Landsat 7 Automatic Cloud Cover Assessment

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ABSTRACT

An automatic cloud cover assessment algorithm was developed for the Landsat 7 ground system. A scene dependent approach that employs two passes through ETM+ data was developed. In pass one, the reflective and thermal properties of scene features are used to establish the presence or absence of clouds in a scene. If present, a scene-specific thermal profile for clouds is established. In pass two, a unique thermal signature for clouds is developed and used to identify the remaining clouds in a scene. The algorithm appears to be a good cloud discriminator for most areas of the Earth. Some difficulty has appeared in imagery over Antarctica, and snow at high illumination angles is occasionally mistaken for cloud.

Keywords: Landsat, ETM+, clouds, classification, ACCA, algorithm

1. INTRODUCTION

A primary goal of the Landsat 7 mission is to provide a global seasonal archive of cloud-free imagery over the Earth's landmasses. To achieve this goal, 250 images or scenes are acquired each day by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and archived. Mission success is determined by the cloud-free nature of each scene acquired. An automatic cloud cover assessment (ACCA) algorithm was deployed for ascertaining the cloud component of each ETM+ image prior to archiving. The resulting cloud cover assessment scores are subsequently used by mission planners to reschedule failed acquisitions, and by users to filter cloudy scenes from database queries.

Discerning clouds from underlying terrain seems intuitively straightforward. Clouds are white and colder than the land surface they obscure and these properties match up well with the multispectral response characteristics of the ETM+. Cloud and land surface variability, however, creates problems. Wide reflectance and temperature profiles for clouds do occur within and between scenes. A cloud signature that works well for one scene may be ineffective for another. Accurate cloud identification is also affected by surface features (e.g. snow, white sand) that have reflectance signatures that are similar and in some cases identical to clouds in the ETM+ bands.

A scene dependent approach for identifying clouds was developed for Landsat 7 to minimize the effects of cloud variability. The algorithm handles the cloud population in each scene uniquely by examining the image data twice. The first pass through the data is designed to capture clouds and only clouds. Eight different filters are used to isolate clouds and to eliminate cloudless areas and problem land surface features such as snow and sand. The pass one goal is to develop a reliable cloud signature for use in pass two where the remaining clouds are identified.

2. EARLIER WORK

The General Electric Corporation built one of the first Landsat 4 and 5 ground processing systems for the U.S. Government. The primary payload of these two satellites is the Thematic Mapper (TM) and the ground system was aptly name the Thematic Mapper Image Processing System (TIPS). The original ACCA algorithm was incorporated as part of TIPS.[1.] Processing limitations of early 1980 computers imposed constraints on the TM ACCA algorithm. To reduce computational load, only three bands were examined, and these were sub-sampled by a factor of 16. The original scenes, 6112 samples by 5984 lines in size, were reduced to 382 by 374 images for determining cloud statistics.

The TM ACCA algorithm is a single pass process that employs radiance thresholds to determine whether pixels are cloud contaminated. Prior to assessment, bands 3, 5, and 6 are radiometrically corrected to absolute units of radiance using pre-launch correction coefficients. The bandwidths for the TM and ETM+ multispectral channels are essentially the same and are shown in Table 1. Each sub-sampled pixel from band 3 is compared to a threshold to determine its brightness and then against band 6 for a cold response. If the pixel is both highly reflective and cold, it is assumed to be either a cloud, snow, or ice. The corresponding pixel in band 5 is then evaluated against a threshold to separate clouds from ice or snow.

At the time of algorithm development a substantial variation was noticed in cloud pixels identified in band 6 data that made a fixed threshold insufficient. An experiment was performed to identify the parameters that influence the band 6 radiance values. The results showed a dependence on both the sun elevation angle and the percentage of snow in a scene. The final TM algorithm dynamically adjusted the threshold for band 6 to account for these two factors.

Table 1. TM and ETM+ Bandwidths (μ)

Sensor	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8
TM	.45 - .52	.52 - .60	.63 - .69	.76 - .90	1.55 - 1.75	10.4 - 12.5	2.08 - 2.35	N/A
ETM+	.45 - .52	.53 - .61	.63 - .69	.78 - .90	1.55 - 1.75	10.4 - 12.5	2.09 - 2.35	.52 - .90

Once TIPS became operational, the user community discovered that sometimes the ACCA scores failed to reflect the actual cloud content in a scene. Analysis revealed the algorithm's deficiencies: it was insensitive to warm clouds, was an imperfect snow/cloud discriminator, in cold landscapes it frequently classified highly reflective features (e.g. tundra, deserts) as clouds, and it performed poorly at low sun elevation angles. To be fair, the Landsat 5 ACCA algorithm was designed 20 years ago for computer systems that could not exploit the full potential of TM data for cloud discrimination.

