

A nationwide soil carbon calculation system for Japanese agricultural land

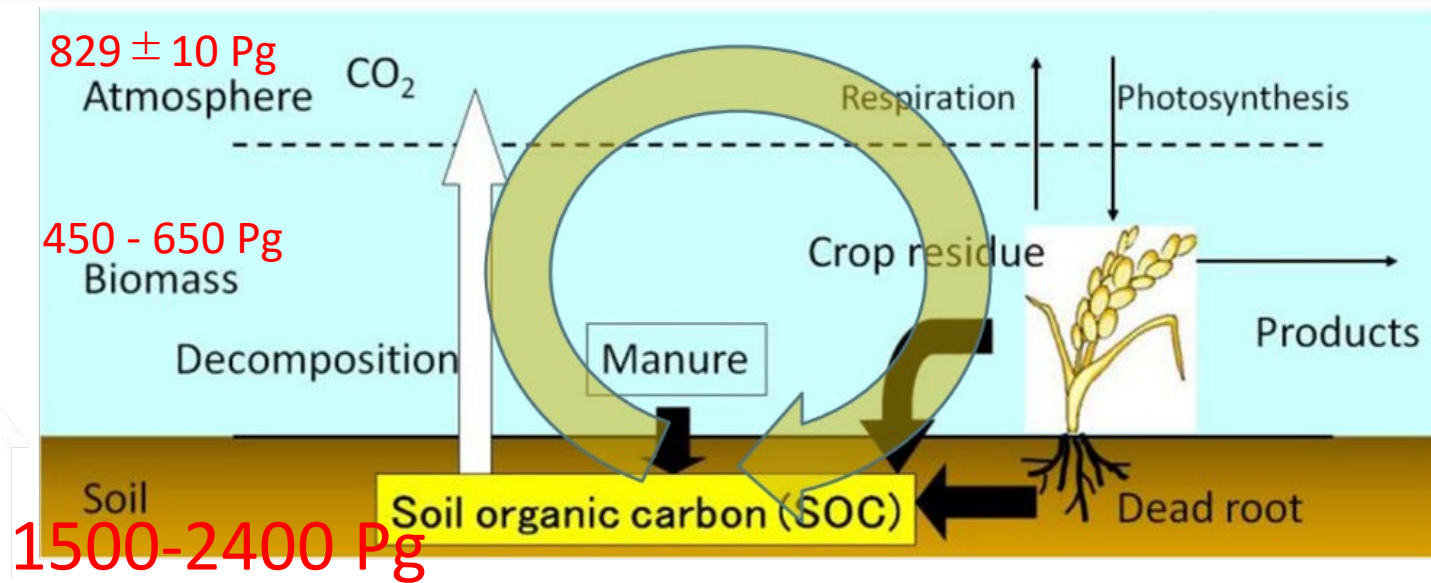
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Japan uses the **IPCC Tier 3 modelling** method to calculate CO₂ emissions or removals derived from changes in **soil carbon** in agricultural land.

- Introduction: Soil carbon sequestration and climate change mitigation.
- Validation and modification of soil C model.
- Development of a nationwide calculation system.
- Use of the system for National Inventory Report (NIR) and Nationally Determined Contribution (NDC).
- Web-based decision support tool by using model.
- Importance of primary data: long-term experiments.



- “Carbon” accumulated as dark-colored “soil organic matter”: Important index of **productivity**.
- Size of soil C pool is huge.

“The 4 per 1000 initiative” for soil C sequestration.

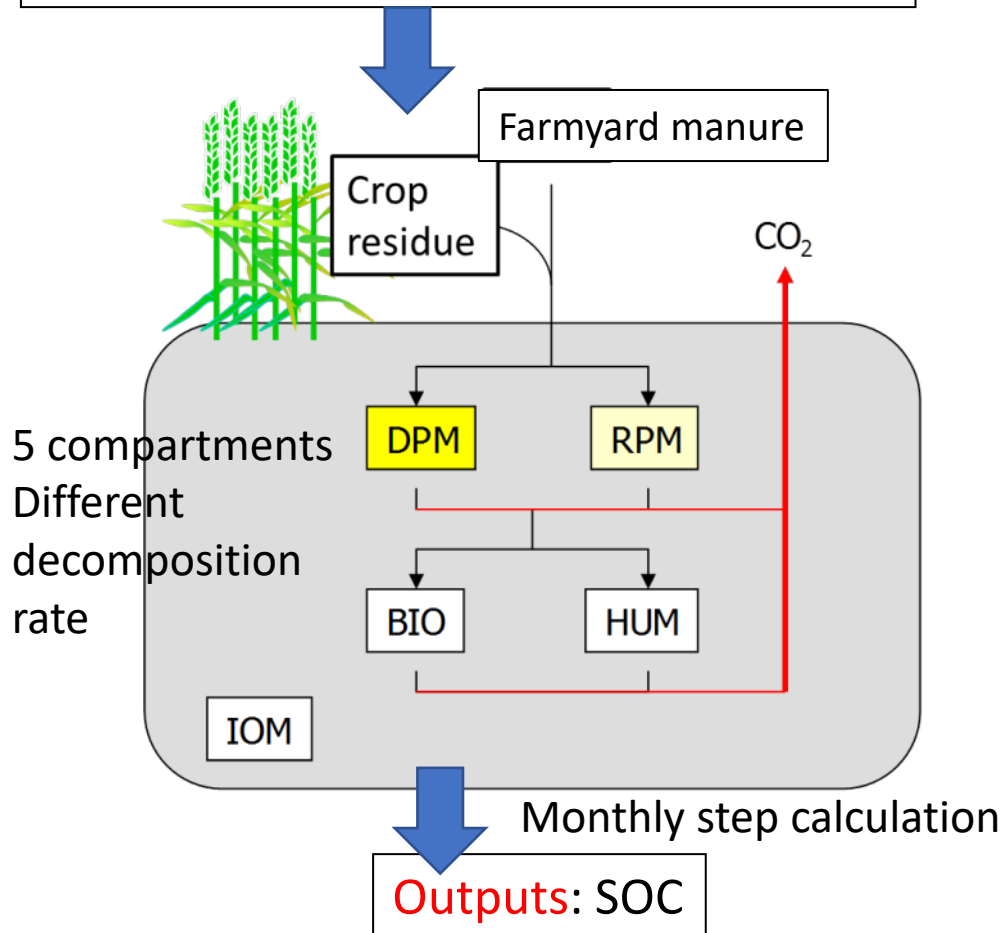
Storing C in soils has huge potential to **mitigate** increase in atmospheric CO₂ and contribute to **sustainable food production**.



Soil C model: useful tool for future prediction and spatial evaluation

Rothamsted Carbon (RothC) model

Inputs: meteorology, soil, management

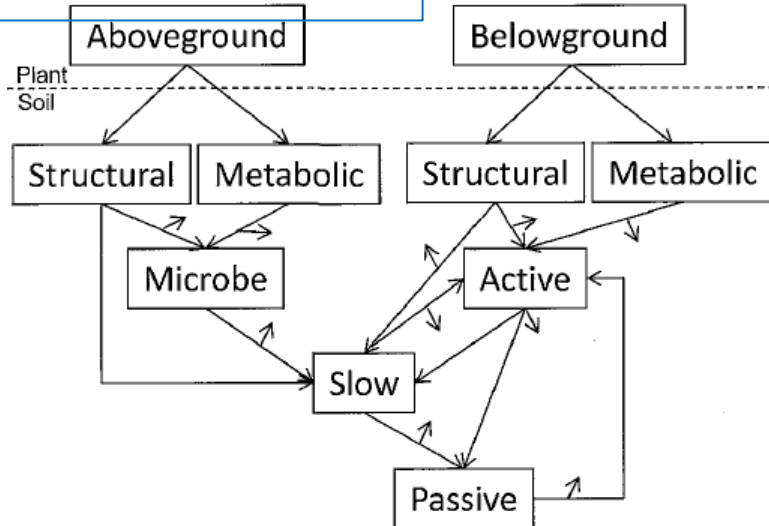


- One of widely used soil C models developed in UK.
- **Simpler structure has advantage for model modification.**

