Referee report for the manuscript HESS-2021-601: 'A Novel Objective Function DYNO for Automatic Multi-variable Calibration of 3D Lake Models'

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General evaluation and major comments

I want to thank the authors for putting great effort in the revision of the manuscript. Although I think that the authors addressed most of the technical remarks well, the major issue that is in my opinion present in this study requires further discussion. I am afraid that the authors reply does not fully dispel my doubts in the study design. I will again address this issue in the next section. In the following section I address minor line-by-line comments.

Continuing the discussion on the synthetic study design

I appreciate that the authors stress the fact of using only synthetic data in their case study in the revised version of the manuscript. Yet, I would like pick up the discussion on the synthetic case study and come back to the arguments that were in my opinion not fully addressed.

I raised two major concerns in my previous review: i) synthetic observation data that were generated with the same set of equations that are then fitted to these date would favour a combined calibration (velocity and temperature), as both data would constrain the function space stronger than each of the variables individually; ii) real world settings are usually trade-off problems in the calibration of multiple variables.

While I can accept the reply to argument ii), I think the reply to argument i) misses the main issue. The authors argue that the model is physically based and should therefore be capable of reproducing observations of physical variables. Further, as the model is physically based it is capable of generating realistic data that can be used as observation data in a test case. The authors also refer to Baracchini et al. (2020) as this study supports the use of velocity data and temperature data for a 3D lake hydrodynamic model calibration.

The theoretical argument may be reasonable, but it misses the fact the measurement uncertainty in real observation data can be substantial. The study of Baracchini et al. (2020) used measured observation data for velocity and temperature. Baracchini et al. (2020) mention that measured flow velocities are often close to their measurement accuracy in one of the case studies while the difference between the variance in temperature measurements and the measurement accuracy is substantially lower. A synthetic example that uses simulated data as observation data cannot account for this property of the observation data. To make the synthetic study more comparable to a real case setting overlaying the synthetic data with an error model may be a probable solution. Although I fully understand that this is likely infeasible to be still considered in this study this aspect should be addressed. I think the distributions of the observation data and their uncertainties can strongly influence the performance of the simultaneous calibration.

Line-by-line comments

p.4 L141 - L143 Please rephrase the sentence. The formulation (e.g. don't) is highly informal.

p.8 L256 Remove *assume*.

p.9 L266 This section give**s**...

p.13 L382 Remove *about*. It is exactly 8 times 24.

p.14 L427 Please revise or remove this sentence. It sounds unnecessary and very vague to me.

p.14 L443 Please rephrase 'is set be the middle'.

p.15 L447 ...in *the* other two scenarios...

p.15 L450 - L452 Please revise the two sentences. The wording sounds odd. Avoid using vague wording such as 'good' and 'bad'.

p.23 L671 - L675 Please revise this section. The formulation (e.g. don't) is highly informal. Further, either it is a physical law or some empirical observation by a human. I would avoid this formulation.

References

Baracchini, T., S. Hummel, M. Verlaan, A. Cimatoribus, A. Wüest, and D. Bouffard (2020). "An automated calibration framework and open source tools for 3D lake hydrodynamic models". In: *Environmental Modelling & Software* 134, p. 104787. DOI: https://doi.org/10.1016/j.envsoft.2020.104787.