CLOUD CLASSIFICATION WITH LAND COVER INFORMATION IN MODIS DATA

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Abstract: Discrimination between cloudy and clear-sky areas poses an important issue for satellite remote sensing because clouds have a large impact on radiance. It is necessary to distinguish cloudy areas from clear ones before further analysis of the images. Many algorithms have been proposed for cloud classification. Ackerman has developed an algorithm in 1998, referred to as MOD35, for operational cloud mask data of MODIS observation. MOD35 consists of many threshold tests with static threshold values. For the land cover types, it considered four possible surface-type processing paths: land, water, desert, or coast. If multiple surface-types are assigned to one pixel, the algorithm chooses the most important characteristic for the cloud masking process, and the precedence are coast, desert, land or water. In this study, we modify this algorithm in two aspects. First, we further classify the land into vegetated area, urban and bare soil area. Secondly, we consider each pixel as mixed pixel of different surface-types and perform spectral unmixing. The preference of surface-types will depend on their abundance in that pixel. The comparison of experimental results will be conducted with MODIS data.

1. INTRODUCTION

The cloud mask is important for retrieving informations like surface temperature or humidity from clear sky areas. Because we care about the changes in the weather, where H_2O plays an important role, we want to know well about the distribution of clouds. The MODIS (Moderate-Resolution Imaging Spectroradiometer) provides global observations of Earth's land, oceans, and atmosphere in the visible and infrared regions of the spectrum with 36 bands from 0.4 to 14.5 μm (see table 1). Different spectral bands can make the same position pixel appear cloudy and clear in another. We refer to the threshold method using in MODIS cloud mask. Try to find the proper threshold with different land cover and different cloud type.

2. METHODS AND EQUATION

Clouds are generally characterized by higher reflectance and lower temperature than the land surface. Simple visible and infrared window threshold approaches offer considerable skill in cloud detection. However, surface conditions reduce cloud-surface contrast in certain spectral regions (e.g., bright clouds over snow and ice). Cloud types such as thin cirrus, low-level stratus at night, and small cumulus typically have low contrast with the underlying background. The land classifications we use the product of MODIS yearly land cover type (MCD12Q1) with four types of land, ocean 、vegetation 、non-vegetation and urban.

There are three groups in order to detect different cloud types. (1) thick high cloud (2) thin cloud (3) low cloud. Follow (Ackerman 1998.) each group contains different tests. (1) band 31 and band27 (2) band31-band32 、band29-band31 、band31-band20 、band31-band27 and band(21/22)-band31 (3) band2 、band1 、band18 and band (21/22)-band20.

Assign a value between zero and 1 for each test, where zero represents high confident cloudy, 1 represents high confident clear (shows in figure 1). If the observed value is larger (smaller) than the upper limit (lower limit), the pixel is discriminated with high confidence as clear (cloudy) and assigned the confidence level of 1 (0).

$$G_{i=1,3} = \min[F_i]$$

where, means the confidence indicators for the individual tests within that group.
The cloud mask Q is determined from the product of the minimum confidences of each group.

$$Q = \sqrt[N]{\prod_{i=1}^{N} G_i}$$

The cloud mask reports four levels of confidence that the FOV has a non-obstructed view of the surface: confident clear (Q > 0.99), probably clear (Q > 0.95), undecided (Q > 0.66), and cloudy or obstructed (Q 0.66). This approach is conservative in the estimation of clear sky, the cloud mask will err on the side of too many cloudy reports rather than too many clear-sky reports. If any test is highly confident that the scene is cloudy ($F_i = 0$), the confidence that the scene is clear will be Q = 0.

Table 1: MODIS Channel Number, Wavelength, and Primary Application

band	wavelength µm	Reflective(O)/Emissive(X) bands	Primary Application
1(250m)	0.659	O	Land/cld bondaries
2(250m)	0.865	O	"
3(500m)	0.470	O	Land/cld properties
4(500m)	0.555	O	"
5(500m)	1.240	O	"
6(500m)	1.640	O	"
7(500m)	2.130	O	"
8	0.415	O	Ocean color/chlorophyll
9	0.443	O	"
10	0.490	O	"
11	0.531	O	"
12	0.565	O	"
13	0.653	O	"
14	0.681	O	"
15	0.750	O	"
16	0.865	O	"
17	0.905	O	Atm water vapor
18	0.936	O	"

19	0.940	O	"
20	3.750	X	Sfc/cld temp
21	3.959	X	"
22	3.959	X	"
23	4.050	X	"
24	4.465	X	atm
25	4.515	X	"
26	1.375	O	Cirrus clouds
27	6.715	X	Water vapor
28	7.325	X	"
29	8.550	X	Sfc/cld temp
30	9.730	X	ozone
31	11.03	X	sfc/cld temp
32	12.02	X	"
33	13.335	X	Cld top
34	13.635	X	"
35	13.935	X	"
36	14.235	X	"

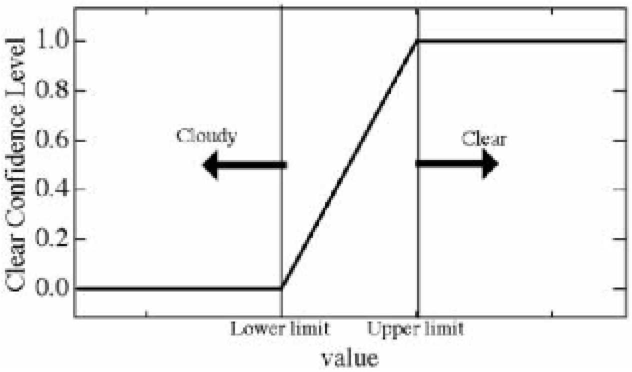

Figure 1: Concept of the clear confidence level with two threshold values, the upper limit and the lower limit.

