# Moderate fraction snow mapping in Tibetan Plateau

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**Abstract:**The spatial distribution of snow cover area is a crucial input to models of hydrology and climate in alpine and other seasonally snow covered areas.The objective in our study is to develop a rapidly automatic and high accuracy snow cover mapping algorithm applicable for the Tibetan Plateau which is the most sensitive about climatic change. Monitoring regional snow extent reqires higher temoral frequency-moderate spatial resolution imagery.Our algorithm is based AVHRR and MODIS data and will provide long-term fraction snow cover area map.We present here a technique is based on the multiple endmembers approach and by taking advantages of current approaches, we developed a technique for automatic selection of local reference spectral endmembers.

**Key words**: Snow mapping, moderate resolution, spectral mixture analysis

## 1.Introducion

Up to 34 percent of the Earth's land surface is seasonally snow covered. The considerable spatial extent combined with high reflectance make the snow cover a significant parameter for the surface energy balance. Hence, the climate is affected by the variability of the snow cover on local, regional and global scales. The snow storage also constitutes an important resource for water management such as flood forecasting and hydropower production. In science studies, the spatial distribution of snow cover area is a crucial input to models of hydrology and climate in alpine and other seasonally snow covered area [1]. Because of capability of observations of large and remote areas, satellite remote sensing is a widely used tool for monitoring the snow cover.

Traditional methods for classifying snow covered pixels from satellite data typically produce a binary map. Such an algorithm has been developed to map global snow cover using EOS/MODIS data based on the criteria tests and a decision rule to identify snow in each 500-m MODIS pixel [2]. Even though it is a good binary snow classification, the RMSE range of snow covered area of each pixel varies with maximum 49.5% because of the different background target; especially in the case of patched snow distribution and forested region [3]. It is obvious that both over-or under-estimations are caused by the "mixed pixel" problem. Linear spectral mixture analysis techniques have been applied to resolve the problem and simultaneously improve the accuracy of classification[4].We present here a technique is based on the multiple endmembers approach in which the spectral endmembers and the number of endmembers can vary pixel-by-pixel accounting for the effect of snow grain size and ground condition. Electing the reference spectral endmembers for unmixing process is a key for spectral unmixing algorithm. Each current technique for selecting the reference spectral endmembers has its own advantages and disadvantages, by taking advantages of current approaches, we developed a technique for automatic selection of local reference spectral endmembers.

## 2. Algorithm Description

Spectral unmixing has been used as a

technique for analyzing the mixture of components in remotely sensed images for almost 30 years. Linear spectral mixture analysis is based on the assumption that the radiance measured at the sensor is a linear combination of radiances reflected from individual surfaces whose spectral signatures are unique and well separated above a random image noise level [5]. Spectral mixture analysis is based on a set of simultaneous linear equations:

$$R(i) = \sum_{j=1}^{m} f(j)\,\mathrm{R_e}(i,j) + \varepsilon(i)$$

$$0 < f(j) < 1, \qquad \sum_{j=1}^{m} f(j) = 1$$

Where $i$ and $j$ represents spectral band and endmember. $R$ and $R_e$ are surface reflectance and endmember reference spectra. $f$ is fraction of each endmember. By finding minimum residual error $\varepsilon$, the fraction quantity and the spectral signature are determined in terms of the best fit to the measured spectral signature at a given pixel. The hypothesis that snow fraction can be determined by assuming that observed reflectance spectra are linear combinations of spectra of a small set of scene components has been supported by several studies.

Because Snow's spectral reflectance is sensitive to grain size, impurity and other attributes, snow spectrally manifests itself as a range of endmembers. Thus multiple snow endmembers are desired to meet the condition and to increase the accuracy of the snow cover mapping[6]. So our approach is based on using a mixture model with known non-snow endmembers (i.e., soil, water and vegetation) for each pixel. The snow cover (fraction) for the pixel is estimated by the mixture model with least mixing mean-square-root error. It is assumed that the reflectance is a linear combination of the non-snow reflectance and a single snow type reflectance.

