Development of compositing algorithm using spectrum information for MODIS data

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Abstract:
In this paper suggest the new composite algorithm for MODerate resolution Imaging Spectroradiometer (MODIS) Data. NOAA/AVHRR data was used for a lot of studies for land cover and land cover change extraction since 1981. But a lot of clouds are included in wide area observation data. Therefore clouds obstacle when it does land surface observation. Most of composition method uses only one element such as NDVI or Temperature data for all land cover element include water. So sometimes the result of composite data remains a cloud and shadow effect. TERRA/MODIS has many bands than Landsat/TM and NOAA/AVHRR. It is possible to analyze a state of surface using a lot of bands. For example, some pixel is vegetation area and some is water area.
In this paper, we suggest a compositing technique to be most suitable for MODIS data to use spectrum information. And it did comparison with other compositing technique. As a result, this technique was able to reduce a cloud and shadow influence than other compositing technique.

Keywords: MODIS, Composite, Spectrum Analysis Composite (SAC), MVC, TMinB

1. Introduction

A lot of satellite data begun to be used for resources search and land cover change after launching of Landsat/TM in 1972. Time series NOAA/NASA Pathfinder AVHRR Land Data Set for 18 years was effectively used for mechanism analysis such as desertification, abnormal weather, EL NINO, land cover changes since 1981 to 1999. MODIS is a key instrument aboard the Terra and Aqua satellites. Terra's orbit around the Earth is timed so that passes from north to south in the morning, while Aqua passes south to north in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands.
However, existence of a cloud becomes an obstacle during land cover analysis with wide area observation data. Therefore various studies were done to remove influence of a cloud. There are two methods. One is to select a data that represents the composite period (composite method) and the other is to interpolate a data using the time series data (profile interpolate method). A composite methods are Maximum Value Composite (MVC), Maximum Temperature Composite (MaxT), a Temperature condition, and there are maximum vegetation index method (TMaxN), Temperature limitation minimum blue belt (TMinB). There are Maximum Value Interpolation (MVI), The Best Index Slope Extraction (BISE), Temporal Window Operation (TWO) as an interpolate method.
A conventional composite method select priority sequence of uniformity for all land cover constitution elements with vegetation index (NDVI) or land surface temperature (LST). It is useful on vegetation area. However, the composite method is not good for non-vegetation area such as water, snow, urban, and desert area. Therefore land cover type was specified during a composite period for a certain pixel, and it is the most suitable data for the land cover type. However, it was very difficult to decide a type of land cover during a composite period (water area, snow area, vegetation level, non-vegetation area) with NOAA/AVHRR data. NOAA/AVHRR has o

nly 2 bands in red and near infrared band which are effective for vegetation analysis in wavelengths area visibl e to short wave Infrared. There are blue band, green band, red band, near infrared band and 3 bands of short wave infrared area in MODIS (Table 1). Therefore, the land cover type was decided because MODIS was easie r and wavelength resolution is high as compared to AVHRR. The purpose of this study are 1) decided the lan d cover type and 2)composite a data suitable for land cover type using multi bands.

2. MODIS DATA

TERRA/MODIS and AQUA/MODIS data was received at Tokyo University of Information Sciences since Ma rch, 2001 and began distributing the data. As for the order of MODIS data, access is possible from Tokyo Uni versity of Information Sciences frontier homepage (http://www.frontier.tuis.ac.jp/). To order data records write t he data the choice of a product (MOD02, MOD03, MOD09, MOD11, MOD28), and area (an area in China, a Japanese area), and last the address. Then it is copied in CD or DVD, and it is sent by the frontier secretariat for free. Data format is in BSQ. MODIS data format is HDF but BSQ is easier to handle than HDF to analyze a program. The product used in this study was only reflection data of MOD09 (500m resolution), but used se a surface temperature of MOD28 (1km resolution), observation condition data set of MOD03 (sensor zenith an gle , sensor azimuth angle, sun zenith angle, sun magnetic angle, 1km resolution) for comparison with other composite method.

3. Land cover type determination by profile analysis

Each pixel observed from a satellite was by linear mixture model of five types such as vegetation, non vegeta tion land (Soil etc), snow, cloud, and water. A characteristic of a spectrum that was examined from an average of 100 pixels from MODIS data according to each type was extracted. As a result, an land coverage for each type was estimated. Therefore a spectrum was analyze during a composite period of each pixel and decided lan d cover type. An algorithm is as follows (fig 1).

