Quantifying the GHG emission in paddy field in China under Climate Change based on the coupling of DNDC, DSSAT and AEZ models

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Summary: Agricultural production constitutes a big portion of global greenhouse gas (GHG) emissions. It is essential for national or global mitigation to quantify GHG emissions from various agricultural sources. How to balance the trade-off between food security concern and GHG emission reduction is an important scientific and policy issue. Accurately quantifying the nonpoint pattern and extent of agricultural GHG emission based on agro-ecological and biogeochemical model simulations is of fundamental importance for science-informed decision making in balance the above-mentioned trade-off between food security concern and GHG emission reduction. In this research three models that had been employed in to quantify the GHG emission in paddy field in China. DNDC model is a site-level biogeochemistry processed model and simulating C and N circulation in agricultural system, However, the original DNDC focus on almost 90 kinds of crops and grasses so that there is brief cultivar information about paddy and it couldn't meet the regional simulation in paddy field in China. Therefore, the DSSAT (Decision Support System for Agro-technology Transfer) and AEZ (Agro-ecological Zones) model will be employed to enhance the paddy cultivar information and provide the up-scaling method to DNDC. 30-years (1981-2010) rice management data from 24 China agro-meteorological stations have been used to validate the simulation result. After the verification, the potential yield and inventories of GHG emission in paddy field will be estimated by the updated DNDC model, we can also compare observations and the simulated outcomes of future climate scenarios, and evaluate the effect of alternative fertilizer application scenarios and irrigation scenarios, such as continuous flooding or mid-season field drying, to find possible win-win GHG emission mitigation methods. At last, the regional simulation result by up-scaled DNDC model could be compared with the GAINS simulation result so as to find complementarities between the two models.

Key words: GHG emission, DSSAT, AEZ, DNDC

China has promised to peak CO_2 emission by 2030 or earlier, which was announced in the China-U.S. Joint Statement on Climate Change on November 12, 2014. Agricultural GHG emission, which include CO_2, CH_4 and N_2O, is the second major source in China. The main forces driving the rising rate of CH_4 and N_2O emission is rice planting. In addition, paddy is the second main food crop in China and it makes lots of contribution to ensuring food security. So how to mitigate the GHG emission in paddy field without decreasing production is a problem to scientists and decision-makers. There are three key models used in this research, one is the denitrification and decomposition model, known as DNDC model which is based on biogeochemical mechanisms of crop growing process and is capable of simulating the dynamics of denitrification-decomposition process. As a consequence, DNDC model has been extensively employed by scientists to simulate CH_4 and N_2O emissions. However, the crop cultivar varieties in DNDC is largely based on the USA and EU agricultural records and cannot represent richness and regional diversity of cultivar varieties in China. Another is agro ecological zones model of IIASA which is a regional level agro-ecosystem model with limited consideration on biogeochemical dynamics. Therefore, it is not suitable for simulating the GHG emission from life cycle of microbes. In contrast, the DNDC model is a farm level biogeochemistry model, which needs very detailed input information at the farm level, but only incorporates brief cultivar information. So the two models have to be coupled to help each other. The coupled method starts from translating some key parameters in land utilization types of AEZ, such as range of optimum cumulated temperature and reference temperature, into crop cultivar library of DNDC and then run the two models respectively to verify the potential yield. The research team led by Dr Zhan TIAN in Shanghai has enriched rice cultivar parameters of AEZ for China in recent years based on coupling DSSAT (modeling the dynamic process of crop growth) and AEZ models. Their AEZ simulation using the enriched cultivar parameters fits well with the observed crop calendar and yields. On the other hand, the AEZ model focuses on agro-ecological process of crop growth and cannot simulate the microbe activity in soil and the emission processes of CH_4, N_2O and NH_3.Therefore, it is necessary and desire to couple DNDC and AEZ so as to accurately quantify the nonpoint pattern and extent of agricultural GHG emission in paddy field in China.