

## Point-by-point response to the Editor review

*We are very thankful to the Editor and the Anonymous Referee #2 for the constructive comments that helped improve the manuscript, as well as for the suggestions for the publication in ACP after a minor revision, which we have done accordingly.*

*In the following, we address the Editor and the Referee's comments.*

*Note: The Editor and Referee's comments (EC and RC2) are referred to in "Arial" font type throughout the texts, and the authors' responses are referred to as "Italic Arial" with indented lines.*

### Editor Comments (EC)

#### Comments to the author:

Dear authors, your manuscript is basically accepted. Only two points are suggested to modify: I copy the following lines from the review. The line numbers are taken from the track changes version of the revised manuscript.

Kind regards

Mathias Palm

*Thank you very much Mathias. We address these points under their respective texts in the following:*

L86ff: The description seems overly complicated. Consider:

"A global forward run is then carried out using 'global' observations to obtain simulated concentrations for the regional sites. A second forward run is conducted applying zero-fluxes outside of the regional domain. This can be considered as a regional run utilizing a global transport model at a coarse spatial resolution. The subtraction of the 'regional' run from the 'global' run results in the far field contribution on the sites within the regional domain. Subtracting the latter from the measurements and yields the remaining regional mixing ratio that is used in the regional inversion applying the regional-scale transport model at finer spatial resolution."

*Thank you for the suggestion. We have modified this paragraph in the revised manuscript accordingly (L84-90).*

Equation 1: To me it is not clear what the matrix  $p$  contains. Is this equivalent to the frequently used prior contribution to the cost function:  $(x - x_{\text{prior}})^T R^{-1} (x - x_{\text{prior}})$ ?  $x$  being the state vector,  $x_{\text{prior}}$  the prior state and  $R$  the prior covariance matrix. Why

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would parameters  $p$  have zero mean? Please also add the variable name for the cost function in the text (L94).

*In fact, in CSR the a-priori probability distribution of the fluxes is defined differently but equivalent to the traditional way indicated as  $(x - x_{prior})^T R^{-1} (x - x_{prior})$  in which the covariance matrix is explicitly defined. In our system, the prior flux information is expressed in a linear flux model  $f = f_{fix} + F x p$  that comprises all flux components with a fixed term  $f_{fix}$ . The second term is an adjustable term that contains the spatio-temporal shape of fluxes in the matrix  $F$  and the adjustable parameters in the vector  $p$ . Information of the uncertainty and correlations of the a-priori are also contained in the matrix  $F$ . This construction allows for splitting flux model into different components (physical processes) and some of these processes can further be split into a different time scales which can be treated in the flux model as a separate component with different shapes. The mathematical description of the system scheme is explained in detail in Rödenbeck (2005).*

*In L94-97 (in the revised manuscript) we added the Equation (2)  $f = f_{fix} + F x p$  and its variable definitions that can help the reader differentiate between the matrix that involves the flux uncertainty and the vector of adjustable parameters mentioned in Eq.(1). We have also referred the reader to Rödenbeck (2005) for more details about the mathematical scheme of the system (L102-103).*

*The variable name of the cost function  $J$  is also added to L91 in the revised manuscript.*

Equation 2: I assume that  $Q_c$  does not only contain observation uncertainty but also representativeness uncertainty?

*Indeed, the  $Q_c$  matrix contains the transport and representation uncertainty, as well as the measurement uncertainty. This has also been clarified in the revised manuscript (L99).*

## Anonymous Referee #2 (RC2)

I would like to thank the authors for carefully replying to comments raised by both referees. The replies are appropriate and clarifications have been added to revised manuscript. There are only some very minor comments remaining, concerning the

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newly added description of the CSR system. Once these are adjusted, the study is fit for publication.

Lines numbers as taken from Track-changes version of revised manuscript.

*Thank you very much for the constructive comments that help improve the manuscript.*

*Please find your comments addressed under the Editor section above.*