3. LANDSAT 7 GROUND SYSTEM OVERVIEW

The Landsat Ground Station (LGS) at the EROS Data Center (EDC) in Sioux Falls acquires wideband data directly from the Landsat 7 spacecraft by way of two 150-megabit-per-second (Mbps) X-band return links. The LGS separates each X-band signal into two 75 Mbps channels (I and Q), and transmits the acquired wideband data over four output channels to the Landsat Processing System (LPS). An I-Q channel pair represents a complete data set. One channel holds bands 1 through 5 and a low gain format of band 6. The other channel holds bands 7 and 8 and a high gain form of band 6.

The LPS retrieves and processes each channel of raw wideband data and produces separate files of Earth image data, calibration data, mirror scan correction data (MSCD), and payload correction data (PCD). Files containing bands 1 through 6, and 6 through 8, become formats 1 and 2, respectively. Metadata are generated for the multi-scene telemetry and on a scene-by-scene basis. The LPS spatially reformats Earth imagery and calibration data into Level 0R data. The image data, PCD, MSCD, calibration data, and associated metadata are bundled for each format and sent to the EDC Distributed Active Archive Center (EDC DAAC) for archiving. The two formats of data are united when a Landsat 7 0R product is ordered.

The LPS also performs cloud assessment for each Landsat 7 scene. The bands used by the ETM+ ACCA algorithm were influenced by the LPS design. LPS performs format 1 and format 2 processing on separate computer strings. Only one string could host the ACCA code. The algorithm was developed to operate on format 1 data because of the importance of bands 2 and 5. The low gain form of band 6 is always included in format 1. This too is important for ACCA due to the band’s wider temperature sensitivity. The actual bands utilized by ACCA are 2 through 5 and the low gain form of band 6. Band 1, which is strongly affected by haze, has limited utility and is not used.

During LPS processing, format 1 bands are duplicated, radiometrically corrected, assessed for cloud cover content, and used to generate browse imagery. The radiometric correction conversion coefficients required by LPS for are extracted from the Calibration Parameter File (CPF). This file is maintained by the Image Assessment System (IAS) and contains essential parameters required for radiometric and geometric processing. The LPS generates cloud cover scores on a scene-by-scene and a quadrant-by-quadrant basis. The browse imagery and cloud cover scores are sent to the EDC DAAC for use as online aids to ordering.

4. LANDSAT 7 ALGORITHM

The Landsat 7 ACCA algorithm requires that ETM+ data be converted from raw digital numbers to units that are more scientifically useful. Bands 2 through 5 are converted to top of atmosphere (TOA) reflectance, and band 6 is converted to at-sensor temperature.[2.] The unit conversion provides a basis for more normalized comparison of data within a scene and between scenes acquired on different dates. Detector normalization removes within scene responsivity differences while conversion to reflectance removes the cosine effect of different sun elevation angles across time and space.

4.1 Radiometric Formulation

The conversion from ETM+ radiometrically raw data to reflectance and temperature is formulated as follows:

In spectral band i, the image quantized level Q_i (in counts) is related to TOA radiance L_i^* (in Watts/(m^2 sr µm)) by

$$Q_i = G_i L^*_i + Q_{0i} , \qquad (1)$$

where G_i is sensor responsivity (in counts per unit radiance) and Q_{0i} is the zero-radiance bias (in counts) in spectral band i. The zero-radiance biases are based on scene averaged dark current shutter values from the ETM+ internal calibrator. Sensor responsivity and the zero-radiance bias for each detector is maintained by the IAS and recorded in the CPF. Radiometric detector normalization is applied in each spectral band. Bias-corrected image values are then given by

$$\Delta Q_i = Q_i - Q_{0i} = G_i L^*_i . \qquad (2)$$

Thus, TOA radiances L^*_i (in Watts/(m^2 sr µm)) are related to image data by

$$L^*_i = \Delta Q_i / G_i . \qquad (3)$$

TOA reflectance for bands 2 through 6 is related to TOA radiance by

$$\rho^*_i = \pi L^*_i d_s^2 / (E_{0i} \cos\theta) , \qquad (4)$$

where E_{0i} is the exoatmospheric solar irradiance in spectral band i (in Watts/(m^2 µm)), θ is the solar zenith angle, and d_s is the Earth-Sun distance in Astronomical Units.

