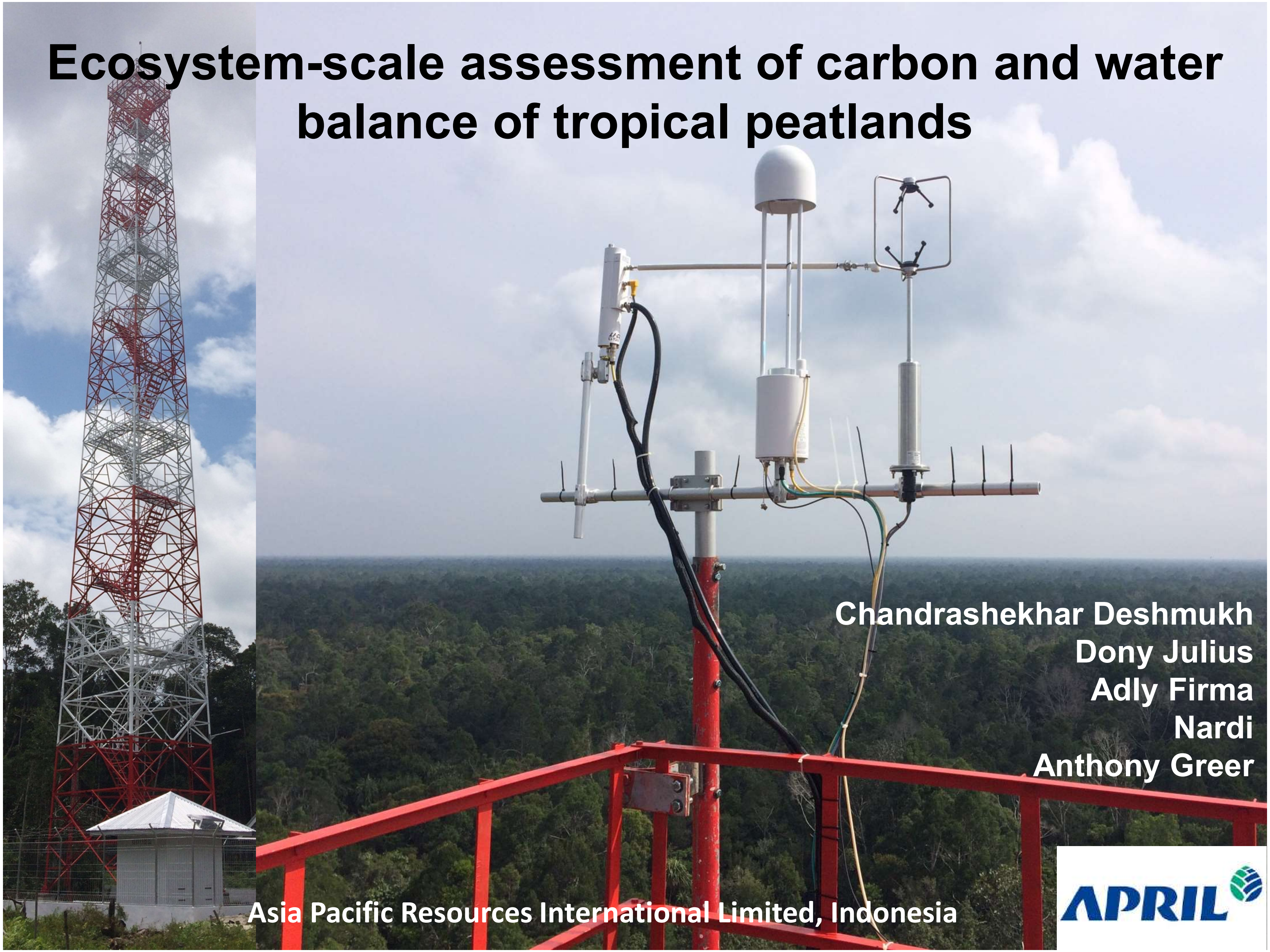
Ecosystem-scale assessment of carbon and water balance of tropical peatlands

