Evaluating the Impact of Groundwater on Cotton Growth and Root Zone Water Balance by HYDRUS Model

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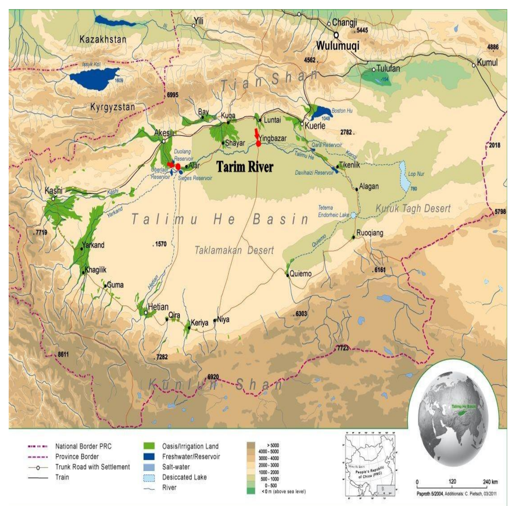
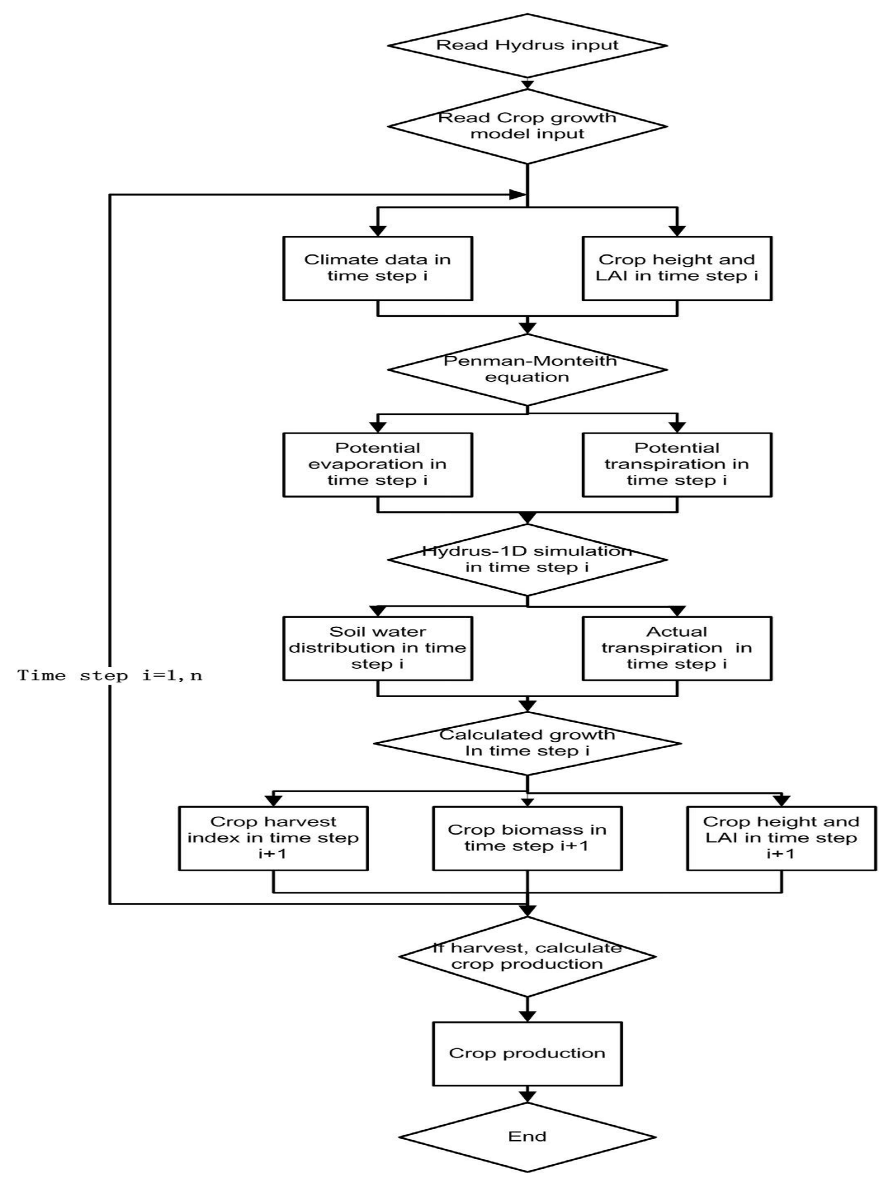
Introduction

Groundwater is an important factor that needs to be considered when evaluating the water balance of the soil-plant-atmosphere system and the sustainable development of arid oases. However, the impact of shallow groundwater on the root zone water balance and cotton growth is not fully understood. Drip irrigation farmland is approximately 5 million hm^2 in Xinjiang. Improve the utilize efficient of canal water from 0.48 to 0.65. Save water resource 1.0 billion cubic meter.