At-satellite temperature for band 6 is related to TOA radiance by

$$T = K2 / 1n ((K1 / L^*_6) + 1) , \qquad (5)$$

where T is the at-sensor temperature in Kelvin, K2 is the calibration constant 1282.71 in degrees Kelvin, K1 is the calibration constant 666.09 in Watts/(m^2 sr µm), and L^*_6 is spectral radiance from equation 3.

4.1 Pass One Processing

The initial pass through the radiometrically corrected image data is designed to isolate clouds. Eight different filters were devised for this purpose. Omission errors are expected. The pass one goal is to develop a reliable cloud signature for use in pass two where the remaining clouds are identified. Commission errors must be minimized as they corrupt the cloud signature and distort the final cloud cover score. Three category classes result from pass one processing – clouds, non-clouds, and an ambiguous group that is revisited in pass two.

Prior to assessment the 60 meter band 6 image is pixel aligned to the 30 meter bands. This is achieved through pixel replication. Each band 6 pixel becomes two and each expanded band 6 image line is repeated. The original 3300 sample by 3000 line band 6 image now spatially matches the 30 meter bands (6600 samples by 6000 lines). The final pre-processing step is to create a single byte cloud mask that dimensionally matches a 30 meter input image in size. The cloud mask is used to store results from pass one and two.

All pixels in a ETM+ scene are processed sequentially. Filtering is performed on each pixel until it is eliminated or classified as cloud. A description of each filter, presented in the order implemented follows.

Filter 1 – Brightness Threshold
Each band 3 pixel in the scene is first compared to a brightness threshold. Pixels that fall below this threshold are identified as non-clouds and are flagged as such in the cloud mask. Pixels that exceed the band 3 threshold, which is set at .08, are passed to filter 2.

Filter 2 – Normalized Snow Difference Index
Pixels values from bands 2 and 5 are used to formulate the normalized difference snow index (NDSI).[3.] The NDSI filter is expressed as:

$$\text{NDSI} = (\text{band 2} - \text{band 5}) / (\text{band 2} + \text{band 5}) \quad (6)$$

This filter is particularly useful for eliminating snow. The reflectance of clouds and snow is similar in band 2. However, in band 5, reflectance for clouds is very high while for snow it is low. Hall discovered that NSDI values greater than .4 represent snow cover quite well. This value was initially tried for ACCA to eliminate snow but clouds composed of ice crystals (e.g. cirrostratus) were also eliminated. The threshold was raised to .7 to capture clouds of this type. NDSI values above this threshold qualify as snow and are recorded as non-cloud in the cloud mask. Snow pixels that remain unfiltered are usually trapped with a subsequent filter. Knowledge of snow in a scene is important for pass two processing so a tally of snow pixels is retained. Pixels that fall below the NDSI threshold are passed to filter 3.

Filter 3 – Temperature Threshold
This filter examines the band 6 temperature values for potential cloud pixels. If a pixel value exceeds 300K, a realistic cloud temperature maximum, it is excluded and labeled as non-cloud in the mask. All pixels with temperature a value less than 300K are passed to filter 4.

Filter 4 – Band 5/6 Composite
Pixel values from bands 5 and 6 are used to formulate the Band 5/6 Composite. The filter is expressed as:

$$\text{Band 5/6 composite} = (1 - \text{band 5}) * \text{band 6} \quad (7)$$

This filter works exceptionally well because clouds are cold and highly reflective in band 5. It is particularly useful for eliminating cold land surface features that have low band 5 reflectance such as snow and tundra. Sensitivity analysis demonstrated that a threshold setting of 225 works optimally. Pixel values above this threshold are labeled ambiguous in the cloud mask and are revisited in pass two. Pixels that fall below this threshold are passed to filter 5.

Filter 5 – Band 4/3 Ratio
This filter eliminates highly reflective vegetation and is simply band 4 reflectance divided by band 3 reflectance. In the near-infrared (band 4), reflectance for green leaves is high because very little energy is absorbed. In the red region (band 3), the chlorophyll in green leaves absorbs energy so reflectance is low. The 4/3 ratio results in higher values for vegetation than for other scene features, including clouds. A threshold setting of 2.0 is used. Pixels that exceed this threshold are labeled ambiguous and are revisited in pass two. Pixels with ratios below this threshold are passed to filter 6.