CENTURY model is used for Forest

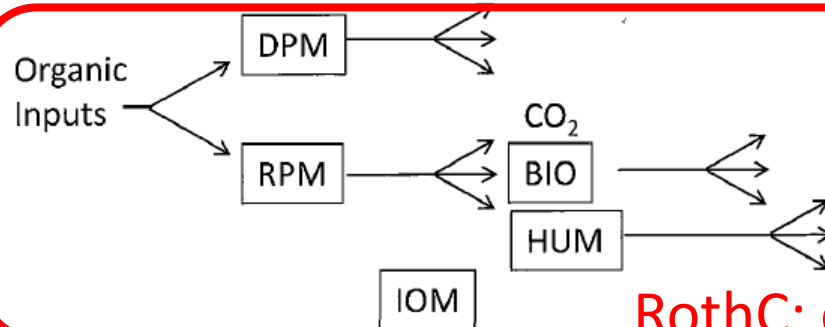
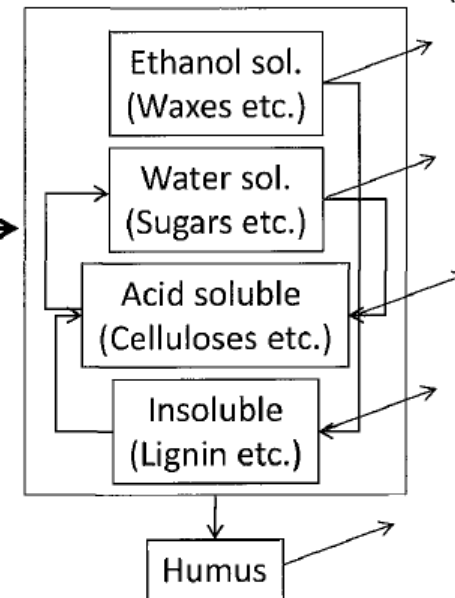
Hashimoto (2025)

CENTURY: forest



Active: Soil microbes and microbial products with short turn over times
 Slow: Resistant plant material and stabilized soil microbial products
 Passive: Physically and chemically stabilized soil organic matter

Organic
Inputs

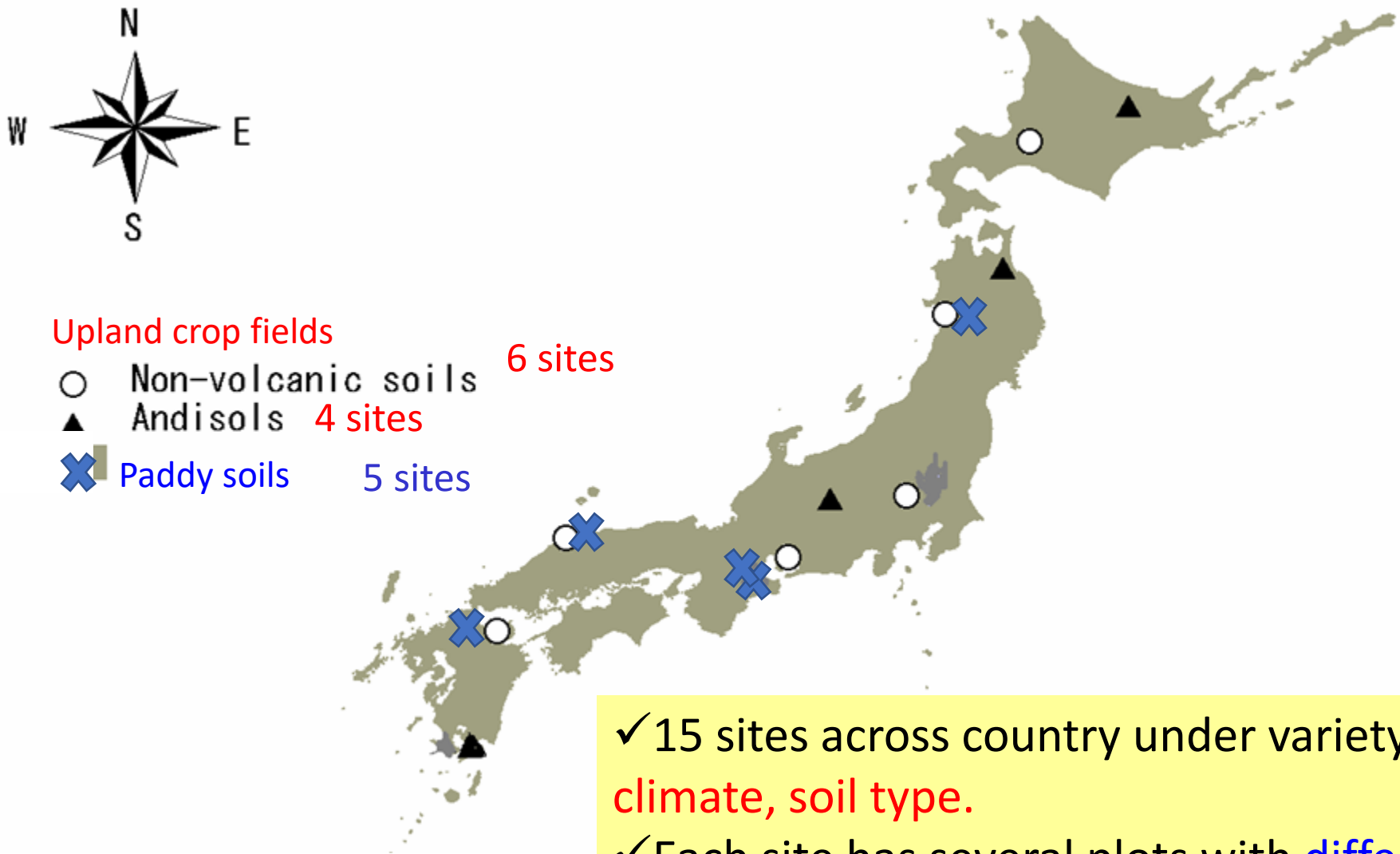


DPM: Decomposable plant material
 RPM: Resistant plant material
 BIO: Microbial biomass
 HUM: Humified organic matter
 IOM: Inert organic matter

RothC: cropland, grassland

- Similar structure. RothC is simpler.