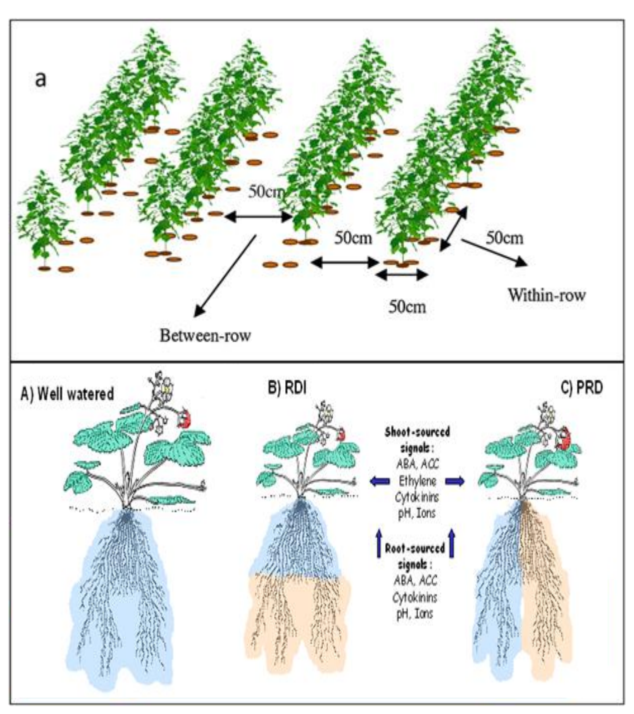
Motivation

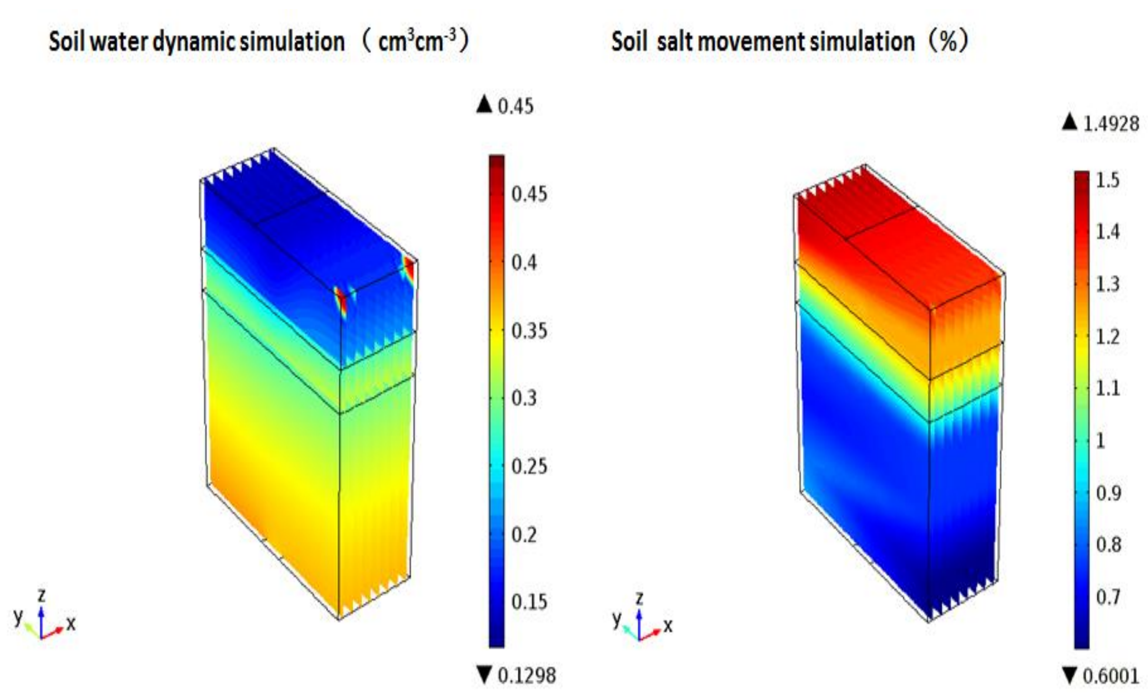
- develop a model to simulate crop production and soil water dynamics with groundwater depth variation by incorporated into HYDRUS model and SWAT model;
- **e**valuate the impact of groundwater change on the cotton root zone water balance and cotton growth;



