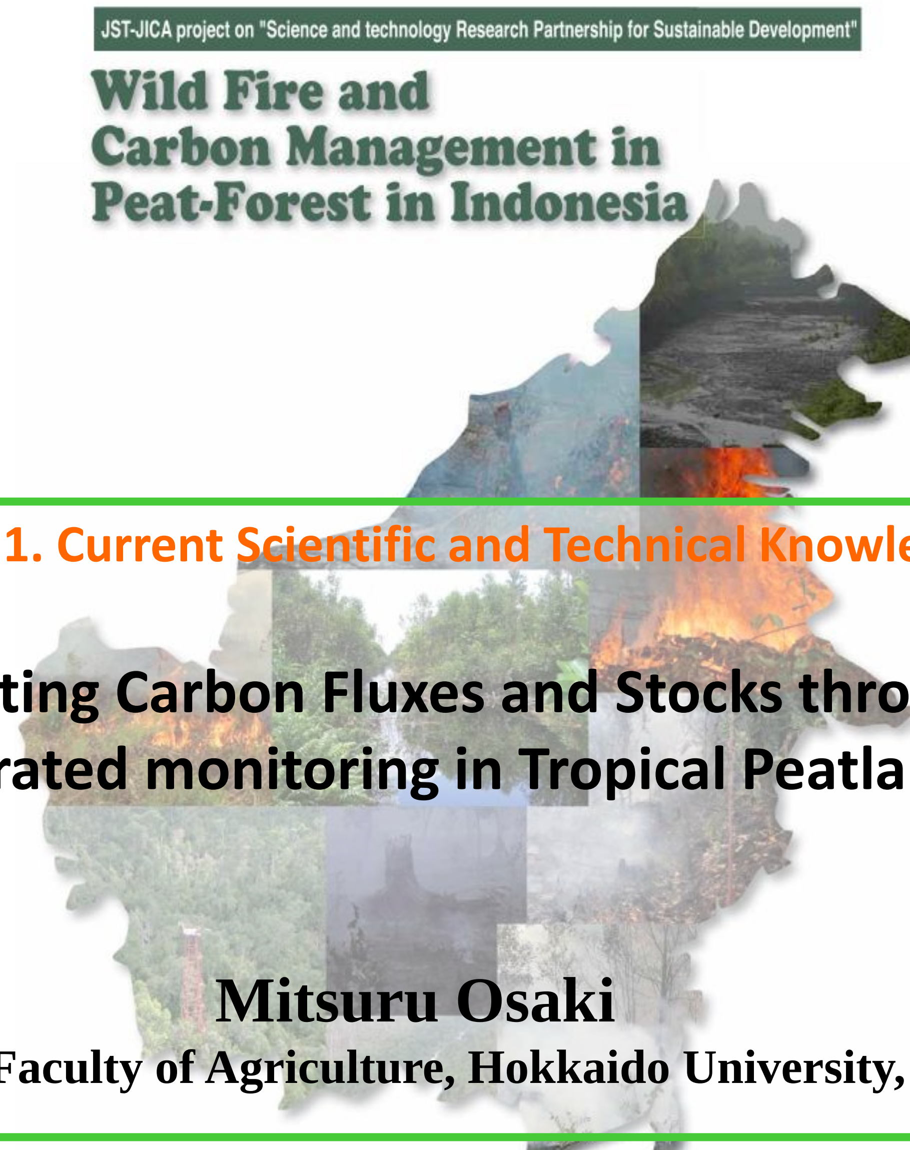
UNFCCC Workshop on
"technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the Convention"
24-25 October 2013
United Nations Campus "Altes Abgeordneten-Hochhaus", Bonn, Germany



HOKKAIDO UNIVERSITY

Session 1. Current Scientific and Technical Knowledge

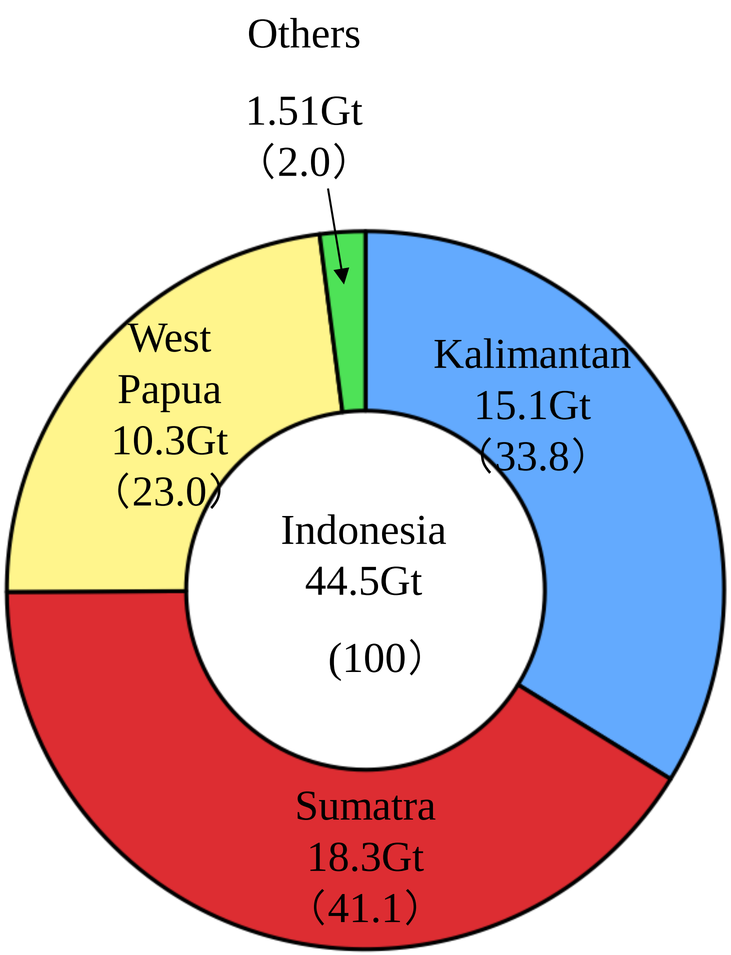
Estimating Carbon Fluxes and Stocks through integrated monitoring in Tropical Peatland

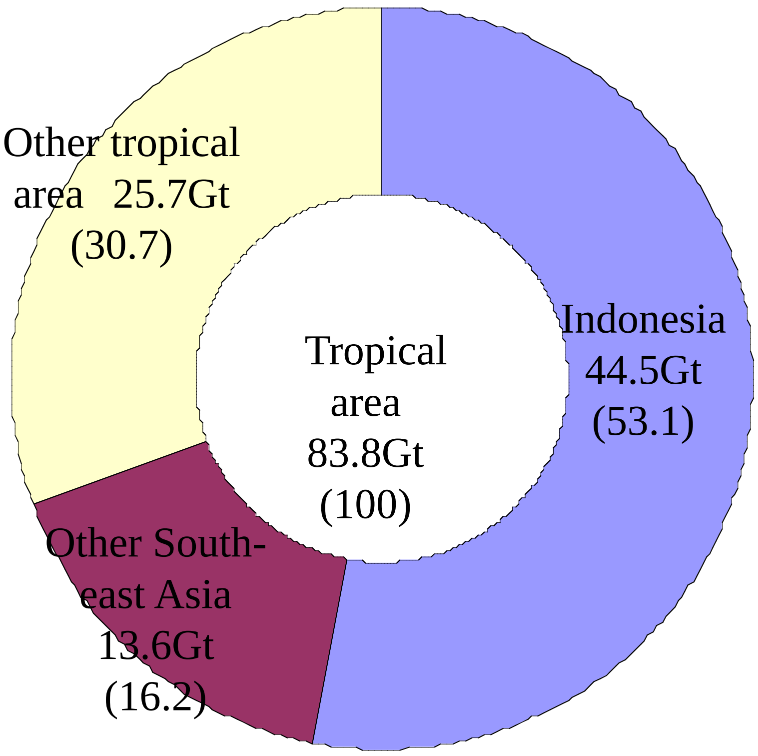
Mitsuru Osaki
Research Faculty of Agriculture, Hokkaido University, Japan

Introduction

Photo from Erianto Indra Putra (UNPAR)

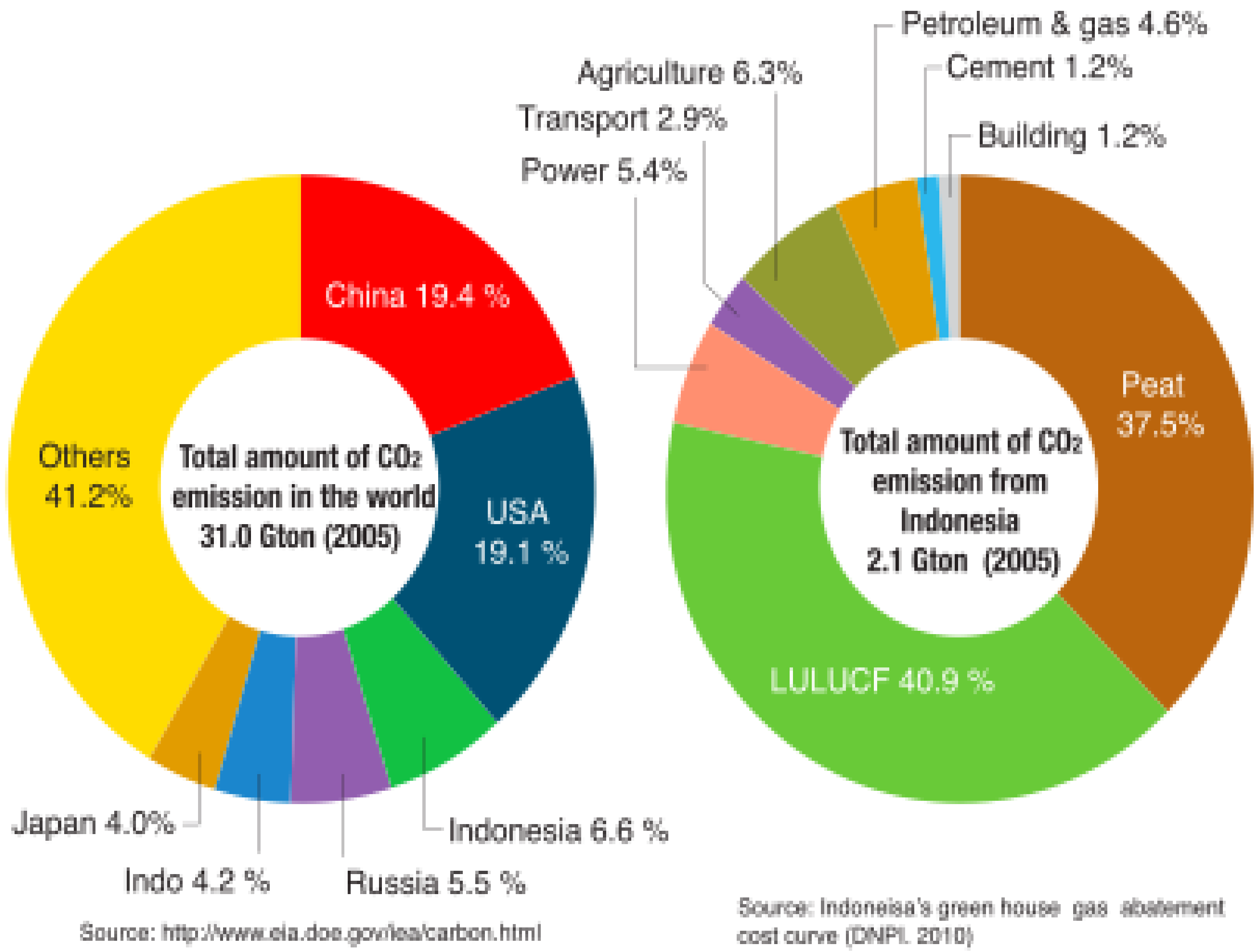
Amount of Carbon in Tropical Peat (GtC (%))





（From Maria Strack ed., 2008: Peatlands and Climate Change. International Peat Society, 223pp.）

Total amount of CO_2 emission



Integrated Monitoring-Sensing-Modeling (MSM) system

Photo from Erianto Indra Putra (UNPAR)

Main Project Sites

→Monitoring was started from 1997

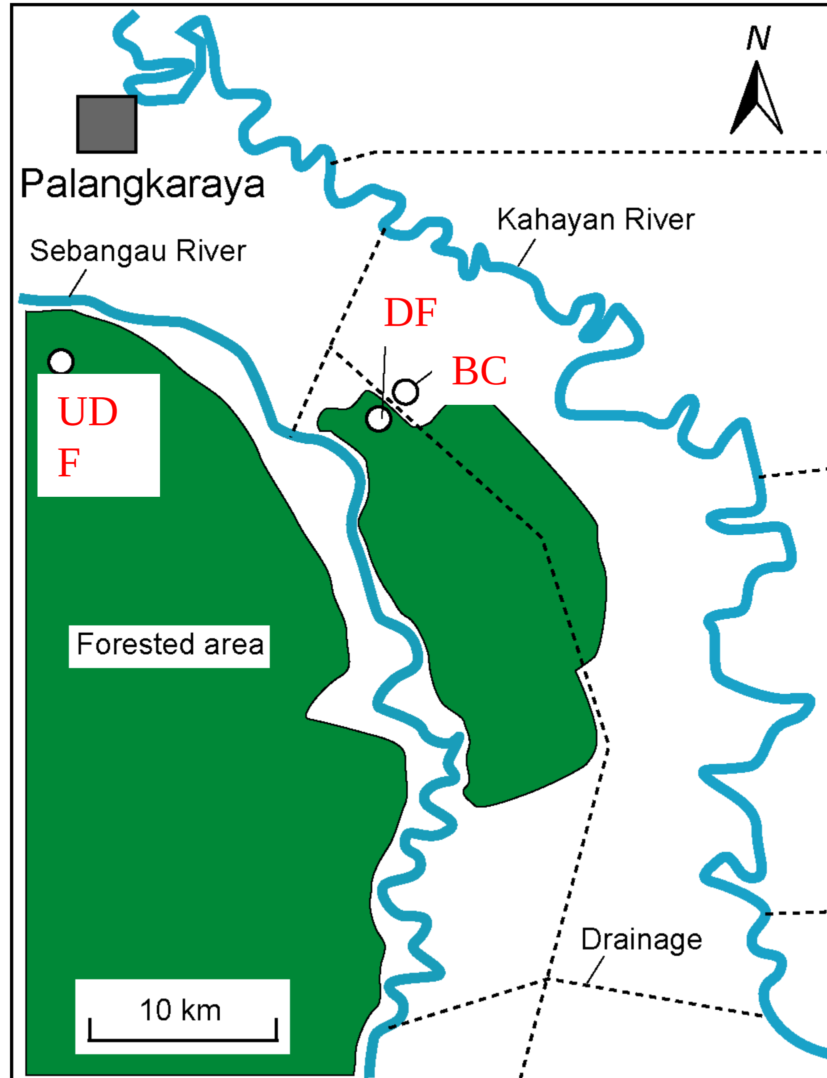
- Central Kalimantan, Indonesia
- Peatland area in Mega Rice Project site

CO_2 observation towers at

UDF : (Un-drained Peat)

DF : (Drained Peat)

