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Interactive comment on "A multiresolution spatial parameterization for the estimation of fossil-fuel carbon dioxide emissions via atmospheric inversions" *by* J. Ray et al.

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The reviewer states: "The use of nightlights versus BUA needs some more detail. The authors indicate that BUA uses nightlights and hence these are not independent, though land-cover maps are also used. Perhaps some further comment on whether or not that makes much difference would help. I worry that these are essentially the same thing and/or what differences do exist are hard to interpret via the results presented here."

Response: BUA maps bring very little prior information to the inversion (vis-à-vis night-lights), and sometimes lead to slightly worse reconstructions. This is discussed on Pg.

1298:10-25, but not succinctly stated anywhere. We will add this to the new 'Discussions' section that we have added to the paper.

The reviewer states: "This effort seems well-suited to explore questions of measurement siting....... What network of CO2 measurements might be more fossil-sensitive? This is independent of radiocarbon. . . there are perhaps locations where the fossil signal from Vulcan is well represented by the treatment here? That would offer some practical guidance to future network expansion or interpretation of OCO2 measurements. I don't expect the addition of these tests to the manuscript but some comment at the end would be a very useful addition to those readers pondering the practical utility of the approach."

Response: We have updated our manuscript to reflect this suggestion.

Our method can infer ffCO2 emissions provided informative measurements of ffCO2 concentrations are available. The current sensor network, sited with an eye towards biospheric CO2 fluxes, does not provide them. The reviewer suggests, quite correctly, our method can be used in OSSEs to design an ffCO2 sensor network. It can be used to determine locations and frequency of measurements of ffCO2 sensors, as well as the fidelities required of the atmospheric transport model and the measurements themselves (i.e., the size of the model-data mismatch). We will add this in the "Discussion" section. It can also be used to quantify the errors introduced into regional scale inversions by uncertainties in the inflow and outflow boundary conditions. These errors may be quite large, and may overwhelm the differences that exist between various ffCO2 inventories i.e., they may all be equally good as a source of prior information.

Page 1280, line 21: "I think a key reason why there have been fewer attempts at inverting for the fossil component of the carbon fluxes is the difficulty of observationally separating the fossil component in observed atmospheric CO2. Other that 14C, expensive and not comprehensively observed, there are few tracers that can offer much constraint. I agree that part of the problem is the underlying spatiotemporal variability *but this is only half the problem."*

Response: We agree and we will add this in the manuscript. In Sec. 1, we will state clearly that ffCO2 inversions are uncommon because of the cost of measuring ffCO2, primarily via radiocarbon.

Page 1288, line 15: "be wary of CARMA – not a peer-reviewed dataset and has many problems."

Response: We agree and we will add this caveat at the end of Sec. 3.1

Page 1296, line 4: "Am I understanding c correctly in that it represents an aggregate total? If so, the aggregate totals in EDGAR aren't really EDGAR values but probably IEA country totals."

Response: The reviewer is correct that c represents an aggregate total. It is the ratio of the aggregate total of ffCO2 emissions to the aggregate total of radiances (for the nightlights) or percentages of built-up areas. We will add this clarification in Sec. 3.2, immediately after Eq. 4.

Interactive comment on Geosci. Model Dev. Discuss., 7, 1277, 2014.