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Visualization of changes in soil carbon and greenhouse gas emission from soil

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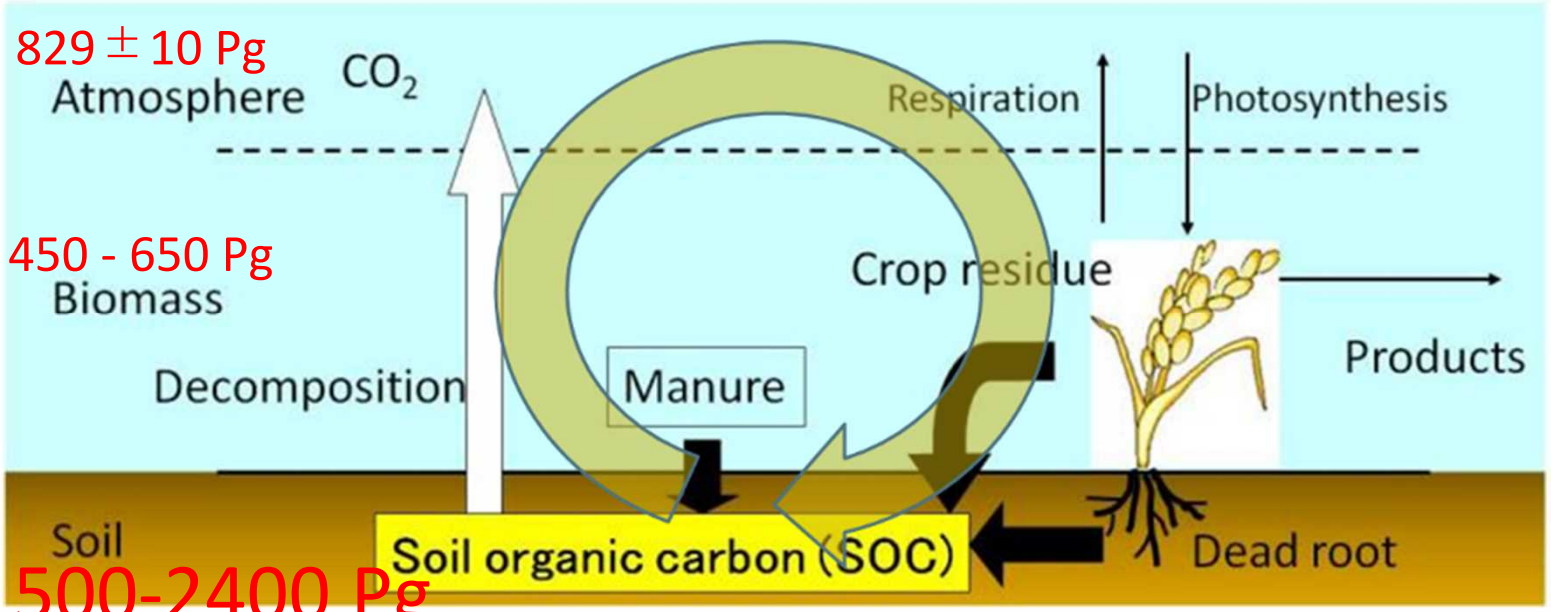
Soil carbon (C) sequestration & climate change mitigation



