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Discussions

Interactive comment on "Impact of climate forecasts on the microbial quality of a drinking water source in Norway using hydrodynamic modelling" *by* Hadi Mohammed et al.

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Response to Comment #1. This is very important, and further discussions on the reasons for the predicted changes shall be included in the revised manuscript. For instance, the predicted increases in E. coli in the Lake may be associated with the changes in streamflow and E. coli concentrations in the tributaries of the Lake in the future, as predicted in SWAT. Changes in streamflow may lead to changes in the concentrations of suspended particles and associated faecal indicator organisms that reach the Lake. In addition, variations in the flow regimes affect the mixing conditions in the lake, and this led to more perfect mixing as indicated in the results (Figure 7). Moreover,

the projected changes in air temperature used in the predictions could have played a significant role, since it is a major factor that affects the persistence and regrowth of microorganisms in water.

Response to Comment #2. The statement only reflects some of the challenges encountered in calibrating the model. Apart from data challenges, not all existing hydrodynamic modelling systems fully account for the variety of processes that affect the fate of microorganisms in both sediments and water column. Moreover, we found that certain solution schemes for the governing hydrodynamic equations may have varying accuracy levels when implemented in different water bodies of different dimensions and environmental conditions.

Response to Comment #3. Well noted and would be corrected in the revised manuscript.

Response to Comment #4. 1. Because there was no local flow data, for the catchment of the Lake, hydrological parameter regionalization method was applied to estimate flow in the major streams. The parameters were used to predict potential flow levels in the future using adjusted precipitation and air temperature data. 2. The SWAT calibrations were performed on the major streams, but not on the minor streams since the required spatial data were not available for those small streams. Therefore, flow in these streams were scaled from the major ones. 3. For E. coli calibrations, we used measured local biweekly data from 8 locations including the major streams.

These have been explained in the discussion as part of the limitations of the study. This would be made more succinct in the revised manuscript.

Response to Comment #5. This is a very insightful comment and might be considered in the revision. The volume of the lake is approximately 250, 000 m3. The retention time of the Lake is indeed more than 1 year. However, the model calibration was restricted one year due to the following reasons: - Simulation stability when running long simulations: Smaller timesteps equals higher stability but increases the time to run the model. To keep the model runs to a realistic time and to keep the stability of the model in check, a model run of one year was found to be the most realistic solution. - Lack of computer processing capacity to run longer simulations in a reasonable time. If the work is to be improved/continued, this is an important part to think of. - We focused on finding the effect of the yearly circulation periods, which happens during spring and autumn, on the climate projections. Without accounting for the retention time, we still see effects of the future climate projections on the lake compared to the current climate.

Response to Comment #6. The collected data was measured every three hours during daytime from 7 a.m. to 7 p.m. Since the model required all meteorological data to have the same time step, the cloud cover data was interpolated to get hourly values.

Response to Comment #7. Eqn. 1 is a simple water temperature model, which describes the rate of change of response temperature. In the eqn., the water temperature is assumed to respond only to surface heat exchange, which is calculated from the other weather parameters as shown in eqn. 2.

D in eqn. 1 is the mean temperature of the water column, and it is variable. The total depth of the water column is rather 99 m.

Response to Comment #8. That is true, some corrections are needed. For instance, the kinematic viscosity terms are wrongly placed, and the signs of the lateral momentum terms (M_x and SM_y) need to be reversed.

Response to Comment #9. That is true. They refer to the horizontal and vertical turbulent kinematic viscosities

Response to Comment #10. Well noted and will be corrected accordingly.

Response to Comment #11. The equation would be added in the revision.

Response to Comment #12. We agree with the reviewer on the limitations of the upwind scheme used in this study. The model was run with other higher order schemes (QUICKEST and QUICKEST with ULTIMATE). However, these schemes yielded very

unrealistic results after repeated iterations. We have previously calibrated another model for a smaller, more shallow lake with a large catchment area. In that case, the higher order schemes; QUICKEST and QUICKEST with ULTIMATE had better fits to the calibration data than the upwind first order.

The Lake (Brusdalsvatnet) for which the model was calibrated in this work is a large, deep lake with a small catchment area, the QUICKEST and QUICKEST with ULTIMATE schemes produced poorer fits than the upwind first order scheme. During the calibration with the higher order schemes, outputs of the temperature profiles and the raw water intake point did not fit the measured data even when model parameters were stretched to their limits (minimum to maximum) to make this happen. The closest fits to the observed data as presented in the results were obtained by the Upwind First Order scheme.