Long-term experiments for model validation



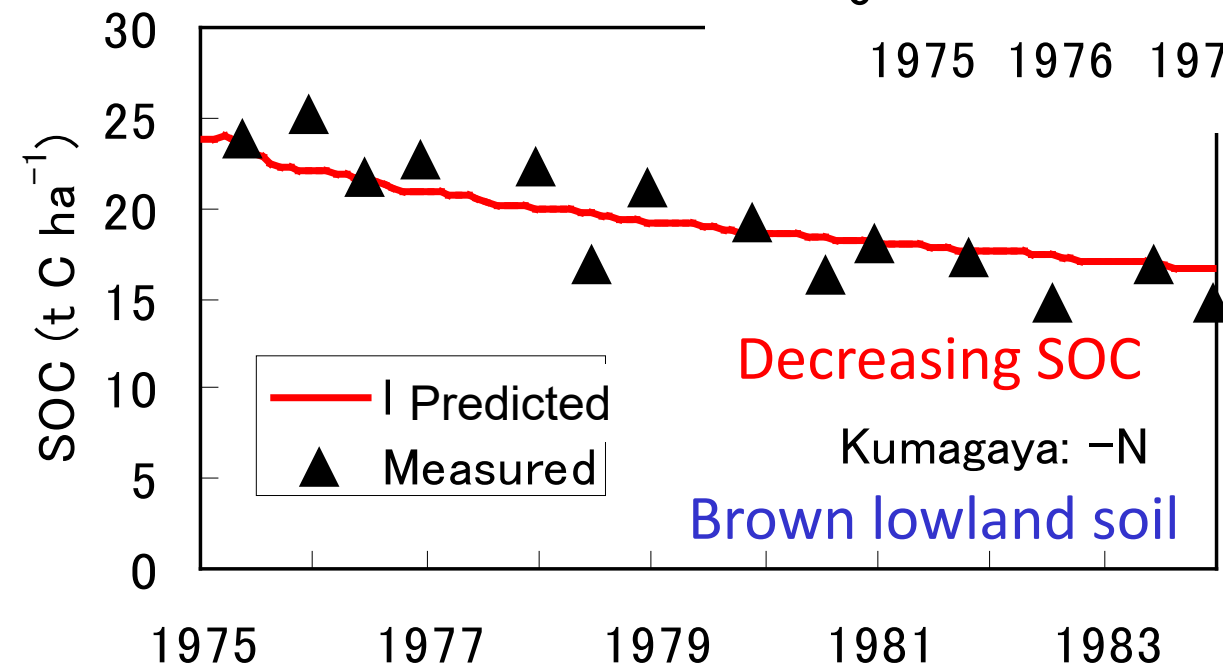
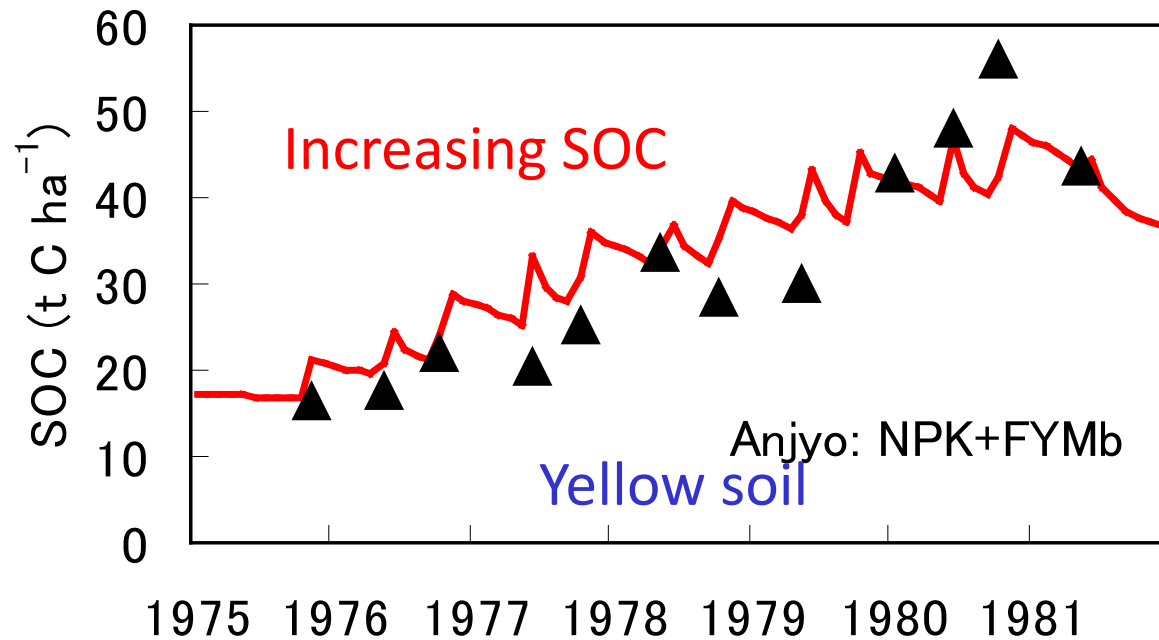
- ✓ 15 sites across country under variety of **climate, soil type.**
- ✓ Each site has several plots with **different management (NPK, manure, straw, etc.).**

Performance of RothC in non-volcanic upland soils



Good performance.

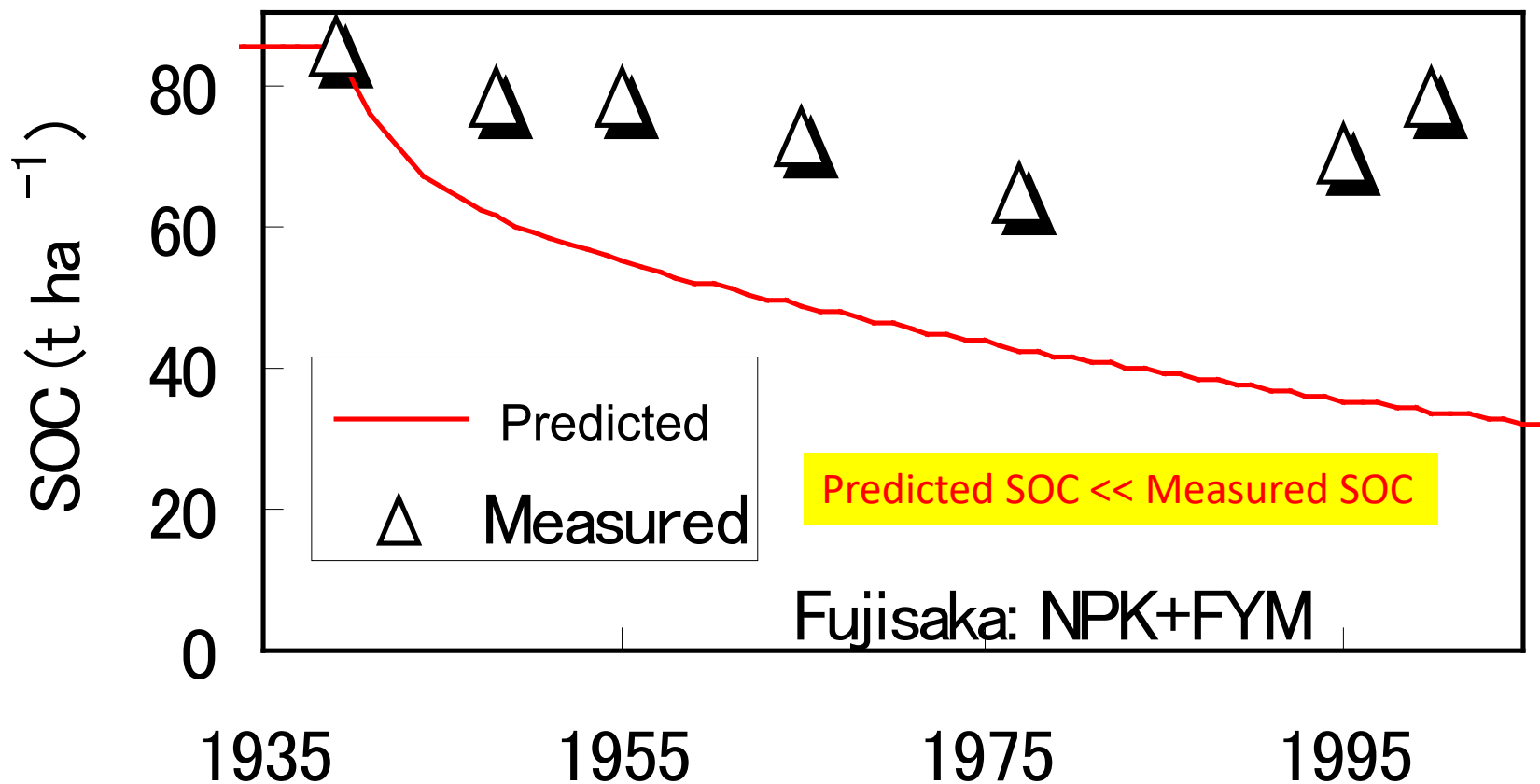
Without any
modification or
calibration.



- 6 sites under various climate condition.
- Various soil types.
- Various management.