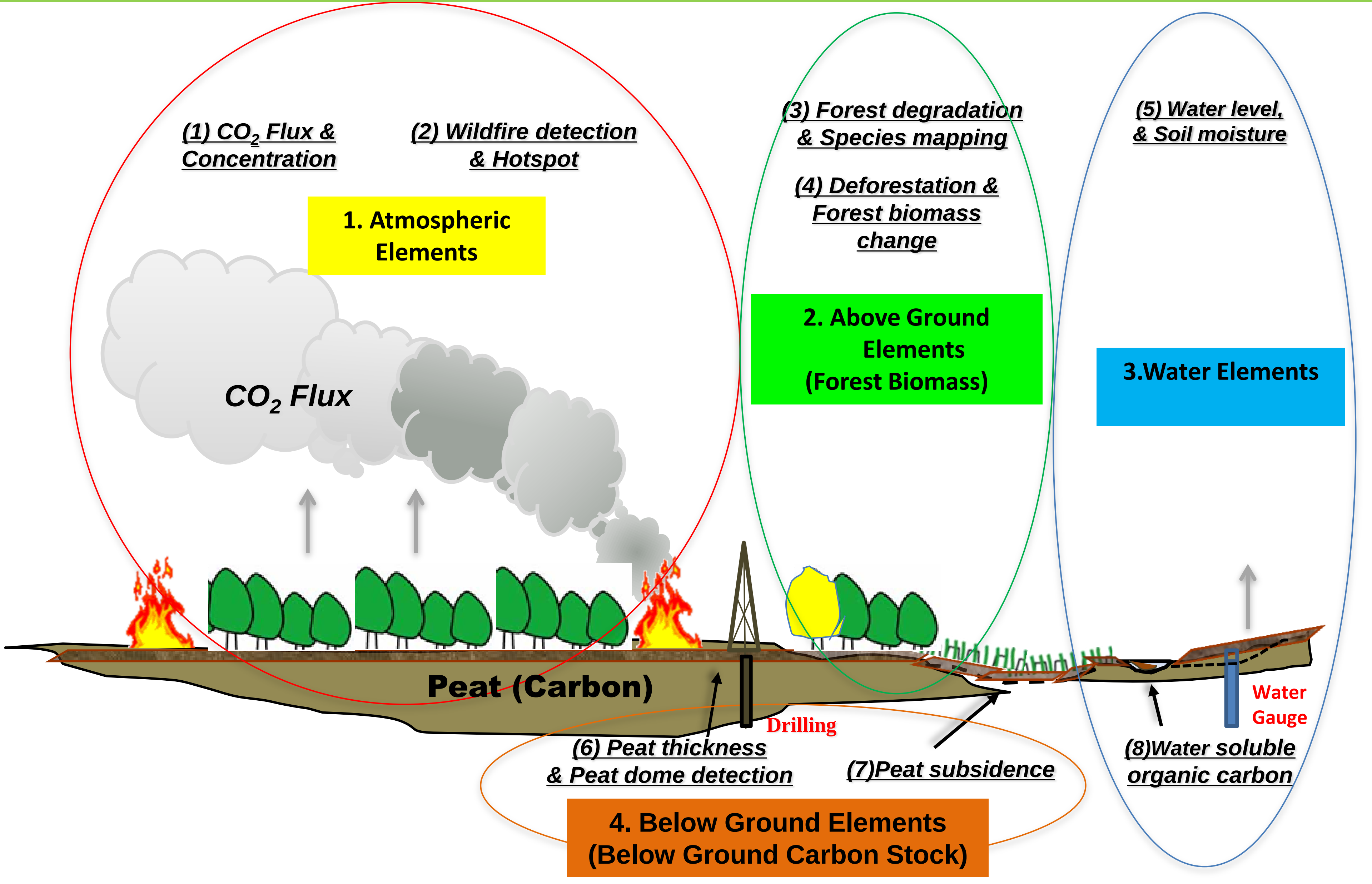
BC : (Burnet Peat)

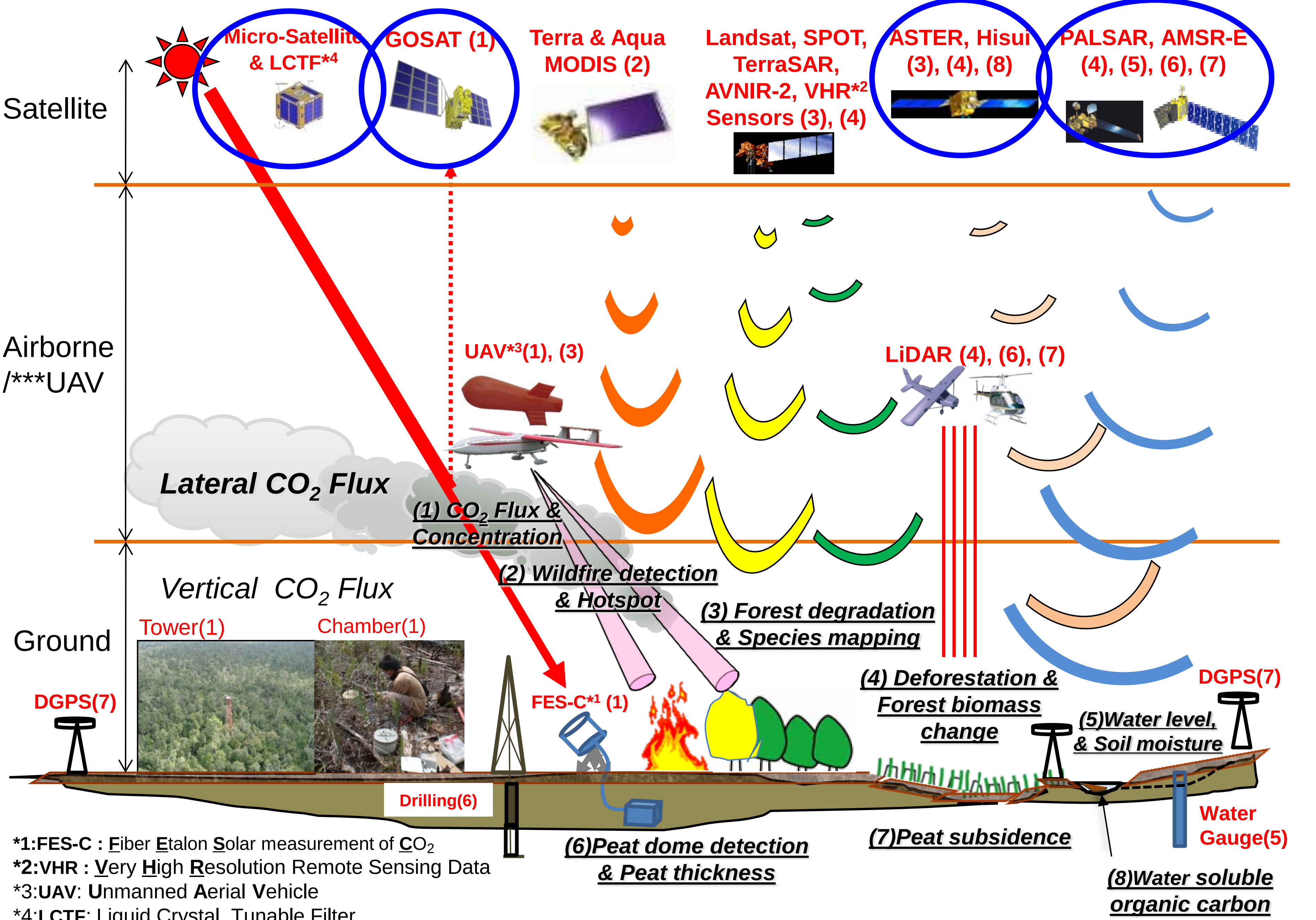


Various Study Topics:

- GHG Flux (CO_2, CH_4, N_2O) measuring
- Fire Detection and Protection
- Water Table Monitoring and Management
- Peatland Ecology
- Soluble Carbon Monitoring
- Peatland Subsidence Monitoring
- etc.

Key elements for integrated Monitoring-Sensing-Modeling (MSM) system of Carbon in peatland





*1:FES-C : Fiber Etalon Solar measurement of CO_2
*2:VHR : Very High Resolution Remote Sensing Data
*3:UAV: Unmanned Aerial Vehicle
*4:LCTF: Liquid Crystal Tunable Filter

Red: Instrument
Black: Target

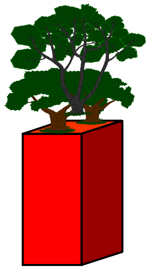
Key Elements of Tropical Peatland MSM System

Integrated Monitoring-Sensing-Modeling (MSM) system:

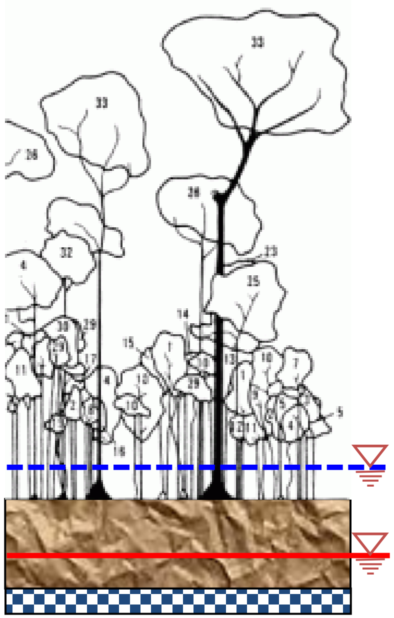
Carbon Stock

Photo from Erianto Indra Putra (UNPAR)

Peat Thickness Estimation (Shimada Model)



Shallow peat layer



Mineral Soil

Vegetation (Physiology)

Adjust Response

(cf. Lugo et al. 1990)

Phenology Classification

Hydroperiod

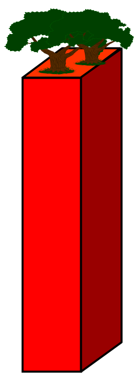
WET

DRY

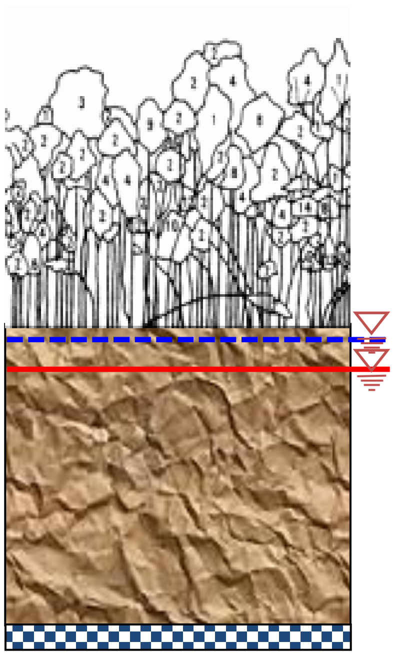
Greater GWL fluctuation

Temporarily High flood condition

Hypothesis



Deep peat layer



Mineral Soil

Moderate GWL fluctuation

Permanently Wet condition

WET

DRY

Seasonal fluctuation of GWL is different; moderate at deep peat, while greater at shallow peat.

This might reflect the vegetation physiologically.

Idea of Peat Depth Classification

In Tropical Peat Swamp Forest, type of forest stand and its phenology are corresponded to Peat Depth, in terms of seasonal groundwater level fluctuations.

Its difference produce

spatial trends of plant activity in each season.

To detect these,

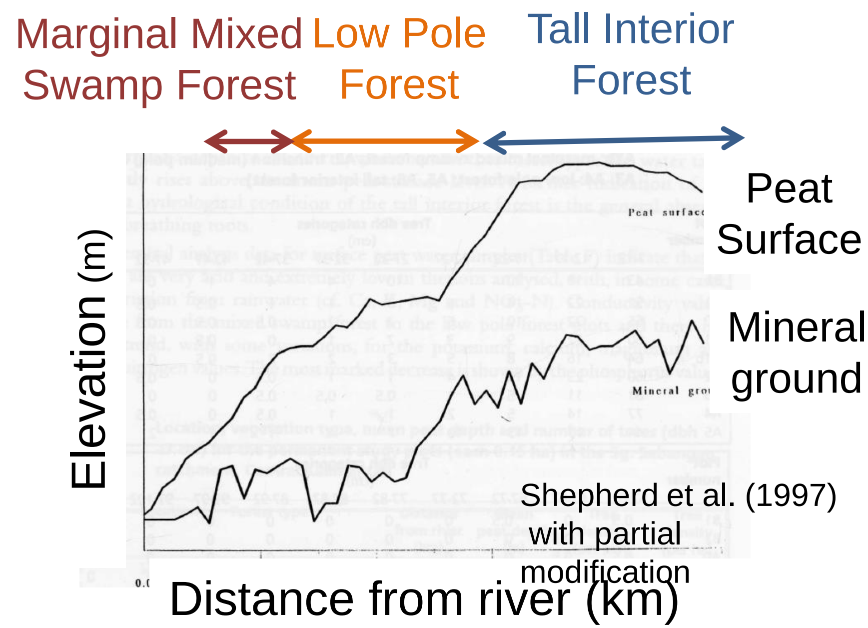
Supervised classification were conducted using **multi-temporal satellite scene** with **Peat Depth Database as training data**.

