LoCARNet in Bandung on 25 Octorber 2016

Carbon monitoring in peatland restoration program

The Environment Research and Technology Development of the Ministry of the Environment, Japan (2015-2017) :2−1503

- Developing an integrated system to evaluate the carbon dynamics of tropical peat ecosystems in Borneo -

Ryuichi HIRATA, National Institute for Environmental Studies (NIES)

Hirano, Hokkaido University

Hirata, Habura, National Institute for Environmental Studies (NIES)

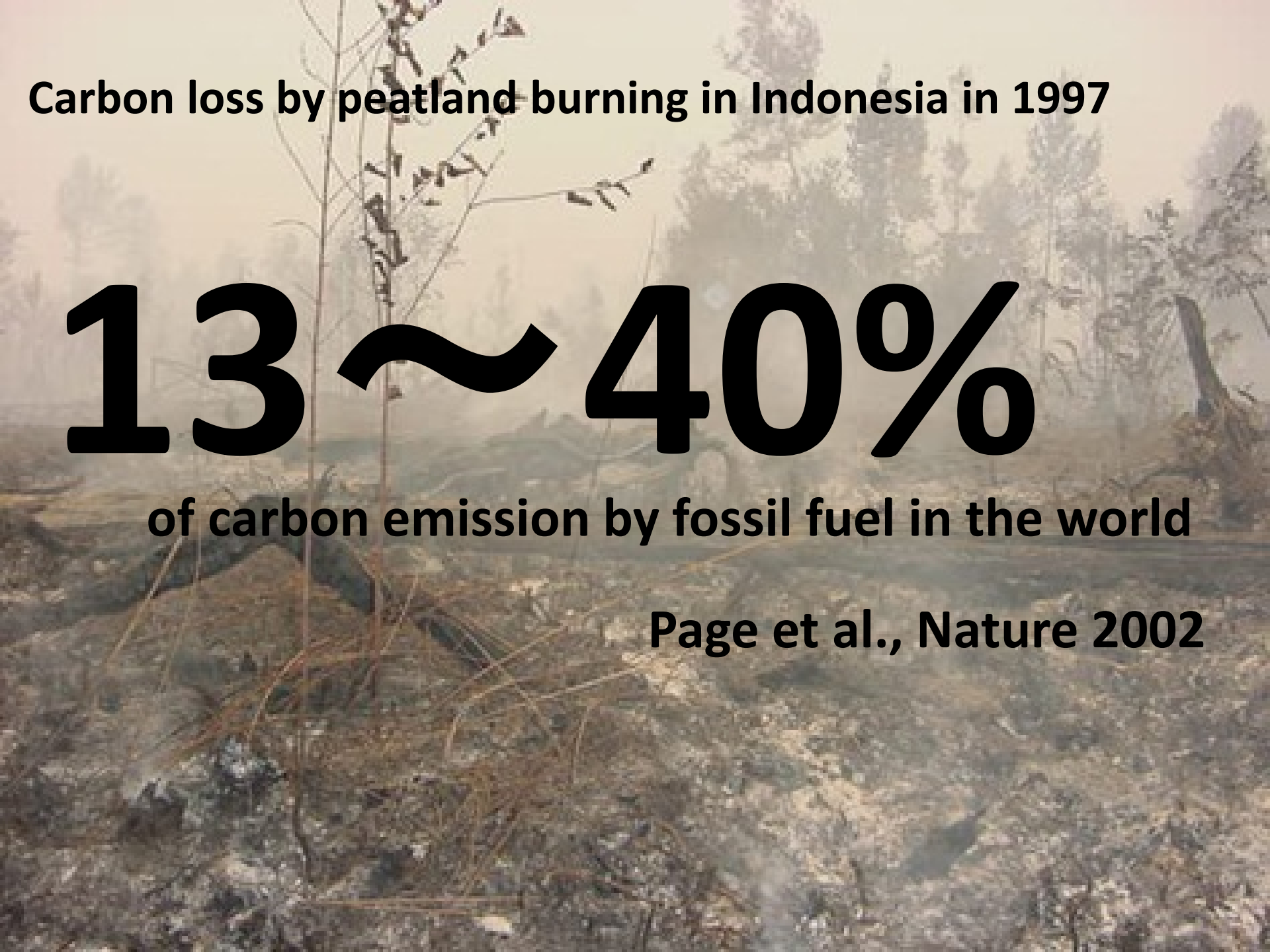
Motohoka, Hayashi, Japan Aerospace Exploration Agency (JAXA)

Hirose, Takeda, Japan Space Systems

Tropical peatland
-Vulnerable ecosystem to carbon balance-

- Organic carbon consisted of dead plants (trees in tropical case) which has not been decomposed under anaerobic condition with high ground water level (GWL) for thousands of years


1982, 1991, 1994, 1997,
2002, 2006, 2009, 2015



Carbon loss by peatland burning in Indonesia in 1997

13～40%

of carbon emission by fossil fuel in the world

Page et al., Nature 2002


Lost of peatland area in Borneo island
by development (mainly oil palm)
about 10% in 10 years
Mietteinen et al., GCB 2012

Degraded tropical peat forest

Peat forest

- High GWL
- Huge carbon pool

Fire risk

Peat fire（CO_2emission）

Deforestation

drainage→Low GWL

Timber

Land use change

Plantation
（Oil palm etc）

Aerobic decomposition
（CO_2 emission）

■Tropical peat:「Huge CO_2 emission source in 21century (hot spot)」
（Global Carbon Project)

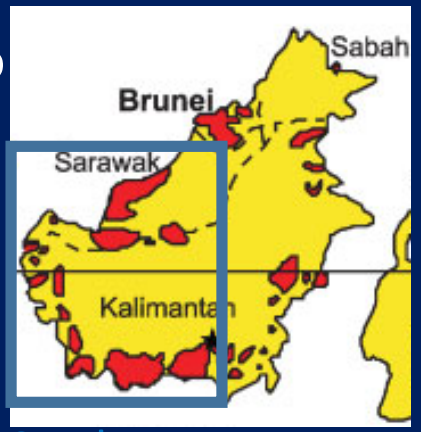
Final goals through three years (2015-17)

To scientifically contribute to the implementation of REDD+ and the evaluation of countermeasure techniques…

Goal #1: Development of an integrated system

A integrated system to evaluate the carbon dynamics and the GHGs balance of tropical peat ecosystems in Borneo will be developed.

Borneo



Study area

Goal #2: Evaluation of countermeasure techniques

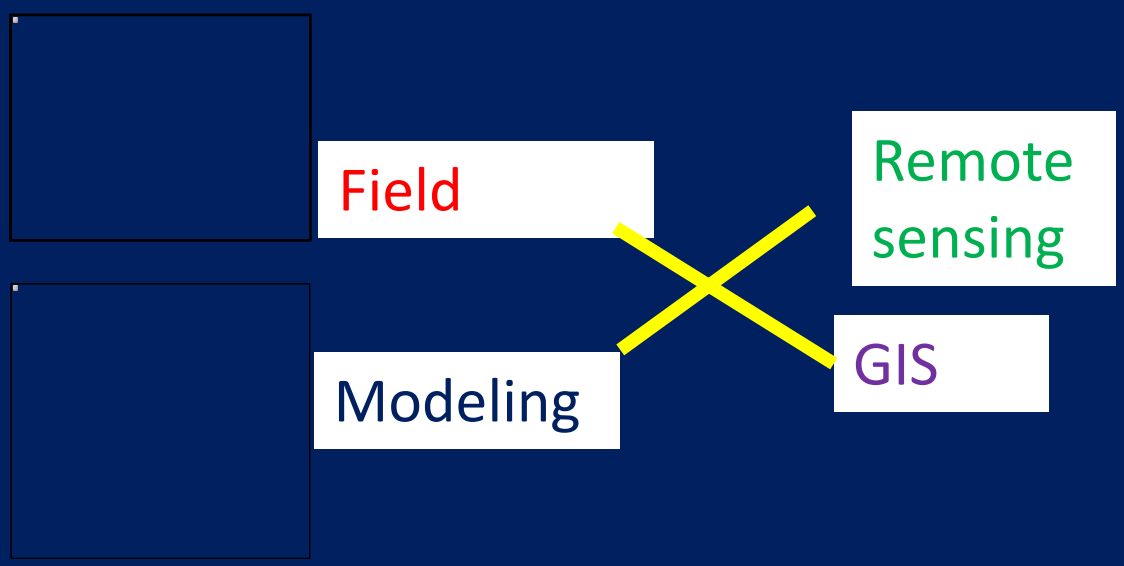
Using an ecosystem model, countermeasure techniques to reduce GHGs emissions, such as damming up of degraded peat lands and fire fighting, will be evaluated.

