Effect of auto-correlated model error on Data Assimilation

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Motivations

- DA process has been often performed under the assumption that our forecasting model is perfect known as the strong-constraint but it's far from the reality.
- We consider the model error has spatial and temporal correlations. We assume that the system has a natural auto-correlated time-scale for the model error ω_r, but our forecast model and DA process use a misspecified memory scale in the model error. And we start to investigate the performance of the EnKS under the assumptions with a simple linear model.
- And the final goal of our project is to find a better way to estimated the decorrelation time-scale of the model error, in order to improve the performance of the forecast and analysis results.

Illustration

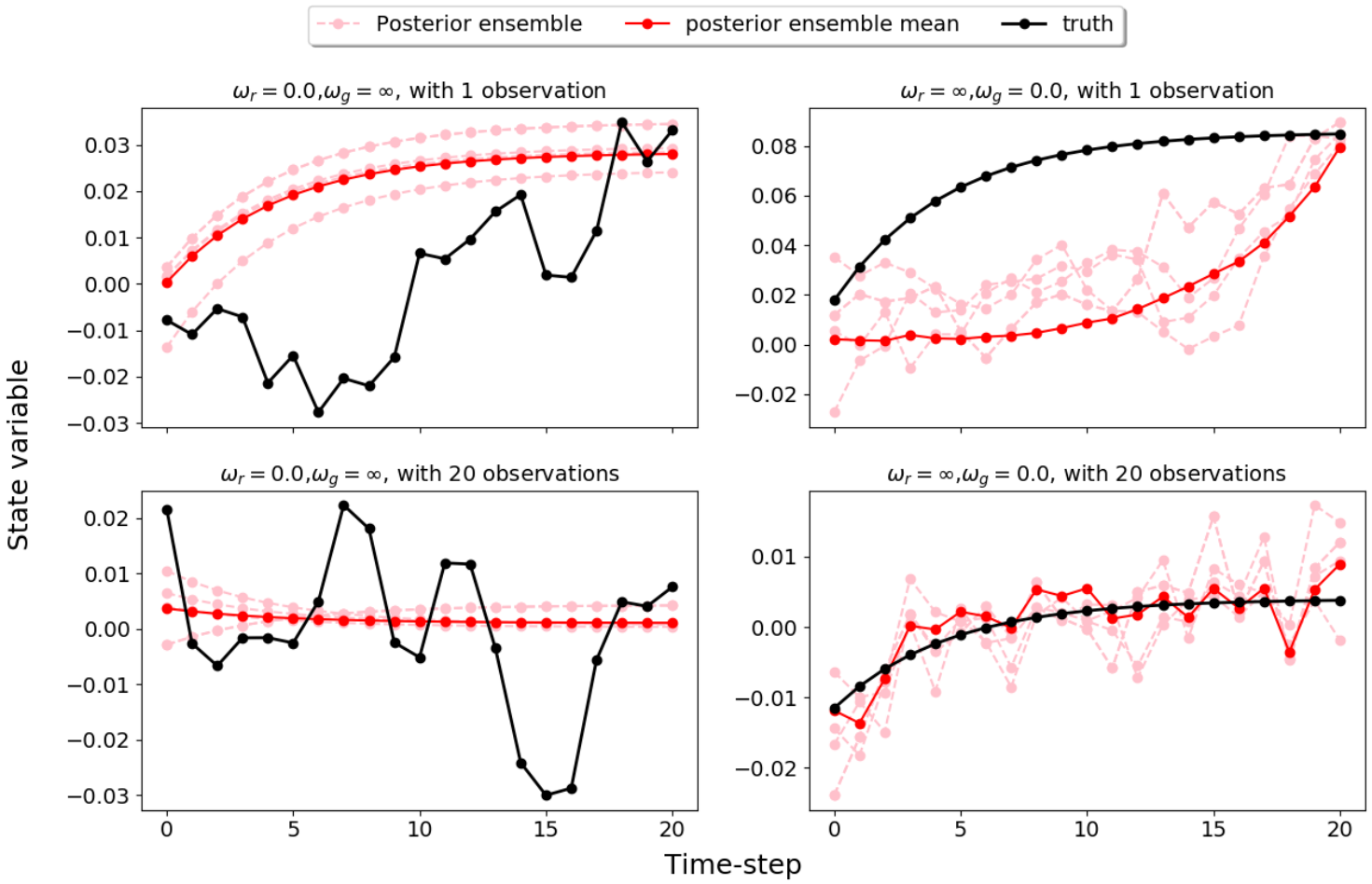


Figure: Consequences of using an incorrect memory time-scale in a simple linear model with the EnKS.

Numerical results of the EnKS

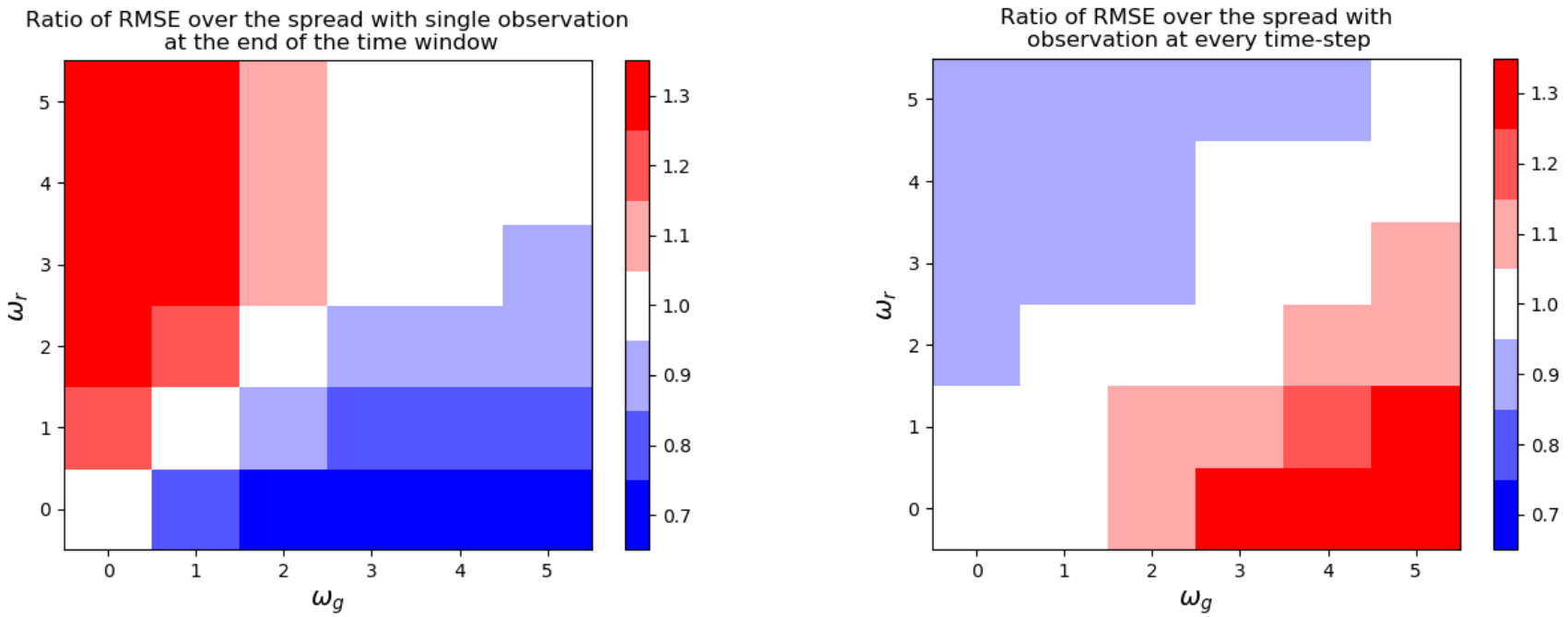
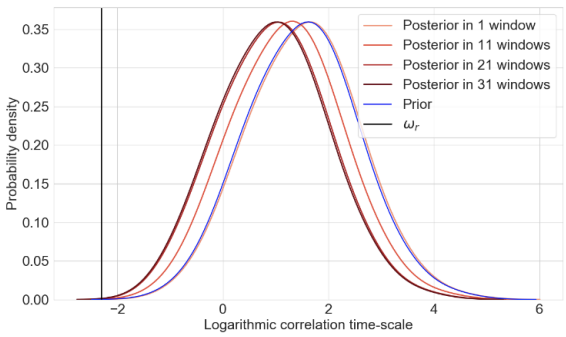
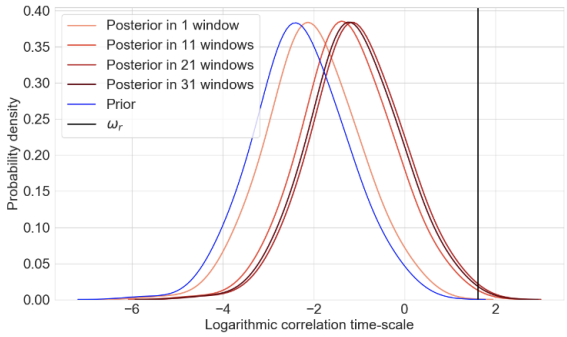


