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Atmospheric Chemistry and Physics Discussions

Interactive comment on "New approach to evaluate satellite derived XCO_2 over oceans by integrating ship and aircraft observations" *by* Astrid Müller et al.

Anonymous Referee #1

Received and published: 18 December 2020

This paper describes a method of splicing together in situ measurements from ships, from aircraft, and from the ACTM model to create vertical profiles of CO2 over the Pacific Ocean. The vertical profiles are integrated to calculate XCO2 values that are then compared with the OCO-2, ACOS-GOSAT, and NIES-GOSAT retrievals over the same region. It's not clear to me whether ACP is the correct journal for this publication; it seems as though AMT might be a better fit for the paper's stated goals.

General comments:

There are multiple ATom and HIPPO profiles throughout the Pacific – it would very much strengthen this paper if you could find coincident data with HIPPO/ATom profiles

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and compare vertical profiles in detail. It would further strengthen the paper if you could extend the most southern box another 4 degrees to 34S, where you could show that the combined in situ + ACTM total column matches that from the (coastal) Wollongong TCCON station (filtering for onshore wind direction, perhaps).

I found the Results and Discussion section confusing in places (see Specific comments for details) and difficult to follow. Uncertainties are large in the differences and trends, and yet conclusions were drawn about whether satellite measurements agreed with the ship+CONTRAIL+ACTM-derived XCO2.

Specific comments:

L38 – Why cite the 2018 value of atmospheric CO2? You could update this using the NOAA value for 2020. L108 – Why do you only use the tropospheric data in your analyses? Wouldn't the lower stratospheric data provide important constraints on the total column and provide a check on the stratospheric model? L125 – "By measuring the amount of light absorbed by CO2 and O2, the column average CO2 dry air mole fraction (XCO2) is estimated by taking ratio of the total column amounts of CO2 and O2, where O2 provides an estimate for the total column of dry air (Wunch et al., 2011)." This is true for TCCON, but I do not believe this is how the ACOS retrievals work. Please clarify. Figure 2 – How does this profile compare with the GINPUT profile? If I understand correctly, the blue stars are a combination of model, in situ, and extrapolated data, is that correct? If so, calling it the "in situ" profile is misleading. L172 – Why use the MIROC-4 ACTM for the stratosphere instead of the GINPUT stratosphere? How do they compare? L335 – "Hence, even though no assumption was necessary at that period, the negative bias persists (Fig. 5d, Fig. 6e), which indicates that the difference between in situ and satellite XCO2 can be linked to measurement uncertainties of the satellites." I do not follow this logic. Why couldn't the bias be caused by a bias in the ACTM stratosphere and not in the satellite retrievals? L353 – "The consistency with long-term studies support the correctness of the in situ XCO2, which implies that satellite XCO2 sometimes show a delayed response to CO2 changes." Again, I do not

follow this argument. The satellites measure the total column in the atmosphere at the time of the measurement. Are you saying that the satellite measurements are wrong? L359 – “In contrast, a significant increase of 3.84 $\pm$ 0.65 ppm yr$-$1 is observed by in situ XCO2 from 2015 to 2016, which is by $\sim$10% larger than that observed by satellites (3.39 $\pm$ 0.03).” Firstly, I don’t see 3.39 $\pm$ 0.03 in Table 4 – is this a typo? Secondly, these numbers do not differ by 10% - their uncertainties overlap and therefore you cannot say anything conclusive about how they differ.

Technical comments:

L55 – change “improves” to “improve” L56 – change “the second NASA” to “NASA’s” L71 – TCCON has a very limited number of sites observing *the atmosphere over* open oceans. I’m not sure how you define this, since there are several coastal and island TCCON stations (e.g., Réunion Island, Ascension Island, Izaña, Burgos, Darwin, Wollongong) and the TCCON footprint is large enough that it would be sensitive to CO2 over oceans.

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