Nonlin. Processes Geophys. Discuss., 1, C154–C158, 2014
www.nonlin-processes-geophys-discuss.net/1/C154/2014/

Nonlinear Processes in Geophysics
Discussions
Open Access

NPGD
1, C154–C158, 2014

Interactive Comment

Interactive comment on "Data assimilation of two-dimensional geophysical flows with a Variational Ensemble Kalman Filter" *by* Z. Mussa et al.

Z. Mussa et al.

Zubeda.Mussa@lut.fi

Received and published: 21 May 2014

1 General Comments

The VEnKF method has indeed been introduced and studied in several articles, such as Solonen et al (2011) and Amour et al. (2014), but in the former paper only toy models were treated, and in the latter paper a single experimental case with one row of sensors. The results of these papers leave many issues open before we can be convinced that VEnKF is indeed a robust and valuable member in the family of approximate Kalman filters.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

The main focus in the current contribution is to study the behavior of VEnKF in two realistic two-dimensional, highly nonlinear cases where model error is also present. Both of the examples used: the 2D observation of the same dam break case as in Amour et al, and a quasi-Geostrophic model with synthetic data but with systematic model error, are realistic models for real life applications.

The biggest contribution of the current paper is empirical evidence that VEnKF is able to assimilate real-life problems with very noisy and sparse data and incorrect models, and yet maintain high computational efficiency. However, there is a surprising and new condition on this stability: the observational data has to be interpolated to every numerical time step to ensure filter stability. And consequently, the VEnKF algorithm generates a new ensemble every single time step.

This last property, albeit a consequence of a stability constraint, is a major deviation from the practice of other Ensemble Kalman Filters. As a result, no ensemble of states is maintained in the assimilation – instead a time-varying estimate to the error covariance is the best description of system state. The classical state is the mode – not the mean, like in EnKF – of this distribution. This also implies that the mode always satisfies the model dynamical equation, which the mean does not do. And it also totally prevents covariance leakage and spurious correlations, which are major problems in EnKF and many other Ensemble Kalman filters.

Finally, an empirical relationship is established between ensemble spread and interpolation distance of observation that governs the stability or divergence of the VEnKF filter.

NPGD

1, C154–C158, 2014

2 Scientific Remarks and Comments

2.1 Page 404, lines 8 to 10

EKF and VEnKF – and indeed all Kalman filters – diverge whenever there are not enough observations to keep the filter on its track. Covariance inflation can be applied in all of them to regularize the filter, but at the expense of losing filter precision.

2.2 Page 406, line 16

Reference about EKF – A reference will be added, “Simo Särkkä (2013). Bayesian Filtering and Smoothing page 68-71. Cambridge University Press”.

2.3 Page 406, line 2

Is about a reference. I will add the reference suggested.

2.4 Page 407, line 26

Is about a reference. I will add the reference suggested

2.5 Page 413, lines 3 to 9

We have not used EnKF for both models and therefore we cannot use the Talagrand diagram to compare EnKF and VEnKF for this particular case. However, we can implement EnKF on the QG model but for the shallow water model we think it is demanding for this moment.

NPGD

1, C154–C158, 2014

Interactive Comment

2.6 Page 416, line 19

We have realized a typing error in that line, instead of the abbreviation "EnKF", it is supposed to be "EKF", we adopt this changes immediately. The EKF is used as a standard assimilation method for comparison with VEnKF performance.

3 Technical correction

3.1 Page 414, line 12

It should be $\sqrt{S}$ because the mean computed there is a sampled value, but not the exact mean. So for the estimator to remain unbiased it should be sqrt(S), but not $\sqrt{S-1}$. This is a well-known fact available in any book about statistical methods. Please refer also Solonen et. Al (2010) page 274.

3.2 Capital letter in EQ.(9)

noted

3.3 Figure page 435-442-443-444-445

Legend over the results lines - Point noted.

Yes we can do this for the QG model, however to run without assimilation for the shallow water model does not comply with the modification of the experiment in which we superimposed a sinusoidal cross-flow over the basic flow fields. In this experiment we have assumed that there is a cross flow which is not explained by the model but the

NPGD

1, C154–C158, 2014

Interactive Comment

modified data which shape the path through the model.

Interactive comment on Nonlin. Processes Geophys. Discuss., 1, 403, 2014.

NPGD

1, C154–C158, 2014

Interactive Comment