

Nationwide agricultural soil C calculation system for GHG inventory and NDC – Japan's experience

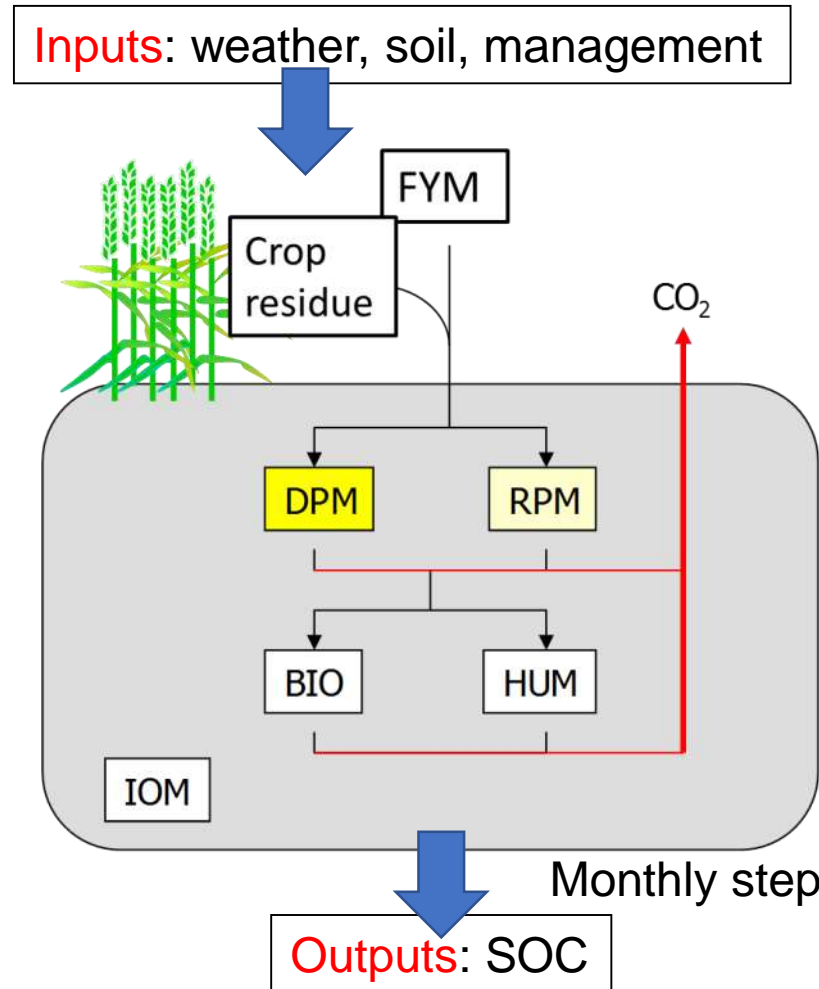
Yasuhito SHIRATO

Institute for Agro-Environmental Science, NARO

National Agriculture and Food Research Organization

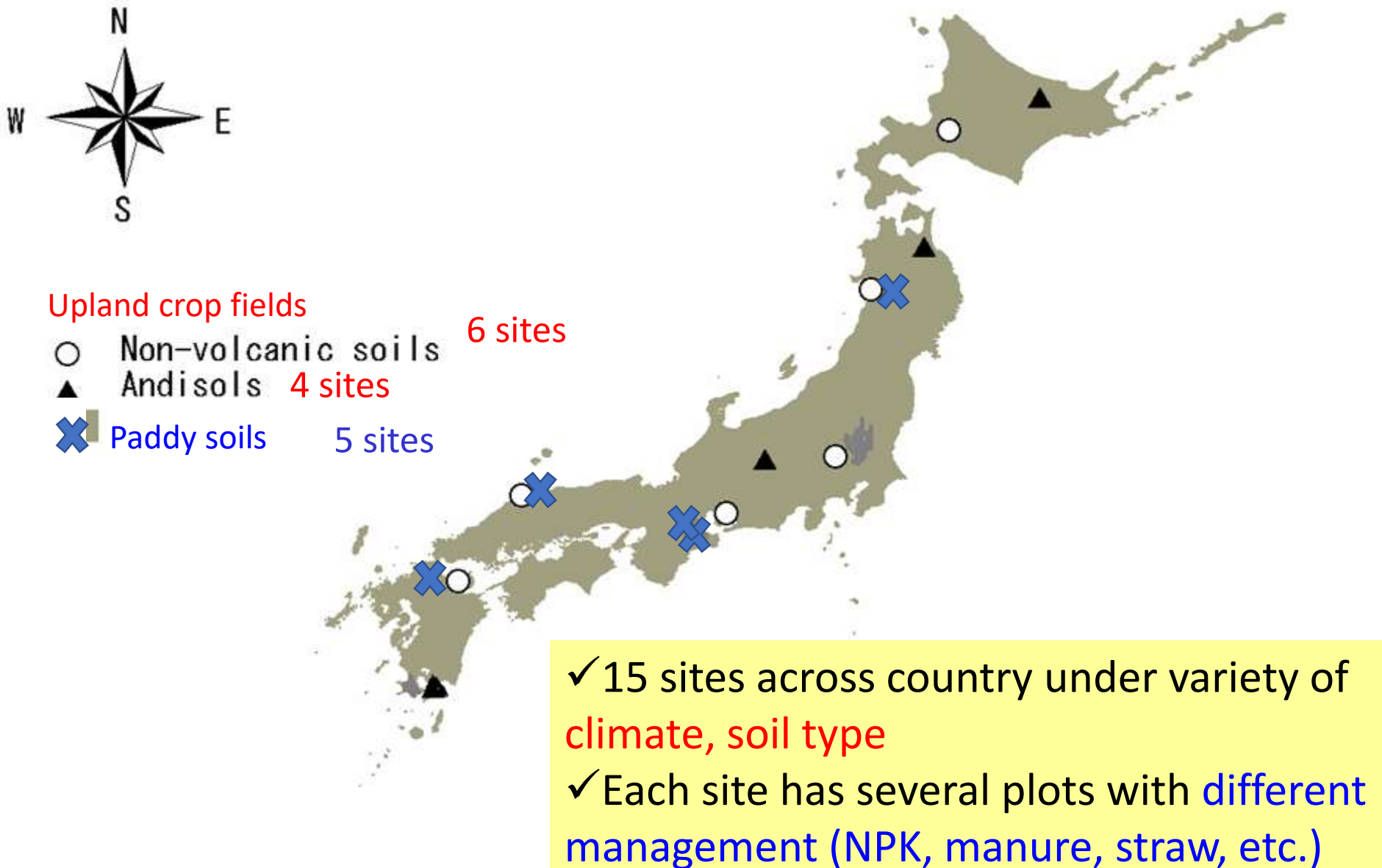
Soil C model: useful tool for future prediction and spatial evaluation

