Plenary II: Emerging scientific findings: Ecosystems and GHG emissions and removals from sources, sinks and reservoirs, including from terrestrial ecosystems

Estimation of carbon and their fluxes in tropical peatlands: Results from a Japan-Indonesia joint project

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SATREPS:
Science and Technology Research Partnership for Sustainable Development
funded by
1) the Japan Science and Technology Agency (JST) and
2) the Japan International Cooperation Agency (JICA).

SATREPS is a Japanese government program that promotes international joint research targeting global issues, involving partnerships between researchers in Japan and researchers in developing countries.

SATREPS projects are expected to lead to outcomes with potential for practical utilization, and to enhance research capacity in the developing country.

http://www.jst.go.jp/global/english/about.html
Wild Fire and Carbon Management in Peat-Forest in Indonesia

http://www.census.hokudai.ac.jp/html/JSTJICA/index.html
Total amount of CO$_2$ emission

- **Total amount of CO$_2$ emission in the world (2005)**
  - USA: 19.1%
  - China: 19.4%
  - Others: 41.2%
  - Japan: 4.0%
  - Indo: 4.2%
  - Russia: 5.5%
  - Indonesia: 6.6%
  - Source: [http://www.eia.doe.gov/leacarbon.html](http://www.eia.doe.gov/leacarbon.html)

- **Total amount of CO$_2$ emission from Indonesia (2005)**
  - Peat: 37.5%
  - LULUCF: 40.9%
  - Petroleum & gas: 4.6%
  - Cement: 1.2%
  - Transport: 2.9%
  - Agriculture: 6.3%
  - Power: 5.4%
  - Source: Indonesia's greenhouse gas abatement cost curve (DNPL 2010)
Amount of carbon dioxide emitted annually from the tropical peatland per 1 million ha. (Indonesia has 20 times the size of this tropical peatland.)

About 13% of the total emission from Japan in 1990. 

Amount of carbon dioxide emitted by microbial degradation (About 3% of the total emission from Japan in 1990.)

Amount of carbon dioxide emitted by peat fire (About 10% of the total emission from Japan in 1990.)
Central Kalimantan, Indonesia
Peatland area in Mega Rice Project site

**CO₂ observation towers at**
UDF : (Un-drained Peat)
DF : (Drained Peat)
BC : (Burnet Peat)

**Various Study Topics:**
- GHG Flux (CO₂, CH₄, N₂O) measuring
- Fire Detection and Protection
- Water Table Monitoring and Management
- Peatland Ecology
- Soluble Carbon Monitoring
- Peatland Subsidence Monitoring
- etc.

→ Monitoring was started from 1997
Collaboration with Indonesia Institutes

Implementation Agency
-National Standardization Agency (BSN)

Executing Agencies
-Forestry Research and Development Agency (FORDA)
-Indonesian Institute of Sciences (LIPI)
-Indonesian National Institute of Aeronautics and Space (LAPAN)
-University of Palangka Raya (UNPAR)
-State Ministry of Research and Technology (RISTEK)

Collaboration Agencies
-National Council for Climate Change (Dewan Nasional Perubahan Iklim, DNPI)
-The Agency For the Assessment and Application Technology (Badan Pengkajian Dan Penerapan Teknologi, BPPT)
-Ministry of Energy and Mineral Resources (ESDM)

Collaboration University
-ITB, IPB, UGM, UI
Kalimantan University Consortium

Education, Capacity Building, and Networking

[Map showing locations of universities in Kalimantan: University of Borneo (UB) East Kalimantan, University of Tanjung Pura (UNTAN) West Kalimantan, University of Palangka Raya (UNPAR) Central Kalimantan, University of Mulawarman (UNMUL) East Kalimantan, and University of Lambung Mangkurat (UNLAM) South Kalimantan.]
What Factors Regulate Carbon in Tropical Peat?

**Deforestation**
- Dryness of ground surface
- Decrease water holding capacity

**Land Use, Land-Use Change and Forestry (LULUCF)**
- Farming / Vegetation

**Forest Degradation**
- Decreasing water table by Drainage

**Carbon Emission by Fire**

**Carbon Loss through Water**

**Carbon Emission by Microorganisms Degradation**

**Tree Growth/Mortality**
Key Elements of Tropical Peatland MRV System

- **Satellite**
  - PALSAR, AMSR-E
  - GOSAT
  - Terra & Aqua MODIS
- **Airborne**
  - Micro-Satellite & LCTF*4
  - UAV*3
- **Ground**
  - DGPS
  - Chamber
  - Tower
  - Drilling
  - DGPS
  - Water Gauge
  - FES-C
  - Water soluble organic carbon
  - Water level & Soil moisture
  - Water

