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Application of Multitemporal Interferometric SAR Data for Land Cover Mapping in Mongolia

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Abstract

The aim of this study is to use the original and other ancillary derived features extracted from multitemporal spaceborne interferometric synthetic aperture radar (InSAR) data sets for land cover mapping. For the actual land cover mapping, supervised (statistical maximum likelihood classification) and unsupervised (isodata clustering) classifications have been performed using a) the original InSAR products, b) 14 features and c) the first 3PCs, and the results were compared. Overall, the research indicated that the multitemporal InSAR data sets have a valuable contribution to efficient land cover mapping.

1. Introduction

At present, InSAR data sets are being widely used for land cover/use and other resources mapping. Unlike the traditional single frequency and single polarisation SAR, the InSAR uses both the amplitude and phase information from a pair of single look complex (SLC) SAR images. From this pair of SLC images, different SAR products such as amplitude and coherence images as well as a digital elevation model can be generated. These derived products or their enhanced features combined with other optical data sets can be used for different classifications to increase the performance of the applied decision rules [1].

In this study, for the land cover mapping, supervised and unsupervised classifications have been applied. As a supervised classification the statistical maximum likelihood classification, whereas as an unsupervised classification the isodata clustering method [4,5,6] have been used. The actual classifications have been performed using a) the original InSAR products, b) 14 features and c) the first 3PCs, and the results were compared.

Within the framework of the study, to support the interpretation and analysis, good quality SAR image maps that could illustrate the spectral and spatial variations of the selected land cover types have been created. Overall, the research indicated that the multitemporal InSAR data sets have a valuable contribution to the efficient land cover mapping.

2. Test Area and Data Sources

As a test site, the Selenga River Basin, Northern Mongolia has been selected. The area represents a forest-steppe ecosystem and is characterized by fertile for agriculture chestnut soil. In the area, such classes as forest, agricultural fields, swampy area, natural vegetation, soil and water are available. As data sources, multitemporal interferometric ERS-1/2 SAR data with a spatial resolution of 25m acquired with 1 day repeat pass interval on 16 and 17 October 1997, and 8 and 9 August 1998 were used.

3. Feature Extraction

For the extraction of different features from the ERS-1/2 tandem pass SAR SLC images, the techniques used in Amarsaikhan and Sato (2003) has been applied.

1) Derivation of the InSAR Coherence and Amplitude Images

The coherence and amplitude images have been derived as follows:

1. Initially, 200 ground control points (GCP) regularly distributed over the images were automatically defined using the satellite orbit parameters and the two SLC images were co-registered with 0.1pixel accuracy. Then, a course registration followed by a fine registration was performed.
2. Coherence has been calculated using 10x3 size window and the coherence image was generated.
3. From the complex images, amplitude images were generated.
4. The preliminary SLC images were converted from the slant range onto a flat ellipsoid surface.
5. The true size (5800x5800) SAR images were generated using image undersampling applying 3x3 size low pass filter.

2) Derivation of the Texture Features

To derive texture features occurrence and co-occurrence measures were applied to the coherence and average amplitude images of the multitemporal ERS-1/2 data sets. The occurrence measures use the number of occurrences of each grey level within the processing window for the texture calculations, while the co-occurrence measures use a grey-tone spatial dependence matrix to calculate texture values. By applying these measures, initially 40 features have been obtained, but after thorough checking of each individual feature only 10 features were selected. Detailed descriptions of the occurrence and co-occurrence measures as well as the texture filters are given in [4].

3) Principal Components (PC) Images

To reduce the dimensionality of the dataset, the principal component analysis (PCA) has been performed to the extracted SAR features. For the PCA 14 features, including the multitemporal ERS-1/2 coherence and average amplitude images, and 10 texture features were used. The PCA has shown that the first 3PCs contained 99.5% (PC1=99.1%, PC2=0.30%, PC3=0.10%) of the total variance. Therefore, the first 3PCs have been selected for further analysis and the remaining PCs were rejected.

4. Creation of SAR image maps

In this study, to support the interpretation and analysis, good quality SAR image maps that could illustrate the spectral and spatial variations of the selected land cover types have been created. For the creation of the SAR image maps the following feature combinations have been used:

a) FCC1 (R=Coh97, G=ERS1amplitude97, B=ERS2amplitude97),
b) FCC2 (R=Coh98, G=ERS1amplitude98, B=ERS2amplitude98),
c) FCC3 (R=Coh97, G=ERS1/2av_amplitude97, B=97ERS1-97ERS2),
d) FCC3 (R=Coh98, G=ERS1/2av_amplitude98, B=98ERS1-98ERS2),
e) FCC4 (R=contrast filtered (Coh97), G=mean filtered (ERS1amplitude97), B=97ERS1-97ERS2),
f) FCC4 (R=contrast filtered (Coh98), G=mean filtered (ERS1amplitude98), B=98ERS1-98ERS2),
g) FCC4 (R=mean filtered (Coh98), G= variance filtered (ERS1amplitude98), B=97ERS2),
h) FCC4 (R=Coh97, G=Coh98, B=97ERS1),
i) FCC4 (R=mean filtered (Coh97), G= mean filtered (Coh98), B=98ERS2),
j) FCC4 (R=mean filtered (Coh97), G= variance filtered (Coh98), B= contrast filtered (ERS1),
k) FCC4 (R=Coh97, G= mean filtered (Coh98), B=enhanced (97ERS2)).

Of these combinations, the best images that could illustrate the spectral and spatial variations of the selected classes have been obtained by the combinations of e), f) and g).

5. Land Cover Classification

In general, before applying a classification decision rule, the speckle noise of the SAR images should be reduced. The reduction of the speckle increases the spatial homogeneity of the classes which in turn improves the classification accuracy. In this study, to reduce the speckle of the selected features a 5x5 size frost filter has been applied [4].

Initially, from the features, 2-4 areas of interest (AOI) representing the six selected classes have been selected using a polygon-based approach. Then, training samples were selected on the basis of these AOIs. The separability of the training signatures was firstly checked on the feature space images and then evaluated using JM distance [8]. Then the samples which demonstrated the greatest separability were chosen to form the final signatures. For the classification, the following feature combinations have been used:

1. The original InSAR products,
2. 10 features,
3. The first 3PCs.

For each of these feature combinations, supervised and unsupervised classifications have been applied. As a supervised classification the statistical maximum likelihood classification (MLC), whereas as an unsupervised classification the isodata clustering method have been used [5,6]. For the accuracy assessment of the final classification results, the overall performance [4] has been used. As ground truth information, for each class 4-5 regions containing the purest pixels have been selected. In all cases, the performance of the MLC was better than the performance of the isodata method. The overall classification accuracies of the selected classes in the selected features are shown in table 1. As seen from table 1, the performance of the classifications using the original InSAR products were higher than any other combinations in both MLC and isodata clustering method.

Table 1. The overall classification accuracy of the classified features.

Feature combinations	Overall accuracy of MLC (%)	Overall accuracy of Isodata (%)
The original InSAR products	84.12	81.89
10 features	82.98	78.26
The first 3PCs	82.58	80.04

6. Conclusions

The aim of this research was to use the original and some ancillary derived features extracted from multitemporal spaceborne InSAR data sets for land cover mapping. For the classification of the individual and extracted features, the statistical MLC and isodata clustering were used and the results were compared by measuring the overall accuracy. In all cases, the performance of the MLC was better than the performance of the isodata method. Overall, the study indicated that the multitemporal InSAR data sets could be efficiently used land cover mapping.

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