

## Response to Reviewer's Report

We thank the reviewer for his review and valuable comments. The manuscript has been modified according to the suggestions proposed by the reviewer. The remainder is devoted to the specific response item-by-item of the reviewer's comments.

RC=Reviewer Comments

AR=Author response

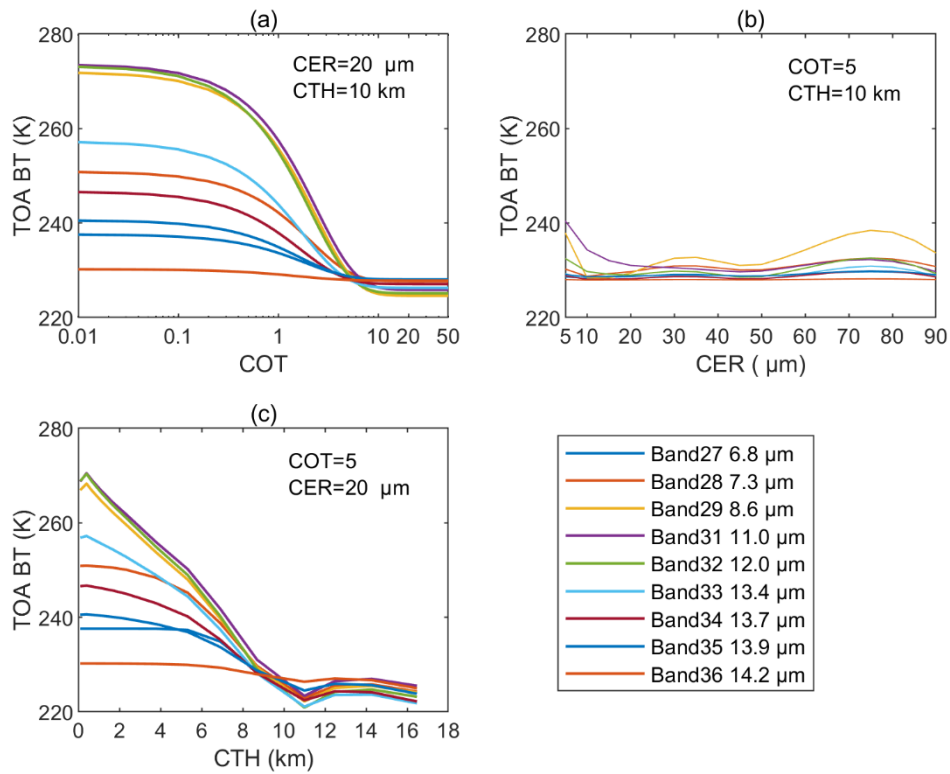
TC=Text Changes

The research "Optimal estimation of cloud properties from thermal infrared observations with a combination of deep learning and radiative transfer simulation" has made significant advancements in the field of cloud property retrieval using satellite imagery. The primary finding of the study is the successful integration of traditional radiative transfer simulations with machine learning algorithm, to retrieve cloud optical thickness (COT), cloud effective radius (CER), and cloud top height (CTH) from Moderate Resolution Imaging Spectroradiometer (MODIS) data. This method, referred to as OE-CNN-IR, is effective under both daytime and nighttime conditions, addressing a long-standing limitation of previous retrieval methods. It combines the strengths of both radiative transfer model (RTM)-based cloud retrieval methods and machine learning models. RTM-based methods are physically grounded and can accurately simulate radiance at the top of the atmosphere, while machine learning models, such as TIR-CNN, can quickly and accurately process large amounts of data. By using TIR-CNN retrievals as priori states for iterative processes in the OE method, the OE-CNN-IR method is able to reconcile observed data with physical radiative processes more effectively. I think there are a few minor issues in the manuscript.

