Validation of DNDC model for estimation of nitrous oxide emission from agricultural fields in Japan

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Nitrous oxide (N_2O) is a greenhouse gas and upland field is one of its main anthropogenic emission source of N_2O. As an Annex I Party that ratified the Kyoto Protocol, Japan is required to estimate N_2O emission from its upland fields to include it in its annual National Inventory Report (NIR) for Greenhouse Gases. N2O is an intermediate product of microbial activity, such as nitrification and denitrification. Under aerobic condition, N_2O is produced through ammonia oxidation process, and produced and reduced through nitrate reduction process under anaerobic condition. Those microbial processes are affected by soil chemical and physical properties, such as soil water content, temperature, porosity, available nitrogen content, organic matter content, etc., intricately. N_2O emissions through the processes have large uncertainty, because of the complexity.

In NIRs, a simplified N_2O estimation method have been adopted to estimate total N_2O emissions from Japanese agricultural fields since 1990s(Akiyama et al., 2006; Tsuruta, 1997). In the method, only amount of nitrogen input was accounted to estimate N_2O emissions, though N_2O emission is also affected by other factors, such as soil properties, weather condition, etc. To improve the accuracy of the national-scale estimates, development of a process model has been required. DeNitrification-DeComposition (DNDC) model is one of the process models, which was widely used to estimate N_2O emission in a field to a national scale. The model has been modified for more than 20 years, but it was not enough validated to simulate N_2O emissions from Andosol fields, which occupies a half of Japanese upland fields.

N_2O emission from Andosols was lower than from other soils (Akiyama et al., 2006; Nishina et al., 2015). The low N_2O emission assumed to be caused by low microbial biomass carbon / total soil organic carbon ratio (Sawamoto, 2005) and the adjustment of the ratio improved DNDC simulation results (Deng et al., 2015; Sawamoto, 2005). However, the validation was conducted against some specific field and versatility of the ratio should be validated by using the other fields.

In this study we validated DNDC using the observed data collected at four Andosols sites (Fukushima, Niigata, Kumamoto, and Kagoshima) and five non-Andosols site (Yamagata, Aichi, Shiga, Tokushima and Nagasaki) from 2010 to 2012. As input data, meteorological data (daily maximum and minimum air temperature and precipitation), soil properties (bulk density, carbon content, nitrogen content, pH, clay content, soil texture, drainage rate, water table depth), crop parameters (ratio of grain, leaf, stem and root, CN ratio of those), and field management data (the date of transplanting, harvesting, fertilizing, and irrigation date, and the amount of maximum yield and fertilizer) were prepared. The soil temperature and water content, and then yield and biomass were validated using the input data at first. After the validation, N_2O emission rates were evaluated.

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