Understanding of Planted Crops Using AVNIR-2 Data

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Keywords: ALOS, AVNIR-2, Land-cover classification, Farm land, Remote sensing

Received January 26, 2009; accepted February 16 2009

Abstract

Since the ALOS performs observations at a comparatively high frequency in Japan, it does not receive as much restriction during observation time. Multitemporal ALOS/AVNIR-2 data in the paddy field zone in Hokkaido were used to carry out the land-cover classification of farmland and the classification of crops. The classification accuracy was examined by performing a supervised classification of major crops in the study site, such as winter wheat, paddy, soybean, azuki bean, sugar beet and onion. This was done by using ALOS/AVNIR-2 data with three scenes that had been observed on the 27th of May, the 28th of July and the 26th of August in 2006. On each observation day, the classification accuracy was above 95% for winter wheat, paddy and sugar beet, but was below 95% for soybean, azuki bean and onion. The classification of land-cover for the whole study area was also carried out by using the data from the three observation days. Regarding the area of each crop classified, the classification accuracy for winter wheat, paddy and sugar beet was high at ±10% compared to that of the statistical data for soybean, azuki bean and onion, which was low. Even the ALOS/AVNIR-2 data, for which the short-wavelength infrared region was not observed, was able to classify the paddy field with high accuracy because of the use of multitemporal data.

1. Introduction

It has been found that, it is necessary to carry out timely observation of the land-cover classification of farmlands using satellite information based upon the status of the fields used as a result of tillage, flood water and the growth condition of crops. It is reported that the precise classification of wheat, sugar beet, maize, potato and soybean was able to be conducted, due to the availability of data from the LANDSAT/TM observed from spring to autumn in the Tokachi district of Hokkaido (Okano et al. 1993), which is one example of land-cover classification of farmland in Japan. Moreover, it is reported that the short-wavelength infrared ray data observed immediately after the transplantation of paddy was able to distinguish paddy fields with high accuracy (Okamoto et al. 1996). However, it is also assumed that observations can not be conducted in due time with a commonly used optical sensor based on weather conditions. On the other hand, although a stable observation is possible using the synthetic aperture radar (SAR), which is a weather resistant sensor and does not depend on the weather conditions, examples in Japan are mainly limited to the classification of paddy fields (Ishitsuka et al. 2003).

The Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) sensors have also been loaded onto the Japanese Advanced Land Observing Satellite (ALOS) which was launched in 2006. Although it does not observe the short-wavelength infrared region, the whole country is being observed with a comparatively high frequency ground resolution of 10 m since the spring of 2006, and it can be expected to be used for classifying crops. In this context, an attempt was made to classify the land-cover of farmland by examining the classification accuracy of major staple crops and using ALOS/AVNIR-2 data observed during multiple times from spring to autumn in 2006 for the paddy field zone in Hokkaido.

2. Materials and Methods

1) Study site

The Naganuma Town was selected as the study site which is the representative paddy zone of Hokkaido possessing low plain fields downstream from Ishikari River. Although most of the farmland in Naganuma Town is occupied by paddy fields,, a conversion into upland fields has been advancing in recent years and the rate of change in crops has reached 60%. The major crops cultivated are winter wheat, paddy, soybean, azuki bean, sugar beet and onion and others include vegetables and grass. The cultivated area and the proportion of main crops are given in Table 1. Since most of the grassland's areas are perennial, it was possible to efficiently understand the cultivation situation in the region by classifying the major crops that occupy almost 75% of the cultivated area.

2) Satellite data and analysis methods

Distinguishing crop types and classifying land-cover were both carried out for major crops such as winter wheat, paddy, soybean, azuki bean, sugar beet and onion by using the ALOS/AVNIR-2 data from three scenes of the targeted region that were acquired on the 27th of May, the 28th of July and the 26th of August in 2006, respectively. The average standard cultivation period of major crops and the observation days of the satellite that had been used for analysis are illustrated in Fig. 1.

A supervised classification was performed by selecting 20 plots each of winter wheat, paddy, soybean and sugar beet, 15 plots of azuki bean and 8 plots of onion from the study site and by acquiring the average digital number (DN) of each field according to the band from each satellite data.

