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Identifying the drivers of lake level dynamics using a data-driven modeling approach

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The standard approach of modeling lake level dynamics today is via process-based modeling. The development of such models requires an extensive knowledge about the investigated system, especially the different hydrological flow processes. When some of this information is missing, these models could provide distorted results and could miss important system characteristics.

In this study, we show how data-driven modeling can help the identification of the key drivers of lake level changes. We are using the example of the Groß Glienicker Lake, a glacial, groundwater fed lake near Berlin. This lake has been experiencing a drastic loss of water in recent decades, whose trend became even faster in the last few years. There is a local controversy whether these changes are mainly weather driven, or caused by water use; and what mitigation measures could be used to counteract them. Due to the strong anthropogenic influence from multiple water-related facilities near the lake, and the lack of geological information from the catchment, there are many unknows about the properties of the hydrological processes, hence the development of a process-based model in the area is challenging. To understand the system better we combine data-driven models with water balance approaches and use this methodology as an alternative to classic hydrological modeling.

The climatic model input (catchment-average precipitation and actual evapotranspiration) is generated by the Central European Refinement dataset (CER), which is a meteorological dataset generated by dynamically downscaling the Weather Research and Forecasting model (Jänicke et al., 2017). First, a data-driven model is constructed to predict the changes in lake levels one day ahead by using precipitation and evapotranspiration values from the last two months, a time interval that was selected after an extensive parameter analysis. This model is then further extended by additional inputs, such as water abstraction rates, river and groundwater levels. The fits of the different simulated lake levels are evaluated to identify the effects of the relevant drivers of the lake level dynamics. For a more mechanistic interpretation, a monthly water balance model was created using the same dataset. By calculating the different fluxes within the system, we were able to estimate the magnitudes of unobserved hydrological components.

With the help of our modeling approach, we could rule out the influence of one of the nearby waterworks and a river. We have also found that the lake level dynamics over the last two decades was mainly weather-driven, and the lake level fluctuations could be explained with changes in

precipitation and evapotranspiration. With the water balance modeling, we have shown that the long-term net outflux from the lake catchment has increased in the last few years. These findings are used to support the development of a local high-resolution hydrogeological model, which could be used to further analyze these processes.

References

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