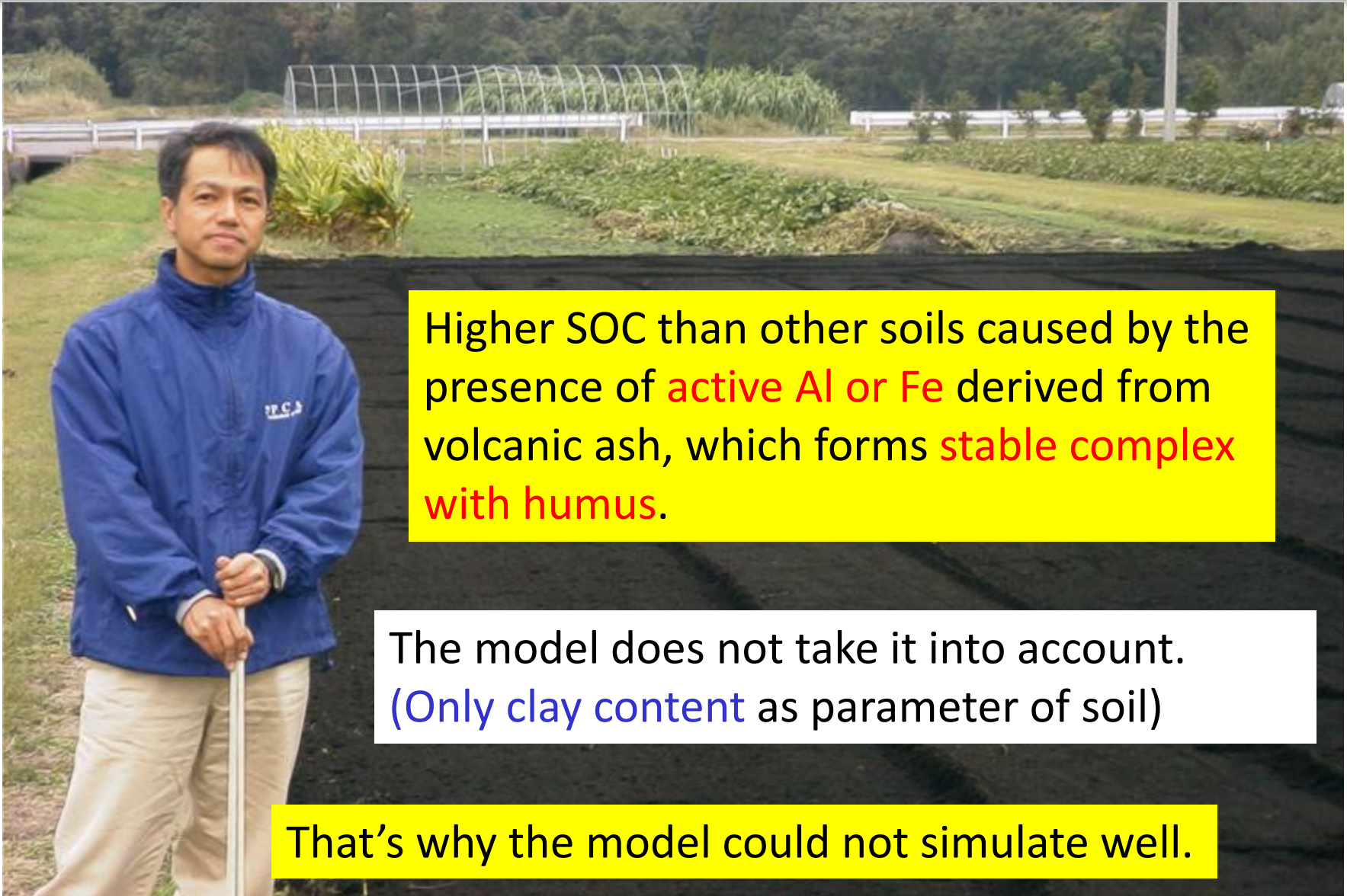
(Shirato & Taniyama, 2003)

But in Andosols.....



The model **underestimated** the SOC.

Andosols have high C concentration



Higher SOC than other soils caused by the presence of **active Al or Fe** derived from volcanic ash, which forms **stable complex with humus**.

The model does not take it into account.
(**Only clay content** as parameter of soil)

That's why the model could not simulate well.

How to modify the RothC for **Andosols**

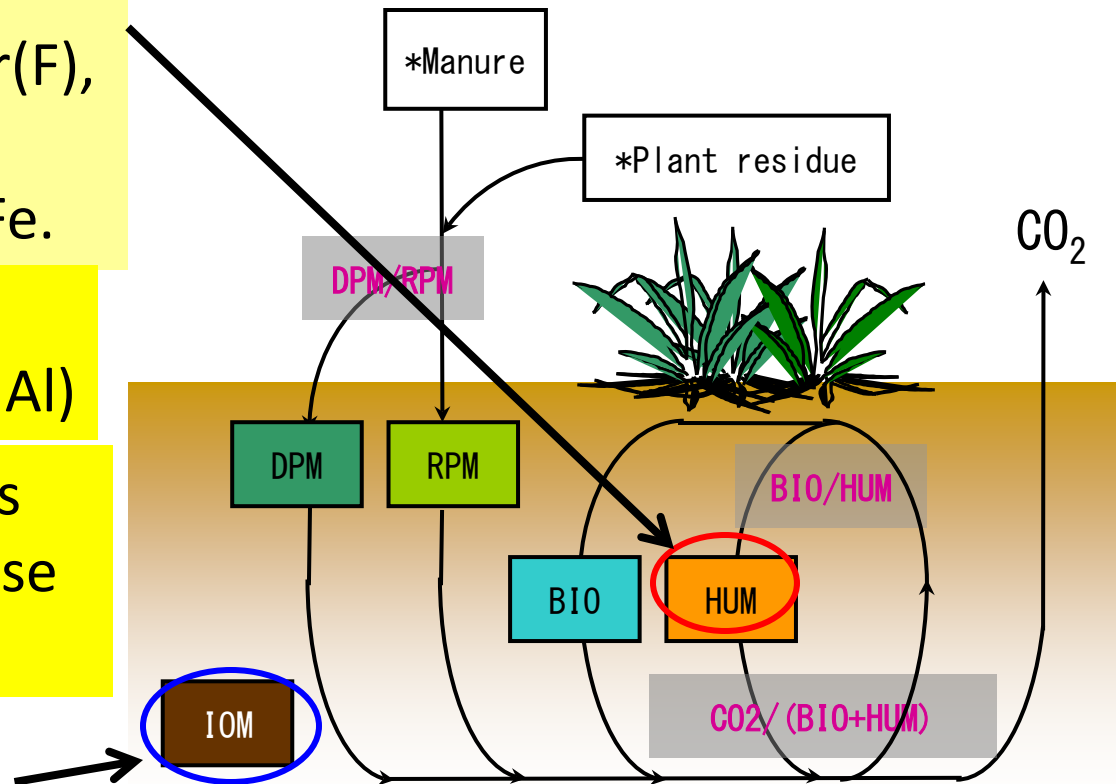
Active Al or Fe derived from volcanic ash forms **stable complex with humus** → Slow decomposition

1. Changing HUM (humus) decomposition rate constant .

by dividing with a factor(F), which changes with the amount of active Al or Fe.