Methods

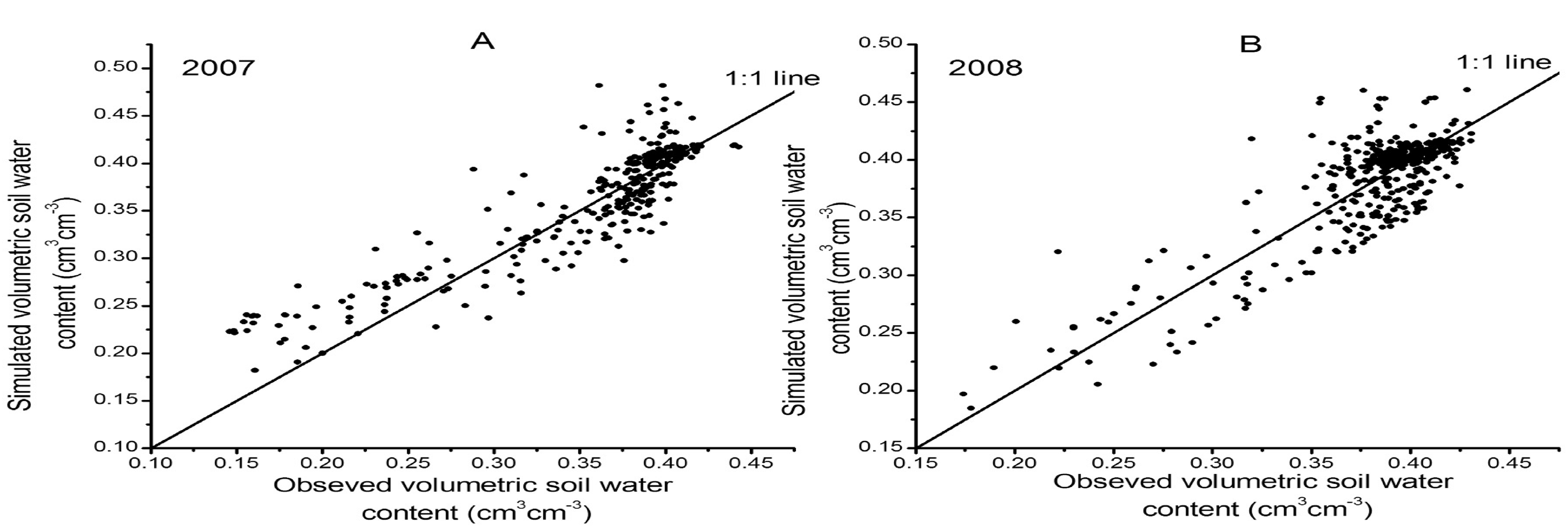
In this study we analyzed the impact of groundwater on the seasonal maximum leaf area index of cotton, the average seasonal water stress, cotton yield, actual transpiration, actual evaporation, and capillary rise using experimental data collected at the Aksu water balance station, in Xinjiang of China and the Hydrus-1D variably-saturated soil water flow model coupled with a simplified crop growth model from SWAT. The coupled model has been first calibrated and validated using field observations of soil water content, leaf area index, cotton height, the above ground biomass, and cotton yield comparisons between measured and modeled variables have shown a reasonable agreement for all variables. Additionally, with a validated model, we have carried out numerical experiments from which we have concluded that groundwater is a major water resource for cotton growth in this region.





Results

The correspondence between measured and simulated volumetric soil water contents during both calibration and validation years is shown in the scatter plot displayed in Fig. 1. Good agreement between simulated and measured volumetric soil water contents was found for both calibration (Fig 1. A) and validation (Fig 1. B) years. Various statistical tests were carried out to investigate the performance of the coupled model. The R^2 values were in the range of 0.70–0.81 during both calibration and validation periods. The *RMSE* values were 0.032–0.027 for the calibration and validation periods, respectively. The statistical measures indicate a high consistency between simulated and measured values during both calibration and validation periods.