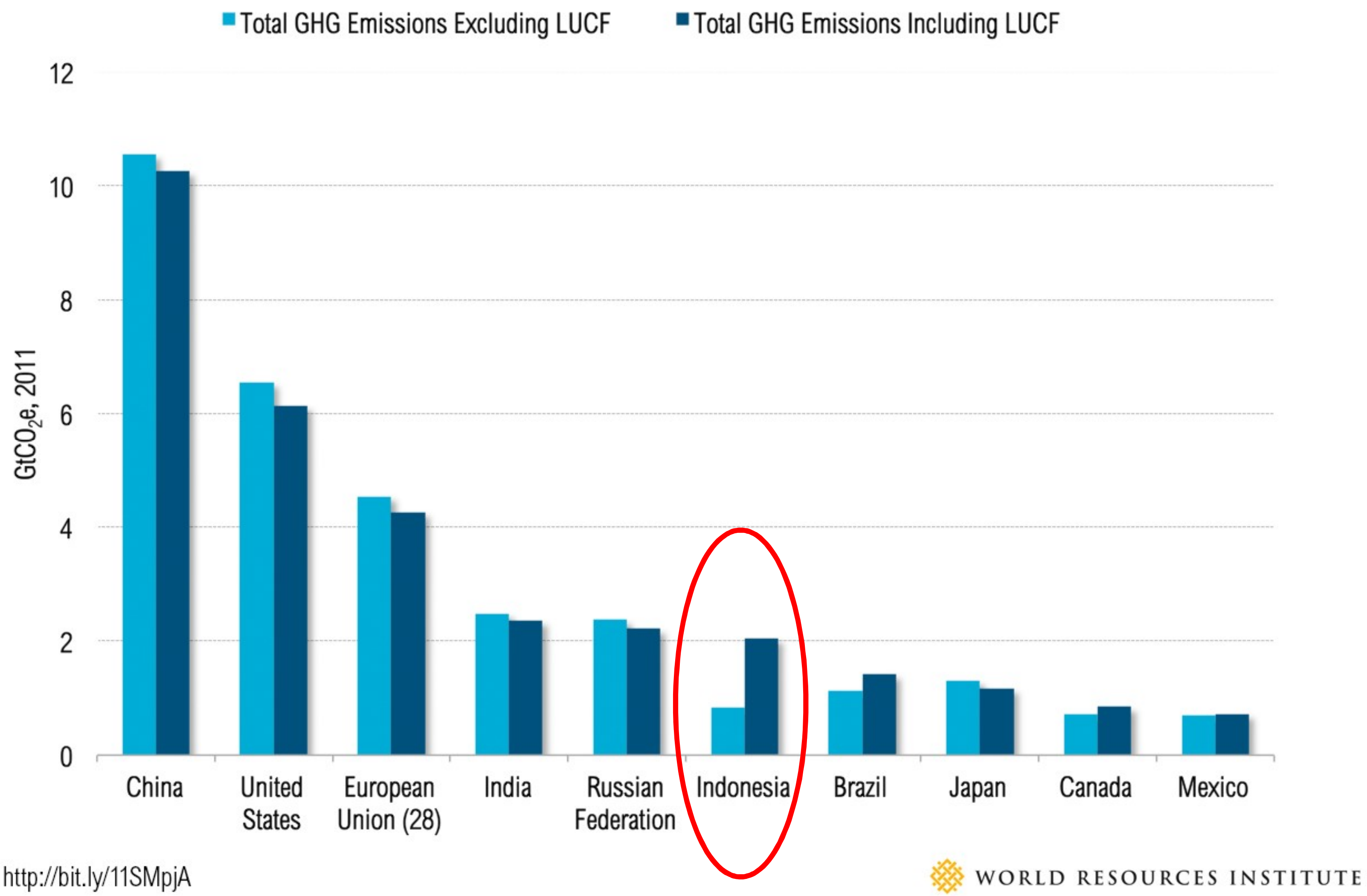


Chandrashekhar Deshmukh
Dony Julius
Adly Firma
Nardi
Anthony Greer

Asia Pacific Resources International Limited, Indonesia

APRIL

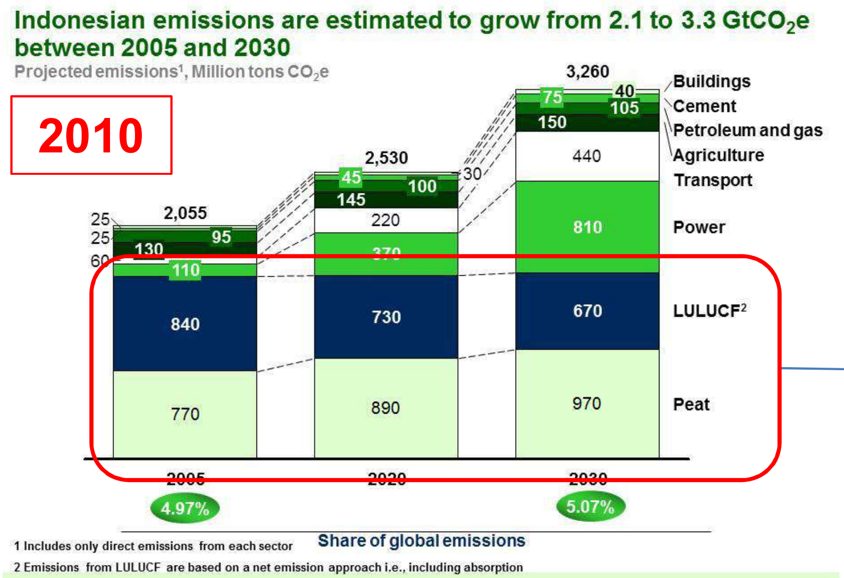
Top 10 GHG Emitters

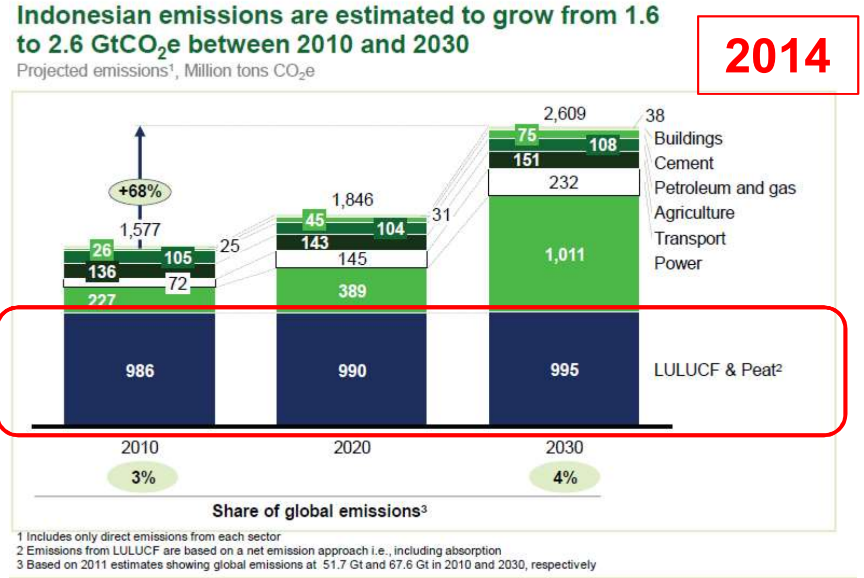


- **Indonesia - under top 10 – but how many eddy covariance flux sites? <10 !**

Motivation

Indonesia and carbon emissions from LULUCF & Peat





- The carbon content to be used for Indonesia peat soils and various above ground carbon stocks – we have used data from official government publications such as RAN-GRK from BAPPENAS this time. The carbon stocks/emission factors used by the Indonesian government are significantly lower than data provided in other publications from academics and NGOs. As a result LULUCF emissions projections and also the abatement potential as a consequence are reduced by nearly 50% compared to our last analysis

- **No common agreement**

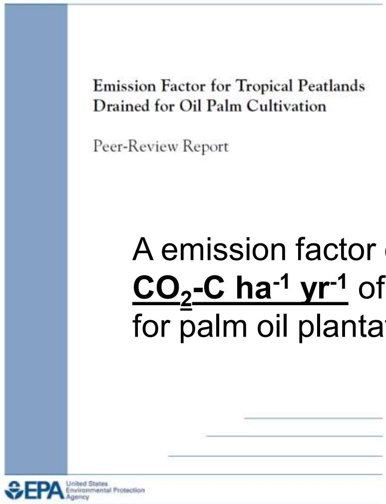
Source: Updating Indonesia's Greenhouse Gas Abatement Cost Curve (2014) by McKinsey & Company and Poyry Management Consulting

Motivation

Emission factor of drained peat for palm oil plantation

Land-use category	Climate / vegetation zone	Emission Factor[a] (tonnes CO_2-C ha^{-1} yr^{-1})	95% Confidence Interval[b]		No. of sites	Citations/comments
Plantations, drained, unknown or long rotations[f]	Tropical	15	10	21	n/a.	Average of emission factors for *Acacia* and oil palm
Plantations, drained, short rotations, e.g. *Acacia*[f, g],	Tropical	20	16	24	13	Basuki *et al.*, 2012; Hooijer *et al.*, 2012; Jauhiainen *et al.*, 2012a; Nouvellon *et al.*, 2012; Warren *et al.*, 2012
Plantations, drained,.oil palm[f]	Tropical	11	5.6	17	10	Comeau *et al.*, 2013; Dariah *et al.*, 2013; DID and LAWOO, 1996; Henson and Dolmat, 2003; Hooijer et al., 2012; Couwenberg, and Hooijer 2013; Lamade and Bouillet, 2005; Maryanto and Agus,

Source: IPCC (2013) Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands



A emission factor of **26 tonnes CO_2-C ha^{-1} yr^{-1}** of drained peat for palm oil plantation

Overall, two peer reviewers (Drs. Sabiham and Hergoualc'h) responded that the previously mentioned factors are likely to overestimate the average GHG emissions from peat soil drainage under oil palm plantations. Two peer reviewers (Drs. Leclerc and Schrier) stated that the factors are likely to underestimate the average GHG emissions. One peer reviewer responded that the GHG emissions are likely to be fairly represented. Table 3-1 summarizes the panel members' responses to each of the individual factors.

