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Reply on RC2

Marina R. L. Mautner et al.

Author comment on "Coupled effects of observation and parameter uncertainty on urban groundwater infrastructure decisions" by Marina R. L. Mautner et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-535-AC2, 2022

Thank you for your detailed comments, we have responded to each point below. Excerpts from the manuscript are shown italicized in quotations with changes in bold. For your convenience, we have also included a PDF version of the response to both reviewers together in-line with the reviewers' comments.

- We agree, the text has been amended as follows,

*"While the impacts of external uncertainties**, such as climate and population growth,** have been widely studied, there is limited understanding of how decision support is altered by endogenous uncertainties arising from model parameters and observations used for calibration."*

- We agree, the text has been amended as follows,

*"**Error metrics (i.e., squared residuals of piezometric head)** are not necessarily controlled by the same parameters as the **head based** objectives needed for decision-making."*

- Yes, this is correct. Updated text:

*"In hydrogeologic models, endogenous uncertainty is contributed by model parameters describing natural and human components of the system, **and** the set of historical observations used to calibrate or constrain the parameters."*

- Upon consideration, the sentence beginning "*Etter et al. (2018)…*" has been removed in the revision.
- We agree that this could be more clear, we have added the following text to provide this context,

*"**In conflict with the previous two objectives, certain parts of the city lie in areas that are affected by seasonal flooding resulting from medium-term groundwater mounding, which is particularly damaging in urban areas. To take into account these possible negative effects from increasing groundwater head within the valley,** the urban flood risk (F) is the sum of the urban area in cells with groundwater mounding (a) divided by the total urban area in the model (A) during the time periods (t) in the last year of the model period."*

- The model would take between 1 and 30 minutes, with most on the order of 5-8 minutes depending on the processor itself and the parameter combinations. We have added the following line to the text,

*"**A single model run is on the order of 5 minutes, depending on the combination of parameters and the processor speed.**"*

- This comment may have been cropped, but we interpret it to refer to lack of clarity on the number of observations used and how that may affect the results. We used all the available observations, which ranged from 1 to 29 annual observations during the 30 year model period, depending on the well. The text has updated as follows,

*"**Well observations vary from** 1 to 29 data points per well over the 30 year model period, **with a maximum of one observation per year.** "*

[Comment numbers skip from 7 to 12]

- We agree, the text has been amended as follows,

*"The sensitivity of the management objectives across the parameter space **with respect to both** management alternatives and cluster behavioral parameter sets indicates the variability of uncertainty with respect to individual physical model parameters."*

- The equation for delta and the accompanying text description have been added as follows,

" $\delta_i = 1/2\ E_{Xi}\ [\ \int |d\mu_Y - d\mu_{Y|Xi}|]$,

where the moment independent sensitivity indicator of parameter X_i with respect to the output Y (δ_i) represents the normalized expected shift in the distribution of Y, as a function of μ_Y and $\mu_{Y|Xi}$, the unconditional and conditional measures of Y, respectively. In this study, the parameters (X_i) are the 33 parameters shown in Table 1 and the output (Y) are the three management objectives described in Equations 1-3."

We have also updated the objective equations (Equations 1-3), so that they read Y_E , Y_W , and Y_F .

- We have rewritten the paragraph in question to be more clear as follows:

*"We evaluate the model results to visualize changes in ranking according to three types of comparisons using sets of heatmaps that **summarize the ranking of the alternatives across all the parameter sets. The comparisons evaluated are: (1) all three objectives across the observation cluster behavioral sets; (2) all three objectives for observation cluster behavioral set C-12345 across the range of the alluvial hydraulic conductivity parameter [HK2]; and (3) the water quality objective (Y_W) across the observation cluster behavioral sets and parameter HK2, simultaneously.***

In all three comparisons, the first step is to rank the alternatives in relation to each other according to the objective(s) from lowest (1) to highest (4) in each individual parameter set. Then, the ranking data for all the parameter sets in each comparison are summarized as follows:

Three objectives across observation cluster behavioral sets - The count of rankings for each alternative. Each column (cluster) in each objective row will

