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Interactive comment on "Continental-scale enrichment of atmospheric $^{14}CO_2$ from the nuclear power industry: potential impact on the estimation of fossil fuel-derived CO_2" *by* H. D. Graven and N. Gruber

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We are grateful to the reviewers, Jocelyn Turnbull and Felix Vogel. Their recommendations permitted us to improve the presentation of our work and to place our study into a better context for the reader.

Comments from Jocelyn Turnbull helped to clarify the context of our work with respect to Eulerian vs. Lagrangian frameworks and the spatial scale of Δ^{14}C gradients addressed by our study. In response to her recommendations, we have revised the in-

troduction and discussion sections to include this clarification. In particular, we added text from our discussion comment to the introduction that specifies how Δ^{14}C observations may be used in the future to determine fossil fuel CO_2 emissions through a continental-scale inversion of CO_2 and ^{14}C.

Felix Vogel raised four issues. The first one is the potential limitation of the coarse model resolution on our conclusions. As described in our reply to his comment, the TM3 model we used sufficiently resolves continental-scale (>200 km) gradients in Δ^{14}C caused by ^{14}C emissions from nuclear sites. However, within the local grid cell of a nuclear site, the coarse model is quite likely to underestimate the enhancement of Δ^{14}C near to the nuclear site and, depending on the setting, either over- or underestimate Δ^{14}C further away from the nuclear site. We have added a general description of this effect in Section 3 and discussed it more specifically in the context of the results for Cape May (new Section 5). We have also reduced the emphasis on the largest simulated β_{nuc} (in the local grid cells of large nuclear sources), now putting more emphasis on simulated large-scale patterns in β_{nuc}, in the Abstract, Section 3 and Discussion.

The second issue is the placing of the potential bias from nuclear influences into context with other uncertainties in the Δ^{14}C observation-based method of estimating fossil fuel CO_2, particularly the measurement uncertainty. We have clarified the significance of the nuclear influence using reported measurement uncertainties from Levin et al. 2003 and simulations of the potential bias from respiration from Turnbull et al. 2009. While in most regions the potential bias from nuclear ^{14}C emissions is much smaller than the measurement uncertainty, our study focuses on annual means that have a much smaller uncertainty due to averaging of individual measurements. Levin et al. 2008 report uncertainties in annual mean δC_{ff} of ±0.3-0.45 ppm, which is comparable to the simulated potential bias from nuclear ^{14}C emissions in large regions. For an individual measurement, our work suggests the sum of nuclear and respiration influences may also be comparable to the individual measurement uncertainty in some regions. Moreover, relative to the fossil fuel influence, trends in the potential bias from nuclear emissions are nearly of the same magnitude as the targeted emission reductions in the Kyoto Protocol, placing an important limit on the potential for observations to provide validation for compliance with the Kyoto Protocol. We have clarified the significance of nuclear influences by improving the descriptions of uncertainty in the text (Discussion and Conclusions, 2nd and 3rd paragraphs).

Third, Felix recommends expanding the comparison of our simulated β_{nuc} with previous estimates. To address this comment, we added a new section “Comparison with previous estimates of β_{nuc}.” While we had already compared our results to Turnbull et al. 2009 for the Cape May site (which we moved into this section), Turnbull et al. 2009 also report simulated β_{nuc} at Orleans, France. We added a comparison with Turnbull et al. 2009's simulated β_{nuc} at Orleans, France. We also added a comparison between our simulated continental-scale nuclear influence and the local-scale nuclear influence at Heidelberg, Germany, as estimated in Levin et al. 2003.

Fourth, Felix suggests comparing our simulations to measurements of Δ^{14}C gradients and δC_{ff} at continental sites reported in the literature. We chose not to pursue such comparisons in this paper since they do not address our main objective: to test whether spatially-resolved ^{14}C emissions from nuclear sites cause large-scale gradients in Δ^{14}C that interfere with fossil fuel dilution of Δ^{14}C. Therefore, we only model these two components, nuclear ^{14}C emissions and fossil fuel CO_2 emissions, and do not consider other relevant processes such as terrestrial respiration, stratosphere-troposphere exchange and ocean-atmosphere exchange.

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