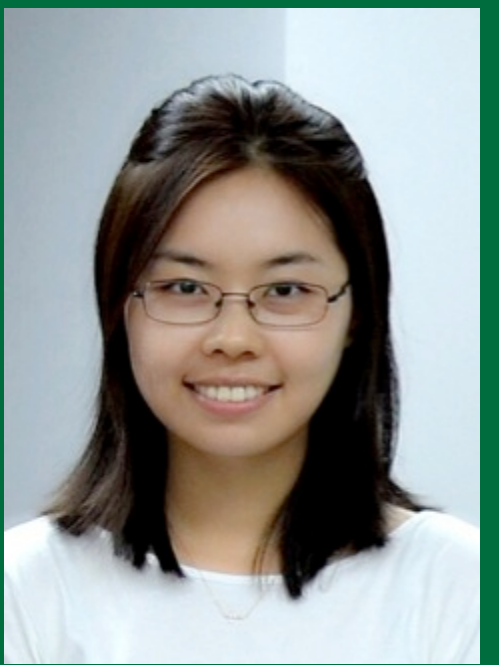IGARSS 2014 in Québec

CO$_2$ BUDGET ESTIMATION WITH CONSIDERING HUMAN EFFECTS OF TROPICAL PEAT LANDS IN INDONESIA

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Carbon dioxide (CO$_2$) budget from tropical peat lands in Indonesia was estimated by using satellite data. Indonesia has many CO$_2$ sources that related with peat lands. Our previous results have been continued to estimate CO$_2$ budget from ground water decreasing. The new motivation of this study is to estimate human impact on the peat lands hydrologic environment. The drainage canal is supposed to be artificial in this region. ALOS PALSAR mosaic data was used for detection of drainage canal in Indonesia. Canny edge detection method was used. As the result, daily soil respirations of Jambi and Palangkaraya became 12.63% and 16.84% larger than before consideration of human effect.

Background

- Global carbon dioxide budget estimation is required for a sustainable development of the Earth. Despite peat land covers only 3% of global land area, the carbon amounts are one-third of global soil organic carbon. The tropical peat forest's organic matter is reported up to 70PgC, which accounts for 20% of global peat soil carbon and 2% of global soil carbon. The water supply is the most important factor to form the peat because of the abundant ground water is needed to make reduction condition.
- However, peat lands of Indonesia have been disturbed by deforestation and oxidation through the human effect such as drainage when Mega Rice Project 1999. Therefore, man-made drainage canal detection is important for estimation of CO$_2$ budget from peat decomposition.

Site Description

The target area of this study is whole land area of Indonesian peat lands (6N95E~11S141E). FAO soil classification map (1km mesh, the category name is HISTOSOL) was used for extracting peat land location and distribution. According this data, Indonesian peat lands area is distributed as 2.56 x 10^{11}(m^2).
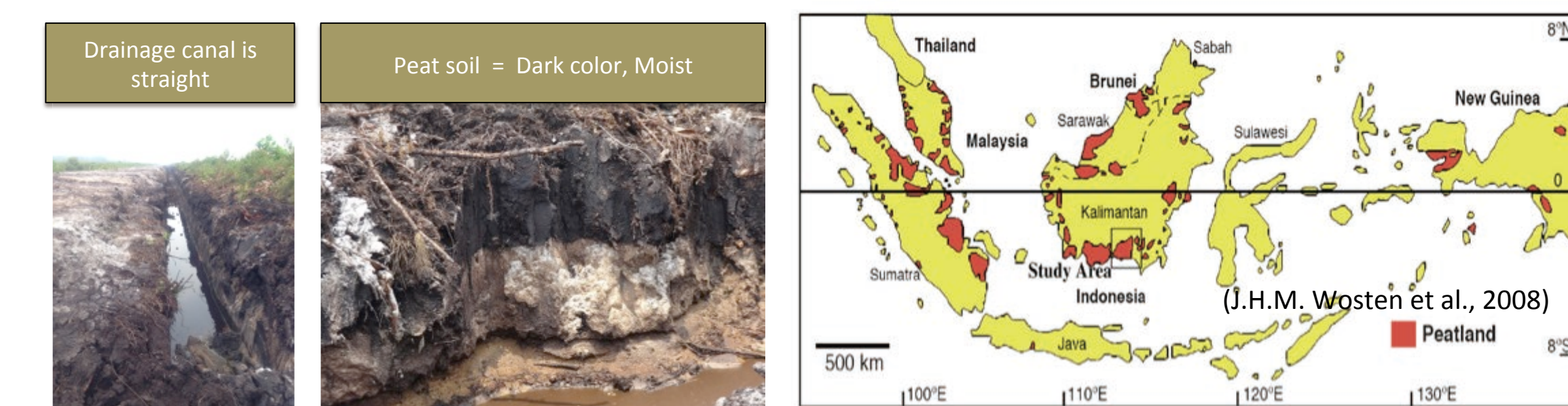
Drainage canal is straight