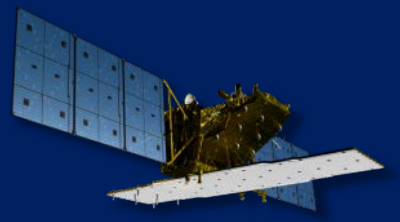
Damming

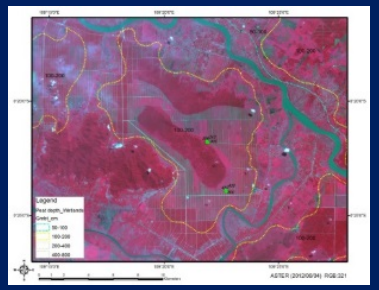
Fire fighting

Four sub-themes by each institutes

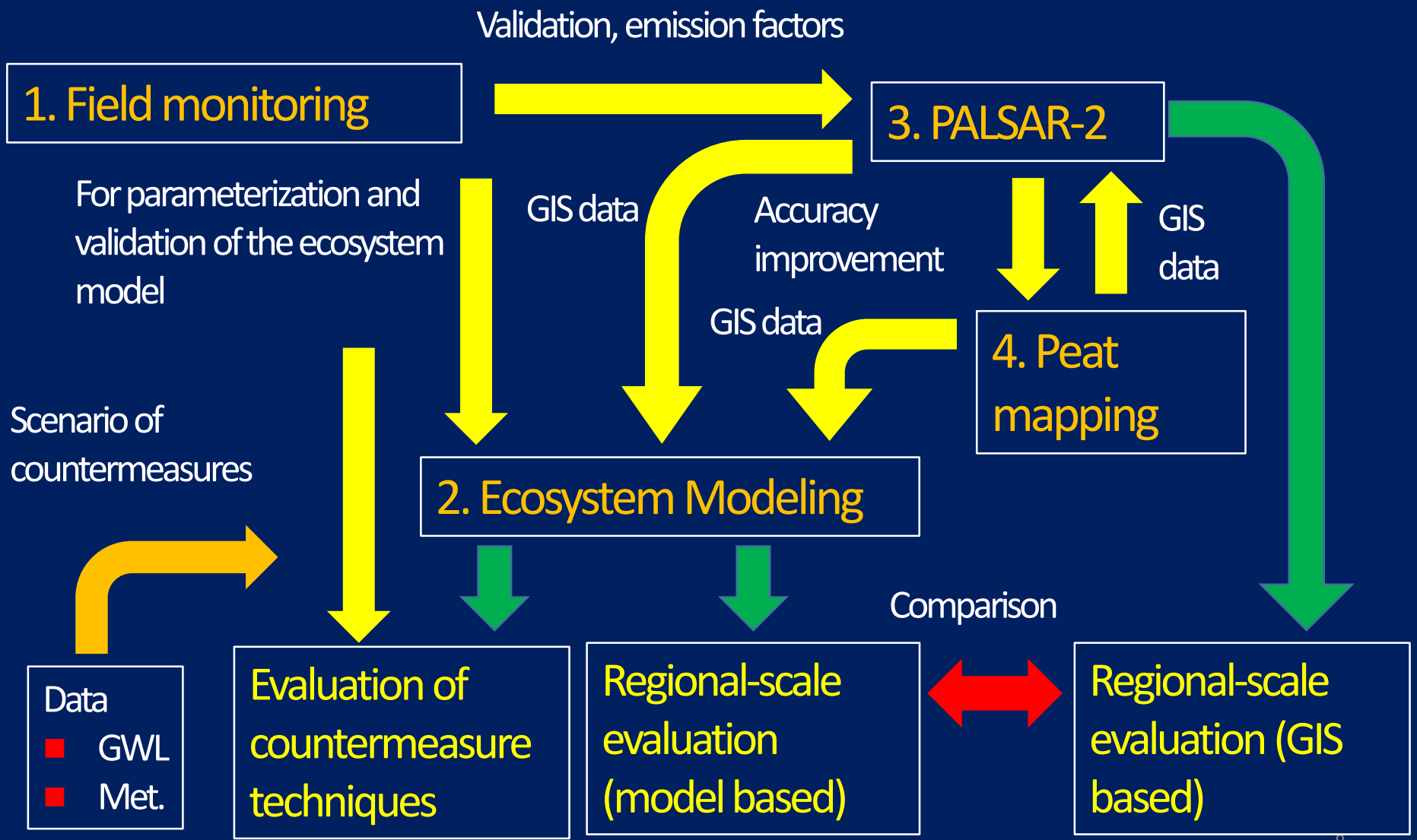
1. Field monitoring of GHGs fluxes: Hokkaido University
2. Development of an ecosystem model for carbon dynamics assessment: NIES
3. Development of an regional-scale evaluation system of carbon dynamics using satellite data (PALSAR-2): JAXA
4. High-precision mapping of peatlands: Japan Space System







Linkage among four sub-themes



Sub-theme 1 (Field monitoring of GHG fluxes)

Oil palm

Secondary PSF

Pristine PSF

Sarawak

- CIMTROP
- Ministry of Agriculture
- Tropical Peat Research Laboratory

Rubber

C. Kalimantan

C. Kalimantan

Undrained PSF

Drained PSF

Drained burnt ex-PSF

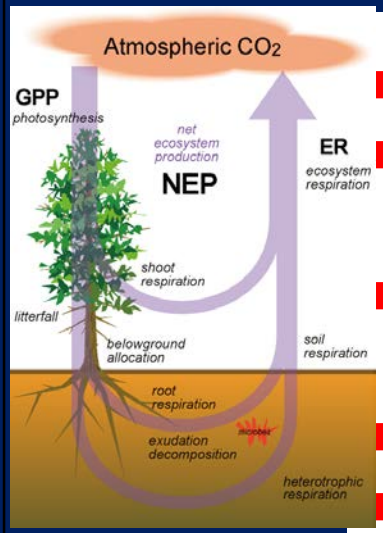
Long-term field monitoring in collaboration with local counterparts

- Met. & hydrological data
- Tower CO_2 flux
- Soil CO_2 and CH_4 efflux
- Biomass
- Subsidence

- Parameterization
- Ground truth
- Validation
- GHG emission factors

Sub-theme 2 (Ecosystem modeling)

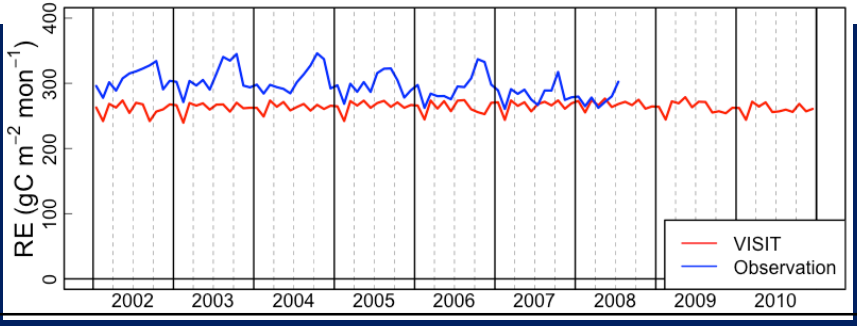
Ecosystem model: VISIT



- Simulation of GHGs
- Carbon dynamics of ecosystems
- Multiple scales: from site to globe
- Daily time steps
- Many applications

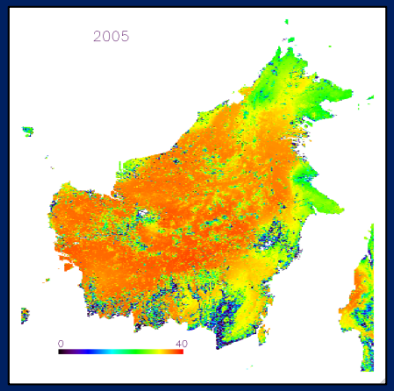
1. Development of a sub-model for tropical peat

- Using field data from the sub-theme 1, the sub-model will be parameterized and validated.



2. Development of a regional-scale model

- Assessment of the carbon dynamics and GHG fluxes in Borneo.
- Evaluation of countermeasure techniques.

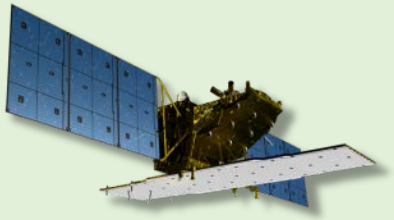


Sub-theme 3 (Satellite-based assessment)

- Development of a high-accuracy regional-scale system to quantify the carbon dynamics and GHG fluxes using a state-of-the-art remote sensing technology, L-band Synthetic Aperture Radar-2 (PALSAR-2) aboard ALOS-2.
- Land-use change, vegetation classification, biomass, biomass and peat burning, water conditions and subsidence will be measured and quantified at high frequency, higher than monthly (1.5 months on average).

ALOS-2, PALSAR-2

Launched on 24 May 2014.



Higher frequency than monthly. High spatial resolution of less than 25 m.

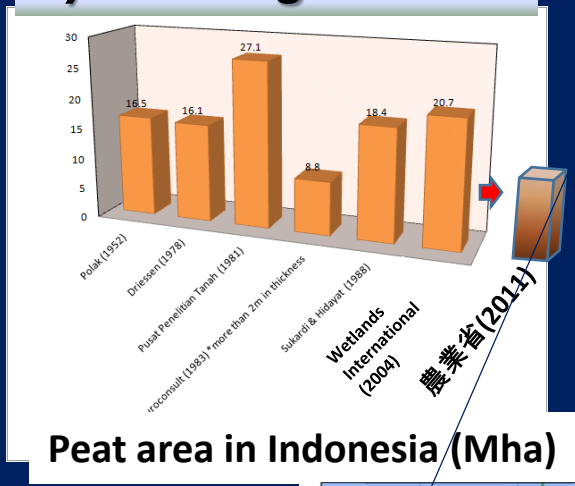
- Land-use change
- Biomass
- Vegetation
- Burning
- Subsidence

Regional-scale evaluation of carbon dynamics and GHGs fluxes based on GIS

Sub-theme 4 (High-quality peat mapping)

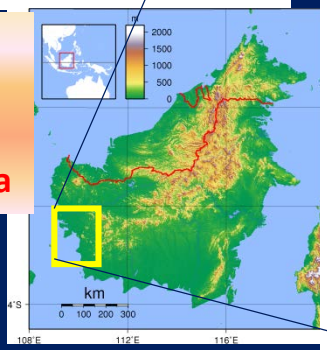
1) Gathering existing data on peat distribution (Wetlands International, Ministry of Agriculture..)
2) Unifying data format for GIS
3) Improving the geographical information by ground truth and remote sensing

