ASSESSMENT OF FLUXES EVOLUTION BASED ON THE COUPLED SURFACE WATER AND GROUNDWATER FLOW MODEL IN A CASE STUDY OF PINGTUNG PLAIN GROUNDWATER BASIN, TAIWAN

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INTRODUCTION

Hydrologic models have been developed and implemented to simulate the dynamics of surface water and groundwater and assess their interactions. The landforms and human activities are essential in quantifying surface water and groundwater interactions (SGIs) for water resources management. Based on the advantages of computational technologies, the integrated hydrologic models (IHMs) have made the coupled solutions possible to analyze complex water resource problems relevant to the SGI systems. Otherwise, in a specific estimation of surface water and groundwater interactions, interflow is a lateral water movement in unsaturated zones in the hydrology system. Interflow assessment for water resources has also become pivotal in supporting land-use planning and regional development. This available water resource from interflow can be considered as the interflow potential for specific reaches of rivers.

OBJECTIVES

(1) To characterize the behaviors of the SGIs in Pingtung Plain Groundwater Basin (PPGB).

(2) To quantify the SGIs induced by complex landforms and human activities in PPGB.

(3) To assess and quantify the interflow potential in Kaoping River.

(4) To validate accuracy between index-overlay and numerical GSFLOW models.

METHODOLOGY

GSFLOW Model

The developed GSFLOW model based on coupling the surface water PRMS modules and the groundwater MODFLOW-2005 packages can only run either PRMS, MODFLOW-2005, or both. GSFLOW model is used to simulate flow with three regions: (1) a boundary between the plant canopy on the top and the soil zone on the bottom, (2) all streams and lakes simulation, and (3) subsurface zone beneath the soil zone. The first region is used PRMS model and the other regions are used MODFLOW-2005 model to simulate hydrologic processes.

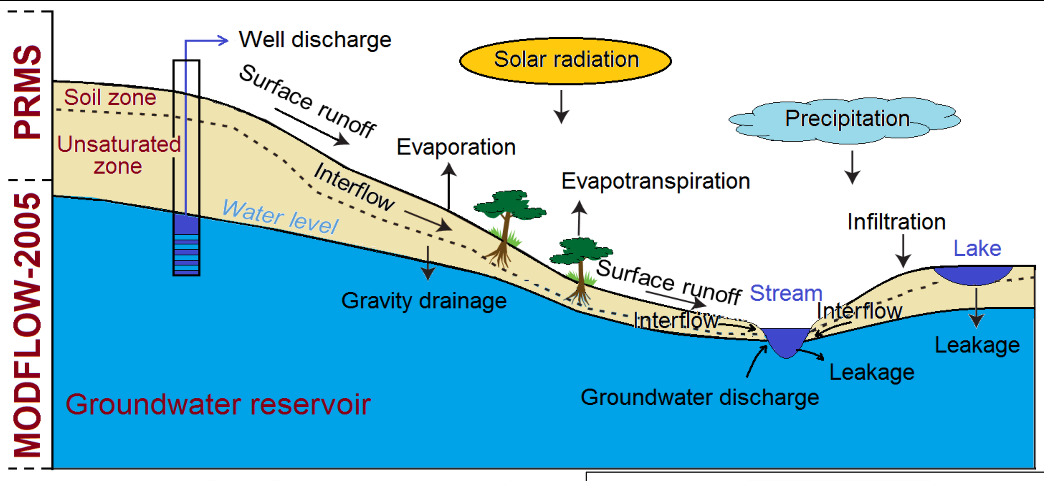


Figure. *The three regions for the GSFLOW model*

Analytical Hierarchical Process Technique (AHP)

AHP is one of the most used methods to perform decision-making processes. It is based on a rational framework for the needed decisions by quantifying the criteria and alternative options and relating those elements to the overall goal.

