IGARSS 2004

20-24 September 2004
Anchorage Alaska

Snow and Cloud Discrimination Factors in the MODIS Snow Algorithm

George A. Riggs
SSAI
Lanham, MD 20706 U.S.A
griggs@ltpmailx.gsfc.nasa.gov

Dorothy K. Hall
Code 971
NASA/Goddard Space Flight Center
Greenbelt, MD 20771 U.S.A

Abstract— **A modification of the Moderate Resolution Imaging Spectroradiometer (MODIS) snow algorithm to eliminate a problem of erroneous snow mapping in certain cloud situations in the swath level product is described. The purpose of this algorithm modification is to improve the snow algorithm in specific cloud situations where the cloud mask misses clouds that have some reflectance characteristics similar to snow. Including a test for reflectance characteristics among MODIS bands 4, 5 and 6 can effectively discriminate between snow and clouds in those situations.**

Keywords-MODIS; snow; cloud; snow-mapping

I. BACKGROUND

Discrimination between clouds and snow is a challenging task because clouds and snow have several reflectance features in common. The ability to discriminate between snow and clouds is affected by the number and wavelength locations of bands of a remote sensing instrument. The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on-board NASA's Terra spacecraft has 36 bands from 0.4 to 14µm, in spatial resolutions of 250 m, 500 m and 1km, of which many are potentially useful for discriminating clouds from snow. The MODIS snow-mapping algorithm uses the cloud mask product (MOD35_L2) to discriminate clouds from snow. The cloud mask algorithm uses 19 of the MODIS bands in 10 processing paths, depending on surface conditions, and multiple cloud spectral tests to determine the presence of cloud. Output of the cloud mask algorithm is a confidence flag indicating the certainty of cloud or clear sky for each pixel as well as data on the processing path and cloud spectral test results applied to a pixel. The snow-mapping algorithm uses data from MOD35_L2 to discriminate clouds from snow with the objective to minimize cloud obscuration and snow-mapping errors while maximizing detection of snow cover. The cloud mask confidence flag is used to map cloud that results in a very conservative cloud mask that results in two situations that can decrease the quality of the snow map. In one situation the cloud mask identifies the perimeter of snow covered areas as cloud because of the brightness of the surface. In the other situation the cloud mask misidentifies some cloudy pixels as clear, which results in those clouds being erroneously identified as snow. The second situation is considered the most serious to correct because the erroneous snow, though usually small (<5% in a swath) greatly decreases the quality of the snow cover thematic map product (MOD10_L2) and is carried forward to the higher level daily snow maps causing decreased quality in those products, especially when the error occurs during non-winter seasons.

II. SNOW ALGORITHM SYNOPSIS

The swath level-2 MODIS snow algorithm uses a grouped criteria technique to detect snow and the MODIS cloud mask product to mask clouds [1, 2]. The output product is a thematic map of snow cover and other features. Snow detection relies primarily on the normalized difference snow index (NDSI) with the NDSI = (band 4 – band 6)/(band 4 + band 6). The NDSI keys on the snow characteristics of high reflectance in visible wavelengths (band 4 at 0.55 µm) and low reflectance in the short-wave infrared about 1.6 µm (band 6 at 1.6 µm. If a pixel has an NDSI >= 0.4 and band 2 (0.85 µm) reflectance > 0.10 and band 4 reflectance > 0.10 then the pixel is mapped as snow. Those low visible reflectance criteria function to screen clear water bodies and very low illumination conditions that could be erroneously identified as snow. To better map snow in dense vegetation, shadows and low illumination conditions where the reflectance signal is low, an NDSI/NDVI decision region was determined [3]. Snow is mapped if the NDSI and NDVI values fall in that NDSI/NDVI decision region and if the band 2 and band 4 reflectance criteria are met. Very few other natural features are confused with snow. A surface temperature screen was add to the snow algorithm to eliminate warm features from being erroneously identified as snow.

V. SUMMATION

Results presented are based on analysis of a lone paired swath and must be subject to further analysis and testing before an objective decision can be reached on the ability to discriminate between cloud and snow, avoiding erroneous snow mapping on these types of clouds globally using the peak 5 ratio as a discriminator. Consistency of the difference in the peak 5 ratio needs to be investigated across a diversity of snow and snow and cloud situations. Further investigation of the peak 5 ratio at high NDSI values where separation between real snow and erroneous snow is least must be done. Though results were very encouraging in this work it must yet be proven that the peak 5 ratio is a useful discriminator for alleviating the erroneous snow in the cloud situations described.