Source: EPA (2014) Emission Factor for Tropical Peatlands Drained for Palm Oil Cultivation. U.S. Environmental Protection Agency, Washington, D.C

- **No common agreement**
- **A large range of emission factor**

Motivation

Carbon emissions from peat oxidation

Indonesia

A significant share of Indonesia's emissions is connected to forestry and land use, due to deforestation, peatland destruction, and land-use change. There is a large uncertainty in LULUCF emissions, particularly related to peat oxidations (not including peat fires), which can be in the order of 30% to 50% of total LULUCF emissions. Uncertainty concerning emissions from peat fires is also high and it is well known that these emissions vary significantly between years. This has made it difficult to determine the emission projections for Indonesia and to assess whether the 2020 pledge will be achieved. As a result, Indonesia's emission reductions resulting from the policies assessed in our analysis are projected

- **No common agreement**
- **A large range of emission factor**
- **A large uncertainty**

Source: Enhanced policy scenarios for major emitting countries. Analysis of current and planned climate policies, and selected enhanced mitigation measures by PBL Netherlands Environmental Assessment Agency (2015)

Motivation

Indonesia and carbon emissions from LULUCF & Peat

- No common agreement
- A large range
- A large uncertainty

⟹ **Need to improve our understanding?**

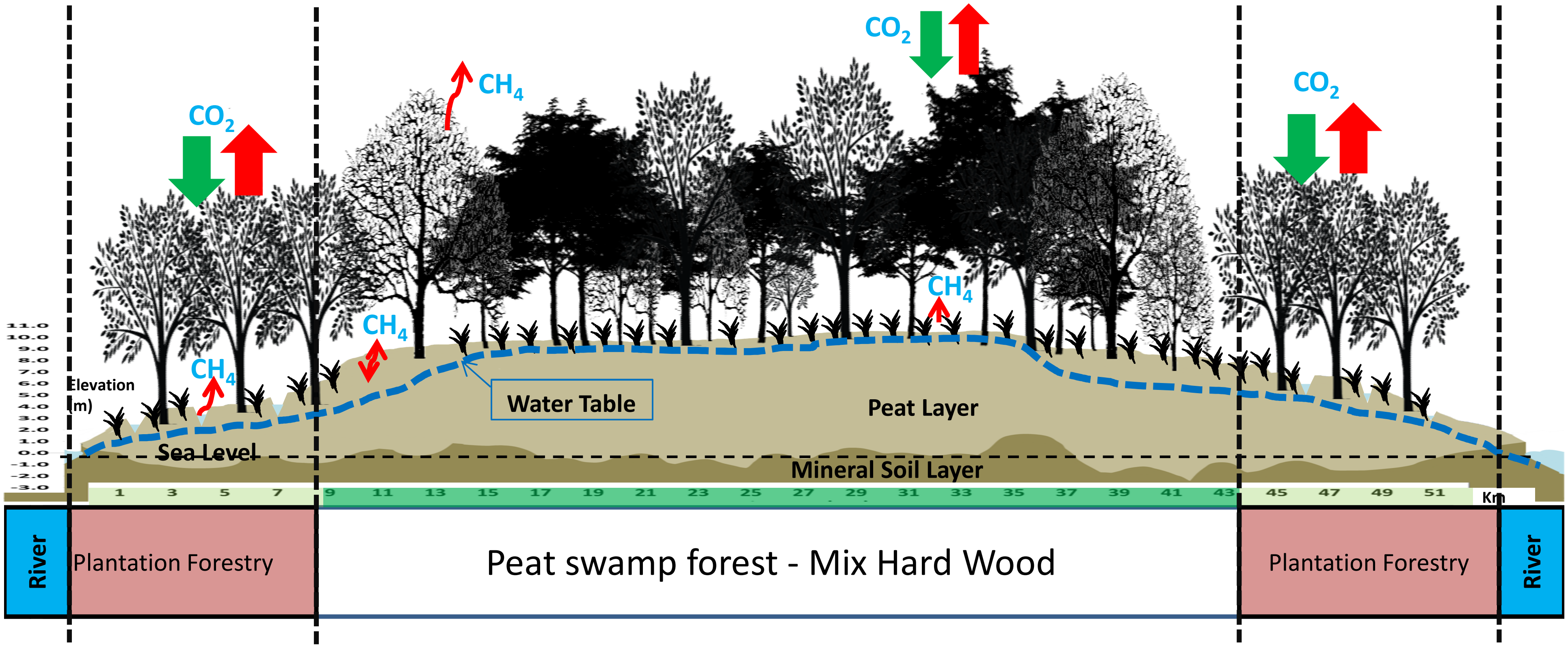
Reasons: Very few **scientifically sound** and **detailed "Tier 3"** flux measurements are available, particularly in Indonesia

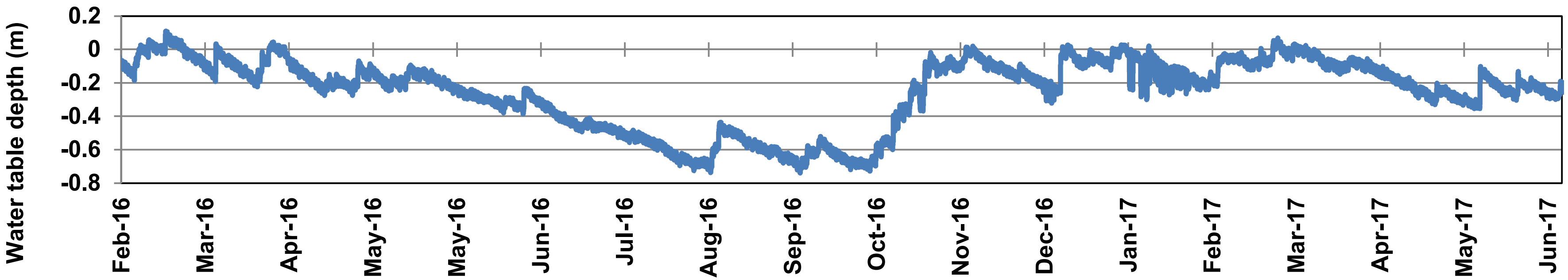
- Inconsistent methodologies **=> not direct**
- Lack of information on spatial and temporal variability **=> point and discrete**