Rothamsted Carbon (RothC) model



- One of widely used soil C models developed in UK.
- Simpler structure has advantage for model modification
- Not validated in Japan

Long-term experiments for model validation

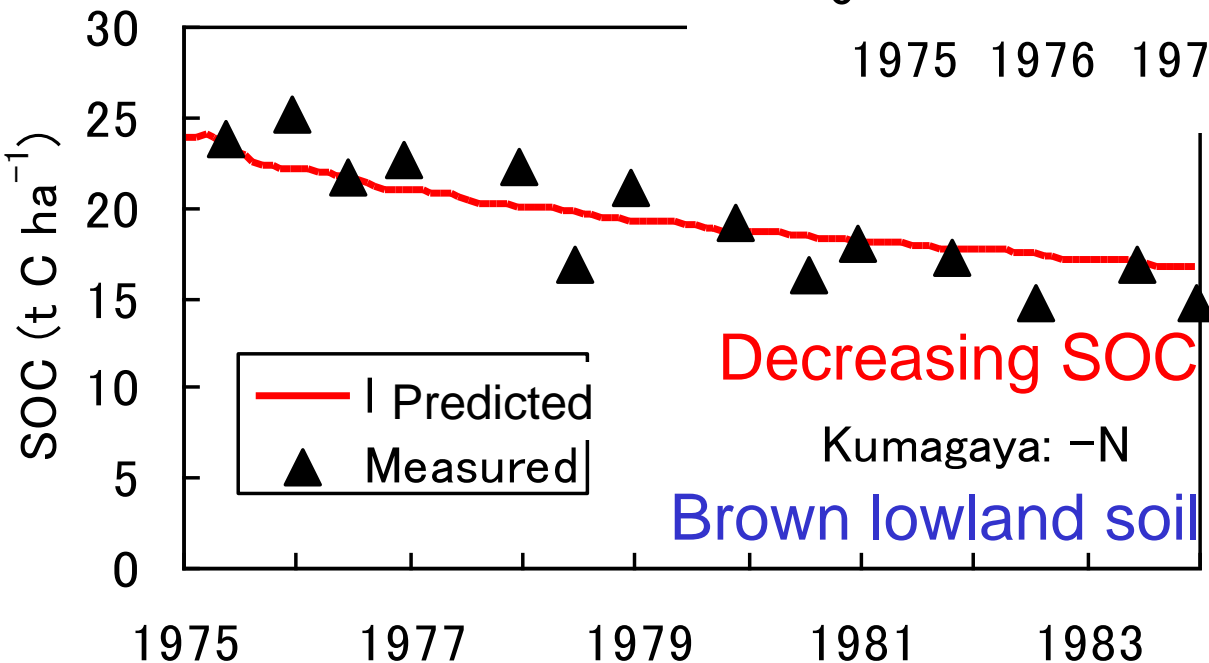
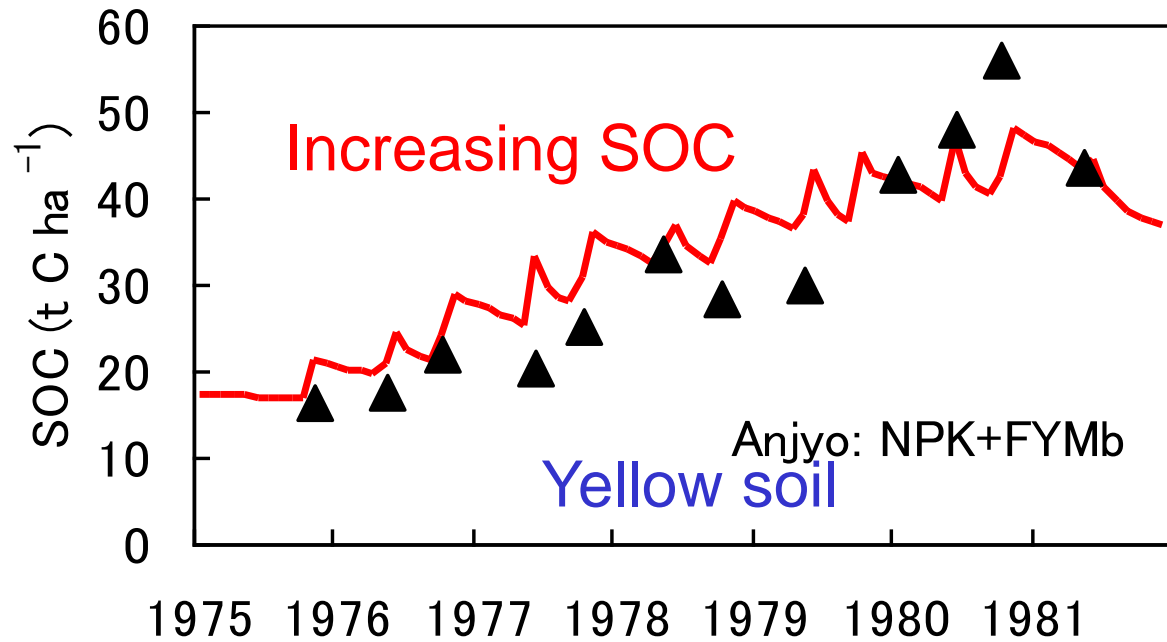




