CLOUD MASK FOR MODIS

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ABSTRACT:

Clouds are both a source of information and a hindrance to the retrival of remote sensing data from the atmosphere. They are particulary important in the energy budget calculation of the earth. This is because clouds are a good shield from infra-red radiation, reflect the visible solar band back into space and cause greenhouse effect by trapping infra-red radiation in the atmosphere (S.G Jennings (1992)). Hence it is important to be able to determine the cloud pixels from remote sensing data and use it to study the distribution of clouds in our atmosphere. Moreover clouds filter out important remote sensing data from the atmosphere hence it is essential to filter out cloud pixels, especially in the creation of Mosiac in any ROI. In this paper, the thermal band at 11.03μm and 3.7μm will be utilised in the determination of the cloud pixels or cloud mask.

1. INTRODUCTION

Clouds exists in a great variety of spatial and physical distribution. They generally exist at three different heights in the atmosphere;in the ranges of 6000 m and above for high clouds, 2000 m to 6000 m for middle clouds and 2000 m and below for low clouds (Lutgens and Tarbuck (1999)). Clouds can be further classified into 10 different types each with its drops density and Mode radius(Jacquelinw Lenoble (1993)). From the classification, there are clouds which are optically thin to certain bands of radiations due to the fact that the refractive index of water is a function of wavelength and each kind of cloud species has a different drop density and Mode radius. The cloud masks of both general and thick clouds is generated by using the different emissive bands of Modis.

2. THE PHYSICS OF THE PROBLEM

Clouds are almost opqaue in the infra-red region while highly reflective in the visble range of the electromagnetic spectrum. The opqaueness of clouds can be accounted due to a very high absorption coefficent $\beta_{a\lambda}$ especially in the region where the wavelength $\lambda$is greater than 1 nm (Murry L.Salby (1996)). Coupling its optical properties with the planck equation in equation (1), this was used as a basis to obtaining the cloud mask in this paper.

$$B_\lambda(\lambda) = \frac{2hc^2}{\lambda^5(\exp^{\frac{hc}{kT\lambda}} - 1)} \tag{1}$$

The temperature could be determined from the radiance by inverting equation (1). With this temperature, a cloud pixel could be determined by a threshold value. This threshold value is usually smaller than a non-cloud pixel.This is because of the fact that the radiance from the earth's surface will not be able to penerate through the optically thick cloud and the temperature of the cloud is basically colder than the earth's surface in the tropics. One of the errors inccured in the determination of the surface temperature of the earth's surface is the great variation in the emissivity of the earth's surface. In the determination of the cloud mask, a threshold value is determined via histogram method. For cloud pixels that has a temperature lower than this threshold value , it is detemined to be a cloud pixel. This method is used to determine a thick cloud pixel.

Since MODIS has a total of 36 bands and a good number of bands in the infar red region , it is important to determine the band from which the Cloud Mask would be constructed. indent: Standard input:1: Warning:Unterminated character constant The first band that would be used would be band 31 centering at 11.03 $mathnormal\mu$m and band 20 centering at 3.75 $mathnormal\mu$m. This former band was chosen because the earth 's emssive band at 300K is center around a dominant wavelength of 9.66 μm(John R.Jensen (2000)). This band also lies in the regions where there is absence of absorption due to molecular water and carbon dioxide (John R.Jensen (2000)). This band is the principal band used to determine the thick cloud pixel. By using a histogram method, the temperature threshold for the thick cloud pixel is obtained. For the determination of a general cloud pixel, the temperature difference between the 3.7 μm and 11.03 μm channel is used. The temperature difference in this two channels would be negative s

ince electromagnetic radiation is able to penerate the 3.7 $mathnormal\mu$m more easily (Murry L.Salby (1996)

) and hence would have a larger temperature obtained by inverting equation (1).

The stronger electromagnetic absorption in the 11.03 μm channel can be explained by the fact that the complex refractive index is about 28 times larger than that of the 3.7 μm channel (Jacquelinw Lenoble (1993)). These two distinct properties can be used to obtain a threshold value for the two type of cloud pixel. However, one important consideration would be the difference in threshold values due to the land and sea mass that it is covering. In total four different thresholds has to be determined.

