Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-122-AC2, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "A high-level cloud detection method utilizing the GOSAT TANSO–FTS water vapor saturated band" *by* Nawo Eguchi and Yukio Yoshida

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Received and published: 14 November 2018

Thank you very much for reviewing our manuscript. The authors understood the major points pointed out by reviewer#2. Following the comments and suggestions from two reviewers, most of them were corrected and modified, including the figures. The English was checked by a native speaker. The major revised points were the following: From the suggestion from reviewers, we did the additional analysis which fixed the program bug. The additional results showed that the water vapor saturated method from the current product of GOSAT and this study were similar, except the middle layer cloud were detected better by the new method by this study (Figure 10 in the revised

manuscript). That means both methods from the current method of GOSAT product and the new method in the present study can detect the thinner cirrus clouds of about 85% cloud frequency compared with CALIOP. Following the above new result, the introduction and summary sections were rewritten significantly. As suggested by the reviewer, some figures were modified or added. The results figures (Figs.6 and 7) were replaced for the 100 km results. Figure 4 was revised; the "Clear and Cloudy supervised data" was added to the part of "Minimum Distance Method" decision. The red line of Figure 7 was corrected; the previous red line was inconsistent with the caption and showed the summation of probability density at each altitude. Figure 10 was added to show the capability (performance) of the new method and to compare the current and new methods. We hope that these revision will be satisfied your comments.

Manuscript number: amt-2018-122 Full title: A high-level cloud detection method utilizing the GOSAT TANSO–FTS water vapor saturated band Author(s): Eguchi and Yoshida

The paper describes an improved method to detect high-level clouds using GOSAT TANSO–FTS spectral measurements. The cloud detection method is evaluated with collocated CALIOP measurements. The matching ratio of clouds (i.e., the ratio of cloud detected by both GOSAT and CALIPSO to clouds detected by GOSAT) is 85% for pixels with the collocated distance between GOSAT and CALIPSO less than 25 km. The cloud flag based on the proposed method is useful to investigate spatial distribution of cirrus clouds. The topic in the presented paper is suitable to the journal, Atmospheric Measurement Techniques. However, the presented paper contains many grammatical mistakes and ambiguity throughout the paper. Although the authors mention the issue in thin cirrus cloud detection in the introduction, the evaluation of the cloud detection is based on all condition including low water clouds, and it is hard to know if the proposed method improves the cloud detection for thin cirrus clouds compared to the existing method. Overall, major revisions with more quantitative analysis are necessary to make the paper being worth publishing to the journal. In particular, quantitative and more detailed analysis against the following question may be needed: How much does the proposed method improve an accuracy of cloud detection compared to the existing water vapor saturation method?

Specific comments: Page 1, line14 “optically thin (optical thickness less than 1.0) and higher-level (above 8-15 km) clouds are in general difficult to detect with conventional passive sensors that measure reflected sunlight” This statement is incorrect. Conventional passive satellite measurements can detect cloud with optical thickness of greater than 0.1–0.3 (e.g., Holz et al., 2016, Fig. 1).

Reply: Along the reviewer comments, the sentence was rewritten (Page 1, Line 16-20).

Page 2, lines 11–16: There are two not show figures, which are seems to be important in terms of the motivation of this study written in lines 19–20 “Therefore the above results suggest that a more precise cloud detection method to remove the higher level clouds is required”. These figures should be shown in the manuscript to enhance clarity.

Reply: From the additional analysis, the new method by this study and the current method from GOSAT product had the similar capability (performance) to detect the thinner cirrus clouds. Because the evidence provided new insight, these results were added in the summary section. Therefore the introduction was briefly rewritten.

Page 4, line 19: “Figure 2(a) shows the simulated spectra for cloud-free cases with different precipitable water vapor amounts.” Which forward model do you use? The authors should describe at least a brief explanation about the model to reduce the ambiguity.

Reply: A line-by-line one-dimensional scalar radiative transfer model HSTAR (Nakajima and Tanaka, 1986) is used. The absorption cross-section of water vapor is calculated by LBLRTM (Clough et al., 2005). These information were added (p.4, l.12-14). T. Nakajima and M. Tanaka, Matrix formulations for the radiative transfer of solar radiation

in a plane-parallel scattering atmosphere. J. Quant. Spectr. Rad. Trans., 35, 13-21, 1986. S.A. Clough, M.W. Shephard, E.J. Mlawer, J.S. Delamere, M.J. Iacono, K. Cady-Pereira, S. Boukabara, P.D. Brown, Atmospheric radiative transfer modeling: a summary of the AER codes. J. Quant. Spectr. Rad. Trans., 91, 233-244, 2005.

Page 4, line 32 to page 5, line 2, and Figure 3: What is the criterion to collect these scenes? Are these scenes from all pixels? If so, it is hard to relate these groups with particular atmospheric conditions. For example, thin cirrus clouds and low-level marine stratocumulus clouds have similar brightness temperature (BT). Even a clear-sky with relatively low sea surface temperature and sub-visual cirrus clouds may be similar BTs. In addition, I suggest the authors to specify the mean and standard deviation of BT for each group.

Reply: The selection criteria are (i) the solar zenith angle is less than 70 deg. and (ii) SNR is larger than 5. As for the BT, it is just used for reordering the groups after classification by the k-mean clustering method. BT itself is not used in both the k-mean clustering and this cloud detection method, therefore, the mean and standard deviation of BT for each group are not shown in the revised paper.