The major difference in various studies is the techniques in selecting spectral endmembers. Our approach is will provide a new method of selecting spectral endmembers. Firstly, we perform an initial selection of possible snow, snow-free and snow mixed pixels by a decision tree. we further classify these initial identified snow mixed pixels by a spectral shape matching classification using the snow and snow-free spectral endmembers. Secondly, we merge the initial selected snow, snow-free endmembers and establishing a look up table for snow mixed pixels. The similar spectral signatures in each class - snow, snow-free, and snow mixed pixels are grouped together using simple criteria, and then, we averaged over those spectral signatures in each group to determine one spectral endmember signature in that class. Thirdly, identify local pure vegetation and bare surface spectral endmembers signatures by performing multi-endmember unmixing on the selected snow-free endmembers using the spectral library obtained from field measurements. This spectral library contains more than 300 field spectral measurements including different types of rock, soil, trees, and short vegetation. In this process, if RMSE is less than 0.015 for a snow-free endmember from multi-endmember unmixing, the spectral signatures from the library of each component will be selected and grouped into the pure vegetation and bare surface endmembers. If RMES is greater than 0.015 when it does not fit well by the measurements from spectral library, we identify the new local endmember spectral signature .

## 3.Validation And Experiment

In order to validate the above method, we chose the ASTER data of cloud-free and snow covered. The selected area located in the Tibetan Plateau edge. The time is March 03,2001.

We compare the MODIS binary snow and linear mixture snow and supervised snow classification snow on the aster covered area data. The results show in the mixture area of the linear mixture algorithm is a better than MODIS binary snow map. We put the MODIS snow in red channel and linear mixture snow in green and aster supervised classification in blue, the result is in figure 1. The snow area error between MODIS snow and ASTER supervised snow is 24.37%, but the error between Linear Mixture Model Snow and ASTER supervised snow result is 20.433%.The linear mixture result can provide better result for snow area mapping.

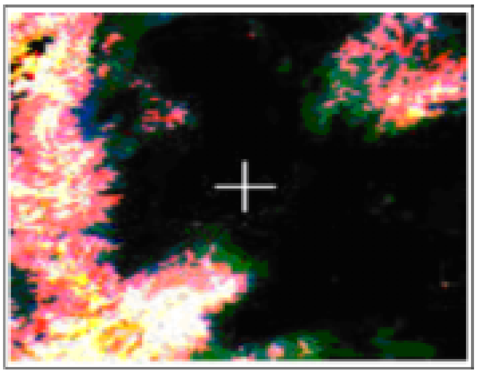
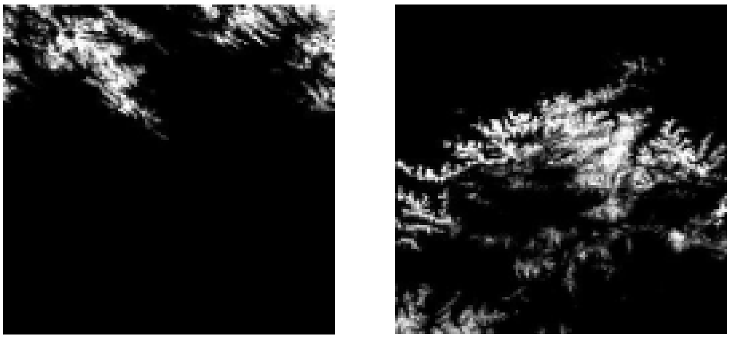


**Fig.1 MODIS snow(R),fraction snow(G)and supervised ASTER snow(B)**

The white area stands for the snow classified by three ways, pink means ASTER and Linear mixture model get the close results and yellow means MODIS snow and Linear mixture model is similar to each other, most of them are in rock area. The dark green means the linear mixture models classified part of snow. As to dirty snow there is a large error both the unmixing algorithm and modis binary snow. The MODIS algorithm is better than unmixing in the snow area on froze lake.

Fig.2 shows 2 examples, one is Modis fraction snow map at the soutn edge of Tibetan Plateau, the other is Modis fraction snow map at the north edge of Tibetan Plateau. We have applied the algorithm to get fraction snow in Tibetan Plateau, and our object is to get long-term snow cover in Tibetan Plateau.



**(a)** **(b)**

**Fig.2 (a) Modis fraction snow map(01/01/2003,soutn edge of Tibetan Plateau)**
**(b) Noaa fraction snow map (01/01/2003,north edge of Tibetan Plateau)**

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