1. Land cover is a vegetation area if there is a characteristic of vegetation area in at least one of the composit e period.
2. Land cover is non-vegetation land area if it has a land characteristic but no vegetation characteristic.
3. Land cover is a water area if there is a characteristic of water area in at least one of the composite period.
4. If it is not included in any of the three, if there is a characteristic of snow area in more than half of the c omposite period the land cover is a snow area.
5. It is not included in any of the four types the land cover type is cloud area.

For example when in the case of flood map making, if judgment of water area priority is higher than that of l and type (Vegetation and bare soil) is possible. In addition, making of a snow map during a composite period is possible when making a map of snowy distribution by doing an item of a snow judgment with precedence.

4 Decision of a composite index according to each type

Each spectrum is considered as a result of mixture by an element of the five profiles during a composite peri od (vegetation, non-vegetation land area, snow, water, a cloud) and judged land cover type to be from profile a nalysis. In this paper, it suggests a composite method for four land cover types (vegetation area, non vegetation land area, water area, snow area) except a cloud area.

A supposition of this study: When an observation condition is the same all the data observed in a satellite are the same during the composite period. However, all the profiles observed in a satellite influence by the atmosp here (a cloud) and difference of an observation condition are different. As for band 3, a value becomes big by the atmosphere and satellite zenith angle. It is thought that the smallest value of band 3 has little atmosphere e ffects. Therefore I revised a profile so that all the value of band 3 of each profile became the same as lowest band 3 during a composite period (fig 2). The index is calculated from the revised profile for land area (vegeta tion area and non vegetation land area).

Vegetation area index: Select the maximum Vegetation Index

Vegetation Index = (m_b2 - m_b1) + (m_b4 - m_b1)

Non vegetation land area (desert area and urban area): Select the maximum Soil Index

Soil Index = (m_b2 - m_b1) or (m_b2 – m_b4)

Here m_b1, m_b2 and m_b4 are a value of band1, band2 and band4 after having revised a profile.

Water area composite method :

Area of the water composite uses the Maximum value of temperature. However, I cannot always say that the t emperature of the atmosphere is lower from area of the water. There are many samples observed that temperat ure becomes lower when it is chilly. Therefore I can reduce the influence of a cloud by choosing the maximu m temperature data among water profile as judged during a composite period. The day that has the maximum t emperature in the profile that has been judged as a water profile. Or it is minimum band3.

Snow area composite method :

When land cover type during a composite period was judged as snow, I choose profile of the maximum value of snow index. Band 6 and 7 of short wave infrared are very effective to distinct a cloud and snow.

Snow index = b2 + b7 – 2 * b6

The area that is not a type of ground (cloud and Hays) chooses the profile when band A is the least.

5. Result

1) A composite result and a land cover map

A composite was done with MOD09-HKM which was level 2 of a MODIS data product (500m resolution). The tested areas are Northern part of China and Hokkaido from January to December 2003. In this study, the land cover was decided during a composite period before doing a composite. Fig 3a) is a composite result and fig 3b) is land cover type from June 1 to 10th 2003 in Hokkaido. A thin cloud is seen from a composite image. As a result, a profile of the forest was judged as the land area that changed as influenced by a cloud. It was understood from fig 3b). In addition, it is judged as the forest in the area where there is no clouds. The result of a composite from the border of non vegetation area and vegetation area has smoothly changed fig 3a).

2) Comparison with other composite methods

The representative composite methods that reduces the cloud effect are MCV and TMinB. This study compares the method suggested (Spectrum Analysis Composite :SAC) and the two methods. figure 4a is the result of SAC method, 4b is MVC and 4c is TMinb. As a result, SPC method and MVC method are almost the same results for land area. There is a thin cloud left as a result of TMinB. The cause is because the temperature with a cloudy atmosphere is 3 degrees higher than the temperature during a clear day. Temperature with thin cloud is 23 degrees. Temperature with clear day is 13 degrees. The SAC method is also suitable to reduce a influence of cloud shadow. A shade of a cloud is left by MVC and TMinB method (fig 5). The reason is because a shade's temperature is 3 degrees higher than the temperature during a clear day.

6. Conclusion

The purpose of this study is to suggest a new method using a profile to remove the influence of cloud. A regular method is a method of uniformity by an index (vegetation index, temperature, a blue band) whole area observed by satellite. As a result, influence of a cloud is left by a kind of land cover. Therefore, In this study it examined the influence of a cloud from a profile observed by satellite. Because, in the MODIS data there are more bands than NOAA data for land cover, therefore during the composite with MODIS data, SAC method is more effective by MVC and TMinB.