Performance of RothC in non-volcanic upland soils

Good performance

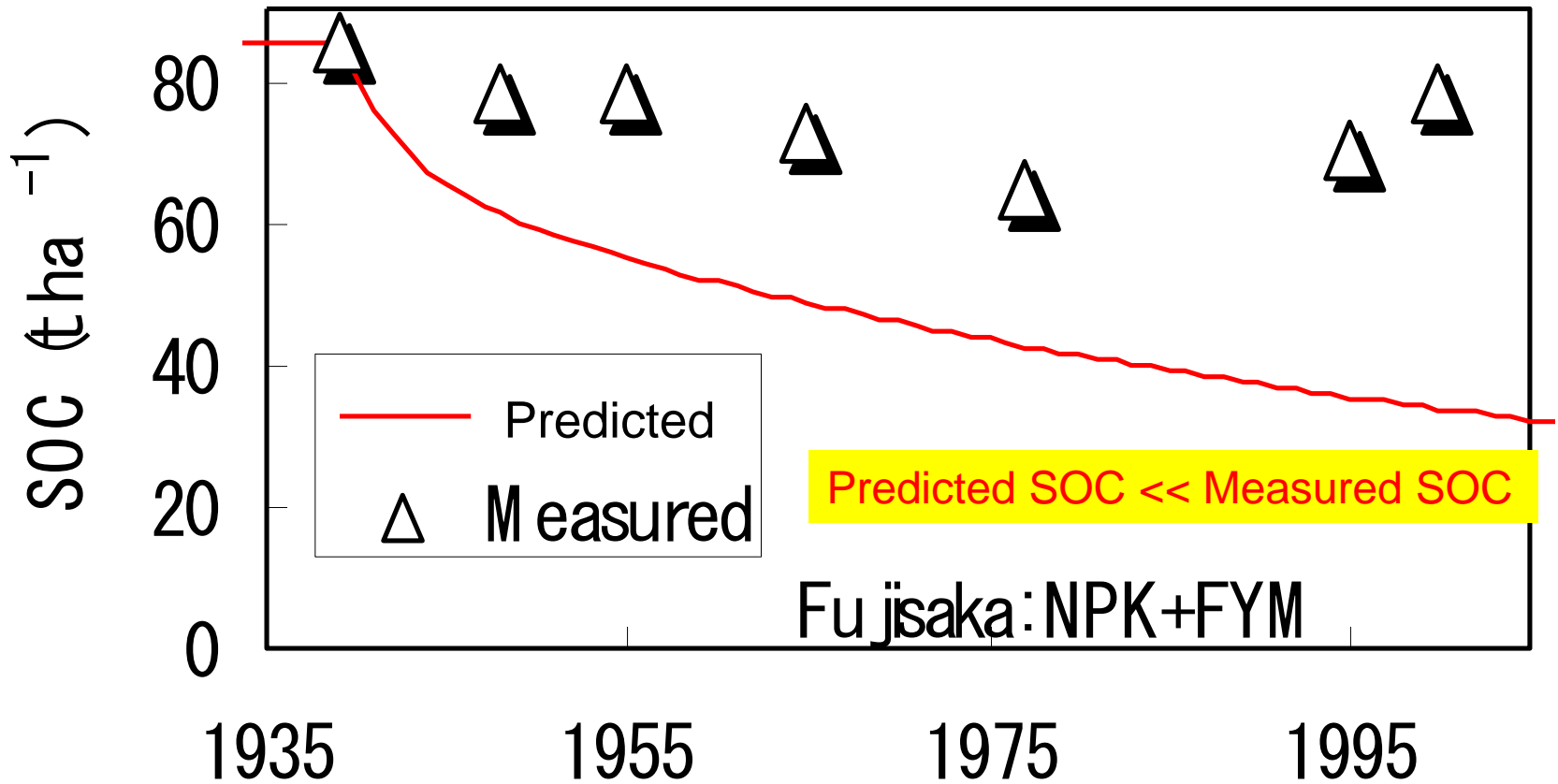
Without any modification or calibration



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

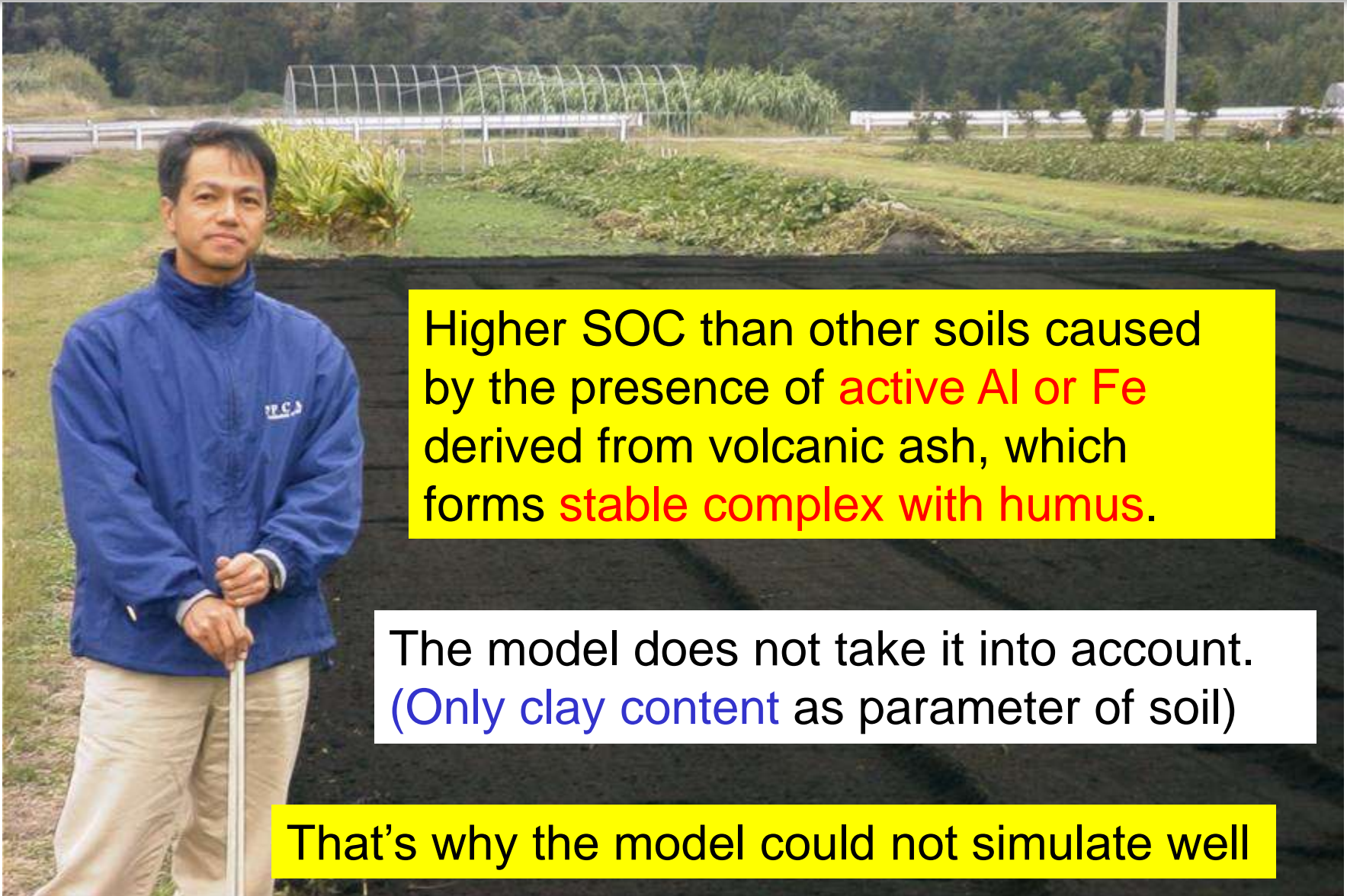
