First and foremost, we would like to express our sincere gratitude to Luca Lelli, the anonymous reviewers, the editor, and the editorial support team for taking the time to review our manuscript and provide valuable feedback. The comments we received were extremely helpful in improving our manuscript, and we are very grateful for them. As outlined below, we have revised the manuscript based on the feedback. The reviewers' comments are copied below and shown in *italics*, while our responses and the corresponding text in the manuscript are shown in red and orange, respectively.

Response to the editorial support team

Regarding figures 3, 7: please ensure that the colour schemes used in your maps and charts allow readers with colour vision deficiencies to correctly interpret your findings. Please check your figures using the Coblis – Color Blindness Simulator (https://www.color-blindness.com/coblis-color-blindness-simulator/) and revise the colour schemes accordingly with the next file upload request.

Answer: In response to the comment, we updated the color scheme for Figures 3 and 4 (excluding Figure 3a) to the 'Scientific Color Maps' recommended on the AMT submission page (https://www.atmospheric-measurement-techniques.net/submission.html).We recognize that adjusting the color scheme of the RGB images in Figures 3a and 7 as well would also be preferable. However, since the values of the three channels are directly assigned to R, G, and B, we are unsure how to modify them to make them colorblind-friendly. Instead, we utilized the 'Coblis – Color Blindness Simulator' to confirm that the RGB images in Figures 3 and 7 can be correctly interpreted by readers with anomalous trichromacy.

<u>Response to Luca Lelli</u>

I read with interest this good article demonstrating the possibility of inferring cloud base height from a single channel in the oxygen absorption band as measured by SGLI but also with the support of multispectral measurements across the e/m spectrum.

It is not my intention with this commentary to provide a full review of the article or to judge the maturity of the work for possible publication. Since I myself am active in remote sensing of cloud properties, I would like to bring the following points to the authors' attention.

Answer: We would like to thank you very much for carefully reading our manuscript and providing us with valuable comments. We have revised our manuscript, by taking full account of your suggestions. The original comments are copied below and shown in *italics*, while our responses and the corresponding text in the manuscript are shown in red and orange, respectively.

In the introductory paragraph, at lines 53-65, there are two inaccuracies. This paragraph cites past work that "derive CBH and CGT using satellite-based passive instruments instead of active instruments" (line 53-54).

The Desmons et al (2019) citation at line 59 is incorrect. In that paper, an algorithm is presented that analyzes the sensitivity of the oxygen B-band centered around 688 nm to changes in cloud fraction and cloud pressure. By "cloud pressure", however, is meant a generic pressure (or height, once this value is converted with the help of an atmospheric profile) located at about the midpoint of the cloud body. The physical reasons are well known, namely that in the forward model of the algorithm the clouds are modeled not as real scattering bodies, but as Lambertian diffusers, for which light is not allowed to penetrate the clouds. But if the process of the photon penetration within a cloud is neglected, then any increase of the oxygen absoprtion line is interpreted as an existence of a cloud at a level that is lower that the actual altitude. This is a feature of the algorithm presented in Desmons et al (2019) and appropriate referenceses therein. In summary, the consequence of this assumption is that it is not possible for the algorithm to approximate multiple scattering inside the clouds, consequently it is not possible to derive any information about the height of the base of the clouds themselves. The authors in Desmons et al (2019), moreover, make no mention of any attempt to find information about CBH or CGT.

The Desmons et al, 2019, reference cannot be cited in the context of the retrieval of CBH nor CGT.

Answer: We appreciate your pointing out the inaccurate citations in our manuscript and providing such a detailed explanation. We have double checked the literature in the light of your explanation and have come to understand our own error. Consequently, in accordance with your comment, we have removed the phrase "or B-band from the Global Ozone Monitoring Experiment (Desmons et al., 2019)" from the relevant paragraph. However, we believe that this paper is a significant contribution to the field of remote sensing using oxygen absorption channels. Therefore, we have added a new paragraph immediately after citing this and similar papers, as follows:

[Section 1; Lines 69 - 75]

"In addition to the literatures cited in the previous paragraph, there are several earlier studies that have investigated or attempted remote sensing of cloud geometric information using oxygen absorption channels while not retrieving both CBH and other geometric information (e.g. thickness). Examples include the use of oxygen A-band measurements (O'Brien and Mitchell, 1992), oxygen B-band measurements from the Global Ozone Monitoring Experiment (Desmons et al., 2019), and two channels in the oxygen A-band and B-band of the Earth Polychromatic Imaging Camera (EPIC) on the Deep Space Climate ObserVatoRy (DSCOVR) (Davis et al., 2018a; 2018b)."

