Ability of the upgraded CNMM-DNDC model to simulate soil erosion, productivity and losses of carbon (C), nitrogen (N) and phosphorus (P)

The upgraded CNMM-DNDC model coupled the biogeochemical processes with soil erosion, which was able to predict the crucial variables relevant to biogeochemical processes, including the productivity, greenhouse gases, contaminated gases and nitrate (NO_3^-) loss and the variables related to soil erosion, including the yields of sediment, particulate carbon (PC), particulate nitrogen (PN) and particulate phosphorus (PP). Figure S4 showed the simulated annual productivity (including crop yield or forest biomass), C sink intensity, emissions of methane (CH_4), nitrous oxide (N_2O), nitric oxide (NO) and ammonia (NH_3), NO_3^- losses through leaching and runoff and yields of sediment, PC, PN and PP among different land uses from 2004 to 2014 in the Jieliu catchment.

The yields of sediment, PC, PN and PP from different land use types from 2004 to 2014, which were resulted from the newly added modules of soil erosion, were illustrated in Fig. S4a. For the winter-flooding paddy with the paddy rice flooding−fallow regime (RF), the upgraded model simulations resulted in no yields of sediment, PC, PN and PP because of the year-round flooding. Although the simulated average sediment yield of the sloping cultivated upland (SU) with the summer maize−winter wheat rotation was approximately 60% higher than that of seasonally waterlogged paddy (SP) with the paddy rice−winter wheat rotation or paddy rice−rape rotation, PC, PN and PP yields of SU and SP were very closer (92.4 versus 78.2 kg C ha^{-1} yr^{-1}, 8.6 versus 7.6 kg N ha^{-1} $yr^{-1}$and 1.2 versus 1.1 kg P ha^{-1} yr^{-1}, respectively). With regard to the forest land (FL), the upgraded model resulted in the lowest yields of sediment, PC, PN and PP among all the land use types.

The simulated annual crop yields of the SU, SP and RF crop systems from 2004 to 2014 averaged 10.6 t d.m. ha^{-1} yr^{-1} with the range of 9.6–11.4 t d.m. ha^{-1} yr^{-1}, while the annual accumulated biomasses of the forests from 2004 to 2014 were predicted to range from 6.1 to 10.8 t d.m. ha^{-1} yr^{-1} with the average of 7.4 t d.m. ha^{-1} yr^{-1} (Fig. S4b). With regard to the C sink simulation, the FL yielded to the maximum C sink of 3372.7 kg C ha^{-1} yr^{-1} on average with the range of 2877.9–4193.6 kg C ha^{-1} yr^{-1} (Fig. S4c). Meanwhile, the crop systems of SU and SP also acted as C sinks, whose C sink intensities were lower than that of the FL. Compared to the C sink intensity of the SP (averaged 316.3 kg C ha^{-1} yr^{-1} within the range of 230.1–416.6 kg C ha^{-1} yr^{-1}), the SU yielded to the larger C sink intensity on the average of 800.7 kg C ha^{-1} yr^{-1} (within the range of 288.4–986.2 kg C ha^{-1} yr^{-1}). However, the C sink intensity of RF ranged from −196.1 to −44.6 kg C ha^{-1} yr^{-1}, with an average of −97.6 kg C ha^{-1} yr^{-1}, which acted as C source (Fig. S4c).

The FL and SU acted as the weak CH_4 sinks, which averaged −1.1 kg C ha^{-1} yr^{-1} (ranged from −1.8 to −0.3 kg C ha^{-1} yr^{-1}) and −1.7 kg C ha^{-1} yr^{-1} (ranged from −1.9 to −1.6 kg C ha^{-1} yr^{-1}), respectively (Fig. S4d). However, the average annual CH_4 emissions of SP and RF reached 233.2 kg C ha^{-1} yr^{-1} (within the range of 180.6–269.8 kg C ha^{-1} yr^{-1}) and 474.6 kg C ha^{-1} yr^{-1} (within the range of 359.2–556.9 kg C ha^{-1} yr^{-1}), respectively. In addition, the annual N_2O emissions of FL were extremely low, which averaged 0.1 kg N ha^{-1} yr^{-1} within the range of 0.1–0.2 kg N ha^{-1} yr^{-1}, while that of RF yielded to 1.2 kg N ha^{-1} yr^{-1} (ranged from

1.0 to 1.7 kg N ha^{-1} yr^{-1}) as Fig. S4e shown. The simulated average annual N_2O emissions of SU and SP were very closer, which averaged to 2.9 kg N ha^{-1} yr^{-1} (within the range of 1.5−4.1 kg N ha^{-1} yr^{-1}) and 3.0 kg N ha^{-1} yr^{-1} (within the range of 1.6−5.0 kg N ha^{-1} yr^{-1}), respectively. Compared to the annual NO emissions of SU and SP, which averaged 1.4 kg N ha^{-1} yr^{-1} (within 0.6−2.2 kg N ha^{-1} yr^{-1}) and 0.5 kg N ha^{-1} yr^{-1} (within 0.2−0.8 kg N ha^{-1} yr^{-1}), the model simulations yielded to slightly lower NO emissions from RF and FL (Fig. S4f). With regard to NH_3 emissions, the model simulations for the SU, SP and RF crop systems resulted in average annual NH_3 emissions of 90.8 (within 59.7−134.9 kg N ha^{-1} yr^{-1}), 29.7 (within 14.4−48.6 kg N ha^{-1} yr^{-1}) and 66.4 (within 54.7−93.1 kg N ha^{-1} yr^{-1}) kg N ha^{-1} yr^{-1}, respectively. Moreover, the annual NH_3 emissions of FL were very slight, which ranged from 4.9 to 7.3 kg N ha^{-1} yr^{-1}on the average of 6.1 kg N ha^{-1} yr^{-1} (Fig. S4g). Compared with the slight NO_3^- runoff loss (within 0.1−2.3 kg N ha^{-1} yr^{-1} among all the land uses), the simulated annual NO_3^- leaching out of the depth of 0–60 cm soil profile averaged 54.5, 24.2, 29.7 and 9.0 kg N ha^{-1} yr^{-1}, with the range of 5.9−112.7, 8.9−54.0, 21.0−37.6 and 3.8−13.8 kg N ha^{-1} yr^{-1}, respectively (Fig. S4h).