Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
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Comment on amt-2022-179

Anonymous Referee #1

Referee comment on "Reducing errors on estimates of the carbon uptake period based on time series of atmospheric CO_2" by Theertha Kariyathan et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-179-RC1, 2022

This study presents a novel method to estimate the carbon uptake period (CUP) from discrete CO2 observation time series. The process of determining CUP from discrete time series includes two critical steps: curve fitting and CUP onset and end determination. Curve-fitting methods are needed to interpolate observation at gaps and to filter out the noise and undesirable modes of variability. When analyzing CO2 mole fraction from background observation sites, this means removing the effects of local fluxes or synoptic-scale transport variations. Previous studies have shown that the conclusions from the analysis of CO2 time series are sensitive to the choice of the curve-fitting method. CUP estimates are also sensitive to the method used. Previous studies have proposed several methods that use the zero-crossing points or crest and trough of the detrended, zero-centered seasonal cycle. The study presents a new CUP estimation method and provides a detailed uncertainty assessment of the curve-fitting methods and compares them with other methods reported in the literature. The CUP method and the detailed uncertainty analysis of the different curve-fitting methods presented in this study are very relevant. Overall, the paper is well-written and the figures are clear. I recommend the publication of the paper after the following issues have been addressed.

Specific comments:
It is unclear which methods described in this paper are novel. The FDT method is new and innovative, however, I have reservations about the newness of the rest of the methods. In the abstract, the authors write "…a novel curve fitting method….". The essence of both CCG and the loess method presented here is the same, Equation 1. Is the novel part of the loess method using local regression to smoothen the residuals instead of a low pass FFT filter used in CCG? Or is it that the author's method uses a 2-degree polynomial and 4 harmonic functions while the CCG method uses a 3-degree polynomial and 4 harmonic function? Moreover, the study note that there is no difference in the performance of the loess and the CCG methods (line 254). Could the authors explain what is then the advantage of the proposed loess method? In the rest of the manuscript, the authors only claim the uncertainty generation and FDT methods are new (Line 64, 264 & 323). The ensemble-based method uses bootstrapping to evaluate the uncertainties of a metric. This is again not so new in my opinion. The main novel method presented in this study is the FDT method. I suggest that the authors (1) make clear which methods are novel. (2) restructure the method section so it does not over-emphasize the newness of the loess method. (3) if the ensemble-generation method is the same for the CCG and loess

methods, describe the ensemble-generation in a separate subsection.

The authors have made a good attempt to describe the FDT method. However, I found it difficult to understand how CUP is calculated using the X% threshold. This statement is confusing: "The value of X is chosen to minimize the threshold value (as the rate of uptake towards the beginning and end of the CUP approaches zero) while keeping the uncertainty in timing across the ensemble members small". Does the authors mean the uncertainties are calculated as a function of threshold within the range of 0 to 20 percent, and the onset and termination times are the threshold points where CUP uncertainty is smallest? This becomes clearer in the results section but it will be good to move some of the explanation from the results section to the method section. Perhaps, a figure or an additional panel in figure 4 illustrating this would make the method easier to understand. I also have some concerns about the tested threshold values. Why only 4 discrete values of the threshold were tested? One can easily do this analysis over a continuum. Where does the choice of 0 to 20 percent come from? Why the range does not include positive threshold values, for example, something like -20 to 20 percent?

Minor comment:
The study focuses on the importance of uncertainties in CUP estimates of the Northern Hemisphere CO2 emissions when estimated using discrete measurements from select background sites. There are intra-annual variations and long-term trends in atmospheric transport which would affect the relationship between the seasonal cycle of the CO2 observations vs the actual emissions (see Krol et al., 2018, Fu et al., 2015). The transport errors will not be an issue when the FDT is applied to a discrete fluxes time series. I suggest the authors add a discussion about the transport-variation-related errors when analyzing fluxes using remote background observation sites to the discussion section.

Technical corrections:
"Curve-fitting" is irregularly hyphenated in the text. It needs to be hyphenated when used as an adjective, for example in Line 6, 16, 19, and so on.
Line 256: "using two different curve-fitting methods " => "using the two different curve-fitting methods" is better.

References:
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Fu, Q., Lin, P., Solomon, S., and Hartmann, D. L.: Observational evidence of strengthening of the Brewer-Dobson circulation since 1980, J. Geophys. Res.-Atmos., 120, 10214–10228, 2015