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Evapotranspiration modeling in mountainous areas for better estimates of groundwater recharge

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In semi-arid areas, water resources are highly solicited mainly for irrigation, including both surface runoff and groundwater use. A sustainable management of this resource requires a better understanding of the hydrological functioning of these watersheds. The water balance equation includes one input term, the precipitations, and three output terms, namely the surface runoff, the evapotranspiration (ET) and the groundwater recharge. Whereas precipitations and runoff can be considered as measured variables and are also correctly modeled, the ET and infiltration towards aquifers are very poorly known, although the first term can be considered as a loss, whereas recharge is a resource. Solving the water balance equation using hydrological models doesn't help because there is a strong equifinality between these two terms. It is therefore of utmost importance to assess theses fluxes. In this study, we propose an approach estimate ET in a mountainous catchment in the high Atlas Mountains (Morocco), in order to improve the deep infiltration recharging the Haouz aquifer located downstream.
The study area is the Rheraya catchment (228 km2) ranging from 1000 to 4167 m.a.s.l. with precipitations ranging from 300 to 700 mm per year. The reference evapotranspiration estimated at 2000 m.a.s.l. is about 1100 mm per year. The landcover in the area includes mainly rangelands with very little vegetation and very stony soils, so that very few bibliographic data is available about the ET of such an area, and physical models are difficult to parameterize. To constrain the simulation of ET, we use a simple bucket soil model in two layers taken from the FAO method, calibrating it based on soil moisture measurements achieved during three years in a site at 2000 m.a.s.l. included in the catchment. For the irrigated areas included in this catchment (about 5% of the area) the dual crop coefficient FAO approach was used (SAMIR model) using Sentinel-2 images. ET was computed during one year and extrapolated to the whole watershed based on rangeland and irrigated crops areas. The Rheraya results where then extrapolated to the whole high Atlas range contributing to the Haouz aquifer and provide an annual recharge of 152 million cubic meters, which is exactly the median of all values used in historical studies based on fully empirical estimates, and which showed a very high dispersion (0-400 million cubic meters).
Although the uncertainties are still high, we show that a better improvement of ET is a key approcha for a better assessment of the hydrological functioning of watersheds and thus for climate change impact simulation looking not only at surface but also at groundwater.