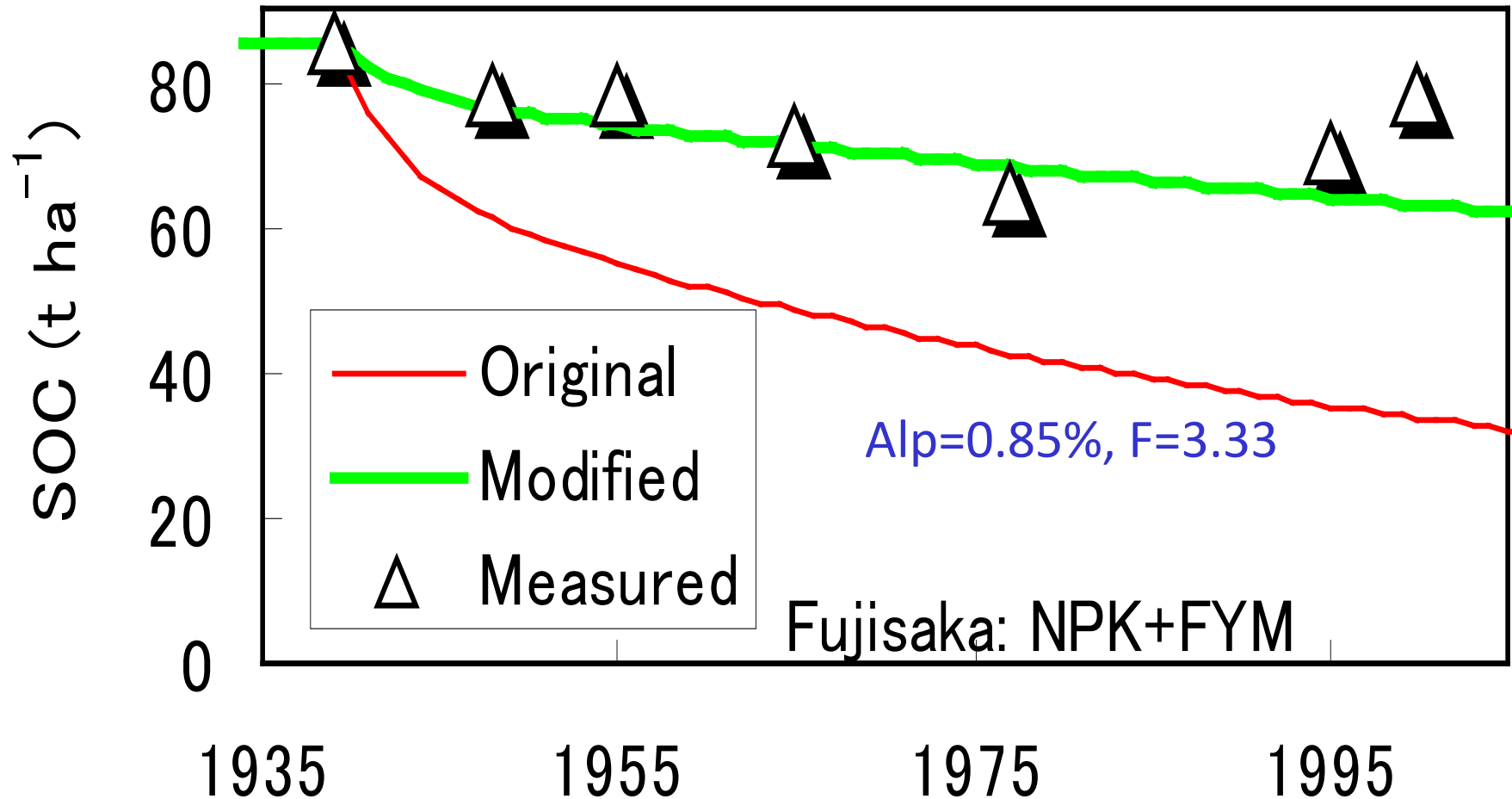
$F = 2.50 \text{ Alp} + 1.20$ (Alp: Pyrophosphate extractable Al)

In soils with much Al-humus complex, SOC decompose slowly.



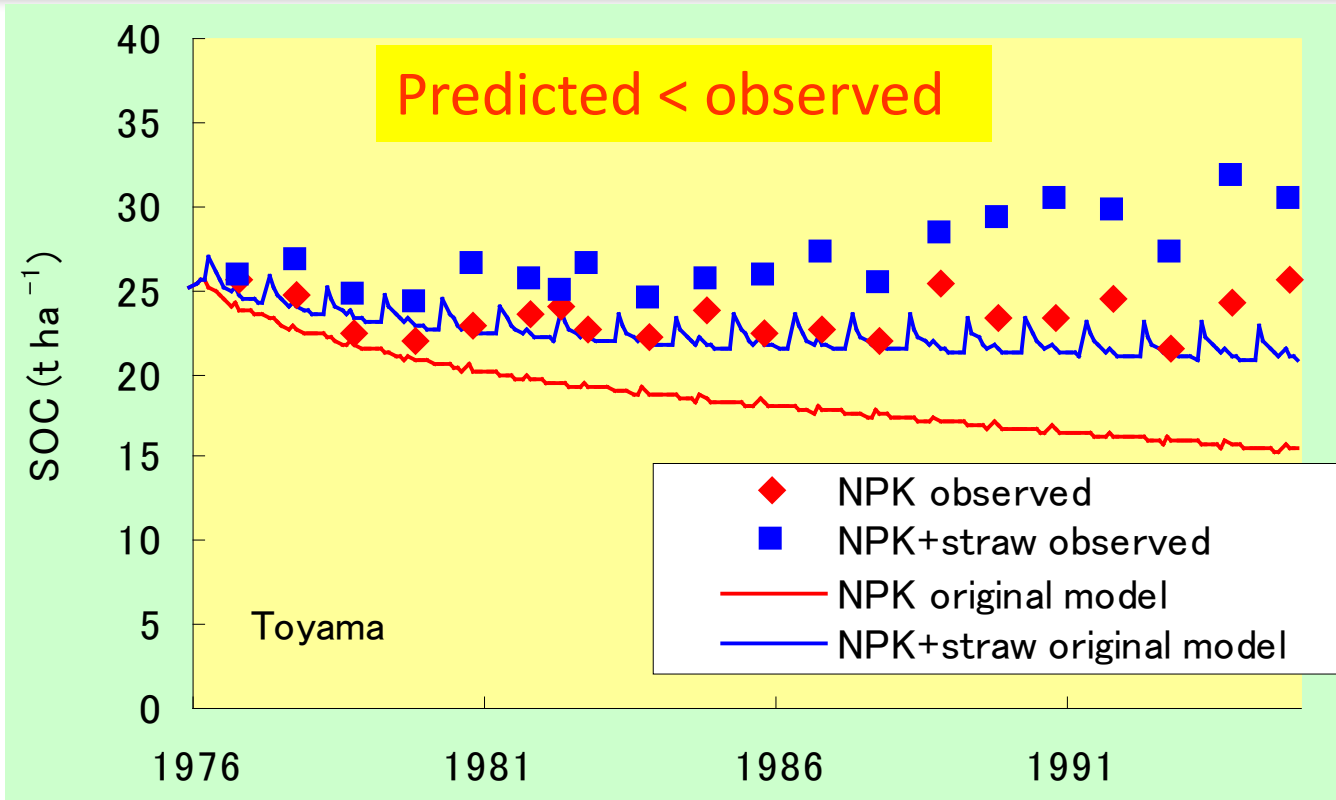
2. IOM (Inert Organic Matter)=0

Modified model for Andosols



The modified model had much improved fit with measurement data.

What happen in paddy soils ?



The model underestimated SOC, as expected
(slower decomposition because of anaerobic condition)

How to modify the RothC for paddy soils?

The model underestimated SOC, as expected
(slower decomposition because of anaerobic condition)

➤ We can slow down the decomposition rate of C in rice growing period.

➤ How about in non-rice growing period?

Paddy soils have different microorganism composition (e.g. Smaller proportion of fungi, which play major role in decomposing lignin or cellulose, than bacteria)

➔ decomposition may slower than upland soils, too.