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Table 1 Comparison of MODIS, AVHRR and TM (Wavelength nm)

	NOAA/AVHRR	Landsat/TM	Terra/MODIS
Blue		450-520	459-479
Green		520-600	545-565
Red	580-680	630-690	620-670
NIR	725-1100	760-900	841-876

SWIR			1230-1250
SWIR		1500-1750	1628-1652
SWIR		2080-2350	2105-2155

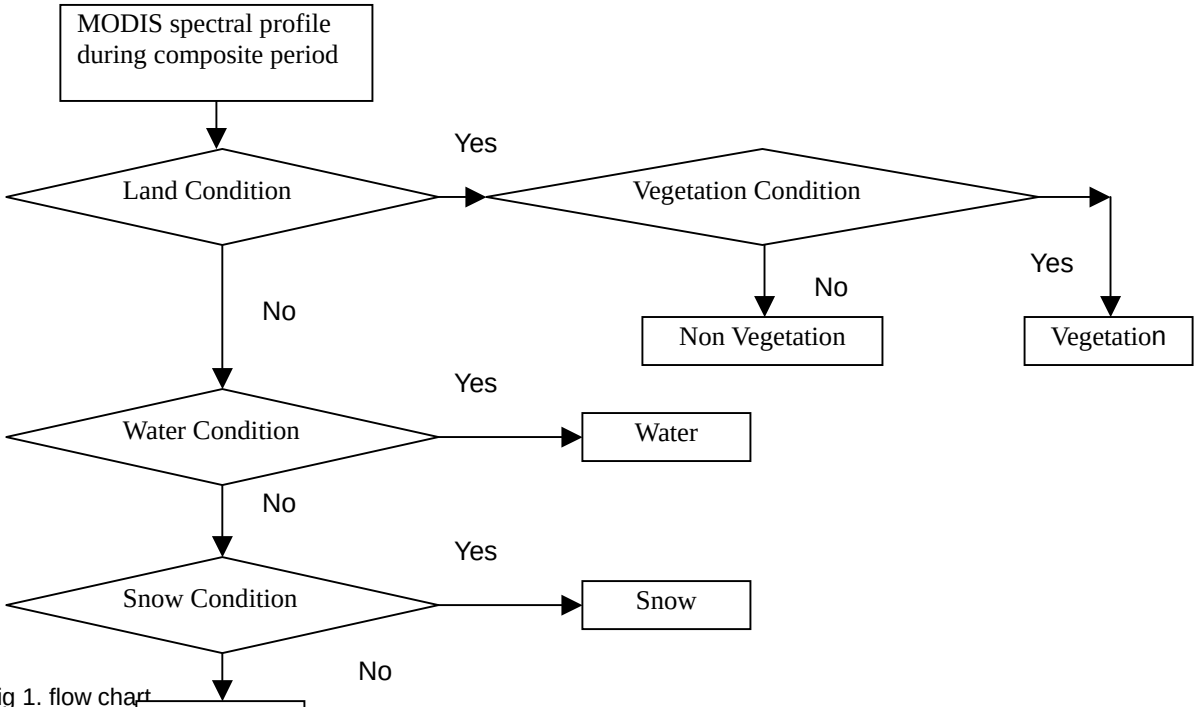
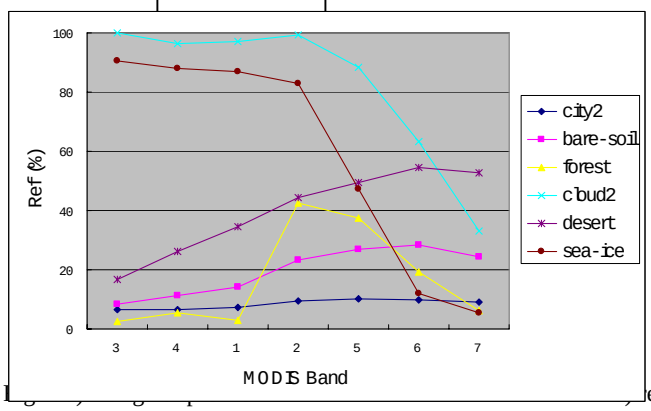
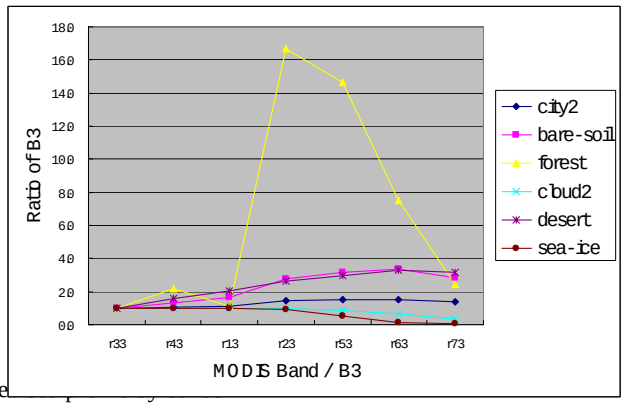


