

Article title	Comparison of three calibration methods for modeling rice phenology
Topic Keywords	Calibration
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Abstract	<p>Calibration is an essential step for all crop modeling studies. The goal of this study was to compare three commonly-used calibration methods including Ordinary Least Square (OLS), Markov chain Monte Carlo (MCMC), and Generalized Likelihood Uncertainty Estimation (GLUE) as applied to the CSM-CERES-Rice phenology model of the Decision Support System for Agrotechnology Transfer (DSSAT). The analysis was performed by considering goodness-of-fit to observations, calibrated parameter values, uncertainty of parameter estimates and predictions, and the practical implementation of methods. The results showed that the selection of the calibration method has some impacts on parameter estimates and uncertainty quantifications. In the situations where goodness-of-fit is the main criterion, OLS is the fastest and most effective method. When the uncertainty of parameter estimates and model predictions are important, the MCMC method is more reliable in quantifying uncertainties. We found that for predicting phenology in our study, the GLUE method was unrealistic in quantifying model uncertainty, because the default model error variance was unlikely small. This study showed that MCMC for model calibration, coupled with estimation of model error variance, is a promising method for quantifying prediction uncertainty and that MCMC should be incorporated into crop modeling platforms.</p>
Publication date	2020.01.15
Citation	Gao, Y., D. Wallach, B. Liu, M. Dingkuhn, K.J. Boote, U. Singh, S. Asseng, T. Kahveci, J. He, R. Zhang, R. Confalonieri, and G. Hoogenboom. 2020. "Comparison of Three Calibration Methods for Modeling Rice Phenology," <i>Agricultural and Forest Meteorology</i> , 280:107785. <a href="https://doi.org/10.1016/j.agrformet.2019.107785">https://doi.org/10.1016/j.agrformet.2019.107785</a>
Link to the actual article	<a href="https://doi.org/10.1016/j.agrformet.2019.107785">https://doi.org/10.1016/j.agrformet.2019.107785</a>