

Atmos. Meas. Tech. Discuss., author comment AC2
<https://doi.org/10.5194/amt-2022-241-AC2>, 2022
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

Reply on RC2

Emily Bell et al.

Author comment on "Exploring bias in the OCO-3 snapshot area mapping mode via geometry, surface, and aerosol effects" by Emily Bell et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2022-241-AC2>, 2022

Q1: The ACOS retrieval uses the retrieved surface pressure to calculate XCO₂. I am wondering how much trouble actually comes from the surface pressure retrieval (mostly informed by the O2A band) and how much from the actual CO₂ retrieval. The large effect of the change in "dP correction" on the SB (section 7) fuels my concerns. Also, the fact that coarse aerosols (with a smooth spectral variation of optical properties between O2A and strong CO₂ band) seem less problematic than fine aerosols (with a substantial spectral variation) could hint at particular difficulties in getting a "consistent scattering picture" from the O2A and CO₂ bands. Would it be possible to separate the surface pressure related portion of the SB? How large is it – if it is large, why not use a priori surface pressure?

A1: We have explored using the a priori surface pressure, in experiments leading to v10. Various surface pressure constraints were tested and the results evaluated after bias correction. The results of using the prior surface pressure, among other tests, were consistently not as good as retrieving the surface pressure and then bias correcting it out after the fact – the reasons for this are unknown.

Regarding dP as a driving force of the swath bias, the best evidence we have addressing this question thus far is our evaluation of the v10 dP bias correction. If dP were a driving force of the swath bias, we believe that applying the v10 bias correction would decrease the number of v10 swath bias cases significantly. We have added text to lines 548-552 addressing this:

"We do note, however, that in tests applying the bias correction and quality filtering separately, the quality filtering had the more substantial effect on the SB: bias correction alone reduced the number of v10 SB SAMs from 325 (in raw data) to 310, and quality filtering reduced it from 325 to 225. While dP had the largest impact within the bias correction, the quality filtering had an even larger impact, indicating that the swath bias is not driven specifically by dP, but rather by extreme aerosol effects generally being characterized poorly within the retrieval."

Q2: While I like the approach to concentrate on understanding individual scenes, I find the focus on one particular scene in Australia quite narrow. The scene is bright and surface reflectivity is probably spectrally smooth throughout the spectral range covered. This implies that the dominating scattering effect in all bands (somewhat depending on geometry) is light path enhancement due to (multiple) reflections between ground and

aerosol layer. While the authors touch on the effect of surface albedo (Fig. 13), I would recommend examining in depth another, darker scene with substantial spectral variation in surface albedo (e.g. vegetation). For darker scenes, light path shortening due to direct backscattering from the aerosol layer would be more important i.e. discussion of such a scene would cover an entirely different radiative transfer regime and thus, it could contribute mechanistic understanding.

A2: We have changed the way we introduce our experimental setup in an attempt to address the concern regarding the limitation of the study to a single site. See lines 307-310:

"We then focus on three SAMs over a single representative target location, and use their geometry as templates to test the SB in a more complete scene state space: [..]" and lines 332-335:

"By examining three SAMs from the same site, we are able to investigate the differences in atmospheric state and/or observation geometries that drive the operational SB, in addition to using their different geometries as a template for a broader array of synthetic scenes, as mentioned above."

While we choose a single scene over Australia as the basis for our simulations, rather than focus solely on the real scene from each of the three dates chosen, we use the geometry of each date to test a broader state space - including albedos ranging 0.1 to 0.6. We also feel that focusing on scenes over bright surfaces is warranted because our vEarly analysis (see Figure5d-f) indicates that swath bias is a more acute problem in SAMs with high surface albedo.

Q3: L165f: I got quite a bit confused with the directions „across swath“ and “along swath“. I understand that a simple “across/along track“ does not work because OCO-3 has a dedicated pointing system such that the scanning is not aligned with forward direction of the space station. Maybe the authors could consider to make a small sketch defining their notations or include the notation in one of the early figures.

A3: Visualization of this language is now included in Figure 1: we identify individual swaths, and indicate the along- and across-swath directions.

Other minor changes:

(1) “We apply our single profile, along with its associated surface elevation and surface reflectivity, to every sounding in the SAM.” Added to Section 4.1. This was not specified previously.

- similarly, in Section 6:

“[...] we manipulate each SAM to include various aerosol types, heights, and optical depths with a realistic surface”

was changed to

“[...] we manipulate each SAM to include various aerosol types, heights, and optical depths with a constant surface elevation and reflectivity” to better reflect the simulation setup.