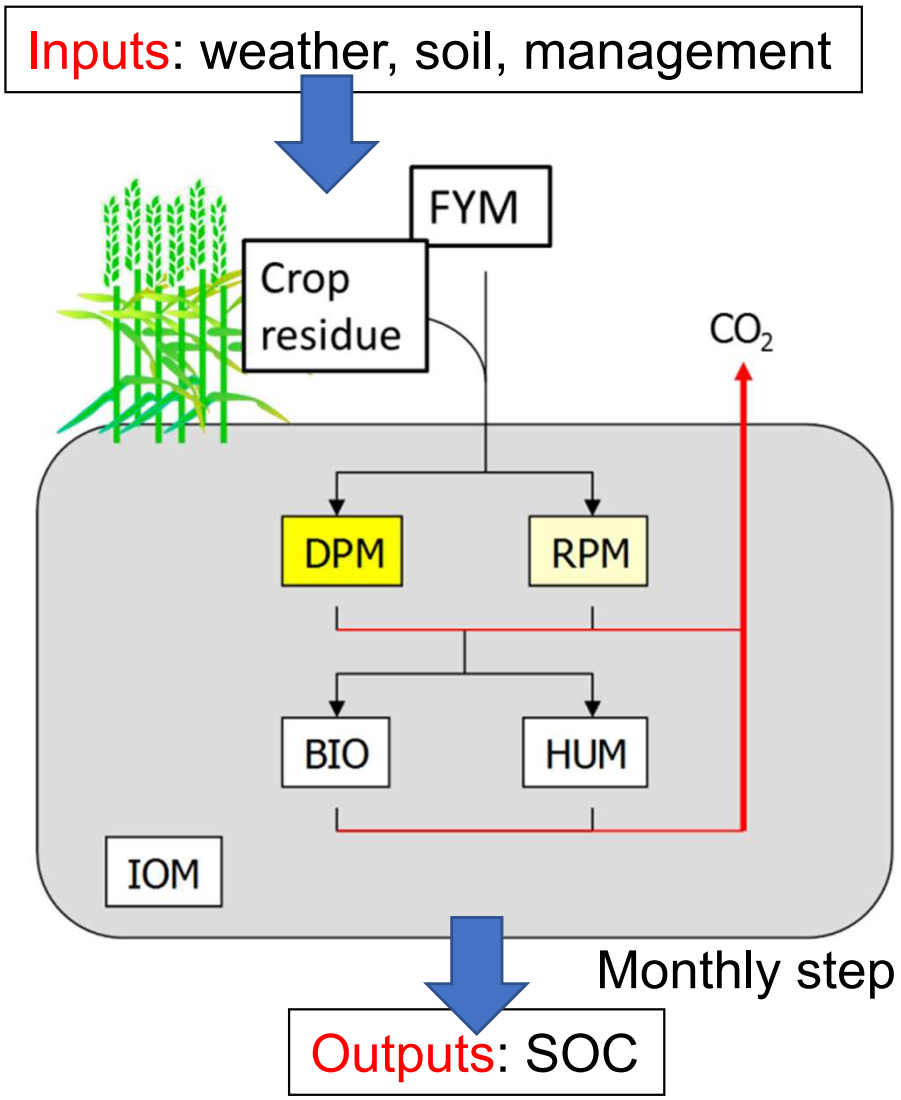
- "Carbon" accumulated as dark-colored "soil organic matter": Important index of productivity
- Size of soil C pool is huge.

"The 4 per 1000 initiative" for soil C sequestration

Storing C in soils has huge potential to mitigate increase in atmospheric CO_2 and contribute to sustainable food production

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

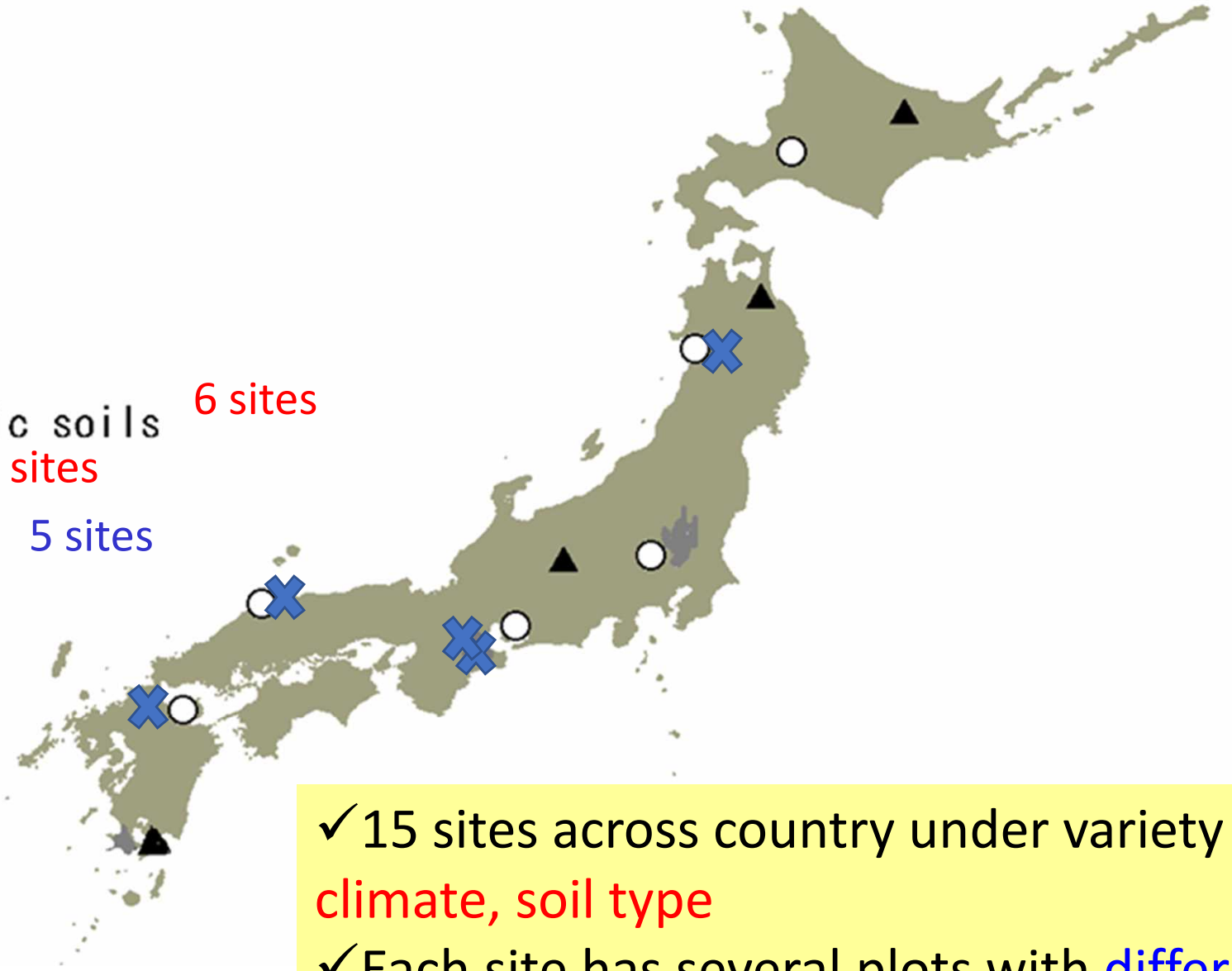
Long-term experiments for model validation

