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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Simultaneous estimation of model state variables and observation and forecast biases using a two-stage hybrid Kalman filter" *by* V. R. N. Pauwels et al.

Anonymous Referee #1

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General Comments

The paper entitled "Simultaneous estimation of model state variables and observation and forecast biases using a two-stage hybrid Kalman filter" presents a methodology to estimate observation and forecast biases, as well as state variables based on an EnKF framework. The bias correction is currently a topic of interest in the hydrology community. The authors present three scenarios: 1) correction of observation bias, 2) correction of model bias, and 3) correction of both observation and model biases. Previous works have studied either bias in observations or bias in models; however, the topic of correcting both observation and model biases has been rarely studied. In

addition, authors present the advantages of implementing a two-stage filter instead of a simultaneous bias-state update. The way how the authors introduce and explain the objectives and assumptions in the paper are clear and concise. Specially, the methodology section explains clearly the statistical bases of the three scenarios. The main contributions of this paper are the insights in the implementation of the filters. The conclusions are in agreement with the objectives of the paper. The objectives are reached all over the paper providing insight in the discussion section.

Specific comments

The methodology section explains clearly the assumptions and bases of the EnKF implementations. All equations to implement the filters to other applications are given in the paper. The authors provide their argument for using the γ and κ tuning factors in the bias correction framework. However, it is desirable to see the effects of using or not using the tuning factors in the bias estimates. Could the authors mention in which cases the tuning factors are compulsory needed? The authors test the bias correction filters using both synthetic and real observations. It is known that when testing a framework validated with synthetic experiments, it suffers degradation in its performance. Could the authors provide insights about the factors or parameters that were not included in the synthetic study but affect the bias correction filters in real scenarios? The paper, in general, is well written, and always focused on the topic of study. All sections are referenced to previous works, outlining the contributions of the paper.

Technical corrections

The title corresponds to the main problem studied in the paper. Both abstract and paper structure are clearly presented and well written. The formulae, symbols, and abbreviations are properly explained in the text. Authors describe all formulae term-by-term allowing the reproduction of the filters' implementation. The number of references is appropriate for the topic studied in the paper. The two appendixes are appropriate to clarify some of the equations derived in the paper.