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Vertical Water Losses in Irrigated Rice Landscapes – Model Development

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An increasing water demand for industrial purposes intensifies water scarcity especially in water intensive rice cropping areas of south-eastern Asia. The plough pan of paddy fields enables the establishment of continuous ponding conditions during the growing season and is therewith a central element of wet rice production. The saturated hydraulic conductivity (Ks) of the plough pan is highly variable in space and time including preferential flow effects. Water flow through the earthen banks of the fields contributes as an additional factor to the uncertainty in water flux calculations. In this study we developed a simple deterministic model with stochastic elements depicting the vertical water flux through the plough pan of paddy fields.

A user-defined number of field is treated simultaneously. Darcy's law is used as the fundamental equation for water flow calculations with the ponding depth h as a time-dependent variable. Flux uncertainty is depicted by a Monte-Carlo-type implementation. Water flow for each individual field site is estimated from one hundred realizations of Darcy's equation with Ks as a random variable of a bimodal probability density function (PDF) accounting for a matrix and a preferential flow domain. The PDF is the weighed sum of two Gaussian PDF with the weighing factor α which is a function of the ponding depth h reflecting an increasing risk for preferential flow situations after drying (shrinking cracks). Lateral and subsequent vertical water losses through the bunds of the field are a function of the ratio of the bunds' width at its base, the extension of the plough pan underneath the bund and the ponding depth. Various examples for the model capabilities depicting the contribution of the individual fluxes – matrix, preferential, bunds – to total flow are demonstrated.