

應用熱示蹤解析-反演方法推估水田瞬態垂向地 下水通量之可行性研究

Assessing the Feasibility of a Heat-Tracing Analytical Inverse Method for Transient Vertical Groundwater-Flux Estimation in Paddy Fields

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摘要

本研究評估以熱示蹤法推估農田瞬態垂向地下水通量之可行性，並著重於建立兼具解析解與反演演算法的技術流程。研究團隊於水田佈設多層土壤溫度感測器，連續量測地溫變化，並結合熱傳導解析解與反演最佳化程序，推算垂向入滲率與地下水通量。結果顯示，本方法可在動態田間條件下提供高時間解析度且精度良好的入滲與通量估計；同時證實感測器配置密度對推估結果具有顯著影響。此一熱示蹤技術可作為農業灌溉管理與水資源調度之決策輔助工具。

關鍵詞：熱示蹤，地下水通量，垂向入滲，反演模式，水田

Abstract

This study evaluates the feasibility of using heat tracing to estimate transient vertical groundwater fluxes in agricultural settings, with an emphasis on developing a combined analytical and inverse-modeling workflow. An array of soil-temperature sensors was installed at multiple depths in a paddy field to obtain continuous thermal profiles. These data were interpreted through a heat-conduction analytical solution coupled with an inverse optimization scheme to derive infiltration rates and vertical groundwater fluxes. Results demonstrate that the proposed approach delivers high-temporal-resolution and accurate estimates under

dynamic field conditions, and that sensor-array density significantly affects estimation quality. The heat-tracing technique shows promise as a decision-support tool for irrigation planning and agricultural water-resources management.

Keywords: Heat tracer , Groundwater flux , Vertical infiltration , Inverse modeling , Paddy field