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A simplified agro-hydrological model for the computation of water fluxes and irrigation efficiency in rice areas

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The main goals of agro-hydrological models are to estimate water fluxes in the soil-plant-atmosphere continuum (SPAC) and to support management and planning of the water resource over specific areas (a field, a farm, an irrigation district, a river catchment, etc.). Hydrological models are 'physically-based' (e.g., SWAP, HYDRUS, FLOWS) if they rely on an accurate mathematical description of processes taking place in the physical system, or are 'conceptual' (e.g., SWAT/SWAT+, DSSAT, IDRAGRA) when they are based on a simplified schematization of the physical system and the processes involved. The Richards' equation (Richards, 1931), modified to include root water extraction, is applied by physically-based models to compute soil water movements, requiring the knowledge of the soil water retention, $\theta(h)$, and unsaturated conductivity, $K(\theta)$, curves, and the use of quite complex and computationally demanding numerical schemes to be solved. On the contrary, conceptual models are based on a bucket/cascade bucket approach to describe water movement into the soil.

Conceptual models are often applied for irrigation planning over large areas in a spatially distributed mode, since they require less data and a lower computational effort than physically-based models. However, when considering rice areas, the strong link between irrigation, soil characteristics and groundwater dynamics dictates the need of a rigorous way to compute soil water fluxes, from which the irrigation efficiency depends. This suggests the application of physically-based models or the development of a novel conceptual approach able to describe the effect of compacted soil layers and shallow groundwater conditions on the percolation/capillary rise dynamics.

This work presents a simplified soil water balance model for rice areas based on the Darcy equation. This approach allows the quantification of vertical fluxes based on a limited number of data that can be retrieved from existent data sources (depth and thickness of the less conductive layer within the soil profile, saturated soil hydraulic conductivity of this layer, ponding water level inside the paddy field and depth of the groundwater table). The new approach was validated comparing the water fluxes obtained with those achieved through a semi-distributed/mechanistic agro-hydrological model based on SWAP (https://www.swap.alterra.nl/) applied to a pilot rice district of about 1.000 ha in northern Italy (San Giorgio di Lomellina, Pavia).

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