Comparison of the Monitored Forests Results from EO-1 Hyperion , ALI and Landsat 7 ETM+

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Abstract The EO-1 spacecraft, launched November 21, 2000 into a sun synchronous orbit behind Landsat 7, hosts advanced technology demonstration instruments, whose capabilities are currently being assessed by the user community for future missions. A significant part of the EO-1 program is to perform data comparisons between Hyperion, ALI and Landsat 7 ETM+. In this paper, a comparison of forest classification results from Hyperion, ALI, and the ETM+ of Landsat-7 are provided for Wangqing Forest Bureau, Jilin Province, Northeast China. The data have been radiometrically corrected and geometrically resampled. Feature selection and statistical transforms are used to reduce the Hyperion feature space from 86 channels to 14 features. Classes chosen for discrimination included Larch, Spruce, Oak, Birch, Popular and Mixed forest and other landuses. Classification accuracies have been obtained for each sensor. Comparison of the classification results shows : Hyperion classification results were the best, ALI's were much better than ETM+.
Keywords: Hyperion, ALI, ETM, Forest Monitoring.

I. Introduction

NASA's EO-1 satellite was launched on November 21, 2000. The satellite is flying in formation with Landsat 7. The acquisitions from Landsat and EO-1 will be within 1 minute of each other[1]. This orbit is very useful for cross comparisons of the instruments on both spacecrafts[2].

EO-1 Hyperion, ALI and Landsat-7 ETM data were acquired on July 14, 2001 covered a subarea of Wangqing Forest Bureau, Jilin Province, Northeast China. Wangqing Forest Bureau is an import national nature reserve in China. Its forest cover is over 95% . No agriculture lands are there.

A major issue for the remote sensing community is the continuity of Landsat products as new sensors are introduced. The goal of our work was to evaluate the ability of Hyperion and ALI to classify forests and compare the results with classifications of Landsat-7 data for the same areas.

II. Remote Sensing Data Preparation

Pre-processing of Hyperion, ALI and Landsat-7 ETM+ data is required before analysis. The Hyperion data used in the current analysis is Level 1 Radiometric Product. If a standard Level 1 data, it has a total of 242 bands but only 198 bands are calibrated. Because of an overlap between the VNIR and SWIR focal planes, there are only 196 unique channels. Calibrated channels are 8-57 for the VNIR, and 77-224 for the SWIR. The bands that are not calibrated are set to zero in those channels[1,3].
For our Hyperion data, there are 112 bands that are set to zero, they are 1-7, 58-76,121,124,126,127,131-133 and 164-242. The reason may be mainly due to the detectors' low responsively. There are 44 bands that have abnormal pixels and striping. So we have used only 86 bands without any abnormal or striping out of a total of 242 bands for our current work. These 86 bands cover a spectral range of 477.6920 nm to 1780.0900nm.

The ALI data obtained is also a Level 1 radiometric product. All ALI Level 1 radiometric processing produces four strips of image data recorded by the instrument's Sensor Chip Assemblies (SCAs) from lift to right, named M4R, M3R, M2R and M1R. Because only M4R overlays with Hyperion data. So we have just used M4R image[1,3].

Landsat 7 ETM+ data was obtained from Chinese Satellite Ground Station. It has been radiometrically corrected by the Station.

Geometric correction have been done for each sensor data. Ground Control points(GCPs) were measured from the topographical maps at scales of 1:50 000. Geometric correcting of the Hyperion data resulted in a root-mean-square (RMS) error of 14.31 meters using 8 GCPs. The GCPs for the ALI M4R data were collected using the multi-spectral bands. For 8 GCPs in the multi-spectral bands of the ALI, the RMS error was 15.56 meters. Compared with the Hyperion and the ALI, the geometric correcting was carried out for the half of ETM image, resulting in a RMS error of less than 15.84 meters based on 11 GCPs. All of the three images were resampled with 30 m pixel size into Transverse Mercator projection with Krassovsky datum parameters(including longitude of central meridian of 129° and false easting of 500 000 m).
Although, ALI has a 10 m panchromatic band, compared to ETM+ with its 15 m panchromatic band. In this paper, we didn't do the data fusion using

panchromatic band with multispectal bands.

