS AND DISCUSSION

The processing steps are as follows: (1) A TM4/TM5 band-ratio image is segmented into the classes 'clean glacier' and 'other' using a threshold value of 2.1 which gives the best result in three different type glaciers because of the influence of slope shadows. (2) The Normalized Difference Vegetation Index (NDVI) from TM bands 3, 4 is used to map vegetation and vegetation-free areas with a threshold value of 0.01. The vegetation map is used to reduce misclassification of pixels during glacier mapping. (3) The Temperature Index(Tindex) was calculated by one window algorithm from band 6 and NDVI. (4) The vector from CGI were converted to image, then morphological expanded and shrank 5 pixels to construct the mask image. The new image was getting by multiple mask images with the initial image. (5) Slope is calculated from the SRTM .(6) IF TM3/TM5 > 2.1 AND (NDVI<0.01) and (Tindex<240) and (Slope<60) then pixel=0 or pixel=255, clean glacier were got. (7) The 'debris' is produced from (1.6> TM3/TM5 > 0.6) AND (0<NDVI<0.1) and (224<Tindex<280) and (Slope<16) then pixel=0 or pixel=255. (8) Combine the 'clean glacier' with 'debris'. In order to reduce misclassification of pixels and noise, a 3 by 3 median filter is applied after the classification.

The method combines the advantages of automated multispectral classification for clean glacier ice and brightness temperature index derived from thermal infrared band with slope information derived from DEM. A significant percentage of the processing can be done automatically. The accuracy of the auto processing is about 90 percent. So, manual corrected is still needed at last step.

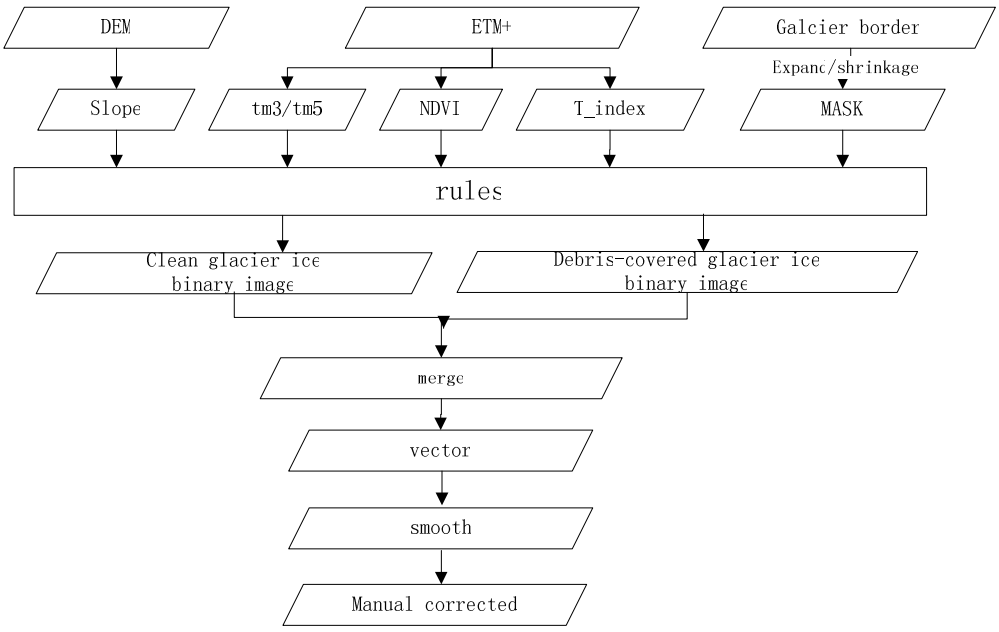

Fig.1 The flow chart mapping debris-covered glaciers. The first row marks the input (ETM+ bands or DEM) required for calculation of the parameters mentioned in the second row. The third row gives the threshold parameters used and the fourth row. The other rows are 'post-processing', which summarizes the final editing.

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