Index of Plant Activity: **NDVI**

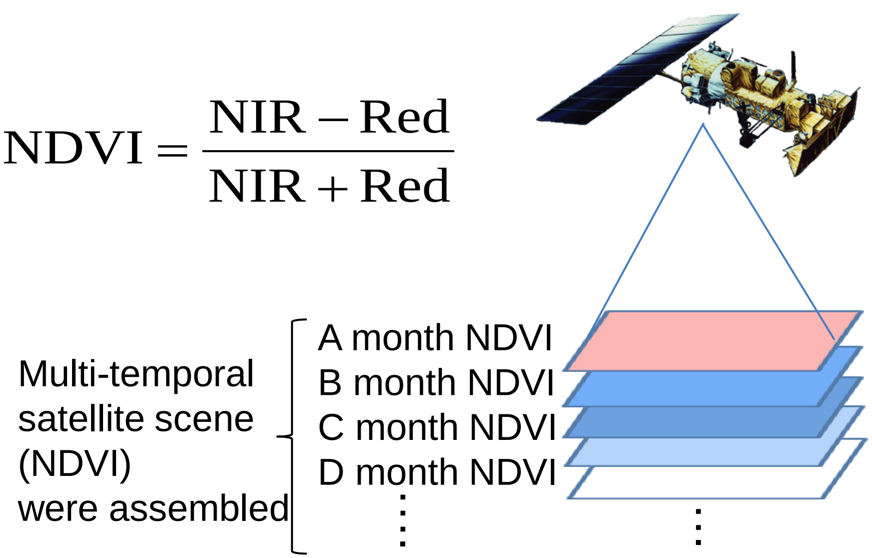
Target Period : **Early 90's**

Relatively Undisturbed Condition

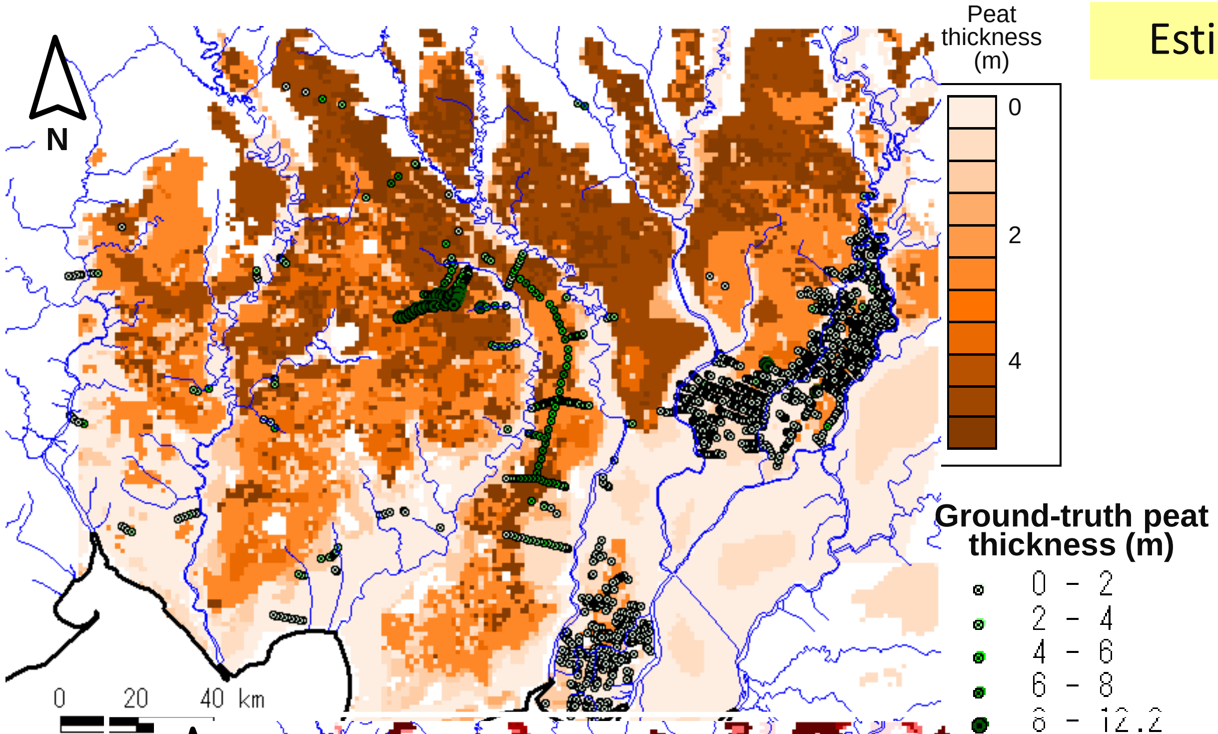
(Before Mega Rice Project)



$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{Red}}{\mathrm{NIR} + \mathrm{Red}}$$



Estimated Map of Peat Thickness

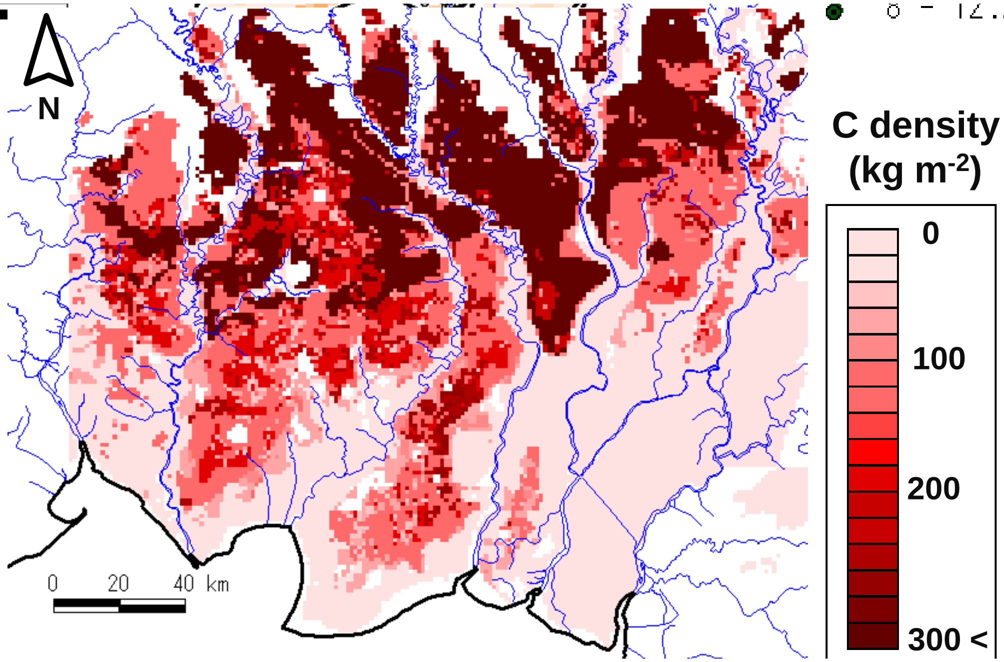


Root Mean Square Error (RMSE)

= 1.64 m

×

Distribution Map of C-density (Shimada et al. 2001)



3.1 Mha

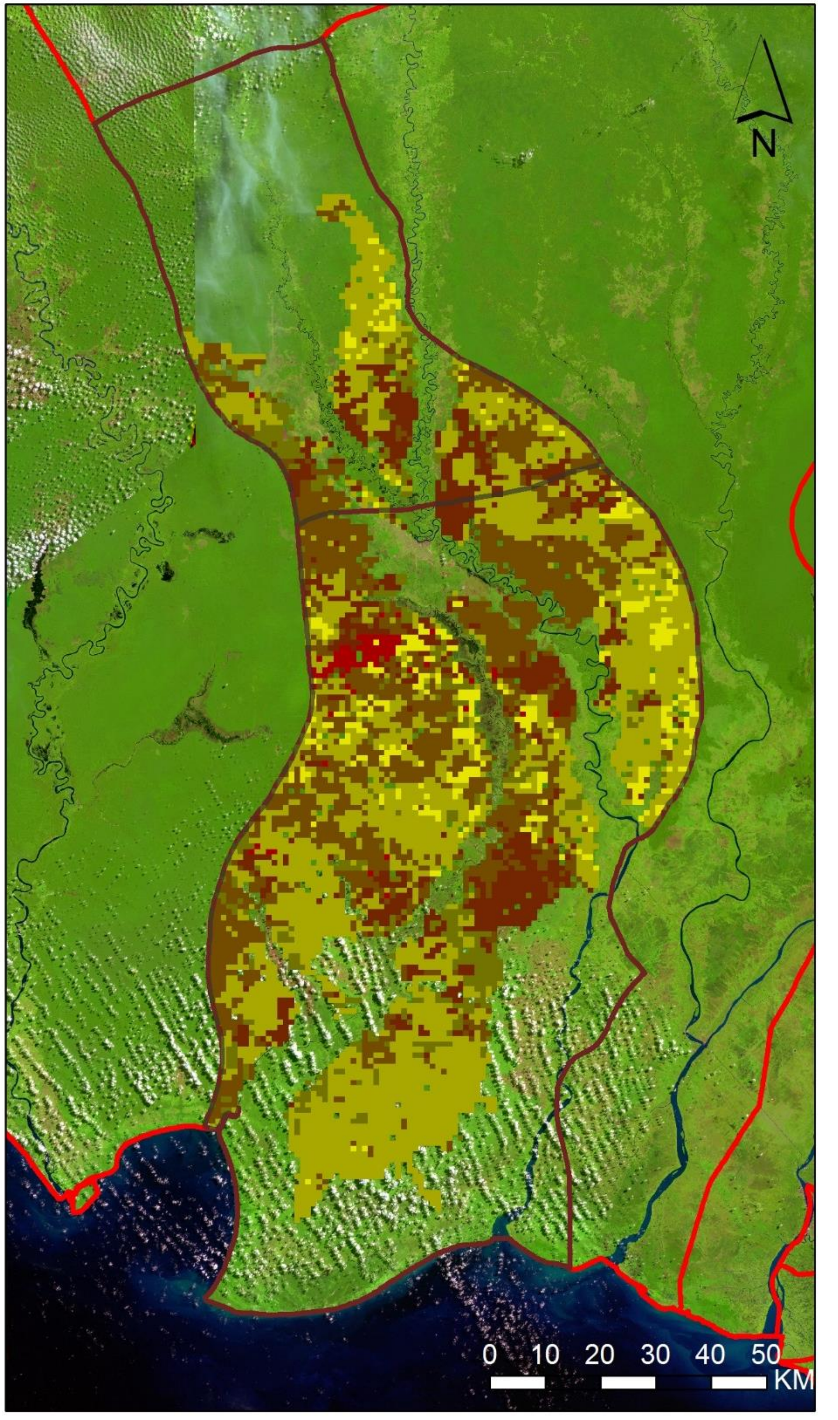
C-pool = 4.2 Gt

$1.4\ Gt\ Mha^{-1}$

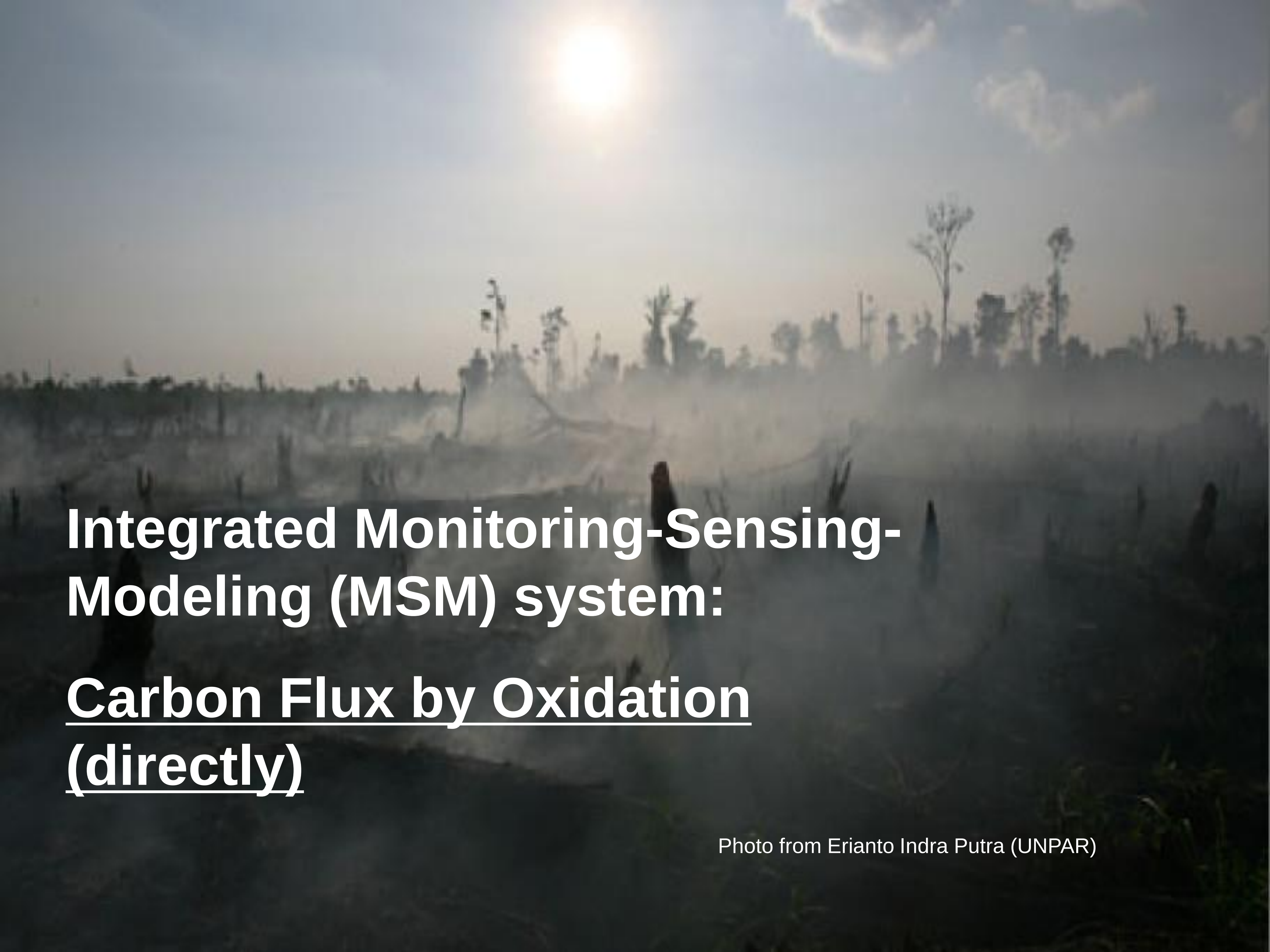
Classified map

- Classification were conducted within the area below
  - 1) Estimated Swamp Forest extent built from Landsat image (1994) and SRTM DEM
  - 2) PalangkaRaya & Pulang Pisau Regency where include core research area of SATREPS

- We are still trying to collect peat drilling data with depth infomation to rebuild the map



category 1 : <=0.5m
category 2 : 0.5–2.0m
category 3 : 2.0–4.0m
category 4 : 4.0–6.0m
category 5 : 6.0–8.0m
category 6 : 8.0m<



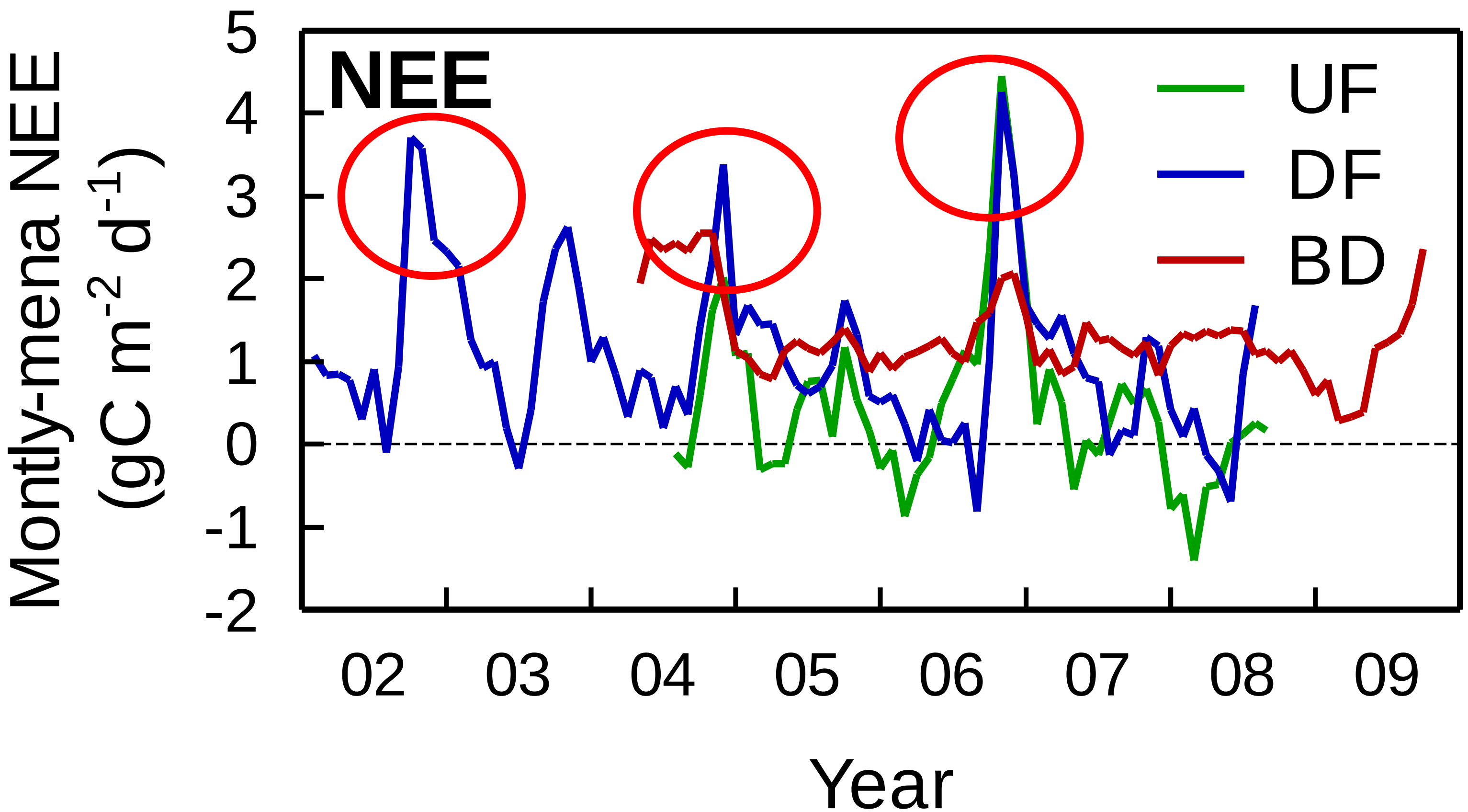
Integrated Monitoring-Sensing-Modeling (MSM) system:

