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ESTIMATION OF TAIWAN'S FORESTED AREAS FROM CALSSIFIED NDVI MAPS FROM NOAA AVHRR DATA

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TAIWAN

ABSTRACT: The goal of this study is by applying NOAA AVHRR data in delineating NDVI maps throughout Taiwan, which can be utilized in surveys of forested areas. Due to the frequent appearance of clouds, the composite NDVI maps were conducted in a monthly basis where the monthly and seasonal variations of the NDVI values around mountainous areas were analyzed. The result showed that the total forest area assessed by the NDVI value reached 54.5%. This percentage was rather close to the surveys conducted on the surface, which was 58%, proving our procedure to be rather practical.

1. INTRODUCTION

The surface vegetation index is an important index in the monitoring of global changes. Therefore, many researches have been focused on the type of canopy, distribution and variation of the plants and trees. Meanwhile, the vegetation index can also be used in the evaluation of environmental issues, such as crop product assessments, landcover or landuse surveys (Tucker et al. 1985; Justice, 1986), forest fire monitoring, deforesting, desertification … etc. For example, Kasischke and French (1995) used a set of the normalized differential vegetation index (NDVI) observed from 1990 to 1992 to analyze the forest fires that occurred over Alaska's densly forested areas, and found that a sudden increase in the surface temperature may speed up the desertification of forestlands, and increase the emission of carbon dioxide. Concerned with the desertification, Tucker et al.(1994) analyzed the composite NDVI values of the Sahara Desert during 1980 to 1992, hoping to understand the area's variation. Their results showed that the NDVI values were proportional to the total biomass amount, as well as to the surface precipitation. In the past decade, several research teams have made tremendous efforts in developing a so-called mixing-pixel NDVI mapping technique of mixed pixels for landuse and landcover classification, which are useful for areas of development, such as urban or adjacent

mountainous areas (Kerdiles and Grondona, 1995).

In this study, NOAA AVHRR data were employed in assessing the vegetation index around Taiwan, as well as analyzing its monthly and seasonal variations based on a data set that included roughly 200 days of clear sky conditions collected from 1998 to 1999. A monthly NDVI database was established for further agricultural surveying and forestry investigations. Assessments of forested areas in Taiwan through a supervised classification are mainly demonstrated in this study.

2. METHODOLOGY

2.1 Clear Image Composed

Because of its location in the sub-tropical zone, it is not easy to obtain a total cloud-free satellite image of Taiwan. A composed satellite image of NDVI with multiple-temporal AVHRR images was adopted to conduct our analysis. Therefore, the accuracy of the geometrical registration between the images was crucial for the final results. Although the orbital parameters of the NOAA satellite can be used to produce an orthogonal image, a simple shift can still influence the registration accuracy. In our study, a correlation-coefficient method was employed to eliminate this shifting error. An image acquired in a clear sky condition was chosen as a reference image. The other remaining images of the same set were compared with it by using the cross-correlation method where approximately 20 control pixels were selected from the images. In our procedure, specific surfaces such as coastal lines were chosen as control points. Generally, the method effectively improved the matching accuracy.

2.2 Classification of NDVI

This study used AVHRR images collected from September, 1995 to March, 1996 to compute the monthly NDVI maps, and further compiled statistics of NDVI values for many landcover types, which included dense and sparse forests, rice fields, artificial constructions, and the ocean. This was conducted through the aid of 1/5000 maps and supervised classifications (see also Table 1). Generally, the NDVI values of the rice fields and artificial constructions owned a larger variation with time, which was probably caused by the mixing pixel effect due to rough spatial resolutions of the AVHRR data. On the other hand, the other surface types owned a more stable NDVI value with time because they had a larger area of coverage.

3. RESULTS AND APPLICATION

3.1 Construction of Monthly NDVI

For 1998, AVHRR images acquired under clear sky or partly clear sky conditions were collected over a time span of 105 days in this study, where monthly dynamic NDVI maps were derived (Fig.1). Because of the cloudy weather pattern, we could not obtain island-wide composite NDVI maps for the months of February, April, May and December. However, the seasonal variation of the NDVI values could still be observed. In winter (Dec.-Feb.), the surface generally had a lower NDVI value (more red and yellow pixels in Fig.1). In spring (Mar.-May), parts of the pixels that were originally red and yellow turned green, indicating the growth of plants. The values reached their maximum in summer (Jun.-Aug.), and decreased during fall. Comparisons showed that the lowest NDVI value was observed in February, and the highest in August.

Similar to the year 1998, an 88-day data set was analyzed in 1999, where the maps of January to October were composed. Basically, the monthly patterns and variations were similar to the results in 1998. In addition, the results in 1999 also showed that a total cloud-free composite NDVI map covering the entire Taiwan island could not be obtained sometimes, even under a monthly basis. Therefore, a long-term collection of satellite images is necessary to construct a complete database. Hence, future works should be made to continuously collect more satellite observations, not only with AVHRR data but also with other satellite images in the visible and near infrared electromagnetic portion. With the different data, we can concurrently analyze the surface information in a large but detailed scale.

3.2 Estimation of Forest Area

Based upon the previous classification result, the forested areas within Taiwan could be assessed, and the monthly-averaged NDVI map derived (Fig. 2). In Fig. 2, the forest distribution of Taiwan in January 1998 is indicated by the green color, and covers about 54.5% of the entire island. Comparing it to the surface survey result (Fig. 4), which reached 58% conducted by the Taiwan Forestry Bureau, it revealed that our procedure was practical, and worthy for further investigations.