Table 1. Composition of cropping area in Naganuma Town

Planted crops	Statistical area (2006) (ha)	Proportion (%)
Winter wheat	2,450	24
Paddy	3,190	32
Soybean	1,680	17
Adzuki bean	107	1
Sugar beet	187	2
Onion	110	1
other	1,170	12
Grass	1,130	11
Total	10,024	100

3. Results

1) Classification accuracy of each crop

The classification accuracy of each crop according to the satellite observation day is given in Table 2. The accuracy during the crop growing period was above 95% on 27th of May for winter wheat. The same results were also found on the 28th of July and the 26th of August for paddy and the 26th of August for sugar beet. However, it was always below 95% for soybean, azuki bean and onion.

2) Land-cover classification

(1) Classification of crops

According to supervised classification of satellite data, the whole study site was categorized into six

Table 2. Classification accuracy

Planted crops	Observation date		
	27th May	28th July	26th August
Winter wheat	100.0	(97.3)	(96.9)
Paddy	91.6	95.5	97.0
Soybean	48.5	64.1	85.3
Adzuki bean	52.2	79.5	72.3
Sugar beet	55.0	85.5	96.5
Onion	73.2	90.5	(93.9)

Note: Values in parentheses denote after harvesting

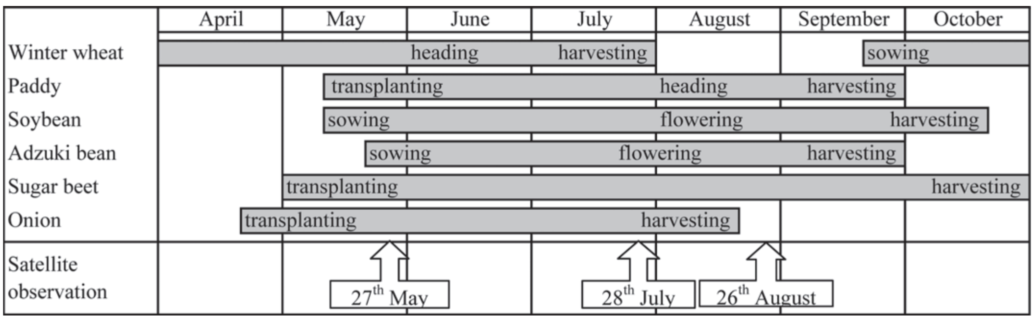

Fig. 1. Calendar of major crops in Naganuma Town and satellite observation

classes, made up of winter wheat, paddy, soybean, azuki bean, sugar beet and onion. Although forests, urban areas and rivers also existed in the study area, the cultivated crops were classified into six classes including them all. The classification of each result from satellite data was then compared and the respective crops were judged by each pixel, considering the classification accuracy of all satellite data. A brief description on the judgment of each crop is given below.

a) Winter wheat

Unlike other crops, winter wheat showed to be strong vegetation on the 27th of May, and the classification accuracy of winter wheat was high on all three observation dates. This is because wheat was harvested in late July and wheat plants had already disappeared completely before the observations on the 28th of July and the 26th of August. Therefore, only the pixels that were classified as “winter wheat” on all three scenes of 27th May, 28th July and 26th were judged as winter wheat. Moreover, both winter wheat and onion had already been harvested before the 26th of August. Therefore, the classified pixels of “winter wheat” on the 27th of May and the 28th of July and of “onion” on the 26th of August were also judged to be winter wheat.

b) Paddy

Similar to all other crops with the exception of winter wheat, paddy did not have vegetation on the 27th of May. Although, the classification accuracy on the 28th July and the 26th of August was high. Therefore, the pixels that were classified as “paddy” on the 28th of July and the 26th of August but not as “winter wheat” on the 27th of May were judged as paddy. However, among these, the pixels having been distinguished as “winter wheat” on the 28th of July and “winter wheat” and “onion” on the 26th of August were not distinguished as paddy.

c) Sugar beet

Sugar beet did not have vegetation on the 27th of May. This was similar to all the other crops with the exception of winter wheat. The classification accuracy on the 28th of July was low. Therefore, out of all pixels other than the ones judged as winter wheat and paddy, pixels that were classified as “sugar beet” on the 26th of August but not “winter wheat” on the 27th of May were judged as sugar beet. However, among these, the pixels that were distinguished as “onion” on the 28th of July were not distinguished as sugar beet.