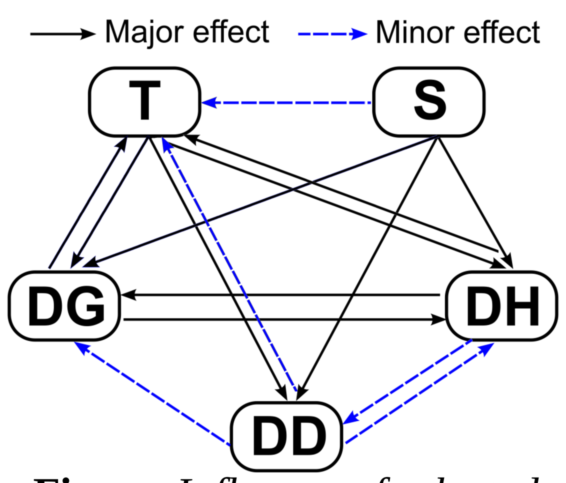


Figure. *Influence of selected thematic factors related to interflow*

Monte Carlo Simulation Model

Monte Carlo simulation is a process used to model the probability of various outcomes. It is a technique that helps explain the risk influence and uncertainty in prediction models due to the intervention of random variables. A basis of this method is used to assign multiple values to an uncertain variable, achieve various outcomes, and then average the results to obtain an estimation.