Carbon Flux by Oxidation (directly)

Photo from Erianto Indra Putra (UNPAR)

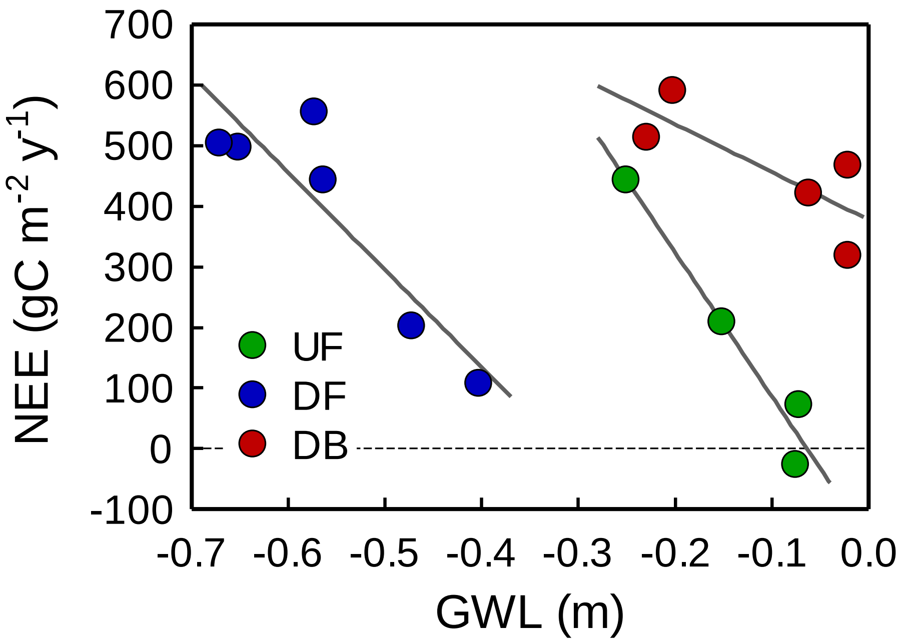
Seasonal variation in net CO_2 exchange (NEE)

NEE = RE - GPP



Large increases were found in the dry seasons of 2002, 2004 and 2006, El Niño years, because of shading by dense smoke and the enhancement of oxidative peat decomposition due to low GWL.

Annual NEE vs. annually mean GWL



Hirano et al., 2012

A negative linear relationship for each site
→ Enhancement of oxidative peat decomposition under low GWL

Slope: UF > DF > DB → Undisturbed peatland is more sensitive.

Annually mean GWL is a robust indicator to assess annual CO_2 balance.

Oxidative peat decomposition vs. GWL in burnt site

With 6 automated chambers

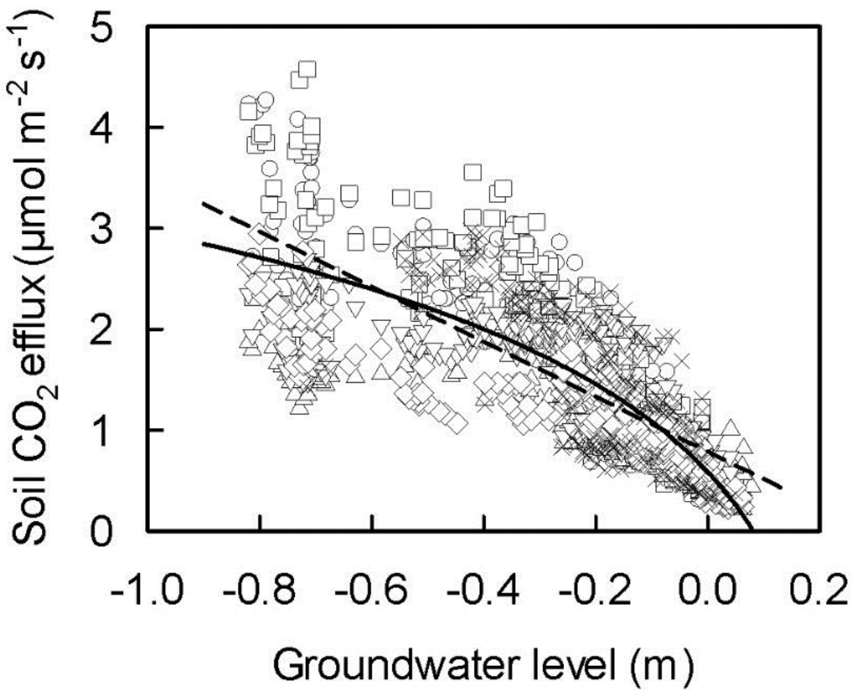
From 2004 to 2005

Fires

Little vegetation

→ Heterotrophic respiration (oxidative peat decomposition)

Peat decomposition (RS)



From a simple relationship,

GWL lowering by 0.1 m

↓

Additional peat decomposition of 89 gC m^{-2} y^{-1}

Hirano et al., 2013 (GCB)

Integrated Monitoring-Sensing-Modeling (MSM) system:

Carbon Flux by Oxidation (indirectly)

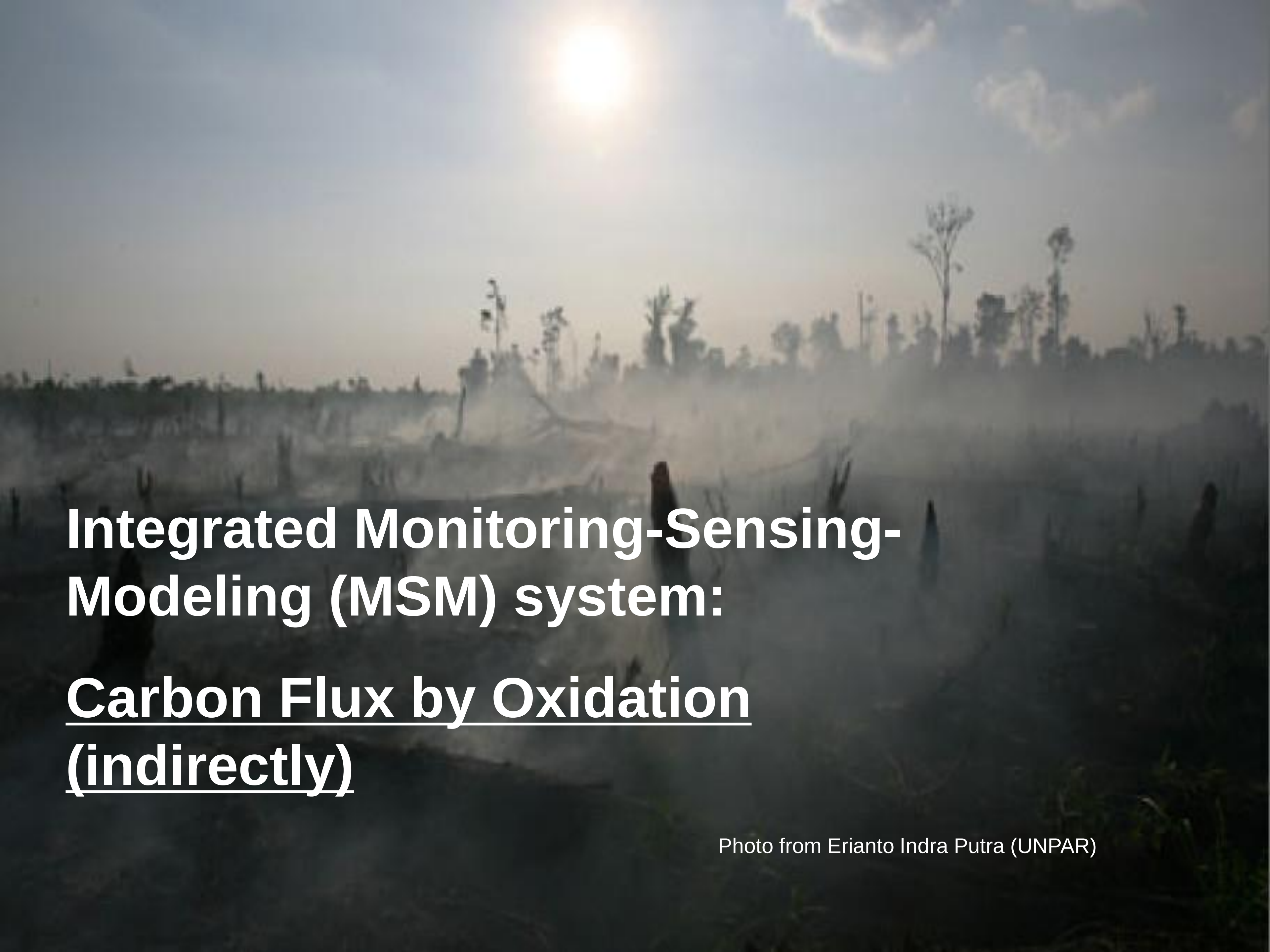


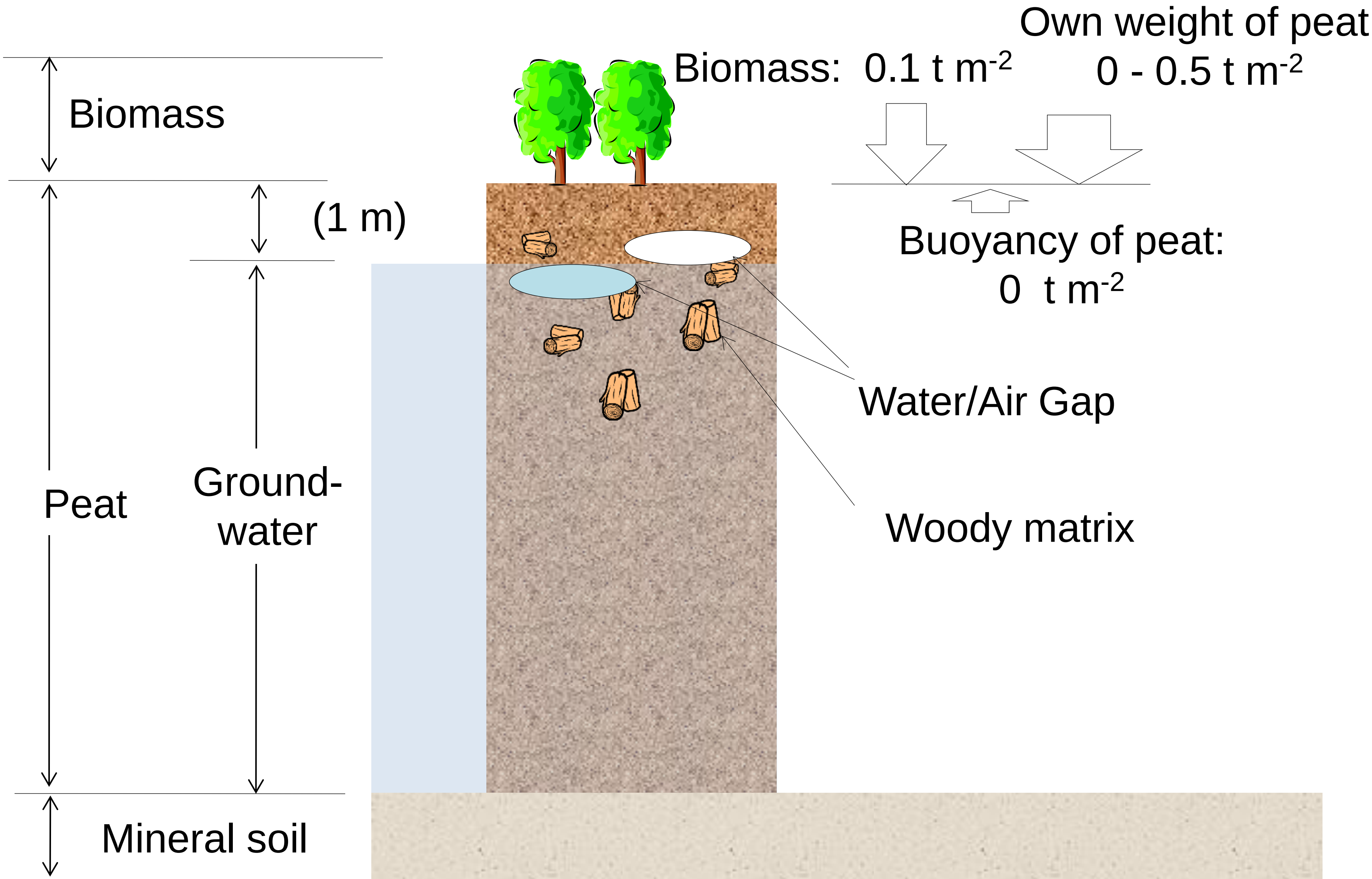
Photo from Erianto Indra Putra (UNPAR)

Subsidence and GHG emissions

Photo: Jyrki J, Johor Bahru, Malaysia

Factors affecting on the level of ground surface in tropical peatland

(1) Weight Effect?



Factors affecting on the level of ground surface in tropical peatland

(2) Bulk Density?