d) Onion

Onion did not have vegetation on the 27th of May. This was similar to all other crops with the exception of winter wheat. The classification accuracy on all three observation days was not high, although the plants had withered before the 28th of July and the vegetation had disappeared due to the harvest before the 26th of August. Therefore, out of all pixels other than ones being judged as winter wheat, paddy and sugar beet, the pixels that were classified as “onion” on the 28th of July, and those classified as “winter wheat” and “onion” on the 26th of August but not “winter wheat” on the 27th of May were judged as onion.

e) Soybean

Soybean did not have vegetation on the 27th of May. This was similar to all other crops with the exception of winter wheat. Although vegetation was present on the 28th of July and the 26th of August, the classification accuracy of all three observation days was not high. Therefore, from the pixels other than ones being judged as winter wheat, paddy, sugar beet and onion, the pixels that were classified as “soybean” and “azuki bean” on the 26th of August amongst the pixels being judged as “soybean” on the 28th of July but not “winter wheat” on the 27th of May were all judged as soybean. This also applies to the pixels being classified as “soybean” on the 26th of August out of all the pixels classified as “azuki bean” and “sugar beet” on the 28th of July but not to those of “Winter wheat” on the 27th of May.

f) Azuki bean

Azuki bean did not have vegetation on the 27th of May. This was similar to all other crops with the exception of winter wheat. Although the vegetation was present on the 28th of July, it turned yellow on the 26th of August. However, the vegetation of azuki bean on the 28th of July is comparatively smaller than that of paddy, soybean and sugar beet. Since the classification accuracy was not high on all three observation days, out of all the pixels, other than the ones being judged as winter wheat, paddy, sugar beet, onion and soybean, the pixels that were classified as "azuki bean" on both the 28th of July and the 26th of August, but not classified as "winter wheat" on the 27th of May were judged as azuki bean.

(2) Improvement in classification accuracy

The classification result was processed as follows and the accuracy improvement in the classification result was performed.

a) Deletion of isolation pixel

The isolated eight pixels that were surrounding the classified pixels and were not classified into any crop group were deleted from the classification results due to the possibility of misclassification.

b) Correction of minute division

Regarding the minute division of classified crops into other crops that was different from the major ones, these pixels were adjusted into similar crops surrounding the eight pixels.

c) Correction of boundary pixel

When there was a pixel classified into other items in the boundary region (for example, the outer parts of the division classified into certain items), a pixel was adjusted to the items that were regarded as the subject of the division, because it was thought that the pixel in the boundary part could be misclassified.

The result mentioned above and the obtained land-cover classification charts are given in Fig. 2.

(3) Summing up of the classification result

The estimated area of the respective crop was summed up from the acquired land-cover classification map, and the results of these, compared with the statistical information of cities, towns and villages are given in Table 3. The area of each crop classified by the satellite data corresponded well to the statistical area by an accuracy of ±10% for winter wheat, paddy and sugar beet. However, the classification accuracy decreased for soybean, azuki bean and onion.

4. Discussion

1) The comparison between the results of land-cover classification and the actual crop information showed that the classification results corresponded well to the actual crop information for winter wheat, paddy and sugar beet that had high classification accuracy. In

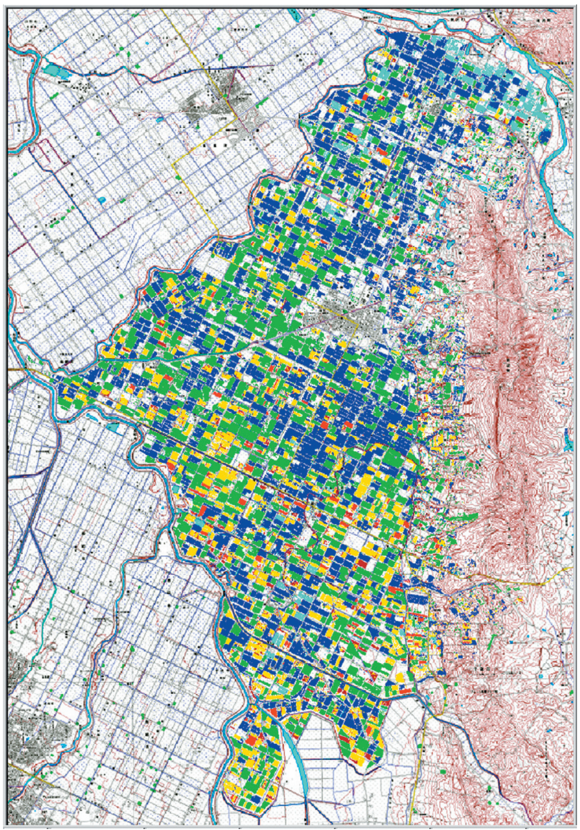

Fig. 2. Distribution map of planted crops in Naganuma Town prepared from the ALOS/AVNIR-2 data ©JAXA

