K&C Phase 4 – Status report

Utilising L-Band SAR Data for Natural Resource Management in the Philippines

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Science Team meeting #23
Hatoyama, Japan, January 18-20, 2017
The project in the Philippines, through the envisioned outputs, can contribute to achieving the ff K&C objectives:

**Carbon Cycle Science**
- Baseline land cover and change maps from SAR data
- National GHG accounting reports
  - UNFCCC reporting requirements

**Forest Cover and Change maps**
- Implementation of Philippine National REDD-Plus Strategy (PNRPS)
- Other international agreements on REDD+ and biodiversity
  - UNFCCC Cancun Agreements (COP16)
  - Warsaw Framework for REDD+ (COP19)
  - Aichi targets under the Convention on Biological Diversity

**International Conventions**
- Mangrove Forest & Change Maps
  - Key Biodiversity Areas (KBA)
  - Protected areas (PA) under the National Integrated Protected Areas System (NIPAS) of the Philippines

**Environmental Conservation**
- Improve management of protected areas and key conservation sites
  - Compliance to Convention on Biological Diversity and Ramsar Convention

**Climate Change**
- UNFCCC reporting requirements
Project Objectives

- **TA1 - Land cover mapping and change detection:** assess the ability of spaceborne L-band SAR systems to support the generation of national baseline land cover and forest cover and change maps.

- **TA 2 - REDD+ and forest management:** for REDD+ initiatives - baseline mapping of forest area changes, and estimation of forest biomass and carbon stocks.

- **TA 3 - Mangrove forest mapping and change monitoring:** map the country’s mangrove cover extent and detect changes.
Project areas: Philippines

TA 1: protected areas (7 sites; red)

TA 2: REDD+ sites (3 sites; yellow)
    ForClim II (1 site; blue)

TA 3: mangrove sites (6 sites; green)

*TA – thematic area
Why is it significant for the Philippines?

**Local**
- Forest Land use plans, water shed management plans, protected area plans

**Nat’l**
- Develop forest cover maps which are consistent with REDD+ reporting requirements
- Transparent and fast assessment of major DENR programs (reforestation, forest protection and forest land tenure management)

**Int’l**
- International reporting requirements (GHGI, REDD+, NatCom, BUR)
Progress and intermediate results (GIZ)

TA 1: REDD+ and Forest Management

• Field data collection in all sites have been completed
  ✓ Eastern Samar
  ✓ Davao Oriental
  ✓ Panay Island
• Forest resource assessment (FRA) database application was developed with all available FRA data (including Leyte Island of KC3) and will be shared to JAXA.
• The reports have been finalized and are available except for the Panay Island site.
FRA Database (sneak peek)
Impact to the Forest Management Bureau

**Forest Resources Assessment:**
- currently looking into the database and all the data available in it.
- also looking at revising its FRA sampling design (rectangular plot)
- results of this project can be used as a model for the circular plot design and sampling intensity.

**Forest cover and change maps**
- Currently being developed for their National Forest Monitoring System (NFMS)
- These project level researches can be inputs for the national framework and methodologies.
Forest Cover and Change Detection Maps

Reference Data Source
- Landsat
- Google Earth
- Sentinel-1/2
- Other VHR data
- Field data

Training Samples
- Forest Land
- Crop Land
- Coconut
- Grassland
- Wetland
- Settlements

Decision Tree Classifier (thresholds)*

Forest Cover Maps
2007-2010-2015
- Forest
- Non-Forest
- Water
- Coconut

Validation samples based on Olofsson, 2014

Radar Data
- ALOS-1 PALSAR-1 (2006/7-2010)
- ALOS-2 PALSAR-2 (2014-present)

Temporal Data Comparison

Change Detection Map
- Stable Forest
- Water
- Deforested

Decision Tree Classifier (thresholds)*

Accuracy Assessment

Area-adjusted Estimates (targeted on small changes i.e. deforestation) for the change map

Training Samples
- Stable Forest
- Stable Non-Forest
- Stable Coconuts
- Water
- Deforested