(Shirato & Taniyama, 2003)

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**

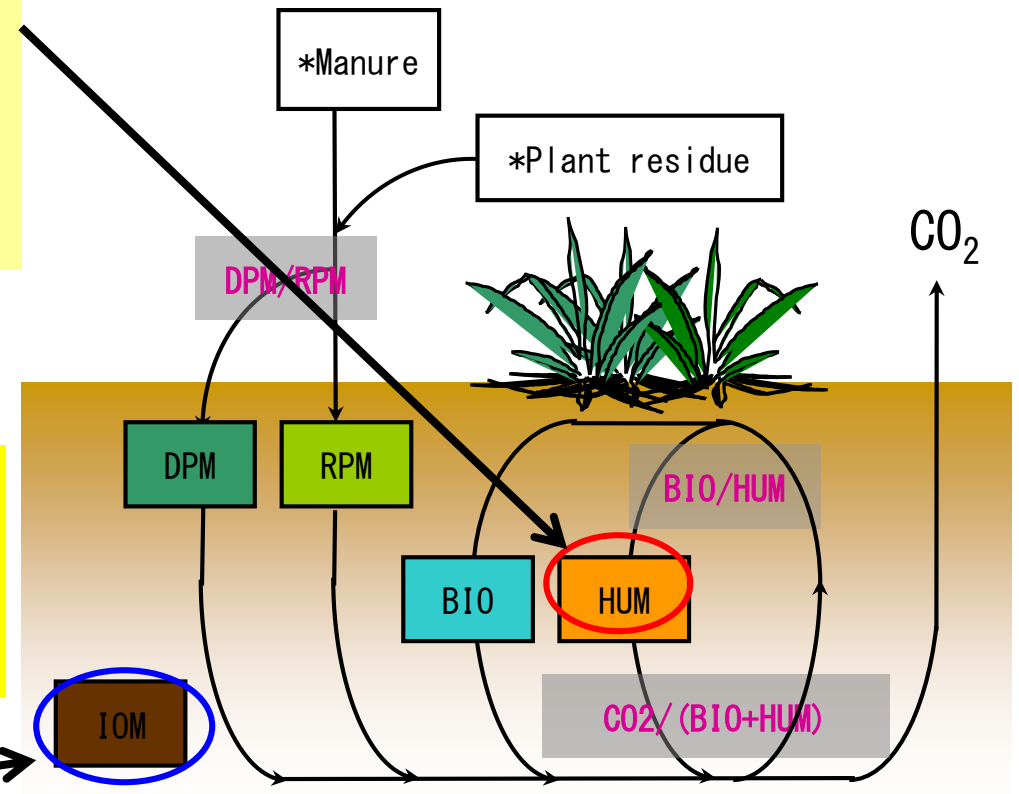
Active Al or Fe derived from volcanic ash forms **stable complex with humus** → Slow decomposition