Fig 1. flow chart





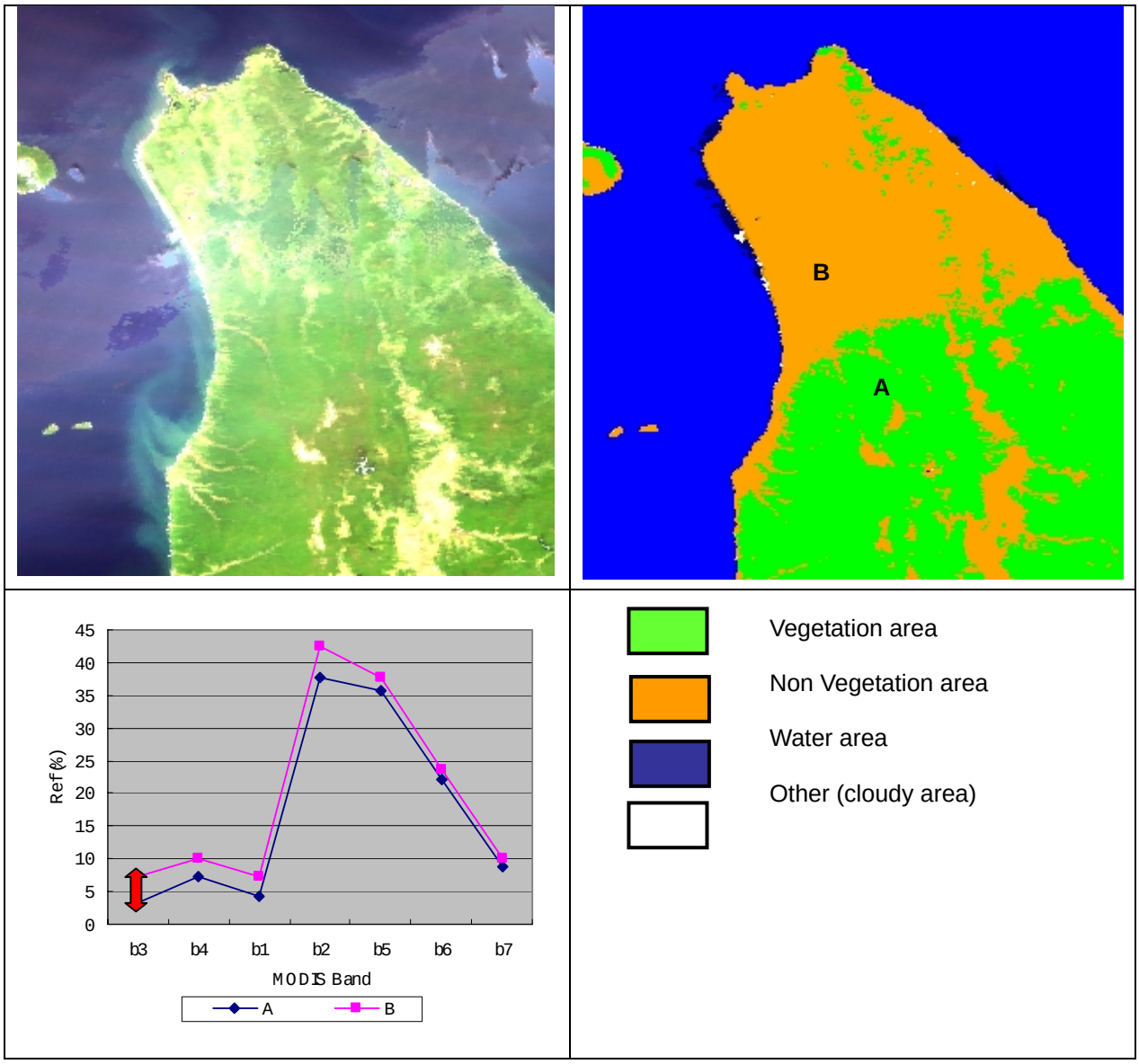
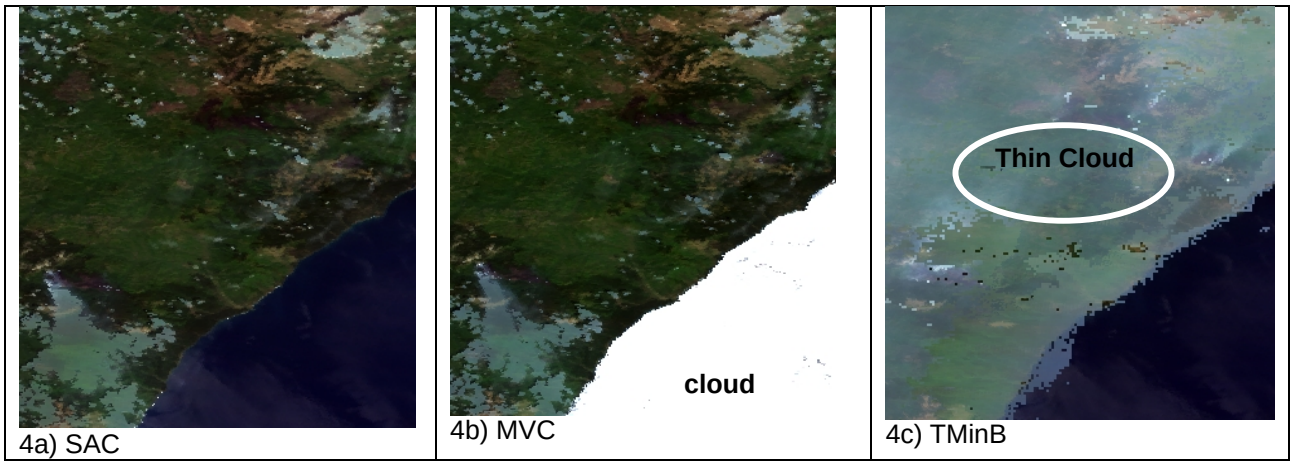
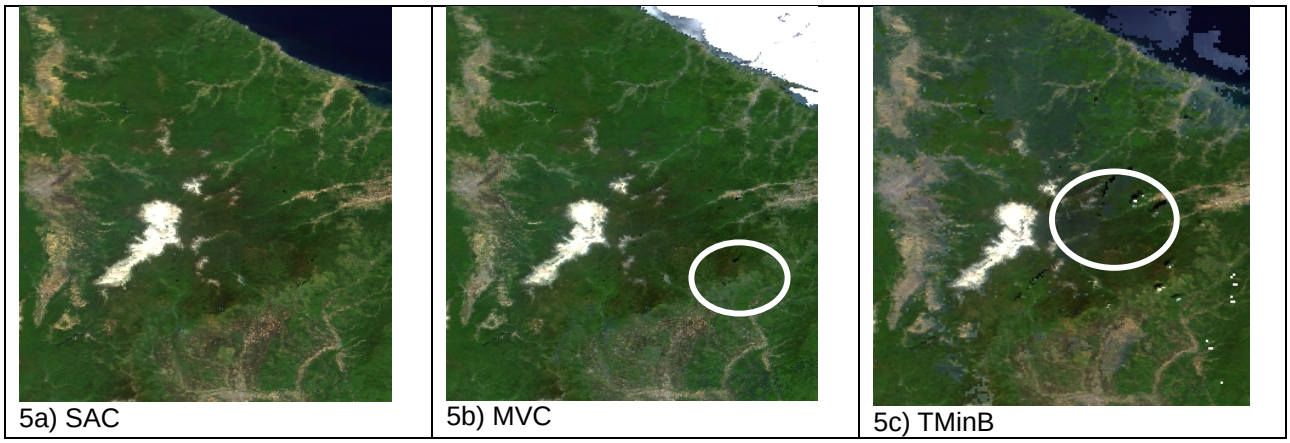


Fig 3. composite result during june 1 to 10th 2003 in Hokaido



4a) SAC 4b) MVC 4c) TMinB

Fig 4 Result of three composite methods in northern part of china. Influence of thin cloud is left MVC method and TMinB.



5a) SAC 5b) MVC 5c) TMinB

Fig 5 Result of three composite methods in northern part of china. Influence of cloud shadow is left MVC method and TMinB.