Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., author comment AC2
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Reply on RC2

Alex Resovsky et al.

Author comment on "An algorithm to detect non-background signals in greenhouse gas time series from European tall tower and mountain stations" by Alex Resovsky et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-16-AC2, 2021

Thank you for your very helpful comments and suggestions. Specific responses follow:

It is true that additional analysis using meteorological data would help to better isolate the contributions of different factors to anomalous signal events. Although we feel that the similarities between the wintertime 30-day anomaly patterns in CO2 and CH4 strongly suggest a link with prevailing wind regime, pinpointing the causes of summertime 90-day anomalies is less straightforward. More conclusive results might be obtained by an atmospheric back-trajectory analysis, but as such an analysis would have to be conducted over several months at ten sites, its scope is a bit unfeasible, especially given the short duration of the lead author's contract at LSCE (Alex Resovsky is now employed at ARIA Technologies, Inc.). As a compromise, we have scaled back our interpretation of the summertime anomaly patterns, particularly the anomaly patterns observed in the summer of 2018, which we admit we can not readily attribute solely to terrestrial carbon cycle imbalances. We now note, in section 3.2, that although the algorithm produces the signals we would expect to see for the summer of 2018 based on the timing and magnitude of continent-wide NBP anomalies known to have occurred during that period, we have not established a causal link in this manuscript.

As for data gaps, the best illustrative example of a problematic gap in our data would be the CH4/CO2 gap observed in October/November of 2018 at GAT. No readings exist for either trace gas at GAT from Oct. 23 to Nov. 21, 2018, likely due to an instrument malfunction at this time. As mentioned in the first paragraph of the discussion section, data gaps such as this are filled using a simple linear interpolation before the CCGCRV fitting procedure is applied, as recommended by, e.g., Pickers and Manning (2015). This interpolation procedure may, in some cases, lead to the selection of "false positives" such as the slight negative anomaly seen at GAT in late October of 2018. One can see from Figure 5 that this erroneous anomaly is linked to the fit of the LOESS curve to the artificially interpolated raw data; since the measurements on the left side of the data gap are near the lower bounds of the 2σ-envelope, the linearly interpolated datapoints just afterward are weighted downward, causing the LOESS curve to fall slightly outside the envelope. This is, admittedly, a drawback of the algorithm, albeit one without an easy solution aside from manual inspection. Using multi-year averaged seasonal cycles instead of harmonic functions from CCGCRV would likely not drastically affect the results, at least not in the case of the GAT example, since the false positive here is linked to the linear interpolation and not the envelope definition. The interpolation procedure could perhaps be improved by interpolating large data gaps with multi-year averaged seasonal cycle

values, but this would raise a couple concerns: 1) any specific improvement would be difficult to ascertain; since the data themselves do not exist, any sort of imputation procedure ports some degree of uncertainty to the results, and 2) determining the multi-year seasonal cycle curve with CCGCRV would require an *a priori* interpolation of any data gaps, i.e. using a linear interpolation, followed by an *a posteriori* re-interpolation of the same gaps, followed by a secondary application of the CCGCRV fitting procedure. It is unclear whether any reduction in false positive detection, which appears to be quite rare overall, justifies this trade-off in efficiency. Nonetheless, we have now noted in the first paragraph of the discussion section that interpolation of large data gaps with multi-year average seasonal cycle values represents one potential way to reduce the detection of rare false positives linked to large data gaps. We also note here that we are prepared to test and implement this change in the methodology if absolutely required. We have alluded specifically to the 2018 data gap at GAT as an illustrative example of the data gaps problem.

Technical changes in response to comments:

The introductory paragraph of section 2.2 has been changed to reflect the current nomenclature of the Global Monitoring Laboratory at NOAA (CCGG/GML). The link to the R code for CCGCRV has also been edited.

The second sentence of paragraph 2 of section 2.2 has been changed to read "Basically, a fit to a time series is first obtained using a linear least squares regression following the 'LFIT' protocol, in which a linear function describing the data is determined from an x^2 minimization of the residuals (Press et al., 1996)."

End effects should be minimal when using our algorithm, which we feel is one of its strongest advantages. We feel that we have adequately circumvented the problem of end effects, which is well-known to CCGCRV users, by calculating our $\pm 2\sigma$ envelope according to the procedure described in equation (3), whereby σ_d for any day, including the very last day in the record, depends on a sufficiently large residual dataset in the vicinity of that same calendar day over several years of data, and only minimally on that day's measurement. Thus, although the smoothed, detrended seasonal cycle, which is based on the polynomial part of equation (1), may be sensitive to end effects, these effects should only minimally affect the envelope calculation.