1. Changing HUM decomposition rate constant by dividing with a factor (F), which changes with the amount of active Al or Fe

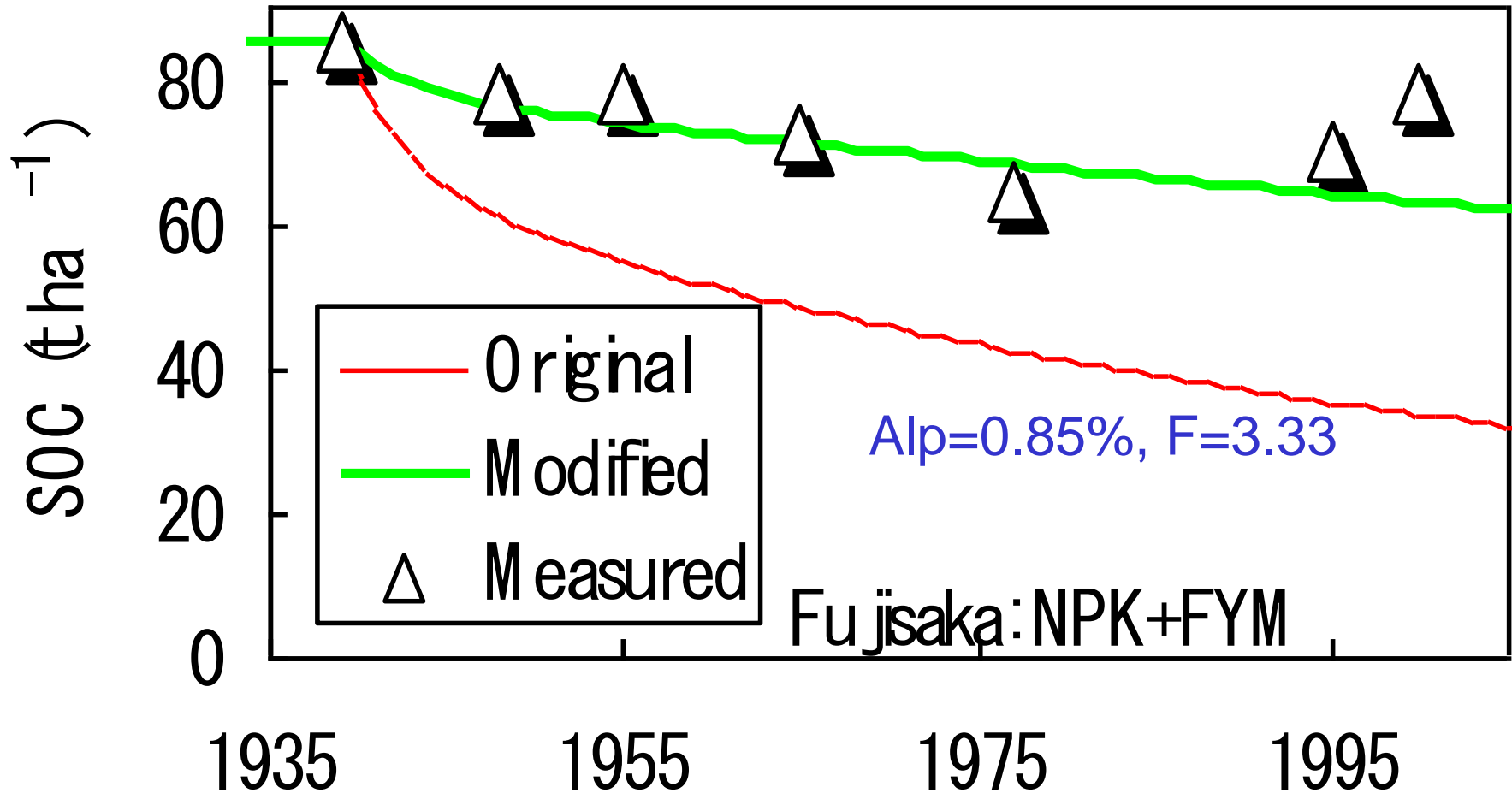
$$F = 2.50 A_{lp} + 1.20 \quad (A_{lp}: \text{Pyrophosphate extractable Al})$$

