A Hydro-Economic Model for Water Level Fluctuations : Combining Limnology with Economics for Sustainable Development of Hydropower

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Water level fluctuations in lakes lead to shoreline displacement. The seasonality of flooding or beaching of the littoral area affects nutrient cycling, redox gradients in sediments, and life cycles of aquatic organisms. Despite the ecological importance of water level fluctuations, we still lack a method that assesses water levels in the context of hydropower operations. Water levels in reservoirs are influenced by the operator of a hydropower plant, who discharges water through the turbines or stores water in the reservoir, in a fashion that maximizes profit. This rationale governs the seasonal operation scheme and hence determines the water levels within the boundaries of the reservoir's water balance. For progress towards a sustainable development of hydropower, the benefits of this form of electricity generation have to be weighed against the possible detrimental effects of the anthropogenic water level fluctuations. We developed a hydro-economic model that combines an economic optimization function with hydrological estimators of the water balance of a reservoir. Applying this model allowed us to accurately predict water level fluctuations in a reservoir. The hydro-economic model also allowed for scenario calculation of how water levels change with climate change scenarios and with a change in operating scheme of the reservoir (increase in turbine capacity). Further model development will enable the consideration of a variety of additional parameters, such as water withdrawal for irrigation, drinking water supply, or altered energy policies. This advances our ability to sustainably manage water resources that must meet both economic and environmental demands.

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