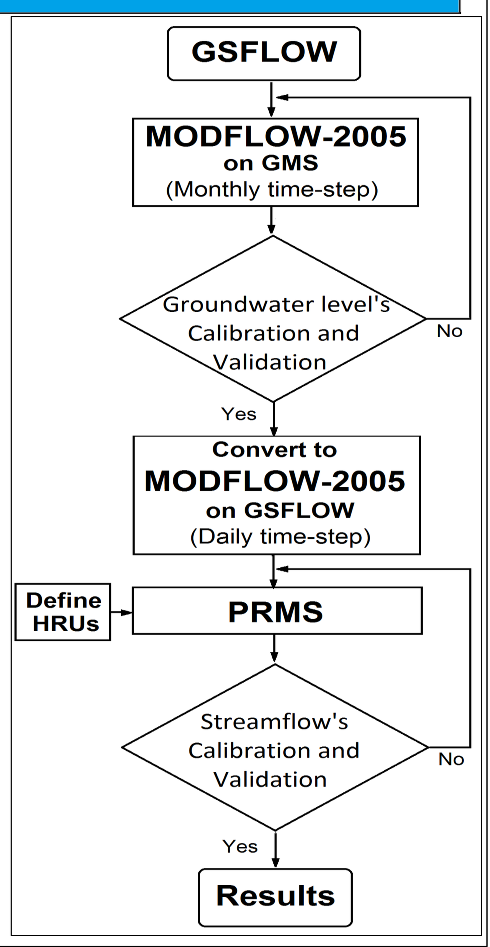


Figure. *The calibration and validation workflow of the numerical model*

STUDY SITE

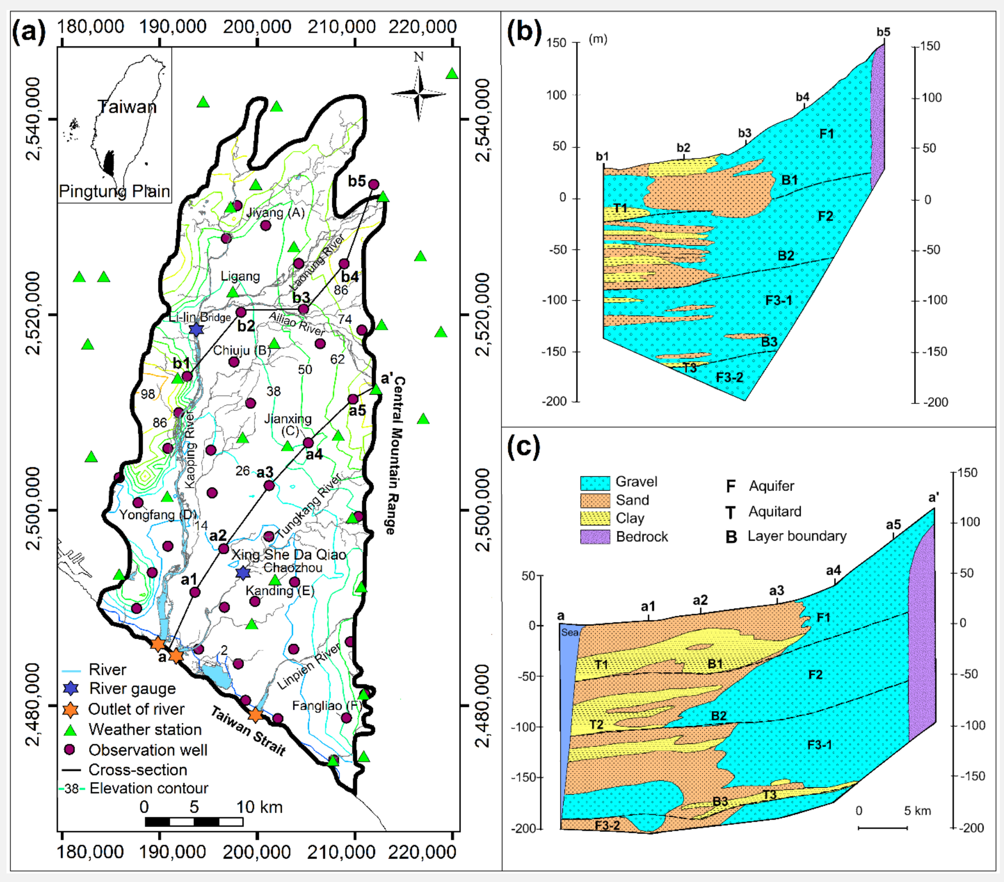


Figure. *The study area: **(a)** Pingtung Plain Groundwater Basin (PPGB), **(b)-(c)** Cross sections*

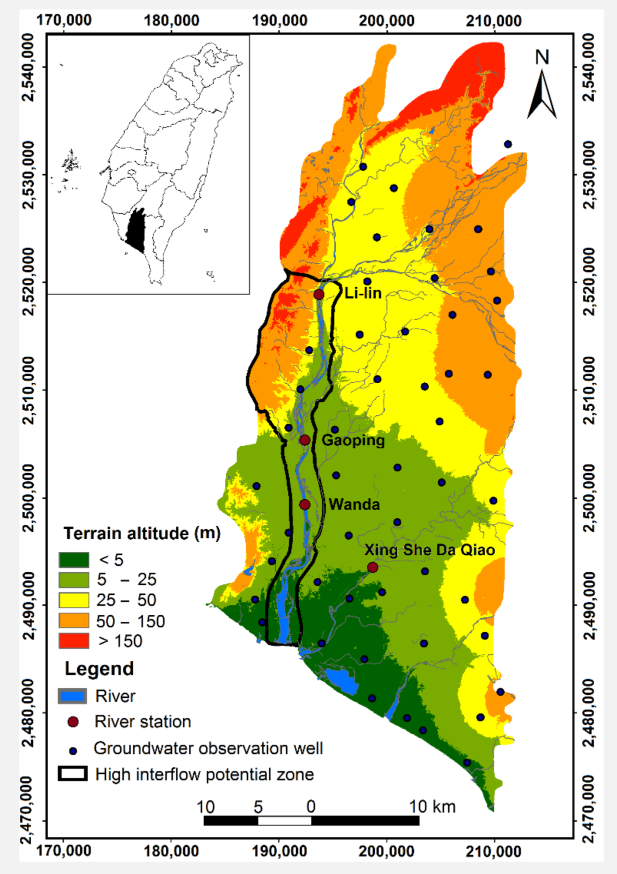


Figure. *The PPGB and the selected area for quantifying the interflow potential in the Kaoping River*