Upland crop fields

○ Non-volcanic soils 6 sites

▲ Andisols 4 sites

✖ Paddy soils 5 sites



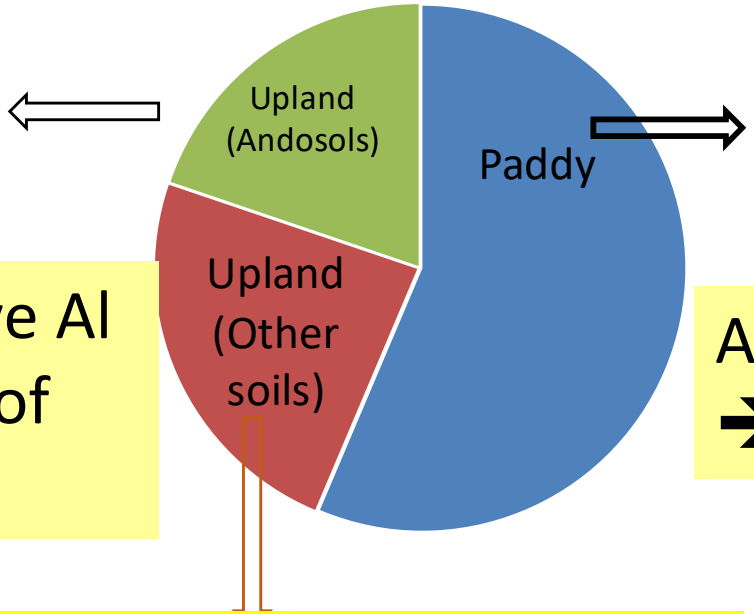
✓15 sites across country under variety of climate, soil type

✓Each site has several plots with different management (NPK, manure, straw, etc.)

Validation and modification of the RothC: Japanese version

Andosols

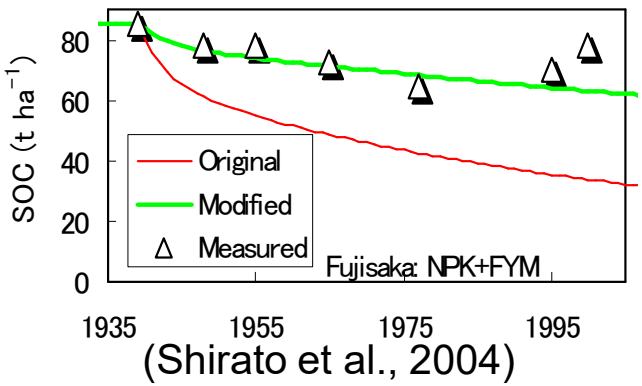
Stable humus with active Al
➔Slow decomposition of "HUM" pool