Need: **A better understanding** of carbon balances from different land-uses

- high frequency + long-term measurements => **temporal variability**
- Represents an ecosystem scale => **spatial variability**

Carbon dynamics in tropical peatlands





- **Ombrotrophic:** rainfall plays a critical role

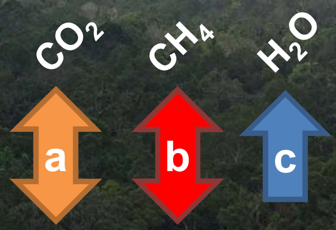
Objective

Evaluating the impacts of hydrological variations on carbon balance

a. Quantifying net ecosystem CO_2 exchange
- Balance between gross primary production (GPP) and ecosystem respiration (RE)

b. Quantifying net ecosystem CH_4 exchange
- Poorly understood in tropical peatlands and impact of land-use change

c. Quantifying water vapor fluxes
- Water balance assessment – rainfall vs. evapotranspiration



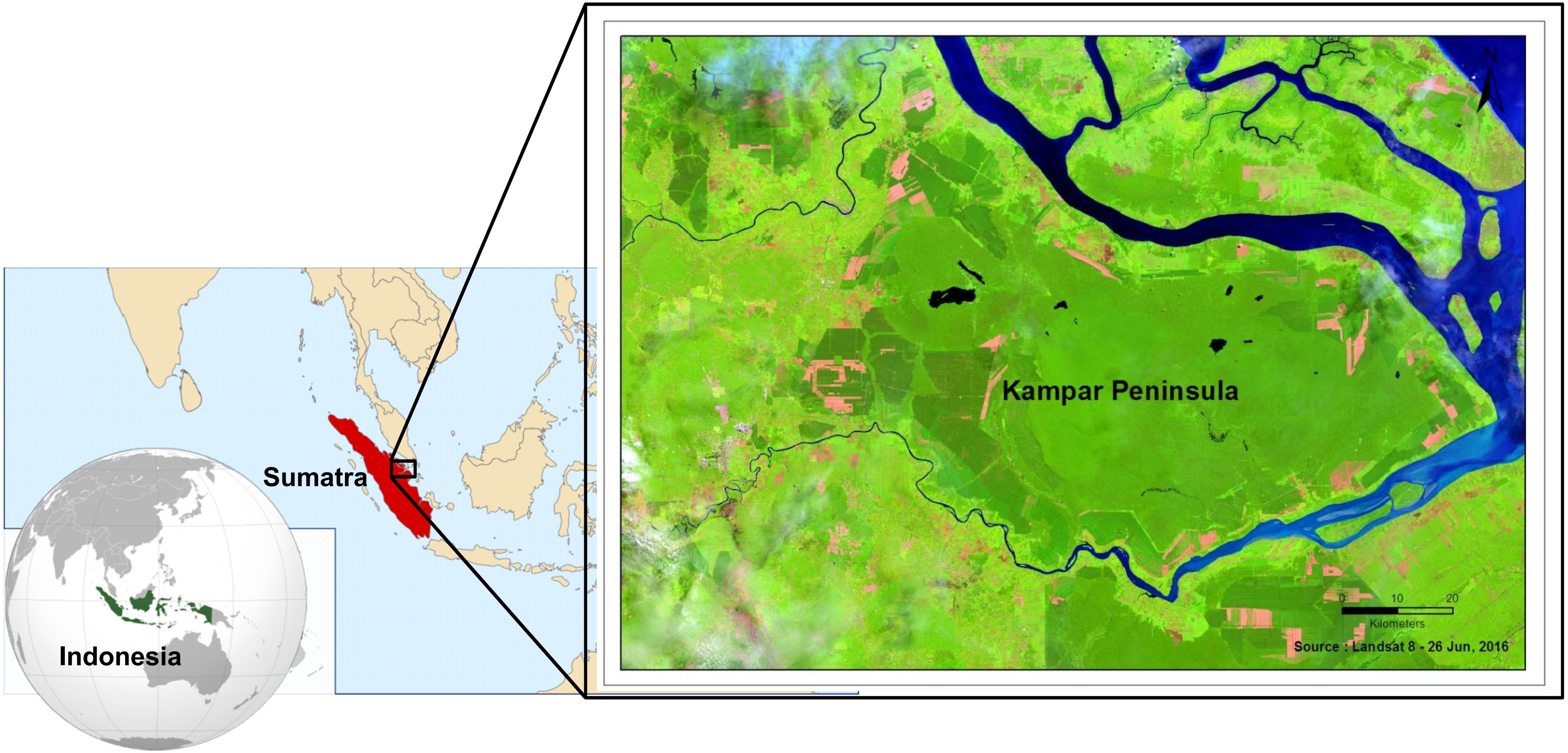
– Exploring spatial and temporal variability
– Investigating drivers – monitoring environmental variables

Study area

Kampar Peninsula, Riau Province in Sumatra, Indonesia

Tropical peatlands => complex ecosystems

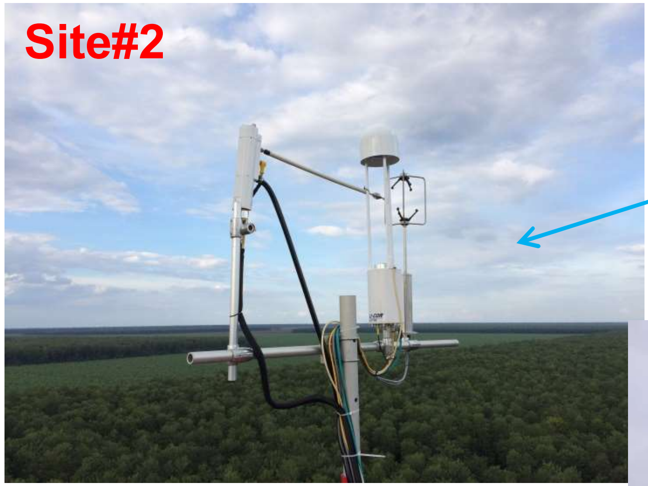
- Poorly understood **biogeochemical and hydrological regimes**