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

2. IOM=0

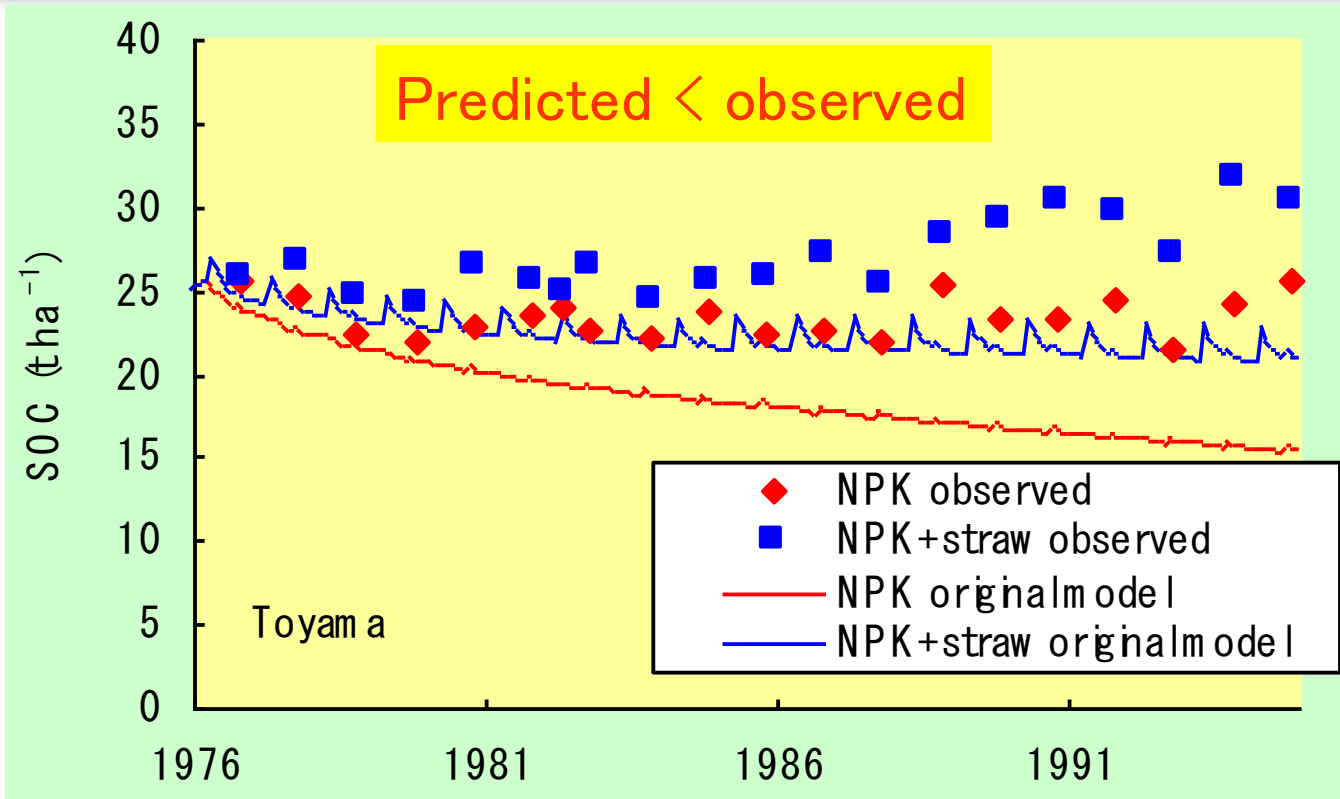


Modified model for Andosols



Better performance than original model

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?



➤ Predicted SOC < observed

➔ Slower decomposition in paddy soils than upland (expected)

➤ Rice growing period: anaerobic condition ➔ decomposition may slow

➤ 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.

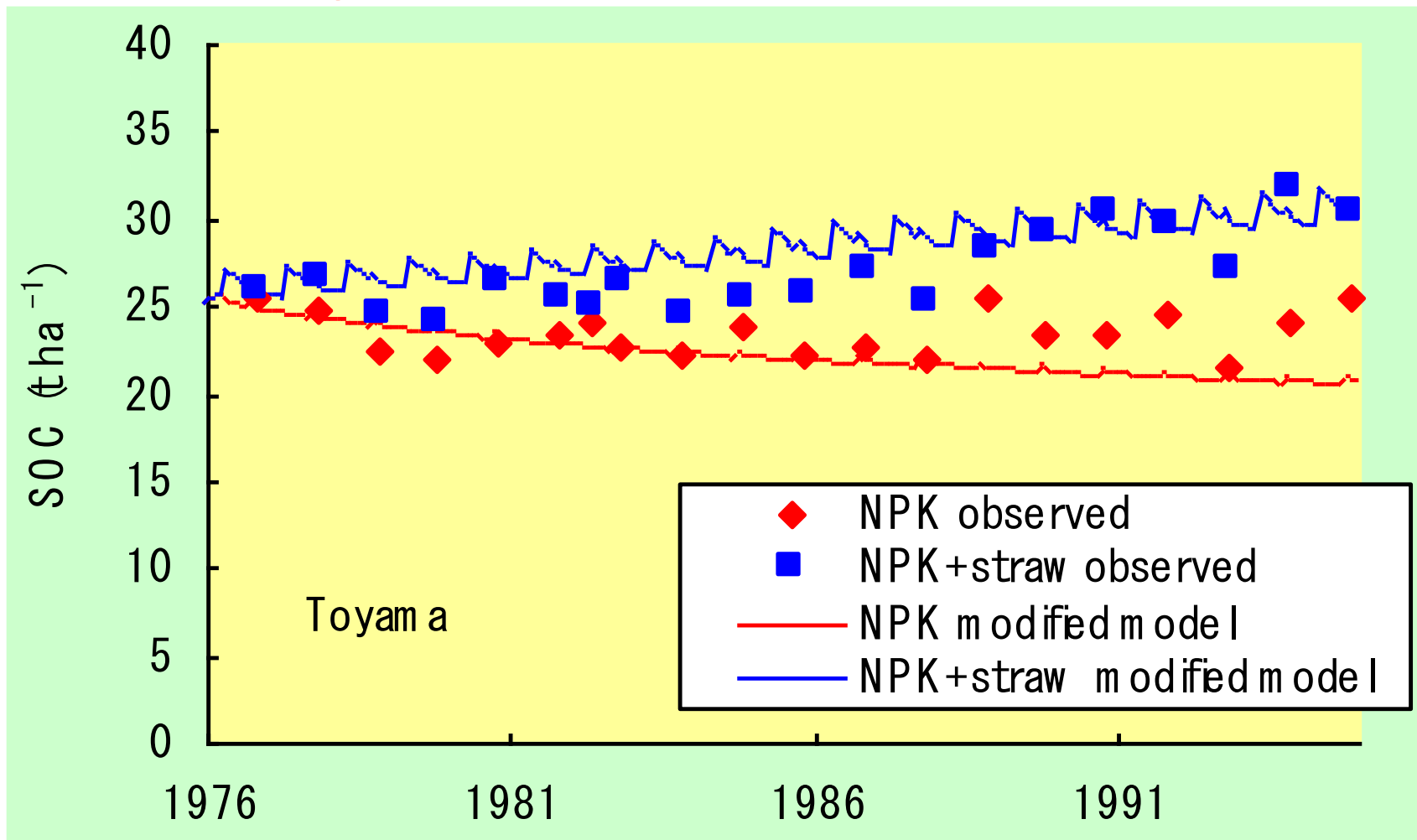
Decided to modify the model by...