Results

Simulated and measured soil water contents at depths of 10 and 200cm are presented in Fig. 2, it shown simulated soil water content are in close agreement with observed values during both calibration and validation periods. The pattern of fluctuating soil water contents consistently reflected the irrigation events, especially in the shallow soil depth of 10 cm. Apparently, the soil water content in the upper soil layers produced more dramatic changes than in the deeper soil layers.

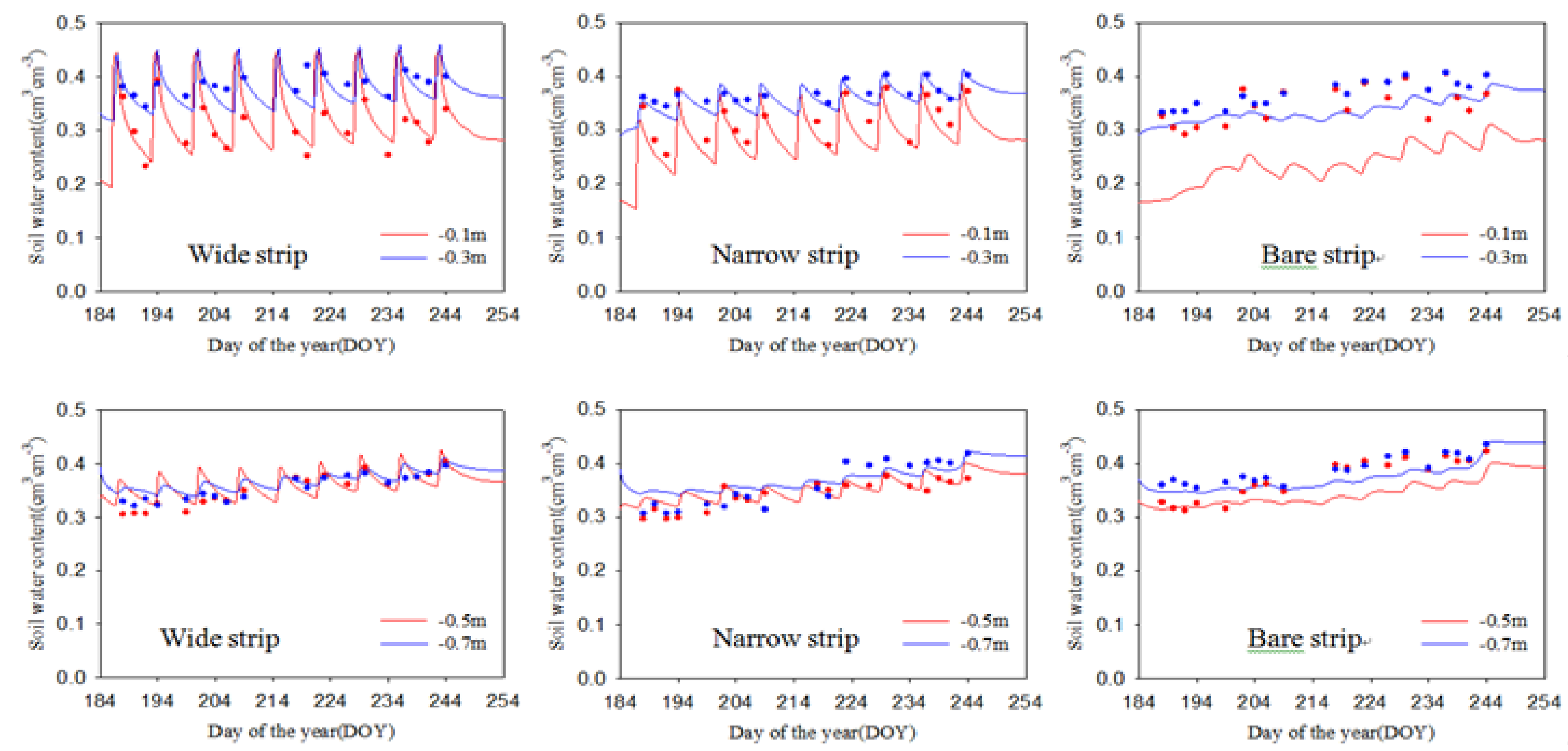


Fig.2 Pattern of fluctuating soil water contents consistently reflected the irrigation events, especially in the shallow soil depth of 30 cm. Apparently, the soil water content in the upper soil layers produced more dramatic changes than in the deeper soil layers.

