Assimilation technique of remote sensing information and rice growth model based on particle swarm optimization

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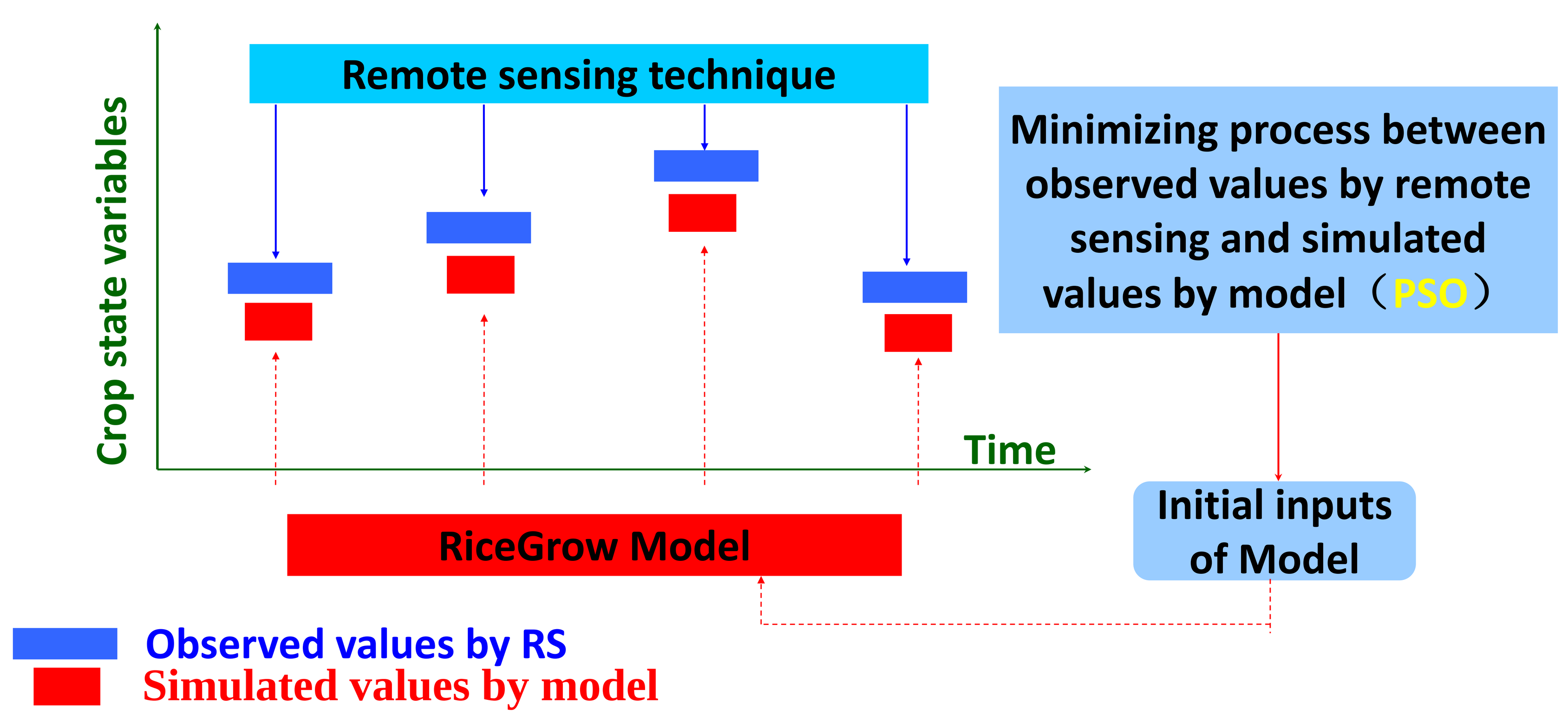
SUMMARY

