J172-P009 **Room: Poster Session Hall** **Time: May 29**

Probabilistic inversion of temperature dependency on soil organic carbon turnover in Japanese arable land

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The response of soil organic carbon (SOC) to global warming is one of the key uncertainties to predict global carbon cycling in the future. The difference in a temperature response of the SOC decomposition is now the main subject of a continuing debate. However, most SOC turnover models (SOC models) used to predict the impact of climate change on the soil carbon cycle assume a similar acceleration function of SOC decomposition with temperature. It is not possible to measure the temperature dependency of SOC compartments separately. Thus we have no choice but to depend on the result from an incubation approach, a stable isotopic method and estimation based on the model approach. This study used the model approach and proposed the inversion estimation with Markov Chain Monte Carlo technique to determine the temperature response of each SOC compartment based on the long-term SOC data in the three Japanese cropland arable soils. The variation in temperature sensitivity of SOC compartment was evaluated by a decomposability of SOC and soil nutrient management.

We used the three long-term SOC monitoring data obtained from Naganuma (Euric Fluvisol), Akita (Gleyic Cambisol) and Kumagaya (Dystric Cambisol) of Japanese upland. These data were obtained from the data of National soil inventory. Soils in the fields were managed in 3 types of nutrient conditions during the experimental period; without N (non-N), with NPK fertilizer (NPK) and NPK fertilizer + manure input (NPK+FYM). Management legacies of these fields such as soil cover and monthly input of plant residues were also obtained. Soil carbon was measured using soil core sampling from the plough layer. We applied RothC model (Coleman and Jenkinson, 1994) to simulate the turnover of soil organic carbon. E_0 based on the function by Lloyd and Taylor (1994) and Q_{10} value were set for each SOC compartment (DPM, RPM, BIO, HUM) and Markov Chain Monte Carlo technique was used to estimate the values in the way introduced by Xu et al. (2005).

Posterior probability density functions (PPDFs) of E_0 for DPM and BIO were poorly constrained in Naganuma site. PPDFs of these compartments were almost similar to the uniform distribution set as a prior distribution initially. The results of the poor constraint for DPM and BIO compartment like this were also obtained for all treatments at all three sites. In contrast, PPDFs of E_0 for RPM and HUM were well constrained. Moreover, PPDF of HUM was more constrained than that of RPM, which was also observed at all treatments in all sites. PPDFs of DPM and BIO were not restricted in this study that may be due that turnover times (inverse number of decomposition rate k) of these compartments were 0.1 and 1.5 years. The turnover times were fairy shorter than the measurement interval of SOC storage, so the monitoring data of SOC storage may be hard to catch the carbon budget of DPM and BIO compartments. Even though RPM and HUM have one order difference in decomposition rate of 0.3 and 0.022 y^{-1}, the mean value of E_0 for RPM and HUM had no consistent trends with all treatments in all sites. We could not also obtain E_0 for the labile SOC compartments of DPM and BIO and compare to RPM and HUM, which would be a reason not to clarify the relationship between the temperature sensitivity and a level of decomposability. However, there is a trend in E_0 values between the soil nutrient conditions. In all sites, the highest E_0 values were obtained in the non-N and decreased with the improvement of soil nutrient conditions by fertilizer and manure input. The trend was observed in both cases for RPM and HUM in all sites. The result suggests that the temperature sensitivity of SOC decomposition would be low in the nutrient rich condition and stored more carbon in the soil.