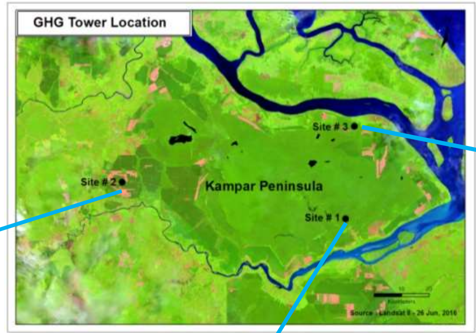


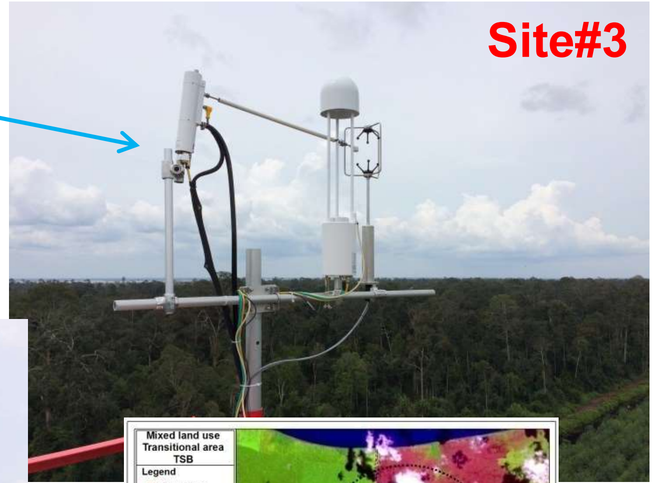
Sampling strategy

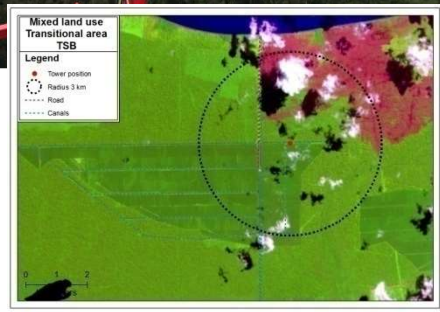
To cover major land covers in the region => main land use scenarios

Land Use	Measurement Height	Measurement Period
Site#1. Ecosystem restoration forest	51.3 m	24 May 2017 - Present
Site#2. Plantation forestry	43.6 m	16 Sep 2016 - Present
Site#3. Mixed land cover	43.8 m	19 Sep 2016 - Present









Environmental parameters

- **Meteorological variables** (Automatic @ every 5 second)
- **Soil moisture and temperature** (Automatic @ every 5 second)
- **Water table depth -** every 30 min
- **Land Cover Change** => Monthly map from Landsat 8 and Sentinel-2

CNR – 4 (x1)

Levelogger Edge

Quantum Sensor (x1)

Vaisala (x5)

Rain Gauge (x1)

Stevens Hydra (x3)

Measuring heterotrophic respiration

Sampling strategy: Exploring temporal variability and investigating drivers

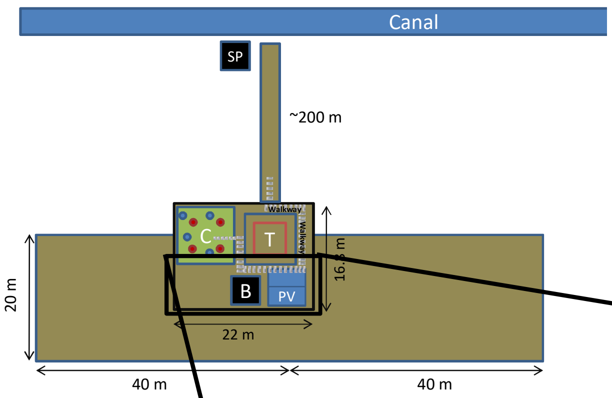
Methodology: Automated Soil CO_2 Flux System => 4 replicates per site

- Provides high frequency (every 30 min)

Soil moisture and temperature

Automated water table depth logger

Power supply



Solar Power System

- Mounted on gazebo roof ~ 4 above ground surface
- Facing south - Tilt angle = ~10-15^{O}
- 716 Amp hours per day from the batteries
  Requirement = ~200 Ah per day
- Supply from the batteries at least 105 W at 24 VDC **Maximum requirement (93.5 W) < minimum supply**

Ventilated Battery House => batteries are stored in battery enclosure

Lucky to be at the equator !!!

Major components

APRIL

1. Data collection, instrument maintenance and calibration

2. Data processing, analysis and reporting

EDDYPRO

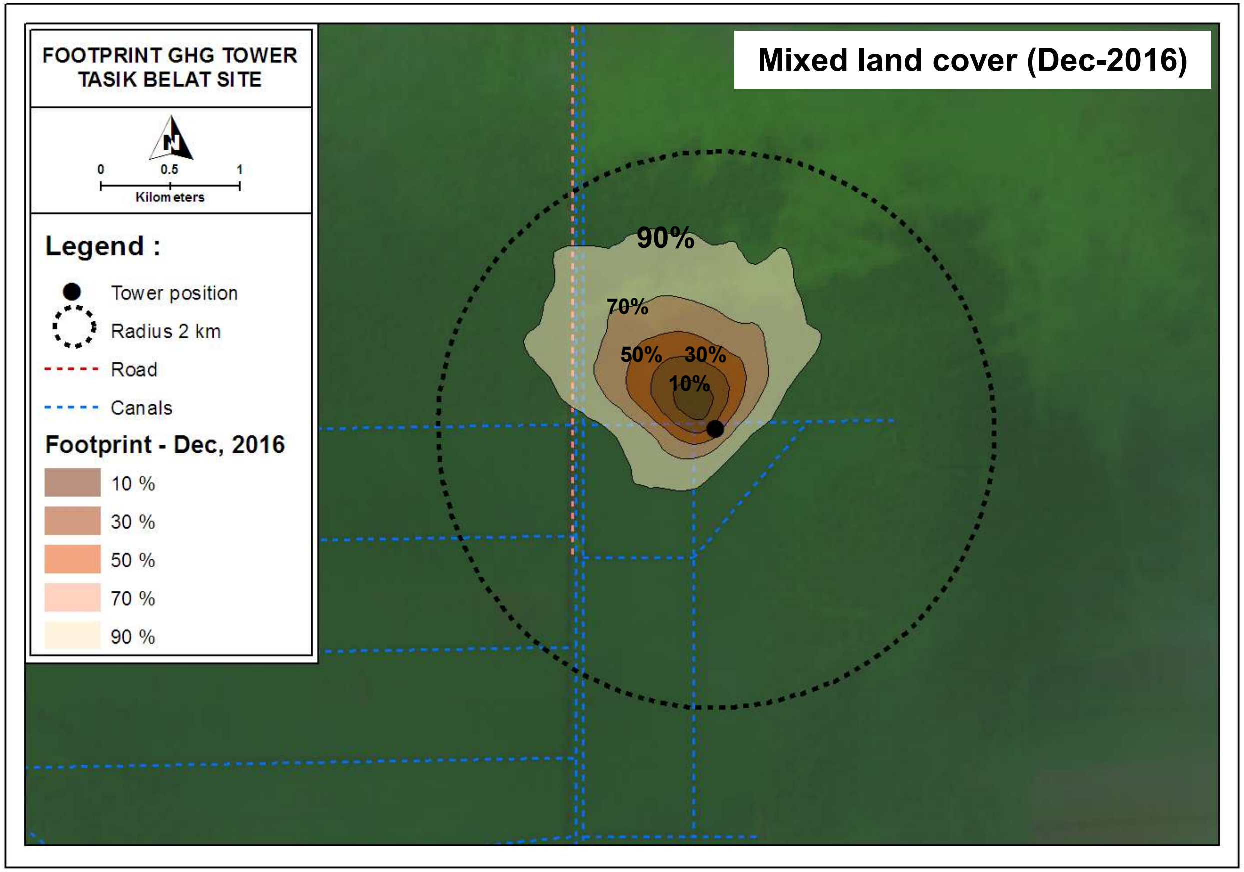
- EddyPro®
- .
- .
- .
- Quality Controls
- Footprint Analysis
- .
- Gap-filling
- Partitioning: GPP, NEE, RE_{eco}