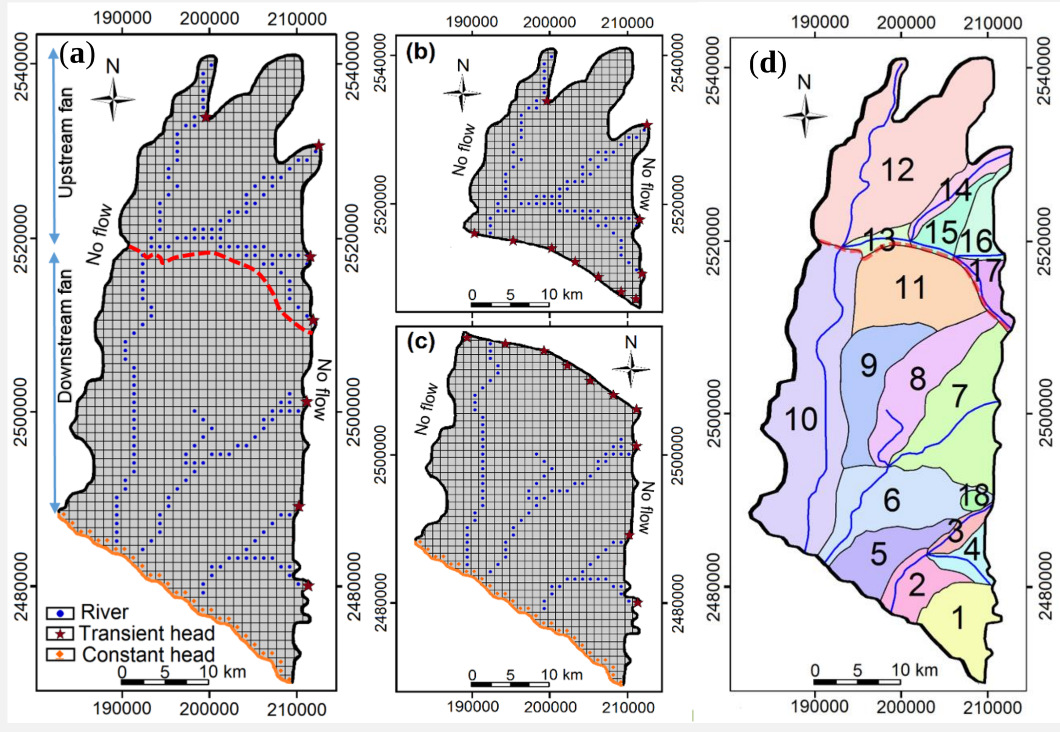


Figure. *Conceptual model and boundary conditions: **(a)** The entire Pingtung, **(b)** Upstream area, **(c)** Downstream area, **(d)** HRUs*