Nonetheless, it may however be possible to achieve better fits with the higher order schemes in other models/software.

Response to Comment #13. Indeed, the grids were not 1m in dimension. Only the vertical dimensions were 1 m. The sentence shall be revised accordingly. The horizontal grid is approximately 100 m x 100 m while the vertical layers are every 1 m.

Response to Comment #14. The calibration temperature data (temporal data), which was compared with the model outputs were measured at the outlet of the treated water reservoir in the water treatment plant, rather than at the raw water intake depth. This means that there might be some difference in temperature from the data and the actual temperature at the intake depth. The retention time, from when the water is pumped from intake level to the measurement of temperature at the outlet of the treated water reservoir, is calculated to be approximately 8 hours. While this may not be the only reason for the relatively large difference between the model outputs and the observations, considerable changes in the water temperature could occur from pumping through treatment steps and in the storage reservoir for the treated water. Therefore, the temporal measurements of water temperature might not be viable calibration data for the model.

This was the main reason for the statement as quoted by the reviewer. We agree that this must be made clearer in the discussion and would be done accordingly in the revision.

Alternatively, we might have to remove the water intake calibration data from the paper so that the calibration data for the temperature model will comprise only the manually measured profile data.

Response to Comment #15. With the input data that was available for the area and the capabilities of the modelling software, we believe this was the best fit we could achieve after many model runs, setting each parameter as best as possible.

Response to Comment #16. The E. coli data as taken from the water treatment plant were composed of detects (count) or non-detects (zeros). Therefore, it was not possible to indicate the measurement errors in the plots.

The 2015 data was added to the plot because as shown in the figure, only two detections of E. coli were recorded in the raw water in 2017. The measurement method has an accuracy of detectable E. coli per 100ml of sample. For example, there could have been up to 9 E.coli colonies per 1L without the test finding any detects. Also, the treatment plant produces 0.37 m3/s while only 100ml of water is tested per week. This is therefore not a well-represented amount of sample.

The 2015 measurements however reflect a typical pattern of observation in the lake, which was predicted by the model. The point was not necessarily to replicate the 2015 data, but to show correlation between the model outputs and the pattern of the 2015 measurements, since more detects were shown in 2015 than in the 2017 measurements.

Response to Comment #17. The model predicts ice cover. However, data on ice cover

was not available for comparison, thus, the output was not presented in this work.

The modelled Lake (Brusdalsvatnet) is located in a mild coastal climate, where ice-forming is not as common and long-lasting as in most other lakes in Norway, therefore, the Lake is never fully covered by ice. The mild climate prevents long periods of cold weather, which is needed to form a stable long-lasting ice cover. Therefore, ice normally only covers smaller portions of the Lake and for short time periods. The model result regarding ice cover is shown in the figures attached.

The figures below show ice cover on the Lake surface predicted by the model in 2017. The ice started appearing on 9th February and ended after 16th February. Ice was formed again on the 7th of March and ended after March 9th.

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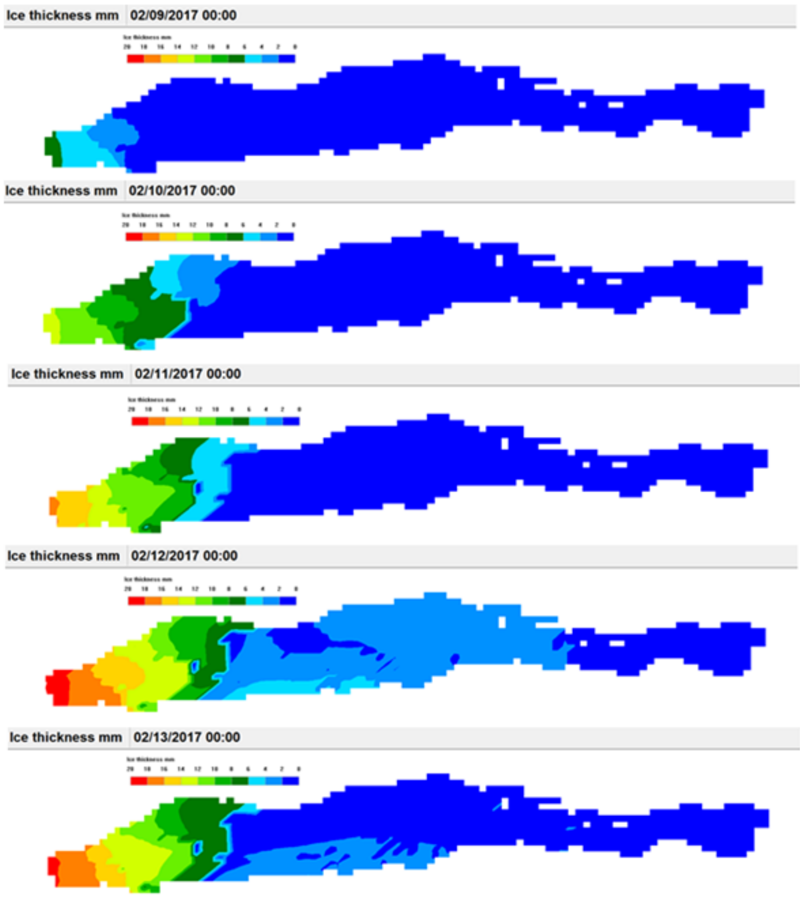

