Review for manuscript: *HGS-PDAF (version 1.0): A modular data assimilation framework for an integrated surface and subsurface hydrological model*

Summary:
This manuscript integrates the Parallel Data Assimilation Framework (PDAF), an open-source data assimilation software, with the HydroGeoSphere (HGS) hydrological model. The integration involves separate and alternating executions of HGS and PDAF, enabling information from one model to inform the other. Similar applications involve combining EnKF with HGS and combining PDAF with ParFlow. PDAF encompasses two fundamental classes of DA methods: Ensemble Kalman Filter (EnKF)-based, offering distributions for estimators, and variational-based, providing point estimators. This study specifically demonstrates the model binding using EnKF-based PDAF, validated through an application in a quasi-hypothetical numerical river-aquifer model. The model's performance on state variables, hydraulic head and soil moisture, is assessed using their ensemble mean. The model parameter, hydraulic conductivity (K), is constrained by the expected prior distribution, aligning with the method's anticipated behavior.

Comments:
Line 21-23: The assertion of operational real-time management may be perceived as over-promising. It heavily depends on the infrastructure of data warehousing and model pipelines.

EnKF related:

- Line 169: Clarify the term "state vector with model parameters." Is Xp representing model parameters sampled at a given realization from its latent distribution?
- Equation 2: Specify whether the forward transient process is noise-free. While understanding that the noise term may be controlled by parameters in Xp, consider presenting EnKF in the standard state space model format, clearly defining states, parameters, and distributions.
- Equation 3: Define the observation model here to maintain a consistent format with Equation 2, rather than introducing it directly from Equation 4.
- Line 200-206: If parameters and states are well-defined, refer to them in this section. Consider adding this information to the suggested flowchart to visually represent the requirements.
- Line 279: I am curious whether the covariance matrix encounters degeneracy problems after many time steps.

Flowchart related:

- Lines 134-152: Clarity in this paragraph could be enhanced with the inclusion of a flowchart, similar to Figure 1.
- Consider improving the flowchart quality in Figures 1 to 4 by incorporating consistent boxes and colors to distinguish observation, model run, configuration, and output steps. Providing a flowchart illustrating the connections between different modules can offer a more comprehensive overview.

Figure 8: Strengthen your claim by plotting the standard error for ensemble mean, demonstrating statistical significance in error reduction to bolster your argument.