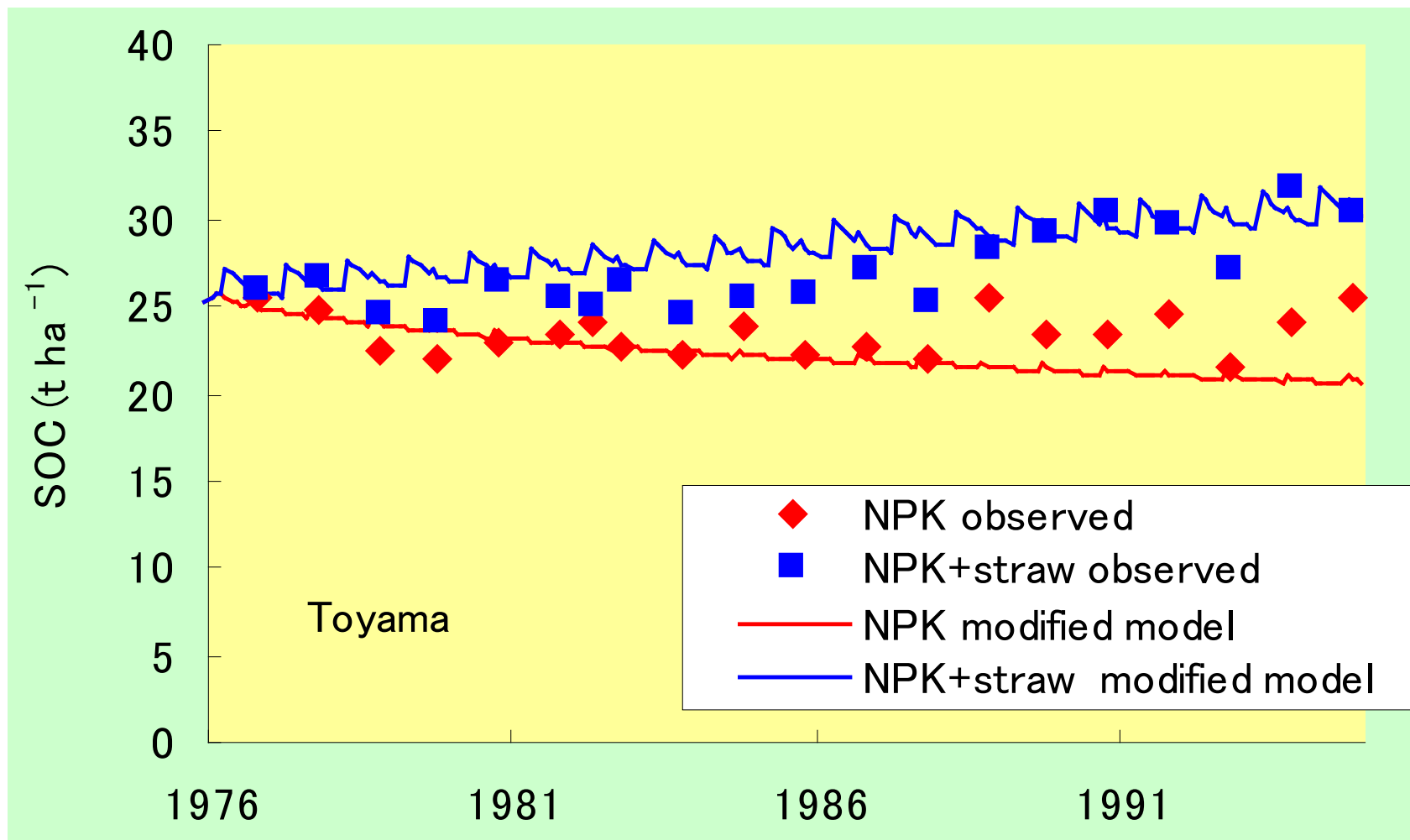
Decided to modify the model by...

1. Changing the decomposition rates of the RothC during the submergence period (summer) and the period without submergence (winter), separately.

2. Find out the optimum combinations of the decomposition rate.

Modified model for paddy soils

0.2 and 0.6 times slower decomposition rate, in rice growing season (submerged) and another period, respectively.



Good agreement with measurement.

(Shirato & Yokozawa, 2005)

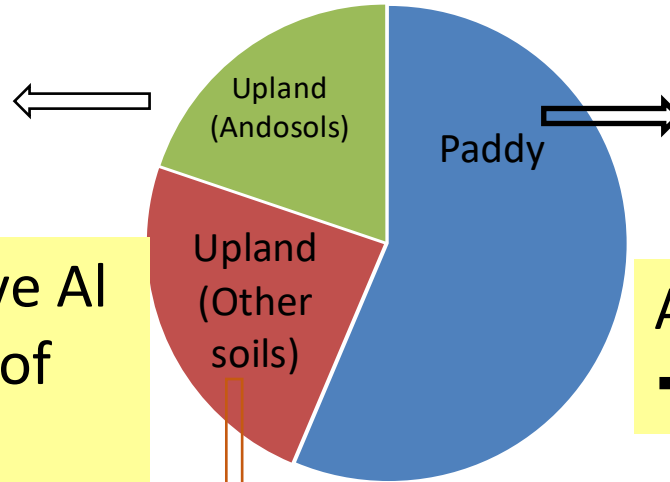
Validation and **modification** of the RothC: Japanese version

