

Review of Kaminski & Mathieu, «Reviews and Syntheses: Flying the Satellite into Your Model»

This review is potentially a useful addition to the literature. However, I think the authors need to do some work to make the paper a valuable contribution within the standards of what a review paper should be. In particular, the authors need to address the following:

- (i) Incompleteness in presentation;
- (ii) Statements not reflecting accurately current developments in the field of data assimilation;
- (iii) Avoid slightly parochial references to data assimilation, e.g., the authors appear to focus too much on work done in the carbon cycle, with little or no reference to other areas of the Earth System;
- (iv) The overall message from the paper should be stronger.

I provide examples of (i)-(iv) in the specific comments below, which the authors must address as well.

Specific comments:

L. 30: I think you should mention both spatial and temporal scales.

L. 150: I think the authors should specify that the observation operator H is generally non-linear.

L. 154: The penalty function (or misfit function) in Eq. (2) can also have extra terms, e.g., constraints due to dynamics. Equation (3) represents the strong-constraint version of 4D-Var (this should be mentioned here). The authors introduce the weak-constraint formulation in L. 192.

L. 194: In principle, one could also have a linear operator \mathbf{H} in Var.

L. 197: Identify the typical size of the state vector, e.g., for NWP this is of order 10^7 elements.

L. 204: I suggest you provide other examples besides carbon dioxide.

L. 217: Particle filters have problems of filter degeneracy with high-dimensional problems, which makes difficult their application. Snyder et al. (2008) discusses this.

L. 240-283 (Section 3.2): The examples of data assimilation should reflect more areas than those mentioned by the authors. For example, they should include chemical data assimilation (for the stratosphere and the troposphere).

L. 249: Currently, efforts at the weather centres focus on hybrid approaches with combination of ensemble and variational methods (so it is not just 4D-Var as the text suggests). Such a hybrid approach has been operational at ECMWF for a while (Buizza et al., 2008; Isaksen et al., 2010; Bonavita et al., 2012), and is now operational, e.g., at the Met Office, UK, for the global model (Clayton et al., 2013) and at Environment Canada (Buehner et al., 2010). Discussion of these methods also took place at the 6th WMO Data Assimilation Symposium (<http://das6.cscamm.umd.edu/>). This is an example where to my mind, the text does not reflect recent developments in data assimilation, and the authors should modify the text.

L. 335: The authors focus is on the specification of the observational error covariance matrix. However, the specification of the background error covariance is a main difficulty in application of data assimilation to realistic problems. There are several reviews on this, including Bannister (2008a, b).

L. 360: The information provided by the text is incomplete. The authors should differentiate between OSEs (observing system experiments) and OSSEs (observing system simulation experiments). The authors should include reviews/overviews of OSSEs from the peer-reviewed literature. Two examples are Masutani et al. (2010), for general OSSEs, and Timmermans et al. (2015) for OSSEs for air quality observations. The authors should also provide more details on the shortcomings of OSSEs in L. 374 (or later in L. 392). The above reviews discuss these shortcomings.

L. 500-515: I suggest the authors provide more balance in their data assimilation examples. As the text reads to me, it shows a strong bias toward the carbon cycle.

L. 536-538: The final sentence in the paper seems weak. Overall, I do not see a strong message from the authors. They should address this. Also, who are these “experienced development teams”? Should they be part of the data assimilation setup at the weather centres? Elsewhere?

Typos, editorial:

L. 8: commonalities.

L. 12: One can misinterpret “derivative code” as code that is not original. I suggest something like “codes for differentiation”.

L. 142: Do you need the word “advanced”?

L. 245: Check that you introduce acronyms in the paper.

L. 412 (and elsewhere): transposed -> transpose.

L. 463: Do you need the word “distinct”?

L. 466: Avoid the use of subjective statements like “luckily”.

L. 498-499: I do not understand the phrase “A straight-forward...at 0”. Perhaps reword.

References:

Bannister, R.N. (2008a). A review of forecast error covariance statistics in atmospheric variational data assimilation. I: characteristics and measurements of forecast error covariances. *Q. J. R. Meteorol. Soc.* 134, 1951–1970. doi: 10.1002/qj.339

Bannister, R.N. (2008b). A review of forecast error covariance statistics in atmospheric variational data assimilation. II: modelling the forecast error covariances. *Q. J. R. Meteorol. Soc.* 134, 1971–1996. doi: 10.1002/qj.340

Bonavita, M., Isaksen, L., and Hólm, E. (2012). “On the use of EDA background error variances in the ECMWF 4D-Var,” in *ECMWF Tech Memo 664*. Available online at: <http://www.ecmwf.int>.

Buehner, M., Houtekamer, P.L., Charette, C., Mitchell, H.L., and He, B. (2010). Intercomparison of variational data assimilation and the ensemble kalman filter for global deterministic NWP. Part I: description and single-observation experiments. *Mon. Weather Rev.* 138, 1550–1566. doi: 10.1175/2009 MWR3157.1

Buizza, R., Leutbecher, M., and Isaksen, L. (2008). Potential use of an ensemble of analyses in the ECMWF Ensemble Prediction System. *Q. J. R. Meteorol. Soc.* 134, 2051–2066. doi: 10.1002/qj.346

Clayton, A.M., Lorenc, A.C., and Barker, D.M. (2013). Operational implementation of a hybrid ensemble/4D-Var global data assimilation system at the Met Office. *Q. J. R. Meteorol. Soc.* 139, 1445–1461. doi: 10.1002/qj.2054

Isaksen, L., Bonavita, M., Buizza, R., Fisher, M., Haseler, J., Leutbecher, M., et al. (2010). “Ensemble of data assimilations at ECMWF,” in *ECMWF Tech Memo 636*. Available online at: <http://www.ecmwf.int>

Masutani, M., J.S. Woollen, S.J. Lord, G.D. Emmitt, T.J. Kleespies, S.A. Wood, S. Greco, H. Sun, J. Terry, V. Kapoor, R. Treadon and K.A. Campana (2010). Observing system simulation experiments at the national centers for environmental prediction. *J. Geophys. Res.*, 115, doi:10.1029/2009JD012528.

Snyder, C., Bengtsson, T., Bickel, P., and Anderson, J. (2008). Obstacles to high dimensional particle filtering. *Mon. Weather Rev.* 136, 4629–4640. doi: 10.1175/2008MWR2529.1

Timmermans, R., W.A. Lahoz, J.-L. Attié, V.-H. Peuch, L. Curier, D. Edwards, H. Eskes, and P. Builtjes (2015). Observing System Simulation Experiments for Air Quality. *Atmos. Env.*, 115, 199-213, doi:10.1016/j.atmosenv.2015.05.032