III. Ground References Data

In Chinese forest management planning, every province includes several forestry bureaus and each bureau is separated in several forest farms (e.g. Wangqing Forestry Bureau includes 13 forest farms). In each forest farm, there are several compartments as an administration units. In addition, the compartments are divided in subcompartments according to silvicultural condition. For each Forest Bureau, subcompartment level forest inventory should be conducted every 10 or 15 years in order to local forest management planning.
In Wangqing Forestry Bureau, the subcompartment level forest inventories have been measured in 1983 and 1997. Altogether 24 different variables are measured from each sample plot and the data have been stored into the subcompartment database. The structures of the databases are relatively simple. All forest characteristics are described in a single table and each sample plot or subcompartment is represented in a single row .

Another result of the forest inventory is creating subcompartment boundaries map. The boundaries of forestry farms, compartments and subcompartments are available in the forest bureau, but only the 1997's map is in a digital format and can utilised in GIS. Each polygon in the map represents a land type. Fig. 1 is the overlay map of EO-1 Hyperion image and digital forest map. In the map database, the geographic data is organized as layers. In addition, an attribute table is linked to each layer including as many records as there are features on the layer (e.g. each subcompartment is one record in the table).
The digitized forest map was converted into a 30 meters grid image for identifying and selecting training areas. Statistics was made for the main forest types from the grid digital forest map. The results shows in Tables1. From Table1 we can find main forest types in the site area are Larch, Oak, Birch, Poplar, Mixed broad-conifer, Mixed B-B-S Forest , Mixed B-B-M forest. All of their area is 98.667% of the total of whole test site. So we are try to identify these seven main forest types, from tree remote sensing data in this paper.

IV. CLASSIFICATION RESULTS

With all of the remote sensing orthorectified to a common map, we were able to proceed to classification. A variety of algorithms could be used and there is the issue of incorporating spatial information. For this paper, we chose to reduce complexity in the sensor comparison and supervised maximum likelihood pixel classification(ML) was applied in the forest types classification. In the future work, we will test the Classification method of Spectral Angle Mapping(SAM) for forest tree identifier from three difference remote sensing data.

Before the classification, according to the compare of the bands spectral of Hyperion and ALI data, feature selection and statistical transforms are used to reduce the Hyperion feature space from 86 channels to 14 features. Subcompartment level data was utilized to select the training data for the ML classification. Some of the training areas were used for classification; others were used to test classification. Classes chosen for discrimination included Larch, Spruce, Oak, Birch, Popular, Mixed forest, Wetland, Water, and Shrub. For the classification result, a specialized filtering was done with the window size 3x3. The center pixel will be replaced by the most common data file value in the window. So that small areas of possible miss-classification were eliminated and combined into the surrounding landuse class. The final thematic map are shown in Fig. 3(Hyperion), Fig. 4(ALI), and Fig.5(ETM+). The classification legend for the classes is shown in Fig.2. Accuracy assessments have been done for three sensor data using train data.

V. CONCLUSIONS

Data from Hyperion, ALI, ETM+ were corrected and fused for a classification comparison. The classification results by sensor in the test areas were: Hyperion 90.1%, ALI 84.8%, and ETM+ 75.6%. The results shows that Hyperion provided operational accuracies for forest classification. ALI classification results were much better (10%) than ETM+. Future research will investigate the spatial properties of these sensors and the improvements in forest species recognition when spatial information is included.

