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Reply on RC1

Andrew F. Feldman et al.

Author comment on "Using Orbiting Carbon Observatory-2 (OCO-2) column CO_2 retrievals to rapidly detect and estimate biospheric surface carbon flux anomalies" by Andrew F. Feldman et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-506-AC2, 2022

We thank the reviewer for the constructive comments. These are great questions that have already led to some thought and will require some short analyses to address. We have some initial thoughts below on how we will address them.

In response to the main four points:

1) XCO_2 spatio-temporally averaged error estimation: Our estimation shows that the errors do not change greatly between spatially autocorrelated and independent errors. With spatial autocorrelation of errors within a domain, averaging spatially will not necessarily reduce the errors because the errors may be skewed toward the same sign (positive or negative errors). However, given spatial autocorrelation of XCO_2 errors across a large region, the averaged XCO_2 value within the target domain and XCO_2 value in the background region will likely have a similar error. For example, if both the background and target region have perfectly spatially correlated errors, and the error is +0.5 ppm for a given month, subtracting the two XCO_2 values to get an enhancement will remove the +0.5 bias entirely

However, we will rethink this argument given the referee's comment. We will revisit how OCO-2 computes its XCO_2 errors and how XCO_2 errors may vary spatially in the context of this question. We will clarify the above point and also rethink the error estimation in the context of the 1/sqrt(n) difference in errors between independent and perfectly correlated errors.

2) Vertical air movement: This is an excellent point. A clarification that all XCO_2 values used in the study are full column integrations. The wind velocity for the mode in Eq. 1 is just of the boundary layer as with previous studies, assuming that this air layer interacts with the surface fluxes. However, it is a great point to think about whether the model in Eq. 1 can properly account for vertical wind velocity and if differences in XCO_2 concentration with height influence the surface flux estimations. Obvious experiments with the CarbonTracker reanalysis data to address this question include: (1) investigating how changes in vertical wind velocity influence the surface flux estimations with XCO2 using Equation 1 and (2) to see whether months with larger XCO_2 vertical gradients lead to larger surface flux estimation errors. Potentially, winds toward the surface could suppress mixing of carbon fluxes on average and increase contributions of anomalous XCO_2 from higher in the atmosphere. Nevertheless, given vertical mixing over a month, we do expect this issue to be smaller than those due to horizontal wind.

3 and 4) Spatial domain selection: Both of these questions deal with the choice of region, which we should give more quantitative treatment to in this study. We can add a figure investigating which factors go into the selection of the region. The main issues the domain selection should consider are the degree to which the surface fluxes and atmospheric carbon concentrations are coupled at monthly timescales as well as how favorable the horizontal wind conditions are for application of the mass balance method (including spatial and temporal wind direction variance and whether the region has variable anthropogenic upwind sources). These considerations should naturally include those that the reviewer mention (i.e. topography, anthropogenic sources) and should screen out unfavorable areas. Such a figure will allow easier selection of hotspots or regional domains for future studies to apply the analysis we did here for the West US.

Additional points: We anticipate that all of these points can be addressed.