Peat soil = Dark color, Moist

Figure 1. Peat land in Indonesia Oct. 2013 photo by Park

(J.H.M. Wosten et al., 2008)

Figure 2. Peat distribution in Indonesia

Objective

- **The objective of this study is to estimate human effect toward CO$_2$ emission on tropical peat lands in Indonesia.** The human effect through drainage canal was computed by water canal detection of microwave satellite image (ALOS PALSAR). CO$_2$ budget of recent 11years (2002~2012) was estimated by combining ground water table and MODIS GPP. Every components of CO$_2$ budget information was obtained by satellite based data.

Methodology

GSMaP (rain fall) · MTSAT (temperature) → Modified KBDI (Takeuchi et al., 2010) → Ground Water Table (GWT) (cm, daily, 4km) → ER, SR (gC/m²/day)

ALOS PALSAR → Canal detection → Peat land & non-forest masking → Canal pixel GWT lowering (drainage effect)

MOD17A2 Daily GPP (KgC/ha) 8days.1km → MOD17A2 GPP calibration (Park et al., 2013) → Gross Primary Productivity (GPP)

Fire Emission (Takeuchi et al., 2013) → Fire emission (FE)

ER:Ecosystem Respiration
SR:Soil Respiration
NEE:Net Ecosystem CO2 Exchange

NEE = (ER+drainage+FE)-GPP

Evaluation of NEE spatio-temporal dynamics from 2002 to 2012

Figure 4. Flow chart

- ALOS PALSAR (50m mosaic) HH polarization was used for detecting anomaly of surface roughness.
- Thresholds of anomaly were chosen region by region.
- Canny method was used for extracting drainage line.
- This drainage line was used for determining affected area distribution.
- Shimiz Corporation company has been measured in-situ GWT in Jambi(Figure 5). According this report, rate of GWT decreasing was derived as 10cm/100m.
- GWT was modified with derived model (Figure 6), then, ER (or SR) and NEE were evaluated for revealing drainage effect.

Figure 5. Decreasing rate derived from in-situ measurement (2012/Aug/01)
(Shimizu Corporation, 2013)

Derived increment from in-situ is adapted to Figure 6.

GWT modification in this study
Decreasing rate =10cm/100m
decreased GWT(m) = 0.4-0.001*distance

Figure 6. Ground Water Table modification model
(Sundari et al., 2012)

Results

Figure 7. GWT map of Indonesia (http://jica-jst.lapanrs.com)

- Daily GWT is provided by KBDI that precipitation and land surface temperature were used. Good correlation was obtained when validate with observation data.
- Drainage area was detected as 0.41x10^{11}(m^2)(Fig.8) → 28.75% of open peat lands area (non-forested)
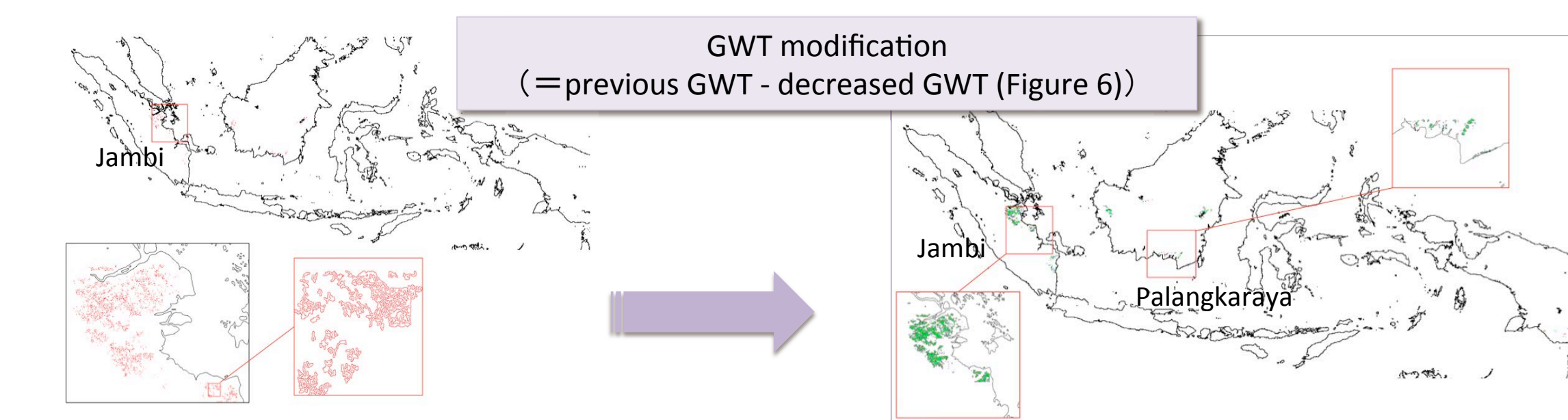- Target region of GWT modification is reached to 400m from drainage canal(Figure 9).