Table 1 Statistics of Forest Types in Test Site for 1997

NO.	Name of F. type	No. of Pixels	Percents(%)	Main types
1	Red Pine	78	0.06	
2	Spruce	1105	0.81	
3	Larch	11641	8.529	●
4	Oak	34434	25.230	●
5	Birch	23077	16.908	●
6	Poplar	18439	13.510	●
7	Mixed Coni-Broad	2753	2.017	●
8	Mixed B-B-M*	27280	19.988	●
9	Mixed B-B-S**	17059	12.499	●
10	Others	616	0.45	
Totals		136482	100	98.677

* Mixed broad-leaved middle grow forest
** Mixed broad-leaved slow grow forest

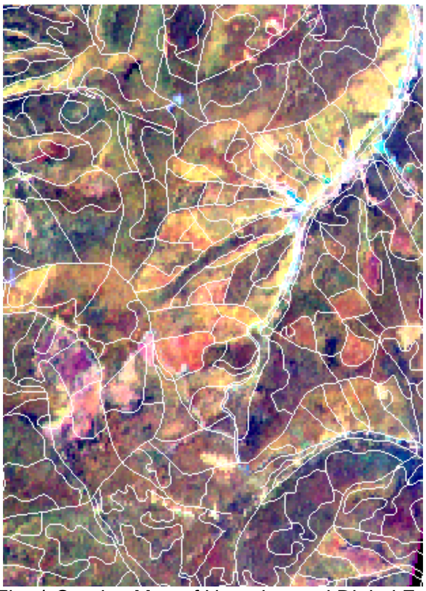

Fig. 1 Overlay Map of Hyperion and Digital Forest Map

Fig. 2 Classification Lengend

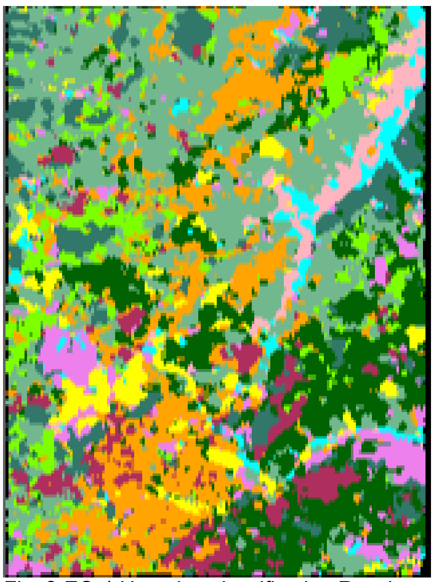

Fig. 3 EO-1 Hyperion classification Results

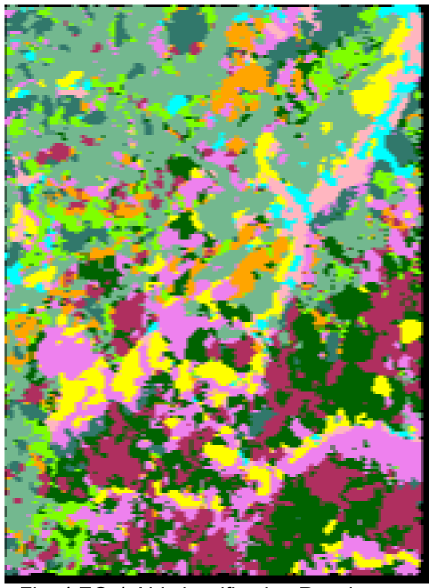

Fig. 4 EO-1 ALI classification Results

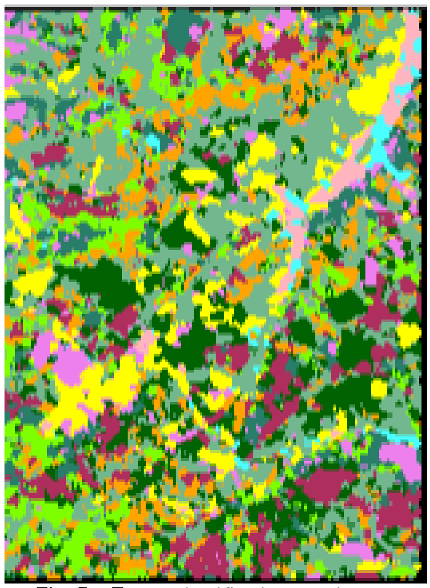

Fig. 5 ETM+ classification Results

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