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Anthropogenically-induced recharge in a semiarid mountain front context

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Mountain-fronts constitute important groundwater recharge areas in arid and semiarid regions. Mountain-front recharge processes are generally identified, in natural systems, as streamflow losses and subsurface inflow from the mountain block. However, another key recharge process is from irrigation practices; where mountain streamflow is distributed across the irrigated piedmont. In this study, coupled groundwater fluctuation measurements and stable isotopes (^{18}O and ^{2}H) were used to identify and compare the natural mountain-front recharge to the anthropogenically-induced irrigation recharge. Within the High-Atlas mountain front of the Ourika basin, Tensift, Central Morocco, the groundwater fluctuation mapping from the dry to wet season showed that recharge from irrigation waters was higher than the recharge along the streambed. Irrigation practices in the region divert more than 65% of the stream water, thereby reducing the potential for stream recharge. Due to the traditional irrigation practices, upstream crops are preferentially irrigated with stream water over downstream areas. In downstream areas irrigation is only via stream water during large flood events and is otherwise supplemented by groundwater resources. These changes in water resources used for irrigation practices between upstream and downstream areas are reflected in the spatio-temporal evolution of the stable isotopes of groundwater. In the upstream irrigation area, the groundwater stable isotope values ($d^{18}O$: -8.4 ‰ to -7.4 ‰) reflect recharge by the diverted stream water. In the downstream irrigation area, the groundwater isotope values are lower ($d^{18}O$: -8.1 ‰ to -8.4 ‰) due to recharge with floods.

The results from this study particularly highlight that irrigation can deeply modify both the recharge processes and the water balance in the mountain front areas. Groundwater resources in such areas become reliant on the irrigation practices as an important source of recharge, and this anthropogenic modification of the hydrological cycle should be assessed and taken into consideration within climate change impacts and integrated water management strategies.