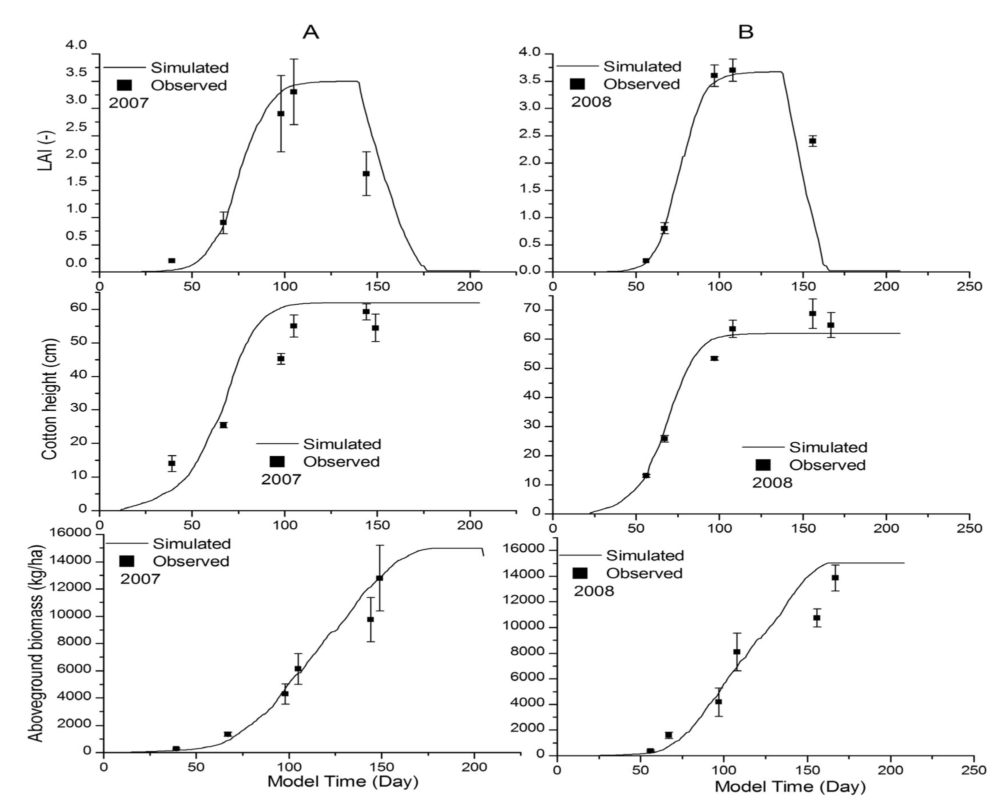
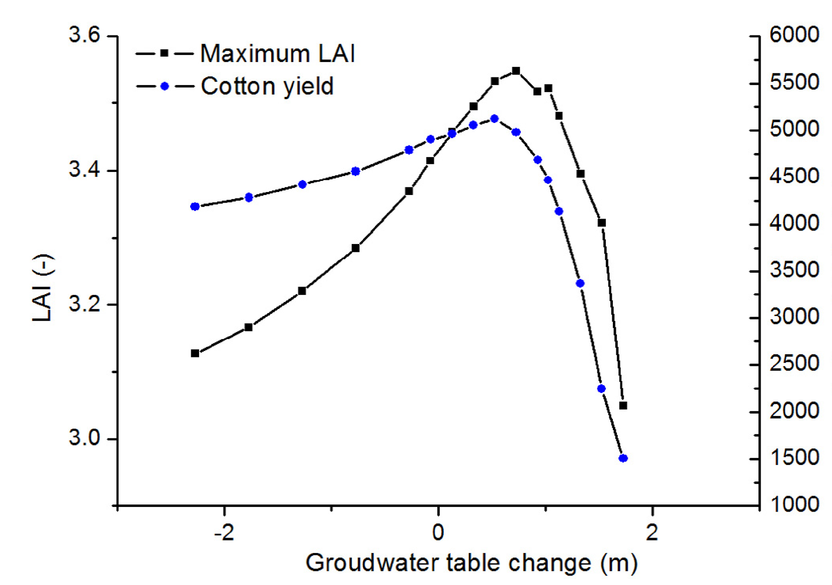
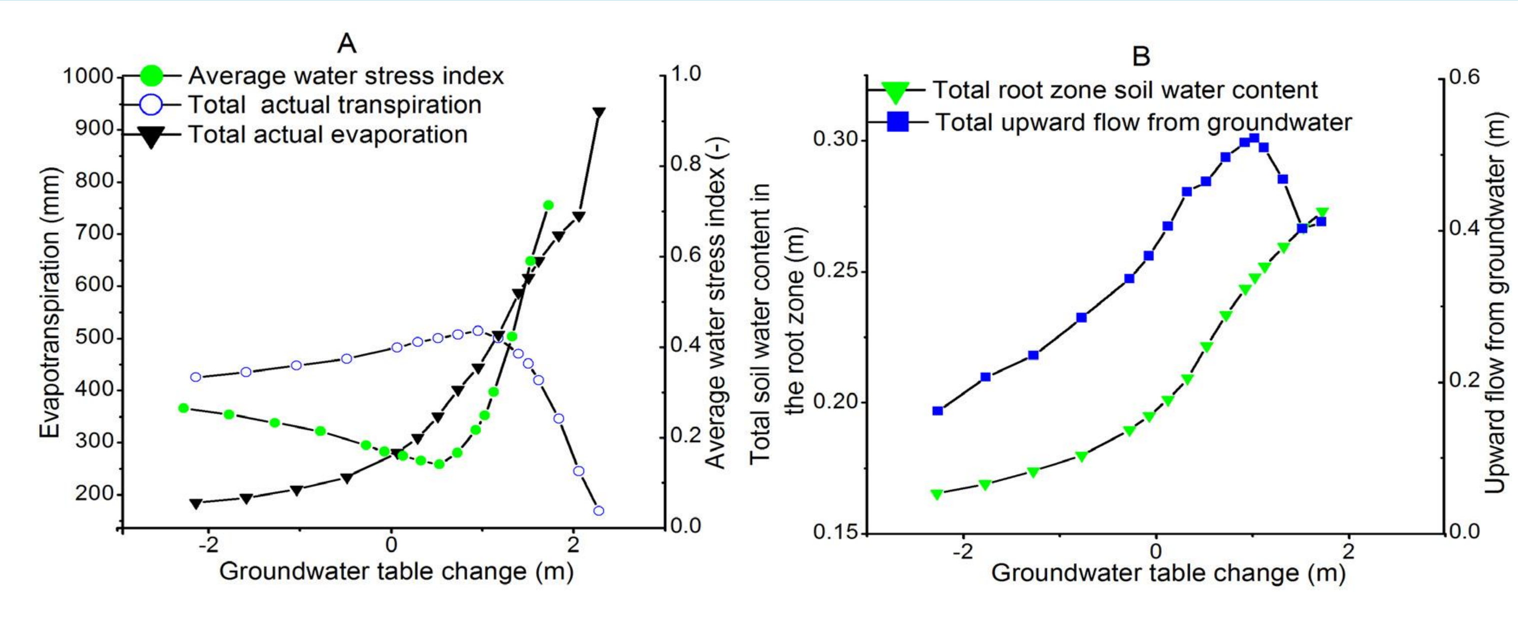


