Bottom up approach to evaluate regional methane emission from the Mekong Delta

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Introduction

The Mekong Delta is one of the most important regions for rice production of the world. The delta’s triple cropping rice paddies are submerged nearly throughout the year and supplied substantial amount of rice stumps derived fresh organic carbon. Since there is a possibility that this environment puts the paddy soils under strongly reductive condition, it would let anaerobic soil bacteria to emit substantial amount of methane (CH_4). Although the importance of agricultural mitigation has been affirmed by the Government of Vietnam which aims to reduce GHG emissions by 20% by Vietnam’s national communication targets a shift in water management with increased drainage periods, it still lacks the integrated research and decision support tools needed for quantifying emissions baselines and evaluating mitigation potential in a scientifically robust, transparent and scalable approach (Torbick et al. 2017).

In this study, we demonstrate a technique to map the regional CH_4 emission from the rice paddies of the Mekong delta with using the proposing semi-empirical model, a rice paddy soil’s hydrological status evaluation method with various satellites data and rice phenology evaluation method.

Methods

Methane flux observation data (collected once per 1-7 days in each paddy) and field waterlevel (collected daily in each paddy) obtained in representative farmers’ paddy fields (6-18 paddies in each site) with different water & straw management were monitored for 1-5 years (2009-2017) were prepared (total number of flux data (mg C m^{-2} h^{-1}): n=16,551; total number of cumulative emission through a rice cropping (g C m^{-2} $cropping^{-1}$): n=588; Arai 2015, Taminato & Matsubara 2014 and Ishido et al. 2016).

Daily flux data or cumulative emission values were fitted by fixed effects derived from satellite remote sensing data and GIS data (i.e., whether soil is flooded or not, days after sowing, the adjacent fallow season’s length, soil types, straw management) using hierarchical Bayesian analysis. As random effects, the difference of observation years, cropping seasons and monitoring sites were considered. The posterior distribution was calculated by the Hamiltonian Monte Carlo method (Hoffman and Gelman 2014) implemented by RStan (Stan Development Team 2015; version 2.15.1).

ALOS-2/PALSAR-2’s quadruple observation datasets (Lv. 1.1; 29 scenes; 20th Nov. 2015-26th Oct. 2016) were applied to lee refined filter (7×7 window) to ease speckle noise, and then decomposed with freeman-durden 3-components decomposition (Freeman and Durden 1998) by using a software PolSARpro 4.0. From each ROI of each scene, 25-30 pixels' values were collected and averaged for the super-vised classification with Hard-margin Support Vector Machine (SVM). As the ground truth training data, above mentioned field observation data (i.e., field waterlevel and days after sowing, harvest date) were employed. The SVM-super vised classification was conducted with the statistical package R (R Development Core Team 2005; version 3.3.0) with kernlab-library. ALOS-2/PALSAR-2's SCAN-SAR datasets (Lv. 1,1; 73scenes) were also applied for flooding soil classification considering bias derived from local incidence angle difference.

To compute cropping calendar (e.g., annual cropping frequency, days after sowing) as long-term as possible with high temporal resolution, MODerate resolution Imaging Spectroradiometer (MODIS)'s 16 days composite NDVI product (MOD13A2) were applied for local-maximum fitting filter and fast fourier transform.

Results

The model with remote sensing data input fitted with ground observation CH4 flux datasets show apparent spatio-temporal dynamics. As validation analysis, comparison with top down approach with GOSAT datasets and long-term and consistent global scale land surface water coverage datasets from Advanced Microwave Scanning Radiometer (AMSR)-E, 2 is being process considering cloud-bias.

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