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Interactive comment on "The "ABC-DA system" (v1.4): a variational data assimilation system for convective scale assimilation research with a study of the impact of a balance constraint" *by* Ross Noel Bannister

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Review of paper The ABC-DA system (version 1.4) : a variational data assimilation system for convective scale assimilation research with a study of the impact of a balance constraint By Ross Noël Bannister Submitted to Geoscientific Model Development Date:

1. MAIN COMMENTS The resolution of operational NWP models increases and is reaching the convective scale. This raises new issues associated with the inclusion of

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ever increasing and complex processes. Moreover, this raises new questions regarding data assimilation methods to be used. Petrie et al. (2017) introduced a simple non-hydrostatic model that could even represent explicitly acoustic waves for data assimilation studies. This paper presents a companion variational data assimilation for this model. The paper is well written and focuses for the most part on the modeling of background error covariance. The emphasis is mostly on 3D-var including the so called FGAT (first-guess at appropriate time) which is also used in many operational systems.

In research, one would like to be able to explore different approaches to assess what could be the best one for the assimilation at the convective scale. I was expecting then that the 4D assimilation would have been more prominent, including 4D-Var in strong and weak constraint for example. In the EnVar, the control variable is the complete model trajectory including temporal correlations for the treatment of background error, which is also used in the weak constraint 4D-Var.

How does this approach compares to using the OOPS/JEDI paradigm which can be used with either a “toy “ model or an operational one? I think that it would be important for a “community” model that the advantages of ABC-DA be presented from that perspective. Little is said about observation operators which can easily be the dominant component of a DA system. Assimilating large volumes of Doppler radar data is one example. The point I am making is the paper should make an effort to emphasize aspects of the ABC-DA that could entice researchers to use it.

As stated line 143, “much of the design of ABC-DA is concerned with how B is modelled”. The emphasis is mostly on multivariate 3D-var including the so called FGAT (first-guess at appropriate time) which is also used in most operational system. Bouttier et al. (1997) introduced balance operators obtained from multilinear regression for a covariance model based on homogenous and isotropic correlations for the analysis variables deemed to have uncorrelated error. This corresponds to some extent to what the paper presents in too much details in my view. I do not see the point of explicitly

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describing how to use the code: this is important but very likely to change with time. This should be included in a user manual or website for users. On the other hand, it would be more important to explain the scientific justifications. Balance appropriate for the convective scale should be discussed: geostrophic balance does not seem to be the most relevant.

The paper ends by presenting the results of experiments to illustrate the impact of the different components representing the balance for this particular model. Is the paper about presenting the ABC-DA emphasizing the advantages of the design to study different aspects of DA that may be important for the assimilation at the convective scale? As it is, most of it is to describe what has been implemented for this particular model of B with some results indicating the impact this may have on the analysis.

I recommend that the author reviews his paper to either present ABC-DA as a polyvalent system for research on DA at the convective scale. Or that it is about a multivariate model for B and its impact on the analysis and forecast. Given the large body of literature on this topic, the latter would be rather thin.

The next section presents some specific comments on some, but not all, issues with the paper.

2. SPECIFIC COMMENTS

2.1 Modelling B : sections 3.4, 4.2, 4.3, 4.4 ($\sim$14 pages) As stated line 143, “much of the design of ABC-DA is concerned with how B is modelled”. Sections The emphasis is mostly on 3D-var including the so called FGAT (first-guess at appropriate time) which is also used in most operational system. Early on, it has been recognized that multivariate covariances should embed dynamical constraints such as an approximate geostrophic balance (e.g., see Daley ,1991). Modeling of a “static” B has been the object of many papers that should be referred to Parrish and Derber (1992) presented the first implementation of 3D-Var and introduced a new approach in which the error was divided into balanced and unbalanced components. They used an ensemble of lagged

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forecasts at 24 and 48-h to represent averaged background error covariances. Bouttier et al. (1997) introduced balance operators obtained from multilinear regression for a covariance model based on homogenous and isotropic correlations for the analysis variables deemed to have uncorrelated error. This is pretty much what is presented in section 4.2. I do not see why the author presents this with so much detail given that this is at best, an example of what could be used in the ABC-DA. Buehner (2005) presents a B based on a EOF representation for stationary covariances that can capture some local effects (e.g., presence of orography).