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 other period, respectively



Good agreement

(Shirato & Yokozawa, 2005)

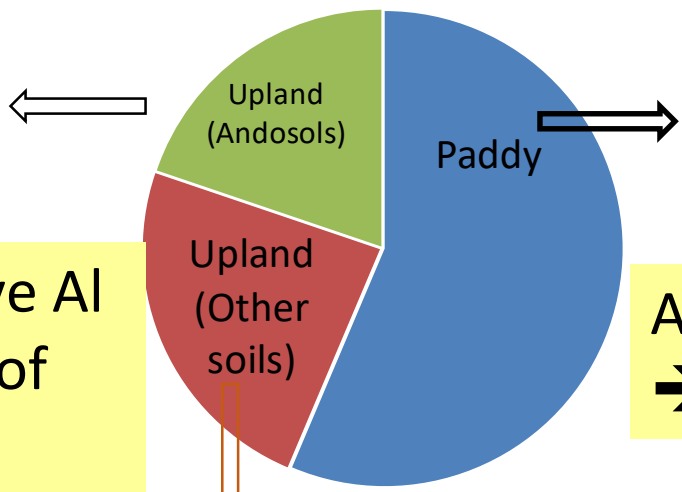
Validation and **modification** of the RothC: Japanese version

Andosols



Stable humus with active Al
 → Slow decomposition of
 "HUM" pool

Arable soils: ~500 million ha

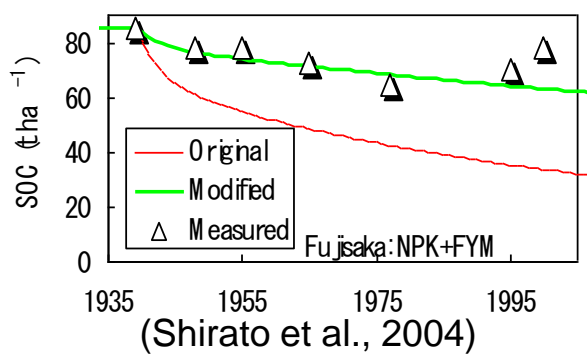


Paddy soils

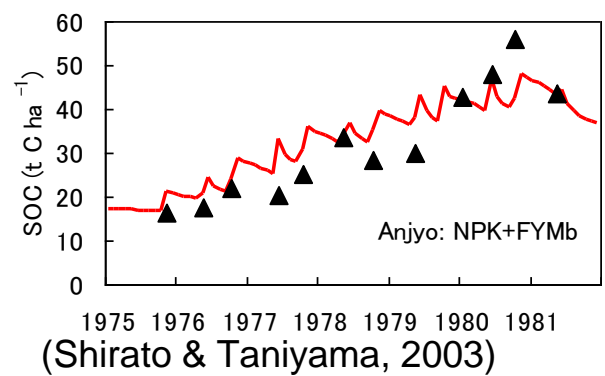


Anaerobic condition
 → Slow decomposition

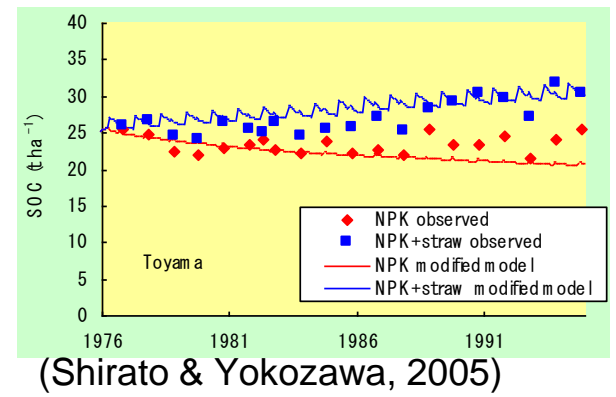
Modified model



Original RothC: successful



Modified model



→ Nationwide soil C calculation system by using 3 versions

Nationwide calculation system of soil C

Spatial resolution: 100m x 100m grid

3rd grid: 30" x 45" (\cong 1 x 1 km)