*Based on Reiche, et al., 2013

More information available in Congalton & Green, 2009 and Olofsson, 2014
## Datasets used

ALOS PALSAR 25m mosaic (2007 and 2010)
ALOS-2 PALSAR-2 25m mosaic (2015)

<table>
<thead>
<tr>
<th>Site</th>
<th>Tile</th>
<th>2007</th>
<th>2010</th>
<th>2015</th>
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<tbody>
<tr>
<td>Eastern Samar</td>
<td>N12 E125</td>
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<td>Jul06, Jul18, Sep19, Oct01</td>
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<tr>
<td>Davao Oriental</td>
<td>N08 E126</td>
<td>Jun09, Jul09, Sep22</td>
<td>Jul13, Sep14, Sep28</td>
<td>Jul4, Jul13, Oct10</td>
</tr>
</tbody>
</table>
1. Automated pre-processing in RSGISLib
2. Manual image to image registration (PALSAR to Landsat)
3. Sampling scheme and sample selection
4. Zonal statistics analysis
5. ROI separability, boxplots, thresholding
6. Decision Tree Classification and Post-Classification
7. Accuracy Assessment
8. Unbiased Area Estimation
**Pre-Processing** (automated in RSGISLib)

**Sampling** (based on Reiche et. al., 2013)

1. **PALSAR mosaic (HH, HV)** → **Extraction to KEA format** → **Stack HH & HV** → **Speckle filter (3x3, LEE)** → **Calculation of radar-cross section values** → **Build radar effects mask band**

2. **Landsat** → **Image to image registration** → **Stack HH, HV, and 5 ratios** → **Mask all bands** → **Calculation of additional 5 ratios**

3. **National Land Cover Map 2010 from NAMRIA** → **aggregation to 6 IPCC classes** → **stratified random sampling** → **Forest samples 2007-2015** → **cross-checking & back tracking** → **Forest Resources Assessment (2014-2016)**

4. **random sample generator** → **20 training samples** → **final cross-checking** → **50 accuracy assessment samples** → **final training samples** → **final AA samples**

*Tools*
- RSGISLib
- ArcGIS
- MS Excel
- ENVI

*NAMRIA - National Mapping and Resource Information Authority*
Zonal Statistics, Thresholding, Classification, Post Classification, Accuracy Assessment

- Georeferenced stacked PALSAR image (07, 10)
- final training samples
- Georeferenced stacked PALSAR image (2015)

ROI separability

- zonal statistics
- Integrate zonal statistics data (CSV format)

identify thresholds

Decision Tree Classification

- Forest Cover Maps
- Majority Analysis
- Combination of Classes (F/NF)

Accuracy Assessment

Unbiased Area Estimation

RSGISLib
ENVI
MS Excel
R
input image
intermediate output
Decision Tree Classifiers
(Davao Oriental & Eastern Samar)

Davao Oriental (2007 & 2010)

- $HV < -17.3115$
  - $HH < 0$
    - Settlement / Bare Soil
      - $HV < -12.211$
        - $HV < -11.5142$
          - Forest
          - Non-Forest
        - $HV < -12.0284$
          - Forest
          - Non-Forest
      - $HV < -12.3115$
        - Wetland / Flooded Crop
        - Non-Forest

Davao Oriental (2015)

- $HV < -17.3115$
  - $HH < 0$
    - Settlement / Bare Soil
      - $HV < -12.211$
        - $HV < -12.0284$
          - Forest
          - Non-Forest
        - $HV < -12.3115$
          - Wetland / Flooded Crop
          - Non-Forest
  - $HV < -12.0284$
    - $HH < -3.0$
      - Settlement / Bare Soil
        - $HV < -11.4833$
          - Forest
          - Non-Forest
        - $HV < -11.7894$
          - Non-Forest
        - $HV < -11.0784$
          - Forest
          - Non-Forest
  - $HV < -12.3115$
    - Wetland / Flooded Crop
    - Non-Forest


- $HV < -10.0$
  - $HH < -3.0$
    - Settlement / Bare Soil
      - $HV < -11.5142$
        - Forest
        - Non-Forest
      - $HV < -11.7894$
        - Non-Forest
    - $HV < -11.0784$
      - Forest

Eastern Samar (2015)

- $HV < -10.0$
  - $HH < -3.0$
    - Wetland / Flooded Crop
    - Non-Forest
## Accuracy Assessment Results

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<td>NF</td>
<td>73.23%</td>
<td>84.07%</td>
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</table>
Albay Decision Tree Classifier

- Severe under-classification of forest in Albay for all PALSAR images

- Only threshold for wetland/flooded crop gave reasonable classification result.