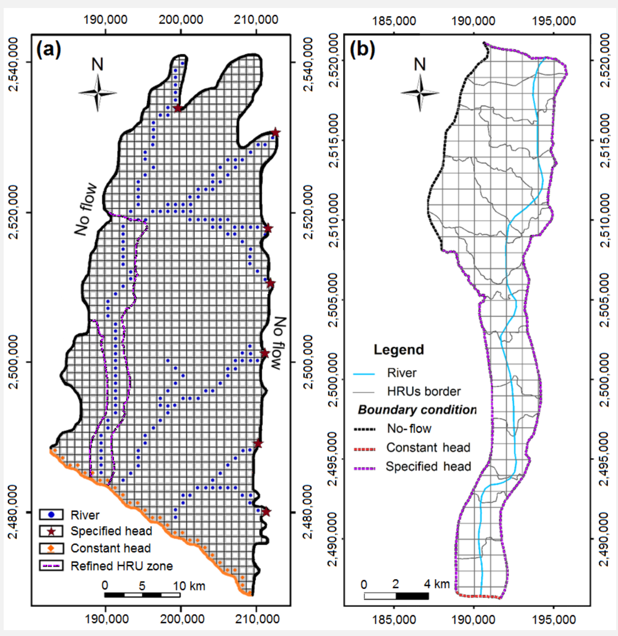
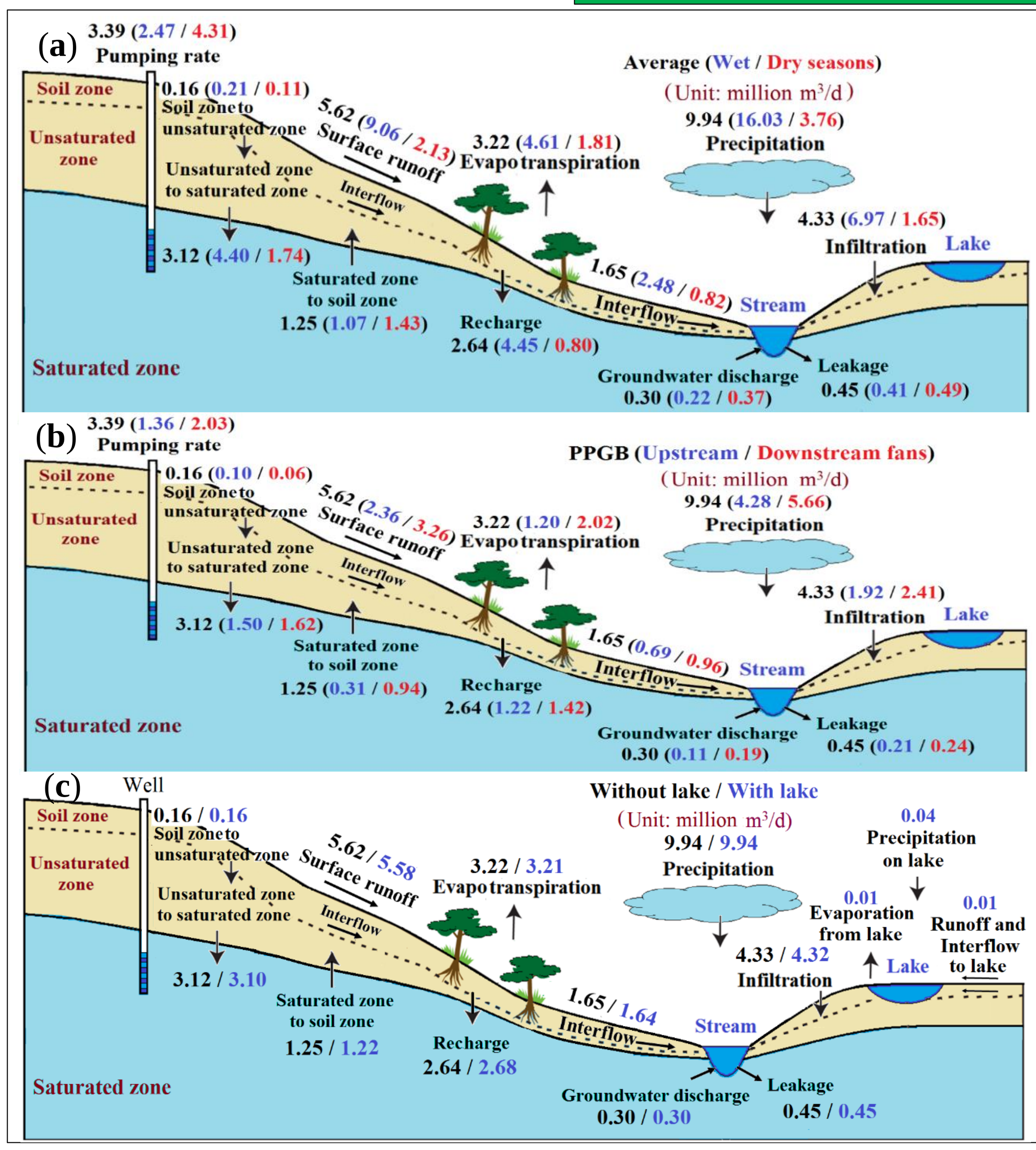


