

Follow-up review of "EnKF and 4D-Var Data Assimilation with a Chemistry Transport Model" by S. Skachko et al.

General comments:

I am confused by the authors' response to my main concern, related to the difference in the window length used for the 4D-Var and EnKF experiments. In response to my first general comment, the authors' response is:

"So we disagree that the difference in window length has such an impact in the context of chemical transport."

Then, when I later bring up the same point again in relation to the discussion of the results, the authors' response is:

"In the context of chemistry, the difference in data assimilation window lengths really has implications, as pointed out by the referee."

Also, I believe the authors' misinterpreted part of my first general comment. I made no suggestion that a hybrid 4D-EnVar experiment be performed, or even mentioned. What I did suggest was that a 4D-EnKF approach (with model error perturbations only applied at the beginning of each window to be equivalent with strong-constraint 4D-Var) should be considered and mentioned, since this would allow a longer window to be used for the EnKF. In this case, the analysis would be forced to simultaneously fit all of the observations distributed over a longer window, while still satisfying the model equations, as in 4D-Var.

I appreciate that the authors have tested two data assimilation methods in configurations as they are usually used for chemical applications. This point should be emphasized in the paper to justify the choice. However, it would be helpful to inform the reader that other configurations are possible that would reduce the differences between the two approaches (i.e. including model error in weak-constraint 4D-Var and using 4D covariances with a longer window in the EnKF). Otherwise, readers will conclude that one approach (i.e. EnKF or 4D-Var) is fundamentally better or worse than the other in some respects, whereas it is more likely the choice of how each approach was implemented that is more important.

Specific comments:

In response to the third specific comment, your revised sentence seems imprecise: "For comparison purposes, we apply the same estimate procedure in the 4D-Var data assimilation, where both, the background and observation error covariance matrices are estimated using the Desroziers' method." I presume it is only the scale factors for both covariance matrices that are estimated and not the full matrices? Please improve the wording.

In response to the fifth specific comment, your revised sentence does not clear up my concern: "The second issue in EnKF with comprehensive atmospheric chemistry models is the spurious error, that

occurs when species are weakly chemically related at the same location." The term "spurious error" is very ambiguous... how can error be spurious? I believe this is again where "error" is used in place of "error covariance". Only the "estimated error covariance" is spurious. [The word "error" on its own really should be reserved for the difference between an estimate and the truth and I don't think this is what is meant in this case. I realize that some published papers have used "error" to mean "error standard deviation" or "error covariance", but I believe this has needlessly caused confusion for some people in the DA community.]