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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The influence of $^{14}CO_2$ releases from regional nuclear facilities at the Heidelberg $^{14}CO_2$ sampling site (1986–2014)" *by* Matthias Kuderer et al.

Anonymous Referee #2

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Kuderer et al. present an analysis of nuclear power plant influences on radiocarbon measurements in CO2 at Heidelberg using emissions data and the Hysplit model at three resolutions. Their main conclusions are that the nuclear correction decreased after the shutdown of Philippsburg BWR, the corrections they estimate are sensitive to model resolution, and nuclear corrections require careful consideration.

The authors' work is useful and important to the community. However, some revisions are needed to clarify the details of their study and to expand the conclusions drawn from their results.

The methods for model simulations are not very clear and there appear to be several

different simulations used that are rather hard to follow. A table describing the different simulations run for each nuclear site would be helpful. Details about how the Hysplit runs were conducted, such as the number of particles and release times should be added. The authors should also clarify that Hysplit was run in forward mode from the locations of the nuclear sites rather in backward mode from the observation site in Heidelberg. There appears to be some details described in the results section 3.2 that would fit better in the methods section.

The authors report in the abstract that "The mean correction for the period from 1986-2014, if based on the 0.5° x 0.5° wind field, which we assume as the most accurate, is 2.3 ‰". However, it appears high resolution 0.5° winds were only used in simulations for 2009 and 2011 – 2014, so it is not correct to say the 1986-2014 correction is from the 0.5° x 0.5° wind field. The other years were estimated from the coarser 2.5° resolution simulations with a correction factor based on comparisons for the years where 2.5° and 0.5° simulations were run for two reactors.

Since Fig 4 shows the difference between simulated corrections at different resolution for individual samples is sometimes very small and sometimes very large (even with fixed emissions), is it valid to apply a mean correction to the data before 2009? Particularly if a main argument the authors are making is that the correction is highly variable in time? The authors argue that, since the correction is highly variable in time, monthly emissions data must be used and average emissions cannot be used, but then seem to contradict themselves by saying an average correction can be applied to account for model resolution, when actually this can be highly variable as well. Another point is that 0.5° is still rather coarse compared to some regional modelling currently being done at 0.1° or finer resolution.

Why do the authors use fixed emissions in the simulations shown in Fig 4?

If the authors have simulations with both fixed and monthly-varying emissions, can they include a comparison of these two simulations to quantify variability due to vary-

ing emissions vs variability due to varying transport? This comparison would be very useful.

The authors note the previous estimate of the average nuclear correction by Levin using the plume model is higher than their estimate. Although the plume model is simpler, it might be considered to be at finer resolution than 0.5°, and therefore a better estimate.

Can the authors make any inference on the detectability of the Philippsburg shutdown based on the Heidelberg Delta14CO2 data?

The authors should discuss the impact the Philippsburg shutdown would have on the inferred fossil fuel CO2 at Heidelberg, if the change in the nuclear correction after 2011 was not accounted for. How does the change in the nuclear correction compare to the average fossil fuel signal in Delta14CO2 at Heidelberg?

Section 3.3 Uncertainty in estimated nuclear correction – this needs more detail and seems rather too qualitative. The authors do not seem to include model transport uncertainty also for the high-resolution case. Do the authors have an estimate for the magnitude of sub-monthly variation in emissions?

Do the authors think that monthly resolution in emissions data is sufficient, in general? Would this depend on the sampling integration time?

Could Fig 2b show the time series of emissions rather than yearly boxplots? It would be interesting to know if there is any pattern to the emissions over the year – for example, are emissions typically higher in summer potentially related to more maintenance undertaken in summer?

The authors should consider the Cattenom reactor in France, to the west and upwind of Heidelberg. The authors should also consider if Heidelberg could sometimes be sensitive to emissions from La Hague, which is further away, but emits >20x more 14CO2 than Philippsburg.

Shouldn't Eq. 3 have a factor of 1000 for per mil units? What is used for XCO2 in this

calculation?

First sentence in abstract – last word "fluxes" should be deleted. Radiocarbon measurements quantify fossil fuel derived CO2, but not fluxes. Also here the Delta notation is used without describing it. The phrase "14CO2 signal" is unclear – do you mean nuclear Delta14CO2 signal? Why are Delta14CO2 and 14CO2 both used in the abstract? Isn't the Heidelberg site monitoring Delta14CO2 rather than 14CO2? Last sentence should be revised to "After operations at the Philippsburg boiling water reactor ceased in 2011, the" . . .

P2, L22 Delete "well". L24 Comment about "normally quickly disperse" needs reference or should be deleted.

P10, L21-24 – Please show some quantitative evidence from the simulations to support these statements.

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