Table 3. Comparison between the estimated areas and the statistical areas

Planted crops	Estimated area (ha)	Statistical area (2006)(ha)	Percentage
Winter wheat	2,524	2,450	103
Paddy	2,992	3,190	94
Soybean	1,201	1,680	71
Azuki bean	224	107	209
Sugar beet	170	187	91
Onion	347	110	315
Total	7,457	7,724	

the case of paddy fields, the pixels involving ridges were often distinguished as anything other than paddy fields. It was considered to be one of the factors causing the classified area to be smaller than the statistical area.

2) In several cases, soybean was either misclassified as azuki bean or was not classified into any of the six major crops. A large variation in the amount of

growth in the region could be considered a contributing factor, because two or more soybean types with different characters were cultivated in the study area.

3) The classification result of onion turned out to be three times above the statistical area. Although onion fields were classified almost exactly, there were a lot of cases in which other vegetables were misclassified as onion. Leafy vegetables were grown on the study site, and it is thought that the leafy vegetables during the growth period could have possibly been misclassified as onion crop due to their similarity.

4) Although crop items were judged by comparing their multitemporal classification results, the classification was not carried out on anything other than six target crops and there was almost no misclassification concerning forest and urban areas. The features showing that vegetation on farmlands change during the seasons demonstrate that farmland and non-farmland can be distinguished with good accuracy. However, since the barren land in the mountainous and urban areas were misclassified; it is thought that classification accuracy can be further improved by distinguishing the farmland pixels beforehand by combining and using techniques such as the Geographic Information System (GIS).

5) Although the flooding state immediately after the transplant of rice (during late May in Hokkaido) had been a proper time for classification till date, the classification accuracy on the 27th of May was not very high. The observation wavelength used for the classification ranged from visible wavelengths to nearly infrared wavelength regions. The short-wavelength infrared region, which is suitable for distinguishing water bodies, could possibly be a factor for not having been observed. Based on the satellite data of late May, Kusume et al. 2004 reported low classification accuracy in the paddy fields where wavelengths ranging from visible to nearly infrared were used for soil with especially a lot of humus content (i.e. peat soils). The major soil types used in the study site were Gleyic and Histic soils (Hokkaido Central Agricultural Experiment Station 2008). The result indicated a possibility of influences from soil conditions on classification accuracy. However, even the ALOS/AVNIR-2 data that do not observe the short-wavelength infrared region were able to classify paddy with high accuracy rates by using the multitemporal data in which the short-wavelength infrared region was not observed.

6) In addition, the improvement in accuracy is expected to be based upon classifying the items in each field by a combined use of GIS data (Takahashi et al. 2003, Kusume et al. 2004). This is because the summation of the classified area is carried out using the unit of pixels.

5. Conclusions

1) The supervised classification of the six major crops (winter wheat, paddy, soybean, azuki bean, sugar beet and onion) in the paddy field region in Hokkaido was carried out using the multitemporal ALOS/AVNIR-2 data, and the accuracy of classification was examined. The results showed that the accuracy of classification varied according to the observation day. The accuracy was above 95% for the winter wheat, paddy and sugar beet while was below 95% for soybean, azuki bean and onion on each observation day.

2) The land-cover classification of the whole study area using the data from the three observation days showed that the area of the classified crops of winter wheat, paddy and sugar beet was estimated with a ± 10% accuracy compared to that of the statistical area where the accuracy was lower for soybean, azuki bean and onion.

3) Even the ALOS/AVNIR-2 data, in which the short-wavelength infrared region was not observed, were able to classify the paddy field with high accuracy as a result of the use of multitemporal data.

4) Since the use of multitemporal satellite data to classify the land-cover could become a limiting factor at a certain point regarding observation costs and data acquisition, technology for distinguishing crop items with high accuracy using a low satellite observation frequency could be made possible by the combined uses of information and techniques such as GIS.

Acknowledgements

The ALOS/AVNIR-2 data used for the analysis were received from Japan Aerospace Exploration Agency (JAXA) as part of the activities of the Satellite Remote Sensing Promotion Committee and the crop information was received from the Naganuma

Agricultural Association. We wish to express our gratitude for this.

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