Woody matrix and water/air gaps

(Yonebayashi et al, 1995)

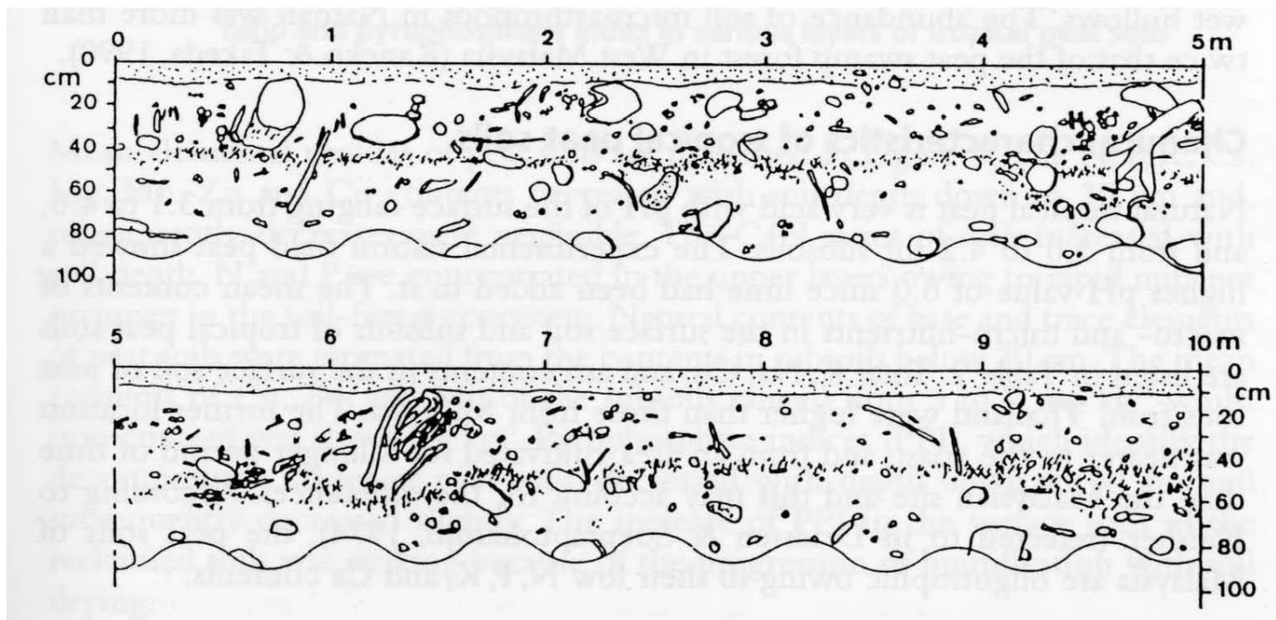
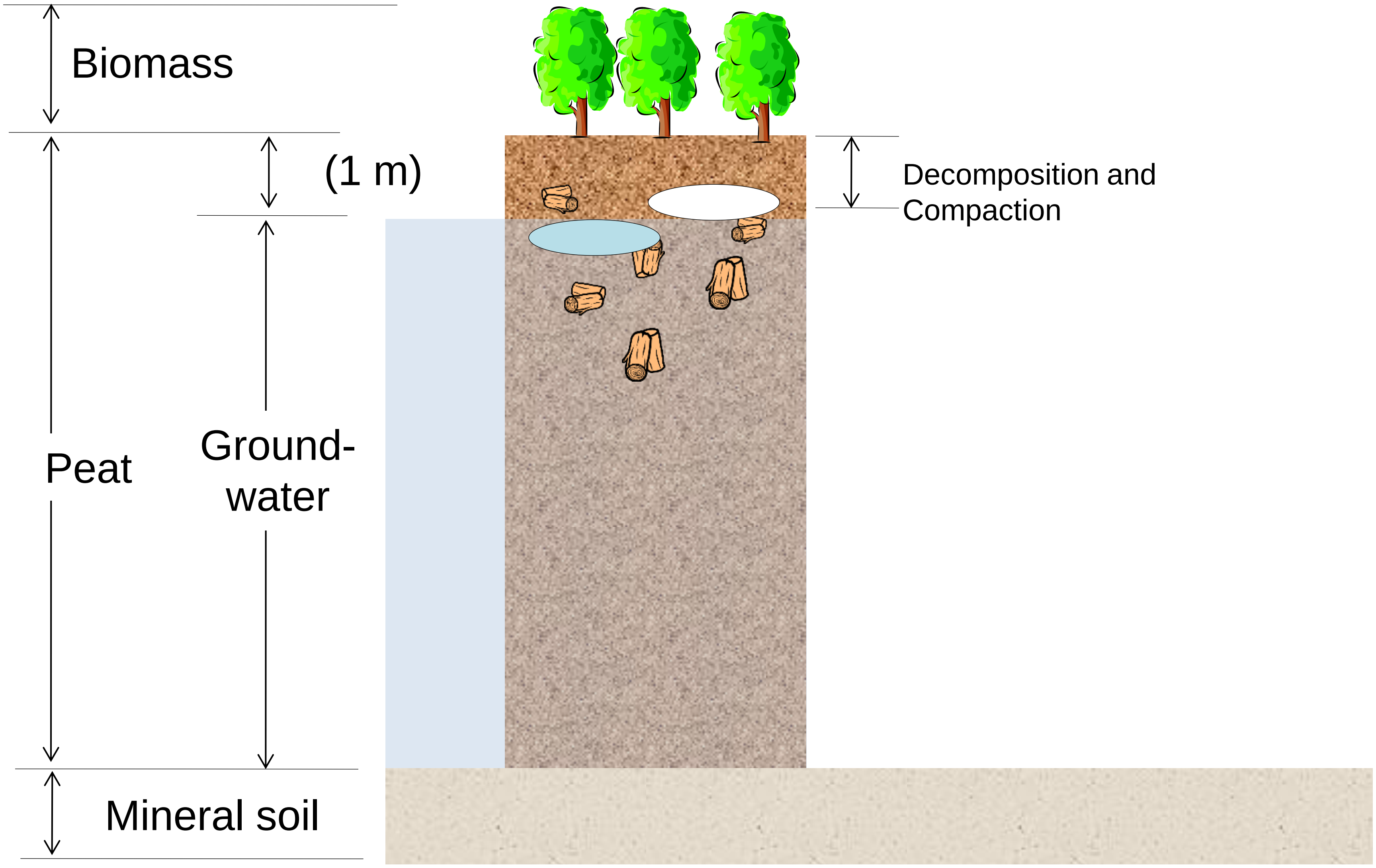


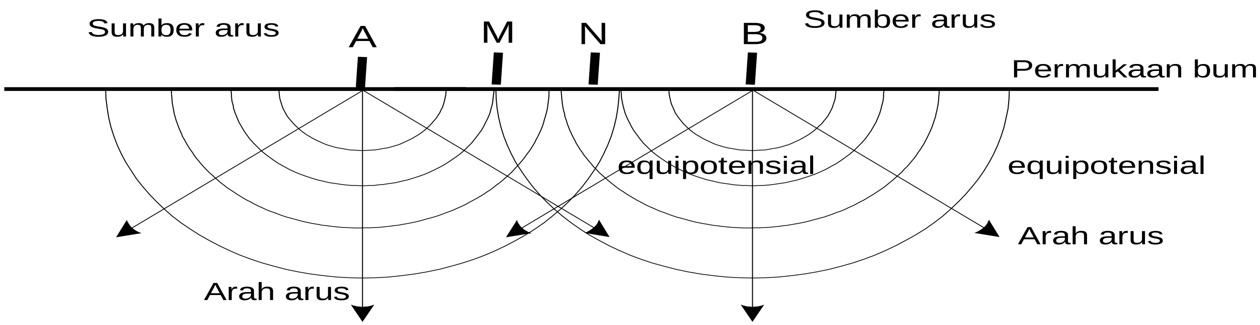
Figure 3 Woody peat profile in Pontian MARDI experimental station, Johor, Malaysia

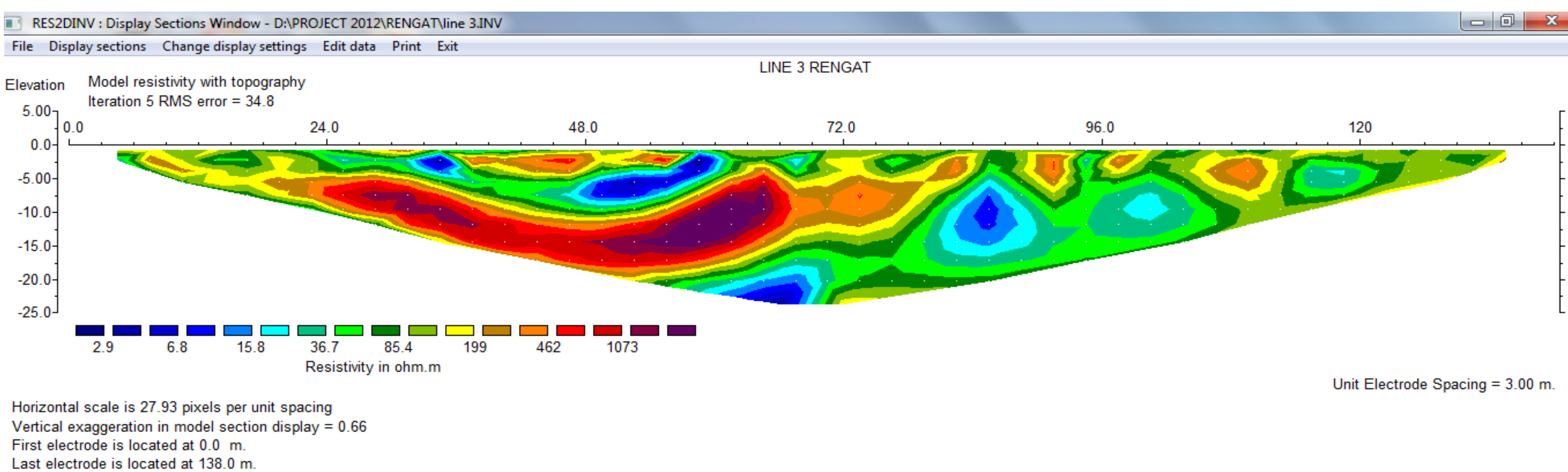
Factors affecting on the level of ground surface in tropical peatland

(3) How separate Decomposition and Compaction?



GEOSCANNER ASSESSMENT





Subsidence measurement by use of a laser distance meter

The laser distance meter is fixed on the pole which is inserted into the soil until it reaches to a clay soil. The target of observation is a plastic pole put on the ground removing the fresh litter on surface. The change of the distance is recorded together with the underground water level. This change corresponds to the peat soil layer thickness change above clay layer. The precision of distance meter is 50 μm.

Peatland Subsidence Monitoring

Peat is shrinking and swelling which is strongly affected by ground water table. It results in uplift and subsidence which are measured by five methods with different precision (Fig. A). ***Laser distance meter*** method enables to monitor the subsidence precisely and reliably (Fig. B).

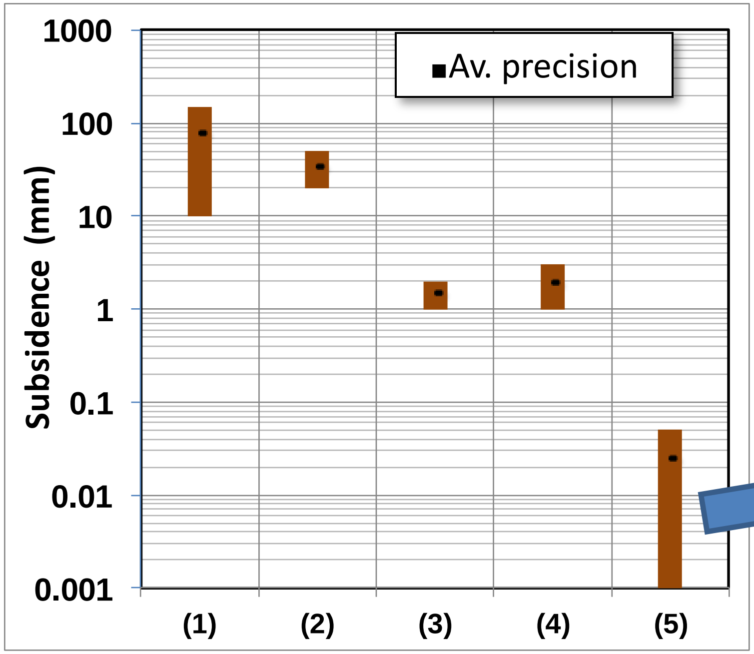


Fig. A: Precisions of five subsidence methods;
(1) Light Detection and Ranging (LiDAR),
(2) Interferometric SAR(InSAR), (3) Leveling pole,
(4) differential GPS, (5) Laser distance meter

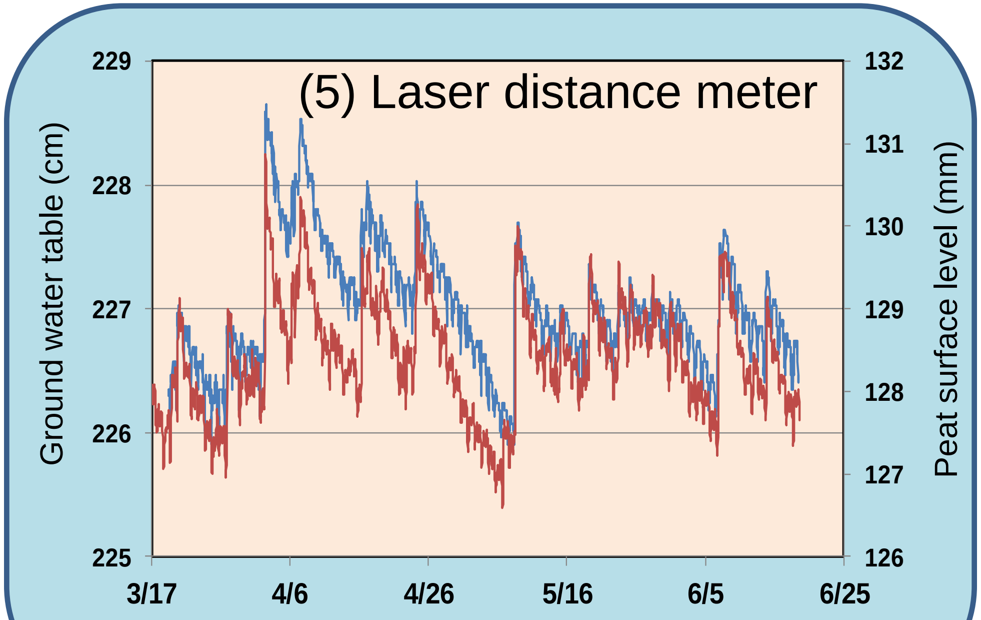
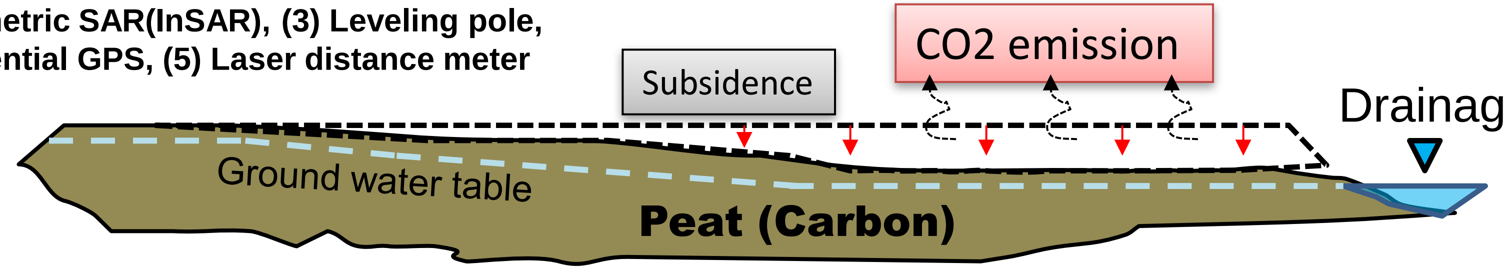