1) Existing data

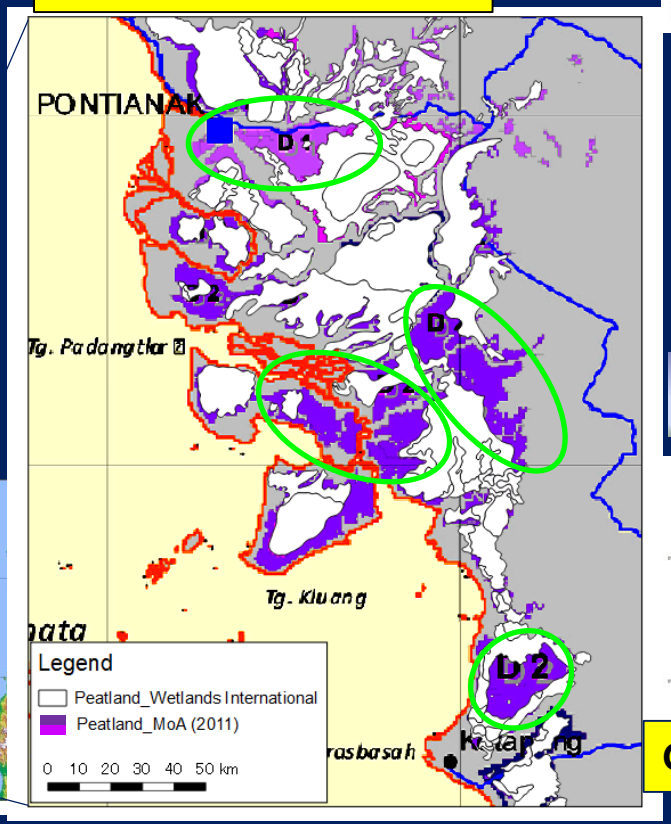


Peat area in Indonesia (Mha)

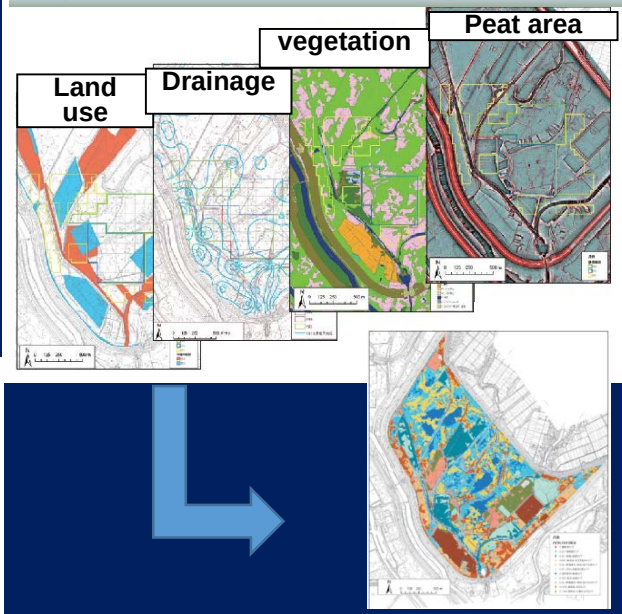
Change in area
2004 : 20.7Mha
2011 : 14.9Mha
▲5.8Mha



Detecting differences

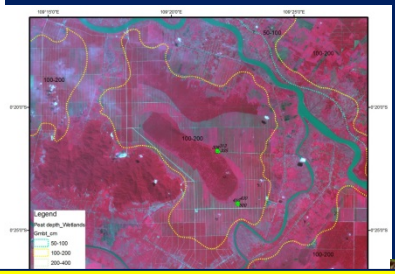


2) GIS-formatting



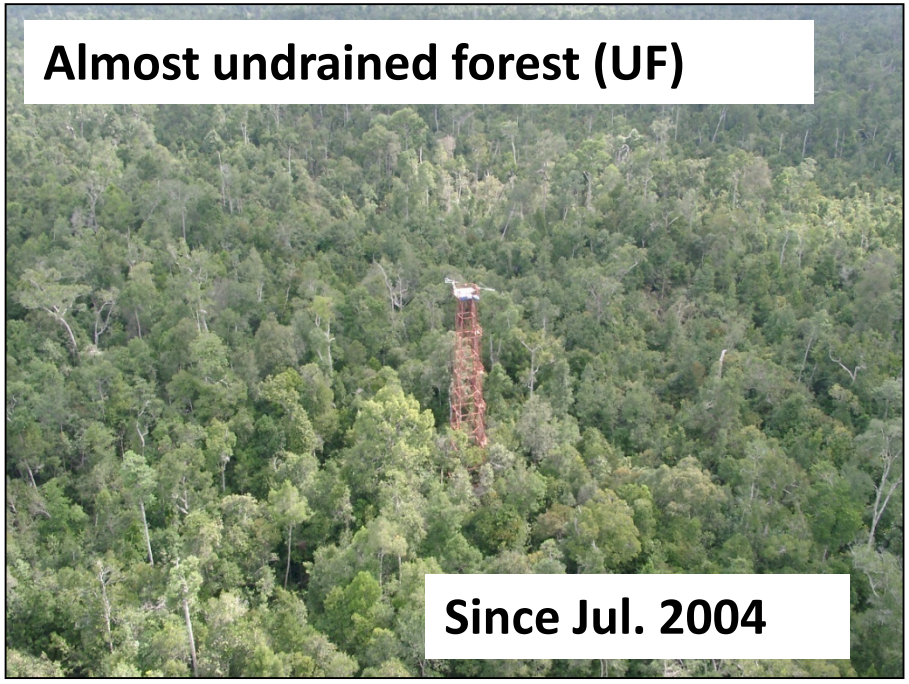
Synthesis approach

3) Low uncertainties



Ground truth, remote sensing

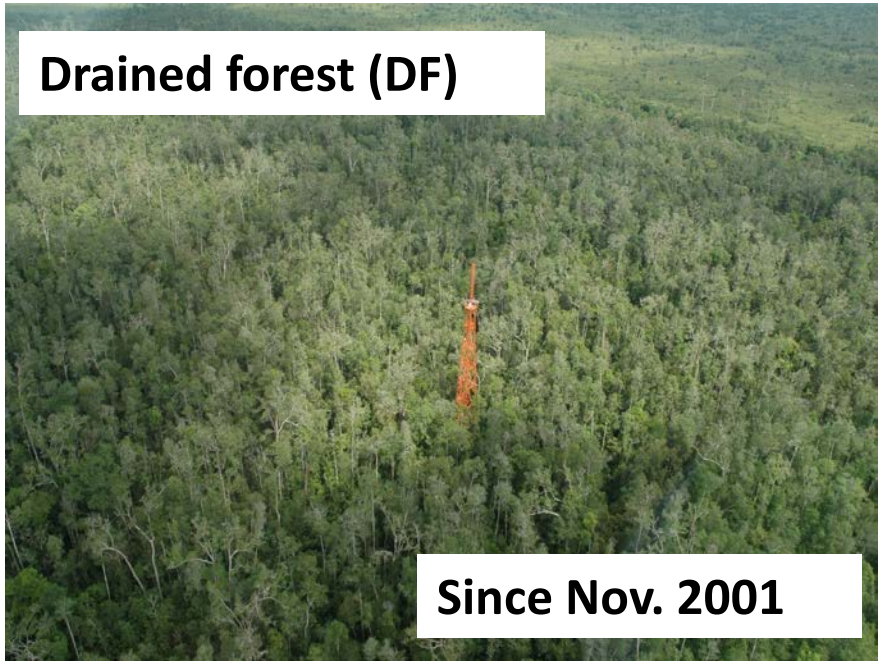
Almost undrained forest (UF)



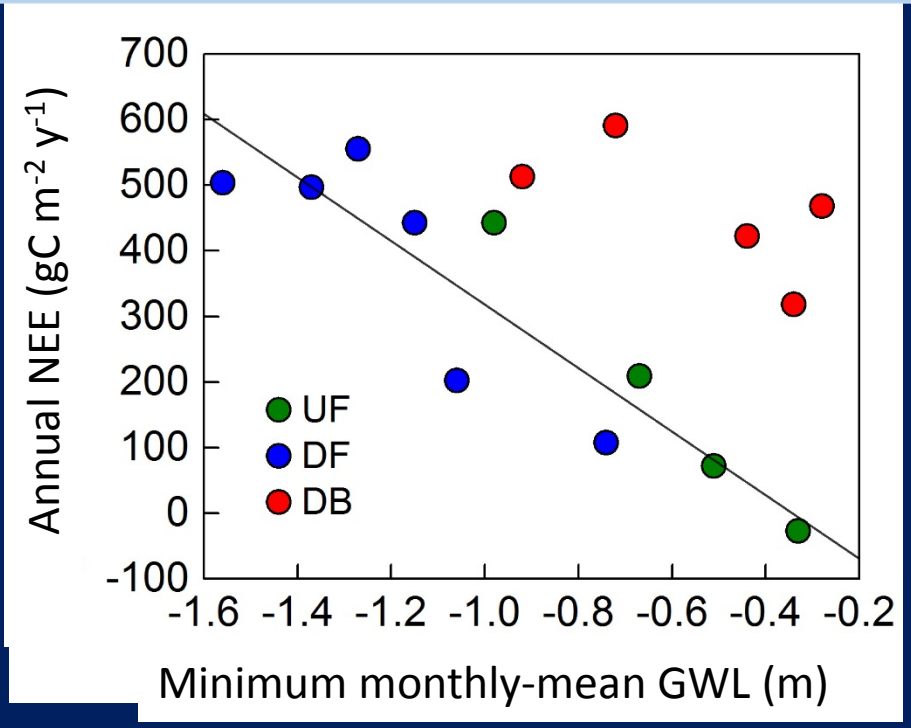
Burnt ex-forest after drainage (DB)