Fig.3 Simulated (lines) and measured (dots) leaf area index (top), cotton height (middle), and aboveground biomass (bottom) during the calibration (2007; left) and validation (2008; right) periods. Error bars represent standard deviations of the measurements.



The impact of the groundwater table on the cotton maximum LAI and yield is shown in Fig.5. As the groundwater depth increases (from−2.27 m to 0.52 m), the maximum cotton LAI and yield are both increasing. This is due to an increase in the total soil water content in the root zone and a decrease in the cotton water stress. As the groundwater depth increases further (from 0.52 to 1.72 m), the maximum cotton LAI and yield both decrease. This is caused by anaerobic conditions in the root zone.

As the change in the groundwater table level increased from .2.27 to 0.72 m, the total transpiration of cotton showed an increasing trend . This occurred because as the groundwater table level increases, so increases the capillary rise from groundwater into the root zone . An increase in capillary rise subsequently leads to an increase in the total soil water content in the root zone and cotton transpiration . Similarly, the average water stress index of cotton (1 – actual transpiration/potential transpiration) decreased to values close to 0, indicating that increasing the groundwater table reduces the cotton water stress and plays a positive role in cotton growth.



Conclusions

- The simulation results of the coupled model were compared with experimental data obtained from cotton field experiments. Results suggest that volumetric soil water contents, LAIs, above ground biomass and cotton yields simulated by the coupled model were in good agreement with the measurements.
- Additional model simulations showed that groundwater is a major source of water for cotton growth. Compared to a control simulation that had no groundwater, 23% of crop transpiration is supplied by a capillary rise from groundwater, producing an increase in cotton yield by 20%.