Reporting

- Scientific Communication

Footprint Analysis

Area that is contributing to flux measurements

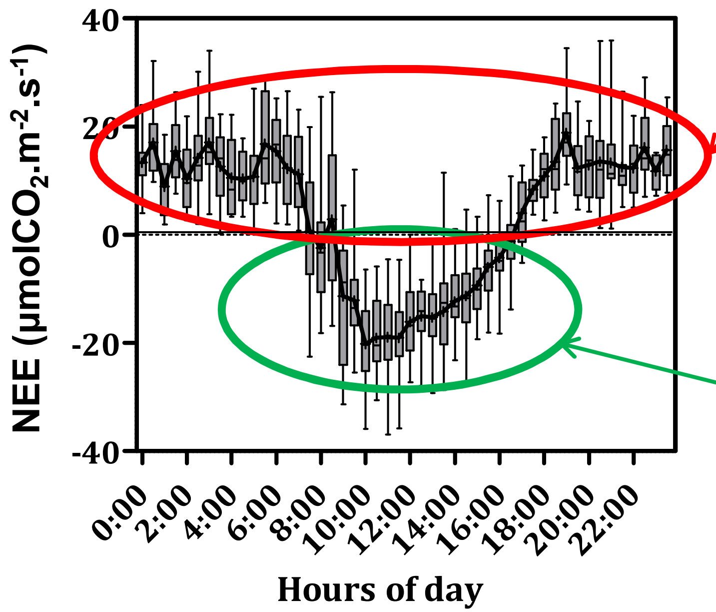


Footprint model: Kljun et al. (2015)

- Flux footprint = >200 ha i.e. represents an ecosystem

Preliminary results

Net ecosystem CO_2 exchange - clear diurnal pattern



Gross Primary Production < Ecosystem Respiration

- Indicate a release of carbon to the atmosphere

Gross Primary Production > Ecosystem Respiration

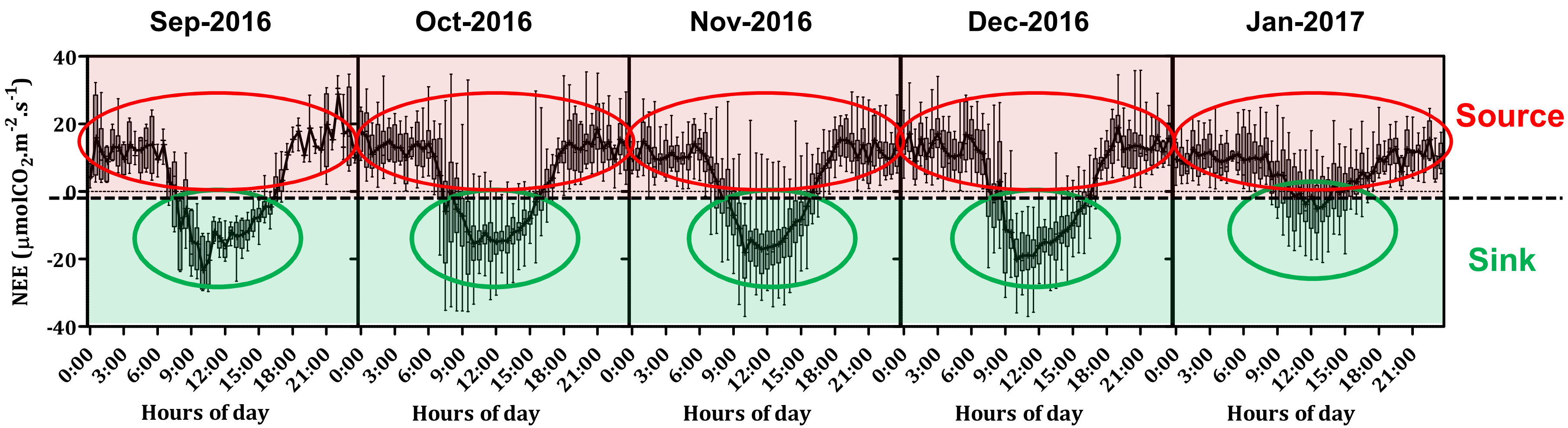
- Indicate a loss of carbon from the atmosphere
- Indicate a gain of carbon by the vegetation
- **Carbon Sequestration**

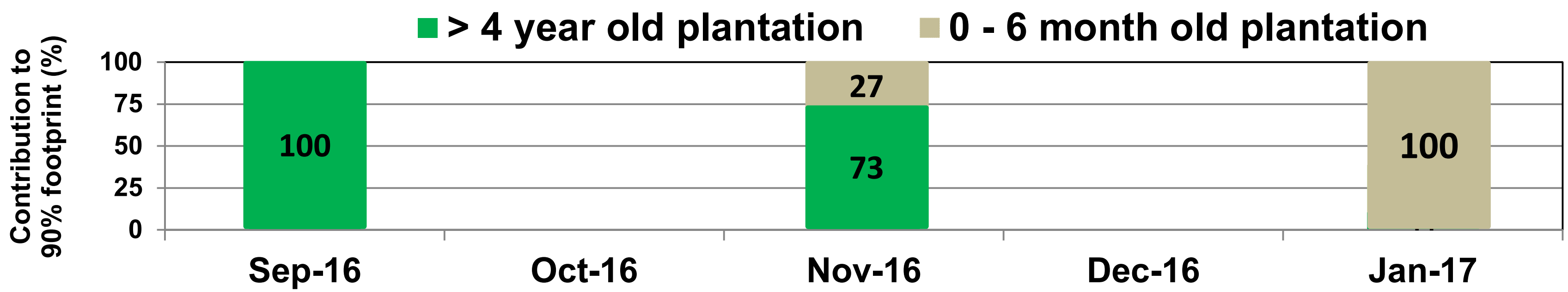
Data: December 2016 from plantation forestry