The second clarification I would like to bring to the authors' attention concerns the quote from Rozanov and Kokhanovsky, 2004 at line 65.

In that article, a set of Global Imager (GLI) and MERIS measurements is indeed analyzed, but the algorithm is concerned with the feasibility of deriving CTH and CBH (hence CGT) at the spectral resolution characteristic of the GOME, GOME-2 and SCIAMACHY family of instruments. Application of the algorithm, based this time on a realistic model of clouds composed of Mie droplets and a Gamma distribution, can be found in Rozanov and Kokhanovsky (2006) for GOME on ERS-2 and in Lelli and Vountas (2018) for SCIAMACHY on Envisat. In the second paper (Figure 3 and Table 1), the authors will find climatological values of CBH derived from SCIAMACHY directly comparable to their Figure 10 (page 23).

V. V. Rozanov and A. A. Kokhanovsky, "Determination of cloud geometrical thickness

using backscattered solar light in a gaseous absorption band," in IEEE Geoscience and Remote Sensing Letters, vol. 3, no. 2, pp. 250-253, April 2006, doi: 10.1109/LGRS.2005.863388

Lelli, L. and Vountas, M., 2018. Aerosol and cloud bottom altitude covariations from multisensor spaceborne measurements. In Remote Sensing of Aerosols, Clouds, and Precipitation (pp. 109-127). Elsevier. *http://dx.doi.org/10.1016/B978-0-12-810437-8.00005-0*

Answer: Following the comment, we have declined to cite Rozanov and Kokhanovsky, 2004, and instead cite the two references you provided as follows:
[Section 1; Lines 64 - 69]
"", and coincident measurements from two sensors providing the oxygen A-band and TIR channels, respectively: the Global Ozone Measurement Experiment (GOME) spectrometer and the Along Track Scanning Radiometer-2 (ATSR-2) on the European Remote-Sensing Satellite-2 (ERS-2) (Rozanov and Kokhanovsky, 2006); the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) and the Advanced Along-Track Scanning Radiometer (AATSR) onboard the European Environmental Satellite (Envisat) (Lelli and Vountas, 2018)."

Furthermore, the seasonal variation of the zonal mean CBH derived from GCOM-C/SGLI is illustrated in Figure S4 in the revised supplemental material. This figure is presented for comparison with Figure 3 of Lelli and Vountas (2018), which was derived from SCIAMACHY. The seasonal variation of the zonal mean of SGLI CBH (top) and the difference between JJA and DJF (bottom) are qualitatively consistent with those of SCIAMACHY CBH reported by Lelli and Vountas (2018). However, the CBH values from SGLI are roughly 1 km higher than those from SCIAMACHY in the low-latitude zone, including the peak value. Investigating the factors contributing to these quantitative differences between SGLI-derived and SCIAMACHY-derived CBHs (for example, differences in algorithms, channels used, or dependence on cloud type), remains an important task for the future research.
Therefore, the following paragraph has been added to the main text as well:
[Last paragraph of Section 4.4; Lines 606 - 613]
"It is also noteworthy that the zonal mean CBH derived from SGLI was in agreement with that retrieved from hyperspectral measurements in the oxygen A-band by

SCIAMACHY. Figure S4 illustrates the seasonal variations of the SGLI-derived zonal mean CBH and the difference between the JJA and DJF months, which generally aligns with those previously reported by Lelli and Vountas (2018) for SCIAMACHY. However, the SGLI-derived zonal mean CBH was approximately 1 km higher than that from SCIAMACHY in the low-latitude zone, including the peak value. Further investigation into the factors contributing to these quantitative differences between SGLI-derived and SCIAMACHY-derived CBHs, such as differences in algorithms, channels used, or cloud type dependencies, remain an important task for the future research."

At line 136 the authors cite Rozanov & Kokhanovsky (2004) again in the context of "using an oxygen A-band channel paired with a TIR channel" (line 135). The Rozanov & Kokhanovksy paper makes no mention of TIR channles for the retrieval of cloud properties, because it focuses on the reflectance at Vis/NIR wavelenghts.

Answer: Following the comment, we have removed the reference to "Rozanov & Kokhanovsky (2004)".