Andosols



Stable humus with active Al
→ Slow decomposition of
“HUM” pool

Arable soils: ~500 million ha

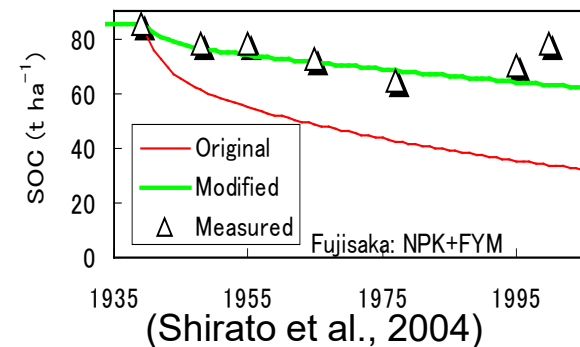


Paddy soils

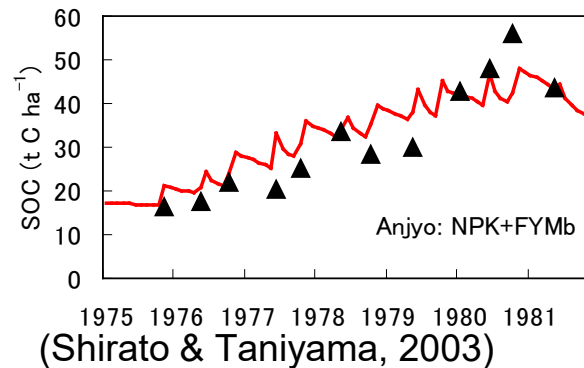


Anaerobic condition
→ Slow decomposition

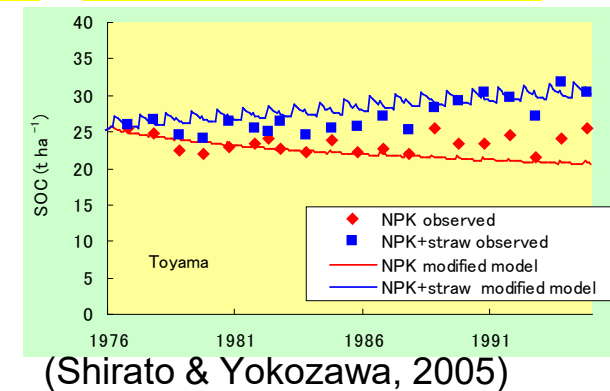
Modified model



Original RothC: successful



Modified model



→ Nationwide soil C calculation system by using 3 versions

Nationwide calculation system of soil C

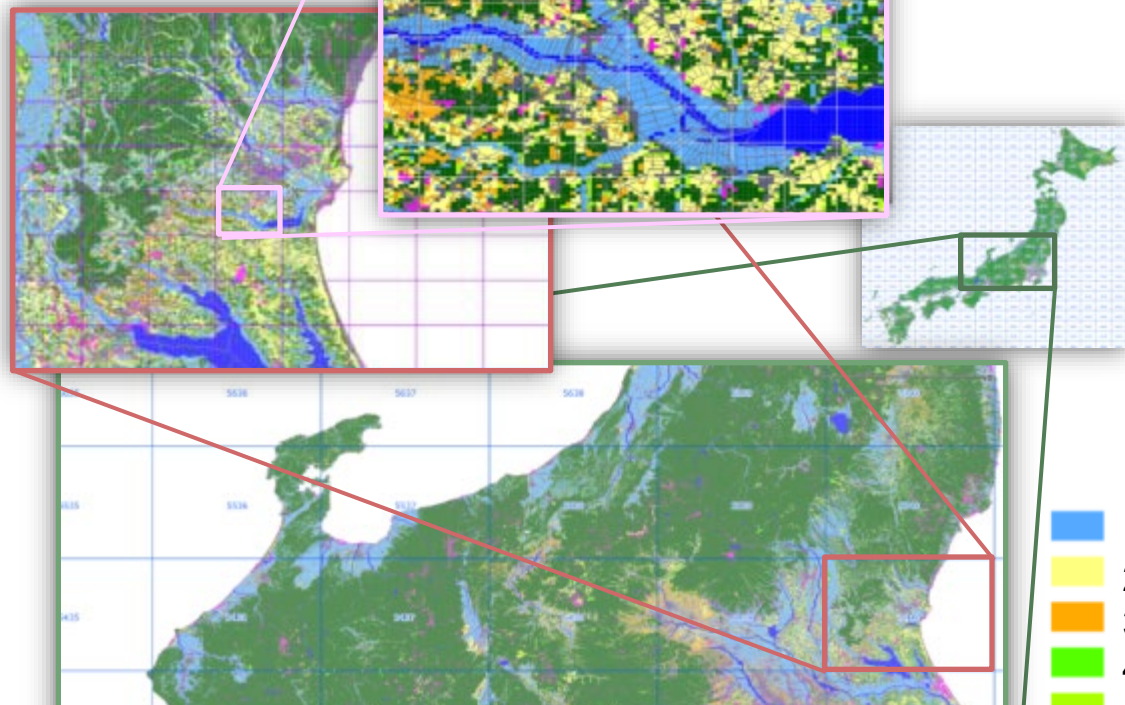
Spatial resolution: 100m × 100m grid

3rd grid: 30" x 45" ($\approx 1 \times 1$ km)

2nd grid:
5' x 7.5' ($\approx 10 \times 10$ km)

4th grid: 3" x 4.5" ($\approx 0.1 \times 0.1$ km)
total: ca. 38,000,000 grids

1st grid:
40' x 1° ($\approx 80 \times 80$ km)



✓ Soil map

✓ Land use map (1976, 1987, 1991, 1997, 2006, 2020)

✓ Meteorology (1km)

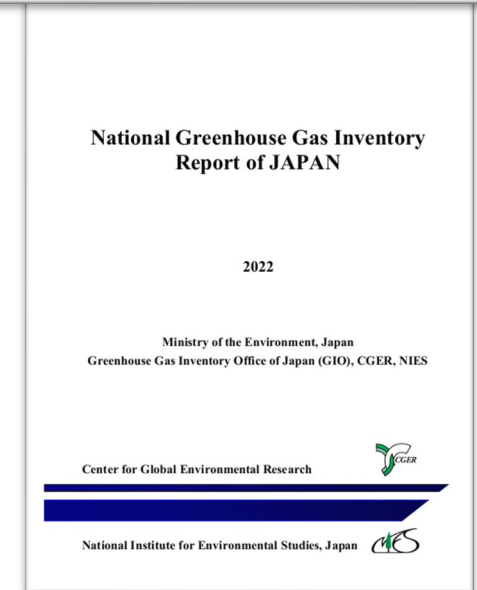
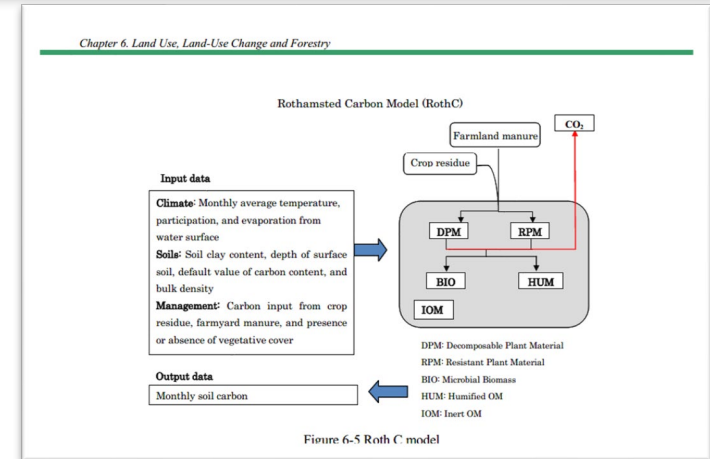
✓ Agricultural activity (47 prefecture)

→ National Inventory report (NIR) and Nationally Determined Contributions (NDC)

- 1 paddy
- 2 cropland
- 3 orchard
- 4 managed grassland
- 5 unmanaged grassland
- 6 forest lands
- 7 wetlands
- 8 settlements
- 9 other lands

Contribution to Japan's NIR and NDC

- NIR:** RothC model calculation is used for CO₂ emission/removal derived from changes in the amount of soil C in cropland & grassland from NIR 2015.
- NDC:** Cropland & grazing land management: **7.9 Mt-CO₂* removal in 2030** by **increasing organic matter input to soils.**



*Intended Nationally Determined Contributions (INDC): Greenhouse Gas Emission Reduction Target in FY2030 (Ministry of Foreign Affairs of Japan)