Filter 6 – Band 4/2 Ratio
This filter eliminates highly reflective senescing vegetation and is formed by dividing the band 4 reflectance by the band 2 reflectance. In the near-infrared (band 4), green leaves that are dead or dying absorb even less energy and are thus highly reflective. In the green region (band 2), the leaves absorb less energy because of chlorophyll loss and exhibit increased reflectivity. The 4/2 ratio values are higher for vegetation than other scene features including clouds. A threshold setting of 2.0 works effectively. Pixels that exceed this number are ambiguous and are revisited in pass two. Pixels with ratios below this threshold are passed to filter 7.

Filter 7 – Band 4/5 Ratio
This filter eliminates highly reflective rocks and sands in desert landscapes and is formed by dividing the band 4 reflectance by the band 5 reflectance. Rocks and sand tend to exhibit higher reflectance in band 5 than in band 4, whereas the reverse is true for clouds. A threshold setting of 1.0 works effectively. Pixels that fall below this threshold are labeled ambiguous and are revisited in pass two. Knowledge of desert pixels in a scene is important for pass two processing. Therefore, a desert pixel tally is retained. Pixels with ratios that exceed this threshold are passed to filter 8.

Filter 8 – Band 5/6 Composite
All pixels reaching this filtering level are classified as clouds. A further separation into two classes is achieved by using the band 5/6 composite filter. For each cloud pixel, the band 5/6 composite is compared against a threshold setting of 210. Pixels above and below this threshold are classified as warm and cold clouds, respectively. These two cloud classes are recorded in the cloud mask.

A sample Landsat scene, imaged over the Caspian Sea, is presented in Figure 1. ACCA was performed on this scene and the pass one cloud mask was generated (Figure 2). The mask has four different categories. White represents warm clouds whereas gray represents colder clouds. Dark gray represents non-cloud areas that are excluded from further analysis. The ambiguous image areas, which are revisited in pass two, are black. The ACCA discussion for this scene continues after pass two is described.

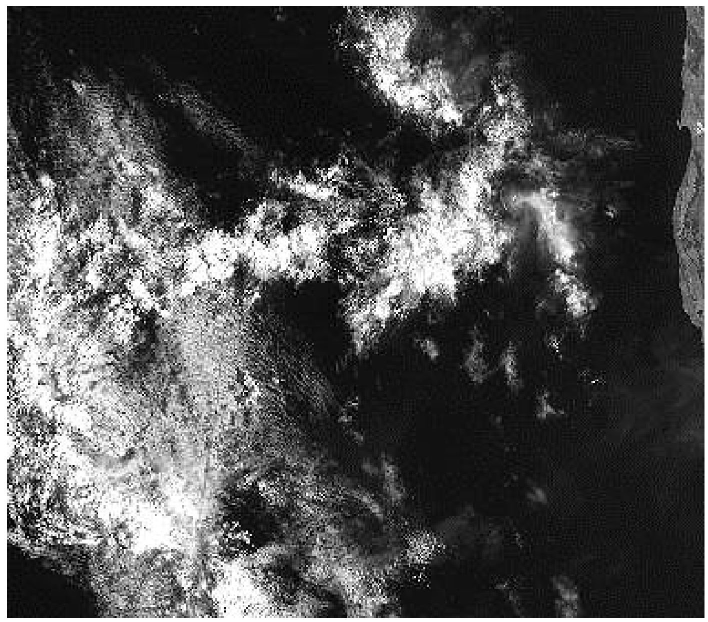

Figure 1. Landsat scene over the Caspian Sea

4.2 Pass Two Processing

Pass two processing involves thermal analysis using band 6 exclusively. A reliable thermal cloud signature is first developed from one or both cloud classes identified in pass one. The two classes are combined and used jointly if the imaged terrain lacks snow. Snow creates cloud classification problems and its presence justifies developing a more conservative cloud signature. Snow is tallied using filter 2, the NDSI filter. If snow in a scene is less that 1 percent it is considered snow free. If snow exists in a scene, the cold cloud class is used exclusively for rendering the cloud signature. For these scenes the warmer clouds are relabeled ambiguous and are revisited with all other ambiguous pixels identified during the first pass.