Paddy soils

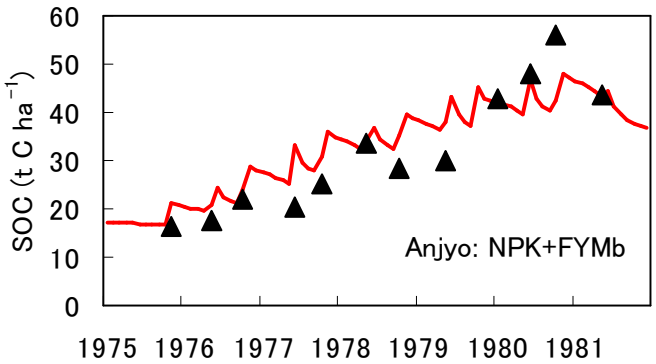
Anaerobic condition
➔Slow decomposition

Modified model



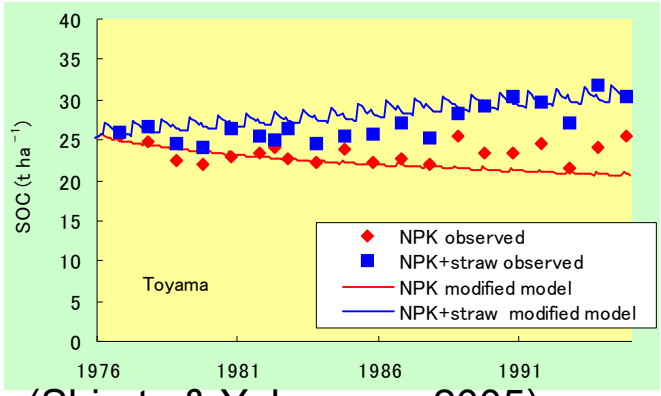
(Shirato et al., 2004)

Original RothC: successful



(Shirato & Taniyama, 2003)

Modified model



(Shirato & Yokozawa, 2005)