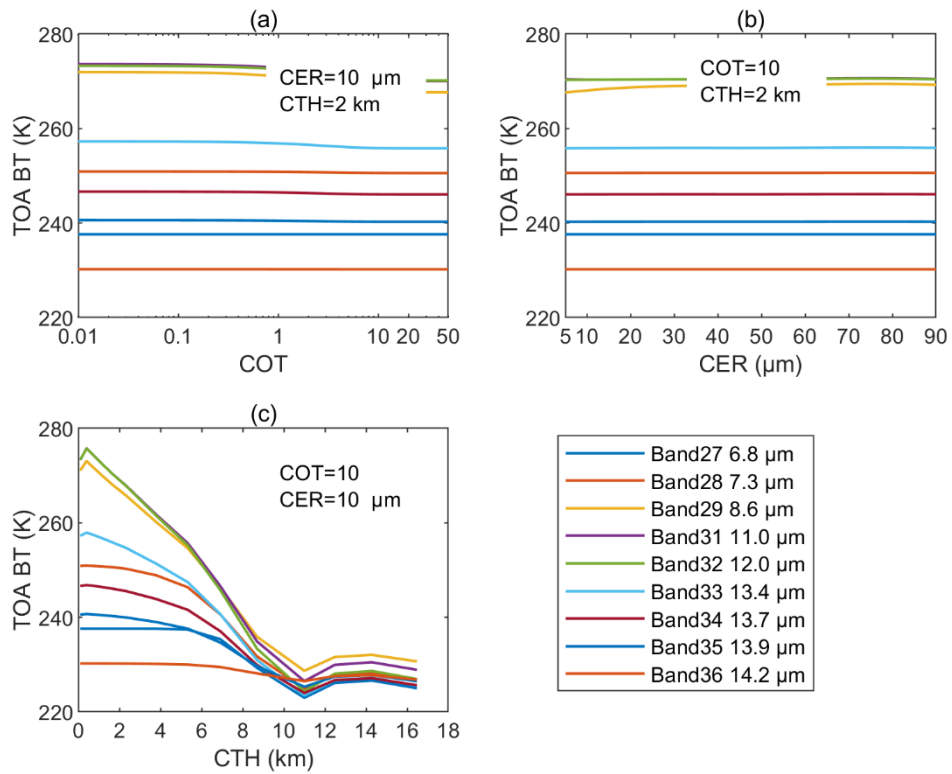
Minor comments:

1. The descriptions of the wavelengths for each band in Table 1 and Figure 2/Figure 3 are inconsistent.

**Reply:** Thank you for pointing our issues and the wavelength in the Figure 2/Figure 3 has been corrected to the appropriate value.



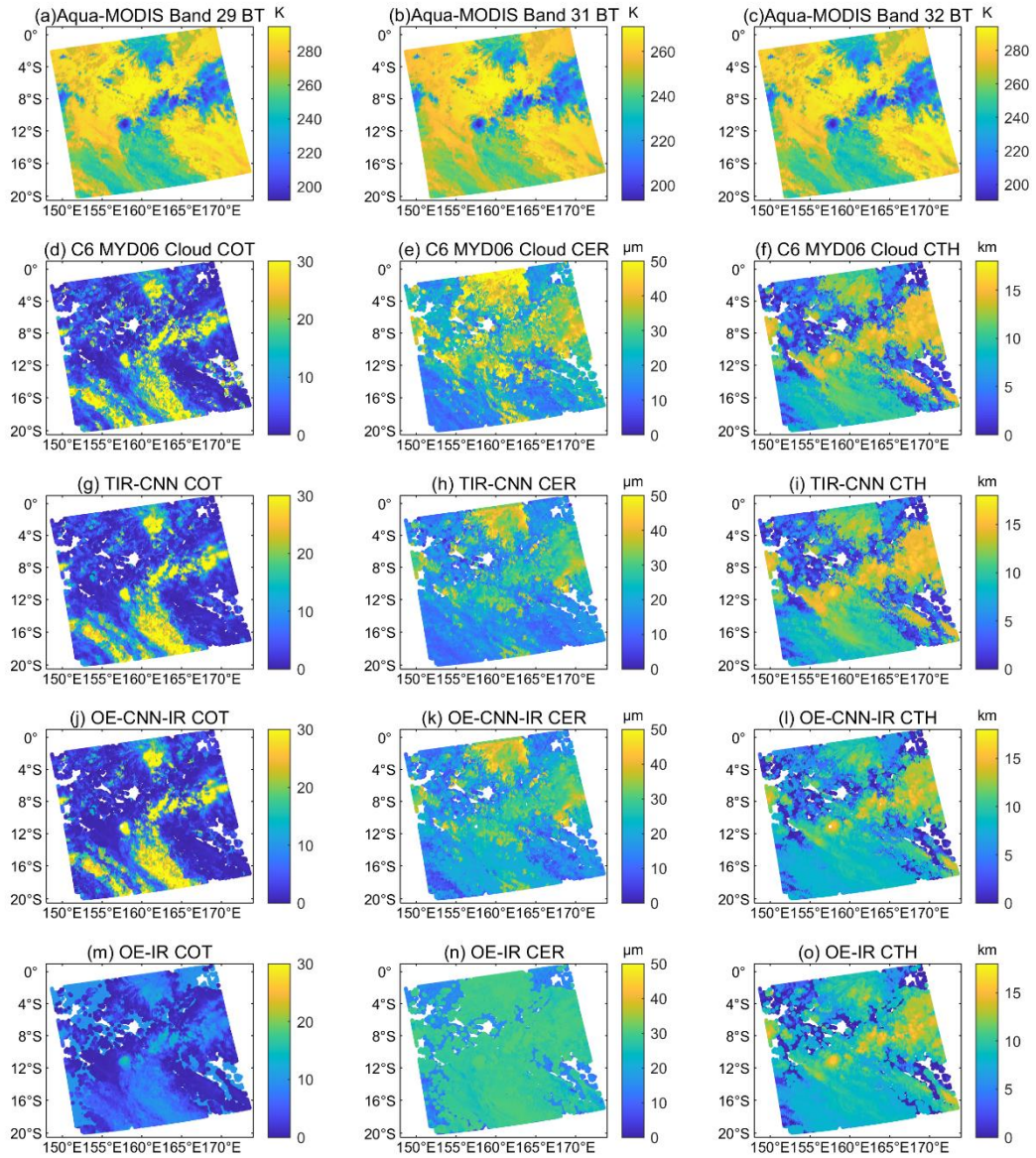
**Figure 2.** Radiative transfer model simulations for ice clouds. The atmospheric profile is from the coordinates with a longitude of  $175.87^\circ$  E and a latitude of  $60.55^\circ$  N, on June 10, 2009, at 00:00 UTC. (a) TOA BTs as a function of COT, when CER and CTH is set to  $20 \mu\text{m}$  and  $10 \text{ km}$ , respectively. (b) BT as a function of CER, when COT and CTH is set to  $5$  and  $10 \text{ km}$ , respectively. (c) BT as a function of CTH, when COT and CER is set to  $5$  and  $20 \mu\text{m}$ , respectively.