Page 5, line 14: How much does the quality filter screen out low-quality data?

Reply: 0.5 – 2.5% data were removed as poor quality data. The result was added in the revised manuscript (p.5, l.15-16).

Page 6, lines 7-8: “The criteria for match-up between TANSO–FTS and CALIOP data were within 400 km for the distance between each footprint center location and within five minutes for the observation time difference.” 400 km is too far and inappropriate for collocated-pixel comparisons. The authors use just four months of data for the comparison. Since GOSAT and CALIPSO has long measurement duration, I suggest the authors to extend the data period and to use more strict and appropriate criterion for the distance in between both satellite pixels.

Reply: As suggested by the reviewer, the results figures were replaced for the 100 km results. We analyzed every month in 2010 and also the other distances from 25 to 400 km. In the results, the features (the cloud top altitude profile by CALIOP) were almost the same in four months (Jan, Apr, Jul, and Oct) shown in the manuscript, although the matching ratio increased while decreasing the distance. Figure 8 in the revised manuscript shows the matching ratio with the function of distance.

Figure 7: Please specify the definition of the matching ratio for each row. In addition, if you use the CALIPSO cloud detection as a benchmark, the matching ratio M1 and M2 are odd. To show the performance of the proposed cloud detection method with TANSO-FTS, it should be M1 = A/(A+C) and M2 = D/(B+D) shouldn't be? Otherwise, we don't evaluate how much TANSO–FTS misses thin cirrus clouds that CALIPSO detect.

Reply: The matching ratios defined by A/(A+B) or D/(C+D) are easy to understand how much the contamination of the opposite scene (if the TANSO clear case are, we know how much the CALIOP cloud case) and the cloud top altitude observed by CALIOP. The cloud top altitudes were derived only by CALIOP.

Page 7, lines 7–20: Does the proposed method improve cirrus cloud detection compared to the current method?

Reply: The new method in this study has the same capacity to detect the thinner cirrus clouds as the old one (the current GOSAT product), except the middle layer clouds can be detected by the new method better than the old one. The new insights were written in the summary section.

What is the minimum optical thickness that the proposed method can detect clouds with an acceptable accuracy?

Reply: As the following figure show, clouds with optical thickness from 0.01 to 5.0 can be detected with the 40-80% matching ratio. That is, the new method in this study

could detect the thin clouds from 0.01 or 0.025.

Why do you include pixel with low stratocumulus clouds detected by CALIPSO into the analysis?

Reply: It is easy to understand that the water vapor saturated method (both the current and new method by this study) cannot detect the low-altitude clouds. If the clouds with the cloud top above 5 km were removed by CALIOP, we can understand the matching ratio which increase as shown in the dashed lines of Figure 8.

Page 8, lines 26–28: I'm not convinced with the statement. In order to state this, I suggest the authors to demonstrate at least the mating ratios (A+D)/ALL or B/(B+D) as function of cloud optical thickness.

Reply: The following figures show that the matching ratios (D/((B+D)) are from 40 to 80% at the optical thickness less than 5.0. The results added to the revised manuscript (p.8, l.28-29).

Figure R2a: The matching ratio (D/(B+D) in Table 2 of the manuscript) between TANSO-FTS and CALIOP with the function of CALIOP optical thickness at each month in 2010. The thin line shows the data number divided by 2. The distance between CALIOP and TANSO-FTS is 100 km.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2018-122/amt-2018-122-AC2-supplement.pdf

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-122, 2018.

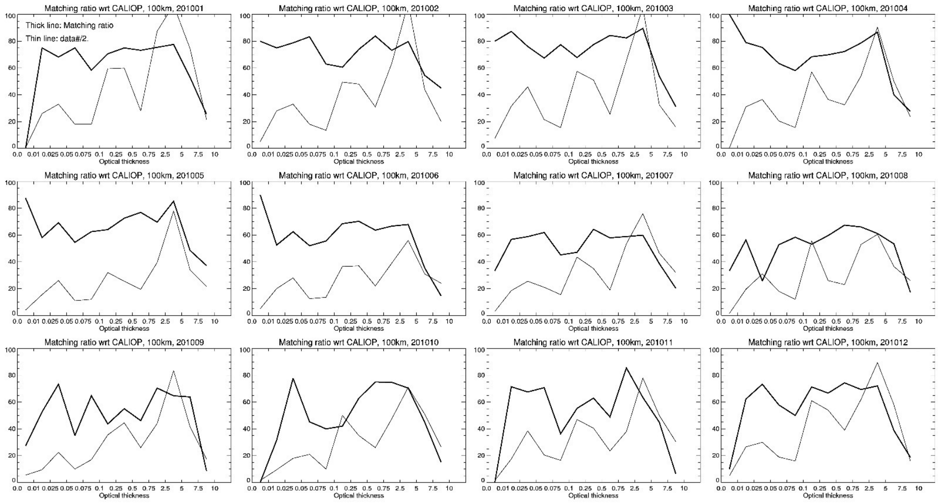

Fig. 1. Figure R2a: The matching ratio (D/(B+D) in Table 2 of the manuscript) between TANSO-FTS and CALIOP with the function of CALIOP optical thickness at each month in 2010.