

Referee #3

This paper focuses on the collocation of OCO-2 and MODIS data, and analyzes the relationship between CO₂ retrievals from OCO-2 and AOD retrievals from both OCO-2 and MODIS. The authors demonstrate that errors in AOD retrievals affect XCO₂ retrievals, and also show that excluding data points with moderate AOD (0.2-0.5) excludes many areas with high XCO₂. As a result, the authors recommend relaxing the MODIS AOD threshold to 0.5.

Reply: We thank the referee for the valuable comments. We have revised the manuscript accordingly, to make the analysis and results clearer.

We see that our main message in section 4.5 was not stated clearly enough. We do not actually recommend relaxing the AOD threshold to 0.5 for the (OCO-2) XCO₂ retrievals; we simply wanted to test the effect of using the looser threshold (planned to be used with CO₂M) on the coverage in different environments. We have modified the abstract and conclusions to emphasize our main results, and section 4.5 to clarify the purpose of the aerosol threshold exercise.

Major comments

The authors note (in lines 181-185) that there is low correlation between MODIS AOD and OCO-2 AOD in Australia, the Sahel, the Western US, and Central Asia, using MODIS Dark Target observations. However, these areas seem to include bright land surfaces like large deserts and snowy mountain ranges, so perhaps using MODIS Deep Blue would be more appropriate for such areas. The Western US and Sahel also show high correlation between XCO₂ and MODIS AOD in Figure 4b. Can this be explained by poor quality MODIS Dark Target observations? Would using MODIS Deep Blue for these areas change the analysis?

Reply: Indeed, the areas of low correlation listed in the manuscript all have bright surfaces, as noted by the Referee. This might be one contributing factor to the observed correlations. We have added this to the text. However, as for MODIS Deep Blue algorithm, the same areas have low AOD correlations, as shown in Fig. A2 c). We have added a more explicit reference to this in the text.

Section 4.5: The authors show that increasing the AOD threshold to 0.5 will increase the fraction of acceptable data, but do not show or discuss how this will affect the quality of XCO₂ retrievals. It seems that improving the quality of XCO₂ retrievals at higher aerosol loads remains an open challenge -- the authors should state this explicitly.

Reply: Clearly the discussion in section 4.5 was not sufficiently clear, as pointed out by all referees. The idea here is that the coming CO₂M mission will have a dedicated aerosol instrument - Multi-Angle Polarimeter (MAP) – which is expected to allow XCO₂ retrieval at heavier aerosol conditions, with AOD threshold of 0.5. Here we use the MODIS AOD data collocated with good quality OCO-2 retrievals, which includes high MODIS AOD pixels (although the OCO-2 quality filter including an AOD threshold of 0.2 has been applied). With this collocated data set, we can test what is the effect of relaxing MODIS AOD threshold from 0.2 to 0.5.

We have clarified the text in section 4.5 to bring these points explicitly out. Please see our reply to Referee #1 for a more detailed answer.

Minor comments/technical corrections

Line 299: Change (A3) to (see Fig. A3)

Reply: The reference was incomplete. We have changed this to “(see Table A3)”.