2nd grid:
5' x 7.5'
(\cong 10 x 10 km)

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

1st grid:
40' x 1°
(\cong 80 x 80 km)

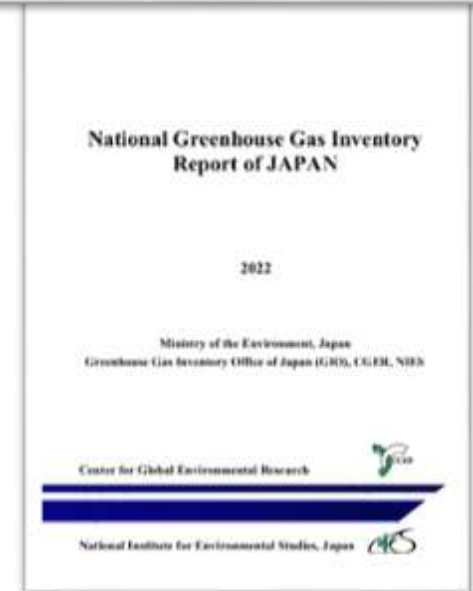
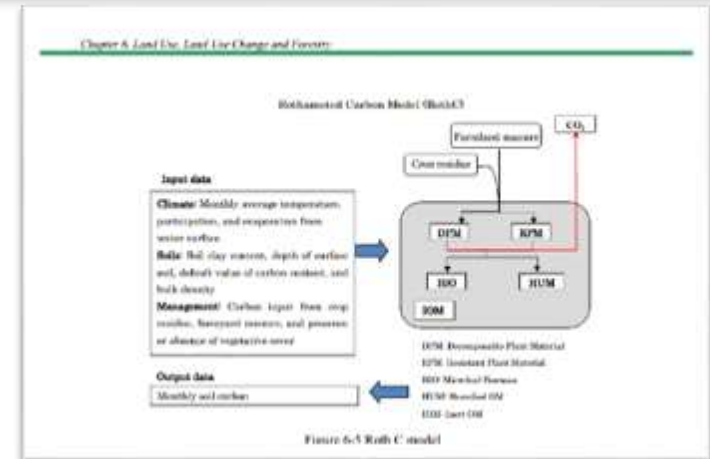
- ✓ Soil map
- ✓ Land use map (1976, 1987, 1991, 1997, 2006, 2020)
- ✓ Weather (1km)
- ✓ Agricultural activity (47 prefecture)

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

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

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。
 このサイトでは、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。
 あなたの場の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



Click on map to get weather and soil data of the field

	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)	0.11	0.07
CO ₂ 換算	0.20	0.20
うち化学肥料由来		
CO ₂ 換算 (tCO ₂ /ha/年)	0.05	0.05
うち堆肥由来 (kg-N ₂ O/10a)	0.08	0.01
CO ₂ 換算 (tCO ₂ /ha/年)	0.23	0.03
うち作物残渣由来 (kg-N ₂ O/10a)	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/yr) (プラスが排出、マイナスが吸収)	2.47	6.12

Total GWP calculation, too

Asian Network of long-term experiments

Highlight the importance of long-term field monitoring



Since 2017

NARO-MARCO International Symposium

Soil Carbon Sequestration: needs and prospects under the 4 per 1000 initiative

✓ Tuesday, February 28, 2017 10 am - 5 pm
 ✓ Tsukuba International Congress Center (Baraki, Japan)

Program

- 10:00 Claire CHENU
 Chair of Soil Science, AgroParisTech/INRA, FRANCE
 Background and current status of 4 per 1000 initiative
 Current understanding of soil C sequestration in agricultural lands and future directions
- 10:30 Minggang XU
 Deputy Director General, MARP, CAS, CHINA
 Soil carbon sequestration in arable land of China based on long-term field experiments
- 11:00 Suphakorn LUAMMANE
 Director, DGA, MOAC, THAILAND
 Effect of long-term soil tillage and cropping management on changing of soil proper ties
- 11:40 Srinivasa Rao CHETTESIMALI
 Director, IARI-ORISA, INDIA
 Long-term field experiments in India: current status & future directions
- 1:40 Hideo KUBOTERA
 CARIZAWA, JAPAN
 Long-term field experiments with organic matter application in Japanese paddy and upland fields
- 3:00 Shoji MATSUDA
 MAES, JAPAN
 Long-term field experiments for soil carbon monitoring in Japanese grasslands
- 3:30 Yasuhito SHIRATO
 MAES, JAPAN
 Validation and re-evaluation of soil carbon models against long-term experiments in Japanese agricultural soils
- 4:00 Jagadeesh YALLAPATI
 The James Hutton Institute, UK
 Analysis of factors controlling soil organic matter dynamics as affected by management practices: A model inter-comparison study
- 4:30 Akiko Ito
 MAES, JAPAN
 Soil carbon modeling and climate change knowledge gaps
- 4:50 Mayumi YOSHIMOTO
 MAES, JAPAN
 MARCO I-Net
 International research network to support the fight against food stress of rice
- 4:50 Summary and Discussion (led by Rota WAGAI, MAES, JAPAN)

Register Online
<http://www.naro.ac.jp/marco2017/>
 FREE AND OPEN TO THE PUBLIC

More information:
 Institute for Agro-Environmental Sciences, NARO
 NARO-MARCO Symposium Office | E-mail: marco@affrc.go.jp

- 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 add new value.
- Enormous variation in climate, soil type, and cultural practices.