Large canal

Drained forest (DF)



Annual NEE vs. annually minimum groundwater level (GWL)



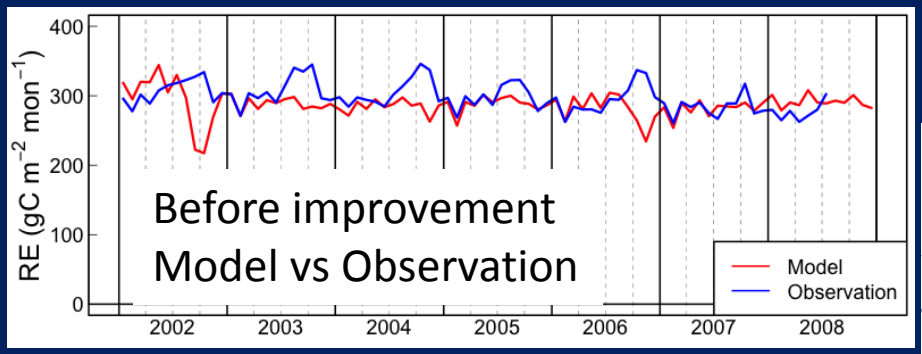
Hirano et al., 2016

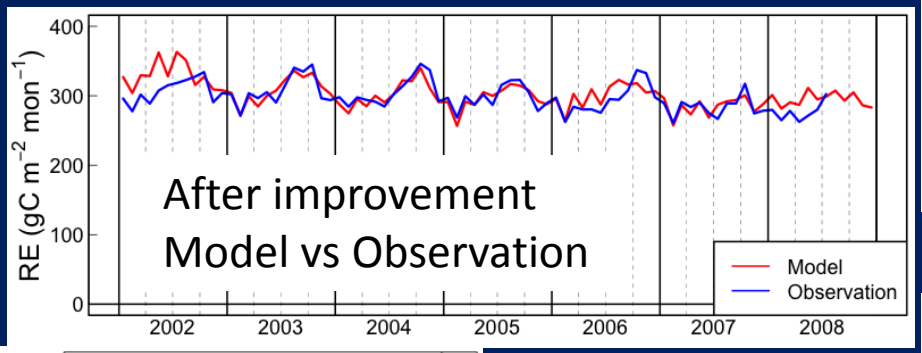
- A negative linear relationship for forest sites

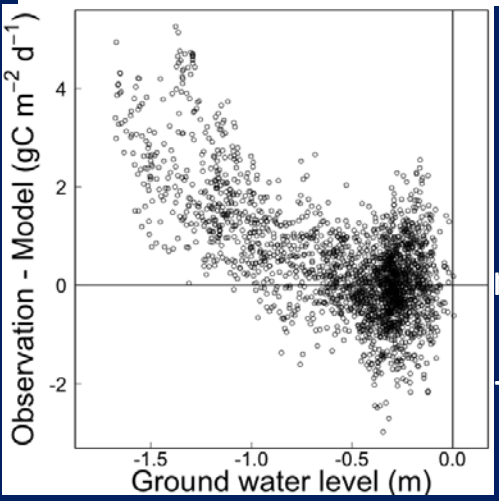
→ Enhancement of oxidative peat decomposition under low GWL

- Minimum monthly-mean GWL explained 82% of interannual variations in NEE for the two forests (r^2 = 0.82).
- Minimum monthly-mean GWL is a practical indicator to assess annual CO_2 balance.

Model improvement for peat forest







GWL cause the discrepancy between model and observation

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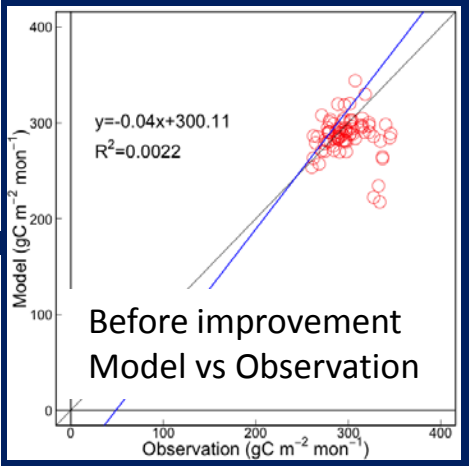
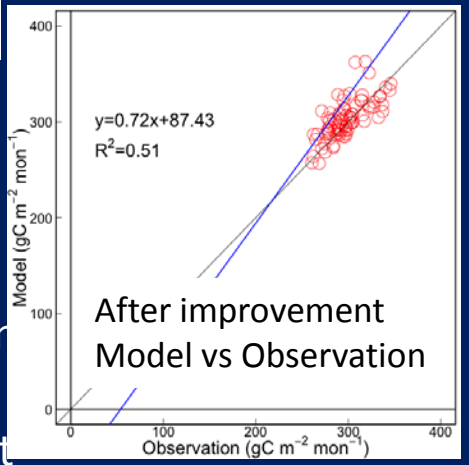
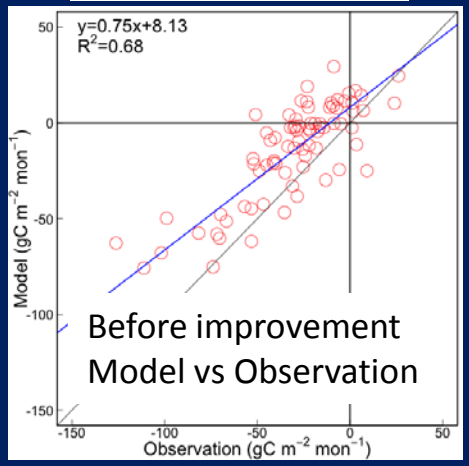
Take GWL into account

