Review comments for brief communication **npg-2021-35**

An innovation-based estimation method for model error covariance in Kalman filters

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This manuscript is concerned with the estimation of the model error covariance matrix, $\mathbf{Q}$, in Kalman filtering and related methods. A method is proposed that uses the discrepancy between the expected and observed innovations, averaged in time.

Regrettably, I struggle to find anything new and noteworthy in this manuscript, and wonder if the authors have made any effort at surveying the existing literature. For example, 'Adaptive Kalman filtering' usually gets a chapter or a section in textbooks [Jazwinski, 1970; Anderson and Moore, 1979], while the estimation of system matrices is already a mature field in data assimilation [Mitchell and Houtekamer, 2000]. In this context, a special case of the method of Berry and Sauer [2013], which is already using the most basic estimator, is not interesting.

Other issues

- The hyperlink to the code is dead.
- $\hat{\mathbf{Q}}$ appears to be defined via the expectation, $\mathbb{E}$, both in equation (6) and on line 54.
- Please be more specific on line 97. What is $\mathbf{Q}$ here? Isn't it unknown? Do you only draw a single vector?
- Comment on need for such a small ρ in your experiments.
- Please motivate the design of $\mathbf{Q}_1$ and $\mathbf{Q}_2$.
  - Why is *banded* $\mathbf{B}$ needed? Note that any $\boldsymbol{A}\boldsymbol{A}^t$ would form a covariance matrix.
  - Why is $\mathbf{J}_{40}$ being subtracted.
- Include the upper and lower tick on the colorbars.

References

B. D. O. Anderson and J. B. Moore. *Optimal Filtering*. Prentice-Hall, Englewood Cliffs, NJ, 1979.

Tyrus Berry and Timothy Sauer. Adaptive ensemble Kalman filtering of non-linear systems. *Tellus A*, 65, 2013.

A. H. Jazwinski. *Stochastic Processes and Filtering Theory*, volume 63. Academic Press, 1970.

Herschel L. Mitchell and P. L. Houtekamer. An adaptive ensemble Kalman filter. *Monthly Weather Review*, 128 (2):416–433, 2000.