Geophysical Research Abstracts
Vol. 21, EGU2019-12860, 2019
EGU General Assembly 2019

Quantifying CO_2 and CH_4 fluxes over an intermittently-irrigated rice paddy

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Rice is a major crop that feeds more than half of global population. Rice paddy plays complex roles in carbon cycle by emitting CH_4 to the atmosphere while CO_2 is sequestered from or released to the atmosphere. Here, we present 3.5 years of eddy covariance measurements of CH_4 and CO_2 fluxes over an intermittently-irrigated rice paddy in Korea in tandem with carbon stock measurements in leaf, stem, grain, and root. The interannual variation of CO_2 fluxes was little although the timings of transplantation and harvest were different for each year. Rice paddy acted as a slight sink or neutral in CO_2 (-47.3 $\pm$ 50.9 g C m^{-2} y^{-1}; mean $\pm$ 95% confidence interval) with 942.2 $\pm$ 129.4 g C m^{-2} y^{-1} and 894.9 $\pm$ 106.5 g C m^{-2} y^{-1} for gross primary production (GPP) and ecosystem respiration (Reco), respectively. Carbon stock in rice showed large interannual variation (760.2 $\pm$ 183.7 g C m^{-2}) with 70 $\pm$ 19.8 g C m^{-2}, 232.1 $\pm$ 83.3 g C m^{-2}, 378.2 $\pm$ 75.5 g C m^{-2}, and 79.8 $\pm$ 12.8 g C m^{-2} for leaf, stem, grain, and root, respectively. The rice paddy emitted 21.7 $\pm$ 2.5 g C m^{-2} y^{-1} of CH_4. When considering the global warming potential of CH_4 (197.3 g CO_2-Ceq m^{-2} y^{-1}), the paddy shift from carbon sink to source (150 g CO_2-Ceq m^{-2} y^{-1}). The CH_4 flux showed a bimodal seasonal pattern caused by the mid-season drainage which turned the soils aerobic conditions so prohibited CH_4 emissions. The irrigation practices, which are different every year, resulted in the significant interannual variation of CH_4 emission ($\pm$ 7%). These findings will be useful to understand carbon budgets and cycles, and develop carbon and water managements in rice paddy.