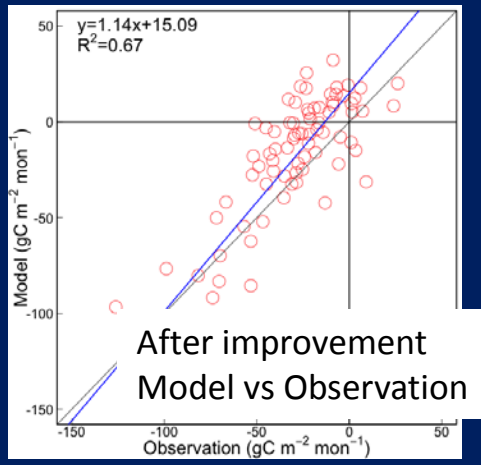
Ecosystem respiration





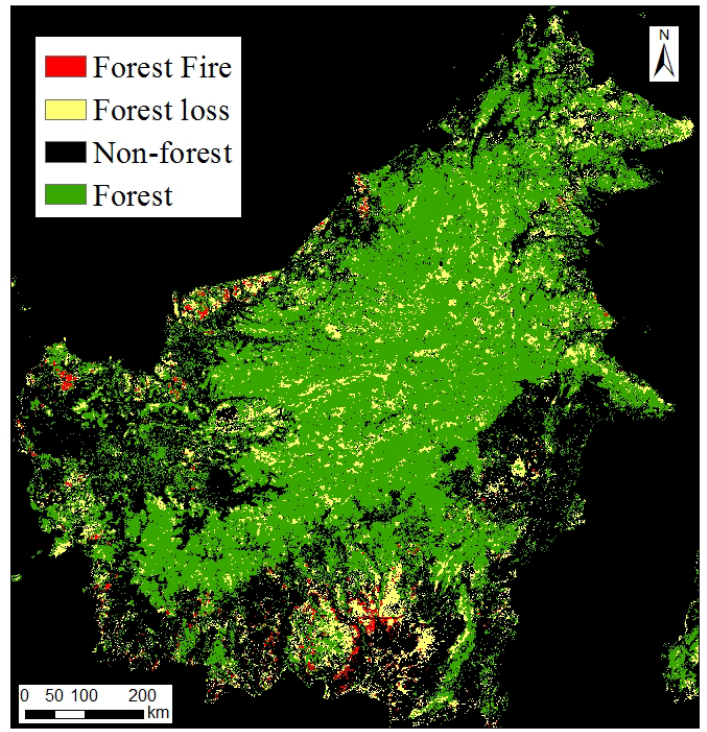
Net ecosystem CO_2 exchange

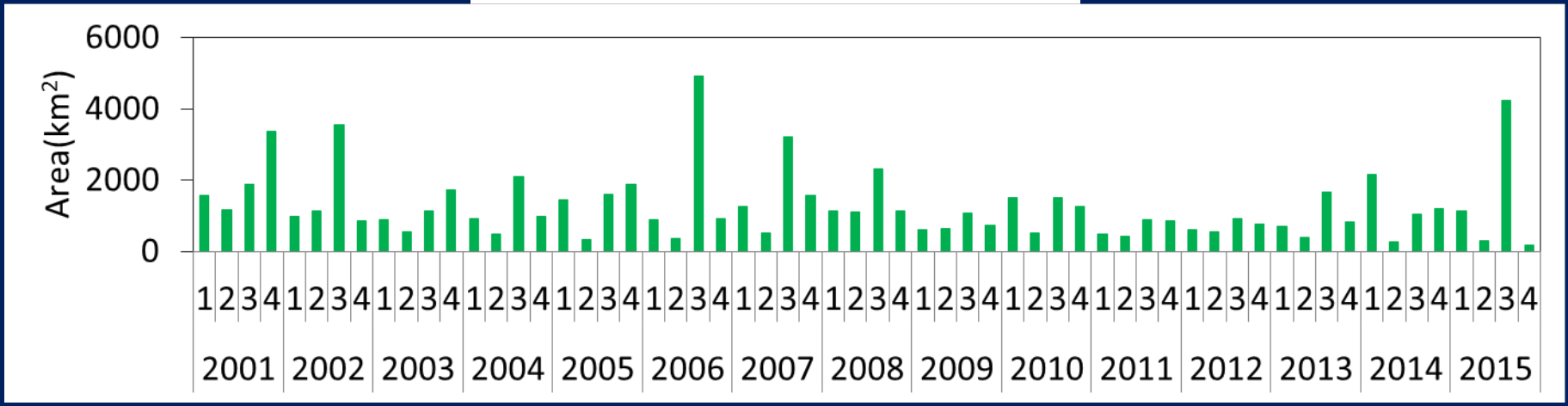




Detecting forest loss using MODIS

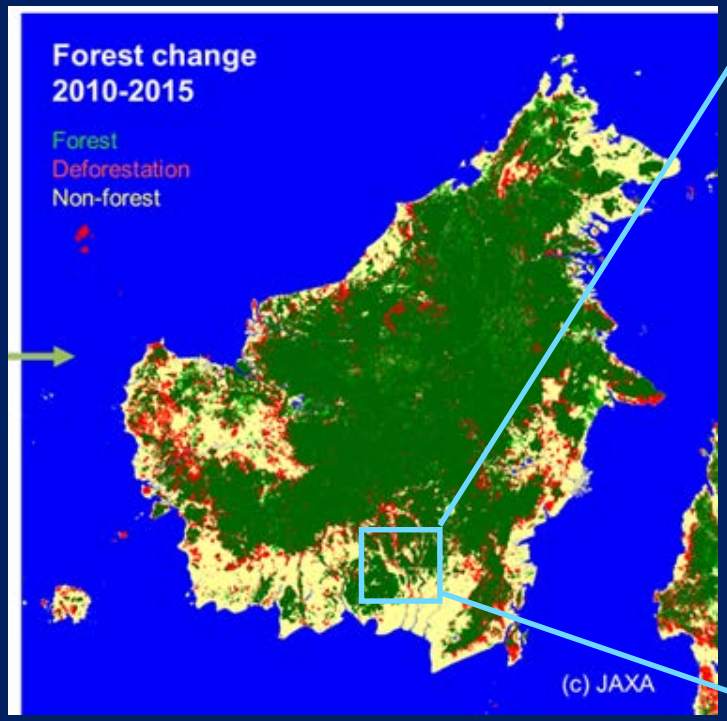
Forest loss & Forest fire(2000-2015)



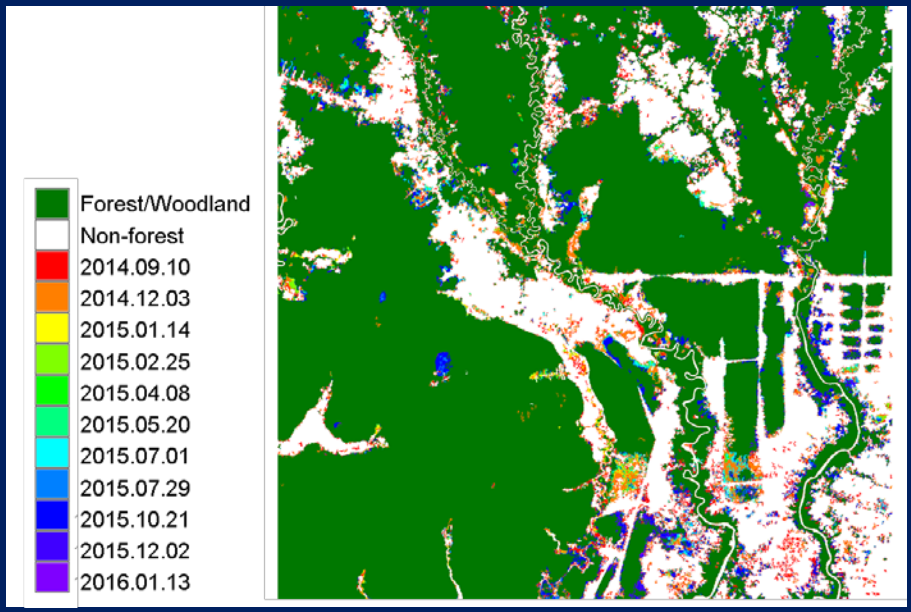


Detecting forest-cover change using PALSAR-2

Mapping of forest change (2010-2015)



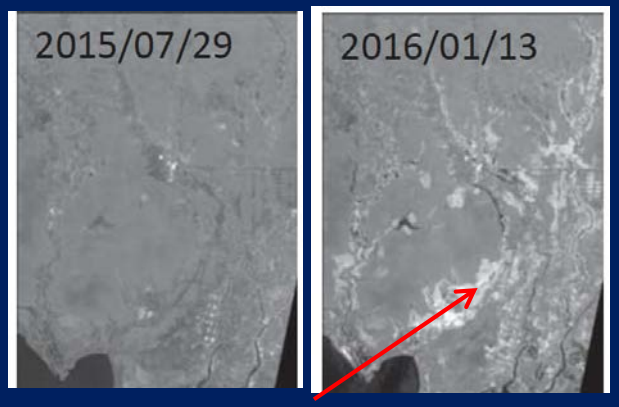
Changing peat swamp forest around Palangkaraya due to fires(Sep. 2014 to Jan. 2016)



- Deforestation was going over Borneo Island at a rate of 1.67% yr^{-1} from 2010 to 2015.
- PALSAR-2 measures high-temporal (every 1.5 months) and spatial (25 m) resolution data and provides high-quality information on land-cover change.

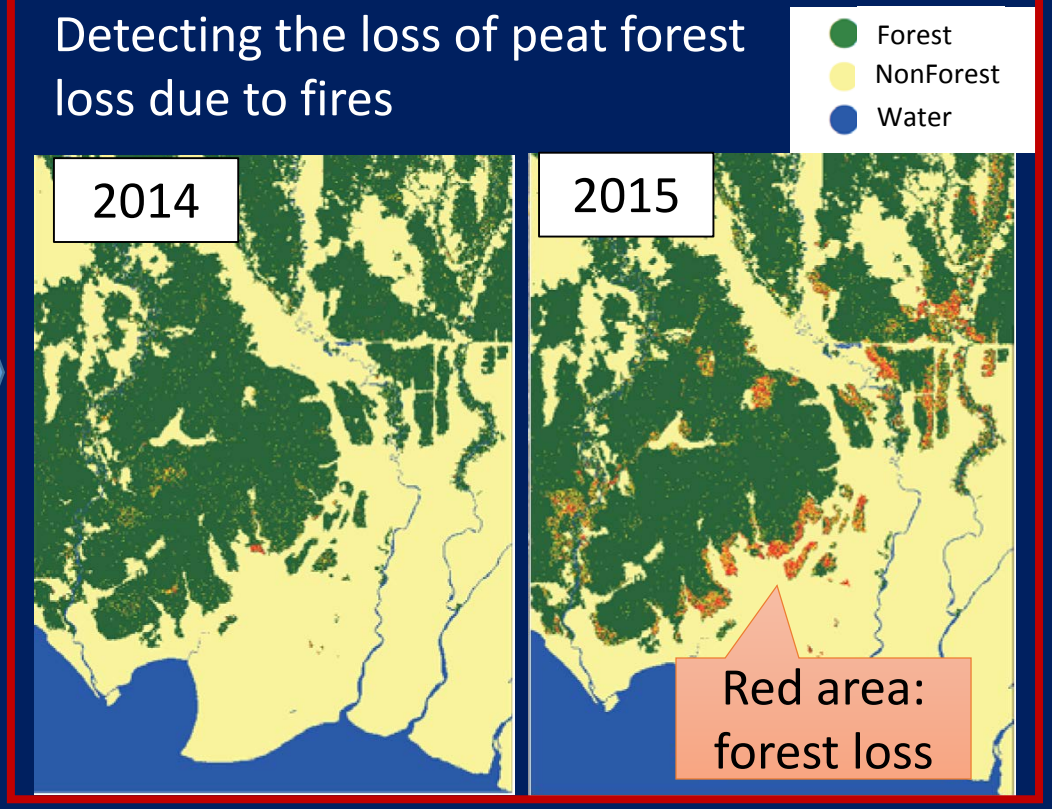
Detecting fire damage to forest using PALSAR-2

Temporal change of back scattering



Remarkable change due to fire

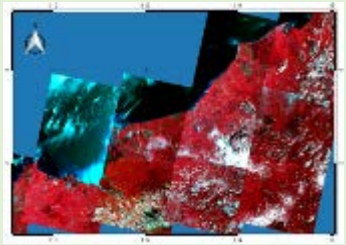
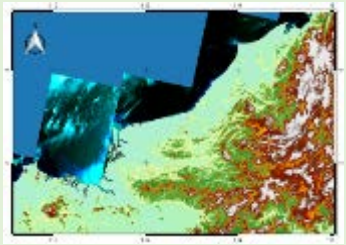
Detecting the loss of peat forest loss due to fires

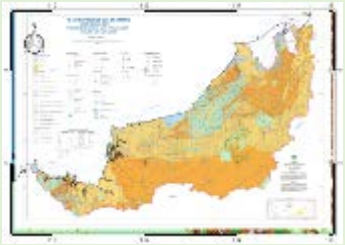
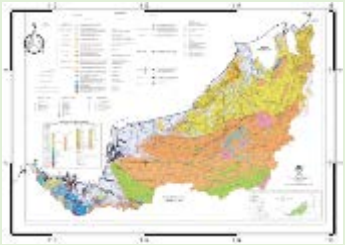


- We develop a new algorithm to determine the area of fire-damaged swamp forest.
- Fires caused by a strong El Niño event in 2015 extinguished 5% of peat swamp forest around Palangkaraya.

Integrate and improve peat map in Borneo

Satellite | Digital elevation map | Soil map | Hydro geological map | Geological map

...