Preliminary results

Net ecosystem CO_2 exchange

- **Diurnal pattern** => varies with plantation age



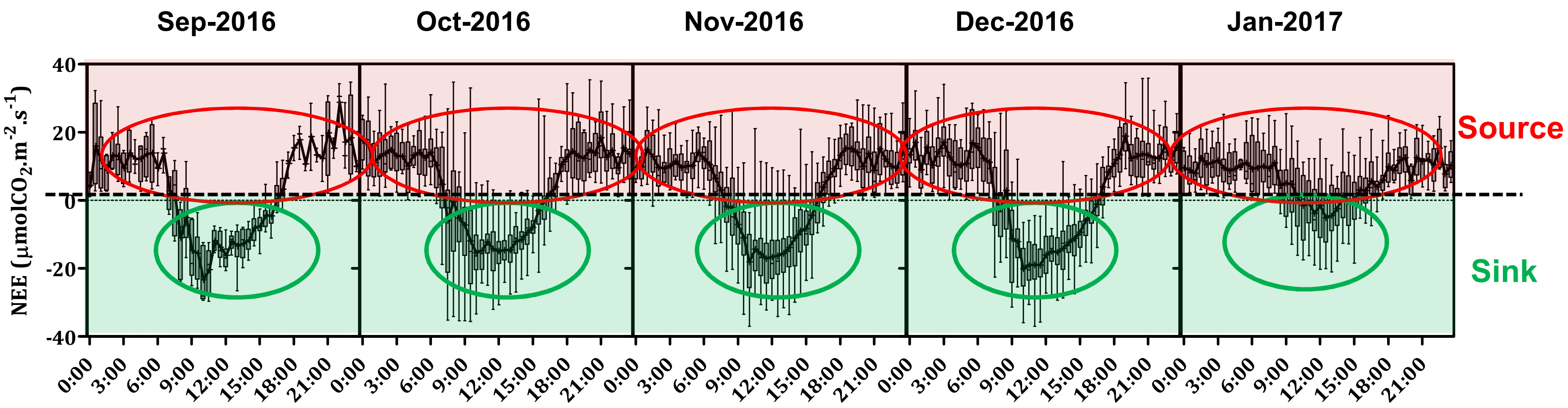


- **Entire plantation cycle must be covered => 4-5 year period**

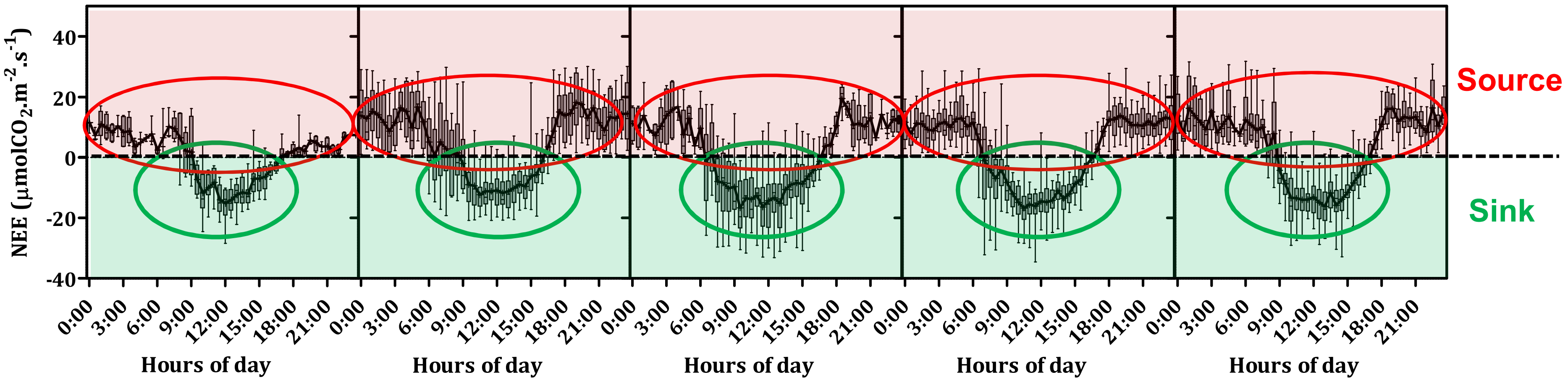
Preliminary results

Net ecosystem CO_2 exchange

Plantation forestry site

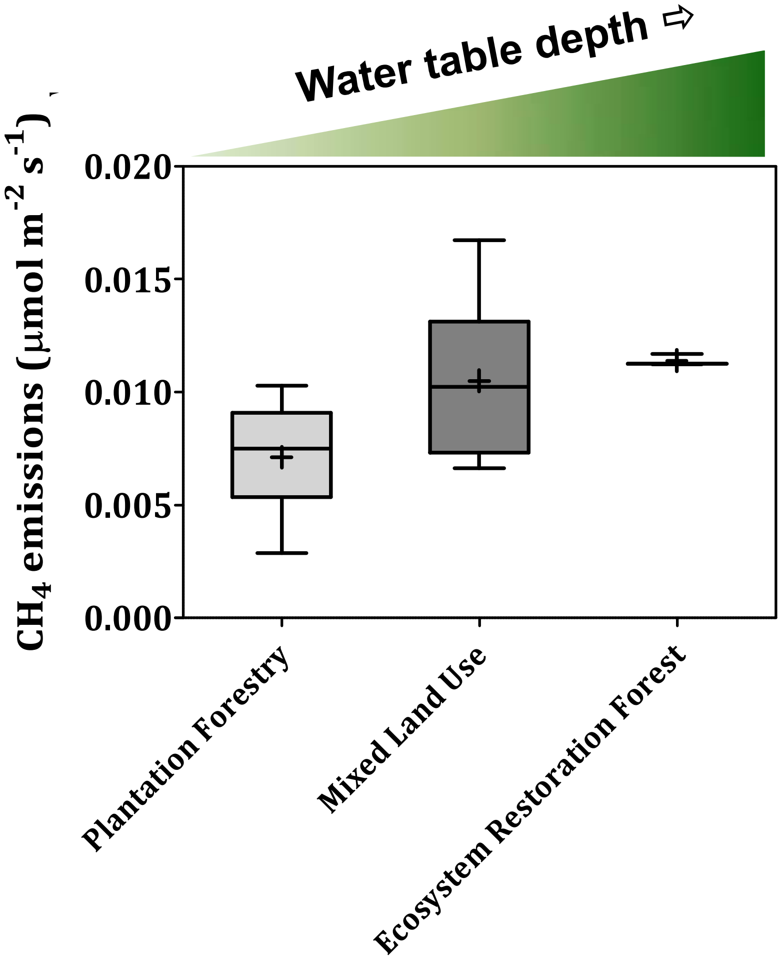


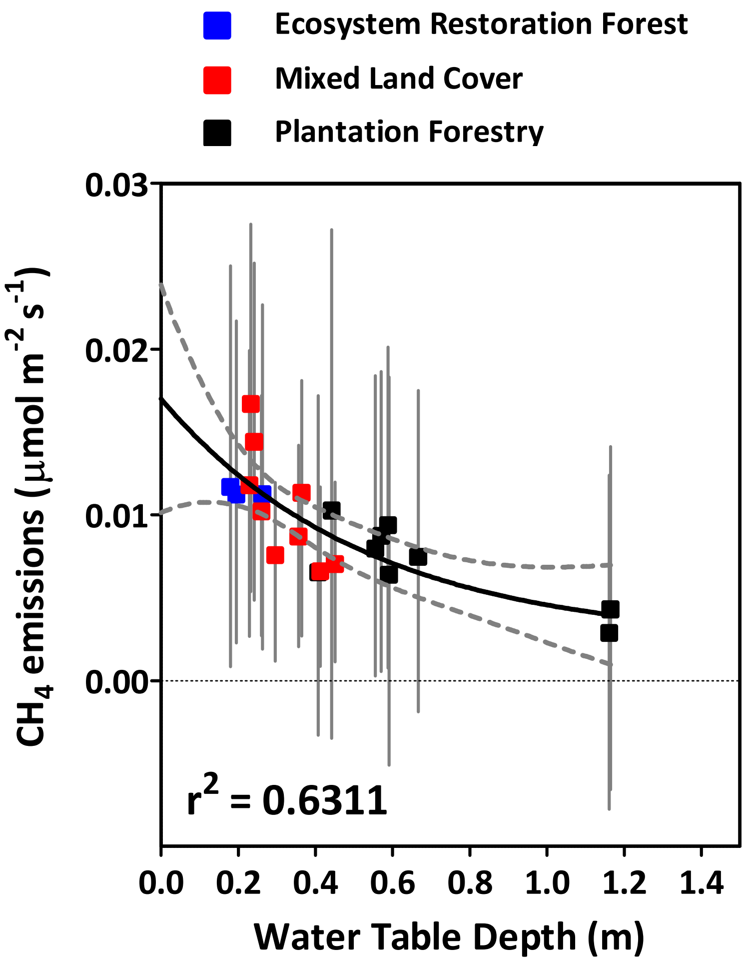
Mixed land cover site



Preliminary results

Net ecosystem CH_4 exchange



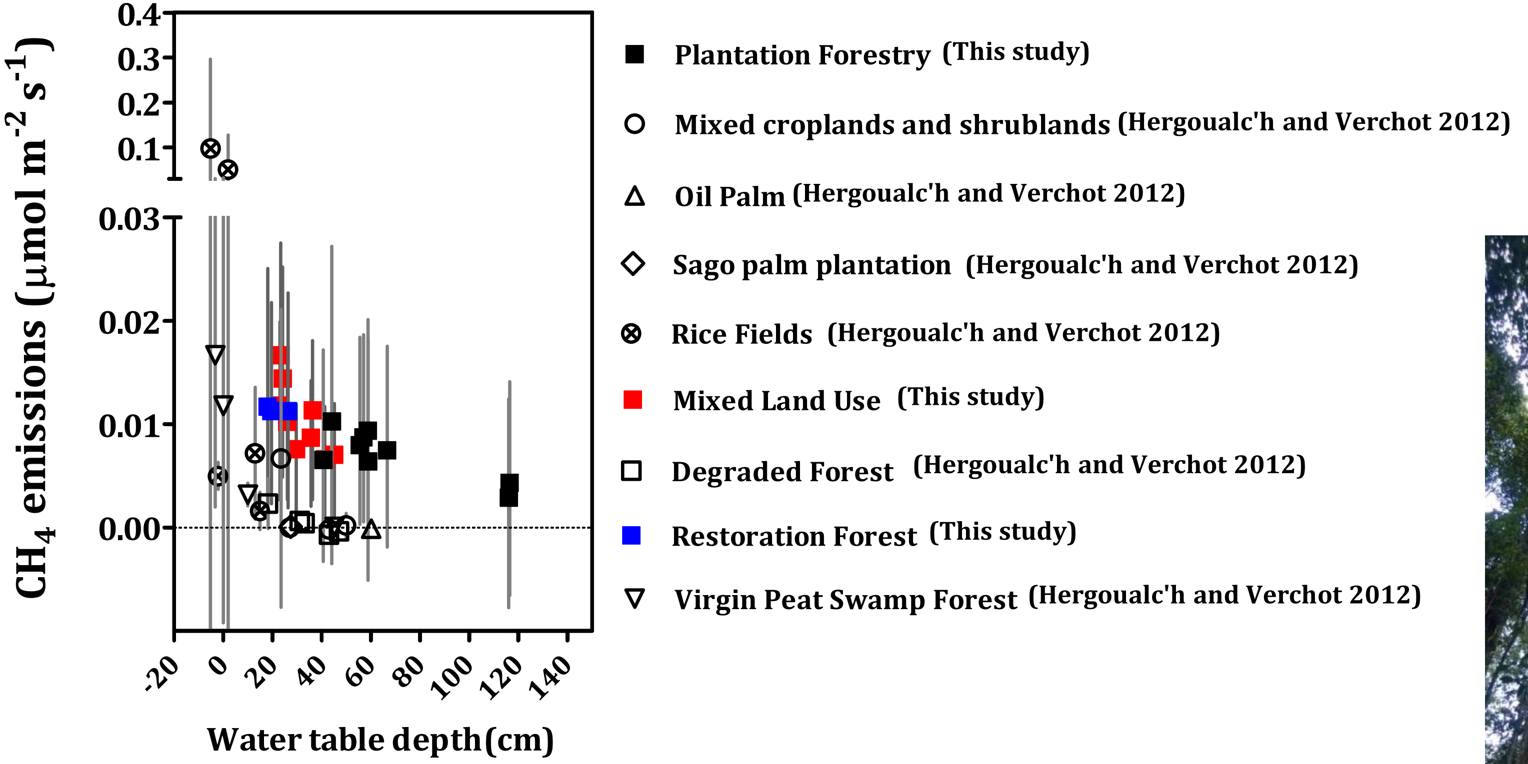


- Ecosystem Restoration Forest > Mixed Land Use > Plantation Forestry
- CH_4 emissions decreases exponentially as water table depth falls

Preliminary results

Net ecosystem CH_4 exchange

- **Comparison with published data (based on chamber measurements)**



- Eddy Covariance measurements > chamber measurements on the soil surface
- Our measurements include all existing pathways of CH_4 emissions
  - **Soil surface, water surface, vascular plant and trunk of living tree**

Take-home Messages *(indicative, not conclusive)*

CO_2 emissions:
- Too early for the climax - next AsiaFlux meeting ☺

CH_4 emissions:
- Peat swamp forest conversion to another land use lowers methane emissions
  - Excluding rice cultivation
  - Methane emissions decrease exponentially with water table depth
- Eddy Covariance measurements > chamber measurements on the soil surface
  - Function of vegetation should be explored and considered
- **Regional estimate => challenging**
  - Available data on carbon emissions in tropical peatlands are yet insufficient
    - Only few detailed studies

Project outcome

A comprehensive GHG dataset of emissions and removals

- To examine the climate impact of land use changes => **Net GHG footprint**

Land use change

- **National/global importance**

A dedicated team – giving the best !!!

Thank you