Fig. B Relationship between ground water level (blue) and peat surface level (red)

Presented by Kawasaki (2013)



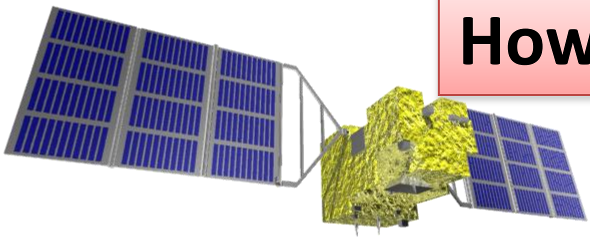
Integrated Monitoring-Sensing-Modeling (MSM) system:

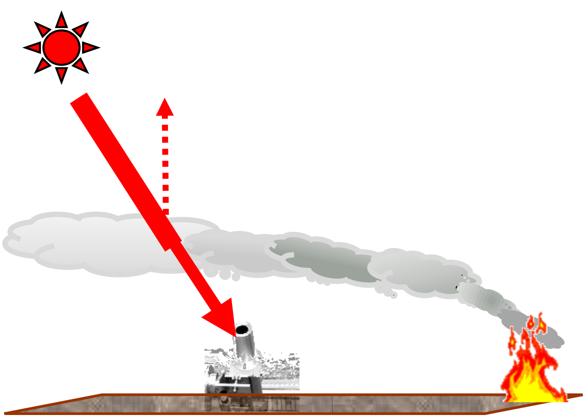
Carbon Flux by Fire

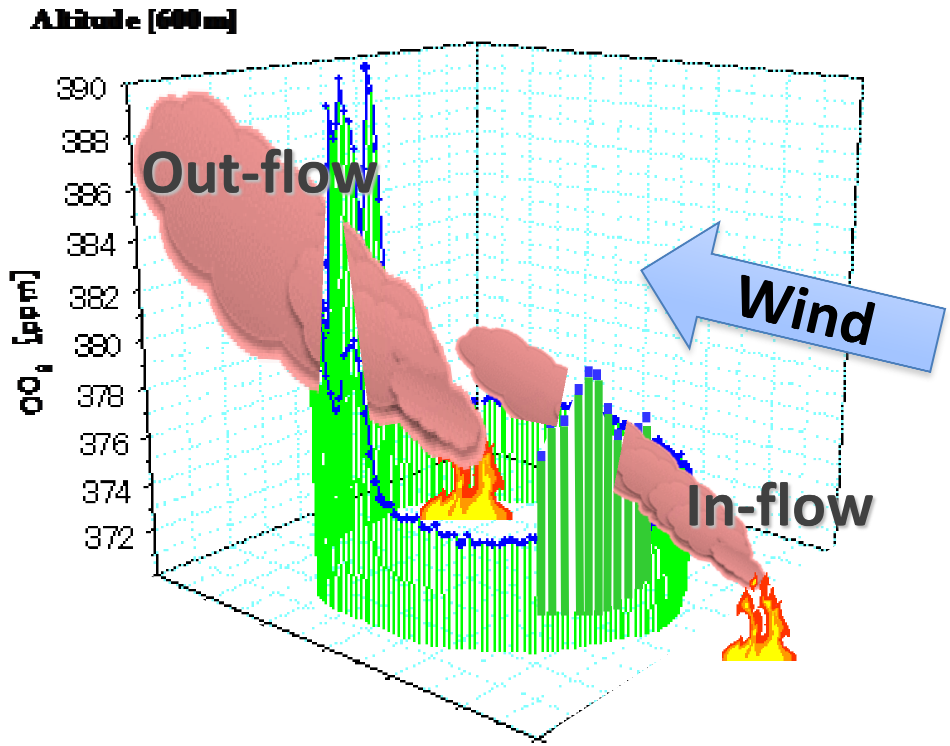
(directly)

Photo from Erianto Indra Putra (UNPAR)

How to evaluate the CO_2 flux from wild fire?



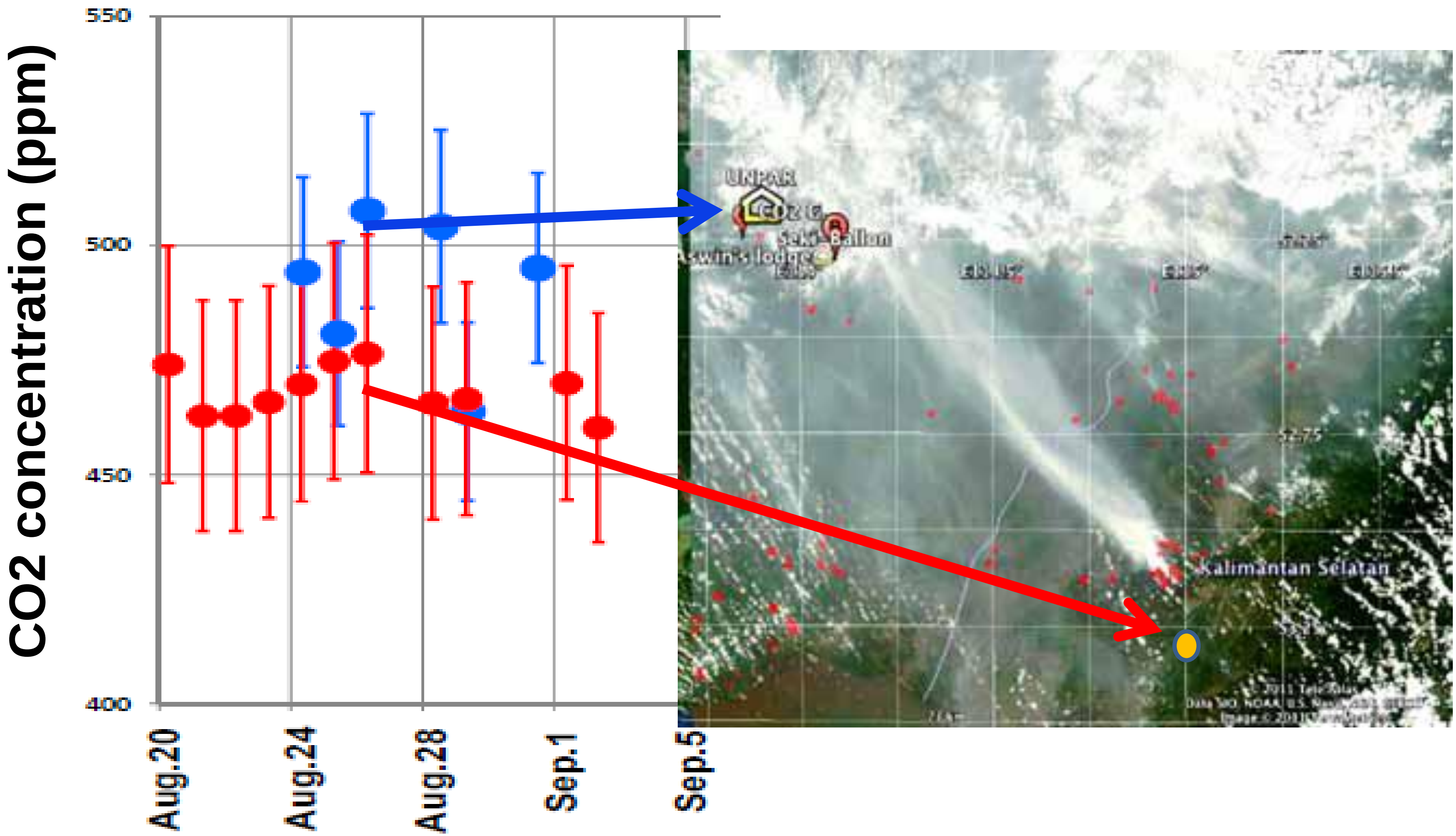




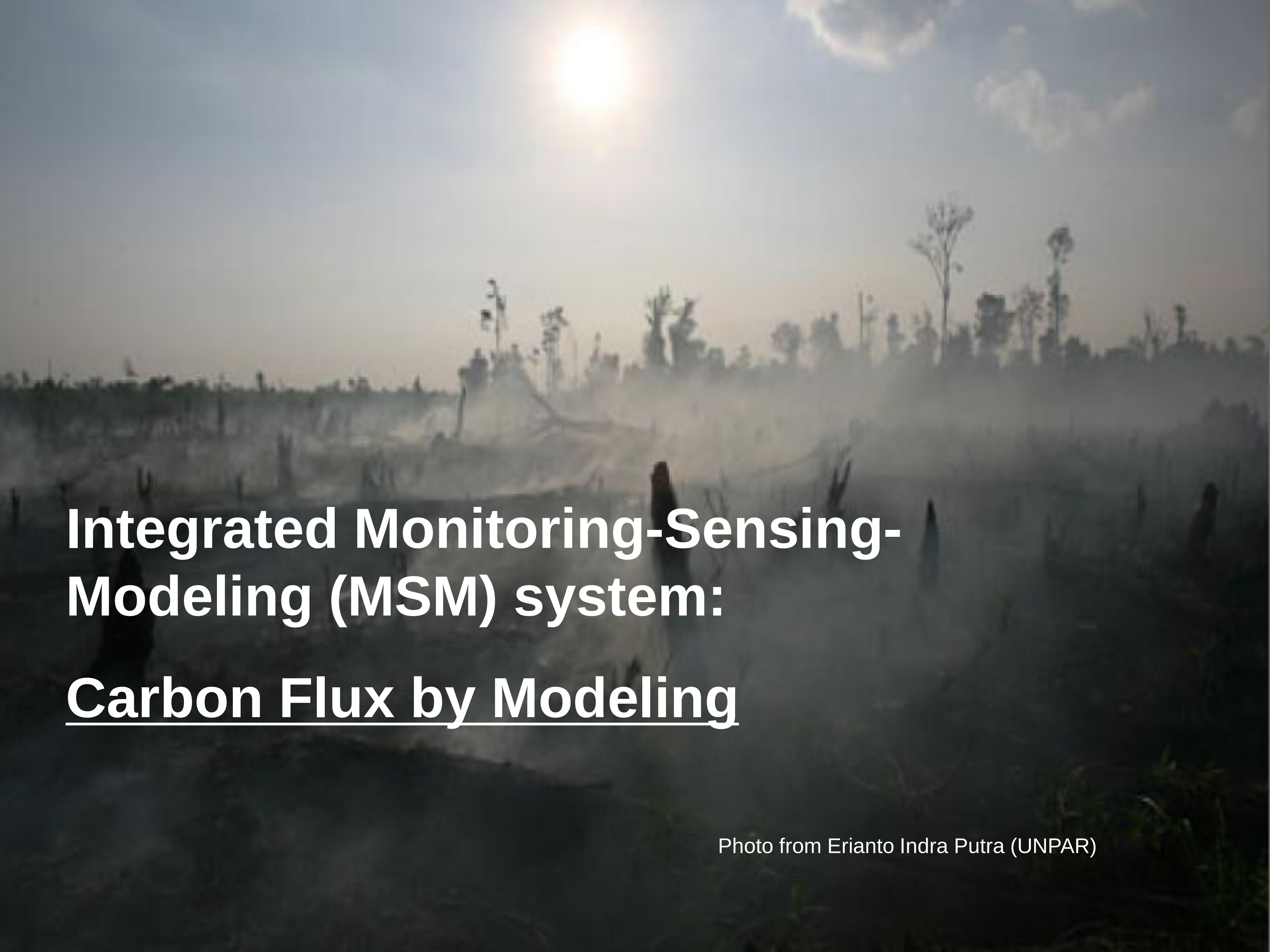
$$\text{Flux} = \int C(h,x)\, v(h,x)\, dx\, dh$$

v: Wind velocity at (h,x)
C: Concentration at (h,x)

Flux is evaluated from concentration of CO_2, wind speed and the plume distribution



	FRP	NDVI	GFED	This work
CO2 emission (Mt in 2002-10)	42±33	1.83±1.47	280±350	2870 (in 2011)



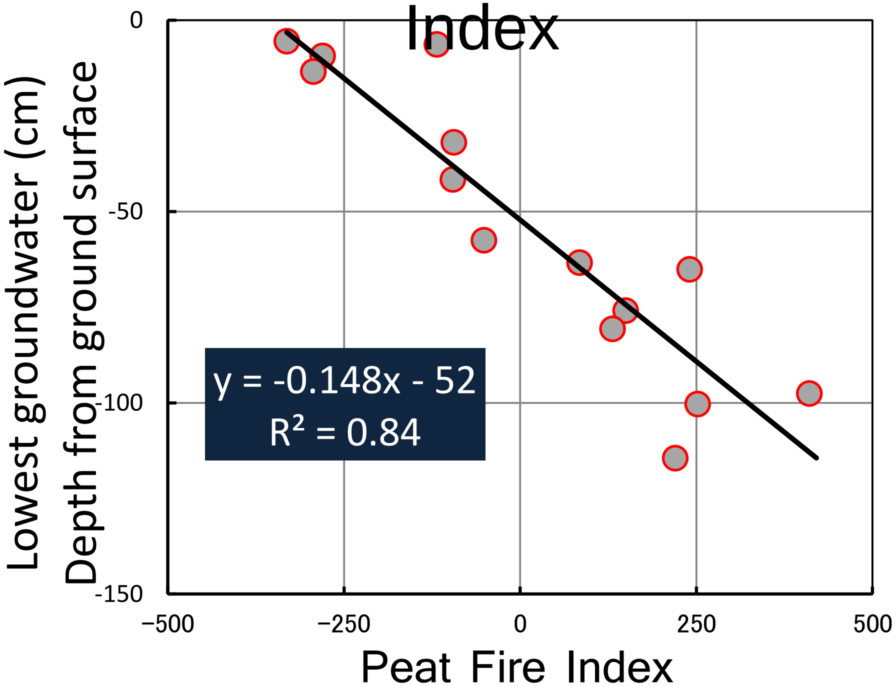
Integrated Monitoring-Sensing-Modeling (MSM) system:

Carbon Flux by Modeling

Photo from Erianto Indra Putra (UNPAR)

Takahashi Model

The lowest GWL in dray season and Peat Fire Index



correlation

Fire occurrence

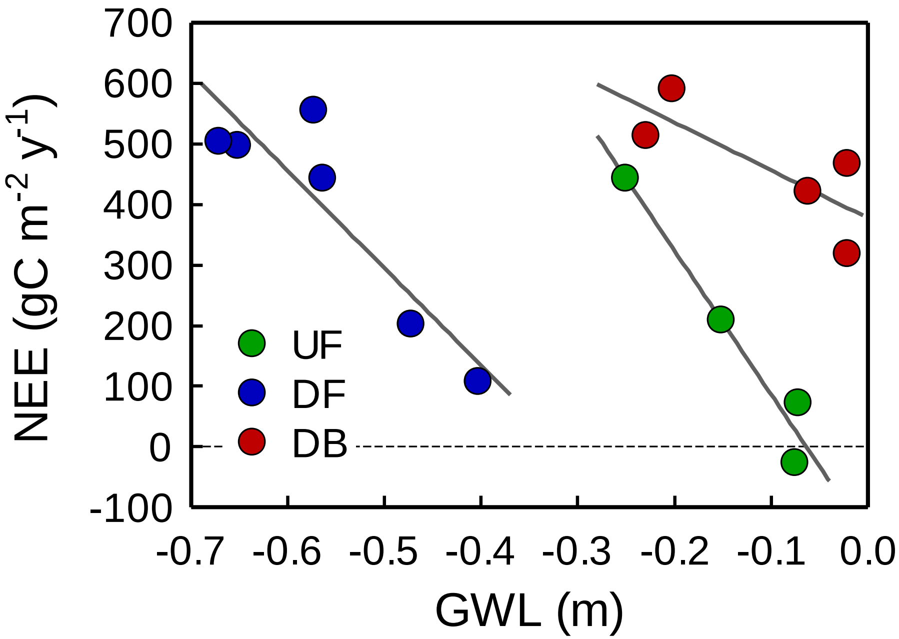
(Takahashi)

