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Estimating rice yield by integrating remotely-sensed data into a crop growth model

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Rice is one of the world's most important food crops, directly feeding more people than any other crops, especially in Asia where around half of the world's poorest people live. Information of rice crop yield is critically important for crop management and food policy making. This is also phenomenal in Taiwan, where rice agriculture sector still plays an important role in the country's economy because it is the major staple food crop and provides employment and income for large rural populations. This study aimed to develop a data assimilation approach by integrating Proba-V satellite leaf area index (LAI) and information of rice crop phenology into the CERES-Rice model embedded in Decision Support System for Agrotechnology Transfer (DSSAT) package to estimate rice crop yields in Taiwan. We processed the data following three main steps: (1) data pre-processing to construct input parameters, (2) crop yield estimation by integrating Proba-V LAI data and information of rice crop phenology into the CERES-Rice model using the particle swarm optimization algorithm, and (3) error verification. The data integrating process used the cost function constructed based on the difference between the simulated LAI data from the CERES-Rice mode and Proba-V LAI data. The optimization process started from an initial parameterization and accordingly adjusted parameters (e.g., transplanting date and plant density) in the crop growth model. The fitness value achieved from the cost function determined whether optimization algorithm has reached the optimized input parameters using a user-defined tolerance. The final crop yield was estimated based on the optimized input parameters. The results of yield estimation for the first and second crops verified with the government's yield statistics indicated the root mean square error (RMSE) of 16.8% and 14.8%, respectively. Although there were several model uncertainties mainly attributed to the quality of input parameters, our study demonstrated that estimating rice crop yields could be successfully modelled by integrating satellite data into CERES-Rice model in Taiwan.