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Satellite retrievals of column averaged dry air mole fraction of CO2 (XCO2) are sensitive to atmospheric aerosols. Moderate Aerosol Optical Depth (AOD) can be accounted for in the state of the art XCO2 retrievals, while heavy aerosol conditions need to be screened out. For the upcoming CO2M mission, targeted at monitoring anthropogenic CO2 emissions globally, the effect of AOD thresholds for quality filtered CO2 retrievals on the satellite coverage and representativiness is important. Since aerosols and CO2 are often co-emitted, the aerosol screening hampers the monitoring of anthropogenic CO2 emissions in areas of heavy aerosol loads, such as urban areas. On the other hand, inclusion of high AOD cases may increase the uncertainties of satellite XCO2 retrieval results.

We have studied the effect of aerosols on the Orbiting Carbon Observatory (OCO-2) XCO2 retrievals using collocated MODIS Dark Target aerosol product as reference aerosol data. From collocated land-global five year (2015-2019) dataset we find that for low AOD values OCO-2 tends to overestimate AOD with respect to both MODIS and ground based AERONET data and underestimate AOD at the high AOD end. Considering the upper AOD thresholds of 0.2 for good quality retrievals, we find that c. 19% of the quality filtered data are affected by high aerosol load (AOD>0.2) according to MODIS. Conversely, 4% of the data passes the threshold for MODIS, but are rejected by OCO-2.

We note that the OCO-2 total AOD is not an aerosol product as such, but one of the many retrieval parameters in the full-physics CO2 retrieval. Thus an error in AOD may be compensated by a change in other parameters, and does not necessarily lead to erroneous XCO2 retrieval. However, we find that XCO2 values are higher when OCO-2 underestimates AOD with respect to MODIS. Similarly, XCO2 values are lower when OCO-2 overestimates AOD with respect to MODIS. By further collocating the MODIS/OCO-2 dataset with ground based TCCON data, we find that the difference between OCO-2 and TCCON XCO2 has a weak dependence on MODIS AOD, such that OCO-2 XCO2 is overestimated at low AOD and underestimated at high AOD.

We also find a weak but statistically significant positive correlation between AOD and XCO2. The correlation arises from natural covariability or co-emissions of aerosols and CO2. The correlation is stronger in urban areas and in polluted geographic regions, suggesting co-emission of anthropogenic CO2 and aerosols, and underlining the need for higher aerosol tolerance in satellite XCO2 retrievals.

Finally, in light of the upcoming CO2M mission, we find that relaxing the MODIS AOD threshold from 0.2 to 0.5 increases the fraction of acceptable data from 81% to 98%. Geographically, this increase is highest in urban areas and regions of high constant aerosol load, further highlighting the importance aerosol treatment in satellite CO2 retrievals.
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