Figure: Ratio of RMSE over the spread of the posterior from the EnKS with (left) a single observation, and (right) observing every time-step.

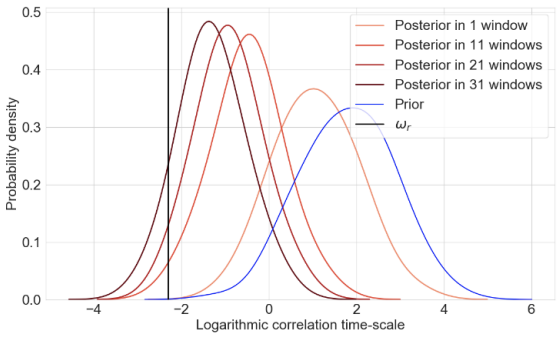
Memory scale estimation with state augmentation



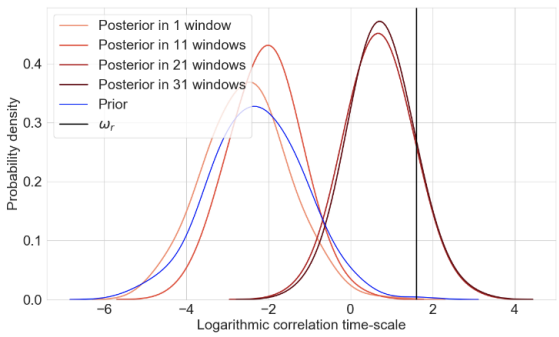
(a) with with small ω_r and larger ω_g and a single observation



(b) with larger ω_r and smaller ω_g a single observation



(c) with with small ω_r and larger ω_g dense observations



(d) with larger ω_r and smaller ω_g dense observations

Figure: The PDF of the posterior estimated ω_g, with different number of simulation windows in different circumstances and observation frequency, against the prior PDF of ω_g and the real correlation time-scale in the true evolution of the system, ω_g.

Conclusion and future work

- The auto-correlated model error does have significant impact on the data assimilation results, which are also highly dependent on the observation frequency.
- Using the state augmentation to estimate the pdf of the decorrelation time-scale can be impressive sometimes, especially with frequent observations, but nor always working.
- We started further experiments with the toy model for atmosphere, Lorenz 63 model, and we will experiment with more complicated model such as the shallow water model with convection.
- For long term, our goal is to have a better estimation of the correct auto-correlation time-scale for the model error, which should lead to more accurate estimation of the system.