This comment naturally leads me to ask the following question, also in light of the concepts presented by the authors in section 4.1 (Potential uncertainty in CBH retrieval).

Clearly, the accuracy of CBH depends on the accuracy of TIR-derived CTH and COT. This is even more important because in reflection, the signal arriving at the satellite will be generated through a different radiation-matter interaction process than in the Vis-NIR, so there will be a difference in the depth of light penetration (i.e. water has a single scattering albedo tending to 1 in the oxygen spectral bands while it fluctuates between 0.6 and 0.4 in the thermal infrared).

It would be extremely interesting if the authors could provide a more quantitative assessment of the errors in coincident COT, CTH(TIR) and CBH(NIR) as preliminary provided in Figure 15 (page 5689) of our paper in ACP (Lelli et al. 2014). There, one can see that errors in CBH are roughly proportional to CTH(NIR) by a factor in range 1.5 - 2.5. This is systematic and well behaved when COT/CTH and CBH are both retrieved in Vis/NIR. I am currently working on this issue and It is not known to me any error assessment in the case of a simultaneous and concurrent retrieval of COT/CTH from the

TIR and the CBH from the NIR.

Lelli, L., Kokhanovsky, A. A., Rozanov, V. V., Vountas, M., and Burrows, J. P.: Linear trends in cloud top height from passive observations in the oxygen A-band, Atmos. Chem. Phys., 14, 5679–5692, https://doi.org/10.5194/acp-14-5679-2014, 2014

Answer: In the supplemental material, we have included a section (Text S2) on sensitivity analysis based on error propagation theory and radiative transfer simulation, together with the results shown in Figures S1 and S2, which we believe provide a response to this comment. Figure S1 demonstrates how perturbations in SW1, SW4, SW3, TI1, and VN9 propagate to the retrievals of COT, CER, ICOTF, CTH, and CBH. Figure S2 illustrates how uncertainties in the measurement vector induce uncertainties in the retrievals. Figures S2a and S2b compare different combinations of channels used in the retrieval process.

First, Figures S2a4 and S2a5 (or S2b4 and S2b5) show that the uncertainty of CBH was proportional to that of CTH by a factor ranging from 4 to 5, which is significantly larger than what Lelli et al. (2014) reported. Another notable feature is that, as shown in the first vertical panels (1-5, 1) of Figure S1, perturbations in SW1 induce not only COT error but also CBH error. This is likely to be a source of the larger uncertainty in CBH, observed in Figure S2. Additionally, the comparison of Figures S2a and S2b offers another important insight: incorporating an additional channel which provides COT information into the retrieval (here, VN11) can reduce not only the uncertainty in COT retrieval (Figure S2a1 → b1) but also the uncertainty in CBH retrieval (Figure S2a5 → b5). Note that the algorithm presented in the main text was performed with the better channel combination shown in Figure S2b, as described in Section 2.2.1.

Therefore, the following paragraph has been added to the main text as well:

[Last paragraph of Section 4.1; Lines 412 - 425]

"In our algorithm, the uncertainty in CBH retrieval is also entangled with the uncertainty in COT retrieval. We performed a sensitivity analysis based on the error propagation theory to examine how measurement uncertainties propagate to retrieval uncertainties (see Text S2 in the supplemental material). Figure S1 demonstrates how perturbations in individual measurement channels induce retrieval errors. Notably, perturbations in SW1, which is a channel sensitive to COT but located outside the oxygen A-band, can induce errors not only in COT retrieval (Fig. S1(1,1)) but also in CBH retrieval (Fig. S1(5,1)). This indicates that COT errors disturb the separation of COT and CBH from VN9 measurements. Figure S2 further demonstrates how the overall uncertainty in the multiwavelength measurements incorporated into the inverse estimation propagates to retrieval uncertainties. The comparison of Figs. S2a1 and S2b1 reveals incorporating VN11 alongside SW1 reduce the uncertainty in COT retrieval, which, in turn, contributes to reduce uncertainty in CBH retrieval. As described in Section 2.2.1, our algorithm utilized both SW1 and VN11. The results of these sensitivity analyses emphasize the importance of carefully addressing uncertainties in COT retrieval when deriving CBH from VN9 measurements. The entanglement of COT, CTH, and CBH retrieval errors associated with oxygen A-band measurements has also been reported by Lelli et al. (2014)."