1. INTRODUCTION

About GOSAT

Greenhouse Gases Observing SAtellite (GOSAT) was launched in 2009 to determine global atmospheric CO2 and CH4 concentrations. GOSAT is equipped with two Earth-observing instruments: the Thermal And Near-infrared Sensor for Carbon Observation-Fourier Transform Spectrometer (TANSO-FTS) and TANSO-Cloud and Aerosol Imager (CAI). The presence of clouds in the instantaneous field-of-view (IFOV) of the FTS leads to incorrect estimates of the concentration1).

Cloud Discrimination

Thus, an important role of CAI is to perform cloud discrimination to identify and reject cloud-contaminated FTS data. Conversely, overestimating clouds reduces the amount of FTS data that can be used to estimate greenhouse gases concentrations. This is a serious problem in the region of tropical rainforest areas, such as Borneo, where the amount of useable FTS data is small because of cloud cover2).

New Cloud Discrimination Algorithm for GOSAT-2

Preparations are continuing for the launch of GOSAT-2 in fiscal year 20173). To improve the accuracy of the estimates of greenhouse gases concentrations, we need to refine the existing CAI cloud discrimination algorithm (CLAUDIA1). A new cloud discrimination algorithm using support vector machines (CLAUDIA3) was developed4).

This Study

Visual inspections can use the locally optimized thresholds, although CLAUDIA1 and CLAUDIA3 use common thresholds all over the world. Thus, the accuracy of visual inspections is better than that of these algorithms in the limited regions without areas such as ice and snow, where it is difficult to distinguish cloud and ground surfaces5). In this study we evaluated the accuracy of CLAUDIA3 by comparing it with CLAUDIA1 and visual inspections of the same CAI images in Borneo.

2. USED DATA AND ALGORITHMS

Study Area and Data

The orbits of the GOSAT platform repeat themselves every 44 revolutions (44 paths) around the Earth. Each path is divided into 60 frames. We used 1) CAI L1B products on Path 7, Frame 30-31 in Borneo, 2010, 2) Surface Albedo data generated from CAI L3 global reflectance distribution products.

Existing Algorithm (CLAUDIA1)

CLAUDIA1 comprises the calculation of clear-sky confidence level (CCL) for every threshold test and their comprehensive integration. Integrated-CCL means that the pixel is cloudy and 1 means that the pixel is cloud-free. Ambiguous pixels between cloudy and cloud-free are described by numerical values from 0 to 1. The threshold below which the integrated-CCL counts the pixel as cloud-free for GOSAT FTS L2 is 0.33, otherwise the pixel is regarded as cloudy6).

New Algorithm (CLAUDIA3)

CLAUDIA3 performs cloud discrimination by using thresholds set based on experience. CLAUDIA3 uses SVM to decide the thresholds objectively by using multivariate analysis. CLAUDIA3 applies the Kernel Trick7) to soft-margin SVM8). The kernel uses a second-order polynomial:

\[ K(x, y) = \frac{1}{2} \]

where K is the kernel function, x is the support vectors, and y is input data.

For CLAUDIA3, the integrated-CCL of 0.5 corresponds to the separating hyperplane of clear support vectors and cloudy support vectors.

3. RESULTS

CAI L1B Image

CLAUDIA1

CLAUDIA3

13 July, 2010 in CAI Path 7, Frame 31
Small scattered clouds (12.3%)

19 July, 2010 in CAI Path 7, Frame 31
Operatively cloudy areas (5.3%)

Results of CLAUDIA1 were exactly as predicted in a preceding study9): CLAUDIA1 has a tendency to overlook optically thin clouds and edges of clouds.

CLAUDIA3 misjudged clear narrow muddy rivers as cloudy in the same manner as CLAUDIA1.

Insufficient training data for muddy rivers

Insufficient resolution of the surface albedo data

CLAUDIA3 may be able to detect optically thin clouds by visual inspection.

Comparison with MODIS cloud mask product and satellite LIDAR data, such as CALIOP

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