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Interactive comment on "How bias correction goes wrong: Measurement of X_{CO_2} affected by erroneous surface pressure estimates" *by* Matthäus Kiel et al.

Anonymous Referee #2

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The paper by Kiel et al. reports on improved calculation of the a priori surface pressure used in the OCO-2 retrieval algorithm for the dry-air mole fraction of carbon dioxide (XCO2). Kiel et al. discovered two errors; one was related to erronous geolocation assignments, which in consequence caused wrong surface elevation going into the surface pressure calculation; the other error was related to wrongly interpolated pressure fields. The paper describes the errors and shows how to remedy them successfully in the next version of the algorithm. The paper should be published with minor modifications suggested below.

The study is probably of broader importance than just for OCO-2. GOSAT also suffered

from substantial uncertainties in its pointing information. The study clearly highlights the importance of accurate surface pressure knowledge – for all past and upcoming CO2 missions targeting at ppm accuracy. I would actually recommend highlighting a bit more that it is in particular localized analyses i.e. studies relying on pairs of geolocations (e.g. megacity urban dome vs. remote background) that require accurate geolocation assignment.

The paper repeatedly argues that it is the bias correction that causes wrong a priori surface pressure to map into wrong XCO2. So, the apparent remedy would be to trust in the retrieved surface pressure and not to bias-correct it (or not to use it for bias correction). The reason to retrieve surface pressure is actually based on the assumption that the a priori is not sufficiently accurate. Probably, that does not work because a) the retrieved surface pressure still must be heavily constraint to the a priori and b) retrieved surface pressure suffers from other errors (both due to the illposedness of the simultaneous aerosol retrieval, spectroscopic errors etc.). In summary, retrieving surface pressure does not lessen the need for accurate a priori information. That aspect could be made clearer in the manuscript.

P1,L6: "bug" -> (coding) error

P2,L12: It largely depends on surface albedo whether "too much aerosol" shortens or lengthens the lightpath. If surface albedo is high, multiple reflections between the surface and the aerosol layer are efficient and lengthen the path. I.e. the statement is not true in general.

P2,L13,14: Similar to the previous comment, spectral variation of surface albedo is probably even more important than spectral variation of aerosol optical properties in changing the radiative transfer regime between the O2A and the CO2 bands. Plus, the third player is the difference in absorption optical thickness structure between the bands that induces different height sensitivities to "wrong aerosol" when retrieving gas columns.

P2,L20: I recommend mentioning that, while ACOS has surface pressure in its state vector, it is heavily constraint to the a priori (I presume).

P2,L31: we are hoping to achieve -> we need to achieve

P4,L26: 0.7 -> 0.76

P5,1st paragraph: A sketch would help.

P6,L15+: 1.8k -> 1.800, 1k -> 1.000

Table 2: "K"? -> "/1000" in the header or at least "k"

Figure 3: To me, the topography related bias is not really apparent in the figures. Would it make sense to plot the slopes instead of the altitudes in the left panels?

App1,L17: Taylor expansion -> Taylor expansion in c around c=0 (right?)

App1, A7: So, strictly, the "c" in equ. (A7) is different from the "c" in equ. (A6).

C3