2.2 Other comments

p.7: section 3.3. devotes 7 lines to observations. Later, section 5 gives 8 more lines to the observation operators. This is a bit short in my view.

p.6, line 173: The propagator is said to be difficult to derive so it is replaced by the identity. It has been theoretically defined (LeDimet and Talagrand, 1988) and developed for operational model. Even more, the "transpose" of it has also been developed, the "adjoint model". In the context of the incremental form of 4D-Var, some simplifications to the model can be made regarding resolution or the used of a simplified physics. It would be important to know whether it should be possible to expand the ABC-DA to make it possible to do 4D-Var.

p.7, line 200: using the analysis variables \delata(x – x_b)= U with B = UUˆT means that we need to get the square root of B but we do not have to invert it. The flip side to this is that if B is singular the increment is built based on the singular vectors of B. For an ensemble like the ETKF, for instance, the increment could only be a linear combination of the members of the ensemble that define B. p.8, lines 207-213: I think this needs to be revised. What is said here only applies to a particular B model with isotropic and homogenous correlations which happens to yield a diagonal matrix when expressed in terms of spectral components (e.g., Fourier, Bessel or spherical harmonics).

p.8, line 224: in the incremental form, there is no need to invert U, insofar as the initial

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point of the minimization is the background state, in which case, initially, \chi =0.

p.8, line 235: the description of the algorithm does not indicate how \lambda is updated.

p.9, line 245: I agree that the test of transpose is useful to test specific part of the code. But the gradient test (based on a Taylor expansion) should also be mentioned. It is simpler and is routinely used to validate complex operational variational DA systems when al components are active. It should be mentioned.

p.10, line 280: I do not think U-1 is needed.

p.10, line 290: the Helmholtz theorem states that there both a potential component and a rotational one (the streamfunction).

p.11, line 296: defining the balance operators is a separate exercise that needs more explanation. Using linear regression has been proposed by Bouttier et al. (1997) and used by others. This requires some insight into the type of balance that could exist. At synoptic scales, geostrophic and Ekman balance have been used to guide the linear regression. What kind of stationary balance can we expect at convective scales. Reference should be made to Parrish and Derber (1992) and Bouttier et al. (1997).

p.12, eq.(23): I think the winds cannot be represented as irrotational and this impacts the very formulation of U. Please revise. This impact the form of B as presented in eq.(22). p.14, line 366: I do not think we can represent B as a finite expansion of its eigenvectors, in general. It is a composition of operators that reflect the general form of the balance operators. In the univariate case for example, with homogeneous and isotropic correlations, this would require a large number of eigenvectors to properly represent it particularly if the characteristic scale is small.

p.15: section 4.3: one diagnostic used to calibrate the error statistics is to verify if the a priori statistics used in the assimilation are consistent with what is measured from the innovation covariances when real observations are compared to the forecast of a

model.

p.15, section 4.3.1: as I understand it, an ensemble of forecasts obtained from the UM is used to define the balance operators. To what extent can we expect those to reflect the balance of ABC forecasts?

p.23, eq.(33): given that only a wind potential is used, the multivariate B of eq.(33) needs some explaining.

3. REFERENCES

Bouttier, F., J. Derber and M. Fisher, 1997: The 1997 revision of the Jb term in 3D/4D Var. ECMWF Tech Memorandum No. 238, 54 pages.

Buehner, M., 2005: Ensemble-derived stationary and flow-dependent background-error covariances: evaluation in a quasi-operational setting. Quart. J.R. Meteor. Soc., 131, 1013-1043.

Gauthier, P., M. Buehner and L. Fillion, 1998: Background-error statistics modeling in a 3D variational data assimilation scheme: estimation of the impact on analyses. In Proceedings of ECMWF workshop on diagnosis of data assimilation systems, Reading UK, 2 to 4 November 1998.

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