Brightly illuminated desert also creates pass two processing problems and must be avoided. A desert index is formulated by examining the results of filter 7. The index is computed by dividing the pixel total output from filter 7 by the input pixel quantity. A value of .5 or less was found to be a good indicator of terrain with brightly illuminated rocks and sand. Pass two is bypassed if these land features exist.

Cloud statistics are computed from either the colder cloud class or the combined group. The cloud population's minimum, maximum, mean, standard deviation, and skewness are computed from the band 6 temperature values. Pass two processing is engaged if the following three conditions are met: the desert index is greater than 0.5 (the image lacks highly illuminated rocks or sand); the colder cloud population exceeds 0.4 percent of the scene (pass two isn't required if the scene is cloud free); the mean temperature for the cloud class is less than 295K (commission errors probably occurred if the mean temperature is this warm). If one or more of these three conditions is breached then thermal analysis is bypassed and processing ends. The colder cloud class from pass one is used to report the cloud cover percentage for scenes with desert, providing the mean temperature does not exceed 295K. Otherwise, the scene is considered cloud free.

Pass two processing requires two new band 6 thresholds against which all ambiguous pixels are compared to. One threshold is set quite low and is used to generate a conservative estimate of clouds in a scene. The other is set high and is used to compute a less restrictive estimate of cloud cover. The thresholds are determined by histogramming the band 6 temperatures for the pass one cloud population. The histogram's 97.5 and 83.5 percentiles are the starting points for two new temperature thresholds needed for pass two.

Threshold adjustments are made if the cloud population skewness is positive. A negative skewness indicates the two thresholds are properly placed at the high end of the temperature range. Consequently, no adjustments are necessary. If skewness is positive, upward adjustments are made to compensate for a warm cloud bias. The shift factor is calculated by multiplying the skewness (the upper limit is held to one) by the standard deviation. Both thresholds are adjusted by this amount. A final check is made to see if the new upper threshold exceeds the histogram's 98.75 percentile (a threshold above or near the cloud temperature maximum is unwanted). If so, the 98.75 percentile becomes the new upper threshold and the lower threshold is adjusted by the amount of skewness compensation actually allowed.

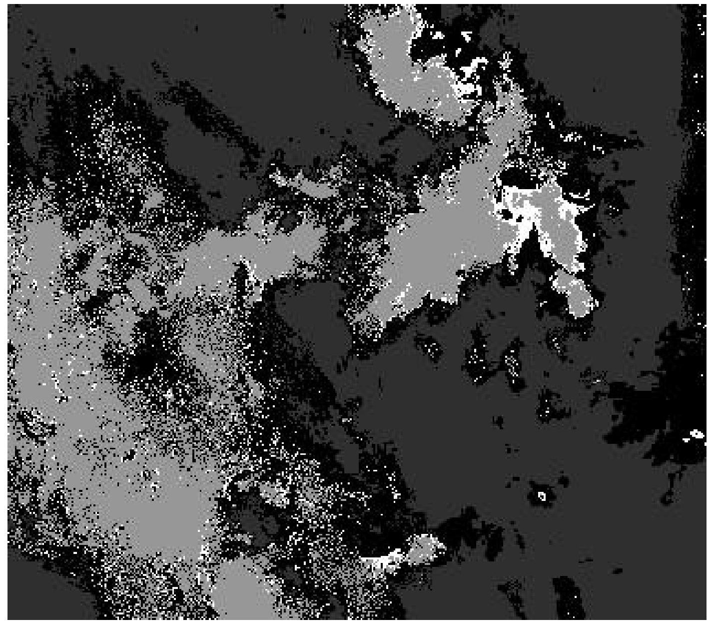

Figure 2. Pass one cloud mask

Processing begins by testing each ambiguous band 6 pixel against the two new temperature thresholds. If a pixel temperature falls below the upper threshold the cloud mask is flagged with a unique number that identifies this class of clouds. This mask value is changed if the pixel temperature also falls below the lower threshold. After band 6 is processed the temperature means and maximums are computed for the two new cloud populations. The percentage of the scene that each cloud class represents is also computed. These two quantities are called the thermal effects.