Summary

1. Peat boundary selection
2. GWT by Takeuchi model
3. CO2 emission by Hirano model
4. Fire occurrence by Takahashi model

Hirano Model

Annual NEE vs. Annually Mean GWL



UF *NEE*=-2376*GWL*-151

DF *NEE*=-1609*GWL*-510

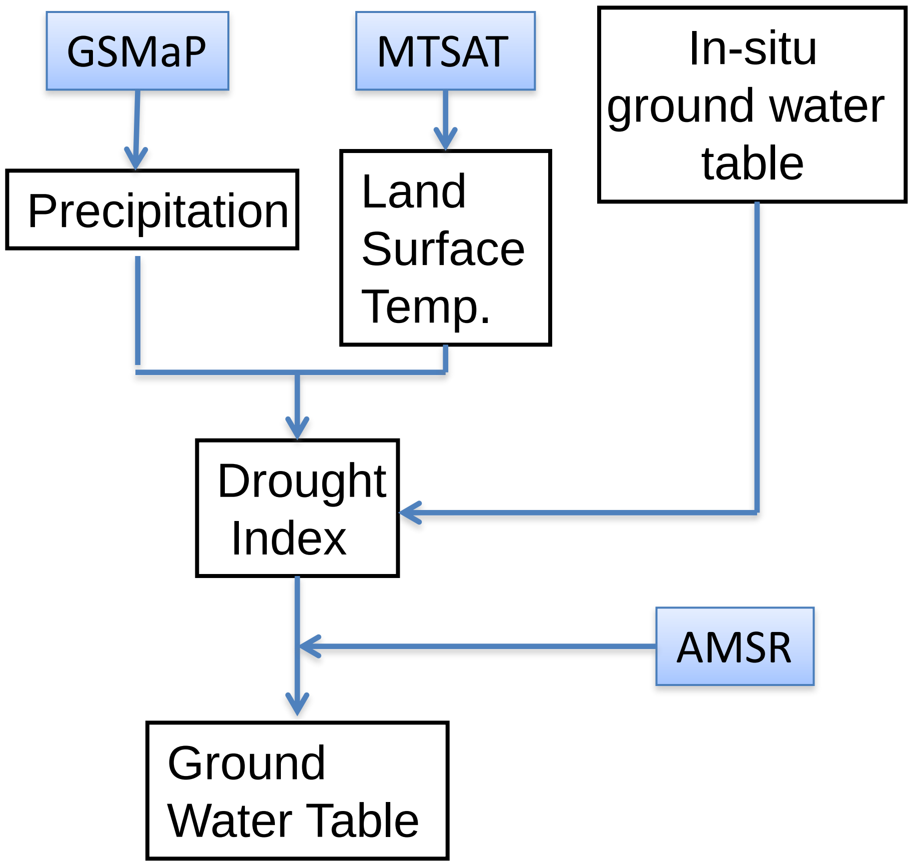
DB *NEE*=-789*GWL*-378

NEE: Net Ecosystem CO2 Exchange

Hirano et al.(2012), GCB

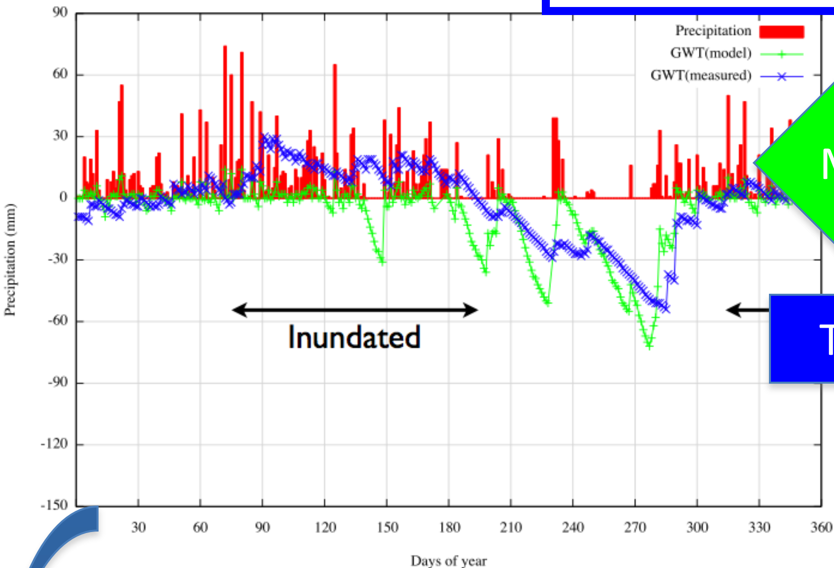
Takeuchi Model

GWT estimation by Remote Sensing Data



Takeuchi, Hirano, Anggraini and Roswintiarti (2010)

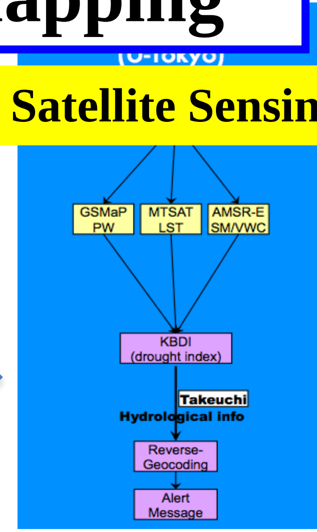
Water Table Mapping

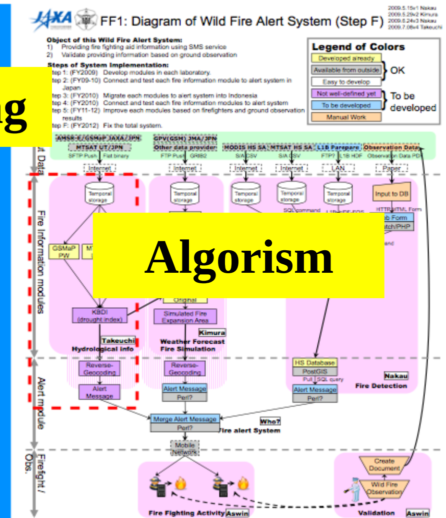


Modeling

Tuning

Satellite Sensing

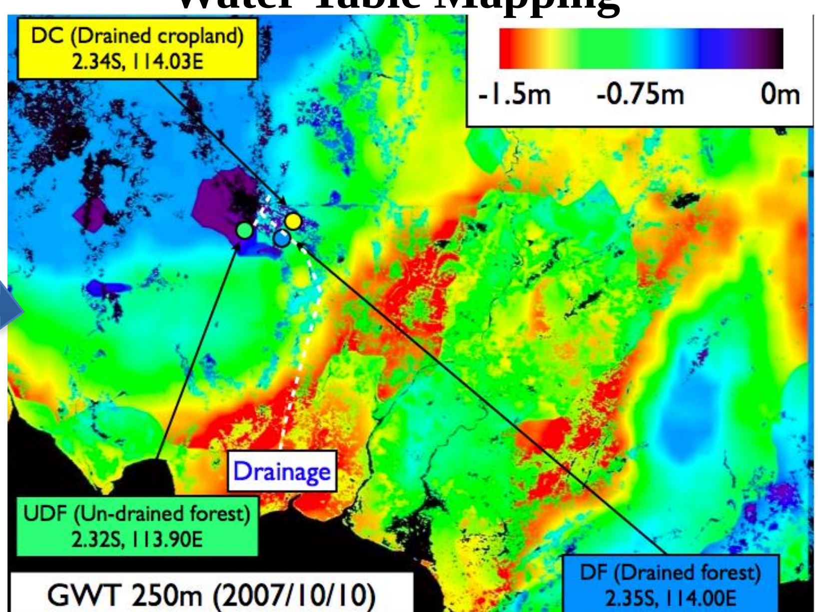




Algorism

By Wataru Takeuchi, University of Tokyo, Japan

Water Table Mapping



Input

Coefficiency between Water Table Level and

1) CO2 emission by Oxidation

2) CO2 emission by Fire Factors

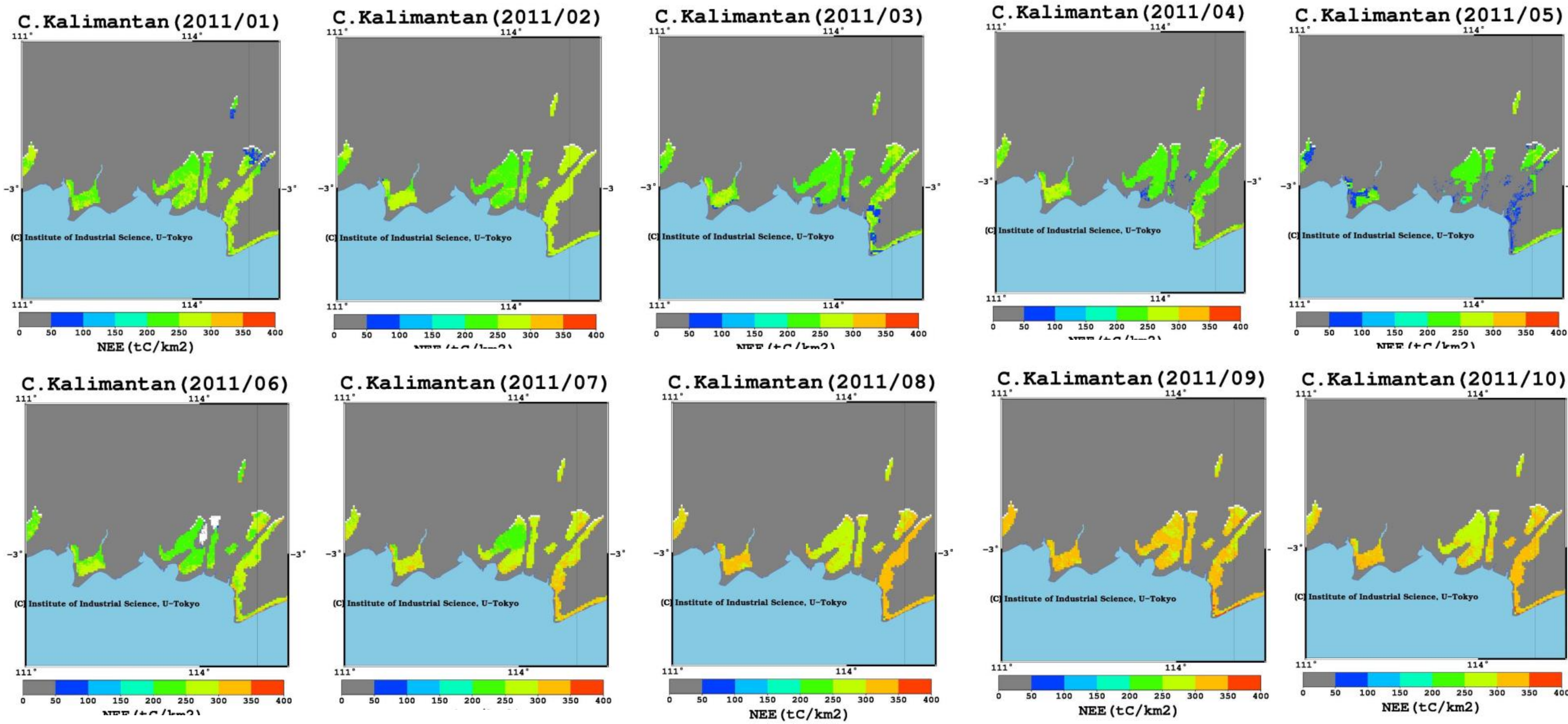
Output

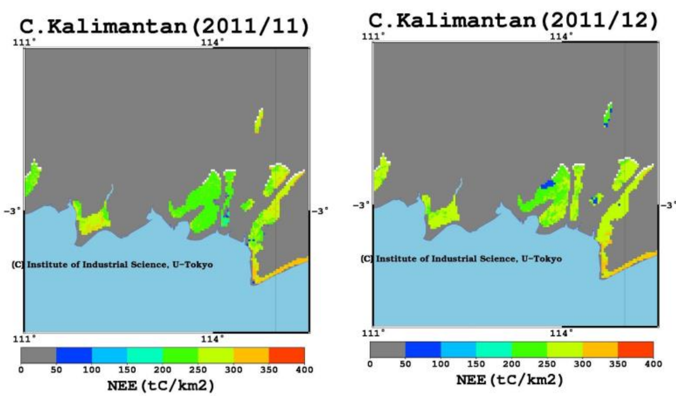
Mapping of

1) CO2 emission by Oxidation

2) CO2 emission by Fire Factors

CO_2 balance (NEE, tC m^{-2} $month^{-1}$) of peatland in Central Kalimantan in 2011





By Park and Takeuchi, University of Tokyo

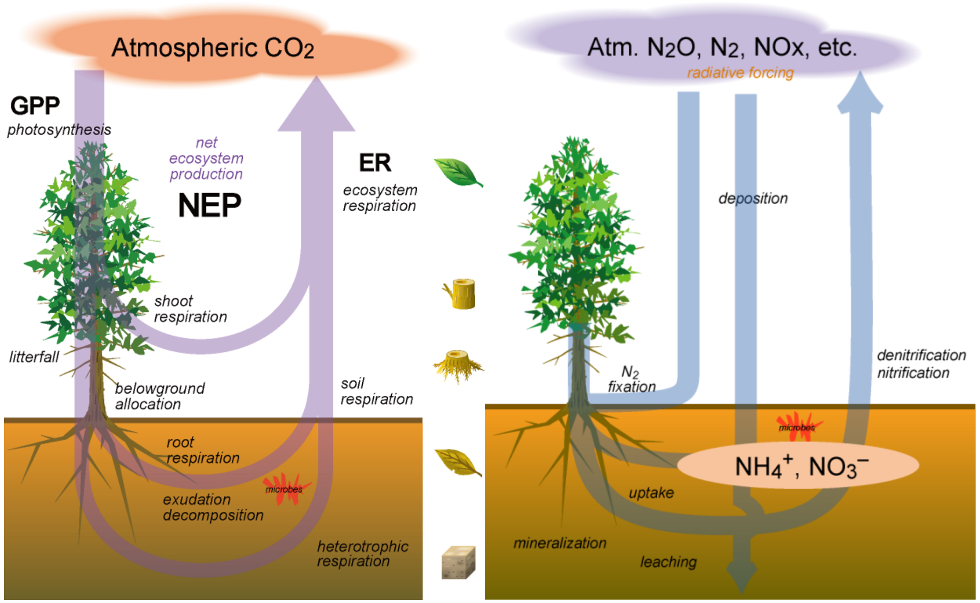
The Ecosystem model developed by NIES(Dr. Ito)

