### Automated Cloud Cover Assessment ACCA

#### Background/Introduction

Cloud cover assessment for L8/9 will be performed via a series of intermediate CCA algorithms, whose outputs will be resolved into a final mask. The ACCA (Automated Cloud Cover Assessment) algorithm is one such intermediate process. It is a decision tree based on the L7 ACCA algorithm. The output of the ACCA algorithms is an intermediate CCA mask.

#### Inputs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Descriptions** | **Units** | **Level** | **Source** | **Type** |
| OLI Scene data (L1G), as TOA reflectance | none (reflectance) | Scene, OLI Bands 2-7. |  | float |
| TIRS scene data (L1G), as TOA radiance | radiance | Scene, TIRS Band 1. |  | float |

#### Outputs

The output of each CCA component is an intermediate cloud mask file – a 16 bit image of the same dimensions as the L1Gs scene. The standardized format of the cloud mask file is:

|  |  |  |
| --- | --- | --- |
| Bit | Flag description | Values |
| 0 | Designated Fill | 0 for image data  1 for fill data |
| 1 | Unused |  |
| 2 | Unused |  |
| 3 | Unused |  |
| 4-5 | Water confidence | 00 = Not set  01 = Low confidence  10 = Mid confidence  11 = High confidence |
| 6-7 | Unused |  |
| 8-9 | Unused |  |
| 10-11 | Snow/Ice confidence | same as water confidence |
| 12-13 | Unused |  |
| 14-15 | Cloud confidence | same as water confidence |

Table 6‑50. Cloud mask file bit format, as used by ACCA

A byte value of 1 (00 01 hex) is reserved for fill data. It should not be possible to reach this value when processing a non-fill pixel.

#### Procedure

The main loop of the CCA process opens the band files and output files, and reads information from the metadata. It then – for each non-fill pixel – passes the band reflectance values to the evaluation function for each CCA algorithm. The return value from the algorithm is written to the intermediate CCA mask file. The detailed procedure for the CCA main loop can be found in the CCA Control System ADD.

The ACCA algorithm follows the structure of phase 1 of the Landsat 7 ACCA algorithm. In addition to clouds, this algorithm may classify a pixel as Water or Snow; flags for those classes are reserved in the intermediate cloud mask file structure. The ACCA algorithm is also capable of Vegetation classification, but because the accuracy is poor it is not planned to use this algorithm for that purpose.

The ACCA algorithm makes use of the following band-derived values:

Bx = The reflectance in OLI band x.

T = The radiance of the thermal band.

ND(x,y) = The normalized difference between x and y.

= (x – y)/(x + y)

The procedure for the ACCA evaluation function is:

1. Phase 1: Perform the ACCA cloud detection algorithm.
   1. B4 test #1: If B4 > 0.08, go to step 1.a.i.
      1. NDSI test #1: If ND(B3,B6) > -0.25 and < 0.7, go to step 1.a.i.1. (ND(B3,B6) is known as NDSI, the Normalized Differential Snow Index.)
         1. Thermal test: If T < 9.390745, go to step 1.a.i.1.a.
            1. B6composite test: If (T < 666.09/(exp(5.70093\*(1-B5) - 1)), go to step 1.a.i.1.a.i.

B54 ratio test: If B5/B4 < 2.25, go to step 1.a.i.1.a.i.1.

B53 ratio test: If B5/B3 < 2.2, go to step 1.a.i.1.a.i.1.a.

B56 ratio test: If B5/B6 > 1, then this pixel is a cloud. Set the output value to high confidence cloud. (CCA\_INT\_CLOUD\_HIGH)

If any of the B56, B53, or B54 ratio tests fail, the pixel is designated as ambiguous. (CCA\_INT\_CLOUD\_MID)

* + - * 1. If the B6composite test fails, perform the B6 test: If B6 < 0.08, then this pixel is clear. Set the output value to clear of unknown class. (Low value for cloud confidence and low value for class confidence. This is set by the value CCA\_INT\_UNKNOWN\_LOW + CCA\_INT\_CLOUD\_LOW.)
        2. If the B6 test fails, designate the output value as ambiguous. (CCA\_INT\_CLOUD\_MID)
      1. If the thermal test fails, this pixel is clear. Set the output value to clear. (CCA\_INT\_UNKNOWN\_LOW + CCA\_INT\_CLOUD\_LOW)
    1. If the NDSI test #1 fails, perform NDSI test #2: If ND(B3,B6) > 0.8, then the pixel is snow or ice. Set the output value to high confidence snow. (CCA\_INT\_SNOW\_HI + CCA\_INT\_CLOUD\_LOW)
    2. If NDSI test #2 fails, the pixel is not snow but is not a cloud. Set the output value to clear. (CCA\_INT\_UNKNOWN\_LOW + CCA\_INT\_CLOUD\_LOW)
  1. If B4 test #1 fails, perform B4 test #2: If B4 < 0.07, then the pixel is water. Set the output value to mid confidence water. (CCA\_INT\_WATER\_MID + CCA\_INT\_CLOUD\_LOW) The confidence is set to mid instead of high because the ACCA algorithm does not do a good job at water discrimination, so this test is not very effective.
  2. If B4 test #2 fails, the pixel is not water but is not a cloud. Designate the output value as ambiguous. (CCA\_INT\_CLOUD\_MID)

1. Return the output value.

#### Maturity

Level 1. Changes will be made to this procedure when the characteristics of the OLI and TIRS instruments are known.

Other possible changes that may occur in the ACCA algorithm are as follows:

* Disambiguation – A disambiguation algorithm may be appended to the output of the ACCA algorithm, to clean up the ambiguous results. This disambiguation algorithm may be the gD02 algorithm used in Expanded AT-ACCA, or may be a new algorithm designed for use with L8/9 ACCA.
* Surface Temperature – The ACCA algorithm may be re-engineered to use a split window algorithm, which uses two thermal bands to calculate an approximate surface temperature. This will require converting two of the TIRS bands into a surface temperature before passing through the ACCA decision tree. The surface temperature algorithm is TBD.
* Whole Scene Processing – The above procedure assumes that each pixel is read in, processed, and written back out in sequence. This method uses less system memory and is parallelizable. However, for performance reasons, it may be desirable to read in all (or a portion) of the bands and process them in memory before writing out the mask. This will require changes to the main loop process flow and to the process flow of the CCA control system.
* Classification Improvements – The AT-ACCA algorithm can be altered to output Vegetation classification for each pixel in the cloud mask. This is not expected to be studied in detail until after the launch of Landsat 8.
* Band 2 – This ADD has been specified with TIRS Band 1 as the input thermal data. As of this writing it is not clear which band will be best for deriving thermal brightness temperature. In the future TIRS Band 1 may be replaced with TIRS Band 2 to improve the algorithm.
* Additional parameters – Any of the above changes to this algorithm may require additional input parameters, most likely including (but not limited to) the Solar Elevation Angle.