Peat map

Indonesia : peat map (digital)
Malaysia : Information about peat (hard copy)

→need improvement

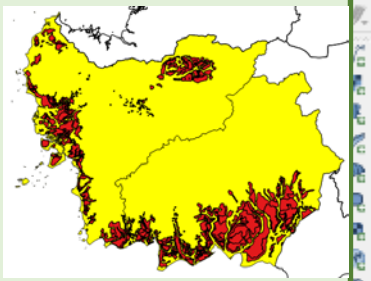


Image data such as hard copy, PDF files, digital data

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Image processing

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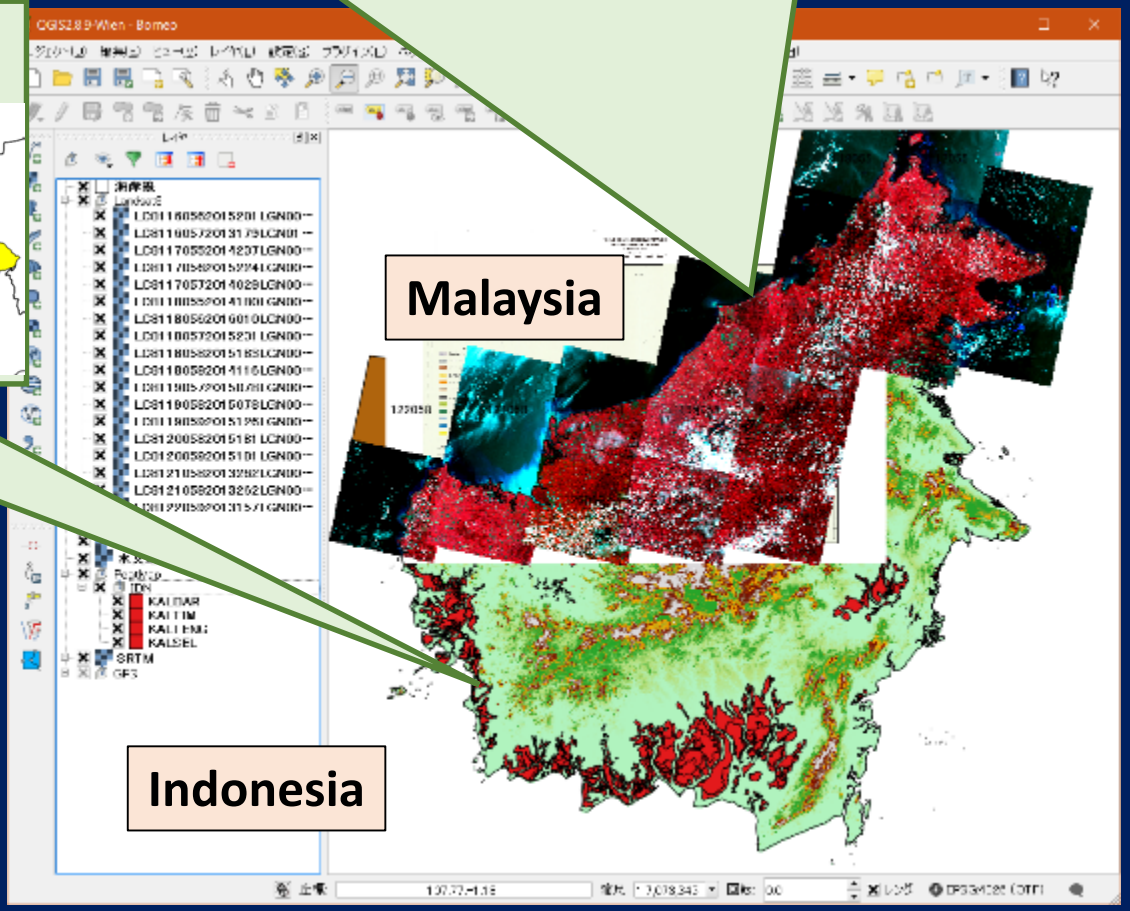
Useful format which are available by GIS software

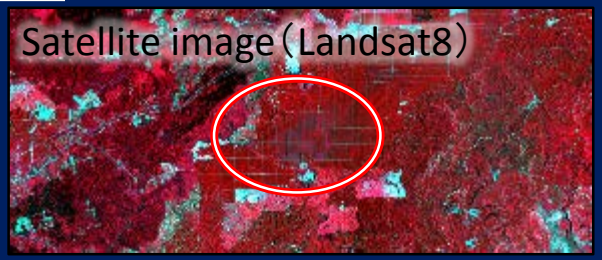


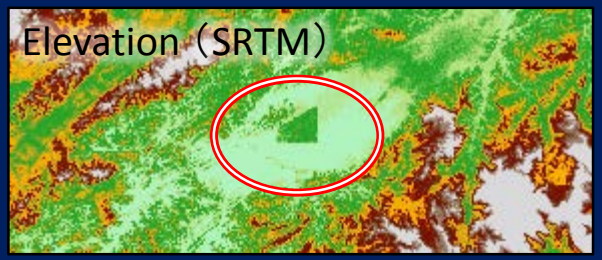
How to improve peat map?

Correct peat area

- No peat on high elevation area and collar of satellite image is also different

Wrong peat area（need improvement）





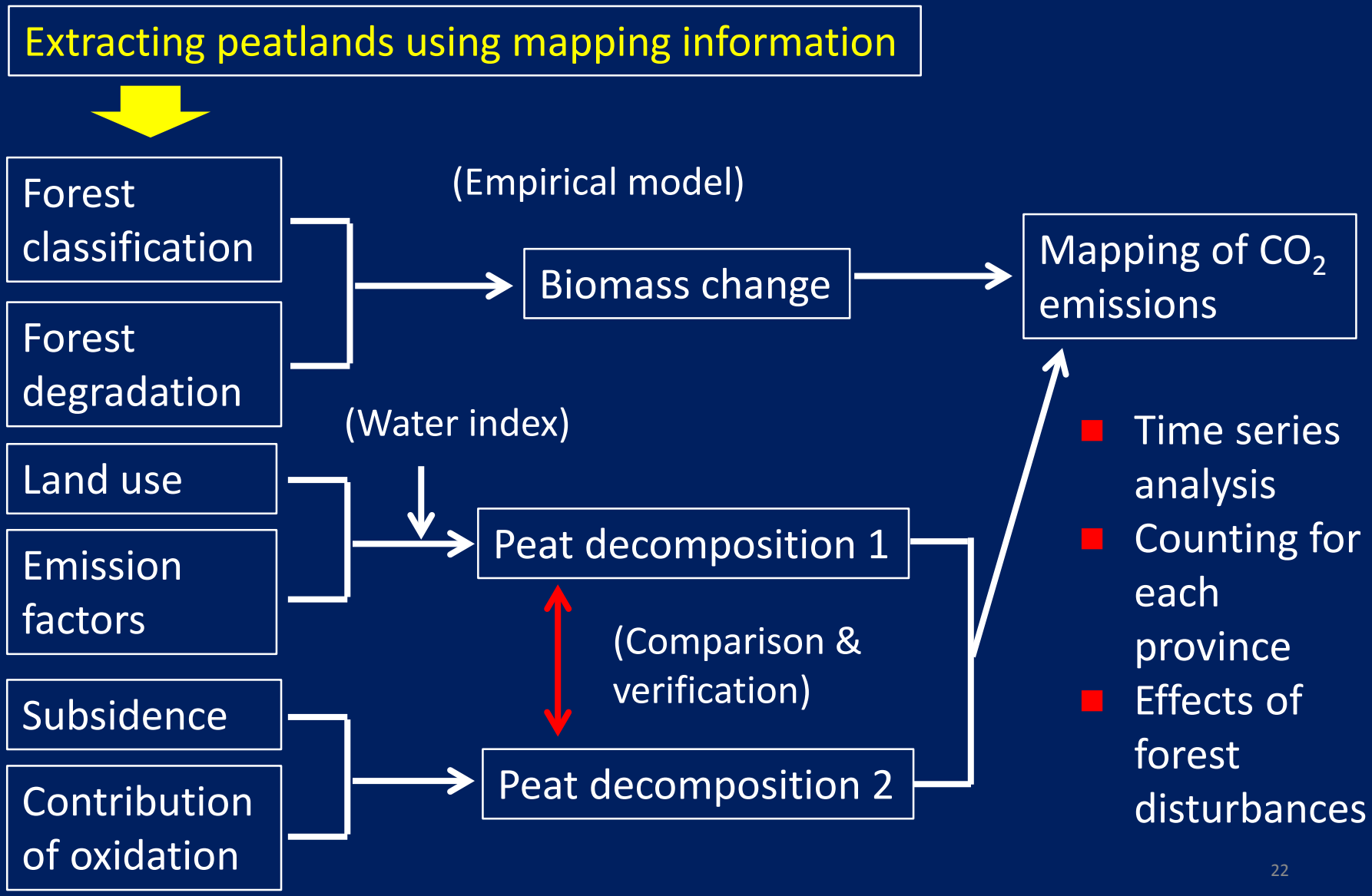
- Peat on undulating area and cultivated land is detected by satellite image.

