Coupled three-dimensional modelling of groundwater-surface water interactions for management of seawater intrusion in Pingtung Plain, Taiwan

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Abstract

This research developed a 3-D model with variable density and a transient groundwater model of the Pingtung shallow aquifer, lying 250 m below mean sea level (MSL). Meanwhile, a 1-D river network model of the Pingtung plain's three main rivers was created. Then, the IFM MIKE 11 coupling interface was used to couple the developed 3-D model with this model. The coupled model was developed with the aim of analyzing the relationship between rainfall, surface water, and groundwater recharge lag time. Besides, the model can also stimulate the changes in the salinity of the mixing zone for this specific region and then analyze potential river inundation and maximum river discharge to choose the best location to apply artificial recharge as a management scenario to mitigate the effect of seawater intrusion (SWI). It can be seen as the first developed coupled model with a detailed integrated framework analyzing the interaction of surface and subsurface water, which is able to contribute to the restoration, rehabilitation, and management of the river network. This research has resulted in the discovery of some new hydrological points for this region. Firstly, the rainfall ratio of the wet season to the dry season is significant compared with other areas in Taiwan. Second, the southern end of Taiwan has the most interaction between sea and river, with the Kaoping River acting as a pathway for inland seawater intrusion.

Keyword: Coupled model, Groundwater, Surface water, SWI, FEFLOW, Taiwan.

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ABSTRACT

Study region: A coupled framework, linking subsurface flow and surface hydrodynamics, is developed and applied to a real-world case study of Pingtung coastal aquifer in southwest of Taiwan, in East Asia.

Study focus: FEFLOW is adopted to develop a 3-D variable density and transient groundwater model of the Pingtung shallow aquifer lying 250 m below mean sea level (MSL). This model is coupled with a 1-D river network model, comprised of the main river and its two tributaries, using MIKE 11 through the IFM MIKE 11 coupling interface. The model is capable of analysing the relationship between rainfall, surface water and groundwater recharge lag time. Also, the analysis of potential river inundation and maximum river discharge enable the model to choose the best location to apply artificial recharge as a management scenario to mitigate the effect of seawater intrusion (SWI). To the authors' knowledge, the developed coupled model is the first detailed integrated framework analysing the interaction of surface and subsurface water, with the capability to contribute to the restoration, rehabilitation, and management of the river network.

New hydrological insights for the region: The rainfall ratio in the wet season to dry season is significant in this plain comparing with the rest of Taiwan. Also, southern Taiwan experiences the largest sea and river interaction, while Kaoping River playing as a pathway role for inland lead of seawater intrusion.