Analysis of each set of results is performed to determine which thermal effect, if any, to accept. The upper threshold thermal effect is first examined. Commission errors in pass one distort the cloud signature, resulting in large thermal effects. A thermal effect of more than 40 percent or a mean cloud temperature greater than 295K are good indicators that commission errors occurred and an erroneous threshold calculation was made. Under these circumstances, or if snow is present, the upper threshold results are not used. If these three conditions are not breached, the upper threshold results are accepted and the three cloud classes are united in the cloud mask

The conservative thermal effect is examined if the warmer cloud effect is rejected. These results are also dismissed if the thermal effect is greater than 40 percent or if the mean temperature is greater than 295K. When this happens, the pass two analysis is considered invalid and the cloud mask reverts to its pass one form. The lower threshold results are accepted and the two cloud classes are united in the cloud mask if these conditions are not breached.

The cloud identification process is now complete. The final step involves processing the cloud mask for holes. Each non-cloud image pixel is examined and converted to cloud if at least 5 of its 8 neighbors are clouds. This operation boosts the cloud cover content to accurately reflect the amount of unusable image data in a scene. At this point, the cloud pixels in the mask are tabulated and a cloud cover percentage score for the scene is computed.

Mean temperature:	253.72K
Maximum temperature:	292.79K
Minimum temperature:	229.73K
Standard deviation:	12.22
Skewness:	0.814
Histogram bins:	64
98.75 percentile	277.799
97.50 percentile	276.799
82.50 percentile	265.799

Figure 3. Pass one cloud profile

4.2 ACCA Example

The Caspian Sea Landsat scene and the pass one cloud mask were presented in Figures 1 and 2. For pass two, the cloud signature was rendered from the combined pass one cloud classes due to the absence of snow. The cloud pixels represent 25.77 percent of the scene. The temperature profile is presented in Figure 3. Pass two processing was implemented because clouds exist, their mean temperature is less than 295K, and the scene lacks any significant desert. The upper and lower temperature thresholds used for pass two were 277.799K and 266.799K respectively. These were adjusted upwards by 1 degree from the percentile thresholds listed in Figure 3 because of the positive skewness.

The thermal effect for the upper threshold was 25.65 percent while the lower threshold produced a 15.01 percent effect. The upper thermal effect was accepted as legitimate because it was less than 40 percent and the mean cloud temperature was 277.47K, well below the 295K limit. The final cloud cover percentage total was 51.42 percent which is two times the pass one total. After the cloud holes were filled the total cloud cover increased to 53.59 percent. The final cloud mask for the Caspian Sea image is presented in Figure 4.

5.0 PERFORMANCE

After the Landsat 7 system became operational, the efficacy of ACCA was examined by sampling the archive and quantifying cloud content of selected scenes with an independent tool. Thirty-two day scene locations were randomly generated across time and space. Browse imagery and ACCA scores were extracted from the EDC DAAC for the 32-scene sample. A variety of visual image processing tools were used to generate binary cloud masks from each of the browse images. Histograms of the cloud masks yielded the cloud cover percentages. The ACCA scores were compared against the cloud mask scores and summarized.

The ACCA versus cloud mask comparisons yielded the following results for the 32 scene study:

- 16 (50%) were within 5%
- 24 (75%) were within 10%
- 28 (88%) were within 15%
- 29 (91%) were within 20%
- 3 images differed by more than 20%

Assuming the mask is truth, ACCA over-reported in 13 and under-reported in 16 cases. ACCA and the derived mask were the same in three cases. The mean difference and standard deviation for the 29 images that closely agreed were 0.067 and 8.39, respectively. A near zero mean suggests a normal distribution with no over-reporting or under-reporting bias.