➔Nationwide soil C calculation system by using 3 versions

Nationwide calculation system of soil C

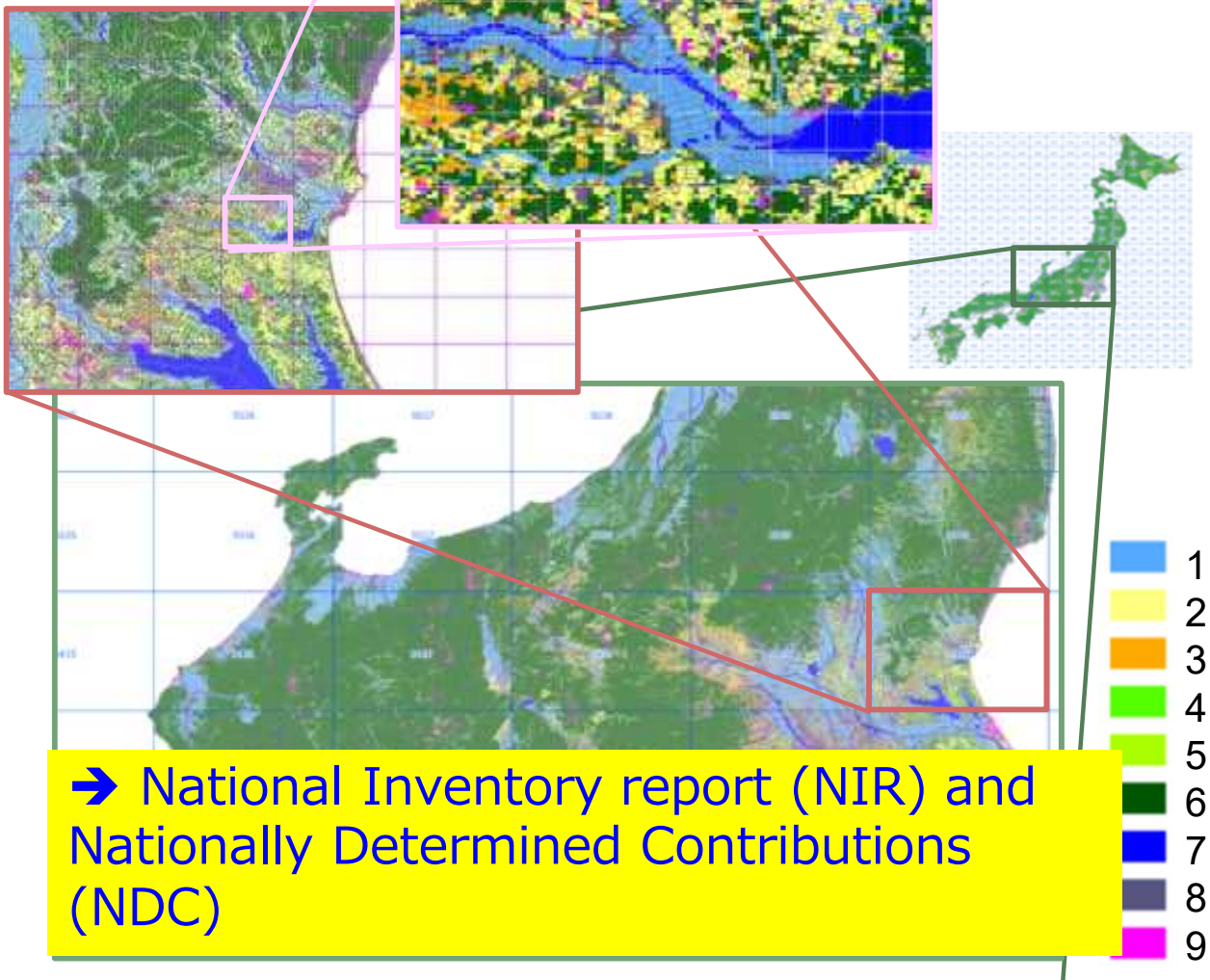
Spatial resolution: 100m × 100m grid

1st grid: 40′ x 1° (≒80 x 80 km)

2nd grid: 5′ x 7.5 ′ (≒ 10 x 10 km)

3rd grid: 30″ x 45″ (≒ 1 x 1 km)

4th grid: 3″ x 4.5″ (≒ 0.1 x 0.1 km)
total: ca. 38,000,000 grids



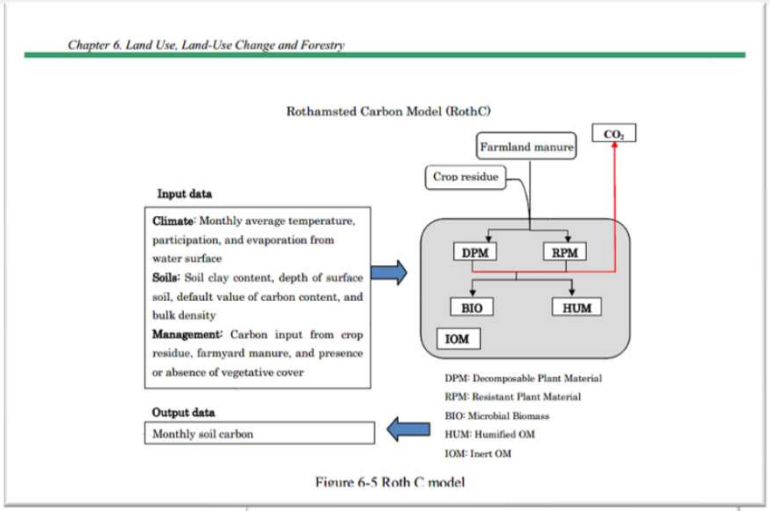
- ✓Soil map
- ✓Land use map (1976, 1987, 1991, 1997, 2006, 2020)
- ✓Weather (1km)
- ✓Agricultural activity (47 prefecture)

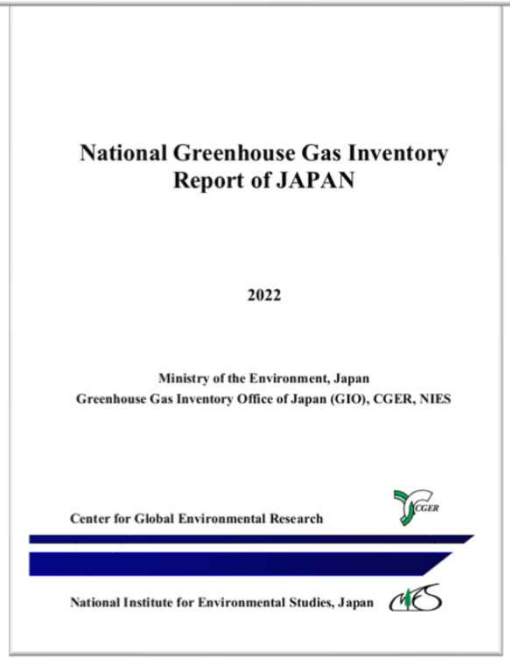
1 paddy
2 cropland
3 orchard
4 managed grassland
5 unmanaged grassland
6 forest lands
7 wetlands
8 settlements
9 other lands

➔ 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.



