K&C Phase 4 – Final Report

F7: Wide area forest monitoring of Insular SE Asia and Guiana Shield

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Project outline and objectives

Describe the original project objectives, and whether any changes have been made to those (and if so, why)

Project areas changed to include Sumatra and Western Amazon (using mosaic data), while Guiana Shield is delayed (start 2019)
Project outline and objectives

1. Continue development of techniques for time-consistency (PALSAR-1/2) and the use of ScanSAR in dynamic and irregularly inundated areas. Integration with C-band Sentinel-1 data, which may significantly increase possibilities for land cover and biomass stratification. Status: Ecological and flood frequency mapping baselines 2017 completed for Sumatra, Borneo and western Amazon (using FB mosaic data).

Project outline and objectives

3. Integration of PALSAR data, aerial LiDAR/photography and field data to support the development of carbon accounting methodology for the Indonesian REDD agency (in collaboration with Bill Salas; 60 LiDAR sites in Kalimantan). Status: DONE; empirical relationships PALSAR and LiDAR derived biomass established.

4. Forest baseline mapping and decadal change mapping (using PALSAR-1/2 and JERS-1). Status: In progress.

5. Study of forest degradation (in combination with TerraSAR-X data at sites in Brazil). Status: New site in Calha Norte; in progress; first results are good. New results available (in combination with Sentinel-1) at sites in Borneo.
Results and significant findings

(1) Tropical Peatland Watch system design (ESA study)

(2) Baseline studies
Land cover / ecological maps: Borneo, Sumatra, Western Amazon
Flood frequency maps: same areas
Decadal change: Borneo, parts of Western Amazon

(3) NRT monitoring systems (using these baselines)
TPW area Central Kalimantan
- Sentinel-1 / Sentinel-2 / PALSAR-2
Rationale for Tropical Peatland Watch project

While peatlands cover 3% of the Earth’s land mass, they contain as much carbon as all terrestrial biomass combined, twice as much as all global forest biomass, and about the same as in the atmosphere.

Top 20 countries with the largest peat carbon stocks in 2008 (Joosten, 2010)

**Tropical countries:**
- #3 Indonesia: 49 Gt C
- #5, 6, 7 PNG, Brazil, Malaysia: each ± 5 Gt C
- #17 Republic of Congo: 1.5 Gt C
- #20 Democratic Republic of the Congo: 1.1 Gt C

Peruvian Amazon: ± 20 Gt C (Lähteenoja et al., 2011).
Cuvette Centrale swamp forest in the Congo Basin: ± 30 Gt C (Dargie et al., 2017)
Only 15% of the world’s peatlands are drained
Global emissions from drained peatlands: ± 0.5 Gt C per year (or ± 5%).
Indonesia: ± 0.2 Gt C per year
Peatland fires (mainly Russia and Indonesia) cause huge additional emissions
Indonesia 2015: 900,000 ha (or 3.5%) of peatlands were on fire

Jakarta 30/10/2018: Governments of Indonesia, Democratic Republic of the Congo, the Republic of Congo and Peru open the International Tropical Peatland Center (ITPC)
Results and significant findings

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TPW area Central Kalimantan
- Sentinel-1 / Sentinel-2 / PALSAR-2
Borneo and Sumatra baselines 2017 based on PALSAR-2 (FB mosaic), Sentinel-1 and Landsat-8 data; 25 m pixel size

<table>
<thead>
<tr>
<th>Land use class</th>
<th>User accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia</td>
<td>98.1%</td>
</tr>
<tr>
<td>Eucalyptus</td>
<td>84.2%</td>
</tr>
<tr>
<td>Hevea</td>
<td>99.5%</td>
</tr>
<tr>
<td>Oil palm</td>
<td>99.6%</td>
</tr>
</tbody>
</table>
LULC 2009

Based on:
Consistent multi-annual analysis of PALSAR-1 FB strip data (2007-2010)

Aggregated classes

Classes cf. Indonesian standard legends
LULC 2017

Based on:
1. PALSAR-2 FB mosaic data
2. Landsat-8
3. Sentinel-1 VV year average

Aggregated classes

Related to ecological characterisation and biomass levels

Classes cf. FAO LCCS
Flood frequency PALSAR-1

Based on: PALSAR-1 ScanSAR strip data (2006-2011)
Based on:
PALSAR-2 ScanSAR standard scenes (2014-2018)
Colombian Amazon: Baseline Map 2008-2010. Based on PALSAR data. Work with ACT-ACA. 15 structural classes following the FAO LCCS legend.
Brazilian Amazon-Mamirahua: Baseline map 2017. Based on PALSAR and Landsat. Work with ACT-ACA. 15 structural classes following the FAO LCCS legend. Detection of wetlands and flooding regimes on the Varzeas.
Brazilian Amazon-Mamirahua: Baseline map 2017. Based on PALSAR and Landsat. Work with ACT-ACA. 15 structural classes following the FAO LCCS legend. Detection of wetlands and flooding regimes on the Varzeas.
Baseline map 2017, Peruvian Amazon: **Pacaya Samiria peatlands**

