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Temperature buffering by groundwater in streams under current and future climate conditions

Vince Kaandorp (1,2), Pieter Doornenbal (1), Henk Kooi (1), Hans Peter Broers (3), Perry de Louw (1,4)

(1) Deltares, Soil and Groundwater, Utrecht, Netherlands (vince.kaandorp@deltares.nl), (2) Utrecht University, Geochemistry, Utrecht, the Netherlands., (3) TNO Geological Survey of the Netherlands, Utrecht, the Netherlands, (4) Soil Physics and Land Management, Wageningen University, Wageningen, the Netherlands

Stream water temperature influences the presence of species, functioning of ecosystems and (bio)chemical processes. Groundwater seepage can provide thermal refugia for aquatic biota by providing relatively warm water in winter and cool water in summer. The contribution of groundwater is however under stress due to anthropogenic activities and climate change. We studied the importance of groundwater for two lowland streams in the Netherlands by measuring winter and summer stream temperatures long fibre-optic cables and sampling of 222Radon. We located several springs and seepage 'hot-spots' which dampen water temperature extremes. In addition, we found decreasing temperatures in shaded stream stretches on summer days. We constructed a stream temperature model to quantify the energy fluxes acting on the stream, which was calibrated using the measurements. Using this model, we separated the contribution of the different parts of the stream thermal budget such as direct solar radiation, air temperature and groundwater seepage. Scenario analysis was done by changing shading, seepage rates and air temperatures, which showed that shading is an important control on summer temperature maxima. Especially with changing climate conditions, protection of groundwater resources is essential for the durability of thermal refugia.