

Interactive comment on “Structure of the transport uncertainty in mesoscale inversions of CO₂ sources and sinks using ensemble model simulations” by T. Lauvaux et al.

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We thank the referee for the several specific comments that we considered carefully. Here is the list of the different corrections we applied following your comments.

Specific comments:

4814-7: We changed the sentence as suggested.

4814-10: ..., but excluding the intrinsic error of the model.

4814-13: Concerning the size of the ensemble, the computational cost was the main reason. Running 11 simulations of the atmospheric model coupled online to the surface scheme corresponds to several days of computation additionally to the perturbed sim-

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ulations. Richardson, 2000 (technical note from ECMWF) demonstrated the required size of an ensemble between 50 to 100, depending on the system. 10 appeared as the minimum size to avoid under sampling of the variability.

4815-3-4: We interchanged the references and the tracers.

4815-14-16: We rephrased the sentence as follows: "In the underlying statistical formulation, the uncertainties normalize quantities such as the model-data mismatch so their specification is vital for a correct solution."

4815-17: We fully agree on your comment and rephrased the sentence to clarify it: "For the prior flux covariance the case is relatively simple theoretically, since the covariance should represent the statistics of the difference between the truth and our chosen prior, nevertheless its characterization is limited by the number of flux observations.

4815-22; We changed the word as suggested.

4816-22: The sentence was not clear. We pointed out the additional effect of error growth on the transport error but we don't discuss this further as it is negligible in our case (strong constraint by the use of high temporal frequency analysis fields). The following sentence was added: "Forecast error growth remains negligible relatively to analysis uncertainties at mesoscale."

4817-1: We specified the acronym.

4817-3: We changed as proposed.

4818-8: We used 102h forecasts as a first step. These methods, e.g. defining the error structures using an ensemble of simulations or perturbed assimilation systems, are still recent in meteorology research field. We checked the temporal evolution of the structures during the 102h of simulation and observed that no significant increase (or decrease) affected the error correlations. Even though 6 hour analyses would have been more appropriate, our estimation was meaningful as long as we don't use the variance of the ensemble to define the standard deviation of the transport error. We

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agree that intrinsic errors are of major importance in the transport model error. We only explore here the structure of the error due to some perturbations. If we want to explore vertical transport error for example, we would test the sensitivity to the parameters or the surface properties (water content especially). These tests are difficult to define, for example the possible range for a given parameter, and the results of such sensitivity tests almost impossible to interpret (the different parametrizations correspond to different models in fact). The present study suggests that structures can be identified with our method but a part of the total transport error remains unexplored.

4820-1: We corrected the equation and detailed the different terms.

SECTION 2.3: The paragraph was re-written for a better readability.

4822-17: Negative correlations only affect less than 10% of the estimated correlations. They occur depending on the size of the ensemble, which suggests that they are mainly relative to the sampling noise. However, negative correlations could be attributed to the dynamics. The way to take them in account remains unclear as it implies to change the gaussian assumption of the local error correlations. A theoretical study with an ensemble of larger size could give an estimation of negative correlations due to purely dynamical effects.

4825-20: We changed as proposed.

4827-6: We explained the fact the nighttime correlation remains small from night-to-night by the following sentence: " Even though nighttime error structures are inferred by more static parameters (orography, surface properties), the sensitivity to perturbations is much larger and implies noticeable differences from night-to-night induced by small variations of the conditions."

4829-end of section 3.5: We added the following sentences to clarify this point in the discussion: "Additionally to these aspects, we defined the prior error covariance matrix as uncorrelated and homogeneous over the domain, that is an over simplification of

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the truth, but would perturb the interpretation of the results if more realistic. Forthcoming inverse systems using CO₂ concentration (not pseudo-data experiment) have to include the error flux correlations that could, for example, limit the impact of transport error correlations over the oceans (ocean flux uncertainty is reduced compared to land fluxes)."

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