Based on PALSAR-2 FB mosaic data and Landsat

Work done with ACT ACA; 15 structural classes following the FAO LCCS legend

Detection of different forest structures on the peatlands
Baseline map 2017, Peruvian Amazon: **Pacaya Samiria peatlands**
Based on PALSAR-2 FB mosaic data and Landsat
Work done with ACT ACA; 15 structural classes following the FAO LCCS legend
Detection of different forest structures on the peatlands **with flooding information**
Results and significant findings

(1) Tropical Peatland Watch system design (ESA study)

(2) Baseline studies
Land cover / ecological maps: Borneo, Sumatra, Western Amazon
Flood frequency maps: *same areas*
Decadal change: Borneo, parts of Western Amazon

(3) NRT* monitoring systems (using these baselines)
TPW area Central Kalimantan
- Sentinel-1 / Sentinel-2 / PALSAR-2

(*) NRT is defined here as availability within 2-3 days after satellite overpass
Typical pattern of forest degradation and access road. Hard to detect with other techniques.

Typical pattern of oil palm plantation development. Easy to detect.
A: Tropical forest with several vegetation layers
B: Degradation by selective logging
C: Clear-cut deforestation seen by radar
C: Clear-cut deforestation seen by optical (in range geometry)
Comparison detections radar degradation (B) radar clear-cut (C) and optical clear-cut (C'). These do not match because radar parallaxes cause shifts in range.
Change between mid-2015 and end of 2018

Degradation → Deforestation →

Part of Sebangau NP

Road development

Canal construction

Fire damage

S1A-Change between mid-2015 and end of 2018
Radar detects road in real time up to 60 times (it is detected in all images)

Optical detections of road are delayed (up to one year) and very sporadic
Sentinel-1, end of 2018

Sentinel-1, animation
One of the best Sentinel-2 images
Example Sentinel-1 image with radio interference. Automatically handled by software.
Example Sentinel-1 image with heavy rain cell. Automatically handled by software.
Change between mid-2015 and end of 2018

Degradation → Deforestation

Timber logging (non-sustainable)

Road development

Border Heart of Borneo area

KC25, Dirk Hockman, 7 Feb 2019
PALSAR-2 Time Series

- C10 Nov 2014
- C16 Feb 2015
- C19 Mar 2015
- C22 May 2015
- C27 Jul 2015
- C39 Jan 2016
- C45 Mar 2016
- C48 May 2016
- 5C3 Jul 2016
- C56 Aug 2016
- C103 Jun 2018
**Effect of canal blocking:** Peat swamp degradation (B) and restoration (A) in the Mawas area between 1998 (JERS-1) (a) and 2006 (PALSAR) (b). The red area is degraded; the blue area is intact or regenerating.
New fire damage caused by dam breach. Is canal still draining today?
Example of fire damage and excess drainage after dam breach; (left) Sentinel-2 September 23, 2018 showing year 2015 fire damage pattern along draining canals; (middle) PALSAR-2 ScanSAR near range October 17, 2018 and (right) idem in far range October 12, 2018. The near real-time combination of near and far range L-band data reveals the existing remaining excess drainage patterns (dry soil is dark in far range). Area: Central-Kalimantan.
Role of PALSAR-2 (such as in TPW)
PALSAR-2 is difficult to use as a NRT monitoring system but can be used well as monitoring system in combination with other sensors (Sentinel-1) and is crucial for wetland/hydrology
PALSAR-2 is very useful for baseline mapping (land cover and land cover change, regeneration and flood frequency)

PALSAR-2 research (short term)
• (KC – Phase 4 next two months and later): refine methods for flood frequency mapping [3 cases related to different incidence angle ranges; different stratification methods]
• BRG water level gauges and soil moisture data
Deliverables and other output

- Peer-reviewed publications

  
  
  
  
  
  
  
  
List of ground truth data provided to JAXA (as per the contract)

- **Borneo.** Field data reports from campaigns in Mawas (2013-2014, and onwards). Mawas is a peat swamp forest near Palangkaraya, Central-Kalimantan. Biomass plots with tree data (species, total height, crown dimensions, dbh).

- **Borneo.** Aerial LiDAR and 14-inch aerial photography (sample areas). Data collected within the framework of a NASA Carbon Monitoring System (CMS) project. Some restrictions may apply. More info: Bill Salas.

