Geophysical Research Abstracts
Vol. 18, EGU2016-16199-1, 2016
EGU General Assembly 2016

Evaluating the relative contribution of methane oxidation to methane emissions from young floodplain soils under Alternative Irrigation Management

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To keep the pace with a yearly growing demand for rice by 1-2%, future rice production must come primarily from high yielding irrigated rice, putting a pressure on fresh water reserves. In this context, water saving Alternative Irrigation Management (AIM) is progressively applied worldwide. By introducing repeated or mid-seasonal drainage, AIM suppresses emission of CH4, otherwise prevalent in continuously flooded rice. However, little is known about the effect of AIM on the balance of CH4 genesis and oxidation in paddy soils. We studied relevant soil parameters and CH4 emissions in continuously flooded (CF) and alternately wetted and dried (AWD) rice paddies. During a field campaign at the Castello d'Agogna experimental station (Pavia, Italy), we measured in situ CH4 oxidation and emission rates using the closed gas chamber technique with or without application of CH2F2 as a selective inhibitor of CH4 oxidation. In addition, we determined potential CH4 oxidation rates using incubated soil slurries originating from the same experimental plots. The dataset was supplemented with depth differentiated monitoring of redox potential, temperature, moisture content and soil solution parameters (DOC, Fe2+, Mn3+, mineral N and dissolved CH4). Peaks in dissolved CH4 manifested at 5 and 12.5cm depth, with much lower and equal levels at 25, 50 and 80cm depth. Also depth distributions of dissolved Fe and Mn followed this pattern, indicating that methanogenic activity was primarily confounded to the topsoil. Seasonal CH4 emissions were about halved by AWD compared to CF management. After a fast decline of in situ oxidation within the AWD treatment at the beginning of the season, CH4 oxidation percentages in CF and AWD increased until the booting stage (67DAS), reaching peak values of 83% and 69% of produced CH4, respectively. CH4 oxidation thereafter gradually declined to nearly 50% in both treatments after the final drainage (103 DAS). Seasonal trends of potential CH4 oxidation rates were alike between CF and AWD fields, except at 52 DAS, when 5cm and 25cm depth CH4 oxidation capacities from CF soil slurries exceeded those under AWD. This could firstly be explained by higher observed soil solution CH4 concentrations of CF paddies, while in mid-season dissolved CH4 was nearly absent in case of AWD. We hypothesize that a larger methanotrophic biomass was present in the CF fields, explaining the higher CH4 oxidation potential, but this requires verification by qPCR. In addition, higher NH4+ concentrations were measured under CF, which as well might have favored methanotrophic activity. Ongoing analysis of stable isotope ratios (12C/13C) in both atmospheric and subsurface gas samples will complement the specific inhibitor-based CH4 oxidation estimates. Currently, the dataset assembled during this field experiment will be used to fine-tune the biogeochemical model 'rice DNDC' (DeNitrification-DeComposition) with specific attention to DNDC's capability to simulate CH4 oxidation and depth profiles . The model revision will take into account the seasonal and depth differentiated behavior of parameters relevant to the processes of CH4 oxidation, production and emission, and hence contribute to a more precise estimation of methane emissions under AIM.