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Constraining recharge and groundwater flow processes in hard-rock aquifers in temperate maritime climate using stable isotope signatures.

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Recharge estimates and in understanding flow process in hard rock aquifers pose significant challenges. These arise from structural complexities of the hardrock aquifers and are further complicated by variability of the superficial cover. A comparative study of three metamorphic catchments situated in the North of Ireland is presented in this study, each with contrasting geology, glaciation history and consequently superficial cover. The presented study focusses on two main strains. Firstly, due to lack of existing records, stable water isotopes in precipitation (δ18O and δ2H) were monitored at the research sites and their temporal and spatial variability was examined. Secondly, flow processes and dynamics of groundwater recharge based on continuous records of stable isotopes in groundwater, collected along catchment transects from various depths, and its variability in relation to the acquired precipitation signal were studied. Each precipitation station exhibited distinct isotopic signatures, where weather effect and proximity to coastline are the main controlling factors governing the isotope signatures. Moreover, in each of the stations the isotopic signature varied seasonally and thus stable isotopes proved a useful tool for assessing the dynamics of groundwater recharge. The analysis of isotope signatures in precipitation and groundwater from various depths within the hard rock aquifers allowed to evaluate the timescale of recharge, with rapid responses varying from few days up to several months. In general, the recharge appeared continuous over the hydrological year within wetter catchments with higher annual precipitation amounts purging the hardrock aquifers throughout the year. However, within comparatively dryer catchments recharge has a more seasonal character, predominantly taking place during the winter half of the year. Spatially, the recharge is highly localised within the elevated catchment areas, where superficial deposits are scarce and the bedrock is exposed. The study also suggests preferential recharge through faults that appear as conductive features. In all the catchments concerned, the precipitation signal was strongly attenuated with increasing depth, inferring the groundwater flow is strongly compartmentalised into a more rapid flow system within the shallow transition zone (decomposed bedrock) and into a much slower system within the underlying more competent bedrock.