PV RESOURCES ANALYSIS IN WORLD SIX DESERTS WITH DETECTING SEASONAL DIFFERENCES AMONG SATELLITE IMAGES

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ABSTRACT

In this paper, the resource of very large-scale photovoltaic power generation (VLS-PV) systems in deserts was estimated by remote sensing approach. The surface conditions for the VLS-PV system installation are basically required to be flat, rigid. The algorithm has been intensively improved by integrated evaluation approach with three kinds of layers. Also, vegetation index analysis has been for tuning seasonal differences among satellite images. The accuracy was verified by comparing to field investigation data in Gobi and Sahara deserts, and has improved spectacularly. Realistic PV resources in world six deserts have been identified by the new algorithm, and it is huge.

1. INTRODUCTION

Very large scale photovoltaic power generation (VLS-PV) system has been studied in order to resolve the world energy and environment problems in recent years. It's contemplated that a desert is very suited for VLS-PV system and has very large energy resource, because a desert has a lot of solar irradiation and a large unused land. However, the VLS-PV system can be put in not all deserts area. In this study, The surface condition for the VLS-PV system installation are basically required to be flat, rigid, and not to be covered with sand.

To calculate concrete resource of photovoltaic system in deserts is very useful for energy plan and installation plan of VLS-PV system. But, it is almost impossible to conduct a field survey at all area. Therefore, in this study, authors selected a remote sensing approach using satellite images for finding a suitable area easily for the VLS-PV system from very large desert area. However, because acquisition condition of satellite image is not same, solution to the problem is necessary. The fundamental algorithm was proposed by Sakakibara et al [1]. It is not enough considered seasonal differences by satellite images. Research purposes in this paper are to improve the analysis method which includes a function of detecting differences between images, and to analyze realistic PV resources in world deserts.

2. SATELLITE IMAGES AND ANALYSIS AREA

2.1 Satellite Images

In this paper, the two satellite images were used for an analysis algorithm. One of the satellite is LANDSAT-7/ETM+ images which are available at web site of the Global Land Cover Facility (GLCF) [2]. It is converted from original image to reflectance [3]. Another is a Normalized Difference Vegetation Index (NDVI) data set which is calculated from NOAA/AVHRR images. This NDVI dataset are released at web site of the Center for Environmental Remote Sensing (CEReS) [4]. The yearly maximum NDVI ($NDVI_{ymax}$) was calculated from the NDVI dataset. For smoothing yearly climate variability, five-year average of $NDVI_{ymax}$ was used, since the amount of precipitation of desert differs widely each year.

2.2 Analysis Area

The world six major deserts (Gobi, Sahara, Great Sandy, Thar, Sonora and Negev) were decided as analysis area. The details of analysis area are shown in Table I. The number of used Landsat-7 images was 361 and the sum of analysis area is over 10 million km^2. It covers about 6.9% of the surface of the earth.

Table I. Analysis area and numbers of landsat-7 images

Name	Number of images	Analysis area [10^3 km^2]
Gobi	68	1,522.6
Sahara	254	7,166.4
Great Sandy	12	372.5
Thar	15	671.5
Sonora	6	26.28
Negev	6	26.31
Total	361	10,258.8

3. ANALYSIS METHOD

It has been intensively improved by integrated evaluation approach with three kinds of layers; the land surface classification by Most Likelihood Classifier

(MLC), the edge extraction of undulation ground by filtering and analysis of the vegetation level by vegetation index (NDVI). The suitable area was estimated by integrating three layers by judgment condition each MLC classes. An estimation result leads true determination even if the misclassification occurred in the MLC layer. Therefore, the new algorithm reduced the erroneous decision.

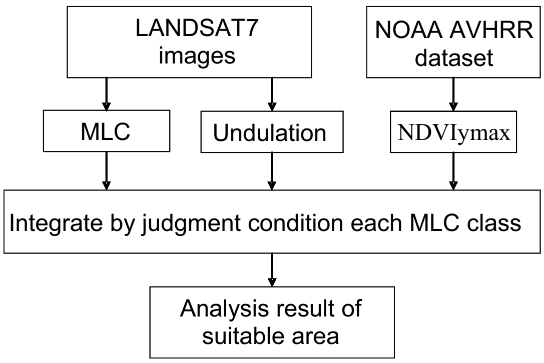

Fig. 1 A flow chart of the algorithm

4. ANALYSIS RESULT

The some parameters for the algorithm were set by using each desert data. The six deserts (Gobi, Sahara, Great Sandy, Thar, Sonora and Negev) were analysis by the new algorithm. The analysis result is shown Table II. A rate of suitable area in Gobi desert was 54% and it is larger than previous result as 47%. The sum of suitable area is about $5x10^6$ km^2 and the average of the rate is near 50%. It is very large potential for PV system.

Table II. Analysis result and rate of suitable area

Name	Suitable area [10^3 km^2]	Rate [%]
Gobi	826.7	54
Sahara	3,163.9	44
Great Sandy	286.5	77
Thar	425.7	63
Sonora	177.0	67
Negev	97.0	37
Total	4,976.8	49

The map of analysis result of Gobi desert is shown in Fig. 2. The suitable areas were separated by color and non-suitable areas were painted in black which is based on the level of $NDVI_{ymax}$ [5]. The analysis result has very little gap among satellite images.

In addition, the analysis accuracy was verified by comparing to field investigation data in the Gobi and Sahara deserts. These data which were used for validation consisted of latitude and longitude by GPS receiver and photographs of each place. The dataset of Gobi desert has 46 points data at September 7, 2001. It is the same dataset as before. The analysis accuracy was improved from 74 % to 84 %. Sahara's data has 97 points at September 10, 2004. The accuracy was 75 %. These results were very high accuracy in remote sensing field.

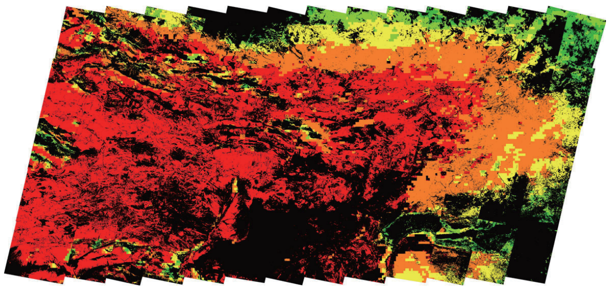

Fig. 2 The analysis result in Gobi desert

5. CONCLUSIONS

The analysis method was improved by an addition of the weight integration method. The six deserts were analyzed by the new algorithm. A half of deserts area is suitable for the PV systems. The accuracy was improved very much. It is concluded that the proposed method can provide sufficient information for the planning of VLS-PV system installations. Additionally, realistic PV resources in world six deserts have been identified by the new algorithm, and it is very large.

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