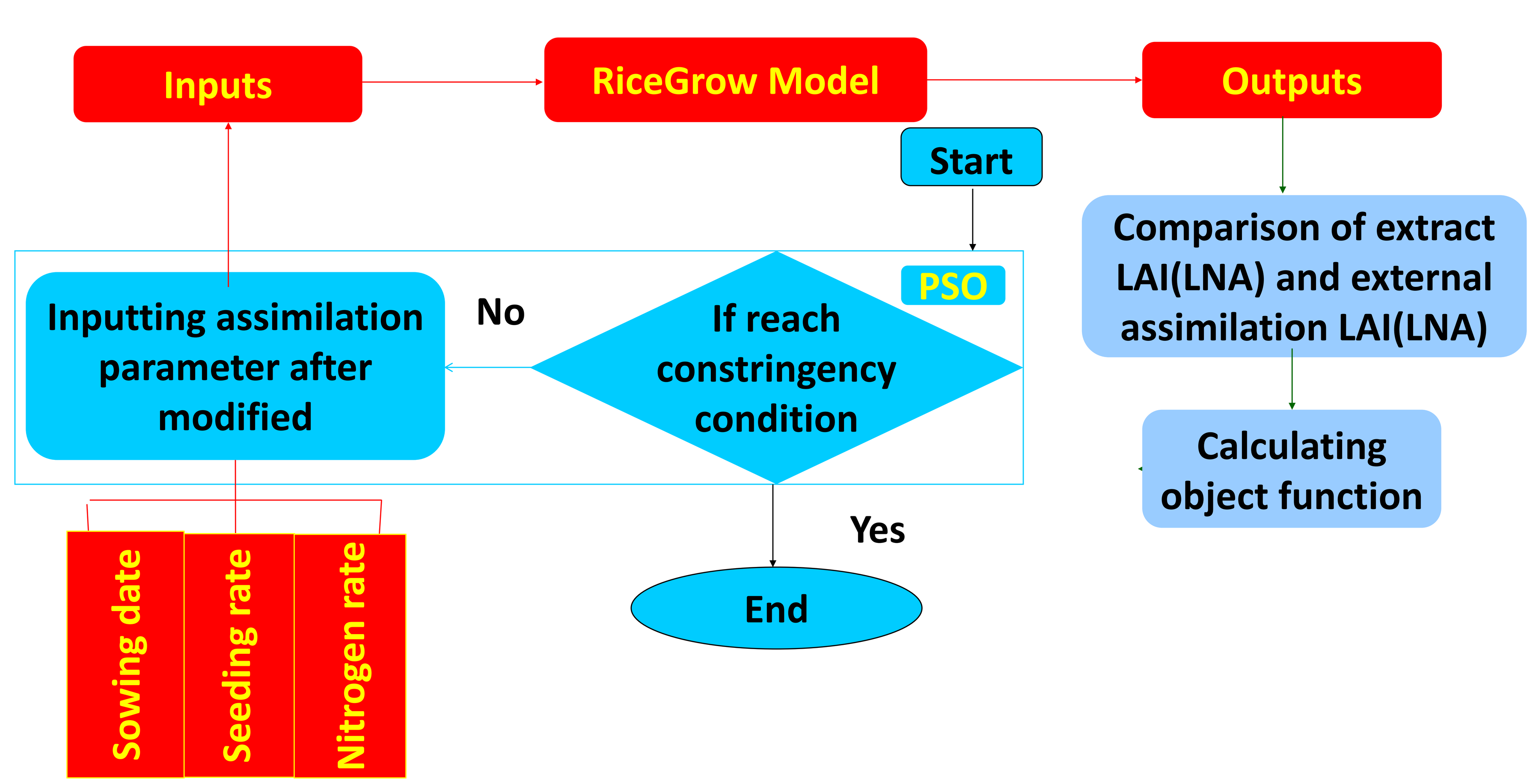
The choice of optimization method is very important in the assimilation process of crop growth model and remote sensing data, and it concerns the running efficiency and result accuracy of assimilation. A new optimization--Particle Swarm Optimization (PSO) technique was used for assimilating remote sensing data and RiceGrow model in minimizing difference between inverted and simulated values by remote sensing and RiceGrow model. PSO and another optimization--Simulated Annealing (SA) was compared when leaf area index (LAI) and leaf nitrogen accumulation (LNA) were used as external assimilation parameters respectively. The results showed that PSO performed better than SA in both running efficiency and assimilation result, which indicated that PSO is a reliable and applicable optimization method for assimilating remote sensing information and model. LAI and LNA each had advantage as external assimilation parameters, sowing date and seeding rate could be well inverted when LAI was selected as external assimilation parameter, while nitrogen rate was better predicted using LNA.

