# SPATIO-TEMPORAL EVALUATION OF SOIL CARBON STORAGE OF CROPLANDS IN JAPAN

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## ABSTRACT
We evaluated the current status and the future projection of soil organic carbon (SOC) storage in Japanese croplands (paddy and upland), using a soil carbon turnover model. The model based on the RothC involves the modification after verification of turnover processes of SOC for the main soil type in Japan, Andosols. The objectives of this study are to i) evaluate the spatial distribution of SOC storage, ii) estimate the annual input organic matter for reaching the equilibrium, and iii) simulate time changes of SOC storage with changing agricultural practices as well as climate conditions.

## INTRODUCTION
The amount of carbon storage in soil is an outcome of balance between inputs of organic matters from vegetation depending on its net primary production and losses in the form of gas, which is mainly carbon dioxide ($CO_2$), by heterotrophic respiration of microbes. These processes are highly influenced by physical environmental factors, mainly temperature and available water. Moreover, human induced changes in land use and management practices in naturally vegetated land as well as agricultural land are also likely to alter terrestrial carbon storage. In 1997, the United Nations drafted the Kyoto Protocol to decrease greenhouse gas emissions and stabilize their atmospheric concentration [*United Nations*, 1997]. It has established credit for carbon sinks through activities including afforestation and reforestation. On the contrary, sequestration in agricultural soils is not now permitted to produce carbon sequestration credit under the Kyoto Protocol because of the perceived difficulty and cost of verifying that carbon is actually being sequestered and maintained in the soils. In agricultural land, crop residue management is an important component of the carbon and nitrogen budget. Crop residues returned to the soil are direct inputs of carbon and nitrogen, increasing water-holding capacity and soil aggregation for an improvement of tilth. Soil organic matters will be stored responding to measurably changes in crop residue management over decades [e.g. *Metting, et al.,* 2001]. We should do accurate estimation about the land areas involved and the changes in soil organic matter that might be occurring under improved managements.

## MODEL
We here used the Rothamsted Carbon model [RothC; *Coleman and Jenkinson,* 1996], which is one of compartment-based models, to evaluate spatio-temporal changes of soil organic carbon (SOC) in uplands of Japan. The model has been applied to SOC dynamics in agricultural land and validated against the experimental results with a broad range of managements, soil types and climatic conditions. In addition, it has an advantage that the required input data can be easily obtained to do the larger scale evaluation. Using this model, this study aimed to i) evaluate the spatial distribution of SOC storage, ii) estimate the annual input organic matter for reaching the steady state, and iii) simulate time changes of SOC storage with changes in agricultural management practices.

The RothC model have been tested against the observation data of long-term experiments for a variety of soil types and vegetation including arable land, grassland as well as forest, although it was originally developed for describing the SOC dynamics in an upland [*Jenkinson, et al.,* 1999]. *Shirato et al.* [2004] applied the original model against the results of long-term experiment on SOC in uplands of Japan and found that it tends to underestimate the total SOC for the Andosols soil. The observed changes in SOC of Andosols were much slower than simulated ones, suggesting that the decomposition rate should be modified in case of the Andosols soils. This is because the soil formed from volcanic ash makes some chemical compounds, including Al, Fe and Si, to prevent the carbon decomposition by microbial attacks. Then, they introduced an empirical factor into the turnover process in the humified organic matter compartment to reduce the decomposition rate depending on the concentration of Al compounds in the Andosols soil.

## RESULTS AND DISCUSSION
Using digital national information [Ministry of Land, Infrastructure and Transportation of Japan, 1997], agricultural lands including paddy and uplands and associated soil category (listed in Fig.1) are extracted. Assuming the soil

surface depth, clay and carbon contents for each soil category based on database on soil properties of representative soil profiles across Japan [*Oda et al*., 1987], we evaluated the total amount of SOC in uplands of Japan ranges from 40 to 100tC/ha and depicted larger SOC storage areas are distributed in the north, northeast and most southern part of Japan (Fig.2). The current total SOC storage and input carbon under the equilibrium were estimated to be 109MtC and 7MtC/yr, respectively.

In addition, we conducted simulation of time changes of SOC storage with changing farmyard manure applications into soil. Assuming the farmyard manure is applied in April by 0.5tC/ha or 1.0tC/ha, every year for 50 years period of 1965 through 2015, the results showed the increment rate takes the maximum at the initial, and then gradually decreases to reach the equilibrium state. It was predicted that Andosols and Brown Forest soils could store larger SOC; especially Andosols could store more than 2.5Mt carbon for the case of 0.5tC/ha application, and more than 5.5Mt carbon for the 1.0tC/ha input.

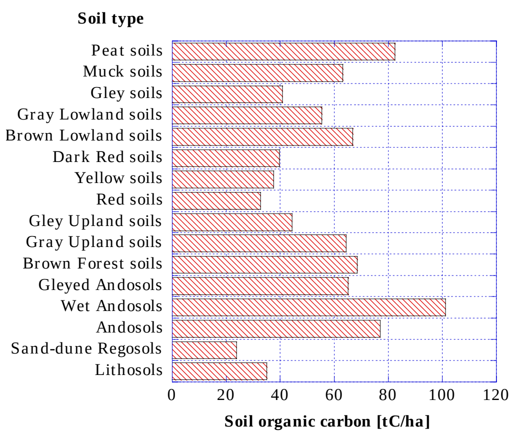


Fig.1. SOC contents averaged over each soil category.

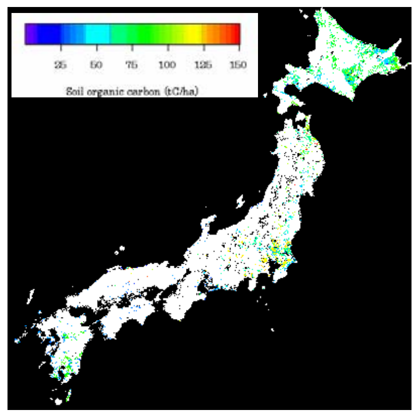


Fig.2. Geographical distribution of SOC contents in uplands under the current climate and agricultural practice.

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