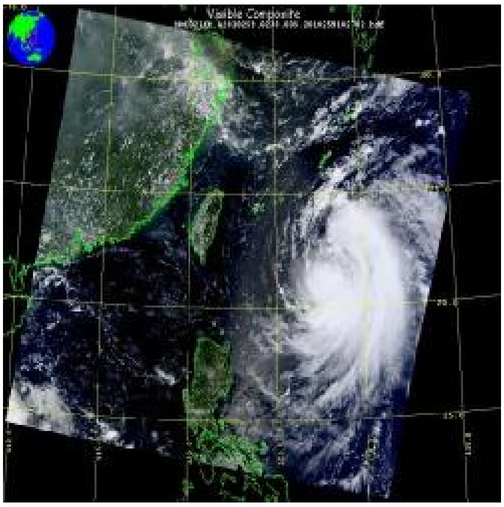

Figure 2: MODIS data in RGB.

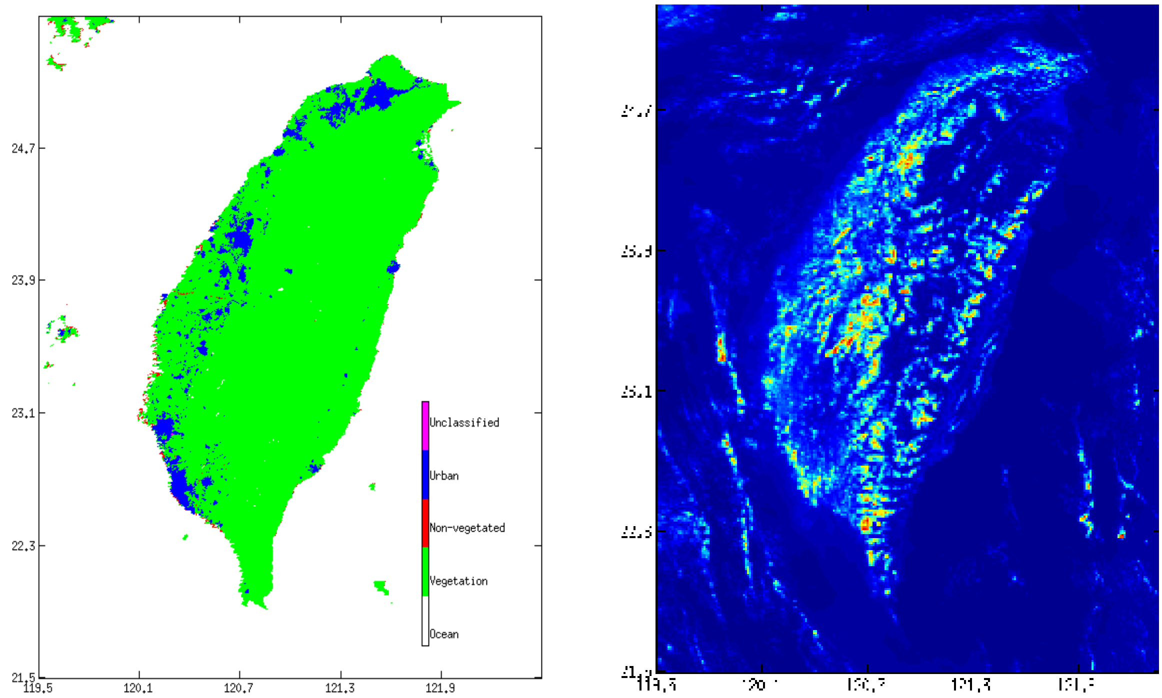

Figure 3: The left is Taiwan land cover classification in 2010 with MODIS MCD12Q1, right is band 1 reflectance of MOD021KM.

3. RESULTS

The results compare to the MOD35 because the adding tests are more fit and adjustable. The algorithm is versatile to be applied to various satellites equipped with different channels, because it can be adjusted simply by adding or removing certain threshold tests according to the wavelength of the available channels.

4. CONCLUSIONS & RECOMMENDATIONS

The cloud classification is more than a simple yes/no decision. Results from observations by different instruments may be different even when the same bands are used. The different cloud conditions are detected by different tests. Spectral tests which find similar cloud conditions are grouped together. We still need to consider different instruments and compare with different tests to check the accuracy of each result.

REFERENCES:

References from Journals:
S. A. Ackerman, K. I. Strabala, W. P. Menzel, R. A. Frey, C. C. Moeller, and L. E. Gumley," Discriminating clear sky from clouds with MODIS", JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 103, NO. D24, PAGES 32,141-32,157, DECEMBER 27, 1998.
Ishida, H., Nakajima, T.Y., "Development of an unbiased cloud detection algorithm for a spaceborne multispectral imager", JOURNAL OF GEOPHYSICAL SEARCH, VOL. 114, D07206, 2009.