GWT modification (＝previous GWT - decreased GWT (Figure 6))

Figure 8. Drainage canal

Figure 9. GWT modification around 400m from canal

Palangkaraya   16.84%   SR / drained SR / GWT

Jambi   12.63%   SR / drained SR / GWT

Figure 10. Ground water table , soil respiration and drained soil respiration on Palangkaraya, Jambi

- Increased amounts of soil respiration were 16.84% in Palangkaraya and 12.63% in Jambi through GWT modification by detected canal(Figure 10). The monthly dynamics of NEE was represented in Figure 11. Peat lands respiration and fire emission are promoted by El nino. From this estimation, drainage effect toward ER was 9.8% of whole emission facts, such as ER, drainage, and fire emission. GPP and ER shows similar quantities. However, NEE(Net CO$_2$ emission) become much larger than 0 because of drainage effect and fire emission, in other words, human effects. After modification, monthly mean NEE increased to 22.6MtC/month (2002-2012) from 14.75MtC/month, increased 1.53times. Previous NEE showed CO$_2$ sink sometimes, however, drainage effect carried out severe CO$_2$ source of peat lands.

El nino   La nina

SOURCE   SINK   (MtC)

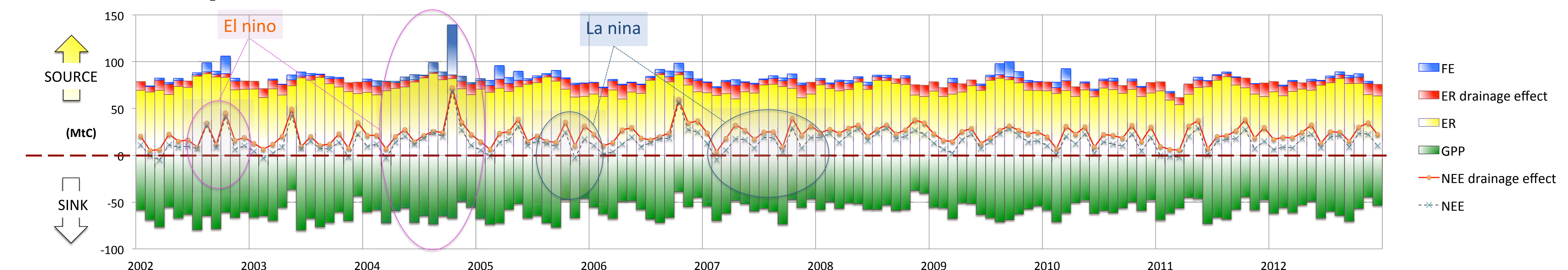FE / ER drainage effect / ER / GPP / NEE drainage effect / NEE

Figure 11. Evaluation of NEE components dynamics from 2002- 2012 monthly in Indonesia. ER, ER with drainage effect and FE are emission factors. GPP is photosynthesis.

Conclusion

- Human impact to ground water table in tropical peat lands in Indonesia was estimated. This study focused on the drainage canal that supposed to cause decomposition of peat soil. Drainage canal was detected using difference of backscattering of ALOS PALSAR HH polarization image and canny edge detection method was used. 28.75% of open peat lands were extracted for drainage canal. As the result, 53% of monthly average of NEE was increased in Indonesia. Large number of increasing of NEE makes severe carbon source from peat lands. Especially, soil respiration was affected this declining of ground water table. Therefore, ground water table of canal area and around canal area have to be considered as lower than others when computing CO$_2$ budget of tropical peat lands, and management of drainage canal can contribute to reduce the carbon emission from Indonesia.

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