Figure. ***(a)** The basin-scale model includes the entire PPGB, **(b)** the sub-model on the Kaoping River*

RESULTS AND DISCUSSIONS



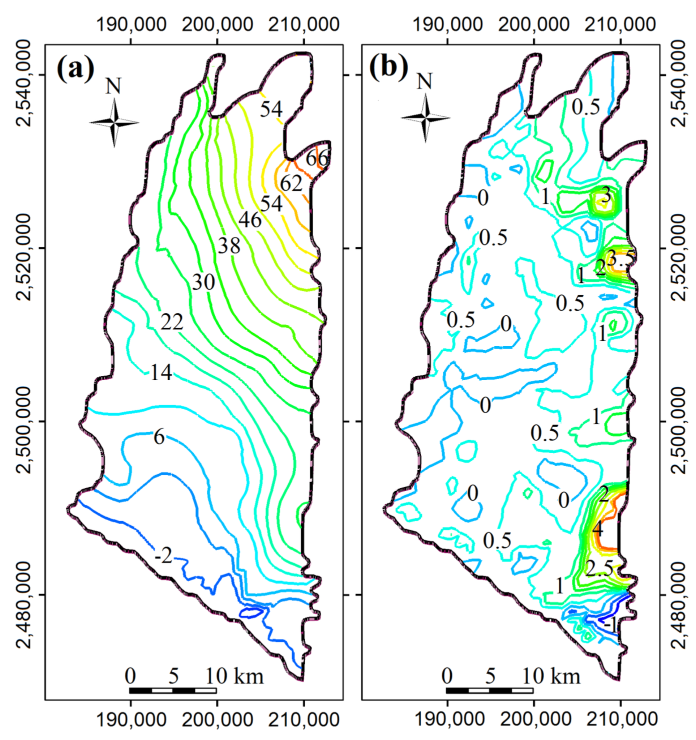


Figure. ***(a)** The simulated average GW head distributions **(b)** GW head differences between wet and dry seasons*

Figure. *Comparison of flow rates of hydrological components: **(a)** in wet and dry seasons, **(b)** in upstream and downstream fans, **(c)** without and with artificial lake*

