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Non-isothermal water flow in the vadose zone of arid and semi-arid environments

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In desert environments thermally-driven vapour flow can be an important component of the total water flux in soils. As such, vapour flow can have considerable impact on recharge estimation, with small errors in soil water flow rates resulting in relatively larger errors in the recharge estimates since recharge is a very small fraction of rainfall. The additional effects of vegetation and temperature contributions may also impact soil water movement and thus calculated recharge rates in arid and semi-arid vadose zones. Currently most methods for estimating large-scale recharge rates do not consider these various processes, which adds an unknown degree of uncertainty to recharge estimation. The HYDRUS-1D numerical simulator was used to simulate coupled isothermal liquid, isothermal vapour, non-isothermal liquid and vapour flow, and heat flow in deep variably saturated vadose zones. The considered climatic conditions are characteristic of central Australia with approximate mean annual precipitation and potential evapotranspiration rates of 300 and 3000 mm, respectively. A time series of 130 years of daily climate data provides the upper boundary conditions. Groundwater recharge under highly erratic rainfall conditions is hypothesized to be primarily episodic and linked to flood events which may be significant only once every few years. The combined effect of vegetation and temperature on water flow and soil water redistribution is discussed for both vegetated and bare soils.