**Key Instruments and Techniques**

1. **CO₂ Flux & Concentration**
2. Wildfire detection & Hotspot
3. Forest degradation & Species mapping
4. Deforestation & Forest biomass change
5. Peat dome detection & Peat thickness
6. Peat subsidence
7. Forest degradation & Species mapping
8. Water level, & Soil moisture

**Footnotes**

- *1: FES-C: Fiber Etalon Solar measurement of CO₂
- *2: VHR: Very High Resolution Remote Sensing Data
- *3: UAV: Unmanned Aerial Vehicle
- *4: LCTF: Liquid Crystal Tunable Filter
Large increases in NEE in the dry seasons of 2002, 2004 and 2006, El Niño years, because of shading by dense smoke and the enhancement of aerobic peat decomposition due to low GWL.
Hirano Model
Annual NEE vs. Annually Mean GWL

\[
\text{GWL (m)} \quad \begin{array}{ccccccccc}
\text{-0.7} & \text{-0.6} & \text{-0.5} & \text{-0.4} & \text{-0.3} & \text{-0.2} & \text{-0.1} & 0.0 \\
\end{array}
\]

\[
\begin{array}{c}
\text{NEE (gC m}^{-2} \text{y}^{-1}) \\
\end{array}
\]

UF
\[\text{NEE} = -2376 \text{GWL} - 151\]
DF
\[\text{NEE} = -1609 \text{GWL} - 510\]
DB
\[\text{NEE} = -789 \text{GWL} - 378\]

NEE: Net Ecosystem CO2 Exchange
Hirano et al. (2012), GCB

Takeuchi Model
GWT estimation by Remote Sensing Data

- GSMaP
- MTSAT
- In-situ ground water table

Precipitation
Land Surface Temp.
Drought Index
AMSRepeat

Hirano et al. (2012), GCB
Water Table Mapping

Satellite Sensing

Modeling

Tuning

By Wataru Takeuchi, University of Tokyo, Japan

Water Table Mapping

Input

Output

Coefficiency between Water Table Level and
1) CO2 emission by Oxidation
2) CO2 emission by Fire Factors

Mapping of
1) CO2 emission by Oxidation
2) CO2 emission by Fire Factors
Seasonal Variations of CO$_2$ Concentration by GOSAT

GOSAT cover few tropical area because of cloud cover.

Map showing GOSAT coverage in different months from Sep. 2009 to Sep. 2012.

Graph displaying concentration of CO$_2$ (ppmv) from 2009 to 2011, with different lines representing CO$_2$ concentrations at different longitudes (133 E-Equator, 101.5 E-Equator, 113.5 E-Equator).
There are notable differences in the CO2 mixing ratios (ppm) between the out-flow point of Parangka Raya and the in-flow point of Banjaru Baru, which were obtained with use of FES-C in August, 2011.
Simulation on CO2 Mapping

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

Carbon-Water Simulator

Integrated, practical carbon budget map

Top-down
- satellite
- airplane
- inverse model

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

Simulator: SimCycle-Visit for East Asia

- Carbon Emission by Fire
- Carbon Loss through Water
- Carbon Emission by Microorganisms Degradation
- Tree Growth/Mortality
Indonesia CTC (Climate Technology Center) at BPPT

Outcomes of SATREPS
- Real Time Monitoring System
- Integrated MRV System
- Real Time CO2 Emission Mapping
Thank you for your attention!

Kalampangan area, Central Kalimantan
Appendix:
Q: How to estimate Forest Degradation and LULUCF?
A: **HISUI (Hyper-spectral Imager Suite)** will be available for these estimation soon.
What is Hyperspectral, Multispectral data?

Hyperspectral data provides vast amount of information.
Using NDWI as a indicator of water stress, blast disease of oak tree is detected in the early stages. This result shows that the analysis using hyperspectral data can monitor the health condition which multispectral analysis (or visual examination) can not detect.

(a) 2008/8/12  
(b) 2009/6/12  
(c) 2009/8/26

**Normalized Difference Water Index (NDWI)**

\[ NDWI = \frac{NIR - SWIR}{NIR + SWIR} \]

(NIR: 880nm, SWIR: 1240nm)

Extract water stressed trees using NDWI (NDWI<-0.2)

Extract dead trees

Validation of extraction result

**Red**: Dead trees in Fig.(c)

**Green**: Water stressed trees in Fig.(b)

**Yellow**: Corresponding area of estimated water stressed trees in June and dead trees in August.
Forest type classification for LULUCF by HISUI-Hyper using airborne

Forested type in tropical forest in peatland

- Many species mix
- Tumih, Grungang
- Low density

Mitsubishi Research Institute, Inc
Japan Space System
Hokkaido University
Agency for the Assessment and Application of Technology, Indonesia (BPPT)