# The OCO-3 mission; measurement objectives and expected performance based on one year of simulated data
# Response to Anonymous Reviewer 1

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Thank you for the very useful comments on our work. We appreciate your time and interest. The reviewer's comments are in black text and our responses are given in blue.

We'd like to note that we took the opportunity to make a few minor changes and improvements to the manuscript during the response-to-reviewers process. Namely the discussion in various places was abbreviated in an attempt to improve the overall flow of the manuscript. The most significant edit was made in Section 3.1 "Simulated OCO-3 observation geometry". Also, a few minor text changes were made throughout to reflect slight updates to the knowledge of expected OCO-3 operations since the time of the original submission in early October, 2018 (nearly 5 months ago).

1. Section 3.2 presents the issue of polarization and the computation of Stokes coefficients, but no further analysis is presented in the results section. Why should the reader be interested in the computation of these Stokes coefficients (Eq. 1 and 2) if they are not used later on? It would be nice to actually see some discussion of polarization effects in Section 5.1, as promised at the end of Sect. 3.2.

   This is a fair point. We felt that some discussion of the polarization angle is warranted as this to some extent drives the "throughput" or "signal" that the instrument measures. Since the polarization angle is a form of geometry, we felt that placement in Section 3 "Simulated geometry, meteorology and L1b dataset" was the appropriate place to introduce it. In an attempt to better tie the discussion of the (expected) OCO-3 polarization angle to the solar zenith angle and the signal to noise ratio, we have provided a more comprehensive discussion of the polarization in Section 3.2 "Simulated instrument polarization angle and Stokes coefficients". This includes addition of a new figure (Fig.6) that shows the theoretical relationship between the polarization angle, the solar zenith angle and the measured signal to noise ratio for a specularly reflecting surface driven by a Cox and Munk model, i.e., glint-water viewing. The reference in Sec 3.2 to further discussion on polarization in Sect 5.1 was removed since Sect 5.1 focuses mainly on the SNR aspect of the measurements, which is of overall greater importance than polarization w/r/t $XCO_2$ retrievals.

2. Page 4, Line 25: Isn't the O2-A band also providing useful information on aerosols?

   Yes, this is true. We have slightly modified the wording in Section 2.1: "The OCO-3 instrument payload" to more accurately describe the function of each of the three spectral bands. A few relevant citations have been added as well.

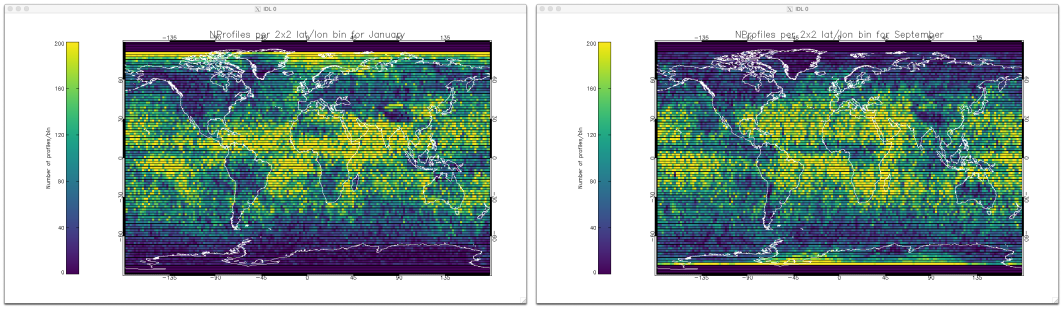


**Figure 1.** Maps showing the number of CALIPSO cloud and aerosol profiles contained in each 2° by 2° lat/lon bin for January (left) and September (right). For each OCO-3 sounding in the simulated data set a single profile was picked at random from the appropriate month and bin.

3. P15, L19: I didn't quite understand how exactly the random selection of cloud and aerosol profiles was made. Was the random selection made following some probability of detecting a cloud based on climatological cloud coverage?

   No, there is no climatological cloud coverage taken into account. However, the static database is composed of real CALIPSO/CALIOP profiles that are binned into monthly 2x2 lat/lon bins, so each randomly selected profile represents a scene that was actually measured by CALIOP, but there is no continuity among adjacent OCO-3 soundings which are order 2x2 km. Some examples of the number of CALIPSO profiles for each lat/lon bin are shown in Figure 1. Although this material is interesting, we feel that the paper is already a bit lengthy so have opted not to include this figure in the text. Some alterations were made to the wording in Section 3.3 "Simulated meteorology, gas and cloud/aerosol fields" in an attempt to more clearly explain the procedure.

4. Small corrections:

   (a) 1. Page 3, line 32: 'then 4 km' -> 'than 4 km' Corrected.

   (b) 2. P3, L12. Point is missing in front of 'Finally' Corrected.

   (c) 3. P9, L14: It should probably be '30 south latitude' Corrected.

   (d) 4. P9, L26: It should probably be '2 longitude x 2 latitude'. Same issue in legend of Fig. 3. Corrected.

   (e) 5. P14, L12: There are two 'a' on this line that should be deleted. Corrected.

   (f) 6. P16, L15: I suggest to delete 'accurately' in this sentence. The calculation will always only be an approximation of reality and will only be (nearly) accurate, if the inputs such as aerosol properties are accurate. Corrected.

   (g) 7. P17, L1: What is the 'NASA DISC'? Removed this reference as it is irrelevant in this context.

   (h) 8. P17, L13: What do you mean by ' a priori state of the atmosphere'? What properties of the atmosphere are described? Slight rewording of Section 4.2 to better describe the setup of the L2 retrieval algorithm.

(i) 9. P18, L29: 'anomoly' -> 'anomaly' Corrected.

(j) 10. P19, L32: delete one of the two 'when' Corrected.

(k) 11. P20, L6: There seems to be a closing bracket missing. Corrected.

(l) 12. P20, L7: 'the OCO-3 SNR' -> 'the SNR' Corrected.

(m) 13. Tables 2-4: These tables are full of acronyms and hard to read. I suggest adding another column 'description' describing the variables. Updated the three tables to include a Variable Description column

(n) 14. P25, L2: Could you be more specific regarding the similarities and differences in the selected variables between OCO-3 and OCO-2 We modified the discussion in Section 5.4 "Bias correction of $XCO_2$" to be more explicit about the similarities and differences with both real and simulated OCO-2 data.

(o) 15. Fig. 13, lower left panel: Why is the x-axis the square root of the AOD and not AOD directly? We found that the $XCO_2$ error was closer to linear versus the square-root of the AOD. Since the BC formulation is linear in nature, this is the optimal variable to make the correction against. Table 4 was corrected to show this variable (was improperly just DS AOD before). It is such a minor detail that we did not insert any additional verbiage into the text for the sake of brevity.

(p) 16. Fig. 18: I can't see any 'tiny black dots' Removed the reference to the tiny black dots since they had been removed from this version of the plot for clarity.