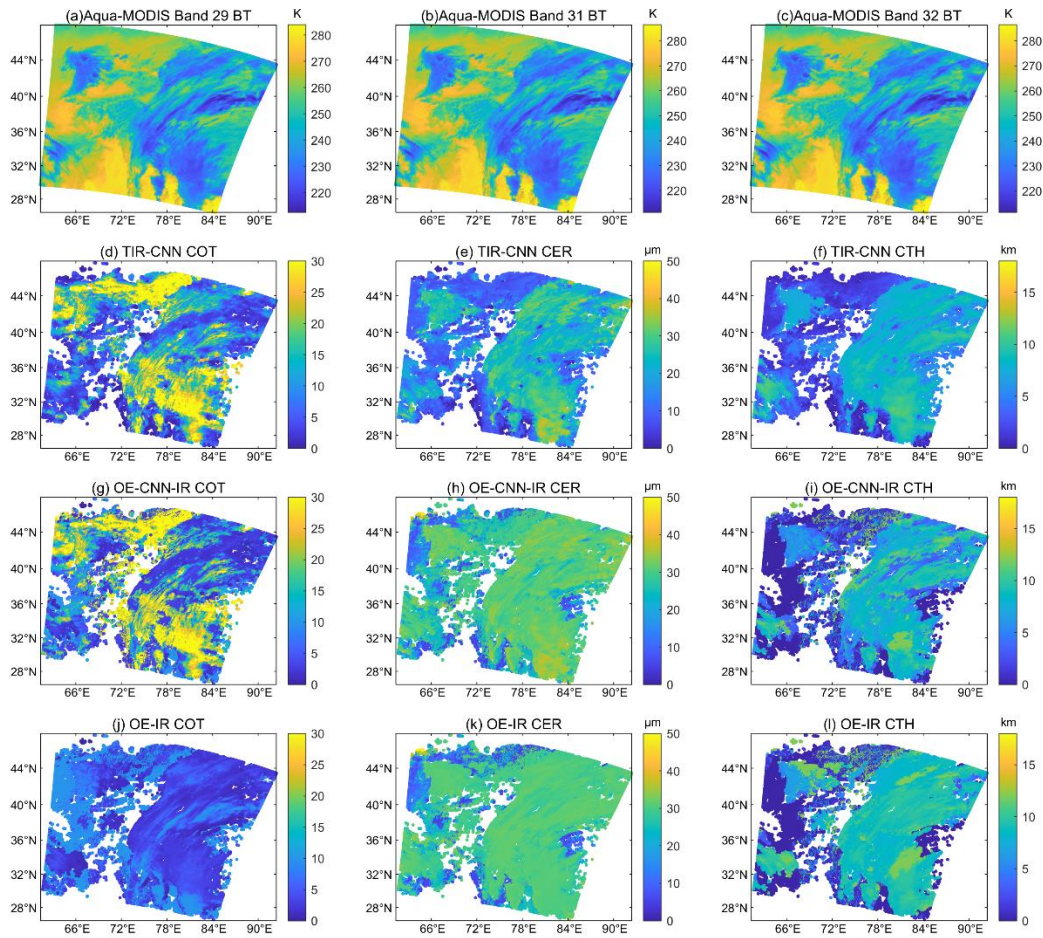
**Figure 3.** Same as Fig. 2, but for liquid clouds.