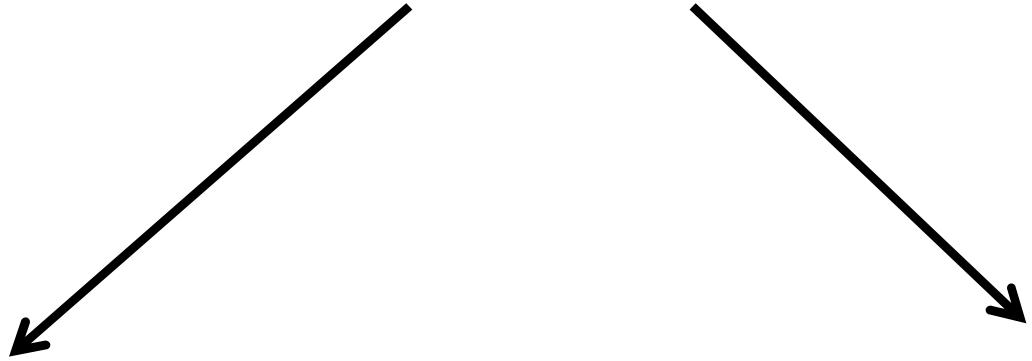


- NDC: Cropland & grazing land management: 7.9 Mt-CO2* removal in 2030 by increasing organic matter input to soils

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

Trade-off: need to evaluate total Global Warming Potential (GWP)

e.g. Increase C inputs to soils



Soil C increase (CO_2 decrease)

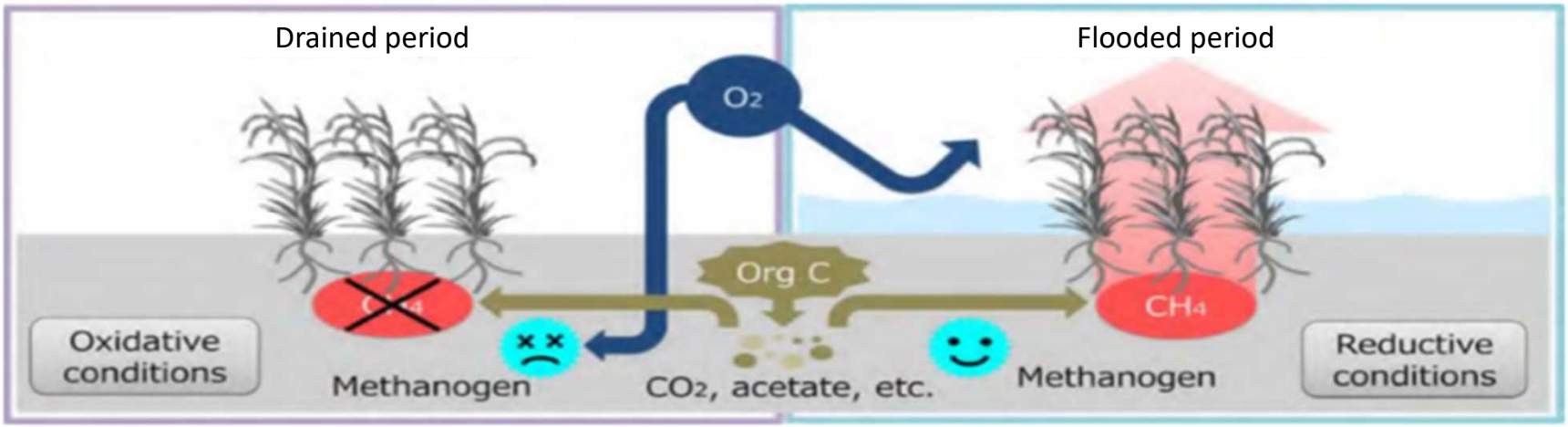
Trade-off

CH_4 and N_2O increase

Total GWP?

- Evaluating total GHGs (GWP) considering “Trade- off”.
- GWP (CO2=1, CH4=25, N2O=298)