Taking into account surrounding situation

Collar of river water

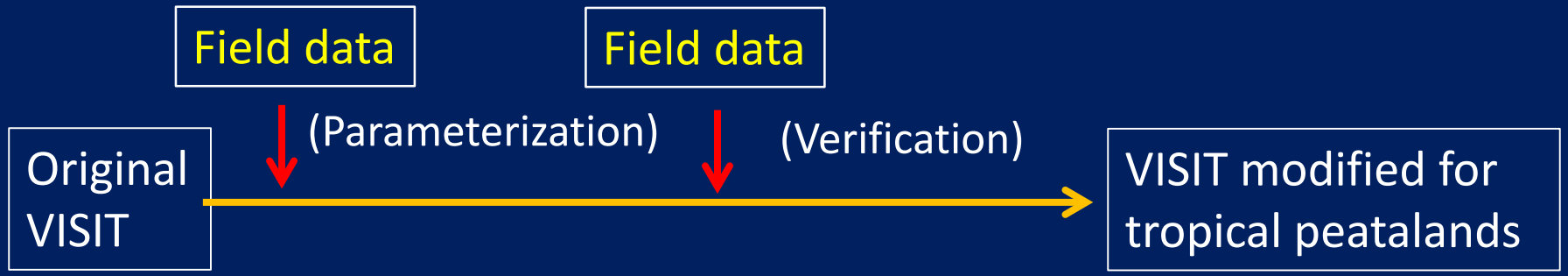
Cross section of stream bank

Next step for evaluating CO_2 emissions from Borneo's peatland using PALSAR-2 (1.5 months, 25 m)

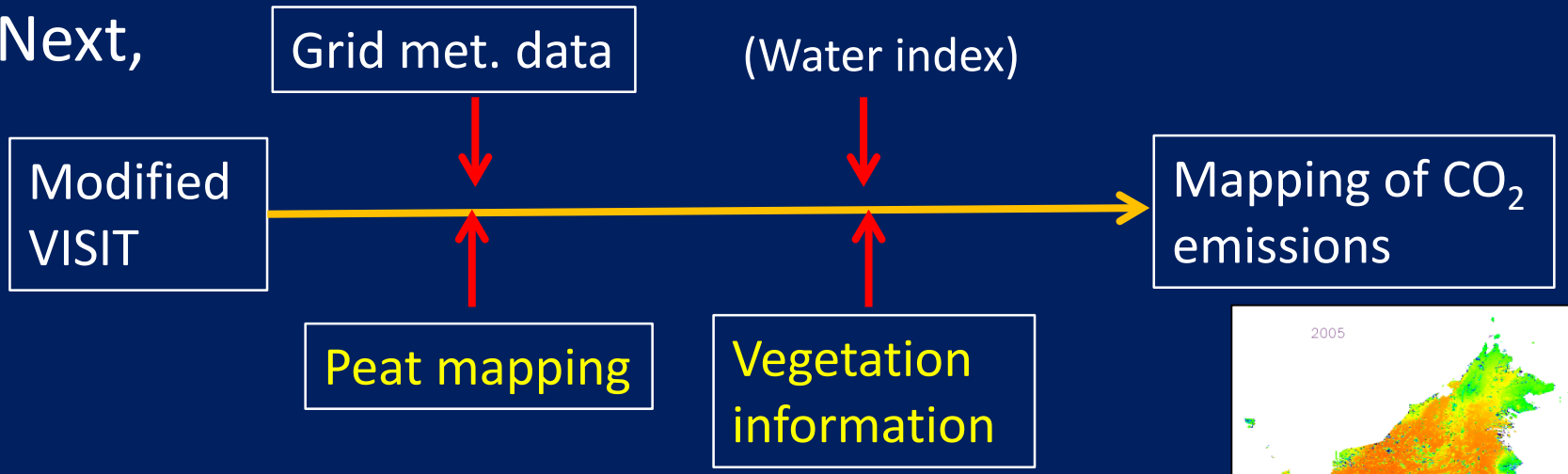


Next step for evaluating CO_2 emissions from Borneo's peatland using an ecosystem model (VISIT)

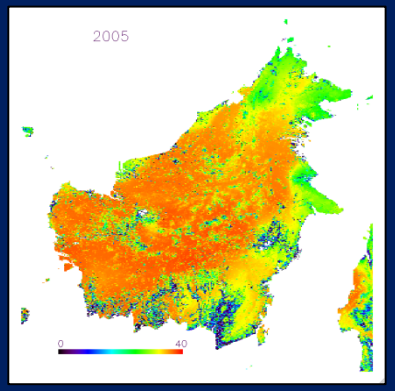
So far,



Next,



- Comparison of two mapping from different methods → improving the performance



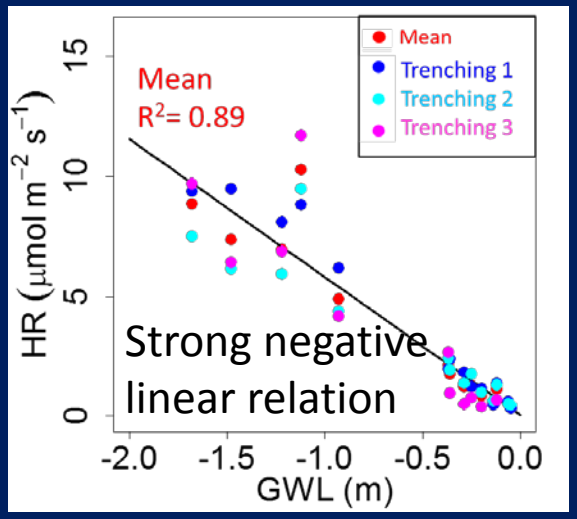
Thank you for your attention.
Terima kasih

Peat decomposition in a rubber plantation on peat

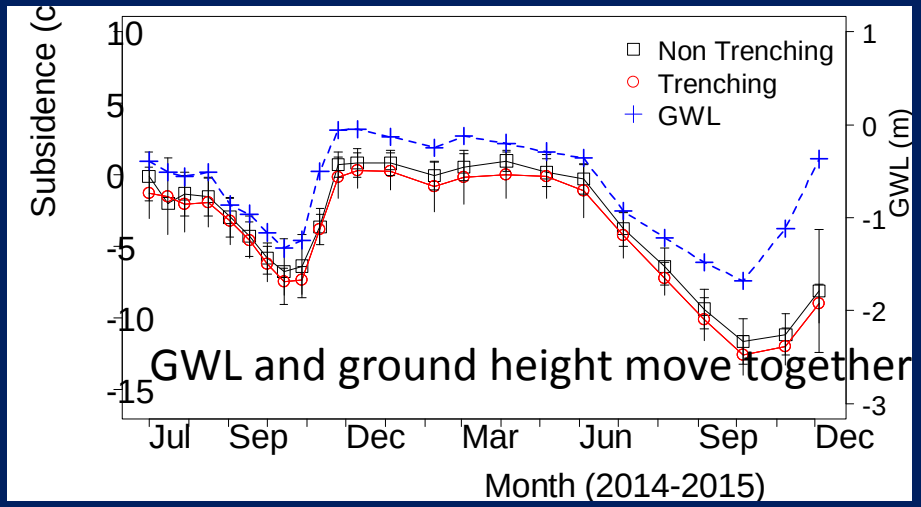
Wakhid et al., in prep.

Peat decomposition in lubber plantation

GWL vs peat decomposition



Seasonality of GWL and ground height



- Data is limited although lubber plantation increasing
- Decrease of GWL → CO_2 emission by peat decomposition increase
- 46% of peat decomposition is attributed to soil respiration (with root respiration)
- 38% of peat decomposition is attributed to subsidence.
- Highly improving accuracy of the emission factor

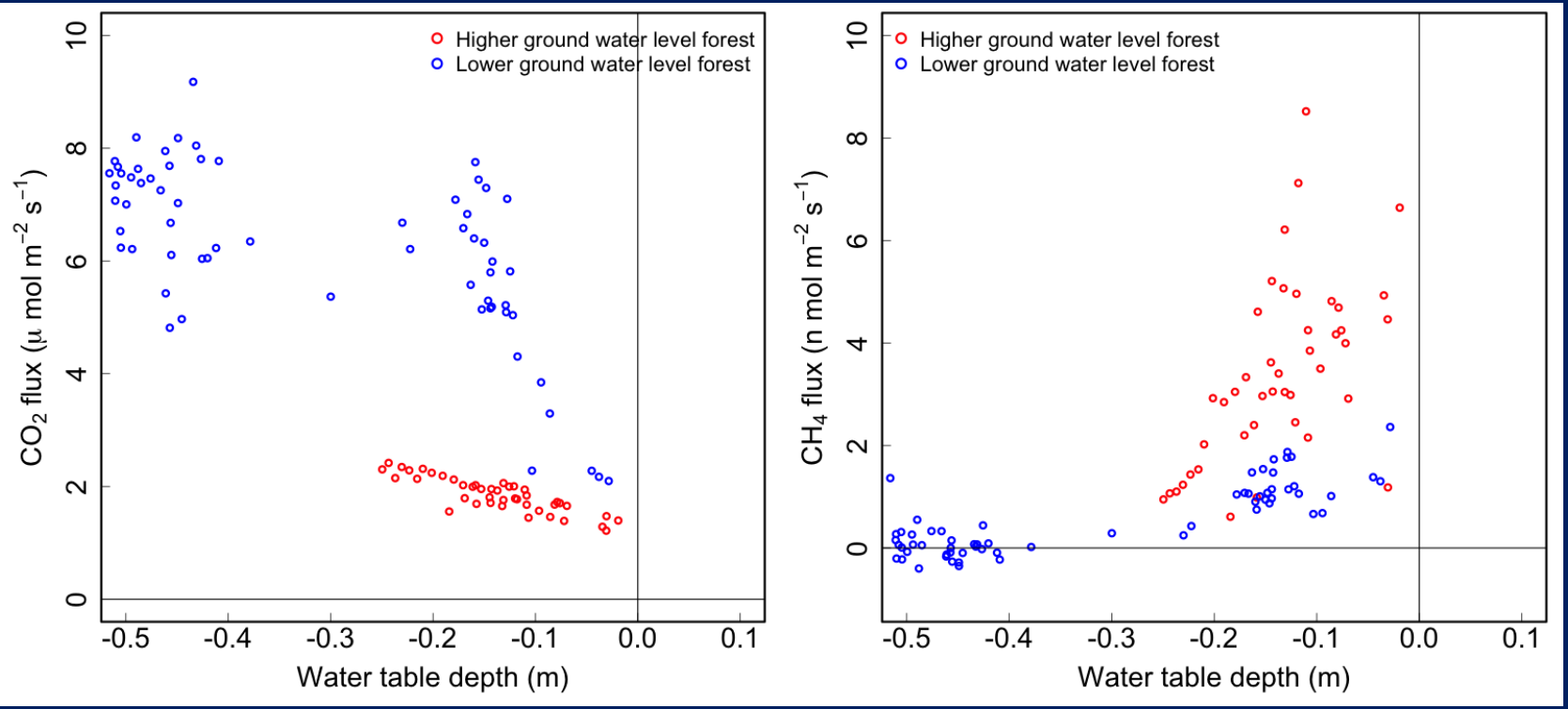
Soil CO_2/CH_4 fluxes in two GWL peat forests