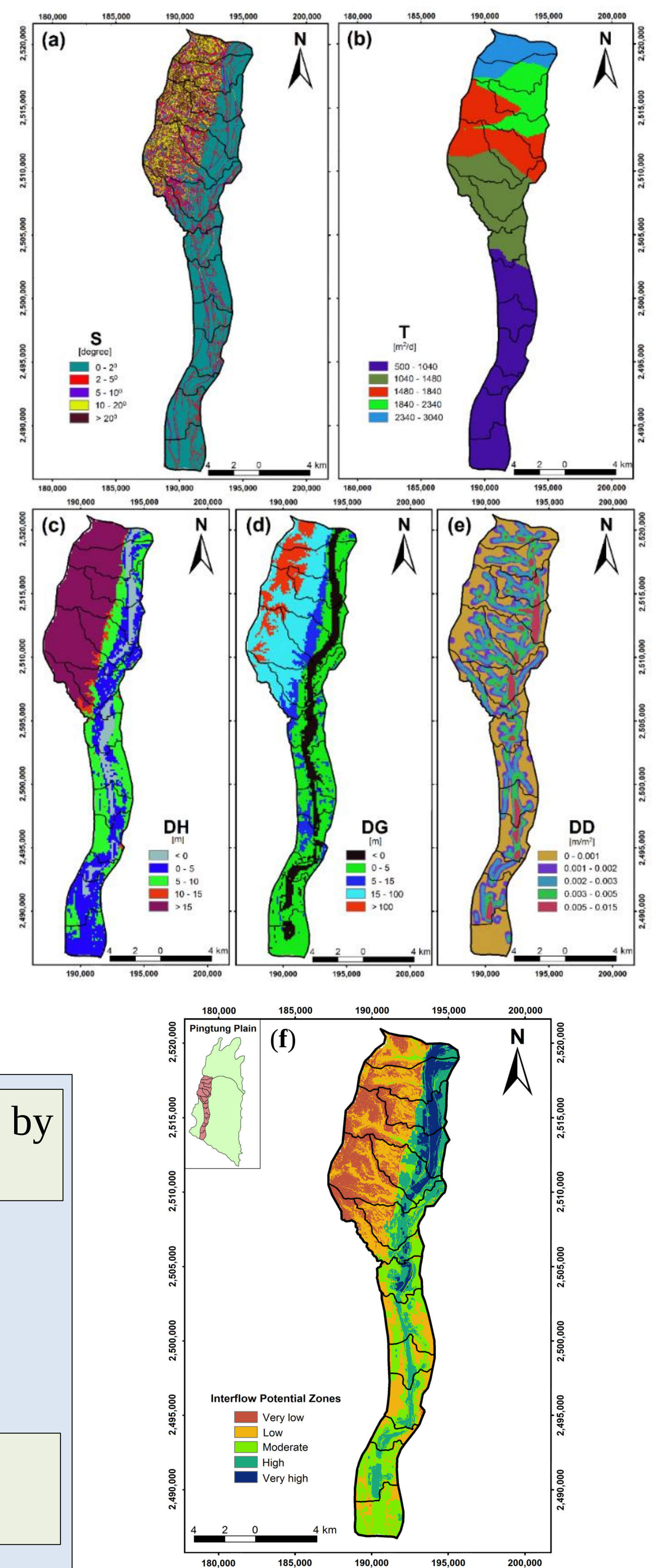


Figure. *Factors used in index-overlay model: **(a)** Slope, **(b)** Transmissivity, **(c)** River-GW levels difference, **(d)** Depth of groundwater, **(e)** Drainage density, **(f)** Interflow potential map*

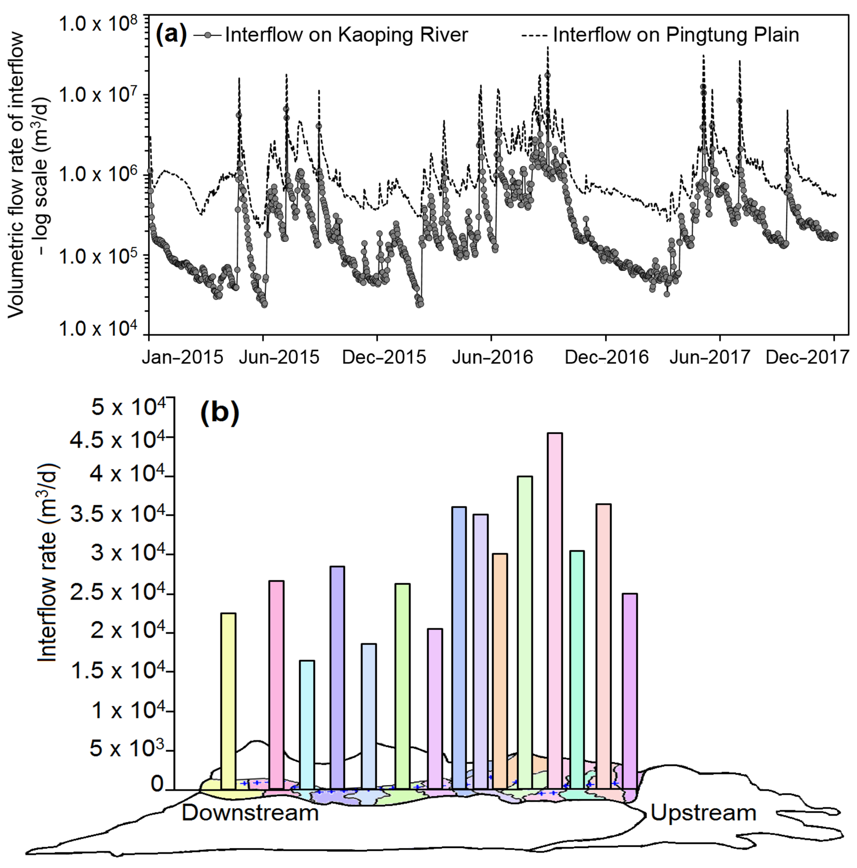


Figure. ***(a)** Comparison of interflow variations between sub-model and PPGB model, **(b)** The averaged interflow rates for HRUs used GSFLOW model along Kaoping River*

