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Modification of the DNDC-Rice model to evaluate the nitrogen balance at a paddy field

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The DNDC (DeNitrification-DeComposition)-Rice model simulates the processes of carbon and nitrogen turnover in ecosystems for estimating greenhouse gas emissions from paddy fields, and can be used to simulate the N balance of a paddy field. In this study, we validated DNDC-Rice using field observation data, including N balance data, to reveal problems when using the model to evaluate a paddy field's N balance. To validate the N balance components of DNDC-Rice, we used data collected at the Mase paddy flux site (36.03N, 140.01E), in the middle of the Kanto Plain of Japan's Ibaraki Prefecture, in 2009. Before the validation, a process for adsorption of ammonium (NH_4^+) ions by clay was modified based on the results reported by Katayanagi et al. (2012) Soil Sci. Plant Nutr. 58:360-372. The modified DNDC-Rice simulated the dry weight of roots, stems, and grains well, but overestimated leaf dry weight. The normalized root-mean-square errors (nRMSEs) for the root, stem, grain, and leaf dry weights were 13, 16, 7, and 60%, respectively. DNDC-Rice also overestimated the leaf area index (LAI) and leaf N content, with nRMSEs of 125 and 37%, respectively. The overestimation of leaf dry weight and LAI resulted from overestimation of N uptake by rice and of N allocation to leaves. The high N uptake could be due to either a high available soil N content, crop N recovery from the soil or both. At harvesting, the simulated N balance (= N input - N output) was -38.8 kg ha^{-1}, which was much lower than the N balance determined by observations and from relevant literature (12.8 kg ha^{-1}). The underestimation of the N balance resulted mostly from the model's inability to calculate dry N deposition and N fixation as inputs and from overestimation of grain N uptake and underestimation of N2 emissions through denitrification as outputs. Based on the result, the model has been being modified using the data collected at Tsukuba FACE (Free-Air CO_2 Enrichment) experimental site. Tsukuba FACE (35.97N, 140.00E) was established in farmers' rice fields in Tsukubamirai City located near the Mase site. The elevated [CO_2] treatments were imposed on experimental plots in Tsukuba FACE to evaluate responses of rice and carbon and nitrogen cycles to high CO_2 and soil temperature. The modification based on the data collected at Tsukuba FACE will make it possible to predict future carbon and nitrogen dynamics at paddy fields more accurately.

Keywords: nitrogen balance, continuous flooding paddy field, DNDC-Rice