3. THE ALGORITHM

The threshold for the Cloud Mask(thick cloud) was first obtained by creating a temperature mask of the land and sea mass respectively. This was done by abstracting the radiance of the MODIS satelite from the Earth View Emissive Bands. The data from the band is in scaled unsigned integer format hence there is a need to transform it into radiance. This is done by equation (2).

$$Radiance = radiancescale * [Data - RadianceOffset] \tag{2}$$

From the Radiance, the temperature is obtained from equation, assuming a emissivity is 1. From the temperature Mask, the histogram is obtained. The histogram for clouds over sea and land is generatred. A Typical histogram is shown in figure 1. From the histogram any transitioal change in the plot represents a likelihood of the transitonal temperature threshold. From figure 1, the circled portion indicates a possible threshold value. Simlarly the temper-

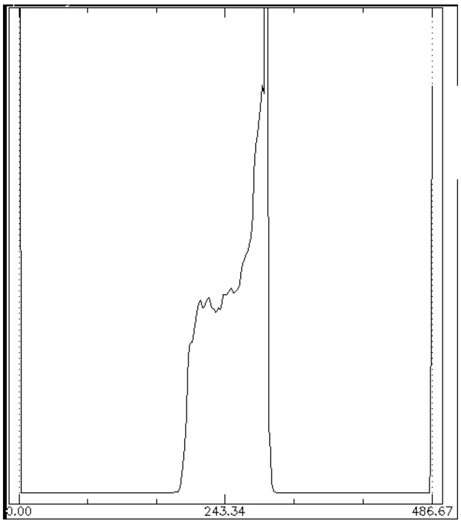

Figure 1: The figure a typical histogram obtained for region over the sea.

ature threshold for the general cloud mask is obtain by creating a mask of the difference in the temperature for two emssive channels. From the histogram, the threshold value is obtained simarly. However the thresholds obtained in such a manner is compared to a true colour image to confirm the temperature selected. However there are cases where the clouds are too sparse to obtain threshold value from the histogram. Hence the threshold value is obtained by corrsponding clouds observed in the true colour image with the regions in the temperature mask. The value is taken to be the value at the boundary of clouds. From the threshold values obtained, four inequalities are set.For the thick cloud mask, any pixel that has a temperature less than the threshold value will be termed as a cloud pixel. For the general cloud mask, any pixel that a temperature greater than the threshold value will be set to be a cloud pixel.

4. RESULTS

The various cloud masks was obtained. However some of the histogram failed to give a clear threshold value as they have smooth histograms. One possible reason is that the scene was sparsely covered by clouds. This leads to the lack of cloud pixels to show any tranistional changes in the histogram. The cloud mask for thin and thick cloud with the actual scene is shown in figure 1,2 and 3 respectively. This mask is one of the five scenes that was tested with the cloud mask algorthm.

Figure 2: The figure shows the general cloudmask.

Figure 3: The figure shows the thincloudmask.

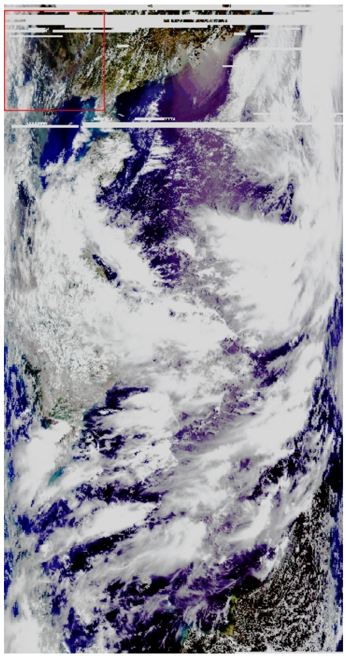

Figure 4: The figure shows the scene in true colour.

The cloud masks are able to mask out the cloud pixels quite effectively. The general cloud mask is capable of removing low clouds and thin clouds.

5. DISCUSSION

From the various scenes that were tested, only a couple of scenes did not give a threshold from the histogram. This is could be due to the lack of cloud pixels to give a good and distinct transitional change in the histogram. Hence the threshold was determined by random sampling of the temperature mask against prominent clouds to give a estimated threshold. From the 5 scenes that was tested, the temperature thresholds of the clouds were not identical for every scenes. From the 5 different cloud masks that were obtained, this algorithm has been tested to be reliable. However one of the weakenes in the algorithm is that it is very dependent on the portion of cloud pixels in the scene. If there is a fairly large amount of clouds, it gives a very clear and distinct threshold from the histogram, however the histogram method will fail if there are insuffcient amount of cloud pixels. Then the threshold has to be determined by visual method. However this method gives the advantage of the error incurred in the obtaining the surface temperature, especially for the great variation of surface emssivity of the earth's surface. This is especially true in the tropics where there is great amount of forests and different vegation. For the 5 scenes tested, they are selected to be in the region of South East Asia, hence providing a reliable cloud mask for the region in spite of the inaccuracy in obtaining the cloud mask.

6. CONCLUSION

The Cloud masks were able to mask out the clouds pixels from the 5 scenes that were tested. The threshold values are not the same for very scene. This could be due to the different Sun Azimuth angles, weather and other numerous factors that could be involved for the particular scene that was anaylsed. Though this method is unable to generate cloud mask base on many physical factors, but it is able to generate a cloud mask based on a empirical approach. Much more work can be done to investigate the various optical and physical properties of clouds to generate a sempircal mask.

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