1. Assimilation of Remote Sensing Data with Rice Growth Model

Minimized the difference between corresponding parameters estimated by RS and simulated by RiceGrow model using PSO optimization, constantly adjusted and initialized parameter values of RiceGrow (sowing time, seeding rate and nitrogen rate). Keeping converging until the difference is minimal, then take the initial parameters after adjusted as the initial input parameters of RiceGrow, and run it to get more accurately predicted value of growth dynamic process and grain yield of rice.



Assimilation scheme of remote sensing and RiceGrow model



Flow chart of assimilation process of remote sensing and model based on PSO

2. Correctness verification of assimilation technique

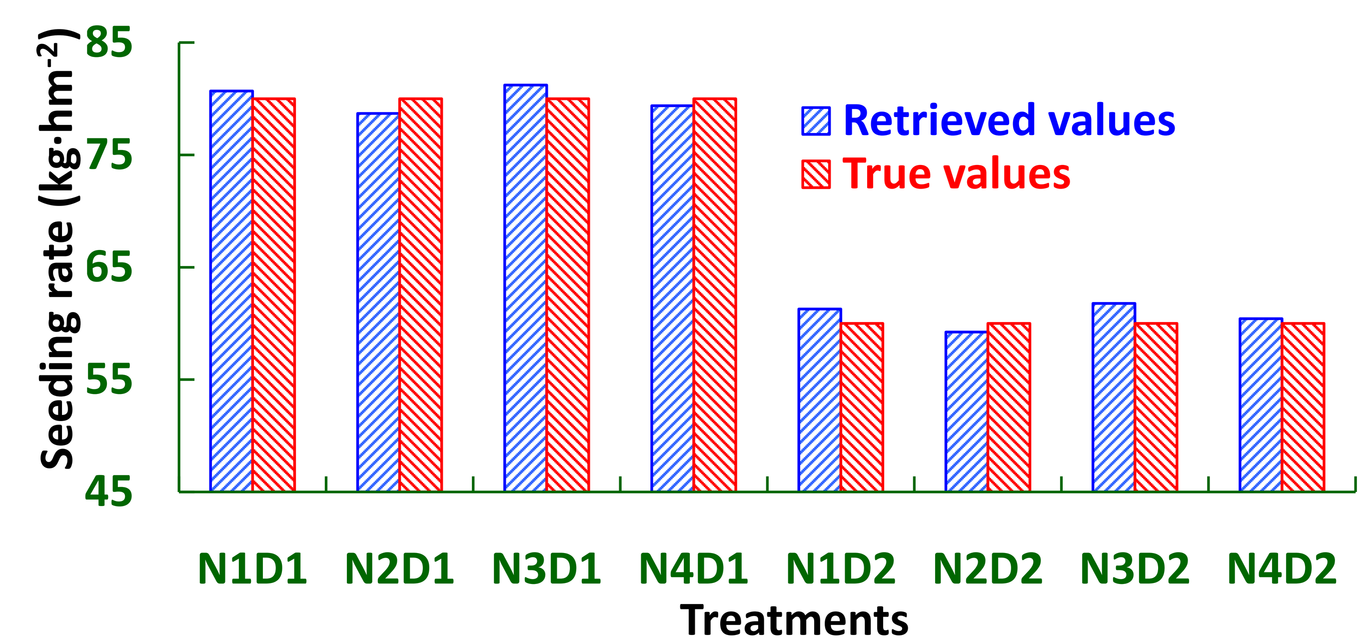
A group of parameters were given as real values, such as sowing date (May 15th), seeding rate (75 kg • hm^{-2}), nitrogen rate (250 kg • hm^{-2}). Then run RiceGrow model to simulate the daily production of LAI/LNA sequence, pick some of them as external assimilation parameters, and run assimilation technique based on the proposed RS-RiceGrow assimilation model to test whether the model can show the correct initial parameter information.