Higher ground water level forest

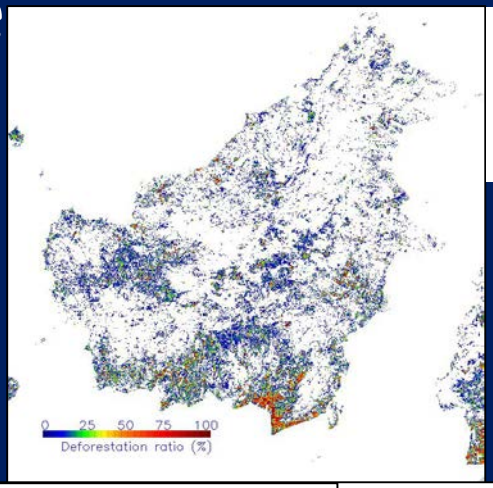
Lower ground water level forest

Soil CO_2/CH_4 fluxes in two GWL peat forests

GWL controls CH_4 · CO_2 fluxes



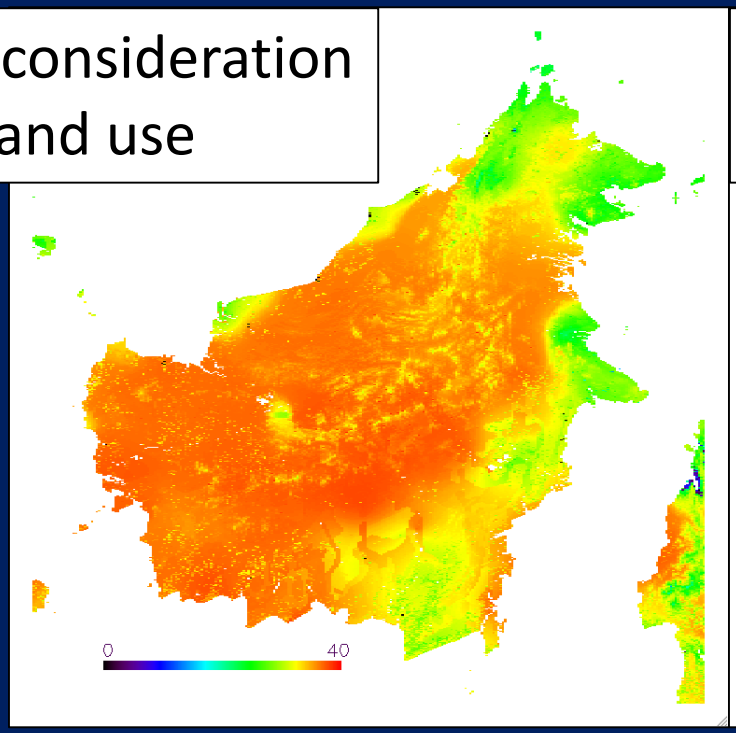
The effect of Land-use change (study by Dr. Adachi)



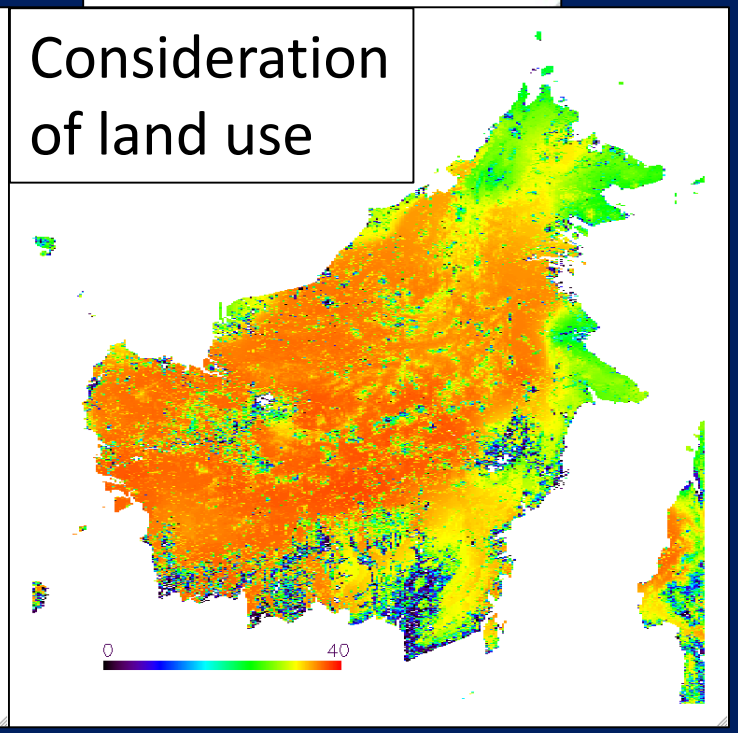
Deforestation area in 2004

GPP in 2005
（Total photosynthesis）

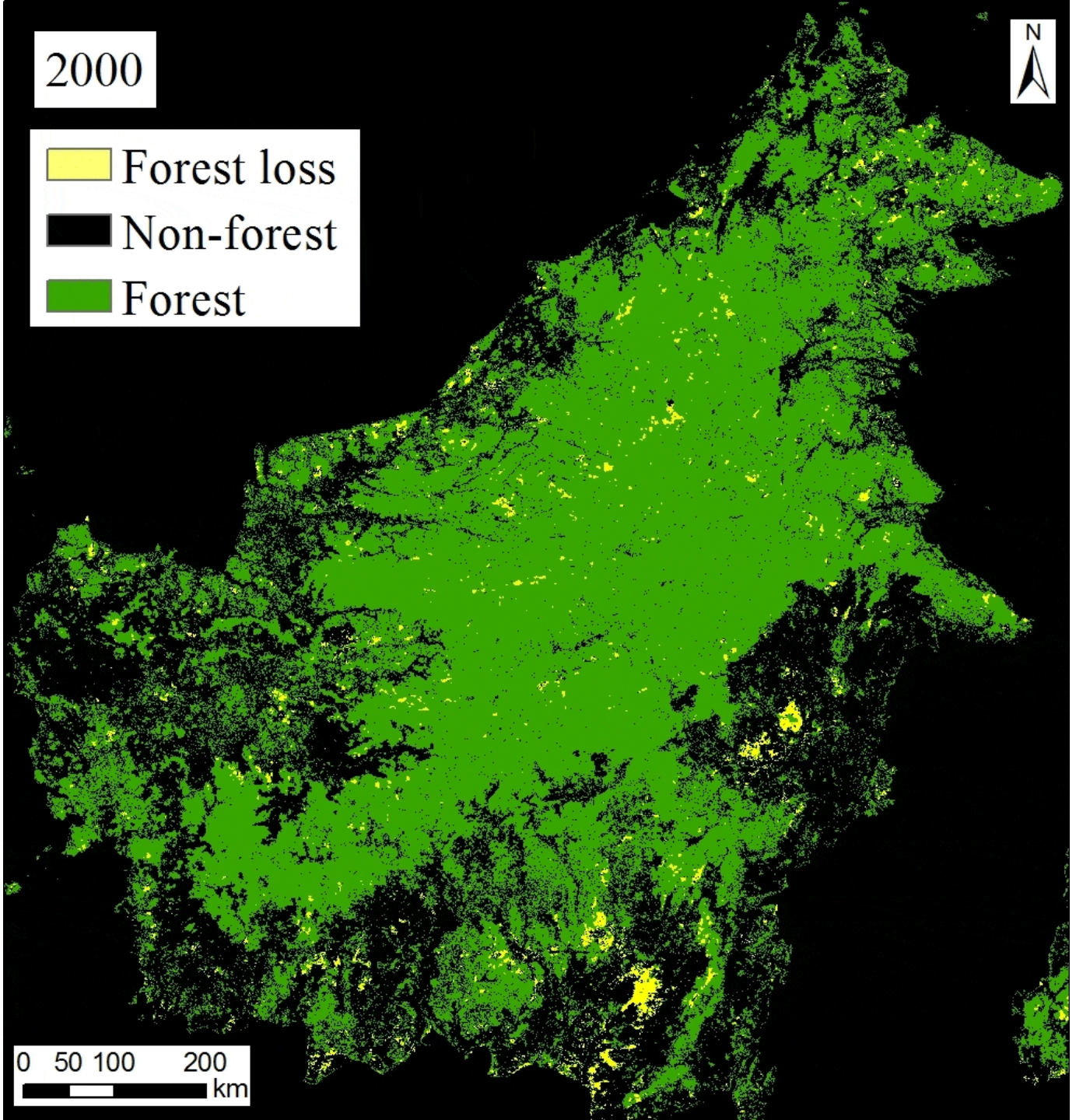
No consideration of land use



Consideration of land use



Overestimated about 13%（13～20%）
without deforestation.


2000
Forest loss
Non-forest
Forest
N
0 50 100 200
km