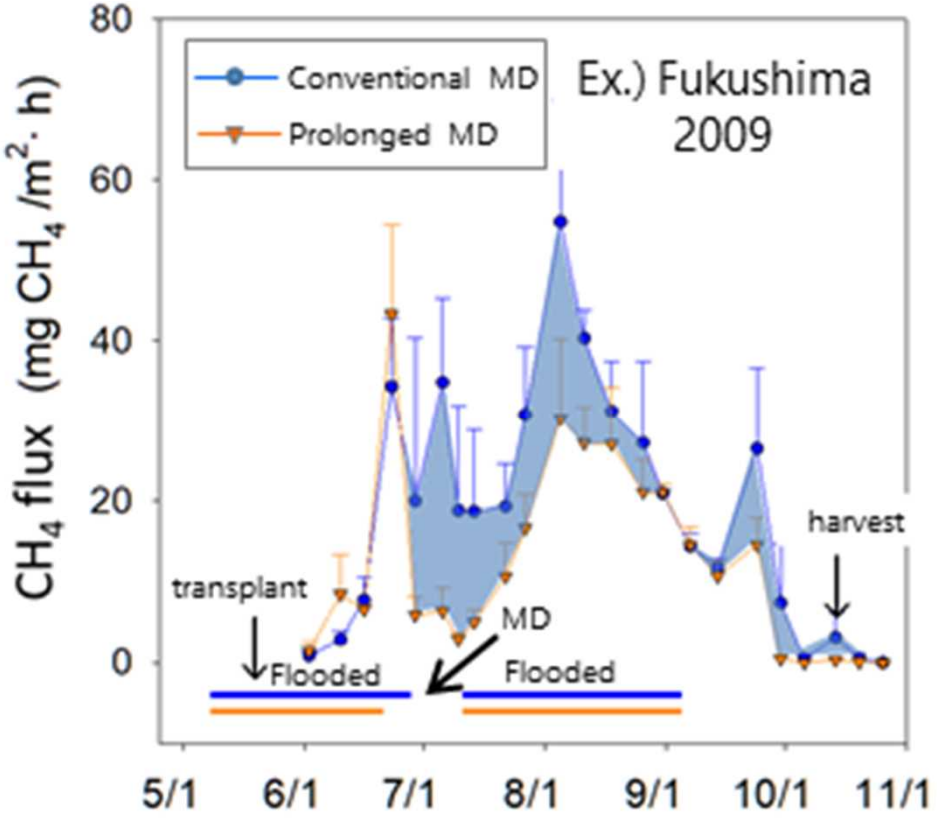
GHG mitigation from paddy field by water management