- Thresholds used for the Decision Tree Classifier for Eastern Samar and Davao Oriental were tested on the Albay PALSAR images.
  - Thresholds for Davao Oriental classified plenty of coconut palm areas as forest.
  - Thresholds of Eastern Samar seemed to give reasonable results.

\[
\begin{align*}
\text{HV} &< -13.2454 \\
\text{HH} &< -3.0 \\
\text{HV/HH} &< 0.551416 \\
\text{HV} &< -11.7894 \\
\end{align*}
\]

Settlement/Bare Soil  
Wetland/Flooded Crop

Forest  Non-Forest
*2007 image have regular lines that look like sensor error
Challenges (Forest Cover Maps)

- Thresholds differed in all three sites.

- The thresholds used to classify the ALOS 1 mosaics were not applicable for ALOS 2 mosaics. Results for ALOS 2 mosaics had severe underestimation of forests in all three sites. Also observed this in 2015 FNF maps from JAXA. (Patricia will illustrate later)

- In Albay, thresholds generated from samples did not generate realistic results.
Challenges (Forest Cover Maps)

- Accuracy Assessment results were quite good and were either made better or lowered (~70-90%) using the Unbiased Area Estimation method by Olofsson (2014) but the generated forest area values greatly differed with the 2010 national land cover maps of the Philippines as well as the estimates from Hansen’s maps.

- Results were also checked against Google Earth, in some areas:
  - forest areas are classified as non-forest
  - non-forest areas are classified as forest
# Challenges (Forest Cover Maps)

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<td>1,680</td>
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<td><strong>Davao Oriental</strong></td>
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<td>32,446</td>
<td>32,294</td>
<td>32,038</td>
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<td>NAMRIA/GE</td>
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Forest Cover Change Maps

Based on Reiche’s (2013) technique.


2. Application of Reiche’s technique: classify all HV DCI values below 2.2 dB as Stable Forest, otherwise, it is considered deforestation.

3. Masking out of non-forest areas so that only deforestation within forest areas are identified.

4. 50 validation samples for stable forests taken from FRA (~2015) and back tracked to 2007 using Google Earth.

5. 50 validation samples for deforestation taken from Landsat and Google Earth.
Forest Cover Change Maps

- Looked like it gave reasonably realistic results but...

Accuracy assessment results:
- Davao Oriental: only 15 samples out of 50 samples of deforestation were correctly classified
- Eastern Samar: only 7 were classified correctly.

Possible reasons:
- The deforestation sample that were selected were incorrectly located in Google Earth.
- Actual field samples may be needed to get accurate mapping of deforestation.
Forest Cover Change Maps

• Replicate forest cover map method
  2. 20 training samples for stable forests taken from FRA (~2015) and back tracked to 2007 using Google Earth.
  3. 20 training samples for deforestation taken from Landsat and Google Earth.
      • Samples were used to identify thresholds specific to sites
      • Separability analyses between Stable Forests and Deforestation were usually good (~1.8-1.9)
      • But, boxplots showed plenty of overlap
      • Some results looked reasonable but accuracy assessment results are not good (<50%!!!)
      • Compared to Hansen maps, too much deforestation.
Progress and intermediate results (FFI)