2. In Figure 5, all parameters are lacking units. It is recommended to add the units either in the caption or above the colorbar. This problem also exist in other figures.

**Reply:** Thank you for your suggestions and we have added units in the figures.

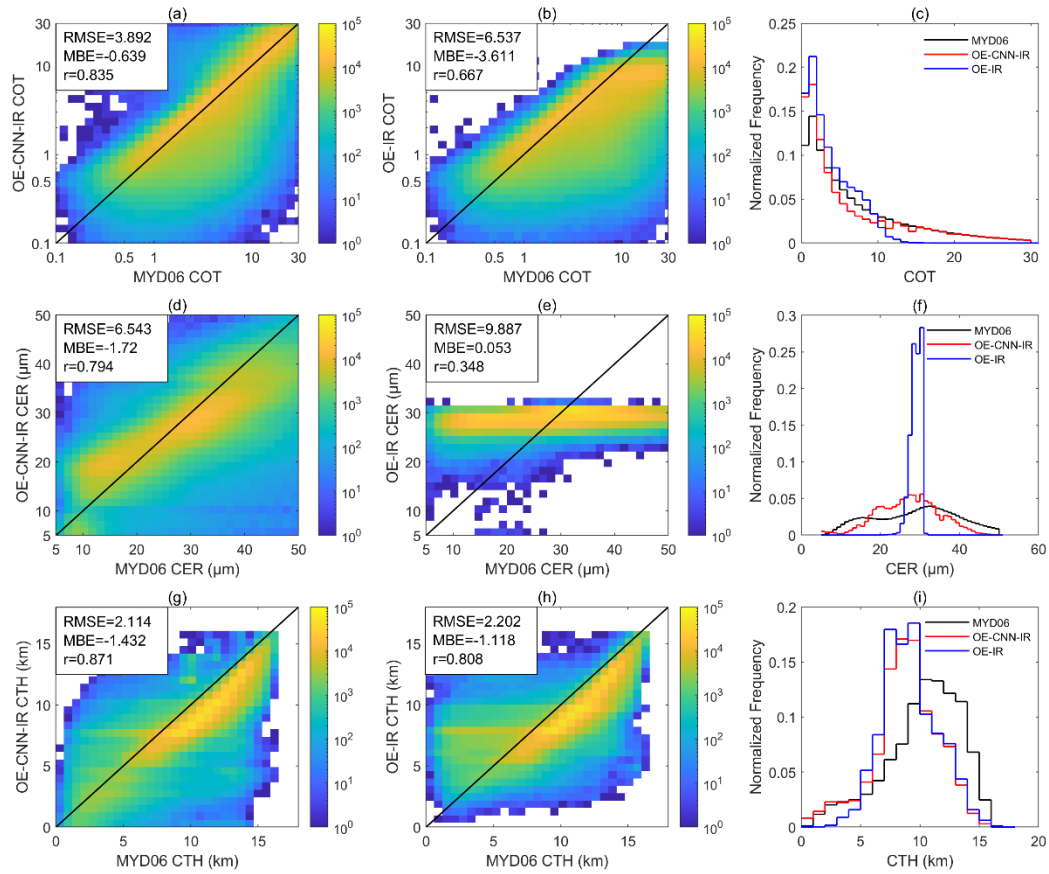


**Figure 5. Comparison of cloud properties obtained from the OE-CNN-IR model, OE-IR model and standard MODIS products for an illustrative daytime granule on 10 June, 2009 (03:00 UTC). (a, b, c) are BT image of MODIS band 29,31 and 32, respectively. (d, e, f) are the COT, CER, and CTH from the MYD06 product, respectively. (g, h, i) are the COT, CER, and CTH from the CNN-IR model, respectively. (j, k, l) are the COT, CER, and CTH from the OE-CNN-IR model, respectively. (m, n, o) are the COT, CER, and CTH from the OE-IR model, respectively.**



