Response to Referee #3

We are very thankful to the reviewer for excellent suggestions that will contribute to greatly improve the clarity of the paper. In the following, the reviewer's comments are in bold and are followed by our response.

The authors present a new approach and they show a clear improvement on the CALIOP optical depth retrievals if a temperature-dependent multiple scattering factor is used instead of a constant value (which is currently the case for CALIOP Version 3 algorithm). It is clear that this is their main result. Nevertheless, the paper is not well organized into the several sections. Provided that it is a long paper, I do not believe that keeps the reader interested throughout the text. Abstract is good content-wise but I would recommend not to start with the expression "This paper...". I would first write a statement addressing the general question that this paper tries to answer to. Then, the authors could write the methodology they implemented. In the conclusions part, there is repetition of what it was stated in the paper. I would recommend that they should try to summarize it better and make this part more compact and effective.
REPLY: the paper will be re-organized as suggested and the conclusion will be shorter. The abstract will start with:

"Cloud absorption optical depths retrieved at 12.05 μm are compared to extinction optical depths retrieved at 0.532 μm from perfectly co-located observations of single-layered semi-transparent cirrus over ocean made by the Imaging Infrared Radiometer (IIR) and the Cloud and Aerosol Lidar with Orthogonal Polarization (CALIOP) flying on-board the CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) satellite."

More specific comments:
- It is often confusing when the authors present equations. For instance, in page 2162, equation 9 comes very late. It should have been mentioned earlier because it contains the multiple scattering correction factor which the authors found to depend on temperature.
REPLY: the apparent optical depth will be introduced in Sect. 2.1.

This is a typical situation in the paper because of structure problems. Another issue with respect to equations is that they consist of variables which are not introduced to the

reader. A characteristic example is equation (4) and (5). As far as I understand, the authors use the error propagation formula to retrieve the error dτa in equation (4) but they refer to dR'x, which comes later in equation (5). I would propose that you write an expression of weighted radiance R'x as a function of equivalent brightness temperature Tx.

REPLY: p2149, lines 10 to 12 will be moved to be immediately after Eq. (2) and Eq. (5) will be introduced before Eq. (4).

-It happens often that authors refer to their findings shown in a figure and later on, they refer to a previous figure. This looks confusing. An illustrative example is found in page 2160, line 2: the authors refer to simulation results in Figure 2 while in the paragraph above, they refer to Figures 5 and 6. Later in this section, in page 2161, line 8, the authors again refer to Figure 2 while in the previous paragraph, they were commenting on Figure 7.

REPLY: figure 2, which shows simulated relationships between τ_{vis}/τ_a against effective diameter D_e, is introduced in Sect. 2.3. We refer to these simulations in Sect. 3 and then refer to Fig. 2 several times in Sect. 4 when the retrieved τ_{vis}/τ_a are discussed and compared to the expected ones.

- Usually, references are sufficient for the reader to follow the paper. Nevertheless, at some points, references are missing. In particular, reference is missing in page 2145, lines 21-25 where they refer to the "constrained retrieval".

REPLY: the reference "Young and Vaughan (2009)" will be given earlier in the paragraph, page 2145, line 22, as this is the reference for the two techniques that are being described.

In addition, reference is missing in page 2150, lines 27-29 when the authors refer to a random error dTBG.

REPLY: we rephrased as:

"*A random error dT$_{BG}$ is assumed, which is arbitrarily augmented from the instrumental random noise dT$_{m}$ = ±0.3 K to ±0.5 K to account...*"

- I believe that the authors should give clear definitions for certain quantities (e.g., different temperatures) that they deal with in the paper at an early section. For instance,

they present Tr and T(i) in section 3-"Cloud radiative temperature" which I think is a bit late.

REPLY: T_c and T_r are defined in section 2.2 (page 2151, lines 6-8).

T(i) is needed only for the equations presented in Sect. 3. We don't understand why it should be introduced earlier.

- The authors should be aware that not all the readers are familiar with standard products of CALIOP and be more descriptive when they refer to certain products (e.g., page 2156, line 5).

REPLY: the sentence will read (changes in bold):

*"IIR absorption optical depths, reported at 1km pixel resolution under the lidar track in the **IIR** Level 2 **track** products, are averaged to a 5 km horizontal resolution to match the resolution at which CALIOP optical depth is reported in the **CALIOP** 5km cloud layer products"*

- The authors should avoid beginning a sentence with a variable. For example, in section 4.1, paragraph begins with τ_{vis}/τ_a which does not look like a nice way to start a statement.

REPLY: this paragraph will begin with:

"The τ_{vis}/τ_a ratios....."

- There are few problems when authors present values. Page 2154, line 1: Better to write 2 ±0.4 than 2 ± 20%.

REPLY: will be fixed in the revised version of the manuscript.

- There is quite a redundancy in the paper. Examples:

(1) Page 2150, line 1-2: "Each term in Eq. 4 ... computation of τa" this goes without saying from the dependence of τa on quantities R'x.

REPLY: the sentence will be deleted.

(2) Page 2166, line 1-2: Of course Scal,Îd' is null, when optical depths are approximately zero. I would recommend that authors remove the word null, which refers to null space of a matrix and not to a matrix with zero elements, if this is what they mean.

REPLY: we will write: *"the relative error in S_{cal} is zero,..."*

In the revised version of the manuscript, these equations will be in Sect. 2.1.

- There is a small problem in the punctuation of symbols. In Page 2150, dR'x is with apostrophe in the text and with prime in the equations. I would try to keep it everywhere consistent.

REPLY: we don't understand the comment.

- There are some confusing long sentences which are difficult to understand. Page 2164, line 17-20: This sentence is long and not of a clear meaning. What is the complex journey of the photons? As far as I know, there is not such a valid expression. Do the authors refer to 2-way transmission within and below the layer or they refer to coherent scattering?

REPLY: the authors refer to scattering and diffraction.