**TA1:** JD De Alban\(^1\), AK Monzon\(^1\), M Parinas\(^1\), SR Reyes\(^1\), RK Veridiano\(^1\), R Tumaneng\(^1\)

**TA2:** AK Monzon\(^1\), RK Veridiano\(^1\), G Mendoza\(^2\), RJ Vinluan\(^3\), O Agoncillo\(^3\), JD De Alban\(^1\)

**TA3:** AK Monzon\(^1\), SR Reyes\(^1\), JD De Alban\(^1\), M Parinas\(^1\), RK Veridiano\(^1\), R Tumaneng\(^1\), P Sanchez\(^4\), NM Roca\(^4\), DM Dela Torre\(^1\)

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\(^1\) Fauna & Flora International (FFI)
\(^2\) Biodiversity & Watersheds Improved for Stronger Economy and Ecosystem Resilience Programme (B+WISER)
\(^3\) United States Agency for International Development (USAID)
\(^4\) Forest Management Bureau, Department of Environment and Natural Resources (FMB-DENR)

Science Team meeting #22
Tokyo, Japan, February 16-18, 2016
Progress and intermediate results (Summary)

- Field data collection in all sites completed
- Used eCognition rulesets for mangrove classification using SAR and Landsat data
- Final forest/non-forest change and mangrove cover change maps and statistics produced for all sites
- Documentation of methods and results have been drafted
## Project Milestones (same as reported in Feb 2016)

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<tr>
<th>Main Activities</th>
<th>2014</th>
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<th>2016</th>
<th>2017</th>
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<td>S2</td>
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<td>1. Image processing</td>
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<td>2. Field data collection and assessments</td>
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<tr>
<td>3. Image post-processing, modeling, and analysis</td>
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<tr>
<td>4. Report writing</td>
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**Legend:**
- **Land cover mapping**
- **REDD+ and forest management**
- **Forest and climate protection**
- **Mangrove mapping and change detection**
## Data sharing

<table>
<thead>
<tr>
<th>Thematic Area</th>
<th>Description</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>TA 1</td>
<td>• FFI: land cover and habitat ground-truth data collected from 2014-2015 in seven sites; GPS coordinates, photos</td>
<td>Collection completed</td>
</tr>
</tbody>
</table>
| TA 2          | • GIZ: FRA in 2015  
  • Eastern Samar (120)  
  • Panay Island (104)  
  • Davao Oriental (150)  
  • FFI/B+WISER: forest inventory data collected in 2015 from one site; 62 plots | Collection completed |
| TA 3          | • FFI: mangrove ground-truth data collected from 2014-2015 in six sites; GPS coordinates, photos | Collection completed |
## Deliverables

<table>
<thead>
<tr>
<th>Thematic Area</th>
<th>Description</th>
<th>Status</th>
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</table>
| TA 1          | • Land cover/FNF cover and change maps, 2007-2010-2015  
                • Documentation report | On-going completion |
| TA 2          | • Forest and non-forest cover and change maps (4 sites)  
                • Forest Biomass Maps (except Albay)  
                • Documentation report  
                • Baseline carbon stock assessment from Forest Resources Assessments (except Albay) | On-going  
                On-going  
                Completed. |
| TA 3          | • Mangrove cover and change maps 1996, 2007-2010, 2015  
                • Documentation report | Done |
| Others        | • Conference papers published/presented in: 14th World Forestry Congress (4) and 36th Asian Conference on Remote Sensing (3) | Done |
PALSAR/PALSAR-2 data access

All requested datasets were delivered and downloaded. 😊

→ 2017 mosaic datasets will be needed by FMB for future forest cover maps

Some datasets may still be needed from JAXA but for the work of Phil-LiDAR FRExLS (forest component) project. They plan to use PALSAR with LiDAR data for forest mapping.

May not have sufficient time to generate forest biomass maps because the GIZ REDD+ project is ending in April and the next 2 months will probably be consumed in refining and finalizing all the other deliverables for JAXA…
Acknowledgements

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

This K&C project is also undertaken through the joint collaboration between Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Fauna and Flora International, University of the Philippines Department of Geodetic Engineering (UP-DGE) and the DENR-Forest Management Bureau (DENR-FMB). The REDD+ project was funded by BMU under its International Climate Initiative through GIZ.

Thank you!