**Supplementary Material**

*S1. Local calibration of the WOFOST model*

The WOFOST model input parameters, including weather, soil, crop, and management information, are responsible for simulating crop growth accurately. Therefore, model calibration is an indispensable process before applying to a new area. This process ensures that the initial parameters of the model could reflect the actual local conditions and crop properties [1,2]. The calibration of input parameters can be categorized into two ways: empirical method and field observation. In this study, the empirical methods mainly refer to parameters used in previous studies of our team and WOFOST default parameters [3-6]. The detail of the primary input parameters of WOFOST is shown in Table 1.

**Table S1.** The main initialization parameters used in the WOFOST model.

| | Parameter (Unit) | Description | Value | Source |
|---|---|---|---|---|
| Phenological Parameters | IDEM (day) | Day of transplanting | TDrs*±5 | Calibration by assimilation process |
| | TSUM1 (°C) | Cumulative temperature from transplanting to heading | - | From MODIS and meteorological data |
| | TSUM2 (°C) | Cumulative temperature from heading to maturity | - | From MODIS and meteorological data |
| | IDVS | Development stage of transplanting | 0-0.5 | Calibration by assimilation process |
| Crop initial Condition Parameters | TDWI (kg·ha−1) | Initial total crop dry weight | 55 | [3-6] |
| | LAIEM (ha·ha−1) | Leaf area index at transplanting | 0.1 | [3-6] |
| Green Area Parameter | SPAN (day) | Life span of leaves growing at 35 °C | 50 | [3-6] |
| | TBASE (°C) | Lower threshold temperature for aging of leaves | 15 | [3-6] |

Note *: Transplanting date extracted from remote sensing time series.

*S2. Assimilation of remote sensing VI with the WOFOST model*

To compare the proposed assimilation approach with other data assimilation strategy, EVI time series data were assimilated into the coupled model (the WOFOST model and PROSAIL radiation transfer model) to simulate rice growth [47]. The input parameters of the WOFOST model is the same as the setting in section 3.3 and the PROSAIL parameters were calibrated based on previous study [17]. Same as the proposed assimilation strategy, the PSO algorithm was employed to adjust IDVS and TD until the difference between simulated and input EVI minimized. The difference was evaluated by cost function as follows:

$$C = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(VI_i' - VI_i)^2} \quad (3)$$

Where $VI_i'$ is the vegetation indices calculated from coupled model at one date point, and the $VI_i$ is the input vegetation indices at the corresponding date. To explore the performance between different assimilation strategy, the EVI time series data was assimilated into a coupled model which consists of WOFOST model and PROSAIL model to simulate rice growth, with 8, 10, 12, 14 images. The details of the assimilation framework are shown in Figure 1. All assimilation frameworks were implemented in the same computer to record computational time (CPU: i7-4710; RAM: 8G).

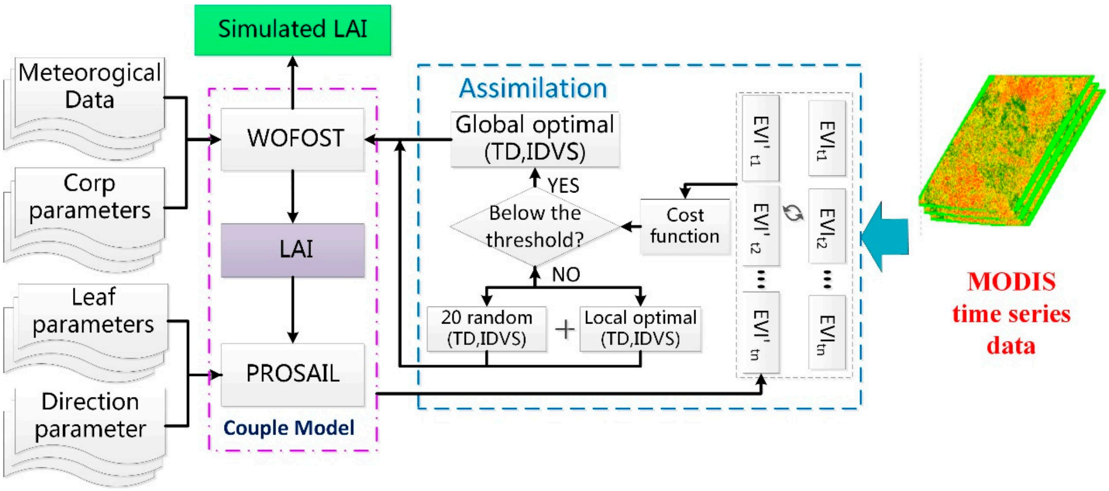


**Figure S1.** Flowchart of rice growth simulation optimization with EVI time series data and the PROSAIL-WOFOST model.

*S3. Effects of the phenological parameter on rice growth simulation in the WOFOST model*

IDVS, which reflects the initial phenology stage of the crop, is an important phenological parameter for crop simulation in the WOFOST model. Therefore, we set IDVS to different values to analyze the effects of the phenological parameter on rice growth and phenology development simulation, thereby determining the optimized parameters in assimilation. Table 2 shows the rice LAI and phenology simulation results with different IDVS. When IDVS is 0, the WOFOST model simulates rice growth starting from emergence. Compared with input phenology date, the simulated results show an obvious difference in heading and maturity date (13 and 33 days, respectively). It indicates that the original definition of phenology development in the WOFOST model is not suitable for rice and should be optimized. To consistent with rice transplanting pattern, the IDVS was set from 0.1 to 0.2. With the increasing of IDVS, the simulated phenology dates (215/257 days) are further away from the input dates (226/267 days) and maximum difference of phenology date can reach 11/10 days in heading/maturity date (IDVS=0.2). Additionally, the simulated maximum LAI in the rice growth period decreased with the increasing of IDVS (maximum difference can reach 1.56). These results indicate that the IDVS is crucial for rice phenology development and growth simulation, which could be optimized in the assimilation.

Table S2. The accuracy of phenology simulation of the WOFOST.

| Input parameters [a] | | Output results | | |
|---|---|---|---|---|
| Transplant/ Emergence, Heading, Maturity dates(DOY) | IDVS | Simulated Heading time | Simulated Maturity time | $LAI_{max}$ |
| 153,226,267 | 0[a] | 240 | 300 | ~ |
| 153,226,267 | 0.10 | 220 | 265 | 4.28 |
| 153, 226,267 | 0.12 | 219 | 263 | 3.90 |
| 153, 226,267 | 0.14 | 218 | 261 | 3.55 |
| 153, 226,267 | 0.16 | 217 | 260 | 3.21 |
| 153, 226,267 | 0.18 | 216 | 258 | 2.96 |
| 153, 226,267 | 0.20 | 215 | 257 | 2.72 |

Note a: The rice growth starts from emergence when IDVS was set to 0.

*S4. The phenology calendar of rice in Dongting lake area obtained from local meteorological bureau and farmers*

Table S3. The phenology calendar of rice in Dongting lake area.

| Stage | Phases | Data range |
|---|---|---|
| Stage | Pre-transplanting/flooding | 30 April to 18 May |
| Vegetation | Transplanting | 19 May to 8 June |
| | Tillering | 9 June to12 July |
| | Stem elongation | 13 July to 22 July |
| Reproductive | Panicle initiation | 23 July to 3 August |
| | Heading-Flowering | 4 August to 24 August |
| Ripening | Milking | 25 August to 7 September |
| | Mature grain and harvest | 8 September to 28 September |

**References**


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