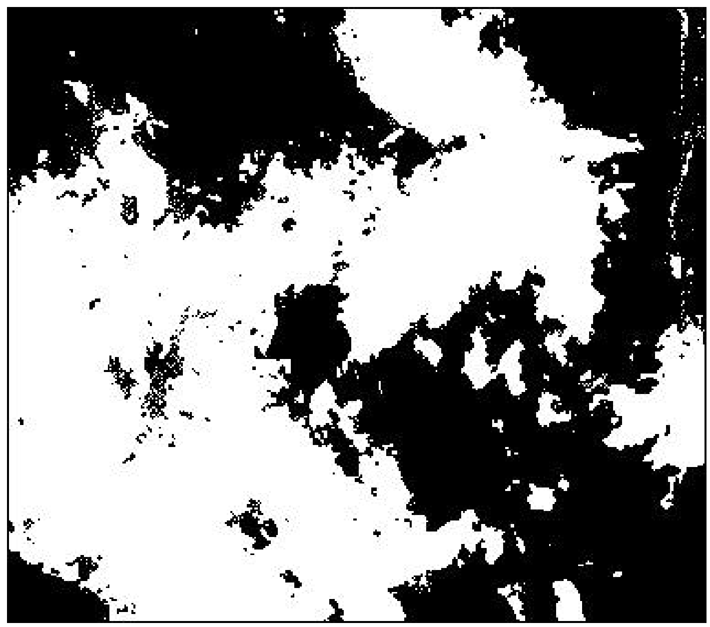

Figure 4. Pass two cloud mask

The three anomalous cases were closely examined to understand why ACCA under performed. The first scene was imaged over Northern Siberia on October 15, 1999. ACCA reported a cloud cover score of 78 percent while the independent cloud mask reported 99 percent. The image is composed of multiple cloud decks that cover most of the scene. Several very large cloud shadows are present due to the low sun elevation angle. The ACCA algorithm was not designed to recognize cloud shadow. The human eye can clearly recognize the cloud shadow and the presence of clouds beneath it.

The second image was collected over Inner Mongolia on December 17, 1999. ACCA reported a cloud cover score of 31 percent while the derived mask reported no clouds. A third of the scene is covered with snow which ACCA mistakenly labeled cloud. The same snowfield exists in a scene acquired 32 days earlier and in a scene collected 48 days later. For these two scenes ACCA recognized the snow and reported a near zero cloud cover score. Analysis of the December scene has revealed that a reflectance boost in the short wave infrared (band 5) for the snow covered regions neutralized the NDSI and band 5/6 composite filters. An explanation may be twofold. Light scattering research has demonstrated that absorptive properties of snow in the shortwave infrared (band 5) are sensitive to grain size and solar illumination angle.[4] New snow exhibits higher reflectance than older snow because of its smaller grain size. A fresh blanket of snow may be present in the December scene. Higher reflectance is also caused by the strong forward-scattering properties of ice in the short wave infrared, an effect that increases with solar illumination angle. The solar illumination angle was 83 degrees for the December 17th scene. The other two scenes had illumination angles of approximately 77 degrees.

The third anomalous image was acquired over Eastern Antarctica on December 11, 1999. ACCA and the cloud mask reported cloud cover scores of zero and 56 percent, respectively. Analysis of this scene has not been started but one possible explanation is that a temperature inversion occurred. ACCA operates on the premise that clouds are colder than the land surface they cover. Warm clouds over an ice sheet undermine this assumption.

CONCLUSIONS

The Landsat 7 automatic cloud cover assessment algorithm was designed to provide a fast and reliable means for evaluating cloud cover content of ETM+ imagery acquired worldwide. The algorithm builds on the experience gained from the Landsat 4/5 heritage algorithm developed for the Thematic Mapper. The improved algorithm utilizes two additional bands, examines all pixels in a scene, and takes advantage of the enhanced band 6 spatial resolution (60 meters for ETM+ versus 120 meters for TM). The algorithm also employs a scene specific two pass approach that examines clouds uniquely for each image.

The algorithm works well for most areas of the Earth. In a recent study it was shown that 75 percent of the ACCA scores were within 10 percent of the actual cloud cover content and that 91 percent were within 20 percent. Problem areas do exist but they tend to involve snow covered terrain at extreme latitudes and high illumination angles. Thin cirrus is also elusive because it lacks a strong thermal response.

The Landsat 7 ACCA algorithm is now used operationally at EDC, where it is used to quantify cloud cover for approximately 250 ETM+ scenes that are received each day. The scores are subsequently sent to the EDC DAAC and Landsat 7 mission planners. For users, cloud content in a scene is the single most important consideration when ordering an ETM+ product. The EDC search and order system allows users to quickly target a desired scene by filtering those with excessive cloud cover. Mission planners use the cloud cover scores to reschedule failed acquisitions in order to realize the mission goal of refreshing the global archive with seasonal and cloud-free imagery.

ACKNOWLEDGMENTS

The Landsat Project Science Office provided funding for this work. The author expresses his appreciation to Darrel Williams, Landsat 7 Project Science, and Jim Irons, Landsat 7 Deputy Project Scientist for the time and freedom they provided to develop the ACCA algorithm.

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