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Atmospheric Measurement Techniques Discussions

Interactive comment on "Robust extraction of baseline signal of atmospheric trace species using local regression" *by* A. F. Ruckstuhl et al.

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We thank the referees for their careful reading of our manuscript and for their constructive and helpful comments. We will carefully consider the questions and suggestions of the two referees in the revised manuscript as described in detail below (the comments by the referees are quoted using [". . ."]).

First one general comment to an issue raised by both referees: Both referees are disappointed that the feasibility of the presented approach for determination of background signal is only demonstrated for one trace gas at one background site (CO at Jungfraujoch). In a very early version of the manuscript, we included various examples from two sites (Jungfraujoch and Mace Head) but decided at a later time to write a

short methodical paper and removed all extra examples. The idea was to provide a clear and detailed description of the statistical approach and not to get too much into the discussion of trends of trace gases and atmospheric processes such as transport of polluted air masses. This turned out to be the wrong decision and we will present and discuss more examples in the revised paper as requested by both referees.

Reply to the referee comments:

Anonymous referee #1:

["I did not find that the application to CO from the Jungfraujoch alone made the case that the method was 'robust'. The application of the same methodology, using the same parameters, to a range of gases measured at the station would be more persuasive."]

The term "robust" is not related to the number of successful applications but is used to characterize the estimation procedure. So-called robustness weights down-weight extreme observations (i.e., outliers). However, as indicated in the general comment above, we will provide additional applications.

["I would like to know how the derived background mole fractions compare to those at a stations where baseline levels can be more easily determined (e.g. Mace Head, Ireland). If the 'regional' (European) signal is indeed being removed from JFJ, then the two baseline signals should be very similar. - Some previous methods were mentioned (Thonning, 1989; Novelli et al., 2003, O'Doherty et al., 2001), but a comparison was only made to the approach of Novelli et al, (2003). A stronger case could be made by comparing the proposed approach with all the cited methods, and showing that it offers distinct advantages (which should be explicitly stated)."]

Again, we will provide more examples in the revised manuscript. In addition to the approach of Novelli et al. (2003), we will also compare our method with the method that is used within the AGAGE network (method described by O'Doherty et al., 2001).

Anonymous referee #2:

["1) Some more examples are needed of the REBS technique applied to a range of other trace gas species measured at Jungfraujoch eg. CH4, CH2Cl2, HFC-134a, CCl2CCl2, ... others? Especially, examples of the technique applied to a trace gas species where there are many 'pollution' episodes (whether they be anthropogenic or natural or both) would be an interesting test of its robustness."]

More examples will be given in the revised manuscript.

["2) Comparison of the REBS technique with more than just the Thoning et al. 1989/Novelli et al. 2003 method would certainly add weight to the manuscript. As a minimum, it would be good to see a comparison of the REBS method (statistical), with the Thoning et al. 1989/Novelli et al. 2003 method (iterative filtering/curve fitting - already done), with the AGAGE statistical ap-proach (O'Doherty et al., 2001/Prinn et al. 2001), and an air mass origin/back trajectory/modelling approach (eg using the UKMO NAME model, Ryall et al. 2001/Derwent et al. 1998)."]

As indicated in the answer to referee #1, we will compare the REBS method in addition with the AGAGE statistical approach. The application of a Lagrangian particle dispersion model such as the UKMO NAME to estimate unpolluted cases are more complex for a site in high Alpine, complex terrain as Jungfraujoch. Therefore, we would like to abandon a comparison of such method with the REBS technique at Jungfraujoch to avoid an exhausting discussion about model performance and verification. Nevertheless, we would like to emphasize that we do not claim that the REBS technique is better than other techniques. As outlined in the manuscript, the usefulness of the REBS technique is (a) its flexibility with respect to the shape of long-term trends, and (b) its availability for any user who is interested in the determination of baseline signals at background sites. The latter is not the case for e.g. the UKMO NAME model as it is based on a complex three-dimensional Lagrangian dispersion model. We think that it is not necessary within the scope of this paper to compare the presented REBS approach with many other widely used techniques, but to demonstrate that it is a conceptually correct and flexible approach that is now available for interested users.

["3) on page 5594, line 17, the authors mention 'Since the regional signal must be non-negative, ...' - this highlights that this method is not suitable for all trace gas species. In particular carbon dioxide (CO2) and hydrogen (H2) both have terrestrial sinks (photosynthesis for CO2 and soil bacteria for H2) that result in 'negative' pollution episodes or draw down events. It should be explicitly mentioned in the manuscript somewhere that the method is not suitable for these species or others that have below baseline events."]

It is true that the method cannot be used for trace species that are strongly influenced by terrestrial sinks. Terrestrial sinks can similar to latitudinal gradients result in "negative" pollution events. "Negative" pollution events would receive too high weight by the asymmetric robustness weights as defined in equation (4) and therefore lead to a baseline estimation that is biased downwards. In the section on the applicability of the REBS (section 5) it is discussed, that (similar to other statistical filters) the REBS cannot correctly cope with trace species that show strong latitudinal gradients. It is suggested that the residuals distribution as provided for CO at Jungfraujoch in Figure 1 is used for judgment if the REBS approach can be used. We suggest that the REBS is applicable as long as the residuals below the mode of the residuals distribution (left side of the residuals distribution) follow approximately a Gaussian distribution. Deviation from a Gaussian distribution is an indication that processes other than random variation of the background signal is significantly influencing the measurements at concentrations that are typical for background conditions (or below that). In the revised version, we will explicitly include negative pollution episodes due to terrestrial sinks in the discussion about the applicability of the proposed method. We will also add a sentence about the applicability of the REBS to the legend of Figure 1.

["4) on page 5602, line 6 of the manuscript the authors mention that 'The differences in the classification of background measurements have a rather small impact on the estimation of average background CO concentrations.' - I disagree with this, especially if looking at monthly averages that would be produced from the blue (REBS) and red

(smooth curve fit) lines in figure 3. There are considerable differences during the peaks in the CO seasonal cycles for most years, which the authors mention at the bottom of page 5602/top of page 5603. So there seems to be conflicting statements between line 6 P5602 and line 28 P5602/line 1 P5603."]

The referee is correct. The statement on page 5602, line 6 refers to annual mean background concentrations, where the differences for the two applied methods are rather small (numbers are given). On the other hand we say that there is "considerable disagreement during the cold period when back-ground CO concentrations are highest" (page 5602/03 lines 28/01). We will resolve this conflict by changing page 5602 line 6 to "The differences in the classification of background measurements lead to small differences in annual average background CO concentrations but to significant differences during the cold season (section 4.2).".

["5) in the manuscript on page 5604, line 16, it is mentioned that the REBS technique can handle gaps in data, an example(s) illustrating this would be good to see."]

In the revised paper the discussion of gaps in the data will be extended. Different types of data gaps might exist: There can be frequently occurring short gaps or few longer gaps. The behaviour of the REBS technique will be demonstrated by introducing synthetic gaps in real time series. The REBS technique will then be applied and the results will be compared with the baseline as estimated from the complete time series.

Technical comments: [" Page 5591, lines 13-14: suggest adding the reference Ryall et al., Estimating source regions of European emissions of trace gases from observations at Mace Head, Atmospheric Environment, 35, 2507-2523, 2001. This paper outlines the baseline selection method that utilises the UKMO NAME model."]

Reference Ryall et al. (2001) will be added as suggested.

Thanks for all other technical comments, they will be included in the revised manuscript as suggested.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 5589, 2010.