**Figure 7. Comparison of cloud properties obtained from the OE model and standard MODIS products for an illustrative nighttime granule on 10 February 2009 (21:00 UTC). (a) BT image of MODIS band 29. (b) BT image of MODIS band 31. (c) BT image of MODIS band 32. (d, e, f) are the COT, CER, and CTH from the TIR-CNN, respectively. (g, h, i) are the COT, CER, and CTH from the OE-CNN-IR model, respectively. (j, k, l) are the COT, CER, and CTH from the OE-IR model, respectively.**





**Figure 8.** Scatterplots of the pixel level comparisons between the retrievals and MYD06 products for ice clouds over oceans. (left column) Pixel-by-pixel comparisons of COT, CER, and CTH from OE-CNN-IR with the MYD06 ice cloud products over ocean in 2009. (middle column) Scatterplots of the pixel level comparisons between the MYD06 cloud products and OE-IR comparable retrievals. (right column) The probability density functions obtained from MYD06 products, OE-CNN-IR and OE-IR derived results are presented. Color shadings denote the number of observations in each respective pixel. All comparable retrievals are constrained to cases with  $SZA < 60^\circ$  and latitude between  $60^\circ$  S and  $60^\circ$  N.

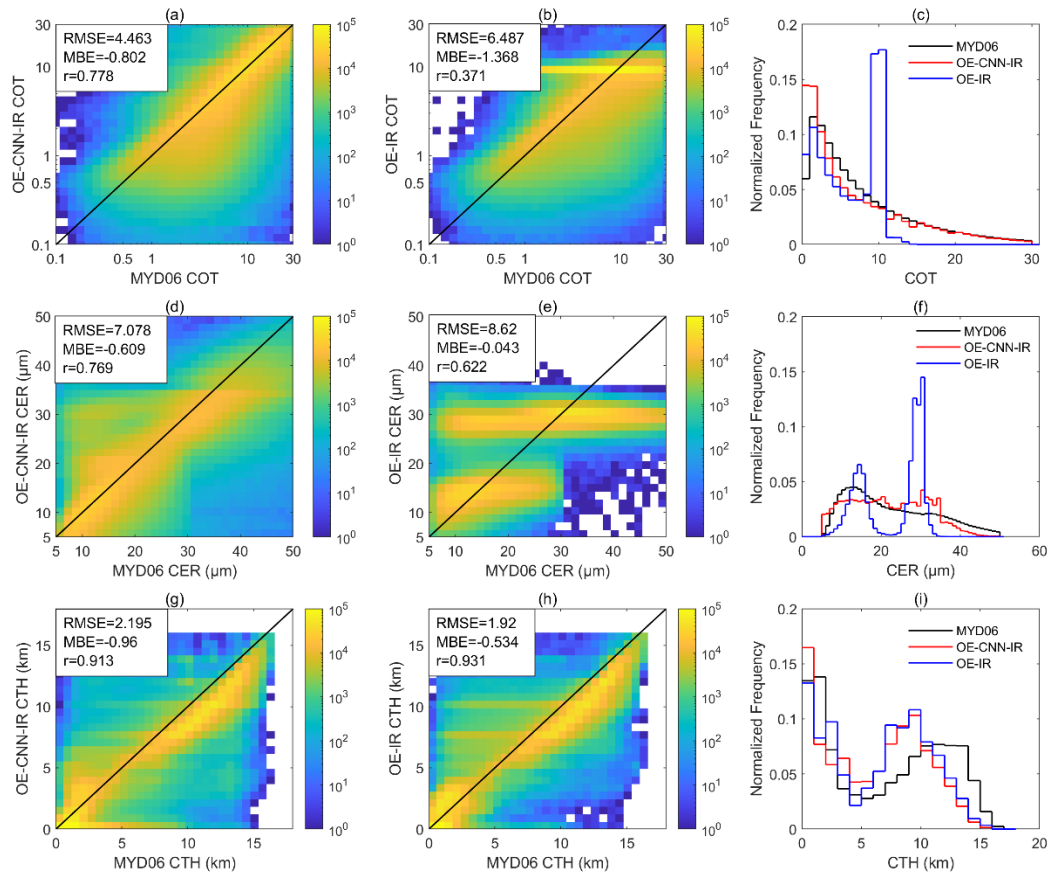


Figure 9. Same as Fig. 8, but includes liquid clouds over ocean, and ice and liquid clouds over land.

3. I think “Earth” should be capitalized. Please check the full text.

Reply: Thank you for your suggestions and all ‘earth’ have been modified as ‘Earth’.

4. Line 111: “6.5 $\mu\text{m}$ ” lacks space between numbers and units, please check the full Text

Reply: Thank you for your suggestions and ‘6.5 $\mu\text{m}$ ’ has been revised as ‘6.5  $\mu\text{m}$ ’.