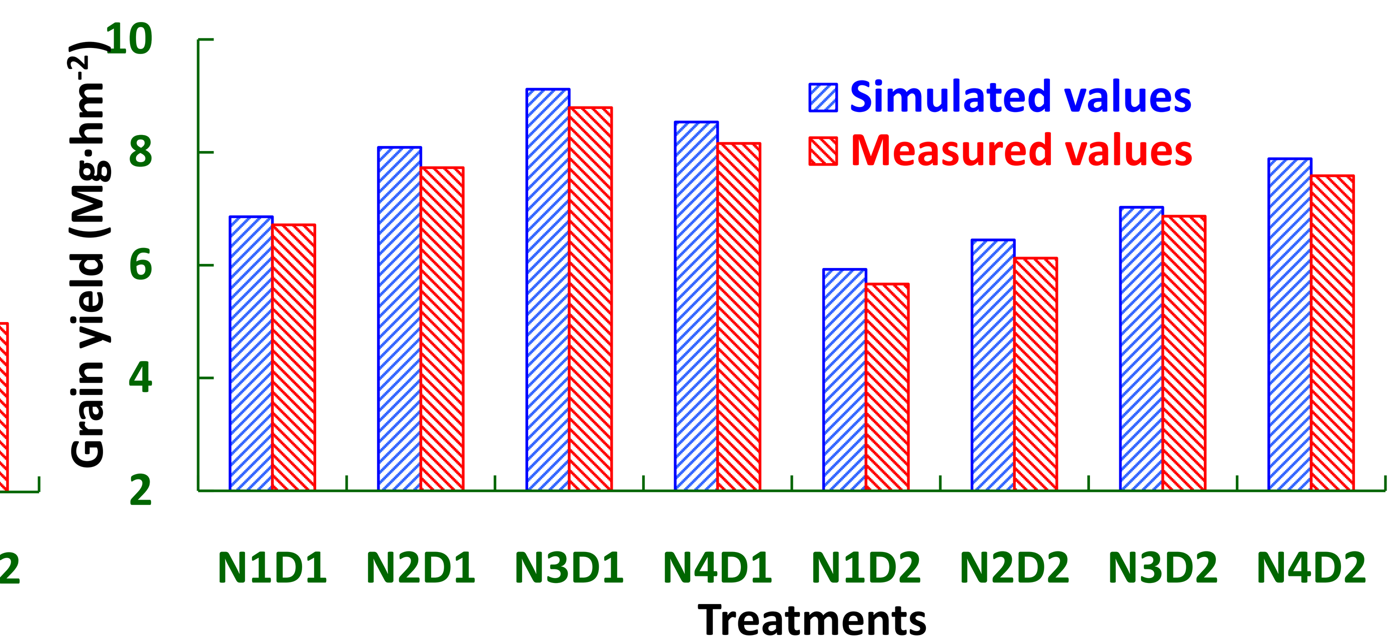
Retrieved average results based on simulated LAI/LNA as external assimilation data