4. DISCUSSIONS

The database of monthly NDVI values gathered from 1998 to 1999 covering Taiwan was established under our procedure. The variations of NDVI have been used for analysis in relevant researches. The data period of the NDVI database is constantly increasing as more applications are being made to monitor the surface landuse change, especially for the forestlands in Taiwan. It is worthy of developing another satellite, or perhaps trying to fuse together different satellite images, to obtain more accurate NDVI mapping and applications. For example, it would be possible to combine together the images of SPOT HRV and SPOT-4 VI. Such methods may help us to construct more accurate and practical

applications, especially for Taiwan's growing complex landuse and utilization in precision farming.

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Table 1. The seasonal variations of NDVI value derived by using the supervised classification.

Year/ Month	Dense forests		Sparse forests		Rice fields		Artificial constructions		Oceans		Clouds	
	ì	ó	ì	ó	ì	ó	ì	ó	ì	ó	ì	ó
1995/9	.36	.05	.20	.10	.16	.06	-.04	.03	-.41	.01	-.12	.04
1995/11	.34	.09	.22	.03	.09	.09	-.05	.06	-.48	.01	-.16	.01
1995/12	.37	.05	.25	.06	.04	.01	-.14	.02	-.42	.06	-.15	.00
1996/1	.31	.09	.25	.14	.00	.02	-.02	.06	-.44	.02	-.12	.00
1996/3	.39	.05	.22	.11	.05	.03	-.09	.03	-.42	.02	-.15	.00

ì : Mean; ó : Standard Deviation

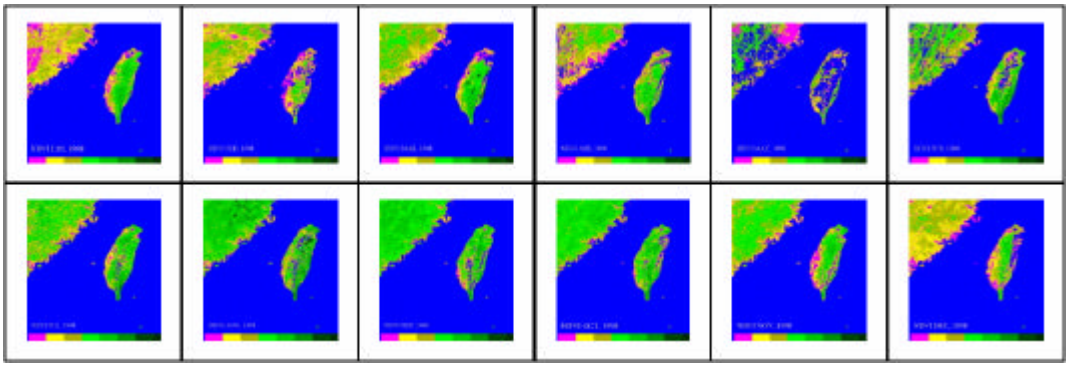

Figure 1. The monthly NDVI maps of Taiwan (Jan.~ Dec, 1998).

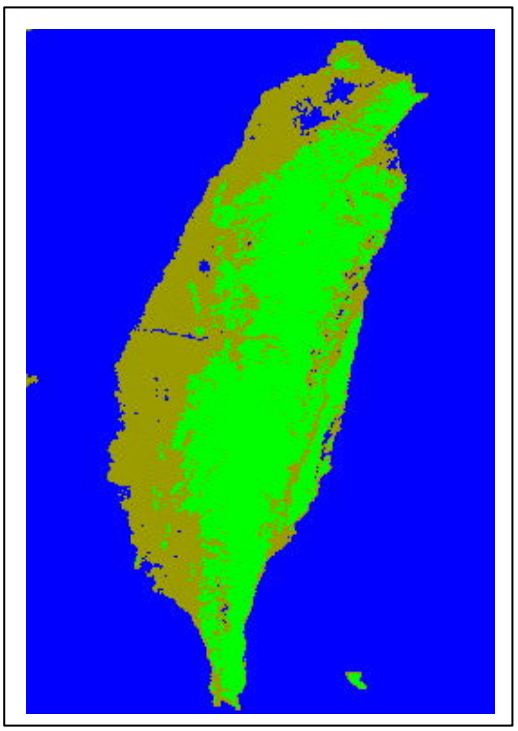

Figure 2. The estimation of the forestlands in Taiwan from NDVI in January 1998.

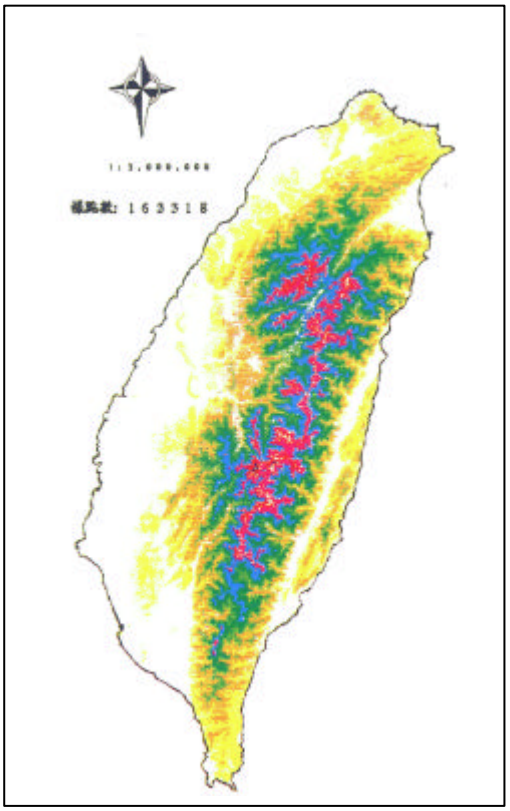

Figure 3. The third survey of the forest resources in Taiwan (Taiwan Forestry Bureau,1995).