EASTERN ASIA LAND COVER CLASSIFICATION USING MODIS SURFACE REFLECTANCE PRODUCTS

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ABSTRACT:

The objective of this study is to develop land cover classification algorithm suited for the eastern Asia by using multi-temporal MODIS land reflectance products; Surface Reflectance 8-Day L3 product and Nadir BRDF-Adjusted Reflectance 16-Day L3 product. In this study, land cover maps derived from these two kinds of source data products are generated and compared. Time-domain co-occurrence matrix is introduced as a classification feature that represents time-series signature of land covers. As results, Nadir BRDF-Adjusted Reflectance product showed higher classification accuracy than Surface Reflectance 8-Day L3 product. Furthermore, those products produced good land cover maps than MODIS land cover product for the target classification area.

1. INTRODUCTION

Land cover maps of Global and/or continental scale are basic information for many kinds of applications, i.e. global change research, modeling, resource management, etc. Several kinds of global land cover maps has been generated, such as IGBP DISCover Global Land Cover, UMD Global Land Cover, and MODIS Land Cover, etc., and these products have been distributed widely. However, accuracies of these global land maps were not sufficiently high. Most of these land cover maps were generated mainly using NDVI and its seasonal changes. However, NDVI data lose most of information contents which were originally included in many channels. NDVI or similar indexes are generated by only 2 or 3 channels and in addition they lose the brightness information. Therefore, we have tried to develop land cover maps suited for the eastern Asia by using multi-temporal MODIS land reflectance products. There are two kinds product of Surface Reflectance 8-Day L3 product and Nadir BRDF-Adjusted Reflectance 16-Day L3 product. Both are composed of 7 spectral bands (620-670nm, 841-876nm, 459-479nm, 545-565nm, 1230-1250nm, 1628-1652nm, and 2105-2155nm) with 500m ground resolution. The former is the atmospheric corrected surface reflectance, while the latter corrects the BRDF effects in addition to the atmospheric correction. In this report, these products are called SR product and NBAR product, respectively.

2. STUDY AREA AND SOURCE DATA SET

The target area set in this study covers around 10,000 km x 6,700 km of 0-60 degree north for latitude direction and 60-150 degree east for longitude direction as shown in Figure 1a. The target region is covered by 51 sinusoidal projection grids which are distribution granule of SR (MYD09A1.5 Surface Reflectance 8-Day L3) and NBAR (MCD43A4.5 Nadir BRDF-Adjusted Reflectance 16-Day L3) products as shown in Figure 1b. The SR and NBAR products of 51 sinusoidal projection grids were mosaicked and transformed to geographic longitude-latitude coordinate system as shown in Figure 2. This processing was performed by using MODIS Reprojection Tool (MRT), which has been distributed from Land Processes DAAC. Because SR and NBAR products have been produced in eight-day period, mosaic images of 46 scenes were generated as classification target data set for one year of 2007 (in Figure 2b).
3. CLASSIFICATION ALGORITHM

3.1 Classification Feature

In this study, time-domain co-occurrence matrix was used as a classification feature, which provides time-series signature of land covers. Each element \((i, j)\) of the time-domain co-occurrence matrix is defined as probability that two pixels with a specified time-separation \(D_t\) in the same spatial position have pixel value \(i\) and \(j\). Conventional co-occurrence matrix (spatial domain co-occurrence matrix) represents spatial texture while the proposed co-occurrence matrix represents time-series signature.

Figure 4a shows pixel values of annual time-series data conceptual. The time-domain co-occurrence matrices shown in Figure 4b are derived from this time-series data in the case of one month separation. That is, a time-series changing pattern of pixel values produces the corresponding probability distribution pattern in the matrix.

Time-domain co-occurrence matrix takes advantage of robustness against data loss and noise derived from cloud and undesirable fluctuation of calculated reflectance values. Two, four and six months as time-separation \(D_t\) were examined in this experiment.
3.2 Classifier and Land Cover Classes

The minimum distance classifier was conducted for time-domain co-occurrence matrix. Euclidean distance \( d_E(x,c) \) and cosine distance \( d_n(x,c) \) between a pixel-\( x \) and a class-\( c \) were examined in this experiments. The distance \( d_E(x,c) \) and \( d_n(x,c) \) are defined as Eq. (1) and Eq. (2), respectively.

\[
d_E(x,c)=\sum_{b=1}^{7}\sum_{i=1}^{j}\sum_{j=1}^{i}(M_{adj}(i,j)-M_{std}(i,j))^2
\]

\[
d_n(x,c)=\sqrt{\sum_{b=1}^{7}\sum_{i=1}^{j}\sum_{j=1}^{i}M_{std}(i,j)}\sqrt{\sum_{b=1}^{7}\sum_{i=1}^{j}\sum_{j=1}^{i}M_{adj}(i,j)}
\]

\( M_{adj}(i,j) \) is a component \((i,j)\) of the time-domain co-occurrence matrix measured from band-\( b \) in time-series data set for a pixel-\( x \). \( M_{std}(i,j) \) is that measured from band-\( b \) time-series data set for the training area of a class-\( c \).

In Table 2, overall accuracy means the percentage of samples correctly classified among a total test samples. Mean producer's accuracy means the category mean of percentage of samples correctly classified among test samples belonging to a land cover category. And, mean user's accuracy means the category mean of percentage of correct samples among test samples classified to a land cover category. MOD12Q1 and MCD12Q1 of MODIS land cover product are produced by using SR products and NBAR products, respectively. Proposed methods using four month time-separation and Euclidian distance show good performance. In that case, NBAR products indicated 93% overall accuracy, 91% mean producer's accuracy, and 92% mean user's accuracy. SR products indicated a little lower accuracy than those values. Furthermore, these accuracies; especially mean producer's and user's accuracy, are higher than that of MOD12Q1(2005) and MCD12Q1(2007) products. Because test pixels were extracted from training area for classification of SR and NBAR products, it is fundamentally presumed that the accuracy of MOD12Q1 and MCD12Q1 products is lower than that of SR and NBAR products. However, we consider that this classification results showed good performance of the proposed simple classification method.

### Table 2. Classification accuracy.

<table>
<thead>
<tr>
<th>Source Product</th>
<th>( \Delta t ) month</th>
<th>Dist. overall accuracy</th>
<th>M.P. accuracy</th>
<th>M.U. accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>2</td>
<td>Eu</td>
<td>91%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Eu</td>
<td>92%</td>
<td>91%</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Eu</td>
<td>91%</td>
<td>73%</td>
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<tr>
<td>NBAR</td>
<td>2</td>
<td>Eu</td>
<td>92%</td>
<td>91%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Eu</td>
<td>93%</td>
<td>87%</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Eu</td>
<td>90%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Table 1. Land Cover Classes (IGBP legend)

Table 2. Classification results. (M.P.: mean producer's, M.U.: mean user's)
Day L3 product. Future study should be carry out in our classification scheme in order to increase the classification accuracy and to obtain more stable results.

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REFERENCES

Alan Srahler, Doug Muchoney, etc., 1 May 1999. MODIS Land Cover Product Algorithm Theoretical Basis Document(Version 5.0)