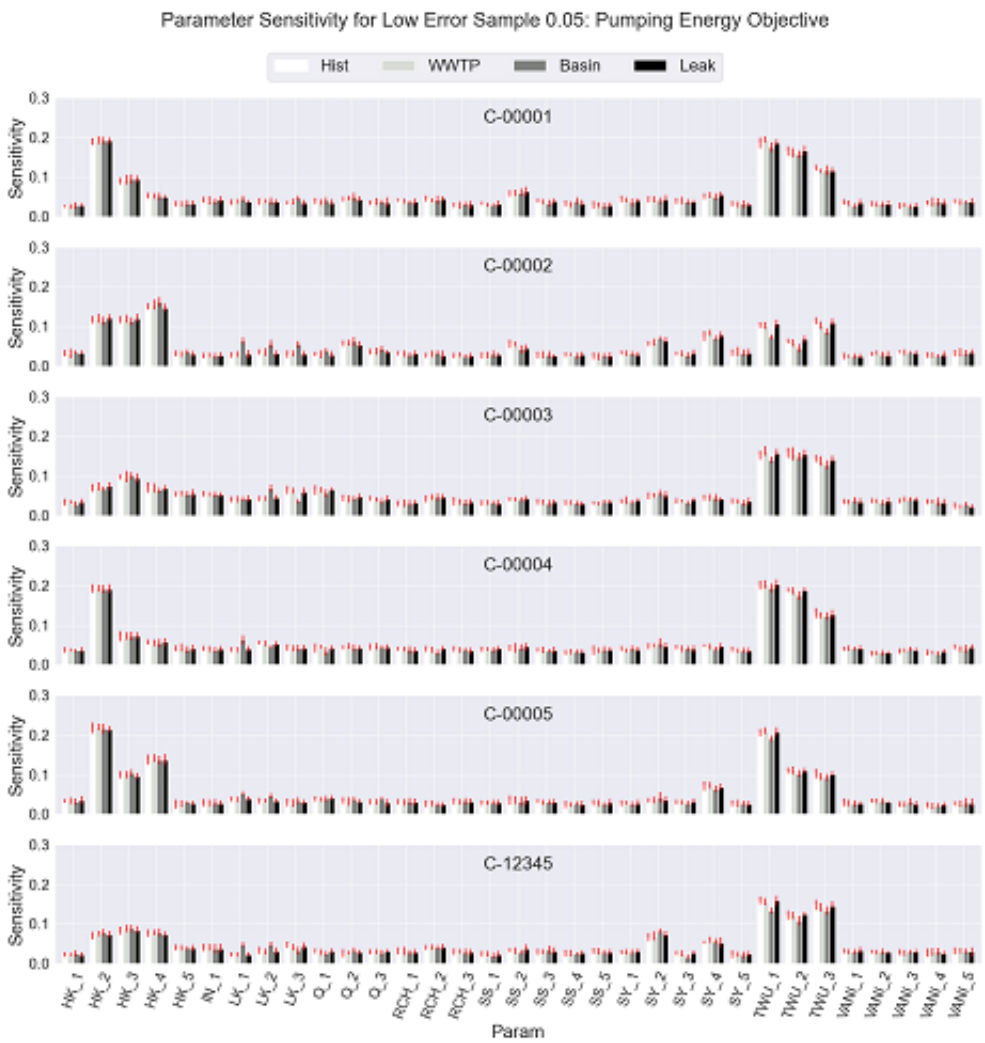
sum to 5,000.

Three objectives for C-12345 across parameter HK2 - The 5,000 sample set is separated into ten bins along the parameter value range from Table 1. The ranking count in each bin is divided by the total number of parameter samples in each bin to allow for direct comparison across all bins. This is necessary because the distribution of behavioral parameters can be non-uniform. Each column (parameter value bin) in each objective row will sum to 100%, or null if there are no parameter sets in that bin.

Y_W across the observation cluster behavioral sets and HK2, simultaneously - Same as in the previous comparison, but for only the water quality objective. This is repeated for the remaining observation cluster behavioral sets (C-00001 to C-00005). Each column (parameter value bin) in each cluster row will sum to 100%, or null if there are no parameter sets in that bin."

- This value is the sum of squared weighted residuals, meaning that it is in units of m^2 and is expected to be large because there are a total of 8,181 observations. Missing simulated values for an observation are by default represented in the model as -1E6, which can be a result of a dry cell or an incomplete model run based on incompatible parameter values. Therefore, the squared residual would be on the order of 1E12, leading to the highest values seen in Figure 4. We have added the units of m^2 to the caption to clarify this point.
- We agree that this will help improve the analysis. The 95% confidence interval for each sensitivity value has been added as a red line over each bar and the caption was updated to indicate this change, a higher resolution image has been included in the Supplement. The confidence intervals have also been included in the relevant supplemental figures. In general, we find that the differences in parameter sensitivity discussed in the text are significant (i.e., 95% intervals do not overlap), which supports the convergence of the sensitivity analysis as recommended by the reviewer. The following text was added to the caption,

"***The bootstrapped 95% confidence interval for each sensitivity value is shown as a red line."***



- You are correct, this has been fixed as follows,

" δ sensitivity of the error metric and three management objectives (rows) according to the 5,000 filtered samples for the ***8*** *model parameters (columns)* ***with the largest differences in sensitivity between clusters*** *for the historical management alternative."*

Please also note the supplement to this comment:
https://hess.copernicus.org/preprints/hess-2021-535/hess-2021-535-AC2-supplement.zip