- **Suriname.** GPS-tagged oblique aerial photography (2010)

**Status:** all delivered (for approved research areas only)

- **Project deliverables**
  Datasets: See presentation KC24
PALSAR/PALSAR-2 data access

Path data PALSAR-2 Cycle 2-88

ScanSAR Borneo: 217 requested, 132 received (61%)
ScanSAR Guiana Shield: 248 requested, 206 received (83%)
Fine Beam (both sites): 460 requested, 413 received (90%)

PALSAR/PALSAR-2 ScanSAR mosaics (both sites)
PALSAR-1/2 ScanSAR: completed until PALSAR-2 cycle 111
JERS-1: 204 mosaics received

Standard ScanSAR data
PALSAR-1: Papua (27)
PALSAR-2: Papua (21); Sumatra (103); Borneo (76)
Acknowledgement

This work has been undertaken within the framework of the JAXA Kyoto & Carbon Initiative. ALOS PALSAR data have been provided by JAXA EORC

Thank you
Post-KC proposal: “Tropical peatland watch”

- **Project objectives**: Build a tropical peatland monitoring system to provide **NRT** information on peat swamp forest degradation and deforestation, construction of new canals and roads on peat, re-opening of old canals, dam breaches, fire risk and fire damage.

- **Satellite data requested from JAXA**: Mainly ScanSAR standard data (and/or stripmap data) and mosaics

- **Other data sources to be used**: Sentinel-1/-2/-3; Landsat-8; MODIS; VIIRS

- **Relevance to the 4 K&C thematic drivers**: Indonesia is a large contributor to global emissions because of drained peatlands and peatland fires. Large efforts are ongoing to “re-wet” peatlands.

- **Project area(s)**: Indonesia & possibly Peru, Congo’s

- **Expected outcomes and deliverables**;
  - Improved baseline maps for peatlands
  - Methods, algorithms and automation for a near real-time tropical peatland monitoring system
  - Technical and scientific support to the International Tropical Peatland Center (ITPC)
For KC members who have submitted proposal for Post-KC

Post-KC proposal

- Project objectives
- Project area(s)
- Satellite data requested from JAXA (sensor, proc. level, amounts, etc.)
- Other data sources to be used
- Relevance to the 4 K&C thematic drivers (Carbon cycle science, Climate Change, International Conventions, Environmental Conservation)
- Expected outcomes and deliverables
Tropical Peatland Watch

L-band has unique observation capabilities to monitor peat (peat swamp forests): (a) below canopy flooding and (b) peat soil wetness

Indonesia has most of the tropical peatlands (±50%)

Until 20 years ago Indonesia’s peatlands were used for selective logging. This was followed by large scale drainage and deforestation. Restoration relies on raising water levels.

The Indonesian Peat Restoration Agency (BRG) has the mandate to implement peat ecosystem restoration in 7 provinces.

The target is to rewet 2 million ha in the next 5 years; blocking more than 10,000 km of canals; for which more than 10,000 dams need to be constructed.
For KC members who have submitted proposal for Post-KC

Post-KC proposal

- **Project objectives:** Build a tropical peatland monitoring system to provide NRT information on peat swamp forest degradation and deforestation, construction of new canals and roads on peat, reopening of old canals, dam breaches, fire risk and fire damage. The system is built with LAPAN (to support peatland restoration in Indonesia) and aims for technical/scientific support to the International Tropical Peatland Center (ITPC).

- **Project area(s):** Indonesia & Peru, possibly Congo’s
Nine peat restoration areas located in Sumatra, Kalimantan and Papua (7 provinces). In these 7 provinces there is 16.1 Mha peatland, of which 5.8 Mha ombrogenous peat (domes) and 2.7 Mha assigned as priority for peat restoration.
PALSAR/PALSAR-2 data access

Standard ScanSAR data covering peat restoration sites
Post-KC proposal

- Satellite data requested from JAXA (sensor, proc. level, amounts, etc.): Mainly ScanSAR standard data (and/or stripmap data) and mosaics
- Other data sources to be used: Sentinel-1/-2/-3; Landsat-8; MODIS; VIIRS
For KC members who have submitted proposal for Post-KC

Post-KC proposal

- Relevance to the 4 K&C thematic drivers (Carbon cycle science, Climate Change, International Conventions, Environmental Conservation):
  - Indonesia, Peru and the Congo’s are the countries with the largest tropical peat stocks
  - Indonesia is a large contributor to global emissions because of drained peatlands and peatland fires. Large efforts are ongoing to “re-wet” peatlands.
  - Governments of Indonesia, Democratic Republic of the Congo, the Republic of Congo and Peru establised the International Tropical Peatland Center (ITPC)
For KC members who have submitted proposal for Post-KC

Post-KC proposal

- Expected outcomes and deliverables:
  - Improved baseline maps for peatlands
  - Methods, algorithms and automation for a near real-time tropical peatland monitoring system (and implementation at LAPAN)
  - Technical and scientific support to the ITPC