Vegetation Integrated SImulator for Trace gases

(Developed in NIES & FRCGC-JAMSTEC)

Objectives

- Atmosphere-ecosystem biogeochemical interactions
- Especially, major greenhouse gases (CO_2, CH_4, and N_2O) budget
- Assessment of climatic impacts and biotic feedbacks



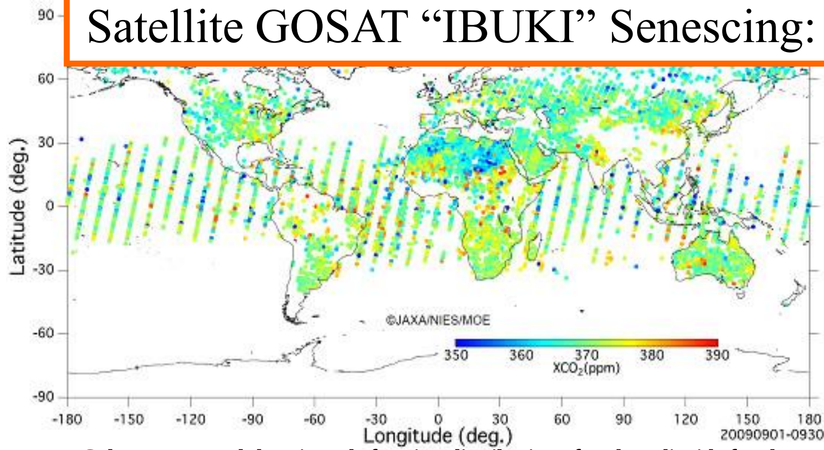
Carbon-cycle (Sim-CYCLE-based)

Nitrogen-cycle

Point-global, daily-monthly

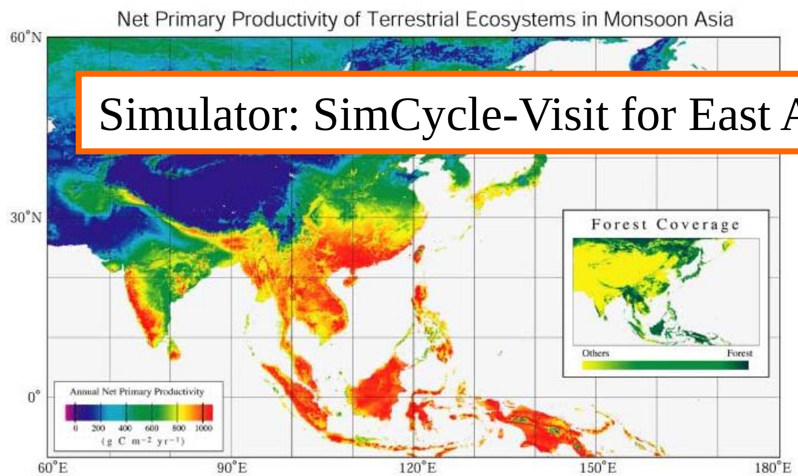
- CO_2: photosynthesis & respiration
- CH_4: production & oxidation
- N_2O: nitrification & denitrification
- LUC emission: cropland conversion
- Fire emission: CO_2, CO, BC, etc.
- BVOC emission: isoprene etc.
- Others: N_2, NO, NH_3, erosion

Satellite GOSAT “IBUKI” Senescing: CO2

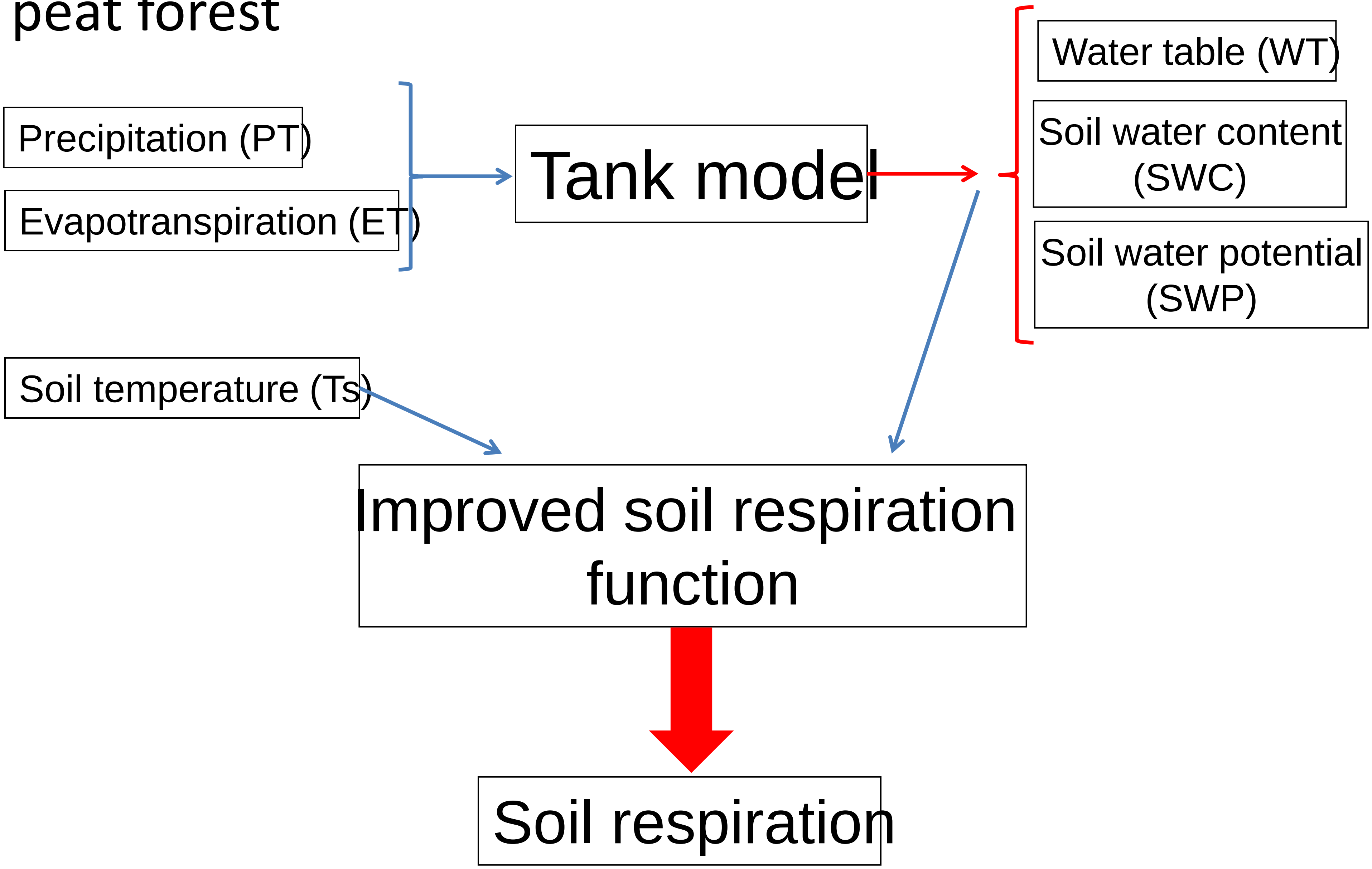


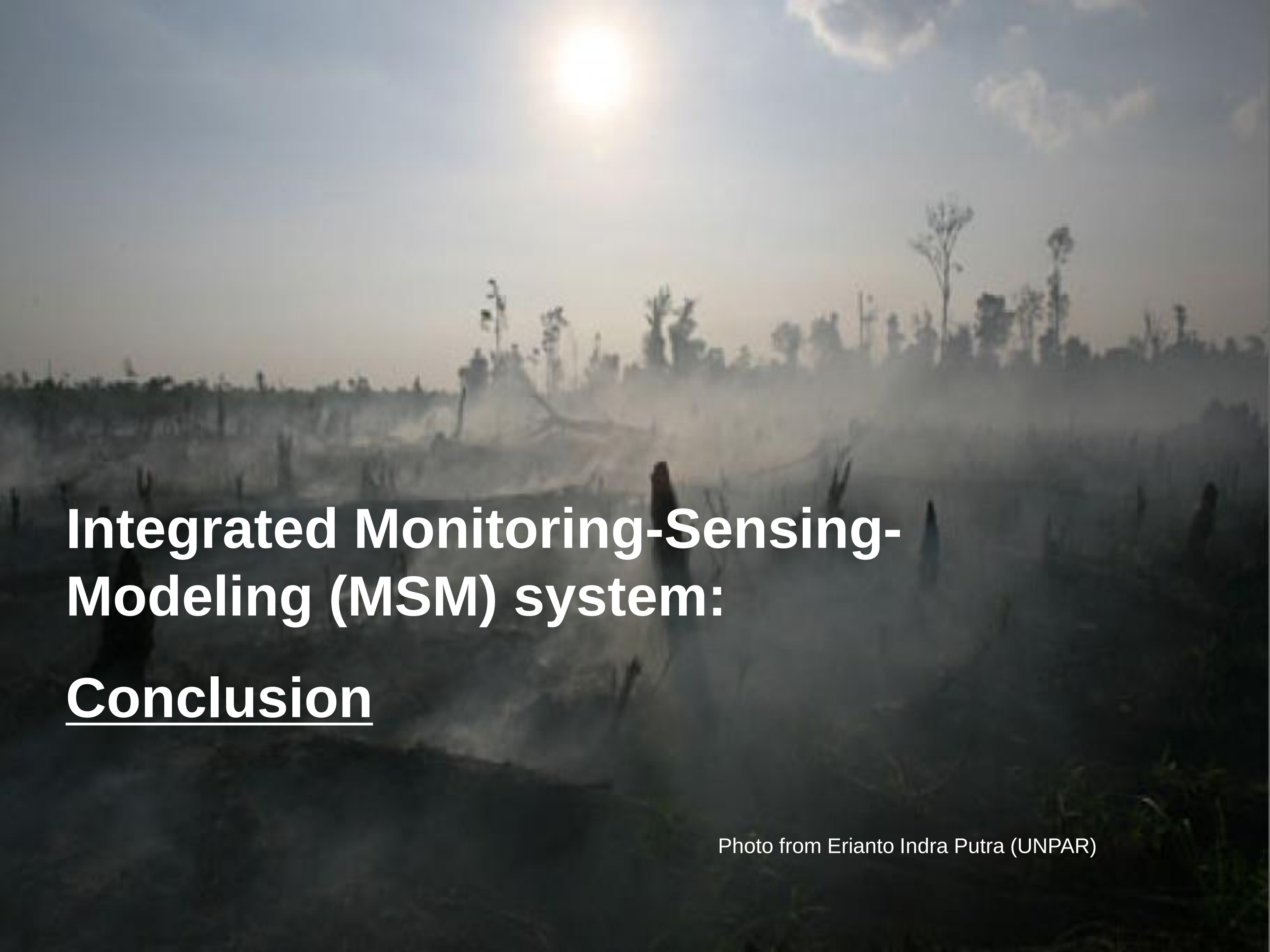
Column averaged dry air mole fraction distribution of carbon dioxide for the month of September, 2009, obtained from IBUKI observation data (unvalidated) By JAXA

Simulator: SimCycle-Visit for East Asia



Improved scheme for soil respiration of tropical peat forest





Integrated Monitoring-Sensing-Modeling (MSM) system:

Conclusion

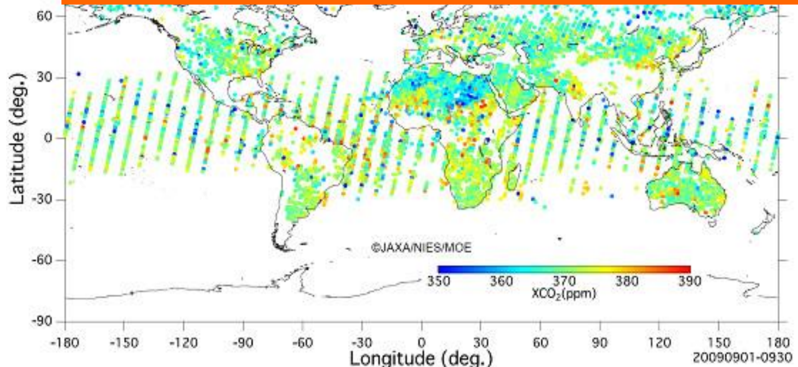
Photo from Erianto Indra Putra (UNPAR)

Top-down
- satellite
- airplane
- inverse model

Integrated, practical carbon budget map

Bottom-up
- field survey
- flux obs.
- process model

Satellite GOSAT "IBUKI" Senescing: CO_2



Column averaged dry air mole fraction distribution of carbon dioxide for the month of September, 2009, obtained from IBUKI observation data (unvalidated) By JAXA

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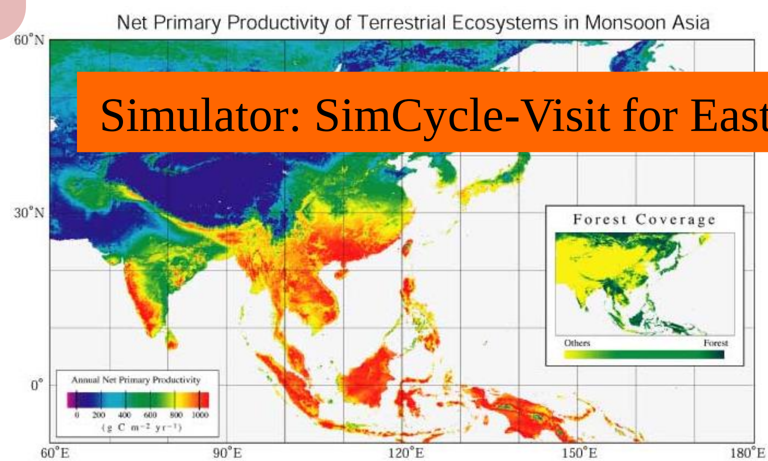
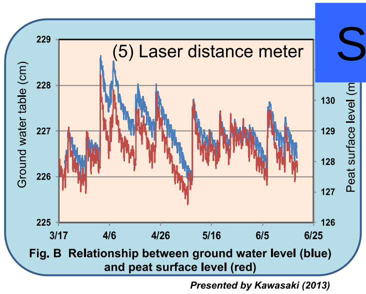
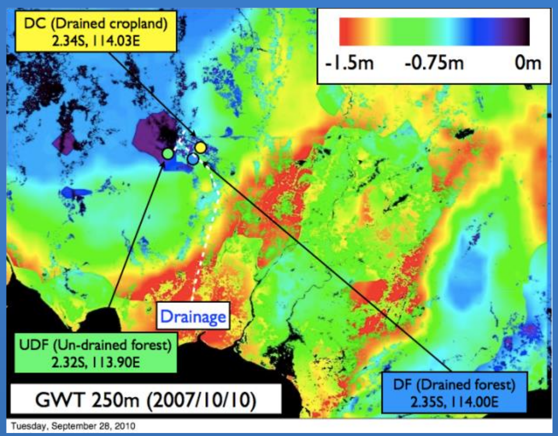


Subsidence Model



Carbon-Water Simulation



- **Carbon Emission by Fire**
- **Carbon Loss through Water**
- **Carbon Emission by Microorganisms Degradation**
- **Tree Growth/Mortality**
- **Pest subsidence**

Thanks for your attention!