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Effects of hydropeaking on the riparian aquifer

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Hydropower is a very flexible source of green energy which counts for the majority of water resources uses in Alpine regions. Energy producers appreciate this source of energy because hydropower plants equipped with reservoirs can adapt quickly to the variability of the energy free market and maximize the company's revenue. In fact, the reservoir allows to store water when the prize of energy is low (typically at night) to use it to increase the production when the prize of energy is high. This often leads to strong and rapid fluctuations of water discharge downstream the hydropower plant, depending on the adopted reservoir operations. This alternate release of water is known as 'hydropeaking', and induces alterations of the river habitat with consequences on the riverine ecosystem. Since the water is taken from the hypolimn of the reservoir (for technical reasons the intake is located well below the surface) also water temperature shows oscillations, which magnitude depends on the timing of the hydropower production, and then ultimately by the aleatoric energy market. In addition, recent field investigations showed that surface water level oscillations are associated with significant mass exchanges between the stream and its riparian aquifer with potentially relevant and still largely unexplored biogeochemical implications.
The aim of this work is to analyze flow and thermal effects of hydropeaking on subsurface flow into the riparian zone surrounding a river downstream a hydropower station. In this work we present a simplified one-dimensional model for surface-subsurface flow and heat exchange. This model allows us to quantify the lateral extent of the riparian region affected by alterations of flow and temperature due to hydropeaking oscillations of streamflow and water temperature. In particular, we identify the key parameters controlling diel variations of mass and thermal exchanges between the channel and the riparian aquifer. The storage effects of the aquifer and its role in damping hydropeaking waves is also quantified. Finally, the role of longitudinal changes in channel morphology as well as of land cover and seasonal variations of boundary conditions was also examined with the proposed modelling framework.