Fig. 1. Ice cover on lake surface from 9th February to 13th February and 14th to 16th February 2017.

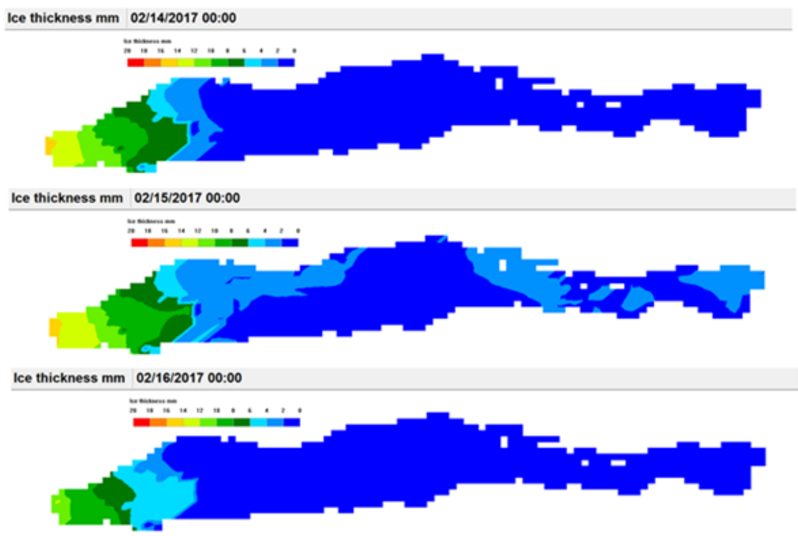

Fig. 2. Ice cover on lake surface from 14th to 16th February 2017.

Fig. 2. Ice cover from model output 2

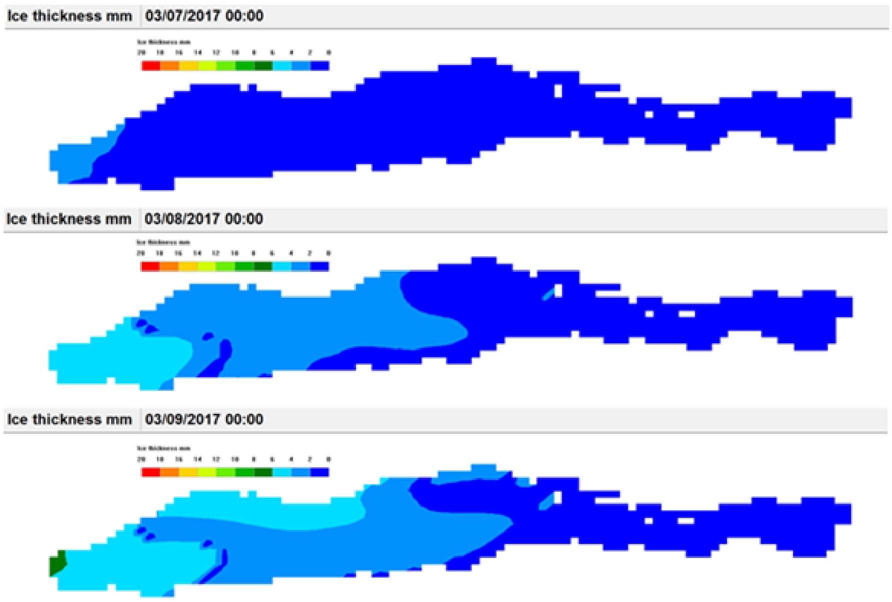

Fig. 3. Ice cover on lake surface from 7th March to 9th March 2017.

Fig. 3. Ice cover from model output 3