Web-based decision-support tool visualizing soil C and GHGs emission



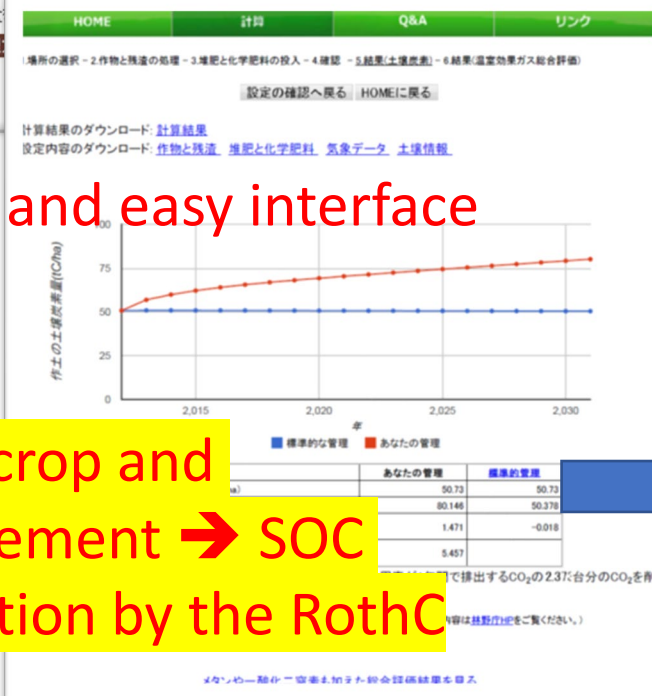
What's New

土壌のCO₂吸収量を簡単に計算できます。

本サイトでは、場所や管理の情報を入力すると、土壌のCO₂吸収量を計算することが出来ます。

あなたの畑のCO₂吸収量

調べたい場所 + 管理



Simple and easy interface

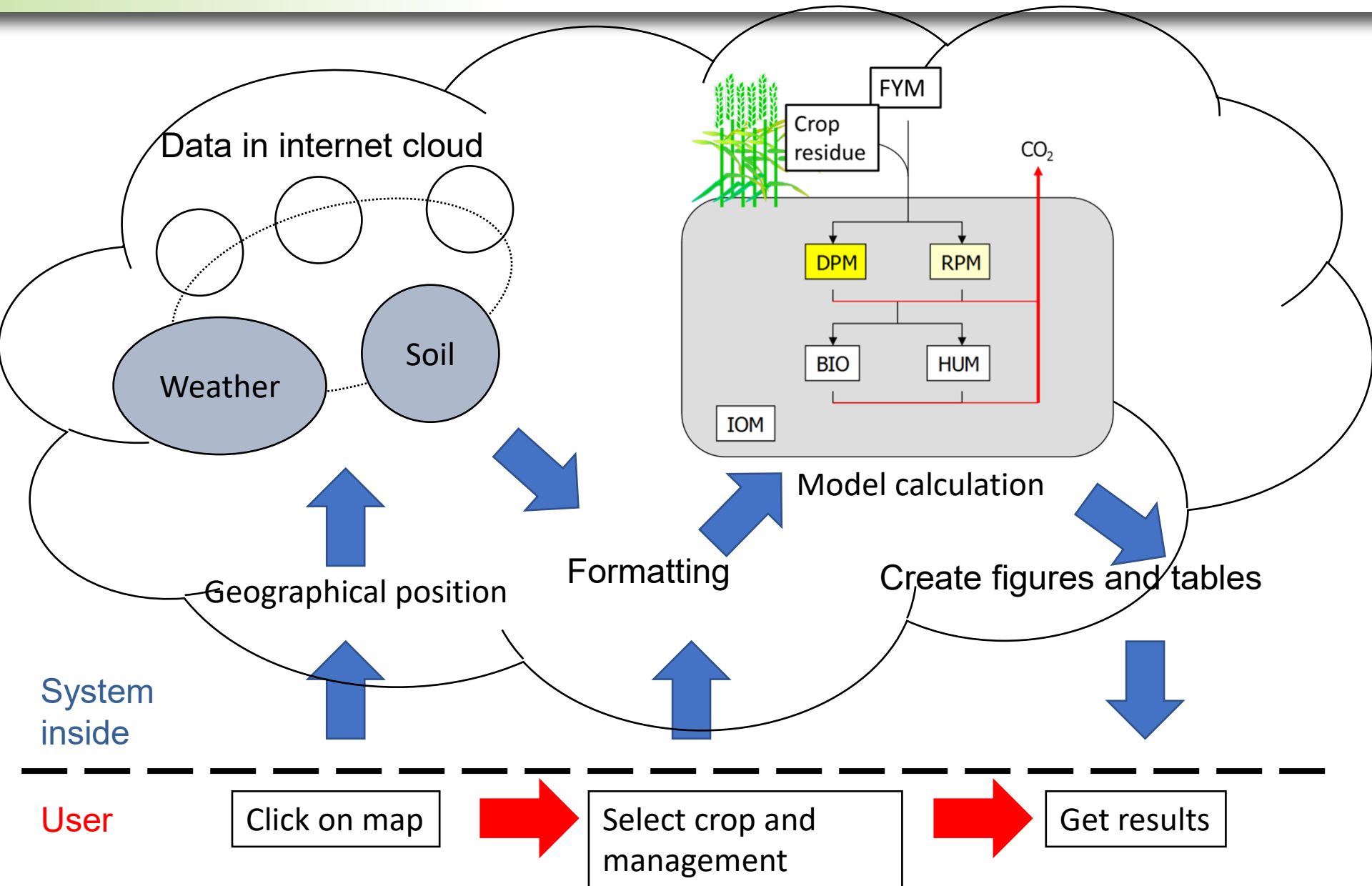
Select crop and management → SOC calculation by the RothC



	あなたの管理	標準的管理
土壌炭素の増減によるCO ₂ (tCO ₂ /ha/年) (プラスが排出。マイナスが吸収)	-3.34	0.5
メタン (g-CH ₄ /m ² /年)	10.00	10.00
CO ₂ 換算 (tCO ₂ /ha/年)	3.40	3.40
N ₂ O (kg-N ₂ O/10a)	0.13	0.07
CO ₂ 換算 (tCO ₂ /ha/年)	0.39	0.20
うち化学CO ₂ 換算	0.02	0.02
うち堆肥CO ₂ 換算	0.05	0.05
うち作物残遺由来 (kg-N ₂ O/10a)	0.08	0.01
CO ₂ 換算 (tCO ₂ /ha/年)	0.23	0.03
化石燃料由来のCO ₂ (tCO ₂ /ha/年)	0.04	0.04
CO ₂ 換算 (tCO ₂ /ha/年)	0.11	0.11
化石燃料由来のCO ₂ (tCO ₂ /ha/年)	2.02	2.02
合計 (tCO ₂ /ha/年) (プラスが排出。マイナスが吸収)	2.47	6.12

Total GWP calculation
(CO₂, CH₄, N₂O)

How it works



Asian Network of long-term experiments

Primary data (long-term experiments) is important.
Models cannot be developed without measurement data.



Since 2017

**Soil Carbon Sequestration:
needs and prospects
under the 4 per 1000 initiative**
✓ Tuesday, February 28, 2017 10 am - 5 pm
✓ Tsukuba International Congress Center (Ibaraki, Japan)

- Most of studies published on long-term field experiments are from Europe and north America. Not many from Asia.
- Networking long-term experiments in Asian countries can be valuable.
- Enormous variation in climate, soil type, and cultural practices.

Program
[Keynote]
10:10 **Claire CHENU**
Chair of Soil Science, AgroParisTech/INRA, FRANCE
Background and current status of 4 per mil Initiative,
Current understanding of soil C sequestration in agricultural lands and future directions
10:55 **Minggang Xu**
Deputy Director General, IARRP, CAAS, CHINA
Soil carbon sequestration in arable land of China based long-term field experiments
11:20 **Suphakarn LUANMANEE**
Director, DOA, MOAC, THAILAND
Effect of long-term fertilizer application and cropping management
on changing of soil properties
11:45 **Srinivasa Rao CHERUKUMALLI**
Director, ICAR-CRIDA, INDIA
Long-term field experiments in India: current status & future directions
1:00 **Hideo KUBOTERA**
CARC/NARO, JAPAN
Long-term field experiments with organic matter application
in Japanese paddy and upland fields
1:50 **Shoji MATSUURA**
NIAES, JAPAN
Long-term field experiments for soil carbon monitoring in Japanese grasslands
2:10 **Yasuhito SHIRATO**
NIAES, JAPAN
Validation and modification of soil carbon models against long-term experiments
in Japanese agricultural soils
2:30 **Jagadeesh YELURIPATI**
The James Hutton Institute, UK
Analysis of factors controlling soil organic matter dynamics
as affected by management practices: A model inter-comparison study
3:30 **Akibiko ITO**
NIAES, JAPAN
Soil carbon modeling and climate change: knowledge gaps
4:00 **Mayumi YOSHIMOTO**
NIAES, JAPAN
MINCERnet
International research network to support the fight against heat stress of rice
4:20 **Summary and Discussion (led by Rota WAGAI, NIAES, JAPAN)**



✓ Register Online
<https://opus.ezra.go.jp/form/information22.html> More information:
Institute for Agro-Environmental Sciences, NARO
NARO-MARCO Symposium Office E-mail: marco@ml.affrc.go.jp
FREE AND OPEN TO THE PUBLIC

Summary

- Japan uses IPCC Tier 3 modelling method to report CO₂ emission/removals from changes in agricultural soil C.
- The RothC model was validated and modified.
- A nationwide soil C calculation system was developed.
- This calculation system is used for NIR and NDC.
- A web-based decision support tool was developed.
- Primary data (e.g. long-term field experiments) are basis for all above.
- Soil C sequestration contribute both climate change mitigation and food security. These models and tools can help to widely disseminate mitigation options.