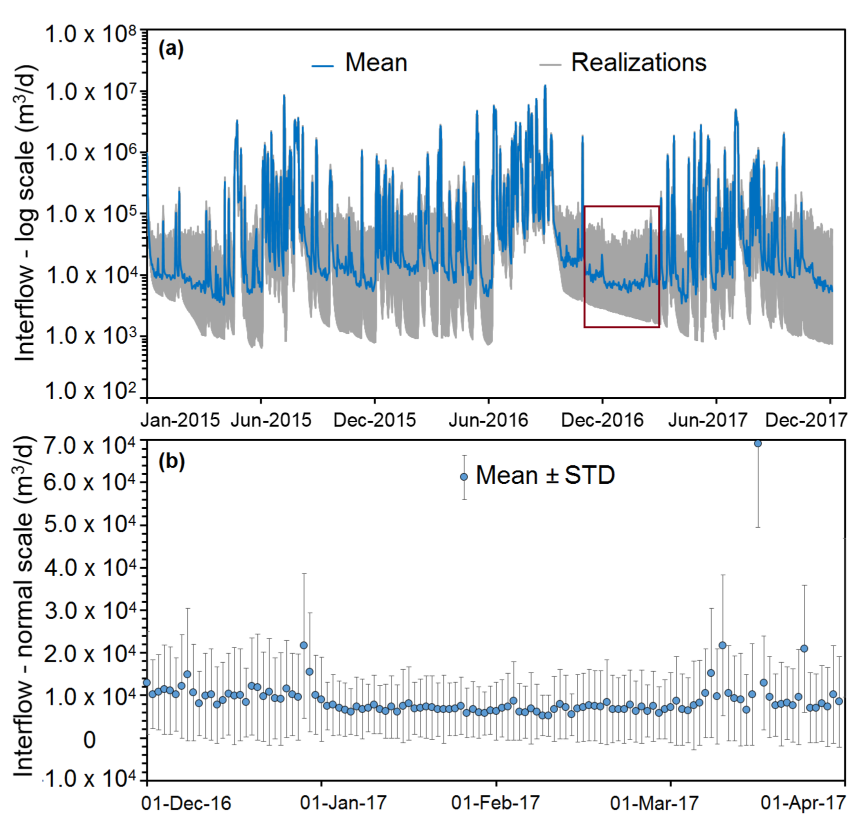


Figure. ***(a)** The temporal interflow variations (100 realizations), **(b)** The selected dry season period to show the mean and STD of interflow rates*

CONCLUSIONS

(1) Obtain behavior characteristics and quantify the dynamics of SGIs in PPGB induced by complex landforms and human activities using GSFLOW model.

- The GW head differences: over 4 m (in the wet and dry seasons).
- The surface runoff 57% and infiltration 40% of the total precipitation.
- Contribute to streamflow: surface runoff (70%), interflow (20%) , GW discharge (10%).
- The interflow rate: wet seasons 200% more than dry seasons.

(2) Develop index-overlay model, assess the interflow potential and quantify the interflow in the downstream area along the Kaoping River.

- Obtain the accuracy verification between index-overlay model and GSFLOW model.
- The average interflow rates: high value in the high elevation upstream zones (3.5 x 10^4 m^3/d) and low value (2.0 x 10^4 m^3/d) near the coastal zones.
- The rainfall-induced uncertainty (100 realizations) influences strongly interflow rates in wet more than in dry seasons.