Mid-Season drainage (MD) in Japan

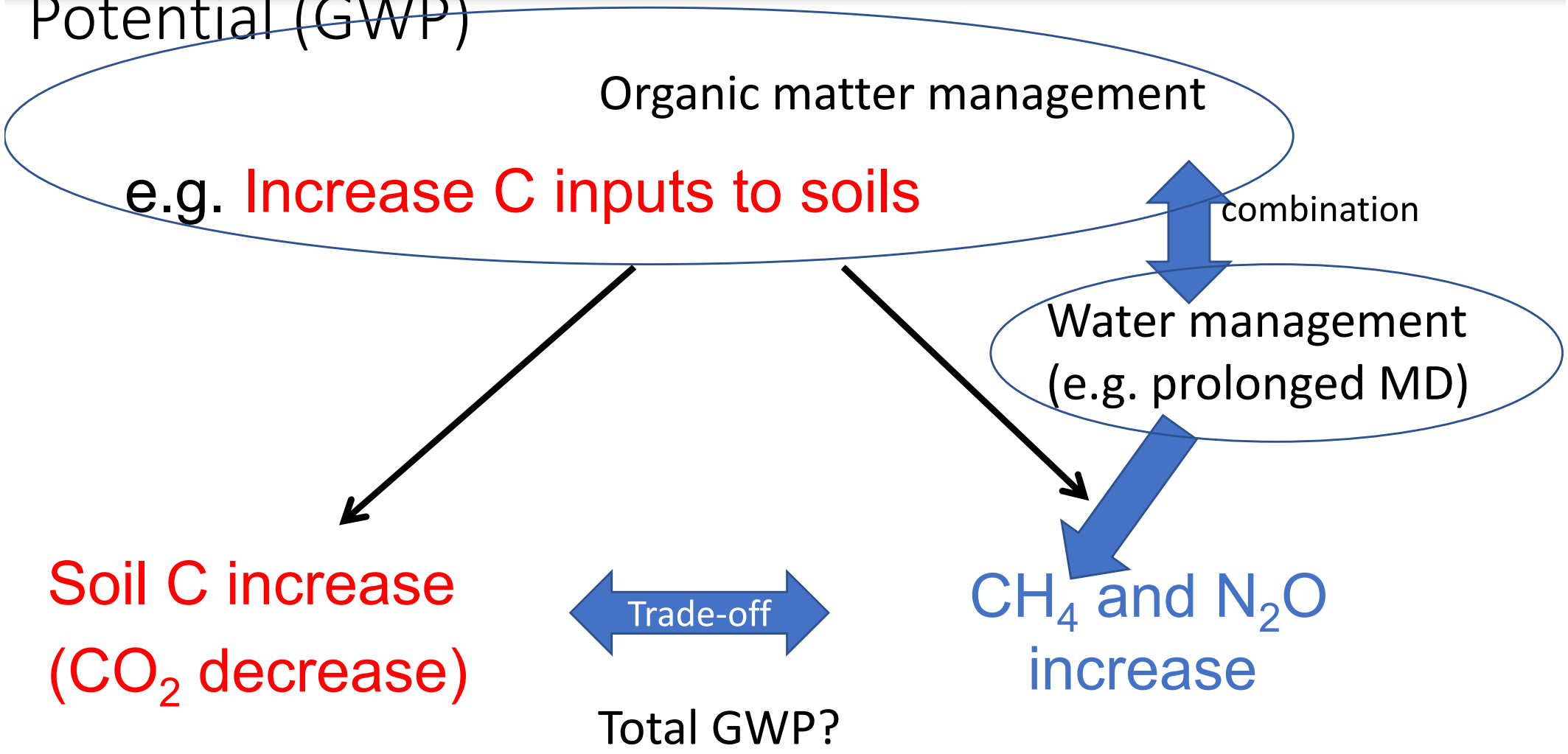
Drain water for 1~2 weeks

Prolonged MD (1 week longer than conventional) can reduce 30% of CH_4 emission <u>without negative effect on yield</u>.



Ito et al. (2011)

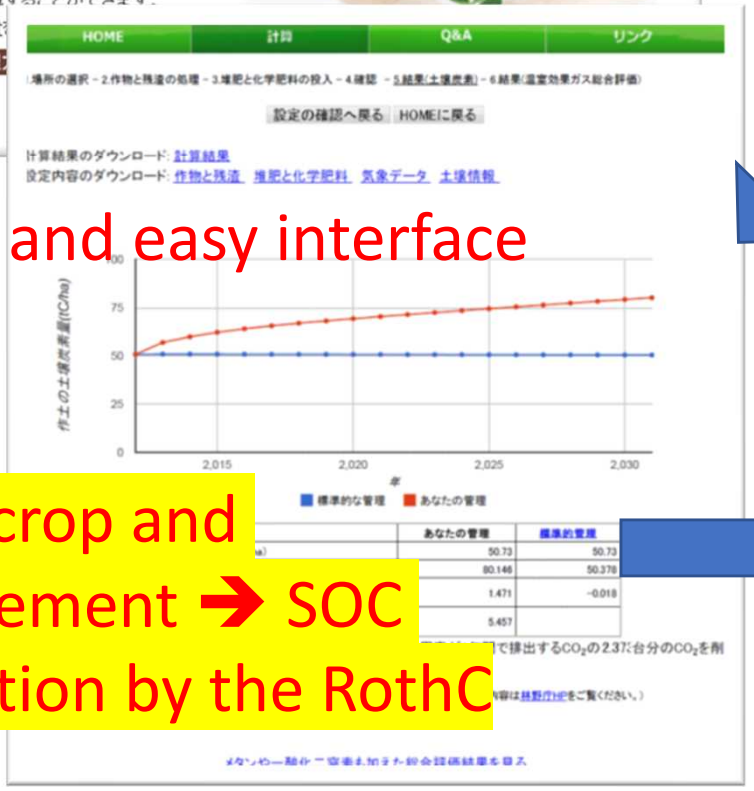
Trade-off: need to evaluate total Global Warming Potential (GWP)



- Evaluating total GHGs (GWP) considering “Trade- off”.
- GWP (CO2=1, CH4=25, N2O=298)

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

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CO2(tCO2/ha/年) (プラスが排出。マイナスが吸収)	-3.34	0.5
メタン(g-CH4/m2/年)	10.00	10.00
CO2換算(tCO2/ha/年)	3.40	3.40
N2O(kg-		0.07
CO2換		0.20
うち化学		0.02
CO2換算(tCO2/ha/年)	0.05	0.05
うち堆肥由来(kg-N2O/10a)	0.08	0.01
CO2換算(tCO2/ha/年)	0.23	0.03
うち作物残渣由来(kg-N2O/10a)	0.04	0.04
CO2換算(tCO2/ha/年)	0.11	0.11
化石燃料由来のCO2(tCO2/ha/年)	2.02	2.02
合計(tCO2/ha/yr) (プラスが排出。マイナスが吸収)	2.47	6.12

Total GWP calculation, too

https://soilco2.rad.naro.go.jp/

Summary

- Soil C sequestration has huge potential. Contribute to climate change mitigation and food security.
- Soil C model is useful: plot scale validation and modification ➔spatial evaluation and future prediction➔ NIR and NDC
- Important to consider Trade off (e.g. soil C vs. CH4)
- Visualization of soil C and GHGs: web-based decision support tool by using models.

Soils can save the earth!