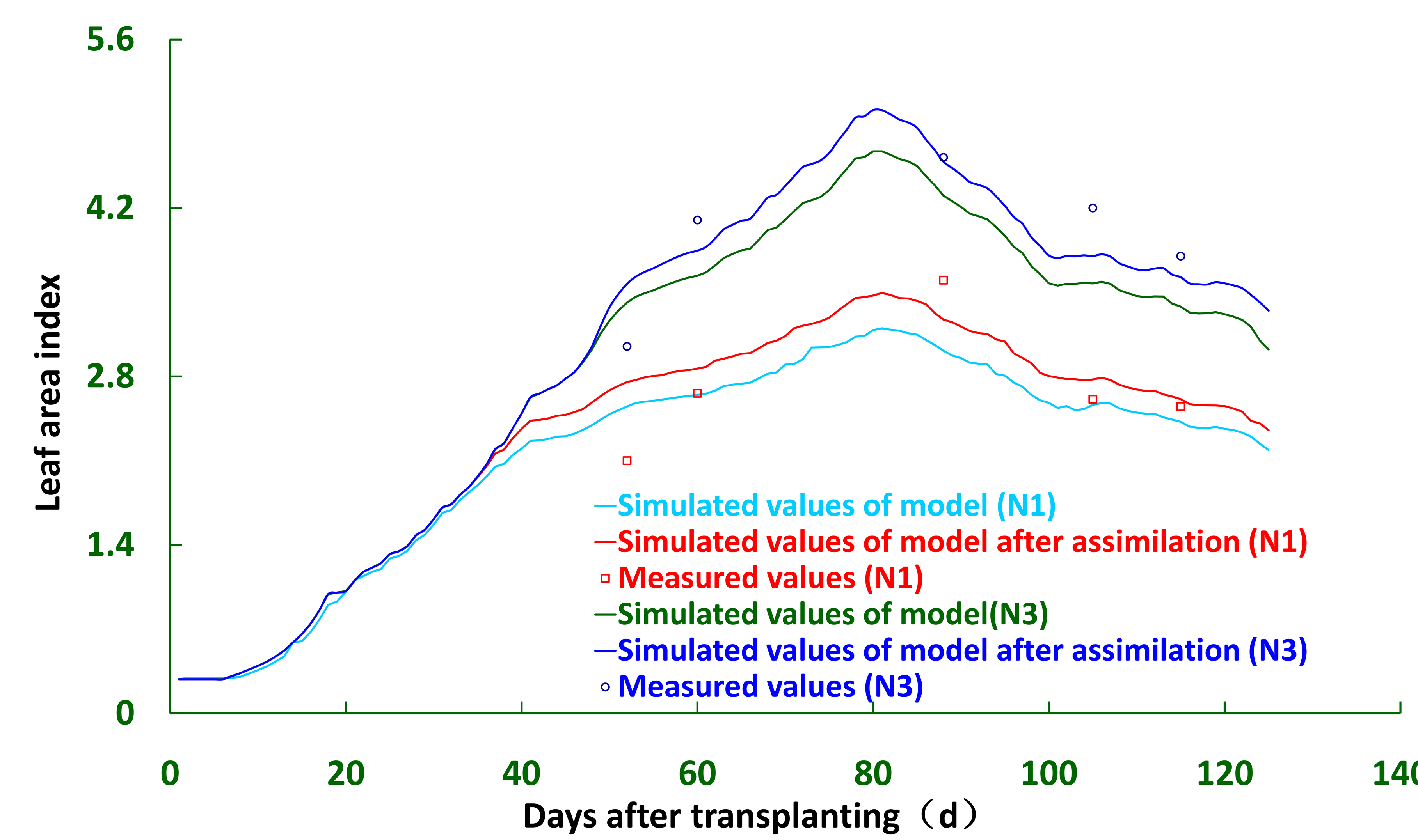
	Retrieved sowing date		Retrieved seeding rate (kg·hm^{-2})		Retrieved N rate (kg·hm^{-2})	
	LAI	LNA	LAI	LNA	LAI	LNA
SA	May 15th	May 13th	78 .0	79.2	147.2	195.0
PSO	May 15th	May 16th	74.8	76.9	252.6	250.9

3. Example analysis of assimilation technique

Running RS-RiceGrow assimilation model by assimilating remote sensed LAI or LNA data to get sowing time, sowing rate and nitrogen rate, the results showed that sowing date, seeding rate could be well retrieved when LAI was selected as external assimilation parameter, while nitrogen rate was better predicted using LNA. And that the simulated growth parameters (e.g. LAI) and grain yield from assimilation model were in good agreement with measured values.







Comparison of inverted, simulated and measured parameters by RS-RiceGrow assimilation model. N1, N2, N3, N4, D1 and D2 denotes 4 nitrogen rates of 150, 240, 330, 420 kg•hm^{-2} and 2 density rates with row and plant spacings of 25 cm and 15 cm, 30 nm and 25 cm, respectively